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Natural Resources Wales

Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation

Report No: 908

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The Mawddach Estuary © NRW.

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- Having a well resourced proactive programme of evidence work;
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Report series:	NRW Evidence Report
Report number:	908
Publication date:	June 2025
Title:	Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation
Author(s):	Hatton-Ellis, M., Wynter, E., Jackson-Bué, M. and Cuthbertson, S.
Technical Editor:	Hatton-Ellis, M.
Quality assurance:	Tier 3
Contributors:	Brazier, P., Burton, M., Camplin, M., Green, M., Goudge, H., Lewis, H., Lindenbaum, C., Self, H., Stringell, T.
Peer Reviewers:	Butterill, G., Camplin, M., Davis, S., Ellis, T., Gjerlov, C., Haines, L. Moon, J., Pauls., L., Ramsey, K., Sharp, J., Winterton, A.
Approved By:	Winterton, A.

Restrictions: None

Distribution List (core)

NRW Library	2
National Library of Wales	1
British Library	1
Welsh Government Library	1
Scottish Natural Heritage Library	1
Natural England Library (Electronic Only)	1

Recommended citation for this volume:

Hatton-Ellis, M., Wynter, E., Jackson-Bué, M. and Cuthbertson, S. 2025. Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation. NRW Evidence Report No. 908, 232pp, Natural Resources Wales, Cardiff.

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Crynodeb Gweithredol

Er mwyn rheoli ein hardaloedd morol gwarchodedig yn effeithiol ac yn gynaliadwy, mae'n hanfodol deall cyflwr eu cynefinoedd a'u rhywogaethau gwarchodedig. Mae gwybod cyflwr nodweddion dynodedig yn caniatáu i ni dargedu rheolaeth ac adnoddau lle mae eu hangen i wella ac adfer cyflwr.

Mae'r adroddiad tystiolaeth hwn, a gyflwynwyd fel rhan o brosiect gwella cyngor cadwraeth forol (IMCA) a ariannwyd gan Lywodraeth Cymru, yn cyflwyno canfyddiadau asesiadau cyflwr Cyfoeth Naturiol Cymru ar gyfer Ardal Cadwraeth Arbennig (ACA) Pen Llŷn a'r Sarnau. Mae adran un yn rhoi trosolwg o'r broses asesu ac mae adran dau yn rhoi disgrifiad o'r ACA a'i nodweddion.

Mae'r asesiadau'n seiliedig ar y dystiolaeth orau a oedd ar gael ar y pryd (e.e. 2024). Adroddir canlyniadau asesiadau gyda hyder cysylltiedig yn y casgliad. Gellir dod o hyd i esboniadau manwl o'r rhesymeg y tu ôl i gasgliadau, ac unrhyw resymau dros fethu, yn yr asesiad cyflwr llawn yn Adran 3. Gellir dod o hyd i adroddiad ar y broses asesu a ddefnyddiwyd yn adroddiad terfynol IMCA.

Crynodeb o asesiadau cyflwr ar gyfer nodweddion dynodedig ACA Pen Llŷn a'r Sarnau.

Nodweddion ACA	Asesiad cyflwr	Hyder yn yr asesiad
Riffiau	Anffafriol	Uchel
Cilfachau a baeau mawr bas	Ffafriol	Canolig
Ponciau tywod sydd fymryn dan ddŵr y môr drwy'r amser	Ffafriol	Canolig
Aberoedd	Ffafriol	Canolig
Morlynnoedd neu Lagynau	Anffafriol	Isel
Gwastadeddau llaid neu dywod nas gorchuddir gan y môr ar lanw isel	Ffafriol	Isel
Dolydd ar forfeydd arfordir y gorllewin *Glauco-Puccinellietalia maritimae*	Anffafriol	Isel
Salicornia a phlanhigion unflwydd eraill sy'n cytrefu llaid a thywod	Ffafriol	Isel
Ogofâu môr sy'n danforol neu'n lleddanforol	Anhysbys	Ddim yn berthnasol
Morlo llwyd *Halichoerus grypus*	Ffafriol	Canolig
Dolffin trwyn potel Tursiops truncatus	Ffafriol	Isel
Dyfrgi *Lutra lutra*	Anffafriol	Canolig

Executive summary

To manage our marine protected areas effectively and sustainably it is vital to understand the condition of their protected habitats and species. Knowing the condition of designated features allows management and resources to be targeted where it is needed to improve and restore condition.

This evidence report, which was delivered as part of the Welsh Government funded improving marine conservation advice (IMCA) project, presents the findings of NRW's condition assessments for the designated features of the Pen Llŷn a'r Sarnau Special Area of Conservation (SAC). Section one gives an overview of the assessment process and section two provides a description of the SAC and its features.

The assessments are based on the best evidence available at the time (e.g. 2024). Assessment outcomes are reported with an associated confidence in the conclusion. Detailed explanations of the rationale behind conclusions, and any reasons for failure, can be found in the full condition assessment in Section 3. A report on the assessment process used can be found in the IMCA final report.

Summary of condition assessments for the designated features of Pen Llŷn a'r Sarnau SAC.

Feature	Condition assessment	Confidence in assessment
Reefs	Unfavourable	High
Large shallow inlets and bays	Favourable	Medium
Sandbanks which are slightly covered by seawater all the time	Favourable	Medium
Estuaries	Favourable	Medium
Coastal lagoons	Unfavourable	Low
Mudflats and sandflats not covered by seawater at low tide	Favourable	Low
Atlantic salt meadows *Glauco-Puccinellietalia maritimae*	Unfavourable	Low
Salicornia and other annuals colonising mud and sand	Favourable	Low
Submerged or partially submerged sea caves	Unknown	Not applicable
Grey seal *Halichoerus grypus*	Favourable	Medium
Bottlenose dolphin *Tursiops truncatus*	Favourable	Low
Otter *Lutra lutra*	Unfavourable	Medium

1. Introduction

It is important for NRW to understand the condition of designated features in marine protected areas (MPAs) to allow NRW to prioritise management actions and advise on activity in the marine environment.

Having robust, evidence-based assessments of feature condition will ultimately lead to better protection through better management. The improvements in condition brought about by implementing targeted management will ultimately improve the resilience of Wales' marine ecosystems. As MPAs in Wales cover extensive areas of sea and coast, it can be challenging and resource intensive to monitor them. This can make thorough assessments of feature condition difficult. The process used for these condition assessments builds on work undertaken to produce indicative condition assessments published in 2018.

The 2018 indicative assessments used all available data and expert judgement to assess features using a workshop approach with internal NRW specialists. The new full assessment process, which has been delivered through the Welsh Government funded improving marine conservation advice (IMCA) project, has been improved by using carefully chosen performance indicators judged to be the most appropriate to assess condition (see Section 3). The best available evidence has been used to conduct the assessments. Due to the differences in assessment methods between these full assessments and the indicative condition assessments, the results are not directly comparable.

1.1. Assessment process

Marine feature condition assessments in NRW consist of selecting performance indicators for the feature, gathering the best available evidence to assess those indicators and conducting the assessment.

Performance indicators have targets which have a primary, secondary or tertiary weighting. Failure of a primary target will mean the feature is classified as unfavourable, on a 'one out all out' basis. If all primary targets pass but two secondary targets fail, the feature would also be classified as unfavourable. Likewise, if all primary and secondary targets pass but three tertiary targets fail, the feature will also be unfavourable. Condition assessment outcomes are not strictly determined by target weightings and are also subject to expert judgement.

Each indicator result has an associated confidence which is determined by the quality and age of the evidence along with the confidence in the indicator itself and what it is telling us about condition of the feature. The confidence in the overall assessment is derived from the confidence in each target pass or failure, as well as expert judgment/ assessor consensus.

Each feature condition assessment will also identify reasons for indicator failure where known and any known threats to feature condition.

Table 1 summarises the steps taken in marine feature condition assessments. Details on the full condition assessment process, including indicator selection and target weighting can be found in the IMCA final report.

Table 1. The main steps of the marine feature condition assessment process.

Assessment Step	Process
Step 1: Preparation and evidence gathering.	Prepare site information. Source relevant evidence and any previous assessments. Evaluate quality of evidence according to suitability for use in assessments and carry out any analysis required.
Step 2: Indicator assessment.	A range of NRW specialists use all available evidence to assess the performance indicators and targets using a pass, fail or unknown. Record findings in the condition assessment form. Provide a confidence score for each target conclusion.
Step 3: Feature level assessments.	Combining the results from the assessment of feature indicators to provide an overall assessment of condition at the feature level.
Step 3.5. Complex features.	If the feature is a complex feature (i.e., estuaries or large shallow inlets and bays) consider the results of any nested feature assessments within the overall complex feature assessment.
Step 4: Condition pressures and threats.	Use the evidence gathered and information on management and activities to determine threats and pressures on feature condition.
Step 5: Finalise the assessments.	Ensure all required fields in the assessment have been completed and all assessed targets have an associated confidence. Circulate the reports to the relevant NRW specialists for review and comment. After issues have been resolved, the assessments will be signed off by the project task and finish group.
Step 6: Publish the assessments.	After signing off, the assessments will be published on the NRW website, and stakeholders and internal staff notified. Assessments are then ready to use by internal and external parties.

2. SAC description

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

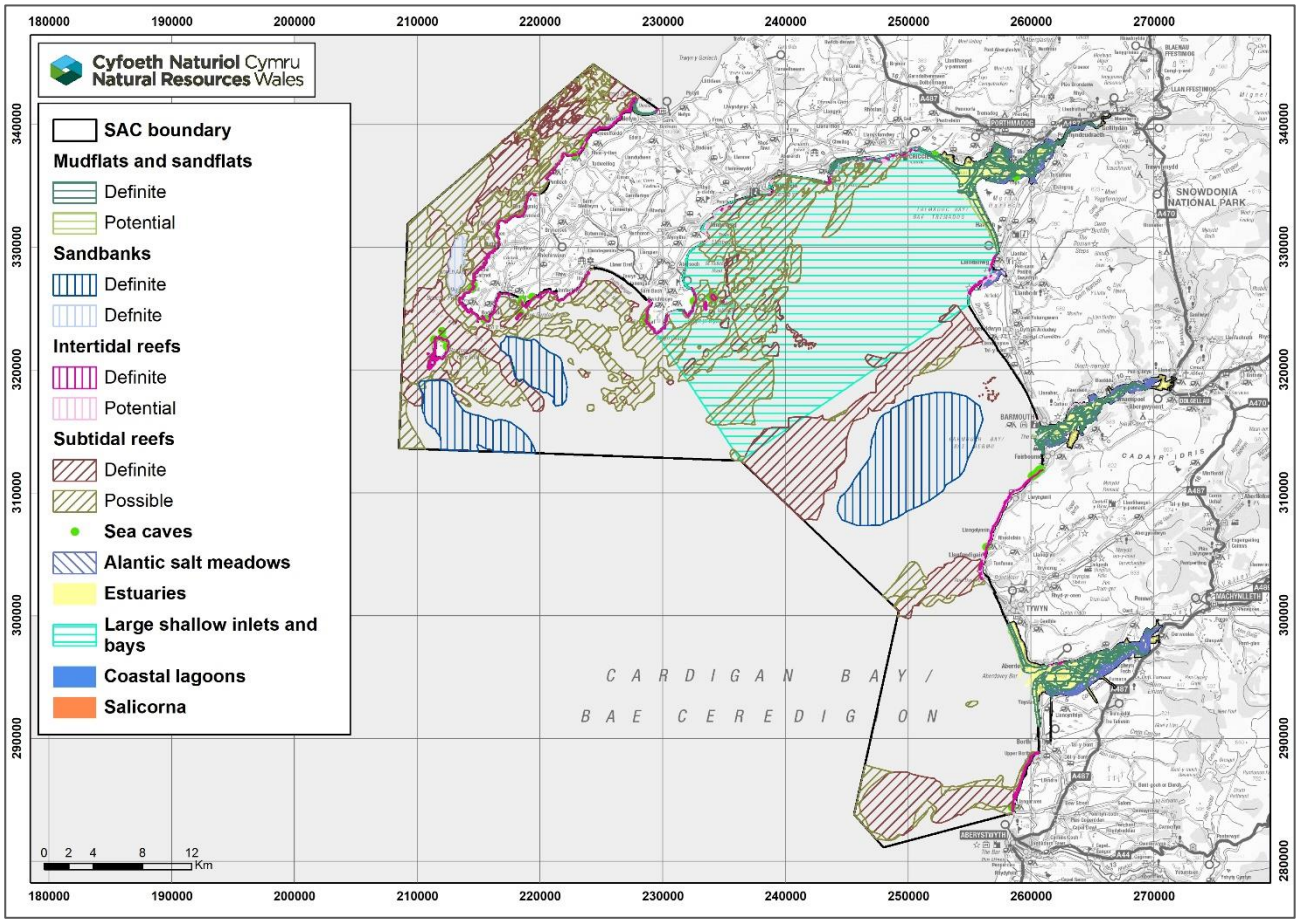
and to support a significant presence of:

- 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*

Figure 1 is a map of the location of the designated features within Pen Llŷn a'r Sarnau SAC. The feature maps in this document are for illustrative purposes only. Detailed maps for the features in Wales can be found on Data Map Wales.

More information on the SAC and its features can be found in NRW's conservation advice for the site on our website.

Figure 1. Map of the designated features of the Pen Llŷn a'r Sarnau SAC.



3. Feature condition assessments for Pen Llŷn a’r Sarnau SAC

This section contains assessments for the following designated features in Pen Llŷn a’r Sarnau SAC:

- 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*

Each feature has been assessed against their own performance indicators using all available evidence. The performance indicators were assessed using a combination of data from NRW Habitats Regulations monitoring, Water Framework Directive (WFD) Regulations 2017 (WFD Regulations) monitoring, commissioned evidence reports, scientific literature, plan and project assessments, external monitoring databases (e.g. National Biodiversity Network) and expert judgement. The outcome of the assessment and reasons for failure are discussed in more detail in the sections below.

In these condition assessments, the WFD 2024 cycle 3 interim classification was the default information used for water quality, however other earlier cycles were referenced, as follows:

- 2009 cycle 1 classification
- 2015 cycle 2 classification
- 2018 cycle 2 interim classification
- 2021 cycle 3 classification

In the WFD classification, results are rolled forward from previous assessments where there are no new monitoring data to provide a new classification. It is used to gap fill and provide a more complete classification. A decision was made to limit roll forward to six years which has been applied to the 2024 cycle 3 interim classification.

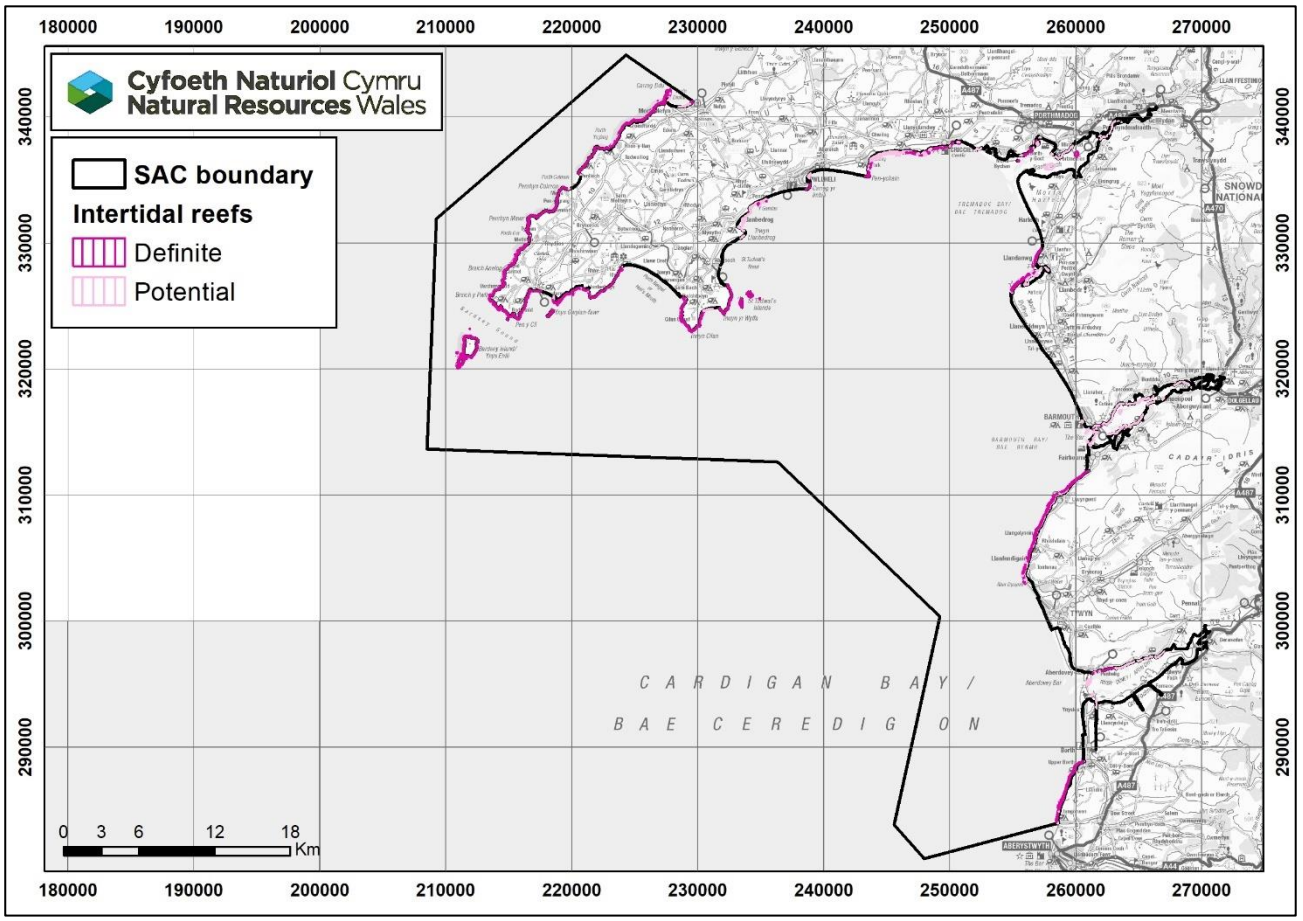
Additional information on water quality can be found in the IMCA final report.

3.1. Reefs condition assessment

Intertidal reefs

The reefs feature in the Pen Llŷn a'r Sarnau SAC comprises a number of intertidal reefs (Figure 2). Given that there are major biogenic and geogenic reef types within this SAC, the extent and distribution indicators have been split up into two targets for geogenic and biogenic reef. The NRW Habitats Regulations monitoring of intertidal reefs has focused on sampling sites within *Sabellaria alveolata* reefs at Llandanwg and West of Afon Dwyfor, and rocky shore communities at Porth Oer including algal turf for intertidal reefs. These locations were surveyed between 2008 and 2022.

Figure 2. Map of the intertidal reefs in Pen Llŷn a'r Sarnau SAC.



The summary of the assessment outcome for intertidal reefs is provided in Table 2. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 2. Condition assessment of intertidal reefs in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of naturally present rocky / geogenic reef types within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of geogenic intertidal reefs in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Extent	No significant decrease in the extent of naturally present biogenic reef types within the SAC, allowing for natural change and variation. (P)	• Comparison analysis of *Sabellaria alveolata* reefs has been used (2015-2023). • There are currently no anthropogenic impacts known to be significantly affecting the extent of the biogenic intertidal reefs *S. alveolata* in the Pen Llŷn a'r Sarnau SAC. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Distribution of the naturally present rocky / geogenic reef	Maintain the expected distribution and extent of naturally present rocky / geogenic reef types, allowing for natural change and variation. (P)	• There is no evidence to suggest that there are anthropogenic impacts that would have a significant effect on the geogenic reefs within the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Distribution of the naturally present biogenic reef	Maintain the expected distribution and extent of naturally present biogenic reef types, allowing for natural change and variation. (P)	• The latest widescale comparison 2015-2023 analysis indicate that the biogenic reefs *S. alveolata* is sustained, with indications of improvement in cover and density at all monitoring sites in the Pen Llŷn a'r Sarnau SAC, except Borth which has deteriorated. • No specific human induced impacts have been associated with the changes seen in the results. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Distribution and extent of habitats and communities	Maintain the distribution and extent of reef habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of intertidal reefs in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the reef(s). (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of intertidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Bathymetry of the feature	Maintain bathymetry of the reef(s), allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the bathymetry of intertidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of intertidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (Dissolved Inorganic Nitrogen - DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the seven WFD waterbodies that overlaps with intertidal reefs was not classified for DIN in any cycles (Tremadog Bay). It overlaps with 25% of intertidal reefs. • The other six WFD waterbodies were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Caernarfon Bay South, Cardigan Bay North, Artro, Dyfi / Leri, Glaslyn and Mawddach). Combined, these waterbodies overlap with 62% of intertidal reefs. ○ Three of these waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to the one unclassified waterbody.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Five of the seven WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Tremadog Bay, Artro, Dyfi / Leri, Glaslyn and Mawddach). Combined, these overlap with 26% of intertidal reefs. • The other two WFD waterbodies were classified with a Good or High status for phytoplankton (Caernarfon Bay South and Cardigan Bay North). Combined, these overlap with 60% of intertidal reefs. • Confidence is medium due to the unclassified waterbodies.	**Pass**	Medium
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Three of the seven WFD waterbodies were classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Artro, Dyfi / Leri, and Mawddach). Combined, these overlap with less than 1% of intertidal reefs. • The other four WFD waterbodies were not classified for opportunistic macroalgae (Caernarfon Bay South, Cardigan Bay North, Tremadog Bay and Glaslyn). Combined, these overlap with 86% of intertidal reefs. • This indicator was assessed as unknown as a large proportion of the feature has not been classified for opportunistic macroalgae.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Four of the seven WFD waterbodies that overlap with intertidal reefs were not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Tremadog Bay, Mawddach, Glaslyn and Dyfi / Leri). • The other three WFD waterbodies were classified with High status for dissolved oxygen (Cardigan Bay North, Caernarfon Bay South and Artro). Combined, these overlap with 60% of intertidal reefs. • Confidence is medium due to samples being taken from the surface of the waterbody.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence

Water quality: contaminants	Water column contaminants not to exceed the environmental quality standards (EQS). (S)	• Five of the seven WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Tremadog Bay, Caernarfon Bay South, Glaslyn and Artro). Combined, these waterbodies overlap with 39% of intertidal reefs.
		• One WFD waterbody has a pass for chemicals, however the chemical classifications were rolled forward from the 2021 cycle 3 classification.
		• The other two WFD waterbodies have a fail for chemicals in the 2024 cycle 3 interim classification.
		  ○ The Cardigan Bay North waterbody failed for mercury and polybrominated diphenyl ethers (PBDE). It overlaps with 47% of intertidal reefs.
		  ○ The Mawddach waterbody failed for PBDE. It overlaps with <1% of intertidal reefs.
		• Confidence is medium as the human health standard has been used for PBDE, and due to unclassified waterbodies or rolled forward classifications.
			Fail	Medium

Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the reefs feature in the Pen Llŷn a'r Sarnau SAC, therefore this target as assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from six NRW subtidal temperature loggers were available. Some indicated an increase in the number of days with higher temperatures, but some showed no clear pattern. • It's not known if the observed increases in temperature are localised to the SAC, or if they are the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

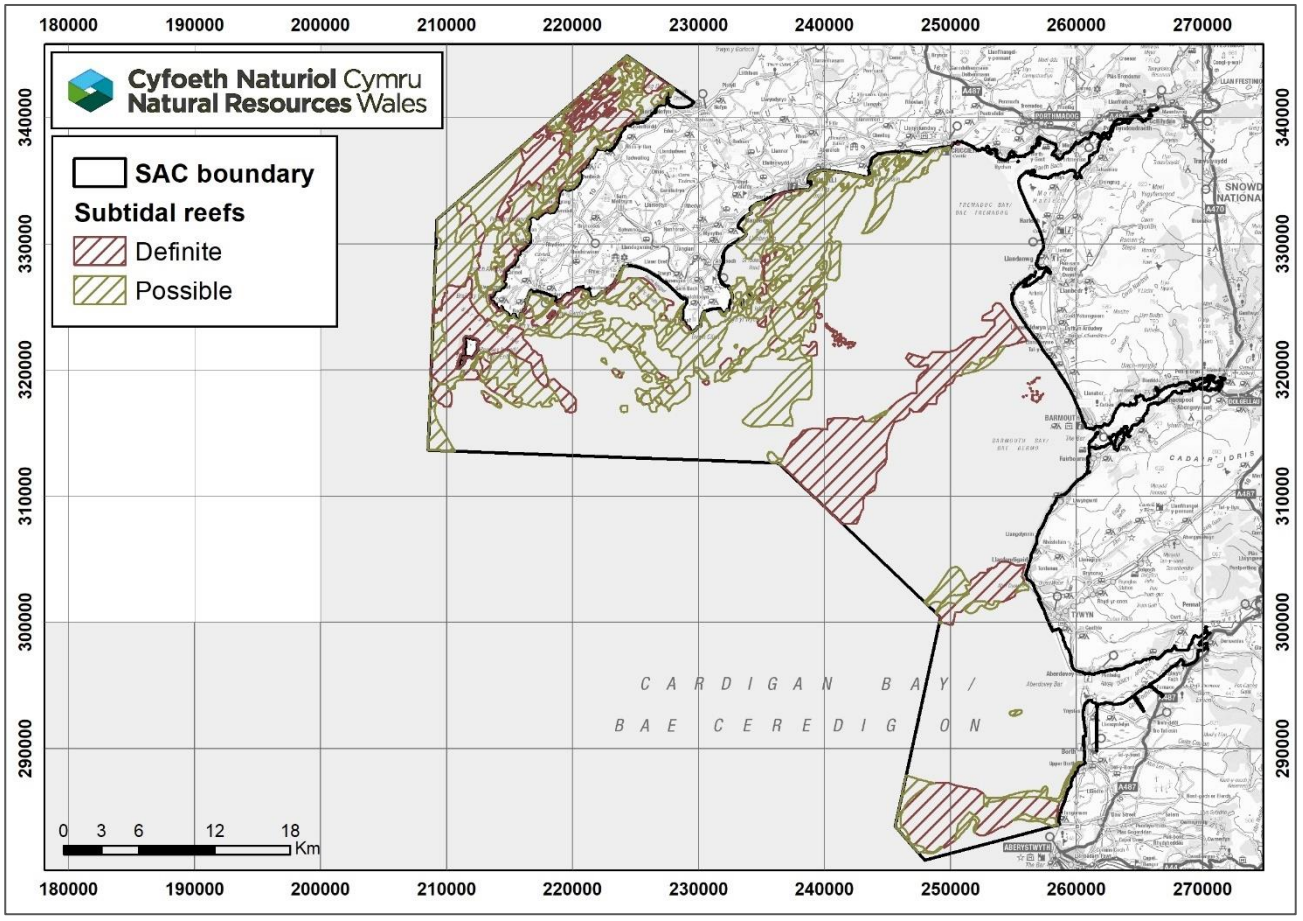
Indicators	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Analysis of the *S. alveolata* reefs in Llandanwg and West of Afon Dwyfor indicated stable communities over the monitoring period. Live worm abundances were low in 2014, however the population has since recovered. • Widescale comparison analysis indicated the cover and density of the *S. alveolata* reef, and live reefs have increased between 2015 and 2023, with the exception of Borth. • Analysis of the rocky shore communities at Porth Oer showed that populations have remained stable over the last five years, with the exception of the barnacle community in 2014. • The populations of limpets have been relatively stable over the sampling period of 2012 to 2022 at Porth Oer. • There are no clear patterns of change in the abundance of *Fucus serratus* at the MarClim sampling sites within the SAC. • Overall, observed changes are considered natural. • Confidence is medium as the sites sampled overlap with a small portion of the SAC (mainly in the north).	**Pass**	Medium
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• Data analysis showed no notable change or trend in species richness for the *S. alveolata* reef communities in Llandanwg and west of Afon Dwyfor. • Species richness of the rocky shore communities at Porth Oer has remained stable with little variation year to year across the monitoring period. • Confidence is medium as the sites sampled overlap with a small portion of the SAC (mainly limited in the north).	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence to suggest that INNS (e.g. the American slipper limpet *Crepidula fornicata*) are currently impacting the condition of the intertidal reefs in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• Recent records of *C. fornicata* have been identified in various locations in the feature (2023-2024). • Other NNS have been recorded previously in the feature including the wireweed *Sargassum muticum*. • There have been targeted INNS surveys at intertidal reef sites as part of the MarClim project and ad-hoc records from the NRW Habitat Regulation monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Subtidal reefs

The reefs feature in the Pen Llŷn a'r Sarnau SAC comprises a number of subtidal reefs (Figure 3). Given that there are major biogenic and geogenic reef types within this SAC, the extent and distribution indicators have been split up into two targets for geogenic and biogenic reef. The subtidal reef monitoring sites include the reef-associated fish community at Holden's Reef (2004-2022), the biogenic horse mussel (*Modiolus modiolus*) reef (2004-2011), the reef-associated epibiota at Carreg Y Trai (2016-2023), and an unusual algal (*Halidrys siliquosa*) biotope at Sarn Badrig (2005-2023).

Figure 3. Map of the subtidal reefs in Pen Llŷn a'r Sarnau SAC.



The summary of the assessment outcome for subtidal reefs is provided in Table 3. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 3. Condition assessment of subtidal reefs in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of naturally present rocky / geogenic reef types within the SAC, allowing for natural change and variation. (P)	• There has been no concerning patterns of change in the extent of the geogenic Holden's Reef. • There are currently no anthropogenic impacts known to be significantly affecting the geogenic reef extent (e.g. the Sarnau) within the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Extent	No significant decrease in the extent of naturally present biogenic reef types, allowing for natural change and variation. (P)	• There has been approximately a 60% decline in the horse mussel *Modiolus modiolus* reefs within the SAC since 2005. • There is an ongoing investigation into the decline of the *M. modiolus* reef. Reasons for the decline are not yet known, however there is some evidence of historic anthropogenic impact. • Confidence is high due to the availability of long term monitoring data and the large decline seen.	**Fail**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Distribution and extent of the naturally present rocky / geogenic reef	Maintain the expected distribution and extent of naturally present rocky / geogenic reef types, allowing for natural change and variation. (P)	• There are no concerning patterns of change at the geogenic Holden's Reef. • There are currently no anthropogenic impacts known to be significantly affecting the geogenic reefs (e.g. the Sarnau) within the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as whilst data was available for Holden's Reef, expert judgement has been used to assess this indicator in the absence of recent data for the rest of the feature.	**Pass**	Medium
Distribution and extent of the naturally present biogenic reef	Maintain the expected distribution and extent of naturally present biogenic reef types, allowing for natural change and variation. (P)	• The biogenic *M. modiolus* reef has been in decline since 2005, causing the failure. • There is an ongoing investigation into the decline of *M. modiolus*. Reasons for the decline are not yet known, however there is some evidence of historic anthropogenic impact. Confidence is high due to the availability of long term monitoring data and the large decline seen.	**Fail**	High
Distribution and extent of habitats and communities	Maintain the distribution and extent of reef habitats and communities, allowing for natural change and variation. (P)	• One of the major reef habitats, *M. modiolus* reef has been in decline since 2005. This has had an impact on the biogenic reef communities. • There is an ongoing investigation into the decline of the *M. modiolus* reef. Reasons for the decline are not yet known, however there is some evidence of historic anthropogenic impact. • Confidence is high to the availability of long term monitoring data and the large decline seen.	**Fail**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (T)	• There are no recent data for sediment contaminants for the subtidal reefs within Pen Llyn a'r Sarnau SAC, as the Clean Safe Seas Environmental Monitoring Programme (CSEMP) data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the reef(s). (S)	• There has been no clear patterns or evidence of loss in rugosity for the geogenic Holden's Reef. • There has been a decline in the *M. modiolus* reef within the SAC since 2005. This has caused a change in the topography of the *M. modiolus* reef which is visible on sidescan, multi beam echo sounder and in situ photography taken by divers and drop down video (causing a general flattening of the reef structure). • Reasons for the decline are not yet known, however there is some evidence of historic anthropogenic impact. • Confidence is high due to the availability of long term monitoring data and the large decline seen in the *M. modiolus* reef.	**Fail**	High
Bathymetry of the feature	Maintain bathymetry of the reef(s), allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the bathymetry of subtidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There has been a decline in the *M. modiolus* reef within the SAC since 2005. This has caused sediment to become more mobile at these reefs as a functional role of the *M. modiolus* in binding and stabilising sediment has been lost. • Reasons for the decline are not yet known. • Confidence is high due to the availability of long term monitoring data and the large decline seen.	**Fail**	High
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the three WFD waterbodies that overlaps with subtidal reefs has not been classified for DIN in any cycles (Tremadog Bay). It overlaps with 17% of subtidal reefs. • The other two WFD waterbodies were classified with a High status for DIN (Caernarfon Bay South and Cardigan Bay North). Combined, these overlap with 50% of subtidal reefs. • Confidence is medium due to the one unclassified waterbody.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the three WFD waterbodies was not classified for phytoplankton in the 2024 cycle 3 interim classification (Tremadog Bay). This waterbody overlaps with 17% of subtidal reefs. • The other two WFD waterbodies were classified with a Good or High status for phytoplankton (Caernarfon Bay South and Cardigan Bay North). Combined, these waterbodies overlap with 50% of subtidal reefs. • Confidence is medium due to the unclassified waterbody.	**Pass**	Medium
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the three WFD waterbodies that overlaps with subtidal reefs was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Tremadog Bay). • The other two WFD waterbodies were classified with a High status for dissolved oxygen (Caernarfon Bay South and Cardigan Bay North). Combined, these overlap with 50% of subtidal reefs. • Confidence is medium due to samples being taken from the surface of the waterbody.	**Pass**	Medium

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Two of the three WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Tremadog Bay and Caernarfon Bay South). Combined, these overlap with 26% of subtidal reefs. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Cardigan Bay North). It failed for mercury and PBDE and overlaps with 41% of subtidal reefs. • Confidence is medium as the human health standard has been used for PBDE, and due to the unclassified waterbodies.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the reefs feature in the Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from six NRW subtidal temperature loggers were available. Some indicated an increase in the number of days with higher temperatures, but some showed no clear pattern. • It's not known if the observed increases in temperature are localised to the SAC, or if they are the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Analysis of the subtidal reefs at Carreg Y Trai indicated some changes but within bounds of natural variation across the monitoring period (2014-2023). • The fish community data from Holden's Reef did not show any sign of concern. • The algal communities at Sarn Badrig showed high variations but they were judged to be natural for this type of community. • The *M. modiolus* reef has been declining in the last few decades, resulting in loss of epibiota community. An NRW led investigation found new evidence of limited recruitment of *M. modiolus.* This caused the indicator to fail. • Confidence is high due to the availability of long term monitoring data and the large decline seen in the *M. modiolus* reef.	**Fail**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• Some small changes were observed for the species richness and diversity of the reef-associated community at Carreg Y Trai but it has since recovered in recent years. • There was a decline in the fish diversity and species richness in the shallow zone at the North transect at Holden's Reef, with no clear explanation. This could be caused by natural variation. • The species richness and diversity of the algal community at Sarn Badrig have remained stable within natural variation. • A large decline in diversity has been observed in the *M. modiolus* reef. This caused the indicator to fail. • Confidence is high due to the availability of long term monitoring data and the large decline seen in the *M. modiolus* reef.	**Fail**	High
Taxonomic spread of species	Maintain the expected taxonomic spread of reef species, allowing for natural change and variation. (S)	• The average taxonomic distinctness of reef-associated epibiota at Carreg Y Trai remained stable across all zones over the monitoring period. • Confidence is medium is due to the time-limited nature of the sampling method.	**Pass**	Medium
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence to suggest that INNS (e.g. *Crepidula fornicata*) are currently impacting the condition of subtidal reefs in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not understood.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• Recent records of *C. fornicata* have been identified in various locations in the SAC (2023-2024). • Other NNS have been recorded previously in the feature including *Sargassum muticum.* • There have been targeted INNS surveys at intertidal reef sites as part of the MarClim project and ad-hoc records from the NRW Habitat Regulation monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

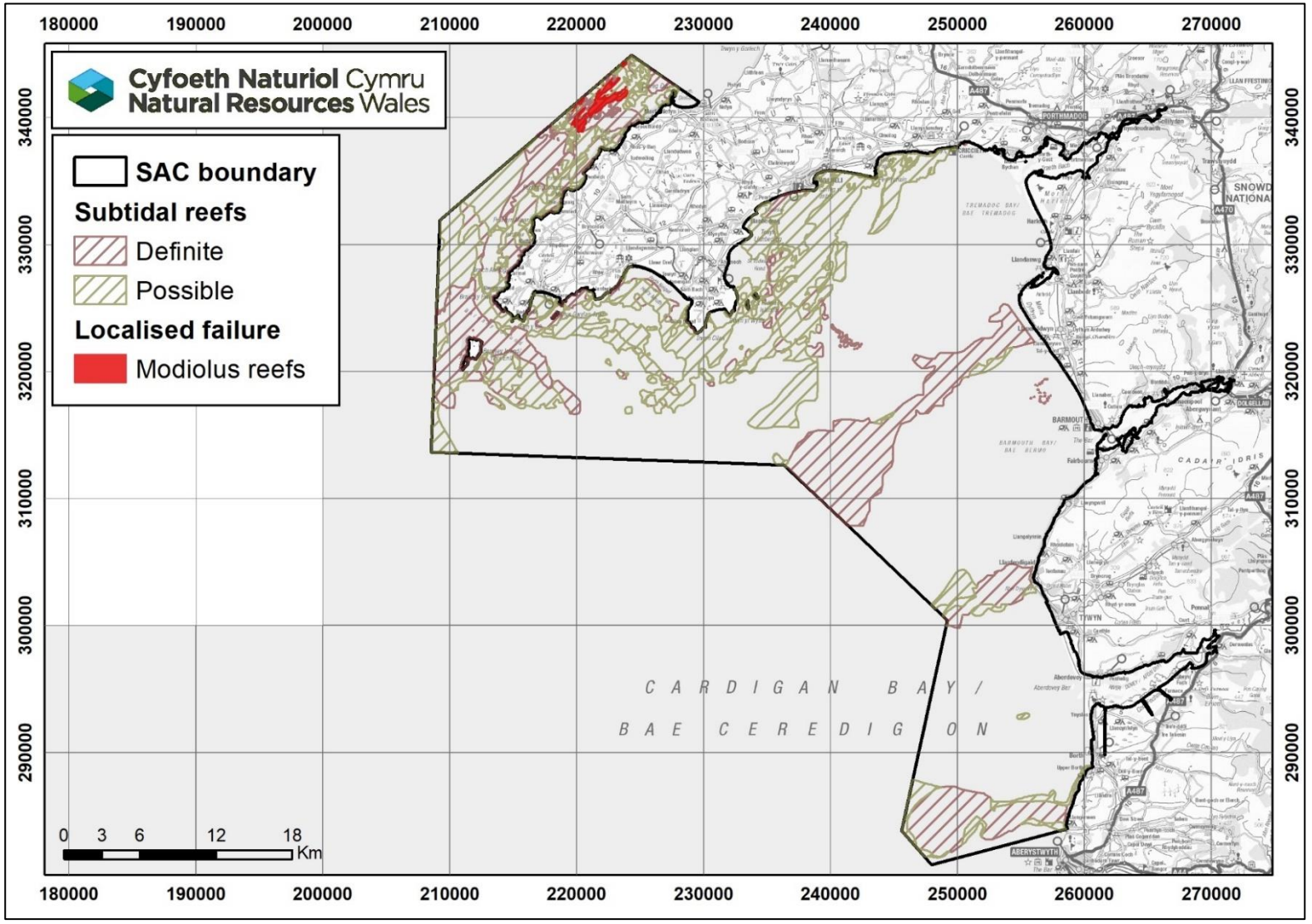
Assessment conclusions

The reefs feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **unfavourable** condition (high confidence). There were a number of failing targets (Table 4). The primary reason for failing indicators is the decline of *M. modiolus* reef extent and structure since 2005. The *M. modiolus* reef represents a small part of the overall reefs feature and this is therefore a localised issue. As the primary failure was localised, it has been mapped to help focus management effort (Figure 4). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition. A summary of the assessment can be seen in Table 4 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 4. Summary of the condition assessment for reefs in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Reefs	**Unfavourable (high confidence)**	Extent (biogenic) (P) Distribution and extent of the naturally present biogenic reef (P) Distribution and extent of habitats and communities (P) Hydrodynamic and sediment transport processes (P) Abundance, distribution and species composition of communities (P) Topography of the feature (S) Water quality: contaminants (S) Species richness and diversity (S) Non-native species (T)	• There has been a decline in abundance and extent of *M. modiolus* reef at the monitoring sites north of the Llŷn Peninsula. This decline is linked to alteration in the biogenic reef topography and sediment mobility, the composition, and species richness and diversity of the subtidal reef communities. • Levels of mercury and PBDE in the Cardigan Bay North and Mawddach waterbodies are failing to meet their relevant environmental quality standards (EQS). • There has been a recent increase in the number of records of *C. fornicata* in the feature.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Figure 4. Map of the localised failure in the subtidal reefs in Pen Llŷn a'r Sarnau SAC.



Detailed assessment information

Extent and Distribution

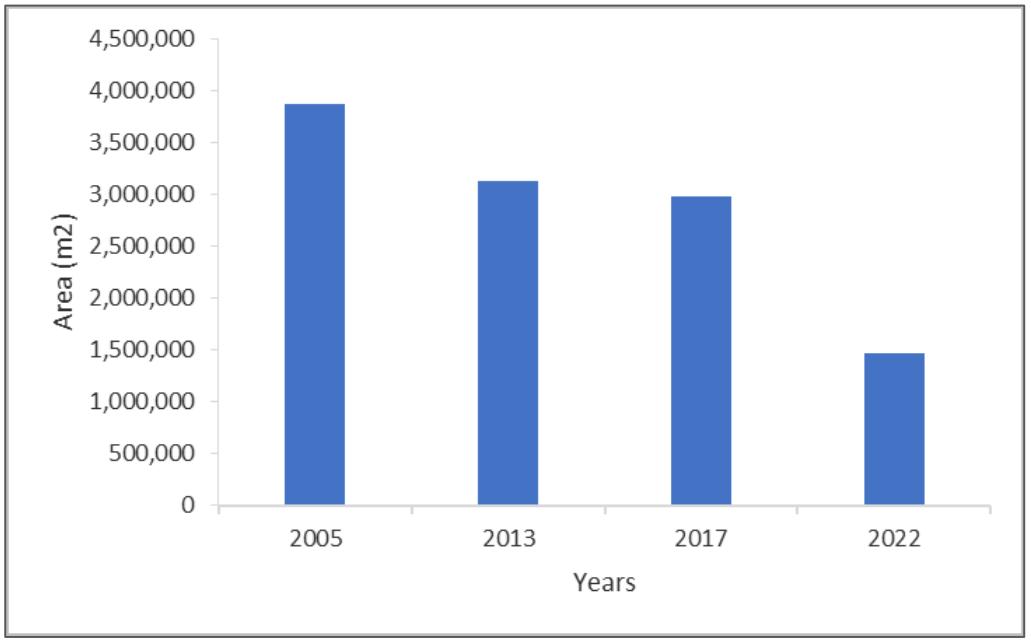
There are no known anthropogenic impacts on intertidal reefs that would significantly affect the extent and distribution indicators for geogenic and biogenic reef types. Comparison mapping has not been used to assess the extent or distribution of geogenic reef types; expert judgment was used in the absence of recent data. This has reduced the confidence in the pass for geogenic reef type targets to medium. The latest comparison analysis of *S. alveolata* reef cover between 2015 and 2023 indicated that overall, the Honeycomb worm *Sabellaria alveolata* reef was sustained with an improvement in cover and density at almost all monitoring sites of the Pen Llŷn a'r Sarnau SAC. The exception to this is Borth, where some deterioration has been seen (Brazier, 2024a). No specific anthropogenic impacts have been associated with the changes seen in the results, therefore this did not lead to a failure in the target. A high confidence was attributed to pass for the extent and distribution indicators for biogenic reef type targets as the assessment was derived from recent surveys. There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of intertidal reefs in the SAC, resulting in a pass for this indicator. The assessment has not been based on mapping of the feature which has reduced the confidence to medium.

For subtidal reefs, there has been approximately a 60% decline in the extent of the horse mussel *Modiolus modiolus* reef in the northern part of the Pen Llŷn a'r Sarnau SAC since 2005 (Figure 5). This decline has been determined by a combination of acoustic survey techniques, drop-down and towed video, *in situ* diver counts of live *M. modiolus*, and dive survey photographs and video. There is an ongoing investigation into this decline, and the reasons for it are not yet known. This decline has caused the extent and distribution indicators for biogenic reef targets to fail. A high confidence was attributed to the failures due to the clear decline in *M. modiolus* based on robust, high quality data. The failures are localised to the *M. modiolus* reef site which is in the northern part of the SAC (see Figure 4).

There are currently no known anthropogenic impacts affecting the extent and distribution of subtidal geogenic (rocky) reefs within the SAC. Monitoring data available on the geogenic Holden's Reef indicated no concerning patterns of change, and there is currently no evidence of anthropogenic impact that would have a significant effect on the geogenic (rocky) Sarnau reefs across the SAC. As a result the extent and distribution indicators for geogenic (rocky) reef targets were met. Confidence was reduced to medium as whilst data was available for Holden's Reef, expert judgement has been used to assess this indicator in the absence of recent data for the rest of the feature.

The distribution and extent of habitats and communities of subtidal reefs in the SAC did not meet its target. As for the previous indicator, the reason for failure was the decline in *M. modiolus* reef and the confidence in the fail was high.

Figure 5. Change in total area (m^2) for the *Modiolus modiolus* reef in PLAS SAC determined by sidescan sonar across the monitoring period 2005-2022.



Sediment and Topography

The sediment quality indicators are relevant to subtidal reefs only. Sediment contaminants were previously monitored at two stations in the SAC by the Clean Safe Seas Environmental Monitoring Programme (CSEMP), however the monitoring ceased in 2015. These data was deemed to be out of date and therefore the sediment quality (contaminants) indicator was assessed as unknown.

The topography, bathymetry, hydrodynamic and sediment transport processes are not well understood for reefs. For intertidal reef, these targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on these aspects of the feature. Some of these indicators, however, failed to reach their targets for subtidal reefs as a result of the decline of *M. modiolus* reef in the northern part of the SAC. This decline is visible on sidescan, multi beam echo sounder and in site photography taken by divers and drop down video (there were no distinct wave forms at the monitoring sites in recent years). When present, *M. modiolus* bind and stabilise sediment and form quasi-regular waves on the seabed. There has been a change in topography of the *M. modiolus* reef in imagery from recent years compared to imagery available from the late 1990s, with a reduction of visible wave forms and general flattening of the reef structure. NRW monitoring data showed that there has been no clear patterns or evidence of loss in rugosity for Holden's Reef. Therefore, the topography indicator for subtidal reefs failed to meet its target. The bathymetry target for subtidal reefs was met as there are no anthropogenic activities known to be impacting the feature.

In the areas of reef where there have been losses of living *M. modiolus* this has led to increased mobility of the sediment and dead shells and a reduction in the reef-associated epibiota, all of which has been observed in diver-held and drop-down video and stills. The

stable hard substrata, created by the binding action of *M. modiolus* byssal-threads, is no longer present, so reef-associated organisms are unable to settle without being scoured off by the now mobile nature of the remaining dead shells. The silty element of the reef, thought to be a combination of mussel pseudo-faeces and trapped silty sediments, is also much diminished and therefore no longer supports its own community either. This will have a subsequent impact on the reef-associated epibiota, causing the failure of the hydrodynamic and sediment transport processes indicator target. As the investigation into the decline is ongoing, the reasons for it are not yet known.

The failures for subtidal reefs are localised to the *M. modiolus* reef site which is in the northern part of the SAC and there are currently no known anthropogenic impacts affecting the topography and sediment transport processes of other subtidal reefs in the SAC.

Water quality

It has been estimated that approximately 87% of intertidal reefs and 67% of subtidal reefs within the SAC falls within seven WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Cardigan Bay North, Tremadog Bay and Caernarfon Bay South waterbodies overlap with a large proportion of intertidal and subtidal reefs in the SAC (Table 5). The Mawddach and Glaslyn waterbodies overlap with a small proportion of intertidal reefs. The Artro and Dyfi / Leri waterbodies overlap with a very small proportion of intertidal reefs and none of the subtidal reefs (Table 5), and have therefore not been considered further in the condition assessment.

Table 5. WFD waterbodies that overlap with intertidal and subtidal reefs within the Pen Llŷn a'r Sarnau SAC.

WFD waterbody	Degree of overlap with intertidal reefs (%)	Degree of overlap with subtidal reefs (%)
Cardigan Bay North	47.18	40.71
Tremadog Bay	24.90	17.02
Caernarfon Bay South	13.21	9.34
Mawddach	0.69	0.00
Galslyn	0.56	0.00
Artro	0.09	0.00
Dyfi / Leri	0.05	0.00
All waterbodies combined	86.68	67.07

Nutrients (Dissolved Inorganic Nitrogen – DIN only), phytoplankton and opportunistic macroalgae

The indicators for nutrients and phytoplankton met their targets for both intertidal and subtidal reef. For both indicators, confidence was medium as some WFD waterbodies were not classified for the DIN and phytoplankton element. This includes Tremadog Bay waterbody, which overlaps with a significant proportion of intertidal and subtidal reefs (Table 5). Classification of phytoplankton for some WFD waterbodies are not suitable or

possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels).

The opportunistic macroalgae indicator was assessed as unknown for intertidal reefs as a large proportion of the feature overlap with WFD waterbodies that were not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification (86%). Some WFD waterbodies are not assessed for opportunistic macroalgae as they don't have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth). This indicator is not relevant to subtidal reefs.

Dissolved oxygen

The dissolved oxygen indicator also met its target for intertidal and subtidal reef as most of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. The dissolved oxygen samples are taken at the water's surface. By the time oxygen depletion at the surface is recorded, oxygen throughout the water column could have been depleted for some time, especially as hypoxia or low oxygen levels, when present, typically occur in bottom water and sediments. Therefore, surface sampling of dissolved oxygen may not detect issues for more demersal features. This reduced the confidence in the pass to medium.

Contaminants

Two of the seven WFD waterbodies that overlap with the reefs feature in the SAC have a fail for chemicals in the 2024 cycle 3 interim classification. This caused the contaminants indicator to fail for both intertidal and subtidal reefs. The failures were in the Cardigan Bay North waterbody, which failed for mercury and polybrominated diphenyl ethers (PBDE), and the Mawddach waterbody, which failed for PBDE. Combined, these waterbodies overlap with 48% of intertidal reefs and 41% of subtidal reefs. There was no change in the failures since the 2021 cycle 3 classification. The environmental quality standards (EQS) for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of reefs are not fully understood.

Five WFD waterbodies that overlap with intertidal reefs, and two that overlap with subtidal reefs were not classified as the chemicals have not been assessed within the last six years. Overall, the confidence in the failure was reduced to medium to reflect that the PBDE failure uses a protection goal which may be over precautionary, and due to some waterbodies being unclassified for chemicals. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. All of the loggers overlap with the reefs feature. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is

not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

Intertidal reefs

Assessment of the species community indicators for intertidal reefs in Pen Llŷn a'r Sarnau SAC used data from various monitoring sites. This includes monitoring of the *S. alveolata* reefs at Llandanwg and west of Afon Dwyfor, and rocky shore communities at Porth Oer including algal turf for intertidal reefs, from 2008 to 2022.

Detailed *S. alveolata* monitoring has been carried out at two sites (Llandanwg and West Afon Dwyfor) between 2014 and 2019. Macrofaunal analysis from this monitoring showed that *S. alveolata* reef communities in both monitoring sites remained relatively stable overall. There were small changes in the total number of littoral taxa recorded in monitoring quadrats, however these were deemed to be within the bounds of natural variation (Mercer, 2022). The lowest number of taxa recorded at both *S. alveolata* reefs was in 2015. There were also low levels of live worms and a low percentage cover of *S. alveolata* reef found in 2014. However, as this was after some particularly destructive winter storms, these trends were not deemed large enough to be of concern. In addition, the cover and density of *S. alveolata* reef has since increased and was considered to be relatively stable in 2019 (Mercer, 2022). The latest NRW widescale comparison of *S. alveolata* reef also indicated an increase in total percentage reef and live reef from 2015 to 2023 across all monitoring sites except Borth in the Pen Llŷn a'r Sarnau SAC (Brazier, 2024a).

The rocky shore communities at Porth Oer indicated little changes year to year across the monitoring period, with the exception of a 15-40% decrease in barnacle community which was attributed to the winter storms in 2013-2014 (Moore, 2022; Brazier, 2024b). The limpet *Patella spp.* population has been relatively stable over the sampling period (2012 to 2022) at this location (Brazier, 2024b). Abundance of the toothed wrack *Fucus serratus* has been assessed using the MarClim dataset between 2017 and 2023 (Mieszkowska and Sugden, 2023; 2024). Over this period there have been no apparent changes in the SACFOR abundance of the species in all MarClim sites within the SAC. Overall, the rocky reefs appeared to be in good condition.

Overall, both the abundance, distribution and species composition of communities, and the species richness and diversity indicators were assessed as passing for intertidal reefs as there were no concerns of anthropogenic activities that could affect the reef feature. The data showed natural variation in community composition and species richness in *S. alveolata* and rocky shore communities at these sites. The confidence was reduced to medium since the monitoring sites only cover the north part of the Pen Llŷn a'r Sarnau SAC. However, it is expected, that other sites in the SAC are in similar condition, with minimal disturbance from anthropogenic activities.

Subtidal reefs

Data for the subtidal reefs assessment included the biogenic horse mussel *Modiolus. modiolus* reef, the fish communities at Holden's Reef, the reef-associated epibiota at Carreg Y Trai and the unusual *Halidrys siliquosa* algal biotope at Sarn Badrig. *M. modiolus*, algal biotope and fish communities have been surveyed since 2004-2005, whilst the epibiota have been surveyed since 2016. The quadrat surveys for *M. modiolus* stopped in 2011 due to absence of live *M. modiolus* recorded at the two monitoring sites.

Analysis of the subtidal reefs at Carreg Y Trai site indicated some change over time, however these were small and considered within the bounds of natural variation. While this was not judged to be enough to fail the abundance, distribution and species composition of communities indicator, these changes will be something to pay close attention to in the next assessment. The analysis of the fish community at Holden's Reef site indicated little concern, with natural variation in community composition. The algal species composition at Sarn Badrig site indicated high variation, but this was deemed to be natural and a result of the dynamic nature of moving sediments amongst the cobble reef. There was a sudden growth of mussel spat in 2010 impacting the algal composition, however the algal community has since recovered from this change.

With the dramatic decline in *M. modiolus* reef extent, the associated biota communities are almost certainly in poor condition as *M. modiolus* density is closely linked to community diversity (Fariñas-Franco et al., 2023). Aggregations of larger living mussels have been shown to host a higher species richness compared to substrates made of dead shells (Rees et al., 2008). The fixed quadrats at the two *M. modiolus* monitoring sites demonstrated a substantial decline in numbers of live *M. modiolus* recorded in earlier years (2004 to 2005) compared with subsequent monitoring years (2007 to 2011). After 2011, partly due to such low numbers of recorded live *M. modiolus*, a decision was made to focus monitoring resources over the wider *M. modiolus* reef and to stop monitoring at these two sites. The decline is still seen in wider monitoring up to 2022 as Figure 5 shows. As a result of this decline, the abundance, distribution and species composition of communities indicator failed to meet its target with high confidence for subtidal reef. The distribution of *M. modiolus* is thought to have remained similar despite the large decline in extent but no new data are available to confirm this.

As *M. modiolus* reef has deteriorated, this will have a knock on effect on the diversity (Rees et al., 2008; Fariñas-Franco et al., 2023), resulting in the overall failure of the species richness and diversity indicator for subtidal reef. Small changes were detected in diversity and species richness of the subtidal reef communities at Carreg Y Trai but this has recovered in most recent years and thus was not deemed a large enough effect to contribute to the failure of the target. Data analysis highlighted a decline in species richness and diversity in fish at the shallow zone of the north transect in Holden's Reef. While this is slightly concerning, no clear loss of fish species was observed overall at Holden's Reef, and fish species tended to fluctuate through the monitoring period with no clear pattern. The algal community at Sarn Badrig site exhibited high variability in species richness and diversity, but this was attributed to the dynamic nature of the habitat and considered natural.

The average taxonomic distinctness was deemed to be within the bounds of natural variation for the reef-associated species at Carreg Y Trai site. As a result, a pass was attributed to the taxonomic spread of species indicator. Confidence was reduced to

medium due to the time-limited nature of the sampling method at Carreg Y Trai site. Where time-limited methods are used, and the allowed time is not enough to generate a full species list, inter-surveyor differences become more of an issue for the assessment of species richness and diversity. Changes such as improvement of taxonomic expertise, taxonomic nomenclature improvement throughout the monitoring period is likely to further affect species richness and average taxonomic distinctness.

NRW led investigations have found new evidence of low recruitment of *M. modiolus* in recent years, suggesting an aging population. While the reasons for this are yet to be found, it is concerning.

Overall, both the abundance, distribution and species composition of communities, and species richness and diversity of communities indicators failed to meet their targets with high confidence. As was the case for the extent indicators, these failures are localised to the *M. modiolus* reef in the northern part of the SAC (Figure 4). There are no concerning patterns of change for all other parts of the monitored reefs feature.

Invasive non-native species

There have been records of the American slipper limpet *Crepidula fornicata* identified (2023-2024) in various locations within the SAC, including on *M. modiolus* reef within the last six years. Therefore, the tertiary target of the non-native species (NNS) indicator failed with high confidence due to the new NNS recorded in the reefs feature within the last reporting cycle.

Other NNS are known to be present in the reefs feature including the wireweed *Sargassum muticum*, which has been present in various locations in the SAC for a number of years (recorded from 2005). This species is currently spreading at Bardsey Island.

The full extent of the impact these species may have on the condition of the reefs feature is currently unknown as there is limited evidence that these NNS are at high enough density to be adversely impacting the condition of the feature. As there is no current impact from the invasive non-native species (INNS) present the primary target of the INNS indicator passed. Confidence is low as the spread and impacts of the INNS present within the feature are not well understood. The impact of *C. fornicata* on the *M. modiolus* reef is a particular concern, and investigation into this is an evidence priority.

Reasons for target failure

The assessment of the reefs feature in the Pen Llŷn a'r Sarnau SAC failed five primary targets, three secondary targets and one tertiary target. This resulted in the feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below:

Extent (biogenic reef types)

This indicator failed to meet its primary target due to the loss in extent of the biogenic *M. modiolus* reef in the northern part of the SAC. There is currently an ongoing NRW investigation into the observed decline of *M. modiolus* and the reasons for the decline are not yet known. Some of the potential pressures that may have impacted the *M. modiolus*

reef (individually or in combination) are connectivity and recruitment decrease, temperature (e.g. change in occurrence of marine heat waves), fishing impacts and pathogens. The failure is localised to the *M. modiolus* reef of the Llŷn Peninsula.

Distribution and extent of the naturally present biogenic reef

This indicator failed to meet its primary target relevant to the naturally present biogenic reef type, due to the loss in extent of the *M. modiolus* reef in the northern part of the SAC (see further information outlined in extent).

Distribution and extent of habitats and communities

This indicator failed to meet its primary target due to the loss in habitat of the *M. modiolus* reef in the northern part of the SAC (see further information outlined in extent).

Hydrodynamic and sediment transport processes

This indicator failed to meet its primary target due to the higher mobility of sediment at the *M. modiolus* reef site as a result of this species' decline. When present, *M. modiolus* bind and stabilise sediment. Their loss has therefore led to the increased mobility of the sediment at the *M. modiolus* reef, which will have a subsequent impact on the reef-associated biota. This is a localised issue that is not causing an impact on the rest of the reefs feature. There is currently an ongoing NRW investigation into the observed decline of *M. modiolus* and the reasons for the decline are not yet known (see further info in extent above).

Abundance, distribution and species composition of communities

This indicator target has a primary weighting. The decline of the *M. modiolus* reef extent which is in the northern part of the SAC has resulted in impoverished habitat with low diversity and number of taxa. This is a localised issue that is not causing an impact on the rest of the reefs feature (see further information outlined in extent).

Topography of the feature

This indicator failed to meet its secondary target as a result of the alteration in topography at the *M. modiolus* reefs following the decline of this species in recent years. This is a localised issue that is not causing an impact on the rest of the reefs feature (see further information outlined in extent).

Water quality: contaminants

This indicator target has a secondary weighting. A large proportion of the reefs feature in the SAC overlaps with two WFD waterbodies (Cardigan Bay North and Mawddach) that have failed for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous

sewage discharge from the water industry. The sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. However, WFD investigations of the failures in both waterbodies are yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

Species richness and diversity

This indicator failed to meet its secondary target as a result of the decline in species richness and diversity in the *M. modiolus* reef which is in the northern part of the SAC. There is currently an ongoing NRW investigation into the observed decline of *M. modiolus* and the reasons for the decline are not yet known. This is a localised issue. (See further information outlined in extent).

Non-native species

This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to records of *C. fornicata* found in the reef feature within the last six years. It is not fully understood how this species, and the other NNS present within the SAC may spread and impact the reef biota, and any effects on the species diversity and composition have not yet been observed. For this reason it did not fail the primary target of the INNS indicator. A biosecurity plan for INNS has been developed for the SAC. The objective is to manage the key pathways by which marine INNS are introduced and spread at the SAC level through the use of good biosecurity.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the reefs. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission process e.g. offshore wind and marine cabling, whereby the impact of the activity on the feature would be assessed have not been included. The threats to the condition of the reefs feature in the Pen Llŷn a'r Sarnau SAC are stated below.

Unconsented infrastructure

New unconsented infrastructures such as private slipways and coastal defences, modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impact to the flora and fauna associated with it.

Invasive non-native species

At high density, *C. fornicata* could cause an impact on the feature as it and has been shown to alter habitats if it settles in large numbers (Blanchard, 2009). It can also compete with native species for space and food (Frésard and Boncoeur, 2006; Mineur et al., 2012). The spread and full impact of *C. fornicata* on the reefs is not fully understood and there is

concern about its increasing abundance especially on the *M. modiolus* reef in Pen Llŷn a'r Sarnau SAC as it can smother and outcompete native species.

The various other NNS recorded in the SACs pose a threat but the spread and future impacts on the reefs feature are not understood.

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. The SACs could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as per- and polyfluoroalkyl substances PFAS) to increase. This could affect some of the biota of the reefs feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Management of coastal defences

The State of the UK Climate 2023 Report highlights an observed acceleration in rates of climate induced sea-level rise which, along with storm surges can cause coastal erosion and flooding (Kendon et al, 2024). Shoreline Management Plans identify the preferred approach to coastal management in light of climate change, which includes maintaining or upgrading defences in some areas and adapting the approach to management in others. Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species. Intertidal habitats may also be lost as a result of coastal squeeze (Oaten et al, 2024).

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024; Oaten et al., 2024):

- Sea level rise, leading to coastal squeeze and loss of extent for some SACs.
- Changes in air and sea temperature,
- Changes in ocean acidification,
- Changes to wave climate, especially storm frequency and intensity.
- Changes in species distribution.
- Potential range expansion in NNS (e.g. grey triggerfish *Balistes capriscus* and *M. gigas*).

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 6) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 6. Evidence gaps for the reefs feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

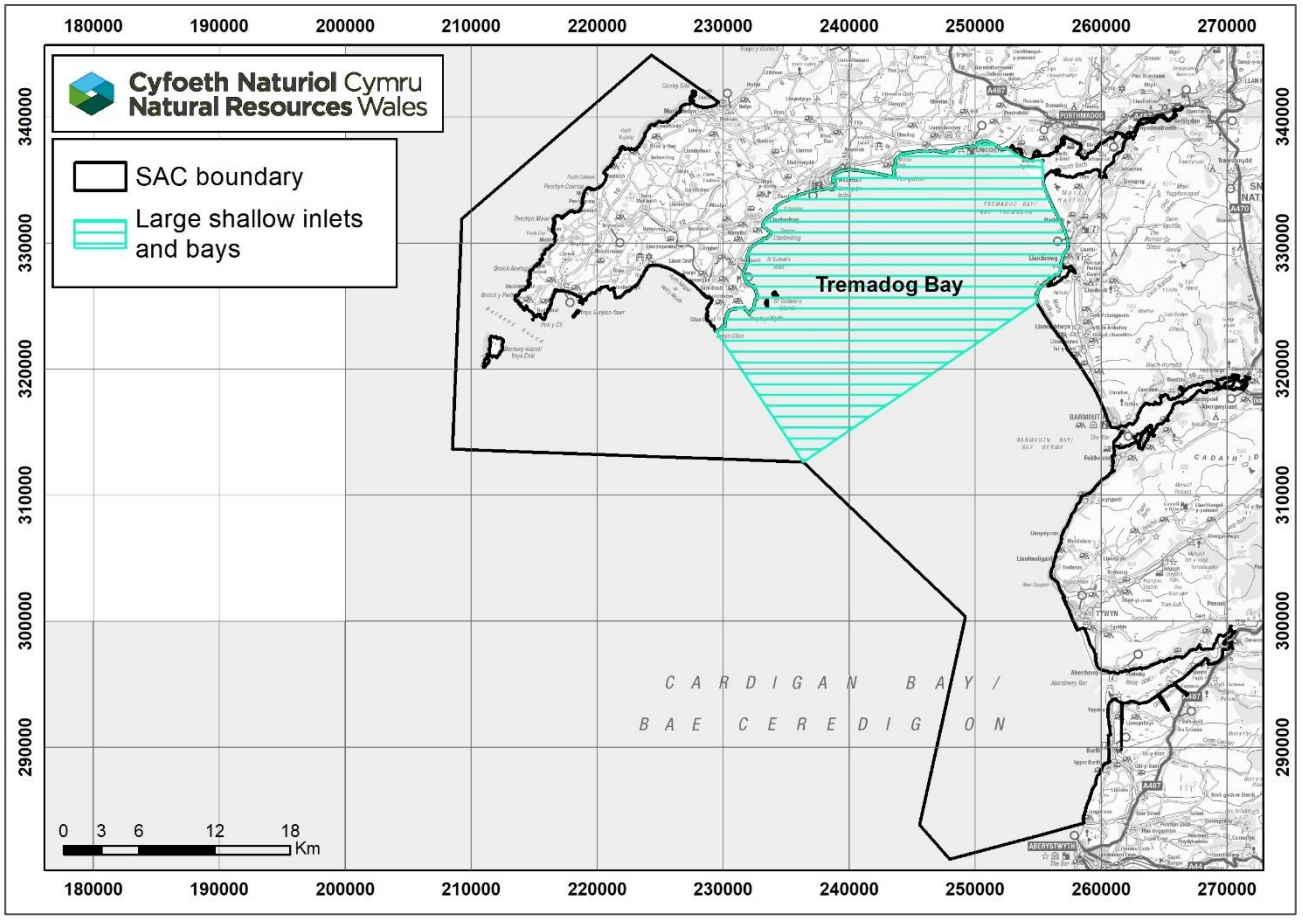
Indicator	Assessed status	Comments
Feature extent (P); distribution of the feature (P); distribution and extent of habitats and communities (P); topography of the feature (S); bathymetry of the feature (P); hydrodynamic and sediment transport processes (P)	Medium confidence (proxy data used)	• There are currently no temporal data available to assess changes for these indicators for intertidal and subtidal reefs across all SACs, and assessment was based on expert judgment.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present within the SAC on the reefs feature is not fully understood. More targeted surveys and investigation on the impact of NNS on reefs are needed.
Sediment: composition and distribution (S); availability (S); depth (S)	Not assessed	• There is no current monitoring of the sediment composition, availability and depth over reefs within all SACs.
Water quality: opportunistic macroalgae (S)	Unknown	• Some of the WFD waterbodies that overlap with the feature in the SAC were not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum.

Indicator	Assessed status	Comments
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.
Sediment quality: contaminants (T)	Unknown	• Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring within the SAC ceased in 2015. These data was deemed to be out of date and there are no recent data available.

3.2. Large shallow inlets and bays condition assessment

The large shallow inlets and bays (LSIB) feature in Pen Llŷn a'r Sarnau SAC is Tremadog Bay (Figure 6). The condition assessment was completed using information specific to the LSIB in combination with any available data on the nested designated features contained within the LSIB.

Figure 6. Map of the LSIB feature in Pen Llŷn a'r Sarnau SAC.



The LSIB includes some nested features: reefs and mudflats and sandflats. Fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Table 7 has a summary of the assessment outcome. This outcome and reasons of failure are discussed in more detail in the sections below.

Table 7. Condition assessment of LSIB in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature Extent	No significant decrease in extent of LSIB within the SAC, allowing for natural change. (P)	• LSIB are a physiographic feature and the extent of the LSIB feature would be unlikely to change. • There are currently no anthropogenic impacts known to be significantly affecting the extent of LSIB in the SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of LSIB habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of LSIB and its nested features in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the LSIB, allowing for natural change and variation. (P)	• No issues were identified for the overlapping nested mudflats and sandflats feature. • The NRW monitoring analysis of the sublittoral soft sediment in Tremadog Bay from 2007 to 2018 indicated that sediment composition was relatively stable across the monitoring period. • Confidence is medium due to the lack of more recent data analysis and the low level of overlap of the mudflats and sandflats feature with the LSIB.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease In the depth of the redox layer from the surface that is considered detrimental to LSIB infaunal communities, allowing for natural change and variation. (S)	• This assessment uses the results of the condition assessment from the mudflats and sandflats feature as a proxy as there were no other data available. The redox layer profile of the monitored mudflats and sandflats indicated no clear trend over the years. • Confidence is low due to the use of proxy data and as a large proportion of the mudflats and sandflats is not within the LSIB. Additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to LSIB communities, allowing for natural change and variation. (S)	• There are no recent data for organic carbon content for the estuaries within Pen Llyn a'r Sarnau SAC, as the Clean Safe Seas Environmental Monitoring Programme (CSEMP) data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (S)	• There are no recent data for sediment contaminants for the estuaries within Pen Llyn a'r Sarnau SAC, as the CSEMP data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the LSIB. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• One of the three WFD waterbodies that overlap with the feature was not classified for DIN in any WFD cycles (Tremadog Bay). It overlaps with the largest proportion of the feature (57%). • The other two WFD waterbodies were classified as High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay North and Glaslyn). Combined, these overlap with 42% of the feature. • Confidence is medium due to the one unclassified waterbody.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Two of the three WFD waterbodies were not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). Combined, these waterbodies overlap with 58% of the feature. • The other WFD waterbody was classified with a High status for phytoplankton (Cardigan Bay North). It overlaps with 41% of the feature. • Confidence is medium as a large proportion of the feature overlaps with waterbodies that have not been classified for the relevant WFD element.	**Pass**	Medium
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• None of the three WFD waterbodies were classified for opportunistic macroalgae in the 2024 cycle 3 interim classification.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Two of the three WFD waterbodies that overlap with the feature were not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). They overlap with 57% and 1% of the feature respectively. • The other WFD waterbody was classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Cardigan Bay North). It overlaps with 41% of the feature. • Confidence is medium due to samples being taken from the surface of the waterbody which may not detect issues for more demersal habitats within the LSIB feature, and as a large proportion of the feature has not been classified.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Two of the three WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Tremadog Bay and Glaslyn). • The other WFD waterbody has a fail for chemicals (Cardigan Bay North). It failed mercury and PBDE and overlaps with 41% of the feature. • Confidence is medium as the human health standard has been used for PBDE, and due to the unclassified waterbodies.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the LSIB feature in the Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties of the water column	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• All three overlapping WFD waterbodies were classified as Good or High status for the Infaunal Quality Index (IQI) WFD element in the 2024 cycle 3 interim classification (Tremadog Bay, Cardigan Bay North and Glaslyn). Combined, these waterbodies overlap with 99% of the feature. • No issues were identified for the overlapping nested features: reefs and mudflats and sandflats. • The sublittoral habitats in Tremadog Bay appeared to be in good ecological health and have remained relatively consistent and within the limits of natural variation throughout the monitoring period. • Confidence is medium as the data time frame of the detailed report analysis only extends up to 2018 and the lack of fish communities data.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence to suggest that INNS (e.g. *Crepidula fornicata*) are currently impacting the condition of LSIB in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There are recent records (2023-2024) of *C. fornicata* within the feature (close to St Tudwal's Islands). • Other records of NNS have been previously recorded within the feature including *Sargassum muticum* and *Magallana gigas*. • There have been targeted INNS surveys as part of the MarClim project and ad-hoc records from the NRW Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The large shallow inlets and bays (LSIB) feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (medium confidence). Overall, the lack of any significant anthropogenic impacts on this feature in term of extent, hydrodynamic processes, topography, sediment composition and its associated community, have contributed to this favourable assessment outcome. There were two indicators with failing targets (Table 8). Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in Table 8 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 8. Summary of the condition assessment for LSIB in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Large shallow inlets and bays	**Favourable (medium confidence)**	Water quality: contaminants (S) Non-native species (T)	• Levels of mercury and PBDE in the Cardigan Bay North waterbody are failing to meet their relevant EQSs. • There has been a recent increase in the number of records of *C. fornicata* in the feature.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

The extent of the feature indicator in the Pen Llŷn a'r Sarnau SAC passed its target as there are currently no known anthropogenic impacts that would significantly affect the extent of the LSIB feature. LSIB are a physiographic feature and the extent of the LSIB feature would be unlikely to change. The distribution and extent of habitats and communities indicator also met its target for this reason, and because there are currently no known impacts to the distribution and extent of the nested features. Comparison mapping has not been used to assess the extent and only expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediments

Composition and distribution

The sediment composition and distribution indicator in the condition assessment of the mudflats and sandflats feature passed its target (Section 3.6). This feature overlaps with only 2% of the LSIB feature.

The monitoring analysis of the sublittoral soft sediment in Tremadog Bay from 2004 to 2018 indicated that sediment composition was relatively stable across the monitoring period (Kirby et al., in draft). Sediment types at almost all stations have been consistent across years where sediment type fell into one or two categories over the entire monitoring period.

Overall, the sediment composition and distribution indicator met its target as there have been no concerning changes in sediments over the monitoring periods. However, confidence was reduced to medium as the Tremadog Bay data goes up to 2018 only.

Oxidation-reduction profile (redox layer)

The redox layer of intertidal sediments has been monitored within the mudflats and sandflats habitat. This habitat feature in the SAC overlaps with only 2% of the LSIB feature. Despite the small spatial overlap, it was deemed acceptable to use the mudflats and sandflats condition assessment as a proxy for the sediment redox layer indicator as there are no known anthropogenic impacts that would affect the redox layer of sediments within Tremadog Bay. The indicator met its target as the redox layer profile from the mudflats and sandflats data indicated no clear trend over the surveyed years (Section 3.6). The confidence was reduced to low because the assessment uses the mudflats and sandflats condition assessment as a proxy and a large proportion of the mudflats and sandflats feature is outside the LSIB feature. Further sampling is also required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer.

Organic carbon content and contaminants

Sediment contaminants and organic carbon content were previously monitored at two stations in the SAC by CSEMP, however the monitoring ceased in 2015. The data were deemed to be out of date and these indicators were assessed as unknown.

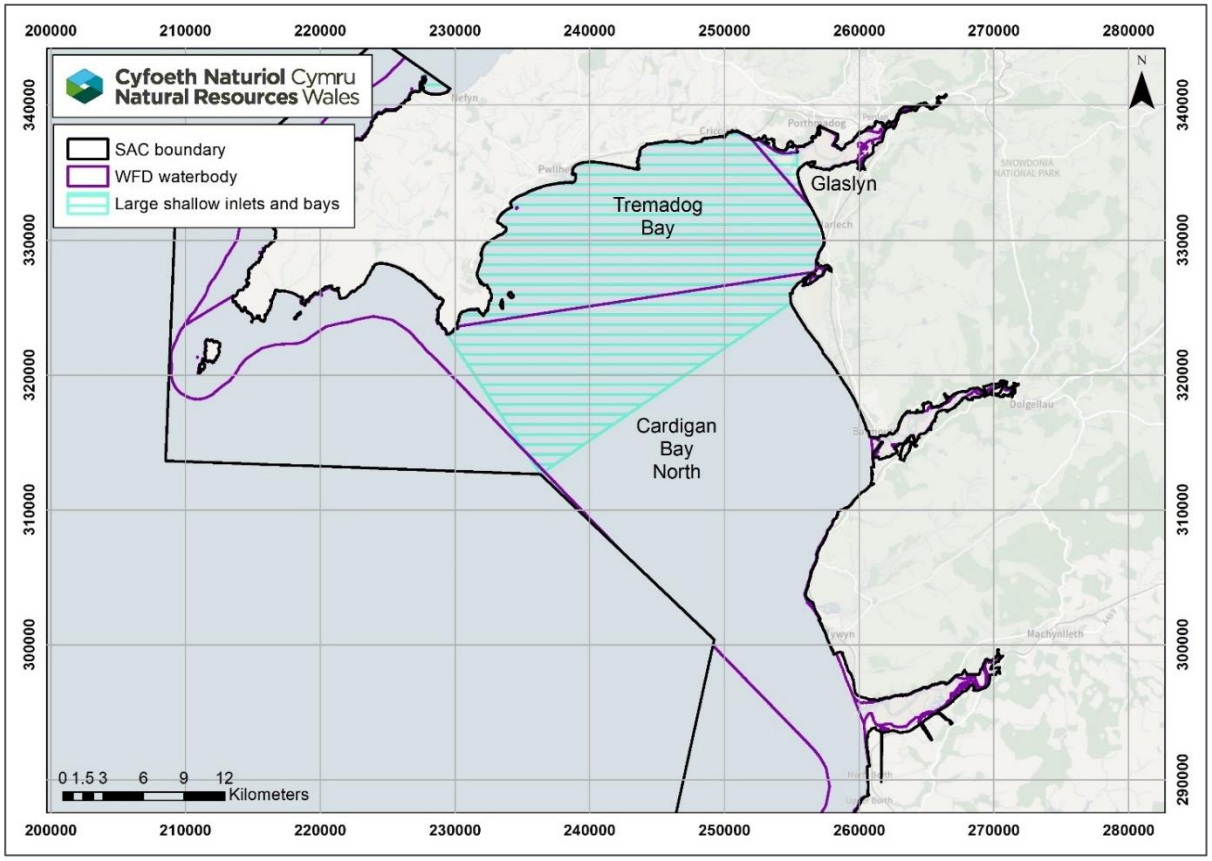
Topography and hydrodynamics

The topography and hydrodynamic and sediment transport processes are not well researched for LSIBs. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the feature within the SAC.

Water quality

It has been estimated that approximately 99% of the LSIB feature within the SAC falls within three WFD waterbodies (Figure 7), therefore these are likely to be a good reflection of the overall effect of water quality on the feature. The Tremadog Bay and Cardigan Bay North waterbodies overlap with the largest proportion of the feature (57% and 41% respectively). The Glaslyn waterbody overlaps with a small proportion of the feature (1%) (Figure 7).

Figure 7. Map of the WFD waterbodies that overlap with the LSIB feature within Pen Llŷn a'r Sarnau SAC.



Nutrients (DIN only)

The nutrients (DIN only) indicator met the target as two of the three WFD waterbodies that overlap with the feature were classified as High status for DIN in the 2024 cycle 3 interim classification. These were Cardigan Bay North and Glaslyn waterbodies. Confidence was reduced to medium because one WFD waterbody, Tremadog Bay, has never been classified for DIN. This waterbody overlaps with the largest proportion of the feature.

Phytoplankton

The phytoplankton indicator met the target. One of the overlapping WFD waterbodies, Cardigan Bay North, was classified with a High status for phytoplankton in the 2024 cycle 3 interim classification. The other two WFD waterbodies have not been classified for phytoplankton in any WFD cycles. Classification of some WFD waterbodies is not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Confidence in the pass was reduced to medium as a large proportion of the feature overlaps with waterbodies that have not been classified for the phytoplankton element.

Opportunistic macroalgae

None of the three WFD waterbodies were classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification, therefore this indicator was assessed as unknown. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Dissolved oxygen

The dissolved oxygen indicator met its target. The dissolved oxygen samples are taken at the water's surface. By the time oxygen depletion at the surface is recorded, oxygen throughout the water column could have been depleted for some time, especially as hypoxia or low oxygen levels, when present, typically occur in bottom water and sediments. Therefore, surface sampling of dissolved oxygen may not detect issues for more demersal habitats within the LSIB feature. This, and as a large proportion of the feature has not been classified for this element, reduced the confidence in the pass to medium. However, these WFD waterbodies are not deemed to be at risk from failing this element.

Contaminants

One of the WFD waterbodies that overlaps with the LSIB feature in the SAC has a fail for chemicals in the 2024 cycle 3 interim classification. This was the Cardigan Bay North waterbody which failed for mercury and PBDE, and therefore caused the contaminants indicator to fail. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of LSIB are not fully understood. The other two WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. The confidence in the failure was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. Three of the loggers overlap with or are close to the LSIB feature. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

All three of the overlapping WFD waterbodies were classified as Good or High status for the Infaunal Quality Index (IQI) element in the 2024 cycle 3 interim classification (Tremadog Bay, Cardigan Bay North and Glaslyn). Combined, these waterbodies overlap with 99% of the feature. One of these overlapping waterbodies, Tremadog Bay, has deteriorated from High status in the 2021 cycle 3 classification to Good status in the 2024 cycle 3 interim classification.

The mudflats and sandflats feature overlaps with approximately 2% of the LSIB feature. The condition assessment for the mudflats and sandflats feature concluded that the abundance, distribution and species composition of communities indicator met the criteria for a pass (Section 3.6).

The reefs feature overlaps with approximately 31% of the LSIB feature. The abundance, distribution and species composition of communities indicator met its target for the intertidal reefs and subtidal reefs where it occurs within the LSIB feature (Section 3.1).

The sublittoral habitats in Tremadog Bay appeared to be in good ecological health and have remained relatively consistent throughout the monitoring period of 2004 to 2018 (Kirby et al., draft). The spatial and temporal variation evident in the analysis is considered to be within the limits of natural variation. Some concerns were raised about the deterioration of the infaunal composition at one of the monitoring sites (station 13, near the mouth of the Glaslyn / Dwyryd). As this is very localised, it was not deemed large enough to fail the indicator but will require further attention in the future.

Although fish within the LSIB are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the LSIB feature. Data from wider Irish sea level studies such as International Council for the Exploration of the Sea (ICES) are difficult to relate to the assessment of condition at the SAC and feature level and some species that have been assessed by ICES may not even occur at the individual SAC level. However, populations of various larger-bodied bony fish species in the Irish Sea, such as bass, cod, herring, whiting, plaice and pollack, have declined in recent years (ICES, 2024a, 2024b, 2024c, 2024d, 2024e, 2024f). While there are limited data on the

status of other species, the depletion of a number of larger, higher trophic level predatory species in the Irish Sea may have shifted the structure of the wider fish community to an overall lower trophic level with fewer larger predatory fish species.

Overall, the abundance, distribution and species composition of communities indicator for the LSIB feature in Pen Llŷn a'r Sarnau SAC met its target. However confidence was reduced to medium because the data only extends up to 2018 and due to the lack of fish communities data for the LSIB feature.

Invasive non-native species

There has been an increase in the number of records for *Crepidula fornicata* identified in various locations within the SAC, including two records in 2023 and 2024 within the LSIB feature for the first time, close to St Tudwal's Islands. Therefore, the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the LSIB feature within the last reporting cycle.

Other NNS are known to be present within the LSIB feature, including the wireweed *Sargassum muticum* and Pacific oyster *Magallana gigas*.

It is not fully understood how some of these species may spread and impact the condition of LSIB and the nested habitat features within the feature, and effects on the species diversity and composition have not yet been observed. As there is no current impact from the INNS present the primary target of the INNS indicator passed. Confidence is low as the impacts of the INNS present within the feature are not well understood.

Reasons for target failure

The LSIB feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, one secondary target and one tertiary target failed to be met and need to be kept under review.

Water quality: contaminants

This indicator target has a secondary weighting. The LSIB feature in the SAC is partly within one WFD waterbody (Cardigan Bay North) that has a fail for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The exact sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown as a WFD investigation of the failure in this waterbody is yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

Non-native species

This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to records of *C. fornicata* found in the LSIB feature

within the last six years. The spread and full extent of the impact that these species, along with other NNS present within the SAC, may have on the condition of the feature is currently unknown. For this reason it did not fail the primary target of the INNS indicator. A biosecurity plan for INNS has been developed for the SAC. The objective is to manage the key pathways by which marine INNS are introduced and spread at the SAC level through the use of good biosecurity.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the LSIB. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the LSIB feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Unconsented infrastructure

New unconsented infrastructures such as private slipways and coastal defences, modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impact to the flora and fauna associated with it.

Invasive non-native species

There have been recent records of *C. fornicata* in the SAC including two records within the LSIB feature, close to St Tudwal's Islands. At high density, this species may cause an impact on the feature (see further detail in Section 3.1).

G. vermiculophylla has been found in the SAC. This species has the potential to establish quickly in shallow soft-bottomed bays and estuaries as it has broad environmental tolerances (Maggs and Magill, 2014). *G. vermiculophylla* can have a detrimental impact on the feature. The species can alter the sedimentation and topography and could alter the habitat in the long-term if at high densities (Maggs and Magill, 2014).

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the LSIB feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Management of coastal defences

The State of the UK Climate 2023 Report highlights an observed acceleration in rates of climate induced sea-level rise which, along with storm surges can cause coastal erosion and flooding (Kendon et al, 2024). Shoreline Management Plans identify the preferred approach to coastal management in light of climate change, which includes maintaining or upgrading defences in some areas and adapting the approach to management in others. Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species. Intertidal habitats may also be lost as a result of coastal squeeze (Oaten et al, 2024).

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024, Oaten et al., 2024):

- Sea level rise.
- Changes to wave climate, especially storm frequency and intensity, which may change the topography.
- Changes in air and sea temperature.
- Changes in ocean acidification.
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 9) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments. There are additional evidence gaps concerning the nested features, which can be found in the relevant sections of this report.

Table 9. Evidence gaps for the LSIB feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

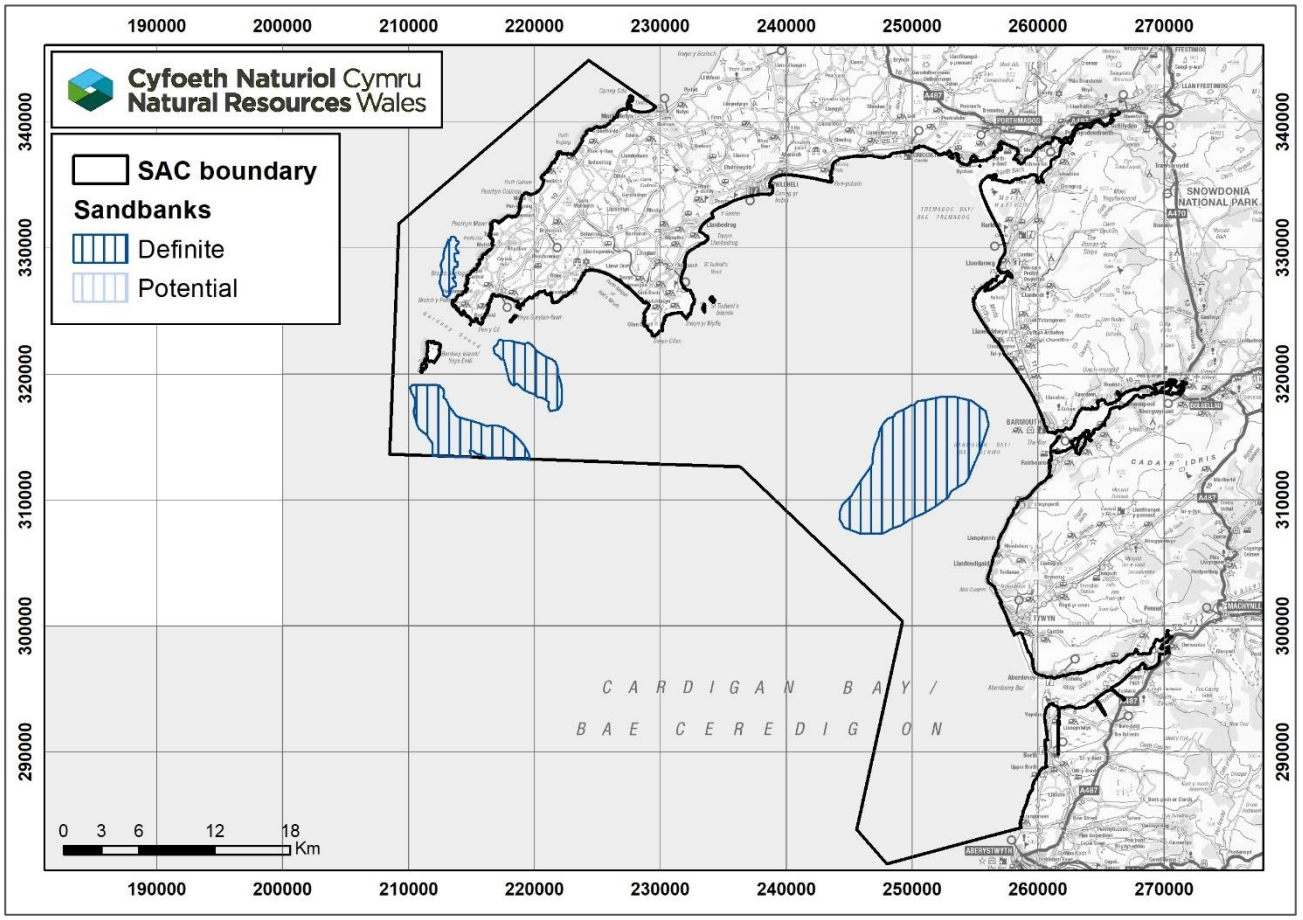
Indicator	**Assessed status**	**Comments**
Abundance, distribution and species composition of communities (P)	The fish community element did not contribute to the condition outcomes.	• Fish communities were broadly discussed for all SACs using reports including ICES data. Although these reports provide an indication of fish numbers, they have certain limitations. The large area covered makes it unsuitable for specific LSIB or individual SACs. More data would be required to adequately assess fish communities in LSIB.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present on the LSIB feature within the SAC is not fully understood. More targeted surveys and investigation on the impact of NNS on LSIB are needed. • Investigation into the use of satellite and or aerial imagery for assessing the extent of *G. vermiculophylla* may be beneficial.
Sediment quality: contaminants (S); organic carbon content (S)	Unknown	• Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring within the SAC ceased in 2015. These data was deemed to be out of date and there are no recent data available.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was difficult to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening for all SACs.
Water quality: opportunistic macroalgae (S)	Unknown	• None of the overlapping WFD waterbodies were classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.

Indicator	Assessed status	Comments
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.3. Sandbanks condition assessment

The sandbanks feature in Pen Llŷn a'r Sarnau SAC comprises a number of sandbanks (Figure 8). The NRW Habitats Regulations monitoring has focussed on three named sandbanks within the SAC: Tripods, Bastram Shoal and Devils Ridge. These sandbanks have been assessed together against the performance indicators and an overall condition was assigned for the feature.

Figure 8. Map of the sandbanks feature in Pen Llŷn a'r Sarnau SAC.



The summary of the assessment outcome is provided in Table 10. These outcomes and reasons of failure are discussed in more detail in the sections below.

Table 10. Condition assessment of sandbanks in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sandbanks within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sandbanks in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain sandbank distribution within the SAC, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sandbanks in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Sediment composition and distribution	Maintain composition of sediment granulometry across the sandbanks, allowing for natural change and variation. (P)	• Granulometric analysis for the three monitored sandbanks showed some changes in sediment composition but this is likely to be natural. • Confidence is high due to the availability of long term monitoring data and lack of concerning patterns.	**Pass**	High
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the sandbanks. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of sandbanks in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of sandbanks in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Both of the WFD waterbodies that overlap with the sandbanks feature have been classified with a High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay North and Caernarfon Bay South). Combined, these waterbodies overlap with 65% of the feature. • Confidence is high as there were no WFD waterbodies that overlap with the feature that were not classified or failed for the DIN element.	**Pass**	High
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Both of the overlapping WFD waterbodies have been classified with a Good or High status for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay North and Caernarfon Bay South). • Confidence is medium as the ecological relationships between phytoplankton and the sandbanks feature are not well understood.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Both WFD waterbodies that overlap with the sandbanks feature have been classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is medium due to samples being taken from surface of waterbody.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• One of the two WFD waterbodies was not classified as the chemicals have not been assessed within the last six years (Caernarfon Bay South). This waterbody overlaps with 2% of the feature. • The other WFD waterbody has a fail for chemicals (Cardigan Bay North). This waterbody failed mercury and PBDE. It overlaps with 63% of the feature. • Confidence is medium as the human health standard has been used for PBDE and one waterbody has not been classified.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the sandbanks feature in the Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Both overlapping WFD waterbodies were classified as Good status for the IQI WFD element in the 2024 cycle 3 interim classification (Cardigan Bay North and Caernarfon Bay South). Combined, these waterbodies overlap with 65% of the feature. • Analysis of macrobenthic infaunal communities for the three sandbanks assessed showed large variation across monitoring stations and years with recent shift towards earlier communities. • Confidence is medium as the changes observed are unexplained and it is not known whether this is due to natural, methodological or anthropogenic causes.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of sandbank species, allowing for natural change and variation. (S)	• Analysis showed an increase in diversity since 2011 for Tripods and Devils Ridge but, an unexplained decline in diversity for Bastram Shoal in recent years (2018, 2021). • Species richness increased over time since the initial drop following 2001 for Tripods and Devils Ridge sandbanks and after 2012 for Bastram Shoal. • Confidence is medium due to uncertainties around the recent decline in diversity at Bastram Shoal.	**Pass**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of sandbank species, allowing for natural change and variation. (S)	• Overall, the average distinctness of the infaunal community of the three sandbanks remained stable and within the expected values over the monitoring period. • Confidence is high due to the availability of high quality monitoring data and lack of concerning patterns in recent years.	**Pass**	High
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence to suggest that INNS are currently impacting the condition of sandbanks in the SAC. • Confidence is medium as whilst there have been no new records of NNS in the last six years, there have been no targeted surveys of NNS and the spread and impacts of any INNS present within the feature are not well understood.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There are no new NNS records across all the three monitored sandbanks within the last six years. • Confidence is medium because there have been no targeted surveys of NNS on sandbanks.	**Pass**	Medium

Assessment conclusions

The sandbanks feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (medium confidence). Overall, the lack of any significant anthropogenic impact on this feature in terms of extent, hydrodynamic processes, topography, sediment composition and its associated community, have contributed to this favourable assessment outcome. There was a failure for one secondary target (Table 11) and there were limited or absent data for one key indicator to inform on the condition of the feature (see evidence gaps). This reduced the confidence in the assessment.

A summary of the assessment can be seen in Table 11 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 11. Summary of the condition assessment for sandbanks in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Sandbanks	**Favourable (medium confidence)**	Water quality: contaminants (S)	• Levels of mercury and PBDE in the Cardigan Bay North waterbody are failing to meet their relevant EQSs.	• INNS • Water quality: contaminants • Climate change

Detailed assessment information

Tripods, Devils Ridge and Bastram Shoal, which are part of the sandbanks feature in the Pen Llŷn a'r Sarnau SAC, were monitored in 2001 and then every three years between 2009-2021 using grab sampling surveys.

Extent and distribution

The indicators for extent and distribution of the sandbanks feature in Pen Llŷn a'r Sarnau SAC pass the target as there are currently no known anthropogenic impacts that would significantly affect the sandbanks feature. Sandbanks within the SAC were mapped using bathymetry in 2016, but no further measurements were taken. As repeat data are not available, it is not possible to make any comparison of extents over time in order to calculate change. This has reduced the confidence in both indicators to medium. More resources are needed to accurately and regularly map sandbanks using bathymetry techniques.

Sediment, topography and hydrodynamics

Granulometric analysis indicated some variations in sediment composition particularly fluctuating between 250-500 µm (medium sand) and 500-1000 µm (coarse sand) grain size. This variation could be explained by the topography of a sandbank. Sample stations are in fixed positions but sandwaves move across the bank over time. This means that sometimes samples may be collected from the peak of a sandwave and sometime from the trough and flanks, which could explain the variation in grain size. Bathymetry images of the sandbank would help further understand these topographic changes, and whether they are responsible for variation in sediment grain size. The macrofaunal abundance was positively correlated (weak relationship) to the sediment composition for both sandbanks, indicating that communities are to some extent determined by sediment characteristics. The sediment composition and distribution indicator met its target based on the knowledge that there were no anthropogenic activities nearby that could significantly impact the sandbank sediment. Confidence in the pass is high due to the availability of long term monitoring data and lack of concerning patterns or changes in sediment composition.

The topography and hydrodynamic and sediment transport processes are not well researched for sandbanks. These indicator targets were met with a medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the sandbanks feature in the Pen Llŷn a'r Sarnau SAC.

Water quality

It has been estimated that approximately 65% of the sandbanks feature within the SAC falls within two WFD waterbodies, therefore these are likely to be a good reflection of the overall effect of water quality on feature. The Cardigan Bay North waterbody overlaps with the largest proportion of the feature (63%).

Nutrients (DIN only) and phytoplankton

The indicator for nutrients (DIN only) met its target with a high confidence as both of the WFD waterbodies that overlap with the feature were classified with a High status for the DIN element in the 2024 cycle 3 interim classification.

The phytoplankton indicator met the target as both of the overlapping WFD waterbodies were classified with a Good or High status for phytoplankton in the 2024 cycle 3 interim classification. Confidence was reduced to medium as the ecological relationships between phytoplankton and the sandbanks feature are not well understood.

Dissolved oxygen

The dissolved oxygen indicator met its target. The dissolved oxygen samples were taken at the water's surface. By the time oxygen depletion at the surface is recorded, oxygen throughout the water column could have been depleted for some time, especially as hypoxia or low oxygen levels, when present, typically occur in bottom water and sediments. Therefore, surface sampling of dissolved oxygen may not detect issues for more demersal features. This reduced the confidence in the pass to medium.

Contaminants

One of the two WFD waterbodies that overlaps with the sandbanks feature has a fail for chemicals in the 2024 cycle 3 interim classification. The failures were in the Cardigan Bay North waterbody, which failed for mercury and PBDE. This waterbody overlaps with the largest proportion of the feature (63%), which caused the contaminants indicator to fail. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of sandbanks are not fully understood. The other WFD waterbody, Caernarfon Bay South, was not classified as the chemicals have not been assessed within the last six years. The confidence in the failure was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. None of the loggers overlap with the sandbanks feature, but three of the six loggers are within 3 km of sandbanks. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

Both of the overlapping WFD waterbodies were classified as Good status for the IQI element in the 2024 cycle 3 interim classification (Cardigan Bay North and Caernarfon Bay South). Combined, these waterbodies overlap with 65% of the sandbanks feature.

Infaunal analysis showed that the species comprising the communities present in the three monitored sandbanks varied widely. There have been some noticeable changes, which are unexplained but there is no evidence to suggest these are attributable to anthropogenic activity. These changes have lowered the confidence to medium in the pass for the abundance, distribution and species composition of communities indicator.

There was a large decline in species richness from 2001 to 2012 seen across the three sandbanks. Species richness has appeared to recover, however, and has continued to increase above previous levels seen in 2001 for Tripods and Bastram Shoal. Diversity followed the same pattern with a decline in 2009 and subsequent increase in recent years for Tripods and Devils Ridge. The diversity at Bastram Shoal sandbank tended to vary a lot over time but indicated a decrease in recent years (2018, 2021), causing some uncertainty. This has reduced the confidence in the indicator pass for species richness and diversity to medium.

In the three most recent monitoring years (2015, 2018 and 2021) the average taxonomic distinctness for Bastram Shoal (analysis based on wider species list) was within the expected levels. The average taxonomic distinctness for the other two monitored sandbanks remained stable and within the expected values over the monitoring period. This resulted in a pass for the taxonomic spread of species indicator with high confidence.

Invasive non-native species

The polychaete *Goniadella gracilis,* a low impact species, was first recorded within the sampling stations in Tripods sandbank in 2001 and has subsequently been found every year in low abundance in Bastram Shoal. No new non-native species (NNS) were recorded in the sandbanks feature within the last six years, resulting in the NNS indicator to meet its tertiary target. Confidence in the pass was reduced to medium as there have been no targeted surveys for NNS on sandbanks.

It is not fully understood how this species may impact the condition of the sandbanks feature within the SAC, and effects on the species diversity and composition have not yet been observed. As there is no current impact from any INNS present the primary target of the INNS indicator passed. Confidence was reduced to medium as whilst there have been no new records of NNS in the last six years, there have been no targeted surveys of NNS, and the spread and impacts of any INNS present within the feature are not well understood.

Reasons for target failure

The sandbanks feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, one secondary target failed to be met and needs to be kept under review.

Water quality: contaminants

This indicator target has a secondary weighting. A large proportion of the sandbanks feature in the SAC overlaps with one WFD waterbody, Cardigan Bay North, which has a fail for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The exact sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. A WFD investigation of the failures is yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

Threats to condition

Part of the condition assessment is to identify threats to the condition of sandbanks. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission process whereby the impact of the activity on the feature would be assessed have not been included. The threats to the sandbanks feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Invasive non-native species

INNS are not currently an issue but high numbers in the future may have an impact on the sandbanks feature.

There have been confirmed records of *Crepidula fornicata* within the Pen Llŷn a'r Sarnau SAC. There are currently no recorded observations of the species on the sandbanks feature. At high densities, this species could cause an impact on the feature (see further detail in Section 3.1).

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the sandbanks feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024):

- Changes in sea temperature and salinity,
- Ocean acidification,
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 12) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 12. Evidence gaps for the sandbanks feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

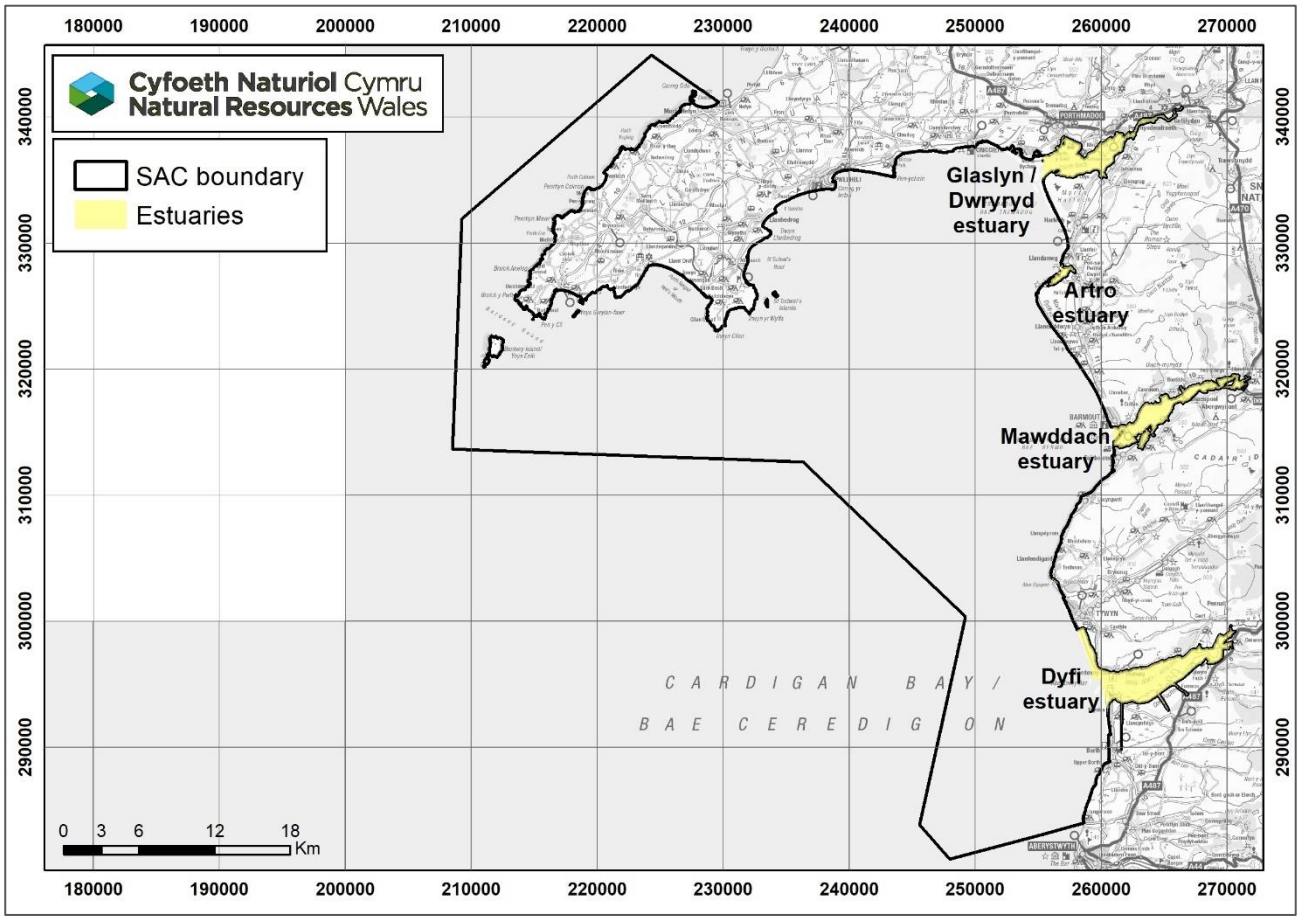
Indicator	Assessed status	Comments
Distribution and extent of habitats and communities (P)	Not assessed	• Biotopes are not well established for sandbanks. There is a lack of any recent information on biotopes classification for sandbanks therefore this indicator was not assessed in any of the SACs.
Topography of the feature (P)	Medium confidence (proxy data used)	• The topography of sandbanks is not well monitored in all SACs. More bathymetry surveys for all sandbanks are required in future.
Hydrodynamic and sediment transport processes (P)	Medium confidence (proxy data used)	• The hydrodynamic regime of sandbanks is not currently monitored in all SACs.
Invasive non-native Species (P)	Medium confidence (limited data)	• The spread and impact of the NNS currently present within the SAC on the sandbanks feature is not fully understood. More targeted surveys and investigation on the impact of NNS on sandbanks are needed.

Indicator	Assessed status	Comments
Sediment quality: oxidation-reduction profile (S); volume (S); organic carbon content (S); contaminants (S)	Not assessed	• These aspects are not currently monitored in sandbank sediment particle size analysis (PSA), but could be incorporated into analysis in future.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.4. Estuaries condition assessment

The estuaries feature in the Pen Llŷn a'r Sarnau SAC comprises four estuaries, Dyfi, Glaslyn / Dwyryd, Mawddach and Artro (Figure 9). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 9. Map of the estuaries feature in Pen Llŷn a'r Sarnau SAC.



The estuaries features in the SAC includes the nested features: mudflats and sandflats, Atlantic salt meadows (ASM), *Salicornia* and reefs. The areas within the estuaries (mainly the estuary channels) that are not covered by the nested features have not been monitored and therefore expert judgement was used in the assessment. Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 13 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 13. Condition assessment of estuaries in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	No significant decrease in extent of estuaries within the SAC, allowing for natural change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the extent of estuaries in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain the distribution of the estuaries within the SAC, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution of estuaries in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of estuarine habitats and communities, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution and extent of habitats and communities of estuaries and its nested features in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the estuaries, allowing for natural change and variation. (P)	• This assessment of sediment composition is based on the condition assessment of the mudflats and sandflats feature as there were no other data available. Mudflats and sandflats cover approximately 50% of the estuaries feature. • Overall, granulometric analysis showed some variation in sediment composition, but this was deemed likely to be natural. • Confidence is medium due to the variation in the sediment composition from river channel changes. Data on subtidal sediments were not available, however the intertidal sediments should be fairly reflective of subtidal sediments in the SAC.	**Pass**	Medium
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to estuarine infaunal communities, allowing for natural change and variation. (S)	• This assessment uses the results of the condition assessment of this indicator from the mudflats and sandflats feature as a proxy as there were no other data available. The redox layer profile of the monitored mudflats and sandflats indicated no clear trend over the years. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to infaunal communities, allowing for natural change. (P)	• There are no recent data for organic carbon content for the estuaries within Pen Llyn a'r Sarnau SAC, as the Clean Safe Seas Environmental Monitoring Programme (CSEMP) data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• There are no recent data for sediment contaminants for the estuaries within Pen Llyn a'r Sarnau SAC, as the CSEMP data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Morphological equilibrium	Maintain the characteristic physical form and flow of the estuary, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the morphological equilibrium of estuaries in the Pen Llyn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the estuaries. (S)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the topography of estuaries in the Pen Llyn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the hydrodynamic and sediment transport processes of the feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Dyfi estuary comprises 46% of the feature, Glaslyn / Dwyryd estuary 27%, Mawddach 25% and Artro 2%. • All five WFD waterbodies that overlap with the feature were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Dyfi / Leri, Glaslyn, Mawddach, Cardigan Bay North and Artro). Combined, these represent 70% of the whole estuaries feature. • Classifications for the Dyfi / Leri, Glaslyn and Mawddach waterbodies were rolled forward from the 2018 cycle 2 interim and 2021 cycle 3 classifications. This caused the confidence to be medium.	**Pass**	Medium
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	Within the SAC, Dyfi estuary comprises 46% of the feature, Glaslyn / Dwyryd estuary 27%, Mawddach 25% and Artro 2%. • One of the five WFD waterbodies was classified with a High status for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay North). It represents 2% of the whole feature. • The other four WFD waterbodies were not classified for phytoplankton. Combined, these waterbodies represent 68% of the whole feature. • This indicator has been assessed as unknown as a large proportion of the feature overlaps with unclassified waterbodies.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	Within the SAC, Dyfi estuary comprises 46% of the feature, Glaslyn / Dwyryd estuary 27%, Mawddach 25% and Artro 2%. • Two of the five WFD waterbodies were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Glaslyn and Cardigan Bay North). Combined, these waterbodies represent 23% of the feature. • The other three WFD waterbodies were classified as Good or High status for opportunistic macroalgae (Dyfi / Leri, Mawddach and Artro). Combined, these represent 47% of the feature. One of these waterbodies' classification was rolled forward from the 2021 cycle 3 classification. • Confidence is medium due to the rolled forward classification, and unclassified waterbodies.	**Pass**	Medium
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Three of the five WFD waterbodies were not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Dyfi / Leri, Glaslyn and Mawddach). Combined, these waterbodies represent 66% of the whole feature. ○ These waterbodies were previously classified as High status prior to the 2018 cycle 2 interim classification and are therefore considered low risk. • Two of the five WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Cardigan Bay North and Artro). Combined, these represent 3% of the feature. • Confidence is low due to samples being taken from the surface of the waterbody, and as a large proportion of the feature has not been classified.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	Within the SAC, Dyfi estuary comprises 46% of the feature, Glaslyn / Dwyryd estuary 27%, Mawddach 25% and Artro 2%.
		• Two WFD waterbodies overlap with the Dyfi estuary.
		  ○ The Cardigan Bay North waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to mercury and PBDE. This coastal waterbody overlaps with 4% of the Dyfi estuary (2% of the whole estuaries feature).
		  ○ The Dyfi / Leri waterbody has a pass for chemicals, but the chemical classifications were rolled forward.
		• The one WFD waterbody that overlaps with the Mawddach estuary has a fail for chemicals, due to PBDE (Mawddach). It overlaps with 73% of the Mawddach estuary (18% of the whole feature). All of the chemical classifications were rolled forward from the 2021 cycle 3 classification.
		• Two WFD waterbodies overlap with the Artro estuary.
		  ○ The Artro waterbody was not classified as the chemicals have not been assessed within the last six years. It overlaps with 60% of the Artro estuary (1% of the whole estuaries feature).
		  ○ The Cardigan Bay North waterbody has a fail for chemicals and overlaps with <1% of this estuary.
		• The one WFD waterbody within the Glaslyn/ Dwyryd estuary was not classified as the chemicals have not been assessed within the last six years.
		• Confidence is medium as the human health standard has been used for PBD, and as some WFD waterbodies were unclassified or had rolled forward classifications.
			Fail	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the estuaries feature in the Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Water quality: physicochemical properties of the water column	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Four of the six overlapping WFD waterbodies were classified as Good or High status for the IQI WFD element in the 2024 cycle 3 interim classification (Cardigan Bay North, Dyfi / Leri, Glaslyn and Mawddach). Combined, these represent 68% of the feature. The other two WFD waterbodies, which represent 1% of the feature, were not classified for IQI. • No issues were identified for the overlapping nested mudflats and sandflats feature. • The indicator was assessed as unknown for the nested ASM feature due to limited data. Heavy grazing occurs in the Dwyryd and Mawddach estuaries and is likely to impact the species composition, however no information is available to confirm this. This nested feature overlaps with approximately 24% of the estuaries feature. • Confidence is medium because of the uncertainty over the impact of grazing in the ASM feature and due to the lack of fish communities data.	**Pass**	Medium
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• Limited evidence to suggest that INNS (e.g. *Gracilaria vermiculophylla*) are currently impacting the condition of estuaries in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• *G. vermiculophylla* has been recorded within the last six years within the Glaslyn / Dwyryd, Mawddach and Dyfi estuaries. • There have been targeted INNS surveys as part of the MarClim project and ad-hoc records from the NRW Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The estuaries feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (medium confidence). Overall, the lack of any significant anthropogenic impact on this feature in term of extent, hydrodynamic processes, topography, sediment composition and its associated community, have contributed to this favourable assessment outcome. There were two indicators with failing targets (Table 14). There were also limited or absent data for four key indicators to inform on the condition of the feature (see evidence gaps). Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in Table 14 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 14. Summary of the condition assessment for estuaries in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Estuaires	**Favourable (medium confidence)**	Water quality: contaminants (S) Non-native species (T)	• Levels of mercury and PBDE in the Mawddach and Cardigan Bay North waterbodies are failing to meet their relevant EQSs. • There has been an increase in the number of NNS in the feature SAC, including *G. vermiculophylla*.	• Unconsented infrastructure • INNS • Overgrazing • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

Extent and Distribution of the feature

The feature extent and distribution indicators in the Pen Llŷn a'r Sarnau SAC passed their target as there are no known anthropogenic impacts that have significantly affected the extent of the estuaries feature since designation in 2004. Comparison mapping has not been used to assess the extent and only expert judgment was used in the absence of recent data. This has reduced the confidence to medium.

Distribution and extent of habitats and communities

Grazing pressure within the SAC could possibly have an impact on the saltmarsh distribution and would be something to pay close attention to in the next assessment (Section 3.7). The indicator was assessed as passing the target but with a medium confidence as the assessment was made using expert judgment.

Sediments

Composition and distribution and oxidation-reduction profile (redox layer)

Sediments are monitored within the mudflats and sandflats habitat within the estuaries feature. The mudflats and sandflats feature in the SAC overlaps with approximately 50% of the estuaries feature. It was therefore deemed acceptable to use the mudflats and sandflats condition assessment as a proxy for the sediment composition and distribution, and redox layer indicators. Both indicators met their targets with medium confidence for sediment composition and distribution and low confidence in the pass for the redox layer indicator. The intertidal sediments in this SAC should be fairly reflective of the subtidal sediments, therefore the absence of data for subtidal sediments did not reduce the confidence further in the composition and distribution indicator. Low confidence was attributed to the redox layer indicator as further sampling is required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer (Section 3.6).

Organic carbon content and contaminants

Sediment contaminants and organic carbon content were previously monitored at two stations in the SAC by CSEMP, however the monitoring ceased in 2015. The data were deemed to be out of date and these indicators were assessed as unknown.

Morphological equilibrium, topography and hydrodynamic and sediment transport processes

The morphological equilibrium, topography and hydrodynamic and sediment transport processes are not well researched. These targets passed with medium confidence based

on the knowledge that there are no anthropogenic activities known to have significantly impacted the feature and its nested features since designation in 2004. The freshwater flow indicator could not be assessed due to limited resource.

Water quality

It has been estimated that 70% of the estuaries feature falls within six WFD waterbodies (Table 15, Figure 10). These are likely to be a good reflection of the overall effect of water quality on the feature. The Dyfi estuary is the largest of the four estuaries within the SAC (46.5% of the estuaries feature). The Glaslyn / Dwyryd (26.9%) and Mawddach (24.6%) estuaries also represent a large proportion of the feature, and the Artro is much smaller (2.1%).

Table 15. Designated estuaries within the Pen Llŷn a'r Sarnau SAC and the WFD waterbodies that overlap.

Estuary	WFD waterbody	Degree of overlap across indv. estuary (%)	Degree of overlap across estuaries feature (%)
Dyfi	Dyfi / Leri	59.40	27.61
Dyfi	Cardigan Bay North	4.45	2.08
Glaslyn / Dwyryd	Glaslyn	77.47	20.82
Mawddach	Mawddach	73.27	17.99
Artro	Artro	59.80	1.25
Artro	Cardigan Bay North	0.30	2.08

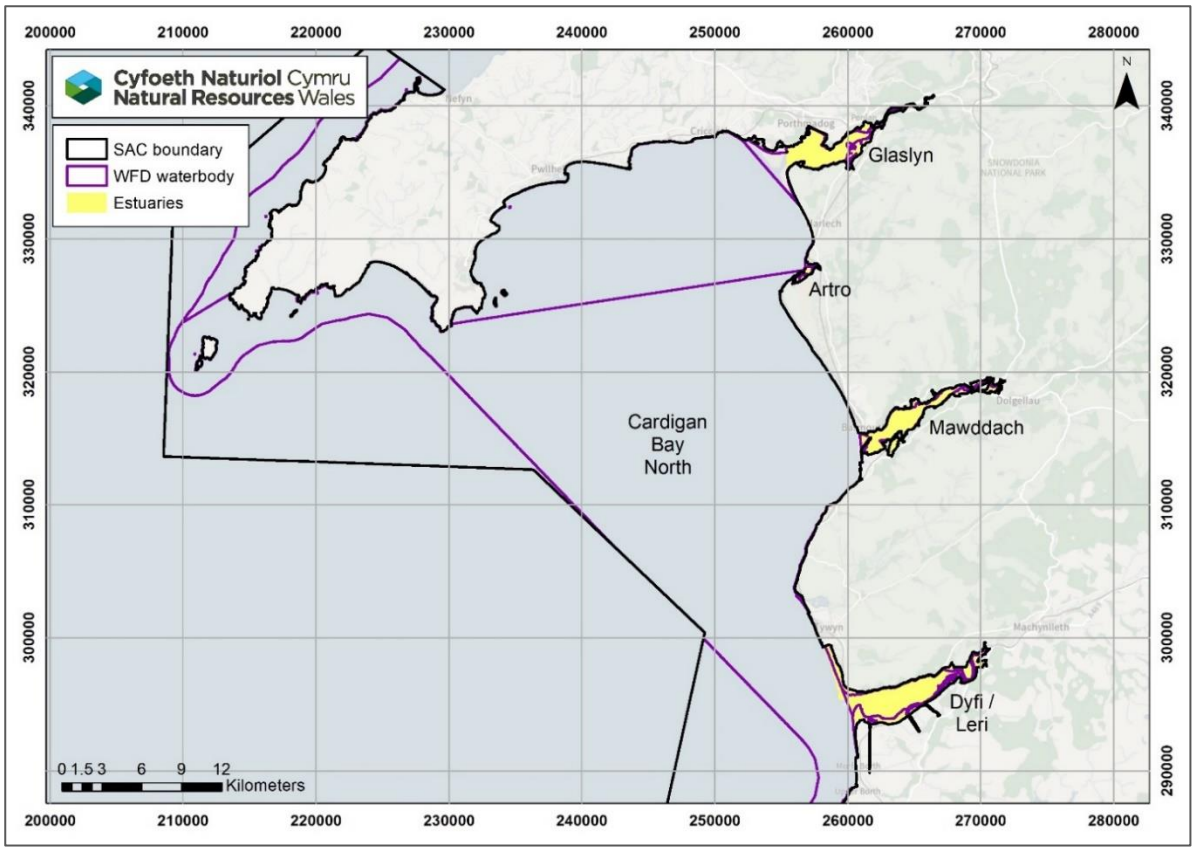
Nutrients (DIN only)

The nutrients (DIN only) indicator met its target as all of the WFD waterbodies that overlap with the feature were classified as Good or High status for DIN in the 2024 cycle 3 interim classification. Some of these classifications were rolled forward from the 2018 cycle 2 interim and 2021 cycle 3 classifications. These WFD waterbodies (Dyfi / Leri, Glaslyn and Mawddach) overlap with the largest three estuaries. This reduced the confidence in the pass to medium.

Phytoplankton

The phytoplankton indicator was assessed as unknown as a large proportion of the feature overlaps with WFD waterbodies that were not classified for the phytoplankton element in the 2024 cycle 3 interim classification (Dyfi / Leri, Glaslyn, Mawddach and Artro). Combined, these waterbodies represent 68% of the whole feature (Table 15). It should be noted that classification of some of these waterbodies may not be suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels).

Figure 10. Map of the WFD waterbodies that overlap with the estuaries feature within Pen Llŷn a'r Sarnau SAC.



Opportunistic macroalgae

The indicator for opportunistic macroalgae met the target as three of the five overlapping WFD waterbodies were classified with Good or High status in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach and Artro). Combined, these waterbodies represent 47% of the whole feature, and overlap with three of the four estuaries within the SAC (Table 15). Confidence was reduced to medium because one of these waterbodies (Mawddach) had a classification that was rolled forward from the 2021 cycle 3 classification. In addition, two WFD waterbodies were not classified for the opportunistic macroalgae element. The unclassified waterbodies represent 23% of the feature (Table 15). Some WFD waterbodies are not assessed for opportunistic macroalgae as they don't have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Dissolved oxygen

The dissolved oxygen indicator met its target. Two of the five WFD waterbodies that overlap with the estuaries feature were classified as High status for DO. Across the whole estuaries feature, these waterbodies represent only 3%. The other three WFD waterbodies were not classified for dissolved oxygen in the 2024 cycle 3 interim classification, however these were previously classified as High status prior to the 2018 cycle 2 interim classification and are therefore considered low risk. The dissolved oxygen samples are taken at the water's surface. By the time oxygen depletion at the surface is recorded, oxygen throughout the water column could have been depleted for some time, especially as hypoxia or low oxygen levels, when present, typically occur in bottom water and

sediments. Therefore surface sampling of dissolved oxygen may not detect issues for more demersal habitats within the estuaries feature. This, and as a large proportion of the feature has not been classified for this element, reduced the confidence in the pass to low. However, the unclassified waterbodies are not deemed to be at risk from failing this element.

Contaminants

Two of the five WFD waterbodies that overlap with the estuaries feature have a fail for chemicals in the 2024 cycle 3 interim classification, which caused the contaminants indicator to fail. The Mawddach waterbody failed for PBDE. This is the only waterbody that overlaps with one of the larger estuaries in the SAC, the Mawddach estuary (Table 15). The chemicals in this waterbody however have not been classified in the 2024 cycle 3 interim classification and were rolled forward from the 2021 cycle 3 classification. The PBDE has failed in this waterbody since the 2015 cycle 2 classification. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of estuaries are not fully understood. The Cardigan Bay North waterbody failed for mercury and PBDE. This coastal waterbody overlaps with a small proportion of two estuaries in the SAC (Dyfi / Leri and Artro), and it represents 2% of the whole estuaries feature (Table 15). Some of the chemical classifications in this waterbody were rolled forward from the 2021 cycle 3 classification, including mercury and PBDE. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife).

Two WFD waterbodies across the feature were not classified as the chemicals have not been assessed within the last six years. These are the Glaslyn and Artro waterbodies, which combined represent 22% of the whole feature. The other WFD waterbody, Dyi / Leri, has a pass for chemicals. However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. The confidence in the failure was reduced to medium due to these unclassified waterbodies or rolled forward classifications, and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. None of the loggers overlap with or are close to the estuaries feature. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

Four of the six overlapping WFD waterbodies were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Cardigan Bay North, Dyfi / Leri, Glaslyn and Mawddach). Combined, these waterbodies represent 68% of the whole feature. The other two WFD waterbodies with small overlaps (representing <2%) have not been classified for IQI.

The mudflats and sandflats feature overlaps with approximately 50% of the estuaries feature. The condition assessment for the mudflats and sandflats feature concluded that the abundance, distribution and species composition of communities met the criteria for a pass. Some concerns were raised, however, for the Dwyryd estuary due to some changes in infaunal communities and will be something to pay close attention to in the next assessment (Section 3.6).

The ASM feature overlaps with approximately 24% of the estuaries feature. In the ASM feature condition assessment, the species composition of the communities indicator was assessed as unknown due to limited data and available resources. However, recent visual observations made in the Dwyryd and Mawddach estuaries in October 2024 has identified some areas of the saltmarshes that remain heavily grazed (H. Lewis (NRW), pers. comm.) (Section 3.7). Overgrazing is likely to have an impact on the species composition of the ASM feature, however no information is available to confirm this.

The reefs feature overlaps with approximately 1.4% of the estuaries feature. The abundance, distribution and species composition of communities indicator met its target for the intertidal reefs relevant to the estuaries feature (Section 3.1).

Although fish within the estuaries are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the estuaries feature. It is likely that European eels are depleted in these estuaries because a general decline is noted in all the rivers in West Wales region (DEFRA, 2021). Depleted numbers of migratory salmonids is also identified due to population reductions in the Mawddach, Dwyryd / Glaslyn and Dyfi estuaries (DEFRA, 2023, 2024a) and catch of sea trout are also failing in these estuaries (DEFRA, 2024b). Data from wider Irish sea level studies such as International Council for the Exploration of the Sea (ICES) are difficult to relate to the assessment of condition at the SAC and feature level and some species that have been assessed by ICES may not even occur at the individual SAC level. However, populations of various larger-bodied bony fish species in the Irish Sea, such as bass, cod, herring, whiting, plaice and pollack, have declined in recent years (ICES, 2024a, 2024b, 2024c, 2024d, 2024e, 2024f). While there are limited data on the status of other species, the depletion of a number of larger, higher trophic level predatory species in the Irish Sea may have shifted the structure of the wider fish community to an overall lower trophic level with fewer larger predatory fish species. None of the WFD waterbodies that overlap with the estuaries feature in the SAC have been assessed using the fish tool in the 2024 cycle 3 interim classification.

Overall, the abundance, distribution and species composition of communities indicator for the estuaries feature in Pen Llŷn a'r Sarnau SAC met its target. However confidence was reduced to medium because of the uncertainty over the impact of grazing in the ASM feature and the potential loss of structural diversity in the ASM vegetation, and due to the lack of fish communities data for the estuaries feature.

Invasive non-native species

Gracilaria vermiculophylla was recorded within the last six years in the Glaslyn / Dwyryd, Mawddach and Dyfi estuaries within the mudflats and sandflats feature (Mercer and Brazier, 2023). Therefore, the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the estuaries feature within the last reporting cycle.

Other NNS are known to be present in the Pen Llyn a'r Sarnau SAC but not within the estuaries feature, including *Crepidula fornicata, Magallana gigas* and *Sargassum muticum*.

It is not fully understood how some of these species may spread and impact the condition of the estuaries and the nested habitat features within the feature, and effects on the species diversity and composition have not yet been observed. As there is no current impact from the INNS present the primary target of the INNS indicator passed. Confidence is low as the impacts of the INNS present within the feature are not well understood.

Reasons for target failure

The estuaries feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, one secondary target and one tertiary target failed to be met and need to be kept under review.

Water quality: contaminants

This indicator target has a secondary weighting. Two WFD waterbodies that overlap with the Mawddach, Dyfi, and Artro estuaries (Mawddach and Cardigan Bay North) had failing levels of chemicals including PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous sewage discharge from the water industry. The sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. WFD investigations of the failures in both WFD waterbodies are yet to be undertaken. Mercury and PBDE are being managed and it is hoped that these levels will reduce in time.

Non-native species

This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to the introduction of *G. vermiculophylla* over the last six years. This species has spread within the mudflats and sandflats feature in the Glaslyn / Dwyryd, Mawddach and Dyfi estuaries in the last reporting cycle. Investigation into the management of spread of this species has not been done widely (Maggs and Magill, 2014). Targeted surveys of the species and investigation into its impact are required. In addition, whilst not yet recorded in the estuaries feature, the number of *C. fornicata* has increased in the SAC in recent years.

The full extent of the impact that these species, along with other NNS present within the SAC, may have on the condition of the feature is currently unknown. For this reason it did not fail the primary target of the INNS indicator. A biosecurity plan for INNS has been developed for the SAC. The objective is to manage the key pathways by which marine INNS are introduced and spread at the SAC level through the use of good biosecurity.

Threats to condition

Part of the condition assessment is to identify threats to the condition of estuaries. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the estuaries feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Unconsented infrastructure

New unconsented infrastructures such as private slipways and coastal defences, modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impact to the flora and fauna associated with it.

Invasive non-native species

G. vermiculophylla has been found in the estuaries feature. This species has the potential to establish quickly in shallow soft-bottomed bays and can have detrimental impact on the feature (see further detail in Section 3.2).

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Overgrazing

Overgrazing can result in a loss of structural diversity in saltmarsh vegetation, resulting in a short uniformly cropped marsh that may be detrimental to some taxa such as waders and invertebrates (Sherry and Douglas, in draft). As healthy vegetation helps reduce tidal and storm surge energy and can change currents within the estuary channels, any changes in vegetation can affect the flood risk, hydrodynamics and sediment transport within an estuary (Bennett et al., 2020; 2023). The impacts of grazing are more pronounced in smaller estuaries. Extensive grazing of some Welsh saltmarsh was found to have a large impact on wave attenuation with increases in wave height and current velocities resulting in erosion (Bennett et al., 2020; 2023).

Additionally, sheep grazing and the subsequent wash-off of faecal material from the intertidal saltmarsh may result in episodic events of high bacteria concentrations. A high

number of grazing sheep can result in poor water quality, even several kilometres from the grazed marsh (e.g. Burry Inlet).

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the estuaries feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Management of coastal defences

The State of the UK Climate 2023 Report highlights an observed acceleration in rates of climate induced sea-level rise which, along with storm surges can cause coastal erosion and flooding (Kendon et al, 2024). Shoreline Management Plans identify the preferred approach to coastal management in light of climate change, which includes maintaining or upgrading defences in some areas and adapting the approach to management in others. Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species. Intertidal habitats may also be lost as a result of coastal squeeze (Oaten et al, 2024).

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Kendon et al., 2023; Kendon et al., 2024; Gihwala et al., 2024; Oaten et al., 2024):

- Sea level rise.
- Changes to wave climate, especially storm frequency and intensity, which may change the topography.
- Changes to freshwater input and flow (i.e. from changes in rainfall).
- Changes in air and sea temperature.
- Changes in ocean acidification.
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 16) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments. There are additional evidence gaps concerning the nested features, which can be found in the relevant sections of this report.

Table 16. Evidence gaps for the estuaries feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Freshwater inputs (P)	Not assessed	• The freshwater flow indicator could not be assessed in all SACs due to limited resource. There are data available on abstractions and flow levels in estuaries therefore this is something that should be used in future condition assessments.
Sediment quality: organic carbon content (P); contaminants (P)	Unknown	• Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring ceased in 2015. These data were deemed to be out of date and there are no recent data available.
Abundance, distribution and species composition of communities (P)	The fish community element did not contribute to the condition outcomes.	• Fish communities were broadly discussed for all SACs using reports including ICES data. Although these reports provide an indication of fish numbers, they have certain limitations. The large area covered makes it unsuitable for estuaries or individual SAC. More data would be required to adequately assess fish communities in estuaries.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present on the estuaries feature within the SAC are not fully understood. More targeted surveys and investigation on the impact of NNS on estuaries are needed. • Investigation into the use of satellite and or aerial imagery for assessing the extent of *G. vermiculophylla* may be beneficial.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was hard to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening for all SACs.
Water quality: phytoplankton (S)	Unknown	• A large proportion of WFD waterbodies that overlap with the estuaries feature in Pen Llŷn a'r Sarnau SAC have not been classified for phytoplankton WFD element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for phytoplankton due to the nature of the waterbodies.

Indicator	Assessed status	Comments
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence in temperature changes is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.5. Coastal lagoons condition assessment

The coastal lagoons feature in the Pen Llŷn a'r Sarnau SAC comprises of a single lagoon, Morfa Gwyllt. The lagoon is a small percolation lagoon that consists of a depression in a shingle bar across the mouth of the Afon Dysynni in mid Wales (Figure 11). Monitoring data collected between 2006-2021, together with other relevant evidence has been used to assess the performance indicators.

Figure 11. Map of the coastal lagoons feature in Pen Llŷn a'r Sarnau SAC.

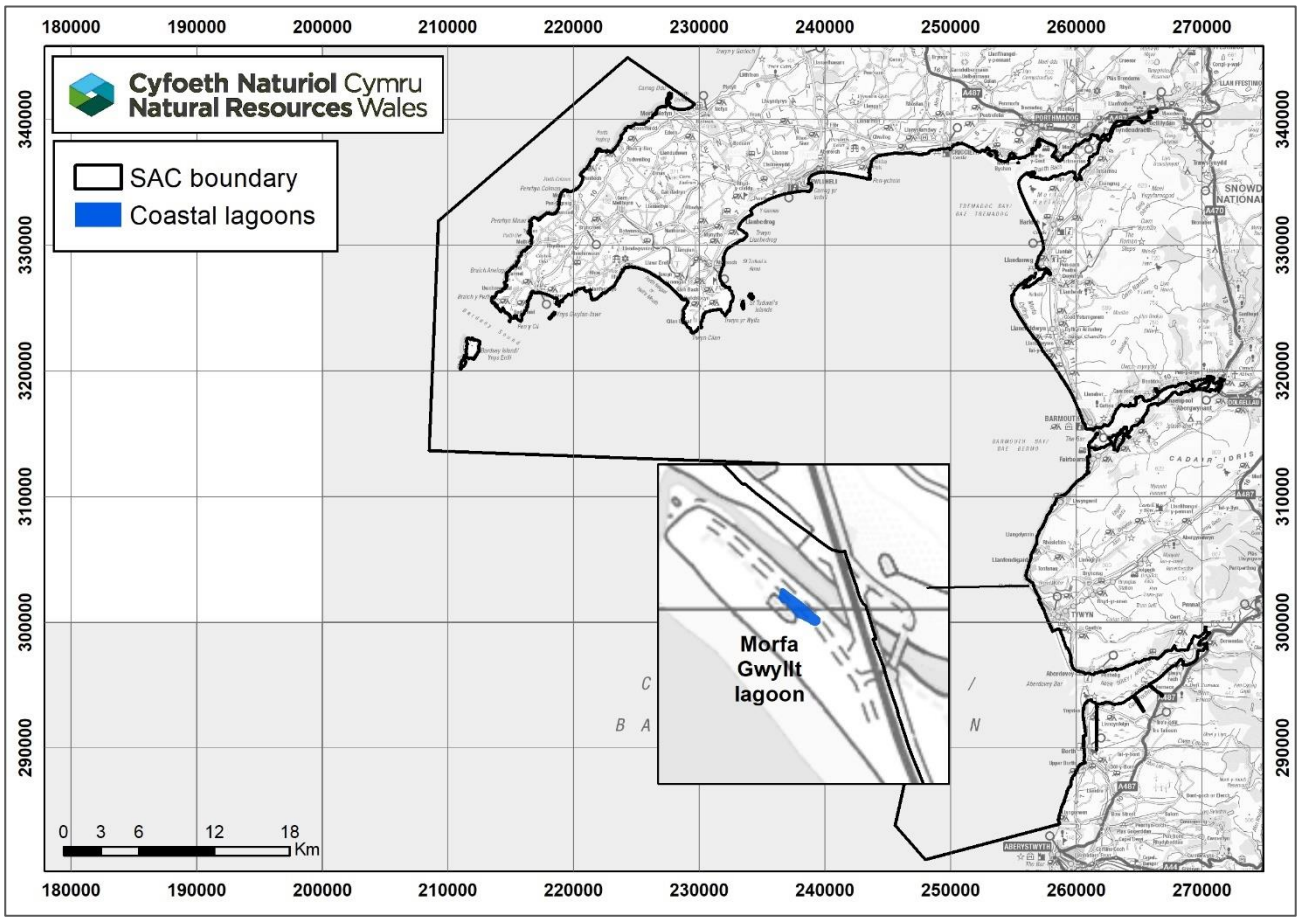


Table 17 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions.

Table 17. Condition assessment of the coastal lagoon in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of coastal lagoon within the SAC, allowing for natural change and variation. (P)	• Extent, determined from aerial imagery, has been judged to be stable. • There have been some very minor losses to the extent since 2000. Due to the small scale of the losses, these are considered to be within the limits of natural variation and the indicator passed. • The lagoon is very shallow and there is some grass encroachment from the intertidal, but it is currently not considered an issue. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Shape of lagoon	Maintain the shape of coastal lagoon, subject to natural change and variation. (P)	• The shape of the lagoon has been determined from aerial imagery. • The overall shape of the lagoon remains broadly similar and the indicator passed. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Isolating barrier integrity	No loss in integrity of any of the lagoons isolating barriers, allowing for natural change and variation. (P)	• Currently, no impacts on barrier integrity have been identified. • However, the confidence is low as there is limited information on this issue.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Integrity of lagoon banks	No loss in integrity of any of the lagoon's banks, allowing for natural change and variation. (S)	• Currently, no impacts on bank integrity have been identified. • However, the confidence is low as there is limited information on this issue.	**Pass**	Low
Species composition of communities	No modification of the expected composition of lagoon communities, allowing for natural change and variation. (P)	• Analysis of macrobenthic infaunal communities showed variation across the sampling period of 2006-2021 but with no defined pattern. There was a sudden change in the year 2020 but communities seemed to come back to previous state in 2021. • The variation in the composition of communities is judged to be within the limits of natural variation. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Abundance of lagoon specialists	Maintain the abundance of lagoon specialist species, allowing for natural change and variation. (P) List of species for the SAC: *Chaetomorpha linum, Conopeum seurati*, *Lekanesphaera hookeri*.	From data collected between 2006-2021: • Abundance of *Lekanesphaera hookeri* varied greatly depending on the sampling methods but was present in high numbers in 2019 using sweep net surveys. • There were declines in two lagoon specialists, which is a cause for concern. • *Conopeum seurati* and *Chaetomorpha linum* have been absent from monitoring in recent years. • Confidence is low as the sampling method may not be appropriate to detect *C. seurati* and *C. linum* .	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of lagoon species, allowing for natural change and variation. (P)	• Analysis of monitoring data has shown declining species richness and diversity over time. • Over the period of 2006-2021, there was a negative correlation in both species richness and species diversity with time. • Confidence in fail is low due to variability in the pattern of decline.	**Fail**	Low
Taxonomic spread of species	Maintain the expected taxonomic spread of lagoon species, allowing for natural change and variation. (P)	• Analysis has shown variation in taxonomic spread across years, however, there were no years where the average taxonomic distinctiveness was below what was expected. • Confidence is medium due to the low number of taxa recorded.	**Pass**	Medium
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is no evidence to suggest that INNS are spreading into the lagoon and impacting its conditions. • Confidence is medium as the impacts of INNS present within the feature are not well understood.	**Pass**	Low
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• No new NNS have been found in the lagoon monitoring surveys within the last six years. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition of sediment granulometry across the lagoon, allowing for natural change and variation. (P)	• Principal Component Analysis (PCA) showed that sediment composition varied through time with no consistency, with no trend detected, and no concerns. • No major anthropogenic changes that could impact sediment composition were identified. • Weak correlation was detected between sediment composition and abundance of macrofaunal community. • Confidence in the pass is high due to the long data series.	**Pass**	High
Water depth	Maintain the expected depth of water within the lagoon, allowing for natural change and variation. (P)	• Water depth has been decreasing on average. • There has been an increasing number of events where the water depth has decreased below 0.3m. • Decrease in depth is potentially linked to the excavation of the channel entrance of the Dysynni river to manage flooding. • Confidence is medium as there are gaps in the data due to missing loggers.	**Fail**	Medium
Presence of materials and debris of anthropogenic origin	Anthropogenic material should not be having a detrimental impact on coastal lagoon. (S)	• Anthropogenic materials and debris have not been surveyed in a targeted way but have been counted or weighed as part of the infaunal surveys since 2017, though not consistently. • Microplastic counts took place in 2016 and 2019-2021. • Confidence is low as it is difficult to determine trends due to the short term and sporadic dataset. Large amounts of debris or microplastics have not been seen in available monitoring data.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• The adjacent WFD waterbodies that feed into Morfa Gwyllt lagoon (Cardigan Bay North and Dysynni) are classified as High or Good status for DIN in the 2024 cycle 3 interim classification. • Morfa Gwyllt is a percolation lagoon therefore the adjacent WFD waterbodies have an influence. • Confidence is medium as there has been no direct monitoring of nutrient levels within the lagoon.	**Pass**	Medium
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the WFD waterbodies that feed into the lagoon was classified as High status for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Cardigan Bay North). • The other WFD waterbody has not been classified for phytoplankton (Dysynni). • Confidence is low due to the unclassified WFD waterbody, and as there is no direct monitoring of phytoplankton in the lagoon.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the WFD waterbodies that feeds into the lagoon has been classified as High status for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification (Dysynni). • The other WFD waterbody has not been classified for opportunistic macroalgae (Cardigan Bay North). • Confidence is low due to the unclassified WFD waterbody, and as there is no direct monitoring of opportunistic macroalgae in the lagoon.	**Pass**	Low
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• One of the adjacent WFD waterbodies was not classified as the chemicals have not been assessed within the last six years (Dysynni). • One of the adjacent WFD waterbodies has a fail for chemicals in the 2024 cycle 3 interim classification, due to mercury and PBDE (Cardigan Bay North). Transfer of contaminated water into the lagoon is thought to be minimal. • Confidence is low as there is no direct monitoring of contaminants in the lagoon, and one WFD waterbody has a fail for this WFD element.	**Pass**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the coastal lagoons feature in Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (P)	• Temperature loggers in the lagoon showed no concerning changes. • Salinity loggers showed increased salinity in 2019 and 2020 (increasing over time and a large number of high salinity events). This increased pattern of salinity had only started in the two most recent sample years. • Increase in salinity is potentially linked to the excavation of the channel entrance of the Dysynni river to manage flooding. • Confidence is low as there are no salinity data post 2020, and as logger data have not been continuous over time. • Only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.	**Fail**	Low

Assessment conclusions

The coastal lagoons feature in Pen Llŷn a'r Sarnau SAC (Morfa Gwyllt) has been assessed as being in **unfavourable** condition (low confidence). There were a number of failing indicators (Table 18). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 18 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 18. Summary of the condition assessment for the coastal lagoons feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failures	Threats to condition
Coastal lagoons	**Unfavourable (low confidence)**	Abundance of lagoon specialist species (P) Species richness and diversity (P) Water depth (P) Water quality: physicochemical properties (P)	• There has been a decline in lagoon specialist species and species richness and diversity. • There is decreasing water depth and increasing salinity, potentially linked to the excavation of the channel entrance of the Dysynni river to manage flooding.	• Physical disturbance • Flood defences • Marine litter • Water quality: contaminants • Climate change

Detailed assessment information

Extent and shape

Aerial imagery and GPS points have been used to determine changes in the extent and shape of the lagoon over the last 21 years. Extent has been judged to be stable as there have only been minor decreases over this time. Due to the small scale of the losses, the change has been attributed to natural variation. There has also been no significant change to the shape of the lagoon during this time. The lagoon is very shallow and there is some grass encroachment from the intertidal, but this was not considered an issue at the time of the assessment. The extent and shape of lagoon indicators were therefore assessed as meeting their targets with a high confidence.

Lagoon barrier and banks

As Morfa Gwyllt is a percolation lagoon, it is isolated from the sea by a shingle ridge. There is a lack of data on the integrity of the isolating barrier and the lagoon banks. However, no serious impacts on either the isolating barrier or lagoon banks have been identified from site knowledge or planning applications. Historically there have been local reports of some impacts to the shingle ridge from motorbike use, but gates have been put in place and there have been no reports since. Both the isolating barrier integrity and integrity of lagoon banks indicators have therefore met their targets, but the lack of data has reduced the confidence of the indicator passes to low.

Species and communities

The angiosperms (*Ruppia*) indicator could not be assessed due to insufficient data.

Changes to the species and communities in a habitat can indicate disturbance to the habitat from various pressures. In Morfa Gwyllt lagoon, the species composition of communities varies across the monitoring period of 2006-2021 with no clear pattern. Community analysis has determined this variation to be within the limits of natural variation, and the species composition of communities indicator meets its target with high confidence.

The isopod *Lekanesphaera hookeri*, a lagoon specialist, was present in high numbers in 2019 using sweep net surveys but showed varying density depending on the sampling methods. However, there has been a decline in the other two lagoon specialists in recent years. *Conopeum seurati* and *Chaetomorpha linum,* have been absent from monitoring surveys in recent years. *C seurati* was recorded previously within the lagoon, with the last record of the species in 2008. There was one unsuccessful targeted survey to look for this species in 2013, and there have been no records in net sweeps or grab samples between 2012-2019. *C. linum* has not been recorded in the lagoon since 2013. Both species are hard to sample with grab and sweep net methods. *C. seurati*, for example, is an encrusting bryozoan commonly inhabiting pebbles on the lagoon floor making them unlikely to be sampled. This means *C. seurati* and *C. linum* may be present and not being picked up in surveys. While it is a concern these species have not been recorded in recent years, it is not certain that they have been lost from the lagoon. This caused the confidence of the

abundance of lagoon specialists indicator to be low. Due to the isolated nature of this lagoon, if the species are truly absent the population is unlikely to repopulate. More targeted surveys are needed.

Analysis revealed a decline in species richness and diversity throughout the lagoon over the monitoring period (2006-2021). This caused the species richness and diversity indicator to fail. However, confidence in the fail is low due to variability in the pattern of decline. The reason for the decline is unclear, though it could be linked to a decrease in water depth reducing the amount of available habitat. Increases in salinity observed in recent years could also be exacerbating the decline.

Analysis of taxonomic spread showed that there were no years where the average taxonomic distinctiveness was below what was expected. Therefore the taxonomic spread of species indicator met its target. There were however a low number of taxa recorded, which reduced the confidence in the pass to medium.

Invasive non-native species

Monitoring between 2006-2021 found only one NNS present in Morfa Gwyllt lagoon. The Ponto-Caspian freshwater hydroid *Cordylophora caspia* has occasionally been recorded between 1998-2017. There have been no records of this species since 2017.

No new NNS were recorded in the coastal lagoons feature within the last six years, resulting in the NNS indicator to meet its tertiary target. Confidence in the pass was high due to the availability of long term monitoring data within the lagoon.

As there is no current impact from *C. caspia* present the primary target of the INNS indicator passed. Confidence is medium as the impacts of the *C. caspia* present within the feature are not well understood.

Sediments, depth and anthropogenic litter

Sediments within Morfa Gwyllt lagoon have varied over the monitoring period of 2006-2021. There has been a general shift from coarser sediments to finer silt over time. However, there have been instances of coarser sand and pebbles at various points before moving back to finer silts. This is not unexpected as it is such a small lagoon, and likely to be heavily influenced by over topping events. The changes seen in sediment granulometry were assessed to be within the limits of natural variation. The sediment composition and distribution indicator target was therefore met with a high confidence.

A conductivity, temperature, and depth (CTD) logger was placed in the deepest part of the lagoon between 2013-2020. This showed an average decrease in depth over time, and an increasing number of events where the water depth has dropped below 0.3m. The water depth indicator therefore failed to meet its target. The data series for loggers in the lagoon is not continuous as there have been periods where the loggers have not worked or have gone missing (i.e. 2018). This reduced the confidence in the fail to medium. The lower water depths are potentially linked to the dredging of the Dysynni river undertaken as part of flood defence works. The river was last dredged in 2018 and water level declines have become more pronounced since 2019 (data missing for 2018). Further investigation is needed, including cross referencing water depth data with meteorological data.

The presence of materials and debris of anthropogenic origin indicator met its target as the small amounts of anthropogenic material found in available monitoring data, were not considered to be having a detrimental impact on the condition of the lagoon. However, there have been no targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This reduced the confidence of the pass to low.

Water quality

No WFD waterbodies overlap with the Morfa Gwyllt lagoon. Morfa Gwyllt is a percolation lagoon and therefore seawater enters predominantly by percolating through the shingle ridge. Therefore the two WFD waterbodies adjacent to the lagoon, Cardigan Bay North and Dysynni, have been used for the water quality assessment.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

Both of the adjacent WFD waterbodies were classified with a Good or High status for DIN in the 2024 cycle 3 interim classification. Other means of nutrient input to the lagoon other than from the adjacent WFD waterbodies is unlikely as the lagoon is on an isolated shingle ridge. The nutrients (DIN only) indicator therefore met its target. The confidence was reduced to medium as there has been no direct monitoring of nutrient levels within the lagoon.

Both the phytoplankton and opportunistic macroalgae indicators met their targets as one of the adjacent WFD waterbodies were classified with a High status for the relevant WFD elements in the 2024 cycle 3 interim classification. The confidence in the passes were reduced to low due to the unclassified WFD waterbodies, and as there has been no direct monitoring for these elements within the lagoon. Classification of some WFD waterbodies is not suitable or possible for the phytoplankton or opportunistic macroalgae elements.

Contaminants

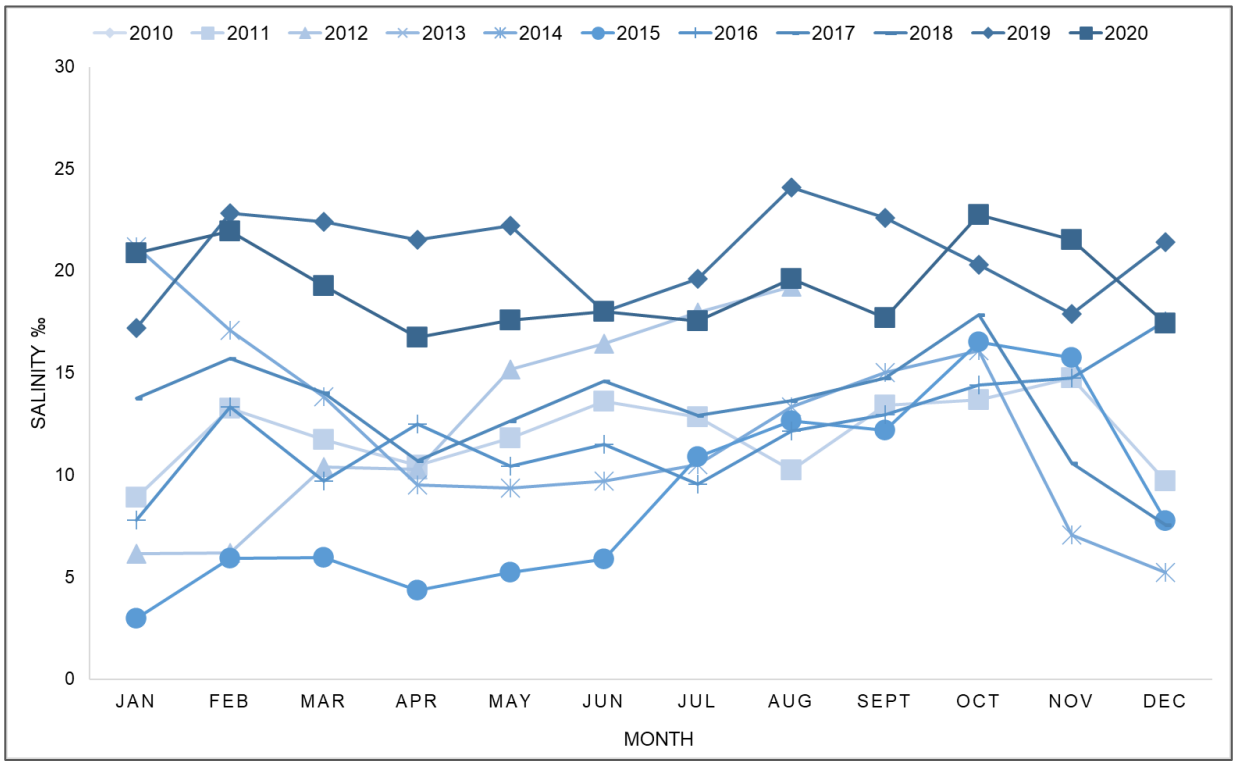
One of the WFD waterbodies adjacent to the lagoon, Cardigan Bay North, has a fail for chemicals in the 2024 cycle 3 interim classification. It failed for mercury and PBDE. Cardigan Bay North is a large coastal waterbody, and previous failing sample locations were collected at a considerable distance from the lagoon, therefore transfer of contaminated water into the lagoon is thought to be minimal. The other WFD waterbody adjacent to the lagoon, Dysynni, was not classified as the chemicals have not been assessed within the last six years. The contaminants indicator met its target, however the confidence was reduced due to the failure of one WFD waterbody and as the other has not been classified. This, together with no direct monitoring for contaminants within the lagoon has led to an overall low confidence.

Turbidity and physicochemical properties

The silt that overlays the bottom of the lagoon is very fine, with a high organic content which can be resuspended in the water column if there is disturbance. The lagoon is frequently used for recreation which could cause disturbance of the silt and increase the turbidity. However, there are limited data on turbidity for the coastal lagoons feature in Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.

Salinity loggers in the lagoon indicated that the salinity increased in 2019 and 2020 (Figure 12). The physicochemical properties indicator therefore failed to meet its target. This increase may be due to the small nature of the lagoon and its low flushing rates, or it could be related to the excavation of the entrance of the Dysynni river channel (last excavated in October 2018). Excavation of the river channel could lower the freshwater table, therefore reducing the freshwater input into the lagoon. Changes in salinity could have consequences for the biota that live within a specific salinity range. Low confidence has been attributed to the failure of the physicochemical properties indicator as there were no salinity data post 2020 available, and because not all physicochemical parameters have been assessed (e.g. pH). There were no concerning changes observed from the temperature loggers in the lagoon.

Figure 12. Average monthly salinity at Morfa Gwyllt lagoon between 2010 and 2020. Some months had incomplete data due to technical issues with the salinity logger.



Reasons for target failure

The assessment of Morfa Gwyllt lagoon failed four primary targets. This resulted in the coastal lagoons feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Abundance of lagoon specialist species

This indicator failed to meet its primary target as two of the three lagoon specialists have been absent from monitoring in recent years (*C. seurati* and *C. linum*). The absence of *C. seurati* may be due to the standard sampling methods not being able to detect the species. However, a targeted survey in 2013 failed to find it. Reasons for the absence of these species is not clear. It could be a natural loss due to the shallow nature of the lagoon limiting the availability of the habitat. However, further investigation is needed, and links

between the decline in water depth and increase in salinity observed should be considered.

Species richness and diversity

This indicator failed to meet its primary target due to a decline in species richness and diversity over time. Declines in these indices can indicate disturbance to the habitat resulting in biodiversity loss. The reductions to species richness and diversity in Morfa Gwyllt lagoon could be due low water depth and concerns around salinity.

Water depth

This indicator failed to meet its primary target due to decreasing depth of water at Morfa Gwyllt lagoon in recent years, with an increase in instances of extreme low water events seen. This was especially the case in 2020. Excavation at the channel entrance of the Dysynni river / Broadwater Lagoon to Tywyn might have affected the depth of the lagoon by lowering the water table, reducing freshwater percolation. The river channel was last dredged in 2018 and extreme low water events within the lagoon have become more evident since 2019. An investigation of the links between dredging and water depth in the lagoon is needed. This is especially important before the dredging work is carried out again. There would be a need to consider air temperature and rainfall data as part of the investigation.

Water quality: physicochemical properties

This indicator failed to meet its primary target due to increasing salinity in the Morfa Gwyllt lagoon in the two most recent sample years (2019 and 2020), with more instances of high salinity events seen. Excavating work of the channel entrance to manage flood risk from the Dysynni river / Broadwater Lagoon to Tywyn might have affected the salinity of the lagoon by lowering the water table reducing the freshwater input to the lagoon.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the lagoon. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the coastal lagoons feature condition in the Pen Llŷn a’r Sarnau SAC are stated below.

Physical disturbance

The area has high levels of recreation which may lead to damage of the lagoon banks or isolating barrier through trampling or vehicle access.

Flood defences

The entrance to the Dysynni river is managed for flood risk through excavation. This has the potential to threaten the water depth in the lagoon.

Marine litter

Marine litter (e.g. microplastics) are increasing and could threaten condition by negativity impacting the sensitive species present.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the coastal lagoons feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024):

- High air temperature increasing evaporation resulting in warming water, lowering water levels, increasing salinity.
- Increased storminess could increase infilling events, turbidity and reduce salinity through increased rainfall.
- Sea level rise in the next reporting cycle could cause the sea to flood the lagoon on more high tides.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 19) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 19. Evidence gaps for the coastal lagoons feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Angiosperms (*Ruppia*) (P)	Not assessed	• At the time of assessment, no surveys of *Ruppia* have been carried out. More targeted surveys to look for *Ruppia* are needed
Distribution and extent of habitats and communities (P)	Not assessed	• Biotopes are not well established for lagoons. Current monitoring is not set up to look at this in depth; additional fieldwork would be required.
Sediment quality: organic carbon content (P); sediment quality: contaminants (P)	Not assessed	• This is not monitored but could be incorporated into PSA analysis in lagoons in future.
Water quality: nutrients (DIN only) (P); phytoplankton (S); opportunistic macroalgae (S)	Low or medium confidence (proxy data used)	• These elements are not currently monitored in the lagoon itself. The assessments have relied upon WFD waterbodies that are adjacent to the lagoon only.
Bathymetry of the feature (S)	Not assessed	• More targeted data would need to be collected to be able to assess changes in bathymetry. There is potential to create continual depth layer for lagoons using LiDAR data.
Hydrodynamic and sediment transport processes (S)	Not assessed	• Lagoon hydrodynamic regimes are not currently monitored.
Presence of materials and debris of anthropogenic origin (S)	Low confidence (limited data)	• Longer datasets and appropriate sampling designs are required for temporal analysis and detecting concerns for the future. A dedicated analysis for plastic should be carried out in a similar fashion to hydrocarbon for sediment. Standardised surveys for large debris are also needed.
Water quality: dissolved oxygen (S)	Not assessed	• Dissolved oxygen is not currently monitored within lagoons. Once a baseline is established monitoring would take place only when intelligence suggests an impact is occurring from an activity.

Indicator	Assessed status	Comments
Water quality: contaminants (S)	Low confidence (proxy data used)	• Contaminants are mostly measured in Wales as part of WFD monitoring, but there is currently no WFD monitoring of contaminants within any of lagoons themselves.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling, but this is limited to only a few samples per year. Therefore, this cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.

3.6. Mudflats and sandflats condition assessment

The mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC is comprised of a number of mudflats and sandflats (Figure 13), but the NRW Habitats Regulations monitoring has been focused on sampling points within mudflats at Black Rock Sands, East Criccieth, Dwyryd estuary, Morfa Dyffryn, Morfa Harlech, Mawddach estuary and Dyfi estuary. These mudflats and sandflats were surveyed between 2008 and 2022 using core sampling as part of the Habitats Regulations monitoring intertidal survey.

Figure 13. Map of the mudflats and sandflats feature in Pen Llŷn a'r Sarnau SAC.

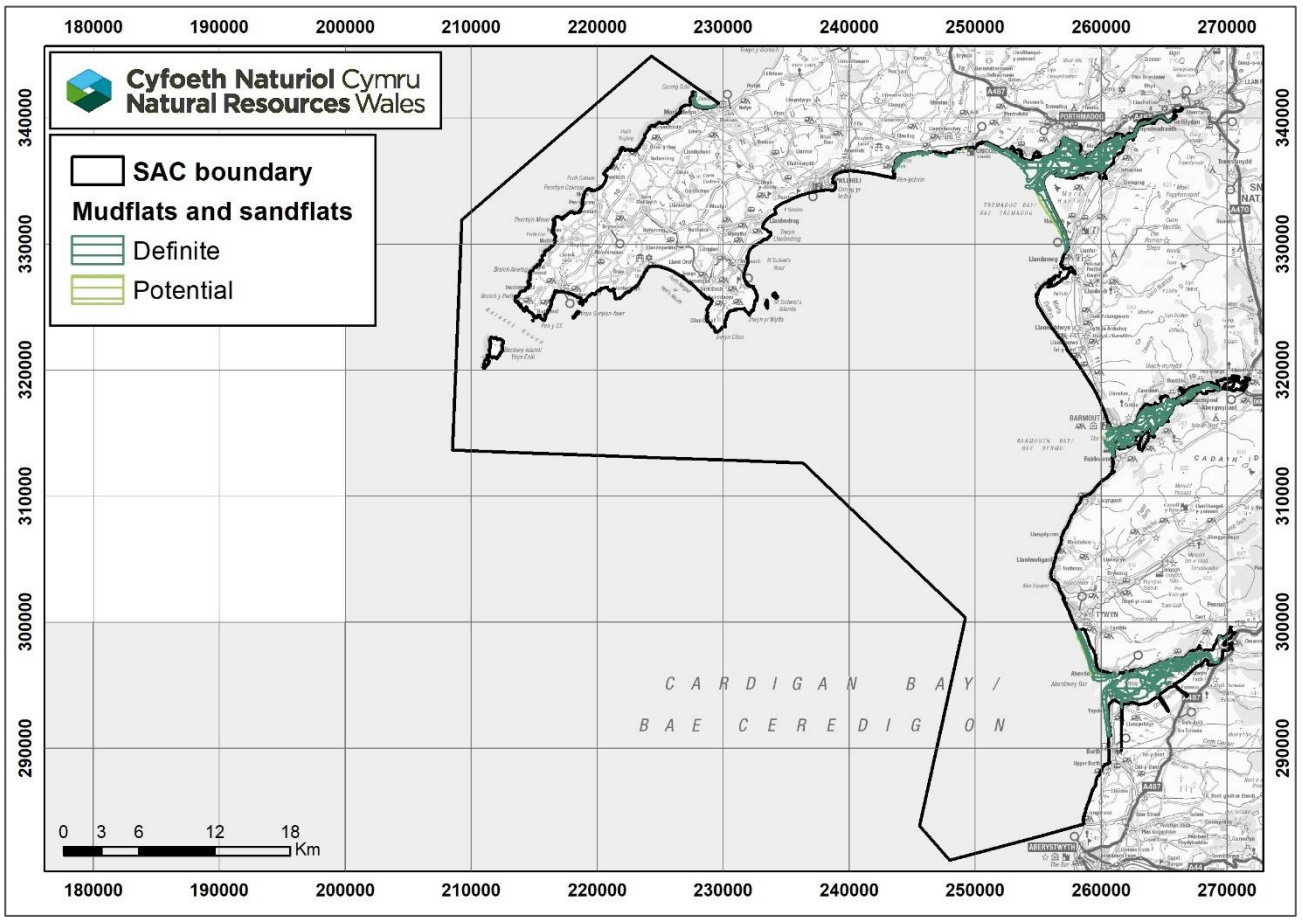


Table 20 has a summary of the assessment outcome. The assessment outcome and any reasons for failure are discussed in more detail in the sections below.

Table 20. Condition assessment of mudflats and sandflats in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	No significant decrease in the extent of mudflats and sandflats within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC. • Mudflats and sandflats are known to be accumulating at the mouth of the estuary near Barmouth due to previous structural modifications. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of mudflats and sandflats habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the mudflats and sandflats. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC. • There is some concern about the ongoing effects from construction of Pont Briwet as there has been no monitoring since the construction. Confidence is low due to this, and as the assessment has been based on expert judgment.	**Pass**	Low
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the mudflats and sandflats, allowing for natural change and variation. (P)	• Granulometric analysis for Criccieth, Black Sand Rocks, Morfa Dyffryn and Harlech mudflats and sandflats showed some variation in sediment composition, but this is likely to be natural. • Sediment composition varied greatly at Mawddach estuary, but this could be explained by the different sampling regime design with the moving channel. • Sediment composition also varied at Dyfi estuary with a decreasing trend of silt fraction resulting in a medium confidence.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to mudflats and sandflats infaunal communities, allowing for natural change and variation. (S)	• The redox layer indicated no clear trend over the years. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low
Sediments: organic carbon content	No increase to the organic carbon content considered detrimental to mudflats and sandflats communities, allowing for natural change and variation. (P)	• There are no recent data for organic carbon content for the mudflats and sandflats within Pen Llyn a'r Sarnau SAC, as the Clean Safe Seas Environmental Monitoring Programme (CSEMP) data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Sediments: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• There are no recent data for sediment contaminants for the mudflats and sandflats within Pen Llyn a'r Sarnau SAC, as the CSEMP data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• One of the seven WFD waterbodies that overlap with the feature was not classified for DIN in any cycles (Tremadog Bay). It overlaps with 8% of the feature. • The other six WFD waterbodies were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach, Cardigan Bay North, Caernarfon Bay South and Artro). Combined, these overlap with 86% of the feature. ○ Three of these waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to the one unclassified waterbody and the rolled forward classifications.	**Pass**	Medium
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Five of the seven WFD waterbodies were not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach, Tremadog Bay and Artro). Combined, these waterbodies overlap with 82% of the feature. • The other two WFD waterbodies were classified with a Good or High status for phytoplankton (Cardigan Bay North and Caernarfon Bay South). These waterbodies overlap with 10% and 1% of the feature. • Confidence is low as a large proportion of the feature overlap with unclassified waterbodies, and as the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Four of the seven WFD waterbodies were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Glaslyn, Cardigan Bay North, Tremadog Bay and Caernarfon Bay South). Combined, these overlap with 52% of the feature. • The other three WFD waterbodies were classified with Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach and Artro). Combined, these overlap with 42% of the feature. ○ The Mawddach waterbody classification was rolled forward from the 2021 cycle 3 classification. • Confidence is medium due to the unclassified waterbodies.	**Pass**	Medium
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Four of the seven WFD waterbodies were was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach and Tremadog Bay). Combined, these overlap with 81% of the feature. • The other three WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Cardigan Bay North, Caernarfon Bay South and Artro). Combined, these overlap with 13% of the feature. • Confidence is low due to samples being taken from the surface of waterbodies, and as a large proportion of the feature overlap with unclassified waterbodies.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the seven WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Glaslyn, Tremadog Bay, Caernarfon Bay South and Artro). Combined, these overlap with 43% of the feature. • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Dyfi / Leri). However, all chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 25% of the feature. • The other two WFD waterbodies have a fail for chemicals (Mawddach and Cardigan Bay North). These waterbodies failed mercury and / or PBDE. Combined, they overlap with 25% of the feature. • Confidence is medium as the human health standard has been used for PBDE, and due to the unclassified waterbodies.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Six of the seven WFD waterbodies were classified as Good or High status for the IQI WFD element in the 2024 cycle 3 interim classification. Combined, these waterbodies overlap with 93% of the feature. • Analysis of macrobenthic infaunal communities for mudflats and sandflats at the Dwyryd estuary showed a directional and linear change in community composition. Changes tended to be smaller in recent years. These changes have raised some concerns. • Infaunal communities at Mawddach and Dyfi estuaries were within the limits of natural variation. • Infaunal communities for open coast mudflats and sandflats showed no distinct pattern, with fluctuations of community composition across the monitoring period within the limits of natural variation. • The abundance and extent of *Zostera marina* has increased in Porth Dinllaen and known to be found in other parts of the SAC. • No clear patterns were observed in the abundance of blow lugworm *Arenicola marina*, common cockle *Cerastoderma edule,* the blue mussel *Mytilus edulis* and the amphipod *Corophium arenarium* derived from the limited information from the monitored core samples. This was no cause for concern. • Confidence is medium due to concerns raised at the Dwyryd estuary.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of mudflats and sandflats species, allowing for natural change and variation. (S)	• Diversity and species richness for the mudflats and sandflats in the estuaries and open coast monitoring sites were within the bounds of natural variation. • Changes observed were mostly related to shifting river channels.	**Pass**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of mudflats and sandflats species, allowing for natural change and variation. (S)	• Overall, the average distinctness of the macrofaunal community of Open coast and estuarine mudflats remained stable and within the expected values over the monitoring period. • The year 2020 indicated a low average taxonomic diversity for the Glaslyn / Dwyryd and Morfa Dyffryn mudflats and sandflats reducing the confidence to medium.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive Non-Native Species (INNS)	Spread and impact of INNS caused by human activities is not adversely altering ecosystems. (P)	• There is limited evidence to suggest that INNS (e.g. *Crepidula fornicata*) are currently impacting the condition of the mudflats and sandflats in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not understood.	**Pass**	Low
Non-Native Species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• Recent records of *C. fornicata* have been identified in various locations in the SAC, including some within or close to the feature (2023-2024). • *Gracilaria vermiculophylla* has been recorded within the last six years within the Glaslyn / Dwyryd, Mawddach and Dyfi estuaries. • Other NNS have been recorded previously including *Magallana gigas* and *Sargassum muticum* within the mudflats and sandflats feature. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The mudflats and sandflats feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (low confidence). Overall, the lack of any significant anthropogenic impact on this feature in term of extent, hydrodynamic processes, topography, sediment quality and its associated community, have contributed to this favourable assessment outcome. There were two failing indicators but none with a primary weighting (Table 21). There were limited or absent data for two key indicators to inform on the condition of the feature (see the evidence gaps). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in Table 21 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 21. Summary of the condition assessment for mudflats and sandflats in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Mudflats and sandflats	**Favourable (low confidence)**	Water quality: contaminants (S) Non-native species (T)	• Levels of mercury and PBDE in the Mawddach and Cardigan Bay North waterbodies are failing to meet their relevant EQSs. • There has been an increase in the number of NNS in the feature SAC, including *C. fornicata* and *G. vermiculophylla*.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

The feature extent and the distribution and extent of habitats and communities indicators in the Pen Llŷn a'r Sarnau SAC passed their target as there are currently no known anthropogenic impacts that would negatively affect the mudflats and sandflats feature. Mudflats and sandflats are known to be accumulating at the mouth of the estuary near Barmouth due to previous structural modifications. Comparison mapping has not been used to assess the extent and expert judgement was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediment quality; topography; and hydrodynamic and sediment transport processes

Overall, sediment composition for East Criccieth, Black Sand Rocks, Morfa Dyffryn and Harlech mudflats and sandflats varied across the monitoring period. Variation in sediment composition was deemed natural. Analysis indicated large variations in sediment composition at the Mawddach estuary across stations and years. These changes could be attributed to the sampling regime that changed through times with the moving river channel. The shifting river channel is an important and natural process in the macro-tidal estuaries of Pen Llŷn a'r Sarnau and therefore changes observed were not deemed to be a concern. There have been some noticeable changes in the sediment composition of the Dyfi estuary mudflat with a decreasing trend of silt content. This decrease is unexplained but there is no evidence to suggest these are attributable to anthropogenic activity.

Analysis of the data showed that macrofaunal abundance was positively correlated (weak relationship) to the sediment composition for most of the Pen Llŷn a'r Sarnau SAC intertidal mudflats and sandflats feature, indicating that communities are to some extent determined by sediment characteristics.

The redox layer indicated no clear trend over the years. A long-term data series spanning from 2008 to 2022 is available, but sampling has not been conducted consistently every year. Further sampling is required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer. For this reason the confidence in the pass was reduced to low.

Sediment contaminants and organic carbon content were previously monitored at two stations in the SAC by CSEMP, however the monitoring ceased in 2015. These data was deemed to be out of date and therefore the indicators were assessed as unknown.

The topography and hydrodynamic and sediment transport processes are not well researched for intertidal mudflats and sandflats. These targets passed based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the feature. However, there were some concerns raised about Pont Briwet, as there has been no subsequent monitoring since construction to confirm the absence of impacts on the mudflats and sandflats feature. As a result, the confidence in the pass for the hydrodynamic and sediment transport processes was reduced to low.

Water quality

It has been estimated that approximately 94% of the mudflats and sandflats feature within the SAC falls within seven WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Glaslyn and Dyfi / Leri waterbodies overlap with the largest proportion of the feature (33% and 25% respectively).

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients (DIN only) indicator met its target as six of the seven WFD waterbodies that overlap with the feature were classified with a Good or High status for DIN in the 2024 cycle 3 interim classification. These were Glaslyn, Dyfi / Leri, Mawddach, Cardigan Bay North, Caernarfon Bay South and Artro waterbodies, which combined overlap with 86% of the mudflats and sandflats feature. The classifications for the Glaslyn, Dyfi / Leri and Mawddach waterbodies (73% combined) were rolled forward from the 2018 cycle 2 interim or 2021 cycle 3 classification. This, and because one WFD waterbody, Tremadog Bay, has never been classified for DIN caused the confidence to be reduced to medium.

The phytoplankton indicator met its target. Two of the overlapping WFD waterbodies, Cardigan Bay North and Caernarfon Bay South, were classified with a Good or High status for phytoplankton in the 2024 cycle 3 interim classification. Combined, these waterbodies overlap with 11% of the feature. The other five WFD waterbodies have not been classified for phytoplankton in the 2024 cycle 3 interim classification. Classification of some WFD waterbodies is not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Confidence was reduced to low as a large proportion of the feature overlap with waterbodies that were not classified for the phytoplankton element (82%), and as the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.

The opportunistic macroalgae indicator met its target. Three of the overlapping WFD waterbodies were classified with a Good status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. These waterbodies, Dyfi / Leri, Mawddach and Artro, overlap with 42% of the mudflats and sandflats feature. The classification for the Mawddach waterbody was rolled forward from the 2021 cycle 3 classification. The other four WFD waterbodies were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth). The confidence in the pass was reduced to medium as 52% of the feature overlap with waterbodies that were not classified for the relevant WFD element, and due to the rolled forward classification.

Dissolved oxygen

The dissolved oxygen indicator met its target. The dissolved oxygen samples were taken at the water’s surface. By the time oxygen depletion at the surface is recorded, oxygen throughout the water column could have been depleted for some time, especially as hypoxia or low oxygen levels, when present, typically occur in bottom water and sediments. Therefore, surface sampling of dissolved oxygen may not detect issues for more demersal features. Confidence in the pass was reduced to low due to this, and as a large proportion of the feature overlaps with WFD waterbodies that were not classified for DO in the 2024 cycle 3 interim classification (81%).

Contaminants

Two of the seven WFD waterbodies that overlap with the mudflats and sandflats feature have a fail for chemicals in the 2024 cycle 3 interim classification. The failures were in the Mawddach waterbody, which failed for PBDE, and the Cardigan Bay North waterbody, which failed for mercury and PBDE. Combined, these waterbodies overlap with 25% of the feature, which caused the contaminants indicator to fail. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of mudflats and sandflats are not fully understood.

One WFD waterbody, Dyfi / Leri, has a pass for chemicals in the 2024 cycle 3 interim classification. However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 25% of the mudflats and sandflats feature. The other four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. Combined, these overlap with 43% of the feature. The confidence in the failure was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. None of the loggers overlap with or are close to the mudflats and sandflats feature. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

Six of the seven WFD waterbodies that overlap with the mudflats and sandflats feature were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach, Cardigan Bay North, Tremadog Bay and Caernarfon Bay South). Combined, these waterbodies overlap with 93% of the feature. The other WFD waterbody, which overlaps with only 1% of the feature, was not classified for this element (Artro).

Infaunal analysis showed that communities present in the Dwyryd estuary indicated a directional change through time. A noticeable trend was observed with a decrease of sand-affinity species including some sensitive taxa (e.g. *Bathyporeia* spp) with increases of mud-affinity species and more tolerant species (e.g. *Cerastoderma* spp and *Peringia*

ulvae) over the years (2008 to 2020) (Mercer 2016; 2022 and NRW unpublished data). This may indicate a higher level of deposition in the sampled areas.

Community composition at the mudflats and sandflats open coast monitoring sites and at Mawddach and Dyfi estuaries varied with no clear pattern (Mercer 2016; 2022 and NRW unpublished data). The variation in composition of communities was judged to be natural with no increase of opportunistic species over time as noticed in the Dwyryd.

The limited information from the core samples showed no clear pattern in the abundance of the blow lugworm *Arenicola marina*, common cockle *Cerastoderma edule,* blue mussel *Mytilus edulis* and the amphipod *Corophium arenarium*, but no cause for concern. Evidence suggests that the seagrass *Zostera marina* has expanded between 2004 and 2016 in Porth Dinllaen (Davies et al., 2017) and known to be present in other areas within the SAC.

Overall, the abundance, distribution and species composition of communities indicator met its target. While the change in infaunal communities in the Dwyryd is concerning, it was not deemed large enough to cause the indicator to fail but did reduce the confidence in the pass to medium. This will be something to pay close attention to in the next assessment. Available data on the distribution and population structure for some mudflats and sandflats associated species were lacking or insufficient. Although these data were not required for the full assessment of the abundance, distribution and species composition of communities indicator, having detailed information on these would strengthen the outcome and could be considered in future.

Both diversity and species richness and taxonomic spread of species indicators for the mudflats and sandflats feature in the estuaries and open coast monitoring sites were within the bounds of natural variation, with most changes related to shifting river channels. This resulted in a pass with medium confidence for both indicators.

The confidence for taxonomic spread of species was reduced to medium due to some concern for the Dwyryd mudflats and sandflats which had several stations in 2020 below the expected level of taxonomic distinctness and for Morfa Dyffryn in 2020, possibly indicating low level of taxonomic diversity. This is something to keep under review.

Invasive non-native species

Gracilaria vermiculophylla has been recorded within the last six years in the Glaslyn / Dwyryd, Mawddach and Dyfi estuaries within the mudflats and sandflats feature (Mercer and Brazier, 2023). In addition, records of *Crepidula fornicata* were found in the SAC in recent years (2023-2024) including close to or within the mudflats and sandflats feature. Therefore the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the mudflats and sandflats feature within the last reporting cycle.

Other NNS are known to be present within the mudflats and sandflats feature of the Pen Llyn a'r Sarnau SAC, including *Magallana gigas* and *Sargassum muticum*.

It is not fully understood how some of these species may spread and impact the condition of the mudflats and sandflats feature and effects on the species diversity and composition have not yet been observed. As there is no current impact from the INNS present the

primary target of the INNS indicator passed. Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.

Reasons for target failure

The mudflats and sandflats feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, one secondary target and one tertiary target failed to be met and need to be kept under review.

Water quality: contaminants

This indicator target has a secondary weighting. The mudflats and sandflats feature in the SAC is partly within two WFD waterbodies (Mawddach and Cardigan Bay North) that have a fail for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous sewage discharge from the water industry. The exact sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. WFD investigations of the failures in both WFD waterbodies are yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

Non-native species

This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to an increase in records of NNS in the mudflats and sandflats feature, including *C. fornicata* and *G. vermiculophylla* within the six years. Investigation into the management of spread of *G. vermiculophylla* has not been done widely (Maggs and Magill, 2014). Targeted surveys of the species and investigation into its impact are required.

The spread and full extent of the impact that these species, along with other NNS present within the SAC, may have on the condition of the feature is currently unknown. For this reason it did not fail the primary target of the INNS indicator. A biosecurity plan for INNS has been developed for the SAC. The objective is to manage the key pathways by which marine INNS are introduced and spread at the SAC level through the use of good biosecurity.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the mudflats and sandflats feature. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the mudflats and sandflats feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Unconsented infrastructure

New unconsented infrastructures such as private slipways and coastal defences modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impact to the flora and fauna associated with it.

Invasive non-native species

There have been concerns about the increasing abundance of *C. fornicata* in the SAC. At high density, this species could cause an impact on the feature (see further detail in Section 3.1)

G. vermiculophylla has been found in the SAC and has the potential to establish quickly, and can have a detrimental impact on the feature (see further detail in Section 3.2).

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the mudflats and sandflats feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Management of coastal defences

The State of the UK Climate 2023 Report highlights an observed acceleration in rates of climate induced sea-level rise which, along with storm surges can cause coastal erosion and flooding (Kendon et al., 2024). Shoreline Management Plans identify the preferred approach to coastal management in light of climate change, which includes maintaining or upgrading defences in some areas and adapting the approach to management in others. Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species. Intertidal habitats may also be lost as a result of coastal squeeze (Oaten et al, 2024).

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024, Oaten et al., 2024):

- Sea level rise, in the medium to long term.
- Changes in air and sea temperature.
- Increases in wave climate, especially storm frequency and intensity which may change the topography.
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 22) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 22. Evidence gaps for the mudflats and sandflats feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Extent (P)	Medium confidence (proxy data used)	• Currently, the extent of mudflats and sandflat is not accurately measured at any of the SACs and there is no repeated measure taken.
Distribution and extent of habitats and communities (P)	Medium confidence (proxy data used)	• Without any recent biotope surveys undertaken, assessing changes in mudflats and sandflats in all SACs is difficult. A new survey is required.
Topography of the feature (P); hydrodynamic and sediment transport processes (P)	Low or medium confidence (proxy data used)	• The topography and hydrodynamic regime of mudflats and sandflats is not currently monitored. • The Wales Coastal Monitoring Centre monitor some sites and are working on a dashboard that will flag up locations with changes outside of natural variability. This could help in assessing in the next cycle of condition assessment.
Sediment quality: organic carbon content (P); contaminants (P).	Unknown	• Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring ceased in 2015. These data was deemed to be out of date and there are no recent data available.

Indicator	Assessed status	Comments
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present within the SAC on the mudflats and sandflats feature is not fully understood. More targeted surveys and investigation on the impact of NNS on mudflats and sandflats are needed. • Investigation into the use of satellite and or aerial imagery for assessing the extent of *G. vermiculophylla* may be beneficial.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was difficult to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening.
Sediment quality: dissolved oxygen (S)	Not assessed	• Dissolved oxygen in sediments is not currently monitored in the mudflats and sandflats feature across Welsh SACs, but there is potential for this to be incorporated into granulometric analysis in future.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.7. Atlantic salt meadows condition assessment

The Atlantic salt meadows (ASM) feature, also known as saltmarsh, in Pen Llŷn a'r Sarnau SAC includes saltmarshes from the Glaslyn, Dwyryd, Mawddach, Artro and Dyfi estuaries (Figure 14). The ASM feature has been assessed against the performance indicators and an overall condition was assigned for the feature.

Figure 14. Map of the ASM feature in Pen Llŷn a'r Sarnau SAC.

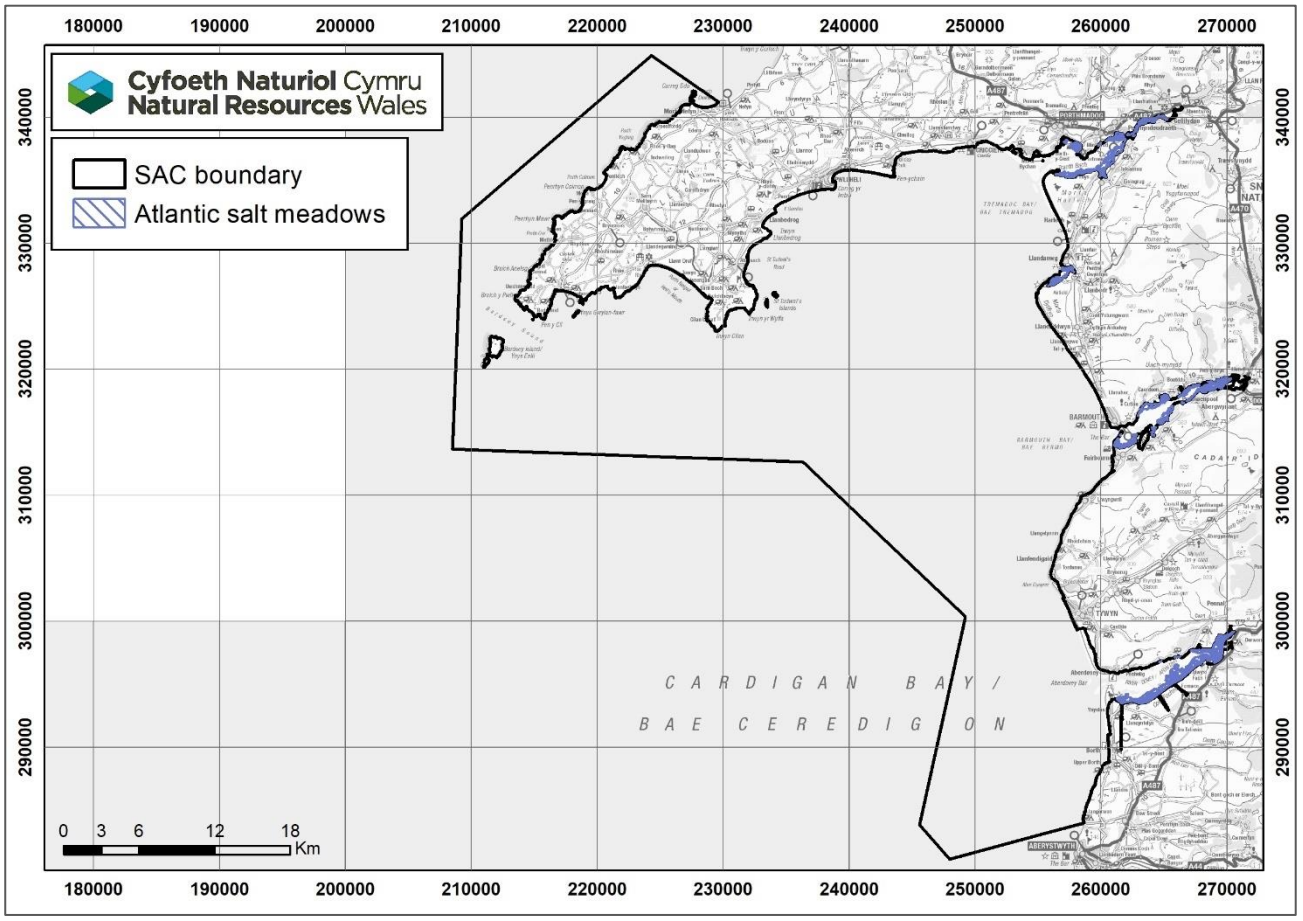


Table 23 has a summary of the assessment outcome against each performance indicator. The outcomes and any reasons for failure are discussed in more detail in the sections below.

Table 23. Condition assessment of the ASM feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	The extent of the saltmarsh within the SAC should be stable or increasing, allowing for natural change and variation. (P)	• Between 2000 and 2020-2021, there has been a gain of 12.4 ha (1%) of saltmarsh extent. • The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. Therefore the confidence associated with the pass is medium.	**Pass**	Medium
Distribution of feature	Maintain the distribution of saltmarsh throughout the SAC, allowing for natural change and variation. No significant loss from any of the defined sectors. Significant is defined as loss from any sector not to exceed 20%. (P)	• There has been no significant loss of saltmarsh extent in any of the defined sectors. • There has been a loss of approximately 5% in the Morfa Harlech sector was highlighted but requires ground truthing to confirm. • The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. Therefore the confidence associated with the pass is medium.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of saltmarsh habitats and communities, allowing for natural change. (P)	• The available NVC maps date from 2003 and are too old to use for an assessment of distribution and extent.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Physical structure: creeks and pans	Maintain the expected patterns of creeks and pans throughout the SAC, allowing for natural change and variation (P). Artificial drainage channels adversely affecting hydrology are absent or rare. (P)	• There are no anthropogenic impacts known to have significantly affected the creeks and pans in the saltmarsh since SAC designation. • There are currently no known artificial drainage channels that would adversely affect the hydrology within the saltmarsh. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (T)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the saltmarsh. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the saltmarsh. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Two of the four WFD waterbodies that overlap with the feature were not classified as the chemicals have not been assessed within the last six years (Glaslyn and Artro). Combined, these overlap with 4% of the ASM feature. • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Dyfi / Leri). However, all chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 4% of the feature. • The other WFD waterbody has a fail for chemicals (Mawddach), due to PBDE. It overlaps with 13% of the feature. • Confidence is medium as the human health standard has been used for PBDE; some waterbodies have not been classified; and WFD water quality sampling is not focused on saltmarshes.	**Fail**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All four WFD waterbodies were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Mawddach, Dyfi / Leri, Glaslyn and Artro). Combined, these overlap with 21% of the feature. ○ Three of these waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to the rolled forward classifications, and as WFD water quality sampling is not focused on saltmarshes.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the four WFD waterbodies was not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Glaslyn). This waterbody overlaps with 3% of the feature. • The other three WFD waterbodies were classified with Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Mawddach, Dyfi / Leri and Artro). Combined, these overlap with 17% of the feature. ○ The Mawddach waterbody classification was rolled forward from the 2021 cycle 3 classification. • Confidence is medium due to the unclassified waterbody and rolled forward classification; and as WFD water quality sampling is not focused on saltmarshes.	**Pass**	Medium
Air quality	Nitrogen deposition should not exceed the critical load range of 10-20 kg N per ha^{-1} per year. (S)	• Nitrogen deposition within the SAC (where data were available) was under 10 kg N per ha per year for all saltmarshes and did not exceed the critical load on average (UK air pollution information system (APIS)). • Confidence is high as the recorded nitrogen deposition is below the lower range of the critical load.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, structure and diversity of ASM plant communities within the sectors of the SAC, allowing for natural change and variation. (P)	• The analysis of WFD transect data showed that overall, plant species richness was good for the Artro waterbody and slightly poorer for the Dyfi / Leri waterbody. • Species richness is only one element to assess the condition of ASM plant communities across the feature. • No WFD sampling stations are available for the saltmarshes in the Mawddach, Glaslyn and Dwyryd estuaries. These sectors represent a large proportion of the ASM feature in the Pen Llŷn a'r Sarnau SAC, therefore this indicator was assessed as unknown. • Heavy grazing in some areas within the ASM feature are likely to impact the species composition, however no information is available to confirm this.	**Unknown**	N/A
Vegetation structure: sward height	Maintain the expected structural variation within the sward height, allowing for natural change and variation. The majority of plants should be able to produce flowers and set seed. (P)	• Heavy grazing was noted in the past in a few locations on the Dwyryd estuary, as well as a section of saltmarsh in the Mawddach and Dyfi estuaries. • The 2011 condition assessment indicated a failure for grazing. • Recent stakeholder interviews (2022) further identified heavy grazing in the Dyfi and the Dywyrd estuaries. • Recent visual observation made in October 2024 showed that heavy grazing is still occurring in the Dwyryd estuary (seaward locations). • Confidence is medium because the assessment was based on expert judgment and visual inspection rather than a targeted survey.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Vegetation structure: zonation of vegetation	Maintain the expected range of saltmarsh zonation for the SAC, allowing for natural change and variation. (P)	• WFD data analysis indicated changes in zonation, but it was judged to be from natural variation. • Confidence is medium as the pioneer zone is difficult to assess using aerial photography.	**Pass**	Medium
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence of INNS presence within the ASM feature. • Confidence is medium as the spread and impacts of any INNS present within the SAC are not well understood, and there have been no targeted surveys of NNS within the ASM feature.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There have been no new NNS recorded within the ASM feature in the SAC. • Confidence is medium as there have been no recent targeted NNS surveys within saltmarsh.	**Pass**	Medium

Assessment conclusions

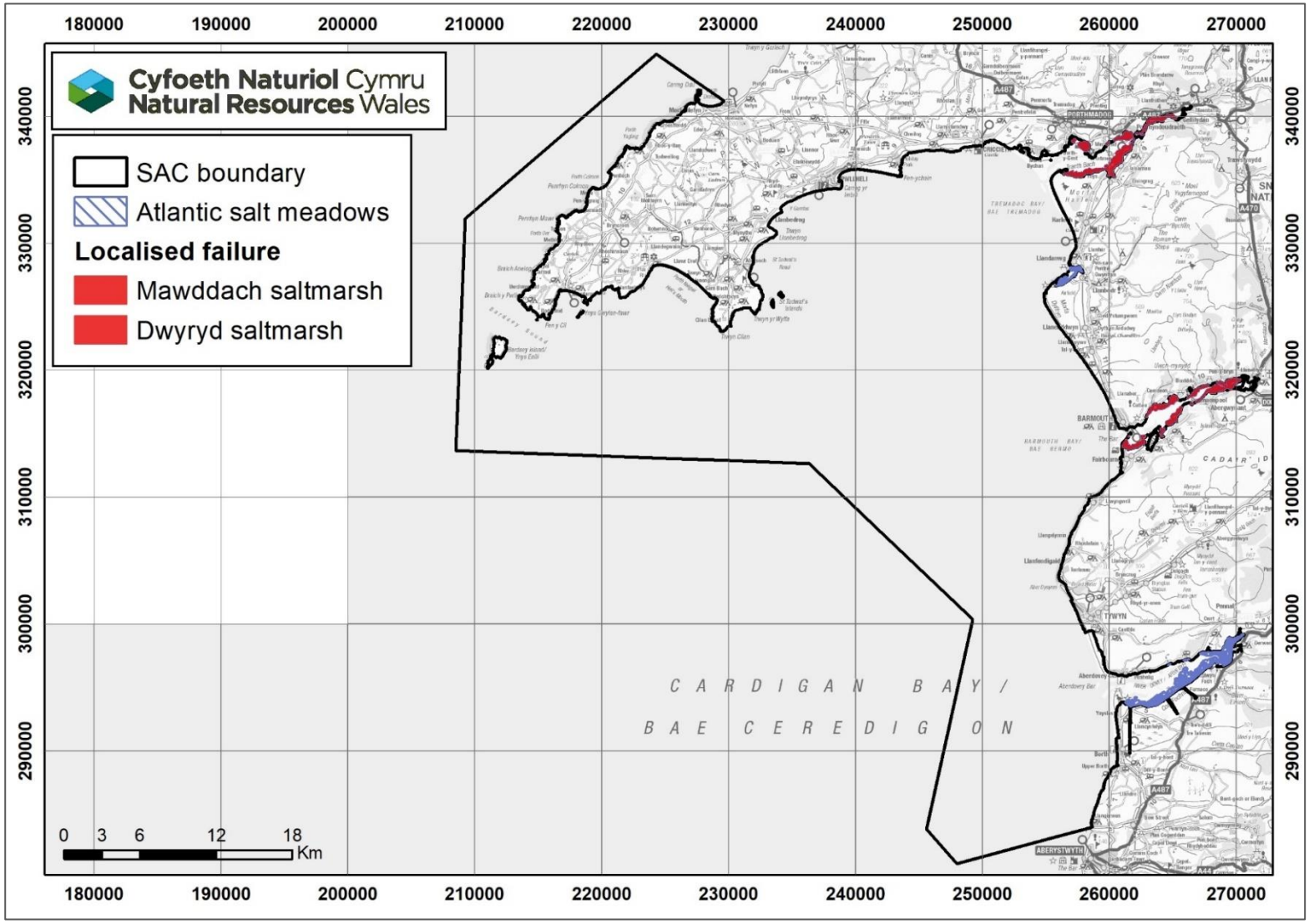
The Atlantic salt meadow (ASM) feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **unfavourable** condition (low confidence). There were a couple of indicators with failing targets (Table 24). There were also limited or absent data for three key indicators to inform on the condition of the feature (see evidence gaps). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition. As the primary failure was localised, it has been mapped to help focus management effort (Figure 15).

A summary of the assessment can be seen in Table 24 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 24. Summary of the condition assessment for the ASM feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Atlantic salt meadows	**Unfavourable (low confidence)**	Vegetation structure: sward height (P) Water quality: contaminants (T)	• There is heavy grazing by sheep in some sections of the Dwyryd and Mawddach saltmarshes. • Levels of PBDE in the Mawddach waterbody are failing to meet its relevant EQS.	• Unconsented infrastructure • INNS • Water quality: contaminants • Climate change

Figure 15. Map of the localised failure in the LSIB feature in Pen Llŷn a'r Sarnau SAC.



Detailed assessment information

Extent and distribution

Saltmarsh extent has been mapped using imagery from 2000 and 2020/2021. The total extent of saltmarsh was measured as 1230.58 ha in 2020/2021 compared to 1217.14 ha in 2000, indicating a total gain of 12.4 ha (1%). There has been no significant loss of more than 20% of saltmarsh extent in any of the defined sectors. The extent of saltmarshes has increased in two of the six defined sectors, and has not changed in one. There has been a minor loss in extent in three sectors. The sector with the largest loss was Morfa Harlech which has lost approximately 5% of the extent. However, ground truthing is required to confirm this loss. Both the feature extent and distribution of the feature indicators met their targets. The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. In addition, the extent includes saltmarsh areas as well as *Salicornia*. Therefore the confidence associated with the pass is medium.

The distribution and extent of habitats and communities, a key indicator to inform on the condition of the feature, was assessed as unknown as the available NVC maps (Prosser and Wallace, 2004) date from 2003. These were deemed too old to be representative of the current situation. The lack of more up to date maps meant change could not be assessed.

Physical structure

There are no anthropogenic activities known to have significantly affected the creeks and pans in the saltmarsh since designation and no known artificial drainage channels that would adversely affect the hydrology within the saltmarsh. The physical structure (creeks and pans) indicator therefore passed its target. The assessment of this indicator was based on expert judgment. Confidence in the indicator pass was reduced to medium as the size of the feature is large and it is difficult to be certain of impacts in this SAC in the absence of specific monitoring data.

Hydrodynamic processes and topography

The hydrodynamic and sediment transport processes, and the topography of the feature indicators were assessed as passing their targets as currently there are no known anthropogenic activities that would have significantly altered these aspects. This assessment was based on expert judgement and knowledge of assessments of plans and projects in and near the SAC. This reduced the confidence in the assessment to medium, as it is difficult to be certain of impacts to the condition of the feature in the absence of data. In future, Lidar data could potentially be used to quantify changes in topography.

Water and air quality

It has been estimated that approximately 21% of the ASM feature within the SAC falls within five WFD waterbodies. The upper marsh areas are above the high-water mark and

are therefore outside of the WFD waterbody boundary. However, marine water input to the upper marsh will be from these waterbodies therefore these waterbodies are likely to be a good reflection of the overall effect of water quality on the feature. However, as the WFD water quality sampling is not focused on saltmarshes, the confidence has been reduced in all of the relevant water quality assessments.

Contaminants

One of the four WFD waterbodies that overlap with the ASM feature has a fail for chemicals in the 2024 cycle 3 interim classification. The failure was in the Mawddach waterbody, which failed for PBDE. Compared to other WFD waterbodies that overlap with the feature, this waterbody overlaps with a comparatively large proportion of the feature across the whole SAC (13%). This caused the contaminants indicator to fail. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of the ASM feature are not fully understood.

One WFD waterbody, Dyfi / Leri, has a pass for chemicals in the 2024 cycle 3 interim classification. However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 4% of the feature. The other two WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. Combined, these overlap with 4% of the feature. Overall, the confidence in the failure was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood. The target weighting of the indicator is tertiary to reflect this.

Nutrients (DIN only) and opportunistic macroalgae

The targets for the nutrients (DIN only) and opportunistic macroalgae indicators were met. A medium confidence was attributed to the pass for both indicators as WFD water quality sampling is not focused on saltmarshes. In addition, as some waterbody classifications for the DIN and opportunistic macroalgae elements for were rolled forward from previous cycles. The nutrients indicator (DIN only) was given a tertiary weighting as the effects of high nutrient levels on the ASM feature are not fully understood.

Air quality

High levels of nitrogen (N) deposition from the atmosphere can have a detrimental impact on saltmarsh since they are nitrogen limited. The nitrogen deposition within the SAC, where data were available, was under 10 kg N per ha per year for all saltmarshes and therefore, did not exceed the critical load of 20 kg N per ha per year (UK air pollution information system (APIS)), resulting in this indicator to pass with high confidence.

Species and communities

This is a key indicator to inform on the condition of the feature. The analysis of transect data from WFD showed that overall, ASM plant species richness was good for the Artro waterbody and slightly poorer for the Dyfi / Leri waterbody. Species richness is one element to assess the condition of saltmarsh communities across the feature, but more analysis is required to pass the abundance, distribution and species composition of communities indicator. Additionally, there are no WFD sampling stations for the

saltmarshes in the Mawddach, Glaslyn and Dwyryd estuaries. These sectors represent a large proportion of the ASM feature in the Pen Llŷn a'r Sarnau SAC. For these reasons, the indicator has been assessed as unknown. Recent visual observations of some areas within the ASM feature (see vegetation structure) has identified some areas of the saltmarshes that are heavily grazed. This is likely to have an impact on the species composition of the ASM feature, however no information is available to confirm it.

Vegetation structure

Sward height

While a proportion of the feature is in good condition, heavy grazing occurred in the past in a significant section of saltmarsh in the Mawddach estuary and a few locations in the Dwyryd estuary (Sherry and Douglas, in draft). This resulted in a failure in the 2011 condition assessment (Lewis, 2011).

Recent visual observations made in the Mawddach estuary in November 2024 found a significant section of the of the Mawddach saltmarsh between Morfa Friog and Morfa Mawddach to be very close cropped with very low sward height and poor structure observed (H. Lewis (NRW), pers. comm.) (Figure 16a). Within the Dwyryd estuary, recent visual observations made in October 2024 identified some areas of the saltmarshes that remain heavily grazed (H. Lewis (NRW), pers. comm.) (Figure 16b). In the eastern part of the Glastraeth section of the Dwyryd saltmarsh few sheep were seen but visible tracks were observed (viewed from the footpath). The low number of sheep could be seasonal as numbers are typically reduced in Autumn. In this area, the sward height was around 5-10 cm in the upper marsh which is acceptable. However, a reduction in sward height was observed seaward. Further west of this area in the Glastraeth marsh, the sward height was very close cropped and scarcely measurable in parts, with sward heights as low as 1 cm in places. There were estimated to be around 150-200 Canada Geese visible in this area at the time of the visit in October, however, 200 geese would equate to a low level of livestock units. In addition to recent evidence, a study of coastal agricultural landscapes found that out of the Welsh saltmarshes considered to be intensively grazed, most were located in the Dwyryd estuary. These were identified in recent stakeholder interviews, with marshes further up the estuary reported to be more intensively grazed (McKinley et al., 2022). As a result, the sward height indicator has been assessed as failing. Confidence was reduced to medium because the assessment was based on expert judgment and visual inspection rather than a targeted survey.

Figure 16. Visual observations of overgrazing within the ASM feature in Pen Llŷn a'r Sarnau SAC. a) In the Mawddach estuary (Nov 2024), b) in the Dwyryd estuary (Oct 2024).

Zonation of vegetation

The analysis of WFD data indicated that the zonation of vegetation was changing but it was deemed to be within the bounds of natural variation. Some changes were observed for the Dyfi / Leri waterbody between the mid-low and upper zone, but these are likely due to natural channel variation. The confidence in the assessment was reduced to medium since WFD data were only available for three out of six WFD waterbodies with some saltmarshes not being assessed. In addition, the changes in zonation were estimated by comparing 2011 and 2019 extents for one out of three WFD waterbodies. Further data and ground truthing investigations would be needed to increase confidence. There was also some uncertainty with the decrease in extent for the pioneer zone. The pioneer zone is difficult to assess by aerial imagery due to the characteristic sparse nature of *Salicornia* areas. A true extent measurement is unrealistic with this sampling technique. This was also considered in the confidence of the assessment. Further investigation with ground truthing evidence or drone imagery will be needed to adequately assess the extent of the pioneer zone in future.

Invasive non-native species

The saline conditions of saltmarshes prevent the common terrestrial NNS in Wales becoming established. There have been no new NNS recorded within the ASM feature in PLAS SAC, and any NNS present are not considered to have an impact on the condition of the feature, resulting in both the primary and tertiary targets for the INNS and NNS indicators to be met.

There were, however, some notable records of NNS within the SAC. *Gracilaria vermiculophylla* was first found in Wales in the Glaslyn / Dwyryd estuary in 2017, and since then it has been recorded in the Mawddach, and Dyfi estuaries (Mercer and Brazier, 2023). These specimens appeared to have been washed into the marsh with the tides and although they continued to grow, they were not necessarily persistent. For this reason, *G. vermiculophylla* has been judged to not be having an impact on the condition of the ASM feature. In addition, the Japanese knotweed *Fallopia japonica* was found in in the Dwyryd, Mawddach, Glaslyn and Dyfi but mainly at the upper edge of the saltmarsh near roads.

Both INNS and NNS targets passed with a medium confidence as there have been no targeted NNS surveys on saltmarshes, which would be required to fully understand the presence and impacts of any NNS species within the ASM feature.

Reasons for target failure

The assessment of the ASM feature in Pen Llŷn a'r Sarnau SAC failed one primary target and one tertiary target. This resulted in the feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Vegetation structure: sward height

This indicator target has a primary weighting. Heavy grazing occurred in the past in some sections of the Dwyryd and Mawddach estuary which was impacting on the structure and function of the ASM feature. This was due to high sheep numbers grazing in some of the marshes. Recent observations (2024) showed that heavy grazing persists in some marshes in the Dwyryd and the Mawddach estuaries. These management issues have led to the loss of structural diversity in the saltmarsh vegetation with a short sward of less than 5 cm in height.

Water quality: contaminants

This indicator target has a tertiary weighting. The ASM feature in the SAC is partly within one WFD waterbody (Mawddach) that has a fail for chemicals due to PBDE. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous sewage discharge from the water industry. The WFD investigation of the failure in this waterbody is yet to be undertaken. The impact of these chemicals on the ASM feature is not fully understood. PBDE is being managed in the UK and it is hoped that these levels will reduce in time.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the ASM feature. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition. The threats to the condition of the ASM feature in Pen Llŷn a'r Sarnau SAC are stated below.

Unconsented infrastructure

New unconsented infrastructure such as private slipways and coastal defences, modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impacts to the flora and fauna associated with it.

Invasive Non-Native Species

The New Zealand pigmyweed *Crassula helmsii* has been found nearby and while it can only persist in area where water is not truly saline, it could possibly be an issue if its distribution expands to the upper saltmarsh transitions.

G. vermiculophylla has the capacity to turn saltmarsh pools anoxic, destroying the pool fauna and flora and can therefore have a detrimental impact on the feature (Maggs and Magill, 2014). At high densities, this red seaweed could turn the sediments anoxic, reducing their capacity to support saltmarsh plants and animals and change the sedimentation regime (increase sedimentation of muds), and could alter the habitat in the long-term if it is in high density (Maggs and Magill, 2014).

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect some of the biota of the ASM feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024; Oaten et al., 2024):

- Sea level rise, leading to coastal squeeze and loss of extent.
- Changes in air and sea temperature.
- Increases in wave exposure.
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 25) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 25. Evidence gaps for the ASM feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Distribution and extent of habitats and communities (P)	Unknown	• There are no recent NVC surveys or monitoring aimed at assessing this target for ASM at any of the SACs. Additional fieldwork would be required to assess this indicator.
Topography of the feature (P)	Medium confidence (proxy data used)	• The topography of the ASM feature is not well monitored. Repeat Lidar surveys taken at mean low water springs for all saltmarshes within the SAC are required.
Abundance, distribution and species composition of communities (P)	Not assessed / unknown / low confidence	• Plant communities are not currently monitored. Therefore there is a lack of information on the abundance and distribution of plant communities of the ASM feature. • WFD Regulations data could potentially be used further in future assessments, however, additional analysis will be required.
Attributes of local distinctiveness (P)	Not assessed	• There is a lack of information on the named distinctive elements of the ASM feature**.** Additional fieldwork would be required to assess this indicator in all SACs.
Sediment quality: contaminants (T)	Not assessed	• Currently, there is no sediment monitoring within the ASM feature in all SACs.
Hydrodynamic and sediment transport processes (T)	Medium confidence (proxy data used)	• The hydrodynamic regime of the ASM feature is not currently monitored in all SACs.

3.8. *Salicornia* condition assessment

The *Salicornia* feature in Pen Llŷn a'r Sarnau SAC includes *Salicornia* from the Mawddach, Glaslyn and Dwyryd estuaries (Figure 17). The *Salicornia* feature has been assessed against the performance indicators and an overall condition was assigned for the feature.

Figure 17. Map of the *Salicornia* feature in Pen Llŷn a'r Sarnau SAC.

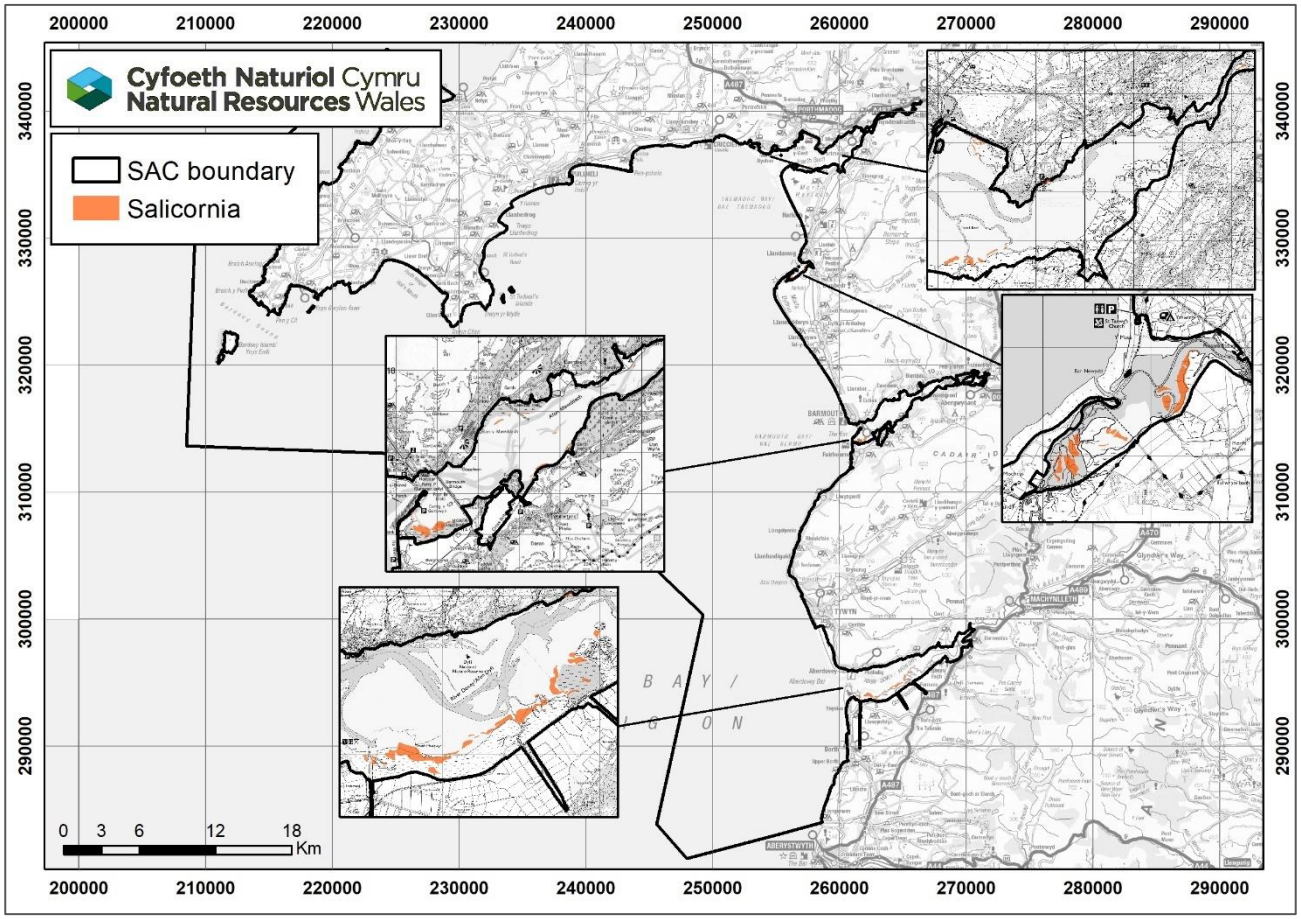


Table 26 has a summary of the assessment outcome against each performance indicator. The outcomes and any reasons for failure are discussed in more detail in the sections below.

Table 26. Condition assessment of the *Salicornia* feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	The extent of *Salicornia* within the SAC should be stable or increasing, allowing for natural change and variation. (P)	• The baseline extent of *Salicornia* in Pen Llŷn a'r Sarnau SAC has been measured as 84.8 ha (1990-2003). • There is no current extent estimate as no up to date mapping of *Salicornia* exists. • There is no evidence to indicate a genuine change in extent of *Salicornia* and the extent of the adjacent ASM feature was maintained. • As there are limited recent data, this indicator was assessed as unknown.	**Unknown**	N/A
Distribution of feature	Maintain the distribution of *Salicornia* throughout the SAC, allowing for natural change and variation. (P)	• *Salicornia* is likely still present within the component estuaries: Dyfi, Glaslyn, Artro and Mawddach. • There is no evidence to indicate a genuine change in range of *Salicornia.* • As there are limited recent data, this indicator was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Physical structure: creeks and pans	Maintain the expected patterns of creeks and pans throughout the SAC, allowing for natural change and variation (P). Artificial drainage channels adversely affecting hydrology are absent or rare. (P)	• There are no anthropogenic impacts known to have significantly affected the creeks and pans in the *Salicornia* feature since SAC designation. • There are currently no known artificial drainage channels that would adversely affect the hydrology within the saltmarsh. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity: allowing for natural variation and change. (T)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of *Salicornia*. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the *Salicornia* feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Two of the four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Glaslyn and Artro). Combined, these overlap with 18% of the *Salicornia* feature. • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Dyfi / Leri). However, all chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 56% of the feature. • The other WFD waterbody has a fail for chemicals (Mawddach), due to PBDE. It overlaps with 20% of the feature. • Confidence is medium as the human health standard has been used for PBDE, some waterbodies have not been classified; and WFD water quality sampling is not focused on areas within the *Salicornia* feature.	**Fail**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All four WFD waterbodies were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach, Glaslyn and Artro). Combined, these overlap with 94% of the feature. ○ Three of these waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to the rolled forward classifications, and as WFD water quality sampling is not focused on areas within the *Salicornia* feature.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the four WFD waterbodies was not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Glaslyn). This waterbody overlaps with 9% of the feature. • The other three WFD waterbodies were classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach and Artro). Combined, these overlap with 85% of the feature. ○ The Mawddach waterbody classification was rolled forward from the 2021 cycle 3 classification. • Aerial images indicated localised growth of opportunistic macroalgae in the pioneer zone in the Artro waterbody, causing the target to fail. • Confidence is low as it is not known how widespread the issue is, and as there are no recorded issues with the DIN in the Artro waterbody.	**Fail**	Low
Air quality	Nitrogen deposition should not exceed the critical load range of 20-30 kg N per ha^{-1} per year. (S)	• Nitrogen deposition within the SAC (where data were available) was under 10 kg N per ha per year for all saltmarshes and did not exceed the critical load on average (APIS). • Confidence is high as the recorded nitrogen deposition is below the lower range of the critical load.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Vegetation structure: sward height	Maintain the expected structural variation within the sward height: allowing for natural change and variation. (P)	• *Salicornia* was present with good structure in areas where relatively heavy grazing was present. • Overgrazing is less likely to occur in *Salicornia* as sheep appear to find *Salicornia* unpalatable. • Confidence is medium as it is based solely on ad-hoc observation and expert judgement.	**Pass**	Medium
Vegetation structure: Zonation of vegetation	Maintain the expected range of saltmarsh zonation for the SAC, allowing for natural change and variation. (P)	• The *Salicornia* mapping is out of date and of poor quality and *Salicornia* is difficult to assess using aerial photography. This indicator was therefore assessed as unknown.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence of INNS presence within the *Salicornia* feature. • Confidence is medium as the spread and impacts of any INNS present within the SAC are not well understood, and there have been no targeted surveys of NNS within the *Salicornia* feature.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There have been no new NNS recorded within the *Salicornia* feature in the SAC. • Confidence is medium as there are no targeted surveys for NNS within the *Salicornia* feature.	**Pass**	Medium

Assessment conclusions

The *Salicornia* feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (low confidence). Overall, the absence of any significant anthropogenic impact on the feature and the presence of *Salicornia* even in heavily grazed areas have contributed to this favourable assessment outcome. There were two indicators with failing targets (Table 27). There were also limited or absent data for five key indicators to inform on the condition of the feature (see evidence gaps). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in (Table 27) with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 27. Summary of the condition assessment for the *Salicornia* feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Salicornia	**Favourable (low confidence)**	Water quality: opportunistic macroalgae (S) Water quality: contaminants (T)	• There is localised growth of opportunistic macroalgae in the pioneer zone of the Artro waterbody. • Levels of PBDE in the Mawddach waterbody are failing to meet its relevant EQS.	• INNS • Water quality: contaminants • Climate change

Detailed assessment information

Extent and distribution

The baseline extent of *Salicornia* in Pen Llŷn a'r Sarnau SAC has been measured as 84.8 ha (1990-2003). The current extent of *Salicornia* cannot be calculated as there is no up to date mapping. The extent and distribution of the feature indicators have therefore been assessed as unknown due to a lack of evidence. *Salicornia* is likely still present within the component estuaries: Dyfi, Glaslyn, Artro and Mawddach. In the Glastreath sector in the Dwyryd estuary, there is potentially significant new pioneer saltmarsh. In the Morfa Harlech sector, the former saltmarsh extent is now sandflat, but it may still be present in the SAC elsewhere. There is no evidence to indicate a genuine change in distribution or range of *Salicornia* in Wales since 2013, nor is one considered likely to have occurred. However, the lack of data resulted in the distribution and extent of habitats indicator not being assessed. These are key indicators to inform on the condition of the feature and the lack of data has influenced the overall confidence in the assessment.

Physical structure

The assessment of this indicator for the *Salicornia* feature has been based on the outcomes of the ASM feature assessment by proxy. There are no anthropogenic activities known to have significantly affected the creeks and pans in the saltmarsh since designation and no known artificial drainage channels that would adversely affect the hydrology within the saltmarsh. The physical structure (creeks and pans) indicator therefore passed its target. The assessment of this indicator was based on expert judgment. Confidence in the indicator pass was reduced to medium as it is difficult to be certain of impacts in this SAC in the absence of data.

Hydrodynamic processes and topography

The hydrodynamic and sediment transport processes, and the topography of the feature indicators were assessed as passing their targets as currently there are no known anthropogenic activities that would have significantly altered these aspects. This assessment was based on expert judgement and knowledge of assessments of plans and projects in the SAC which has reduced the confidence in the assessment to medium, as it is difficult to be certain of impacts in the absence of data. In future, Lidar data could potentially be used to quantify changes in topography.

Water and air quality

It has been estimated that approximately 94% of the *Salicornia* feature within the SAC falls within five WFD waterbodies. There is no up to date mapping of *Salicornia* therefore this overlap figure may not be completely accurate. Due to this and as the water quality sampling is not focused on areas close to the *Salicornia* feature, the confidence has been reduced in all of the relevant water quality assessments.

Contaminants

One of the four WFD waterbodies that overlaps with the *Salicornia* feature has a fail for chemicals in the 2024 cycle 3 interim classification. The failure was in the Mawddach waterbody, which failed for PBDE. This waterbody overlaps with 20% of the feature, which caused the contaminants indicator to fail. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on *Salicornia* are not fully understood. One WFD waterbody, Dyfi / Leri, has a pass for chemicals in the 2024 cycle 3 interim classification. However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 56% of the feature. The other two WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. Combined, these overlap with 18% of the feature. The confidence in the failure was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood. The target weighting of the indicator is tertiary to reflect this.

Nutrients (DIN only) and opportunistic macroalgae

The target for the nutrients (DIN only) indicator was met. A medium confidence was attributed to the pass as WFD water quality sampling is not focused on areas within the *Salicornia* feature, and as some WFD waterbody classifications for DIN were rolled forward from previous cycles. The nutrients indicator (DIN only) was also given a tertiary weighting as the effects of high nutrient levels on the *Salicornia* feature are not fully understood.

Three of the four WFD waterbodies that overlap with the *Salicornia* feature were classified with a Good status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. However, in the Artro waterbody, aerial image analysis in the pioneer zone indicated evidence of opportunistic macroalgae, resulting in a fail for the nutrients indicator. The confidence in this assessment was low since it is difficult to assess how widespread the issue is, and as there have been no recorded issues with the DIN or opportunistic macroalgae elements in the relevant WFD waterbody classifications.

Air quality

High levels of nitrogen deposition from the atmosphere can have a detrimental impact on saltmarsh since they are nitrogen limited. The nitrogen deposition within the SAC, where data were available, was under 10 kg N per ha per year for all saltmarshes and therefore did not exceed the critical load of 20 kg N per ha per year (APIS), resulting in this indicator passing with high confidence.

Vegetation structure

While overgrazing is happening in the Glaslyn and Mawddach saltmarshes, *Salicornia* appeared to be in high abundance from ground observations. Overgrazing is less likely to occur in the *Salicornia* feature as sheep appear to find *Salicornia* unpalatable. The sward height target was therefore met but the confidence was reduced to medium as it is based solely on ad-hoc observation and expert judgement.

The zonation of vegetation indicator has been assessed as unknown. *Salicornia* is difficult to assess by aerial imagery as its density can be sparse. True extent measurement is unrealistic with this sampling technique. Further investigation with ground truthing evidence will be needed to adequately assess the extent of *Salicornia* in future.

Invasive non-native species

The saline conditions of saltmarshes prevent the common terrestrial NNS in Wales becoming established. There have been no new NNS recorded within the *Salicornia* feature in PLAS SAC, and any NNS present are not considered to have an impact on the condition of the feature, resulting in both the primary and tertiary targets for the INNS and NNS indicators to be met.

There were, however, some notable records of NNS within the SAC. *Gracilaria vermiculophylla* was first found in Wales in the Glaslyn / Dwyryd estuary in 2017, and since then it has been recorded in the Mawddach, and Dyfi estuaries (Mercer and Brazier, 2023). These specimens appeared to have been washed into the marsh with the tides and although they continued to grow, they were not necessarily persistent. For this reason, *G. vermiculophylla* has been judged to not be having an impact on the condition of the *Salicornia* feature.

Both INNS and NNS targets passed with a medium confidence as there have been no targeted NNS surveys within *Salicornia*, which would be required to fully understand the presence and impacts of any NNS species within the *Salicornia* feature.

Reasons for target failure

The *Salicornia* feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, one secondary target and one tertiary target failed to be met and need to be kept under review.

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. Aerial imagery shows evidence of opportunistic macroalgae in the pioneer zone in the Artro waterbody, causing the indicator to fail. There were no failures for the relevant elements in the overlapping WFD waterbodies in the 2024 cycle 3 interim classification, including in the Artro waterbody, therefore there have not been any WFD investigations into the sources of nutrients. Further investigation is required to assess how widespread the issue is.

Water quality: contaminants

This indicator target has a tertiary weighting. The *Salicornia* feature in the SAC is partly within one WFD waterbody (Mawddach) that has a fail for chemicals due to PBDE. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous sewage discharge from the water industry. The WFD investigation of the failure in this

waterbody is yet to be undertaken. PBDE is being managed in the UK and it is hoped that these levels will reduce in time.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the *Salicornia* feature. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition. The threats to the condition of the *Salicornia* feature in Pen Llŷn a'r Sarnau SAC are stated below.

Invasive non-native species

G. vermiculophylla has the capacity to smother *Salicornia* plants, reducing the density of *Salicornia.* At high densities, this red seaweed could block recruitment of *Salicornia* and other angiosperms and turn the sediments anoxic, reducing their capacity to support saltmarsh plants and animals and change the sedimentation regime (increase sedimentation of muds), altering the topography of the sediment flats / saltmarsh. *Salicornia* is likely to be more at risk than the ASM feature. More research is required to understand whether the species would be detrimental to *Salicornia*, and if it is present in areas within the *Salicornia* feature.

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant WFD waterbodies have not been classified for any chemicals.

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024; Oaten et al., 2024):

- Sea level rise, leading to coastal squeeze and loss of extent.
- Changes in air and sea temperature.
- Increases in wave exposure.
- Changes in species distribution.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 28) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 28. Evidence gaps for the *Salicornia* feature in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Feature extent (P); distribution of feature (P); vegetation structure: zonation of vegetation (P)	Unknown	• The *Salicornia* mapping is out of date and of poor quality in all SACs. *Salicornia* is difficult to assess using aerial photography. More detailed mapping, possibly using drones, in combination with ground truthing is required.
Distribution and extent of habitats and communities (P)	Not assessed	• There is a lack of information on the distribution and extent of habitats and communities for *Salicornia* in all SACs. More detailed mapping, possibly using drones, in combination with ground truthing is required.
Topography of the feature (P)	Medium confidence (proxy data used)	• The topography of the *Salicornia* feature is not well monitored in any of the SACs. Repeat Lidar surveys taken at mean low water springs within the SAC are required.
Attributes of local distinctiveness (P)	Not assessed	• There is a lack of information on the named distinctive elements of the *Salicornia* feature**.** Additional fieldwork would be required to assess this indicator in all SACs.
Water quality: opportunistic macroalgae (S)	Low confidence (limited data)	• While a localised issue has been identified within the *Salicornia* feature from aerial photos for the Artro in the Pen Llŷn a'r Sarnau SAC, further data are required to determine how widespread and persistent the issue is.
Sediment quality: contaminants (T)	Not assessed	• Currently, there is no sediment monitoring within the *Salicornia* feature in all SACs.
Hydrodynamic and sediment transport processes (T)	Medium confidence (proxy data used)	• The hydrodynamic regime of the *Salicornia* feature is not currently monitored in all SACs.

3.9. Sea caves condition assessment

The sea caves feature in Pen Llŷn a'r Sarnau SAC includes a number of submerged and partially submerged sea caves (Figure 18). The summary of the assessment outcome for sea caves is provided in Table 29. This outcome and reasons for failure are discussed in more detail in the sections below.

Figure 18. Location map of the sea caves feature in the Pen Llŷn a'r Sarnau SAC.

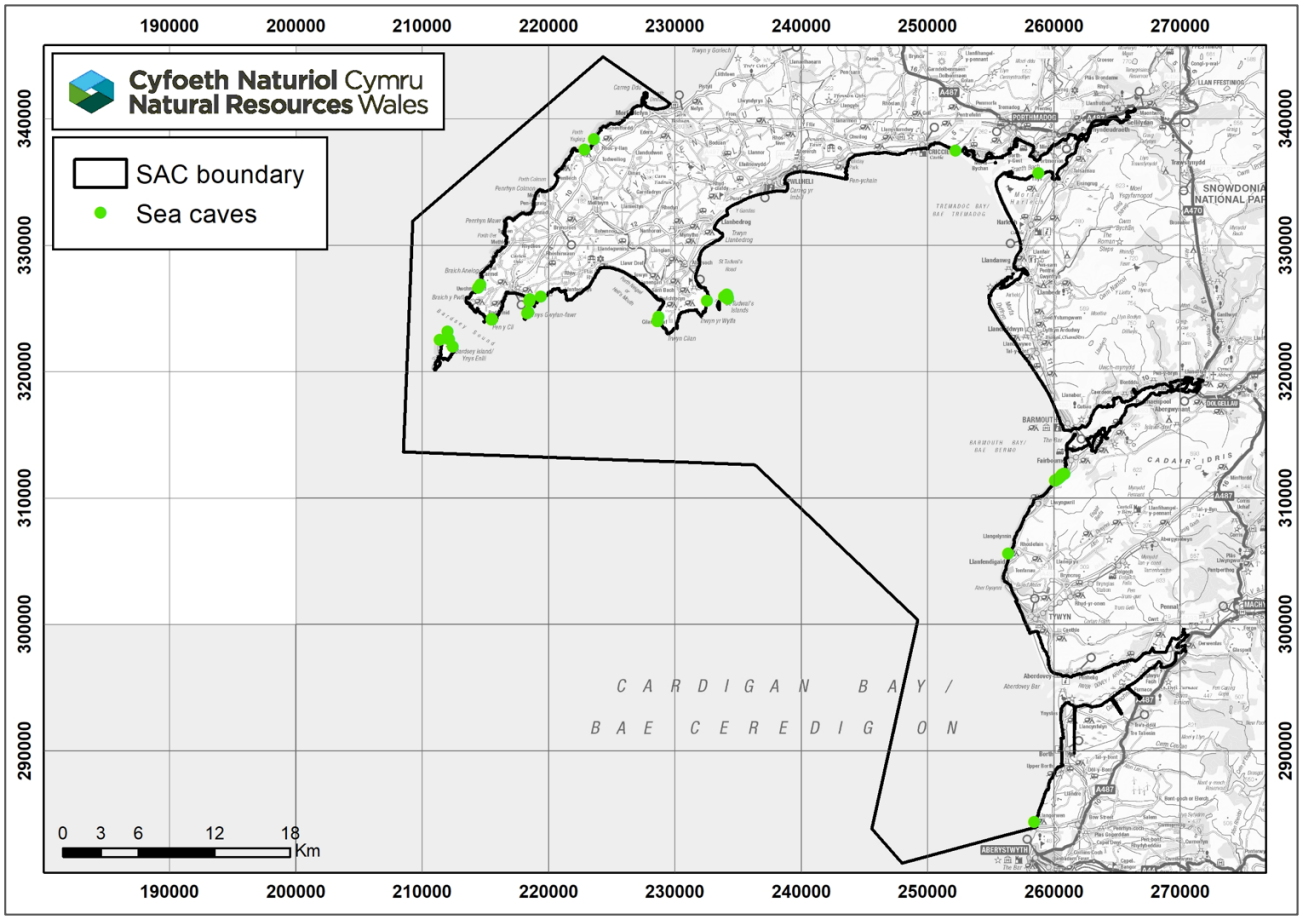


Table 29. Condition assessment of sea caves in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of sea caves allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of sea caves communities in the Pen Llŷn a'r Sarnau SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves on this site.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves on this site.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the four WFD waterbodies that overlaps with the sea caves feature was not classified for DIN in any cycles (Tremadog Bay). It overlaps with 29% of the mapped sea caves. • The other three WFD waterbodies were classified with a High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay North, Caernarfon Bay South and Glaslyn). Combined, these waterbodies overlap with 71% of the mapped sea caves. ○ One of these waterbody classifications was rolled forward from the 2018 cycle 2 interim classification. • Confidence is low due to the one unclassified waterbody and as ecological relationships between DIN and sea caves are not fully understood.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the four WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). Combined, these overlap with 31% of the mapped sea caves. • The other two WFD waterbodies were classified with a Good status for phytoplankton (Cardigan Bay North and Caernarfon Bay South). Combined, these overlap with 69% of the mapped sea caves. • Confidence is low due to the unclassified waterbodies, and as ecological relationships between phytoplankton and sea caves are not fully understood.	**Pass**	Low
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the four WFD waterbodies that overlap with the sea caves feature were not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). Combined, these overlap with 31% of the mapped sea caves. • The other two WFD waterbodies were classified with High status for dissolved oxygen (Caernarfon Bay South and Cardigan Bay North). Combined, these overlap with 69% of the mapped sea caves. • Confidence was high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Three of the four WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Tremadog Bay, Caernarfon Bay South and Glaslyn). Combined, these waterbodies overlap with 36% of the mapped sea caves. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification due to mercury and PBDE (Cardigan Bay North). It overlaps with 64% of the mapped sea caves. • Confidence is low as the human health standard has been used for PBDE, some waterbodies were not classified, and the impact of these contaminants on sea caves is unknown.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (T)	• There are limited data on turbidity for the sea caves feature in Pen Llŷn a'r Sarnau SAC, therefore this target as assessed as unknown.	**Unknown**	N/A
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• No information on sea cave communities has been collected for this SAC since 2000-02. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • There is also little information on the impact of any INNS present in the SAC on the condition of sea caves.	**Unknown**	N/A
Non-native species (INNS)	No increase in the number of introduced NNS by human activities. (T)	• No information on sea cave communities has been collected for this SAC since 2000-2002.	**Unknown**	N/A

Assessment conclusions

The sea caves feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **unknown** condition (N/A confidence). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps). There was one tertiary failing indicator (Table 30). A summary of the assessment can be seen in Table 30 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

For features where an unknown result is recorded a simple assessment was undertaken to see what level of risk the feature might currently be experiencing that could cause it to be in unfavourable condition, if a full assessment were possible.

This simple assessment for sea caves looked at:

- Other indicators assessed in the condition assessment e.g. extent.
- What pressures are present on the SAC or adjacent to the SAC.
- Any other relevant data e.g. other relevant condition assessments.

Eight indicators were assessed as passing in the assessment of condition for sea caves in the Pen Llŷn a'r Sarnau SAC including extent and distribution. These can be seen in Table 29. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

The following was discussed: there are no major anthropogenic pressures on the SAC that might cause the feature to be unfavourable. However, there were concerns about the accumulation of marine litter, especially in south-west facing caves, but due to the lack of sea cave surveys the scale of this could not be verified. There were also concerns about infilling of caves to support coastal infrastructure, this has happened in the past. Other activities that might affect the feature were also discussed. The condition assessment results for intertidal reefs feature at the same SAC was also discussed. On the balance of knowledge of anthropogenic activities in the area and the fact that intertidal reefs in the same SAC passed their species and communities targets it was decided that the sea caves on this SAC were unlikely to be in unfavourable condition.

The sea caves were assessed as being at medium likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment but the confidence was judged to be low (Table 30).

Table 30. Summary of the condition assessment for sea caves in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Sea caves	**Unknown (confidence not applicable)**	**Medium (low confidence)**	Water quality: contaminants (T)	• Levels of mercury and PBDE in the Cardigan Bay North waterbody are failing to meet their relevant EQSs.	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences

Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Pen Llŷn a'r Sarnau SAC passed their targets as there are no known anthropogenic impacts that would negatively affect the sea caves feature at the present. Although there were concerns about infilling of sea caves in one part of the SAC for coastal infrastructure that happened in the past, it was not felt to be enough to fail this indicator. It should be noted that not all sea caves in this SAC have been mapped. Comparison mapping has not been used to assess the extent and expert judgment was used to assess these indicators in the absence of recent data. This has reduced the confidence to medium.

Bathymetry and hydrodynamic processes

The bathymetry and hydrodynamic and sediment transport processes are not well researched for sea caves. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the sea caves within this SAC.

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within four WFD waterbodies where 64% overlap with the Cardigan Bay North waterbody, 29% with the Tremadog Bay waterbody, 5% with Caernarfon Bay South waterbody and 2% with the Glaslyn waterbody.

Nutrients (DIN only) and phytoplankton

The indicators for nutrients and phytoplankton met their targets. Some of the relevant WFD waterbodies were not classified for the DIN and phytoplankton element. This includes the Tremadog Bay waterbody, which overlaps with a significant proportion of the mapped sea caves. This caused the confidence in the assessments to be reduced to low. Classification of phytoplankton for some WFD waterbodies are not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). For phytoplankton, there has been a deterioration from High status prior to the 2021 cycle 3 classification to Good status thereafter in the Cardigan Bay North waterbody. This waterbody overlaps with the largest proportion of the feature. This also contributed to the low confidence outcome. In addition, the ecological relationships between DIN and phytoplankton, and the sea caves feature across all SACs are not fully understood.

Dissolved oxygen

The dissolved oxygen indicator also met its target as most of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence was high as sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

One of the four WFD waterbodies that overlaps with the sea caves feature in the SAC, Cardigan Bay North, has a fail for chemicals in the 2024 cycle 3 interim classification due to mercury and PBDE. This waterbody overlaps with the largest proportion of the mapped sea caves (64%), which caused the contaminants indicator to fail. There was no change in the failure since the 2021 cycle 3 classification. The Cardigan Bay North waterbody failed for tributyltin (TBT) in previous cycles. This chemical is no longer assessed. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of sea caves are not fully understood. Three WFD waterbodies that overlap with the sea caves feature were not classified as the chemicals have not been assessed within the last six years. Overall, the confidence in the failure was reduced to low to reflect that the PBDE failure uses a protection goal which may be over precautionary, and due to some waterbodies being unclassified for chemicals. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data. There were some data available from WFD Regulations sampling of suspended particulate matter. However, this is limited to only a few samples per year and therefore cannot be used to adequately assess the turbidity.

Data from six NRW monitored subtidal temperature loggers within the SAC were available. Three of the loggers are close to some of the mapped sea caves (<1km away). Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

No information on sea cave communities has been collected for this SAC since 2000-2002. It should also be noted that not all sea caves have been mapped on this SAC. Along the south coast of Pen Llŷn, Two-levels cave on East St Tudwal's Island had exceptional examples of species-rich un-scoured littoral and sublittoral biotopes. Of special note were the encrusting sponges, the large patch of the anemone *Epizoanthus couchii* and the presence of the rare red seaweed *Schmitzia hiscockiana*. The complex tunnel at Pen-y-Cil had extensive areas of rich, tide-swept but un-scoured sublittoral biotopes and included

species not commonly encountered in other caves studied including the ascidian *Polysyncraton lacazei* and many large growths of the sponge *Tethya aurantium*. The large-scale rock architecture of this tunnel was not encountered elsewhere in the 2000-2002 surveys (Bunker and Holt, 2003).

Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. Subtidal reefs did fail but not for reasons that would be linked to the sea caves. However, reef was not used as a proxy so this indicator has been assessed as unknown.

Invasive non-native species

There is no information available on the establishment or impact of non-native species in sea caves in this SAC as there have been no surveys within the sea caves since 2000-2002. For this reason the INNS and NNS targets were assessed an unknown. It is not fully understood how any NNS present in the SAC could impact the sea cave biota and any potential effects on the species diversity and composition are unknown.

Reasons for target failure

The assessment of the sea caves feature in Pen Llŷn a'r Sarnau SAC failed one tertiary target. There were also six targets that were assessed as unknown due to limited data availability. Overall the feature was assessed to be in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: contaminants

This indicator target has a tertiary weighting. A large proportion of the sea caves feature in the SAC overlaps with one WFD waterbody, Cardigan Bay North, which has failed for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. The WFD investigation of the failures is yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the sea caves. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission process e.g. offshore wind and marine cabling, whereby the impact of the activity on the feature would be assessed have not

been included. The threats to the sea caves feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Recreational access and collection

Access for recreational activities particularly coasteering can have a trampling effect on intertidal sea caves. This could have detrimental impact on the sea cave communities.

Invasive non-native species

Invasive non-native species are a threat to most of the features in the Welsh SACs. The impact of INNS on the sea caves feature is not well understood, and as they are mostly shady environments many of the invasive seaweeds are unlikely to be an issue.

Further INNS were identified as potential threats to the UK and were listed in the latest horizon scanning exercise (Roy et al., 2019). There is a high likelihood for some of these species to be found in Wales in the future. The SACs could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Management of coastal defences

The State of the UK Climate 2023 Report highlights an observed acceleration in rates of climate induced sea-level rise which, along with storm surges can cause coastal erosion and flooding (Kendon et al., 2024). Shoreline Management Plans identify the preferred approach to coastal management in light of climate change, which includes maintaining or upgrading defences in some areas and adapting the approach to management in others. Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species.

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024; Oaten et al., 2024):

- Sea level rise, leading to coastal squeeze and loss of extent for some SACs.
- Changes in air and sea temperature,
- Changes in ocean acidification,
- Changes to wave climate, especially storm frequency and intensity.

Marine litter

Caves especially south-west facing caves are known to accumulate marine litter. This litter can breakdown and cause smothering and leaching effects on sea cave communities. The scale of the issue in the SAC is unknown but is definitely a threat.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 31) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 31. Evidence gaps for sea caves in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Distribution and extent of habitats and communities (P)	Low confidence (proxy data used)	• There are currently no data available to assess changes for these indicators from within sea caves across all SACs. Assessment was based on expert judgment.
Abundance, distribution and species composition of communities (P); species richness and diversity (P)	Unknown	• There are no current data available to assess this indicator for sea caves across all SACs.
Invasive non-native species (P); non-native species (T)	Unknown	• Investigations into the impact of the recorded NNS on sea caves is required. • There have been no targeted surveys for NNS in sea caves across all SACs.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling, but this is limited to only a few samples per year. Therefore, this cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.10. Grey seal condition assessment

The grey seal *Halichoerus grypus* population in Pen Llŷn a'r Sarnau SAC has been monitored sporadically since 2001. A summary of the condition assessment for grey seal in Pen Llŷn a'r Sarnau SAC can be seen in Table 32 which contains a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions.

Table 32. Condition assessment of grey seal in Pen Llŷn a'r Sarnau SAC. Indicator targets have a primary (P) or secondary (S) target (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Seal population size relevant to the SAC	The wider seal population relevant to the SAC is stable or increasing. (P)	• The population relevant to the SAC encompasses all of Wales and the wider Irish and Celtic seas. • A census of grey seals in south-west Britain (including the entire coast of Wales) was done via aerial survey in August 2023. • The population of grey seals in Wales was estimated to be 5,284 seals at the time of the survey. This is a minimum estimate due to cryptic haul outs (e.g. caves). • Pup production models estimate the adult (1 year +) population of Wales to be approximately 5,300. • The population relevant to the SAC was judged to be doing well and assumed to be increasing. • Confidence is medium as updated methods and survey areas in the latest aerial survey make comparisons to previous surveys difficult. The lack of systematic monitoring of seals at the all-Wales scale also lowered the confidence.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Colony pup production	A stable or increasing pup production at the colony level, that support the SAC population, allowing for natural change and variation. (P)	• There is one monitored colony in Pen Llŷn a'r Sarnau – Bardsey Island. NRW monitoring stopped after 2019. There is some monitoring available from the Bardsey Bird and Field Observatory up to 2023. • 52 pups were born on Bardsey in 2023. There has been generally increasing trend in pup production on the island with peaks and troughs throughout. • Bardsey Island appears to be the key pupping colony in North Wales and the SAC, supporting almost 80% of all pups born within the SAC in 2017. • Seal pup production at Bardsey is considered to be increasing up to 2023 but showing signs of stabilising. • Confidence is medium as monitoring is only on Bardsey Island.	**Pass**	Medium
SAC pup production	A stable or increasing pup production within the SAC that supports the SAC population allowing for natural change and variation. (S)	• Surveys of pup production between 2002-2017 in Pen Llŷn a'r Sarnau showed the number of pups born almost doubled over the survey period where comparisons were possible (Robinson et al., 2023). • In 2017, pup production in the SAC represented 57% of all pups produced within the North Wales region. • The pup production estimates from 2017 suggest that the SAC contributes approximately 10% of all pup births in Wales. • This highlights the importance of the SAC as a source of new recruits to the population. • Confidence is low due to the age of the pup production data for the SAC as a whole and as monitoring is only at a single colony on Bardsey Island.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Distribution of grey seal pupping sites within the SAC	The distribution and extent of pupping sites in the SAC is stable or increasing, allowing for natural change and variation. (P)	• There was an increase of 145% in the number of pupping sites in the 2017 North Wales census compared with the 2002 to 2004 censuses. • As there have been no reports of pupping sites decreasing post 2017 and there is a general increasing trend in pup production in Wales and the UK, possibly associated with expansion of pupping site distribution, the indicator passes. • Monitoring of pupping by the Bardsey Island Field Observatory have not noted any changes to pupping distribution in the island as of 2023. • Confidence is medium as monitoring is only on Bardsey Island and due to the age of the census data.	**Pass**	Medium
Accessibility to habitat used by seals	No evidence of significant constraints on grey seal access to habitat within or associated with the SAC. (P)	• There is currently no knowledge of 'barriers' that would be a concern. • Seal numbers are stable or increasing across the SAC suggesting no significant constraints on seals' access to habitat required to support them. • Confidence is medium as the data on seal numbers are mainly from Bardsey island.	**Pass**	Medium
Anthropogenic disturbance	No significant anthropogenic disturbance affecting the grey seal population associated with the SAC. (P)	• There is currently no evidence of significant anthropogenic disturbance impacting the seal population associated with the SAC. • The confidence in the pass is medium as while the population is increasing there is no activity monitoring in the SAC.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Prey availability	Maintain the quality, abundance and diversity of prey species needed to support the grey seal population. (S)	• There is no reason to believe that grey seals are prey limited, or prey availability is limiting the grey seal population, or there has been a reduction in diversity of available prey species. • Grey seal population is expanding in Wales which strongly suggests prey is abundant enough to support the population. • Confidence in the pass is medium as the assessment is based on proxy data (seal numbers and fisheries data).	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water, sediment and prey contaminants	Ensure water, sediment and prey contaminants are at levels not detrimental to the grey seal population. (S)	• Six of the nine WFD waterbodies in the SAC were not classified as the chemicals have not been assessed within the last six years (Caernarfon Bay South, Tremadog Bay, Artro, Dwyfor, Dysynni and Glaslyn). • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Dyfi / Leri). However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. • Two waterbodies have a fail for chemicals (Cardigan Bay North and Mawddach), due to PBDE and mercury. • OSPAR report mercury and lead are above ecological guidelines in the North East Atlantic region, as is one congener of polychlorinated biphenyls (PCB). • OSPAR report the PCB range in 2010-2020 was lower than the 1980s but still above marine mammal toxicity thresholds. • A study of marine mammals from around the UK found grey seals had the lowest mean concentrations of persistent organic pollutants (POPs) of all 11 species studied, with only 17% above toxicity thresholds. However, the sample size was small. • Contaminants are deemed not to be having a detrimental impact on seals at present, but confidence is low due to lack of sampling in seals and lack of understanding of the impact contaminants have at the population level.	**Pass**	Low

Assessment conclusions

The condition of the grey seal feature in the Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable condition** (medium confidence). All performance indicators met their targets (Table 33). The wider population and pup production data all suggest grey seal numbers have been increasing in recent years. While contaminants are present, they are not thought to be impacting grey seals at a population level at present but remain a threat to condition. There is significant bycatch of grey seals in net fisheries in the Celtic Seas of the south-west UK and Ireland (SCOS 2022; Taylor et al., 2022). While seal bycatch is likely to be minimal inside Pen Llŷn a'r Sarnau SAC, bycatch outside of the SAC affects the wider population, of which the SAC is part.

A summary of the assessment can be seen in Table 33 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 33. Summary of the condition assessment for grey seal in the Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Grey seal *Halichoerus grypus*	**Favourable (medium confidence)**	None	None	• Disturbance • Contaminants • Fisheries bycatch

Detailed assessment information

Grey seal population

Based on pup production, it is estimated that approximately 3-4% of the UK's grey seal population resides in Wales (SCOS, 2022). An estimated 2,250 pups are born per year in Wales (Russell and Morris, 2020). However, there is uncertainty around this estimate given the age and sporadic nature of most of its underlying data (e.g. Baines et al., 1995; Westcott 2002; Westcott and Stringell 2003). Pup production at regularly monitored sites in Wales has increased markedly since monitoring began (Bull et al., 2017; Morgan et al., 2018; Strong et al., 2006; Robinson et al., 2023).

While grey seals show fidelity to their chosen breeding sites (Pomeroy et al., 2000; Langley et al., 2020), they have been shown to range widely within Wales, southwest England, and Ireland as demonstrated by satellite tracking studies (SCOS, 2013; Thompson, 2011; Russell et al., 2017) and photographic identification (photo ID) (Langley et al., 2020; Pomeroy, et al., 2014; 2015). Females have been shown to range between Skomer in the south and Bardsey in the north within the 8–10-week breeding season. This suggests some females are moving away from breeding sites after pups are reared (approx. 20 days), or that non-breeding females are coming in and out of the breeding areas from around Wales (Langley et al., 2020).

Outside of the breeding season, satellite telemetry has shown that animals (weaned pups/yearlings and adults) also move large distances and seals tagged in Wales have been tracked hauling out around the Irish and Celtic Seas (see Carter et al., 2022 for synopsis).

For these reasons, the population of seals relevant to the Pen Llŷn a'r Sarnau SAC can be said to be part of the wider seal population inhabiting the UK, particularly within the Irish and Celtic Seas region. Within this area there are several Seal Monitoring Units (SMUs) (SCOS, 2022), of which SMU 12 is the whole of Wales.

An aerial survey in August 2023 counted 1,313 grey seals across Wales. As approximately only 25% of the population are hauled out and visible at any one time, this equates to a population estimate of around 5,284 individuals (95% confidence intervals 4571- 6195) (Thompson, in prep). This represents a minimum estimate due to the use of cryptic haul outs not visible to aerial photography e.g. in caves (Stringell et al., 2014). Ground counts of some haul out sites taken at the same time as aerial surveys, were higher than aerial counts, suggesting a further 10% could also be added to the estimate (Thompson, in prep).

The aerial survey estimated a 64% increase in the number of hauled-out seals, based on the difference since the last summer composite estimate of 800 hauled-out seals that represented data from 2002-2020 (Thompson, in prep). This increase is likely due to more extensive coverage of mainland and offshore island sites in the aerial survey which were not included in the previous estimate (probably a large under estimation) and the apparent increase in numbers of hauled-out seals at previously included sites (Thompson, in prep). Seals hauled-out at cryptic coastal sites, e.g. caves and overhanging cliffs, however, were not counted by the aerial survey and represent an unknown but possibly large bias. Due to the differences in the way these estimates were produced it is hard to tell how large the

increase has been with certainty. The fact that a similar 65% increase is estimated at directly comparable North Wales sites from surveys in August 2002, supports the suggestion of a population increase in Wales (Thompson, in prep).

Pup production is typically used to estimate the size of the overall population (Russell et al., 2019; Thomas et al., 2019). The most recent Welsh pup production estimate, based on pup production between 2016-2019 from sites across Wales, is 2,250 pups (Russell and Morris, 2020). This pup production estimate is used to give an estimate of total population size (1+ year old). Pup production is multiplied by a scaling factor of 2.31, which represents a ratio of pups to adults from systematically monitored pup colonies in Scotland and east England. Based on pup production, the Welsh population is estimated to be approximately 5,200, which is, perhaps coincidentally, very close to the total population estimated from hauled-out seals in summer (Thompson, in prep).

The population of grey seals relevant to the SAC was judged to be doing well and assumed to be increasing, meeting the indicator target. The confidence in the pass was reduced to medium, however, to reflect the caveats on the aerial survey results, the conservative estimates of pup production and the fact that comparisons between the latest aerial survey of summer population and previous ground-based survey results are challenging and potentially unreliable. This makes it harder to say with certainty that the estimated increase is a true increase, but our judgement is that an increase has occurred.

Colony pup production

Female grey seals are assumed to give birth to one pup in a breeding season meaning pup production can be used as a suitable proxy for breeding female abundance and a good indicator of the health of the population (JNCC, 2005).

In 2017, a census of seals in North Wales was undertaken (Robinson et al., 2023). This followed on from previous censuses between 2001-2004 (Westcott 2002; Westcott and Stringell 2003; Westcott and Stringell 2004; Stringell et al., 2014). The results of the 2017 census suggest that the number of grey seal births across North Wales has increased significantly since 2004 (Figure 19). Almost half of the pups born in 2017 came from Bardsey Island, located in the SAC (Robinson et al., 2023). The south of the Llŷn peninsula, the Skerries and Carmel Head on Anglesey were also identified in the 2017 survey as important pupping sites. However, Bardsey had almost twice as many pups as the Skerries, the second most productive area in North Wales (Robinson et al., 2023).

Bardsey is considered a key breeding site in North Wales and has been monitored regularly up to 2019 by NRW. Monitoring is also undertaken by the Bardsey Bird and Field Observatory (BBFO) with counts up to 2023 available. Their data showed pupping has over been increasing on Bardsey over all since 1998, though the data show peaks and troughs (Figure 20) (BBFO, 2024).

As Bardsey is the main colony in the SAC and the North Wales region and pup production at this site has been increasing, the colony pup production indicator passed. Confidence in the pass, however, was medium because the latest census is seven years old at the time of assessment and only Bardsey Island is monitored.

Figure 19. Total observed pup production across the North Wales region from surveys conducted in 2001, 2002, 2004 and 2017. Reproduced from Robinson et al., 2023.

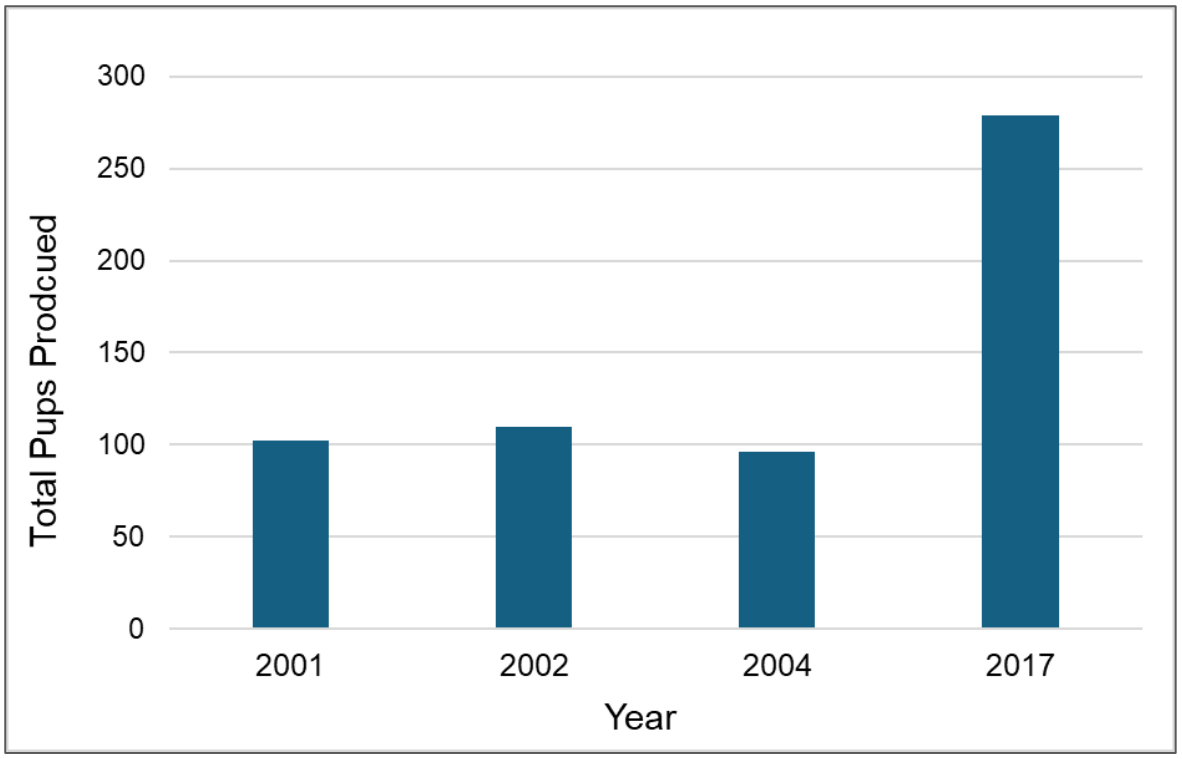
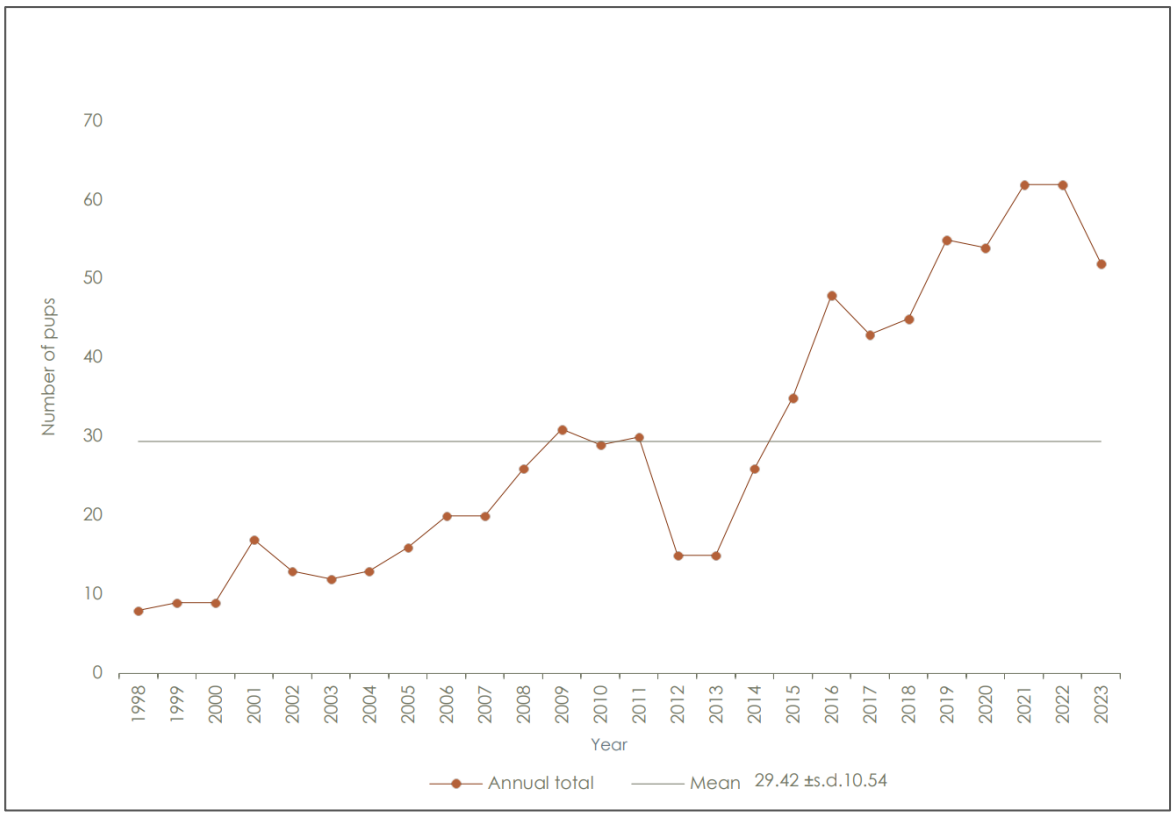


Figure 20. Pup production on Bardsey Island between 1998 and 2023. Reproduced from BBFO, 2024.



SAC pup production and distribution

The 2017 census of grey seals in North Wales estimated that production within the Pen Llŷn a'r Sarnau SAC was 159 pups (all classes). This represented 57% of all pups born in North Wales that year. The minimum-maximum estimate for the whole of North Wales was 207-351 pups (Robinson et al., 2023). Pup production in the SAC almost doubled between 2002-2017 where comparisons were possible. Of the pups counted within the boundary of the SAC, 80% were born on Bardsey Island. This suggests that the Pen Llŷn a'r Sarnau SAC contributes approximately 10% of the pups born in Wales (Robinson et al., 2023).

There has also been a trend across the UK for increases in the grey seal populations in all regions. The seal population in the UK has increased steadily since the 1960s, though this increase is now slowing (1.4% per year over the last survey interval) (SCOS, 2022).

With the 2017 census showing pup production across the whole SAC (and North Wales region) increased up to 2017, which mirrored the UK national trend, the SAC pup production target is judged to have been met. Confidence in this pass is low due to the age of the census data and only a single site in the SAC has monitoring data.

The distribution of breeding across the SAC can reflect factors impacting on seals, both positive and negative. Monitoring seal pupping distribution can identify areas that are important to breeding seals (JNCC, 2005). These areas can then be managed for anthropogenic impacts. If the distribution of breeding seals changed across the SAC it could be indicative of disturbance or reduction in habitat quality.

The breeding colony at Bardsey Island has been a key pupping site since at least 2002, when monitoring began. While the Island has seen significant increases in pup production in more recent years, there is no evidence to suggest the increase at this site is a result of females shifting from other areas within the region; the increase in pup production over time appears consistent at several other survey areas (Robinson et al., 2023). Monitoring data from the BBFO found no change in the distribution of pupping sites on Bardsey Island up to 2023 (BBFO, 2024). In 2017 the number of sites used for pupping across the North Wales region has increased by 145% compared to 2004. However, increased survey effort should be kept in mind when interpreting these results (Robinson et al., 2023).

The evidence of a large increase in the number of pupping sites, increasing pup production and no evidence of activities that would disrupt seal pupping distribution, has meant the indicator has met its target. The confidence in the pass, however, was reduced to medium due to the age of the census data and the fact monitoring is only done at a single colony on Bardsey Island.

Habitat accessibility and disturbance

Grey seals require suitable coastal habitat with which to haul out onto to rest after foraging, to give birth and rear their pups and to moult. In general haul out and breeding sites are undisturbed areas of rock, sandbank or beach with good access to the open sea (JNCC, 2005). In Wales, seals show a strong preference for breeding in sea caves (Baines et al., 1995; Stringell et al., 2014). Seals also require suitable foraging habitat that supports sufficient prey to maintain the population. There is a lack of understanding of the availability of suitable habitat in Pen Llŷn a'r Sarnau SAC. However, the number of grey seals and number of pupping sites in the SAC have been increasing (Robinson et al.,

2023). Further to this, the wider population is assumed stable or increasing (SCOS, 2022), and there is no evidence of constraints to their movements. For these reasons, it is assumed that grey seals have access to the habitats needed to support them and the indicator passed with medium confidence. Confidence was lowered as the data on seal numbers are mainly from Bardsey island.

Disturbance on land mainly comes in the form of recreational disturbance (e.g. dog walkers, kayakers, coasteering, wildlife watching boats, drones etc) or from airborne noise such as from construction, military exercises and recreation e.g. fireworks. Disturbance can lead to seals escaping into the water to avoid the perceived threat. This can stress seals and comes with an energetic cost. It is also a danger to new pups and can result in pup death through physical harm as adults flee to the water or starvation as the mother abandons the breeding site and pup altogether (SCOS, 2013). Changes in the distribution of breeding seals could be indicative of disturbance.

Disturbance to seals at sea comes largely from underwater noise associated with construction of industrial developments e.g. windfarms. There is concern that loud underwater noise can lead to hearing damage, cause animals to flee from or avoid their natural habitat, reduce foraging, and cause physiological stress (Southall et al., 2019; Hastie et al., 2015; Russell et al., 2016; Whyte et al., 2020). Behavioural changes have energetic and fitness costs and may have consequences on populations (e.g. Chudzinska et al., 2024).

It is vital that seals have unconstrained access to sufficient suitable habitat both on land and at sea. There is currently no evidence of significant disturbance to seals in the SAC so the indicator passed with medium confidence. Confidence was lowered due to a lack of regular seal monitoring in the SAC, no activity monitoring across the SAC and no data on disturbance of seals outside monitored colonies in the SAC.

Prey availability

Grey seals are generalist predators and their diet varies depending on their location and the time of year, taking whatever food source is locally abundant (Bowen et al., 2006; Brown et al., 2012; Hammond and Prime, 1990). A study on grey seal diet in Pembrokeshire between 1992 and 1994 found seals ate a wide range of fish species, most of which are not commercially fished, reflecting their opportunistic feeding behaviours. Gadoids and flatfish dominated seal diet (70%) over 3 years in Pembrokeshire (Strong, 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). Some commercial species are potentially depleted in the Irish / Celtic Seas (cod, whiting, seabass, herring and plaice which made up 33% of seal diet by weight in the Strong (1996) Pembrokeshire study. However, other commercial species like sole remain abundant, and herring and seabass appear to be making slow recoveries following cessation or restrictions on fishing.

There is no reason to believe that prey is limited or has reduced diversity in the areas of Pen Llŷn a'r Sarnau SAC that grey seal are using to forage, therefore the indicator passes. Confidence was medium as there is no targeted surveying of prey abundance or recent seal diet studies.

Contaminants

Grey seals, like all marine mammals, are exposed to a variety of anthropogenic contaminants. The main route of exposure is through ingestion of prey, as these mammals are top predators, making them 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) and heavy metals (e.g. mercury), which are lipid soluble. The toxic effects of these contaminants are well studied with impacts such as reduced reproduction and high susceptibility to disease (Hammond et al., 2005).

Two of the WFD waterbodies in the Pen Llŷn a'r Sarnau SAC have a fail for chemicals in the 2024 cycle 3 interim classification. These are Cardigan Bay North, which fails for PBDE and mercury, and the Mawddach, which fails for PBDE. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on grey seals are not fully understood. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife), which may be more relevant to grey seals and is sampled from biota they may eat.

The Dyfi / Leri waterbody passes for chemicals in the 2024 cycle 3 interim classification, however the chemical classifications were rolled forward from the 2021 cycle 3 classification. In addition, there have been failures for PBDE in this waterbody in previous cycles, but it has not been assessed in the cycle 3 classifications. All of the other waterbodies within the SAC were not classified as the chemicals have not been assessed within the last six years.

CSEMP sediment sampling has been carried out in the Mawddach and Dyfi estuaries; however, this ceased in 2015. The data were not used in the assessment as they were deemed to be too old.

The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR, assess the state of the seas in the region. The latest quality report published in 2023 states that hazardous substances are still a cause for concern across the region, including the Irish Sea. Both mercury and lead are above ecological guidelines in the North-East Atlantic region, as is the most toxic congener (CB118) of PCB when measured in sediments and biota (fish, shellfish, birds and mammals) (Larsen and Hjermann, 2022; Webster and Fryer, 2022). Overall, PCBs in 2010-2020 were lower than the 1980s, but concentrations in some areas are still at levels that may cause adverse effect to marine life (Webster and Fryer, 2022).

While concentrations of POPs in marine mammals have declined over the last 30 years a recent study found a substantial proportion of individuals across 11 species sampled around the UK had POPs above toxicity thresholds (Williams et al., 2023). It should be noted that grey seals had the lowest mean concentrations of all 11 species studied and only 17% of studied grey seals (21 individuals) were above the threshold for PCBs and DDTs (0% above PBDEs), though the sample size was very small (Williams et al., 2023).

Marine litter is also a concern for seals in the waters around Wales. Litter impacts on seals are monitored at the Skomer MCZ every year. The most obvious marine litter impacts are consistently from monofilament line and netting from fishing activity. In 2023, 29 individual seals were photographed with obvious signs of damage from entanglement with fishing nets. The most common injury is a deep scar on the neck, often with the net still

embedded (Lock et al., 2024). Microplastics have also been found in seal stomachs and scat (Hernandez-Milian et al., 2019; Lofthouse, 2017). It is not clear if the microplastics are ingested directly or are present inside their prey (Lofthouse, 2017). Marine litter and microplastics are not currently having an impact on seals at population level but are a threat to future condition if they were to increase significantly.

Contaminants are still a threat to all marine mammals around Wales, not just grey seals. Despite bans and strict controls on mercury, PBDE and PCBs, there is still risk of historical deposits being released into the environment from sediments. Novel contaminants are also emerging. However, at the time of this assessment, contaminants are not considered to be having a detrimental impact on grey seal at the population level, given the long-term increase in seal pupping in the SAC and increasing UK population. Therefore the water, sediment and prey contaminants indicator met its target. The confidence in the pass was low because there is a lack of monitoring of contaminants in grey seals and a lack of understanding around the impacts contaminants have at a population level.

Reasons for target failure

The grey seal feature in the Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition as none of the targets failed.

Threats to condition

Part of the condition assessment is to identify threats to the condition of grey seal. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes e.g. dredging whereby the impact of the activity on the feature would be assessed have not been included. The threats to the grey seal feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Disturbance

While there is some evidence that seals can tolerate human presence in areas close to easily accessible coast, they are still vulnerable to disturbance, especially for seals that haul out in remote places where they are less likely to encounter regular anthropogenic activity. Increases in recreation to more remote areas via watercraft, the use of drones, noise or physical barriers from industrial development and increases in ongoing military activity in the area all have the potential to significantly disturb seals.

Contaminants

At the time of the assessment, grey seals are thought not to be adversely impacted by contaminants at the population level. However, the high levels of some contaminants within the SAC are cause for concern. While some contaminants like mercury and PBDE are being managed and it is hoped that these levels will reduce in time, there is the potential for unregulated contaminants (such as PFAS and pharmaceuticals) to potentially increase in the future. This could affect grey seals as PFAS has been shown to

bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). Even though mercury levels are decreasing and the 2024 WFD classification passes for mercury in Milford Haven Outer waterbody, this classification was based on concentrations of mercury in mussels. Due to the bioaccumulation potential of mercury, the levels in top predators such as seals, may still be of some concern. Many contaminants have been shown to have a detrimental impact on reproductive success and can be passed to pups through their mother's milk (Hammond et al., 2005; Nyman et al., 2003; Robinson et al., 2018). Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant waterbodies have not been classified for any chemicals.

Fisheries bycatch

There is significant bycatch of grey seals in net fisheries in the Celtic Seas of the south-west UK and Ireland (SCOS, 2022; Taylor et al., 2022). The estimated total annual bycatch of grey seals in the Celtic Sea Assessment Unit was 1632 in 2020 (Taylor et al., 2022). Despite this, the population of grey seals is thought to be growing and models suggest the amount of bycatch is below the threshold the population in the wider Celtic Seas can support. While seal bycatch is likely to be minimal inside the SACs, bycatch outside of the SACs affects the wider population, of which the SACs are part.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 34) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 34. Evidence gaps for grey seal in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comment
Seal population size relevant to the SAC (P) (all SACs)	Medium confidence (proxy data in some cases)	• Regular systematic monitoring at the scale of the SAC and/or regions is needed. • Both pupping and haul out counts are needed across the region to establish whether those sites regularly monitored (e.g. Skomer) are sufficient index sites for the population. • Continued funding for monitoring at key sites (e.g. Skomer) is critical to our understanding of seal status. Only a single systematic survey of hauled out seals has been conducted (in summer 2023) in Wales and should be repeated at regular intervals (e.g. 2-5 years).

Indicator	Assessed status	Comment
Habitat quality and function (S)	Not assessed	• There is a lack of understanding of what is quality habitat for seals and how much is sufficient to support the population using the SAC.
Anthropogenic disturbance (S)	Medium confidence (limited data)	• There is a lack of information on levels of recreational activity in the SAC, their impact on seals and if codes of conduct are being followed. • There is limited information on bycatch in net fisheries in Wales. Some studies are underway to estimate the likely bycatch in parts of Wales, but further work is required to provide robust estimates.
Water, sediment and prey contaminants (S)	Low confidence (limited data)	• There are very little data on the level of contaminants in grey seals. Dead seals are rarely autopsied and sampled for contaminants.

3.11. Bottlenose dolphin condition assessment

Monitoring of the bottlenose dolphin *Tursiops truncatus* population in the wider Cardigan Bay that includes part of the Pen Llŷn a'r Sarnau SAC began in 2005 to expand the monitoring already taking place in the Cardigan Bay SAC. Monitoring uses a combination of photo ID and boat-based transect surveys. A summary of the condition assessment can be seen in Table 35. The assessment conclusion, a detailed summary of the assessment, any reasons for failure and threats to condition can be found in the sections below.

Table 35. Condition assessment of bottlenose dolphin in Pen Llyn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population size: Number of bottlenose dolphins using the SAC in the long term	A stable or increasing number of bottlenose dolphins using the SAC over the long term, allowing for natural change and variation. (P)	• Long term is 20 years, or more. • There is only one CMR estimate and two distance sampling estimates for the SAC from recent monitoring. Monitoring of the Cardigan Bay SAC and the wider Bay is also used as a proxy to assess the Pen Llyn a'r Sarnau SAC as a whole. • The bottlenose dolphins in the Cardigan Bay and Pen Llŷn a'r Sarnau SACs are part of the same population residing in the whole of Cardigan Bay. • The population using the SAC (i.e. based on Cardigan Bay SAC and wider Cardigan Bay estimates) has fluctuated over the monitored period (2001 - 2024). However, the population has been stable over the long term. • Confidence in the pass is medium due to lack of estimates in the Pen Llyn a'r Sarnau SAC and gaps in the wider Cardigan Bay monitoring data.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population size: Number of bottlenose dolphins using the SAC in the short term	A stable or increasing number of bottlenose dolphins using the SAC over the short term, allowing for natural change and variation. (P)	• Short term is five years, or less. • At the time of the assessment and due to gaps in monitoring, there were only two and three years of data (2022-2024) in the last five years for the SAC and wider Cardigan Bay area respectively. • The data were deemed insufficient to assess a trend. • Therefore the indicator was assessed as unknown.	**Unknown**	N/A
Reproductive success: crude birth rate.	A stable or increasing crude birth rate (proportion of newborns in the population) over the short term. Allowing for natural change and variation. (S)	• Crude birth rate is calculated for the wider Cardigan Bay rather than Pen Llŷn a'r Sarnau SAC • Crude birth rate data shows large inter annual variation over the monitoring period but seems to follow a pattern: years with a high crude birth rates (baby boom) are followed by a couple of years of low rates. • Data over the short term (five years) seem to be following this same pattern but appear to be lower compared to earlier data from the long term data series, and when compared to other coastal bottlenose populations. This warrants further investigation. • No newborns were recorded in the Pen Llŷn a'r Sarnau SAC in 2024. • Confidence in the fail is low due to the difficulty in collecting birth rate data accurately, the lack of specific coverage in Pen Llŷn a'r Sarnau SAC and the uncertainty in causes of low birth rate. Further analyses are required.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Reproductive success: calf survival	Calf survival in each of their first 3 years should be no less than 80%, allowing for natural change and variation. (S)	• Bottlenose dolphin calves needs to survive to their 4th year to be considered independent. • Data from the wider Cardigan Bay shows the proportion of calves surviving to three years old (i.e. their 4th year) fluctuates annually but with no significant trend. • When comparing recent values to those from previous reports, the proportions are similar. • From 2001 to 2019 (latest available analyses), average calf survival for the population in each assessment year was: 1st year (0-1 year) = 87%, 2nd year (1-2 years) = 80%, and 3rd year (2-3 years) = 92%. • Confidence is low due to the lack of recent data and the inherently difficult nature of studying this indicator.	**Pass**	Low
SAC Residency	No significant decline in the proportion of the dolphin population considered to be resident to the SAC, allowing for natural change and variation. (P)	• Data are focused at the level of the wider Cardigan Bay not the Pen Llŷn a'r Sarnau SAC. • Monitoring data indicate the proportion of residents in the wider Cardigan Bay is stable at around 68%. • CMR evidence shows that net movement outside of the Bay fluctuates over the years but should be no less than 65%. • Confidence in the pass is low due to the fact that residency in the SAC itself is not estimated (only in wider Cardigan Bay and Cardigan Bay SAC).	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Accessibility to habitat used by bottlenose dolphins	No evidence of significant anthropogenic constraints on access of bottlenose dolphin using the SAC to necessary habitat within or associated with the site. (S)	• There is some evidence of both short and long-term negative relationships with recreational activities in the Pen Llŷn a'r Sarnau SAC, therefore any unregulated increase in tourism could lead to bottlenose dolphins avoiding the area in the future • Marine developments are routinely assessed for impacts to bottlenose dolphins, but such developments are largely absent at present from Pen Llŷn a'r Sarnau SAC and so are not likely to be limiting access to habitat. • There is currently no compelling evidence that bottlenose dolphins are avoiding any areas of necessary habitat due to anthropogenic drivers and are thus not being significantly constrained in accessing necessary habitats. • Confidence is low due to uncertainties around the population level impacts that activities have on bottlenose dolphins and the difficulty in defining when accessibility has been constrained.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Anthropogenic disturbance	No significant anthropogenic disturbance affecting the bottlenose dolphin population associated with the SAC. (S)	• There is some evidence of both short and long-term negative relationships with recreational activities in the Pen Llŷn a'r Sarnau SAC. Compliance with marine codes of conduct is generally good, although improvements are needed for compliance from some users. • It is known that some disturbance is occurring to bottlenose dolphin in the SAC through recreational boat use, but the extent and consequences are currently not well understood. • Marine developments are routinely assessed for disturbance impacts to bottlenose dolphins, but such developments are largely absent at present from Pen Llŷn a'r Sarnau SAC. • However, while anthropogenic disturbance can have consequences such as adverse behavioural reactions even if it does not reach the level of resulting in displacement from an area, there is a lack of understanding on the population level impact. • Therefore this indicator has been assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water, sediment and prey contaminants	Ensure water, sediment and prey contaminants are at levels not detrimental to the bottlenose dolphin population. (S)	• Two waterbodies relevant to the bottlenose dolphin have a failed for chemicals in the 2024 cycle 3 interim classification (Cardigan Bay North and Mawddach), due to PBDE and mercury. • OSPAR report that mercury and lead are above ecological guidelines in the North East Atlantic region, as is one congener of PCB. • OSPAR report that the PCB range in 2010-2020 was lower than the 1980s but still above marine mammal toxicity thresholds. • A study of marine mammals found 80% of stranded bottlenose dolphins were above toxicity thresholds for PCBs. Several were found in Welsh waters. • PCBs are at levels that would be expected to have a physiological impact on bottlenose dolphins. While birth rates are low in recent years, it is not possible to equivocally attribute this to PCBs. • As the population is stable and both mercury and PBDE are being managed, contaminants are deemed not to be having a detrimental impact on bottlenose dolphins at present. • Confidence is low as the population impact of the possible levels of contaminants in the bottlenose dolphins using the SAC is not clear.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Prey availability	Maintain the quality, abundance and diversity of prey species needed to support the bottlenose dolphin population. (S)	• Bottlenose dolphins feed on a wide variety of prey. • The population using the SAC is stable in the long term with an increase in recent years, suggesting prey is, at least in part, not limiting population growth. • There is insufficient evidence to suggest that bottlenose dolphins are prey limited or that there has been a reduction in the diversity or abundance of available species. However, changes in habitat use and decline in birth rates could indicate the population may be adapting to a change in resource availability. • Confidence in the pass is low due to the potential link between prey availability and declining birth rate, the presence of several depleted fish stocks in the region and as the assessment is based largely on expert judgement.	**Pass**	Low

Assessment conclusions

Bottlenose dolphin in Cardigan Bay SAC have been assessed to be in **favourable** condition (low confidence). Overall the stable population of bottlenose dolphins using the SAC in the long and short term as well as no significant evidence of reduction in habitat quality led to the favourable assessment. However, one indicator with a secondary target failed due to an apparent decline in birth rate (Table 36). Two indicators with secondary targets were also assessed as unknown. This contributed to the low confidence in the overall favourable assessment. Further investigation is required to see why the crude birth rate is in decline.

A summary of the assessment can be seen in Table 36 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 36. Condition assessment summary for bottlenose dolphin in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Bottlenose dolphin *Tursiops truncatus*	**Favourable (low confidence)**	Reproductive success: crude birth rate	• Declining crude birth rates in the long term.	• Recreational disturbance • Contaminants • Prey availability

Detailed assessment information

Population

The Pen Llŷn a'r Sarnau SAC is assessed primarily using data collected in wider Cardigan Bay and Cardigan Bay SAC. The SAC is within the northern half of Cardigan Bay. Being a mobile species, the bottlenose dolphins found in the SAC are the same as those in Cardigan Bay SAC and the surrounding seas.

Cardigan Bay SAC is a key area for semi-resident coastal bottlenose dolphins, the largest of two such populations in the UK (Evans and Waggitt, 2023). Dedicated monitoring with photo-identification of bottlenose dolphins commenced in 2001 in Cardigan Bay SAC and was expanded in 2005 to include the wider Cardigan Bay, including a large part of the Pen Llŷn a'r Sarnau SAC. Bottlenose dolphins identified in Cardigan Bay have been recorded ranging from north Pembrokeshire to Anglesey, Liverpool Bay and the Isle of Man, though none have been matched to individuals seen outside of the Irish Sea (Feingold and Evans, 2012; Lohrengel et al., 2018). Numbers in Cardigan Bay are highest in the summer with many moving out of Welsh waters to the Isle of Man and Liverpool Bay to the north in the winter (Lohrengel et al., 2018; Evans and Waggitt, 2023).

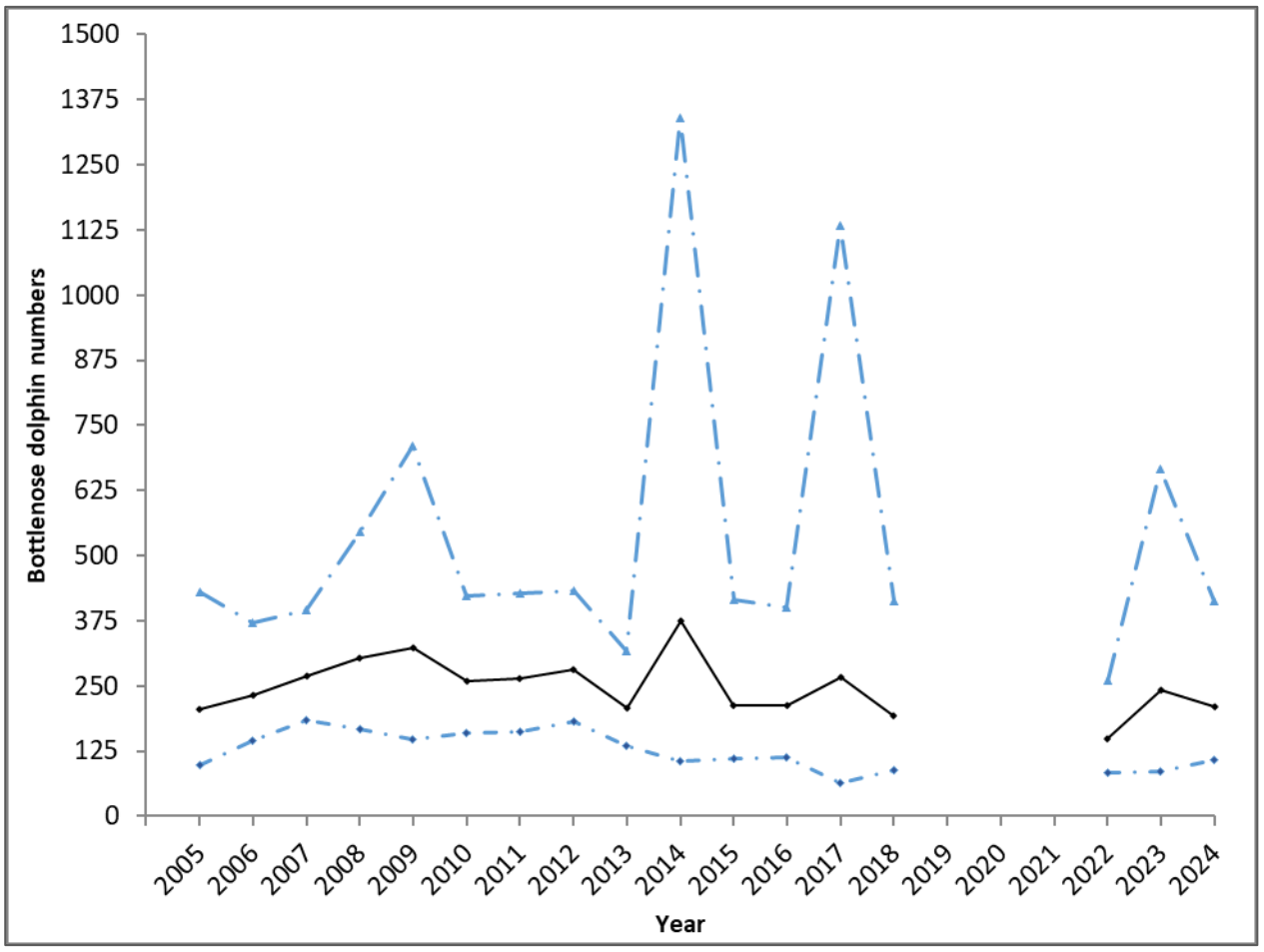
A combination of boat-based line transect surveys and photo identification have been carried out since 2001. These were used to produce bottlenose dolphins population abundance estimates through distance sampling along a line transect and capture-mark-recapture (CMR) analysis of photo-identified individuals (Lohrengel et al., 2018). The CMR data are fed into two types of models: a closed model that assumes an unchanged population between sampling, and a robust design model which takes into account the population being open to births, death and individuals entering and leaving the population (Lohrengel et al., 2018). NRW recommend that estimates derived from the closed CMR model are used preferentially, owing to their overall robustness.

For the Pen Llyn a'r Sarnau SAC, the 2024 abundance estimate based on distance sampling was 218 (95% CI=34-1043; CV = 0.83). The closed model CMR estimate for Pen Llyn a'r Sarnau SAC in 2023 was 106 bottlenose dolphins (95% CI = 73-192; CV = 0.691); no CMR estimate was available in 2024.

The wider Cardigan Bay abundance estimates for 2024, based on distance sampling, was 734 (95% CI = 403 -1383; CV = 0.34); this is a larger estimate than usual with which we have low confidence. The CMR model estimates for the wider Cardigan Bay area are typically larger than those of the SACs alone because they include individuals in the SACs as well as those in the whole of the bay (Figure 21). However, the closed estimate for the wider Cardigan Bay in 2024 was lower than for Cardigan Bay SAC, likely due to the poor fit of the model for Cardigan Bay SAC in that year. The closed model CMR estimate for the wider Cardigan Bay area in 2024 was 211 animals (95%CI = 107 - 414; CV = 0.355), while the robust model was again lower at 143 individuals (no CV available) (Lohrengel et al., in draft). While the closed and open models for the wider Cardigan Bay area gave different results, the smoothed trend lines followed similar patterns to those from Cardigan Bay SAC analyses. As before, the smoothed trend line for wider Cardigan Bay from distance

sampling also showed similarities to the CMR trends, except for a steeper increase in recent years.

Figure 21. Population estimates for bottlenose dolphins in the wider Cardigan Bay from 2001 to 2024 (solid line) obtained from CMR using a closed population model including 95% confidence intervals (dashed lines), excluding 2019-2021 when no data were collected (Lohrengel et al., in draft).



Over the whole monitoring period (2001-2024), numbers of bottlenose dolphins using the wider Cardigan Bay fluctuate but appear to be stable overall. This meant the indicator of the number of bottlenose dolphins using the Pen Llŷn a'r Sarnau SAC in the long term passed. As the data is mainly based on the wider bay and not the SAC itself, the confidence in the pass was reduced to medium. A decline since the peak of the population around 2008 may have been part of a naturally fluctuating cycle or may have indicated individuals moving out of the area, rather than a decline in the overall population of bottlenose dolphin. In the last three years, however, the population appears to have increased slightly. More monitoring data are needed to track this.

In order to detect problems in the bottlenose dolphin population in a timeframe that would allow management measures to be put in place before declines became established, it is important to look at the population abundances in the short term. Short term has been defined as five years for the purposes of these condition assessments. Due to the covid-19 pandemic and funding constraints, there were only three years of data (2022-2024) in the last five years (at the time of the assessment) for the wider Cardigan Bay. This was

deemed to be insufficient to assess trends over the short term and thus the indicator was classified as unknown.

Reproduction

The SAC adjacent to the Pen Llŷn a'r Sarnau SAC (Cardigan Bay) has historically been considered an important nursery ground for bottlenose dolphins (Feingold and Evans, 2014; Lohrengel et al., 2018). In the wider Cardigan Bay area the majority of newborn bottlenose dolphin calves have been recorded in Cardigan Bay SAC in the last 10 years, and only within the SAC for several of those years (Lohrengel et al. in draft). This suggests Cardigan Bay SAC remains an important area for calving bottlenose dolphins.

Female bottlenose dolphins in Cardigan Bay can give birth in any month of the year but most births are in the summer, with 75% of births between July and September (Lohrengel et al., 2018). The mean calving interval is 3.4 years (range 2-8 years) (Lohrengel et al., in draft).

Crude birth rate

Crude birth rates appear to have declined over the longer term in the wider Cardigan Bay area (Table 37). This is used as a proxy for the Pen Llŷn a'r Sarnau SAC. No newborns were recorded in the Pen Llŷn a'r Sarnau SAC in 2024.

Table 37. Crude birth rates over time in Cardigan Bay SAC and the wider Cardigan Bay area data from Lohrengel et al. (in draft).

Monitoring period	Wider Cardigan Bay crude birth rate (%)
2001-2008	6.51
2009-2016	5.11
2017-2024	2.96

Due to this apparent decline in birth rate in the wider Cardigan Bay, and thus the SAC, the Reproductive Success: Crude Birth Rate indicator failed to meet its target. Confidence in the failure was low due to the challenge of estimating this parameter, the lack of specific coverage in Pen Llŷn a'r Sarnau SAC and the uncertainty in causes of low birth rate. Further investigation is required.

Calf survival

Another measure of reproductive success is calf survival. This is calculated for wider Cardigan Bay rather than the SAC. Between 2009 and 2019, the 1st year calf survival (0-1 year) is 87%, 2nd year survival (1-2 years) is 80%, and 3rd year survival (2-3 years) is 92% (Lohrengel et al., in draft). Between 2017 and 2023, only five mother and calf pairs were observed sufficiently to determine survival, all of which survived the first three years of life. Sample size since 2019 was low due to no data in 2020 (Covid) and calves born after 2021 were excluded from analysis as survival to their third year of life could not yet be determined. Calf survival data were deemed sufficient to allow the Reproductive Success: Calf Survival indicator to pass. Confidence was reduced to low due to the lack of recent data and the inherently difficult nature of studying this indicator.

Residency

The bottlenose dolphin population in Cardigan Bay is one of only two major semi-resident populations of coastal bottlenose dolphins in the UK. Detecting residency in a mobile species is difficult and requires long term intensive monitoring with photo identification, ideally over the entire range of the population. Photo identification of bottlenose dolphin has taken place in Cardigan Bay since 2001, allowing residency to be determined. A bottlenose dolphin is deemed to be a resident if it is seen within the region for a minimum of seven years or on 12 separate occasions (Pesante et al., 2008; Feingold and Evans, 2012; 2014; Lohrengel et al., 2018).

Analysis of data between 2001 and 2024 showed that 'residents' made up 67% of animals in the wider Cardigan Bay area. There is no estimate of residency for Pen Llŷn a'r Sarnau SAC alone. The proportion of residents appears to be stable over the monitoring period and as such we expect residency to be no less than 65%, in the wider region; there is nothing to suggest that the proportion of residency has changed over the monitoring period and the indicator passed. Despite the length and quality of photo ID data in the wider Cardigan Bay area, the confidence in the pass is low due to these data being a proxy for the Pen Llŷn a'r Sarnau SAC.

Habitat accessibility and disturbance

The mobile nature of bottlenose dolphins means that they utilise a wide area for their functional needs (e.g. feeding, breeding). While presence of bottlenose dolphin at a particular location is likely to indicate some degree of reliance on the habitat associated with the location of that sighting, there is a lack of understanding on what constitutes suitable habitat for the species. Suitable habitat, however, is likely to be strongly correlated with prey availability. Repeated sightings of animals over time in particular areas are likely to indicate the habitat in that area is important for the species. An analysis of 30 years of sightings data and modelling with various factors representing habitat features, confirm that the wider Cardigan Bay area, especially Cardigan Bay SAC, the Llŷn Peninsula and west coast of Anglesey are persistently important areas for the regional coastal bottlenose dolphin population (Evans and Waggitt, 2023). For this reason it is vital that bottlenose dolphins continue to have unimpeded access to the whole of the SAC and areas beyond it.

It is not only physical barriers that could reduce access to the SAC and areas beyond it that are considered to be functionally important/linked (i.e. necessary). Noise and visual stimuli could also disturb bottlenose dolphins and prevent them from accessing an area. Bottlenose dolphins that move away from an area due to disturbance (physical or otherwise) are said to be displaced. However, disturbance can occur at levels that does not cause bottlenose dolphins to leave an area but can still lead to negative outcomes. It is important to distinguish between activity and physical barriers that may displace bottlenose dolphins using the SAC from necessary habitats, with disturbance that may lead to adverse behavioural changes.

Bottlenose dolphins are known to 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.

Habitat accessibility

Studies have suggested both short and long-term negative relationships with recreational activities in Cardigan Bay. This may be as a result of recreational vessel users that do not comply with marine codes of conduct, causing increases in negative behaviour responses of bottlenose dolphins compared to those vessels adhering to the code (Koroza and Evans, 2022). Negative responses tended to be more pronounced in transient bottlenose dolphins compared to residents, suggesting some habituation is occurring (Koroza and Evans, 2022). While this is of concern, there is currently a lack of evidence that this activity is significantly constraining access for bottlenose dolphins to an extent that would impact the population associated with the SAC.

Projects and activities taking place outside of the Pen Llŷn a'r Sarnau SAC can pose a risk of preventing the bottlenose dolphins that use or are associated with SAC from accessing the SAC (i.e. from offsite impacts). These risks mainly come from marine industrial developments and associated activities, especially in relation to collision and underwater noise. However, there is currently no evidence from developments or specialist knowledge that bottlenose dolphins are being significantly constrained in accessing the SAC from activity outside of it.

At the time of assessment, accessibility to habitat in the SAC used by bottlenose dolphins was not considered to be significantly constrained, allowing the indicator to pass. The confidence was reduced to low as there are uncertainties around the impacts that recreational activities are having on the ability of bottlenose dolphins to access the site, and the difficulties in defining when accessibility has been constrained.

Disturbance

Bottlenose dolphins, like all cetaceans, are sensitive to disturbance, particularly from underwater noise, as they rely heavily on sound to understand their surroundings and to communicate (Evans, 1996). Disturbance to bottlenose dolphin comes largely from underwater noise associated with boat traffic as well as noise from construction of industrial developments e.g. windfarms.

Disturbance can lead to behaviour changes such as reduced foraging and may have energetic and fitness costs that have negative consequences on populations (e.g. Chudzińska et al., 2024). One of the main sources of 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 and references therein). An increase in tourist boats was shown to lead to a decrease in bottlenose dolphin abundance in Australia (Bejder et al., 2006); while this decrease in abundance was not thought to endanger that large genetically diverse population, such a decrease in smaller, resident populations could be damaging.

It is known that there is a moderate amount of disturbance occurring to bottlenose dolphin in Pen Llŷn a'r Sarnau SAC through recreational vessel use. As mentioned above, recreational users that were observed not to follow the marine codes of conduct, caused negative changes to bottlenose dolphin behaviour compared to those vessels adhering to the codes (Koroza and Evans, 2022). However, there is a lack of understanding on the impact that this level of disturbance is having at a population level. For this reason this

indicator has been assessed as unknown and monitoring of disturbance is a gap in evidence.

Habitat quality

Contaminants

As top predators, marine mammals are vulnerable to contaminants, particularly those which biomagnify and / or bioaccumulate, such as POPs. Example of POPs include various pesticides, PCBs that were historically used in manufacturing, and PBDEs that were 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, resulting in the term ‘persistent’. Despite their use now being prohibited, they continue to enter the marine environment via use and disposal of products made before bans were introduced.

POPs pose a risk to bottlenose dolphins, which bioaccumulate and biomagnify these contaminants over their long life spans and store these lipophilic contaminants in their fat tissue (e.g. blubber) (Williams et al., 2023, and references therein). High levels of PCBs continue to be found in dolphins and cetaceans in European waters (Jepson and Law, 2016; Williams et al., 2023; Zanuttini et al., 2019).

POPs are known to cause a variety of negative health implications in marine mammals such as anaemia, endocrine disruption (Tanabe et al., 1994; Vos et al., 2003; Schwacke et al., 2012), immune system suppression (Tanabe et al., 1994) and the subsequent increased vulnerability to infectious disease (Aguilar and Borrell, 1994; Jepson et al., 2005), and reproductive impairment and developmental abnormalities (Tanabe et al., 1994; Schwacke et al., 2002, Vos et al., 2003). However, the impacts of these chemicals at the population level are not well understood.

In this condition assessment, two of the WFD waterbodies in the Pen Llŷn a’r Sarnau SAC have a fail for chemicals in the 2024 cycle 3 interim classification. These are Cardigan Bay North, which fails for PBDE and mercury, and Mawddach, which fails for PBDE. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on bottlenose dolphins are not fully understood. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife), which may be more relevant to bottlenose dolphins and is sampled from biota they may eat.

The Dyfi / Leri waterbody passed for chemicals in the 2024 cycle 3 interim classification; however, the chemical classifications were rolled forward from the 2021 cycle 3 classification. In addition, there have been failures for PBDE in this waterbody in previous cycles (Cycle 2), but it has not been assessed in the cycle 3 classifications. All of the other waterbodies within the SAC were not classified, as the chemicals have not been assessed within the last six years. However, most of these, along with the Dyfi / Leri are transitional (estuarine) waterbodies, unlikely to be used by bottlenose dolphins.

The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR, assess the state of the seas in the region. The latest quality report published in 2023 states that hazardous substances are still a cause for concern across the region,

including the Irish Sea. Both mercury and lead are above ecological guidelines in the North-East Atlantic region, as is the most toxic congener (CB118) of PCB when measured in sediments and biota (fish, shellfish, birds and mammals) (Larsen and Hjermann, 2022; Webster and Fryer, 2022). Overall, PCBs in 2010-2020 were lower than the 1980s, but concentrations in some areas are still at levels that may cause adverse effect to marine life (Webster and Fryer, 2022). A recent UK study of 11 marine mammal species found 80% of stranded bottlenose dolphins were above toxicity thresholds for PCBs, with several washed up in Welsh waters (Williams et al., 2023).

Despite PCBs persisting in the Irish sea and being found in bottlenose dolphins at levels that would be expected to have a physiological impact on them, the population using the SAC remains stable. As there is no evidence that contaminants are having a detrimental impact to the population, the indicator passed. However, confidence is low for this indicator because the link to population level effects is unclear, and it is not certain whether those stranded bottlenose dolphins with measured levels of PCBs represent the coastal bottlenose dolphin population using the SAC. It is also not clear what the PCB levels are in live animals. Contaminants remain a threat to the coastal bottlenose dolphin population from both historical POPs and new emerging contaminants. There is an evidence need to better understand the impacts of POPs on the population and to measure levels in live bottlenose dolphins. This is especially important given the apparent reduction in crude birth rate in Cardigan Bay bottlenose dolphins and the known impacts of contaminants on reproductive parameters seen in some marine mammal populations (Murphy et al., 2018; Tanabe et al., 2004; Schwacke et al., 2002, Vos et al., 2003).

Prey availability

Bottlenose dolphins are generalist and opportunistic feeders, eating a wide range of pelagic and benthic (demersal) fish, crustaceans and molluscs (i.e. squid and octopus), both within and outside of the SAC. From visual observations of the surface behaviour of bottlenose dolphins in Cardigan Bay, 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 from NRW, Sea Watch Foundation and the Wildlife Trusts). Hernadez-Miliam 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.

Prey availability is likely to be a key factor in determining the abundance and distribution of bottlenose dolphins in the Irish Sea, Cardigan Bay and the SAC. Recent analyses suggest that there have been changes in habitat use by Cardigan Bay bottlenose dolphins and an observed decline in birth rates (Lohrengel et al., in draft). Such declines have been linked to changes in prey availability in other marine mammal populations (Vermeulen et al., 2023; Wild et al., 2019; Williams et al., 2013) and could indicate the Cardigan Bay population may be adapting to a change in resource availability (Lohrengel et al., in draft). A recent study in the Celtic Sea ecoregion found evidence of a decline in the nutritional health of common dolphin *Delphinus delphis* through measuring ventral blubber thickness, which is potentially linked to shifts or declines in prey availability (Albrecht et al., 2024).

There is currently insufficient robust evidence to suggest that bottlenose dolphin prey is limited in terms of abundance or diversity in the Pen Llŷn a'r Sarnau SAC, although some key prey species are thought to be depleted in the Irish and Celtic Seas (ICES, 2024a,

2024b, 2024c, 2024d, 2024e, 2024f). The stability of the overall population and number of bottlenose dolphins using the SAC suggests prey availability is sufficient to sustain them. For this reason, the indicator passed. However, confidence was reduced to low due to several factors: the lack of understanding and targeted surveys on prey availability, the presence of several depleted fish stocks in the region and the potential links with the observed decline in crude birth rate. The assessment of the indicator was largely based on expert judgment.

Reason for target failure

The bottlenose dolphin feature in the Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition. However, However, a secondary target failed to be met and needs to be kept under review.

Reproductive success: crude birth rate

This indicator target has a secondary weighting. Crude birth rate data show large inter annual variation over the monitoring period. However, birth rates appear to have declined over the longer term. Due to this apparent decline in birth rate in the wider Cardigan Bay, the indicator failed its target. The reasons for the decline in crude birth rate are not clear. Low birth rates have been linked to changes in prey availability in other populations. It is also known that high levels of contaminants in a population can suppress the birth rate. Further investigation is needed to understand why the birth rate is declining and if management can be put in place to help rates recover.

Threats to condition

Part of this condition assessment process is to identify threats to the condition of the bottlenose dolphin feature. A threat is defined as an activity that has the potential to have a negative impact on feature condition over the next reporting cycle, if activity levels increase or are unmanaged to the point that the activity is regarded as damaging. It is important to identify these threats to, where relevant, be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes e.g. dredging whereby the impact of the activity on the feature would be assessed have not been included. The threats to the bottlenose dolphin feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Disturbance

Recreational disturbance when users do not adhere to marine codes of conduct has been shown to produce negative behavioural responses in the bottlenose dolphins of Cardigan Bay (Koroza and Evans, 2022). If this recreational disturbance was to increase it could have a detrimental impact on the population, and may result in bottlenose dolphins not using or being displaced from the SAC. There is also a lack of understanding around the long term impacts the current level of recreational disturbance is having on the population.

Underwater noise from construction, operation or decommissioning of marine developments may disturb cetaceans. However, environmental impacts from these

developments are routinely assessed and managed; for example, mitigation measures are sometimes used to reduce or remove underwater noise. Noisy developments are, however, largely absent from Cardigan Bay at present.

Contaminants

At the time of the assessment, bottlenose dolphins are not thought to be detrimentally impacted by contaminants at the population level. However, the levels of some contaminants exceeding ecological guidelines within the SAC are cause for concern and could potentially be linked to the declining crude birth rate observed. While some contaminants like, PCBs mercury and PBDE are under management and will not increase, there is the potential for unregulated contaminants (such as PFAS and pharmaceuticals) to potentially increase in the future. Bioaccumulation potential of POPs means the levels in top predators such as bottlenose dolphins, may still be of some concern. Many contaminants have been shown to have a detrimental impact on bottlenose dolphins (Tanabe et al., 1994; Schwacke et al., 2002; Vos et al., 2003).

Prey availability

Prey availability is likely to be a key factor in determining the abundance and distribution of bottlenose dolphins in the Irish Sea, Cardigan Bay and the SACs. There is currently insufficient robust evidence to suggest that bottlenose dolphin prey is limited in terms of abundance or diversity, although some key prey species are thought to be depleted in the Irish and Celtic Seas (ICES 2024). The stability of the overall population and number of bottlenose dolphins using the bay and SACs suggests prey is sufficient to sustain them. However, with incomplete understanding of prey availability, limited targeted surveys on prey, and presence of several depleted fish stocks in the region, more research is needed.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 38) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 38. Evidence gaps for bottlenose dolphins in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Population size: Number of bottlenose dolphins using the SAC in the short term (P)	Unknown	• There are insufficient data to assess this indicator. More targeted surveys within the SAC are needed.

Indicator	Assessed status	Comments
SAC residency (P)	Low confidence	• There is currently no residency estimate for Pen Llŷn a'r Sarnau SAC. More targeted surveys within the SAC are needed.
Accessibility to habitat used by bottlenose dolphins (S)	Low confidence	• Lack of understanding on what constitutes necessary habitats for bottlenose dolphins that use the SAC and the impacts of recreational boats use on habitat use.
Anthropogenic disturbance (S)	Unknown	• Lack of understanding on the population level impacts of disturbance from recreational vessels on bottlenose dolphins that use the SAC.
Water, sediment and prey contaminants (S)	Low confidence	• Lack of understanding on the population level impacts of contaminants and the levels found within live bottlenose dolphins that use the SAC.
Prey availability (S)	Low confidence	• There is a lack of data on the diversity and abundance of dolphin prey in the SAC. More targeted surveys on key prey species are needed.

3.12. Otter condition assessment

A summary of the condition assessment for otter *Lutra lutra* in Pen Llŷn a'r Sarnau SAC can be seen in Table 39. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the detailed assessment information

Table 39. Condition assessment of otter in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Otter population health (hydrometric areas)	Relevant hydrometric areas used for the Otter Survey of Wales have 80% positive sites. (P)	• The Glaslyn and Dyfi hydrometric areas are relevant for this SAC. • The Glaslyn had 62% positive sites, a statistically significant 33% decrease since the last survey. • The Dyfi had 71% positive sites. • Both areas did not meet the required 80% positive sites, so the target failed. • Confidence in the overall fail is medium given the age of the survey data.	**Fail**	Medium
Otter population health (wider population)	The wider otter population relevant to the SAC is stable or increasing. (P)	• The relevant wider population is the northwest subpopulation which includes the hydrometric areas of Anglesey, Conwy and Clwyd, the Dee, the Dyfi, the Glaslyn and the Ystwyth. • All have seen a statistically significant decline in positive otter sites since the last survey. • The wider population was assessed as not being stable or increasing so the target failed to be met. • Confidence in the overall fail is medium given the age of the survey data.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Presence within the SAC	Positive signs otters using sites within the SAC (P)	• Local Environmental Records Centres (LERC) data shows otter signs have been observed in the SAC boundary and within 1km of the boundary over 500 times in the 10-year period 2023-2013. • The last available record at the time of assessment in the LERC is from 2021. • No inference can be made on the number of otter as multiple record signs may have been left by the same otter. • There is strong evidence to suggest that otters were using the SAC up until 2021. • Confidence is medium as there have been no targeted surveys of use of the SAC and the last sign was record in 2021.	**Pass**	Medium
Habitat connectivity	No evidence of barriers that impact the safe passage and movement of otters into, within and away from the SAC. (P)	• No major barriers have been identified from development related plans or projects. • No major road schemes planned or under construction. • Confidence is low as there have been no surveys to map barriers.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Contaminants within the water column do not exceed the EQS. (S)	• Six of the nine WFD waterbodies in the SAC were not classified as the chemicals have not been assessed within the last six years (Caernarfon Bay South, Tremadog Bay, Artro, Dwyfor, Dysynni and Glaslyn). • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Dyfi / Leri). However, the chemical classifications were rolled forward from the 2021 cycle 3 classification. • Two waterbodies have a fail for chemicals (Cardigan Bay North and Mawddach). Both fail for PBDE, which is classed as a POP. Cardigan Bay North also fails for mercury. • Confidence was reduced to low as the human health standard has been used for PBDE, and due to the unclassified waterbodies.	**Fail**	Low

Assessment conclusions

The otter feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **unfavourable** condition (medium confidence). There were two failing indicators (Table 40). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 40 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 40. Summary of the condition assessment for otter in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Otter *Lutra lutra*	**Unfavourable (medium confidence)**	Otter population health (P) Water quality: contaminants (S)	• Declining population adjacent to the SAC. Declining wider population. • Levels of PBDE and / or mercury in the Cardigan Bay North and Mawddach waterbodies are failing to meet EQSs.	• Road traffic collisions • Water quality: contaminants

Detailed assessment information

Otters are a mobile species travelling between resting, foraging and breeding sites over large home ranges. Male otters have larger home ranges than females. 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. The latest report was published in 2021 with the surveys taking place over 2015-2018. Each survey consists of sites across all river catchments (hydrometric areas) in Wales. This equates to 1108 sites over 15 hydrometric areas (see Figure 222). The same sites are revisited during each survey creating a data set currently spanning 40-years of otter occurrence in Wales. Professional surveyors or trained volunteers look for positive signs of otter (e.g. spraints or footprints) at each site. If they are found the site is recorded as positive; if they are not the site is recorded as negative. Comparisons across surveys can then be made to see if there has been a change in the number of positive sites in a hydrometric area. Surveying in this way is considered a good proxy for assessing population size.

In the fifth Otter Surveys of Wales and England (Strachan, 2015 and Crawford, 2010 respectively) the baseline target for favourable condition was set at 80% positive sites for two consecutive surveys. This was assumed to be the maximum population size any given habitat could support (carrying capacity). Although there is lack of evidence for this figure, this target was chosen as the performance indicator on population health in the relevant hydrometric areas for this condition assessment of the otter SAC marine sites.

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 Hobbs study recommended each subpopulation be treated as a management unit. The basis for this is that management of the otter population needs to consider gene flow between subregions by understanding what barriers (landscape or anthropogenic features) are creating the population structure within each of the regions. Ideally, gene flow should be re-established between the regions. Therefore, the second target, ‘otter population health’ performance indicator has been set to look at the wider population relevant to the SAC. Any declines in the wider population are likely to impact the number of otters using the SAC.

Local Environmental Records Centres (LERCs) hold records of otter signs (sightings, spraints, footprints, roadkill) and these records include those made as part of the Otter Survey of Wales as well as those submitted by members of the public. These records allow an insight into otter usage of the SACs. LERC records held on file by NRW were filtered to the ten years before and including the assessment year (2013-2023). From those, records that were located within the SAC boundary or within 1km were selected and mapped. The 1km buffer was chosen as it is assumed otters this close to the coast will be likely to use it in some way, be it travelling via the coast, feeding or resting.

Otters in Pen Llŷn a’r Sarnau SAC have been assessed against the chosen performance indicators using the Otter Survey of Wales, LERC data, WFD data, licensed activities assessments and expert knowledge.

Otter population health

The latest Otter Survey of Wales was published in 2021 with the surveys taking place over 2015-2018. The same sites are revisited every seven years, allowing comparisons between surveys to determine if there has been a change in the number of sites with positive signs of otter in a hydrometric area (river catchment).

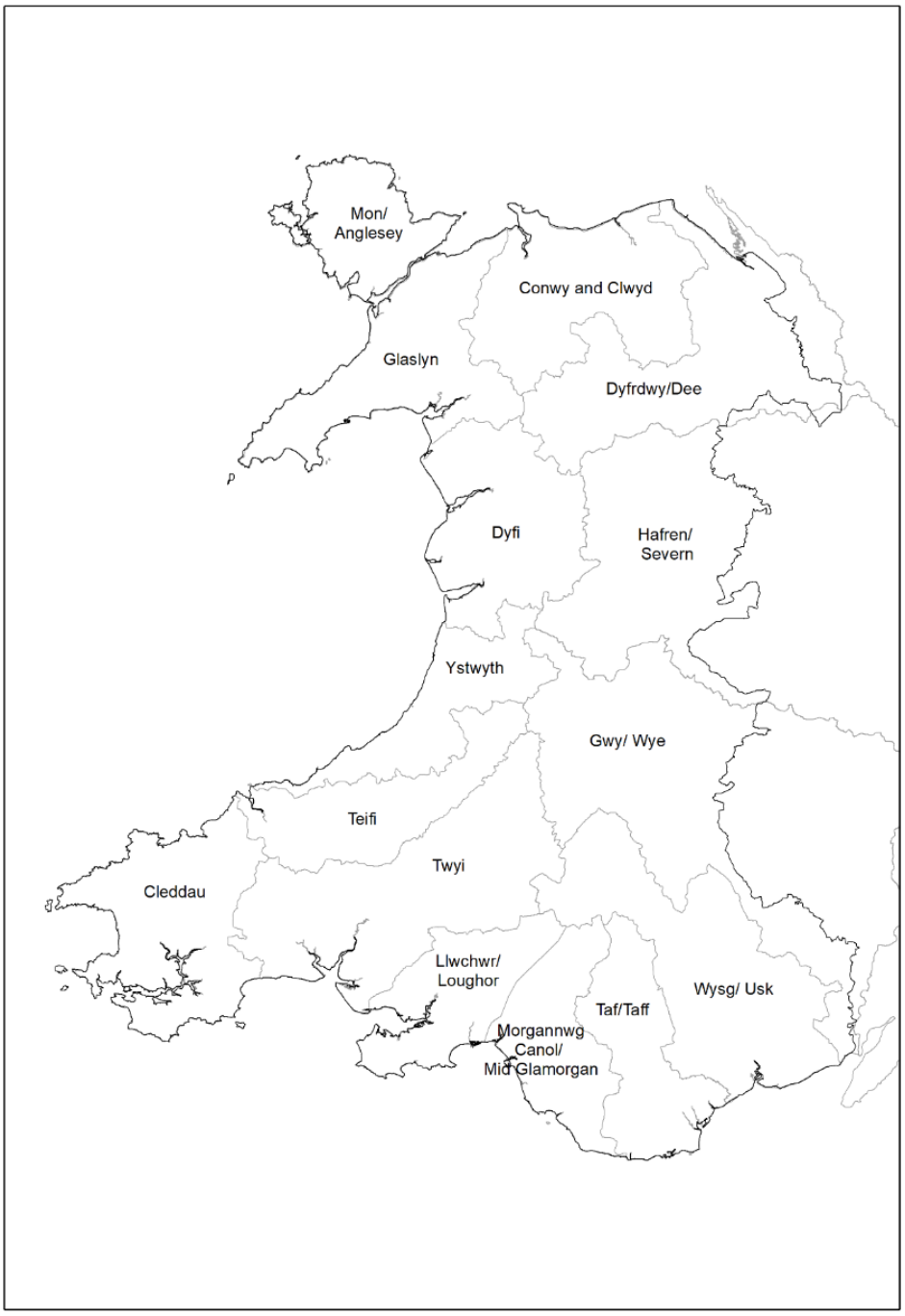
The relevant hydrometric areas for a SAC are those whose boundaries border the SAC boundary. For the Pen Llŷn a'r Sarnau SAC the relevant hydrometric areas are the Glaslyn and Dyfi (Figure 22).

Both the Glaslyn and the Dyfi hydrometric areas have seen a decline in positive sites in the 6th Otter Survey of Wales compared to the 5th Otter Survey of Wales (Kean and Chadwick, 2021). Of the 99 sites in the Glaslyn area surveyed between 2017-2018, 61 sites showed positive for signs of otter (62%). This was a statistically significant 33% decrease since the last survey. Of the 93 sites surveyed in the Dyfi between 2017-2018, 66 sites showed positive for signs of otter (71%). This was a slight (non-significant) decrease of 9% since the last survey, but there were four fewer sites surveyed. As the Glaslyn and Dyfi hydrometric areas failed to meet the 80% positive site target, the target failed. The age of the data reduces the confidence in this fail to medium, as recovery in declining sites may have occurred.

The second indicator for the population heath indicator is around the wider otter population. A genetic study found that otters in Wales are comprised of three genetically distinct sub-groups; southwest Wales, northwest Wales and mid-east Wales (Hobbs et al., 2011). Therefore, the performance indicator target has been set to look at the wider population relevant to the SAC for the assessment, as any declines in the wider population are likely to impact the number of otters using the SAC. The relevant subpopulation is the northwest.

The hydrometric areas that cover the northwest population are, Anglesey, Conwy and Clwyd, the Dee, the Dyfi, the Glaslyn and the Ystwyth. All areas have seen declines in the number of positive sites. The largest decline was seen in the Glaslyn (33%) followed by Anglesey (22%), and Conwy and Clwyd (18%). These declines were all statistically significant. The declines in the Dyfi (9%) and the Dee (9%) were not significant but still relatively large. A resurvey of the Dyfi and Conwy hydrometric areas in 2021 showed no further decline (Kean and Chadwick, 2021), but was only a subset of sites in two hydrometric areas. Due to the large declines in the northwest subpopulation hydrometric areas the wider population was not deemed to be stable, and the target failed. The fact the main survey data ranges from 8-10 years old at publication reduces the confidence in the failure to medium. The population may have recovered in the last 10 years or may have declined further. The next Otter Survey of Wales is due to take place in 2024-2025.

Figure 22. Hydrometric areas of Wales. Map taken from the 6th Otter Survey of Wales (Kean and Chadwick, 2021).



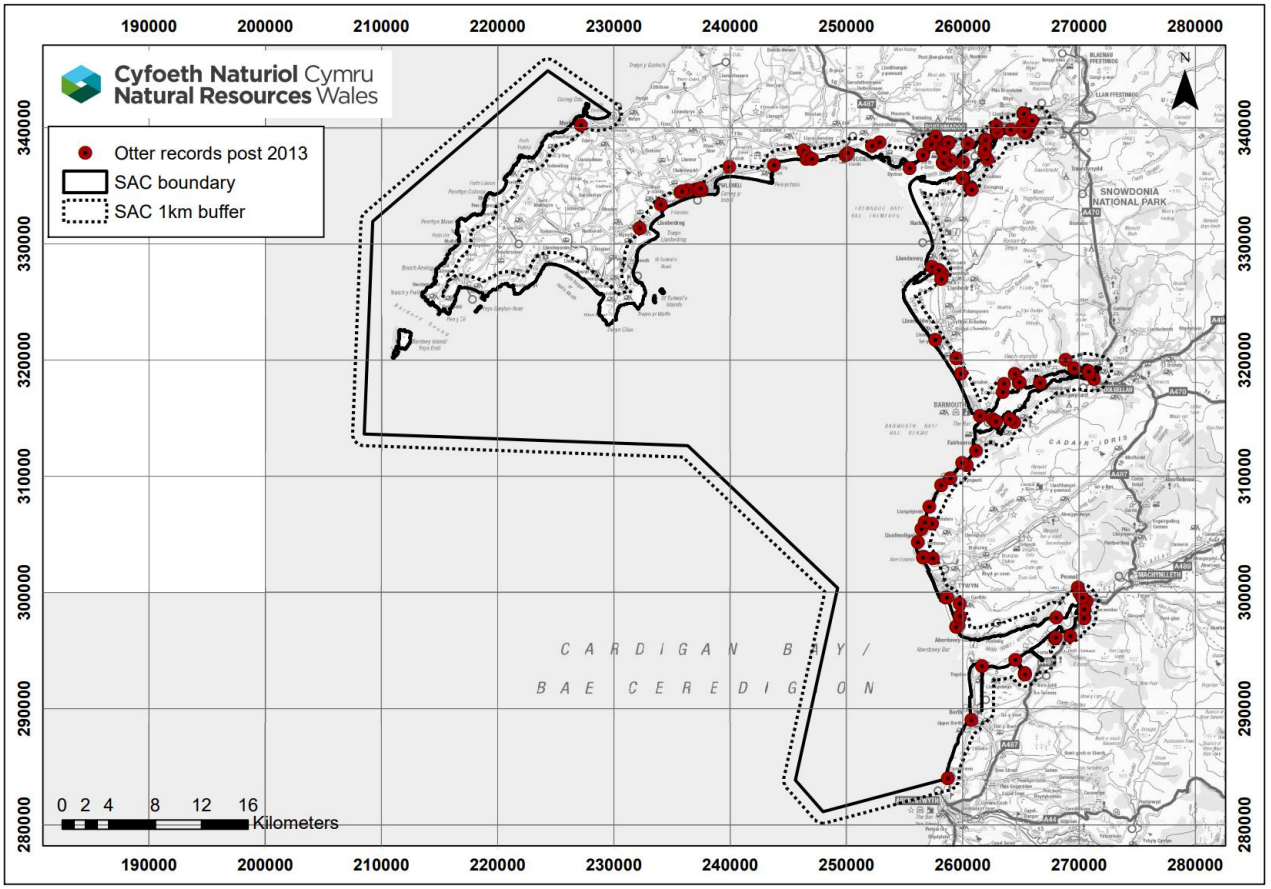
Otter presence in the SAC

Otter presence in the SAC has not been directly surveyed, although some sites in the Otter Survey of Wales are close to the coast (within 500m). Local Records Centres (LERCs) hold records of otter signs (sightings, spraints, footprints, roadkill) and these records include those made as part of the Otter Survey of Wales as well as those submitted by members of the public.

For the Pen Llŷn a'r Sarnau SAC, signs of otter were recorded over 500 times inside the SAC boundary or within 1km of it between 2013-2023 (Figure 23). At the time of the

assessment the last recorded sign in the database was in 2021 (database accessed in November 2023). No comment can be made on the numbers of otter, as multiple recorded signs may have been left by the same otter. However, it is clear otters use and benefit from this SAC. The target for this indicator is met but confidence in the target pass is reduced to medium as the last record in the LERC at the time of assessment is from 2021 and the LERC records are a proxy. More targeted surveys of otter use of coastal areas are needed.

Figure 23. Otter signs in the Pen Llŷn a'r Sarnau SAC between 2013-2022.



Habitat quality and connectivity

It is known that coastal sites are important to otter in terms of travelling between sites, foraging for food and resting. Therefore, it is important that the habitat quality and functionality is maintained within the SAC. In Pen Llŷn a'r Sarnau SAC there is a lack information on available otter habitat and its quality along the coast, so it was not possible to assess the habitat quality and function indicator. This will be noted as an evidence gap to try and fill before the next assessment.

As otters are a highly mobile species that have large home ranges, unimpeded movement across their range is vital. Looking at developments in the area, assessors found no evidence of obvious barriers to otter movement within the SAC or the wider area, therefore the habitat connectivity indicator met its target. However, as there has been no specific surveys of more localised barriers to movement the confidence in the pass is low.

Water quality

Many contaminants are known to persist and bioaccumulate in top predators through the food chain. As well as this past declines in otter populations have been linked to POPs. For this reason water quality: contaminants was chosen as a performance indicator for otter.

The water quality target failed to be met for PBDE (a group of POPs) in two waterbodies that otters are likely to use, Cardigan Bay North and the Mawddach in the 2024 cycle 3 interim classification. The Cardigan Bay North waterbody also failed for mercury. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on otters are not fully understood. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife), which be more relevant to otters and is sampled from biota they may eat. The Dyfi / Leri waterbody passes for chemicals in the 2024 cycle 3 interim classification, however the chemical classifications were rolled forward from the 2021 cycle 3 classification. In addition, there have been failures for PBDE in this waterbody in previous cycles, but it has not been assessed in the cycle 3 classifications. All of the other waterbodies within the SAC were not classified as the chemicals have not been assessed within the last six years.

Confidence in the failure is low as the impact of these chemicals on the otter population is not clear, and because the human health standard has been used for PBDE. Further to this, even though historic declines in otter populations have been linked to POPs, otters in Wales reached 90% sites occupied in the 2009-2010 national survey when POPs levels were high. Since the POPs use has been banned under the Stockholm Convention (2001), this makes it is unlikely that POPs are responsible for the declines recorded in the 2015-2018 survey (Kean and Chadwick, 2021), lowering confidence in the fail.

Otters are exposed to a variety of pollutants, not only those monitored as part of WFD, but there is a lack of information on otter health implications to priority substance exposure. As otter numbers were at record highs when PBDE and mercury levels were also high, the available evidence suggests these specific chemicals are not restricting populations (Kean and Chadwick, 2021). It is not known if other contaminants not currently monitored are having an impact on otter populations either directly or through their prey. Contaminants in general should not be ruled out as a cause of the declines seen in otters across Wales.

Reasons for target failure

The assessment of the Pen Llŷn a'r Sarnau SAC otter feature failed two primary targets, and one secondary target. As a result the feature was assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are summarised below.

Otter population health

Two primary targets failed to be met. The two hydrometric areas that border the SAC have both seen declines in the most recent survey. The wider otter population relevant to the SAC (the Northwest subpopulation) had also seen declines in all relevant hydrometric areas.

It is not yet clear what has caused the declines seen in the otter population. In the previous Otter Survey of Wales (2009-2010) the population was at record high levels (an average of 90% of sites had positive signs across Wales). It may be that the population had reached carrying capacity and the declines seen in the most recent survey are the population naturally settling out. However, some of the steep declines seen are cause for concern. Further investigation is needed, and a full resurvey of Wales's otter population is a priority and should provide more clarity.

Water quality: contaminants

This secondary target failed due to PBDE and mercury exceeding their EQS in two waterbodies that otters are likely to use frequently (Cardigan Bay North and the Mawddach). Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The PBDE in the Mawddach waterbody may be derived from diffuse sources from contaminated waterbody sediments from industry, and point sources from continuous sewage discharge from the water industry. The exact sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. WFD investigations of the failures in both waterbodies are yet to be undertaken. The impact of these chemicals on otter are not understood and further investigation as to the impact of these at a population level is needed. Although this indicator fails, mercury and PBDE are being managed in the UK and it is hoped levels will reduce over time.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the otter feature. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition. The threats to the otter feature condition in the Pen Llŷn a'r Sarnau SAC are stated below.

Road traffic collisions

Otters can travel several miles in a night, and often cross roads where rivers are culverted or bridged. Road traffic accidents cause a large number of casualties.

The Cardiff Otter Project typically receives around 200 otters per year, of which 80-90% have been killed as a result of road traffic accidents. The death of otters on roads can have a serious impact on populations, particularly where population densities are low or where danger-spots impact on breeding females (Cardiff Otter Project).

Water quality: contaminants

There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect the otter feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant waterbodies have not been classified for any chemicals. It is possible that WFD contaminants that are not monitored, or emergent contaminants, are present and impacting the otter population.

Evidence gaps

There are gaps in the current evidence that NRW feel are needed to be filled to fully understand condition in this feature.

Listed below (Table 41) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 41. Evidence gaps for otter in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Presence in SAC (P)	Medium confidence	• There has been no targeted survey of otter use in the Pen Llŷn a'r Sarnau SAC. • Sites in the Otter Survey of Wales have not been selected based on their proximity to the coast and other records rely on public sightings. • Work has been done to survey otter SAC use in Pembrokeshire Marine SAC. The assessment of Pen Llŷn a'r Sarnau SAC would benefit from similar work.
Habitat quality and function (P)	Not assessed	• No surveys of the habitat quality for otter have been done in the Pen Llŷn a'r Sarnau SAC. • Work has been done to survey otter habitat in Pembrokeshire Marine SAC and future assessments of Pen Llŷn a'r Sarnau SAC would benefit from similar work.
Water quality: contaminants (S)	Low confidence	• Impacts of contaminants at a population level are not understood. It is not clear if other chemicals not currently monitored are present and having an impact.
Prey availability (S)	Not assessed	• There is a lack of understanding on the diet of otters foraging in coastal SACs. • This make it difficult to assess if food sources are sufficient to sustain the population. Further research is needed for all SACs.

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