Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

Pen Llŷn a'r Sarnau /Lleyn Peninsula and the Sarnau European Marine Site

comprising:

Pen Llŷn a'r Sarnau /Lleyn Peninsula and the Sarnau Special Area of Conservation

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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A Welsh version of all or part of this document can be made available on request.

PEN LLŶN A'R SARNAU SPECIAL AREA OF CONSERVATION

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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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 *Pen Llŷn a'r Sarnau 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 *Pen Llŷn a'r Sarnau/ Lleyn Peninsula and the Sarnau SAC, Glannau Aberdaron ac Ynys Enlli /Aberdaron Coast & Bardsey Island SPA, Mynydd Cilan, Trwyn y Wylfa ac Ynysoedd/Saint Tudwal SPA and Aber Dyfi / Dyfi Estuary SPA*, 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 *Pen Llŷn a'r Sarnau 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 an 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 to 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 *Pen Llŷn a'r Sarnau* SAC.

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 Pen Llŷn a'r Sarnau SAC 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 5 (conservation objectives) and 6 (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:

- gain a greater understanding of feature and factor variability,

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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

- 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 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;
- 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.

[13] www.jncc.gov.uk/page-

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 feature 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.

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

[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.

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 Pen Llŷn a'r Sarnau SAC encompasses areas of sea, coast and estuary that support a wide range of different marine habitats and wildlife. The nature of the seabed and coast and the range of environmental conditions present vary throughout the SAC. Differences in rock and sediment type, aspect, sediment movement, exposure to tidal currents and wave action, water clarity and salinity together with biological and food chain interactions have created a wide range of habitats and associated communities of marine plant and animal species, some of which are unique in Wales.

Pen Llŷn a'r Sarnau SAC is a multiple interest site that has been selected for the presence of 9 marine habitat types and associated wildlife (Habitats Directive Annex I habitat types) and 3 mammal species (Habitats Directive Annex II species). For the qualifying habitats and species, the Pen Llŷn a'r Sarnau SAC is considered to be one of the best areas in the UK for:

- Reefs
- Large shallow inlets and bays
- Sandbanks which are slightly covered by seawater all the time
- Estuaries
- Coastal lagoons

and to support a significant presence of:

- Mudflats and sandflats not covered by seawater at low tide
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- *Salicornia* and other annuals colonising mud and sand
- Submerged or partially submerged sea caves
- *Halichoerus grypus* – grey seal
- *Tursiops truncatus* – bottlenose dolphin
- *Lutra lutra* – otter

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 of the Pen Llŷn a'r Sarnau SAC Bay SAC are shown in Maps 1 & 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 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

A considerable body of information is available on the marine environment and associated wildlife of the area within the Pen Llŷn a'r Sarnau SAC. Studies relevant to the area go back as far as the mid 1800's, but the majority of information has been collected since the early 1980's when there was a significant increase in studies and research, especially on subtidal areas. Some locations have been subject to a considerable amount of ongoing scientific research such as the Dyfi estuary while for other parts of the SAC there is a much less extensive history of study. The majority of the data for the area of the SAC is point source, although since the mid 1990's seashore and subtidal mapping work has provided both a broader contextual background as well as baseline information that can be used for future monitoring. Most of the Pen Llŷn a'r Sarnau SAC is subtidal which makes it difficult to map accurately. Habitats that are part of the SAC features may also occur in parts of the SAC that have yet to be surveyed.

Despite the quantity of information available about the SAC, it is not complete given the many difficulties associated with collecting and understanding marine data. Information on the distribution of the habitats is indicative only and all the information within this document is provided on the basis of current knowledge and may be subject to change as knowledge improves.

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 Pen Llŷn a'r Sarnau 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 Pen Llŷn a'r Sarnau SAC also overlaps wholly or in part with a number of Special Protection Areas (SPA) classified under the Birds Directive: Glannau Aberdaron ac Ynys Enlli SPA, Mynydd Cilan, Trwyn yr Wylfa ac Ynysoedd Sant Tudwal SPA and Dyfi SPA. The conservation objectives and core management plans for these locations can be found on the CCW website. The location of these protected areas is shown in Maps 2i and ii

a) Range

The Pen Llŷn a'r Sarnau SAC is situated in northwest Wales. The SAC boundary extends from Nefyn on the north coast of Llŷn and includes parts of the seashore and the waters and seabed around the Llŷn Peninsula, in north Cardigan Bay and along the Meirionnydd coast to Clarach in Ceredigion south of the Dyfi estuary, including the Glaslyn/Dwyryd, Atro, Mawddach and Dyfi estuaries (Map 1)[19]. Much of the area of the SAC is subtidal, but there are also extensive intertidal areas. The site covers an area of about 146,023 ha.

The boundary of the SAC encompasses the 9 marine habitat features and areas important for the 3 mammal species for which it was selected as an SAC. The features are distributed throughout the SAC with no single feature occupying the entire SAC and with features overlapping in some locations. The general location of the Annex I habitat features of the Pen Llŷn a'r Sarnau SAC is shown on Map 3.

b) Structure

i. Geology

The bedrock geology of Pen Llŷn a'r Sarnau SAC is rich and diverse. From Nefyn around the coast to Aberdaron there are ancient Precambrian igneous rocks and early Cambrian sedimentary and volcanic rocks. The majority of the rocks on the southern coast of Llŷn are Ordovician in age including sedimentary rocks and igneous intrusions. The bedrock geology from Criccieth to near Tywyn on the Meirionnydd coast is dominated by the Cambrian rocks of the Harlech Dome, but there is also an area of onshore Tertiary rock which is obscured by the sand dunes at Morfa Harlech and Morfa Dyffryn. From around Tywyn southwards the bedrock geology is Silurian in age and comprises turbidites (repetitive sequences of sandstones, siltstones and mudstones in varying proportions).

[19] The seaward boundaries of marine SACs are drawn as close as possible to include the qualifying interests, but in straight lines between landmarks or buoys or in open sea areas to ensure ease of marking on navigational charts. Where intertidal areas are included the landward boundary of the SAC has been drawn to encompass the wildlife habitats / species of the site and where intertidal areas are not included, the landward boundary generally follows mean low water.

Surrounding Llŷn, the offshore bedrock largely reflects the coastal geology apart from just offshore between Harlech and Tywyn where Tertiary rocks are found, and older Permian and Jurassic rocks further out into the fault-bounded Cardigan Bay Basin.

ii. Sedimentology
There is a very wide range of sediments within the site from fine, soft mud in parts of Tremadog Bay, through sands, gravels, including mixed sandy and muddy gravels, consolidated and unconsolidated pebbles and cobble, and cobble and boulder reefs. There are large areas of boulder and cobble, both in the intertidal and subtidal parts of the SAC, the most extensive being the sarnau reefs. Sediment structures vary from uniform to very mixed.

iii. Geomorphology
The underlying geology has created a complex coastal morphology. The south-western tip of Llŷn is dominated by rocky cliffs with narrow sandy beaches at points of erosion. On the southern coast of Llŷn the headlands are more prominent with wider beaches backed by Quaternary deposits, for example Aberdaron, Porth Neigwl and Porth Ceiriad. These contribute large boulders and cobbles to the beaches and subtidal areas. Larger expanses of sands are often confined to lower shores. Eastwards from St. Tudwal's there are spectacular fish-hook beaches and small spits while the Meirionnydd coast north of Barmouth is characterised by large areas of dunes with long, swash-aligned, sandy beaches at Morfa Harlech and Morfa Dyffryn. Morfa Harlech includes a well-developed spit across the Glaslyn/Dwyryd estuaries and Morfa Dyffryn includes a fine example of a tombolo linking the dunes with Mochras.

The Mawddach Estuary at Barmouth is similar to the other estuaries on the Meirionnydd coast and is characterised by a prominent spit which has developed in a northward direction due to longshore drift. The Glaslyn/Dwyryd and Mawddach estuaries resulted from glaciation when the Welsh icecap gouged two main valleys into the Cambrian rock. The first valley now terminates in Tremadog Bay as the estuary of the rivers Glaslyn and Dwyryd, and the second in Barmouth as the Mawddach estuary. The Dyfi lies in the slates, grits and sandstones of the upper Ordovician and lower Silurian rocks and was probably formed as a result of glaciation and subsequent river erosion.

South of the Dyfi estuary in Ceredigion, a shingle-gravel ridge has developed which becomes increasingly sandy northwards forming a prominent beach at Borth. Dunes have developed behind the northern part of the spit which juts out into the Dyfi estuary.

The topography of the seabed within the SAC is varied, with areas of rugged, mainly igneous rocks off north and southwest Llŷn, some of which rise to considerable heights above the surrounding seabed and even extend about the water surface as small islets and islands. Along much of the south Llŷn coast from Porth Neigwl to the Meirionnydd coast, the seabed topography is generally less rugged although the overall geomorphology is still varied. Extensive areas of various types of sediment are present through much of the site, often interspersed with reefs formed of bedrock, boulders and cobbles. Offshore the bed of Cardigan Bay is marked by three major SW-trending low, smooth-topped ridges composed of cobbles and boulders (the sarnau) which are believed to be the remains of glacial moraines. From the north, they are Sarn Badrig, Sarn y Bwch and Sarn Cynfelin. Further exploration offshore has revealed the presence of deep channels in Cardigan Bay such as Muddy Hollow in the northern part of Tremadog Bay.

The bathymetry of the SAC varies with deeper water (over 40m) off the north and southwest Llŷn coasts. In this part of the SAC the 30m isobath comes close inshore (particularly around the southwest tip of the Llŷn and Bardsey Island). Eastwards from southwest Llŷn to Tremadog Bay, there are extensive areas of seabed between 20-30m, whilst the majority of Tremadog Bay is relatively shallow at less than 20m. The Sarnau are shallow reefs structures occurring for the most part in less than 10m surrounded by shallow, smooth-floored sediments at depths of less than 20m.

c) Function

i. Hydrography and meteorology.

The tidal regime within the SAC generally reflects that of Cardigan Bay, with semi-diurnal tides and a range of 2m at neap tides and 4m at spring tides. For much of the site, spring low waters occur early morning and mid-late afternoon exposing intertidal marine life to significant levels of sunlight and temperature fluctuations.

The tidal flow within the SAC is considered to follow the generalised pattern of tidal flow for the Irish Sea which is northward on the flood tide and to the south on the ebb tide. Tidal streams tend to run parallel to the coastline but are complicated by islands, headlands and seabed topography. Tidal streams are generally relatively weak within Tremadog Bay and the rest of north Cardigan Bay (between 0.1 – 1 knot on spring tides) compared to areas off the southwest Llŷn, such as Bardsey Sound where, at between 5-6 knots, they rank amongst the fastest tidal flows in the Irish Sea. Interaction with seabed and coastal topography creates considerable local variation in tidal stream strength, direction and phenomena, including turbulence and tidally induced overfalls and standing waves, particularly around southwest Llŷn.

Much of the SAC is moderately exposed to wave action, but there are localised areas of shelter in the lee of headlands and islands. Islands, headlands and large blocks of reef refract wave action, increasing the exposure of some shores and shallow areas and reducting it in others. Information on non-tidal circulation is sparse but it has been suggested that the distribution of residual surface currents in the SAC flows west along the southwest part of the Llŷn, clockwise in north Cardigan Bay and northerly in south Cardigan Bay, and that the distribution of residual bottom currents within the SAC is northerly in Cardigan Bay and westerly along the south Llŷn.

Sea surface temperature averages around 7ºC in February/March and around 14.5-15ºC in August/September. In summer, surface temperatures in the shallower water of Cardigan Bay and Tremadog Bay can be much higher than the average e.g. 20ºC recorded in Tremadog Bay. Tremadog Bay also has greater overall variation between the minimum winter and maximum summer temperatures than further west in the SAC at Bardsey Island.

Water clarity in the SAC can be high, but periods of strong wave action, heavy rainfall and greater volume of water movement during spring tides can increase the level of suspended particles in the water and the turbidity. Clarity is highest around Llŷn and Bardsey Island although temporarily decreased by seasonal phytoplankton blooms. Within Tremadog Bay and around the sarnau, the shallower conditions and greater proportion of sediments close to the reefs and the shore means that sediment in this part of the SAC are re-suspended more easily in rough weather.

During the summer the water in Cardigan Bay stratifies with warm, relatively fresh water overlying cooler, more saline water. This stratification breaks down along a line running south of Trwyn Cilan on the south Llŷn coast, known as the Cardigan Bay front, where there are strong horizontal surface gradients of temperature, salinity, density and water clarity.

ii. Water and sediment chemistry

The western part of the SAC around the Llŷn is open coastal waters that are fully saline whereas in Tremadog Bay and around the sarnau the sea water is freshened by the river flow from the estuaries. Observed surface salinities within Cardigan Bay in summer are less than 34‰, decreasing towards the shore and observed to drop by 0.5‰ crossing the Cardigan Bay front from west to east.
There is very little data on water column and sediment dissolved oxygen levels in the SAC but no reason to believe that the water column dissolved oxygen is generally less than 100% saturation. Interstitial sediment dissolved oxygen will vary with sedimentology and infaunal biological activity.

iii Sediment processes

The distribution of seabed sediments within the SAC is a result of processes that have been occurring over several thousand years with the re-working of glacial moronic and till material that was

transported by the ice age glaciers. There is a general direction of fine material drift in a northerly direction through Cardigan Bay and westerly along the south coast of the Llŷn. The northward elongated spits on the southern shores of the Dyfi, Mawddach and Glaslyn/Dwyryd estuaries, as well as at Morfa Dyffryn, were produced by this longshore movement of sediment while Tremadog Bay acts as a sink for offshore fine sand and mud. Between Bardsey Island and the Glaslyn/Dwyryd estuary, littoral bed load drift is to the east and increases closer to the mouth of the Glaslyn/Dwyryd. The north coast of the Llŷn has low, north eastward littoral bed load drift towards the Menai Strait.

v. Biological interactions
The variety and magnitude of biological interactions have a major influence on species variety and conservation status, however the range of interactions within and between species and between species and their habitats is immeasurable. Grazing and predation by vertebrate predators (including species features) such as seabirds, waders and wildfowl, marine mammals, fish and crustaceans both remove energy from the habitat features and contribute to nutrient enrichment which may be significant.

d) Typical Species
The variety of rock and sediment types in the SAC and their complex formations provide very varied substrata for colonisation by many different species and has a strong influence over the species that will become established in any one location.

Rocky substrates provide habitats and surfaces for attachment for example by seaweeds, anemones, sea squirts, sponges, sea firs (hydroids), sea mats (bryozoans) and soft corals. Cobbles and boulders also provide a hard surface for marine life to attach to as well as providing shelter and space in between the rocks and under boulders for more delicate species that are not able to survive on open rock surfaces. Rocks with fissures, cracks and crevices provide habitat for shade-tolerant species and those less tolerant of wave action and tidal currents. Softer rocks such as calcium carbonate and other soft substrata such as peat and clay provide a habitat for infaunal species such as piddocks and boring sponges that are able to bore into these softer substrates.

Sediment type has a similarly significant influence on the marine life that can live in and on it. The surface of the sediment is often apparently devoid of marine life, although mats and films of micro algae and evidence of burrowing creatures are common. Sediments that include a proportion of coarser material such as gravel, pebble and shell remains often support a surface assemblage of animals and plants attached to the shell and stone. This adds to the overall diversity of such mixed sediment areas which often support a diverse assemblage of burrowing animals as a result of their heterogeneous sediment composition and more complex surface microtopography.

The muddy areas of the SAC are highly productive, containing high levels of organic material. They generally have a high abundance of organisms, but with low diversity and a few rare species. Diversity of various species, including marine worms tends to increase with increasing levels of sand and gravels. However, in areas of coarse sand where the sediment is of similar grain size, the sediment is easily moved by waves and tides and so only a few specialist species survive.

The mixed sediment habitats, such as the sandy and muddy gravel and fine muddy sand support diverse and abundant assemblages of animals. They also support epifaunal communities of animals and plants attached to stones and shell fragments on the surface which increases the overall diversity of species supported by these habitats. The biogenic honeycomb worm reefs support diverse assemblages of animals that differ from those associated with other reef habitats.

Tidal streams play a key role in structuring many of the habitat features of the SAC and their associated species assemblages, particularly along the north and southwest coast of the Llŷn and around headlands and islands. Characteristic communities in these conditions are dominated by filter feeding animals fixed on or in the seabed, typically including soft corals, hydroids (sea firs), bryozoans (sea mats), sponges, sea anemones, sea squirts and mussels. The fast flowing water brings a

good supply of food and nutrients supporting the growth of these animals. In areas of extreme tidal currents, such as the central part of Bardsey Sound, species are restricted to those that grow as thin encrusting layers across the seabed, since anything larger would quickly get swept away. Where tidal currents are less, other animal and plant communities develop.

Much of the SAC is moderately exposed to wave action and in intertidal areas this results in rocky shores dominated by a mixture of seaweeds, mussels and barnacle, and sandy shores with characteristic communities of burrowing animals that are able to tolerate the movement of sediment caused by the waves. Where wave action is reduced (such as in the lee of headlands) there is an opportunity for other species to become established and, combined with varied seashore substrate this can result in the development of unusual and more diverse communities (such as in muddy and sandy gravel). Waves can also influence the size and shape of animals and plants.

Increases in water temperature due to climate change may have a greater effect on the marine plants and animals within areas like North Wales, which straddle a biogeographic boundary where many southern species reach their northern range limits and many northern species reach their southern range limit. Consequently, increases in mean annual water temperature will result in changes to the distribution of many plants and animals in this area. Changes may be more extreme in areas such as Tremadog Bay which already has elevated summer water temperatures.

The waters of the SAC are relatively clear compared to further north along the North Wales coast, although there are seasonally raised levels of suspended material. The communities present in the site have developed in response to the prevailing and seasonal water clarity.

Sediment processes clearly have the potential to greatly influence the sedimentology within the SAC, which in turn has an influence over the types of marine plants and animals that are present in areas of sediment, as well as harder substrata. Some of the marine communities in the SAC are particularly adapted to survive in conditions where there is a high level of scour caused by sediment carried in the water column.

3.3 GLANNAU ABERDARON AC YNYS ENLLI SPA

The Glannau Aberdaron ac Ynys Enlli Special Protection Area (SPA) includes the coast at the tip of the Llŷn peninsula together with Bardsey Island (Ynys Enlli) and two smaller islands, the Gwylan Islands. The area includes a rocky coastline with many crags, screes and low cliffs supporting coastal heath and grassland. The seaward boundary of the SPA is to mean low water.

The site qualifies as an SPA by supporting a breeding population of 14 pairs of chough *Pyrrhocorax pyrrhocorax*, representing 5% of the British population (Article 4.1 of the 1979 EC Birds Directive), and by supporting about 4,300 pairs of Manx shearwater *Puffinus puffinus* representing 2% of the British breeding population (Article 4.2 of the EC Birds Directive).

The site also supports other notable breeding populations of a number of birds species: cormorant *Phalacrocorax carbo*, shag *P. aristotelis*, peregrine *Falco peregrinus* and puffin *Fratercula arctica*. Whilst these do not specifically qualify the site for classification as an SPA, they are important populations in terms of the conservation of these species.

3.4 MYNYDD CILAN, TRWYN Y WYLFA AC YNYSOEDD SANT TUDWAL SPA

This coastal SPA consists of a 10km stretch of Atlantic vegetated sea cliff and exposed sandy shore. The cliffs have adjacent habitats of interest that include unimproved permanent pasture, maritime grassland, semi-improved grassland, arable farmland, coastal and maritime heath.

The site qualifies for classification as an SPA as it is used regularly by 1% or more of the Great Britain population of chough *Pyrrhocorax pyrrhocorax* in the breeding (9 pairs, 2.6 % GB

population) and non-breeding (18 individuals 2.6% GB population) seasons (Article 4.1 of the EC Birds Directive).

The site also supports other species of interest: breeding peregrine *Falco peregrinus*, raven *Corvus corax*, kestrel *Falco tinnunculus*, shag *Phalacrocorax aristotelis*, guillemot *Uria aalge*, razorbill *Alca torda*, kittiwake *Rissa tridactyla* and fulmar *Fulmarus glacialis* nest on the cliffs. The islets around the headland support breeding cormorants *Phalacrocorax carbo*, herring gull *Larus argentatus*, lesser black-backed gull *Larus fuscus* and great black-backed gull *Larus marinus*. Breeding linnet *Carduelis cannabina*, yellowhammer *Carduelis flavirostris*, whitethroat *Sylvia communis*, wheatear *Oenanthe oenanthe* and stonechat *Saxicola torquata* can be found in the large areas of maritime heath and scrub along the mainland coastal strip.

3.5 ABER DYFI SPA

The Aber Dyfi SPA comprises the Dyfi estuary, with adjoining saltmarsh, marshy grassland and improved grassland. The estuarine complex includes sandbanks, mud-flats, saltmarsh, peat bogs, river channels and creeks, with an extensive sand dune complex across the mouth of the estuary.

The site qualifies as an SPA for the greenland white-fronted goose *Anser albifrons flavirostris* as it supports 1% of the wintering population in Great Britain (144 individuals representing at least 1% of the wintering population in GB (Article 4.1 of the EC Birds Directive)). The site is of importance as a traditional wintering area for this species and is the most southerly regularly used area for this population in the UK. Until the early 1980s the geese roosted on the estuary and flew inland either to the Cambrian mountains or to the raised bog of Cors Fochno to feed. The geese now use the saltmarsh and grasslands for feeding and roost on the sandbanks and mud-flats. In addition, the site supports significant numbers of breeding waders, especially lapwing *Vanellus vanellus* and redshank *Tringa tetanus* which are the largest populations of these species in Wales.

3.6 OPERATIONS WITHIN THE SAC

The area within and around the Pen Llŷn a'r Sarnau SAC is fundamentally rural with very little, if any, heavy industry. The sea and adjacent land is widely used for a variety of commercial and recreational activities with tourism, farming and fishing providing key sources of income to the local economy. The main settlements of the area are concentrated around the coast (e.g. Pwllheli, Porthmadog, Barmouth, Aberdyfi) although the inland towns of Dolgellau and Machynlleth are in close proximity to the upper reaches of the estuaries of the SAC. Although parts of the coast of the SAC are relatively inaccessible due to their topography or restricted land access, many areas within the SAC can be accessed from the main coastal settlements or from small roads, slipways and beaches throughout the site.

Many parts of the landward boundary of the SAC remain unmodified but others have been altered and there are extensive stretches of coastal and flood defences in some areas. Along the coast these defences comprise mainly sea walls and rock armour and, within the estuaries, flood defence embankments of one sort or another. Smaller stretches of defence using gabions, rock armour and less organised rock rubble are used to protect some properties. Beach re-charge using coarse sediment dredged from the entrance to Pwllheli harbour is being used in conjunction with rock armour defences to protect part of the coastal frontage near Pwllheli (at Traeth Crugan).

In the past extensive modifications have been made to the estuaries which have generally resulted in land take from each estuary. This has usually been due to the construction of embankments, sea defence works and land drainage schemes, with the process of land reclamation starting before the end of the 19th century and continuing up until the 1980's in some areas. Many of the historical impacts were as a result of the large scale construction of structures within and adjacent to the estuaries, such as the Cob at Porthmadog, the railway bridge in the Mawddach and the railway embankment in the Dyfi. Flood embankments have also been constructed to protect agricultural land reclaimed from the estuary.

A wide range of recreational activities take place in and around the SAC. Water-based recreation (such as swimming, sailing, power boating (including jet skis), diving and kayaking) is very popular and a very important part of the tourist-based economy of the area. There are various facilities around the site to support this including marinas, harbours, slipways and associated support services. Several national and international boating events (sail and power boats) take place in the SAC every year, many of them using the marina facilities at Pwllheli. There are a number of beaches that are particularly popular with holidaymakers during the summer season and these see visitor numbers peak during the summer months. Equally, there are many smaller quieter areas around the coast that people specifically come to the area to enjoy. Recreational sea angling is popular in the SAC and takes place from the shore and from boats. Some angling charter boats operate within the SAC. Wildlife watching is increasing in popularity and there are boats which operate during the summer months to take people out to some of the more accessible islands and coast to see the wildlife.

The area of the SAC is important for commercial fishing, with the main fishing being potting for lobsters and crabs, although potting for prawns and whelks also occurs. Some netting (drift and set gill nets and some tangle netting) occurs in the SAC. Historically very little trawling and dredging has taken place in the SAC, although there is an increased interest in scallop dredging in general and this has resulted in the implementation of a number of closed areas in the SAC through byelaws of the North Western and North Wales Sea Fisheries Committee in order to safeguard the features of the SAC. Whilst there has been interest expressed in possible mariculture activities in an adjacent to the SAC currently the only commercially operating business is a land-based fish farm on the Llŷn using a recirculating water system. There are, however, some small-scale mussel rope culture trials underway in the SAC.

Extensive areas of the adjacent coastal land bordering the SAC are farmed and the saltmarsh areas of the estuaries of the SAC (Glaslyn/Dwyryd, Mawddach and Dyfi) are grazed, mainly by sheep but also cattle and horses.

There have been historical changes in sewage treatment and disposal with a number of improvements over recent years through upgrading of the main sewage treatment plants and installation of small treatment systems for those premises not using the main sewage system (e.g. installation of small individual treatment systems for homes and businesses adjacent to the SAC, e.g. caravan sites). As a result water quality within the SAC should have improved. Diffuse inputs into the SAC, particularly within the estuary catchments, together with discharges via combined sewer outfalls are not well known. With the prospect of increasing rainfall as a result of climate change this input may become a more substantial contribution.

Forestry is a significant land use within the catchment area of the Mawddach and Dyfi estuaries, with many of the forests here composed of even-aged stands of predominantly mixed conifer.

3.7 MODIFICATIONS AS A RESULT OF HUMAN ACTIVITY

Various human activities currently taking place within the SAC have an influence on the 9 habitat and 3 species features. 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. The structural and functional characteristics of the SAC and its habitat features are inherently important attributes of the marine ecosystem, but it is the effect that these characteristics have on the wildlife of the SAC that is of particular conservation importance.

The undersea environment has for many years been seen as a relatively undisturbed wilderness, but this is now known not to be the case. Humans have exploited the sea and its resources for thousands of years, benefitting from its natural biological and geological resources and the biological, physical

and chemical processes that help, amongst other things, to assimilate and treat human waste and regulate our climate. Until relatively recently it was thought to be impossible to deplete or overwhelm the resources of the sea, but we now know that this can happen. On a global scale we know that we are altering the marine environment (for example increased sea water temperatures as a result of climate change and subsequent major shifts in species in the plankton (the base of the food chain)); examples such as the collapse of the cod fishery on the Grand Banks and its failure to recover show that the sea can be fundamentally changed by human activities.

But how does this relate to Pen Llŷn a'r Sarnau SAC? Historically the SAC's location has been rural and has had a low population density, factors that still remain in place today. This has meant that the SAC has not been subject to the impacts of industrialisation to the same extent as many other areas and the SAC probably remains relatively unimpacted by human activity. Historically local fisheries have been small scale, relying primarily on static gear (pots and nets) to catch fish and shellfish; it is considered that there has been little use of mobile fishing gear within many areas of the SAC and, as a result, rich seabed communities on rock and in sand, mud and gravel are still present such as along the north Llŷn and in Tremadog Bay.

In spite of the relatively low impact of human activity we do know that many of the habitats and wildlife of the SAC have been modified in the past: in the estuaries the construction of embankments, sea defence works and land drainage schemes have reduced the overall areas of the estuaries and the habitats within them. The building of the Cob cut the Glaslyn estuary in half and the sediment processes in the remaining Glaslyn/Dwyryd estuarine system are still responding to that change. Past mining operations in many of the estuary catchment areas have left a legacy of contaminated mine water that discharges into the environment. Coastal developments and coastal defences have resulted in a loss of habitat and have modified the coast and coastal process. Productive fisheries that used to be present around the Llŷn (herring and crayfish for example) have disappeared as a result of local and wider over-exploitation.

The marine habitats and species of Pen Llŷn a'r Sarnau SAC have been, and are being modified by human activity - they are not pristine. However, having said that, it would be wrong to assume that all the habitats and the wildlife of the SAC are in poor condition; we do not believe this to be the case, although some are in need of restoration or particular management measures to prevent further decline or degradation. The habitats and wildlife are modified – it would be wrong to think otherwise since there has been a process of humans removing species from the environment for the past few thousand years – but they are still functioning and productive natural habitats, several of which are rare or particularly notable because of unusual species assemblages, and high diversity and/or abundance of species that they support. The SAC contains a wide variety of marine and coastal habitats and wildlife; several of these are believed to be in a good condition (as far as we are able to define this based on our current knowledge), whist others have been highly modified and require restoration if they are to be able to continue to provide the resources we expect from them and are able to respond to global environmental changes in the future.

Many activities have the potential to affect the SAC features by causing direct or indirect damage or deterioration of habitats, disturbance to wildlife or by modifying structural and functional characteristics of the SAC that support the habitats and species. These effects are considered to be *significant* where a subsequent detrimental impact on the species and communities associated with the habitat features of the SAC would result. Some activities are localised in a part of the site and may be time limited or more prevalent at certain times of the year (e.g. coastal development proposals, high speed water craft). Other pressures and threats on the wildlife and habitats of the SAC are more long term and may be directly or indirectly caused or influenced by human activity, such as climate change

issues (sea level rise, increased storminess, coastal squeeze). An assessment of the conservation status of each of the habitat features was first reported in 2001 and then again in 2007[20].
Further information about human modifications to the SAC features is provided for each feature in section 4.

Some of the key activities and issues directly or indirectly influenced by human activity that are currently believed to be actual or potential threats to the long term sustainability of the habitats and wildlife of the SAC and which either require better management or further investigation include (not in any particular order):

- Coastal & flood defence: constraint on the functioning of the coastal and estuarine areas from artificial boundaries which affects the extent of habitat (coastal squeeze). Need for strategic plans for vulnerable areas of the coast
- Land use management in the surrounding catchments (including forestry management) and the influence of this on the estuarine and coastal habitats. Need for integrated planning
- Water quality and nutrient enrichment
- Harvesting of marine resources (commercial and non-commercial): need for improved management and regulatory regime to prevent damage to SAC features and support sustainable harvesting regimes.
- Mobile fishing gear
- Over grazing in some locations in the estuaries
- High speed power craft (including PWCs)
- Litter & debris
- Climate change issues (e.g. warming sea water temperature, sea level rise, increase storminess)
- Introduction of non-native species
- Marine wildlife watching / Eco tourism
- Scientific research
- Poor public awareness and lack of understanding or interest in the marine environment.

[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 REEFS

Reefs are widespread in northern and southern Europe and occur widely around the UK coast. They are defined in the EU Interpretation Manual [21] 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*.

4.1.1 Range

The reef feature occurs throughout the entire SAC and incorporates a range of different habitat types. These include rocky intertidal and subtidal reefs, biogenic reefs formed by the horse mussel *Modiolus modiolus*, the green crenella *Musculus discors* and the honeycomb worm *Sabellaria alveolata* and carbonate reef structures formed by methane gas leaking from the seabed (the most prominent of these reefs is known as Holdens Reef). Only two *Modiolus* reefs in reasonable condition, including the north Llŷn reef, are still known to exist within the Irish Sea. The carbonate reef structures are also very unusual; these structures would almost certainly qualify as an additional Annex I habitat under the Habitats Directive - *Submarine structures made by leaking gases* - but in the meantime they will be addressed as part of the reef feature of the SAC.

The general location of the reef feature within the SAC is indicated on map 3. Due to the difficulty of mapping the actual distribution of most of the subtidal portions of reef, the indicative map also shows areas of 'possible reef' – these are areas where survey data (acoustic mapping, spot ground-truthing and survey points) indicate the possible presence of reef.

4.1.2 Structure and function

The structure of the reef has a fundamental influence on the type of reef communities that develop. Bedrock provides solid habitat for plants and animals to attach to whilst softer rock (such as the carbonate reef) and clay and peat exposures provide a habitat that certain species (such as sponges and boring molluscs) are able to bore into.

There is a considerable range of reef morphology, topography and associated bathymetry including variations in the slope, aspect, nature of the surface and size of the reefs. Around Pen Llŷn most of the intertidal reef comprises steep bedrock faces, although broader rocky platforms (with rockpools) are present along the north coast of the Llŷn peninsula and between Borth and Clarach in Ceredigion.

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

Bedrock reefs and boulder reefs extend into the subtidal areas, particularly in the northern part of the site off the north and southwest Llŷn coast, around Bardsey Island and the other smaller islands in the SAC. These reefs can have a very rugged structure, with fissures, cracks and crevices in the rock increasing the complexity of the habitat structure and providing an opportunity for other species (such as shade-loving species) to become established.

Geomorphological processes have shaped and continue to shape the reefs, particularly in the case of the pebble, cobble and boulder reefs. Within Tremadog Bay a significant proportion of the reef habitat in the intertidal and subtidal is derived from glacial till. This includes the stones and rocks that form the sarnau and many of the patch reefs along the south Llŷn coast. The continued erosion of boulder clay cliffs releases further pebble, cobbles, boulders and finer materials into the intertidal and eventually, through wave action, into nearshore areas. Areas of boulder, cobble and pebble reef often provide more complex habitat structure with underboulder spaces providing shelter for some species. But boulder, cobble and pebble reefs can also be more mobile and, in these instances, support communities that are able to tolerate less stable conditions (such as on the sarnau reefs).

The reefs are surrounded by areas of sediment and some of the reef surfaces will be subject to long or short term sediment deposition affecting the composition of the wildlife communities present. The amount and nature of the sediment will vary with the prevailing hydrodynamic regime and the origin of the supply of sediment. Some of the communities require the presence of sediment such as those characteristic of scour and biogenic reefs formed by the worm *Sabellaria alveolata* and the related *Sabellaria spinulosa.* The extensive subtidal boulder and bedrock reefs along the north Llŷn coast are surrounded by areas of mixed sediment and isolated rocks, creating a mosaic of different habitat types on the seabed.

The depth range of the reef feature varies throughout the site. Around the Llŷn reef extends from the shore into water depths greater than 30m. Elsewhere (reefs in Tremadog Bay, the sarnau and carbonate reefs), much of the reef is in less than 15m.

The sarnau are glacial moraines and are composed entirely of boulders, cobbles, and pebbles mixed with various grades of sediment. They are surrounded by sediment plains and are exposed to tidal currents and wave action with low-lying parts periodically covered and un-covered by sand. Wave action, particularly during winter storms, mobilises the loose rocky material creating a less stable habitat than other areas of bedrock and boulder reef within the SAC.

Biogenic reefs often have very complex 3-dimensional habitat structure that provides many spaces and micro-habitats for other species to live in, and consequently biogenic reefs often support a high diversity of species. The structure of the biogenic reefs varies depending on the dominant species forming the reef and their interaction with physical forces. The horse mussel reefs are a complex 3-dimensional structure up to a metre high created by the binding of individual mussels and incorporating silt and the waste 'sediment' material produced by the mussels. The mussel reef comprises undulating waves on the seabed created by the mussels themselves with most of the live mussels living on the crests of each wave and the troughs comprising empty shells. Samples from the north Llŷn horse mussel reef have shown that some of the individual mussels are over 50 years old but juvenile mussels also appear to be recruiting onto the reef.

The *Musculus discors* reef is formed from dense aggregations of this small mussel attached to rock and gravely sediments. As the reef forms it consolidates the sediment surface by binding it and a thick layer of pseudofaeces together with the byssus threads of the mussels, creating a reef structure that is several centimetres high. This low-lying 3-dimensional matrix provides a habitat particularly for small cryptic species.

The honeycomb worm reefs provide a structure that can be inhabited by other species both within and between the network of worm tubes, or attached to the surface. *Sabellaria* reefs in the SAC have high associated species richness due to the complex structure of the reefs themselves, and fact that the reef

structures stabilise and often forms rock pools in what would otherwise be more mobile and free draining shores. The reefs, which are made of sand grains, rely on the supply of sand via unhindered coastal processes. At the same time, by forming a thick crust over rocky surfaces the *Sabellaria* reefs change the nature of the substratum as well as forming reef structures in their own right.

The carbonate reefs are quite low-lying, with a varied topography across their surface and are surrounded by areas of sediment which are used in the chemical process that forms the reefs, but also influences the reef community through scour, and periodic covering and un-covering of the very low lying parts.

A large proportion of the reef habitat is exposed or moderately exposed to wave action and tidal streams. Particularly strong tidal streams occur in the narrow tidal rapid channel of Bardsey Sound between Bardsey Island and the mainland but there are also some localised areas of more sheltered reef in the lee of headlands and islands and within Tremadog Bay.

The level of suspended particles in the water column affects the amount of light reaching the seabed. This can be seen in the difference between the maximum depth of kelp growth around Pen Llŷn (10-15m) compared to only a few metres in the Menai Strait. The animal communities on the reef are dominated by filter feeding animals. Whilst these communities are adapted to living in the concentrations of suspended matter present in the SAC, excessive sediment loading above the normal ambient levels could potentially lead to smothering of habitats and species. The reefs may be exposed to intermittent or regular sediment deposition and removal. Those that are low lying and shallowly sloping areas in the shallow subtidal (such as the sarnau) may be subject to large scale deposition and erosion of sediment over part of the reef.

The reefs support many species that use such areas for some of their life cycle and food requirements. The role that the reefs play in the ecology of the local and wider marine environment, and the fine detail of the interactions between species is not understood. Some of the reef communities are particularly species rich, such as the horse mussel reef where 23,000 animals in a single square meter of reef have been recorded. Productive areas such as this are believed to play a significant role in the marine food chain, providing an important food source for other creatures, including different species of fish and marine mammals. For example, Risso's dolphins have been observed feeding in the sea area over the horse mussel reef.

Mobile species play structural and functional roles in the reef systems.The reefs contribute directly or indirectly to the food resource of mammals such as otter, grey seal, bottlenose dolphin, harbour porpoise and Risso's dolphin as well as sea birds and diving birds, many of which breed on the surrounding coastline and offshore islands.

4.1.3 Typical species

The reefs of the Pen Llŷn a'r Sarnau SAC are extremely varied and support a very wide variety of communities of marine animals and plants reflecting the broad range of physiographic factors around the site such as wave action, tidal streams, variation in sea bed type, scour regimes, water clarity and variation in water depth.

Some species are long lived and part of relatively stable populations often with low levels of recruitment. Other species are subject to much greater fluctuations in their distribution and extent and may show much greater dynamism in their recruitment. There are also some that are rare and/or scarce, at or near their biogeographical limit of distribution, that have a key role in the ecology of the reefs and wide ecosystem, and/or are components of diverse and/or abundant species assemblages.

Whilst all the reef communities within the site contribute to the overall representation, range and integrity of the feature within the site, a number of notable reef habitats and their associated assemblages of marine plants and animals are of particular conservation importance.

Rocky intertidal reefs

The intertidal reef communities include lichen-dominated communities at the top of the shore and various seaweed-dominated communities in the upper, middle and lower shores. There are specialised communities in rock pools, under boulders and in rocky gullies. Species rich examples of nationally important kelp and brown seaweed-dominated communities are found in lower shore areas exposed to strong tidal currents.

Rocky subtidal reefs around the Llŷn Peninsula

In general, the shallow water reefs around the Llŷn and Bardsey Island are dominated by dense growths of various kelp communities representing conditions of high, medium and low energy conditions; overall the SAC supports a wide range of kelp communities. In areas with strong tidal flow the under story flora and fauna associated with the kelp tends to be very abundant and species-rich.

An extensive and luxuriant turf of red seaweed species grows amongst and below the kelp and there are seaweed communities with high biomass and species richness that occur on reefs in the northwest of the site. Such extensive and luxuriant growth of algae is possibly attributable to relatively low grazing pressure from the common sea urchin *Echinus esculentus* which is more abundant in other parts of the British Isles, particularly throughout Scotland and the English North Sea coasts. Common sea urchins are generally rarely seen on the reefs of the SAC.

On the boulder and cobble reefs surrounded by sediment, sugar kelp and other brown seaweeds are more common amongst a varied turf of red seaweeds and invertebrate animal species. These communities are particularly prevalent on the south side of the Llŷn and are more akin to the communities on the sarnau. Below the kelp forests and red seaweed zone the reefs are colonised by animal dominated communities. Some are species rich and unusual within a UK context such as those dominated by assemblages of sponges, hydroids, anthozoans and bryozoan turf around Bardsey Island. Another example is the species-rich reef community comprising dense crusts of sand-grain tubes of the worm *Sabellaria spinulosa* supporting a rich animal turf of ascidians (sea squirts) and sponges on the low-lying reefs on the north side of Pen Llŷn. Territorial fish including various species of wrasse, are often associated these species-rich communities as well as areas of kelp forest.

Reef communities in Bardsey Sound (and to a lesser extent around the other headlands in the SAC) are characterised by communities that include scour-tolerant species. Various scour-tolerant seaweeds are often present as part of these scour-tolerent/characterising communities in shallower areas (such as in parts of Tremadog Bay and on the sarnau).

There is a marked difference in the presence and dominance of particular animal species and assemblages around the Llyn peninsula. Reefs in Bardsey Sound, for example, are characterised by communities that include scour-tolerant species.

Extensive rocky boulder and cobble subtidal reefs – the Sarnau

The sarnau reefs support dense seaweed beds of opportunistic ephemeral, perennial and annual species that are tolerant of sand cover and scour. Bootlace weed (*Chorda filum*), sugar kelp (*Laminaria saccharina*) and red seaweeds flourish on or near the reef crest. On other parts of the sarnau there are extensive forests of the pod weed (*Halidrys siliquosa*) together with a wide variety of other seaweeds forming a species rich community. Animal-dominated biotopes are found in the deeper parts of the reefs, including crustaceans, cnidarians, sponges, hydroids and encrusting bryozoans.The extensive areas of under-boulder spaces provide a habitat for many small animals (such as small crabs and worms) and it is likely that these form an abundant and important food source for larger animals. Aggregations of bottlenose dolphins and red-throated divers have been recorded feeding around the sarnau reefs.

Biogenic reefs
Horse mussel reefs provide a broad range of sub-habitats and the complex microtopography over the reef supports a high biomass of a wide variety of species living in amongst and on the surfaces of the matrix of the mussel bed. Soft coral, molluscs, echinoderms, sea anemones, crustaceans and fish are some of the more conspicuous examples. Honeycomb worm, or *Sabellaria alveolata* reefs also provide a habitat for other species and those in Cardigan Bay are amongst the best examples of this biogenic reef type in the British Isles. There has been a limited amount of work on fauna associated with *Musculus discors* reefs

Carbonate reef structure formed by methane gas leaking from the seabed
The carbonate reefs are heavily pitted and bored by bivalve molluscs and sponges and provide refuges for cryptic animals including anthozoans (anemones, soft corals and related animals), crustaceans, molluscs and fish. There also appears to be an abundant assemblage of mobile species associated with the reef.

4.1.4 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 can fluctuate.

The diversity and type of wildlife communities found on reefs varies according to the nature and type of rock habitat present. It 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 animal, 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 areas for many other species.

4.1.5 Modifications as a result of human activities
The reefs of the SAC and their associated communities of marine wildlife are most susceptible to physical damage and abrasion and changes in the quality of the surrounding water and the hydrological processes operating throughout the site. Some of the reef communities are relatively robust and are more likely to be able to re-colonise relatively quickly, but there are other species, such as the horse mussel, honeycomb worm reefs, some sponges, anemones and sea squirts that are much more susceptible to damage and less likely to be able to recolonise and recover once damaged or removed from the reef. In the intertidal, the most likely influences on the reef communities are from constructions on or along the shore, either directly on the reefs or that alter the hydrodynamic processes supporting the reefs, and from pollution (for example run off from land and discharges). In the subtidal, physical damage to the reefs is possible, for example from fishing activities (direct

physical impact as well as smothering from sediment that is resuspended by mobile fishing gear), or impacts as a result of changes in the surrounding water quality due to land or sea-based activities..

The extent and quality of the intertidal reef and shallow subtidal reef in the SAC may have been reduced locally by the construction of coastal structures in the past, but this has generally been restricted in location and scale. Coastal defences are modifying the intertidal reef along parts of the open coast of the SAC by hindering the erosion of boulder clay cliffs and the release of new reef material (boulders, cobbles and pebbles) on to the shore. The coastal defences also affect sediment processes which have an important influence on the reef communities and are particularly important for the maintenance of the honeycomb worm reefs. In the longer term, coastal defences prevent the natural coastal processes operating and this can result in lowering of beach levels and changes in the degree of wave exposure of parts of the coast. There are a number of places within the SAC where this is a concern.

Trampling by people walking over the intertidal reefs can be a problem if it is sustained over a period of time. The honeycomb worm reefs are particularly susceptible to trampling because the reef structure is made of sand grains and is fragile. There may be a few localised areas in the SAC where trampling is having an affect on the quality of the intertidal reef communities but currently this is considered to be limited in extent.

The distribution and extent of the majority of the subtidal reef is not known to have been reduced by human action. The possible exception to this is the horse mussel reef. Horse mussel beds have been lost from, or significantly reduced in size in other areas due to the impact of activities that have damaged or removed the reef (e.g. trawled bottom fishing gear). The horse mussel reef was recorded in the same location 40 years ago and has probably persisted there for over 150 years. No written records are known to refer to it before this, but it is likely to have existed for much longer because horse mussels are slow growing and the reef takes many, many years to form. Whilst earlier samples confirm the presence of horse mussels and reef in the area where it exists today, it is not known how large the horse mussel reef used to be. Extensive areas of dense horse mussel shell is present over areas of seabed surrounding the reef and wider, and it is possible that the reef used to be more extensive.

The overall depth range of reef is assumed unmodified by human action and there is no known evidence for modification of subtidal reef surface microtopography as a result of human activity, other than as part of gross modification of reef in localized areas. 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, but it is considered that until very recently this impact was minimal. Recent increased interest in scallop dredging, in particular, and fishing activity in parts of the SAC (including illegal incursions into areas closed to scallop dredging) mean that areas of reef may have been impacted by this activity in the last few years.

Minor temporary modification of suspended particulate concentrations can occur in the SAC due to local or distant activities mobilising or influencing sediment transport (such as coast protection and construction activities, harbour/marina dredging) and/or inputting of sediment into the open coast and watercourses draining into the SAC (e.g. increased land runoff as a consequence of deforestation and modern farming practices). Increased sedimentation in the water will reduce the amount of light reaching the seabed (increased turbidity) and can affect the growth of seaweeds.

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.

The concentrations of major nutrients and contaminants within the coastal and open sea areas of the SAC are not believed to be above levels that would be of concern for the reefs, but more information about the specific levels present is required.

The degree to which reef species populations may have been modified or degraded by human activity is difficult to assess. Species subject to commercial exploitation may be depleted well below historical pre-exploitation levels – this is certainly the case for crayfish in the SAC the stocks of which were decimated by divers in the 1970's-1980's. But in terms of the other species that are fished on a commercial and recreational basis there is no specific stock data to compare the current situation with. Scientific evidence suggests that aspects of ecosystem functioning may be modified or adapted as a consequence of excessive removal of key mobile species, however, the magnitude of such modification is both unknown and, in the absence of pre-exploitation data, unquantifiable.

Discarded and accidentally misplaced artificial materials are present throughout the reef habitat Whilst the scale of this in the SAC is considered to be relatively low, lost and discarded fishing gear and persistent rubbish continues to form a physical hazard to many species and some are a source of chemical contamination. Modern synthetic fishing gears are capable of 'ghost fishing' both commercial and non-commercial species for prolonged periods. Overall habitat quality of the Pen Llŷn a'r Sarnau SAC reefs is considered to be high.

4.2 LARGE SHALLOW INLETS AND BAYS

Large shallow inlets and bays are defined in the EU Habitats Interpretation Manual 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).

The feature in this SAC is an embayment.

4.2.1 Range

The large shallow inlet and bay feature of the SAC is the embayment known as Tremadog Bay at the northern end of Cardigan Bay. The feature is referred to either as 'Tremadog Bay' or as 'the bay', or 'bay feature' in this document.

The bay feature extends from Trwyn yr Wylfa in the northwest, to the western tip of Sarn Badrig reef, and northeast to Morfa Dyffryn. It is delineated by part of the south Pen Llŷn coast from Porthmadog to Cilan Head in the north, the Merionnnydd coast at Harlech and Mochras in the east and Sarn Badrig reef in the south and covers approximately 41,570 ha.

4.2.2 Structure and function

The Cardigan Bay basin is aligned NE-SW, following the trend of the Caledonian lines of structural weakness. The basin formed over a long period of time by subsidence of the surface crust and infilling by sediment eroded off the adjacent basement rocks. The seabed and seashore sediments are largely derived from the glacial till (material collected and moved by the action of glaciers) deposited by the Irish Sea and Welsh ice sheets. This was reworked as sea levels rose at the end of the last ice age and this process continues to the present day. In the outer parts of Cardigan Bay the bulk of the seabed sediments are gravely, whereas closer to the coast finer sediments, moved by tidal currents, have accumulated forming thicker sands and areas of accumulated mud.

The seabed and seashore of Tremadog Bay is made up of a high diversity of different sediment types with a wide variation in degree of sorting, each of which supports specific assemblages of animals and plants. The bay acts as a sink for finer sand and mud that is washed in through the action of tidal currents from further offshore in the Irish Sea. Some material is also derived from the local boulder clay cliffs and sediments around the bay.

Some of the sediments in Tremadog Bay are unusual in the context of the inshore areas around Wales in that there are areas of mixed muddy and sandy sediments (particularly in the northwest of the bay) with a high proportion of gravel and pebbles that appear to be relatively consolidated and undisturbed from surface impact. These poorly sorted sediments provide a complex habitat that supports assemblages of animals and plants attached to the larger sediment and stones on the surface and an animals living within the sediment.

The general overall pattern of seabed sediments in Tremadog Bay is;

- moderately well sorted finer and muddier sands in the north eastern and central western part of the bay;

- well-sorted soft muddier sediments in deeper areas (such as the area in the western part of the bay marked as 'muddy hollow' on Admiralty Charts of the area, and in an area to the southeast of Pwllheli)
- well sorted fine and medium sands along the southern part of the bay (along the north side of Sarn Badrig);
- poorly sorted sandy and muddy gravel sediments with cobbles and pebbles over an extensive area in the northwest part of the bay.

Within this overall distribution of different sediment types there are patches of more gravely, poorly sorted sediments and well sorted medium sand as well as areas of bedrock and patches of boulder, cobble and pebble reef (particularly in the northern half of the bay).

The structure of the intertidal habitats is also varied and comprises:
- areas of bedrock around the main headlands of the bay in the north
- mixed sediment shores of boulder and cobble reef with sand and gravel, which in places support biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* (particularly between Pen-ychain and Criccieth along the north coast of the bay and at Shell Island);
- muddy sand and gravel (notably at Llanbedrog and to the east of Carreg y Defaid);
- shingle and sand (along the north and east coasts of the bay);
- outcrops of red and grey clay and peat;
- precipitative reef structures (notably at Llanbedrog and southeast of Carreg y Defaid).

Tremadog Bay is a relatively shallow embayment less than 20m deep over much of its area. The shallow areas around the north, east and southern parts of the bay where water depth is less than 10m grade into a deeper central section. The deepest areas of the bay area between 20-30m and are at its western end in the area marked 'Muddy Hollow', and to the southeast of Trwyn Cilan and Trwyn-yr-Wylfa.

A large proportion of the shore and seabed of the bay comprises sediment habitat, including soft mud, muddy sand, sandy and muddy gravel sediment, fine, medium and coarse sand, shingle, clay and peat. There are also areas of reef throughout the bay in both the intertidal and subtidal comprising areas of bedrock (mainly around headlands and the St Tudwal's Islands), boulder, cobble and pebble and biogenic reef structures.

Tremadog Bay is relatively exposed to wind and wave action. Tidal currents within the bay are weak compared to other parts of Cardigan Bay and the Irish Sea. The most tide swept areas are around headlands and the St Tudwals Islands. Elsewhere, apart from localised modifications, average current flows are less than 1 knot. The deeper parts of Tremadog Bay are deposition areas collecting fine sediments, whilst in the shallow near shore areas there can be considerable onshore and offshore sediment movement, particularly during stormy weather. The tidal range within Cardigan Bay is fairly uniform and is in the range of 2-4m. Tremadog Bay is something of a warm-water summer 'enclave' within Cardigan Bay and this in part results in this area supporting an unusual assemblage of plants and animals.

Water clarity in the SAC can be high, although within Tremadog Bay the shallower conditions and greater proportion of seabed and coastal sediments means that sediments in this part of the SAC are re-suspended more easily in rough weather.

Tremadog Bay acts as a sink for finer sand and mud that is washed in through the action of tidal currents from further offshore in the Irish Sea. Within the southern part of Cardigan Bay from St David's Head to the Glaslyn estuary accretion of sediment along this coastline is supplied largely by the erosion of the glacial till cliffs in the southern part of Cardigan Bay. Within the intertidal areas, the adjacent till cliffs supply material to the beach where there is a reworking and transport of sediments to and from the adjacent nearshore areas. This includes material forming the boulder,

cobble and pebble reef habitat in Tremdaog Bay. Whilst some sediment is derived from the local boulder clay cliffs and sediments around the bay, the specific locations and extents of the sources are not known.

Tremadog Bay contains a variety of habitats that support many different plant and animal species some of which are commercially important to fisheries within the SAC (such as lobster, crab and prawns). The wildlife communities of the bay, particularly those within the sediment habitat are a productive and important food resource for other species. We do not fully understand the role that the bay plays in the ecology of the local and wider marine environment, nor the fine detail of the interactions between species. Observations and records from fishermen, biologists and others indicate that bay provides a nursery area for juvenile lobster, with the muddy gravel seabed in the northwest of the bay being the main area where these have been recorded. Other parts are believed to act as nursery areas for juvenile fish and may also provide breeding areas for rays.

4.2.3 Typical species

Tremadog Bay contains a wide variety of seabed and seashore habitats that support varied assemblages of animals and plants. A number of notable bay habitats and their associated assemblages of marine plants and animals are of particular conservation importance.

The typical species of the bay include those that are rare and scarce, at or near their biogeographical limit of distribution, those that have a key role in the ecology of the bay and wider ecosystem, and those that are components of diverse and/or abundant species assemblages. Some are long lived and part of relatively stable populations often with low levels of recruitment, whilst others are subject to much greater fluctuations in their distribution and extent and may show much greater dynamism in their recruitment. Several of the bay communities are considered to be relatively stable and unmodified in terms of their physical structure and support diverse, rich and unusual species assemblages. It is not expected that these communities or the inherent nature of their species assemblages would vary greatly over time unless impacted by human activity.

Tremadog Bay is one of two areas in the UK where seasonal concentrations of leatherback turtles *(Dermochelys coriacea)* have been recorded. Their presence here has been linked to the seasonal consistent occurrence of aggregations of barrel jellyfish (*Rhizostoma octopus*).

<u>Subtidal sediment communities</u>

The sediment communities of the bay support a rich and diverse assemblage of invertebrate species. The diverse infaunal communities are composed of representatives from most of the marine invertebrate phyla, including marine polychaete worms and other marine worms, amphipods, isopods, crabs, molluscs, and echinoderms.

The moderately well sorted finer and muddier sands in the north eastern and central western part of the bay support communities characterised by the bean-like tellin *Fabulina fabula* and the polychaete worm *Magelona mirabilis*, with venerid bivalves (such as the striped venus *Chamelea gallina*) and amphipods. Occurring close to this community in fine sand close inshore in the northeast of the bay is a sediment community dominated by bivalve molluscs such as *Angulus tenuis* and polychaetes.

Well-sorted soft muddier sediments in deeper areas (such as the area marked as 'muddy hollow' on Admiralty Charts of the area, and in an area to the southeast of Pwllheli) support different communities depending on the proportions of muddy and coarser sediment present. Deeper offshore mud and sandy mud supports an infaunal community characterised by polychaete worms, such as *Levinsenis gracilis* and *Heteromastus filiformis*. Extensive areas of sandy mud in the central and northern inshore areas of the bay support a diverse infaunal community characterised by super-abundant burrowing brittlestars (*Amphiura filiformis*) and small bivalves (*Mysella bidentata* and *Abra nitida*) together with different species of worms (polycheates, sipunculids and cirratulids) as well as sea potatoes (echinoderms) and crustaceans (burrowing mud shrimp and *Eudorella truncata*). Data

indicates that rich and diverse assemblages of infauna occur as part of this community; up to 80 species per 0.1 m^2 and over 1,500 individual animals per 0.1 m^2 have been recorded at some locations. Muddy sands to the south of this community are characterised by bivalve molluscs *Mysella bidentata* and *Thyasira* spp. This is the similar community to that occurring in the mixed sediments in the northwest of the bay and it supports diverse and abundant infauna - between 40-80 species per 0.1m^2 and abundance of animals between 500-1,500 per 0.1m^2 have been recoded in such areas.

Well sorted fine and medium sands along the southern part of the bay (to the north of Sarn Badrig) are characterised by polychaete worms (in particular *Nephtys cirrosa*) and amphipods (e.g. *Bathyporeia* spp.). This community is typical of sediment subjected to greater physical disturbance, primarily from wave action, than the other sediment habitats of the bay. Sand eels may sometimes be observed in this sediment type.

Poorly sorted sandy and muddy gravel sediments with cobbles and pebbles cover an extensive area in the northwest part of the bay. This habitat supports a rich community of burrowing infauna characterised by bivalve molluscs *Mysella bidentata* and *Thyasira* spp. with polychaete worms, small crustaceans and echinoderms, as well as attached epifauna and epiflora. The species diversity of this infaunal community is very high in places with samples recording over 80 species per 0.1 m^2 at some locations. The gravel, shell remains and pebbles and cobbles associated with this sediment habitat also allow a variety of plants and animals (such as sea squirts, sponges, hydroids and bryozoans) to grow attached to the sediment surface, increasing the overall species diversity of this community. Many mobile species such as small fish and crustaceans are present in this habitat. Several of the more unusual species in the bay are associated with this mixed sediment habitat, this includes various species of red seaweed, including individual nodules of maerl *Phymatolithon calcareum*, and the mantis shrimp *Rissoides desmaresti*. Close to this community in medium to coarse gravely sand close to the St Tudwal's Islands is a community dominated by bivalve molluscs (*Moerella* sp.and venerid bivalves) with low numbers of polychaetes and other invertebrates.

Subtidal rocky communities

Bedrock reef around the St Tudwals Islands and headlands along the mainland coast together with boulder, cobble, and pebble patch reefs within the bay support communities of kelp and mixed red and brown seaweeds. Animal communities are dominated by filter feeders such as sea firs (hydroids) and sea mats (bryozoans) with sponges, ascidians (sea squirts) and a variety of other sessile and mobile animals. Development of the animal-dominated communities is greatest in deeper water below the kelp and red seaweed zones, and in areas of increased current flow. On the boulder and cobble reefs in shallow water the upper surfaces of the rocks are generally colonized by mixed red and brown seaweeds, whilst the sides of the rock are colonized by a short turf of varied animal species. In areas of mixed sediment with cobbles and pebbles, such as the shallow water between the St Tudwal's Islands and across Oyster Bank in the north of the bay, the cobbles and pebbles support various seaweed species that can tolerate sand scour. The reefs support a variety of mobile species including commercially important crustaceans (such as lobster and crab) and contribute to the role of the bay as a breeding and nursery habitat by providing shelter in underboulder spaces and rocky crevices. Wrasse and dogfish are known to breed on the reefs.

Intertidal communities

Much of the intertidal around the bay is composed of sandy or mixed sediment with rocky areas at a few locations, such as the headlands at Porth Ceiriad, Pen-ychain and the St Tudwal's Islands. Mixed sediment shores of sand, gravel, cobbles and boulders that predominate between Pen-ychain and Criccieth and at Shell Island, support extensive beds of seaweed, honeycomb worm reefs (built and inhabited by the worm *Sabellaria alveolata*) and rockpools. In contrast there is a muddy sand and gravel area at Llanbedrog and to the east of Carreg y Defaid that supports an unusual and diverse community of carpet shells and other species and there are patchy exposures of red and grey clay that have been colonised by piddocks (an unusual shellfish that can bore into and live in soft rock, clay and peat). At Llanbedrog beach there are also boulder overhangs that support rich assemblages of animal species including sponges, sea squirts and bryozoans. The lower shore at Llanbedrog and to

the east of Carreg y Defaid also has unusual precipitative reef structures. Whilst these do not appear to support a particularly distinctive assemblage of species they are an unusual geological feature of the lower shore and shallow subtidal areas in this part of the bay. To the east from Carreg y Defaid the steep gravel beach in front of the sand dunes at Pwllheli supports the nationally rare amphipod shrimp *Pectenogammarus planicrurus*.

Exposed sand at the mouth of the Galslyn at Morfa Harlech and Morfa Buychan supports mainly amphipod shrimps and isopods. North of the estuary mouth near Criccieth and further west at Afon Wen, finer more sheltered sand is colonised by seagrass beds (*Zostera marina*) that extends from the shallow subtidal into the lower shore areas.

4.2.4 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 granulometry and structure are primary factors in determining biological community structure. Sediment topography is the product of sediment structure and sediment transport 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.

4.2.5 Modifications as a result of human activities

Some of the main influences from human activities on the large shallow inlet and bay have occurred along the coastal area, primarily as a result of construction of hard structures such as shore defences, retaining walls and slipways. Quite a large proportion of the coastline of the bay has been affected by these modifications. Coastal construction, in particular coastal defence, has modified the bay communities through direct impact, and also through modifying coastal processes (hindering release of rocks and sediments from boulder clay cliffs, affecting sediment processes, altering the nature of the beach sediments and preventing natural evolution of the coastline in the longer-term (see also section 4.1.5)).

The gross structure, bathymetry, distribution and extent of the bay are not known to have been modified by human action. Tidal range and exposure to currents and wave action in the bay is predominantly unmodified by human actions except for localised influences in the vicinity of built structures.

It is believed that there has been relatively little modification of the overall sedimentology of the bay, and the seabed is considered to be relatively unimpacted by human activities. This is believed to be one of the main reasons why the area supports unusually species diverse and species-rich seabed

communities, including rarely recorded plant and animal species. Past and present use of mobile fishing gear is probably the main human activity that has occurred in the bay that would impact the nature of the seabed sediments. Whilst it is thought that there is only limited mobile fishing gear currently used within the bay, illegal fishing by scallop dredgers is a continued concern because of the large impact this form of fishing has on the seabed and its wildlife.

Trampling by people walking over some of the intertidal bay communities can be a problem if it is sustained over a period of time. There is impact from vehicles at Morfa Bychan (Black Rock Sands) which will result in compaction of the intertidal sediment communities – this impact is greatest in the peak holiday season. There is periodic use of vehicles on other intertidal areas of the bay, generally associated with coastal defence works. Careful planning of these works is required to avoid any potential impact on the bay communities. There have been a few instances of farmers dragging land ploughs through areas of intertidal sediment in the SAC to clean the plough blades.

Modification of suspended particulate concentrations is complex and influenced by several human activites (e.g. construction activities, dredging and land management practices). These are predominantly relevant to the near coast areas of the bay.

There are local reductions in salinity in the vicinity of freshwater run-off and streams crossing areas of intertidal bay, leading to variations in the local habitat and species diversity. There is potential for modification by watercourse diversion, abstraction and engineering.

The concentrations of major nutrients and contaminants within the coastal and open sea areas of the SAC are not believed to be above levels that would be of concern for the bay, but more information about the specific levels is required.

The degree to which bay species populations may have been modified or degraded by human activity is difficult to assess in any quantifiable way. Species subject to commercial and recreational exploitation may be depleted well below historical pre-exploitation levels; this is known to be the case for some species such as oysters and some elasmobranch species such as skates and rays and angel sharks. For most of these species there is very little stock data and so the scale of modification to the functioning of the bay ecosystems as a result of removal of these species is unknown and unquantifiable.

Overall habitat quality of the Pen Llyn a'r Sarnau SAC bay is considered to be high. Discarded and accidentally misplaced artificial materials are present in the bay and are most obvious in the intertidal. Generally the scale of this in the bay is considered to be relatively low, although high in certain areas (e.g. to the east of Criccieth). Lost and discarded fishing gear and persistent rubbish continues to form a physical hazard to many species and some are a source of chemical contamination.

4.3 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 eg. Devils Ridge, Bastram Shoal (Pen Llŷn) and Bais Bank (Pembrokeshire) and those that are less exposed to these conditions eg. 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 Pen Llŷn a'r Sarnau SAC are in the sandbank sub-type 'gravely and clean sands'.

4.3.1 Range

The subtidal sandbanks of Pen Llŷn a'r Sarnau SAC are the Tripods sandbank to the west of Braich Anelog, Bastram Shoal to the south of Bardsey Island and Devil's Ridge to the south east of Aberdaron Bay and also an area west of Barmouth, marked on charts as Four-fathom bank. The general location of the subtidal sandbanks is shown on map 3. The total extent of the subtidal sandbank feature in the SAC is estimated to be around 12,650 ha of which Tripods is around 443 ha; Bastram Shoal 2,775 ha; Devil's Ridge 1,651 ha; and Four-fathom bank 7,785 ha.

4.3.2 Structure and function

The existence of the subtidal sandbanks, their shape, size, and orientation, are predominantly the result of a combination of interactions between sediment supplies and hydrodynamic processes (tidal streams, water depth, wave action) operating since the end of the last ice age.

The Tripods is a linear sandbank, orientated in a north-south direction. At its base, the sandbank extends into waters around 25-30m and the shallowest part is around 10m. Bastram Shoal is more rounded in shape, and runs northwest-southeast in water depths of 6-30m Devil's Ridge is also relatively rounded in shape, and also runs northwest-southeast with a depth range of 8-25m. Four-fathom bank consists of a raised area, with two tails extending seaward, parallel to Sarn Badrig. The depth of this sandbank ranges from 6-15m.

Sandbanks exposed to stronger tidal and wave action like the Tripods are composed predominantly of coarser sediment compared to those in more sheltered conditions, such as Four-fathom bank. The sediments are mostly medium sands although the landward side of the Devil's Ridge sandbank and seaward side of Bastram Shoal have coarser sediments with a higher proportion of gravel. Four-fathom bank comprises fine sands.

The site includes examples of subtidal sandbanks subject to a range of exposures to prevailing winds, weather and tidal currents. On Devil's Ridge, Bastram Shoal and the Tripods strong tides mean that the sand, shell and gravel sediments are constantly shifting and, as a result, the sandbanks support animals that can tolerate these high levels of disturbance. The more mobile sediments on the upper parts of the sandbanks have relatively species poor communities whilst less mobile and more mixed sediments at the base of the sandbanks support more stable species-rich wildlife communities.

4.3.3 Typical species

The diversity and types of wildlife associated with subtidal sandbanks are determined particularly by the type of sediment together with a variety of other physical, chemical and hydrographic factors. They include burrowing animals such as worms, crustaceans, molluscs and echinoderms that live within the sandbank sediments and more mobile species such as shrimps, molluscs, crabs and fish that live closer to and on the surface.

Within the context of the Welsh SAC series relatively species rich communities have been recorded from the base of Tripods, Bastram Shoal and Devil's Ridge sandbanks. The finer sands of the less-exposed Four-fathom bank support different communities of echinoderms, molluscs, worms and crustaceans.

The millions of tiny microscopic animals that live in the small spaces between the sand grains are also part of the sandbank wildlife and are important in terms of the overall productivity of these sediment communities. Other animal species that live on or just underneath the sediment surface are part of a more mobile assemblage of wildlife. Where there are large stones in the sediment other animals such as hydroids may attach themselves to the surface of the sandbank. Subtidal sandbanks can be important nursery areas for fish, and feeding grounds for seabirds.

4.3.4 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.

4.3.5 Modifications as a result of human activity

There is no known evidence that the gross distribution or extent of subtidal sandbanks within the site, their size or morphology, nor the wave climate, tidal streams or sediment processes creating and maintaining them have been directly modified by human action. There is no history of sediment extraction from the subtidal sandbanks of the SAC nor disposal of sediment at or nearby the subtidal sandbanks and there are currently no known major impediments to the dynamic factors (physical, chemical and biological) that determine and maintain the sandbanks and their inherent variability. Modification of wave action as a result of anthropogenically-influenced climate change is considered likely to increase.

The degree of exploitation of fish populations associated with the sandbank in terms of its impact on their abundance and biomass is unknown.

There is however the potential for impacts on the subtidal sandbanks from activities that directly impact them and the wildlife species that are associated with them, or which affect the nature and distribution of the sediment forming the sandbanks.

4.4 ESTUARIES

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'.

The estuaries of the Pen Llŷn a'r Sarnau SAC are bar-built estuaries.

Estuaries are widespread throughout the Atlantic coasts of Europe, but approximately one quarter of the area of estuaries in north-western Europe occur in the UK.

4.4.1 Range

The estuary feature of the SAC comprises the three main bar-built estuaries situated along the Meirionnydd and Ceredigion coasts; the Glaslyn/Dwyryd estuary, the Mawddach estuary and the Dyfi estuary. Collectively they comprise about 2% of the UK's estuary resource. The location of the estuaries is shown on map 3. The boundary of the estuary feature also encompasses adjacent functional areas of sediment, such as sand dunes, that are considered to be an integral part of the functioning of the estuaries.

4.4.2 Structure and Function

The estuaries of the SAC are good examples of bar-built estuaries and exhibit an unusual and specific suite of physical and chemical conditions.

Sediment movement is a core process within each estuary with constant interchange and movement of sediment within the estuary and between the estuary and coastal and marine areas. Associated with each estuary is a sediment spit that extends from the south across the estuary mouth and an ebb tide delta (the 'delta' of sediment banks that forms just offshore from the estuary mouth). The sediments in the estuaries are derived primarily from marine sediments carried in by seawater. They are predominantly sandy and relatively mobile and have built up to a relatively high platform so that the

majority (80-90%) of each estuary dries at low tide, with only the main channel continuing to hold water. Across each estuary the average tidal range is probably around half of the quoted tidal range (which refers to the range at a specific point) as a result of the high level of the sediments. There is very little input of fine material into the estuaries via seawater or freshwater and as a consequence the expanses of estuarine sediment are dominated by coarser, sandier sediments. This is in contrast to many other estuaries in the UK (for example along the east coast of England) that have large expanses of muddy sediments. Even the muddy sediments of the Pen Llŷn a'r Sarnau SAC estuaries contain a relatively high proportion of coarser sediment.

The subtidal and intertidal sediments grade from clean sands near the entrance of the estuaries to mud or muddy sands in the sheltered extremes, particularly in association with salt marsh communities. Although the entrance of each estuary is exposed to prevailing winds, the bar at the mouth provides protection from wave action. All three estuaries are predominantly sandy-sandy/mud. Unusually for estuaries, there is also quite a lot of rocky habitat in each estuary. This occurs primarily as a thin band around the shore. Sediment movement within the estuaries and between the estuaries and Cardigan Bay and coastal habitats is vital if the estuaries are to be able to establish and maintain a dynamic equilibrium state.

The estuaries are located within mountainous, rocky catchment areas with only a thin layer of soil covering the surrounding land and relatively little in the way of discharges (industrial in particular) into the rivers and estuary. This provides a specific type of water flow profile (flood hydrograph) within each estuary and has a significant effect on the water and sediment chemistry, with little stratification of fresh and saline water.

The relatively low level of water retention by the catchment also means that the freshwater flow in the estuary can be very low during dry periods, raising an issue about possible concerns over water abstraction upstream and the potential impact of this on minimum water flows during dry periods.

The mountainous, rocky catchments result in rapid runoff of freshwater at times of high rainfall and a correspondingly large input of freshwater into the estuaries at these times in the form of rapidly flowing pulses of freshwater.

The mountainous catchments with little soil cover and the limited input of nutrients from industry mean that the background level of nutrients within each estuary is low, particularly in comparison to other estuarine systems such as on the east coast of the UK where more nutrient enriched catchments drain into the estuaries. However, this low background level of nutrients is likely to have been enriched from a lower background level in past times as a result of increases in the background levels of nitrous oxides and ammonia from sources such as atmospheric deposition on the surrounding land and increases in stocking levels, particularly of sheep, in the catchments.

The Dyfi is the most extensive of the three estuaries and exhibits a number of differences when compared to the other two estuaries. It has more muddy sediment habitat in its upper reaches than the Mawddach and Glaslyn/Dwyryd estuaries and slightly higher background nutrients levels as a result of a higher input of riverine sediment due to the larger river flow in the Dyfi and also as a result of the less mountainous catchment to this estuary which provides a greater opportunity for sediment (and nutrient) input.

4.4.3. Typical species

Similar marine communities have been recorded within each estuary, but there are also notable differences for example because of the different proportions of muddy and coarse sand, the extent of hard rock and the mobility of the sediment.

The more mobile sand in the mid and lower shores is characterised by small burrowing crustacea (amphipods and isopods such as *Erydice pulchra*). In some areas the sand is very soft and aerated,

supporting only burrowing amphipods and occasional bivalve molluscs. In the Mawddach and Glaslyn/Dwyryd mobile sand with the amphipods *Bathyporea* sp. and *Haustoriuous arenarius* characterises the more exposed mobile sand in the lower shore nearer the entrance to the estuary. Where there is less water movement (for example on the outside of meanders and 'blind' channels), well sorted fine sand with burrowing errant polychaete worms and the thin tellin shell *Angulus tenuis* occurs. Muddy sand in the mid shore of the estuaries is dominated by the lugworm (*Arenicola marina*) and bivalves such as the cockle *Cerastoderma edule*, the baltic tellin *Macoma balthica*, the sand gaper *Mya arenaria* and the thin tellin *Angulus tenuis*. Patches of muddy gravel in areas of increased water movement, for example on the outside of meanders, may be characterised by polychaetes and some oligochaetes. Clumps of the edible mussel *Mytilus edulis* have also been recorded from the mid shore on fine mud in both the Mawddach and the Dwyryd. In the upper estuary mobile sand a community of the amphipods *Bathyporea* sp. and *Corophium* sp. is common, whilst in the upper reaches of the estuaries, oligochaete worms are the main species present in the lower shore muddy sand and gravel habitats.

The thin band of intertidal rock which is most extensive in the Mawddach is dominated by yellow and grey lichens and the tar lichen *Verrucaria maura* at higher elevations with fucoid seaweeds (*Pelvetia canaliculata*, *Fucus* spp. and *Ascophyllum nodosum*) lower down. The brown seaweed *Fucus ceranoides* is also present, reflecting the reduced salinity of the estuaries. Lower shore rocky biotopes are not present due to the influence of the sand level. Large dense clumps of the edible mussel *Mytilus edulis* do, however, occur in the lower shore on rocky outcrops in the Mawddach and the Dwyryd.

Saltmarsh is present along the margins of each of the estuaries. Mature saltmarsh dominates the top of the shore while pioneer saltmarsh (*Salicornia* sp. and *Spartina* spp.) grows at the seaward edge. The extent of the saltmarsh varies within each estuary, and is greatest in the Dyfi where there are relatively large expanses of mature saltmarsh. Many of the channels within the saltmarsh, often in the lower and middle reaches of each estuary, are dominated by the polychaete worm *Hediste diversicolor* and the peppery furrow shell *Scrobicularia plana*. In the steep muddy banks adjacent to the saltmarsh a community made up of sparse polychaete and oligochaete worms and the amphipod *Corophium* sp. is often found. The Dyfi saltmarshes are notable for the variety and quality of their invertebrate fauna. Characteristic ground beetles such as *Bembidion laterale*, *B. minimum* and *B. iricolor* are present and the scarce scarabaeid *Aphodius plagiatus* is frequent amongst strandline debris. In addition, Roesel's bush -cricket occurs on the upper saltmarsh of the Dyfi, its only location in Wales.

Mobile animal species that form part of the estuary feature include crustaceans, such as crabs and shrimps, and many fish species (thirty species of fish have been recorded from the Dyfi estuary). The estuaries, in particular the saltmarsh creeks, form important nursery areas for different fish species; the three estuaries have been designated as nursery areas for bass *Dicentrarchus labrax*, and the Dyfi is also an important nursery area for mullet. The estuaries also act as essential migratory routes for salmon and sea trout as they make their transitions between fresh and salt water conditions.

The abundance of food provided by the sediment communities supports assemblages of different bird species that feed in and are dependant on the estuaries. The Glaslyn/Dwyryd estuary is nationally important for pintail and the Dyfi estuary is of international importance for its over-wintering population of Greenland white-fronted geese and supports a nationally important population of wigeon. Other species recorded from the estuaries include shelduck, red breasted merganser, teal, dunlin, redshank, oystercatcher and curlew.

The productivity of the estuaries is also important for two of the Annex II species, the otter and bottlenose dolphins. The estuaries are an important habitat for otters, providing food and access to freshwater. They also appear to be important for bottlenose dolphins with observations that these marine mammals frequent the areas just offshore of the estuary mouths, apparently engaged in feeding.

4.4.4 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, an 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, this would be considered coastal squeeze.

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.

4.4.5 Modifications as a result of human activity

Of all the features within the SAC, the estuaries have probably received the greatest degree of impact and physical modification from what might be considered their natural state in the absence of human interventions. This has affected other SAC features that are components of the estuaries (mudflats and sandflats, Atlantic salt meadow and *Salicornia* communities). Past and recent modifications have resulted in loss of estuary habitats, constraining the estuaries' functioning and ability to evolve. Any further constraints or modifications affecting the estuaries may further prejudice the condition of these features.

The modifications and interventions in the estuary systems have generally resulted in land take from each estuary, leading to loss of saltmarsh, swamp and transitional areas extending into brackish, maritime and freshwater habitats. This has in turn resulted in a reduction in tidal area within each estuary. The main causes have been construction of embankments, sea defence works and construction of land drainage schemes. Many of the historical impacts were as a result of the large scale construction of structures within and adjacent to the estuaries that hindered the movement of sediments, and/or reduced the area and shape of the estuaries. Examples include the construction of the Cob at Porthmadog, the railway bridge in the Mawddach and the railway embankment in the Dyfi. Flood embankments have also been constructed to protect agricultural land reclaimed from the estuary. This process of land reclamation started before the end of the 19th century and continued up until the 1980s in some areas. The network of banks has then been maintained and continues to

significantly affect the functioning of the estuaries. The Barmouth breakwater on the north side of the estuary was constructed relatively recently to improve navigation and shelter the harbour. This has restricted flows entering the Mawddach and is likely to have resulted in accretion upstream through the impact of this structure on the tidal prism of the estuary.

Restoration of the condition of at least part of the estuary feature is a realistic and positive aspiration in terms of the conservation management of the estuaries. As a general principle, a reduction in the artificial constraints (such as flood banks) on the tidal limits within the estuaries would provide opportunities for improving and restoring the condition of this feature. There is the potential to increase and re-establish estuary communities that have been reduced or lost to past interventions in the estuaries. Of the three estuaries of the SAC, the Mawddach and the Dyfi estuaries provide the greatest potential for restoration in terms of biodiversity benefits. In the light of predicted sea level rise and the potential inundation of coastal habitats (coastal squeeze), restoration may become more critical to the management of the SAC in order for this feature to be in favourable condition.

Past interventions in the estuaries of the SAC through human activities have resulted in the estuaries responding to re-establish their equilibrium. The Mawddach and Dyfi are believed to be close to their eqilibrium position in response to past modifications of the estuaries, but the Glaslyn/Dwyryd was subject to a much higher degree of intervention, principally through the construction of the Cob at Porthmadog, and this estuary system is still trying to re-establish its equilibrium position in response to these changes.

In the scenario of sea level rise, floodplains along the upper estuary will experience increased tidal inundation and change to saltmarsh. If the estuaries are not able to expand laterally as sea level rises (due to man-made or natural obstructions), it is likely that saltmarshes in the lower estuaries will increasingly be eroded with potential loss of this and other estuary habitats. Constraints on the estuary that prevent them from adapting to these predicted changes are a major issue in terms of the long-term management of the SAC to maintain the estuaries and their component features (mudflats and sandflats, Atlantic salt meadow and *Salicornia*) in favourable conservation status.

Land management practices in the catchment areas of the estuaries are of critical importance in terms of their impact on levels of suspended particulate concentrations and diffuse nutrients and pollutants entering the estuaries. Activities such as forestry and farming practices have an important influence on the rate of rainwater run-off and the levels of suspended sediment and diffuse inputs of nutrients entering the estuaries. For example, felling of trees in forestry areas in the catchments will affect the rate and sediment loading of run-off into the estuaries. It may also have a significant impact on flood events as a result of altering the ability of the catchment area to retain water in periods of heavy rainfall. Increased annual rainfall and frequency of intense rainfall also has an influence on the diffuse discharges into the estuaries. Relatively low nutrient status is an important characteristic of the estuaries. The influence of the land management practices and varying patterns of rainfall on this are not well understood in terms of their actual impact on the estuaries and their wildlife and further work is required in order to determine what this is.

Historical mining operations within the areas surrounding the estuaries have resulted in a legacy of some contaminated water discharging into the estuaries. There is no evidence that these are having an adverse impact on the estuary habitats and wildlife.

The degree to which species populations of the estuaries may have been modified or degraded by human activity is difficult to assess. Certainly some species that have been subject to commercial or recreational exploitation locally or further afield or have been impacted by land management practices may be depleted, e.g. salmon, sea trout, eel. The scale of modification to the functioning of the estuary ecosystems as a result of removal of these species is unknown. Additional information on the assemblage and populations of mobile species of the estuaries is required.

4.5 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 lagoons are identified as a priority Annex 1 habitat within the Habitats Directive.

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 seawater enters the inlet on each tide and salinity is usually high, particularly at the seaward part of the inlet.

4.5.1 Range

There is one coastal lagoon within the SAC, this is the Morfa Gwyllt lagoon on the south side of the mouth of the River Dysynni is the only saline lagoon on the Cardigan Bay coast. It is one of only four saline lagoons identified in Wales and the only example of a percolation lagoon in Wales.

4.5.2 Structure and function

The lagoon is the result of man-made changes to the shingle spit at the mouth of the Dysynni river that extended the existing shingle bar and retained a relict depression from the old river course that became established as the percolation lagoon. It is roughly oval in shape, covers approximately 0.25 ha and is shallow, with a maximum depth of 0.7 m (when surveyed in 1998), although the majority of the pool is around 0.25 m deep. Rainfall and seawater percolating through the shingle spit are the two sources of water and the amount held shows considerable seasonal variation. This in turn affects the maximum and minimum water depths and the lateral extent of the lagoon at different times of the year. The lagoon bed is a mosaic of medium sand over/amongst shingle, with muddier patches within the deeper pockets, and scattered larger pebbles. The sediments deposited within the lagoon basin are not very deep, providing little more than a veneer over the shingle in most areas.

The lagoon is protected from the seaward side by a bank of shingle. The structure of this bank and the adjacent beach is important since it allows the ingress of seawater through a slow process of percolation which is, as yet, not well understood, but allows the input of saline water to create brackish conditions in the lagoon. Rainfall has a large influence on the lagoon and during periods of high rainfall the lagoon water will have a lowered salinity.

4.5.3 Typical species

Due to the extreme nature of the environment that they provide, lagoons are stressed habitats, with typically reduced numbers of species and specialist fauna that are able to withstand the extreme conditions. Fourteen species have been recorded from Morfa Gwyllt, some present in very high abundance. Three of these are lagoonal specialists; the amphipod *Lekanosphaera hookeri*, the sea mat (bryozoan) *Conopeum seurati* and the green alga *Chaetomorpha linum*. These species are able to

tolerate the comparatively wide range of environmental parameters and the variation in these. Their survival is dependent on particular physical, chemical and biological conditions. *Conopeum seurati*, for example, requires a hard substrate of plant material, stone, wood or artificial substrata since it forms an encrusting colony over the surface.

4.5.4 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.

4.5.5 Modifications as a result of human activity

The Morfa Gwyllt lagoon a small, shallow lagoon in an easily accessible location and is sensitive to a number of direct and indirect human impacts.

Direct physical impact from motorbikes driving through the lagoon has been observed and motorbike tracks are often seen in the area around the lagoon. As well as the direct disturbance of lagoon habitat, this activity may destabilise the edges of the lagoon, potentially infilling the edges of what is already a very shallow basin. Although there is no direct freshwater or seawater inflow to the lagoon, potential sources of pollutants and enrichment are the motorbikes (hydrocarbons washing off the chain etc) and dog faeces (it is a very popular dog walking area). Cars and other vehicles used to have access to the shingle spit but this has been prevented in recent years through the placement of a series of large boulders blocking the entrance. The degree to which the species of the lagoon have been modified by human activity (in particular the use of motorbikes and dog fouling) is unknown, but a study in 2006 failed to find a number of species recorded in an earlier survey in 1998, this included the loss of one of the three lagoonal specialist species previously recorded.

Discarded debris and artifical materials are present in the lagoon. These form a physical hazard to some of the lagoon species (e.g. smothering of the bottom of the lagoon basin) and some are a source of chemical contamination, although some of these materials also provide an opportunity for colonisation by some of the lagoon species.

The lagoon is dependent on rainfall for its freshwater input. Anthropogenically influenced climate change may result in changes in the pattern and intensity of rainfall and periods of drought, which have the potential for a major impact on the water levels, salinity and water quality of the lagoon.

4.6 MUDFLATS AND SANDFLATS

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

The intertidal mudflats and sandflats of the SAC are present in two different situations (map 3):

- Within the three estuaries of the SAC (the Glaslyn/Dwyryd, Mawddach and Dyfi estuaries); and
- In fully marine open coast situations on moderately exposed and exposed sandy shores at Porth Dinllaen on the north Llŷn coast, along the south Llŷn coast between Pen-ychain and Criccieth and between Criccieth and Afon Glaslyn and along the Meirionnydd coast at Harlech and the mouth of the Mawddach and Dyfi estuaries.

4.6.2 Structure and function

The sediments within the estuaries and open coast intertidal areas are derived primarily from Holocene deposits which, in the case of the estuaries, have been infilling the estuary valleys since the end of the last ice age. The mudflats and sandflats continue to develop and be influenced by the physical forces influencing the movement and settlement of sediment.

The sediments of the estuarine mudflats and sandflats are unusual in that they are predominantly sandy and even communities typically associated with muddier sediments are present in sandier substrate in the estuaries. More mobile coarser sands representative of full salinity seawater are present at the mouth of each estuary and along the main estuary channel, grading into finer muddier sands and mud in more sheltered areas, with communities representative of freshwater conditions present in the upper reaches of each estuary. The level of nutrients within each estuary is also of note in that it is relatively low for an estuarine system, and this will influence on the nature of the biological communities that develop.

Outside of the estuaries, the mudflats and sandflats of the SAC are located around the coast in fully marine conditions (i.e. full salinity sea water) where the degree of wave exposure and exposure to tidal currents are the dominant physical factors influencing these habitats. As a result of the degree of exposure to wave action at these locations, the open coast intertidal mudflats and sandflats are characterised by sandflat communities with fewer muddier sediment communities present.

4.6.3 Typical species

The intertidal mudflat and sandflat communities present in the estuarine and open coast areas are largely determined by the physical nature of the available sediment and the influence of the prevailing physical conditions such as the degree of exposure to wave action and tidal currents and the salinity regime of the surrounding water. Within the estuaries the distribution of the mudflat and sandflat sediment communities reflects the continuous gradient of exposure of different parts of the estuary to these conditions; communities representative of freshwater conditions are present in the upper reaches of each estuary and and those representative of fully saline conditions are present near the estuary mouth. Outside of the estuaries the degreee of exposure to wave action and tidal currents are the main factors determining the distribution of the different sediment communities of the open coast mudflats and sandflats. The open coast intertidal mudflat and sandflat communities are found on shores that are exposed or moderately exposed to wave action with more mobile sediments and fewer types of marine communities present as the degree of exposure increases

Similar marine communities have been recorded within each estuary, but there are notable differences between them. In the more mobile sand in the mid and lower shores of the estuaries, the communities are characterised by small burrowing crustacea (amphipods and isopods such as *Eurydice pulchra*). Where the sand is very soft and aerated, only burrowing amphipods and occasional bivalve molluscs are present. In areas with less water movement (such as on the outside of meanders and 'blind' channels), fine sand with burrowing polychaete worms and the thin telling shell *Angulus tenuis* occurs. The mid shore of the estuaries is dominated by the lugworm (*Arenicola marina*) and bivalves such as the cockle (*Cerastoderma edule*), Baltic tellin *Macoma balthica*, sand gaper *Mya arenaria* and the tellin *Angulus tennuis*. Patches of muddy gravel, which are usually in areas of slightly increased water movement, may be characterised by polychaete and oligochaete worms. Clumps of mussels *Mytilus edulis* have been recorded from the mid shore on fine mud in all three estuaries.

The saltmarsh channels, particularly in the lower and middle reaches of the estuaries, are dominated by the polychaete worm *Hediste diversicolor* and the peppery furrow shell *Scrobicularia plana*. In the steep muddy banks adjacent to the saltmarsh, a community made up of sparse polychaete and oligochaete worms and the amphipod *Corophium* sp. is often found. In the upper reaches of the estuaries, oligochaete worms are the main species present in the lower shore muddy sand and gravel habitats. Mobile sand in the upper estuary is commonly populated with a community of amphipods *Bathyporeia* sp. and *Corophium* sp.

Outside of the estuaries, the open coast intertidal mudflats and sandflats are characterised by sandflat communities with fewer muddier sediment communities present. The upper part of the open coast shores generally supports relatively species poor areas of sand and shingle often with a strandline community of sandhoppers (amphipods such as *Talitrus saltator*) where decomposing seaweed accumulates on the upper shore. The mid and lower shore sandflats support communities of burrowing amphipod crustaceans such as *Bathyporeia* spp. and *Eurydice pulchra* together with a variety of burrowing polychaete worms such as the lugowrm *Arenicola marina*, catworm *Nephtys cirrosa* and other polychaete worm species. In areas more exposed to wave action these mid and lower shore communities differ in terms of the number of amphipod and polychaete worm species that they support (the more exposed sandflats support more amphipod species and fewer polychaete worms). Patches of sand mason worm *Lanice conchilega,* which can be identified by the tubes that the worms make using sand grains and which stick up above the sediment surface, are also found on the moderately exposed sand shores on the lower shore or waterlogged areas in the mid shore.

In more sheltered areas, fine sediments have a chance to settle out producing muddier sand habitats. In these areas other communities develop that are dominated by lugworm and other polychaete worms together with bivalve molluscs such as the Baltic tellin *Macoma balthica*. On the lower shore in these muddier sediments, communities of sea potato sea urchin *Echinocardium cordatum* and bivalve

molluscs are present, generally in the lower shore areas of coast that have a slightly greater degree of shelter. Also, patches of the marine flowering plant sea grass *Zostera marina* are present in sheltered areas on the lower shore of the open coast sandflats at Porth Dinllaen, Afon Wen and east of Criccieth.

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

The mudflats and sandflats in the estuaries have been modified by the same past and present human activities as for the estuaries (see section 4.4.5). Existing data indicates that the extent of the mudflats and sandflats in the estuaries is declining as a result of accretion that is favouring an increase in saltmarsh, particularly the pioneer *Salicornia* saltmarsh communities. There will be natural fluctuations in the relative extent of each of the estuary habitats, but constraints on the functionality of the estuarine systems preventing their development and expansion in response to sea level rise means that the rate of decrease of some of the habitats will be abovee that which would be expected within the context of natural change. Ultimately it could lead to substantial losses of some of the estuary habitats such as mudflats and sandflats. Localised damage to the mudflats in the estuaries has occurred due to use of vehicles (primarily ATV's) generally by people seeking access to harvest shellfish in the estuaries.

Due to the intertidal location of the mudflats and sandflats along the open coast, the main influences are from human activities in the coastal area. The overall distribution of mudflats and sandflats in open coast and their exposure to tidal range, currents and wave action and the broad scale sediment processes are not known to have been modified by human action, except perhaps some modification of localised influences in the vicinity of some built structures.

Some of the open coast mudflats and sandflats are present in areas where structures such as shore defences, retaining walls and slipways have been constructued. Coastal construction, in particular coastal defence, has modified the mudflat and sandflat communities in a few locations in the SAC through direct impact, and also through modifying coastal processes (hindering release of rocks and sediments from boulder clay cliffs, affecting sediment processes, altering the nature of the beach sediments and preventing natural evolution of the coastline in the longer-term (see also section 4.1.5)).

Aside from the influence of coastal constructions on sedimentology, it is believed that there has been relatively little modification of the overall sedimentology of the open coast mudflats and sandflats.

Modification of the extent and quality of the seagrass/eelgrass (*Zostera marina*) beds has been recorded at Porth Dinllaen due to trampling, use of vehicles on the beach and boat moorings. The degree of impact varies seasonally, with greatest use of the beach area where the eelgrass extends into the intertidal in the summer. There is seasonal impact on sandflats at Morfa Bychan (Black Rock Sands) from vehicles on the beach. This causes compaction of the intertidal sandflats, with the impact being greatest in the peak holiday season. There is periodic use of vehicles on other open coast sandflats, generally associated with coastal defence works. Careful planning of these works is required to avoid any potential impact on the mudflat and sandflat communities

The concentrations of major nutrients and contaminants within the coastal sea areas of the SAC are not believed to be above levels that would be of concern for the open coast mudflats and sandflats, but more information about the specific levels is required.

The degree to which species populations of the intertidal mudflats and sandflats may have been modified or degraded by human activity is difficult to assess because of the paucity of biological time series data and, to some extent, information on the distribution and intensity of human activities. The species of the open coast mudflats and sandflats have been less subject to commercial or recreational exploitation compared to some of the other SAC features.

4.7 ATLANTIC 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.

There is a variation in the plant communities from the lower reaches of the saltmarsh to the most inland limits. At the lower reaches of the saltmarsh the vegetation is often naturally species-poor and may form an open sward of common saltmarsh-grass *Puccinellia maritima*. Further up the marsh, the vegetation becomes herb-dominated and red fescue *Festuca rubra* becomes more important. The upper saltmarsh shows considerable variation, particularly where there are transitions to other habitats. Communities present may include tussocks of sea rush *Juncus maritimus* dominating a herb-rich vegetation, and saltpans supporting patches of species-poor vegetation dominated by saltmarsh flat-sedge *Blysmus rufus* (in the north) or slender spike-rush *Eleocharis uniglumis*.

There may be transitions from upper saltmarsh to a number of habitats, including sand dune, machair, coastal shingle, freshwater marshes and woodland. This part of the saltmarsh succession has been particularly vulnerable to destruction by enclosure, usually involving the erection of a sea bank to exclude sea water, and remaining areas are regarded as particularly important for biodiversity conservation.

4.7.1 Range

The Atlantic salt meadow within the SAC is located within the estuaries of the Meirionnydd and Ceredigion coasts: the Glaslyn/Dwyryd, Atro, Mawddach and Dyfi estuaries. The most extensive areas occur in the Dyfi Estuary with over 380 ha, whilst the greatest variety of vegetation types occurs in the Mawddach Estuary.

4.7.2 Structure and function

Atlantic salt-meadow is dependent on environmental processes in the main body and waterway of the estuaries. 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 muddy sand, although the sandy nature of the estuaries means that the muddy substrate is very sandy in nature. A range of Atlantic salt-meadow geomorphology and topography is present with the overall shape determined by the morphology of the estuaries. This is locally influenced by the presence and morphology of rock out crops and wide intertidal sediment flats.

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 the estuaries, and local topography, hydrodynamics and proximity to drainage

channels. Sediment inputs, suspended sediment in the water column 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.

4.7.3 Typical species

The saltmarsh communities of the Atlantic salt meadow vary from transitional low marsh vegetation to extreme upper marsh vegetation often dominated by sea couch *Elytrigia atherica*. In total these saltmarshes have zonations which include some seven different communities.

These Atlantic salt meadows are typically characterised by the presence of common saltmarsh-grass, but may also include areas characterised by other common saltmarsh species such as red fescue, sea aster or sea rush. Apart from the seaward pioneer zone of *Salicornia* and other annuals, the Atlantic salt meadow feature constitutes all of the middle and upper saltmarsh communities, and may be divided into several different zones. There are also important transition zones into other habitats such as mires, swamps and sand dune.

A number of unusual communities and species are present in the Atlantic salt meadow. The SAC includes the rare *Eleocharis uniglumis* (slender spike-rush) saltmarsh community which occurs locally along the west coast from the Dyfi Estuary northwards. The Atlantic salt meadow also provides habitat for a variety of rare or uncommon plant species such as sharp rush, spiral tasselweed, lax-flowered sea-lavender, dwarf spike-rush and Welsh mudwort.

Grazing by domestic stock plays a significant role in determining the character of this saltmarsh. Some areas are lightly grazed and have good vegetation structure. These may be important for breeding waders. Other areas are more heavily grazed creating stands of short turf that can form important feeding areas for wildfowl. Wintering waterfowl populations create ecological effects through grazing, nutrient enrichment, trampling effects on vegetation and sediment substrate and seed redistribution.

4.7.4 Natural processes

The location, character, and dynamic behaviour of saltmeadows are 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 and 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 are 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.

4.7.5 Modifications as a result of human activity

The Atlantic salt meadow is influenced by the same past and present human activities (land claim and development) as the estuaries of the SAC (see section 4.4.5). There will be natural fluctuations in the relative extent of each of the estuary habitats, but constraints on the functionality of the estuarine systems preventing their development and expansion in response to sea level rise means that the rate of decrease of some of the habitats will be above that which would be expected within the context of natural change. Ultimately it could lead to substantial losses of some of the estuary habitats such as Atlantic salt meadow.

The presence of man-made structures along the landward sides of the estuaries has modified the zonation of the Atlantic salt meadow and the presence and extent of transition communities of upper saltmarsh into other habitat that would be expected to be present in the absence of such barriers.

Much of the Atlantic salt meadow is grazed primarily by sheep and cattle. In the Dwyryd estuary this has reduced the quality of the Atlantic salt meadow communities in specific locations, probably as a result of localised over-grazing.

Localised damage to Atlantic salt meadow communities has occurred as a result of use of vehicles (primarily ATV's) generally by people seeking access to harvest shellfish in the estuaries.

4.8 *SALICORNIA* AND OTHER ANNUALS COLONISING MUD AND SAND FEATURE

Salicornia and other annuals colonising mud and sand are defined in the EU Habitats Interpretation Manual as;

"Formations composed mostly or predominantly of annuals, in particular Chenopodiaceae of the genus *Salicornia* or grasses, colonising periodically inundated muds and sands of marine or interior salt marshes. *Thero-Salicornietea, Frankenietea pulverulentae, Saginetea maritimae.*"

This form of saltmarsh is widely distributed throughout coastal areas of the EU. In the UK it is widespread in the saltmarshes of England and Wales, but the area of this habitat type is restricted in Scotland and Northern Ireland because of a lack of new sediment for saltmarsh development. There is much less variation within this habitat type compared with the Atlantic salt meadow habitat and, in the UK, *Salicornia* and other annuals colonising mud and sand encompasses four different plant communities.

4.8.1 Range

Salicornia pioneer saltmarsh communities colonise intertidal mud and sandflats in areas protected from strong wave action. It is an important precursor to the development of more stable saltmarsh vegetation. *Salicornia* and other annuals colonising mud and sand develops at the lower reaches of the saltmarsh where the plants are frequently flooded by the tide. It can also colonise open creek sides, depressions or pans within saltmarshes, as well as disturbed areas of upper saltmarsh.

Within the SAC, the *Salicornia* and other annuals saltmarsh communities are present as a pioneer zone on the marine fringe of saltmarshes in the Glaslyn/Dwyryd, Artro, Mawddach and Dyfi estuaries and fringing part of Tremadog Bay. The largest proportion of this feature occurs in the Dyfi estuary.

4.8.2 Structure and function

Salicornia grows on a wide variety of marine sediments in intertidal habitats, ranging from gravels and shelly sands, through silts to fine clays, and is invariably associated with saline, brackish or alkaline substrates. Although an early colonist of soft, unconsolidated sediments, the densest stands tend to be on firm silts and clays. The substrates of *Salicornia* span the tidal range and are often waterlogged for much or all of the time, depending on elevation and drainage condition so plants may be shallow rooted. One consequence is that tidal flow, perhaps associated with scouring of the sediment and wave action, can be a major source of mortality for *Salicornia* seedlings at lower elevations on a saltmarsh.

Salicornia is extremely tolerant of regular flooding although growth of *S. europaea* is reduced by cultivation under continuous water-logging, in comparison with free drainage at the same salinity. As a halophyte, *Salicornia* is tolerant of exceptionally low water potentials in its root environment, whether they arise from salinity, drought or a combination of both.

Individual populations and taxa of *Salicornia* may be very sensitive to elevational variations associated with microtopography on the gradient from land to sea of tidal saltmarshes. Populations on the lower shore need to be more tolerant of prolonged submergence, tidal scour and water-logging, whereas those at high elevations may experience hypersalinity in summer.

In temperate regions the growing season is generally 7-8 months, and the *Salicornia* is typically a summer-annual. Flowering occurs mainly from mid-August to mid-September and seeds reach maturity from then falling out of the dead or dying parent plant although some may remain in situ for germination the following spring. Germination tends to coincide with low sediment salinities in winter in Britain. Characteristically lower-marsh populations, such as *S. europaea*, tend to germinate earlier than upper marsh ones, e.g. *S. pusilla*.

The lower limit of establishment of *Salicornia* on saltmarshes often appears to be set by the time necessary for the seedlings to penetrate the sediment and develop a ring of roothairs, in order to become fully anchored. A threshold period of tidal exposure of 2-3 days for rooting sufficient to resist tidal action on the low part of an estuarine marsh has been suggested.

4.8.5 Modifications as a result of human activity

The *Salicornia* communities are influenced by the same past and present human activities (land claim and development) as the estuaries of the SAC (see section 4.4.5) and the Atlantic salt meadow (see 4.7.5). Existing data indicates that accretion in the estuaries is favouring an increase in the extent of the saltmarsh communities, particularly the pioneer Salicornia communities, at the expense of the mudflats and sandflats. There will be natural fluctuations in the relative extent of each of the estuary habitats, but constraints on the functionality of the estuarine systems preventing their development and expansion as sea level rises means that the rate of decrease of some of the habitats will be above that which would be expected within the context of natural change. Ultimately it could lead to substantial losses of some of the estuary habitats such as the pioneer *Salicornia* saltmarsh.

There has been modification of the zonation of the saltmarsh communities of the SAC. At the landward edges of the estuary this is mainly due to the presence of man-made structures inhibiting lateral expansion of the saltmarsh. In the case of the Salicornia communities it is thought that grazing pressure may also be a contributory factor.

Localised damage to *Salicornia* communities has occurred as a result of use of vehicles (primarily ATV's) generally by people seeking access to harvest shellfish in the estuaries.

4.9 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 vary considerably depending on the structure and extent of the caves system, their degree of submergence and of exposure to scour and wave surge, as well as water clarity and the nature of their geology. 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.

4.9.1 Range

Within the SAC, sea caves are present around Pen Llŷn including the Tudwal Islands and also along the Merionnydd coast north of Tonfannau and the Ceredigion coast north of Clarach. The main locations where sea caves have been recorded are shown on map 3.

Fully intertidal caves are present in the bedrock cliffs from Porth Towyn on the north-west side of Pen Llŷn to Clarach Bay north of Aberystwyth. Most caves in the SAC have an intertidal portion with varying proportions remaining permanently below sea level (e.g. St Tudwal's Islands) or, more unusually, are fully subtidal throughout (such as the subtidal tunnel at Pen y Cil). Between Aberystwyth and Tywyn the caves are predominantly in the intertidal, whilst around Pen Llŷn the caves have both intertidal and subtidal elements and are increasingly exposed to wave and tide energy towards the end of the peninsula and Bardsey Island. Those caves with both intertidal and subtidal parts support a large variety of cave wildlife communities because of the more varied cave habitats that they provide.

4.9.2 Structure and function

Sea caves are formed where the specific geology of an area allows for the weathering and erosion of material to create overhangs, clefts, caves and tunnels that provide very specialised conditions for marine animals and plants. The geology of the SAC is complex and the variety of rock types and other geological features such as folding, fracturing and faulting and erosion have provided the basis for the formation of a wide variety of cave types. They have differing morphology and are exposed to varying degrees of wave action, tidal streams and scour from sand suspended in the water and stones/rocks on the cave floors. The inventory of sea caves of the SAC is incomplete but current information has identified cave types within the SAC that vary from small clefts in the rocks to tunnels whilst others are deep caves extending over 100m into the rock face.

A high proportion of caves are intertidal or in shallow water. These caves often experience conditions of strong wave surge and the base of the cave is usually composed of some sort of coarse sediment, rounded cobbles and/or boulders. Caves that occur in deeper water tend to be subject to less violent water movements from the surrounding sea and silt may accumulate on the cave floor.

4.9.3 Typical species

The wide spectrum of sea cave habitats in the SAC (spanning the intertidal and subtidal zones and exposed to a variety of physical (e.g. light, wave energy, scour) and chemical (e.g. rock type) gradients) means that almost all known sea cave communities have been recorded from somewhere in the site.

Thirty biotopes have been recorded from the sea caves of the SAC. These range from scoured sparse communities characterised by lichens, red seaweed (such as the sand-binding seaweed *Audouinella purpurea*), and molluscs grazing on biotic films (e.g. at Porth Towyn, Trwyn Cilan, Black Rock, Rhoslefain, and Clarach) to those rich in seaweeds, sponges, anthozoans and sea squirts (e.g. at Porth Llanllawen NE of Bardsey Sound, Ogof Deuddrws at Aberdaron, and East St Tudwal's Island).

In caves with both intertidal and permanently submerged subtidal portions (e.g. St. Tudwal's Islands) and those fully subtidal (e.g. tunnel at Pen-y-Cil), communities present include distinct local variations of tide-swept communities rich in sponges, hydroids and ascidians, scoured sparse communities of calcareous tubeworms, and communities typical of surge gullies that experience strong and violent water surge. Some of the caves that have been surveyed near Hell's Mouth, St. Tudwals Islands and at Bardsey Island support particularly extensive examples of cave communities. These include dense communities of baked bean sea squirts *Dendrodoa grossularia*, the white lacy sponge *Clathrina coriacea* and the oaten pipes hydroid (sea fir) *Tubularia indivisa*.

The larger caves in the area (those surveyed near Hell's Mouth, St Tudwal's Islands and Pen y Cil) exhibit gradients of environmental facts – vertically from intertidal to subtidal, and horizontally from the sunlit entrances to shaded and permanently dark rears. Gradients of scour, water movement and rock type also influence the layout of different wildlife communities inside the caves. With this variety of sub-habitats and communities these caves also tend to be those with greatest species richness. Species include ephemeral and robust colonisers such as calcareous tubeworms to dense turfs of filter feeding sea squirts and hydroids, and long-lived sponges and cup corals.

The sea caves of the SAC are also home to a number of species that are considered to be rare or scarce in a UK context or are present in unusually high abundance These include three sponge species (*Stelletta grubii*, *Stryphnus ponderosus, Thymosia guernei)*, an anemone *(Epizoanthus couchii)*, a cup coral (*Caryophyllia inornata*), a mollusc (*Otina ovata*), a sea squirt (*Polysyncraton lacazei)* and a red seaweed *(Schmitzia hiscockiana)*.

The shingle and rock 'beaches' that form at the back of some of the sea caves are important as seal haul-out and pupping areas in this SAC.

4.9.4 Natural processes

Cave morphology and topography is strongly determined by the underlying geology and erosion processes and has an important influence on the qualities of the cave rock 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 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.

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.

4.9.5 Modifications as a result of human activity

The distribution and extent of the sea caves are determined by the underlying geology and geomorphological processes that have created the caves. Human activity has modified the distribution and extent of the intertidal sea caves as a result of intentional and consequential, partial or complete unfilling of caves as part of coastal defence works and foreshore development. The main area where this has occurred is along part of the Meirionnydd shore where past coastal defence works to safeguard part of the Cambrian coast rail line have resulted in infilling and permanent loss of some of the intertidal caves. Such modifications are not known for those sea caves that are partially or wholly permanently submerged.

There has been localised damage to some of the intertidal sea cave communities at Morfa Bychan (Black Rock Sands) as a result of people scraping off the marine life from the cave walls (rock graffiti). These sea caves are the most easily accessible caves in the SAC and therefore most vulnerable to this sort of disturbance. Other than this localised example, there is no known evidence to suggest that the viability of species populations in sea caves within the SAC has been modified by human action. There is little or no modification of water movement patterns into and within the sea caves.

There is no known evidence of human activity having restricted physical access by grey seals to sea caves, other than possible temporary inhibition caused by human presence.

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 mean that materials such as lost and discarded synthetic fishing gear and other durable rubbish is retained 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 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, coast protection or construction operations.

Intertidal sea cave caves are exposed to groundwater seeps and these are strongly influenced by agricultural or other management practices on overlying land surfaces. There is no evidence that this is currently having an adverse impact on sea caves of the SAC.

The status of biological interactions structuring the ecology of cave communities is poorly known. Other than the specific examples described above, 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 some typical species of the sea cave feature may be depleted with respect to historical levels.

4.10 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. Globally, there are three reproductively isolated stocks of grey seal: a west Atlantic (northern North America) stock, a Baltic stock and an East Atlantic stock that extends from Iceland and northern Norway southwards to northern France, with the majority breeding around Great Britain and Ireland. At the start of the 2000 breeding season, Great Britain held some 124,000 grey seals, with a further 300-400 found around the Isle of Man and Northern Ireland.

The UK clearly has a special responsibility to protect the grey seal and the selection of SACs has taken account of this. The largest breeding colonies, based on pup production, have been selected, but also sites have been selected to ensure coverage of the geographical range of breeding in the UK. While the SAC series makes a contribution to securing favourable conservation status for this Annex II species, wider measures are also necessary to support its conservation in the UK.

4.10.1 Population dynamics

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 grey seals of the Pen Llŷn a'r Sarnau SAC may be part of the west Wales breeding population.

Grey seals present within the SAC at any one time are thought to be a part of a wider North Wales population. It is not known at present to what extent they form a discrete colony as part of the larger assemblage of seals found in Pembrokeshire (and whether this assemblage is a discrete Welsh population), or whether they form part of a larger population, for example distributed throughout the Irish Sea.

It is believed that the persistent breeding individuals in the SAC are part of a wider population that extends to southwest Wales and to the southeast and eastern Irish coasts, and possibly extends beyond the Irish Sea. It is likely that there are occasional but as yet unquantified migrations to and from populations further afield. Recent tracking data (from a study using satellite tags to track seal movements and diving behaviour) show that seals moved from haul out sites on Bardsey Island and West Hoyle Sandbank to the east coast of Ireland, Inner Hebrides, and Pembrokeshire.

Population size is determined by a complex of density-dependent and independent biological processes, including physiological health, reproductive success and the carrying capacity and quality of the habitat. The fact that grey seals are wide ranging and are thought to inter-mix makes it very difficult to estimate seal numbers in the SAC (and outside of the SAC) with confidence. In 2002 grey seal numbers were tentatively estimated at 365 based on pup data and calculations. However, the number of grey seals present in the waters of North Wales at all haul-out sites was, at all times, greater than this, with no less than 700-750 seals in winter and the maximum figure (June, July, August) at around 1100. This reflects the extent to which seals circulate around the Irish Sea and perhaps beyond. The southwest Wales (Pembrokshire and surrounding islands) grey seal 'population' size, determined from pup production estimates, is approximately 5000 individuals.

The Pen Llŷn and Bardsey Island grey seal 'population' is the largest breeding colony in the north of Wales. The SAC contains a number of important pupping sites for the grey seals concentrated around the north-west of the SAC including Bardsey Island.

The reproductive capability of the grey seals of the SAC is unknown. Population estimates derived from pup production information assume a fixed ratio of pupping females : population size ratio. As described above, there is currently only limited information available on annual pup production within the SAC.

The main period of pup production in North Wales is in September to October, but with some activity from early August to the end of November. The average number of births annually within the site is not known with any accuracy. A study of pupping sites from Aberystwyth to the Dee recorded a total of 103 pups born in 2001-2002 and 110 pups born in 2002-2003 of which the greatest number (67 pups) were born within the SAC on south west Pen Llŷn and Bardsey Island. A previous pup production study in 1974 estimated annual pup production at 55. Since then, pup production has been recorded annually only at Bardsey Island, where a slow rise appears to have been observed during the past decade.

The rate of pup survival to weaning in the SAC and throughout north Wales is not known. For the west Wales population this typically ranges from 70% to over 90%. On average, one pup in five dies during the first three weeks from natural causes such as desertion, disease or physical injury; between about a half to two thirds survive their first year.

The age frequency and sex ratio of the grey seal population in the SAC is unknown. It has been suggested that North Wales is an important area for female grey seals year round. The Tudwals area has, for the most part, been recorded as being almost exclusively used by females while at Rhosgor, on the north coast of the Llŷn, females comprised 75% of all seals counted. In general, males rarely comprise more than 25% of any assembly in the SAC. At no locations in the SAC or in North Wales are juveniles a major component of the seal assemblies. The highest numbers (but not percentages) of juveniles were recorded in the assemblies using Bardsey Island. At four sites (Gwylans Coast, Ynys Arw/North Stack Coast, Trwyn y Gader/Carmel Head and Trwyn Cilan) pups form a high percentage of the total number of seals counted through the year, indicating that these locations are heavily used during the breeding season but little outside that time.

The physiological health of the grey seals in the SAC (and wider west Wales population) is unknown. The very limited *post-mortem* data available does not suggest that the physiological health of grey seals in this part of the UK is being adversely affected by any specific pollutants or diseases. A range of viral, bacterial and parasitic diseases are known to be endemic within seal populations but appear to have limited effect on healthy, unstressed, adult seals. Disease probably exerts a (density dependent) population control mechanism. There have been no records of phocine distemper epizootic (PDV) virus in North Wales' seals, and their physiological health as a regional group is presumed good/intact.

4.10.2 Range

As highly mobile predators, seals are widely distributed within (and travel beyond) the site. Only their pupping, haul-out and regular moulting sites may be determined with any precision. Grey seals range throughout the open coast areas of the site, but are more commonly observed within the SAC around the Llŷn, Bardsey Island and the islands along the south Llŷn coast. Recent tracking studies showed wide ranges for individual seals from Northern Irish Sea to SW England.

Seals haul-out singly and in small groups in undisturbed locations throughout the site with some overlap of pupping and non-pupping haul-out sites. Most pupping takes place in the northwest of the SAC and around Bardsey Island in suitable habitat (i.e. physically accessible to the seals, remote and/or undisturbed rocky coast beaches, coves and caves). A high proportion use sea caves in the SAC for pupping. This is similar to the situation in west Wales where secluded coves and caves are used for pupping. This is an unusual variation in breeding behaviour compared to elsewhere in the UK where large 'rookery' congregations of pupping females form on open sites.

Moulting and resting haul-out sites are distributed throughout the SAC and non-pupping seals are present year-round at these haul out sites. Frequent counts indicate a great deal of variation throughout the year. On Bardsey Island, for example, numbers of hauled out seals varied from 20 to 228 on the 25 September 2002 and 30 July 2003 respectively. A study of grey seal movements at sea

generalised that seals spend a high percentage of time at or near haul-out sites, taking short trips to local offshore foraging areas and conducting dives to the seabed as well as travelling long distances.

The number of seals assembled ashore is generally greater in the summer months for the North Wales region as a whole and locations within the SAC such as Bardsey Island. In contrast much more intensive use is made of the islands off the east coast of Anglesey in the winter than in summer. Use of Bardsey Island and the West Hoyle Sandbank rises to a peak in the summer months; counts of adults at haul out sites on Bardsey Island were at a maximum of 228 in July 2003; winter counts here showed up to 107 seals in November 2002. Smaller but regionally significant assemblies of seals were counted at the Tudwals Islands (up to 66 in August 2002) and the Gwylans coast from Carreg Chwislen to the Gwylan Islands (up to 42 in December 2002). The largest north Wales haul out site, however, is located outside of the SAC at the West Hoyle Sandbank.

4.10.3 Supporting habitat and species

Grey seals require feeding, pupping, moulting and resting haul-out habitat but the exact habitat requirements of the grey seal are unknown as seemingly suitable habitat is often not occupied by seals. Within the SAC and elsewhere in North Wales they use intertidal rocky outcrops, rock and boulder/cobble beaches, sea caves that are tidally exposed, and occasionally sandy beaches and tidally exposed sandflats. Grey seals are assumed to feed throughout the site and some are known to make long foraging trips offshore to deeper waters from south through southwest to northwest off the Pembrokeshire coast.

For north Wales in general and specifically within the SAC, sea caves are a major supporting habitat with approximately 67% of seals pupping within caves during 2002 and the remainder being born on beaches . The non-pupping haul out sites are concentrated around the NW of the SAC and include Bardsey Island. Preferred pupping sites are those with maximum seclusion (isolation from disturbance), shelter from heavy wave action and all-tide access by females.

Moulting and resting haul-out sites are distributed throughout the SAC and seals are present year-round at these haul out sites (non-pupping). Details of the moulting / resting haul-out habitat requirements are not known precisely, but habitat that is understood to be suitable is extensive throughout the northwest part of the SAC in particular, and is assumed to be adequate.

Grey seals forage underwater, and feed on a wide range of fish species as well as crustaceans and molluscs. Their feeding habits in north Wales are unknown, but there is no reason to assume that they differ significantly from grey seals in other locations. The diet of grey seals in west Wales for example, is known to be highly varied and assumed to be a reflection of local prey availability.

4.10.4 Modifications as a result of human activity

One of the key considerations for the conservation of the grey seal within the SAC specifically, and as part of an extended population in North Wales and beyond, is disturbance of breeding and haul-out sites by human activity. With very few exceptions, seals within the SAC choose to haul-out on rocky shores or in sea caves currently remote from access by humans. In areas that have a high incidence of human influence through coastal walking, boating, fishing or other activity, the grey seal is generally not present where it may once have been. Other issues relate to entanglement and incidental capture of seals in line and netting, pollution and reduction or changes in food availability.

Grey seals inhabit and are adapted to an inherently harsh environment. However, artificially introduced hazards and reductions in the natural quality and suitability of the grey seal habitat in the SAC can occur through:

- the presence and persistence of artificial inert or toxic materials (e.g. plastics, synthetic fibres, hydrocarbons) causing entanglement, smothering or ill-health;
- a decrease in seclusion because of noise and visual disturbance;
- competition with human activities for space causing displacement, collision, noise and visual

disturbance and increasing density dependent pressure on sites and increased stress rendering animals susceptible to the effects of normally dormant endemic viral diseases;
- contamination of prey.

There has been a very considerable decline in commercial fish stocks over the last two centuries, and particularly in the last 50 years. However, the current stock status of likely prey species of grey seal in Wales is generally unknown. It is not known whether seals taking prey from commercial fishing gear, aquacultural operations or at fish concentration points (e.g. fish passes) is opportunistic exploitation or an indicator of increased energy/economic costs of catching free-ranging prey.

As a top predator, seals are prone to accumulation of contaminants present within their food chains, particularly those that are persistent and those that tend to bioaccumulate and biomagnify. Frequency and magnitude of contamination of prey is unknown, but the limited post mortem data for seal contaminant burden appears to indicate that at least some of the prey is contaminated with persistent pollutant. However, the quality status of likely prey species is generally unknown.

4.11 BOTTLENOSE DOLPHIN *TURSIOPS TRUNCATUS*

Bottlenose dolphins (*Tursiops truncatus)* are a cosmopolitan species, widely distributed in a range of mainly nearshore coastal habitats from tropical to temperate seas, in sheltered and exposed areas of estuaries, lagoons, continental coasts, and also in pelagic waters offshore and around oceanic island coasts. They have a near-global distribution (except the polar regions) and are widely distributed in North Atlantic, West African, Mediterranean and UK waters (but are scarce in the southern North Sea).

There are two main areas of UK territorial waters where there are semi-resident groups of bottlenose dolphin (where individual identified animals persistently occur in a relatively discrete area): Cardigan Bay and the Moray Firth (Scotland). Away from these two areas, there are smaller groups off south Dorset, around Cornwall and in the Sound of Barra, Outer Hebrides. There is also a resident population in the Shannon Estuary, Ireland and another based around the Channel Islands. In addition small groups have been recorded regularly elsewhere in UK waters, including along the coasts of Cornwall, Devon and Dorset, in the waters around the Hebrides, and occasionally in offshore waters of the North-east Atlantic, Irish Sea and St. George's Channel.

Dolphins from all of these areas may occasionally move some distance from their apparent core range. For example, regular sightings in the Firth of Forth probably involve dolphins from the Moray Firth and sightings in North Wales involve Cardigan Bay dolphins. Other dolphin groups, presumed to be transients, are recorded further offshore in deeper water in the Celtic Deep and to the west of Scotland.

The total population in UK inshore waters is probably less than 500 individuals. Abundance estimates from the SCANS II survey were 5,370 for the offshore Celtic Sea area and 12,643 in total for the European Atlantic continental shelf. The species was formerly more widespread, especially in the southern North Sea and English Channel and has certainly declined in range.

Bottlenose dolphins are considered of significant importance within Pen Llŷn a'r Sarnau SAC even though they do not appear to form a semi-resident group within the sea area encompassed by this site. Bottlenose dolphins have been seen all around the Welsh coast since the early part of the 20th Century, but mainly throughout Cardigan Bay where they use the area for all essential activities including feeding, socialising and nurture of young.

4.11.1 Population dynamics

Bottlenose dolphins do not form a discrete site based population within Pen Llŷn a'r Sarnau SAC but instead should be seen as part of a wider population that ranges across waters of southwest UK and Ireland, and includes the Cardigan Bay SAC.

The number of bottlenose dolphins that use Pen Llŷn a'r Sarnau SAC is not currently known. Between 1989 and 1998 there were about 90 sightings of bottlenose dolphins distributed throughout the whole site, with clusters around the entrance to the Dyfi estuary (25 sightings), the Mawddach estuary (12 sightings), and Tremadog Bay (8 sightings). Recently, high sightings rates have been made around Sarn Badrig.

Dolphins associated with the group within Cardigan Bay move into and through Pen Llŷn a'r Sarnau SAC as revealed by photographic identification studies. These showed that of the 57 dolphins identified, 12 were sighted in the SAC at some point during the five year study period. The numbers recorded are greatest between July and October although some animals are present near shore in every month of the year.

Important characteristics relating to population dynamics will be common to bottlenose dolphins in both Pen Llŷn a'r Sarnau and Cardigan Bay SACs. Both sites are within Cardigan Bay where various abundance estimates have been made. Population estimates for the bottlenose dolphins of the

Cardigan Bay SAC in the years 2001-07 (obtained considering the proportion of marked dolphins in each group and the mark-recapture method), provide an estimate of 210 individuals for the population using Cardigan Bay SAC in 2007. A higher estimate of 379 individuals is made when calculated for the whole period 2001-07.

There appears to be an overall increase in population size although there is considerable variability between years and low confidence in some estimates. However, it has been estimated that detection of any trends will require more than 8 years of research effort.

Calving is known to have taken place within Cardigan Bay and newborn and very young calves have been reported in the bay from April to September, suggesting a seasonal pattern to calving. There is a likely preference for more sheltered shallow areas. Both age frequency and sex ratio is unknown given that it is extremely difficult to determine the size, age or sex of wild dolphins. The level of basic information on population dynamics is low for the species as a whole where populations have only been studied for a proportion of an individual's likely life, i.e. about 14 years. Research is required to determine whether the population interacts with dolphins from other areas such as Ireland or the south of England, and whether the number of animals using Cardigan Bay is stable, increasing or declining.

Bottlenose dolphins are highly social animals. Group sizes of bottlenose dolphins vary seasonally and the size of the groups tends to increase throughout the summer, with quite large aggregations seen in late September and October. The dolphins are reported less frequently and in fewer numbers during the winter months but this may be because of the poorer weather conditions and fewer observers watching the sea.

4.11.2 Range

Bottlenose dolphins are present in Welsh coastal waters throughout the year. There is a strong peak in numbers in summer and only a few animals are seen between November and April. They are most commonly seen in Cardigan Bay within 10 miles of the coast, and most concentrated within 2 miles near headlands and estuaries, such as New Quay, Aberporth, Mwnt, Cemaes Head and around the Teifi estuary, from April to October, although they are also seen in North Wales and around Pembrokeshire.

Bottlenose dolphins from Pen Llŷn a'r Sarnau SAC interact with dolphins in Cardigan Bay SAC and probably interact with animals in waters of southwest UK and Ireland, and are likely to be moving and exchanging with more distant populations. Bottlenose dolphins using the SAC contribute to this wider population. It is becoming clear that the dolphins of the Cardigan Bay are not as sedentary as was once thought. Although the same identified dolphins occur in particular coastal areas of the Bay, during winter they range much more widely. Vessel surveys in North Wales (particularly from Anglesey eastwards towards Liverpool Bay) during 2007-08 have revealed that a sizeable portion of the Cardigan Bay population spends at least part of the winter in this area. Furthermore, even in summer, there are bottlenose dolphins regularly using the waters around North Wales northwards to at least the Isle of Man and Cumbrian coast.

There is evidence for periodic range shifts that suggest that distribution patterns are more flexible than previously believed. Recent sightings indicate that other groups occur in the English Channel, around the west coast of Scotland, and in the Shannon Estuary off the west coast of Ireland. There is currently no evidence of exchange of individuals or gene flow via females between areas.

4.11.3 Supporting habitat and species

The precise habitat requirement of bottlenose dolphins is poorly understood, but includes habitat that is of sufficient quality for feeding and calving, as well as resting and travelling. The Pen Llŷn a'r Sarnau SAC provides a proportion of the overall habitat requirements of the bottlenose dolphins that occur within the site. Different areas are used indicating that the habitats required by the bottlenose dolphin are spread throughout the site and include the overlying water column. In coastal waters,

bottlenose dolphins appear to favour habitat with uneven topography and/ or strong tidal currents. Some of the habitat requirements of bottlenose dolphin are supported by other Annex I habitats.

Observations of bottlenose dolphins in the SAC have recorded centres of activity for bottlenose dolphins in Tremadog Bay, at the entrances to estuaries and also close to some of the sarnau reefs, indicating that the catchments of the freshwater tributaries entering the site together with the offshore reefs contribute to the overall site integrity for the species. The only natural predator is the killer whale *Orcinas orca* that has been sighted in Cardigan Bay, if infrequently.

Bottlenose dolphins are generalist and opportunistic feeders eating a wide range of fish, crustaceans and molluscs. Prey species include haddock *Melanogrammus aeglefinus*, saithe *Pollachius virens*, cod *Gadus morhua*, hake *Merluccius merluccius*, mullet *Mugil* spp., eels *Anguilla anguilla* and *Conger conger*, salmon *Salmo salar*, trout *Salmo trutta*, bass *Dicentrarchus labrax* and sand eels Ammodytidae, as well as octopus *Eledone cirrhosa*, *Loligo* spp., and other cephalopods.

From visual observations of the surface behaviour of bottlenose dolphins in Cardigan Bay, it is known that they capture pelagic fish such as sea trout (sewin), salmon, bass, mullet, mackerel, and garfish. There is little knowledge of the degree to which the species preys upon demersal fish or benthic invertebrates. Several studies have related visual and acoustic behavioural observations to foraging activities and have indicated the importance of sandbank and reef habitats.

The distribution and movement of prey are believed to influence the distribution and movement patterns of cetaceans, and feeding activities have been recorded throughout the inshore waters of the Bay. Understanding of the behaviour of Cardigan Bay dolphins is still in its infancy, but it is possible that the fatal interactions between bottlenose dolphins and porpoises may involve competition for prey as both species have been observed feeding at the same time when porpoise have been killed by bottlenose dolphin. In Newport Bay for example, herring were spawning in the area and in North Wales whiting were present in large concentrations when such behaviour was observed.

As bottlenose dolphins forage widely a decline in prey species in one area may not immediately impact the population. The status of likely prey species and the degree to which the bottlenose dolphin population is limited by current, reduced, prey availability is generally unknown. Prey availability is likely to be a key factor in determining the abundance and distribution of dolphins in Cardigan Bay.

Food resources appear to be a primary factor in determining movements and site fidelity in bottlenose dolphins. The Pen Llŷn a'r Sarnau SAC contains important potential feeding areas for bottlenose dolphins and they have been observed feeding while in waters of the SAC. Bottlenose dolphins are highly adaptable with respect to diet and feeding strategy and it is likely that variation in group size could be related to foraging strategies and the increased protection from predators provided by large groups.

4.11.4 Modifications as a result of human activity

Bottlenose dolphins are a top predator and are prone to accumulation of contaminants present within their food chains, particularly those that are persistent and those that tend to bioaccumulate and biomagnify. High levels of some contaminants have been found in stranded bottlenose dolphins in Cardigan Bay; 15 bottlenose dolphins were found to have levels of PCBs over 80mg/kg; that is, well over the 17mg/kg threshold for adverse effects. This was considered of great concern for a long-lived species such as this with a relatively small population size and which reproduces every 4 years or so. A likely source of these contaminants is Liverpool Bay considering the use of this area by a sizeable proportion of the bottlenose dolphin population. It is not known how current levels of contaminants are affecting the bottlenose dolphins but they are a cause for concern in a species such as this where contaminants accumulate up the food chain and, in the case of organohalides accumulated in fatty tissue, are passed to the calves in the female's milk.

It is possible that visual signs such as changes in behaviour or skin lesions may be indicators of health but no clear links have yet been established. There is a possibility that incidence of skin lesions is linked to environmental factors, such as low water temperature and low salinity. The majority of dolphins identified in Cardigan Bay have injuries (fin nicks, tooth rakes etc) or lesions on their skin as is common in bottlenose dolphins world-wide and the severity in Cardigan Bay is about average in comparison with other populations.

Strandings provide data on the occurrence and distribution of stranded dolphins and post-mortem analysis provides information on patterns of mortality, disease and diet. This is an important baseline for detecting unusual mortality events and the programme continues to add to a collection of biological samples that can provide additional data on the life history characteristics and foraging ecology of the population.

One of the other key considerations for the conservation of the bottlenose dolphin within the SAC and wider seas is disturbance by human activity. This may occur within close proximity to the dolphins, such as disturbance by power craft, or at some distance away, for example through use of underwater sonar equipment that has to potential to have a lethal effect on cetaceans. There is a continual increase in the number of power craft of all sizes operating within the SAC and Cardigan Bay as a whole and minimising disturbance to cetaceans, including the bottlenose dolphin will need to be part of the focus of the management of the site. As with the grey seal, other issues relate to entanglement and incidental capture of seals in line and netting and reduction or changes in food availability.

Bottlenose dolphins are adapted to living in the marine environment and are adapted to the many challenging aspects of that environment. However, artificially introduced hazards and reductions in the natural quality and suitability of the bottlenose dolphin habitat in the SAC can occur through:

- the presence and persistence of artificial inert or toxic materials (e.g. plastics, synthetic fibres, hydrocarbons) causing entanglement, smothering or ill-health;
- competition with human activities for space causing displacement, collision, noise and visual disturbance and increasing density dependent pressure on sites and increased stress rendering animals susceptible to the effects of normally dormant endemic viral diseases;
- contamination of prey.

Physiological health affects susceptibility to disease and reproductive success. A range of viral, bacterial and parasitic diseases are known to be endemic within bottlenose dolphin populations but have a limited effect on healthy, unstressed adult animals. They are susceptible to certain diseases of domestic animals such as such as brucellosis and morbilliviruses, as well as cross infections from interactions with humans.

4.12 OTTER *LUTRA LUTRA*

The 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. The otter is still scarce over much of England, where the highest concentrations are in the south-west. 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.

Within the context of this document, the population for this site is being considered to be those individuals that use the site and have, as part of their core range, the site and/or the catchments of any freshwater tributaries that enter the site.

4.12.1 Population structure

The number of otters within the SAC is not known, but there is evidence that they use areas of the coast within and adjacent to the SAC. Otters present within the site at any one time do not form a discrete population, but are part of a population living around freshwater habitats in Gwynedd and Ceredigion, 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 one time and its distribution is likely to be dynamic. It is not known whether the numbers of animals that use the site are an approximately fixed proportion of the wider population, or are a variable proportion with a preference for using marine habitat.

The SAC contributes to supporting the otter population as a foraging ground, access corridor and for social activity.

The site contributes to the population's reproductive success, through physiological health and reproductive capability, and by providing a proportion of food energy requirements. The number of otters that breed within the SAC or details on the movements of breeding animals in and out of the SAC is not known. There is lots of potential good habitat for breeding sites for otter within the SAC; they are known to breed on Llyn Ystumllyn adjacent to the SAC on the south side of the Llyn Peninsula and the River Leri that flows into the Dyfi estuary. Otters are also likely to breed inland, along watercourses adjacent to the SAC and use the SAC for foraging. 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 dominated by animals of a specific age range or sex. Scottish studies suggest that male otters make more use of exposed rocky shores than females. The physiological health of the otters present within and using the SAC is unknown. A range of viral, bacterial and parasitic diseases are known to affect 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. Reproductive capability, exposure and immunity to endemic and anthropogenic disease and contaminant burden of otters within and using the SAC are unknown.

4.12.2 Range

Otters are widespread on and close to the coastline throughout Pen Llyn a'r Sarnau SAC, both on the open coast and within the estuaries of the SAC as well as adjacent areas.

The distribution of otters is known primarily from spraint records in the SAC and adjacent areas, including on the foreshore, on access points from watercourses, along watercourses and river and estuarine locations. Whilst it may be considered that otters are more commonly found in and around the estuaries of the SAC, recent surveys have shown that otters have extended their range to other coastal areas around Pen Llyn. A study of the Llyn Peninsula in 2002 found otter signs within 1km of the shore at 8 out of 10 sites surveyed. It is reasonable to assume that otters may be found in any of the coastal areas of the SAC. Surveys indicate regular otter use of the Glaslyn/Dwyryd and Dyfi estuaries as well as signs of otters by the Mawddach estuary and in mine adits along the estuary. Information from surveys, sightings, and road casualties suggest that the Soch, Rhydhir, Erch, Dwyfor, Artro and Dysynni rivers are all now used by otters. There is also evidence of otter use of tidal reaches, for example, otter signs are found regularly at Broadwater on the Dysynni River

Availability of essential habitat and accessibility of these habitats to otters within the site and from adjacent areas and watercourses are major influences on the range and distribution of otters in and adjacent to the SAC. Access points and routes with scrub and tree cover from and between watercourses and coastal areas are generally preferred and the availability of these will influence the range that otters are able to inhabit.

4.12.3 Supporting habitat and species

Otters require appropriate habitat for feeding, resting, washing and breeding together with suitable access routes to enable otters to move freely between the SAC and marine habitats and freshwater areas e.g. rivers, streams and pools outside the SAC. Access points to the site from adjacent habitats, e.g. watercourses and vegetated valleys for feeding and other activities are widespread throughout the site. Within the site otters use intertidal and shallow subtidal rocky coasts, estuaries and their associated habitats, lagoons, and watercourses between these habitats.

The SAC contains important potential feeding areas for otters. Coastal fringes where suitable prey habitat is readily accessible are widespread throughout the site. These include sheltered shallow water such as rock-pools, lagoons and estuary shallows all accessible from freshwater habitat. Coastal otters can hunt as far as 100m offshore in water over 10m deep, but most feeding is done close to the shore in water less than 3m deep. The presence of many rivers and streams flowing into the SAC together with long stretches of coast being low lying land with wetland or sand dune habitats provide easy access to the marine environment for foraging.

Over most of their range otters are nocturnal or diurnal, probably due mainly to disturbance and persecution. When inactive they may sleep in areas known as dens, holts or couchs. These can be holes in the ground, under tree roots, within rock piles, dense scrub or in quite open places. Otters are known to breed and rest within the SAC but there is little information on numbers and locations. The coast around the SAC is well supplied within rivers and streams and it is highly likely that they travel from one watercourse to another along the coast.

Otters living on the coast must have access to freshwater streams and pools for drinking and washing. Otters need to wash in freshwater in order to maintain the insulating properties of their fur. The lack of available freshwater might explain the restricted distribution of otters living along the coast in some areas of the UK, however the SAC is well served with rivers and streams throughout its length.

Habitat essential for otters, i.e. well vegetated stream and river valleys, access to the shore, access to freshwater, secluded resting habitats, is high throughout much of the site. The structural and functional integrity of this essential habitat is considered to be good.

Otter diet can be highly varied, though it is normally focussed on favoured prey species and a reflection of local prey availability. It is not known specifically what the otters living in and using the SAC feed on, nor the quality of food available to them within the marine environment. The main hunting areas will be largely determined by the habitat preferences of the prey species. Studies in Scotland have shown that fish form a large proportion of the diet with crabs and sea urchins also eaten but in lesser quantities. Various fish species are know to be eaten, such as eelpout *Zoarces viviparous*, rockling *Ciliata mustela*, sea scorpion *Taurulus bubalis*, butterfish *Pholis gunnalus*, corkwing wrasse *Crenilabrus melops*, eel *Anguilla anguilla* and fifteen-spined stickleback *Spinachia spinachia*). Otters are likely to be able to take advantage of seasonally abundant food sources. It is also likely that otters are not wholly dependent on the coast for food and that they also feed in adjacent rivers.

4.12.4 Modifications as a result of human activity

Historically, otters *Lutra lutra* occurred over most of the UK however, persecution, habitat loss and, more recently, the impact of toxic organochlorine insecticides caused a marked reduction in the range of the species. Otters are re-colonising marine sites at a slower rate than rivers. The regular presence of otters in the SAC makes this an important site for the conservation of this species.

There have been localised modifications that have affected the structural and functional integrity of this habitat, e.g. coastal developments, coastal defences, engineered watercourses, increased human use of coastal areas, and cleared and managed vegetation that has modified the ease of access for otters and reduced the ease of concealment as they move around. Many man-made 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 otter behaviour is widespread. Much of this activity is concentrated in residential and urban areas. There is less risk of disturbance from human activities in secluded sections of waterway and coast. The times of day favoured by otters for activity (early morning and dusk) help to minimise the amount of interaction with people.

Whilst good quality essential habitat is available within the SAC and adjacent area, the quality and suitability of this habitat can be reduced in a variety of ways, including:

- the presence and persistence of artificial inert materials (e.g. plastics, synthetic fibres, static fishing gear) leading to entanglement and smothering;
- 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, including the risk of fur contamination from oil discharged into freshwater and marine environments;
- availability and quality of prey.

Most of the common prey species recorded are not commercially exploited and the current stock status of these likely prey species is generally unknown. However, populations of European eel (often the dominant recorded prey species of otter) are below safe biological limits and the current fisheries are unsustainable. The level of contamination of otter prey is generally unknown. 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.

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 Conservation Objectives and core management plans for the three SPAs can be found on the CCW website.

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

CCW's vision for the Pen Llŷn a'r Sarnau SAC is for a high quality marine and coastal environment which is healthy, productive and biologically diverse, supporting resilient marine ecosystems and communities. The special habitat and species features of the SAC will be maintained and, where necessary, restored so that they will be able to sustain themselves in the long-term as part of naturally functioning ecosystems. The diversity of the wildlife habitats and species in the SAC will not be degraded.

The varied physical character and processes in different parts of the SAC will operate without any undue interference, this includes the natural processes of tides, waves and currents and the associated processes of sediment erosion and deposition. The quality of water in the SAC will be maintained or restored to a level necessary to maintain the features in favourable condition for the foreseeable future. The health and quality of the 12 SAC features are inter-related and will also depend on the state of other non SAC feature marine habitats within the site, as well as structural and functional components of the marine ecosystem.

The *reefs* of the SAC should continue to comprise a large variety of habitats and their associated biological communities both on the shore and underwater. The different components of the reef habitat should continue to be present with no significant loss of extent, and the quality of the wildlife communities they support should be maintained or enhanced; these components comprise reef formed from different types of hard substrate throughout the site (bedrock, boulders, cobbles and mixed ground), biogenic reefs and carbonate reef. The potential for expansion of the biogenic reef communities on the shore and underwater will be safeguarded through appropriate management.

The *large shallow bay feature* (Tremadog Bay) should continue to comprise a variety of high quality sediment and hard substrate habitats and their associated biological communities. The special characteristics of the bay will be maintained, including species rich and species diverse subtidal sediments as the dominant habitat type within the bay. The subtidal sediments should comprise a mosaic of sediment types including extensive areas of muddy gravel, fine and muddy sand and mud. On the shore, the condition of the varied habitat types and their associated communities will be expected to be maintained or improved under appropriate management. The intertidal habitat types present will include muddy and sandy gravel, mixed sediment and boulder shores, bedrock, sand and shingle. The natural biological productivity of the bay and its ability to function as a nursery area for fish and shellfish species will be maintained and safeguarded. The potential for expansion of the biogenic reefs and eelgrass (seagrass) communities that are components of the bay feature should be safeguarded through appropriate management.

The *subtidal sandbanks* for the SAC should continue to comprise mobile or highly mobile sediment habitats and their associated communities. The overall structure, sediment characteristics and biological communities of the Tripods, Bastram Shoal and Devil's Ridge sandbanks will reflect their exposure to the prevailing south-westerly winds and strong tidal flow. The sediment characteristics and biological communities of the Four-fathom bank

sandbank will reflect conditions of slightly less exposure to wind and tidal currents. Sediment supply and hydrodynamic processes forming the sandbanks will continue unhindered. The condition of the biological communities within and on the sediment, together with mobile species associated with the sandbanks, will be maintained or improved under appropriate management.

Each of the three *estuaries* of the SAC will continue to be shallow, bar-built drying estuaries supporting a mosaic of habitats and associated wildlife that reflects the transition from the estuarine to terrestrial habitats. The estuaries will support good quality saltmarsh transitions to other habitats such as shingle, sand dune, peat mire, brackish and freshwater marsh, reed swamp, bog and woodland. The sediments of the estuaries will continue to comprise a high proportion of sandy to muddy sediments, and the sediment type and biological communities associated with them will reflect a gradient from more exposed and saline conditions at the mouth of each estuary to more sheltered freshwater-influenced communities in their landward reaches. The structure and characteristics of each estuary will be determined by unhindered geomorphological and biological processes, including sediment transport, erosion and accretion and the influence of flood events and by appropriate management of the surrounding catchments. Artificial constraints on the estuaries form and functioning will be minimised to ensure thelong-term presence and viability of estuary habitats; restore floodplain functions and habitats; and improve the ecosystem resilience to climate change. The estuaries will continue to function as fish nursery areas and to support important populations of migratory fish and birds, and other key species such as otter.

The Morfa Gwyllt *coastal lagoon* will continue to be present in its current location with no loss of extent or reduction in its ability to provide a specialised brackish water lagoon habitat. Specialist lagoon species will continue to be present as viable populations together with a range of other marine species characteristic of the predominantly sediment habitat in the lagoon basin. The negative impact of disturbance to the lagoon from human activities would be expected to be reduced under appropriate management, thereby improving the ability of Morfa Gwyllt to continue to exist and function as a coastal lagoon.

The *intertidal mudflats and sandflats* feature should continue to comprise an array of sediment habitats and their associated biological communities, ranging from exposed and moderately exposed sands in open coast situations, through exposed to sheltered sands and muds in estuarine conditions. Complete examples of zonation of exposed and moderately exposed sediment communities will continue to be present. The quality of intertidal mudflat and sandflat communities would be expected to be maintained or improved. The potential for expansion of the nationally scarce eelgrass (seagrass) community should be safeguarded through appropriate management. The long-term viability and quality of the intertidal mudflats and sandflats in estuarine conditions may be enhanced by restoration of more naturally functioning estuary systems.

The site retains its complete sequences of *saltmarsh vegetation*, from pioneer vegetation, such as glasswort, through to upper saltmarsh. The variety of communities will continue to be present and their quality will be maintained or improved. The long-term viability and quality of the saltmarsh features will be improved through management of the estuaries that restores more naturally functioning estuary systems.

The *sea caves* feature should continue to comprise intertidal and subtidal caves, clefts, crevices and tunnels in the bedrock substrate within the SAC. The extent of the sea caves and the variety and quality of the biological communities they support will be maintained or improved. Many of the caves (intertidal and subtidal) will continue to support well-developed zonation of sea cave communities. The sea caves of the SAC will continue to provide accessible and high quality breeding places for grey seal.

The SAC will continue to provide a productive and supportive marine area for *grey seals*. The population of grey seals frequenting the SAC will form and important component of a larger southwest UK population of grey seals. Grey seals will continue to be widespread throughout the SAC predominantly in areas of open coast and sea. Grey seals will have access to, and sufficient availability of prey, and they will have widespread availability and access to good quality essential habitats, including areas for hauling out and pupping, that are free from excessive disturbance. The quality and distribution of haul out and breeding sites for grey seals within the site will be maintained or improved through appropriate management.

The SAC will continue to provide a productive and supportive marine area for *bottlenose dolphin*. Bottlenose dolphin will continue to be widespread within the waters of the SAC and those frequenting the SAC will reflect a healthy population structure including immature and adult male and female dolphins. The bottlenose dolphins in the SAC will form an important component a larger population of this species present in Cardigan Bay and in the wider sea area around Wales and the north east Atlantic. The animals using the SAC will reflect good

physiological health. The bottlenose dolphins will have access to and sufficient availability of prey, and they will have widespread availability and access to good quality essential habitats free from excessive disturbance. The quality and distribution of essential habitats (such as for feeding, calving, resting and travelling) within the site will be maintained or improved through appropriate management.

Otters will continue to be widespread throughout the SAC both in areas of open coast and within the estuaries. Otters will have sufficient availability of prey and widespread availability and access to good quality essential habitats including freshwater and undisturbed resting and breeding sites to allow the otter population to thrive. The distribution, breeding centres and actual/potential breeding sites of otters within the site and adjacent catchments will be maintained or improved through appropriate management.

The landscape quality and conservation value of the area will continue to be high. The presence of the Pen Llŷn a'r Sarnau SAC and its special wildlife enhances the economic and social values of the area by providing a high quality environment for fisheries, outdoor activities, ecotourism, scientific and educational study, and peaceful enjoyment by local people and visitors. The positive contribution of the SAC to the natural, social and economic quality of the area will be recognised and promoted through appropriate sea and land management which ensures compatibility between activities and the sustainable use of the site. Local communities will take pride in their surroundings and work actively to make sustainable improvements for future generations.

CONSERVATION OBJECTIVES FOR THE PEN LLŶN A'R SARNAU 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

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

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 **reef** feature these include:

- Rocky intertidal reefs
- Rocky subtidal reefs
- Extensive boulder and cobble reefs – the sarnau
- Biogenic reefs (horse mussel *Modiolus modiolus* reef / green crenella *Musculus discors* reef and Honeycomb worm *Sabellaria alveolata* reef
- Carbonate reef formed by methane gas leaking from the seabed.

For the **intertidal mudflat and sandflat** feature these include:

- *Mya arenaria* and polychaetes in muddy gravel

- Eel grass *Zostera marina* beds.
- Muddy gullies in the Mawddach estuary.

For the ***Salicornia*** feature this includes:

- Communities characterised by the species *Sarcocornia perennis.*

For the **intertidal mudflats and sandflats** and **sandbanks** features this requires an overall stability or increase in the amount of the feature, taking into account the areas of long term stability and localised losses and additions arising from environmental processes.

For **estuaries** this includes the stability of sandy sediments in proportion to the muddy sediments.

Restoration and recovery
As part of this objective it should be noted that; for the **estuaries** feature additional land which should form an integral part of the estuarine ecosystem should be restored

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.

For **Atlantic saltmeadows** this includes the morphology of the saltmarsh creeks and pans

Restoration and recovery
As part of this objective it should be noted that; for the **estuaries** feature the structure and functions of the estuaries that have been damaged/degraded by the constraints of artificial structures such as flood banks, are restored.

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 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

As part of this objective it should be noted that; for the **reefs** feature the potential for expansion of the horse mussel *Modiolus modiolus* community off the north Llŷn coast is not inhibited.

SPECIES FEATURES

Grey seal
Bottlenose dolphin
Otter

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 **bottlenose dolphin, otter and grey seal**; contaminant burdens derived from human activity are below levels that may cause physiological damage, or immune or reproductive suppression

- **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 **bottlenose dolphin, 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
As part of this objective it should be noted that for the **bottlenose dolphin** and **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 feature 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 as a result of human action. 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[22].

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

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

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.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
DOCKS, MARINAS & SHIPPING																						
Dock, harbour & marina structures: construction* *Small to medium-scale Ports and, harbours around the Llŷn and Meirionydd coasts. Medium scale marina at Pwllheli. Marina at Aberystwyth (outside of SAC to the south) Possible extension to marina at Pwllheli. Proposal for marina at Aberdyfi. Proposals for developments / improvements to port & harbour facilities at Abersoch, and Barmouth.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 As above.	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 * None at present. Future proposals possible associated with port, harbour, marina developments (c.f. aggregate extraction; also see dredge spoil disposal)	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate. Establish best operational practices suitable to secure features at FCS
Dredging: maintenance * *Primarily to maintain navigable depths in approaches to Pwllheli marina (adjacent to SAC) and periodically to Porthmadog, Barmouth and Aberdyfi harbours – scale variable. Extent unknown.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Shipping: vessel traffic *No data available. Most shipping in transit in Irish Sea unlikely to pass through SAC, except to seek shelter on passage.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	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 *Main areas for mooring in ports & harbours around the site, and in sheltered embayments. Also St Tudwal's Road area in summer. Existing moorings in the SAC used primarily for recreational boating and fishing boats rather than shipping.*	✓				✓	✓				✓	✓	✓				✓						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
Shipping: anchoring *Little current activity in relation to commercial shipping in SAC as area is not across the main shipping lanes around North Wales. Occasionally vessels may anchor if seeking shelter during rough weather or if working in the area. Anchoring primarily of small recreational and commercial fishing craft in various locations throughout the SAC.*	✓				✓	✓				✓	✓					✓	✓					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 used as commercial anchorages and for casual recreational anchoring
Shipping: vessel maintenance (incl. antifouling) *Not known in site.*		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	Review, revise or establish management practices and spatial, temporal & technical operational limits suitable to secure features at FCS; monitor compliance and enforce.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Shipping: ballast water discharge *Extent unknown in site. Likely little current activity in SAC as area is not across the main shipping lanes around North Wales. Occasionally vessels may anchor if seeking shelter during rough weather or if working in the area. Potential exists for effects from shipping transiting in Irish Sea.*		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 *. Possibly occurs in SAC, at unknown level – likely low level in site as not on main shipping routes. Potential exists for effects from shipping transiting in Irish Sea.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 *Possibly occurs in SAC, at unknown level – likely low level in site as not on main shipping routes. Potential exists for effects from shipping transiting in Irish Sea.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 *No known recent events.Potential exists for a damaged or struggling vessel to be brought into Tremadog Bay*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Maintain, keep under review and improve as 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, EAW)
Shipping: accidents -fuel oil & / or petrochemical discharges *. No known recent events. Potential exists for a damaged or struggling vessel to be brought into Tremadog Bay*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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, EAW)

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Shipping: accidents -non-petrochemical cargo losses / discharges	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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, EAW)
Shipping: accidents - salvage operations *. No known recent events.* *Potential exists for a damaged or struggling vessel to be brought into Tremadog Bay*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	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 throughout the site – mainly linked (but not confined) to centers of population. Scale of developments very variable*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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 * *Majority of past reclamation of land in the estuaries and associated with agricultural activities.* *In other areas little land reclamation.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate, taking into account proposed subsequent operational use and likely effects.
Coast protection: hard defence (sea walls / breakwaters) *# *Present at various locations along the coast – many rock armour defences varying in scale.* *Offshore defence structures have been proposed, e.g. offshore at Borth.* *Future proposals for coast protection likely due to nature of parts of coast increased storminess / sea level rise*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Treat as plan or project as appropriate, taking into account long term management requirements & predicted climatic impacts

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Coast protection: hard defence (railways) *# . *Coastal defence associated with Cabmrian Coast line- includes coastal and flood protection works particularly where railway line very close to the sea, als filling in of caves below the railway and Ffriog & Llanfair,*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		As above
Coast protection: soft defence *# *At some locations in SAC, but not extensive. Possible future developments*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		As above
Coast protection: groynes *# *Present at various locations along the coast (south Llŷn, Barmouth, Towyn, Borth).*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		As above
Coast protection: beach replenishment *# *Has taken place on south Llŷn coast (Traeth Crugan) and at Aberdyfi. Future proposals likely*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		As above
Coast protection: storm surge / tidal barrage *# . None at present. Unlikely, but possible proposals in estuarine areas or embayments.	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	Treat as plan or project as appropriate.
Barrage: amenity *# None present. No known proposals	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	As above
Foreshore deposit of rock, rubble *etc.* *Anecdotal & opportunistic observations*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		Continued surveillance and monitoring. Appropriate implementation of SSSI procedures.
Artificial reef *# *None present. Although artificial reef with sea defence and recreational function (surfing) being considered at Borth (not yet part of formal proposal.)Other development interest feasible.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Hard-engineered freshwater watercourses *# *Associated with some locations in SAC - in and adjacent to the estuaries in particular.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Power station *# *. None at present in SAC. No known proposals. Development interest feasible.*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Pipelines *# *Development proposals possible*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate, taking into account long- term management requirements & likely effects.
Power / communication cables *# *Some present in SAC, e.g. electricity cable across Dyfi. Future proposals possible*	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
WASTE DISPOSAL																						
Effluent disposal: domestic * *EAW There are a number of discharges throughout the catchment and directly into the waters of the SAC. Majority are sewage effluent. Little heavy industry in the area. EAW and DCWW datasets available on locations and inputs. General trend of improved treatment resulting in discharge with lower solids and nutrients*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat new discharges and proposed changes to existing discharges as plan or project as appropriate.
Effluent disposal: industrial * *As above.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Effluent disposal: thermal * *None known*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Sludge dumping * *None at present*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Inorganic wastes & debris (including refuse & litter). *Widespread and common from varied sources. Precise nature and distribution no known. Keep Wales Tidy active in area with clearn-up groups covering several of the main beaches*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Maintain, keep under review and improve as 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 * *Currently no licensed offshore disposal sites within or adjacent to the SAC. Nearest offshore*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
disposal site is at Holyhead Deep (NW Anglesey)																						
Urban & industrial run-off .	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	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
Agricultural run-off .	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Continued surveillance and monitoring of inputs and water quality by EAW; continued development and promulgation of good practice.
EXPLOITATION OF LIVING RESOURCES																						
Trawling: beam *Some activity in the SAC. Exact scale and location of operation not fully known. SFC byelaws limit larger vessels fishing within SAC.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Trawling: otter . *Some activity in the SAC. Exact scale and location of operation not fully known. SFC byelaws limit larger vessels fishing within SAC.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Dredging: toothed *. Fishing occurs in locations off north Llŷn. Increase in effort since 2005. Closed areas in SAC to scallop dredging as condition of authorisations issued under SFC byelaw in order to protect SAC features. Possible future increase in fishing within SAC*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	Treat new fisheries and new gear as plan or project as appropriate. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Dredging: bladed – mussel *Not known to occur in SAC. Possible interest in future.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	As above
Dredging: bladed – mussel seed *May have occurred at a few localised areas in SAC. Possible interest in future.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Dredging: bladed - oyster *Not known to occur. Possible within SAC in future if stocks present*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	Treat new fisheries and new gear as plan or project as appropriate. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Dredging: mechanical –cockle *Not known to occur. Not a "fishing instrument of an approved pattern" under NWNWSFC byelaw.*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓					✓			As above .
Dredging: deep hydraulic (*e.g.* WJID) *. Prohibited within the SAC under NWNWSFC byelaw – special authorisation would be required Some forms prohibited under Welsh Statutory Instrument 2003 No. 607.*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Dredging: shallow hydraulic (*e.g.* suction) *Not known to occur. Prohibited under*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
NWNWSFC byelaw – special authorisation would be required. *Target species are shellfish*																						

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Netting: bottom-set gill	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Netting: bottom-set tangle / trammel *Occurs within SAC, around Llŷn and in estuaries. Scale and location of operations not known.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓	As above
Netting: surface-set gill *Occurs within SAC. Scale and location of operations not known*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓	✓		✓	✓	✓	As above
Netting: beach seine *May occur in SAC. Frequency and intensity unknown.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓			As above
Netting: demersal seine *Not currently known to occur within the SAC. Possible in the future, particularly from vessels under 12m. Target species are flatfish species such as plaice, sole, dab.*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓	✓			✓	✓	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. Monitor and manage fisheriesso that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Netting: beach-set gill *Occurs within SAC. Scale and location of operations not known.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓	✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Netting: other (*e.g.* fyke) *Not known if occurs in SAC. Potential exists. Target species are eels*	✓		✓		✓	✓	✓	✓	✓		✓					✓			✓			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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Potting: lobster / crab *Widespread and common – main fishing activity in area. Mainly lobster and brown crab. Exact scale and location not known*	✓		✓		✓	✓	✓	✓	✓	✓						✓				✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Potting: prawn *Occurs in SAC. Exact scale and location not known*	✓		✓		✓	✓	✓	✓	✓	✓						✓				✓	✓	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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Potting: whelk *Substantial but little precise information other than effort widely distributed; has shifted and continues to shift further offshore into deeper water*	✓		✓		✓	✓	✓	✓	✓	✓						✓	✓			✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Line: long-line *May occur in SAC. Frequency and intensity unknown. Possible in future, particularly from vessels under 12m*	✓		✓		✓	✓	✓	✓	✓	✓						✓	✓			✓	✓	As above
Line: handline *May occur in SAC. Frequency and intensity unknown.*	✓		✓		✓	✓	✓	✓	✓	✓						✓	✓			✓	✓	As above
Electro-fishing: molluscs *Prohibited under EU Regulations. Interest be expressed in future but this would require special exemption*	✓		✓		✓	✓	✓	✓	✓		✓	✓				✓	✓		✓			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. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Fisheries; predator control *Not currently known in SAC*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	Enforce relevant wildlife protection legislation.
Hand gathering: cockles (excluding access issues) *Occasional gathering in esutaires – main interest in Dyfi. Casual private collection in estuaries. Licenced by NWNWSFC permit scheme*	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓							✓			Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.
Hand gathering: mussels (excluding access issues) *Occasional gathering from naturally occurring mussel beds throughout site likely. Exact scale and location not known*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓			As above .
Hand gathering: mussel seed (excluding access issues) *Periodic collection in Dyfi under licence from NWNWSFC*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓			As above .
Hand gathering: razor clam (including salting) *Not known in SAC. May occur. Likely at low levels. Frequency and intensity unknown*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓			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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Hand gathering: other bivalves *Frequency and intensity unknown, but probably very low levels in SAC*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓			As above
Hand gathering: winkles *Occurs in SAC on rocky shores. Frequency and intensity unknown*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓			✓			As above
Hand gathering: crustacean / shellfish *Occurs in SAC. Frequency and intensity unknown*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓			✓			As above
Hand gathering: algae & plants for human *Occurs in SAC. Likely low level. Frequency and intensity unknown.*	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			✓		✓	As above
Hand gathering: access and vehicle use *Integral to hand gathering activities. Access by foot and vehicle occurs in different parts of the site.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓		As above
Hand / mechanical gathering: algae for chemical extraction / biomas *Not known to occur in SAC.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓					✓			✓	✓	✓	Treat new fisheries and new gear as plan or project as appropriate. Monitor and manage fisheries so that populations of prey species subject to existing commercial fisheries are equal to, or at greater abundance, than that required to achieve maximum sustainable yield.

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Bait collection: digging *Generally low level of activity. Lug worm, harbour rag and occasional razor fish are collected. Frequency and intensity not 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
Bait collection: pump *Generally low level of activity. Frequency and intensity not 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
Bait collection: boulder turning *Generally low level of activity. Frequency and intensity not known.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓					✓						As above
Collection, for aquarium / curio trade *May occur in SAC. No information*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Review, revise or establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS
Grazing of saltmarsh *Occurs in estuaries*	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓								As above
CULTIVATION OF LIVING RESOURCES																						
Aquaculture: algae *Not known to occur in SAC. Future proposals feasible*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			Treat new proposed developments as plan or project as appropriate. Review consenting procedures.
Aquaculture: finfish -sea cages or impoundments * *Not known to occur in SAC. Future proposals feasible*		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	As above
Aquaculture: crustaceans - sea cages or impoundments * *Not known to occur in SAC. Future proposals feasible*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Aquaculture: molluscan 'ranching' * *Not known to occur in SAC. Future proposals feasible*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	As above
Aquaculture: molluscan 'farming' * (molluscan culture using trestles, ropes, cages or other structures) *Trial mussel rope rigs deployed 2008. Possible future interest*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	As above
Aquaculture: land based semi-enclosed / recirculation * *Land-based fish farm at Afon Wen. Future proposals feasible*		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			Consider as industrial effluent Treat new proposed developments as plan or project as appropriate.
Aquaculture: predator control *Not currently known in SAC*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	Establish, monitor and enforce operational limits (spatial, temporal, technical, effort) suitable to secure features at FCS.
Aggregation devices (*e.g.* 'crab tiles')	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓				✓			✓			As above
EXPLOITATION OF NON-LIVING RESOURCES																						
Water abstraction * *Widespread in catchment area for hydropower, public water supply, industry, agriculture, amenity & fish farming*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			Treat new proposed developments as plan or project as appropriate. Review existing consents
Aggregate extraction * (mineral & biogenic sands & gravels) *Not known at present. Past proposals for mineral/ore extraction in Mawddach. Historical operations – potential pollution issues*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Oil & gas exploration: seismic survey * *. No blocks currently licensed. Possible future*	✓					✓	✓	✓	✓							✓	✓			✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
interest.																						
Oil & gas exploration & production: drilling operations *.	✓	✓			✓	✓	✓	✓	✓	✓						✓	✓	✓		✓	✓	As above
Oil & gas exploration & production: operational * & accidental discharges *. No blocks currently licensed. Possible future interest.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above .
Renewable energy generation: tidal barrage *# *. No proposals at present. May be future proposals for parts of SAC*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Treat as plan or project as appropriate.
Renewable energy generation: tidal impoundment *# No proposals at present. May be future proposals for parts of SAC	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Renewable energy generation: tidal current turbine *#. No proposals at present. May be future proposals for parts of SAC	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	As above
Renewable energy generation: wave energy *# No proposals and present	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					✓	✓		✓	✓	✓	As above
Renewable energy generation: offshore wind *#. *No proposals at present. May be future proposals for parts of SAC*	✓	✓		✓	✓	✓	✓	✓	✓	✓						✓	✓		✓	✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
POLLUTION RESPONSE																						
Oil spill response: at sea *Reactive only. No recent activity.*	✓	✓			✓	✓	✓	✓	✓	✓						✓	✓	✓	✓	✓	✓	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
Oil spill response: shore cleaning – washing *Reactive only. No recent activity.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	As above
Oil spill response: shore cleaning - chemical *Reactive only. No recent activity.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	As above
Oil spill response: shore cleaning - physical *Reactive only. No recent activity.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	As above
Oil spill response: shore cleaning - ancillary activities (access creation, vehicular impacts, wildlife rescue) *Reactive only. No recent activity.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	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 and common: from shore, recreational and charter boats. Frequency and intensity unknown*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓	✓		✓	✓	✓	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 *Generally low level of activity. Frequency and intensity not known*	✓		✓		✓	✓	✓	✓	✓	✓	✓					✓			✓			As above
Bait collection: digging & other sediment shore collection techniques *Generally low level of activity. Lug worm, harbour rag and occasional razor fish are collected. Frequency and intensity not known.*	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓				✓			✓			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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Recreational boating: high speed power craft (incl. PWC) *Common in SAC with peak activity during summer season. Higher volume activity in certain areas – particularly along parts of the south Llŷn and around specific popular launch points. Powerboat races also held along part of south Llŷn coast. Information held on number of registered power craft*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	Education & awareness raising Activity surveillance
Recreational boating: low speed power craft *Common in SAC with peak activity during summer season. Higher volume activity in certain areas – particularly along parts of the south Llŷn and around specific popular launch points. Powerboat races also held along part of south Llŷn coast. Information held on number of registered power craft*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	As above
Recreational boating: sail *Widespread and extensive throughout SAC, seasonally. Higher volume of activity in certain areas – particularly along parts of the south Llŷn. Sail boat races of different classes held, including international competitions. Occurs in vicinity of, and between marina facilities. Information held on number of registered sail boat craft using local ports, harbours, marinas*	✓					✓	✓	✓	✓	✓						✓			✓	✓		As above
Recreational boating: canoeing *Sea kayaking occurs in SAC. Frequency and intensity unknown*	✓					✓	✓	✓	✓										✓	✓		As above
Recreational boating: other non-mechanically powered craft (*e.g.* kite-surfing, board-sailing, *etc.*). Occurs at some locations in SAC. Frequency and intensity unknown	✓					✓	✓	✓	✓										✓	✓		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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Recreational boating: moorings *Main areas for mooring in ports & harbours around the site, and in sheltered embayments. Also St Tudwal's Road area in summer*	✓				✓	✓	✓	✓	✓	✓	✓	✓		✓		✓						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.
Recreational boating: anchoring *. Refer to 'Shipping: anchoring' in DOCKS, MARINAS and SHIPPING section above*	✓				✓	✓	✓	✓	✓	✓	✓	✓		✓		✓						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 (*ie* outwith MHPA port limits) used as commercial anchorages and for casual recreational anchoring
Surfing *. Occurs at Hells Mouth Porth Neigwl*																						
Scuba diving, snorkelling *. Common at certain locations in SAC (north Llŷn, Bardsey Island, Aberdaron Bay,St Tudwal Island)s. Greater level of activity during summer. Unquantified*	✓		✓			✓	✓	✓	✓	✓						✓		✓		✓	✓	Education & awareness raising; develop participation in environmental site feature observation schemes. Activity surveillance.
Spearfishing *No information available.*	✓		✓		✓	✓	✓	✓	✓	✓	✓									✓		Enforce relevant legislation prohibiting spearfishing in UK waters.
Coastal access for recreation (bathing, dog walking, coasteering, etc). *. Substantial, but unquantified. Seasonally and spatially highly variable.*	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		Education & awareness raising
Vehicles on foreshore *Intensive use at some locations around the SAC (e.g Black Rock sands/ Ynys Las) and less intensive but widespread at various other locations in SAC – associated with boat launching, intertidal fisheries, recreation. Total scale and frequency unquanitifed.*	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		Activity surveillance Education & awareness raising Appropriate implementation of SSSI procedures & access byelaws

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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Light aircraft *Occasional craft flying over SAC*	✓					✓	✓	✓	✓											✓		Activity surveillance
Wildfowling *Occurs in SAC, primarily in estuaries*	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓					✓			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 *. Some charter boats operate in area. Some coastal activity. Possible increased interest in future.*	✓					✓	✓	✓	✓	✓						✓			✓	✓	✓	Activity surveillance
MILITARY ACTIVITIES																						
Military activity: ordnance ranges *r No ranges within or near to SAC*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Research potential effects on features
Military activity: marine exercises Not known within SAC	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	As above
Military activity: aircraft *Llanbedr airfield now disused. No impact areas within SAC. Site used to be over flown by drones and other aircraft. No known current activity*	✓					✓	✓	✓	✓										✓	✓	✓	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	Reefs	Estuaries	Mud and sandflats	Saltmeadow	Salicornia	Lagoons	Inlets & bays	sandbanks	seacaves	otter	Grey seal	Bottlenose dolphin	
Marine archaeology & salvage *Presence of coastal and marine archaeological / historic interests. Two subtidal protected wreck sites within SAC.* *Unofficial marine salvage may occur. Scale unknown.*	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Education & awareness raising
Education A few popular sites, e.g. Dyfi, Atro, Harlech. But other areas visited infrequently	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	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
Science research *. Similar to educational use. CCW, Environment Agency Ales, Universities (particularly in Wales) and non-governmental organisations (e.g. Whale & Dolphin Conservation Society; Friends of Cardigan Bay) are main bodies undertaking research in SAC* *Refer also to various categories in EXPLOITATION OF LIVING RESOURCES section above.*	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	As above
Animal welfare operations & sanctuaries *Not known in site*	✓	✓	✓			✓	✓	✓	✓										✓	✓	✓	Activity surveillance Education & awareness raising Review, develop and/or implement and monitor best practice suitable to secure features at FCS

USEFUL REFERENCES

Afon Dwyryd Otter Partnership (2004). A study of the coastal ecology of the otter (*Lutra lutra*) in North Wales. The Snowdonia National Park, September 2004. The Afon Dwyryd Otter Partnership.

Axelsson, M., Turrell, A., Holt, R.H.F., and Lough, N. (In press). *Drop-down video monitoring and survey work in Welsh Special Areas of Conservation (SAC).* Marine Monitoring Report No 24a.
Baines, M. & Earl, S. (1999) Analysis of sightings data for indications of harbour porpoise breeding off the Welsh coast. Countryside Council for Wales Scientific report No. 379.

Bamber, R. N. Evans, N. J. Sanderson W. G. & Whittall, A. (2001) Coastal saline lagoons and pools in Wales: review and proposals. Countryside Council for Wales scientific report No 464.

Brazier, P., Birch, K., Brunstrom, A., Bunker, A., Jones, M., Lough, N., Salmon, L and Wyn, G. (2007). When the tide goes out. The biodiversity and conservation of the shores of Wales - results from a 10 year intertidal survey of Wales. Bangor: Countryside Council for Wales.

Bunker, F. St. P. D. (1999) *Sublittoral survey of the North Pen Llŷn*. Bangor: Countryside Council for Wales. Contract Science Report No. 370.

Bunker, F.St.P.D. & Holt, R. H. F. (2003). Survey of sea caves in Welsh Special Areas of Conservation 2000-2002. A report to the Countryside Council for Wales by Marineseen, Pembrokeshire. Countryside Council for Wales marine monitoring report No: 6.

Coastal Geomorphology Partnership (1996). *The geomorphological and hydrological status of the maritime coastal shingle resource.* Countryside Council for Wales Scientific Report No. 359.

Countryside Council for Wales, (1993). Welsh Estuaries Review. Science Report.

Cunningham, P.N., Hawkins, S.J, Jones, H.D. and Burrows, M.T. 1(984). The geographical distribution of Sabellaria alveolata (L.) in England, Wales and Scotland, with investigations into the community structure of, and the effects of trampling on Sabellaria alveolata colonies. N.C.C Contract No HF3/11/22)

Darbyshire, T. Mackie, A. S. Y. May, S. J. & Rostron, D. (2002) A macrofaunal survey of welsh sandbanks. Countryside Council for Wales Scientific report No.539.

Davis, J. and Foster-Smith, B. (1994) *Mapping the distribution of benthic biotopes at Sarn Badrig and St. Tudwal's Island, Tremadog Bay.* A Biomar report produced for the Countryside Council for Wales.

Dobson, M. R. and Wittington, R. J. (1987) The geology of Cardigan Bay. *Proceedings of the Geologists Association* 98: 331-353.

Edwards, M. Bunker, F. Maggs, C. A. and Johnson, M. P. (2001) Biodiversity within eelgrass (Zostera marina) beds on the Welsh coast: analysis of epiflora and recommendations for conservation. Marine Conservation Society.

EMU Limited. (2003) Native oyster beds (*Ostrea edulis*) in Wales. Report No 548

European Commission. (2007) Interpretation manual of European Union Habitats. European Commission, DG XI - Environment, Nuclear Safety and Civil Protection. European Commission.

European Commission. (2000) Managing Natura 2000 sites. The provisions of Article 6 of the "Habitats Directive" 92/43/EEC. European Commission.

Evans, R.G. (1947). The intertidal Ecology of Cardigan Bay. *Journal of Ecology* 34: 273:309.

Hiscock, S. (1986). A survey of the mid-Wales Sarns (reefs): Sarn Badrig, Sarn-y-Bwch and Cyfelin patches. July 2nd to July 9th, 1986. Volume 1 Survey report. Nature Conservancy Council. CSD report No 696.

Hughes, P and Thomas, E. (2005). Sarns and Ceredigion Cetacean surveys, 2004. Friends of Cardigan Bay. Species Challenge Fund Report 04/01/03 (Grant No SC 7916)

Kay, L.A. & Bartley, N. (1996) A preliminary bibliography for the sea and coast around Bardsey island and the south-western Lleyn Peninsula. Bangor, Countryside Council for Wales Science Report 96/6/1.

Kay, Q.O.N. (1998). A review of the existing state of knowledge of the ecology and distribution of seagrass beds around the coast of Wales. Countryside Council for Wales Contract Survey No FC 73-01-168.

Liles, G. (2006). Current & Potential distribution, condition and breeding success of the otter in the Afon Mawddach catchment area. CCW Environmental Monitoring Report No 32. Contract Number FC73-05-69.

Liles, G. (2006). Current & Potential distribution, condition and breeding success of the otter (Lutra lutra) in the Afon Gwyrfai and the Dyfi Estuary. CCW Environmental Monitoring Report No.36. Contract Number FC72-02-97.

Mills, D. J. L. (1991) Benthic marine ecosystems in Great Britain: a review of current knowledge. Cardigan Bay, North Wales, Liverpool Bay and the Solway (MNCR Sectors 10 and 11). Marine nature conservation review. Peterborough: Nature Conservancy Council.

Moore, J. (2002) An atlas of marine biodiversity action plan species and habitats and species of conservation concern in Wales. 2nd (ed.). Coastal Assessment, Liason and Monitoring. Countryside Council for Wales Scientific report No. 509.

Pesante, G., Evans, P.G.H., and Baines, M.E. (In prep for 2008). Abundance & Life History Parameters of Bottlenose Dolphin in Cardigan Bay and Pen Llŷn a'r Sarnau SACs, 2005-2007. Report to Countryside Council for Wales. Sea Watch Foundation, Caernarfon.

Penrose, R. & Pierpoint, C. (1999) The use of Welsh coastal habitats for the calving and nursery grounds of the harbour porpoise. Countryside Council for Wales Scientific report No. 378.

Prosser, M.V. and Wallace, H.L. 2004. Pen Llŷn a'r Sarnau cSAC and adjacent areas salt marshes review and National Vegetation Classification survey 2003 : main report. CCW Science Report 642.

Rees, E.I.S., Sanderson, W.G., Mackie, A.S.Y and Holt, R.H.F. (2008). Small-scale variation within a Modiolus modiolus (Mollusca: Bivalvia) ref in the Irish Sea. III. Crevice, sediment infauna and epifauna from targeted cores. Journal of the Marine Biological Association of the United Kingdon 88 (1), 151-156.

Sanderson, W.G. Holt, R.H.F. Kay, L. Wyn, G. & McMath, A.J. (eds). (2001) The establishment of a programme of surveillance and monitoring for judging the condition of the features of the Pen Llŷn a'r Sarnau cSAC: 1. Progress to March 2001. Bangor, Contract Science report No 380 (UK Marine SACs peoject), 400pp.

Westcott, S. M. (2002) The distribution of grey seals (*Halichoerus grypus*) and census of pup production in North Wales 2001. Countryside Council for Wales Scientific report No. 499.

Westcott, S.M. and Stringell, T.B. (2005). Field observations on the disturbance of grey seals in North Wales, 2003. Marine Monitoring Report No 15. 53pp.

<u>See also reports from</u>
British Geology Survey
Bardsey Bird and Field Observatory
Cardigan Bay Coastal Group.
Countryside Council for Wales
Friends of Cardigan Bay
Marine Nature Conservation Review (Joint Nature Conservation Committee)
Seasearch
Seawatch Foundation

APPENDIX 1Glossary 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 [23]). 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[24]). "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*)

[23] Baretta-Bekker, Duursma & Kuipers (eds) 1998. Encylopedia of marine sciences. Second edition. Springer
[24] 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

Porth Dinllaen i Borth Pistyll

Porth Towyn i Borth Wen

Glannau Aberdaron

Ynys Enlli

Wig Bach a'r Glannau i Boreth Alwn

Porth Ceiriad, Porth Neigwl ac Ynysoeed Sant Tudwal

Mynydd Tir y Cwmwd a'r Glannau at Garreg Yr Imbill

Glanllynnau a Glannau Pen – Ychain I Cricieth

Tiroedd a Glannau rhwng Cricieth ac Afon Glaslyn

Morfa Harlech

Morfa Dyffryn

Aber Mawddach - Mawddach Estuary

Glannau Tonfanau i Friog

Broadwater

Dyfi

Borth –Clarach

SPAs that are partly or wholly within the SAC

Glannau Aberdaron and Ynys Enlli – Aberdaron Coast and Bardsey Island

Mynydd Cilan, Trwyn y Wylfa ac Ynysoedd Sant Tudwal

Aber Dyfi – Dyfi Estuary

Locations are shown on Maps 2i and 2ii

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 important in mediating reproduction and survival of species, shielding submerged species from the more extreme

ELEMENT	Rationale
	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 modifing 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 (*eg* 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 (*eg* PCBs, biocides etc) and anthropogenic elevation of naturally occurring chemical components (*eg* 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 (*eg* 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

TYPICAL SPECIES & SPECIES FEATURES

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. 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,

ELEMENT	Rationale
	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.