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

Advice provided by Natural Resources Wales in fulfilment of Regulation 37(3) of the Conservation of Habitats and Species Regulations 2017.

June 2025

The Mawddach Estuary © NRW.

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Mae'r ddogfen hon yn cynnwys cyngor Cyfoeth Naturiol Cymru ar gyfer ardal cadwraeth arbennig (ACA) Pen Llŷn a'r Sarnau a gyhoeddwyd o dan Reoliad 37(3) o Reoliadau Cadwraeth 2017. Sef amcanion cadwraeth a chyngor ar weithrediadau.

Mae Adran 1 yn cyflwyno'r safle, pwrpas y cyngor a strwythur yr amcanion cadwraeth. Mae Adran 2 yn cynnwys esboniad o'r rolau a'r cyfrifoldebau, ac mae Adran 3 yn amlinellu amcanion cadwraeth pob nodwedd a gwybodaeth ategol. Mae cyngor ar weithrediadau mewn perthynas â'r safle hwn i'w gael yn Adran 4. Mae rhagor o wybodaeth am yr ACA wedi'i chynnwys yn Atodiad 1.

Isod mae rhestr o nodweddion dynodedig yr ACA hon a dolen uniongyrchol i'r amcanion cadwraeth, ond mae'n bwysig darllen pob adran yn llawn.

Tabl 1. Crynodeb o nodweddion yr ACA a'r ddolen i'r amcanion Cadwraeth.

Enw'r ACA	Nodweddion Dynodedig	Cysylltiad â'r Amcanion Cadwraeth
Pen Llŷn a'r Sarnau	• Riffiau • Cilfachau a baeau mawr bas • Ponciau tywod sydd fymryn dan ddŵr y môr drwy'r amser • Aberoedd • Morlynnoedd neu Lagynau • Gwastadeddau llaid neu dywod nas gorchuddir gan y môr ar lanw isel • Dolydd ar forfeydd arfordir y gorllewin • *Salicornia* a phlanhigion unflwydd eraill sy'n cytrefu llaid a thywod • Ogofâu môr sy'n danforol neu'n lleddanforol • Morlo llwyd *Halichoerus grypus* • Dolffin trwyn potel *Tursiops truncatus* • Dyfrgi *Lutra lutra*	Amcanion cadwraeth

Executive Summary

This document contains NRW's advice for Lleyn Peninsula and the Sarnau special area of conservation (SAC) issued under Regulation 37(3) of the Conservation Regulations 2017.

Section 1 introduces the site, the purpose of the advice and the structure of the conservation objectives. Section 2 includes an explanation of the roles and responsibilities before Section 3 outlines each feature's conservation objectives and supporting information. Advice on operations in relation to this site is found in Section 4 which information on climate change and restoration in section 5. Further information on the site is captured in Appendix 1.

Table 1 lists the designated features of this site and provides a direct link to the conservation objectives, but it is important that all sections are read in full.

Table 1. Summary of SAC features and link to conservation objectives.

SAC Name	Designated Features	Link to Conservation Objectives
Lleyn Peninsula and the Sarnau	• 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 *Glauco-Puccinellietalia maritimae* • *Salicornia* and other annuals colonising mud and sand • Submerged or partially submerged sea caves • Grey seal *Halichoerus grypus* • Bottlenose dolphin *Tursiops truncatus* • Otter *Lutra lutra*	Conservation objectives

1. Introduction

The ardal cadwraeth arbennig Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau special area of conservation (SAC) is located in northwest Wales and encompasses large areas of sea, coast and estuary. The site supports 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.

The Pen Llŷn a'r Sarnau SAC was designated in December 2004 under Article 4.2 of the Conservation of Natural Habitats and of Wild Fauna and Flora Directive (92/42/EEC) for multiple habitats and species. The site was selected for the presence of 9 habitat features under Annex I and 3 species features under Annex II of the Habitats Directive. 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 (abbreviated to LSIB)
- Sandbanks which are slightly covered by seawater all the time (abbreviated to sandbanks)
- Estuaries
- Coastal lagoons

and to support a significant presence of:

- Mudflats and sandflats not covered by seawater at low tide (abbreviated to mudflats and sandflats)
- Atlantic salt meadows *Glauco-Puccinellietalia maritimae* (abbreviated to ASM)
- *Salicornia* and other annuals colonising mud and sand (abbreviated to *Salicornia*)
- Submerged or partially submerged sea caves (abbreviated to sea caves)
- Grey seal *Halichoerus grypus*
- Bottlenose dolphin *Tursiops truncatus*
- Otter *Lutra lutra*

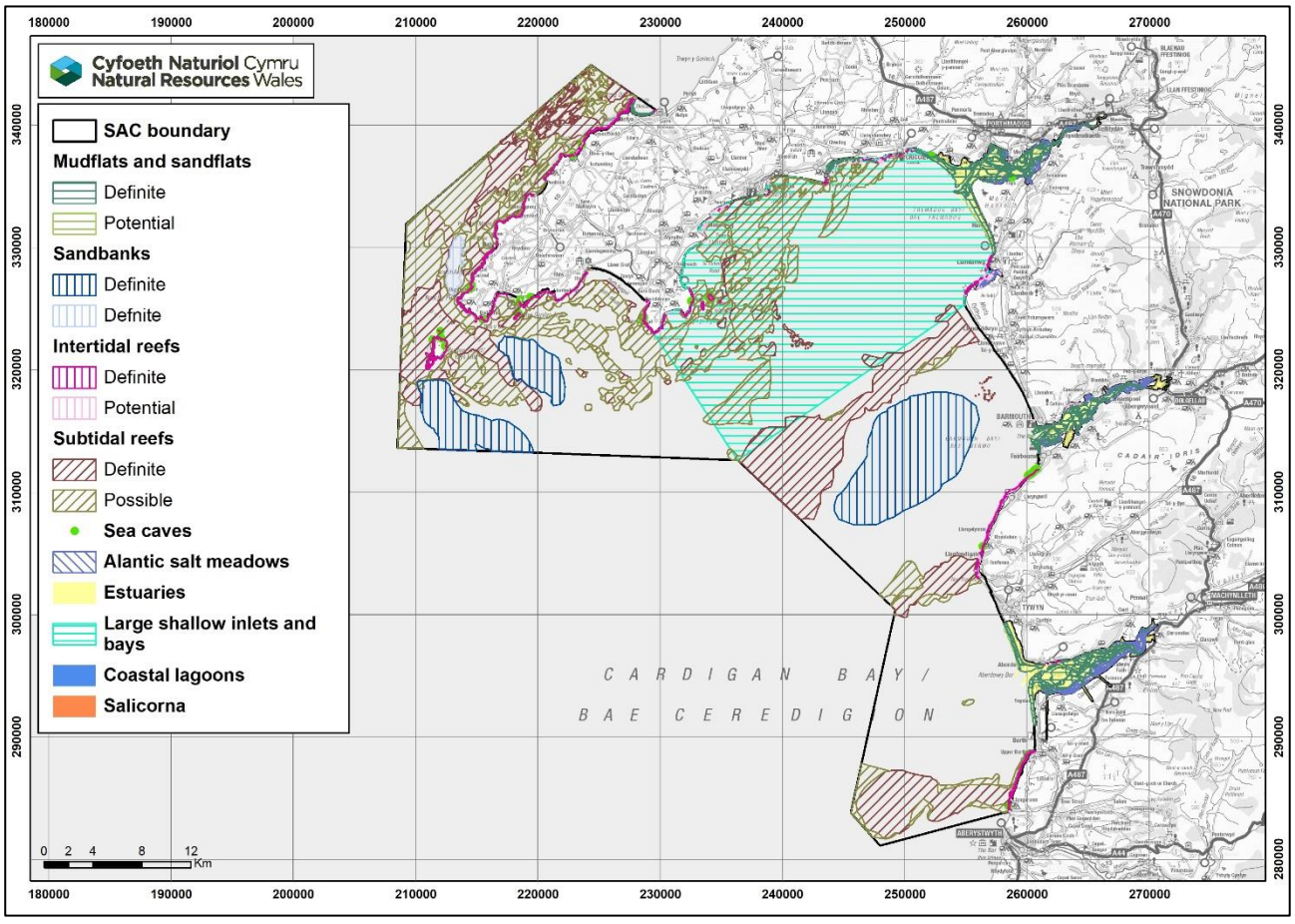
A number of other protected sites overlap the Pen Llŷn a'r Sarnau SAC, including one SAC, four special protection areas (SPAs) and 18 sites of special scientific interest (SSSIs). A list of overlapping protected sites can be seen in Appendix 2 and their conservation objectives, or site management statements, can be found on the NRW website. The boundaries and geographical extents of these sites can be seen on the Joint Nature Conservation Committee (JNCC) MPA mapper. Several habitats and species within the SAC are also listed in Section 7 of the Environment Act (Wales) which lists habitats and species of principal importance in Wales. There are also OSPAR threatened and declining species and habitats within the SAC. For these additional conservation interests see Appendix 2.

1.1. SAC feature map

The feature locations in maps are indicative and represent the best available evidence at the time of publication. No single habitat feature occupies the entire SAC and features overlap in some locations (see Figure 1). The extent of most habitat features is not known precisely because accurate mapping is very difficult, expensive and resource intensive. This is further complicated due to the dynamic and mobile nature of some habitats. Work is ongoing to improve our knowledge of where designated habitat features occur in our SACs and maps are updated periodically. When new areas of Annex I habitat are discovered within the boundary of a SAC they automatically become part of the SAC feature where it is already a designated feature of the site.

A map of each habitat feature within the SAC is shown before its conservation objectives. All feature maps in this document are for illustrative purposes only. Detailed maps for the features in Wales can be found on Data Map Wales.

Figure 1. Map showing the SAC boundary and designated habitat features of Pen Llŷn a'r Sarnau SAC.



1.2. The purpose of conservation advice

Conservation advice provides a framework for assessing developments and activities with the potential to affect the features for which a European marine site (EMS) is designated.

An EMS is a SAC or SPA which consists of marine areas. Conservation advice presents site specific information, in addition to highlighting activities that are potentially capable of having an impact on the site and its designated species (known as a feature).

This SAC is an EMS subject to protection under the Conservation of Habitats and Species Regulations 2017, as amended (referred to in this document as the 'Habitats Regulations'). Under the Habitats Regulations, relevant and competent authorities with functions in relation to an EMS must exercise those functions to comply with the requirements of the 1992 European Commission (EC) Habitats and Species Directive and the 2009 EC Wild Birds Directive. The key requirements of these Directives include the conservation of the features (habitat types or species) for which SACs or SPAs are designated. This requires taking appropriate steps to avoid deterioration or disturbance of SAC or SPA features and carrying out appropriate assessment of any plan or project likely to have a significant effect on a SAC or SPA.

This document contains the conservation advice for the Menai Strait and Conwy Bay SAC. It is prepared by Natural Resources Wales (NRW) and given under our duty in Regulation 37(3) of the Habitats Regulations (see Section 2.1).

This advice is based on the best available evidence and information at the time of writing. In some cases, evidence can be limited. It will be kept under review by NRW and updated as and when appropriate.

1.3. Conservation objective structure

The conservation objectives for the designated features in this SAC are underpinned by conservation objective attributes. These attributes describe the ecological characteristics (e.g. population), and the ecological requirements that allow the conservation objectives for each feature to be met.

Conservation objective attributes have a target which is either quantified or qualified depending on the available evidence. The target identifies, as far as possible, the desired state to be achieved for the attribute. In many cases, the attribute targets show if the current objective is to either 'maintain' or 'restore' the attribute and are based on the latest condition assessment for the feature. Some aspects of feature condition may be assessed as unknown. In these cases, a maintain target will be set as necessary. For attributes that have been assigned 'unknown' in the condition assessment, further information on feature condition and/or activities impacting the feature will be required to inform further advice. Each attribute target will need to be assessed on a case-by-case basis using the most current information available and all are subject to natural change.

The conservation objective attributes that underpin the conservation objectives are used to measure if the objective is being met. This in turn can be used to see if site integrity is being maintained. Failure to meet any attribute means that the conservation objective is not being met and thus site integrity is not being maintained. Below is an example of a conservation objective and associated conservation objective attributes and targets.

Example Objective 1: The overall distribution and extent of the mudflats and sandflats feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Example Objective attribute	**Example Site specific target**
Feature extent and distribution	Maintain/restore the extent and distribution of mudflats and sandflats
Component habitat extent and distribution	Maintain/restore the extent and distribution of mudflat and sandflat component habitats.

The conservation objectives for The Pen Llŷn a'r Sarnau SAC are set out in Section 3. As noted in Section 1.2, NRW may refine these in the future as further information becomes available and increases our understanding of the feature.

The feature's conservation objective section provides:

1. A clear statement of each conservation objective for the feature.

2. A table summarising the attributes, and the targets for those attributes.

3. Supporting information that underpins the selection of the attributes and targets.

2. Roles and responsibilities

2.1. NRW's role

Under Regulation 5 of the Habitats Regulations, NRW is a Nature Conservation Body and, in relation to Wales, is the Appropriate Nature Conservation Body (ANCB).

In its role as the ANCB, NRW has a duty under Regulation 37(3) of the Habitats Regulations to advise relevant authorities in respect of a EMS as to:

(a) the conservation objectives for that site

(b) any operations which may cause deterioration of natural habitats or the habitats of species, or disturbance of species, for which that site has been designated (see Section 1.2).

Advice on operations which may cause deterioration, together with the conservation objectives, is designed to assist relevant authorities and other decision-makers in complying with their statutory duties under the Habitats Regulations. The advice on operations which may cause deterioration given in this document is without prejudice to other advice given. This includes the conservation objectives themselves, and other advice which may be given by NRW from time to time in relation to any specific operations.

"Operations" is taken to cover all types of anthropogenic activity, irrespective of whether they are under any form of regulation or management. Thus, the advice contains reference to operations which may not be the responsibility of any of the relevant authorities.

NRW will provide additional advice for the site to relevant authorities and competent authorities to allow them to fulfil their duties under the Habitats Regulations. For example, by providing advice to a competent authority assessing the implications of plans or projects on the features of the EMS. Each plan or project will be judged on its own merits, and this will determine the nature of any additional advice required.

2.2. The role of competent and relevant authorities

The expressions used in this advice of "relevant authority" and "competent authority" are as defined in Regulation 3 of the Habitats Regulations. Relevant authorities are specified in Regulation 6 of the Habitats Regulations. Competent Authorities are specified in Regulation 7 of the Habitats Regulations.

Under Part 6 of the Habitats Regulations, all competent authorities must undertake a formal assessment of the implications that any new plans or projects may have on the designated features of a protected site. The implications must be assessed in the context of other plans and projects affecting the same site. Activities outside the site may also affect the features of the site, therefore, plans and projects located outside of a designated site may still need to be assessed.

In respect of the assessment provisions in Part 6 (assessment of plans or projects) of the Habitats Regulations, NRW is also the ANCB in relation to Wales.

The assessment provisions comprise several distinct stages which are collectively described as a Habitats Regulations Assessment (HRA), for which guidance is available. Before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and is not directly connected with or necessary to the management of that site, the competent authority must make an appropriate assessment of the implications of the plan or project for that site in view of that site's conservation objectives.

In light of the conclusions of the HRA and subject to derogation under Regulation 64, the competent authority may agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the EMS. In considering whether a plan or project will adversely affect the integrity of the site, the competent authority must have regard to the manner in which it is proposed to be carried out or to any conditions or restrictions subject to which it proposes that the consent, permission or other authorisation should be given.

Carrying out the HRA process is the responsibility of the decision maker as the competent authority. However, it is the responsibility of the applicant to provide the competent authority with the information that they require for this purpose.

The competent authority has a duty to consult the ANCB for the purposes of the assessment. Under Regulation 63(3) of the Habitats Regulations the competent authority must have regard to any representations made by the ANCB when reaching its decision.

Under Regulation 38(1) of the Habitats Regulations it states that, "*the relevant authorities, or any of them, may establish for a European marine site a management scheme under which their functions (including any power to make byelaws) are to be exercised so as to secure compliance with the requirements of the Directives in relation to that site".*

In other words, a group of relevant authorities, or any individual relevant authority, may create a management plan for an EMS. Management plans should be used to help relevant authorities carry out their duties to secure compliance with the Habitats Regulations. Only one management scheme may be made for each EMS. A management scheme may be amended. An authority which has established a management scheme must as soon as practicable thereafter send a copy of it to the ANCB. Any management plans created on this site should be guided by the advice in this package.

Within their areas of jurisdiction relevant authorities must have regard to both direct and indirect effects of an activity on the designated features of the site. This may include consideration of issues outside the boundary of the site. Nothing within a Regulation 37(3) package will require relevant authorities to undertake any actions to maintain or improve the condition of designated features if it is shown that the changes result wholly from natural causes.

NRW will continue to review any new evidence or information about this site and will provide further advice as appropriate. This does not stop relevant authorities from taking any appropriate conservation measures to prevent deterioration to the designated features. Such actions should be undertaken when required.

2.3. The purpose of conservation objectives

The purpose of the conservation objectives for an EMS is to help meet the obligations of the Habitats Regulations in relation to that site. They do this by supporting:

- **Communication**. The conservation objectives help convey to stakeholders what is needed to maintain or restore a feature in/to favourable condition.
- **Site planning and management**. The conservation objectives guide the development of management measures for sites. Achievement of conservation objectives may require management action to be taken inside or outside the site boundary.
- **Assessment of plans and projects**. The Habitats Regulations require the assessment of plans and projects in view of a site's conservation objectives. Subject to certain exceptions, plans or projects may not proceed unless it is established that they will not adversely affect the integrity of a site. Conservation objectives can help develop suitable compensatory measures.
- **Monitoring and reporting**. Conservation objectives provide the basis for defining the evidence that will be used for assessing the condition of a feature.

This document includes both a statement of the conservation objectives and explanatory text on their intent and interpretation specific to the site (supporting information).

2.4. The purpose of advice on operations

NRW must provide advice to relevant authorities about operations that may cause,

- deterioration of designated natural habitats
- deterioration of the habitats of designated species
- the disturbance of designated species

This is statutory advice required by Regulation 37(3)(b) of the Habitats Regulations when considering operations which may cause impacts to designated features. These are operations which could take place within or outside the boundary of the [insert SAC/SPA].

NRW can provide specific advice on existing activities and management, advising on the extent to which activities are consistent with the conservation objectives. This advice, together with the list of activities in Section 4 and the latest condition assessments, should direct required management measures within a site..

2.5. When to use this advice

This advice should be used together with case-specific advice issued by NRW when developing, proposing or assessing an activity, plan or project that may affect the features of the site. Any proposal or operation that has the potential to affect a site must not prevent the achievement of the feature's conservation objectives. Any such prevention would amount to an adverse effect on the integrity of the site.

The advice given here is without prejudice to any advice which may be provided by NRW in relation to the consideration of individual plans or projects in the carrying out of the assessment provisions as defined in Part 6 of the Habitat Regulations.

2.6. Feature condition

NRW has a dedicated condition assessment process to assess feature condition. Each feature designated in Welsh EMS have their own set of performance indicators. These indicators have targets which are assessed with the most up to date evidence available. When all required indicator targets are met a feature is in favourable condition.

The condition assessment of a feature helps to determine if its conservation objectives are being achieved. Results determine if maintain or restore conservation objectives are needed. Appropriate management must be in place to enable conservation objectives to continue being met and for feature condition to be maintained or restored as required. The conservation objectives cannot be achieved if a feature is in unfavourable condition.

Feature condition is recorded in condition assessment documents. These are available on the NRW website. NRW will update this advice package when new condition assessment information is available.

2.6.1. Favourable conservation status and National Site Network

If features are in favourable condition, it is likely they are making an appropriate contribution to Favourable Conservation Status (FCS) of the feature at the UK level. A feature cannot make an appropriate contribution to FCS without meeting its conservation objectives. More information on FCS can be found in the joint statement from the UK Statutory Nature Conservation Bodies.

Regulation 16A of the Habitats Regulations creates the National Site Network on land and at sea, including both the inshore and offshore marine areas in the UK, and sets out the powers and duties of the appropriate authority (Welsh Government).

Information on how features in a site are meeting their conservation objectives will feed into the assessment of the National Site Network management objectives. The management objectives for the National Site Network are to maintain or restore designated SAC and SPA features to favourable conservation status across their natural range. More information on the UK National Site Network and its management objectives can be found on the gov.uk website.

2.7. Climate change and coastal squeeze

2.7.1. Vulnerability of Annex I habitats to climate change pressures

The oceans play a vital role in the global carbon cycle, and the importance of the oceans in mitigating against climate change is now widely recognised.

Oaten et al. (2021) determined the vulnerability of Welsh Annex I marine features to a range of climate change pressures. The method involved developing a Geographical Information System (GIS) model using the best available climate projections and spatial data on marine habitats in Wales at that time. This was undertaken for a number of emissions scenarios and management timeframes.

A literature review on the sensitivities of Annex I habitats to physical and chemical pressures as a result of climate change was carried out which also informed the assessment. The biological resolution of Annex I habitats was considered too broad to undertake a meaningful vulnerability assessment, as individual biotopes that comprise the Annex I habitats have differing sensitivities to climate change pressures. Thus, the initial assessment was based on the vulnerabilities of component biotopes of Annex I marine habitats in Wales. The biotopes were then re-assigned to the respective features within each MPA. While it was not possible to achieve full spatial coverage of biotopes that comprise the Annex I features (due to spatial gaps in data in some of the features), the resulting data was considered to sufficiently represent the types of communities that would be found (Gihwala et al., 2024).

The climate change pressure that were assessed included:

- Air temperature
- Deoxygenation
- Ocean acidification
- Salinity
- Sea level rise
- Sea temperature
- Wave exposure

There are other pressures that have not been assessed such as those arising from the terrestrial environment for example increased river and sediment run off due to predicted higher rainfall levels.

The vulnerability categories used in the analysis were ‘Not relevant’, ‘Not sensitive’, ‘Low’, ‘Medium’ and ‘High’. The overall vulnerability score for each climate change pressure was based on the vulnerability category with the greatest spatial coverage for the respective feature (based on the underpinning biotopes). It should be noted that climate change vulnerabilities assigned to each respective feature at the site level were only based on biotope sensitivities and did not consider any local circumstances (e.g. specific management policies or existing coastal structures) and were based under an RCP 8.5 scenario – 2049 (Gihwala et al., 2024).

In Section 5.1 a summary of the climate change vulnerabilities for each assessed feature on this site can be found. The full report includes the impact on Blue Carbon and maps of the different climate change pressures.

Climate change is likely to cause changes across a site and across the network of sites in Wales. There are likely to be differences in impacts across features with some features being more impacted by certain climate change pressures than others. There may also be perceived conflicts between features where potential management measures may impact one feature to the detriment of another e.g. the protection of a coastal lagoon may affect adjacent mudflats and sandflats. These challenges are difficult to address through conservation advice and a lot more thinking needs to be done on this issue. In the meantime they will need to be considered on a site-by-site basis, as and when they arise.

2.7.2. Vulnerability of coastal features to coastal squeeze

Besides the general work on climate change vulnerabilities above more specific detailed work has been carried out on the impacts of sea-level rise on our MPA network (Oaten et al., 2024). This work regards the extent to which sea-level rise may cause coastal squeeze and natural squeeze, an issue which affects intertidal habitats.

Coastal Squeeze is “The loss of natural habitats or deterioration of their quality arising from anthropogenic structures, or actions, preventing the landward transgression of those habitats that would otherwise naturally occur in response to sea level rise in conjunction with other coastal processes. Coastal Squeeze affects habitat on the seaward side of existing structures.”

Natural squeeze is defined as the loss of habitat against any natural frontage that restricts the rollback of intertidal habitats. Two types of natural frontage are considered within the assessment of natural squeeze:

- Natural Ridge – e.g., a shingle / dune ridge or a natural bank that has an area of low-lying land behind that could be inundated by the tide if the ridge is breached; and
- High ground – naturally high ground that limits any inundation of the tide into the hinterland.

Seven broad intertidal habitat groups were identified as being subjected to coastal squeeze. The following are of relevance for our marine Annex I habitats in our Welsh MPA network,

- Saltmarsh
- Mudflats and sandflats
- Intertidal reef
- Vegetated shingle.

The affected habitats for this SAC are saltmarsh, mudflats and sandflats and intertidal reefs. Coastal lagoons were considered using a different methodology. Further information on the specific feature impacts is provided in Section 5.2. The different timeframes, climate change scenarios and management scenarios can be found in the full assessment of coastal squeeze report.

3. Conservation objectives for Pen LlŷN a'r Sarnau SAC

The conservation objectives for each designated feature are outlined in the sections below. Each objective is accompanied by objective attributes and targets (see Section 1.3) and supporting information specific to each objective. General site information can be found in Appendix 1. General feature descriptions and ecological characteristics can be found in the JNCC habitats list and species list.

The following terms are used in the conservation objectives.

Anthropogenic: In this document anthropogenic specifically relates to environmental changes caused or influenced by people, either directly or indirectly. NRW consider anthropogenic influences to include climate change.

Component habitat: Habitats that constitute the named features. E.g. Muddy gravels in mudflats and sandflats not covered by seawater at low tide.

Maintain: Where existing evidence from the most recent condition assessment suggests the feature to be in favourable condition, the conservation objective is for the feature to remain in favourable condition.

Natural change: This is defined as species or habitat changes which are not a result of anthropogenic influences. NRW consider anthropogenic influences to include climate change.

Natural variability: This is defined as species or habitat variability, which are not a result of anthropogenic influences. NRW consider anthropogenic influences to include climate change.

Restore: Where existing evidence from the most recent condition assessment suggests the feature, or part of the feature, to be in unfavourable condition the conservation objective is to return the feature to favourable condition. As the feature is being returned to favourable condition, further decline in the aspects of condition that are causing it to be unfavourable should be prevented. The ability to achieve favourable condition should not be inhibited.

Structure and function: Structure encompasses both the physical structure of a habitat feature (e.g. geology and morphology), together with the biological structure, including habitat forming species (both plant and animal) and species composition. Function encompasses the ecological processes influencing the habitat feature at different temporal and spatial scales.

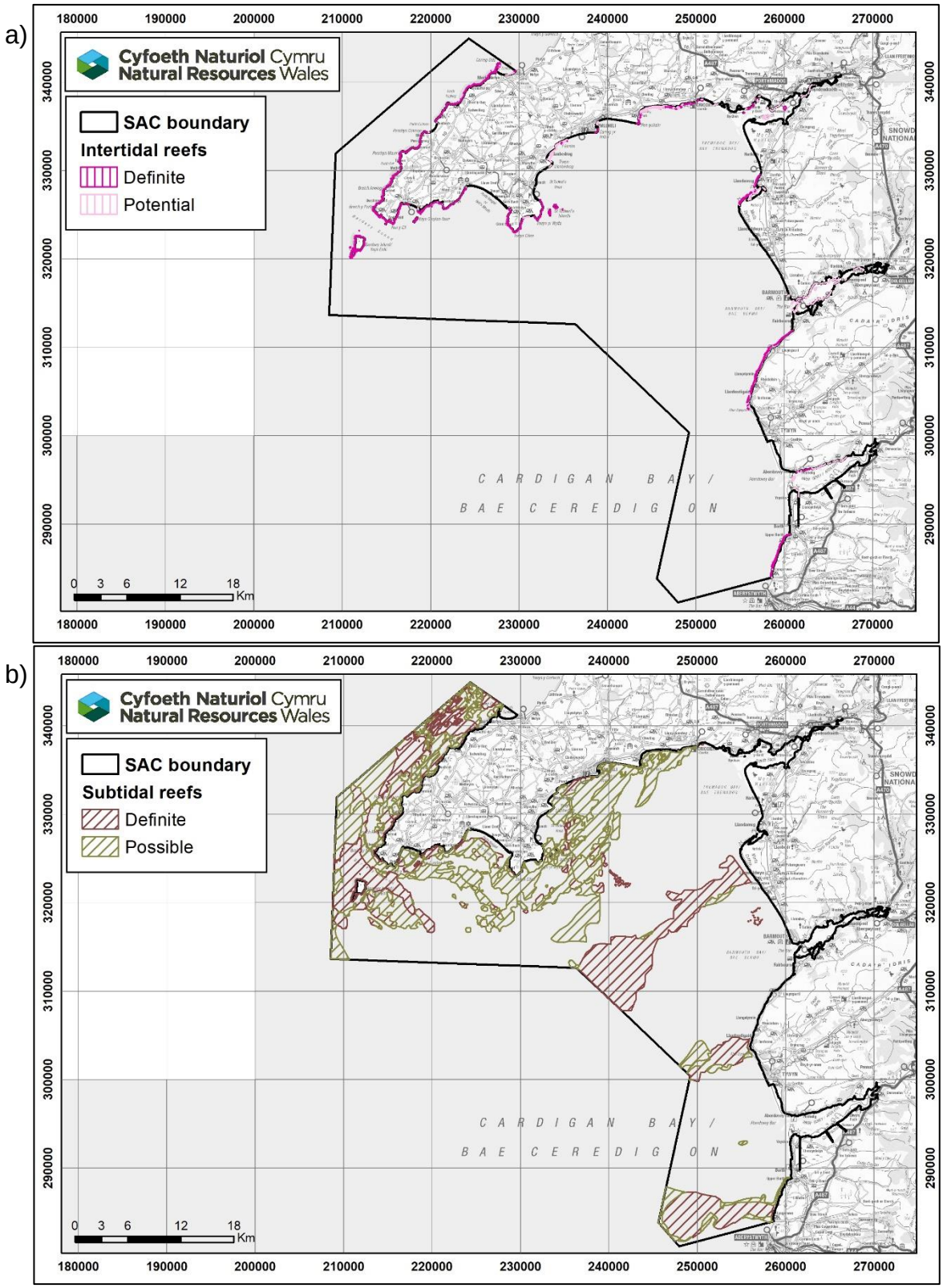
Unknown: Where there is not enough suitable evidence to conduct a condition assessment the feature is assigned an unknown condition.

3.1. Feature 1: Reefs

The reefs feature within Pen Llŷn a'r Sarnau SAC is currently in **unfavourable** condition (high confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 2 is a map of the location of the reefs feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales. The attributes and targets for each conservation objective, alongside supporting information, follow Figure 3.

Figure 2. Map of the reefs feature within Pen Llŷn a'r Sarnau SAC. a) intertidal reefs and b) Subtidal reefs.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the reefs feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Objective attribute	Site specific target(s)
1a. Feature extent and distribution	Maintain the extent and distribution of the reefs feature and reef types, subject to natural change.
1b. Component habitat extent and distribution	Maintain the extent and distribution of the component habitats and communities necessary for the structure and function of the reefs feature. Restore the extent and distribution of the *Modiolus* bed in the SAC necessary for the structure and function of the reefs feature.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the habitat across the whole site, even where it is patchy. The distribution describes the more detailed locations and patterns of different habitats that comprise the feature across the site. The reefs feature occurs throughout the entire SAC in intertidal and subtidal areas.

The reefs feature incorporates a range of different habitat types. These include rocky intertidal and subtidal reefs (bedrock, boulder and cobble), biogenic reefs (e.g. those formed by the horse mussel *Modiolus modiolus* or 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 Holden's Reef).

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. 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.

The reefs extent and distribution attribute is being met, allowing a maintain target to be set for objective 1a. For further information see the latest condition assessment (Jackson-Bué et al., 2025b).

1b. Component habitat extent and distribution

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.

Reef habitats and communities need to be maintained by sustaining suitable environmental conditions and limiting activities which they may be sensitive to. Information on these and other reef habitat can be seen in Appendix 1.

While several reef habitats can be distinguished within the SAC there are some reefs of particular note in the SAC including,

- Horse mussel *Modiolus modiolus* located to the north of Tudweiliog on the northern side of the Llŷn. Relatively few *Modiolus* beds are still known to exist within the Irish Sea, and the north Llŷn reef is considered one of the best examples in this area.
- Green crenella *Musculus discors* beds located to the north of the Llŷn.
- Honeycomb worm *Sabellaria alveolata* located along the coast in areas of mixed substrata within Tremadog Bay from west of the Afon Dwyfor to Llanfendigaid in the south. Subtidal *Sabellaria spinulosa* reefs are found within the SAC, but the extent and quality of this habitat is unknown.
- Carbonate reef located within Tremadog Bay to the north west of Barmouth.
- Extensive rocky boulder and cobble subtidal reefs (The Sarnau) south of Tremadog Bay. These include Sarn Badrig off Mochras point in the north, Sarn-y-Bwch off Pen Bwch Point and Sarn Cynfelin in the southern end of the bay near Aberystwyth.
- Bedrock reef, particularly around offshore islands (e.g. Bardsey Island), headlands and the north coast of the Pen Llŷn.

The latest condition assessment found that the *Modiolus* bed extent has been decreasing since 2005. The loss of extent in this biogenic reef type, an important component habitat, has resulted in a loss of component habitat extent. The cause of decline is under investigation. For further detail see the latest condition assessment (Jackson-Bué et al., 2025b).

Due to the *Modiolus* bed decline the reefs habitats and communities attribute is not being met. As this decline is localised a specific restore target has been set for the *Modiolus* bed for objective 1b. No other issues have been identified in the component habitats extent and distribution for the rest of the feature. This has allowed a maintain target to be set for all reef outside of the *Modiolus* bed within the Pen Llŷn a'r Sarnau SAC. For further detail see the latest condition assessment (Jackson-Bué et al., 2025b).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the reefs feature are stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the reefs feature. Nutrients are at levels not detrimental to the structure and function of the reefs feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the reefs feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the reefs feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the reefs feature is maintained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living in the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on the nature of the contaminant. Contaminants include heavy metals (e.g. mercury and zinc), poly-aromatic hydrocarbons, poly-chlorinated biphenyls (PCBs), organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

High concentrations of nutrients (nitrogen and phosphorus) in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can lead to reduced dissolved oxygen availability especially in warmer months. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007). Overgrowth of opportunistic macroalgae species because of increased nutrient input on intertidal reef can reduce biodiversity, though the effect of grazers and wave action can help limit the impacts (Bokn et al., 2003; Worm and Lotze, 2006). High nutrient loads may be more of an issue on sheltered intertidal reef with low grazing pressure (Bokn et al., 2003).

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats alone or in combination to affect habitats in terms of the abundance, distribution and composition of communities present. Changes in any of these properties, because of anthropogenic activities, may impact habitats and the communities they support.

Some quality issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025b).

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input),coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which in turn can change the waves and the currents; meaning there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

Many anthropogenic activities can change the hydrodynamic and sediment transport process. For example, changes to depth or the introduction of barriers (including energy extraction) can change the speed of currents and the degree of wave exposure, while dredging and construction can cause large, though short lived, increases in the volume of sediment deposited on a habitat.

Morphology of hard substrata reefs is unlikely to change without direct anthropogenic action (e.g. construction or demolition). Cobble and boulder reef morphology can be altered by large wave events. Biogenic reef morphology can be affected by changes to the nutrient, food or sediment supply required for their maintenance, as well as storm events or anthropogenic activity.

Many of these reef habitats are 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.

Some hydro-morphology issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025b). Information on the hydro-morphology of the SAC can be found in Appendix 1.

2c. Sediment supply

Sediment type, distribution and supply are important in determining the species and communities present in a habitat. The rate at which sediment is deposited is known to influence reef habitats and their associated communities. Sedimentation influences community composition, alters species growth rates, inhibits feeding or photosynthesis and potentially affects reproductive success by reducing larval recruitment. High levels of sediment deposition could lead to smothering or burying of sessile benthic species.

Sediment supply is important for reef forming *Sabellaria* species, as tube growth is dependent on the presence of suspended particles. A reduction in sediment transport may reduce the amount of sediment available for tube construction. Conversely an increase in sediment may facilitate tube building but clog up feeding apparatus. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

Some sediment supply issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025b). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the reefs feature are stable or improving, subject to natural variability.

Objective attribute	**Site specific target(s)**
3a. Habitats and communities	Maintain the abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the reefs feature. Restore the abundance, distribution and diversity of species within communities necessary for the structure and function of the *modiolus* bed.
3b. Invasive and non-native species	Introduction or spread of new non-native species to the site by anthropogenic activities should not have a detrimental impact on the structure and function of the reefs feature.

Supporting Information

3a. Habitats and communities

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. Some of the reef communities are particularly species rich, such as the horse mussel reef *Modiolus modiolus*. Changes to the spatial distribution of communities across the feature could highlight changes to the overall feature.

All the habitats and communities within the reefs contribute to the overall condition of the feature. However, a number of notable reef habitats and their associated assemblages of marine plants and animals are of particular conservation importance, namely,

- Rocky intertidal reef, open coast and estuarine rocky communities, intertidal boulder communities, peat and clay exposures
- Rocky subtidal reef around the Pen Llŷn, including fragile sponge and anthozoan communities
- Extensive rocky boulder and cobble subtidal reefs (The Sarnau)
- Biogenic reef (*Modiolus modiolus, Musculus discors, Sabellaria spp. Mytilus edulis*)
- Carbonate reef (formed by methane gas leaking from the seabed)

More information on each of these habitats and their communities and reef communities in general can be found in Appendix 1.

The latest condition assessment found declines in the *Modiolus* bed habitat since 2005, with a lack of recruitment resulting in an ageing population. Where there are dead *Modiolus,* associated species diversity declines. The cause of the decline is under investigation (Jackson-Bué et al., 2025b).

The habitat and communities attribute is not being met specifically for the decline seen in the *Modiolus* bed. Due to this localised failure the *Modiolus* bed has its own restore target for objective 3a. There have been no other issues identified for the habitats and communities, allowing a maintain target to be set for objective 3a for the rest of the reefs feature in the Pen Llŷn a'r Sarnau SAC. For further detail see the latest condition assessment (Jackson-Bue et al., 2025b).

3b. Invasive and non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

While there are INNS recorded in the SAC there is limited evidence to suggest that any INNS are currently impacting the reefs feature in the SAC. See the latest condition assessment for more information (Jackson-Bue et al., 2025b).

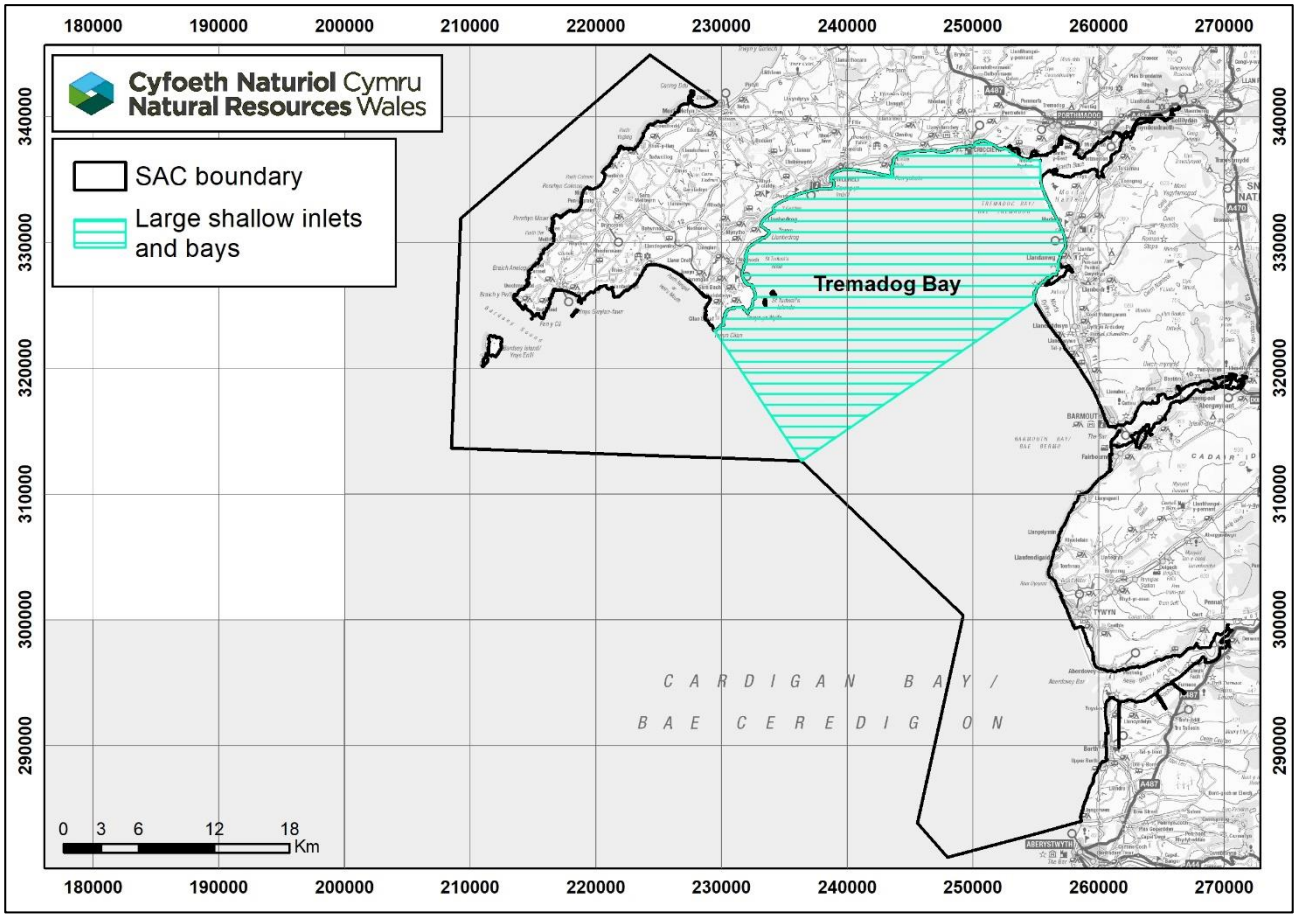
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.2. Feature 2: Large shallow inlets and bays

The large shallow inlets and bays within Pen Llŷn a'r Sarnau SAC feature is currently in **favourable** condition (medium confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 3 is a map of the location of the large shallow inlets and bays feature within Pen Llŷn a'r Sarnau SAC SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 3. Map of the large shallow inlets and bays feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the large shallow inlet and bays feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of the large shallow inlets and bays feature, subject to natural change.
1b. Component habitat extent and distribution	Maintain the extent and distribution of large shallow inlet and bays component habitats and biological communities necessary for the structure and function of the large shallow inlets and bays feature.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the feature across the whole site. The distribution describes the more detailed locations and patterns of different habitats that comprise the feature across the site.

The large shallow inlets and bays feature (LSIB) of the SAC is the embayment known as Tremadog Bay at the northern end of Cardigan Bay. It extends from Trwyn yr Wylfa in the northwest, to the western tip of Sarn Badrig reef, and northeast to Morfa Dyffryn.

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.

The extent attribute of the LSIB feature has been met, allowing a maintain target to be set for objective 1a. See the latest condition assessment for more information (Jackson-Bué et al., 2025d).

1b. Component habitat extent and distribution

Within the LSIB there are several component habitats and include other Annex I habitats designated in the site (mudflats and sandflats, reefs, sandbanks, and sea caves). Annex II species are also found within the Bay and are designated as features of the site. Both bottlenose dolphin and grey seal breed within the SAC and otter may use the feature for passage and/ or feeding.

A large proportion of the seabed and seashore of Tremadog Bay is comprised of sediment habitat, made up of a high diversity of different sediment types. 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.

The general overall pattern of seabed and intertidal habitats in Tremadog Bay are;

- moderately well sorted finer and muddier sands in the north eastern and western areas
- well-sorted soft muddier sediments in deeper areas (such as ‘muddy hollow’ 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 north west part of the bay
- 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-y-Chain 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)
- precipitative reef structures (notably at Llanbedrog and southeast of Carreg y Defaid)
- outcrops of red and grey clay and peat.

Component habitats of the feature need to be maintained by sustaining suitable environmental conditions and limiting activities to which they may be sensitive to. The recovery of habitats will be influenced by the habitat type as well as the type and duration of impact.

The component habitats and communities extent and distribution attribute is being met, allowing a maintain target to be set for objective 1b. See the latest condition assessment for more information (Jackson-Bué et al., 2025d).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the large shallow inlets and bays feature are stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the large shallow inlets and bays feature. Nutrients are at levels not detrimental to the structure and function of the large shallow inlets and bays feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the large shallow inlets and bays feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the large shallow inlet and bays feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the large shallow inlet and bays feature is maintained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living in the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on the nature of the contaminant. Contaminants include heavy metals (e.g. mercury and zinc), poly-aromatic hydrocarbons, poly-chlorinated biphenyls (PCBs), organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

High concentrations of nutrients (nitrogen and phosphorus) in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can lead to reduced dissolved oxygen availability especially in warmer months. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007).

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats alone or in combination to affect habitats in terms of the abundance, distribution and composition of communities present. Changes in any of these properties, because of anthropogenic activities, may impact habitats and the communities they support.

Some water quality issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025d).

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which can change the shape of the seabed, which in turn changes waves and currents; in other words there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

The types of sediment and hard substrata habitats within the LSIB are largely determined by the underlying geology and sedimentology. They are also influenced by the dominant physical conditions, such as the degree of exposure to wave action and tidal currents. 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.

A change in these environmental conditions could detrimentally affect the quality and variety and therefore functions of the various habitats in the site.

Tremadog Bay is a relatively shallow embayment 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. Tudwal's Islands. 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.

No hydro-morphology issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025d). Information on the hydro-morphology of the SAC can be found in Appendix 1.

2c. Sediment supply

Sedimentary habitats are subject to a range of deposition and erosion processes, which anthropogenic activity can influence. The size, shape, quantity and characteristics of sediments are important to the structure and function of the feature. Sediment type strongly influences the species present within a community, for example muddy areas are highly productive, containing high levels of organic material.

The sedimentology of the LSIB is variable throughout the site, depending on aspect, coastal topography, shore morphology, wave exposure and sediment budget present. Maintaining the natural sediment transport pathways (both quantity and sediment grain size) is important to ensure maintenance of the morphology and sediment type. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

Sediment type will also determine whether contaminants can accumulate. Mobile, loosely aggregated sands will not accumulate contaminants unlike muddy sediments. Activities that disturb sediments can release contaminates back into the water column.

No sediment supply issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025d). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the large shallow inlets and bays are stable or improving, subject to natural variability.

Objective Attribute	Site specific target
3a. Habitats and communities	Maintain the abundance, distribution and diversity of species within component habitats and communities necessary for the structure and function of the large shallow inlets and bays feature.
3c. Invasive and non-native species	Introduction or spread of new non-native species to the site by anthropogenic activities should not have a detrimental impact on the structure and function of the reefs feature.

Supporting Information

3a. Habitats and communities

Tremadog Bay contains a wide variety of seabed and seashore habitats that support varied assemblages of animals and plants. 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. Bedrock reef around the St. Tudwal's 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, including elasmobranch and bony fish species.

Designated Annex I features, intertidal mudflats and sandflats, Atlantic salt meadow, and reef form a mosaic throughout the feature. All the habitats and communities within the LSIB contribute to the overall condition of the feature. However, some notable habitats and their associated communities are of particular conservation importance, namely,

- sheltered muddy gravels
- subtidal mixed muddy sediments
- seagrass *Zostera marina* beds
- Intertidal and subtidal reef communities (which are further noted within the reef feature attributes)
- Mud communities, including burrowing megafauna such as the volcano worm *Maxmuelleria lankesteri*
- Peat and clay exposures that have been colonised by piddocks

Further information on LSIB habitats and communities can be found in Appendix 1. Information on habitats and communities of Annex I features found within the LSIB can be found in the corresponding conservation objectives.

The abundance, distribution and diversity of species within component habitats and communities attribute for the is being met, allowing a maintain target to be set for objective 3a. See the latest condition assessment for more information (Jackson-Bué et al., 2025d).

3b. Invasive and non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

The American slipper limpet *Crepidula fornicata* has recently been recorded near the Tudwells on the edge of Tremadog Bay in 2023 and more recently further north along the coast around Abersoch in 2024. The Leathery sea squirt *Styela clava* has a number of subtidal records between Abersoch and Criccieth. *Sargassum muticum* is one of the more common INNS species found throughout the SAC and has been recorded in the feature at Llanystumdwy. *Bonnemaisonia hamifera* (a red algae) is also found at a number of sites within this feature including areas of dense concentrations off of Llanbedrog in Tremadog Bay. Pacific oyster *Magallana gigas* is recorded in a few locations in the LSIB near Criccieth and close to the SAC boundary at Barmouth and Llandanwg.

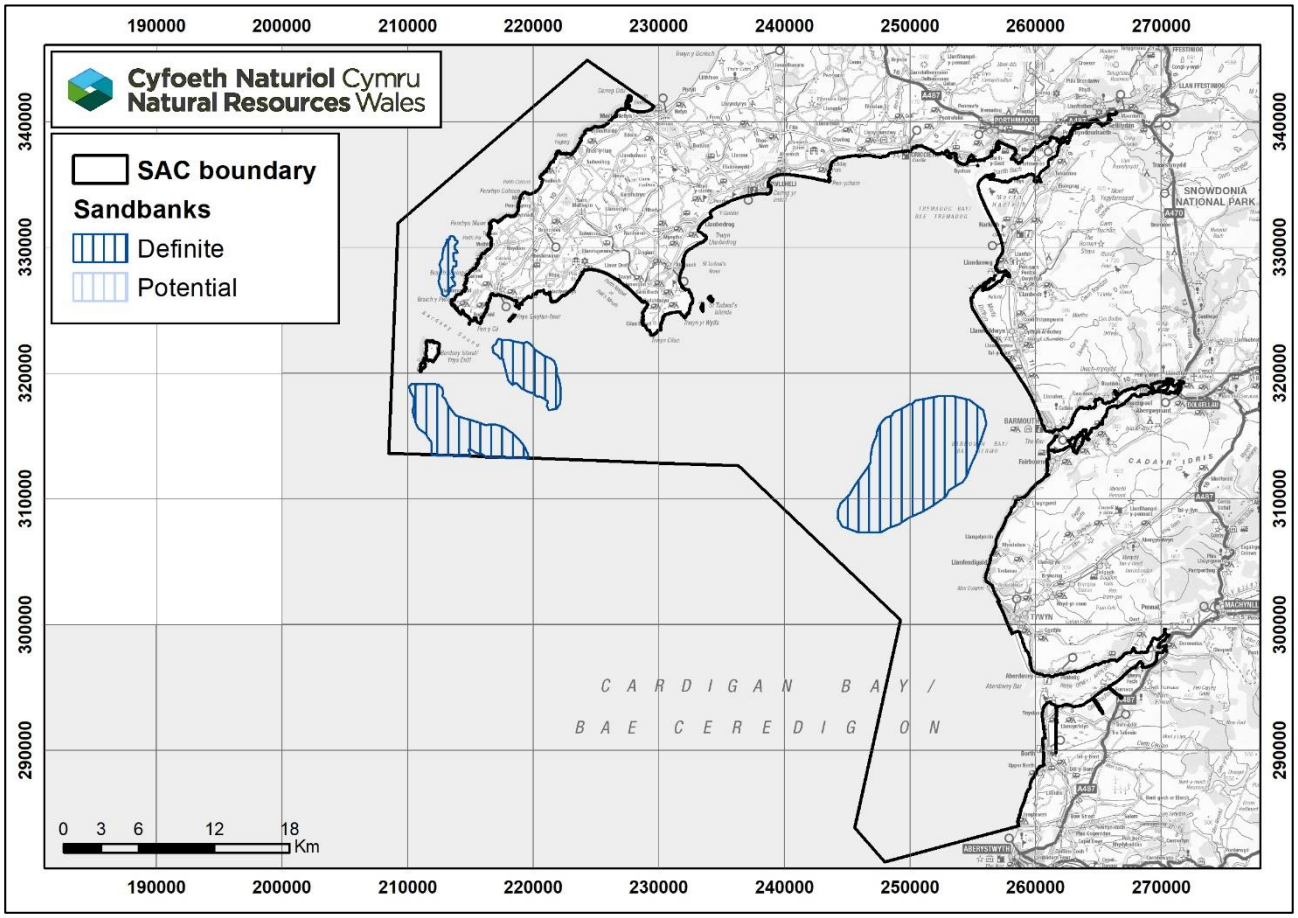
There is limited evidence to suggest that INNS are currently impacting the LSIB feature. For more information see the latest condition assessment (Jackson-Bué et al., 2025d). Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.3. Feature 3: Sandbanks which are slightly covered by seawater all the time

The sandbanks which are slightly covered by seawater all the time (sandbanks) feature within Pen Llŷn a'r Sarnau SAC is currently in **favourable** condition (medium confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 4 is a map of the location of the sandbanks feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 4. Map of the sandbanks feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information

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Objective 1: The overall distribution and extent of the sandbanks feature within the SAC is stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of each of the sandbanks that form the sandbanks feature, subject to natural change.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the habitat across the whole site. The distribution describes the more detailed locations and patterns of different habitats that comprise the feature across the SAC.

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 extent and distribution attribute of the sandbanks feature is being met, allowing a maintain target to be set for objective 1a. See the latest condition assessment for more information (Jackson-Bué et al., 2025e).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the sandbanks feature are stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the sandbanks feature. Nutrients are at levels not detrimental to the structure and function of the sandbanks feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the sandbanks feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the sandbanks feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the sandbanks feature is sustained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living within the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on its nature. Contaminants include, but are not limited to, heavy metals (e.g. mercury and zinc), polybrominated diphenol ethers (PBDEs), poly-aromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs) and organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

Much of the sandbank feature lies outside of WFD waterbodies and outside of the 1 nautical mile from mean high water routine sampling area. Accumulation of sediments in sandbanks is likely to be minimal due to the coarse and mobile nature of the sand. Dilution effects of chemicals are also likely.

High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can smother the sediment, reducing oxygen availability. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007). However, sandbanks may be at lower risk from issues caused by excess nutrients.

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats in terms of the abundance, distribution and the composition of communities present. Physicochemical characteristics can vary widely in the intertidal and shallow coastal waters, at relatively local scales. Changes in any of these properties, as a result of anthropogenic activities, may impact habitats and the communities they support.

Some water quality issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025e).

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input) coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which can change the shape of the seabed, which in turn changes waves and currents. In other words, there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

Sandbanks often have smaller rhythmic morphological features (described as ripples, mega-ripples or sand waves depending on length scales) superimposed on the bank morphology. These smaller features are important to water flow and sediment transport around or over the sandbanks.

No hydro-morphology issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025e). Information on the hydro-morphology of the SAC can be found in Appendix 1.

2c. Sediment supply

The size, shape, aspect and orientation, as well as the macro- and micro-topography and sediment characteristics of sandbanks are 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, most large banks are relatively stable and long-established. Mobile sediments that form temporary sandbanks are associated sediments that should be retained in the system, although their location may change.

Typically, well-sorted medium sand occurs on uppermost parts of a sandbank, becoming coarser down the flanks and poorly sorted with increased silt and coarse sediments around the base. Sandbanks exposed to stronger tidal and wave action like the Tripods sandbank 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. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

No sediment supply issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025e). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the sandbanks feature are stable or improving, subject to natural variability.

Objective attribute	Site specific target
3a. Habitats and communities	Maintain the abundance, distribution and diversity of species within component habitats and communities necessary for the structure and function of the sandbanks feature.
3b. Non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the sandbanks feature.

Supporting Information

3a. Habitats and communities

Biological processes and interactions such as competition, predation and bioturbation play an important structural and functional role in influencing the assemblages of marine species associated with the subtidal sandbanks feature throughout the SAC. All the habitats and communities within the sandbank contribute to the overall condition of the feature.

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.

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. Subtidal sandbanks can be important nursery areas for fish, and feeding grounds for seabirds. More information on sandbank habitats and communities can be found in Appendix 1.

The abundance, distribution and diversity of species within component habitats and communities attribute has been met, allowing a maintain target to be set for objective 3a. See the latest condition assessment for more information (Jackson-Bué et al., 2025e).

3b. Non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community

structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

There is no evidence to suggest that INNS are currently impacting the sandbanks feature. For more information see the latest condition assessment (Jackson-Bué et al., 2025e).

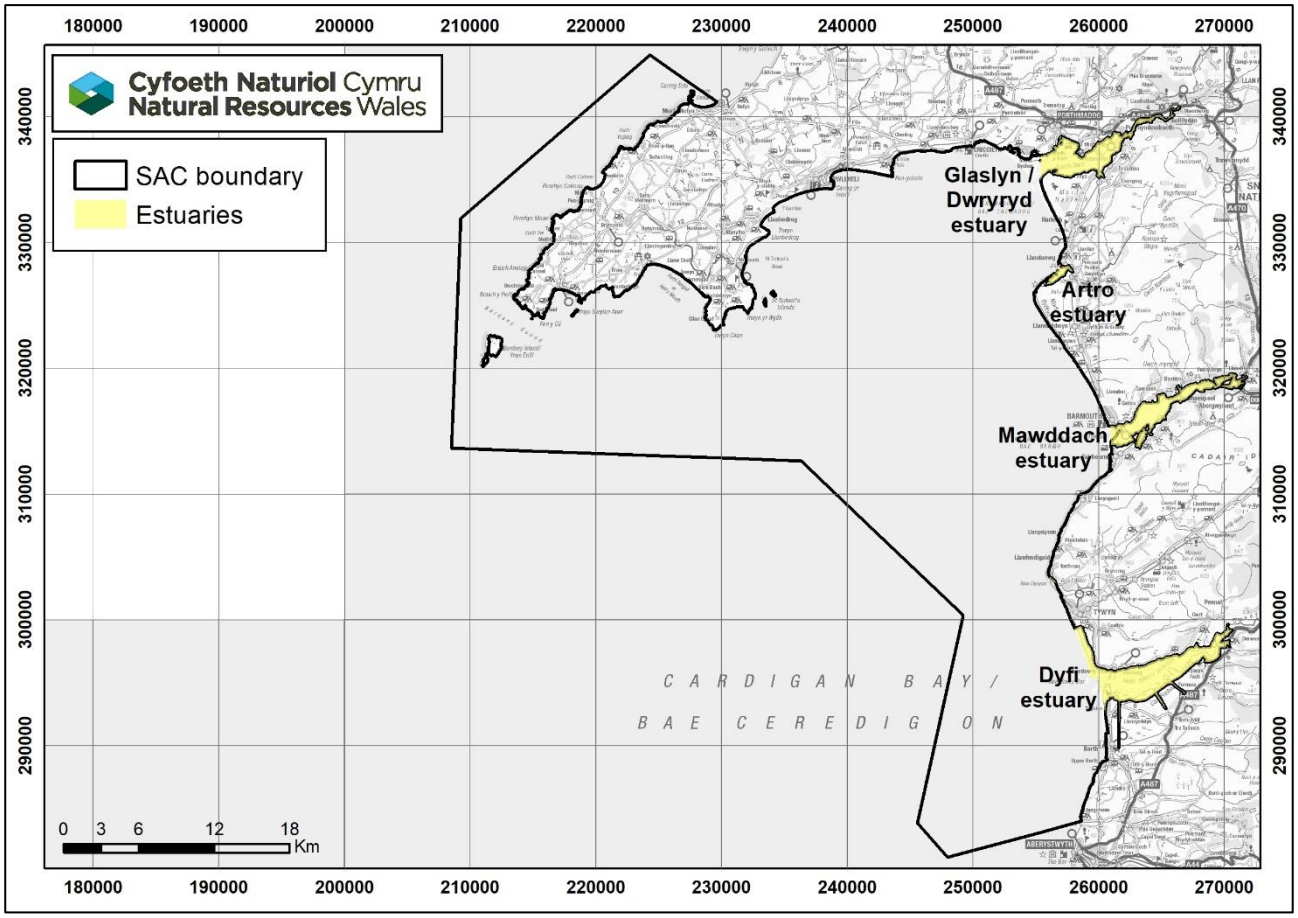
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.4. Feature 4: Estuaries

The estuaries feature within Pen Llŷn a'r Sarnau SAC is currently in **favourable** condition (medium confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 5 is a map of the location of the estuaries feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 5. Map of the estuaries feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the estuaries feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of estuaries, subject to natural change.
1b. Component habitat extent and distribution	Maintain the extent and distribution of estuaries component habitats and biological communities necessary for the structure and function of the estuaries feature.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the feature across the whole site. The distribution describes the more detailed locations and patterns of different habitats that comprise the feature across the site.

The estuary feature of the SAC comprises the three main bar-built estuaries situated along the Meirionnydd and Ceredigion coasts; the Glaslyn / Dwyryd, Mawddach, Dyfi, and the smaller estuary of the Artro.

Construction of embankments and sea defences (e.g. the Cob at Porthmadog and the railway bridge in the Mawddach) have reduced the area of the estuaries. However, these structures were put in place a long time before the SAC was designated and are accepted as part of the baseline of the site.

The extent and distribution attribute is being met, allowing a maintain target to be set for objective 1a. See the latest condition assessment for further detail (Jackson-Bué et al., 2025c).

1b. Component habitat extent and distribution

The estuaries of Pen Llŷn a'r Sarnau are complex systems comprised of different component habitats, some of which are designated Annex I features. Extensive areas of intertidal mudflats and sandflats, Atlantic salt meadow, *Salicornia* habitat and a proportion of reef form a mosaic throughout the feature. The Annex II species of Eurasian otter may use the feature for passage and feeding.

Due to the low amounts of fine material entering the estuaries from marine or freshwater inputs, the three main estuaries are predominantly sandy in contrast to many other estuaries in the UK. Even the muddy sediments of the Pen Llŷn a'r Sarnau SAC estuaries contain a relatively high proportion of coarser sediment.

Estuarine rocky habitats occur primarily as a thin band around the shore in these main estuaries

Component habitats of the feature need to be maintained by sustaining suitable environmental conditions and limiting activities to which they may be sensitive to. The recovery of habitats will be influenced by the habitat type as well as the type and duration of impact.

The component habitats and communities extent and distribution attribute is being met, allowing a maintain target to be set for objective 1b. See the latest condition assessment for more information (Jackson-Bué et al., 2025c).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the estuaries feature are stable or improving, subject to natural change.

Objective attribute	**Site specific target(s)**
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the estuaries feature. Nutrients are at levels not detrimental to the structure and function of the estuaries feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the estuaries feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the estuaries feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the estuaries feature is sustained.
2d. Freshwater flow	The freshwater flow and volume into the estuary necessary for the structure and function of the feature is sustained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living in the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on the nature of the contaminant. Contaminants include heavy metals (e.g. mercury and zinc), poly-aromatic hydrocarbons, poly-chlorinated biphenyls (PCBs), organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

High concentrations of nutrients (nitrogen and phosphorus) in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can lead to reduced dissolved oxygen availability especially in warmer months. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007).

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats alone or in combination to affect habitats in terms of the abundance, distribution and composition of communities present. Changes in any of these properties, because of anthropogenic activities, may impact habitats and the communities they support.

Information on water quality can be found in the latest condition assessment (Jackson-Bué et al., 2025c).

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which can change the shape of the seabed, which in turn changes waves and currents; in other words there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

Estuaries are complex dynamic systems that have a natural tendency to accumulate sediment. The width and depth of the estuary may change over time towards a state of dynamic equilibrium or “most probable state”. This equilibrium is a balance of tidal prism (volume of water leaving an estuary between high and low tide), current velocities and erosion/ depositional thresholds of the local sediment. A change in these environmental conditions could detrimentally affect the quality and variety and therefore functions of the various habitats in the estuaries.

Some estuaries in Pen Llyn a’r Sarnau have adjacent functional areas of sediment, such as sand dunes, that are considered to be an integral part of the functioning of the estuaries. For example, the mouths of the Mawddach and Dyfi are defined by sand dune covered spits.

Similarly, saltmarsh is present in the estuaries of Pen Llyn a’r Sarnau and this not only provides a store of sediment but has an important role in modulating the estuary hydrodynamics when it is submerged: this is important under storm and surge conditions when the saltmarsh dissipates the tidal and wave energy.

No hydro-morphology issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025c). Information on the hydro-morphology of the site can be found in Appendix 1.

2c. Sediment supply

Sedimentary habitats are subject to a range of deposition and erosion processes, which anthropogenic activity can influence. The size, shape, quantity and characteristics of sediments are important to the structure and function of the feature. Sediment type strongly influences the species present within a community, for example muddy areas are highly productive, containing high levels of organic material.

The sedimentology of the estuaries is variable throughout and between the sites, depending on the available marine sediment, terrestrial sediment input from rivers and

wave and tidal conditions. Maintaining the natural sediment transport pathways (both quantity and sediment grain size) is important to ensure maintenance of the morphology and sediment type. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

Sediment type will also determine whether contaminants can accumulate. Mobile, loosely aggregated sands will not accumulate contaminants unlike muddy sediments. Activities that disturb sediments can release contaminants back into the water column.

No sediment supply issues have been identified for this feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025c). Information on the sediment transport in the SAC can be found in Appendix 1.

2d. Freshwater flow

The rate, quantity and variability of freshwater flow influences the salinity of an estuary, levels of stratification, location of the turbidity maximum and associated variation in suspended sediment concentrations, and flux of contaminants out to sea. Levels of salinity and turbidity can influence the species and communities present.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the estuaries feature are stable or improving, subject to natural variability.

Objective attribute	Site specific target
3a. Habitats and communities	Maintain the abundance, distribution and diversity of species within component habitats and communities necessary for the structure and function of the estuaries feature.
3b. Invasive and non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the estuaries feature.

Supporting Information

3a. Habitats and communities

Extensive areas of designated Annex I features, intertidal mudflats and sandflats, Atlantic salt meadow, and reef form a mosaic throughout the feature. All the habitats and communities within the estuaries contribute to the overall condition of the feature. However, there are some notable habitats and their associated assemblages of marine plants and animals are of particular conservation importance.

Sediment flats within the estuaries are predominantly sand and sandy muds, which are usual within the UK context. Small areas of estuarine rocky habitats fringe the back of the shore in many of the estuaries. Ephemeral Blue mussels beds have been found in the

Mawddach and Glaslyn/Dwyryd estuaries, due to their nature their abundance and location can change.

The Atlantic salt meadows have important transitions demonstrating complete zonation from the marine to the terrestrial, of particular note are the species rich saltmarsh transitions to sand dune and mire communities. In addition, the Pen Llŷn a'r Sarnau SAC also supports rare examples of the Annex I Habitat: Mediterranean and thermo-Atlantic halophilous scrubs *Sarcocornetea fruticose,* within the Artro and Mawddach estuaries. These are the only examples of this rare habitat outside of England. However this habitat is not a designated feature of this SAC.

The estuaries, in particular the saltmarsh creeks, form important nursery areas for different fish species as well as essential migratory routes and feeding areas for salmonids, shads and European eel. The Dyfi is important to overwintering birds, including the Greenland white fronted goose, for which is designated a special protection area. More information on the habitats and communities found within the estuaries can be found in Appendix 1.

The abundance, distribution and diversity of species within component habitats and communities attribute for the is being met, allowing a maintain target to be set for objective 3a. See the latest condition assessment for more information (Jackson-Bué et al., 2025c).

3b. Invasive and non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

The red alga *Agarophyton vermiculophyllum* is found within the estuaries of the SAC, notably the Dwyryd and Mawddach Estuaries, where it was first found from 2018. There is limited evidence to suggest that INNS are currently impacting the estuaries feature in the SAC. See the latest condition assessment for more information (Jackson-Bué et al., 2025c).

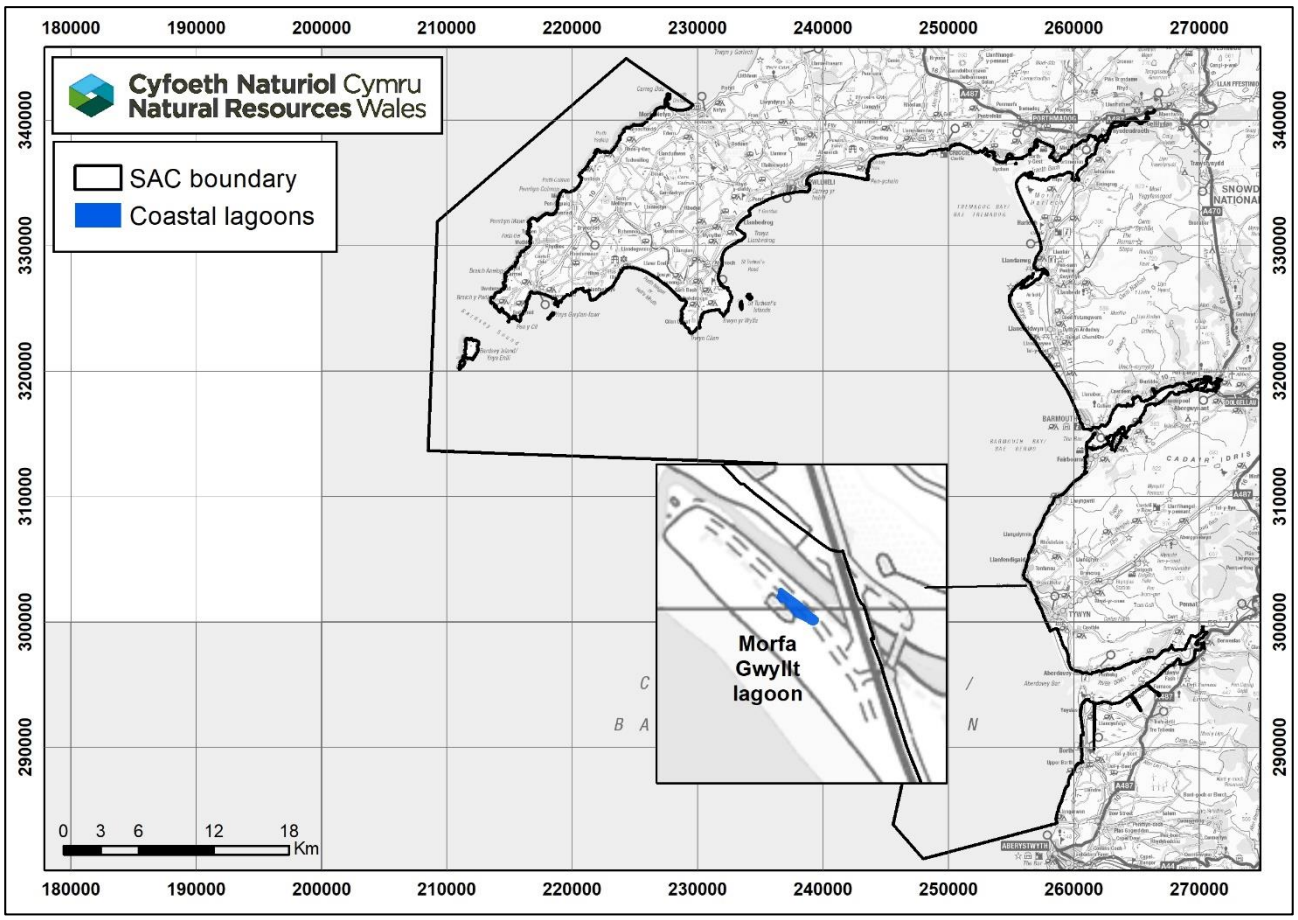
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.5. Feature 5: Coastal lagoons

The coastal lagoons feature within Pen Llŷn a'r Sarnau SAC is currently in **unfavourable** condition (low confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 6 is a map of the location of the coastal lagoons feature within the Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 6. Map of the coastal lagoons feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall extent of the coastal lagoon feature within the SAC is stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent	Maintain the extent of the coastal lagoon.

Supporting Information

1a. Feature extent

There is one coastal lagoon within the in the SAC, Morfa Gwyllt lagoon on the south side of the mouth of the River Dysynni. It is the only example of a percolation lagoon in Wales.

The extent of a coastal lagoon is primarily determined by the morphology of the surrounding area and the artificial impoundment structures. Seasonality and weather play a part in extent and should be considered. The extent of a lagoon's water in winter is likely the extent of the lagoon basin. The lagoon's extent influences the sensitivity of the habitat, and combined with its shape, the biological communities present. An increased variation in shape (or islands) results in sites with more diverse communities (JNCC, 2004a).

Lagoons are thought to be quite tolerant to change as they are ephemeral in nature and change in their status is inevitable with time. For some physical aspects of lagoons (hard bedrock and boulders/cobbles) we would not expect significant change in its extent via natural processes. However, where there are softer sediments there may be physical changes in extent and distribution over time through natural processes.

The extent attribute is being met, allowing a maintain target to be set for objective 1a. for more information see the latest condition assessment (Cuthbertson et al., 2025a).

Objective 2: The hydro-morphological and chemical structure necessary for the function of the coastal lagoon feature is stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water depth	Restore the water depth needed to support the structure and function of the coastal lagoon feature.
2b. Isolating barrier	Maintain the presence and integrity of the lagoon isolating barrier.
2c. Water quality	Contaminants are at levels not detrimental to the structure and function of the coastal lagoon feature. Nutrients are at levels not detrimental to the structure and function of the coastal lagoon feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the coastal lagoon feature.
2d. Sediment quality	Sediment contaminants are at levels not detrimental to the structure and function of the coastal lagoon feature. Sediment organic content is at level not detrimental to the structure and function of the coastal lagoon feature.
2e. Sediment type	The sediment size and distribution necessary for the structure and function of the coastal lagoon feature is maintained.

Supporting Information

2a. Water depth

Water depth in a lagoon needs to be shallow enough to allow photosynthesis to take place but also deep enough to submerge plants and provide optimal habitat for lagoon animals (JNCC, 2004a). Depth strongly influences environmental parameters such as temperature and salinity which in turn contribute to determining the species and communities that reside within the lagoon.

Lagoons are prone to becoming shallower over time due to the natural process of sedimentation. Anthropogenic activities such as infilling, land claim, increased runoff or adjacent developments impacting sediment transport processes have the potential to impact the sedimentation rate of a lagoon and subsequently the depth.

The depth of water at Morfa Gwyllt has been decreasing in recent years, with more instances of extreme low water events. This was especially the case in 2020. This has

resulted in a restore target being set for objective 3a. Further information can be found in the latest condition assessment (Cuthbertson et al., 2025a).

2b. Isolating barrier

The presence, nature and integrity of the isolating barrier is fundamental to the structure and function of a lagoon.

Morfa Gwyllt is seperated from the sea by a shingle ridge. While there is no monitoring of the ridge, no activities with potential to cause negative impacts have been identified. Historical damage from motorbike use is no longer an issue as gates have been erected to limit access. The ridge is therefore assumed to have integrity and a maintian target has been set for objective 2b. For more information see the latest condition assessment (Cuthbertson et al., 2025a).

2c. Water quality

Various contaminants are known to affect species living in the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on the nature of the contaminant. Contaminants include heavy metals (e.g. mercury and zinc), poly-aromatic hydrocarbons, poly-chlorinated biphenyls (PCBs), organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

Lagoons tend to have low flushing rates which may mean they are slow to clear any contaminants or slow to recover from any impacts (JNCC, 2004a). The degree of sensitivity will be influenced by the type of communities and species present and by the type of lagoon.

High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can lead to reduced dissolved oxygen availability especially in warmer months and can smother benthic habitats. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007). Coastal lagoons act as sinks for nutrients, which are introduced through seawater, freshwater and run-off from surrounding areas, and can be increased through a variety of land uses (JNCC, 2004a).

Salinity and temperature in lagoons are primarily linked to water depth, tidal exchange and the degree of freshwater input into the lagoon. Any changes to these, e.g. through artificial diversion or blocking of drainage ditches and streams, could alter the balance of seawater and freshwater inputs and result in either a lower or high salinity system. Salinity plays a primary role in controlling the biological communities present (Joyce et al., 2005).

No water quality issues have been identified for the feature. Information on water quality can be found in the latest condition assessment (Cuthbertson et al., 2025a).

2d. Sediment quality

Lagoons tend to have low flushing rates which may mean they are slow to clear any contaminants or slow to recover from any impacts (JNCC, 2004a). This makes lagoonal sediments vulnerable to accumulating contaminants. Various contaminants are known to affect the species that live in or on the surface of sediments. These can impact species sensitive to particular contaminants, degrading the community structure (e.g. heavy metals) and bioaccumulating within organisms, entering the marine food chain (e.g. poly-

chlorinated biphenyls) (OSPAR Commission, 2012). The degree of sensitivity will be influenced by the type of communities and species present and by the type of lagoon.

Sediment organic enrichment may be of less concern given that lagoonal sediments are naturally high in organic material (Johnston and Gilliland, 2000). Lagoonal sediments commonly have an organic content of 10-15 % by weight, compared with 3-8 % in coastal muddy sands (Bamber et al., 2010). This organic loading encourages the seasonal growth of annual algae and phytoplankton. Some lagoons may be adapted to low oxygen conditions (Bamber et al., 2010). However, elevated organic inputs might be of concern in some cases because of low flushing rates in particular lagoons or parts of lagoons.

There is currently a lack of data on sediment quality within the lagoon of the SAC.

2e. Sediment type

Sediment type is important in determining the biological communities present within a lagoon. The sedimentary bed of the lagoon is usually a combination of original sediment present prior to the isolating barrier formation and input of fine silts and clays subsequently deposited (Bamber et al., 2010). Commonly the substrate will become progressively, but slowly, finer with time. The most common sedimentary substratum within UK lagoons is muddy sand (Bamber et al., 2010).

In Morfa Gwyllt there has been a general shift from coarser sediments to finer silt over time. This variation is deemed to be natural. See the latest condition assessment for further information (Cuthbertson et al., 2025a).

Objective 3: The abundance, distribution and diversity of species within communities and habitats necessary for the structure and function of the coastal lagoon feature are stable or improving, subject to natural variability.

Objective attribute	**Site specific target**
3a. Habitats and communities	Restore the abundance, distribution and diversity of species within the habitats and communities necessary for the structure and function of the coastal lagoons feature.
3b. Lagoonal specialist species	Restore the abundance, distribution and extent of listed lagoonal specialist species and habitats.
3c. Invasive and Non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the coastal lagoon feature.

Supporting Information

3a. Habitats and communities

Lagoon communities are generally considered to be made up of opportunistic and specialist species from freshwater, marine and brackish sources (Barnes, 1988; 1994). Coastal lagoons often support filamentous green and brown algae and several aquatic vascular plants. They have an abundance of molluscs and crustaceans (Barnes, 1994), despite an often-limited invertebrate diversity (Bamber et al., 2001). All the habitats and communities within the lagoon contribute to the overall condition of the feature.

The composition of communities in Morfa Gwyllt has varied naturally over the years. However, there was a decline in species diversity over time (2006-2021). The habitats and communities attribute is not being met and a restore target has been set for objective 3a. See the latest condition assessment for further information (Cuthbertson et al., 2025a).

3b. Lagoonal specialist species

Many species characterising lagoons are rare and of conservation importance. Some species seem to be mostly restricted to saline lagoons and hence known as lagoonal specialists (see Bamber et al., 2001). It has been argued that specialist lagoonal species are better able to tolerate the large environmental variations (e.g. in salinity, hydrology) than freshwater, estuarine and marine species (Bamber et al., 1992).

The lagoonal specialist species in Morfa Gwyllt are, *Lekanesphaera hookeri*, *Conopeum seurati and Chaetomorpha linum*.

In recent years two of the three named lagoonal species have been absent from monitoring (*Conopeum seurati* and *Chaetomorpha linum*). Therefore the lagoonal specialist species attribute is not being met, resulting in a restore target being set for objective 3b. See the latest condition assessment for further information (Cuthbertson et al., 2025a).

3c. Invasive and Non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

The non-native freshwater hydroid *Cordylophora caspia*, originating from the Caspian Sea, has occasionally been recorded in the lagoon between 1998-2017. There have been no records of it since 2017. There are no other records of non-native species in the lagoon (Cuthbertson et al., 2025a).

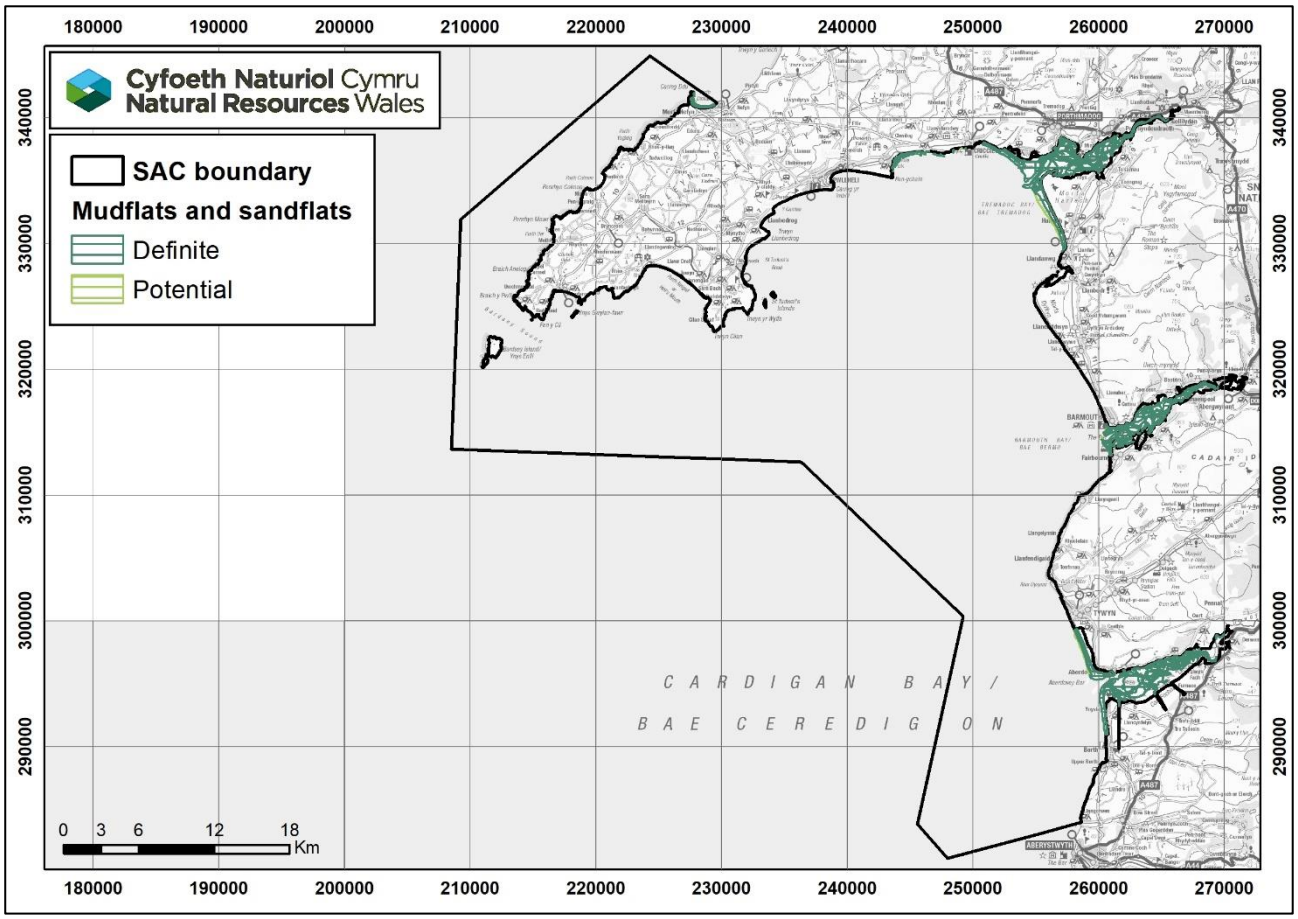
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.6. Feature 6: Mudflats and sandflats not covered by seawater at low tide

The mudflats and sandflats not covered by seawater at low tide (mudflats and sandflats) feature within Pen Llŷn a'r Sarnau SAC are currently in **favourable** condition (low confidence).). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 7 is a map of the location of the mudflats and sandflats feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 7. Map of the mudflats and sandflats feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the mudflats and sandflats feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of mudflats and sandflats
1b. Component habitat extent and distribution	Maintain the extent and distribution of component habitats and communities necessary for the structure and function of the mudflats and sandflats feature.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the feature across the whole site, even where it is patchy. The distribution describes the more detailed location(s) and pattern of different habitats that comprise the feature across the site.

The mudflats and sandflats feature is mainly present in the SAC within the estuaries and on fully marine open coasts. The sediments of the estuarine mudflats and sandflats are predominantly sandy with more mobile coarser sands, representative of full salinity seawater, are present at the mouth of each estuary and along the main estuary channel.

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 habitat.

The extent and distribution attribute has been met, allowing a maintain target to be set for objective 1a. See the latest condition assessment for more information (Jackson-Bué et al., 2025a).

1b. Component habitat extent and distribution

There are a variety of component habitats within the mudflats and sandflats feature, ranging from sandy coarse mobile sediment at the mouth of estuaries to finer muddier sands in more sheltered reaches. The sediments within some of the estuaries are unusual in that they are predominantly sand. Away from the estuaries on the open coast, the sediment habitats are characterised by sandflats as a result of the degree of exposure to wave action.

Component habitats of the feature need to be maintained by sustaining suitable environmental conditions and limiting activities to which they may be sensitive to. The recovery of soft sediment habitats will be influenced by the type of sediment as well as the type and duration of impact.

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.

The component habitat extent and distribution attribute has been met, allowing a maintain target to be set for objective 1b. See the latest condition assessment for more information (Jackson-Bué et al., 2025a).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the mudflats and sandflats feature are stable or improving, subject to natural change.

Objective attribute	**Site specific target(s)**
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the mudflats and sandflats feature. Nutrients are at levels not detrimental to the structure and function of the mudflats and sandflats feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the mudflats and sandflats feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the mudflats and sandflats feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget within the SAC necessary for the structure and function of the mudflats and sandflats feature is sustained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living in the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on the nature of the contaminant. Contaminants include heavy metals (e.g. mercury and zinc), poly-aromatic hydrocarbons, poly-chlorinated biphenyls (PCBs), organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms. These blooms can lead to reduced dissolved oxygen availability especially in warmer months. This can have lethal and sub-lethal impacts on sensitive fish, epifauna and infauna communities (Best et al., 2007).

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats alone or in combination to affect habitats in terms of the abundance, distribution and composition of communities present. Changes in any of these properties, because of anthropogenic activities, may impact habitats and the communities they support.

Some water quality issues have been identified for the feature. Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025a).

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which can change the shape of the seabed, which in turn changes waves and currents; in other words there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

Intertidal mudflats and sandflats are dynamic. Their distribution, extent, shape, topography, aspect and orientation are the product of complex interaction between hydrodynamic and sediment transport processes, sediment supply and coastal morphology. In shallower areas, wave driven processes largely dictate current and sediment movement, whereas lower down the profile a delicate balance of wave and tidal forcing can be important. The hydrographic functions that structure intertidal mudflats and sandflats vary on a range of timescales from short (e.g. storm events to spring – neap tidal cycles) to longer-term (e.g. summer – winter wave seasonality), to climatic influences. Importantly, the two-way feedback means as well as maintaining the wave and tidal forcing, maintaining the broad shape (e.g. beach type classification) of the feature is important.

The status of these parameters provides suitable conditions for sustaining the mudflats and sandflats feature. A change in the hydro-morphology that influences the SAC could lead to changes in extent or the communities present, and therefore functions of the mudflats and sandflats in the site.

No hydro-morphology issues have been identified for the feature. See latest condition assessment for further information (Jackson-Bué et al., 2025a). Information on the hydro-morphology of the site can be found in Appendix 1.

2c. Sediment supply

Sedimentary habitats are subject to a range of deposition and erosion processes, which anthropogenic activity can influence. Most intertidal sediments stabilise over time so maintaining the sediment composition supports natural succession of the habitats and communities (Gray and Elliott, 2009). Sediment type strongly influences the species present within a community, for example muddy areas are highly productive, containing high levels of organic material.

The size, shape, quantity and characteristics of sediments are important to the structure and function of the feature. For example, grain size can influence morphology with coarser grained areas often having steeper beach profiles.

The sedimentology of the mudflats and sandflats feature is variable throughout the SAC, depending on aspect, coastal topography, shore morphology, wave exposure and

sediment budget present. Maintaining the natural sediment transport pathways (both quantity and sediment grain size) is important to ensure maintenance of the morphology and sediment type of intertidal sand and mudflats. Projects outside the SAC can still alter the sediment supply to features within the site.

No sediment supply issues have been identified for the feature. See latest condition assessment for further information (Jackson-Bué et al., 2025a). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the mudflats and sandflats feature are stable or improving, subject to natural variability.

Objective attribute	**Site specific target**
3a. Habitats and communities	Maintain the abundance, distribution and diversity of species within component habitats and communities necessary for the structure and function of the mudflats and sandflats feature.
3b. Invasive and Non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the mudflats and sandflats feature.

Supporting Information

3a. Habitats and communities

All the habitats and communities within the mudflats and sandflats contribute to the overall condition of the feature. Changes to the spatial distribution of communities across the feature could highlight changes to the overall feature.

Within the estuaries of the sites patches of muddy gravel, which are usually in areas of slightly increased water movement, may be characterised by polychaete and oligochaete worms. Clumps of blue mussels *Mytilus edulis* have been recorded from the mid shore on fine mud in all three estuaries. Outside of the estuaries, the open coast intertidal mudflats and sandflats are characterised by sandflat communities with fewer muddier sediment communities present.

While all the communities within the estuaries contribute to the overall condition of the feature, there are some notable habitats and their associated assemblages of marine plants and animals are of particular conservation importance. Seagrass *Zostera marina* beds are found in sheltered areas on the lower shore of the open coast sandflats at Porth Dinllaen, Afon Wen and east of Criccieth. A community of typical of muddy gravels is found at Llanbedrog in coarse mixed sediments. More information mudflats and sandflats habitats and communities can be found in Appendix 1.

The abundance, distribution and diversity of species within component habitats and communities attribute is being met, allowing a maintain target to be set for objective 3a (Jackson-Bué et al., 2025a).

3b. Invasive and Non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

The red alga *Agarophyton vermiculophyllum* is found on mudflats and sandflats within the estuaries of the SAC, notably the Dwyryd and Mawddach, where it was first found from 2018. There are also a small number of records of the American slipper limpet *Crepidula fornicata* in various locations, some of which are within the feature. There is limited evidence to suggest that INNS are currently impacting the mudflats and sandflats feature in the SAC. See the latest condition assessment for more information (Jackson-Bué et al., 2025a).

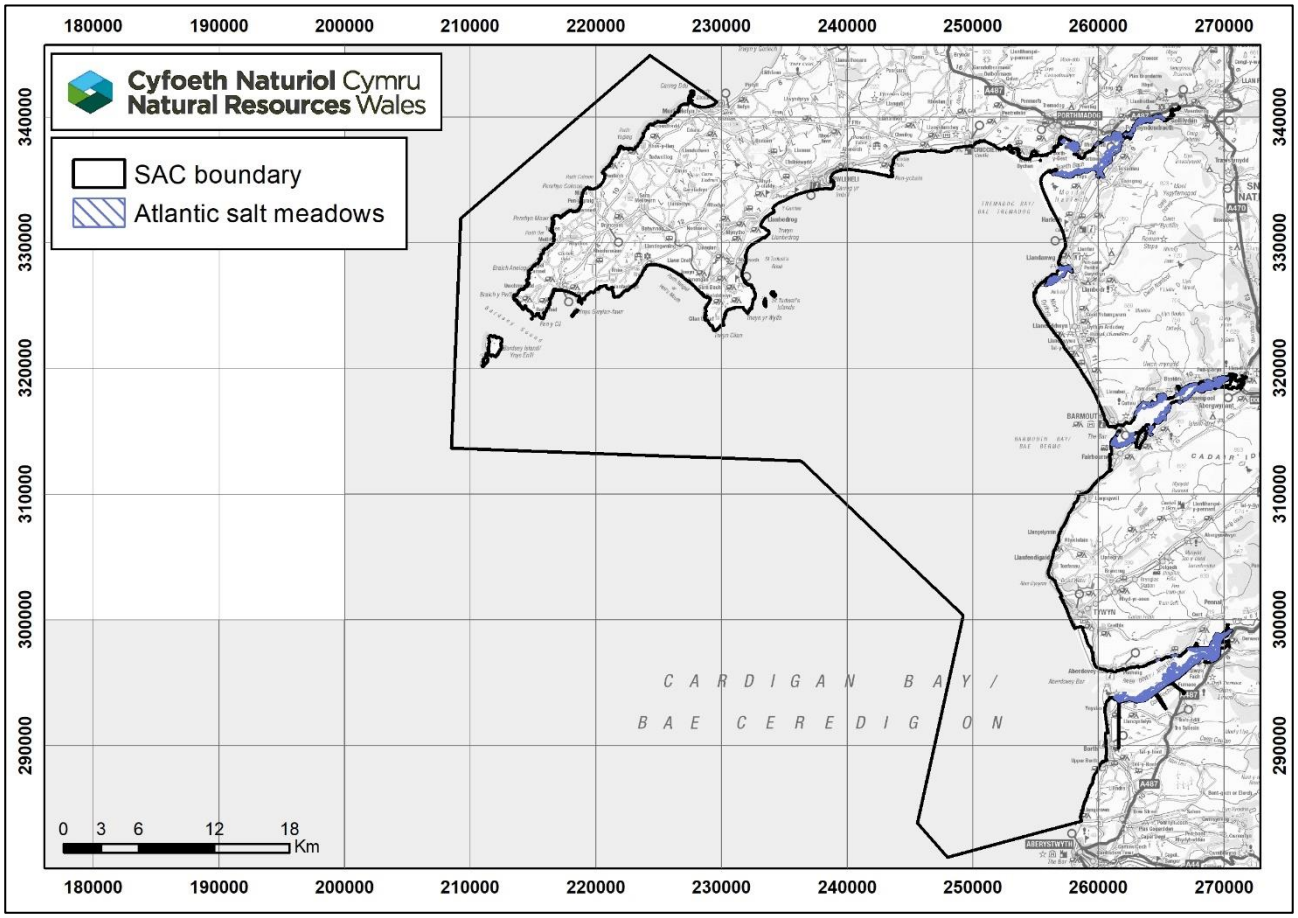
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.7. Feature 7: Atlantic salt meadows *Glauco-Puccinellietalia maritimae*

The Atlantic salt meadows *Glauco-Puccinellietalia maritimae* within Pen Llŷn a'r Sarnau SAC are currently in **unfavourable** condition (low confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 8 is a map of the location of the Atlantic salt meadows feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 8. Map of the Atlantic salt meadows feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the Atlantic salt meadow feature within the SAC and each of its main plant communities are stable or increasing, subject to natural change.

Objective attribute	Site specific target(s)
1a. Feature extent and distribution	Maintain the extent of Atlantic salt meadow habitats and its natural transitions within the sectors of the SAC, subject to natural change. Maintain the broadscale distribution patterns of Atlantic salt meadow and natural transitions within the sectors of the SAC, subject to natural change.
1b. Zonation extent and distribution	Maintain the expected zonation extent and distribution of Atlantic salt meadow zones within the sectors of the site, subject to natural change.

Supporting Information

1a. Feature extent and distribution

Atlantic salt meadows habitat (ASM) is present together with pioneer saltmarsh and natural transitions within the estuaries of the Meirionnydd and Ceredigion coasts: the Glaslyn/Dwyryd, Artro, Mawddach and Dyfi estuaries. The most extensive areas occur in the Dyfi Estuary, whilst the greatest variety of vegetation types occurs in the Mawddach Estuary.

Saltmarsh is a naturally dynamic habitat which can change with coastal processes such as channel movement therefore, some natural change in extent and distribution is acceptable. However, the overall extent of ASM across the SAC should be maintained. ASM in Pen Llŷn a'r Sarnau SAC is divided into sectors to aid monitoring. There should be no significant loss of extent within each sector, as this will help maintain the broadscale distribution of saltmarsh within the SAC. A change in distribution that leads to fragmentation of the ASM would be a negative impact.

The sectors of the site are, Artro, Dwyfor, Dyfi, Mawddach, Morfa Harlech, Glaslyn/ Dwyryd complex. The total extent of saltmarsh was measured as 1230.58 ha in 2020 and there has been no loss of more than 20% of saltmarsh extent in any of the defined sectors (Jackson-Bué et al., 2025f).

The extent and distribution attribute of ASM have been met, allowing maintain targets to set for objective 1a. See the latest condition assessment for more information (Jackson-Bué et al., 2025f).

One of the biggest threats to the extent and distribution of saltmarsh in the SAC is climate change and coastal squeeze as a result of rising sea levels. See Section 5 and the latest condition assessment for more detail (Jackson-Bué et al., 2025f).

1b. Zonation extent and distribution

A feature of saltmarsh vegetation is the zonation of different communities with increasing elevation from the sea. Zonation is generally displayed as bands of characteristic species assemblages that generally run parallel to the shoreline, although in many sites this is more complex. Both the pioneer saltmarsh and saltmarsh transitions to more terrestrial or freshwater habitat types are an important part of the zonation in terms of structure and function. If expected zonation is not maintained, it can be a sign anthropogenic activities are impacting the feature and natural processes are being inhibited.

Sustaining suitable environmental conditions and limiting activities to which ASM may be sensitive to will allow ASM zones to maintain themselves within their natural variation.

The expected zonation extent and distribution attribute has been met, allowing a maintain target to be set for objective 1b. See the latest condition assessment for more information (Jackson-Bué et al., 2025f).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the Atlantic salt meadow feature are stable or improving, subject to natural change.

Objective attribute	**Site specific target(s)**
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the Atlantic salt meadow feature. Nutrients are at levels not detrimental to the structure and function of the Atlantic salt meadow feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the Atlantic salt meadow feature.
2b. Air quality	Maintain nitrogen (N) deposition at levels not detrimental to the structure and function of the Atlantic salt meadow feature.
2c. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the Atlantic salt meadow feature are sustained.
2d. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the Atlantic salt meadow feature is maintained, subject to natural change.

Supporting Information

2a. Water and sediment quality

Studies have demonstrated that saltmarsh habitats can be a sink for pollutants including herbicides, pesticides, organochlorines, polychlorinated biphenyls and heavy metals. A significant proportion of contaminants in these pollutants are adsorbed onto fine sediment particles which are then deposited on the saltmarsh, locking them in. This can reduce the toxic impact in some cases. For example, Tributyl tin (TBT) has a half-life period of tens of years and burial of sediment contaminated with TBT over this time period can reduce loadings within a system. However, 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 (Adnitt et al., 2007). There is little evidence available on the negative impact contaminants can have on saltmarsh plants themselves (Pontee et al., 2021).

Nutrient cycling within saltmarshes can have a significant effect on coastal and estuarine water quality. Healthy, functional saltmarsh habitat may have an important role to play in the control of nutrients. While saltmarsh habitats can remove land derived nutrients from a system, excessive nutrient loading (at levels that would induce eutrophication) has been shown to decrease root growth in some circumstances in saltmarsh plants, reducing sediment stability and increasing erosion over a 9-year period (Deegan et al., 2012). The threshold at which nutrients start to have a detrimental impact on saltmarsh is poorly understood.

High concentrations of nutrients (nitrogen and phosphorus) in the water column can cause phytoplankton and opportunistic macroalgae blooms. The impact of opportunistic macroalgae blooms is not well understood. It is possible short term or low-level exposure to macroalgae provides beneficial nutrient input (Wasson et al 2017). However, more intense exposure could be harmful as macroalgae mats have been shown to have negative impacts on saltmarsh, including reduced growth and biomass as a result of smothering (Wasson et al., 2017 and references therein).

Information on water and sediment quality can be found in the latest condition assessment (Jackson-Bué et al., 2025f).

2b. Air quality

There are few studies of the effects of nitrogen (N) deposition on saltmarsh habitats. Work from the Netherlands suggest saltmarsh vegetation is N limited (Mitsch and Gosselink, 2000), which would make it vulnerable to eutrophication effects. However, as N addition experiments have neither used very realistic N doses nor input methods, results should be approached with caution.

Input of atmospheric N deposition is likely to be less than the large nutrient N loadings from river and tidal inputs. A review by Boorman and Hazelden (2012) suggested pioneer low to mid saltmarsh areas are more resilient and have a lower sensitivity to N deposition than the mature upper areas. These more mature areas may also be subject to direct run-off from the surrounding catchment. Sensitivity of saltmarsh is likely be a function of existing N supplies together with the maximum salinity of the habitat (Boorman and Hazelden, 2012). Sensitivity will vary with site conditions.

The deposition critical range for saltmarsh habitat was updated in 2022 and is set at 10-20 kg N per ha per year for mid and upper saltmarsh on the recommendation of an expert working group, based on expert judgement and a 25-year Dutch monitoring study (Bobbink et al., 2022). The load is a conservative estimate. Evidence of exceedance of the deposition critical load would be indicated by increases in late successional species, increased productivity and increased dominance of graminoids (Bobbink et al., 2022).

The current condition assessment found deposition levels are not exceeding the target (Jackson-Bue at al., 2025f).

2c. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves wind and tides), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which can change the shape of the seabed, which in turn changes waves and currents; in other words there is two-way feedback between the hydrodynamics and the morphology. Hydro-morphology plays an important role in determining the species communities and zones present. Geomorphology and tidal regime primarily determine ASM extent and distribution, while the topography is determined by foreshore breadth, morphology of waterway, and hydrodynamic and sediment processes.

Four elements are necessary for growth of a saltmarsh: (1) relatively stable sediment that is covered by the tide for a shorter period than the time it is exposed; (2) a suitable supply of sediment within the period of tidal cover; (3) water velocities low enough for some sediment to settle out; and (4) a supply of seeds or other propagules for the establishment of vegetation cover.

Creeks and pans of varying size and density are frequent features of saltmarsh habitat influenced by vegetation cover, suspended sediment load and tidal influence. Creeks absorb tidal energy and assist with the delivery of sediment into saltmarshes. Creeks allow pioneer vegetation like *Salicornia* to be established along their banks higher into the saltmarsh system.

Significant erosion of saltmarsh is indicated by internal dissection and enlargement of the drainage network, ultimately leading to the creation of mud basins or fragmented sections of saltmarsh. Erosion of the outer saltmarsh edge can be caused by changes to main channel position, increases in wave exposure (e.g. through dredging) or reduction in sediment availability.

No hydro-morphology issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025f). Information on the hydro-morphology of the site can be found in Appendix 1.

2d. Sediment supply

The sediment structure of ASM habitat is predominantly muds or muddy sands, though many fringes and ribbons have developed in areas of mixed muddy gravels and stones and, in places, are associated with rocky substrate.

The sediment supply into and through the ASM is influenced by the saltmarsh morphology, which dictates water flow, energy dissipation and hence sediment deposition. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

No sediment supply issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025f). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of plant communities necessary for the structure and function of the Atlantic salt meadow feature are stable or improving, subject to natural variability.

Objective attribute	Site specific target(s)
3a. Plant communities	Restore the abundance, distribution, structure and diversity of Atlantic salt meadow plant communities within the sectors of the SAC. Maintain the abundance and distribution of locally distinctive plants in the sectors of the SAC.
3b. Invasive native and invasive non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the Atlantic salt meadows feature.

Supporting Information

3a. Plant communities

All communities present in the ASM feature contribute to its overall condition. Changes to the spatial distribution of communities across the feature could highlight changes to the overall feature.

Species composition of ASM plant communities are influenced by numerous factors such as morphology, sediment type, physical processes operating at a site and grazing management. Changes to the species that make up communities and structure are a good indication of changes to influencing processes and management practices. Species composition, variation and complexity of communities within and between areas of ASM, community structure, temporal patchiness in community distribution and extent, and variation in sward height together indicate species populations are dynamic, reproducing and recruiting successfully and self-maintaining.

Livestock grazing has been carried out historically throughout Pen Llŷn a'r Sarnau SAC and the practice continues, particularly in the Drywrd estuary (Jackson-Bué et al., 2025). Grazing can influence the plant community type, composition, structure and overall condition. Un-grazed saltmarsh provides good conditions for invertebrate species, particularly where the saltmarsh has not be grazed historically. However, saltmarsh plant diversity and structure can also benefit from grazing under appropriate management regimes.

The latest condition assessment found that heavy grazing in the Drywrd estuary and parts of the Mawddach estuary has severely reduced the sward height. This will have a negative impact on the communities that grow on the marsh (Jackson-Bué et al., 2025). This resulted in the abundance, distribution, structure and diversity target having a restore. Further detail can be found the latest condition assessment.

There is currently no monitoring of locally distinctive plants in the SAC. Therefore a maintain has been set for this target.

3b. Invasive native and invasive non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Saline conditions in ASM habitats prevent the more common terrestrial invasive non-native species in Wales becoming established. The red seaweed *Agarophyton vermiculophyllum* and Japanese knotweed *Fallopia japonica* have been found in the Glaslyn / Dwyryd, Mawddach, and Dyfi estuaries. Neither species is currently having a negative impact on the ASM feature (Jackson-Bué et al., 2025f).

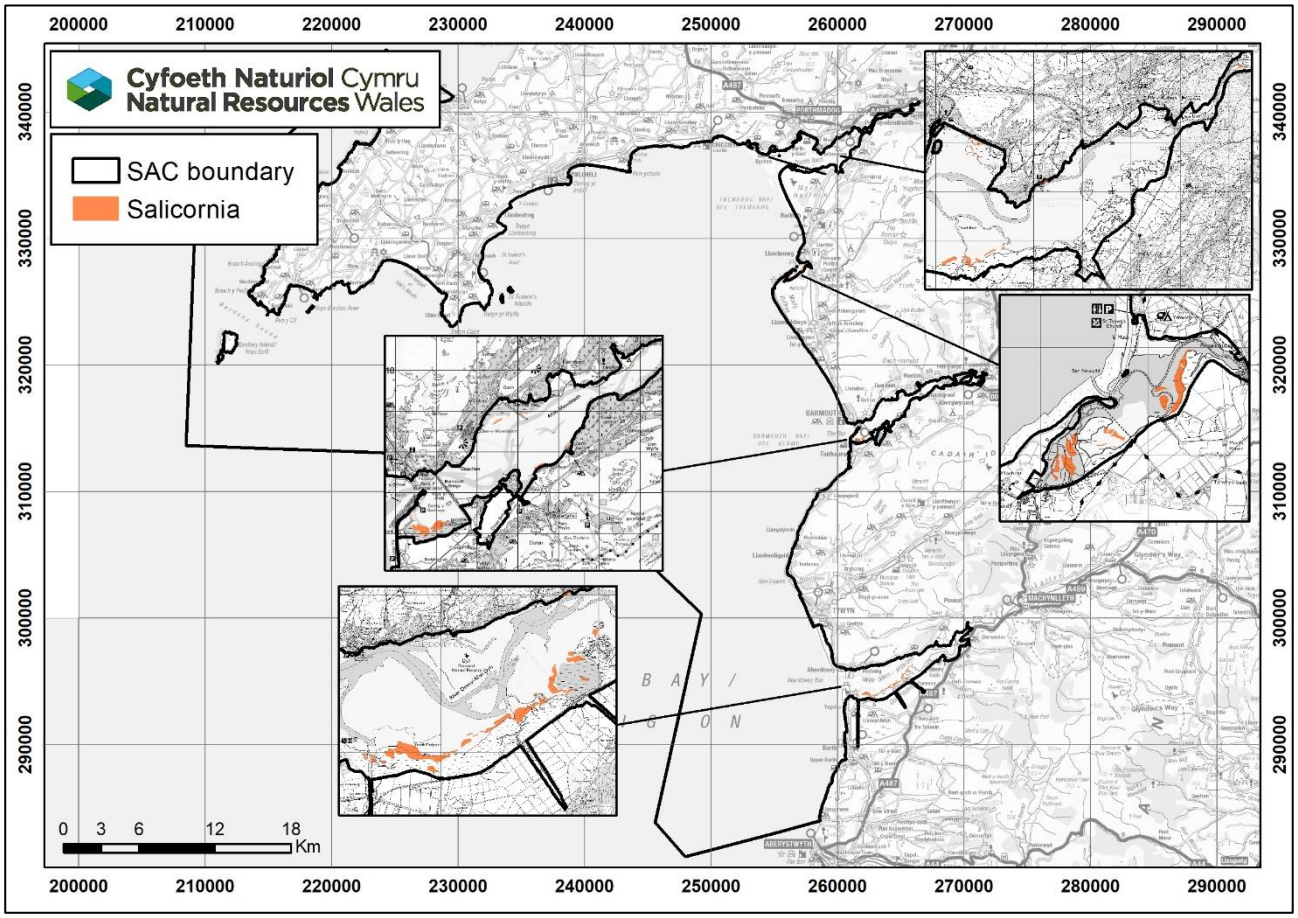
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.8. Feature 8: *Salicornia* and other annuals colonising mud and sand

The Salicornia and other annuals colonising mud and sand (*Salicornia*) within Pen Llŷn a'r Sarnau SAC are currently in **favourable** condition (low confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 9 is a map of the location of the *Salicornia* feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 9. Map of the *Salicornia* feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the *Salicornia* within the SAC and each of its main plant communities are stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of *Salicornia* habitats within the sectors of the SAC, subject to natural change.

Supporting Information

1a. Feature extent and distribution

The *Salicornia* feature is primarily pioneer saltmarsh that colonises intertidal mud and sandflats in areas protected from strong wave action. It 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* 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 however, the distribution is not continuous. The largest proportion of this feature occurs in the Dyfi estuary.

The overall extent of *Salicornia* feature across the site should be maintained. There should be no significant loss of extent within each sector. *Salicornia* in Pen Llŷn a'r Sarnau SAC is divided into sectors to aid monitoring. The sectors of the site are, Artro, Dwyfor, Dyfi, Mawddach, Morfa Harlech and the Glaslyn/ Dwyryd complex.

The current extent of the Salicornia feature is unknown, however as of the latest condition assessment, there is no evidence to suggest a change in extent. Therefore, both targets have defaulted to maintain for objective 1a. For more information see the latest condition assessment Jackson-Bué et al., 2025f).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the *Salicornia* feature are stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the *Salicornia* feature. Nutrients are at levels not detrimental to the structure and function of the *Salicornia* feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the *Salicornia* feature.
2b. Air quality	Maintain nitrogen (N) deposition at levels not detrimental to the structure and function of the *Salicornia* feature
2c. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the *Salicornia* feature are sustained.
2d. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the *Salicornia* feature is maintained, subject to natural change.

Supporting Information

2a. Water and sediment quality

Studies have demonstrated that saltmarsh habitats can be a sink for pollutants including herbicides, pesticides, organochlorines, polychlorinated biphenyls and heavy metals. A significant proportion of contaminants in these pollutants are absorbed onto fine sediment particles which are then deposited on the saltmarsh, locking them in. This can reduce the toxic impact in some cases. For example, Tributyl tin (TBT) has a half-life period of tens of years and burial of sediment contaminated with TBT over this time period can reduce loadings within a system. However, 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 (Adnitt et al., 2007). There is little evidence available on the negative impact contaminants can have on saltmarsh plants themselves (Pontee et al., 2021).

Nutrient cycling within saltmarshes can have a significant effect on coastal and estuarine water quality. Healthy, functional saltmarsh habitat may have an important role to play in the control of nutrients. While saltmarsh habitats can remove land derived nutrients from a system, excessive nutrient loading (at levels that would induce eutrophication) has been

shown to decrease root growth in some circumstances in saltmarsh plants, reducing sediment stability and increasing erosion over a 9-year period (Deegan et al., 2012).

High concentrations of nutrients (nitrogen and phosphorus) in the water column can cause phytoplankton and opportunistic macroalgae blooms. The impact of opportunistic macroalgae blooms is not well understood. It is possible short term or low-level exposure to macroalgae provides beneficial nutrient input (Wasson et al 2017). However, more intense exposure could be harmful as macroalgae mats have been shown to have negative impacts on saltmarsh, including reduced growth and biomass as a result of smothering impacts (Wasson et al., 2017 and references therein).

For information on water and sediment quality see the latest condition assessment (Jackson-Bue et al., 2025f).

2b. Air quality

There are few studies of the effects of nitrogen (N) deposition on saltmarsh habitats. Work from the Netherlands suggest saltmarsh vegetation is N limited (Mitsch and Gosselink, 2000), which would make it vulnerable to eutrophication effects. However, as N addition experiments have neither used very realistic N doses nor input methods, results should be approached with caution.

Overall atmospheric N deposition is likely to be of low importance for these systems as inputs are probably significantly below the large nutrient loadings from river and tidal inputs. A review by Boorman and Hazelden (2012) suggested pioneer low to mid saltmarsh areas are more resilient to N deposition than the mature upper areas. These more mature areas may also be subject to direct run-off from the surrounding catchment. Saltmarshes under a strong marine influence may show a lower sensitivity to additional (aerial) N but sensitivity is likely be a function of existing N supplies together with the maximum salinity of the habitat (Boorman and Hazelden 2012). Sensitivity will vary with site conditions.

The deposition critical range for saltmarsh habitat is set at 10-20 kg N per ha per year (Bobbink et al., 2022). The load is a conservative estimate. Evidence of exceedance of the deposition critical load would be indicated by increased productivity and increase in late successional species (Bobbink et al., 2022).

At the time of the last condition assessment the N deposition within *Salicornia* in the SAC is not exceeding the critical load, allowing a maintain target for objective 2b. See the latest condition assessment for more information (Jackson-Bue et al., 2025f).

2c. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves wind and tides), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents move sediment, which in turn can change the waves and currents; meaning there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

Salicornia is extremely tolerant of regular flooding, growing at the lowest edge of the saltmarsh. 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. 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 hyper-salinity in summer.

Four elements are necessary for growth of a saltmarsh: (1) relatively stable sediment that is covered by the tide for a shorter period than the time it is exposed; (2) a suitable supply of sediment within the period of tidal cover; (3) water velocities low enough for some sediment to settle out; and (4) a supply of seeds or other propagules for the establishment of vegetation cover.

Creeks and pans of varying size and density are frequent features of saltmarsh habitat influenced by vegetation cover, suspended sediment load and tidal influence. Creeks absorb tidal energy and assist with the delivery of sediment into saltmarshes. Creeks allow pioneer vegetation like *Salicornia* to be established along their banks higher into the saltmarsh system.

No hydro-morphology issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025f). Information on the hydro-morphology of the site can be found in Appendix 1.

2d. Sediment supply

The sediment structure of *Salicornia* habitat is predominantly muds and clays, though can grow on mixed muddy gravels and shelly sand. Although an early colonist of soft, unconsolidated sediments, the densest stands tend to be on firm silts and clays.

The sediment supply into and through *Salicornia* is influenced by the saltmarsh morphology (which is in part is determined by vegetation extent and density), which dictates water flow, energy dissipation and hence sediment deposition. Sediment budgets and transport often operate on a regional scale. Therefore, projects outside the SAC can still alter the sediment supply to features within the site.

No sediment supply issues have been identified for this feature. For more information see the latest condition assessment (Jackson- Bué et al., 2025f). Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of plant communities necessary for the structure and function of the *Salicornia* feature are stable or improving, subject to natural variability.

Objective attribute	**Site specific target**
3a. Plant communities	Maintain the abundance and distribution of plant communities of the *Salicornia* feature within the sectors of the SAC
3b. Invasive native and invasive non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the *Salicornia* feature.

Supporting Information

3a. Plant communities

All communities present in the *Salicornia* feature contribute to its overall condition. Changes to the spatial distribution of communities across the feature could highlight changes to the overall feature.

Both of the *Salicornia* feature vegetation community types are present within this site; Annual *Salicornia* saltmarsh and *Suaeda maritima* saltmarsh. These communities are primarily located on the Dyfi, Mawddach, Artro and Dwyryd estuaries. The *Salicornia* feature is naturally species poor. The dominant species *Salicornia sp.* and *Suaeda maritima* are able to colonise areas of high salinity and tolerate higher frequency tidal inundation than almost all other plants are able to, with the exception of Cord grasses *Spartina* species and Sea grass *Zostera* species.

A reduced marine fauna is usually present which may include amphipods, ragworm and gastropods. There are often algal films, including diatoms, and algal mats over the substrate surface, but vascular companions are usually very few.

There is no information on the current abundance and distribution of plant communities in the *Salicornia* feature. Therefore, the target has defaulted to maintain for objective 3a.

3b. Invasive native and invasive non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Saline conditions in *Salicornia* habitats prevent the more common terrestrial invasive non-native species in Wales becoming established. The red seaweed *Agarophyton vermiculophyllum* has been found in the Glaslyn / Dwyryd, Mawddach, and Dyfi estuaries. However, the species is currently not having a negative impact on the *Salicornia* feature. It is likely to be more associated with mudflats and some records are likely to be washed up specimens (Jackson-Bué et al., 2025f).

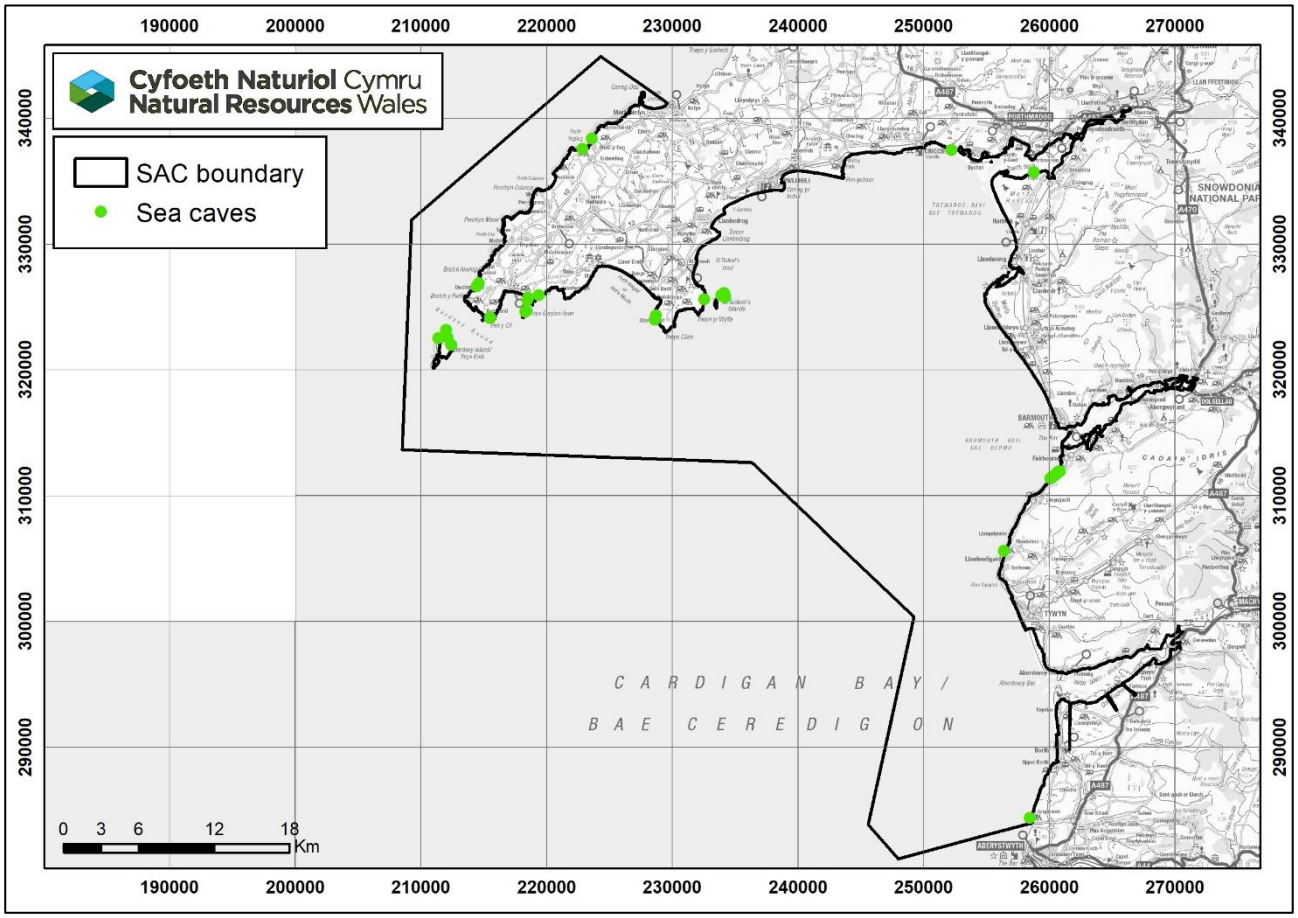
Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.9. Feature 9: Submerged or partially submerged sea caves

The submerged or partially submerged sea caves (sea caves) within Pen Llŷn a'r Sarnau SAC are currently in **unknown** condition. NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Figure 10 is a map of the location of the sea caves feature within Pen Llŷn a'r Sarnau SAC. The map is for illustrative purposes only. Detailed maps for this feature in Wales can be found on Data Map Wales.

Figure 10. Map of the sea caves feature within Pen Llŷn a'r Sarnau SAC.



Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The overall distribution and extent of the sea caves feature within the SAC and each of its main component habitats are stable or increasing, subject to natural change.

Objective attribute	Site specific target
1a. Feature extent and distribution	Maintain the extent and distribution of sea caves habitat. Subject to natural change.

Supporting Information

1a. Feature extent and distribution

The extent describes the presence and area of the feature across the whole site. The distribution describes the more detailed locations and patterns of different cave types that comprise the feature across the SAC.

Within the SAC, sea caves are present around Pen Llŷn including the Tudwal Islands and also along the Meirionnydd coast north of Tonfannau and the Ceredigion coast north of Clarach.

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). Caves are increasingly exposed to wave and tide energy towards the end of the peninsula and Bardsey Island.

The extent and distribution attribute has been met, allowing a maintain target to be set for objective 1a. For further information see the latest condition assessment (Hatton-Ellis et al., 2025).

Objective 2: The hydro-morphological and chemical elements necessary for the structure and function of the feature are stable or improving, subject to natural change.

Objective attribute	Site specific target(s)
2a. Water and sediment quality	Contaminants are at levels not detrimental to the structure and function of the sea caves feature. Nutrients are at levels not detrimental to the structure and function of the sea caves feature. Physicochemical characteristics are at levels not detrimental to the structure and function of the sea caves feature.
2b. Hydro-morphology	The characteristic hydrodynamics, sediment transport and morphology necessary for the structure and function of the sea caves feature are sustained.
2c. Sediment supply	The sediment type, size distribution and budget necessary for the structure and function of the sea caves feature is sustained.

Supporting Information

2a. Water and sediment quality

Various contaminants are known to affect species living within the water column and in or on the surface of sediments. The biological effect of a contaminant will vary depending on its nature. Contaminants include, but are not limited to, heavy metals (e.g. mercury and zinc), Polybrominated diphenol ethers (PBDEs), poly-aromatic hydrocarbons (PAHs), poly-chlorinated biphenyls (PCBs) and organotin and pesticides such as hexachlorobenzene. These chemicals (e.g. heavy metals) can degrade community structure and bioaccumulate within organisms, entering the marine food chain (e.g. PCBs) (OSPAR Commission, 2012).

High concentrations of nutrients in the water column can cause phytoplankton and opportunistic macroalgae blooms, leading to reduced dissolved oxygen availability. This can impact sensitive fish, epifauna and infauna communities. Overgrowth of opportunistic macroalgae species because of increased nutrient input on intertidal reef can reduce biodiversity, though the effect of grazers and wave action can help limit the impacts (Bokn et al., 2003; Worm and Lotze, 2006). High nutrient loads may be more of an issue on sheltered intertidal reef with low grazing pressure (Bokn et al., 2003). This is likely to be true for intertidal and shallow sub-tidal sea caves.

Physicochemical characteristics include salinity, pH, temperature, dissolved oxygen and turbidity. They influence habitats alone or in combination to affect habitats in terms of the abundance, distribution and composition of communities present. Changes in any of these

properties, because of anthropogenic activities, may impact habitats and the communities they support.

2b. Hydro-morphology

Hydro-morphology refers to patterns of water movement (caused by waves, wind, tides and fluvial input), coastal processes (e.g. erosion and deposition), and the physical characteristics of the environment. Waves and currents can move sediment, which can change the shape of the seabed, which in turn changes waves and currents; in other words there is two-way feedback between the hydrodynamics and the morphology. As water movement transports nutrients, sediment and other particles, it also strongly influences the species and communities present.

The most important structure and function characteristics for the sea caves feature are the geology and geomorphology, including topography (surface features), together with hydrodynamic processes (wave action and tidal currents) and water quality and clarity (turbidity). Sea cave morphology and topography is varied and determined by the underlying geology. Microtopography is a further important dimension to habitat variation. Cave surfaces range from smooth, unbroken rock walls to fractured, fissured and perforated surfaces.

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.

Information on the hydro-morphology of the site can be found in Appendix 1.

2c. Sediment supply

Sediment type, distribution and supply are important in determining the species and communities present in a habitat. The rate at which sediment is deposited is known to influence sea cave habitats and their associated communities. Sedimentation influences community composition, alters species growth rates, inhibits feeding or photosynthesis and potentially affects reproductive success by reducing larval recruitment. High levels of sediment deposition could lead to smothering or burying of sessile benthic species.

The mobilisation and deposition of sediment as a result of water movement is regular and widespread and can lead to rapid fluctuations in sediment height. The floors of many sea caves are areas of sediment or mixtures of sediment and pebbles, cobbles and boulders, with sheltered locations in caves tending to accumulate silt. The sediments contribute to the habitat and species diversity and composition and have a strong influence on the amount of scouring of cave walls. Suspended particulate concentrations are generally significantly higher in sea caves subject to water movement with sediment floors or with a nearby sediment source, than levels in the adjacent external water column.

The combined effects of scour from suspended particulates and sediment and food particle supply are particularly important to the development, survival and diversity of cave species populations, especially in caves adjacent to sediment or with sediment floors. The species populations in different sea caves reflect the differing balance between these effects.

Information on the sediment transport in the SAC can be found in Appendix 1.

Objective 3: The abundance, distribution and diversity of species within communities and component habitats necessary for the structure and function of the sea caves feature are stable or improving, subject to natural variability.

Objective attribute	Site specific target
3a. Habitats and communities	Maintain abundance, distribution and diversity of species within component habitats and communities necessary for the structure and function of the sea caves feature.
3b. Invasive and non-native species	Introduction or spread of new non-native species to the SAC by anthropogenic activities should not have a detrimental impact on the structure and function of the sea caves feature.

Supporting Information

3a. Habitats and communities

All the sea cave communities within the SAC contribute to the overall condition of the feature. Changes to the spatial distribution of communities across the feature could highlight changes to the overall feature.

A range of sea cave communities have been recorded within the caves of the SAC. These range from scoured sparse communities characterised by lichens, red seaweed, 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).

More information on sea cave communities in the SAC can be found in Appendix 1.

3b. Invasive and non-native species

Non-native species (NNS) may become invasive non-native species (INNS) and displace native species by predating them or out-competing them for food, space or both. This can lead to the loss of indigenous species from certain areas or changes to community structure (JNCC, 2004b; Levin et al., 2002), as well as changes to biotope and habitat type. The introduction or spread of NNS within the SAC can occur through various regulated and unregulated pathways. Further information on introduction pathways can be found on the GB non-native species secretariat website.

There is currently no information on INNS in the sea caves of the SAC. Information on INNS in the SAC as a whole can be seen in Appendix 1.

3.10. Feature 10: Grey seal *Halichoerus grypus*

The grey seal *Halichoerus grypus* feature within Pen Llŷn a'r Sarnau SAC are currently in **favourable** condition (medium confidence).). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The grey seal population that use the SAC is maintained in favourable condition and stable or increasing over the medium and long term.

Objective attribute	**Site specific target**
1a. Population using the SAC	Maintain the grey seal population that use the SAC in favourable condition, and stable or increasing in the medium and long term.
1b. SAC pup production	Maintain a stable or increasing grey seal pup production within the SAC in the medium and long term, including at important pupping sites.

Supporting Information

1a. Population using the SAC

Based on pup production estimates, Wales hosts around 3-4% of the UK's grey seals (SCOS, 2022). The Pembrokeshire coast contains the main grey seal colonies in Wales and the Irish and Celtic Seas region (SW British Isles) it's the most southerly in Europe of any significant size (Baines et al., 1995).

Grey seals within Pen Llŷn a'r Sarnau SAC are considered part of the wider regional population, which is not isolated, but extends from the west coast of Scotland to France (SCOS, 2013; Carter et al., 2022; Langley et al., 2020; Pomeroy, et al., 2014; Russel et al., 2017; Sayer et al., 2019).

An estimated 2,250 pups are born per year in Wales (Russell and Morris, 2020), though there is some uncertainty around this value (Thompson, in prep). Pup production at regularly monitored sites in Wales has increased markedly since monitoring began (Bull et al., 2017; Morgan et al., 2018; Robinson et al., 2023). This reflects similar regional and UK wide increases (SCOS, 2022).

Summer haul out census data obtained via aerial survey in 2023 estimated the grey seal population in Wales to be 5,284 individuals, + or - 4,571- 6,195 (Thompson, in prep). This is thought to be an increase in the population (Thompson, in prep).

The population attribute is being met, allowing a maintain target to be set for objective 1a. Further detail on the wider population can be found in the latest condition assessment (Cuthbertson et al., 2025d).

1b. SAC pup production

There is a single monitored colony (pupping areas) in the SAC: Bardsey Island. This is the major pupping site for grey seals in North Wales. Though regular monitoring ceased in 2019, production at this colony has been used as a proxy to give SAC pup production figures for the whole site. It is important that production of the colony remains stable or increases even if distribution of pupping across the SAC and/or total SAC pup production remains stable. Declines in production within this major colony could indicate issues of concern, such as breeding seals being subject to disturbance.

Pup production in Pen Llŷn a'r Sarnau SAC has seen an upward trend since 2008 to 2017 (Robinson et al., 2023). It is accepted that pup production across the whole SAC is likely to have followed that of monitored colony (and wider population) and increased or at the least remained stable (Cuthbertson et al., 2025d).

The pup production attribute is being met, allowing a maintain target to be set for objective 1b. For more information see the latest condition assessment (Cuthbertson et al., 2025d).

Objective 2: The grey seal population that use the SAC continue to have access to, and be able to utilise habitats necessary to maintain the population in favourable condition.

Objective attribute	**Site specific target**
2a. Distribution of grey seal pupping sites within the SAC	Maintain a stable or increasing grey seal pupping distribution across the SAC. Allowing for natural change and variation.
2b. Accessibility to habitat used by seals	Grey seal that use the SAC should not be significantly constrained from accessing necessary habitats within or outside of the site.
2c. Anthropogenic disturbance	Grey seal that use the SAC should not be subject to significant anthropogenic disturbance within or outside of the site.

Supporting Information

2a. Distribution of grey seal pupping sites within the SAC

Pupping takes place throughout the site on the coast where there is suitable habitat i.e. physically inaccessible, remote and/or undisturbed rocky coast beaches, coves and caves. Unusually for the species, about 42% of pupping sites in West Wales contain caves which host pups (Baines et al., 1995).

The distribution of pupping sites across the SAC is likely to reflect influencing factors impacting on seals, both positive and negative. Monitoring seal pupping distribution can help identify areas that are important to breeding seals, and enable sites to be managed

for impacts where needed (JNCC, 2005). Impacts are most likely to be managed when they are anthropogenic rather than natural. Physical processes may alter the availability of some sites (e.g. rock falls caused by storms), but are considered to be part of the natural variation.

Any changes in the distribution of breeding seals across the SAC could be indicative of a reduction in habitat quality caused, for example, by disturbance. Reduction in use of available pupping sites may put pressure on the remaining sites and potentially limit seal pupping productivity due to lack of available space to pup.

The latest condition assessment suggests the distribution of pupping sites is stable. The pupping distribution attribute is being met, allowing a maintain target to be set for objective 2a. For more information see the latest condition assessment (Cuthbertson et al., 2025d).

2b. Accessibility to habitat used by seals

Grey seal coastal habitat serves to support the species during all of its life phases and needs. From breeding, pupping, moulting and resting whilst on land, to foraging on the seabed and in the water column and travelling whilst at sea. Grey seals are a highly mobile species, and individuals that breed within the SAC may spend other times of the year in areas far from the site, dispersing widely within the Irish and Celtic Seas (Carter et al., 2022; Sayer et al., 2019). Similarly, seals that haul out in Pembrokeshire Marine SAC outside of the breeding period may also pup elsewhere in the wider region (Langley et al., 2020). It is vital that grey seal continue to have unimpeded access to habitats within and outside of the SAC that are necessary to maintain the population that use the SAC in favourable condition. It is not only physical barriers or constraints that could reduce access to their habitat, noise and visual stimuli could also prevent grey seals from accessing an area.

For example, West Hoyle sandbank in Liverpool Bay is a major, if not the biggest, grey seal haul out in the Irish and Celtic seas, and has demonstrated connectivity to the SAC (e.g. Carter et al., 2022; Langley et al., 2020) and is considered to have functional linkage (i.e. necessary). If access to this sandbank was impeded, for example, it may impact the seals that use Pen Llŷn a'r Sarnau SAC. Whether an activity is causing significant constraint will be judged on a case by case basis.

There is currently no evidence grey seals that use the SAC are significantly constrained from accessing necessary habitats. For more information see the latest condition assessment (Cuthbertson et al., 2025d).

2c. Anthropogenic disturbance

Seal disturbance on land mainly comes in the form of recreational disturbance (e.g. dog walkers, wildlife watching boats, etc), and from airborne noise such as from construction, military exercises and recreation (e.g. fireworks). Disturbance to seals while at sea is largely through underwater noise associated with construction of industrial developments. Changes in the distribution of breeding seals could be indicative of disturbance (see objective attribute 2a).

Disturbance can lead to seals abandoning haul outs as they flush into the water to avoid the perceived threat. This can stress seals and can also be a danger to new pups due to physical harm, as adults rush to the water, or through starvation due to temporary or permanent abandonment (SCOS, 2013).

We know grey seals forage and breed outside of the SAC boundaries. Therefore, we need to ensure that grey seals that use the SAC are not disturbed in such a way that the population that is adversely affected. Whether an activity is causing significant disturbance will be judged on a case by case basis.

Disturbance is currently not at levels significantly affecting the seal population. See the latest condition assessment for further information (Cuthbertson et al., 2025d).

Objective 3: The grey seal population that use the SAC have high quality habitat and sufficient food supply to support and maintain the population in favourable condition.

Objective attribute	**Site specific target**
3a. Habitat quality and function	Maintain the quality and functionality of habitat to support the grey seal population that use the SAC in favourable condition.
3b. Prey availability	Maintain the quality, abundance and diversity of prey needed for the grey seal population that use the SAC to remain in favourable condition.
3c. Water, sediment and prey contaminants	Contaminants are at levels not detrimental to the grey seal population that use the SAC.

Supporting Information

3a. Habitat quality and function

The exact habitat requirements of grey seals are not known (seemingly suitable habitat is often not occupied), but must include suitable pupping, moulting and resting haul-out areas on land as well as access to suitable foraging and passage areas at sea. Adults and weaned pups are assumed to feed at sea throughout the site, and some are known to make long foraging trips offshore to deeper waters off the Pembrokeshire coast (Thompson, 2011).

Many grey seals in Wales tend to use secluded coves and caves for pupping instead of forming large congregations of pupping females on open beach sites, differing from seals elsewhere in Britain (Baines et al., 1995; Stringell et al., 2014). Other preferred breeding sites tend to be secluded and sheltered from heavy wave action. Moulting and resting haul-out sites are distributed throughout the site, though only a small number of sites are regularly used as haul-outs by large numbers of seals (Baines et al., 1995; Thompson, in prep). Known winter moulting haul-outs and non-moulting / resting haul-outs are limited to offshore islands and remote, undisturbed and inaccessible rocky shores and beaches.

Pupping occurs mainly at Bardsey Island (Robinson et al., 2023). Suitable habitat for moulting and resting haul-out requirements is extensive throughout the SAC and is assumed to be adequate (Cuthbertson et al., 2025d).

The habitat quality and function attribute is being met, allowing a maintain target to be set for objective 3a. See the latest condition assessment For more information (Cuthbertson et al., 2025d).

3b. Prey availability

Grey seals are generalist feeders, taking whatever food source is locally abundant (Brown et al., 2012; Thompson et al., 1991). They forage primarily on the seabed, taking a wide variety of prey including sandeels, gadoids (cod, whiting, haddock, ling), and flatfish (plaice, sole, flounder, dab (SCOS, 2013). A study of grey seal diets from scats collected in Pembrokeshire, found that gadoids (mainly whiting) and flatfish (mainly sole) dominated the diet (70% by weight) (Strong et al., 1996). Similar results were seen from a more recent comprehensive study of grey seal diet in Wexford Harbour, Southeast Ireland (Gosch et al., 2019) and in small seal diet study on Skomer Island (Lofthouse, 2017).

While stocks of some key prey species are depleted in the Irish/Celtic sea region, there is no reason to believe that prey is limited or has reduced diversity in the areas that grey seal are using to forage. The grey seal population in Wales has been expanding and pupping has an increasing trend in the SAC, suggesting prey is abundant enough to support a growing population.

The prey availability attribute has been met, allowing a maintain target to be set for objective 3b. See the latest condition assessment for more information (Cuthbertson et al., 2025d).

3c. Water, sediment and prey contaminants

Grey seals, like many marine mammals, are exposed to a variety of anthropogenic contaminants. The main route of exposure is through ingestion of prey. As grey seals are top predators, they are at risk from contaminant biomagnification through the food chain (Hammond et al., 2005). This is particularly the case for persistent organic pollutants (POPs) like polychlorinated biphenyls (PCBs), which are lipid soluble, and heavy metals, like mercury. The toxic effects of these contaminants are well studied with impacts such as reduced reproduction and high susceptibility to disease (Hammond et al., 2005).

There is no evidence contaminants are having a detrimental impact on the grey seal population been identified as an issue for grey seal in this SAC. See the latest condition assessment for more information (Cuthbertson et al., 2025d).

3.11. Feature 11: Bottlenose dolphin *Tursiops truncatus*

The bottlenose dolphin *Tursiops truncatus* feature within Pen Llŷn a'r Sarnau SAC is currently in **favourable** condition (low confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The bottlenose dolphin population that use the SAC is maintained in favourable condition and stable or increasing over the medium and long term.

Objective attribute	**Site specific target(s)**
1a. Population using the SAC	Maintain the bottlenose dolphin population that use the SAC in favourable condition, and stable or increasing in the medium and long term. Population demographics such as reproductive success and survival rates are at levels needed for the population to be maintained in favourable condition.
1b. SAC residency	Maintain bottlenose dolphin residency in the SAC over the medium and long term.

Supporting Information

1a. Population using the SAC

For the purposes of this objective, medium and long term have been defined as 10 and 20 years respectively.

Bottlenose dolphins are common and found throughout UK and NE Atlantic waters, especially offshore. However, populations of coastal bottlenose dolphins are much rarer in the UK. Cardigan Bay is one of the very few areas around the UK where significant numbers of coastal bottlenose dolphin are known to occur regularly. The population of bottlenose that live here have been studied intensively since the late 1990s.

While the dolphins of Pen Llŷn a'r Sarnau SAC are thought to be semi-resident here, they do range widely within the Irish Sea (a Management Unit for the species: see IAMMWG, 2023). Their full distribution is not known precisely but individuals recorded regularly within the SAC have also been seen further afield around the Welsh coast, NW English waters and the Isle of Man. Bottlenose dolphin distribution varies from year to year, which is likely to be a consequence of natural environmental changes, such as fluctuations in prey distribution.

A combination of boat-based line transect surveys (distance sampling) and photo identification (capture-mark-recapture (CMR)) have been carried out in the SAC since 2001 and in the wider Cardigan Bay region since 2005. These monitoring techniques have been used to produce coastal bottlenose dolphin population abundance estimates (Lohrengel et al., 2018; Lohrengel et al., in draft).

From 2001 to 2024 the number of dolphins using the SAC and the wider Cardigan Bay (monitored since 2005) are variable but the population is considered to be broadly stable over that time frame. More information on bottlenose dolphin numbers and monitoring methods used for their assessment can be found in in the condition assessment for this feature (Cuthbertson et al., 2025c).

Bottlenose dolphin is a long-lived species that may survive in the wild for 40-50 years or more. The reproductive rate of bottlenose dolphins is low: females produce a single calf every 3.4 years on average once they mature at around 7-8 years old. The gestation period is about one year, and the pregnancy rate does not appear to decrease with age.

1b. SAC residency

The coastal bottlenose dolphin population in Pen Llŷn a'r Sarnau SAC is one of two major semi-resident coastal populations in UK; the other resides in Moray Firth, Scotland for which the Moray Firth SAC was designated. Smaller coastal populations can also be found in SW England and West Scotland (see IAMMWG, 2023).

Detecting residency in a mobile species is difficult and requires long term intensive monitoring with photo identification of individuals. A bottlenose dolphin is considered to be a resident if it is seen for a minimum of seven years and on at least 12 separate occasions.

Analysis of the latest values found the percentage of residency to be stable in the long term (Lohrengel et al., in draft;). The SAC residency attribute has been met, allowing a maintain targets to be set for objective 1b. For more information see the latest condition assessment (Cuthbertson et al., 2025c).

Objective 2: The bottlenose dolphin population that use the SAC continue to have access to, and be able to utilise habitats necessary to maintain the population in favourable condition.

Objective attribute	**Site specific target**
2a. Accessibility to habitat used by bottlenose dolphin	Bottlenose dolphins that use the SAC should not be significantly constrained from accessing necessary habitats within or outside of the site.
2b. Anthropogenic disturbance	Bottlenose dolphins that use the SAC should not be subject to significant anthropogenic disturbance within or outside of the site.

Supporting Information

2a. Accessibility to habitat used by bottlenose dolphin

The mobile nature of bottlenose dolphins means that they utilise a wide area for their functional needs (e.g. feeding, breeding etc). However, there is a lack of understanding on what constitutes suitable habitat for the species but repeated presence of bottlenose dolphin at a particular location is likely to indicate reliance on the habitat associated with that location. It is vital that bottlenose dolphin continue to have unimpeded access to habitats within and outside of the SAC that are necessary to maintain the population that use the SAC in favourable condition. It is not only physical barriers or constraints that could reduce access to their habitat, noise and visual stimuli could also prevent dolphins from accessing an area.

The degree of concern about habitat accessibility will differ depending on the life stage of the individuals and the severity of the constraint. For example, there may be more concern around access constraints that impact mother and calf pairs, large areas, or that persists for a long time.

We know bottlenose dolphins forage and breed outside of the SAC boundaries. Therefore, we need to ensure functionally linked (i.e. necessary) habitats are available to them and their use of them is not constrained in such a way that the population that uses the SAC is adversely affected. Whether an activity is causing significant constraint will be judged on a case by case basis.

There is currently no evidence bottlenose dolphin that use the SAC are significantly constrained from accessing necessary habitats. For more information see the latest condition assessment (Cuthbertson et al., 2025c).

2b. Anthropogenic disturbance

Like all cetaceans, bottlenose dolphins are sensitive to disturbance, particularly from underwater noise, as they rely heavily on sound to sense their surroundings, detect prey and to communicate (Evans, 1996). One of the main anthropogenic sources of underwater noise in Cardigan Bay is from vessel traffic. Boat noise has been shown to mask cues, affect the behaviour of bottlenose dolphins and their prey and cause stress (Pirotta et al., 2015).

The degree of concern about anthropogenic disturbance will differ depending on the life stage of the individuals and the severity of the disturbance. For example, there may be more concern around disturbance that impacts mother and calf pairs, large areas, or that persists for a long time.

We know bottlenose dolphins forage and breed outside of the SAC boundaries. Therefore, we need to ensure that bottlenose dolphin that use the SAC are not disturbed in such a way that the population that is adversely affected. Whether an activity is causing significant disturbance will be judged on a case by case basis.

Disturbance is currently not at levels significantly affecting the bottlenose dolphin population the use the SAC. See the latest condition assessment for further information (Cuthbertson et al., 2025c).

Objective 3: The bottlenose dolphin population that use the SAC have high quality habitat and sufficient food supply to support and maintain the population in favourable condition.

Objective attribute	Site specific target
3a. Habitat quality and function	Maintain the quality and functionality of habitat to support the bottlenose dolphin population that use the SAC in favourable condition.
3b. Prey availability	Maintain the quality, abundance and diversity of prey needed for the bottlenose dolphin population that use the SAC to remain in favourable condition.
3c. Water, sediment and prey contaminants	Contaminants are at levels not detrimental to the bottlenose dolphin population that use the SAC.

Supporting information

3a. Habitat quality and function

There are two ecotypes of bottlenose dolphin, those that live in the offshore and those that live mainly inshore (Louis et al., 2014). Each has different habitat and dietary preferences (Hernandez-Milian et al., 2015). In coastal waters, bottlenose dolphins appear to favour habitat with uneven topography and/or strong tidal currents. The precise habitat requirements of coastal bottlenose dolphins, however, are poorly understood, but includes habitat that is of sufficient quality for feeding and calving, as well as resting and travelling.

Coastal bottlenose dolphins use different areas throughout the Irish Sea Management Unit, Cardigan Bay, and the SAC. However, Pen Llŷn a'r Sarnau SAC represents a core area of habitat used by the population.

The habitat quality and function attribute is being met, allowing a maintain target to be set for objective 3a. See the latest condition assessment For more information (Cuthbertson et al., 2025c).

3b. Prey availability

Bottlenose dolphins are generalist and opportunistic feeders eating a wide range of pelagic and benthic (demersal) fish, crustaceans and molluscs both within and outside of the SAC.

From visual observations of the surface behaviour of bottlenose dolphins in Cardigan Bay and prey capture, it is known that they catch pelagic fish (such as sea trout and bass), bottom dwelling fish (e.g. flatfish) and invertebrates (e.g. squid) (unpublished data, Seawatch Foundation). Hernandez-Milian et al. (2015) analysed stomach content of bottlenose dolphins stranded on the west coast of Ireland and indicated a wide variety of both benthic and pelagic prey was consumed. However, this study may better represent the offshore ecotype rather than coastal bottlenose dolphin associated with the Irish Sea and Cardigan Bay.

As bottlenose dolphins forage widely within and outside of the SAC, a decline in a single prey species in one area may not immediately impact the population. However, prey availability is likely to be a key factor in determining the abundance and distribution of dolphins in the Irish Sea, Cardigan Bay and the SAC.

The prey availability attribute has been met, allowing a maintain target to be set for objective 3b. See the latest condition assessment for more information (Cuthbertson et al., 2025c).

3c. Water, sediment and prey contaminants

As top predators, marine mammals are vulnerable to contaminants, particularly those which biomagnify and/or bioaccumulate, such as persistent organic pollutants (POPs). These include, but are not limited to, pesticides, polychlorinated biphenyls (PCBs) historically used in manufacturing, and polybrominated diphenyl ethers (PBDEs) typically used as flame retardants in a variety of products. While many POPs have been banned in Europe since the 1970s and 80s, they take a very long time to degrade (i.e. persistent). Despite this, these contaminants continue to enter the marine environment via use and disposal of products made before bans were introduced. This is evidenced by the high levels of PCBs found in dolphins and cetaceans in European shallow coastal waters (Jepson and Law., 2016; Williams et al., 2023; Zanuttini et al., 2019).

POPs pose a risk to bottlenose dolphin as these harmful contaminants are lipophilic in nature and are stored in their fat (e.g. blubber) and bioaccumulate over their long life spans (Williams et al., 2023, and references therein).

POPs are known to cause a variety of negative health impacts in individual marine mammals such as immune system suppression, reproductive impairment and developmental abnormalities (Aguilar and Borrell, 1994; Jepson et al., 2005; Tanabe et al., 1994; Schwacke et al., 2002; 2012; Vos et al., 2003;). The impacts these chemicals have at a population level, however, are not well understood.

Contaminant levels are not thought to be having a detrimental impact on the bottlenose dolphin population of the SAC at the time of writing, but are considered to pose a threat. For more information see the latest condition assessment (Cuthbertson et al., 2025c).

3.12. Feature 12: Otter *Lutra lutra*

The otter *Lutra lutra* feature within Pen Llŷn a'r Sarnau SAC is currently in **unfavourable** condition (medium confidence). NRW published the latest condition assessment in June 2025. NRW will review these conservation objectives when new condition assessment information is available.

Below are the attributes and targets for each conservation objective alongside supporting information.

Objective 1: The otter population that use the SAC is restored to favourable condition and stable or increasing in the long term.

Objective attribute	**Site specific target**
1a. Otter population health	Restore the otter population relevant to the SAC to favourable condition. The wider population should be stable or increasing in the long-term.

Supporting Information

1a. Otter population health

Otters present within the SAC are part of a wider population living around freshwater habitats around the Llŷn peninsula, which itself is not completely isolated but extends further afield and between which there are movements and exchanges. A genetic study found that otters in Wales are comprised of three genetically distinct subregions; Southwest Wales, Northwest Wales and Mid-East Wales (Hobbs et al., 2011). The relevant wider region to the SAC is the northwest population.

In Wales otters have been monitored through the Otter Survey of Wales since the 1970s. The first report was published in 1978 and repeated every 7 years since. Each survey consists of sites across all river catchments (hydrometric areas) in Wales. This equates to 1108 sites over 16 hydrometric areas. The number of positive sites in a hydrometric area are used as a proxy for population size.

Relevant hydrometric areas are those that border the SAC boundary. For Pen Llŷn a'r Sarnau these are the Glaslyn and Dyfi hydrometric areas. In the 6th Otter Survey of Wales, the Glaslyn had 62% positive sites, a statistically significant 33% decrease since the last survey. The Dyfi had 71% positive sites. (Kean and Chadwick, 2021). Neither met the 80% minimum of positive sites required, resulting in 'restore' for the first target of objective 1a.

The latest survey showed this wider population has seen large declines across the region meaning the wider population is not stable or increasing (Kean and Chadwick, 2021). This sets a restore target for objective one. More detail can be found in the latest condition assessment (Cuthbertson et al., 2025b).

Objective 2: The otter population that use the SAC continue to have access to, and be able to utilise habitats necessary to restore the population to favourable condition.

Objective attribute	Site specific target
2a. Accessibility to habitat used by otters	Otter that use the SAC should not be significantly constrained from accessing necessary habitats within or outside of the site.
2b. Habitat connectivity	Maintain safe passage and movement of otters into, within and away from the SAC.

Supporting Information

2a. Accessibility to habitat used by otters

Little is known about otter activity within the SAC boundary. However, the coast within the SAC is well supplied with rivers and streams and it is highly likely that otters 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.

It is vital that otters continue to have unimpeded access to habitats within and outside of the SAC that are necessary to restore the population that use the SAC to favourable condition. It is not only physical barriers or constraints that could reduce access to their habitat, noise and visual stimuli could also prevent otter from accessing an area. Whether an activity is causing significant constraint will be judged on a case by case basis.

While otters are elusive, records of otter sightings (which can include live sightings as well as footprints, spraints and roadkill), can provide evidence that otters are able to access suitable habitat in the SAC. There is currently no evidence otters that use the SAC are significantly constrained from accessing necessary habitats. For more information see the latest condition assessment (Cuthbertson et al., 2025b).

2b. Habitat connectivity

Otters in Wales primarily use riverine habitats to feed, rest and breed. However, it can be assumed that the coast and adjacent seas of the SAC contribute to supporting the otter population as a foraging area and corridor to movement between their primary riverine habitats. They also use the coast to rest. It is therefore essential that unimpeded access into, within and away from the site is maintained. Barriers should not block otter movement or threaten otter movement through increased risk of incidental injury or killing.

There is no evidence of barriers to movement of otter within the SAC. The habitat connectivity attribute has been met, allowing a maintain target to be set for objective 2b. See the latest condition assessment for more information (Cuthbertson et al., 2025b).

Objective 3: The otter population that use the SAC have high quality habitat and sufficient food supply to support and restore the population to favourable condition.

Objective attribute	Site specific target
3a. Habitat quality and function	Maintain the quality and functionality of habitat to support the otter population that use the SAC.
3b. Water quality	Contaminants are at levels not detrimental to the otter population using the SAC.

Supporting Information

3a. Habitat quality and function

The coast and adjacent seas of the SAC are important to otters for foraging, resting and as an access corridor, it is important that the SAC habitat is maintained in sufficient quality to support the population.

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

Otter diet can be highly varied, though is normally focused on favoured prey species and a reflection of local prey availability.

Due to the lack of understanding on the quality and function of habitat in the SAC attribute, a default maintain target has been set for objective 3a.

3b. Water quality

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. This is particularly the case for persistent organic pollutants (POPs) like polychlorinated biphenyls (PCBs) which are lipid soluble and heavy metals like mercury. The status of contamination of most likely prey species is unknown, although European eels are known to be substantially impacted by a range of contaminants. PCB contamination of otter prey species has been an issue elsewhere in the UK.

Contaminants have been identified as an issue for otter in this SAC. It is not clear what the impact of these chemicals could be on the otter population, either directly or through their prey. Information on water quality in the SAC can be seen in the latest condition assessment (Cuthbertson et al., 2025b).

4. Advice on operations

NRW must provide advice to relevant authorities about operations that may cause,

- deterioration of designated natural habitats
- deterioration of the habitats of designated species
- the disturbance of designated species

This is statutory advice required by regulation 37(3b) of the Habitats Regulations.

This advice is to help relevant authorities direct and prioritise their management of activities that are of greatest threat to the features of the site. The advice given here is without prejudice to any advice provided in relation to the consideration of plans or projects within the meaning of Part 6 of the Habitat Regulations.

Activities operating at distance from the site may cause pressures that travel into the site. These external pressures may affect features within the SAC.

4.1. Operations which may cause deterioration or disturbance to the features of the site

Table 2 lists activities that have the potential to deteriorate or disturb the designated features of Pen Llŷn a'r Sarnau SAC and if they are known to occur within the SAC.

This list of operations is not exhaustive. If an operation or activity is not listed in Table 2 it may still have the potential to deteriorate the features of the site. Activities occurring outside of the site may still have the potential to impact the features within the SAC. The occurrence information was correct at time of publication, but activities may have ceased or started since. Advice on individual operations should be sought on a case-by-case basis.

Additional information can be found on the Natural England's designated sites website and Marine Scotland's Feature Activity Sensitivity Tool (FEAST). It is important to note that NRW has not agreed sensitivity thresholds with either Natural England or Nature Scot and the information should be used as a general guide. Specific advice on operations should be sought from NRW on a case-by-case basis.

Table 2. Advice on operations for Pen Llŷn a'r Sarnau SAC.

Operation/Activity	Occurrence in SAC
Dredging: construction and maintenance, including disposal.	Occurs within the SAC primarily to maintain navigable depths in approaches to relevant harbours and marinas.
Shipping: Vessel traffic and maintenance (including antifouling).	No data available. Most shipping transiting the Irish Sea is unlikely to pass through SAC, except to seek shelter on passage.
Shipping: anchoring (commercial).	Limited activity in relation to commercial shipping in SAC.
Shipping: Conventional and accidental discharges. (Including ballast water discharge, refuse, sewage, operational, petrochemical, cargo losses and salvage).	Potential to occur but likelihood is low as the site is not on main shipping routes.
Land claim (gain of land from the sea or coastal wetlands e.g. for agricultural purposes, industrial use and harbour expansions).	Lots of historical land claim in the SAC. Majority of the past reclamation of land has been in the estuaries and is associated with agricultural activities in the estuaries.
Coast protection: Hard defences (including sea walls, breakwaters, railways and foreshore deposit of rock, rubble etc.).	Present at various locations along the coast with many rock armour defences present at varying in scales. The Cambrian Coast railway line includes coastal and flood protection works, particularly where railway line runs very close to the sea.
Coast protection: Soft defences (including groynes, beach replenishment etc).	At some locations in SAC, but not very extensive. Groynes present at various locations along the coast (south Llŷn, Barmouth, Towyn, and Borth).
Coast protection: Barrages (including storm surge, tidal and amenity).	Not currently present in the SAC.
Hard-engineered freshwater watercourses.	Associated with some locations in SAC, in and adjacent to the estuaries in particular.
Power station.	Not currently present in the SAC.
Pipelines.	Not currently present in the SAC.

Operation/Activity	Occurrence in SAC
Power / communication cables.	Some present in SAC, e.g. electricity cable across the Dyfi estuary.
Effluent disposal by vessels at sea: disposal of sewage, chemical, thermal and sludge dumping. Not CSOs.	NRW and DCWW datasets available on locations and inputs. No sludge disposal.
Miscellaneous wastes and debris.	Widespread and common from varied sources.
Run-off: Agricultural, urban and industrial run-off.	Occurs within the SAC, primarily from agriculture.
Fishing: All trawling (Including beam, otter, toothed and any trawled gear).	Occurs within the SAC. Location and intensity information is unknown. A Statutory Instrument limits larger vessels fishing within SAC.
Fishing: All dredging (including toothed, bladed, mechanical, hydraulic and any other great not listed).	Historically there has been scallop dredging of Modiolus bed. Dredging is now illegal. Mussel seed collection may have occurred at a few localised areas.
Fishing: All netting (including gill, tangle, trammel, seine, fyke and any other fishing with netted gear).	Bottom set gill netting occurs mainly for Bass. Other forms may occur within the SAC but location and intensity information is unknown.
Fishing: All potting (including lobster, crab, prawn, whelk and any other fishing with potted gear).	Widespread and common in the SAC and is the main fishing activity. Mainly lobster, brown crab and whelk. Intensity, location and effort information is unknown
Fishing: All line fishing (including long-line and handline).	Occurs in SAC. Location and intensity information is unknown..
Fishing: All methods of hand gathering (including cockles, Mussels, mussel seed, razor clam, bivalves, winkles, crustaceans, shellfish, algae and plants for human consumption and chemical extraction and biomass (excluding access issues).	Occurs within the SAC. Low level collection of winkles and recreational collection of cockles in the Drwyd and Mawddach. Frequency and intensity unknown. Commercial cockle beds are closed.

Operation/Activity	Occurrence in SAC
Fishing: Bait collection commercial and recreational (including digging, pump, boulder turning etc).	Occurs in and directly adjacent to the SAC at low levels in the Mawddach and Barmouth for recreational purposes. Frequency and intensity unknown.
Aquaculture: All forms of aquaculture (including algae, sea cages, impoundments, ranching, shellfish ropes and trestles and enclosed recirculation).	A land-based fish farm is no longer operational at Afon Wen.
Livestock grazing: Grazing of saltmarsh.	Long history of livestock grazing in the site and is still occurring in all estuaries. most heavily grazed in The Dyrwyd estuary and Mawddach and in Dyfi to less extent..
Water abstraction.	Widespread in catchment area for hydropower, public water supply, industry, agriculture, amenity and fish farming.
Aggregate extraction (including mineral and biogenic sands & gravels).	Not currently occurring in the SAC.
Oil and gas exploration: All oil and gas exploration activity (including seismic survey, drilling and discharges both operational and accidental).	Not currently occurring in the SAC.
Renewable energy generation: All forms of renewable energy (including tidal barrage and impoundments, tidal and wave energy, offshore wind both fixed and floating).	Not currently present within the SAC.
Oil spill response: All activities of responding to oil spills at sea and on shore (including chemical, physical and access).	Reactive only. No recent activity.
Recreation: Fishing (e.g. angling and spearfishing).	Widespread and common: from shore, recreational and charter boats. Location and intensity unknown.
Recreation: Boating (e.g. power craft, sailing, canoeing, surfing, kite surfing, paddle boarding, etc).	Common in the SAC, with peak activity during the summer season. Main areas for recreational mooring in ports and harbours around the SAC, and in sheltered embayments.

Operation/Activity	Occurrence in SAC
Recreation: Coastal activities (e.g. Scuba diving, snorkelling, dog walking, coasteering etc).	Widespread and common. Location and intensity unknown but seasonally and spatially highly variable.
Recreation: Coastal access.	Widespread and common. Frequency and intensity unknown but seasonally and spatially highly variable.
Recreation: Light aircraft.	Occasional craft flying over the SAC. Llanbedr airfield is operational. Potential for drones.
Recreation: Wildfowling.	Occurs in the SAC, in the Dyrwyd and Glaslyn estuary. Two licenced operations.
Recreation: Marine wildlife watching / eco-tourism.	Some charter boats operate in in the SAC.
Military activity: All forms of military activity (including ordnance ranges, marine exercises, aircraft etc).	No ranges within or near to SAC.
Marine archaeology and salvage.	Presence of coastal and marine archaeological / historic interests. Two subtidal protected wreck sites within the SAC. Unofficial marine salvage may occur. Scale unknown.
Science and outreach: Education.	A few sites are popular for education and outreach e.g. Dyfi, Artro, Harlech. Other areas visited infrequently.
Science and outreach: Animal welfare operations and sanctuaries.	Not known to occur.
Science and outreach: Science research.	Similar to educational use. NRW, universities (particularly in Wales) and non-governmental organisations (e.g. Whale and Dolphin Conservation Society; Friends of Cardigan Bay) are main bodies undertaking research in the SAC.

5. Climate change

5.1. Climate change vulnerability

Marine intertidal habitats are most at risk from climate change. Marine ecosystems will be impacted by climate change through both direct and indirect effects on the distribution and abundance of biotopes and species. Climate change pressures include, rising sea surface temperatures, sea level rise, ocean acidification, air temperature increases, deoxygenation, changes in salinity and increasing wave exposure. There are other pressures that have not been assessed such as those arising from the terrestrial environment for example increased river and sediment run off due to predicted higher rainfall levels.

Climate induced changes could include irreversible impacts to ecosystems from loss of species, degradation of carbon sequestrating habitats (blue carbon habitats) leading to carbon being released and exacerbating the problem.

Below is a climate change profile for each Annex I habitat in the SAC. The profile summarises the climate change pressures each habitat is vulnerable to in this site, excluding sea caves although sea caves are likely to have similar vulnerabilities to both intertidal and subtidal reefs. The summary of impacts for all features can be seen in Table 3.

Table 3. Climate change summary indicating the climate change vulnerabilities for the features of the Pen Llŷn a'r Sarnau SAC. ASM = Atlantic Salt Meadows, LSIB = Large shallow Inlets and Bays, MF&SF = Mudflats and sandflats. H = High vulnerability, M = Medium vulnerability, L = Low vulnerability, N/V = Not vulnerable

Climate change pressure	Intertidal reefs	Subtidal reefs	Sandbanks	MF&SF	Estuaries	LSIB	ASM
Air temperature	M	N/V	N/V	M	M	L	H
Deoxygenation	L	L	L	L	L	L	N/V
Ocean acidification	L	M	M	L	L	M	N/V
Salinity	L	L	L	L	L	L	L
Sea level rise	L	L	N/V	M	M	L	H
Sea temperature	M	L	L	M	M	M	M
Wave exposure	M	L	N/V	M	M	L	M

5.2. Coastal squeeze

Extensive work has been carried out (Oaten et al., 2024) regarding the extent to which sea-level rise may cause coastal squeeze and natural squeeze, an issue which affects intertidal habitats. Overall, this SAC is projected to lose 2% of its intertidal habitats

(saltmarsh, mudflats and sandflats, and intertidal reef) due to coastal squeeze by 2155 under a RCP 8.5 95th percentile sea-level rise scenario. There are significant opportunities for habitat gain adjacent to this SAC if shoreline management plan policies of managed realignment and no active intervention are implemented. If defences continue to be maintained, the opportunities for habitat gain are significantly reduced, and coastal squeeze losses are predicted to be slightly higher overall.

Saltmarsh

The predicted change in the extent of this habitat (which includes both the Atlantic Salt meadows and *Salicornia* features) due to coastal squeeze is a loss of 13% (153 ha) by 2055, reducing to 3% (39 ha) by 2155 under a RCP 8.5 95th percentile scenario, assuming that defences are managed in line with shoreline management plan policies.

For the same management and sea-level rise scenario, natural gains may occur in the short term, but by 2155 an additional 7% (83 ha) of saltmarsh habitat is expected to be lost to natural squeeze.

If all current defences are maintained into the future, a significant increase in both coastal and natural squeeze losses (a combined figure of up to 75%, 890 ha by 2155) is predicted (Oaten et al., 2024).

Mudflats and sandflats

The predicted change in the extent of this habitat due to coastal squeeze is a loss of 3% (94 ha) by 2055, reducing to 2% (54 ha) by 2155 under a RCP 8.5 95th percentile scenario, assuming that defences are managed in line with shoreline management plan policies.

For the same management and sea-level rise scenario, natural gains may occur over both the short and longer term.

The opportunity for natural gains reduces significantly if current defences are maintained into the future (Oaten et al., 2024).

Reefs

The predicted change in the extent of intertidal reef due to coastal squeeze is a modest loss of 0.2% (0.5 ha) by 2055, increasing to 1% (2 ha) by 2155 under a RCP 8.5 95th percentile scenario, assuming that defences are managed in line with shoreline management plan policies.

For the same management and sea-level rise scenario, natural gains may occur over both the short and longer term.

If current defences are maintained into the future, there is predicted to be an increase in coastal squeeze losses, and natural squeeze in the long term rather than natural gain. Overall, the total predicted losses by 2155 are 9% (19 ha) (Oaten et al., 2024).

Coastal lagoons

Morfa Gwyllt lagoon is situated within a shingle spit at the mouth of the Broadwater/Dysynni Estuary. The open coast section of the shingle spit is currently not defended but does have a ‘hold the line’ Shoreline Management Plan policy (which extends from the northern end of the spit south to Tywyn) which relates to protection to the railway line. To the rear of the shingle spit, within the Broadwater/Dysynni Estuary there is a policy for the whole estuary which is noted as managed realignment from 2025. The policy intent is to reduce defences in the short to medium term, allowing the estuary to function in a more natural manner. According to Oaten et al., (2024), the lagoon is not expected to be subject to natural or coastal squeeze but may be vulnerable as a result of changes in approach to coastal defence in response to climate change. Any management changes would need to consider potential impacts for the lagoon.

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Appendix 1: Additional information

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. The SAC is situated in northwest Wales and the boundary extends from Nefyn on the north coast of Llŷn, 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. It includes the Glaslyn/Dwyryd, Artro, Mawddach and Dyfi estuaries. 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.

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 the 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).

Surrounding the 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.

Sedimentology

There is a very wide range of sediments within the SAC 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.

Geomorphology

The underlying geology has created a complex coastal morphology. The south-western tip of the Llŷn is dominated by rocky cliffs with narrow sandy beaches at points of erosion. On the southern coast of the 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.

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 0.05 – 0.5 m/sec on spring tides) compared to areas off the southwest Llŷn, such as Bardsey Sound where, at between 2.5 – 3 m/sec,

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 reducing 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 the 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.

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. The status of the waterbodies within the SAC including levels of nutrients and chemicals is available in the latest condition assessments.

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.

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 (such as the volcano worm *Maxmuelleria lankesteri*). 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.

Invasive non-native species

Based on NRW records, the noteworthy invasive non-native species (INNS) are those listed as High or Medium on the Marine INNS Priority Monitoring and Surveillance List. This includes the high risk American slipper limpet *Crepidula fornicata* which has recently been recorded in this SAC off of the north Llŷn on *Modiolus* reef and also near the Tudwals (south Llŷn) in 2023 and more recently in Abersoch in 2024 and Porthdinllaen (awaiting review).

The site has a number of medium risk INNS. Notably these include the Leathery sea squirt *Styela clava* with a number of subtidal records between Abersoch and Criccieth in Tremadog Bay. The red alga *Agarophyton vermiculophyllum* is found within the estuaries in the site, notably the Dwyryd and Mawddach Estuaries, where it was first found from 2018 on the mudflats and sandflats, Atlantic salt meadow and estuaries features. Japanese wireweed *Sargassum muticum* is one of the more common INNS species found throughout the site, with records concentrated in the intertidal and shallow subtidal areas with concentrations around Porthdinllaen, Porthor and tip of Llŷn Peninsula and Llanystumdwy.

Pacific oyster *Magallana gigas* is recorded in a few sporadic locations in the SAC from 2005 to 2008 with examples near Twywn and Criccieth and close to the SAC boundary at Barmouth and Llandanwg. *Bonnemaisonia hamifera* (a red algae) is also found at a number of sites within this SAC. Examples of areas of dense concentrations include Porth Colmon (north Llŷn), off of Llanbedrog in Tremadog Bay and subtidally from Aberystwyth on the raised rocky Sarn Cynfelyn Patches.

Additional information for features of the site

General feature descriptions and ecological characteristics can be found on the JNCC habitats list and species list. Habitat definitions can be found in the European Union Interpretation Manual of Annex I habitats.

Reefs

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.

Habitats

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.

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. Areas of boulder, cobble and pebble reef often provide more complex habitat structure with underboulder spaces providing shelter for some species. However, 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 honeycomb worm *Sabellaria alveolata* and the related Ross worm *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 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 horse 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 the 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.

Communities

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. Some of these 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.

Whilst all the reef communities within the SAC contribute to the overall condition of the feature, 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 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-tolerant/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 Llŷn 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

Usually the Sarnau reefs support dense seaweed beds of opportunistic ephemeral, perennial and annual species that are tolerant of sand cover and scour but there are occasional heavy settlements of mussel *Mytulis edulis* seed. 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. *Musculus discors* reefs support an abundance of infauna and epifauna, with the infauna including polychaete worms, bivalve molluscs, crustaceans and other worms (Hopkinson, 2011).

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 in some years.

Large shallow inlets and bays

Habitats

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.

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 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 the 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 (Ellis et al. 2012; 2024).

Communities

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 pulmo*.

Tremadog Bay is identified as a particularly important area for the angelshark *Squatina squatina (*Barker et al., 2022) which will generally live on and over the sandy and gravel substrates, as well as being an important nursery and breeding ground for other elasmobranch species such as thornback ray *Raja clavata* and spotted ray *Raja montagui* (Ellis et al., 2012; 2024)

Tremadog Bay also appears to hold the principal population of the black sea bream *Spondyliosoma cantharus* in Welsh waters, with a concentration of records from both NBN atlas and ICES fisheries-independent surveys. Large numbers of juveniles and adults have been observed around Tremadog Bay. There is suitable habitat and numerous juveniles found in inshore waters between Pwllheli and Llanbedrog on the Llŷn Peninsula. Adults and juveniles are often found on Sarn Badrig (St Patrick's Causeway) shingle reef on the edge of Tremadog Bay, and large adults have also been seen off Tywyn and Barmouth. The species is likely to play a role in maintaining the structure and function of the reefs feature, along with other species like wrasses, through predation. The species also interacts with the seabed during reproduction (nesting).

Subtidal sediment communities

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 spp*, 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 *Macomangulus tenuis* and polychaetes. 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.

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 (*Kurtiella bidentata* and *Abra nitida*) together with different species of worms (polychaetes, 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 *Kurtiella 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 recorded 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 *Kurtiella 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. Tudwal's 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-y-Chain and the St

Tudwal's Islands. Mixed sediment shores of sand, gravel, cobbles and boulders that predominate between Pen-y-Chain 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 called beachrock. While 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 *Echinogammarus incertae sedis planicrurus*.

Exposed sand at the mouth of the Glaslyn at Morfa Harlech and Morfa Bychan 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.

Sandbanks sightly covered with seawater all the time

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.

Habitats

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.

Communities

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.

The fish community of the sandbank feature will disturb the sediments through burrowing or resting behaviours thereby contributing to the continued mobility of the sediments and support the maintenance of the habitat feature. They also contribute to the food web of the sandbanks and predator-prey dynamics. Species within the community include sandeels, lesser weever, gobies, flatfish and rays/skates. Sandeels and grazing species such as mullets are also important components of the biological communities of the intertidal mudflats and sandflats feature and saltmarsh feature given their bioturbating and grazing behaviours to maintain the features, as well as contribute to predator-prey interactions of the feature.

Estuaries

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

Habitats

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 saltmarsh 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.

Communities

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 *Eurydice 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 *Macomangulus 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 *Macomangulus 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 blue mussel *Mytilus edulis* have also been recorded from the mid shore on fine mud in both the Mawddach and the Dwyryd. Within the mobile sand of the estuary, communities of the amphipods *Bathyporea* sp. and *Corophium* sp. are 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 blue 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 ragworm *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 estuaries are also well known for their unusual saltmarsh dwelling algae including *Bostrychia scorpioides* and the free-living *Fucus vesiculosus* and *Pelvetia canaliculata* ecotypes (Brazier et al., 2007). 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 dependent 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 species features of the site, the otter and bottlenose dolphin. 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.

The Dyfi, Mawddach and Dwyryd/Glaslyn estuaries support appreciable glass eel runs and resident yellow eel populations within the Western Wales Eel Management Plan (EMP) area. The influx of glass eels/elvers annually to these larger estuaries features in the SAC represent a significant food source and supports the trophic structure and functioning of the estuaries feature,.

There is some evidence of twaite shad and allis shad migrating through the Dyfi, Mawddach and Dwyfor estuaries and spawning in the upstream rivers (NRW, in prep) These fish migrate to spawn in (generally lower) freshwater catchments but reside in estuarine and coastal waters as juveniles and adults. They are likely to be supportive of the trophic structure and functioning of the estuary if present in abundant numbers. However, at present we do not know the abundance of the species in these estuaries.

Sea trout will also migrate through and reside within the LSIB and estuaries features of the SAC. As a high trophic level predator in coastal/estuarine feature areas, abundant and resident in coastal waters, they will form an important part of the ecosystem and food web, and significantly influence predator-prey interactions in the LSIB and Estuaries features

Mudflats and sandflats not covered by seawater at low tide

Habitats

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.

Communities

The intertidal mudflats and sandflats 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 mudflats and sandflats 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 those representative of fully saline conditions are present near the estuary mouth. Outside of the estuaries the degree 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 *Macomangulus 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 *Macomangulus tenuis*. 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 ragworm *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 lugworm *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.

Submerged or partially submerged sea caves

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.

Communities

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 *Rhodochorton purpureum*), 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. Tudwal's 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 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.

Appendix 2: Additional conservation interest

SPAs 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
- Northern Cardigan Bay / Gogledd Bae Ceredigion

SACs partly or wholly within the SAC:

- West Wales Marine / Gorllewin Cymru Forol

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

Section 7 and OSPAR threatened and declining habitats and species:

- *Ammodytes marinus*
- *Anotrichium barbatum*
- *Arctica islandica*
- Carbonate reef

- *Clupea harengus*
- *Cruoria cruoriaeformis*
- *Dermocorynus montagnei*
- *Dipturus batis*
- Estuarine rocky habitats
- Fragile sponge and anthozoan communities on subtidal rocky habitats
- *Haliclystus auricula*
- Horse mussel (*Modiolus modiolus*) beds
- Intertidal mudflats
- Intertidal Underboulder Communities
- *Lucernariopsis campanulata*
- Mud habitats in deep water
- *Musculus discors* beds
- Mussel beds
- *Ostrea edulis*
- *Palinurus elephas*
- Peat and clay exposures
- *Phymatolithon calcareum*
- *Pleuronectes platessa*
- *Raja clavata*
- *Sabellaria alveolata* reefs
- *Sabellaria spinulosa* reefs
- Seagrass beds
- Seapens and burrowing megafauna
- Sheltered muddy gravels
- *Solea solea*
- Subtidal mixed muddy sediments