Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

Pembrokeshire Marine
European Marine Site

ADVICE PROVIDED BY THE COUNTRYSIDE COUNCIL FOR WALES IN FULFILMENT OF REGULATION 33 OF THE CONSERVATION (NATURAL HABITATS, &c.) REGULATIONS 1994

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PEMBROKESHIRE MARINE

EUROPEAN MARINE SITE

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SUMMARY: PLEASE READ THIS FIRST

This document contains CCW's advice issued under Regulation 33 of the Conservation (Natural Habitats, &c.) Regulations 1994, for the *Pembrokeshire Marine Special Area of Conservation* (SAC), namely conservation objectives and advice on operations. It also includes an explanation of the purpose and format of CCW's "Regulation 33 advice".

This latest version of the Regulation 33 package has been revised to improve consistency across the marine SACs in Wales. The intent of the conservation objectives and of the advice on operations which may cause deterioration or disturbance to the feature is the same as in previous versions. The Conservation Objectives are now shorter and more generic but there has been no change in what is considered to represent Favourable Conservation Status.

Section 1 is a brief introduction to the legal context for Regulation 33 advice.

Section 2 explains in more detail the legal basis and practical requirements for setting conservation objectives for Natura 2000 sites, as understood by CCW. It also explains the legal and practical basis of the operations advice.

Section 3 contains a brief overall description of *Pembrokeshire Marine SAC*, current operations taking place with the SAC and information on modifications as a result of human activity.

Section 4 describes habitats and species for which the *Pembrokeshire Marine SAC* has been selected as an SAC as well as why they are considered important. The information is presented using the same headings as those used to describe the conservation objectives so that useful underpinning information in support of these objectives can easily be referenced.

Section 5 contains CCW's advice as to the conservation objectives (Regulation 33(2)(a)) for the features for which the site has been selected as a SAC. This includes a vision statement which is a descriptive overview of what needs to be achieved for conservation on the site. It brings together and summarises the Conservation Objectives into a single, integrated statement about the site.

Section 6 contains CCW's advice as the operations which may cause deterioration or disturbance of the habitats and species for which the site has been selected (Regulation 33(2)(b)). This is provided to assist the relevant authorities and others in understanding the implications of the designation of the site and the requirements of the Habitats Regulations and government policy towards it.

The **Appendices** provide a glossary of terms, a list of other types of protected areas within the SAC and more detail on the elements of Favourable Conservation Status. Other background information such as lists of additional species and habitats of particular note (*e.g.* species and habitats subject to Biodiversity Action Plans or threatened and declining species and habitats identified by the OSPAR Commission) and the variety of biotopes associated with Annex 1 features may be added in due course.

The **Maps** show the boundaries of the SAC, the location of other protected areas which occur within the SAC, and give an indication of the location of features for which the site was designated. Further maps, for example of adjacent designated areas or giving an indication of the location of habitat components (*e.g.* types of reef or types of mudflat and sandflat), may be added in due course.

1 INTRODUCTION

The 1992 EC Habitats Directive [1] aims to help conserve the diversity of habitats and species across the European Union. It represents one of the ways in which EU member states are fulfilling the commitments they made at the "Earth Summit" in Rio de Janeiro in 1992, for the conservation of the Earth's biological diversity[2].

The Habitats Directive requires member states to take a variety of measures aimed at the conservation of biodiversity. These measures include the designation of Special Areas of Conservation (SACs) on land and sea. Each SAC is to be designated for particular habitats and species, and they are to be managed in ways that help conserve those habitats and species.

The Habitats Directive is given effect in the UK largely through the Conservation (Natural Habitats, &c.) Regulations 1994 ("the Habitats Regulations")[3]. These Regulations set out the powers and duties of UK statutory bodies towards compliance with the requirements of the Habitats Directive. Under these Regulations, SACs together with Special Protection Areas (SPAs) classified under the 1979 EC Birds Directive for the conservation of birds, are called "European sites" and those that include marine areas are called "European marine sites" [4].

Regulation 33 of the Habitats Regulations requires the Countryside Council for Wales (CCW) to advise the relevant authorities[5] for each European marine site in, or partly in, Wales as to "(a) the conservation objectives for that site, and (b) any operations which may cause deterioration of natural habitats or the habitats of species, or disturbance of species, for which the site has been designated." This document contains CCW's advice under Regulation 33 in relation to the *Pembrokeshire Marine* EMS.

None of the information contained in this document legally binds any organisation (including CCW) to any particular course of action. However, in exercising their functions in accordance with the requirements of the Habitats Directive, as required by the Habitats Regulations, and in accordance with government policy towards Ramsar sites, the relevant authorities should be guided by the advice contained in this document. This applies amongst other things to the establishment of a "management scheme"[6], if such a scheme is established.

Relevant authorities and others may have obligations towards the conservation of habitats and species that are not features for which the Pembrokeshire Marine EMS has been designated and such obligations are not affected by this document.

The information contained in this document is based on best available knowledge at time of writing and is subject to review at CCW's discretion. Further guidance relating to European marine sites is published by the National Assembly for Wales (*European marine sites in England and Wales*, June 1998, Department of the Environment and Welsh Office), CCW (*European marine sites: an introduction to management*, 1998, CCW Bangor) and European Commission (*Guidelines for the establishment of the Natura 2000 network in the marine environment. Application of the Habitats and Birds Directive, May 2007*).

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[1] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (OJ No L 206)

[2] Biological diversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." (1992 International Convention on Biological Diversity, Article 2. http://www.biodiv.org/convention/)

[3] SI 1994/2716, HMSO, London. http://www.legislation.hmso.gov.uk/si/si1994/uksi_19942716_en_1.htm)

[4] "Marine area" is defined in Regulation 2 of the Habitats Regulations as "any land covered continuously or intermittently by tidal waters, or any part of the sea in or adjacent to Great Britain up to the seaward limit of territorial waters".

[5] The types of bodies that are "relevant authorities" are identified in Regulation 5 of the Habitats Regulations.

[6] Regulation 34 of the Habitats Regulations.

2 EXPLANATION OF THE PURPOSE AND FORMAT OF INFORMATION PROVIDED UNDER REGULATION 33

The information provided under Regulation 33 is in two parts: the conservation objectives, and the advice on operations. The legal context for each of these elements, the format of the advice and its underlying rationale are explained here. Sections 4 (conservation objectives) and 5 (operations advice) should be read in conjunction with these explanatory notes.

2.1 CONSERVATION OBJECTIVES BACKGROUND

2.1.1 LEGAL BACKGROUND

The conservation objectives for a European marine site are intended to represent the aims of the Habitats and Birds Directives in relation to that site. The Habitats Directive requires that measures taken under it, including the designation and management of SACs, be designed to maintain or restore habitats and species of European Community importance at "favourable conservation status" (FCS), as defined in Article 1 of the Directive (see Table 1).

Table 1:
Favourable conservation status as defined in Article 1 of the Habitats Directive

Conservation status of a natural habitat means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species within the territory referred to in Article 2.

The conservative [sic] status of a natural habitat will be taken as 'favourable' when:

- its natural range and the areas it covers within that range are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- conservation status of typical species is favourable as defined in [Article] 1(i).

Conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term natural distribution and abundance of its populations within the territory referred to in Article 2;

The conservation status will be taken as 'favourable' when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis

Guidance from the European Commission[7] indicates that the Directive intends FCS to be applied at the level of an individual site, as well as to habitats and species across their European range. Therefore, in order to properly express the aims of the Habitats Directive for an individual site, the conservation objectives for a site are essentially to maintain (or restore) the habitats and species of the site at (or to) FCS.

[7] European Commission (2000). *Managing Natura 2000 sites: the provisions of Article 6 of the Habitats Directive 92/43/EEC*. DGXI, Brussels, p.18.

2.1.2 PRACTICAL REQUIREMENTS

In practical terms, the conservation objectives for a site set the standards which must be met if the habitats and species (collectively referred to as "features") are to be at FCS. There are four elements to this. The conservation objectives must:

(i) form the basis for proactively identifying what actions, if any, need to be taken by those bodies responsible for the management of operations in and around the site, in order to conserve the features.

(ii) inform the consideration of proposed developments, or "plans or projects"[8], which are likely to significantly affect the features of the site. In order for a plan or project to proceed, it must be ascertained that it will *not* adversely affect the "integrity of a site"[9]. This depends on whether or not the plan or project will adversely affect the conservation status of one or more of the features and therefore requires direct reference to the conservation objectives.

(iii) set the standard against which CCW reports to government on the conservation status of the features on the site. Government in turn will use this information, together with that from other SACs and on the status of habitats and species outside designated sites, to report to the EC on the implementation and effectiveness of the Habitats Directive.

(iv) set the standard against which the appropriateness of management can be judged. If the conservation objectives are not being met it may be due to inappropriate management of the site, or to factors originating outside the site or outside the control of those responsible for management, or a combination.

To achieve this we provide conservation objectives covering all the elements of FCS as set out in the Directive, at the same time as being suitable for guiding the preparation of management plans and testing the acceptability or otherwise of the effects of plans and projects. Table 2 indicates the various aspects of conservation status described in this package to help explain the conservation objectives. CCW also uses a related set of "performance indicators" which supports monitoring[10] and allows judgements to be made about site condition[11] and conservation status of features for purposes such as reporting and review of management.

The results of the monitoring of feature condition, combined with information on security and suitability of management and the results of surveillance support the making of judgements about whether or not the conservation objectives are being met. Knowledge of the dynamics of many marine species and communities and their sensitivity is limited. Accordingly, in many cases it is not yet possible to identify values above or below which conservation status would be considered unfavourable. Surveillance[12] is necessary to:

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[8] Plans and projects are certain types of operation that the Habitats Directive and Regulations require be subject to specific procedures. Plans or projects considered likely to have a significant effect on a European (marine) site must be subject to appropriate assessment of their implications for the site in view of the site's conservation objectives. The carrying out of an appropriate assessment must include consultation with CCW, and such consultation is a separate process to the advice in this document. The information in this document is intended to assist in the identification of plans and projects which are likely to require appropriate assessments, and will form the basis for advice given by CCW in relation to individual plans and projects.

[9] "Integrity of the site" is not defined in the legislation, but has been defined by the UK government as "the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified [i.e. designated]". This definition is similar in intent to FCS.

[10] Monitoring is defined as "Surveillance undertaken to ensure that formulated standards are being maintained. The term is also applied to compliance monitoring against accepted standards to ensure that agreed or required measures are being followed." (*A statement on Common Standards Monitoring*, 1998, Joint Nature Conservation Committee, Peterborough . http://www.jncc.gov.uk/page-2198

[11] The status of the site at a particular moment in time.

[12] Surveillance is defined as "a continued programme of surveys systematically undertaken to provide a series of observations in time" (*A statement on Common Standards Monitoring*, 1998, Joint Nature Conservation Committee, Peterborough. http://www.jncc.gov.uk/page-2198

- gain a greater understanding of feature and factor variability,
- provide information which can assist in the interpretation of the results of monitoring of the performance indicators *e.g.* information on trends in other attributes and factors can assist the identification of the causes of changes observed in the performance indicators;
- improve the overall level of understanding of the site, its features and the factors affecting them.

The performance indicators and surveillance requirements for the features of the site are not included in this document. Information about these will be provided by CCW in due course.
Each of the habitat features of the SAC represents part of the range and variation of that feature within the UK and Europe. The SAC and all its features makes up part of a suite of sites across the UK that were selected to represent the range and variation of all relevant features within the UK, and to become part of the pan-European network of conservation areas – Natura 2000. Additional information about the selection of SACs in the UK is provided on the website of the Joint Nature Conservation Committee[13].

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TABLE 2:
Elements of favourable conservation status described in this document to help explain the conservation objectives*

(I) For each HABITAT feature

- RANGE – including distribution and extent
- STRUCTURE & FUNCTION – including geology, sedimentology, geomorphology, hydrography & meteorology, water and sediment chemistry and biological interactions
- TYPICAL SPECIES – including species richness, population dynamics and range and as defined for the species features (below)
- NATURAL PROCESSES

(II) For each SPECIES feature

- POPULATION – including size, structure, production and physiological health
- RANGE – including areas of the site which the population/individuals use
- SUPPORTING HABITATS & SPECIES – including distribution and extent, structure, function and quality and prey availability & quality.

For both habitats and species information is provided on natural processes, current condition and modifications as a result of human activity.

More detail on why these elements are important is provided in Appendix 4

*The information is limited by the availability of data and in many cases our understanding of these elements is incomplete. All descriptions are therefore based on the best available information at the time of writing.

2.2 OPERATIONS WHICH MAY CAUSE DETERIORATION OR DISTURBANCE

2.2.1 LEGAL CONTEXT

CCW's specific duty in Regulation 33 to give advice on operations that are potentially damaging needs to be seen in the context of the Habitats Directive, which requires that for a SAC:

- the necessary conservation measures are established which correspond to the ecological requirements of the habitats and species on the site;

[13] http://www.jncc.gov.uk/page-2198

- appropriate steps are taken to avoid deterioration of habitats and significant disturbance of species.
- any plan or project which is likely to have a significant effect on a site is subject to an appropriate assessment in view of the site's conservation objectives.

The operations advice, in combination with the conservation objectives, is designed to assist relevant authorities and other decision-makers in complying with these provisions. The operations advice given in this document is without prejudice to other advice given, including the conservation objectives themselves and other advice which may be given by CCW from time to time in relation to particular operations.

The term "operations" is taken to cover all types of human activity, irrespective of whether they are under any form of regulation or management.[14] This is because the obligations in the Directive are defined by the conservation requirements of the habitats and species, not by existing regulatory or management regimes. Thus the advice contains reference to operations which may not be the responsibility of any of the relevant authorities.

2.2.2 PRACTICAL REQUIREMENTS

Operations manifest themselves through one or more factors[15]. The conservation status of a given habitat or species could potentially be affected by many different types of factor, and hence many different types of operation[16]. The key practical purpose of the Regulation 33 operations advice is to assist in the identification of priorities for management, by identifying operations to which features are both 'sensitive' and 'vulnerable'. Sensitivity is defined as 'the intrinsic intolerance of a habitat, community or individual of a species to damage from an external factor.' Vulnerability is defined as 'the likelihood of exposure of a habitat, community or individual of a species to a factor to which it is sensitive'[17]. Thus the potential for an operation to deteriorate or disturb a feature depends both on the sensitivity of the feature to the operation – through its associated factors - and the location, intensity, duration and frequency of the operation and the factors that it affects or causes.

Formulating the operations advice has three main elements:

1. Identifying factors to which the features are sensitive.
2. Identifying the types of operation that can cause or affect those factors.
3. Assessing the likelihood of those factors (and hence the features) being affected by those operations,. in other words the vulnerability of the features to those effects.

The first and second of these elements relies on current understanding of the inherent sensitivity of features to particular factors, and the effect of operations on factors. Although there will be site-specific elements to this information, it may often rely on information from a variety of sources which are not specific to this site. The third stage is very site-specific, relying on information about the types, location, intensity, duration and so on, of operations occurring or likely to occur in or around the site.

[14] The term also includes what the Habitats Directive and Regulations call "plans and projects" (see footnote 9).

[15] A factor is defined as "A component of the physical, chemical, ecological or human environment that may be influenced by a natural event or a human activity" (*Sensitivity and mapping of inshore marine biotopes in the southern Irish Sea (Sensmap): Final report.* CCW, Bangor, December 2000.)

[16] The complexity of formulating operations advice is compounded by the "many-to-many" relationship that exists between operations and factors, where an operation may manifest itself through several factors, and a factor may be affected by several operations, in different ways and to different magnitudes.

[17] Adapted from Hiscock, K. [ed] 1996. *Marine Nature Conservation Review: rationale and methods.* Peterborough: JNCC.

Given that in many cases, information of the type indicated in the previous paragraph is rudimentary, or simply not available a precautionary approach is adopted for the identification of factors and operations. This means that where there is uncertainty about the relevance or otherwise of a factor or operation, CCW favours including it in Regulation 33 advice. The output from this process is a list of operations that CCW considers may cause deterioration or disturbance to the features of the site, with accompanying information on the factors through which the each operation affects the feature. The operations advice clearly has to be based on the best available knowledge at the time and is subject to continual review. It necessarily involves an element of risk assessment, both in terms of assessing the likelihood of an operation or factor occurring, and the likelihood of it having an adverse effect on a feature.

CCW's advice to the relevant authorities is that, as a minimum, the extent and management of the operations identified in Section 6 should be reviewed in the context of the conservation objectives. The list should also help identify the types of plans or projects that would be likely to have a significant effect and should be subject to appropriate assessment, noting that such judgements will need to be made on a case-specific basis.

The advice in Section 6 of this document is not a list of prohibited operations, or operations necessarily requiring consultation with CCW, or CCW's consent[18]. The input of the relevant authorities and others is a legal and practical necessity in determining the management needs of the site. Thus, the operations advice is provided specifically with the intention of initiating dialogue between CCW and the relevant authorities.

[18] However, in relation to land included within the SAC, which has been notified as a Site of Special Scientific Interest (SSSI), owners or occupiers require CCW's consent for any operations included in the SSSI notification, and statutory bodies intending to carry out or permit potentially damaging operations must notify CCW and comply with certain other provisions. (Wildlife and Countryside Act 1981, section 28, as amended by the Countryside and Rights of Way Act 2000, section 75). General guidance on the operation of SSSIs is given in the CCW leaflet *Sites of Special Scientific Interest: A guide for landowners and occupiers* (Countryside Council for Wales, Bangor, 2001).

3. SITE DESCRIPTION

3.1 INTRODUCTION

The seas around Pembrokeshire have long been recognised for their marine conservation importance. The area around Skomer Island and the adjacent Marloes peninsula was designated a Marine Nature Reserve (MNR) in 1991 and remains Wales' only Marine Nature Reserve. Many characteristics have been identified as being important in the Pembrokeshire marine environment, including the:

- extremely wide range of physical habitats;
- distribution and extent of the physical entity of habitats;
- very wide array of habitat structures and functional (environmental) processes;
- integrity of structures and functional (environmental) processes;
- species diversity;
- extent, sizes and integrity of species populations resulting from the relatively limited modification of distribution and extent of habitat and structure and functional (environmental) processes by human activity;
- presence of specific habitats and species judged to be of particular importance because of their rarity, ecological importance or isolated position at the edge of population ranges.

High habitat and biological diversity is of great importance throughout the site, particularly the well documented *reefs* habitat and the Milford Haven ria-estuary. The site's location at a biogeographical boundary between northern and southern species distributions contributes to the biological diversity.

The habitat features are characterised by complex interrelationships with and between biotic and abiotic functional (environmental) processes and species populations. It is the combination of all these components together which gives the overall importance to the habitat features of the site. Each of these individual components contributes to the integral, global importance of each feature, and each of the features contributes to the importance of the site.

Pembrokeshire Marine SAC is a multiple interest site that has been selected for the presence of 8 marine habitat types and associated wildlife (Habitats Directive Annex I habitat types) and 7 Annex II species (Habitats Directive Annex II species). For the qualifying habitats and species, the Pembrokeshire Marine SAC is considered to be one of the best areas in the UK for:

- Large shallow inlets and bays (abbreviated to inlets and bays)
- Estuaries
- Reefs
- *Halichoerus grypus* – grey seal

and to support a significant presence of:

- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- Mud-flats and sand-flats not covered by seawater at low tide (abbreviated to intertidal mud and sand-flats)
- Coastal lagoons
- Submerged or partially submerged sea caves (abbreviated to sea caves)
- Sandbanks which are slightly covered by seawater all the time (abbreviated to subtidal sandbanks)
- *Alosa alosa* - allis shad
- *Alosa fallax* - twaite shad
- *Lampetra fluviatilis* – river lamprey
- *Petromyzon marinus* – sea lamprey
- *Lutra lutra* – otter
- *Rumex rupestris* - shore dock

The features are distributed throughout the SAC with no single feature occupying the entire SAC and with features overlapping in some locations. The SAC boundary and the general location of the Annex I habitat features are shown in maps 1 and 3. These are indicative maps as the extent of most features is not known precisely and some, such as sandbanks, are dynamic and can be highly mobile. A number of habitats and species occurring in the SAC also have Biodiversity Action Plans or are on other lists specifying conservation action such as, 'Nationally Rare and Scarce Species'.

3.1.1 SOURCES AND LIMITATIONS OF SITE INFORMATION

The history and breadth of marine survey and study within the site is considerable with some areas such as Milford Haven and the Skomer MNR amongst the most well surveyed near-shore areas in the UK. Much survey work has focussed on reefs within the area with information on habitats and communities including many marine biological surveys over a period of more than 30 years although the precise distribution of, particularly offshore reefs is incomplete. Coastal processes are relatively less well known, except for broad scale processes and processes in some localities, especially within Milford Haven.

There is a considerable amount of descriptive literature in both published material and limited circulation reports yet, despite this less than 1% of the area of seabed that has been biologically observed or sampled. The limitations of available data are therefore substantial.

Most survey data are point source so that extrapolation for areas between survey points is, and will remain necessary. The accuracy and validity of extrapolation and interpretation depends on availability and quality of supplementary, broad-scale contextual information.

Survey data for the site has been collected over a considerable time period, though the majority has been collected since *c*1960, and most data sets are from single survey events. Another issue is that the development of survey techniques has resulted in data of differing quality and precision. For example, improved accuracy in position fixing techniques means that data from locations for which there are two or more data sets and from surveys conducted during different time periods are not necessarily directly comparable.

There has been a considerable amount of survey work to supply information for specific requirements, particularly in association with commercial development or activity. The outputs from such studies have not necessarily been comparable with other survey data and some have been confidential. Reported outputs placed in the public domain make a valuable contribution to the knowledge base but the information may be out of date and most of the original data unavailable. Development of surveillance and monitoring since the late 1980s has begun to overcome such limitations, but only for a limited suite of functional determinands and species, and at a limited number of locations.

All feature descriptions are based on best available knowledge at the present time. In some cases this is limited but will become more detailed as further survey work is carried out.

3.2 SUMMARY SITE DESCRIPTION

The Pembrokeshire marine SAC encompasses areas of sea, coast and estuary that support a wide range of different marine habitats and wildlife some of which are unique in Wales. In places the SAC landward boundary abuts the boundary of SACs encompassing terrestrial / coastal habitats and species and some intertidal areas that are part of the marine SAC have been notified as Sites of Special Scientific Interest (SSSI) (see Appendix 2). The Pembrokeshire Marine SAC also overlaps wholly or in part with the Skomer Marine Nature Reserve and a number of Special Protection Areas classified

under the Birds Directive. For the location of these SACs, MNR, SSSIs and SPAs see Maps 2.i and 2ii
All references to depths should be taken as Below Chart Datum (BCD) unless stated otherwise.

a) Range

Pembrokeshire Marine SAC extends from just north of Abereiddy on the north Pembrokeshire coast to just east of Manorbier in the south, and includes the coast of the islands of Ramsey, Skomer, Grassholm, Skokholm, the Bishops and Clerks and The Smalls[19] (Map 1).

b) Structure

i) Geology

The site has a rich and complex geology. The northern part is dominated by both sedimentary and igneous precambrian, cambrian and ordovician rocks; the southern part by old red sandstone and carboniferous rocks, notably the limestone block of the Castlemartin coast, and the silurian volcanics of the Marloes Peninsula, Skomer and offshore rocks and islands. There has been a spectacular degree of rock faulting and folding.

The coastal cliffs of highly faulted Cambrian (northern St Brides Bay shoreline) and old red sandstone (southern St Brides Bay, West Dale, Freshwater West) shorelines have extensive sublittoral extension. Softer more recent rocks form cliffs behind and underlying sediment on the lower shores on eastern shorelines.

ii) Sedimentology

There is an extremely wide range of sediments within the site from the very fine muds in sheltered areas of the Milford Haven waterway, through sands and gravels, to consolidated and unconsolidated pebbles and cobbles in deep subtidal areas subject to strong currents and storm beaches. Sediment structures vary from uniform to very heterogeneous.

iii) Geomorphology

The SAC is dominated by the two major westward projecting peninsulas of St David's and Marloes with their associated series of offshore rocks and islands, the large, square shaped St Brides Bay that lies between the peninsulas, the deep ria (drowned river-valley) of Milford Haven and the broad limestone peninsula of the Castlemartin coast.

The coasts are dominated by rugged headlands of hard igneous rock, interspersed by bays and inlets situated on fault lines and where less resistant rocks have been eroded. Many bays are characterised by shores of pebbles, cobbles and boulders of size ranges reflecting the exposure to wave energy while the larger expanses of sands are confined to lower shores.

The topography of the seabed within the site is dominated by rugged, mainly igneous, but also sandstone and limestone, rocky reefs. Many rise to considerable heights above the surrounding deep seabed, some forming islands and islets. Sandbanks formed in the lee of rocky reefs and in other tidal conditions are also prominent seabed features. Between the elevated areas of seabed are extensive undulating areas of rock, such as west of the Dale peninsula, and plains and gentle slopes of sediments.

c) Function

i) Hydrography and meteorology

The range and times of high and low water varies considerably throughout the site. The maximum

[19] "*As a general principle, site boundaries have been drawn closely around the qualifying habitat types or the habitats of species for which the sites have been selected, taking into account the need to ensure that the site operates as a functional whole for the conservation of the habitat type(s) or species and to maintain sensible management units.*" McLeod et al, 2002.

mean spring tide range at Dale Roads, in the entrance to Milford Haven, is around 7.8m compared to around 4.4m in Ramsey Sound. This creates an extensive intertidal zone with broad and high shores. Spring tide low water occurs during the middle of the day which is of significance to littoral organisms, exposing them to maximum sunlight and temperature.

Strong tidal streams are a characteristic of the SAC, particularly around the islands, islets and headlands and narrows, including parts of the Milford Haven waterway, with maximum speeds reaching *c* 10 knots through Jack and Ramsey Sounds during spring tides. There are huge variations in the tidal stream patterns and timing over very short distances and, in some areas, tidally induced overfalls and standing waves. Areas of weaker and negligible tidal streams are widespread, particularly in embayments. There are also unusual tidal conditions, such as the modified salt wedge in Milford Haven and rotary tides in central St Brides Bay. Within the site residual currents are generally south to north.

The open coast is exposed to a considerable amount of wave action and to swell from a prevailing south-westerly direction. The west and south-west coasts are most exposed to the frequently large, widely spaced oceanic swell that also penetrates into the Milford Haven waterway but there are also areas of coastline sheltered from all but the heaviest swells.

Exposure to wave action varies widely with seabed depth, ranging from extreme in shallow, open coast locations with southern to south-western aspects, through shelter from all but the longest wavelength waves in deep areas north of the islands and headlands and in Milford Haven, to almost totally sheltered in tributary estuaries of the Milford Haven waterway.

The water masses in and around the SAC are partly of coastal origin with an oceanic input through the Celtic Sea. Water circulation is seasonally modified as a result of summer heating and stratification in the Celtic and Irish Seas but waters are generally well mixed. The site lies within the overlapping boundaries of two biogeographical provinces: the cold-temperate boreal ('northern') biogeographical province and the warm temperate lusitanean ('south-western') province. The Celtic Sea front forms during summer months and extends west-north-west from the site.

ii) Water and sediment chemistry

Suspended particulate concentrations are highly variable with season, wave action, tidal conditions and freshwater discharge. As a consequence water clarity and seabed and water column light intensity are also highly spatially and seasonally variable. The site is very wind exposed, but variable depending on location and topography.

There is a complex, dynamic salinity regime with in Milford Haven waterway. Published data suggests that offshore salinity remains at a constant 34.5-35‰ although water column data collected in the Skomer MNR from 1992 indicates that inshore salinity is more variable, falling to 33.5‰ during winter months and rising to 36‰ in summer months.

Nutrient and contaminant levels are variable throughout site. Highly dynamic water movement maintains levels of many contaminants below detectable limits although low level chronic hydrocarbon residues are present in sediment sink areas in St Bride's Bay. Coastal waters are considered to have raised levels of nutrients, predominantly as a consequence of diffuse agricultural sources. The Milford Haven Estuary has high levels of nutrients, levels that are of concern. The limited data available for water column nutrient concentrations and fluxes in the open coast water column suggest they are comparable with typical inshore open coast background levels. Water column contaminant concentrations and fluxes are poorly known. Available data suggest that these too are comparable with typical inshore background levels.

Available data suggests water column dissolved oxygen is generally 100% saturation though recent survey suggests that parts of Milford Haven suffer levels at least as low as 86%. Interstitial sediment dissolved oxygen varies with a variety of factors including sedimentology, infaunal biological activity and macroalgal cover. Levels within the estuarine inlets of Milford Haven are of concern as a consequence of the current levels of excessive green algal overgrowth during summer months. A seasonal oxycline (and thermo- and haloclines) develops in Abereiddy quarry lagoon in summer months; during this period the deeper waters are anoxic.

iii) Sediment processes

Detailed sediment processes in St George's Channel are poorly known but inferred to be dominated by tidal current action on mainly coarse, relict or locally derived sediments (from glacial and glacio-fluvial beds) where strong currents have prevented the accumulation of fine sediment. Long period wave action also has a major local modifying effect.

There is a net westward transport of sediments from the Bristol Channel across and into southern Irish Sea although possibly different transport paths for the sand compared to the muddier fractions in suspension. The presence of major sandy bed-forms indicates the transport of large volumes of material.

Deposition, erosion and redistribution of sediments in the site are variable and complex. Detail of local sediment processes is not well known with information limited to Milford Haven where studies indicate a complex of transport paths with inshore transport in a net northerly direction, determined by tidal streams strongly modified by wave action. Areas of medium – long-term sediment deposition are present in the tidal lee of islands and headlands.

iv) Biological interactions

The variety and magnitude of biological interactions have a major influence on species variety and conservation status however the range of interactions is immeasurable. Some examples are included in feature descriptions.

Grazing and predation by vertebrate predators including seabirds, waders and wildfowl, marine mammals and fish. All both remove energy from the habitat features and contribute to nutrient enrichment which may be significant, *e.g.* in the case of wildfowl populations on sheltered mud-flats and seabird colonies on algal communities in adjacent sheltered shallow waters.

The long history of commercial fisheries and exploitation of other species resources has reduced population sizes of many ecologically important species. The perceived impact of recreational and commercial exploitation of sea urchins, a key ecological structuring species, was one of initial reasons leading to demand for the designation of the Skomer MNR.

d) Typical species

The different rock and sediment types and their complex formations present throughout the SAC provide very varied substrata for colonisation by many different species of marine plants and animals and has a strong influence over the types of marine animals and plants that will become established in any one location. These are associated with rocky substrates, areas of soft sediment, tidal current areas and those exposed to different degrees of wave exposure, turbidity and temperature both intertidally and subtidally. Species accounts primarily describe conspicuous macro- and megafauna and macroalgae. With very few exceptions cryptic macrofauna and meiofauna, microfauna and flora have not been described and demersal species are also poorly documented.

A major factor in the nature conservation importance of Milford Haven is the continuum of ecological variation within the system. Of particular importance is the transition from the exposed, fully saline conditions near the entrance, through the sheltered fully saline conditions of the central section and up to the variable/low salinity and extremely sheltered conditions in the upper reaches. Subtidal marine communities penetrate deeply into the Haven, well beyond the central section. The transition in environmental conditions up the Haven has similar effects on subtidal and intertidal communities, except that a significant reduction in subtidal species and community diversity caused by decreasing salinity and increasing turbidity does not occur until upstream of Pembroke Dock

Species variety is better known in some habitats and locations (*e.g.* the Skomer MNR area, Milford Haven waterway) than others. These include populations that are rare, scarce, new to science, edge of range, particularly well developed or exceptionally good examples of their type, slow-growing, long-lived, possibly infrequently recruiting, structurally fragile and species with very precise and / or infrequently occurring habitat requirements. Many of these have specific individual scientific and / or conservation interest.

Population sizes of particular species are unknown or poorly known for most species; where data exist it is patchy both spatially and by species group. Quantitative time series data are available for several long-lived reef species and species assemblages in the Skomer MNR. Biomass is unknown or poorly known for most species as is population structure, reproductive capability, recruitment and the physiological health of most species.

3.3 OPERATIONS WITHIN THE SAC

There is a dichotomy of human activities within the SAC; between the Milford Haven estuary, and the open coastal waters.

Open coastal waters are relatively quiet. Commercial shipping transits to and from the port or anchors in St Bride’s Bay. Recreational and commercial diving, angling and wildlife watching boats frequent the islands and nearshore areas. The coastline is mainly agricultural, with a few small but busy coastal towns. The limited coastal development is focused around the primary centers for tourism. Coastal MOD ranges are dominant along the south coast. Pembrokeshire is one of the most suitable areas of the UK for wave and tidal energy generation.

Milford Haven estuary is a busy centre of commercial and urban activity. As a deep water shipping port it supports substantial petrochemical industry infrastructure. Civil engineering projects are common and the estuary forms both a busy recreational resource and a means of industrial and urban waste disposal. The estuary, fed by its riverine catchment, is susceptible to impacts from changing land management many miles inland from the coast. Fishing activity, whilst limited, coincides with sensitive habitats suited to the shelter of estuarine waters.

3.4 MODIFICATIONS AS A RESULT OF HUMAN ACTIVITY

Various anthropogenic activities currently taking place within the SAC have an influence on the habitat and species features and Section 6 provides additional information on the ways in which such activities might affect the features. Some of the activities will have a direct effect whilst others will have an indirect effect, by altering or modifying the physical, chemical and environmental factors and processes (structural and functional characteristics) which affect the habitats and species. Whilst the structural and functional characteristics of the SAC and its habitat features are inherently important attributes of the marine ecosystem, it is the effect that these characteristics have on the wildlife of the SAC that is of conservation importance.

Human activity has, over the years, modified the marine environment of the Pembrokeshire Marine SAC. The most significant changes have been as a consequence of fisheries, coastal development and land use.

Fisheries have resulted in major changes to abundance and population dynamics of target and by-caught species of fish, crustacean and mollusc. Species such as herring, crawfish and oyster have all shown major declines in abundance. Use of mobile demersal gear, such as dredges and trawls, has resulted in changes to the seabed and its marine life. With the unsustainable exploitation of target species, stock reductions have resulted in declines and changes in fisheries activity, which are now dominated by use of static gear (pots, lines and set nets) and occasional, sometimes intensive, shellfish dredging. Fishing activity continues to impact features of the SAC through removal of target and non-target species and by impacting seabed habitats and their marine communities. Changes in fishing activity since designation that are a cause for concern and in need of management action include; oyster dredging expansion in the Milford Haven estuary, shellfish dredging in Wales' only remaining live maerl bed, scallop dredging in St Bride's Bay and a three fold increase in potting intensity within the Skomer Marine Nature Reserve.

The urbanisation of the coastal zone has resulted in habitat modification and loss. This has been relatively limited on the open coast but very significant within the port of Milford Haven where there has been considerable industrial and urban development over the past 150 years. Development of the estuary since the 1960s, largely associated with the oil industry, has resulted in loss of intertidal flats, hardening of the foreshore, substantial dredging of the seabed, increases in vessel traffic, and associated issues of pollution. Whilst major oil spills have impacted the site infrequently, the ongoing input of chemicals from urban areas, water-borne traffic and the petrochemical industry has likely had the greater long-term effect. Contaminant levels are, in places, well in excess of those known to have deleterious effects on marine biota. Construction projects have significantly impacted the site's maerl bed and restoration is required. New industrial discharges will exacerbate the detrimental effects of the estuary's high nutrient load. Capital dredging has resulted in permanent modification of the seabed and ongoing maintenance requirements will ensure reduced biodiversity of these areas.

Changes in land use, both urban and agricultural have strongly influenced runoff from river catchments within the site. Water increasingly enters the site's rivers as peak events rather than steady flow. Sediment inputs to coastal waters, particularly estuaries, have increased greatly through increases in surface water flows, reduction in standing vegetation, increased stocking and use of the plough. Nutrients put on the ground to increase crop yields, deposited from the air as products of hydrocarbon combustion and discharged direct to the sea by industry, have increased nutrient loads to our estuaries and coastal water to the extent that Milford Haven supports persistent and damaging blooms of green algae. Nutrient enrichment results in major physicochemical and biological changes in the marine ecosystem, particularly within estuaries and enclosed waters.

The improvements in infrastructure in close vicinity to the wild and spectacular wildlife of the west coast have increased recreational use and tourism of coastal waters. Levels of disturbance to wildlife have consequently been increasing. Part of the attraction of the area is that the site supports breeding seabirds, pupping seals and calving porpoise, all of which make use of the area's food resources. These important life stages are particularly vulnerable and sensitive to the disturbance impacts.

The site has also been modified by wider environmental influences; the most obvious of these is perhaps climate change

Many anthropogenic activities have the potential to affect the structural and functional characteristics of the SAC and these effects are considered to be *significant* where a subsequent detrimental impact on the species and communities associated with the habitat and species features of the SAC would result. An assessment of the conservation status of each of the habitat features was first reported in 2001 and then again in 2007[20].

[20] Joint Nature Conservation Committee. 2007. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17

4 FEATURE DESCRIPTIONS

4.1 LARGE SHALLOW INLETS AND BAYS

Large shallow inlets and bays are defined in the EU Habitats Interpretation Manual [21] as;
"Large indentations of the coast where, in contrast to estuaries, the influence of freshwater is generally limited. These shallow indentations are generally sheltered from wave action and contain a great diversity of sediments and substrates with a well developed zonation of benthic communities. These communities have generally a high biodiversity."

In the UK, there are several physiographic types of large shallow inlet and bay that meet the EC definition: embayments which are a type of marine inlet typically where the line of the coast follows a concave sweep between rocky headlands, sometimes with only a narrow entrance to the embayment; fjards which are series of shallow basins connected to the sea via shallow and often intertidal sills; rias which are drowned river valley in an area of high relief (known as voes in Scotland). Those particularly relevant to the Pembrokeshire Marine SAC are the embayment of St Brides Bay (described below) and the ria of Milford Haven. The feature is referred to as inlets and bays in this document.

4.1.1 Range

St. Brides Bay is a large, deeply indented, embayment with peripheral embayments and inlets, located within a predominantly rocky coastline and geographically isolated from very large bays to the north and the east (Carmarthen and Cardigan Bays). Peripheral embayments within, either side of and between St Brides Bay and Milford Haven ria include Whitesands Bay, South Haven, Skomer; Gateholm to West Dale Bays, and Freshwater West. (Map 3).

There are a variety of component habitats within the inlets and bays feature of St.Brides Bay. For example, a large proportion of the seabed is comprised of soft sediments with broad distribution information available through HABMAP. There is also a significant presence of three Annex 1 habitats (reefs, intertidal mudflats and sandflats, and sea caves). The broad intertidal sediment flats extend widely around the coasts of the inlets and bays, particularly on the eastern shore of St Brides Bay, while the extent of exposed reef surface varies with sediment movement.

4.1.2 Structure and function

Resilient Precambrian and Silurian igneous rocks form much of the core and western extremities of the northern and southern arms of St Brides Bay and smaller open coast bays while the southern headland of Freshwater West is formed of carboniferous limestone. Extensive coastal cliffs of highly faulted Cambrian (northern St Brides Bay shoreline) and Old Red Sandstone (southern St Brides Bay, West Dale, Freshwater West) shorelines have extensive sublittoral distribution. Softer more recent rocks back cliffs and underlie sediment on the lower shores on eastern shorelines.

There is an extremely wide range and complex mosaic of sediment habitats in St. Brides Bay. This includes: moderately sorted medium to very fine sands in shallow and near-shore areas in the northern half of the bay; fine sands inshore; well sorted muddy sediments in deep central areas of the bay: poorly sorted muddy gravel / shell in sheltered near-shore areas in the southern part of the bay, particularly east of the Handmarks and Stack Rocks reefs; and a mosaic of tide swept gravels and cobbles, muddy gravel and well sorted medium sand along the axis of strongest tidal streams at the seaward edge of the bay.

St Brides Bay is a deeply indented, west facing, roughly square shaped embayment. Peripheral embayments are both deeply indented between prominent headlands, and broad bays in a topographically complex coastline. Most of the peripheral bays face south to west. The seabed in central and inner central St Brides Bay and peripheral open coast bays is generally gently sloping;

[21]Interpretation Manual of European Union Habitats. EUR27, July 2007. European Commission. DG Environment.

areas of more complex sediment topography (sand waves and ripples) occur in the north-west and south-west generated by tidal streams, and in the vicinity of reefs and islets. Broad sediment flats extend widely around the coasts of the inlets and bays, particularly on the eastern shore of St Brides Bay and within Milford Haven.

Depth generally increases from east to west across St Brides Bay with most of the bay less than 30m deep. Extensive shallow sandy areas extend south from St David's Peninsula in the north of the bay and an extensive shallow reef is present in the southern bay. The seabed within smaller bays is mostly less than 20m.

Broad areas of near-shore and intertidal reef extend along the northern and southern shores of St Brides Bay and large, isolated reefs and islets are also present immediately off both the north and south coasts. The Handmarks is a large horizontal reef in the southern part of the St.Brides Bay, and West Dale Bay. The south-eastern coast of Freshwater West is predominantly reef habitat with many sea caves and tunnels particularly along the rocky cliff and reef coastline of St.Brides Bay.

The central outer area of the bay appears to have a rotary (circular) tidal stream during part of the tidal cycle. Tidal streams within St Brides Bay are generally weak, though varying considerably between spring and neap tides and there are also differences in exposure to wave action from very exposed in parts of St Brides Bay, Gateholm – West Dale Bays and Freshwater West, to extremely sheltered in parts of Milford Haven ria. Large areas of wave sheltered stable sediment seabed are present at depth and to the north of the islands and headlands as well as within Milford Haven.

Suspended particulate concentrations and water transparency are seasonally very variable and locally influenced by freshwater inputs with moderately high to high turbidity during and following strong wave action and spring tides. There are also prolonged periods of low turbidity especially during spring and summer and in areas of weak tidal current streams, though seasonal phytoplankton blooms temporarily increase particulate concentrations and decrease water clarity during these periods.

Sediment nutrients status is poorly known and assumed to reflect concentrations in the overlying water column. Open coast bays are fully saline and inlets with freshwater inputs, particularly Milford Haven, are subject to varying salinity during the tidal cycle. There are also local, generally irregular, modifications of salinity near managed watercourses.

Little is known about water column contaminant and nutrient concentrations and fluxes. Available data suggest open coast concentrations of contaminants are comparable with typical inshore background levels and nutrients comparable with typical inshore open coast, Celtic Sea, background levels. Open coast sediment contaminant concentrations appear to be comparable with typical inshore background levels.

Hydrocarbon data for St Brides Bay sediments (mostly from areas within Skomer MNR) indicates levels near or at typical inshore background levels. Other contaminant concentrations in open coast bay sediments are poorly known. Information on dissolved oxygen is also very limited but indicates that the water column is largely fully saturated throughout bays and inlets. Oxygen availability within sediments is mostly likely to be typical for the sediment structure.

Detail of local sediment processes in open coast bays is not well known. There are known areas of medium to long-term sediment deposition in deeper depressions and on sediment banks in areas of St Brides Bay. These areas are adjacent to major tidal streams in the southern bay and in areas of weak tidal streams in the central bay; they are inferred in the northern bay from bathymetry. The Handmarks reef in the southern part of the bay has a strong influence on water movement and sediment distribution. There are known areas of erosion at the seaward edge of St Brides Bay where strong tidal streams maintain areas of unconsolidated coarse material free from fine sediments. Some sediment transport processes may be inferred from significant bedforms in St Brides Bay (*i.e.* sandbanks and sandwaves). The status of depositional areas as sediment sinks is unknown. Seasonal exchange between the intertidal and near-shore subtidal is significant though unquantified, and determined by wave exposure, aspect, granulometry and degree of consolidation.

Biological interactions that structure communities and the populations of ecological structuring species such as the sea urchin, *Echinus esculentus*, crustacean shellfish and whelk, *Buccinum undatum* are poorly known. They are most likely typical of near-shore rocky and sediment habitats. Bioturbation and interspecific competition are important processes in stable areas of mostly deeper mixed sediments with high species richness and abundance.

4.1.3 Typical species

Species diversity is high and also highly variable between and within habitats in the Pembrokeshire marine SAC inlets and bays. They include populations of species typical and characteristic of intertidal and subtidal reefs, sea caves, intertidal sand-flats, tidal stream structured sandbanks, and varied and heterogeneous subtidal sediment habitats. Areas of deep, wave sheltered, sands are particularly species rich, and stable, relatively wave and current sheltered mixed sediments support a wide variety of species including long-lived macrofauna buried within and living on the sediment surface. Infauna includes populations of long-lived and/or rare and scare species including bivalve molluscs (*e.g. Ensis, Arctica*); anthozoans (*e.g. Mesacmea, Peachia and Aureliania*), tube living polychaetes and echinoderms. Sediment epifauna includes a relatively isolated population of king, or great, scallop (*Pecten maximus*) and a wide variety of species characteristic of reefs living on and in stony material, molluscan shell debris and in association with species consolidating mobile substrates, *e.g.* ross coral (*Pentapora folicea*).

Areas of coarse, current exposed, shelly gravel are unusual, supporting a low variety of physically resilient species and are a contrast to sheltered fine sands and muds; *e.g.* shallow fine sands in North Haven, Skomer (including a small bed of eelgrass *Zostera marina* with high epifloral variety). Of the large mobile fauna there are resident and seasonally migrating crustacean including the spiny spider crab, *Maja squinado,* grey seal, otter, fishes (*e.g.* sand eels - important prey species of seabird populations; herring), seabirds and sea-duck.

Quantitative time series data on population sizes of particular species is patchy, only being available for species in some habitats in the Milford Haven waterway and for several long-lived species and species assemblages in the Skomer MNR in a few habitats.

Little biomass data has been collected within inlets and bays and current knowledge is poor for most species and most locations. The same is true for the physiological health and reproductive capability of most species.

Some data are available on population structure of several long lived invertebrates in the Skomer MNR indicating that a proportion is subject to intermittent reproductive success and irregular recruitment. The sex ratio is unknown or poorly known for most species. Specific recruitment information for a few species is known for the Skomer MNR.

The spatial range of most species characteristic of the habitats within bays is extensive; the habitat range of some highly specialised species is restricted in distribution and/or extent. Because of the hydrodynamic regime and the continuous throughput of water masses of distant and varied origins, species are inferred likely to be both capable of recruiting from and contributing to recruitment, from both nearby and distant populations. True ranges of apparently rare or scarce species are unknown.

4.1.4 Natural processes

The distribution, extent and shape of inlets and bays is a reflection of the underlying geology, with some structures of resistant rock, areas of rock amenable to erosion and zones of geological weakness. Sediment shores and submerged sediment plains are much more dynamic features subject to natural change influenced by factors such as tidal flow, tidal range, currents, weather conditions and aspect.

Shallow inlets and bays are sedimentologically linked with the two couplets of mudflat and saltmarsh, and beach/sandflat and dunes. There is generally an exchange of sediments between these dynamic environments by way of bi-directional sediment transport pathways.

The types of sediment and hard substrata habitats within large shallow inlets and bays are largely determined by the underlying geology and sedimentology, along with orientation and aspect and the influence of the prevailing physical conditions such as the degree of exposure to wave action and tidal currents. These factors, combined with the influence of others, such as water quality (including turbidity) and sediment chemistry, influence the assemblages of marine species associated with the different habitats throughout large shallow inlets and bay.

Sediment particle size and structure are primary factors in determining biological community structure. Sediment topography is the product of sediment structure and sediment transport is determined by hydrodynamic process and these can vary with short and long-term natural cycles, climate influences and stochastic events. The variety of species in inlets and bays is often high as a result of wide habitat variety, the wide range of wave exposure, current strength, depth, light and substrate type, and presence of habitats that support high diversity.

4.1.5 Modifications as a result of human activity

The gross structure, bathymetry, distribution and extent of the open coast bays are not known to have been modified by human action. Historically, the structure of solid geology has been locally modified, mostly by quarrying, and obscured or overlain by land claim and structures. Mobile geological features (*e.g.* boulders, cobbles) have also been modified by human activity, for example as a result of coastal defence works and pollution response and there have been very minor localised modifications to the shape of small inlets and embayments. Overall habitat quality is high except for the presence of persistent marine litter and, locally, the presence of shipwrecks.

Information on modification of dynamic sediment feature change resulting from human activity is sparse. The sedimentology of the open-coast bays is considered largely unmodified by human action except for the addition and possible retention of fine sediments arising from dredge spoil disposal. Tidal range and exposure to currents and wave action in inlets and bays is predominantly unmodified by human actions except for localised influences in the vicinity of built structures.

Modification of suspended particulate concentrations is complex and influenced by several human activities (*e.g.* dredging, disposal of dredge spoil, agricultural run-off). These are predominantly relevant to Milford Haven but also localised in other areas. Concentrated dinoflagellate blooms (red-tides) commonly occur in bays during calm warm summer weather, probably associated with elevated nutrient concentrations.

As a consequence of the history of commercial fisheries, species subject to commercial exploitation are known, or inferred to be depleted substantially below pre-exploitation levels. The mobility of commercially exploited species is (naturally) impeded by capture methods. Free-swimming vertebrate species are also locally impeded by commercial fishing gear and their distribution is influenced by human presence. Fisheries activities have also resulted in impacts to seabed habitats and there has been coastal nutrient enrichment. Consequently, aspects of ecosystem functioning are modified or adapted.

The degree to which the inlets and bays species populations may have been modified or degraded by human activity is difficult to assess because of the uneven distribution of historical species survey data and, until relatively recently, of information on the effects of human activities on the marine habitats and species. Changes in population sizes attributable to both natural and anthropogenic causes include: reduction in abundance and or biomass of commercially exploited species, changes in mollusc populations (from both antifouling compounds and unknown causes) and increases in populations of non-native species. Populations of commercially exploited species have been modified by fisheries, and prey and / or competing species are inferred to be modified as a consequence. There are no known major impediments to the recruitment of any species, assuming a viable reproductive reservoir. Many invertebrate species have planktonic juvenile stages and may be at least partly dependant on recruitment from outside the site. The scale of modification of habitat structure and function also suggests that the range of species distributions is likely to be largely unmodified by human activity. Following reduction in extent of habitat in areas lost to development or land claim, the extent of some species populations will have been reduced proportionately.

4.2 ESTUARIES

MILFORD HAVEN WATERWAY, ESTUARIES, COASTAL LAGOONS AND ATLANTIC SALT-MEADOW AND INLET (RIA)

The Milford Haven waterway is a single geomorphological, hydrological, ecological and functional unit that encompasses a wide range of estuarine and marine components, distributed in an extremely complex mosaic that varies over time. Most components contribute to two or more of the Habitats Directive features encompassed within the waterway however this section describes the estuary feature.

Estuaries are defined in the EU Habitats Interpretation Manual as:

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

"An estuary forms an ecological unit with the surrounding terrestrial coastal habitat types"

There are four major types of estuary recognised within the EC definition:

1. Coastal plain estuaries: formed where pre-existing valleys were flooded at the end of the last glaciation and usually less than 30 m deep, with a large width-to-depth ratio. The main sub-type of estuary, by area, in the UK.

2. Bar-built estuaries: characteristically have a sediment bar across their mouth and are partially drowned river valleys that have subsequently been inundated. Bar-built estuaries tend to be small but are widespread around the UK coast.

3. Complex estuaries: formed by a variety of physical influences, such as glaciation, river erosion, sea-level change and geological constraints from hard rock outcrops. There are few examples of this sub-type of estuary in the UK.

4. Ria estuaries: drowned river valleys, characteristically found in south-west Britain. The estuarine part of these systems is usually restricted to the upper reaches. The outer parts of these systems are little diluted by freshwater and typically conform to Annex I type 'large shallow inlets and bays'.

Estuaries are widespread throughout the Atlantic coasts of Europe, but approximately one quarter of the area of estuaries in north-western Europe occurs in the UK. Milford Haven is a high quality example of a ria estuary and considered to be one of the best examples of a ria in Britain.

4.2.1 Range

Milford Haven waterway is the only example of a large ria in Wales and the largest ria-estuary complex in the UK. It is approximately 170 km long with an area of around 55 km^2 of which *c* 1710 ha (*c* 30%) is intertidal]. This is around 34% UK resource of the estuary type. Tributary estuaries throughout the length of the waterway, particularly in the upper reaches, contribute to the structural complexity and ecological diversity.

The main components are:

- tributary estuaries that drain into the ria-estuary system: Eastern & Western Cleddau; Garron Pill; Carew / Cresswell Rivers; Cosheston Pill; Pembroke River; The Gann; Sandy Haven Pill;
- Daugleddau (from Picton Point downstream to Cosheston - Barnlake Points);
- central waterway (Cosheston - Barnlake Points, to a line between South Hook & Thorn Point);
- outer waterway (seaward of South Hook / Thorn Point line);
- major peripheral embayments (*e.g.* Angle Bay, Dale Roads, Sandy Haven)

4.2.2 Structure and function

Post-glacial drowning of the valleys of the Cleddau rivers formed Milford Haven. The underlying geology is responsible for the overall complex shape of the waterway and the diversity of habitats. This complex structure strongly influences hydrographic processes and the structure of individual habitats. The deep, sinuous, steep sided main tidal channel and tributary estuaries are characteristic of a drowned river valley and reflect the underlying geology and major east-west rock faults and folds.

There are an exceptionally wide range of sediment habitats within the waterway including large quantities of coarse, stony and (molluscan) shell debris material in both the intertidal and subtidal. Sediment structure varies in a continuum along the major gradient of wave exposure, modified by gradients in tidal stream strength and salinity. The axes of these gradients are both along and across the main axis of the waterway.

Near the entrance to Milford Haven there are dynamic, predominately sandy, shores exposed to wave action. Upstream from Dale Point and Thorn Island, sediment shores range from coarse cobbles and shingle, through mixed shelly gravels, to fine sands and muds that characteristically become increasingly stable with increasing shelter from wave action. Mixed sediments include coarse stony and shell debris substrates at the sediment surface and are particularly extensive in narrow subtidal channels. A bed of calcareous algal maerl deposits is present in the lower waterway.

Wide intertidal and subtidal sediment flats flank the main deep-water channel and form a large proportion of embayments such as Dale Roads, Sandy Haven and Angle Bay. The topography of intertidal sediment flats is increased by sinuous freshwater drainage channels and there is evidence of ancient river drainage channels in subtidal sediment plains.

Wide, relatively level sublittoral seabed sediment plains dominate the floor of the channel and typically extend from the intertidal mud & sand-flats towards the main tidal channel where the increasing tidal flow tends to result in coarser sediments in the channel's base and on its often steep slopes. The topography of many areas of sediment flats and salt-marsh is complicated by sinuous drainage channels, isolated patches of salt-marsh and pools.

Areas of reef and banks of boulders, cobbles, shell and sediments rise above the flatter sediment areas. These intertidal and subtidal reefs are discontinuous and topographically varied with their morphology constrained by the adjacent cliff, reef, hinterland, main estuary channels and other structural forms. The microtopography of the reefs, sediments and saltmarshes is also variable.

Deep-water penetrates far along the central channel of the waterway with large areas more then 20 metres deep and extensive areas more than 12 metres deep even 23 km from the entrance. Deep areas are also found at the junction of strong tidal streams and rocky substrates like Dockyard Bank and west of Cosheston Pill.

Extensive shallow sediment plains, slopes and reef blocks flank the main deep-water channel, particularly in the lower waterway for example at Dockyard Bank, Dale Roads, Milford Shelf – Sandy Haven Bay and Chapel Rocks. The hydrography of the waterway is complex, with multiple hydrographic gradients distributed, mainly, along and across the waterway and within tributaries of the estuaries and varying with short and long-term natural cycles, climate influences and stochastic events.

Tidal range and time varies throughout the waterway. For example, at the entrance the mean spring range is 6.5 m at Dale Roads and the maximum range of approximately 7.8m. At the confluence of the Cleddau it is around 1m greater than at Milford Haven on spring tides and then decreases rapidly. Tidal excursion up the water way is 8-10km on mean spring tides and 4-5km on mean neap tides. Standing tidal waves are a distinctive characteristic of the waterway as is the asynchronous flood and ebb tide duration. Current speeds are highly variable being moderately strong in upper and lower reaches, strong in middle reaches and low in embayments and over shallow sediment banks to the sides of the main channels. There is a complex water circulation system and net upstream near-bed water movement. The rapid flushing time in the Daugleddau and slow flushing in the lower waterway despite high tidal range and volume is a distinctive characteristic.

Wave action varies from ‘exposed’ in the entrance to ‘ultra sheltered’ in the lagoons and smaller tributaries. Most of the waterway east of a line between Thorn Island and Littlewick Point is sheltered from wave swell and the very wave exposed southern shore close to the entrance gives way to moderately exposed shores along the north side of the Angle peninsula and gradually more sheltered shores further east.

Sea temperatures within the waterway are generally closely comparable with adjacent sea temperatures with localised variation for example in shallow tributary estuaries, particularly during cold winters and hot summers, and in vicinity of fresh water flows.
There is a wide variation of incident and ambient seabed light caused by range of aspect, topography and, in the Daugleddau, local shading by woodland.

The suspended sediment load is relatively low compared with estuaries with less rock although spatially and seasonally variable. Turbidity is generally lowest towards the open coast, though increased both widely and locally in areas affected by strong wave action, spring tides or heavy freshwater runoff. There are prolonged periods of low turbidity, especially during spring and summer months and in areas of weak tidal current streams. Algal growth within the waterway is limited by available light, determined by water transparency.

The freshwater input, mainly from rivers, is low relative to volume of waterway. There is a complete transition from fully saline (a significant distance upstream) to brackish along the main axis of waterway and complete and partial transitions within tributary estuaries. Strong vertical salinity gradients and modified salt-wedge [22] tidal incursion are distinctive characteristics of the waterway.

Riverine flow is the major source of the nitrogen load with nitrates concentrations exhibiting biologically dominated seasonal variation. Sediment nutrient levels are poorly known but are inferred to reflect concentrations in overlying water column. The extensive mud-flats and salt-marshes are important in buffering nutrients within the waterway.

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[22] See explanation in section 3.1.3.b

Sediment contaminant levels are broadly comparable with moderately polluted estuaries with fine sediments. Sediment transport patterns tend to retain and concentrate contaminants in the waterway. Synthetic organic pollutant concentrations are unknown and temporal trends in other contaminants are poorly known.

Dissolved oxygen is at or close to 100% saturation throughout waterway, throughout year. The extent of local depletion in coastal lagoons and areas with limited water exchange is largely unknown. Recent work in Pembroke River has recorded levels down to 86%. Sediment dissolved oxygen concentrations are poorly known, but the very limited information available suggests that oxygen availability within sediments is typical of sediment structure. Many of the estuarine inlets of the Haven are currently subject to excessive green macro algae growth and consequently show raised levels of anoxia. Surface sediments in these areas commonly show anoxic conditions directly beneath the algae.

There is an extremely wide range of intertidal and subtidal sediment substrates and degree of sorting, discontinuously distributed within waterway and largely determined by the complex interactions between wave exposure and current speed. Erosion and deposition processes and sediment transport paths are complex. Flood dominated, up-stream, residual sediment transport in the central and northern side of channels leads to net deposition and accumulation, and consequent contaminant concentration, in Pembroke River, Garron Pill & Western Cleddau. The ebb-dominated, down-stream, residual transport along southern side of main channel dilutes and exports contaminants to open sea.

Important and complex food web links occur within the waterway. Examples are links within and between sediment invertebrate populations and biomass and waterfowl numbers; ecological effects of waterfowl populations on sediment flats, salt-marsh and salt-meadow structure, function and community structure; substantial energy input to the waterway in the form of roe from the local spring-spawning herring population –estimated as up to 100 tonnes *per annum* during the late 1980s.The status of many biological interactions structuring ecology of communities and of populations of non-avian ecological structuring species is poorly known as are any long-term and inter-annual trends.

4.2.3 Typical species

The species richness of the waterway complex is extremely high because of the range and variety of habitats, functional variation and the waterway's biogeographical position in a region of overlap between northern and southern species distribution. Few biomass data are available and current knowledge of population size is poor for most species and highly variable between the different waterway habitats. Species abundances vary throughout the waterway from the most wave exposed area within the entrance. Wide, horizontal intertidal mudflats fringing the estuaries draining into the main waterway support abundant and productive invertebrate (mainly annelid and mollusc) communities. Muds typically support a greater biomass than other intertidal sediments, the abundance of bivalve and polychaete species being particularly high. The intertidal sediment infauna is an important food source that supports large numbers of overwintering waders and wildfowl. Many species populations in lower shore mud banks have high biomass, particularly in the Pembroke River and at Pwllcrochan, and are an important source of food for both fish and birds, contributing to the importance of Milford Haven as a wintering area for waders and wildfowl.

There has been an increase in the number of opportunistic colonisers indicative of a degree of degradation but, except for small areas of local impoverishment, such as those regularly dredged for navigation, the infauna is very diverse and abundant. Many sponge populations are abundant with high biomass and there are mature beds of perennial algal species.

There is some information on the distribution of many species within the waterway, particularly the most widely distributed and frequent but with limited spatial and temporal resolution. Species ranges within the waterway are limited by availability of suitable substrate and hydrodynamic and hydrological gradients, and are likely to vary over time and space. Species populations are variously distributed within the waterway along the main physical and chemical gradients and include those typical of sediment and rocky substrates.

Sediment substrates

There is a spatially varying mosaic of intertidal sediments in the SAC supporting different characteristic species depending on the conditions. The predominately sandy shores exposed to wave action in the lower waterway, for example, typically support a small number of specialised hardy species. This is in contrast to stable, moderately wave-sheltered, sandy-mud shores in full salinity *e.g.* Gann Flats, Dale Beach, Angle Bay, Gelliswick and Pwllcrochan that support stable infaunal populations of a wide variety of species. The Gann Flats are the most biologically diverse intertidal sediment site in the Haven, despite being used heavily for bait digging. This area of very mixed substrate supports a mosaic of distinct communities including sandy *Echinocardium cordatum* and muddy sand *Macoma balthica* communities. The muddy gravel *Venerupis senegalensis* community at the Gann is considered to the richest in south-west Wales.

At Pwllcrochan and other shores on the central waterway the generally stable sediments enables the recruitment and survival of a variety of long-lived and slow growing infaunal species; coarse stony and shelly substrates at the sediment surface also enables epibiotic species of both algae and animals to occur in the same habitat. Variety is highest in areas of shore subject to moderate tidal flow.

The continuum of sediment structure along and across the seabed of the waterway creates suitable habitat for a wide variety of sediment-living species with varying distributions in the central channel, the shallower areas at the sides of the channel and within embayments and estuaries. Except in the most exposed area, sediment communities contain many species. The infauna includes widely distributed burrowing anemones, polychaetes, crustaceans and echinoderms. Fine, moderately wave sheltered, sediments support eelgrass (*Zostera marina*) which in turn supports a wide variety of epifloral algal species. There are also wave sheltered sediments overlain with a bed of maerl supporting a wide variety of epifloral algal species, other epibiota and infauna.

Rocky substrates

The rocky shores of different rock types and topography exposed to strong gradients of wave exposure, tidal streams, salinity, water clarity and other functional processes are colonised by a wide variety of algae, sponges, polychaetes, crustaceans, molluscs and ascidians. There is a higher species diversity where there are crevices, overhangs, rock-pools and boulders (and thus underboulder surfaces) however wave sheltered shores support a particularly wide variety of algae and tidal-stream exposed lower shore bedrock and boulder shores support good assemblages of sponges and ascidians. The stable, tidal-stream swept, consolidated stony / shingle / shell shores at Wear Spit, for example supports a wide variety of algal species, including several rare species, and also sponges.

Species present on the variety of subtidal bedrock reefs and rocky substrates range from those typical of exposed open coastal reefs including soft corals, echinoderms, bryozoans and hydroids, to species typical of wave-shelter and tolerant of reduced salinity or water clarity. The deep, fully or near fully saline, tidal-stream swept, wave-sheltered rock and consolidated stony cliffs and steep slopes in locations such as Dockyard Bank, Burton Reach, and Castle Reach support a particularly wide variety of sponge species some of which are inferred from their size and growth forms to be a substantial age.

In the upper water and areas such as the Daugleddau where there are stable, consolidated stony and shell substrates with sediment pockets in fully or near fully saline, wave sheltered, tidal-stream swept conditions, there are a wide variety of sponges, burrowing and tube dwelling species of worms and anemones, crustaceans, ascidians and, in shallow water, a wide variety of algae, particularly fine filamentous red algae.

4.2.4 Natural Processes

The structure of estuaries is largely determined by geomorphological and hydrographic factors, with the original shaping forces having their beginnings in the geological origins of the adjacent land areas and the influence of major geological events such as ice ages and periods of higher and lower sea levels. The shape of the estuaries, their macro- and micro-topography, and bathymetry, are important components of the character of the habitats and influences the distribution and abundance of marine life, *i.e.* the features' typical species. It is both determined by, and influences, natural environmental processes and consequently, can be impacted either directly or indirectly (through changes to natural processes) by man.

Estuaries are complex dynamic systems that have a natural tendency to accumulate sediment, thereby changing their form from their original Holocene morphology to a state where tidal energy is dissipated by sub- and intertidal sediment banks. The width and depth of the estuary will therefore change over time towards a state of dynamic equilibrium or "most probable state".

The velocities of currents passing through the mouth are determined partly by the tidal range and partly by the cross sectional area of the mouth itself. If these velocities are higher than the sediment erosion threshold, erosion will widen the channel and lower velocities will ensue. If velocities are lower than the sediment depositional threshold, deposition will narrow the mouth and higher velocities will ensue. In this way, a dynamic equilibrium cross section will evolve which balances tidal prism, velocities and erosion/depositional thresholds. Sea level rise means that estuaries will show a natural tendency to translate inland (roll-over) and may erode at the mouth. Where changes in extent are attributable to the estuary adjusting to equilibrium, then the feature should be determined favourable. Where this process is constrained by hard sea defence, then this would be considered as coastal squeeze. (JNCC CSM Estuaries (version 4)).

A complex pattern and combination of physical, chemical and biological conditions and processes operates within estuaries, with many parameters varying temporally and spatially. These parameters establish the baseline conditions in the estuary and continually shape the estuaries and the habitats and wildlife they support. The key parameters are: the flood hydrograph; the nature of the catchment and its influence on freshwater flow and nutrient and sediment input; the nature of the estuary sediment; and the relatively high sediment levels in the estuaries resulting in low water retention within the estuary system and exposure of significant proportions of sediment at low tide. The biological communities of the estuaries have developed in response to these prevailing conditions and the daily patterns of water flow, exposure, sediment movement and water chemistry.

4.2.5 Modifications as a result of human activity

The Milford Haven waterway complex encompasses a wide range of habitats, including several which are SAC features in their own right. Modifications to the latter are discussed in the relevant sections. Gross distribution of the estuaries feature is unmodified, though distribution and extent of parts of habitats have been locally reduced or modified. Land claim and permanent freshwater impoundment for industrial and recreational developments has reduced the area of the waterway complex by over 100 ha since the 1860s and by around 70 ha since the 1950s, almost all in the intertidal tributary estuaries. Former, land-claimed, modified or excluded tributaries lie adjacent to or drain into the site (including Hubberston Pill, Castle Pill, Westfield Pill, East and West Llanion Pills, and west Pembroke River).

The major intertidal eelgrass beds appear to have maintained their extent though small beds in tributary estuaries and at Pwllcrochan possibly up to the 1970s were no longer present in the late 1990s. The extensive subtidal *Zostera marina* bed in shallow water between Gelliswick Bay and South Hook Point appears to have maintained its area and plant density.

Deepening, widening and maintenance of navigational channels and vessel berths has locally modified areas of sediment seabed topography. Modifications have been caused by constructions on and reduction in extent of the foreshore by tidal defences. There are also many ancient quays and quarry workings, many of which are now wholly or partially naturalised. Changes to water movement are greatest in the vicinity of the modifications and the gross physical hydrography of the waterway is considered little modified as a result of human activity. The degree of modification of sedimentology by human action is unknown, though the effects of agricultural run-off and of capital and maintenance dredging are inferred as having had a negative influence.

A wide variety of activities, including pipeline and cable crossings, discharge outfall installations, harbour installations and intensive bait digging have resulted in localised modification of seabed and intertidal sediment topography. Other localised modifications include sediment load, ambient light, and salinity.
Exposure to wave action has been locally modified in the vicinity of built structures as has water temperature near domestic and industrial discharges. In the past there was significant local modification in vicinity of power station cooling water outfall, with wider consequential effects along virtually the entire waterway. There are likely long-term adverse consequences as a result of climatic warming - local seas show in increasing temperature trend.

Concentrations of major nutrients (phosphates and nitrates) in Milford Haven ria indicate hypertrophication. However, because algal growth is more limited by light than nutrient availability, the waterway is considered to be at risk of eutrophication under certain conditions. Domestic effluent inputs, which have decreased considerably with increased effluent treatment, comprise the main source of phosphate nutrient elevation. The nitrogen loads for Milford Haven are high, but phytoplankton levels are largely below guideline standards, possibly as a consequence of the high levels of estuarine flushing. Levels of green macroalgae are, however, very high in the sheltered parts of the Milford Haven Waterway, are cause for concern and indicative of eutrophication.

Long-term average hydrocarbon concentrations are marginally elevated over near-shore coastal background and there are elevated metal concentrations (including chromium, cobalt, cadmium, nickel, vanadium and zinc) in the central industrialised section of the waterway and in known or inferred sediment sink areas and attributed to chronic anthropogenic inputs. Levels in many of the estuarine inlets of Milford Haven are above levels known to have adverse effects on biota (*e.g.* Cosheston Pill, Angle, and Carew/Creswell). Elevations are predominantly attributed to chronic (domestic, industrial discharges) rather than acute inputs. Formerly extensive contamination from TBT antifouling paints has decreased from *c* 1990 and continues. Biological tissue metal concentrations are lower than in industrial estuaries such as the Dee and Severn.

Gross sediment transport processes are inferred not to be significantly modified as a result of human activity, though local, chronic and acute, modification occurs in the vicinity of maintained navigational channels, vessel moorings, anchorages and berths, built structures and from shipping movements.

Ecosystem functioning, determined by intertidal grazing molluscs, has been subject to temporary acute modification by pollution incidents and locally to chronic influences from discharges and antifoulant paints. Accidental and deliberate introductions of non-native species that have become successfully established have affected biological interactions.

Interactions have also been indirectly but substantially altered through modification of components of structure and function. For example, modification of community structure at Gann Flats through bait digging disturbance and substrate alteration has resulted in decline in several species of molluscs and worms and an increase in *Nereis virens* (king rag) abundance and associated increase in predation on other invertebrates by this species. The degree to which gross species richness may have been modified within the waterway complex or encompassed habitats as a consequence of human activity is not known.

Populations of some species have been subject to local and wide-scale, short and long-term reduction (and recovery) following both acute perturbations (*e.g.* pollution accidents, harbour dredging) and chronic habitat modification, contamination or exploitation (*e.g.* domestic and industrial discharges, fishing operations), *e.g.*native oyster, mollucs near refinery outfalls and crustaceans following the Sea Empress oil spill. Other species populations have declined from unknown or uninvestigated causes. Biomass is inferred to be typical of encompassed habitats except possibly in areas of organic enrichment or chronic disturbance.

Anthropogenic effects on population structures are generally unknown or poorly known for most invertebrate and algal species. Known effects include temporary perturbation of some, mostly crustacean and mollusc species populations following the Sea Empress oil spill in 1996; the effects of TBT antifoulant on some mollusc species populations and the effects of fisheries on target and non-target species such as herring and native oyster, though incidental effects are unstudied.

There are no known current major impediments to species recruitment from viable species population reservoirs. Previously there would have been substantial losses of eggs, larvae and juveniles due to passage through the cooling water system of the (now demolished) Pembroke Power Station. Presence of pollution tolerant species in areas of organic enrichment and other chronic pollutants suggests preferential recruitment compared with pollution intolerant species.

Establishment of non-native species populations suggests recruitment at the expense of native species. Raised levels of silt are likely to be adversely affecting recruitment of various sessile organisms that require clean substrata *e.g.* oyster.

4.3 REEFS

Reefs are widespread in northern and southern Europe and occur widely around the UK coast. They are defined in the EU Interpretation Manual as:

"either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions."

Rocky reefs are extremely variable, both in structure and in the communities they support. They range from vertical rock walls to horizontal ledges, sloping or flat bedrock, broken rock, boulder fields, and aggregations of cobbles. Reefs are characterised by communities of attached algae and invertebrates, usually with a range of associated mobile animals. Algae tend to dominate the more illuminated shallow water and intertidal areas and animals the darker deeper areas. The specific communities vary according to a variety of factors such as, rock type, wave exposure, slope, aspect, and tidal streams.

There is less variation in biogenic reefs, but the associated communities can vary according to local conditions of water movement, salinity, depth and turbidity. The main species which form biogenic reefs in the UK are blue mussels *Mytilus edulis*, horse mussels *Modiolus modiolus*, ross worms *Sabellaria* spp., the serpulid worm *Serpula vermicularis*, and cold-water corals such as *Lophelia pertusa*.

4.3.1 Range

Reefs are distributed throughout the site (Map 3). Much of the intertidal zone is reef habitat particularly along the open coast. Extensive areas of sublittoral rocky reefs stretch offshore from the west Pembrokeshire coast and around the islands and many small rocky islets. There are large, isolated reefs and islets immediately offshore both the north and south coasts of St.Brides Bay. West Dale Bay and the south-eastern coast of Freshwater West predominantly comprise reef habitat and the Handmarks is a major extensive horizontal reef in the southern part of the St.Brides Bay.

The Milford Haven waterway has a variety of sizes and shapes of reefs at different depths including large, extensive and smaller discrete reefs such as the Mid-channel and Chapel Rocks complex and Stack Rocks. As reefs are predominately a feature of exposed coasts, the range of reefs in the sheltered conditions of the Milford Haven waterway is exceptional. Specific, geographically defined, areas of *reefs* that may be considered recognisable within the site are:

- Offshore, extremely exposed, Grassholm to The Smalls and the Bishops & Clerks reef complexes;
- Skomer / Marloes Peninsula
- Ramsey / St David's Peninsula
- Skokholm – St Anne's Head and south St Brides Bay
- Milford Haven (reefs at entrance contiguous with above)
- South Pembrokeshire limestone

The extent of exposed reefs varies substantially due to covering and uncovering by sediment. The linear extent of intertidal reef is large, but the overall area restricted because of the high proportion of steeply sloping shore. The extent of sublittoral reef is large but not known precisely. Within the approximately 7% of the site surveyed by advanced acoustic bathymetric techniques c 47% (4356 ha) was identified as reef.

4.3.2 Structure and function

Rock types forming reefs within the site include extensive areas of igneous rock, relatively friable old red sandstone and limestone. Habitat variety is increased by the presence of rock types that favour rock-boring and crevice-dwelling species. Rock folding, faulting, fracturing and the variability of erosion underlie the complex and ecologically important reef geomorphology within the site.

Large areas of reef are covered by sediment intermittently or regularly, and on a long or short-term basis. The overlying sediments vary from very fine deposits in wave and / or current sheltered locations to extremely coarse sands and fine shell gravel in current exposed offshore locations. Several reef types can be distinguished within the SAC but only their broad distribution is known. These include;

- massive shallow reefs and reef platforms;
- complex isolated reefs;
- vertical and steep surfaces over wide depth ranges from above sea level to 50 metres below sea level (many contiguous with sea-cliffs);
- discontinuous, irregular and continuous, even reef slopes;
- deep, roughly horizontal reef;
- islands and islets.

There is also variety in the Milford Haven reef types from the Mid-Channel Rocks complex at the entrance to isolated, mainly low lying reefs in the upper Daugleddau. Reefs within the site are subject to an exceptional variation in strength of tidal streams and wave exposure with many extending onto the shore and provide examples of both the most exposed and the most sheltered intertidal rock communities in southern Britain.

Reef habitat diversity is increased by caves, tunnels and surge gullies in both subtidal and intertidal zones and the wide range of rock surface microtopography as well as the depth range over which they occur, including extensive areas of deep (>30m) reef.

There are few comparable areas in UK with such a range and extent of reef habitats exposed to such extreme wave exposure and tidal streams. Specific broadly defined combinations include:

- reefs exposed to both strong to very strong tidal streams and strong wave action. Extensive areas of open coast reef, offshore complexes of pinnacles and islets, and the west coasts of islands exposed to extreme wave and tide-swept conditions.
- reefs exposed to strong to very strong tidal streams and sheltered from wave action. Extensive areas of deep, offshore reef sheltered from prevailing swell; Milford Haven waterway.
- reefs sheltered from tidal streams and exposed to strong to very strong wave action and surge. Many long, narrow or tapered inlets and sea-caves, particularly on Ramsey and Skomer islands

and Castlemartin coast.

- reefs sheltered from strong water movement. Deep sheltered reef off north and east coasts of islands and within bays; Milford Haven waterway. The deep, lagoonal, former slate quarry at Abereiddy is an extreme example. Ultra-sheltered from water movement. Water exchange, mixing and flushing are exceptionally limited, resulting in establishment of seasonal thermoclines, oxyclines & haloclines.

Reefs in areas exposed to intermittent, or occasionally reduced water movement are subject to intermittent or regular sediment deposition and removal. Areas of reefs adjacent to sediment habitats, particularly low lying and shallowly sloping areas in the shallow subtidal or intertidal reefs, are subject to large scale deposition and erosion of sediment.

The biological interactions structuring reef ecology are known to be complex and include inter- and intra-species competition for space and resources, grazing and predation. Status of many biological interactions structuring ecology of communities and the population structures and dynamics of most key ecological structuring species (*e.g.* sea urchin, *Echinus esculentus,* and crustaceans) are poorly known.

4.3.3Typical species

The wide range of substrate type, topography, depth, wave and tidal current exposures, and light are major contributors to high species diversity on the reefs. This is supported by species migration and the potential for recruitment of reproductive products from a wide area. They include; limestone and other architectured and / or friable rock which support a variety of rock boring and crevice-dwelling species, including species restricted to limestone; specialised micro-habitats such as surge gullies and crevices which support rich variety of many species including encrusting sponges, ascidians and anemones and fully saline, extremely wave-sheltered, tidal stream-swept bedrock and consolidated boulder / cobble (*e.g.* Milford Haven sponge populations).

Information on the population dynamics is available for a range of reef species in the Skomer MNR and intertidal habitats in the Milford Haven waterway. Many populations exhibit spatial and temporal patchiness. Many long-lived, slow-growing species populations show apparent long-term stability but sporadic recruitment. Biomass is highly variable between different reef habitats, species, seasons and between years.

Time series data for several long-lived reef species and species assemblages in the Skomer MNR indicate that some are subject to intermittent reproductive success and irregular recruitment. Many species are at least partly dependant on recruitment from outside the site and the variations in population structure contribute to the complexity of community mosaics and to biodiversity.

The spatial range of most species characteristic of reef habitat is extensive, though the habitat range of many, particularly highly specialised species, is restricted in distribution and / or extent. Because of the hydrodynamic regime and the continuous throughput of water masses of distant and varied origins, species are inferred likely to be both capable of recruiting from and contributing to recruitment from both nearby and distant populations. The true ranges of apparently rare or scarce species are unknown.

4..3.4 Natural processes

The distribution and extent of reefs are shaped predominantly by physical conditions, including geology, geomorphological processes, water movement (mainly wave action and tidal streams) and sediment transport processes and, as such, is dynamic and fluctuates.

The diversity and type of wildlife communities found on reefs varies according to the nature and type of rock habitat present and is strongly influenced by a number of physical characteristics, in particular how exposed or sheltered a site is to wave action and tidal currents. Extremely exposed areas are dominated by a robust turf of animals such as sponges and anemones and, in shallower water, foliose red seaweed, while reefs in the most sheltered locations such as sea lochs and rias support delicate or silt-tolerant seaweed, fan-worms, sea squirts and brachiopods. Stronger tidal streams often increase species diversity, although some communities require very still conditions. Other physical, chemical and biological factors are also an important influence on reef communities, such as depth, clarity of the water, salinity, whether there is a lot of sediment nearby or held in suspension in the water and has a scouring effect and availability of food supply. Temperature also has an important influence and in the UK there is a marked biogeographical trend in species composition related to temperature, with warm, temperate species such as the pink sea-fan (*Eunicella verrucosa*) occurring in the south, and cold-water species, such as the deeplet sea anemone (*Bolocera tuediae*) in the north.

Biogenic reefs are not as varied in comparison but do differ according to the local conditions of water movement, salinity, depth and turbidity. The main species which form biogenic reefs in the UK are blue mussels (*Mytilus edulis*), horse mussels (*Modiolus modiolus*), ross worms (*Sabellaria* spp.), the serpulid worm (*Serpula vermicularis*), and cold-water corals such as *Lophelia pertusa.* In addition to the reef-building animals, biogenic reefs can be very rich in species as the structure often provides more than one type of habitat. For example the sediment and spaces in and amongst the mussels of a horse mussel reef are suitable for some species whilst others live attached to the surface of the mussel bed. Biogenic reefs are often highly productive and may be important ecologically as feeding, settlement and breeding and nursery areas for many other species.

4.3.5 Modifications as a result of human activity

There is a history of local modification of reef distribution mostly within the Milford Haven waterway, largely through topographical modification, covering with structures or because of sediment accretion as a consequence of human activity. The extent of littoral reef has been locally reduced by the construction of harbour infrastructures and landing facilities at a few locations, particularly in Milford Haven.

Although subtidal reef topography has been historically modified by capital dredging in Milford Haven, and a resulting increase in sedimentation is likely to have covered reef areas, the gross distribution and extent of subtidal reef within the waterway is not known to have been reduced. Mobile reef features (*i.e.* boulders, cobbles etc) have historically been modified by human activity, for example as a result of coastal defence works, coastal construction, and pollution response. Reef geomorphology is predominantly unmodified except for localised exceptions within the Milford Haven waterway.

Distribution and extent of topographical reef types are not known to have been reduced by human action, the overall depth range of reef is assumed unmodified by human action and there is no known evidence for modification of reef surface microtopography as a result of human activity,. However, use of heavy mobile fishing gear (*e.g.* trawls and dredges) is known to alter the topography of reef structures in quite major ways. The degree to which this has occurred within the site is unknown.

Localised modifications of orientation and aspect within the Milford Haven waterway have resulted from widening and deepening navigational channels.

Discarded and accidentally misplaced artificial materials are present throughout reef habitat. These include the remains of shipwrecks, lost and discarded fishing gear and persistent rubbish which can be a physical hazard to some species and for some, a source of chemical contamination. Modern synthetic fishing gears are capable of ‘ghost fishing’ both commercial and non-commercial species for prolonged periods. Many inert materials are colonised by marine wildlife (forming ‘artificial reefs’) though usually to the detriment of other, previously existing, species populations.

The gross physical hydrography is considered little modified as a result of human activity, except in the case of artificially created habitat such as flooded coastal quarries. Reefs exposure to tidal water movement and wave action is predominantly unmodified by human action except for localised influences in the vicinity of built structures such as navigational installations in Milford Haven and in the artificial lagoon of Abereiddy quarry.

Former power station thermal outfalls in Milford Haven modified temperature regimes within the waterway and there are likely to be long-term adverse consequences as a result of climatic warming - local seas show in increasing temperature trend.

There is localised modification of incident light within Milford Haven in vicinity of built developments. Reduced light penetrating the water is likely as a consequence of modern farming practices, increased land runoff and consequential increase in water turbidity. Minor temporary modification of suspended particulate concentrations during and following offshore dredge spoil disposal operations have occurred when an inshore disposal site was in operation. Concentrations may also be modified by local or distant activities mobilising or influencing sediment transport, such as coast protection or construction operations. Modification of suspended particulate concentrations within Milford Haven is influenced by several human activities and is more complex. Concentrated dinoflagellate blooms (red-tides) commonly occur in bays during calm, warm summer weather, and are possibly associated with elevated nutrient concentrations.

Local reductions in salinity occur in the vicinity of freshwater run-off and streams crossing areas of intertidal reef increases corresponding local habitat and species diversity. There is potential for modification by watercourse diversion, abstraction and engineering.

Concentrations of major nutrients in the Milford Haven waterway are generally above near-shore background values and concentrations of a number of contaminants are above background values.

Mobilisation or deposition of sediment into the water column by human action is regular and widespread. Sediment processes may have been locally modified by changes in water movement patterns in the vicinity of artificial structures upstream from reefs and are inferred to have been modified by dredge spoil disposal and fishing operations. There is reasonable evidence that reefs in the path of residual currents from spoil disposal sites and watercourses with elevated sediment loads have been subject to modified levels of deposits of, mostly, fine sediments for varying periods of time depending on the hydrodynamic regime at each reefs' location. Localised, transient modifications of reef sediment burdens are inferred to have been caused in the vicinity of other operations; *e.g.* civil engineering, modification of navigational channels and fishing.

Species subject to commercial exploitation are known, or inferred, to be depleted well below historical pre-exploitation levels. Scientific evidence suggests that aspects of ecosystem functioning may be modified or adapted as a consequence. However, the magnitude of such modification is both unknown and, in the absence of pre-exploitation data, unquantifiable. The mobility of commercially exploited species is (obviously) impeded by capture methods. Free-swimming vertebrate species are locally impeded by commercial fishing gear and distributions are influenced by human presence.

Ecosystem functioning determined by intertidal grazing molluscs, has been subject to temporary acute modification by pollution incidents and, locally, to chronic influences from discharges and diffuse sources such as antifouling paints.

The degree to which reef species populations may have been modified or degraded by human activity is difficult to assess. The physiological health of some species and their reproductive capability is inferred as potentially modified in areas of contaminant elevation e.g. dog whelks as a result of tin-based antifoulant paints.

4.4 Grey seal (Halichoerus grypus)

Grey seals *Halichoerus grypus* are among the rarest seals in the world: the UK population represents about 50% of the world population and 95% of the EU population. At the start of the 2000 breeding season, Great Britain had some 124,000 grey seals, with a further 300-400 found around the Isle of Man and Northern Ireland.

The south-west Wales population is the most southerly in Europe of any significant size and is relatively isolated from those elsewhere in the UK. It forms around 4% of the UK population or about 3.5% European population. This sub-population or stock is centred on the west Pembrokeshire coast.

The breeding ecology differs from that of grey seals elsewhere in the British Isles as the seals here tend to use secluded coves and caves for pupping instead of forming large congregations of pupping females on open sites. Whilst most of the important pupping beaches, caves and haul-out sites occur in Pembrokeshire, grey seals are known to range throughout Cardigan Bay and there are a significant number of pupping sites in south-western Ceredigion.

4.4.1 Population dynamics

Grey seals present within the site at any one time do not form a discrete population, but are part of the SW Wales population. This population itself is not completely isolated but extends to SW England and SE Ireland and from this population there are seasonal movements further afield and exchanges with distant populations. Population size is determined by a complex of density dependent and independent biological processes, including physiological health and reproductive success, and the carrying capacity and quality of the habitat.

The south-west Wales 'population' size, determined from pup production estimates, is approximately 5000 individuals. Pup production within the site represents a small proportion of the south-west Wales production. Most long-term survey data collected is from small parts of the Pembrokeshire Marine SAC with trends for the south-west Wales population inferred from this data.

Following several decades of irregular but substantial population increase, the population size (measured as pup production) slowed or possibly stabilised in the late 1990s to the early 2000s. A comparable slowing of increase has been observed in Scottish populations and there is evidence that this slowing is density dependent. The population is not known to be subject to predation although potential predators such as killer whales and large sharks are occasionally recorded within the Irish Sea.

Annual pup production within the site is approximately 980 births which is approx 75% of the SW Wales population. The average survival rate to weaning is 80% though an average of one pup in five dies during first three weeks from natural causes such as desertion, disease or physical injury; between half to two thirds survive their first year.

The age frequency and sex ratio of the population is unknown as is the reproductive capability and physiological health. A range of viral, bacterial and parasitic diseases are known to be endemic within seal populations but appear to have with limited effect on healthy, unstressed, adult seals. Disease probably exerts a (density dependent) population control mechanism.

4.4.1 Range

As highly mobile predators, seals are widely distributed within and travel beyond the site. Only their pupping and regular moulting sites may be determined with precision. They range throughout the open coast areas of site, but use the Milford Haven waterway less frequently and are predominantly confined to few favoured locations (*e.g.* Stack Rock). Pupping takes place throughout the site on open coast in suitable habitat (*i.e.* physically accessible, remote and/or undisturbed rocky coast beaches, coves and caves) (Map 2.3) and the high proportion of use of sea-caves by the south-west Wales population is a particularly unusual variation in breeding behaviour.

Moulting and resting haul-out sites are distributed throughout the site, though only a small number of sites are regularly used as haul-outs by large numbers of seals. Known winter moulting haul-outs and non-moulting / resting haul-outs are limited to offshore islands and remote, undisturbed and inaccessible rocky shores and beaches.

4.4.2 Habitat and species

The exact habitat requirements of grey seals is not known (seemingly suitable habitat is often not occupied) but must include suitable feeding, pupping, moulting and resting haul-out areas. They are assumed to feed throughout the site and some are known to make long foraging trips offshore to deeper waters from south through south-west to north-west off the Pembrokeshire coast.

Rocky coast beaches, coves and caves along most of the coast provides pupping habitat but preferred sites tend to be the most secluded, sheltered from heavy wave action and accessible by females at all phases of the tide. Pupping tends to occur at a limited number of favorable sites (towards the south-western end of the SAC) with some use of less optimal sites. Moulting / resting haul-out habitat requirements are not known precisely but suitable habitat is extensive throughout the southern part of the site and is assumed to be adequate.

The structure of pupping beaches and caves, moulting and resting haul-out sites and feeding range throughout the site, and the associated functional processes are almost entirely determined by inherent coastal geomorphology and hydrography. Occasional use of artificial substrates (*e.g.* jetties) for pupping and haul-out has been recorded.

Grey seal diet is known to be highly varied and assumed to be a reflection of local prey availability.

4.4.3 Modifications as a result of human activity

Grey seals were historically subject to human exploitation. Although large numbers were killed and taken until early in the twentieth century there is no reliable contemporaneous information on population size at that time, or of likely pre-exploitation numbers.

There are occasional, often unattributable, anecdotal reports of seals being shot or accidentally captured and drowned in fishing gear; the magnitude or importance of such deaths to population dynamics are unknown.

There is no known evidence that human influences have contributed to the reduction / stabilisation of pup production. Although increased disturbance or suppression of physiological health from various anthropogenic activities remains a possibility.

Although there are various potential causes of anthropogenic modification of pup survival, there is limited hard evidence for significant direct modification of pup survival as a result of human action. Entanglement in persistent synthetic debris (particularly fishing gear debris) causes low-level mortality and there are historical records of pup deaths (Skomer and Ramsey Islands) caused by oil spills. Disturbance may disrupt the mother-pup bond and cause separation, but the magnitude and consistency of effects are unknown. Animal welfare activities (capture and treatment) are known risks but have unknown impacts. There is no contemporary evidence to suggest age frequency or sex ratio is in any way modified by human action.

The effects of persistent pollutants burdens or modified food resources on health or reproductive capability have not been investigated within the site and any modification caused by burdens of persistent pollutants or modified food resources is unknown. However, contaminants are present within seal food chains, including those that are persistent and those that tend to bioaccumulate and biomagnify. Lipophyllic contaminants such as organohalides are of particular concern as they tend to accumulate within fatty tissue and are remobilised during lactation. Contamination of female seals by hydrocarbon residues may be detrimental to suckling pups.

There are no data on persistent pollutants burdens from post-mortem examinations of seals from within the site but the very limited post mortem data from seals collected in Cardigan Bay (closest data source to the site) indicate significant levels of several persistent pollutants. Frequency and magnitude of contamination of prey is unknown but some is inferred, from the very limited post mortem data for seal contaminant burden, as contaminated with persistent pollutants. However, the quality status of likely prey species is generally unknown.

Seals are regularly recorded entangled in persistent synthetic materials (predominantly fishing nets) and unknown numbers are killed. Minor, temporary, modifications of distribution are routinely caused by various coastal and maritime human activities. For example pupping activity appears modified as seen by both avoidance of sites easily accessible by and often used by humans, and by increasing tolerance of human presence; these influences have opposing effects. The inaccessibility and predominantly winter use of moulting haul-out sites minimizes their exposure to human disturbance however anecdotal reports and observations suggest that seals maybe becoming increasingly habituated to human presence.

4.5ATLANTIC SALT-MEADOW

Atlantic salt-meadow (*Glauco-Puccinellietalia maritimae*) is defined in the EU Habitats Interpretation Manual as “Salt-meadows of Baltic, North Sea, English Channel and Atlantic shores”

Eleven different plant communities are represented by this SAC habitat in the UK which occurs on North Sea, English Channel and Atlantic shores.

Atlantic salt meadows develop when plants able to tolerate salty soil conditions colonise soft intertidal sediments of mud and sand in areas protected from strong wave action. The vegetation forms the middle and upper reaches of saltmarshes, where tidal inundation still occurs but with decreasing frequency and duration than areas nearer to the low water mark in estuaries and coastal locations.

The vegetation that is present varies with climate and the frequency and duration of tidal inundation. Grazing by domestic livestock is particularly significant in determining the structure and species composition of the habitat type and in determining its relative value for plants, invertebrates and wintering or breeding waterfowl.

4.5.1 Range

Atlantic salt-meadow is present together with lower salt-marsh and adjacent transitional / freshwater marsh occurs through the Milford Haven waterway. Tributary estuaries and lagoons within the waterway are characterised by extensive pioneer salt-marsh and Atlantic salt-meadows and the habitat is distributed discontinuously on upper shores throughout and flanking both sides of the central-lower waterway, and extending into the large shallow bays of Dale, Angle Bay and Sandy Haven (Map 3). Small fringes and ribbons of salt-meadow in the central waterway have not been surveyed.

The area covered by Atlantic salt-meadow increased in area by around 25% to approximately 173 ha between 1982 and 2002, although the total extent of salt-marsh (mainly the *Spartina* community) declined by around 15% during the same period. Relative proportions of the component salt-meadow communities also changed but the reasons are not clear.

4.5.2 Structure and function

Atlantic salt-meadow is dependent on environmental processes in the waterway and water column both local to its immediate vicinity and of the Milford Haven waterway as a whole. Its distribution and extent is predominantly governed and constrained by the geomorphology and tidal regime and the topography is determined by foreshore breadth, morphology of waterway and sediment processes. The sediment structure is predominantly muds, though many fringes and ribbons have developed in areas of mixed muddy gravels and stones and, in places, are associated with rocky substrate. A range of *Atlantic salt-meadow* geomorphology and topography is present in the waterway with the overall shape determined by the morphology of the Milford Haven particularly the hinterland and the main waterway and estuary channels. This is locally influenced by the presence and morphology of rocky reef and wide intertidal sediment flats.

Geomorphological ‘variants’ of salt-meadow such as ‘saltings’, fringing, and ‘perched’ marsh above rocky substrates, occur throughout the site. Extensive saltings are present in tributary estuaries where most slope gently across muddy shores toward drainage channels. The only large area of horizontal marsh is within the Gann Estuary.

The shape and topography of fringing and perched salt-meadow reflect shore topography and so occurs predominantly as narrow ribbons. The microtopography reflects the flooding / drainage regime and sediment erosion / accretion balance as determined by slope, exposure to water movement and local sediment transport processes. It is highly varied within and between individual areas of salt-meadow. Areas of open sediment and saltpans are mainly limited to horizontal saltings. Most are relatively uniform, gentle slopes with complex drainage channels and localized erosion ‘cliffs’, in places more than 0.5 m high. The most complex and varied microtopography is in horizontal marshes with pools and patches of bare mud. Microtopographical heterogeneity is also high in ribbons and patches in association with rock and gravel / shingle.
Most of the Atlantic salt-meadow, and the largest extents, are in wave-sheltered tributary estuaries. The ribbons and areas of salt-meadow closest to relatively open waters of central waterway, such as the outer Gann Estuary and Angle Bay, are variously exposed to the effects of the heaviest swell wave action and locally wind generated wave action. Suspended particulate concentrations are a product of riverine, marine and anthropogenic inputs. The water and sediment chemistry in the waterway is inferred to reflect the chemistry of adjacent sediments and the water column.

The sediment processes appear to be in a dynamic balance on a broad scale. Sediment deposition and erosion varies within and between areas of salt-meadow dependant on gross sediment inputs and transport within Milford Haven waterway, and local topography, hydrodynamics and proximity to drainage channels. Sediment inputs, suspended sediment water column load and sediment transport patterns result in sediment deposition in many areas, though this is balanced by local sediment erosion within and at the edges of salt-meadows.

Wintering waterfowl populations create ecological effects through grazing, nutrient enrichment, trampling effects on vegetation and sediment substrate, and seed distribution. The effect of the increase and subsequent decrease in *Spartina* population since its introduction in the late 1940’s – early 1950’s on the salt-meadow (as distinct from endemic pioneer salt-marsh) is unknown, though there was a considerable increase in salt-meadow extent coincident with decrease in extent in *Spartina* in the two decades to 2002. The status of salt-meadow prior to *Spartina* introduction is unknown.

4.5.3 Typical species

Species and community richness is proportionately high relative to the extent of saltmarsh and comparable areas of Atlantic salt-meadow in south Wales [23] but also highly variable between and within areas of Atlantic salt-meadow. The range of substrates and topography are particularly important in contributing to this diversity. Communities, species and species assemblages of particular nature conservation importance, including nationally rare and scarce Atlantic salt-meadow / salt-marsh transition species have been recorded. Populations of notable salt-marsh species include: ***Limonium humile, L. procerum, Salicornia pusilla, Althaea officinalis, Apium graveolens, Carex punctata, Hordeum secalinum*** and ***Lathyrus palustris***.

Species composition, variation and complexity of communities within and between areas of *Atlantic salt-meadow*, community structure, temporal patchiness in community distribution and extent, and variation in sward height together indicate species populations are dynamic, reproducing and

[23] Prosser & Wallace, 2002 *ibid*

recruiting successfully and self-maintaining.

The range, distribution and frequency of salt-meadow species is widespread through the waterway, but is inferred as restricted by geomorphology and habitat availability.

4.5.4 Natural processes

The location, character, and dynamic behaviour of saltmeadows are mainly governed by four physical factors: sediment supply, tidal regime, wind-wave climate and the movement of relative sea level. There are four elements necessary for the development and growth of a salt marsh: (1) a relatively stable area of sediment that is covered by the tide for a shorter period than the time it is exposed; (2) a supply of suitable sediment available within the period of tidal cover; (3) water velocities that are sufficiently low for some of the sediment to settle out; and (4) a supply of seeds or other propagules for the establishment of vegetation cover.

The topography and microtopography of areas of Atlantic salt meadow are the product of complex interaction between hydrodynamic and sediment transport processes, sediment supply and coastal morphology. These can be highly dynamic and vary with short and long-term natural cycles, climate influences and stochastic events, including: tidal range and excursion, salinity, water temperature and suspended particulate concentrations. The marsh-edge morphology provides information on the short to medium term trends of marsh morphodynamics. Accreting and stable seaward marsh edges have an accretional ramp upon which pioneer and low-marsh vegetation can become established. Erosional margins are characterised either by the presence of mud-mound topography or by marsh-edge cliffs fronted by:

- toppled cliff blocks with live or dying vegetation
- rotational slide
- overhanging (cantilever) blocks.

Terraced marsh margins indicate episodic erosion and accretion on timescales over decades to centuries.

Creeks and pans of varying size and density are frequent features of the saltmeadows. Creeks absorb tidal energy and assist with the delivery of sediment into saltmarshes. The efficiency of this process depends on creek pattern. Creek density is influenced by vegetation cover, suspended sediment load and tidal influence. Creeks allow pioneer vegetation to be established along their banks higher into the saltmarsh system. Natural salt pans can occur at any level in a saltmarsh. Major erosion of saltmarsh is indicated by internal dissection and enlargement of the drainage network, ultimately leading to the creation of mud basins. Contaminants may be tied up in saltmarsh sediments for relatively long periods of time and shifts in the dynamics of processes can lead to the remobilisation of sediments. Cyclical patterns of erosion and accretion may, therefore, lead to the release and re-deposition of pollutants within the system.

Nutrient levels are a strong influence on the growth of estuarine saltmarsh plants. Nutrient cycling within saltmarshes can also have a significant effect on coastal and estuarine water quality. In this respect, healthy, functional saltmarsh habitat may have an important role to play in the control of nutrients, which is important in determining water quality.

Given favourable conditions, depending on sediment supply and hydrodynamic regime, mudflats evolve into saltmarshes by way of substrate stabilisation by algae, diatoms and early pioneer plants, giving rise to enhanced sediment accretion rates.

4.5.5 Modifications as a result of human activity

The feature has been historically modified as a result of land-claim and development as well suffering minor localised modification as a result of stock grazing.

Many areas of salt-meadow have been subject to oil pollution and response since the 1940s; Small areas have also been used for experimental investigations into the effects of oil pollution and cleaning techniques on salt-marsh. The resulting damage has been variable and mostly, apparently, short-term. Persistent hydrocarbon horizons remain in several locations such as Martin's Haven (Pwllcrochan) where they have persisted for more than 25 years. Subsurface oil from historical pollution incidents is present within sediments in areas of salt-meadow in, or adjacent to, the central waterway however the buried oil does not apparently impede ecological processes.

A wide range of persistent, discarded and accidentally lost, artificial materials are present in salt-meadow in the vicinity of developed areas and on the strand line. This may modify sediment processes, particularly accretion, and salt-meadow topography. The presence of unstable mud 'cliffs' at salt-marsh edges in wave sheltered locations but in the proximity of vessel activity suggests localized acceleration of erosion by vessel wash.

Livestock grazing mainly takes place on upper areas of salt-meadow. Light grazing may have locally increased microtopographical heterogeneity and influenced vegetation structure. Poaching by cattle has locally decreased the structural integrity of salt-meadow and increased the potential for erosion for example in Western Cleddau, Carew/Cresswell, Daugleddau. It is not possible to determine the long-term effects of the intermittently recorded pattern and history of grazing.

Suspended particulate concentrations are modified by agricultural run-off and raised nutrient levels are known to affect saltmarsh with cover by green macroalgae. This has been observed to smother salt-meadow. There are also intermittent to regular local short-term modifications in vicinity of vessel traffic and irregularly from dredging operations.

As a consequence of the history of human impact on the structure and function of the Milford Haven waterway, it is inferred that salt-meadow species populations are likely to be modified to some degree; however, the magnitude and extent are unknown and, because of the paucity of historical information, not likely to be quantifiable. Oil pollution has had localised effects on salt-meadow since the 1960s, but the degree of resultant long-term modification of species population sizes is unknown. There is no known evidence of anthropogenic modification of the species richness of the Atlantic salt-meadow or known major impediments to species recruitment from viable species population reservoirs.

4.6 MUD-FLATS AND SAND-FLATS NOT COVERED BY SEAWATER AT LOW TIDE

Mudflats and sandflats not covered by seawater at low tide are defined in the EU Interpretation Manual as:

"Sands and muds of the coasts of the oceans, their connected seas and associated lagoons, not covered by sea water at low tide, devoid of vascular plants, usually coated by blue algae and diatoms. They are of particular importance as feeding grounds for wildfowl and waders". Eelgrass communities are included in this habitat."

In this document they are referred to as the 'intertidal mudflats and sandflats' feature.

There are three major categories of intertidal mudflats and sandflats although in practice they tend to be present as a continuous gradation between these categories depending on the prevailing conditions:

1. Clean sands - in areas exposed to wave action and strong tidal currents. May be found on open coast areas and estuary mouths.
2. Muddy sands – occur on more sheltered shores along the open coast and the lower reaches of estuaries.
3. Mudflats – only form in the most sheltered areas of the coast, usually where large quantities of silt derived from rivers are deposited.

Intertidal mudflats and sandflats form a major component of two other Annex I habitats (estuaries and large shallow inlets and bays) but also occur independently, sometimes covering extensive areas along the open coast.

4.6.1 Range

Intertidal mudflats and sandflats are widespread in the site, occurring, from lowest to highest astronomical tide to the highest influence of tidal waters. They are distributed throughout embayments, inlets, estuaries and on the open coast within the site (Map 3). Sediment flats in open coast bays are often extensive, separated by rocky headlands, and often restricted in the upper shore by rock features at the base of cliffs. Flats in more sheltered bays, inlets and estuaries range from 'pockets' of sediment restricted by coastal geomorphology to extensive mud-flats fringing inlets and estuaries.

The extent of open coast sandflats is constrained by cliffs, upper shore rock and, occasionally by cobble berms and / or coastal defences. Middle shore sediments are characteristically gently sloping and restricted in area; lower sediment shores within embayments are much flatter and therefore much more extensive. The extent and height of all open coast sediment shores varies considerably over time with wave generated sediment accretion and erosion. In more exposed locations the variation is significant, often within short periods of time but also inter-annually.

Tributary estuaries and other wave-sheltered areas in the Milford Haven waterway are characterised by extensive upper, mid and low shore mudflats, supporting extensive pioneer salt-marsh and Atlantic salt-meadows. Moderately sheltered embayments in the lower Milford Haven waterway have very extensive lower shore flats with either sloping, or constrained mid-upper shores similar to open coast embayments, or grading into adjacent tributary estuary mud-flats.
Sediment flats in Milford Haven in particular are considerably constrained by the geomorphology of the waterway complex. They are accreting slowly in places but expansion is curtailed by channel structure throughout much of the waterway.

4.6.2 Structure and function

The sedimentology of the intertidal mudflats and sandflats is highly variable throughout the site depending on aspect, coastal topography, shore morphology, wave exposure and sediment budget. The open coast embayment sediment shores are characteristically comprised of well-sorted sands while the sediment flats within the Milford Haven waterway range from well sorted fine sands to fine muddy sediments. Many of the latter contain varying amounts of stony material – gravel, shingle and shell – which increases habitat diversity. The extensive lower shore flats in moderately sheltered embayments within the waterway are predominantly composed of fine, in places muddy, sands.

The morphology and topography of open coast sediment flats is seasonally and inter-annually variable within the constraints of natural upper shore structures (*e.g.* cliff, rock or, in Milford Haven waterway, vegetated hinterland) and lower shore sediment accretion / erosion and estuary / ria low water channels or wave action.

A variety of sediment types are present including wide gently sloping exposed sandy shores on the open coast, particularly St Brides Bay and Freshwater West; steeply sloping exposed sandy shores on the open coast and in the entrance to inlets and muddy sediment flats within small estuaries and inlets and the Milford Haven estuary complex. The shape of sediment flats within Milford Haven is more complex than on the open coast where many are crossed by sinuous freshwater drainage channels and the sediments vary considerably, from wide gently sloping mud, muddy sand or muddy gravel shores to steeper muddy mixed sediments.

The open coast sediment flats are predominantly south to west facing, occur on the lower shore and are mostly bounded by natural coastal structures. Topography is shaped by these and natural processes, particularly wave action and sediment supply. Together with the moderately sheltered sands, these open coast sediment flats characteristically comprise well-drained smooth slopes to smooth to rippled lower shore flats. Low shore sediment pools are infrequent, the pools mostly associated with local erosion in the immediate vicinity of rock. Shores crossed by freshwater discharges are characterised by dynamic drainage channels.

Muddy shores within Milford Haven waterway vary from extensive and even to topographically complex structures with vegetated patches (salt- marsh and meadow) and intricate drainage channels. They are predominantly lower shore flats in the lower reaches of the waterway complex and become increasingly whole shore or upper shore with increasing distance up stream in the main channel and tributary estuaries. All aspects are present within Milord Haven because of the complex shape of the waterway complex.

The large tidal range contributes to the extensiveness of intertidal sediment flats and the tidal streams, as well as to the channel structure within Milford Haven, shape and limit the down-shore extent of sediment flats. Some intertidal areas are subjected to raised tidal streams, particularly in Milford Haven, in narrows, and on surf beaches where beach topography generates rip currents. Detailed patterns and strength of tidal streams are largely unknown except for mid-lower Milford Haven waterway, and then not generally for intertidal areas.

The exposure of intertidal mudflats and sand-flats to wave action varies from ultra-sheltered (*e.g.* Cosheston Pill and Cleddau River mud-flats) to extremely exposed (*e.g.* west and south-west facing sands such as at Freshwater West and Newgale). A large proportion of open coast intertidal mudflat and sandflat is exposed to at least moderate to heavy wave action. The highly variable wave climate impacting open coast and moderately sheltered Milford Haven sediment shores is a major influence on the dynamics of sandflat extent and height.
Subsurface sediment water and water chemistry are primarily determined by tidal seawater influence, surface and coarse-grained sediments are potentially strongly influenced by air temperature, precipitation and wind.

The intertidal mudflats and sandflats are distributed across salinity gradients from fully saline to almost fresh-water. Muddy sediments in the upper reaches of the site's estuaries tend towards very low salinity, increasing along a gradient towards fully saline on the open coast. The sediment surface salinity is inherently variable, varying with rainfall, evaporation and tidal rise and fall. Subsurface interstitial salinity and oxygen concentrations vary inherently with sedimentology and biological processes and are buffered in a similar manner to temperature changes.

The sediment processes are highly variable between sediment shore types depending on sedimentology, exposure to water movement and sediment budget. On open coast sediment flats sediment processes are dominated by wave action. Seasonal storm and tidally generated on and off-shore movement of sediment between the intertidal and near-shore subtidal is significant though unquantified, and determined by wave exposure, aspect, granulometry and degree of consolidation. Significant short-term changes occur in open coast sediment flats as a result of strong wave action. Sediment transport processes within the Milford Haven waterway are complex and dominated by tidal streams.

The biological interactions are highly variable, complex and characteristically functionally important. They are dependent on sedimentology and type and abundance of species present. Examples include: predation (*e.g.* by birds and other organisms) in all sediment habitats, including hardy species inhabiting highly dynamic, high stress, coarse mobile sands; nutrient enrichment and sediment stabilisation through incorporation of plant material into sediments; nutrient enrichment of stable muddy sediments from seasonally large populations of wildfowl and waders; complex bioturbation in fine and mixed sediment flats with dense and varied populations of sediment living species.

4.6.3 Typical species

The wide range of sediment flat topography, particularly slope and associated bathymetry, is a major contribution to sediment flats biodiversity within the site. The overall species diversity is high but varies considerably between and within communities, sediment types and individual sediment flats. The exposed, coarser sand-flats typically have low diversity of species highly adapted to dynamic mobile substratum. Homogeneous mud-flats also characteristically support a relatively low variety of species. Other sediment flats, depending on habitat complexity and stability are typically very rich in species, including worms, burrowing crustaceans and bivalve molluscs. Whilst macroalgae are limited to coarser sheltered sediments, *Zostera*, pioneer saltmarsh and unicellular algal species are important photosynthesising components of the intertidal sediment flat habitat.

Naturally mobile sediments typically support rapidly reproducing and recruiting or extremely hardy species. The population sizes of rapidly recruiting species are inherently very variable so, for example, those characteristic of mud flats tend to be highly dynamic, frequently productive and with high biomass. Many species populations inhabiting relatively stable sediments also have high biomass but are relatively long lived and slow growing. Sediment flat populations with high biomass are a rich food source for birds and fish.

Although the biology of many species characteristic of sediment flats is reasonably well known, the dynamics of most sediment flat species populations within the site have not been studied. Time series data for several, differing sediment flat shores in the Milford Haven waterway indicate considerable spatial, seasonal and inter-annual variation in population size and distribution for many species.

Species abundance varies throughout the site, contributing to community structure, diversity and biomass. Population structure, physiological health and the reproductive capability is unknown or poorly known for most species. Many invertebrate species have planktonic juvenile stages and may be at least partly dependant on recruitment from outside the site and certainly outside the local discrete intertidal sediment flats. Biomass is highly variable between the different sediment flat habitats. Flats with high organic input typically support high species biomass, contributing significantly to the maintenance of typical predatory species such as nationally and internationally important populations of waders and wildfowl.

The range of most species characteristic of sediment flats is extensive. Species are likely to be both capable of recruiting from and contributing to recruitment in populations both within and outside the site. While there is good information on the distribution of many species within the site, particularly the most widely distributed and frequent, the spatial and temporal resolution of the data is mostly insufficient to show precise distribution or temporal variation.

4.6.4 Natural processes

Intertidal mudflats and sandflats are dynamic features. Their distribution, extent, shape, topography, aspect and orientation is the product of complex interaction between hydrodynamic and sediment transport processes, sediment supply and coastal morphology. Hydrographic functions that structure intertidal mudflats and sandflats encompass highly dynamic hydrodynamic and other properties that vary with short and long-term natural cycles, climate influences and stochastic events.

The structure of intertidal muflats and sandflats varies depending on the physical conditions and forces acting on them (in particular the degree of exposure to wave action and tidal currents) as well as the nature of the sediments occurring in any one location. The sediments vary from mobile coarse sand in more wave exposed areas to stable, fine sediment expanses of mudflat in estuaries and other marine inlets.

Intertidal mudflats and sandflats support a variety of different wildlife communities. These are predominantly infaunal communities of a variety of different animal species such as worms, molluscs and crustaceans living within the sediment habitat. The type of sediment, its stability and the salinity of the water have a large influence on the wildlife species present.

4.6.5 Modifications as a result of human activity

Historical land claim and coastal development has resulted in loss and modification of sheltered sediment flats within the Milford Haven ria-estuary but outside the SAC. Within the SAC extent has been reduced through intertidal land claim, shoreline development and indirectly as a consequence of navigational dredging. The total degree of modification of sediment flat sediments by human activity is unknown but is clearly substantial. Open coast flats, as well as being more robust, appear to have been impacted to a far lesser degree.

Some intertidal mud and sand-flat in the central and lower Milford Haven waterway are bounded by artificial structures, which have resulted in varying degrees of modification of slope (and sediment structure). Topography has been locally modified in the vicinity of built structures (*e.g.* as a result of locally accelerated tidal streams, deposition of construction materials and modified sediment processes) and historical land claim within Milford Haven waterway. Microtopography has also been locally modified in the vicinity of built structures through their influence on water movement and sediment transport.

Intertidal mud and sand-flats habitat has been locally modified by the presence and persistence of artificial inert or toxic materials (*e.g.* building rubble, glass & ceramics, metal work, synthetic plastics and fibres, and hydrocarbons), particularly adjacent to the most industrialised and urbanised sections of the coast. Some sediment flats appear largely free from anthropogenic debris (*e.g.* relatively exposed sand-flats). At these sites debris characteristically accumulates in particular areas, particularly high up the shore (strandline) and can be quite substantial.
Intertidal mud and sand-flats are subject to local modification in the vicinity of engineered watercourses in some locations. The sediment structures of flats favoured for bait digging have been locally modified.
The gross hydrography of the site is largely natural though some localised modification in the vicinity of intertidal mud & sand-flats has occurred. The degree to human activities influence hydrodynamic processes affecting intertidal mud and sand-flats is not known.

Temperatures locally and temporarily modified by physical disturbances such as bait digging and by concentrated fresh-water flow. Previously the thermal regime was modified within the Milford Haven estuary by a power station discharge. There are likely long-term adverse consequences as a result of climate change - local seas show in increasing temperature trend.

Concentrations of major nutrients in Milford Haven water column are elevated. Green macroalgal abundances on sheltered flats within Milford Haven are considered to be excessive, having adverse effects on biota, and present as a consequence of the high levels of nutrient. Concentrations are locally modified by freshwater, domestic and industrial discharges. Concentrations of many contaminants are elevated above typical background levels in sediment flats in the Milford Haven waterway, particularly in sediment sink areas. Sediments in the flats of estuarine inlets contain levels of many contaminants, predominantly hydrocarbons, which exceed levels known to have adverse effects on biota.

Dissolved oxygen is assumed to be unmodified in high-energy environments but potentially modified in low energy areas subject to organic enrichment (*e.g.* estuarine inlets such as Pembroke River).
Although sediment transport processes and budgets in open coast bays are generally poorly known, there is no evidence to suggest wide scale processes have been modified although there may be local, chronic and acute, modification in the vicinity of vessel moorings.

Changes in land use and surface water management have increased the likelihood of heavy rainfall creating spate events, which increase short-term flow rates, soil erosion and particulate suspension.
Gross salinity gradients are unmodified but there are local, short term, regular, modifications near modified discharges from managed or engineered watercourses.

The effect of human action on biological interactions has not been quantified. However, changes to habitat structure and function and the introduction of non-native species will have resulted in changes to biological interactions. These will probably have been greatest within the Milford Haven Waterway where there has been, for example, habitat modification, introduction of non-natives, changes to nutrient and contaminant levels, fisheries and recreational activity.

Changes in structure and function alter the competitive balance between species (*e.g.* increased nutrients favouring growth of green macroalgae, bait digging at the Gann flats favouring *Nereis spp* (king rag) even though it is the target species. Species variety has been modified within the Milford Haven waterway by anthropogenic sediment and water inputs, physical disturbance and alteration of the habitat. The physiological health and reproductive capability of some species is inferred from toxicological knowledge as potentially modified in areas of contaminant elevation.

The degree to which the intertidal mud and sand-flats' species populations may have been modified or degraded by human activity is difficult to assess because of the paucity of biological time series data and relevant information on the distribution and intensity of human activities. Conclusions can however be inferred from knowledge of environmental impacts and the affects they tend to have on biota. Exceptions include targeted studies following pollution incidents in Milford Haven waterway.

4.7 Coastal Lagoons

Coastal lagoons are defined in the EU Habitats Interpretation Manual as "… expanses of shallow coastal salt water, of varying salinity and water volume, wholly or partially separated from the sea by sandbanks or shingle, or, less frequently, by rocks. Salinity may vary from brackish water to hypersalinity depending on rainfall, evaporation and through the addition of fresh seawater from storms, temporary flooding of the sea in winter or tidal exchange. With or without vegetation from *Ruppietea maritimae, Potametea, Zosteretea* or *Charetea*" Salt-marshes form part of this complex.

Coastal saline lagoons are an unusual and rare habitat in the UK. Despite this, they show a wide range of geographical and ecological variation and five main sub-types have been identified in the UK as meeting the definition of the Annex I habitat type, on the basis of their physiography:

1. Isolated lagoons - separated completely from the sea or estuary by a barrier of rock or sediment.
2. Percolation lagoons - normally separated from the sea by shingle banks.
3. Silled lagoons. Water in silled lagoons is retained at all states of the tide by a barrier of rock (the 'sill').
4. Sluiced lagoons – where the natural movement of water between the lagoon and the sea is modified by artificial structures, such as a culvert under a road or valved sluices.
5. Lagoonal inlets – where **s**eawater enters the inlet on each tide and salinity is usually high, particularly at the seaward part of the inlet.

There has been one specifically directed survey of coastal lagoons within the site.

4.7.1 Range

Three small coastal lagoons are located in the upper extremities of tributary estuaries in the upper, middle and lower Milford Haven waterway (Map 3). All are naturalised impoundments formed by artificial structures.

- Gann Estuary (Pickleridge Lagoon; established as saline lagoon between 1950s and 1980s)
- Westfield Pill (Neyland Weir Pool; established as saline pool mid-1980s)
- Carew River (Carew Castle Millpond; date of establishment as saline lagoon unknown, history of flushing via sluices variable over time).

Lagoon areas, particularly in the case of Pickleridge Lagoon and Neyland Weir pool, are dynamic over tidal cycles as well as longer time scales as a result of sediment accretion and erosion). Approximate areas as measured in 1998 were 5.6ha for Pickleridge, 0.3ha for Neyland Weir Pool and 4.8ha for Carew Castle Millpond. The extents of the coastal lagoons are primarily determined by the morphology of the hinterland and the artificial impoundment structures. Pickleridge Lagoon and

Carew Mill Pond are subject to slow sediment accretion while Neyland Weir Pool is subject to encroachment by salt-meadow, possibly accelerated by anthropogenically elevated water column suspended sediments.

4.7.2 Structure and function

The range of sediment substrates and degree of sorting is poorly known, but differs between each lagoon and will be determined by the differing shapes as well as the freshwater and saline flow regimes. Pickleridge Lagoon sediments consist of mud, gravel, shingle and poorly sorted sand mosaic. There is well sorted medium sand in the vicinity of inflow channel. Neyland Weir Pool sediments are muddy gravel (*c* 20% mud with *c* 65% “flaked” gravel - possibly former railway line ballast) and terrestrial plant debris. Carew Castle Millpond is mostly muddy/sandy gravel (*c* 35% gravel, 45% sand, 20% silt/clay) with boulders at least around the periphery.

The gross shapes of the coastal lagoons are wholly or partially artificial, as a result of either impoundment of tributary estuaries or creation of artificial basin and channel structures. For Pickleridge Lagoon in particular this has changed greatly since its creation as a combination of natural processes and human modifications of the connecting channel to the Gann Estuary. The morphology of hinterland, estuary channels, banks other structural forms constrains the morphology of the lagoons.

Pickleridge Lagoon has an irregular shape and an approximate orientation SW – NE. There is a boulder/cobble/shingle embankment facing SE across Gann Flats toward Milford Haven waterway. It has a ‘potholed’, irregular bed, and is steeply sloping adjacent to embankment The south west end is mostly open water and the north eastern end has some drying sandy islets. The lagoon is apparently undergoing slow successional change. Neyland Weir Pool is an irregular shape shallow pool with a boulder/part concrete topped embankment facing south into Westfield Pill. The lagoon is apparently undergoing successional change. Carew Castle Millpond is an area of estuary dammed by a sluiced stone weir. The lagoon bed is generally flat with a sinuous central drainage channel.

All three coastal lagoons are shallow (depth below sill level) and their depths are decreasing, apparently slowly, because of sediment deposition. Maintenance of the impoundment structures contributes to maintenance of the lagoons’ bathymetry. Pickleridge Lagoon is mostly c 0.1–0.3 m, max 1.5 m; bathymetry dynamic depending on integrity of outlet channel. The depth of Neyland Weir Pool varies between 0– *c* 0.4 m, apparently reducing rapidly because of sediment accumulation while Carew Castle Millpond is less than 1m deep.

Tidal ranges within the lagoons are determined by sill heights and are considerably less than those in the Milford Haven waterway. These ranges have not been measured but in each lagoon are estimated to be one meter or less. The strength and patterns of tidal streams within the lagoons are the product of impoundment and channel structures and morphology of the lagoon. A longer ebb tide is a distinctive characteristic of the Pickleridge and Carew lagoons.

The water circulation, exchange and flushing time are determined by sill height and lagoon morphology, varying considerably with tidal height and freshwater flow. The sill structure of Pickleridge Lagoon has been modified historically by wave action. The salinity is variable and inflow and outflow occurs through the channel on most high tides although there may also be some percolation of saline water through embankment. Neyland Weir Pool has a reported sill height of 6.9 m but this may be incorrect. Salinity is variable and saline intrusion occurs during spring high tides. Water circulation and flushing is extremely low in Carew Castle Millpond with saline intrusion limited to high spring tides therefore the water salinity is extremely low.

Neyland Weir Pool and Carew Castle Millpond are extremely sheltered from wave action while the embankment and outfall channel of Pickleridge is exposed to local wave generated wave action from E to SE. Water temperatures have not been recorded but inferred to be more variable than either adjacent sea or freshwater temperature. They are likely to reflect adjacent sea temperatures during tidal inundation whilst low water neap tide temperatures are likely to be higher and lower in hot and cold weather respectively because of shallow bathymetry, low water volume and influence of air temperature.

Suspended particulate concentrations and water transparency is determined by a continuously variable combination of freshwater inflow and marine inputs but is unrecorded. Dissolved oxygen concentrations in the sediments and water column are unknown as are sediment nutrient concentrations, water column and sediment contaminant levels. These are likely to be determined by a combination of freshwater inflow and marine inputs. Concentrations of major nutrients (phosphates and nitrates) in Milford Haven waterway indicate hypertrophication and there are regular summer blue-green algal blooms indicative of eutrophication in freshwater input to Neyland Weir Pool.

Sediment movement and distribution is mostly unknown and thought to be mainly determined by saline tidal flow regimes and strongly influenced by height, breadth and structure of seawater flow channel and strongly influenced by height, breadth and structure of seawater flow channel. Historical aerial images of Pickleridge Lagoon indicate considerable temporal variation in sediment transport processes with a complex known history of sediment accretion and erosion. Sediment processes most active at NE end, particularly in vicinity of outflow channel. Neyland Weir Pool is an apparently active sediment sink and in Carew Castle Millpond there is a slow accumulation of fluvial sediments.

The presence and abundance of a variety of waders, wildfowl and sea-birds at Pickleridge and Neyland lagoons inferred as likely major ecological influence but biological interactions largely unknown.

4.7.3 Typical species

A limited number of typically estuarine, brackish water or lagoonal species are present in the coastal lagoons [24]. Pickleridge Lagoon has a typically estuarine/marine sandy substratum fauna at SW end and sparse fauna at NE end. The lagoon cockle, *Cerastoderma glaucum* is present and there is fringing salt-marsh. Neyland Weir Pool has a sparse fauna. This includes the tentacled lagoon worm, *Alkmaria romijni* and the amphipod, *Gammarus chevreuxi*. There are fragments of salt-marsh around the pool and on retaining weir. Carew Castle Millpond has a low diversity, sparse estuarine community with patchily dense oligochaete worms. The tentacled lagoon worm, *Alkmaria romijni* is present.

All species population sizes are inferred to be strongly influenced by or dependent on the extent, morphology and functional processes of the lagoons as moderated by the artificial impoundment structures. Recruitment and biological interactions structuring lagoon species populations and population recruitment reservoirs are unknown.

Pickleridge lagoon: has possibly the largest lagoon cockle population in Wales with the population is inferred (from history of lagoon development) to have established during 1980s. The population structure is indicative of irregular recruitment or survival. The tentacled lagoon worm population in Neyland Weir pool is apparently very small and that of *Gammarus chevreuxi* “sparse”. In Carew Castle Millpond the tentacled lagoon worm population is in, apparently, very low numbers.

Biomass, physiological health and reproductive capability are unknown or poorly known for most species and the relative degree of endemic recruitment is unknown. The isolation of the lagoons from similar habitats is inferred to present a barrier to recruitment of lagoonal specialist species however the establishment of an apparently viable lagoon cockle population in Pickleridge Lagoon within a relatively short period following development of the lagoon habitat suggests opportunistic recruitment of some lagoonal specialist species.

[24] Bamber et al 2000 *ibid*

The range of lagoonal specialist species is severely limited by habitat availability and recruitment. The ranges of the species present in the site's coastal lagoons are enabled, rather than engendered, by the artificially impounded water bodies. The ranges are within constraints of each species' adaptation to physical factors and biological interaction, and are temporally and spatially variable. Habitat isolation and strong physico-chemical gradients are major impediments to species access.

4.7.4 Natural processes

Lagoons are in a continuous state of development, being gradually filled as sediment settles out into the basin. The result is a range of conditions with some lagoons of 'open water' and others which are 'marshy' eventually becoming land. There is also the possibility that the whole lagoon may be inundated and destroyed after a major breach of the barrier which separates it from the sea. These stages of development and the different physical and chemical characteristics cause them to be very varied habitats.

All three, but particularly the Pickleridge and Neyland lagoons, are actively undergoing successional change. All are integral parts of the waterway, and are inextricably dependent on the waterway's functional processes.

4.7.5 Modifications as a result of human activity

The gross shapes of the coastal lagoons are wholly or partially artificial, as a result of either impoundment of tributary estuaries or creation of artificial basin and channel structures. Pickleridge Lagoon has changed shape greatly since its creation, as a result of natural processes and subsequent human modifications of the connection channel to the Gann Estuary. Discarded debris and artificial and moved natural (stone) materials are present in each lagoon.

Agricultural run-off and management of freshwater flows are inferred as having had an influence. For example suspended particulate concentrations and water transparency are potentially modified by agricultural run-off and Neyland Weir Pool is likely to have been modified by marina dredging operations.

The degree to which the coastal lagoons' species populations have been created and / or modified by human activity is unknown, though clearly the artificial creation of the habitats provided the initial opportunity for colonisation.

4.8 SUBMERGED OR PARTIALLY SUBMERGED SEA CAVES

Submerged or partially submerged sea caves (abbreviated to ***sea caves***) are defined in the EU Habitats Interpretation Manual as "*Caves situated under the sea or opened to it, at least at high tide, including partially submerged sea caves. Their bottom and sides harbour communities of marine invertebrates and algae*."

Caves can vary in size, from only a few metres to more extensive systems, which may extend hundreds of metres into the rock. There may be tunnels or caverns with one or more entrances, in which vertical and overhanging rock faces provide the principal marine habitat. The UK has the most varied and extensive sea-caves on the Atlantic coast of Europe. Sites encompass the range of structural and ecological variation of sea-caves and cover their geographic range in the UK. Selection was confined to well-developed cave systems, with extensive areas of vertical and overhanging rock, and those that extend deeply (ca. 4 m and more) into the rock, which are likely to support a wider range and higher diversity of plants and animals.

Some of the Welsh sea-caves are used as pupping sites by grey seals *Halichoerus grypus*. All the sea-caves in Welsh SACs are considered to be of significant conservation value.

There have been few specifically directed surveys of *sea caves* within the site. Additional information is available for some *sea caves* (particularly within Skomer MNR) from the wide range of marine habitat surveys undertaken within the site, of the distribution and size of *sea caves* used by seals from seal breeding censuses, and of the distribution of *sea caves* in the Castlemartin limestone coast from a survey of bat hibernation sites.

4.8.1 Range

Sea caves are distributed widely throughout much of the SAC with most of the known examples at the land/sea interface or rock/sediment interface where marine erosion processes are most intense. The largest known concentrations of intertidal sea caves are on St. David's peninsula, Ramsey Island, Skomer Island and the Castlemartin coast. There are also probably many small, inconspicuous or inaccessible intertidal caves that are undetected. Individual sea caves range is size from little more than deep enclosed overhands to larger structures like some on Ramsey Island that are more than 50m long and the high and wide caves in limestone along the Castlemartin coast.

The distribution and extent of subtidal sea caves is less well known as most have been discovered opportunistically. These tend to be from just below the surface down to around 20m. As sea levels were up to 40m below present levels during previous glacial periods many more are likely to have been formed, including in deeper water. The total area of both intertidal and subtidal sea caves is small relative to the size of the SAC.

Sea caves are predominantly a feature of exposed coasts therefore their presence within the shelter of Milford Haven is particularly unusual.

4.8.2 Structure and Function

The predominantly rocky coastline of the SAC is geologically complex, both in the range of rock types and the complexity of faulting and folding and is highly predisposed to sea cave formation. Structural integrity is mainly determined by hydrodynamic and geomorphological processes such as erosion, rock falls.

Sea caves in the SAC can be broadly grouped on the basis of their underlying geology with those on Skomer and Ramsey in rocks of volcanic origin, the south Pembrokeshire coast caves in limestone and those on Ramsey, north and south S.Brides Bay, St.David's and Marloes Peninsulas in areas of faulted sedimentary rock and complex geology. Habitat variety is increased by the presence of limestone, slates and shales that support rock boring and crevice dwelling species.

The floors of many sea caves are areas of sediment or mixtures of sediment and pebbles, cobbles and boulders, with sheltered locations in caves tending to accumulate silt. The sediments contribute to the habitat and species diversity and composition and have a strong influence on the amount of scouring of cave walls. Caves within the site have a wide range of shape, size, orientation and aspect, resulting in an equally wide range of hydrographic conditions and habitat variation.

Sea cave morphology and topography is varied and determined by the underlying geology. There are long and narrow caves and tunnels; tall and narrow fissure-like caves; deep, broad overhangs; massive high, wide and occasionally long caves; complex, multiple-armed / chambered / floored sea caves with two or more entrances; straight and sinuous caves and tunnels; and small, shallow caves that are little more than large depressions in rock surfaces.

The microtopography is a further important dimension to habitat variation. Cave surfaces range from smooth, unbroken rock walls to fractured, fissured and perforated. A few cave ceilings are comprised of massive boulder chokes and cave floors range from rock through cobble / boulder to sand. Individual sea caves range in size from little more than deep enclosed overhands to larger structures like some on Ramsey Island that are more than 50m long , and the high and wide caves in limestone along the Castlemartin coast. Their position on the shore means that some dry entirely at low water.

The depths and heights of known subtidal sea caves are not as great with the greatest being Paynes Rock, Skomer which has an estimated depth of 4.5m

Sea caves of every orientation and aspect are present in the site providing differing degrees of shelter to water movement and exposure to light, orientation and aspect which are important influences on sea cave ecology. The hydrography of the water column within and in the vicinity of sea caves is complex and highly variable spatially and temporally.

Tidal streams in the vicinity of sea caves vary from nil to extremely strong (>5 m sec^{-1}; *e.g.* Jack Sound, Ramsey Sound). The inside of the majority of sea caves themselves are inherently current sheltered, though many tunnel-caves, particularly those in headlands and islands, are exposed to, and accelerate moderate to strong tidal streams.

Exposure of sea caves to wave action varies extremely widely within the site and over time. Most partially submerged sea caves are subject to at least moderate wave action; many are regularly subject to extreme wave action, others are sheltered from all but the most severe wave action. Submerged sea caves are particularly exposed to strong wave surge. Tidal streams in the vicinity of sea caves vary from nil to extremely strong (>5 m sec^{-1}; *e.g.* Jack Sound, Ramsey Sound). The inside of the majority of sea caves themselves are inherently current sheltered, though many tunnel-caves, particularly those in headlands and islands, are exposed to and accelerate moderate to strong tidal streams.

Ambient light levels within sea caves differ considerably between sea caves within the site. Many caves with large entrances and a generally southern aspect receive some natural light in their deepest recesses, though in some cases insufficient to support plant growth. Others, like the submerged caves and long, north facing caves on Ramsey Island, with different aspects, that are narrow, have small entrances and are deep receive no natural light.

Suspended particulate concentrations are generally significantly higher in sea caves subject to water movement with sediment floors or with a nearby sediment source, than levels in the adjacent external water column. They are also geographically and seasonally highly variable.
The combined effects of scour from suspended particulates and sediment and food particle supply is particularly important to the development, survival and diversity of cave species populations, especially in caves adjacent to sediment or with sediment floors. The species populations in different sea caves reflect the differing balance between these effects.

Particulate concentrations are generally significantly higher in sea caves subject to water movement with sediment floors or with a nearby sediment source, than levels in the adjacent external water column but also geographically and seasonally highly variable. The water and sediment chemistry is mostly likely to reflect that of the adjacent water column but modified by any groundwater seeps particularly in intertidal sea caves.

The mobilisation and deposition of sediment as a result of water movement is regular and widespread and many sea caves with sediment floors are subject to rapid and considerable fluctuations in floor height and sedimentology as a result of sediment mobilisation or deposition caused by constantly varying water movement. Intertidal sea caves (in particular) in the vicinity of sediments are subject to varying degrees of scouring from sediment movement, particularly low on cave walls.

Many sea cave habitats provide highly favourable environmental conditions for key ecological structuring species (*e.g.* grazing molluscs, scavenging crustaceans). The possible presence of species atypical of areas immediately external to caves provides further opportunity for development of additional species interactions.

4.8.3 Typical species

The wide range of rock type, cave morphology, topography, depth and exposures to water movement, scour and light contribute to the high species diversity in sea caves within the site. Sea caves also typically support species that seem out of place, because caves provide environmental conditions which differ from those immediately outside, for example sponges typical of deep-water in intertidal caves and mud dwelling anemones in sediments on the floor of caves in exposed rocky areas. The number of marine algal and invertebrate species associated with sea-caves can be high, but highly variable between and within sea-caves

Species populations in sea caves include those tolerant of scour, of extreme wave surge and cryptic, apparent cave specialist species, including the rare snail *Palludinella littorina*. The range of caves in different rock types increases variety of species; caves in limestone have high species variety in part because of the complex microtopography of the rock surface and the species that can bore into the rock. Sea caves with beaches undisturbed by human activity are used by grey seals for breeding and resting sites and particularly tall sea caves with dry ceilings are used as bat hibernation sites.

Very little population data exists for non-mammalian species in sea caves and population structure is also poorly known or unknown for most species. Information is available for seals and bats and some limited data are held for a few rare or scarce species in caves in the Skomer MNR and South Pembrokeshire).

Most species living in sea caves are part of wider populations in nearby suitable habitats. Their distribution is mostly a determined by recruitment from populations with widespread distributions both within and outside caves. A few cave specialists have a restricted distribution and are only known from a few locations but it is unclear whether this is a function of survey effort or a truly limited distribution. Species with genuinely restricted distribution are more vulnerable than those that may recruit from large, widespread populations.

4.8.4 Natural processes

Cave morphology and topography is strongly determined by the underlying geology and erosion processes and has an important influence on qualities as a substratum for plants and animals. The microtopography, derived as a result of rock type and exposure to physical, chemical and biological processes also strongly influences niche diversity within caves. Localised protection from scour provided by microtopographical features, for example often strongly influences the distribution of sessile organisms within caves.

Physical conditions, such as inclination, wave surge, scour and shade, change rapidly from cave entrance to the inner parts of a cave and this often leads to a marked zonation in the communities present. The combined effects of scour from suspended particulates, sediment and food particle supply is particularly important to the development, survival and diversity of cave species populations, especially in caves adjacent to sediment or with sediment floors.

Caves on the shore and in the shallow sublittoral zone are frequently subject to conditions of strong wave surge and tend to have floors of coarse sediment, cobbles and boulders. These materials are often highly mobile and scour the cave walls. Caves that occur in deeper water are subject to less water movement from the surrounding sea, and silt may accumulate on the cave floor. Intertidal *sea cave* communities and species ecology and function are strongly influenced by humidity and air temperature, mediated by air movement. Although overall air movement is climatic, movement may be reduced in sea caves depending on their structure and exposure to wave action. Air temperatures may be buffered as a result of restricted airflow, seawater and / or underground rock temperatures, and incident sunlight, compared to the adjacent external environments. Humidity may also be elevated as a result of reduced airflow as well as use by grey seals. In combination, these conditions in intertidal *sea caves* tend to favour species sensitive to desiccation.

4.8.5 Modifications as a result of human activity

Changes to the distribution of sea caves is by human action is poorly known, although there are examples of intentional and consequential, partial or complete blockage of entrances, and infill of small caves near foreshore development (*e.g.* former jetty works on offshore islands). Natural structural changes to sea caves occasionally occur as a consequence of rock falls.

There is no known evidence to suggest that the viability of species populations in sea caves has been modified by human action or that such action has created major impediments to the physiological health, reproductive capability or recruitment of any cave dwelling species. Invertebrate species with planktonic juvenile stages are likely to be at least partly dependant on recruitment from outside the site. The mobility of invertebrate and algal species reproductive products and young are inferred, from the little or no modification or impedance of water movement into and within sea caves, to be unimpeded by human activity.

There is no known evidence of human activity having restricted physical access by grey seals to sea caves, other than temporary inhibition caused by human presence or any modifications to their structural integrity although there are examples of collapse or infill adjacent to development (*e.g.* jetty works on offshore islands).

The influence of human activity on sea-caves sedimentology is unknown. Discarded and accidentally misplaced artificial materials are present in some caves. Hydrodynamic conditions tend to retain such materials as lost and discarded synthetic fishing gear and other durable rubbish in sea caves, particularly those caves with complex shapes and / or boulder/cobble floors. Lost and discarded fishing gear and persistent rubbish form a physical hazard to many species, particularly grey seals and other vertebrate species, and some are a source of chemical contamination. The variation in cave structure and hydrodynamics tends to both retain and flush out chemical contamination, including hydrocarbons, depending on exposure to water and air movements.

The gross physical hydrography within, and in the vicinity of sea caves is considered little modified as a result of human activity and any localised effects are small. Suspended particulate concentrations may be modified by localised or distant human activity including, for example, dredge spoil disposal, coast protection or construction operations. There is no known evidence for modification of sea cave air temperatures a result of human activity however, it is possible that regular use of sea caves for recreational or eco-tourism purposes may increase air exchange.

Species populations in *sea caves* are exposed to nutrients and contaminants in groundwater seeps which are strongly influenced by agricultural or other management practices on overlying land. The magnitude and persistence of elevated hydrocarbons and exhaust gases in sea caves used by powered craft, and the potential consequences of such contaminants are unknown. Sediment transport in the vicinity of sea caves may be modified by many activities but such effects are unknown.

The status of biological interactions structuring the ecology of cave communities is poorly known although ecosystem functioning, determined by grazing molluscs, has been subject to temporary acute modification by pollution incidents.

There is no known documented evidence to suggest that species variety in open coast sea caves has been modified by human action although populations of several typical species of the sea cave feature are severely depleted with respect to historical levels as a consequence primarily of human exploitation. There is a need for some restoration of these populations.

4.9 SANDBANKS WHICH ARE SLIGHTLY COVERED BY SEAWATER ALL THE TIME

Sandbanks which are slightly covered by sea water all the time are defined in the EU Habitats Interpretation Manual as:

"elevated, elongated, rounded or irregular topographic features, permanently submerged and predominantly surrounded by deeper water. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata.

In this document they are referred to as 'subtidal sandbanks'.

Within the UK's inshore waters subtidal sandbanks can be categorised into four main sub-types:

- gravelly and clean sands
- muddy sands;
- eelgrass *Zostera marina* beds;
- maerl beds (composed of free-living Corallinaceae).

A variety of different sandbank types and their associated communities exist in Wales. Of the few moderate sized sandbanks in Wales there are those that are exposed to prevailing winds and currents e.g. Devils Ridge, Bastram Shoal (Pen Llŷn) and Bais Bank (Pembrokeshire) and those that are less exposed to these conditions e.g. the Four Fathom Banks complex and Constable Bank (off Colwyn Bay). As well as these types that occur in fully marine environments there are also extensive mobile sandbanks that exist under reduced or variable salinity and turbid regimes in the Severn Estuary.

The sandbanks of the Pembrokeshire Marine SAC are of sub-types gravelly and clean sands, and muddy sands.

There has been one specifically directed survey that sampled three of the subtidal sandbanks within the site. Additional relevant data and information is available from a series of sediment infauna surveys in the Skomer MNR, other general surveys of sediment habitats and studies associated with identification of dredge spoil disposal grounds.

4.9.1 Range

Subtidal sandbanks are distributed throughout the site, typically associated with headlands, islands, islets or sublittoral reefs which modify tidal streams to favour sandbank establishment and maintenance, but include the southern part of a major offshore linear sandbank (Map 3). The depth ranges in which the banks are distributed vary significantly, resulting in diversity of bank structure, function and associated species.

The major known subtidal sandbanks include: Bais Bank, Turbot Bank, sandbanks in the vicinity of Skokholm (Wild Goose Race & The Knoll) and sandbanks associated with Grassholm Island. There are also deeper *subtidal sandbanks* associated with the Bishops & Clerks, Hats & Barrels and St Govan's Shoals reefs, and in north-west and south-west St Brides Bay. The gross distribution of the main *subtidal sandbanks* themselves appears quite stable and stability is likely to increase with depth.

Approximately 7% of the SAC has been surveyed by advanced acoustic bathymetric techniques and in this area around 800 ha have been identified as sandbank. In less well-surveyed areas a further 4200 ha has been identified, suggesting that subtidal sandbanks may cover around 3.5% of the site.

4.9.2 Structure and Function

The distribution, extent and shape of subtidal sandbanks are determined by complex interactions between hydrodynamic processes (tidal streams and wave action), sediment supply and transport processes, and seabed and coastal morphology.

Their sedimentology varies according to local seabed topography, bathymetry, hydrodynamics and sediment processes is largely unknown. Typically well-sorted medium sand occurs on uppermost parts of sandbank, becoming coarser down the flanks and poorly sorted with increased silt and coarse sediments around the base. Micro-distribution of sediments within each bank appears highly dynamic due to the strong tidal streams and high wave exposure. Bais bank is mostly uniform medium sand and Turbot Bank fine to medium sand. Wild Goose Race Bank is heterogeneous sandy gravel and South St.Brides Bay medium-coarse sand to gravely sand.

Subtidal sandbanks within the site are broadly distinguished into those that are distinct (from surrounding sediments) structures (Bais Bank is most distinct example), and those which are extensions of near-shore sediments (*e.g.* sandbanks in St Brides Bay). They are largely elongate or ovoid and lie along the axis of tidal streams, and are strongly influenced by land-masses (headlands and islands). The Knoll and Turbot Bank are relatively broad and the bank extending SSE from Grassholm is an elongated comma shape.

All the subtidal sandbanks in the site lie in relatively deep-water (between 20–40 metres) and rise 20–>30 metres above the surrounding seabed. The aspects of the subtidal sandbanks vary within the site. For example Bais Bank is orientated north-east – south-west, parallel to prevailing long period wave action; The Knoll and Turbot Bank lie approximately north- west– south-east, roughly perpendicular to long period wave action.

Dune, wave and ripple microtopography of sandbanks provide important sandbank micro-niches that contribute to habitat, community and species diversity are likely to be present as significant features on all of the subtidal sandbanks. Tidal streams are strong to very strong, though variable, in the vicinity of all sandbanks in the site, for example around 2–3 knots across Bais Bank and Turbot Bank) to 4–5 knots on other sandbanks during spring tides.

All subtidal sandbanks within the site are exposed or extremely exposed to wave action and exposure is also highly variable across individual sandbanks. Most of the sandbanks are orientated roughly perpendicular to the prevailing wave direction and have an exposed southern or western flank and a more sheltered northern or eastern flank although Bais Bank lies roughly parallel to prevailing wave action. Associated islands or headlands provide a degree of shelter to at least a part of most of the sandbanks.

The nutrient concentrations within sediment structures are likely to be at or close to that of the surrounding water column. Both calcium carbonate and organic carbon content vary considerably within and between the three surveyed sandbanks with organic carbon is lowest in Bais Bank sands.

Sediment transport processes have a major effect on topography and microtopography at all depths. However, sediment movement and circulation on short (*e.g.* tidal) and long-term time scales and sediment budgets are unknown.

Modification of tidal streams by landmasses and reef blocks has a considerable influence on sediment processes and sandbank morphology; *e.g.* Grassholm southern sandbank. Fate of dredge spoil studies indicate a net south to north transport of fine and very fine sediment through the area of the site and the apparently temporary inclusion in some sandbank structures and potentially longer deposition in others (St Brides Bay). Biological interactions are thought to be dominated by predation by fish and, in less current and wave exposed locations, by molluscs, echinoderms and crustaceans.

4.9.3 Typical species

The depth and exposed and mobile nature of the sites' open coast subtidal sandbanks tends to minimise the presence of photosynthesising organisms. Suspended fine particulates also affect faunal feeding and respiration and coarse sediments cause abrasion. Most sediment processes involve movement of bed load, local high strength tidal streams result in the suspension and transport of a wide size range of sediment grains.

Species richness is higher in deeper, more heterogeneous sediments toward the lowest extremities of the banks and where there is less exposure to waves and currents. It is lowest in the dynamic well-sorted sands on the upper parts of the banks. Species colonising sandbanks provide a rich food source for birds and fish. Infauna of surveyed banks is dominated by polychaete worms, crustaceans and molluscs.

The limited time series data for the south St Brides Bay bank and Turbot Bank indicate species richness is spatially and temporally highly variable, in part determined by variation in sedimentology. Samples from the shallowest areas of Turbot Bank indicate a, possibly seasonally, related variation in numbers of taxa of an order of magnitude. Epifaunal species richness is generally lower in distinct (from surrounding sediments) sandbanks and generally higher in sandbanks forming extensions of near-shore sediments.

The only information on species population dynamics for sandbanks within the site is for Bais Bank in southern St Brides Bay. Species abundances are very low on Bais Bank, and strongly influenced by ephemeral species populations at other locations. It is therefore inferred that species populations of all sandbanks are likely to be dynamic and a reflection of recent hydrographic conditions and species recruitments.

The infaunal species population sizes are unknown but assumed to be typical of habitat for many species. Population structure, physiological health and biomass is unknown or poorly known for most species. Many invertebrate species have planktonic juvenile stages and may be at least partly dependant on recruitment from outside the site and certainly from beyond each individual sandbank. Biomass is likely to be highly variable between the different sandbank habitats and species.

The species typical of the sandbanks have a wide range both within and outside the site especially as there is a large extent of suitable habitat near-shore and deep sandy-gravel sediment habitats within the site, and large tidal sand ridges in the Celtic Sea. The spatial and temporal resolution of the data is mostly insufficient to show precise distribution or temporal variation in distribution.

4.9.4 Natural processes

Subtidal sandbanks are dynamic features with their size, shape, aspect and orientation, as well as the macro- and micro-topography and sediment characteristics largely determined by the sediment supply and the influence of the hydrodynamic processes affecting each bank. They change shape over time and while some are ephemeral others may be relatively stable and long established. Mobile sediments that form temporary sandbanks are considered to be associated sediments that should be retained in the system but their location may change.

4.9.5 Modifications as a result of human activity

There is no known evidence that the gross distribution or extent of subtidal sandbanks within the site has been directly modified by human action. Any effects of climate change on subtidal sandbanks location, size or morphology are unknown.

There is no information to suggest modification of subtidal sandbanks sedimentology by human action, though the proximity of Turbot Bank to a formerly significant dredge spoil disposal site may have influenced the bank’s sediment composition. Sediment tracer studies suggest that a proportion of the spoil dumped at the former disposal site is likely to have deposited in the vicinity of Skokholm and Skomer Islands and southern St Brides Bay. There is no known evidence of gross modification of subtidal sandbanks geomorphology as a result of human activity.

The subtidal sandbanks in the immediate vicinity of Milford Haven (Turbot Bank) and Skokholm and Skomer Islands and St Brides Bay are inferred to have been historically influenced by disposal of dredge spoil at the former dump site immediately south of the Milford Haven entrance but not by sediment extraction within the site.

Tidal streams in vicinity of subtidal sandbanks are not known to be modified by human activity. Exposure of sandbanks to wave action is not currently considered significantly modified by human activity, though modification of wave action as a result of anthropogenically influences climate change is considered likely to increase.

Turbidity is likely to have increased as a consequence of increased nutrient enrichment of coastal waters (and consequential phytoplankton growth) and increased suspended sediments in coastal waters due to changes in land use. Sediment transport is inferred, from the absence of local modification of hydrodynamic processes, not to be locally modified as a result of human activity. Any effects from sediment disposal and long-term effects of land use change are unknown.

Long-term exploitation of fish populations is inferred to have depleted abundance and biomass and affected biological interactions of sandbanks populations. The mobility of species larvae and juveniles are inferred, from the absence of modification or impedance of water movement, to be unimpeded. Mobility of commercially exploited species are (obviously) impeded by capture methods. Free-swimming vertebrate species are influenced and, potentially locally impeded by, commercial fishing gear.

4.10 ALLIS SHAD (ALOSA ALOSA) AND TWAITE SHAD (ALOSA FALLAX)

Shad are herring-like fish that spend most of their adult lives in the sea but spawn in rivers (or, occasionally, in the upper reaches of estuaries) and usually migrate through estuaries in spring on their way to the spawning grounds. Shads in the marine environment are completely dependent on the riverine stage of their life cycle and thus on the appropriate conservation of their riverine habitats.

The shad occurs in several rivers in Wales, the most important populations being in the Tywi, Usk, Wye and Severn.

4.10.1 Population dynamics

There are a few *ad-hoc* records of shad from the SAC which is used as an access corridor between the sea and riverine breeding habitat. They use the site as an access corridor between the open sea and riverine breeding habitat. The numbers of individuals within the site at any time, and their distributions and proportions of wider populations, are likely to be dynamic and highly seasonal but are unknown. The age, sex and physiological heath of shad using the site are also unknown.

4.10.2 Range

There are no data available on the areas used and therefore the range of shad within the site.

4.10.3 Habitat and species

Shad feed primarily on zooplankton at sea, especially planktonic crustaceans such as calanoids, mysids and euphausids, but also to some extent on small fish (Maitland & Lyle, 1995). Areas supporting high densities of these species are potential feeding grounds for juvenile and adult fish. Juvenile shad feed primarily on plankton such as mysids and copepods, taking larger crustaceans as they grow (*e.g.* shrimps).

Shad are thought to be adversely affected by poor water quality and temperature also appears to affect recruitment, although this may be more relevant in the riverine phase of the life cycle. Suitable habitats must also include abundant, suitable prey. The water column throughout the site is assumed to suitable habitat and the water quality to be of sufficiently high quality in open coastal water. The importance of the site for feeding, the feeding requirements, the status of preferred prey species within the site, and any potential contamination load of prey species is unknown.

4.10.4 Modifications as a result of human activity

There are no known physical impediments to access within or transit though the site, though there are at the boundary between the marine site and the adjacent rivers (weirs and fish passes). There is also no known information on historical or contemporary by-catch within the site other than very occasional records of individuals caught by anglers.

There is no known evidence that shad and lamprey habitat structure is inadequate. There are no known or likely physical obstructions to passage and although there are entrainment hazards (*e.g.* seawater intakes) within the site there is no known evidence of incidental capture. The presence and persistence of artificial inert materials (*e.g.* synthetic fibres) create an entanglement risk.

4.11 River lamprey (Lampetra fluviatilis) and sea lamprey (Petromyzon marinus)

Lampreys are primitive type of fishes that have a distinctive suckered mouth, rather than jaws. The river lamprey *Lampetra fluviatilis* is found only in Western Europe, where it has a wide distribution. The sea lamprey *Petromyzon marinus* occurs over much of the Atlantic coastal area of western and northern Europe and eastern North America where it is found in estuaries and easily accessible rivers.

River lampreys are widespread in the UK, occurring in many rivers. They spend much of their adult life in estuaries and inshore waters but spawn and spend the juvenile part of their life cycle in rivers. The larvae (ammocoetes) spend several years buried in sandy sediment in rivers feeding on organic matter before metamorphosing after around 4 years. Juveniles migrate to estuaries and inshore waters where they feed parasitically on various fish species. Once fully grown, they migrate upstream to spawn. There are a few land-locked populations, including one in Scotland. During their marine phase, river lampreys are predominantly an inshore species feeding on small fish such as herrings and sprats.

Sea lampreys have a similar life cycle to the river lamprey, although they are much larger and more oceanic, feeding parasitically on big species such as basking sharks. It is an anadromous species (i.e. spawning in fresh water but completing its life cycle in the sea). Like the river lamprey, sea lamprey need clean gravel for spawning, and marginal silt or sand for the burrowing juvenile ammocoetes. However, unlike the other species, they tend to spawn in the lower to middle reaches of rivers, in deep, fast-flowing waters. Sea lampreys occur in many Welsh rivers, including the Teifi, Tywi, Usk, Wye, Cleddau and Dee. These sites all include estuaries or areas adjacent to estuaries that are thought to be either part of the migratory route or used by river lampreys.

4.11.1 Population dynamics

The population size of river and sea lamprey within the SAC is unknown. Lamprey must pass through the open coast waters of the SAC and the Milford Haven waterway to access the rivers systems as the most recent Cleddau Rivers surveys indicate presence of river lamprey. There were no records of sea lampreys and no data from marine waters.

The numbers of individuals within the site at any one time, their distributions and their proportion of the wider populations, are likely to be dynamic and highly seasonal but are unknown. There is also no information on the age and sex of individuals using the site and their condition.

4.11.2 Range

There are no data available on the range of lampreys within the SAC.

4.11. 3 Habitats and species

The water column throughout the site is assumed to be suitable habitat for river and sea lamprey. The feeding requirements of populations within the site, the importance of the site as a feeding habitat, and the status of their preferred prey species is unknown. There is also no information about any potential contaminant levels in prey.

4.11.4 Modifications as a result of human activity

Very little is known about impacts of human activity on these species in this site. For example there is no known information on historical or contemporary by-catch within the site. There is also no known evidence that shad and lamprey habitat structure is inadequate. Water column contaminants are a threat to physiological health, but water quality is assumed to be sufficiently high in open coastal waters. Water quality obstacles within Milford Haven waterway are unknown.

There are no known physical impediments to access within or transit though the site, though there are at the boundary between the marine site and the adjacent rivers (weirs and fish passes).There are entrainment hazards (*e.g.* seawater intakes) and the presence and persistence of artificial inert materials (*e.g.* plastics and synthetic fibres) create an entanglement risk within the site. There is no known evidence of incidental capture. The absence of known by-catch records suggests low risk from fisheries

4.12 OTTER

The (Eurasian) otter *Lutra lutra* is a semi-aquatic mammal which occurs in a wide range of ecological conditions, including inland freshwater and coastal areas. Populations in coastal areas use shallow, inshore marine areas for feeding but also require freshwater for bathing and terrestrial areas for resting and breeding holts. Coastal otter habitat ranges from sheltered wooded inlets to more open, low-lying coasts. Inland populations utilise a range of running and standing freshwaters. These must have an abundant supply of food (normally associated with high water quality), together with suitable habitat, such as vegetated riverbanks, islands, reed beds and woodland, which are used for foraging, breeding and resting.

At present, the majority of the otter population in Great Britain occurs in Scotland, with a significant proportion of this number being found in the north and west of the country. Other strong populations survive in Wales and Ireland. Recent surveys suggest that the otter population is recovering well and recolonising parts of its former range. While the SAC series makes a contribution to securing favourable conservation status for this Annex II species, wider countryside measures, in particular implementation of the UK's Biodiversity Action Plan, are important to its conservation in the UK.

4.12.1 Population dynamics

Otters present within the site are part of a wider population living around freshwater habitats in Pembrokeshire, which itself is not completely isolated but extends further afield and between which there are movements and exchanges. The proportion of the otter population within the site at any time and its distribution is likely to be dynamic and it is not known whether the numbers of animals that use the site are a fixed or variable proportion of the wider population with a preference for using marine habitat.

Females with cubs have been recorded very occasionally on the foreshore in, and in the vicinity of, the site but breeding activity is not known within the site and specific information on the use of the site by juveniles is unavailable.

The age frequency and sex ratio of otters using the site is not known, nor is it known whether the age or sex of animals using the site are representative of the wider population, or are dominated by animals of a specific age range or sex. There is a single recent record of female with cubs on foreshore in St Brides Bay (Broad Haven).

Many aspects of the population dynamics of otters using the SAC are unknown. These include their physiological health, reproductive capability, exposure and immunity to endemic and anthropogenic disease and contaminant burden. A range of viral, bacterial and parasitic diseases are known to otter populations but these apparently have limited effect on healthy, unstressed, adult otters. The dispersed nature of the population may limit disease transmission and the influence of disease as a density dependent population control mechanism.

4.12.2 Range

Otters are widespread on, and close to, the coastline throughout the site, both on the open coast and within the Milford Haven waterway, particularly within the Daugleddau and Cleddau Rivers. Spraint records and analysis and distribution of suitable feeding locations indicate a wide feeding range. Distribution is mostly associated with foreshore access via small river and stream valleys with sufficient scrub or tree cover, suitable feeding locations (rock-pools, sheltered boulder shores, with freshwater pools/streams for washing off salt) and ease of access to and along the shore. Sightings records suggest that otters use both the sea and foreshore to move between freshwater watercourses.

4.12.3 Habitat and species

Otters appear to use most foreshore habitats in the site, other than the steepest rock, and especially moderately sheltered waters close to the shore. There is evidence that the site contributes to supporting the otter population, as a foraging ground, access corridor and for social activity but there is no evidence for cub production within the site, though it is known and inferred in riverine habitat adjacent to the site and connected to it via vegetated watercourses and valleys.

There are many widely distributed access points to the site from adjacent habitats such as watercourses and vegetated valleys. Coastal fringes where suitable prey habitat is readily accessible to otters is widespread throughout the site; i.e. sheltered shallow water such as rock-pools, lagoons and estuary shallows, accessible from freshwater habitat. The small size of many of the inland rivers and streams are means they are considered unlikely to be capable of providing all the otters' food requirements throughout the year, though details are unknown.

Potential resting sites amongst dense vegetation cover on coastal streams draining into the site, cavities amongst rocks, reed beds, tree root systems and scrub are widespread. Variously sized watercourses draining into the sea and the Milford Haven waterway that are suitable for bathing are found distributed widely throughout the site. No holts are known but potential holt (breeding) sites are present within the site in the Milford Haven waterway, mostly in the Cleddau / Daugleddau.

The structural and functional integrity of habitat essential for otters like well-vegetated stream and river valleys, access to the shore, rock-pools with salt and fresh water, secluded resting habitats, is high throughout much of the site.

Otter diet can be highly varied, though is normally focused on favoured prey species and a reflection of local prey availability. Fourteen marine species (mostly fish) were recorded from spraint collected within the site in 2002; European (freshwater) eels were the most important single component of their diet (present in 67% spraint samples). A wider variety of marine species was present in spraint from Milford Haven waterway than those from open coast sites.

4.12.4 Modifications as a result of human activity

Habitat quality and suitability for use has been reduced by, amongst other things:

- the presence and persistence of artificial inert materials (*e.g.* plastics, synthetic fibres, static fishing gear) presenting entanglement & smothering risk;
- decrease in seclusion because of noise and visual disturbance, as a result of increased human access, habitation and waterborne activities;
- the presence and persistence of toxic contaminants;
- risks of fur contamination from oil discharged into either freshwater or marine environments;
- availability & quality of prey

Feeding habitat and access corridors between riverine habitats and foreshore have been historically modified by urbanisation, development and vegetation clearance. However, because of apparent acceptance of man-made structures for access, the scale of any impedance to access or former range is unknown. Whether the apparent regular use of areas close to human habitation and activity is indicative of tolerance or of pressure on (feeding) habitat or access between watercourses and the foreshore is unknown.

Scrub and vegetated areas suitable for resting or breeding are vulnerable to clearance for agricultural and recreational requirements but the extent of such modification is unquantified. Localised modification of other habitat, mainly near urban areas, *e.g.* coastal defences, engineered watercourses (culverts etc) and managed vegetation, has reduced ease of access and concealment. However, man-made physical structures do not appear to be a deterrent to otters although the extent to which they modify behaviour is unknown.

Human activity causing disturbance with the potential to affect behaviour is widespread but concentrated in residential and urbanised areas. The times of day favoured by otters for activity (early morning and dusk) also tend to minimise interaction with people. There is no known information to suggest human activity has modified the production and survival of young of animals using the site, or the age structure and sex of otters using the site.

As a top predator, otters are vulnerable to accumulation of toxic contaminants present within their food chains, particularly those that are persistent and /or bioaccumulate and biomagnify. The current status of contamination of most likely prey species is unknown although European eels are known to be substantially impacted by a range of contaminants. PCB contamination of otter prey species has been an issue elsewhere in the UK.

Most of the common prey species recorded are not commercially exploited and their stock status is generally unknown although for European eel (the dominant recorded prey species) populations are below safe biological limits and the current fisheries are unsustainable.

4.13 SHORE DOCK (RUMEX RUPESTRIS)

The Shore dock (*Rumex rupestris*) is one of Europe's most threatened endemic vascular plants. The species is locally extinct in former parts of its range and is currently known from about 40 locations in south-west Britain, only three off which are in Wales. Colonies supporting 50-100 individuals are considered large as most, especially those on rocky shores, generally hold fewer than ten individuals. The total UK population is estimated to comprise less than 650 plants.

In the following text the term 'population' is used to describe those individuals present within the site.

4.13.1 Population dynamics

Data for 2000-2006 indicate a fairly stable population in the SAC with an average count of 76 mature plants, which is large for this species. Flowering plants, vegetative plants and seedlings have been observed as has successful annual fruiting. The health of the populations is therefore not considered to be significantly compromised.

4.13.2 Range

The shore dock is known from two separate locations within the SAC with two sub-populations in each (Map 2.1).

4.13.3 Habitat and species

There is limited suitable habitat for this species within the SAC as it requires cliff niches and constant freshwater. One colony is known to have been affected by cliff falls.

4.13.4 Modifications as a result of human activities

The known existing colonies are in locations at low risk from human activities.

5 CONSERVATION OBJECTIVES

This latest version of the Regulation 33 package has been revised to improve consistency across the marine SACs in Wales. The intent of the conservation objectives and of the advice on operations which may cause deterioration or disturbance to the feature is the same as in previous versions. The Conservation Objectives are now shorter and more generic but there has been no change in what is considered to represent Favourable Conservation Status.

In order to meet the aims of the Habitats Directive, the conservation objectives seek to maintain (or restore) the habitat and species features, as a whole, at (or to) favourable conservation status (FCS) within the site.

The Vision Statement is a descriptive overview of what needs to be achieved for conservation on the site. It brings together and summarises the Conservation Objectives into a single, integrated statement about the site.

VISION STATEMENT

Our vision for the Pembrokeshire Marine Special Area of Conservation (SAC) is one of a high quality marine environment, where the protected habitats and species of the site are in a condition as good as or better than when the site was selected; where human activities co-exist in harmony with the habitats and species of the site and where use of the marine environment is undertaken sustainably.

CONSERVATION OBJECTIVES FOR THE PEMBROKESHIRE MARINE SPECIAL AREA OF CONSERVATION

To achieve favourable conservation status all the following, subject to natural processes, need to be fulfilled and maintained in the long-term. If these objectives are not met restoration measures will be needed to achieve favourable conservation status.

HABITAT FEATURES

Sandbanks which are slightly covered by seawater all the time
Estuaries
Mudflats and sandflats not covered by seawater at low tide
Coastal lagoons
Large shallow inlets and bays
Reefs
Submerged or partially submerged sea caves
Atlantic salt meadows

RANGE
The overall distribution and extent of the habitat features within the site, and each of their main component parts is stable or increasing.

For the **inlets and bays** feature these include;
- The embayment of St.Brides Bay
- The ria of Milford Haven
- Peripheral embayments and inlets

For the **coastal lagoons** feature this is subject to the requirements for maintenance of the artificial impoundment structure and maintenance of the lagoons for the original purpose or subsequent purpose that pre-dates classification of the site.

STRUCTURE AND FUNCTION

The physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include;

- geology,
- sedimentology,
- geomorphology,
- hydrography and meteorology,
- water and sediment chemistry,
- biological interactions.

This includes a need for nutrient levels in the water column and sediments to be:

- at or below existing statutory guideline concentrations
- within ranges that are not potentially detrimental to the long term maintenance of the features species populations, their abundance and range.

Contaminant levels in the water column and sediments derived from human activity to be:

- at or below existing statutory guideline concentrations
- below levels that would potentially result in increase in contaminant concentrations within sediments or biota
- below levels potentially detrimental to the long-term maintenance of the features species populations, their abundance or range.

Restoration and recovery

As part of this objective it should be noted that; **the Milford Haven waterway complex** would benefit from restorative action, for example through the removal of non-natural beach material, and the removal, replacement or improved maintenance of rock filled gabions. There is also need for some restoration of the populations of several typical species of the Milford Haven waterway complex that are severely depleted with respect to historical levels as a consequence primarily of human exploitation.

In the **Milford Haven waterways complex** inputs of nutrients and contaminants to the water column and sediments derived from human activity must remain at or below levels at the time the site became a candidate SAC.

For the lagoons feature this is subject to the requirements for maintenance of the artificial impoundment structures of **coastal lagoons** and maintenance of the **lagoons** for their original purpose or subsequent purpose that pre-dates classification of the site.

TYPICAL SPECIES

The presence, abundance, condition and diversity of typical species are such that habitat quality is not degraded. Important elements include

- species richness:
- population structure and dynamics,
- physiological heath,
- reproductive capacity
- recruitment,

- mobility
- range

As part of this objective it should be noted that:

- populations of typical species subject to existing commercial fisheries need to be at an abundance equal to or greater than that required to achieve maximum sustainable yield and be secure in the long term
- the management and control of activities or operations likely to adversely affect the habitat feature is appropriate for maintaining it in favourable condition and is secure in the long term.

Restoration and recovery

For the **inlets and bays** features this includes the need for some restoration of the populations of several typical species which are severely depleted with respect to historical levels as a consequence, primarily of human exploitation.

In the **Milford Haven waterways complex** inputs of nutrients and contaminants to the water column and sediments derived from human activity must remain at or below levels at the time the site became a candidate SAC.

SPECIES FEATURES

Grey seal
Otter
Shad *Alosa* spp.
River lamprey
Sea lamprey
Shore dock

POPULATIONS

The population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements are population size, structure, production, and condition of the species within the site.

As part of this objective it should be noted that for **otter** and **grey seal**;

- Contaminant burdens derived from human activity are below levels that may cause physiological damage, or immune or reproductive suppression

For **grey seal,** populations should not be reduced as a consequence of human activity

RANGE

The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.

As part of this objective it should be noted that for **otter** and **grey seal**

- Their range within the SAC and adjacent inter-connected areas is not constrained or hindered
- There are appropriate and sufficient food resources within the SAC and beyond

- The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing

SUPPORTING HABITATS AND SPECIES

The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include;

- distribution,
- extent,
- structure,
- function and quality of habitat,
- prey availability and quality.

As part of this objective it should be noted that;

- The abundance of prey species subject to existing commercial fisheries needs to be equal to or greater than that required to achieve maximum sustainable yield and secure in the long term.
- The management and control of activities or operations likely to adversely affect the species feature is appropriate for maintaining it in favourable condition and is secure in the long term.
- Contamination of potential prey species should be below concentrations potentially harmful to their physiological health.
- Disturbance by human activity is below levels that suppress reproductive success, physiological health or long-term behaviour
- For **otter** there are sufficient sources within the SAC and beyond of high quality freshwater for drinking and bathing.

Restoration and recovery

In the **Milford Haven waterways complex** inputs of nutrients and contaminants to the water column and sediments derived from human activity must remain at or below levels at the time the site became a candidate SAC.

As part of this objective it should be noted that for the **otter,** populations should be increasing.

5.1 Understanding the Conservation Objectives

A dynamic marine environment

The conservation objectives recognise and acknowledge that the features are part of a complex, dynamic, multi-dimensional environment. The structures, functions (environmental processes) and species populations of habitat features are inextricably linked. Marine habitats are complex ecological webs of species, habitat structure and environmental functions that vary dynamically in time and space. Variety and change in habitat structure is primarily driven by environmental and physico-chemical factors, including water movement, water quality, sediment supply and prevailing weather conditions.

The species populations associated with these habitats also vary in time and space and this is, in part, a direct reflection of the variable habitat structure and dynamic environment. It is also the product of stochastic events and the great variation in survival and recruitment of species, particularly those with dispersive reproductive strategies.

Within the dynamism of habitats and species, there is also an element of stability and persistence, where species' and communities' populations as well as physical habitat structure show little overall long-term variation.

Human activities
These conservation objectives recognise and acknowledge that human activity has already modified and continues to modify habitats and species populations in various ways, to varying degrees and at varying spatial and temporal scales, either acutely or chronically. The conservation objectives do not aim to prevent all change to the habitat and species features, or to achieve an indefinable, abstract natural or pristine state, since these would be unrealistic and unattainable aspirations. Rather, they seek to prevent further negative modification of the extent, structure and function of natural habitats and species' populations by human activity and to ensure that degradation and damage to the features that is attributable to human activities or actions is prevented. Consequently, in order to meet the requirements of the Directive and ensure the site makes its appropriate contribution to conservation of biodiversity, the conservation objectives seek to:

- Encompass inherent dynamism rather than to work against it;
- Safeguard features and natural processes from those impacts of human activity that cause damage to the features through the degradation of their range, extent, structure, function or typical species;
- Facilitate, where necessary, restoration of features or components of features that are currently damaged or degraded and in unfavourable condition.

The term *degradation* is used to encompass damage or deterioration resulting only from such human activities or actions as have a detrimental effect on the feature. The magnitude of any degradation is dependent on the longevity and scale of the impact and the conservation importance of the species or habitats on which the impact occurs. This is influenced by:
- the type of human action, its nature, location, timing, frequency, duration and intensity,
- the species or habitats, and their intolerance and recoverability.

Outcomes arising from human action that are likely to be considered detrimental include such effects such as:
- permanent and long-term change of distribution or reduction in extent of a feature or features component, or temporary modification or reduction sufficiently significant to negatively impact on biota or ecological processes;
- reduction in ecological function caused by loss, reduction or modification of habitat structural integrity;
- interference in or restriction of the range, variety or dynamism of structural, functional or ecological processes, *e.g.*: alteration of habitat structure, obstruction of tidal streams, chronic or acute thermal, salinity or suspended sediment elevations or reductions;
- hypertrophication or eutrophication;
- contamination by biologically deleterious substances;
- reduction in structure, function and abundance of species populations;
- change in reproductive capacity, success or recruitment of species populations;
- reduction in feeding opportunities of species populations
- reduction of health to a sub-optimal level, or injury, rendering the population less fit for, *inter alia,* breeding, foraging, social behaviour, or more susceptible to disease;
- increase in abundance and range of opportunist species through the unnatural generation of preferential conditions (*e.g.* organic enrichment), at the expense of existing species and communities.
- increase in abundance and range of non-native species.

The following table provided illustrative examples of specific changes and whether they would constitute degradation of the feature.

Degradation	Not Degradation
Reduction in grey seal reproductive potential as a result of sub optimal physiological health caused by high tissue burdens of anthropogenically derived contaminants.	Reduction in grey seal reproductive potential as a result of sub optimal physiological health caused by density dependent incidence of endemic disease.
Modification of a seabed community by organically rich effluent from a new sewage outfall.	Modification of a seabed community as a result of a reduction in organic material entering the sea from a sewage outfall.
Change in seabed community composition as a result of coastal engineering that has altered local wave exposure.	Change in seabed community composition as a result of a cliff fall, the debris from which has altered local wave exposure.
Change to the species composition of a seabed community as a result of an increase in scallop dredging intensity.	Change to the composition of a seabed community as a result of a reduction in scallop dredging intensity.
Permanent reduction of extent of sand and mud-flat as a result of new coastal development.	Permanent reduction of extent of sand and mud-flat as a result of long-term natural changes in sediment transport.
Changes in sediment granulometry as a result of beach recharge operations	Changes in sediment granulometry as a result of natural cliff fall and erosion

It is important to note that many human activities can either be beneficial (reduce or reverse detrimental human influence (*e.g.* improve water quality)), trivial (*e.g.* no significant and/or substantive long-term effect) or benign (no outcome) in terms of their impact on marine habitats and species.

Advice on potentially detrimental human activities is provided in Section 6 (activities or operations which may cause damage or disturbance to features).

Use of the conservation objectives – Site management

The components of favourable conservation status detailed in the conservation objectives have different sensitivities and vulnerabilities to degradation by human activities. Conservation and protection of site features is provided by management, which should be based on levels of risk. The form of management and degree of protection necessary will vary spatially, temporally and from one feature component to another due to their differences in conservation importance and their sensitivity and susceptibility to change and their ability to recover from human actions. Therefore it needs to be understood that these conservation objectives require a risk-based approach to the identification, prioritisation and implementation of management action.

Security of management is provided in part by sections 48 to 53 of the 1994 Conservation Regulations, which require the assessment of plans and projects likely to have a significant effect on the site.

Where there is a potential for a plan or project to undermine the achievement of the conservation objectives, CCW will consider the plan/project to be likely to have a significant effect and require appropriate assessment. Unless it is ascertained, following an appropriate assessment, that a plan or project will not undermine the achievement of the conservation objectives, the plan/project should be considered as having an adverse affect on the integrity of the site[25].

Appropriate and secure management of activities may also be provided through a site management plan.

[25] Uncertainty should not result in a conclusion of no adverse affect on site integrity.

1 6 ADVICE AS TO OPERATIONS WHICH MAY CAUSE DETERIORATION OR DISTURBANCE TO THE FEATURES

The range of different habitat types within each of the SAC's features is extremely wide and marine habitats and species populations are inherently dynamic. The range and scale of both natural and anthropogenic stressors on the marine habitats and species within the SAC are also very large. Human activities have the potential to impose stresses on each habitat's structure and function in many ways that result in acute, chronic or permanent impacts at different spatial scales. Species populations may also be affected at many levels e.g. physiological, genetic, single organism, population and groups of species.

The following table identifies where there is a potential for operations or activities to have an adverse effect on a feature or component of a feature exists. This does not imply a significant actual or existing causal impact. The potential for, and magnitude of, any effect will be dependent on many variables, such as the location, extent, scale, timing and duration of operations or activities, as well as proximity to features that are sensitive to one or more factors induced or altered by the operation. Due to the complexity of the possible inter-relationships between operations or activities and the features, the factors and effects listed in this table are the predicted most likely effects and are not exhaustive.

- The 'activity' column lists potentially damaging operations and gives an indication of their current known status within the SAC. Operations or activities marked with an asterisk (*) may have associated consents, licences, authorisations or permissions which are (or may be) plans or projects, within the meaning of Article 6 of the Habitats Directive. (The potential effects of the construction phase of operations marked with a hash (#) are included in the general operation 'construction'.
- The 'key relevant factors' columns (physical, chemical and biological factors) give an indication of the key mechanisms by which the operation or activity may cause an effect on each habitat feature.
- The 'most likely effects' columns indicate the most likely components of Favourable Conservation Status that might be affected by each operation or activity.
- The 'features' columns indicate which Annex 1 habitats and Annex II species could potentially be affected by the operation or activity.
- The 'advice as to likely required action' column provides an indication of the actions required (from CCW and others) to undertake specific risk assessments of relationships between the operation or activity and relevant features, including any further information that would be necessary to further refine / tailor advice.

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Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features											Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
DOCKS, MARINAS & SHIPPING																						
Dock, harbour & marina structures: construction *# *Widespread in inlets (notably Milford Haven waterway)*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate. Consenting bodies ensure appropriate integration, inclusion and consultation Consenting bodies ensure assessment of cumulative effects in association with others plans and projects
Dock, harbour & marina structures: maintenance *# *Widespread & common in inlets (notably Milford Haven waterway)*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat as plan or project as appropriate. Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce.
Dredging: capital * *Widespread in inlets (notably Milford Haven waterway)*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat as plan or project as appropriate. Develop long-term, whole-Haven maintenance dredging strategy. Establish best operational practices suitable to secure features at FCS
Dredging: maintenance * *Widespread & regular in inlets (notably Milford Haven waterway)*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat as plan or project if appropriate. Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Develop long-term, whole-Haven maintenance dredging strategy.
Shipping: vessel traffic (commercial) *Widespread & common*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	Continue to monitor shipping movement within port limits. Determine effects of vessel movement on sediment transport, mobilisation and turbidity. Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters to minimise risk to features FCS
Shipping: moorings *# (commercial & recreational inc.mooring installation) *Widespread & common*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓					Treat new mooring developments as plan or project as appropriate. Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of moorings in open coastal locations (*i.e.* outwith MHPA port limits)

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Shipping: anchoring (commercial & recreational) *Widespread & common*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓					Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of open coastal locations (*i.e.* outwith MHPA port limits) used as commercial anchorages and for casual recreational anchoring
Shipping: vessel maintenance (incl. antifouling) *Widespread & common (notably in Milford Haven waterway)*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce.
Shipping: ballast water discharge *Widespread & common (notably in Milford Haven waterway)*		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters to minimise risk to features FCS
Shipping: refuse & sewage disposal *Widespread & common (notably in Milford Haven waterway)*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters so as to secure features at FCS Apply existing legal mechanisms, monitor compliance and enforce, to secure features at FCS
Shipping: operational discharges *Widespread & common (notably in Milford Haven waterway)*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters so as to secure features at FCS
Shipping: accidents -may be associated with cargo / bunkers discharges (may be associated with cargo / bunkers discharges) *Rare*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				✓	Maintain, keep under review and improve as a appropriate, shipping management and operational practices suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters so as to secure features at FCS Seek advice from relevant environmental agencies (CCW, EA)
Shipping: accidents -fuel oil & / or petrochemical discharges *Occasional (notably in Milford Haven Waterway)*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	As above

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Shipping: accidents -non-petrochemical cargo losses / discharges ***Rare***	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Shipping: accidents - salvage operations *Rare*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	Maintain, keep under review and improve as a appropriate, management and operational practices suitable to secure features at FCS; monitor compliance and enforce. Secure appropriate management of vessels transiting coastal waters so as to secure features at FCS Provide environmental advice to salvage managers and salvors.
CIVIL ENGINEERING																						
Construction *# *Widespread in inlets (notably Milford Haven Waterway)*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project, taking into account proposed subsequent operational use and maintenance. Consenting bodies ensure appropriate integration, inclusion and consultation Consenting bodies ensure assessment of cumulative effects in association with others plans and projects
Land claim *# *Occasional in inlets (notably Milford Haven Waterway)*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate, taking into account proposed subsequent operational use and likely effects.
Coast protection / defence (including beach replenishment) *# Widespread in urban areas	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate, taking into account long term management requirements & predicted climatic impacts
Barrages (amenity, storm surge, tidal) *# *Historical and recent structures at extremities of and immediately outwith tributary estuaries (Carew, Neyland, Cleddau rivers).* *No major barrages within main water-bodies, although proposed in past*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Artificial reef *#	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	As above
Engineered freshwater watercourses *# *Occasional throughout site, mainly in bays and inlets*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Power station *# (potentially also related to shipping, water abstraction & waste disposal operations) *None at present – proposals likely to focus on Milford Haven Waterway*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Pipelines *# *Present mainly in the Milford Haven Waterway*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		Treat as plan or project as appropriate, taking into account long term management requirements & likely effects.
Power / communication cables *# *Present*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
WASTE DISPOSAL																						
Effluent disposal [26] *(sewage & chemical) *Widespread & common*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat new discharges and proposed changes to existing discharges as plan or project as appropriate.
Effluent disposal: thermal * *None current; historical power station effluent*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat new discharges and proposed changes to existing discharges as plan or project as appropriate.
Sludge dumping * *None at present*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Wastes & debris (including refuse & litter) *Widespread & common*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Maintain, keep under review and improve as a appropriate port waste management plans Secure appropriate promulgation & enforcement of national and international dumping at sea measures so as to minimise risk to features' FCS Education & awareness raising
Dredge spoil disposal **Former disposal site immediately outside Milford Haven; routine disposal of Milford Haven waterway spoil at licensed offshore disposal sites adjacent to site; trickle-feed disposal authorised within waterway*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat proposed spoil disposal outwith a designated spoil disposal site as plan or project as appropriate. Develop and implement best practice appropriate for disposal sites
Urban & industrial run-off * *Widespread & common*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Continued surveillance and monitoring of inputs and water quality by EAW. Continued development and promulgation of good practice. Maintain review of consents to take account of new scientific information. Include in assessment of plans and projects as appropriate

[26] See also Code, S, Codling, I D, Parr, W & Zabel, T. 1999. Guidelines for managing water quality impacts within UK European marine sites. WRc Swindon for UK Marine SACs Project.

Activity	**Key Relevant factors**			**Most likely effects on FCS elements *Habitats***			**Most likely effects on FCS elements *Species***			**Features**												**Advice/Action/Notes**
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Agricultural run-off *Widespread & common*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Continued surveillance and monitoring of inputs and water quality by EAW; continued development and promulgation of good practice.
EXPLOITATION OF LIVING RESOURCES																						
Trawling (beam, otter) & dredging: scallop (and other relatively rapidly towed, heavy seabed gears not listed below) * *Widespread & common offshore; limited within site. Scallop dredging occasional*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓		✓	Where appropriate, review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Treat new fisheries and new gear as plan or project as appropriate. Determine maximum sustainable yield for target species; monitor & manage fisheries to maintain population levels at or above MSY.
Dredging: mussel and oyster * *Oyster dredging common in Daugleddau (mostly winter)*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓	Urgent review and establishment of adequate operational limits (spatial, temporal, technical, effort) to secure features at FCS; monitor compliance and enforce. Treat new fisheries and new gear as plan or project as appropriate. Determine maximum sustainable yield for target species; monitor & manage fisheries to maintain population levels at or above MSY.
Dredging: hydraulic dredge * *Limited activity anecdotally - Carmarthen Bay/St Bride's Bay*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓		Treat new fisheries and new gear as plan or project as appropriate. Establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Determine maximum sustainable yield for target species; monitor & manage fisheries to maintain population levels at or above MSY.
Netting (gill, tangle, trammel, beach seine, demersal seine, salmon, fyke) * *Widespread & common (inshore waters)*	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Determine maximum sustainable yield for target species; monitor & manage fisheries to maintain population levels at or above MSY.
Potting * *Widespread & common (inshore waters)*	✓		✓		✓	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓	✓	As above
Commercial line fishing * *Occasional hand fishing (bass/salmonids), occasional long-lining offshore*	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓		✓		✓		✓	✓	✓	As above
Hand gathering * (collection, boulder turning, digging, raking, spearfishing) *Widespread, generally small scale. Commercial winkle collection in Milford Haven waterway*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	As above

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Bait collection: commercial * *Commercial bait digging common especially at 'hot spots'; commercial collection of other species (crustaceans, molluscs, sand-eels) as bait poorly known*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		Urgent review and establishment of adequate spatial, temporal, technical and effort operational limits to secure features at FCS; monitor compliance and enforce Appropriate implementation of SSSI procedures Education & awareness raising
Collection, for aquarium / curio trade * *Restricted and small scale.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS
Grazing of salt-marsh * *Occasional on upper reaches of Milford Haven Waterway*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									Review, revise or establish, monitor and enforce spatial & temporal operational limits suitable to secure features at FCS
Gathering algae and higher plants for human consumption * (see also vehicles on foreshore) *Widespread, generally small scale. Localised commercial collection Porphyra spp*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓				✓	and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS
CULTIVATION OF LIVING RESOURCES																						
Aquaculture: wild stock enhancement / 'ranching' * (i.e. deposition of juveniles on seabed, semi-managed ongrowing and later collection of commercially sized individuals; see also mussel dredging) None at present alth*ough interest has been expressed*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓						Treat new proposed developments as plan or project as appropriate. Review consenting procedures.
Aquaculture: finfish, crustaceans; sea or waterway based cages or impoundments *# *Currently one salmonid farm on the Daugleddau, currently non-operational*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	Treat new proposed developments as plan or project as appropriate. Review consenting procedures Review existing operations and consents.
Aquaculture: molluscan 'farming' *# (molluscan culture using trestles, ropes, cages or other structures) *None at present although interest has been expressed and consents sought.*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	Treat new proposed developments as plan or project as appropriate. Review consenting procedures
Aquaculture: land based semi-enclosed / recirculation *# *None at present although interest has been expressed*		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	Consider as industrial effluent Treat new proposed developments as plan or project as appropriate.

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
EXPLOITATION OF NON-LIVING RESOURCES																						
Water abstraction *# *Regular in upper reaches of tributaries to the Milford Haven waterway*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	Treat new proposed developments as plan or project as appropriate. Review existing consents
Oil & gas exploration: seismic survey * *Gas exploration likely in near future west of site.*	✓				✓	✓	✓	✓	✓	✓	✓				✓	✓	✓		✓		✓	Treat new proposed developments as plan or project as appropriate.
Oil & gas exploration & production: drilling operations * *Gas exploration likely in near future west of site.*	✓	✓		✓		✓	✓	✓	✓	✓	✓				✓	✓	✓		✓		✓	Treat new proposed developments as plan or project as appropriate.
Oil & gas exploration & production: operational * & accidental discharges *Gas exploration likely in near future west of site*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓		✓		✓	As above
Aggregate extraction * (mineral & biogenic sands & gravels) *None within site at present*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓		✓	Treat as plan or project as appropriate.
Alternative energy production: tidal barrage *# *None at present*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	As above
Alternative energy production: coastal wave & tidal current *# *Tidal current turbine trials underway; applications and/or expressions of interest in wave energy and tidal stream developments.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓	As above
Alternative energy production: wind *# *None at present*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓				✓	As above
POLLUTION RESPONSE																						
Oil spill response; at sea *Rare*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Develop and maintain appropriate pollution response contingency plans Inclusion and maintenance of information on site features and sensitivity to at-sea response activities in West Wales standing Environment Group pollution response advice contingency plan

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Oil spill response: shore cleaning – washing *Rare*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	As above
Oil spill response: shore cleaning - chemical Rare	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	As above
Oil spill response: shore cleaning - physical *Rare*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	As above
Oil spill response: shore cleaning - ancillary activities (access creation, vehicular impacts, wildlife rescue) *Rare*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	Develop and maintain appropriate pollution response contingency plans Inclusion and maintenance of information on site features and sensitivity to on-shore cleaning activities in West Wales standing Environment Group pollution response advice contingency plan Treat as plan or project as appropriate.
RECREATION																						
Angling *Widespread & common*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	Education & awareness raising Effort surveillance Establish, monitor and enforce spatial, temporal, technical and effort operational limits suitable to secure features at FCS.
Bait collection: boulder turning * *Widespread & common*	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓		✓					✓		Education & awareness raising Effort surveillance
Bait collection: digging & other sediment shore collection techniques * *Common, widespread with 'hot posts' of activity*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓							✓	✓	Education & awareness raising Effort surveillance Establish, monitor and enforce spatial, temporal, technical and effort operational limits suitable to secure features at FCS.
Recreational boating: high and low speed power craft (see also mooring and anchoring) *Widespread & common (seasonally skewed to Apr-Oct)*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	Education & awareness raising Activity surveillance.
Recreational boating: non-mechanically powered craft (see also mooring and anchoring) *Widespread & common (seasonally skewed to Apr-Oct)*	✓	✓				✓	✓	✓	✓	✓	✓				✓		✓			✓	✓	As above
Recreational boating: moorings * *Common and widespread in Milford Haven and other sheltered locations.*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Installation – treat as plan or project.

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features												Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Recreational boating: anchoring *Present, in both sensitive and non-sensitive locations*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓							Education & awareness raising. Review, monitor and enforce spatial, temporal and effort operational limits suitable to secure features at FCS
Casual shore recreation (bathing, dog walking, coasteering etc) *Widespread, common*	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	Education & awareness raising Review, monitor and enforce spatial, temporal and effort operational limits suitable to secure features at FCS
Vehicles on foreshore * *Widespread, occasional*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	Activity surveillance Education & awareness raising Appropriate implementation of SSSI procedures & access byelaws
Light aircraft *Occasional*	✓					✓	✓	✓	✓											✓	✓	Activity surveillance
Wildfowling *Common on upper reaches of Milford Haven waterway*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						✓		Activity surveillance Education & awareness raising Review, monitor and enforce spatial, temporal and effort operational limits suitable to secure features at FCS Appropriate implementation of SSSI procedures & access byelaws
Marine wildlife watching / eco-tourism ***No data available.***	✓				✓	✓	✓	✓	✓	✓	✓		✓		✓		✓			✓	✓	
MILITARY ACTIVITIES																						
Military activity: ordnance ranges * *Regular (South Pembrokeshire)*	✓	✓			✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓	✓	✓	Research potential effects on features
Military activity: marine exercises *Regular (South Pembrokeshire)*	✓	✓			✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓	✓	✓	As above
Military activity: aircraft *Occasional*	✓					✓	✓	✓	✓					✓						✓	✓	Activity surveillance
MISCELLANEOUS OPERATIONS AND USES																						

Activity	Key Relevant factors			Most likely effects on FCS elements *Habitats*			Most likely effects on FCS elements *Species*			Features													Advice/Action/Notes
	physical	chemical	biological	range	Structure & function	Typical species	population	range	Habitats & species	Inlets and bays	Estuaries	Saltmeadow	Mud & sandflats	Coastal lagppms	reefs	Sea caves	Subtidal sandbanks	Shore dock	Shad & lamprey	Otters	Seals	
Marine archaeology & salvage *Regular visits to wrecks by recreational divers*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	Education & awareness raising
Education & science * *Regular use of favoured sites*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	Review, develop and/or implement and monitor best practice suitable to secure features at FCS Appropriate implementation of SSSI procedures & access byelaws Development and encouragement of information exchange
Animal welfare operations & sanctuaries *Regularly operating in Pembrokeshire*	✓	✓	✓			✓	✓	✓	✓											✓	✓	Activity surveillance Education & awareness raising Review, develop and/or implement and monitor best practice suitable to secure features at FCS

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APPENDIX 1 Glossary of Terms

Common appreciation of the meaning of the terms employed in these conservation objectives is critical to their understanding. Many terms may be understood differently and are therefore potentially ambiguous. To overcome any preconceptions and to ensure the greatest clarity, the meanings of certain terms for the purpose of this document, are defined below.

baroclinic	Seawater circulation pattern arising when density and pressure gradients are perpendicular to each other
benthos; benthic	The forms of marine life that live on, or in, the sea or ocean bottom. Pertaining to the sea or ocean bottom.
bioaccumulation	The uptake and retention of a 'bioavailable' chemical form from any one of, or all possible external sources (*cf* biomagnification *qv*).
biodiversity	Biodiversity has been widely defined and is understood in various ways. It is widely used to capture the concept of the 'variety of life' and includes genetic, species and community diversity.
biogenic	Produced directly by the physiological activities of organisms, either plant or animal (Baretta-Bekker *et al* 1998 [27]). Biogenic reefs – long-lived, hard, biological structures comprised of large numbers individual organisms such as mussel or sand-tube building worms *Sabellaria*.
biomagnification	The process whereby a chemical, as it is passed through a food chain or food web, builds to increasingly higher concentrations in the tissues of animals at each higher trophic level (*cf* bioaccumulation *qv*).
biotic and abiotic *factors* (*qv*)	Biotic: "Pertaining to life … influences caused by living organisms", *cf* abiotic: "characteristics and elements of the environment (which) influence survival or reproduction of organisms, that are not alive themselves" (Baretta-Bekker *et al ibid*) Influences and elements of both a biological and non-biological nature that: contribute to the composition of a habitat, its structure, function or biology (*i.e.* the factors that the comprise habitat, as defined in Habitats Directive, Article 1f: "*habitat of a species* means an environment defined by specific abiotic and biotic factors, in which the species lives at any stage of its biological cycle"); contribute to a result or to bringing about a result; affect the course of events. Many factors are *processes* (*qv*) Biotic factors include competitive interaction (e.g. for space and food, predation, scavenging and grazing).
bioturbation	Biological perturbation, or reworking, of sediment by organisms, affecting the exchange of organic matter, oxygen, nutrients etc between buried sediment and the sediment surface and overlying waters.
by-catch	"The catch of non-target species and undersized fish of target species." (CCW 2001[28]). "The part of the catch that does not belong to the retained part of the target species of a fishery. … unmarketable component of target species, marketable species which were not aimed for, … accidental catches. The term is often used rather loosely" (Baretta-Bekker *et al ibid*)
contaminant	Anthropogenically synthesised chemicals (e.g. PCBs, biocides etc) and anthropogenically elevated naturally occurring chemical components (e.g. heavy metals) that are toxic or otherwise detrimental to the physiological health or well-being of typical species.
degrade	(*degrade*: to lower in rank or grade, to lower in character, value or position or in complexity; *degraded*: declined in quality or standard. *Chambers Dictionary 1998*). In this document, the meaning of degrade is applied to damage or impairment resulting from such human action as has a detrimental outcome for features. See also section 5.1
demersal	Living on or near the seabed.
detrimental	Causing damage or harm; damaging, disadvantageous
dioecious	Sexes separate, *i.e.* not hermaphrodite
epifauna (-flora, -biota)	Animals (fauna), plants (flora), organisms (biota) that live on top of seabed or other organisms, either attached to them or freely moving over then; *cf* infauna (*qv*)

[27] Baretta-Bekker, Duursma & Kuipers (eds) 1998. Encylopedia of marine sciences. Second edition. Springer
[28] CCW 2001. Glossary of marine nature conservation and fisheries. CCW Bangor

eutrophic	Waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the reduction or extinction of other organisms.
evolve	To alter with time, either remaining *stable* (*qv*) or changing
extent	The area a feature, or one of its components, covers within its natural *range* (*qv*) within the site.
factor	A circumstance, fact, influence or element that: • contributes to composition of a habitat, its structure, function or biology; • contributes to a result or to bringing about a result; • affects the course of events. Many factors are *processes* (*qv*)
functions	Functions are processes that may, directly or indirectly, influence: • the state of a physical habitat; • the marine life associated with that habitat.
habitat components	Contributing to the composition of a habitat. This includes physical and biological sub-habitats e.g. different types of reef, as well as different elements such as particular communities that make up reef habitats
halocline	The boundary zones between layers of seawater at different salinities (see also thermocline and oxyclines). Together with thermoclines, halocline have a strong influence on seawater density, circulation and species distribution
hydrodynamics	The mechanical effects of moving fluids; *i.e.* the motions of the sea. (Baretta-Bekker *et al ibid*)
hydrography	The description of the seas: 1) "marine cartography" (coastlines, bathymetry); 2) "descriptive oceanography" (the "description of water properties, their distribution and variation"; encompasses hydrodynamics *qv*) (Baretta-Bekker *et al ibid*)
hypertrophic	Waters in which mineral and organic nutrients are elevated above natural levels (*cf* eutrophic *qv*).
infauna	Animals that live within sediment
inherent	Existing in and inseparable from something else; innate; **natural;** the relation between a quality or attribute and its subject (Oxford English and Chambers Dictionaries)
inhibit	To hold in or back; to keep back; to restrain or check; to restrict or prevent
maerl	A calcareous red alga (seaweed) that is an important habitat-structuring component. Maerl is very slow growing and maerl beds tend to support particularly rich and biodiverse marine communities.
maximum sustainable yield (MSY)	Maximum use that a renewable resource can sustain without impairing its renewability through natural growth or replenishment. Fishing at MSY levels means catching the maximum proportion of a fish stock that can safely be removed from the stock while, at the same time, maintaining its capacity to produce maximum sustainable returns, in the long term. Considered as an international minimum standard for stock rebuilding strategies (i.e. stocks should be rebuilt to a level of biomass which could produce at least MSY). See EU press release
mega, macro, and meio- (biota / flora / fauna)	The sizes of plants and animals. *Mega*-: no internationally agreed definition, but commonly defined as large enough to be seen discriminated in photographs, 2 cm or larger. *Macro* - large enough to be seen by the naked eye, greater than 0.5 mm, to up to 2cm. *Meio*-: organisms that cannot be observed without a microscope; organisms between 0.03 or 0.06 mm and 0.5 mm (*cf* micro-: organisms invisible to the naked eye, smaller than meiofauna; defined as <32µm) (*Multiple references*)
natural	In this document, the meaning of natural is taken to be as defined in standard English dictionaries: **inherent**, innate, self-sown and uncultivated, not the work of or the direct product of interference by human action; in accordance with nature; relating to or concerning nature; existing in or produced by nature; in conformity with nature; not artificial. ***It does not mean or imply pristine*** (*i.e.* an original, unmodified, state).
oxycline	The boundary zones between layers of seawater with different dissolved oxygen concentrations (see also halocline and thermocline). Strong influence on species distribution.
process	A series of actions, events or changes that vary in space and over time. In this context processes include physical, chemical and biological environmental changes which are inherently natural but which may be modified by human activity (*e.g.* wave action, nutrient fluxes).

	All processes are factors.
quality (of habitat)	The relative absence of anthropogenic modification of naturalness of habitat extent, structure, function and typical species as a result of, *inter alia*: • change in distribution, extent, geology, sedimentology, geomorphology, hydrography, meteorology, water and sediment chemistry and biological interactions; • change in species richness, population structure and dynamics, physiological health, reproductive capacity, recruitment, mobility and range or of anthropogenic modification of suitability of habitat as a result of, inter alia; • level of disturbance • alternation of prey/food supply • contamination of food supply
range	The natural spatial distribution of a feature, habitat, habitat componentor species. Depending on the context, this term either describes the global distribution of the feature or, in the context of the site, the distribution of the feature within the site
safe biological limits	ICES definition of fisheries sustainability. "Within SBL" defined as stock at full reproductive capacity and harvested sustainably. ICES Advice Autumn 2004 & summarised at www.defra.gov.uk/environment/statistics/coastwaters/cwfishstock.htm
salinity	Seawater salinity is measured in parts of salt in one thousand parts water (‰).
salt wedge	When freshwater and seawater meet in an estuary or sheltered marine inlet, the two water masses or different density often do not mix completely. A distinguishable inflowing tongue of dense seawater beneath a less dense layer of freshwater is referred to as a salt wedge. The shape of the salt wedge in Milford Haven is measurably deflected to the south side of the Haven by the earth's rotation.
sessile	Benthic (qv) organisms living attached to the seabed substrate.
species richness	Variety of species. The total number of species: • among a fixed number of individuals; • per unit of surface area (of habitat).
spraint	Descriptive term for otter faeces. Spraint has a distinctive smell and appearance; it contains indigestible food remains from which prey species may be identified.
stable	Tendency towards an equilibrium state in spite of varying external conditions
structure	The composition and arrangement of those: • parts of the feature, • parts of the natural environment, • circumstances, that constitute the feature or are required by the feature for its maintenance in both the long term and foreseeable future.
stochastic	Random, chaotic, possible but unpredictable.
thermocline	A boundary zone between layers of seawater at different temperatures (see also halocline and oxycline). Together with haloclines, thermoclines have strong influences on seawater density, circulation and species distribution.
supporting sediments	Sediments with strong geomorphological / sediment-transport links to the feature. Particularly relevant to areas of sediment exchange and supply.
thermohaline circulation	Seawater circulation driven by density differences caused by seawater temperature and salinity differences.
typical species	Species that are, from time to time, associated with a specified habitat within the site; *i.e.* all species that contribute to the biodiversity of the specified habitat within the site.

APPENDIX 2 List of SSSIs and SPAs partly or wholly within the SAC

Sites of Special Scientific Interest that are partly or wholly within the SAC

Arfordir Abereiddi
St.David's Peninsula Coast
The offshore islets of Pembrokeshire/Ynysoedd Glannau Penfro
Ramsey/Ynys Dewi
Arfordir Niwgwl – Aber Bach/Newgale to Little Haven Coast
De Porth Sain Ffraid/St Bride's Bay South
Skomer Island and Middleholm
Grassholm/Ynys Gwales
Skokholm
Dale and south Marloes coast
Milford Haven Waterway
Hook Wood
Afon Cleddau Gorllewinol/Western Cleddau River
Slebech Stable Yard Loft, Cellars & Tunnels
Afon Cleddau Dwyreiniol/Eastern Cleaddau River
Minwear Wood
Carew Castle
Arfordir Penrhyn Angle/Angle Peninsula coast
Broomhill Burrows
Castlemartin Cliffs and Dunes
Stackpole
Stackpole Quay – Trewent Point
Freshwater East Cliffs to Skrinkle Haven

SPAs that are partly or wholly within the SAC

Ramsey and St.David's Peninsula coast
Grassholm
Skokholm and Skomer
Castlemartin Coast

Locations are shown on Map 2 ii

APPENDIX 3 Important elements of Favourable Conservation Status

HABITATS

ELEMENT	Rationale
RANGE	
Distribution	Distribution of habitat features within the site, and also within a national and European context, has a key role in determining the distribution and abundance of typical species. Also important is the distribution within a habitat feature of components of habitat structure (e.g. Sediment granulometry) and of habitat function (e.g. Wave exposure).
Extent	Overall extent, large examples or extensive areas are inherently highly rated and contribute to conservation of structure and function The extents of habitat components, both structural functional are important determining factors of habitat and species diversity.
STRUCTURE	Physical structures of habitat features and their variation are the foundation of habitat diversity and, accordingly, species diversity. Along with environmental processes (function), habitat structure strongly influences where things live.
Geology	Geology at all spatial scales underpins the structure of the habitats, from overall coastal structure, which determine exposure to major environmental processes, to local habitat structure. The range of rock types and the distribution of rock folding, faulting and fracturing determine the overall complexity of shape of the seabed and coast and the diversity of habitats.
Sedimentology	Sedimentology is the result of complex processes significantly influenced by water movement. Sediment granulometry, structure and degree of sorting (from well sorted fine – medium sands and muddy sands to poorly sorted, mixed substrata containing mud, gravel, shell and stones) creates an extremely wide range of sediment habitats.
Geomorphology	
morphology (shape)	The gross shape of features and of individual sections of features is an essential component of habitat structure and contributes to habitat diversity.
topography (surface structure)	Surface relief of all substrates is a fundamentally important component of habitat structure, underpinning biological diversity through the provision of different habitats and microhabitats and a range of depths below sea level or intertidal drying heights. Topography, together with morphology, has a critical influence on hydrodynamic processes. Rock topography is fundamentally determined by geology. The range of rock topography is a particularly important contributor to reef biodiversity. Sediment topography is important in sediment habitats. For example granulometry and slope together determine sediment flats' ability to retain water during low tide (the amount of interstitial water retained is important in determining community composition); the breadth of the shore (related to slope) in combination with shore aspect, is important in determining the degree of wave energy expended on any part of the shore, therefore influencing community composition.
microtopography	Rock microtopography is determined by geology, with surface pits, cracks, fissures, bore-holes etc providing additional niches for marine wildlife. The microtopography of sediment flats is important in determining water runoff (including the formation of rips) and retention and, in turn, influence the distribution of surface biota and granulometry.
orientation and aspect	Orientation and aspect are products of morphology and topography that, in combination with functional processes such as wave or light exposure, extend the variety of niches provided by habitat features. Range and variation in orientation and aspect enhance habitat and species diversity.
bathymetry	Bathymetry is determined by other structural components and by hydrodynamic and sediment processes. Depth of seabed is in turn a critical influence on hydrodynamic processes, such as wave exposure and tidal streams. In combination with water clarity, depth determines light attenuation through the water column thereby contributing directly to community structure. Bathymetric variation within and between individual parts of features enhances habitat and species diversity
FUNCTION	Distribution, extent, abundance and variety of species populations is shaped by spatial and temporal variation of a wide range of physico-chemical and biological processes (functions).
Hydrography & meteorology	Hydrographic & meteorological processes are fundamental to the structure and function of habitats and their species populations. The magnitude of hydrographic factors varies along gradients determined by the underlying geomorphology of the site and complex interactions with other functional processes.
hydrodynamics (water movement)	Water movement is a fundamentally important environmental process that determines the species composition present at any particular location, both directly and indirectly through its effect on other important processes such as nutrient, sediment and dissolved gas transport. The range of relative contributions of tidal streams, wave action and residual currents to water movement is particularly important in determining biological composition.
	Tidal range and rise - fall is of critical importance to structure, function and species population of habitats both directly – determining extent of intertidal areas and the emergence regime; and indirectly through the action of tidal streams.
	Tidal streams (currents): the strength, patterns, relative constancy, lack of attenuation with depth, general bidirectionality and spatial and temporal variations in tidal streams are important in structuring the distribution of species populations; food, sediment and chemical transport processes; water mixing.
	Wave exposure. Wave action is one of the most physically powerful, chaotic and relatively unpredictable processes. Exposure to wave action is determined by habitat morphology, topography, aspect, attenuation with depth and meteorological processes and has a major influence on distribution of species populations; water clarity and water mixing. The range of wave exposure within the site is extreme.
	Residual current flows modify local hydrodynamic and meteorological processes for example through inputs of water masses with elevated suspended sediment loads, temperature and / or nutrients and contaminants.
temperature (water)	Water temperature strongly influences water chemistry and biological processes, such as reproduction and metabolism. The biogeographical location of the sites and the degree of buffering of winter minima and summer coastal warming by oceanic waters (North Atlantic Drift) strongly influences and limits the sea temperature range. Temperature range is

ELEMENT	Rationale
	important in mediating reproduction and survival of species, shielding submerged species from the more extreme temperatures experienced by intertidal species and reducing the ability of some non-native species to become established. Global processes (global warming, shifts in ocean currents), influenced by climate change, also influence local seawater temperature regime temporarily, seasonally or chronically.
light intensity (ambient seabed and water column)	Seabed light intensity has an important influence on community structure, particularly through algal species distribution, mediated by bathymetry, water transparency and localised shading (*e.g.* from overhangs, caves or aspect). Spatial and temporal variation in light intensity has considerable broad and local scale impacts on species population distributions and community variation. Water column light intensity in combination with shelter from extreme water movement and elevated nutrients is important in the occurrence and distribution of seasonal plankton blooms.
Seston concentrations and water transparency (clarity/ turbidity)	Seston (suspended particulate matter) concentrations are critically importance as a food-energy resource, is a factor in sediment processes and deposition including smothering and scouring of biota, and through absorption of light modifying light availability at seabed and in water column. Seston composition and water column loads are determined by the origins of the particulate matter – biological productivity and / or riverine, coastal or oceanic water inputs.
meteorology	
temperature (air)	Air temperature is an important factor in several aspects of intertidal habitat function (heat / cold tolerance, control of reproduction, desiccation, dissolved oxygen, salinity). Although overall air temperature is climate controlled, it is subject to local modifications by habitat structure and species populations.
light (solar irradiance)	Solar irradiance is a fundamental requirement for plant primary production. It is determined by meteorological conditions, and seabed and water column irradiance is mediated as described above. It also has direct effects on temperature, desiccation, UV exposure, dissolved oxygen and salinity in intertidal habitats, where it is mediated by localised shading (*eg* from overhangs, caves or aspect).
humidity	In association with temperature and air movement, humidity is an important factor controlling evaporation, and consequently salinity and the desiccation of intertidal species. Although overall humidity is climate controlled, it is subject to local modifications by habitat structure and species populations.
air movement (wind)	Wind strength, direction and fetch are the fundamental influences on wave action. The effect of air temperature and humidity on intertidal species and communities is strongly influenced by air movement. Although overall air movement is climate controlled, it is subject to local modification by habitat structure and local topography.
precipitation	Rainfall locally modifies salinity in intertidal areas, modifies temperature and humidity and increases transport of terrestrial sediments and other materials (*e.g.* nutrients, contaminants) into the marine environment. Land use and surface water management influences the effect of heavy rainfall in creating spate events that increase short term flow rates, soil erosion and particulate suspension.
Water & sediment chemistry	
salinity	Salinity is of fundamental physiological and ecological significance. Horizontal and vertical salinity gradients from average fully saline open coast seawater through brackish to freshwater and temporal variation in the gradients are of primary importance in species distribution.
nutrients	Dissolved organic nutrients and trace elements are essential to biochemical processes. Major nutrients in unmodified conditions vary seasonally within ranges characteristic of individual water bodies with the uptake by and decomposition of biota. Acute or chronic anthropogenic elevation causes ecologically important eutrophication or toxic effects.
contaminants	Levels of acutely or chronically toxic anthropogenically synthesised chemicals (*e.g.* PCBs, biocides etc) and anthropogenic elevation of naturally occurring chemical components (*e.g.* some hydrocarbons, heavy metals) are critical influences for example on species survival, physiological health, and reproductive capacity
dissolved oxygen	Oxygen availability is of fundamental physiological and ecological significance. Availability is influenced by water movement and surface disturbance, water temperature, sediment granulometry and disturbance, organic content and biological oxygen demand. Reduced oxygen flow and / or increased oxygen demand (through decomposition of trapped organic matter) within sediments tends to result in significantly reduced levels; anaerobic conditions in sediments may result in the formation of toxic substances (*e.g.* hydrogen sulphide).
Sediment processes	
	Sediment erosion, transport and deposition are critical in determining extent, morphology and functional processes of sediment based habitats and have important functional influences on rock-based habitats. Sediment processes in the site are a reflection of many complex causal processes and are themselves complex, contributing to high habitat and community diversity.
TYPICAL SPECIES	As the rationale for selection of components of species conservation status is similar for both species features and typical species of habitat features the rationale for both has been combined and is given the species table below

SPECIES

ELEMENT	Rationale
SPECIES RICHNESS (Variety of species)	Species richness is most likely to be applicable as a component of FCS for typical species of Habitat features. However, the variety of available prey is likely to be important to predatory species features such as dolphins, seals, otter, lamprey and shad, and, as such, it forms an important measure of a species features habitat quality. Biological variety is a key contributor to biodiversity and applies at both taxonomic and genetic levels. Species variety "typical" of different habitats is dependent on the ecological opportunities available (niche diversity), particularly the degree of stress from natural processes.

ELEMENT	Rationale
	Habitats and communities subject to moderate levels of disturbance tend toward high species diversity. A high proportion of the species in such highly diverse communities are usually present at low frequencies and, individually, may make a small contribution to the overall functioning of the community. Nevertheless, such "species redundancy" is a vital contribution to biodiversity in many marine habitats and communities, and is consequently extremely important in terms of the conservation of the habitat features.
POPULATION DYNAMICS	Species population dynamics are inherently important in maintaining viability of species populations and species variety.
Population size	
Population size (species abundance)	Sizes of species populations vary widely depending on their biology and ecology (e.g. Reproductive, competitive, survival and life history strategies; recruitment, habitat requirements; adaptation to natural processes and factors) and stochastic events. For a species feature, population size is a key measure of the species ecological success or failure. Along with a typical species' distribution, its population size determines its contribution to biodiversity and to habitat structure and function. Populations sizes of small, short-lived, rapidly reproducing species are orders of magnitude greater than large, long-lived, slowly reproducing and infrequently recruiting species. Populations of many species fluctuate widely in response to natural and artificial perturbations and opportunities; many others remain stable for long periods and many of these are particular sensitive to anthropogenic disturbance or habitat degradation.
Contribution to the integrity of wider population	The full range of some species features are only partly encompassed by the site. The long-term viability of the species population may therefore be in part or mainly determined by stock outside the site, and vice versa (e.g. through immigration and emigration, genetic variation etc). The contribution a species population occurring within a site makes to the wider population status is important to the long-term viability of the species as a whole, including that occurring within the site.
Biomass	Biomass is the potential energy of species populations, and thus fundamental to species physiological health, reproductive capacity and energy reserves, and is an energy resource for other species. Sediments with high organic input typically support a species biomass and rate of turnover (productivity) sufficiently high to contribute significantly to the maintenance of predatory typical species such as fish and waders and wildfowl. However, high biomass and low species variety may also be indicative of environmental stress or perturbation. Biomass of different reef habitats is extremely variable, varying with species composition and recruitment, age structure, health and environmental stress and consequently frequently varies widely within a small area of apparently similar habitat for a variety of reasons.
Reproductive success	The ability to successfully reproduce is critical to a species population's long-term viability. Reproductive success is a function of reproductive capability and the survival of young. Reproductive capability is a function of many factors including physiological health, temperature regime and population density. Reduced physiological health and other stressors can reduce reproductive capability as, under these circumstances, most species concentrate internal resources on survival instead of reproduction. For many species (not mammals and birds) gonadal somatic index (ratio between body mass and gonad mass) is a good measure of reproductive capability. High reproductive capability does not necessarily translate to high reproductive success. Survival of young to age of recruitment to the population is a function of reproductive strategy and varies by orders of magnitude depending on the strategy, ecological hazards and stochastic events. Dispersive invertebrate larval stages vary extremely in the numbers surviving from place to place and time to time with weather, currents, availability of food, period spent in the plankton, predation and intrinsic variability in processes killing and removing species e.g. competition for food and space, predation. At the other extreme, survival of young marine mammals is very high because of the heavy parental investment in low numbers of offspring. However, the relative survival rates of all strategies are vulnerable to modification by stochastic events.
recruitment	Recruitment of young is critical to the maintenance of species population's long-term viability. Natural variation in successful recruitment is a critical factor contributing to species variety. Many invertebrate and algal species are at least partly dependant on recruitment from outside the feature.
Population structure	
Age frequency	Age frequency is important in determining the degree of success of population reproduction and resilience to perturbation for many species. Variation in population structure contributes to the complexity of community mosaics and to biodiversity. Age or size frequency is an important indicator of a species population's long-term viability.
Sex ratio	Sex ratio is important in determining the degree of reproductive success and therefore the long-term viability of dioecious species populations.
Physiological health	Physiological health is a critical component of a species population's long-term viability. It encompasses both genetic and physiological fitness. Knowledge of the physiology of most marine species is inadequate to directly express health in positive terms. Indicators of healthiness include reproductive capacity (e.g gonadal somatic index) and immunity to disease; and of potential poor health: contaminant burden, immunosuppression, epibiota burden, nutritional state and physical damage.
Immunity to endemic disease	Reduced physiological health, e.g. through raised stress or chemical contamination, typically increases susceptibility to endemic diseases.
Exposure to anthropogenic disease	Certain species may contract diseases of humans and domesticated animals. Certain anthropogenic activity can increase the risk of this. Whilst diseases that can cross such species barriers are few, if it were to occur there is the potential for very significant impact on the wild species population.
RANGE	
Distribution throughout site	Species populations are distributed within their habitats according to their ecological requirements (particularly sessile species). The distribution of most species across and along environmental gradients results in extremely complex mosaic of communities (aggregations of species) that vary over time. The distribution and extent of species are, within constraints of species' adaptation to physical factors and biological interaction, variable in time and space. Modification of structural and functional factors by human action will likely result in alterations to species distribution, extent and abundance.

ELEMENT	Rationale
Distribution of specific behaviours throughout the site	Some mobile species (e.g. dolphins, seals, spider crabs & bass) use different parts of their habitat for different behavioural purposes (e.g. feeding, moulting, breeding). The locations used are usually important for the particular behaviour displayed. Displacement of this behaviour to other less favourable locations can be detrimental to the species.
Mobility (ability to move about the site, within and between features, unimpeded)	For most non-sessile species the ability to move around unimpeded is a prerequisite to maintenance of viable populations through, inter alia, successful feeding, predation-avoidance and reproduction. This includes both territorial species with localised mobility requirement and highly mobile and / or migratory species which are dependent on features for a part of their ecological requirements (inter alia otter, seals, sea and river lamprey, shad, herring) Unimpeded mobility of reproductive products, larvae and juveniles of species is critical to the maintenance of viable species populations.
SUPPORTING HABITAT & SPECIES	Any components of habitat conservation status (Table 2.1 above) will apply to typical species of habitat features, and may apply to a species feature where the component is relevant to the conservation of that species feature. The most likely components of habitat conservation status that are relevant to the conservation of species features are given below.
Distribution and extent	
Preferred habitat	The habitat used by the species within the site. For wide ranging species this will likely be the whole area of the site.
Habitats utilised for specific behaviours	The distribution and extent of habitat necessary for specific behaviours, such as feeding, breeding, resting and social behaviour.
Structure & function	
Structural and functional integrity of preferred and specific habitats	The structure and functions that maintain the habitat in a form suitable for the long-term maintenance of the species population. This is linked to habitat quality.
Quality of habitat	The natural quality of habitat features may be reduced by modification of structural components identified above and, including by: the presence and persistence of artificial inert or toxic materials (e.g. synthetic plastics and fibres, hydrocarbons) causing entanglement, smothering or ill-health; decrease in seclusion because of noise and visual disturbance. Human activity with the potential to cause disturbance, affecting behaviour or survival potential includes waterborne leisure and commercial activities, wildlife watching; competition for space, causing displacement, collision, noise and visual disturbance, increased density dependent pressure on preferred sites, exposure to disease (see above); Contamination of prey (see below);
Prey availability	The presence and abundance of prey within the site may contribute to the species presence and its long term viability.
Prey contamination	Contamination of species feature prey can reduce the long-term viability of the species population. Contaminants that bioaccumulate and biomagnify and which affect the species physiological health would be of particular concern.