Ariennir gan
Lywodraeth Cymru
Funded by
Welsh Government

Cyfoeth Naturiol Cymru
Natural Resources Wales

Condition Assessments for Reefs in Welsh Special Areas of Conservation

Report No: 900

Author Name: M. Jackson-Bué, E. Wynter, M. Camplin, H. Goudge, D.P. Brazier, S. Cuthbertson and M. Hatton-Ellis.

Author Affiliation: Natural Resources Wales

Subtidal reefs © Kate Lock (NRW)

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Report series:	NRW Evidence Report
Report number:	900
Publication date:	June 2025
Title:	Condition Assessments for Reefs in Welsh Special Areas of Conservation
Author(s):	Jackson-Bué, M., Wynter, E., Camplin, M., Goudge, H., Brazier, D.P. Cuthbertson, S., and Hatton-Ellis, M.
Technical Editor:	Hatton-Ellis, M.
Quality assurance:	Tier 3
Contributors:	Cooper, A., Fairley, I., Grant, L., Lough, N., Lowe, E., Sharp, R., Wray, B.
Peer Reviewer(s):	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:

Jackson-Bué, M., Wynter, E., Camplin, M., Goudge, H., Brazier, D.P., Cuthbertson, S. and Hatton-Ellis, M. 2025. Condition Assessments for Reefs in Welsh Special Areas of Conservation. NRW Evidence Report No. 900, 136pp, 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 riffiau o fewn ardaloedd cadwraeth arbennig dynodedig (ACA) ledled Cymru. Mae Adran 1 yn rhoi trosolwg o'r broses asesu ac mae Adran 2 yn darparu disgrifiad a lleoliad y nodwedd(ion).

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 yr IMCA.

Crynodeb o asesiadau cyflwr ar gyfer riffiau mewn ACAau ledled Cymru

Lleoliad y nodwedd ACA	Asesiad cyflwr	Hyder yn yr asesiad
Y Fenai a Bae Conwy	Anffafriol	Canolig
Pen Llŷn a'r Sarnau	Anffafriol	Uchel
Bae Ceredigion	Anffafriol	Isel
Sir Benfro Forol	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 reefs feature within designated special areas of conservation (SACs) across Wales. Cross-border sites are not included in this report but will hopefully be considered in future. Section 1 gives an overview of the assessment process and Section 2 provides a description and location of the feature(s).

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 reefs in SACs across Wales.

SAC feature occurs in	Condition assessment	Confidence in assessment
Menai Strait and Conwy Bay	Unfavourable	Medium
Lleyn Peninsula and the Sarnau	Unfavourable	High
Cardigan Bay	Unfavourable	Low
Pembrokeshire Marine	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. Cross-border sites are not included in the assessment report due to resource limitations, but NRW hopes to take forward cross-border sites condition assessments in the future.

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. Feature description

The following text is the habitat description from the JNCC list of Annex I marine, coastal and halophytic habitats.

“Reefs are rocky marine habitats or biological concretions that rise from the seabed. They are generally subtidal but may extend as an unbroken transition into the intertidal zone, where they are exposed to the air at low tide. Intertidal areas are only included within this Annex I type where they are connected to subtidal reefs. Reefs are very variable in form and in the communities that they support. Two main types of reef can be recognised: those where animal and plant communities develop on rock or stable boulders and cobbles (geogenic reefs), and those where structure is created by the animals themselves (biogenic reefs).

Rocky reefs are extremely variable, both in structure and in the communities they support. A wide range of topographical reef forms meet the EU definition of this habitat type. These range from vertical rock walls to horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles. Reefs are characterised by communities of attached algae (where there is sufficient light – on the shore and in the shallow subtidal) and invertebrates, usually associated with a range of mobile animals, including invertebrates and fish. The specific communities that occur vary according to a number of factors. For example, rock type is important, with particularly distinct communities associated with chalk and limestone. There may be further variety associated with topographical features such as vertical rock walls, gully and canyon systems, outcrops from sediment, and rockpools on the shore.”

3. Reefs condition assessments

This section contains assessments for the reefs in Welsh only marine ardal cadwraeth arbennig (ACA) / special areas of conservation (SAC). The feature is designated in four SACs in Wales (Figure 1):

- Y Fenai a Bae Conwy / Menai Strait and Conwy Bay
- Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau
- Bae Ceredigion / Cardigan Bay
- Sir Benfro Forol / Pembrokeshire Marine

More information on the SACs and their features can be found in NRW's conservation advice on our website.

Reefs have been assessed against the chosen performance indicators. Any gaps in evidence that would improve the assessment of condition have been identified for each SAC (Section 5).

The performance indicators were assessed using a combination of NRW Habitats Regulations monitoring, Water Framework Directive (WFD) Regulations 2017 (WFD Regulations) monitoring, commissioned evidence reports, plan and project assessments, scientific literature, 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.

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.

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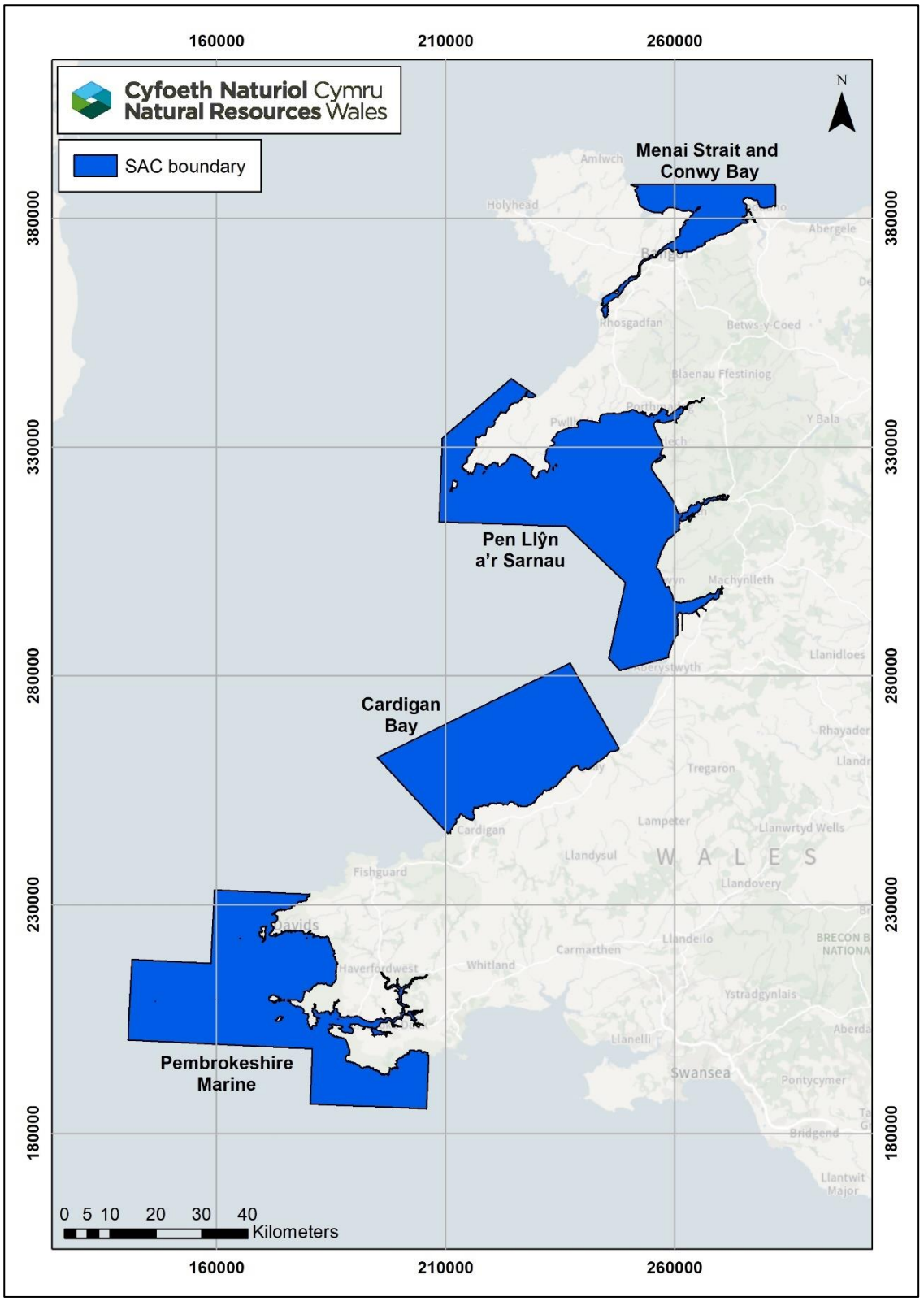
Figure 1. Location of designated reefs feature in special areas of conservation across Wales.

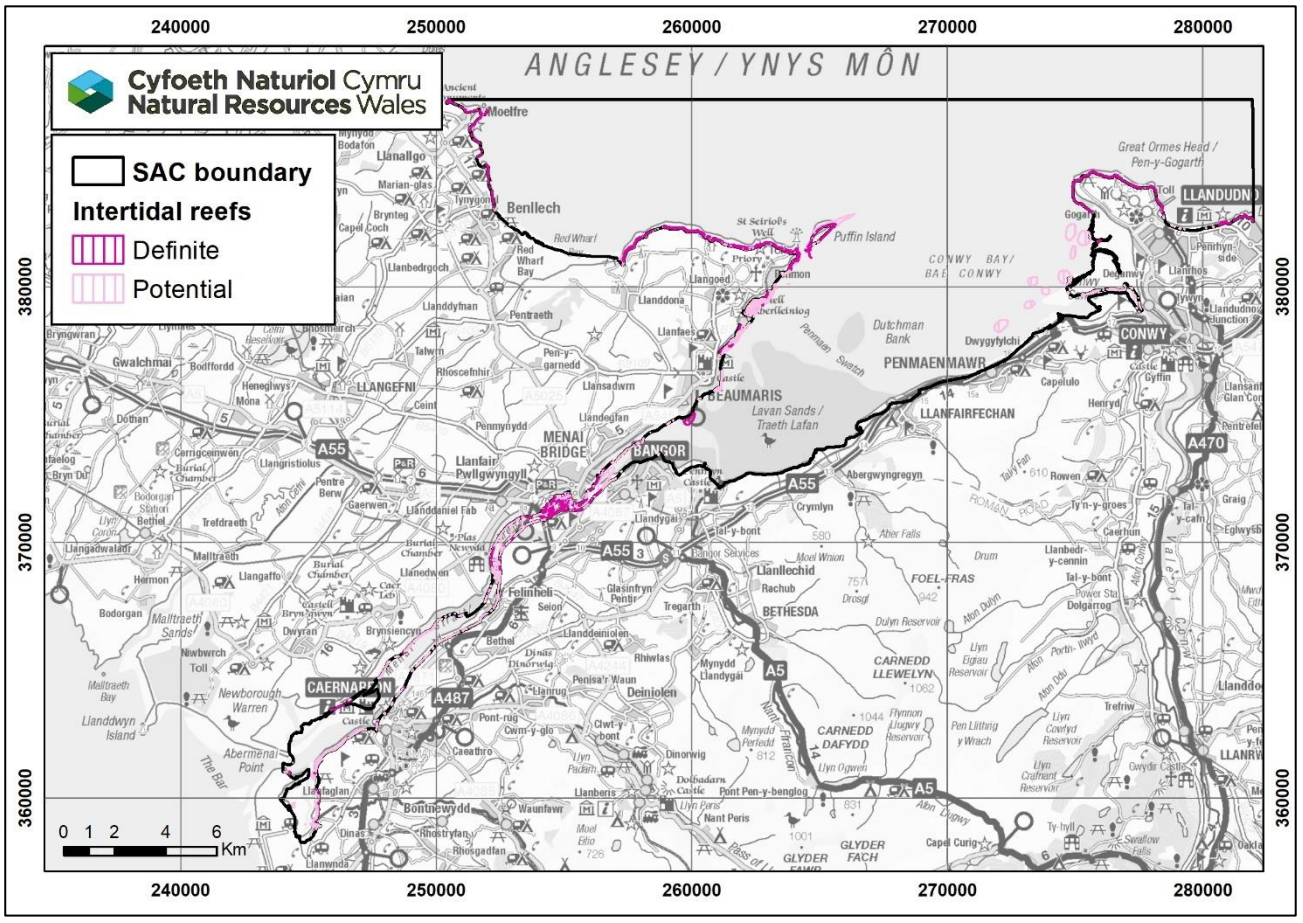


3.1. Menai Strait and Conwy Bay SAC

Intertidal reefs

The reefs feature in the Menai Strait and Conwy Bay SAC comprises a number of intertidal reefs (Figure 2). The NRW Habitats Regulations monitoring for intertidal reefs has focused on sampling sites within the tide-swept boulder communities at Britannia Bridge and Felinheli, and the tide-swept *Fucus serratus* communities in Brynsiencyn (Llanidan and Castell Gwylan sites). While some of the locations are just outside the SAC boundary they are deemed to be representative of intertidal reefs. These locations were surveyed between 2007 and 2022.

Figure 2. Map of the intertidal reefs in Menai Strait and Conwy Bay SAC.



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

Table 2. Condition assessment of intertidal reefs in Menai Strait and Conwy Bay 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of intertidal reefs in the Menai Strait and Conwy Bay 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 intertidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of intertidal reefs in the Menai Strait and Conwy Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 Menai Strait and Conwy Bay 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 at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
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 at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**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 intertidal reefs 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 (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 the 2024 cycle 3 interim classification (Anglesey North). It overlaps with a small proportion of intertidal reefs (7%). • The other six WFD waterbodies have been classified as Good or High status for DIN (Conwy Bay, Menai Strait, North Wales, Conwy, Foryd Bay and Seiont). Combined, these overlap with 88% of intertidal reefs. • 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)	• One of the seven WFD waterbodies was classified with a Moderate status for phytoplankton in the 2024 cycle 3 interim classification (North Wales). However, it overlaps with 2% of intertidal reefs. • Two WFD waterbodies have not been classified for phytoplankton (Anglesey North and Seiont). These overlap with 7% and <1% of intertidal reefs. • The other four WFD waterbodies were classified as Good or High status for phytoplankton (Conwy Bay, Menai Strait, Conwy and Foryd Bay). Combined, these overlap with 86% of intertidal reefs. Two of these waterbody classifications were rolled forward from previous cycles. • Confidence is low due to the failure of one waterbody, unclassified waterbodies and rolled forward classifications.	**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 overlapping WFD waterbodies have not been classified for opportunistic macroalgae in the 2024 cycle 3 interim classification. These overlap with 90% of intertidal reefs. • The other three WFD waterbodies were classified with a Good or High status for opportunistic macroalgae (Conwy, Foryd Bay and Seiont). Combined, these overlap with 5% of intertidal reefs. ○ There have been observations of nuisance algae in watercourses that feed into the Foryd Bay waterbody. This waterbody classification was rolled forward from the 2018 cycle 2 interim classification. • Confidence is low as the waterbodies classified in the 2024 cycle 3 interim assessment overlap with small proportion of intertidal reefs.	**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. (S)	• One of the seven WFD waterbodies that overlaps with intertidal reefs was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Seiont). • The other six WFD waterbodies were classified with a High status for dissolved oxygen. ○ One of these classifications was rolled forward from the 2021 cycle 3 classification (Anglesey North). • Confidence is medium due to samples being taken from the surface of the waterbody.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the environmental quality standards (EQS). (S)	• One of the seven overlapping WFD waterbodies was not classified as the chemicals have not been assessed within the last six years (Seiont). It overlaps with <1% of intertidal reefs. • Two of the seven WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification (Menai Strait and North Wales). In both waterbodies the classifications were rolled forward from previous cycles. Combined, these waterbodies overlap with 82% of intertidal reefs. • The other four WFD waterbodies that overlap with intertidal reefs have a fail for chemicals in the 2024 cycle 3 interim classification (Anglesey North, Foryd Bay, Conwy and Conwy Bay). These waterbodies failed for contaminants including mercury, polybrominated diphenyl ethers (PBDE), polycyclic aromatic hydrocarbons (PAH) and cypermethrin. Combined, these waterbodies overlap with 12% of intertidal reefs. • Confidence is medium as the failing waterbodies overlap with a small proportion of the feature; the human health standard has been used for PBDE; and some chemical classifications were rolled forward.	**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 Menai Strait and Conwy Bay 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 subtidal temperature loggers from within the SAC were available. Loggers at one monitoring site indicated a potential increase in temperature in recent years. It is not clear if this is a localised change or in line with global trends. • An external report from Bangor University indicates that annual mean sea surface temperature is gradually rising in their Menai Strait temperature logger data. • 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)	• Analysis of the tide-swept boulder communities data showed a decrease of *Fucus serratus* by almost a third at both monitoring sites between 2010 and 2019. No local anthropogenic causes have been identified. • There was some changes in tide-swept boulder communities from 2007 to 2013. However, these were within the expected levels of natural fluctuation. Then, from 2014 to 2022, the tide-swept boulder communities have been more stable. • Analysis of the tide-swept *F. serratus* communities data showed the epibiota assemblage to be very variable in both time and space. These changes do not indicate any trends of concern. • Confidence is medium due to the unexplained decrease of *F. serratus* in the boulder communities, and the concern on impacts of boulder turning and bait collection at the Felinheli monitoring site. • Additionally, the sampling areas that the assessment is based upon overlap with a small proportion of the feature.	**Pass**	Medium

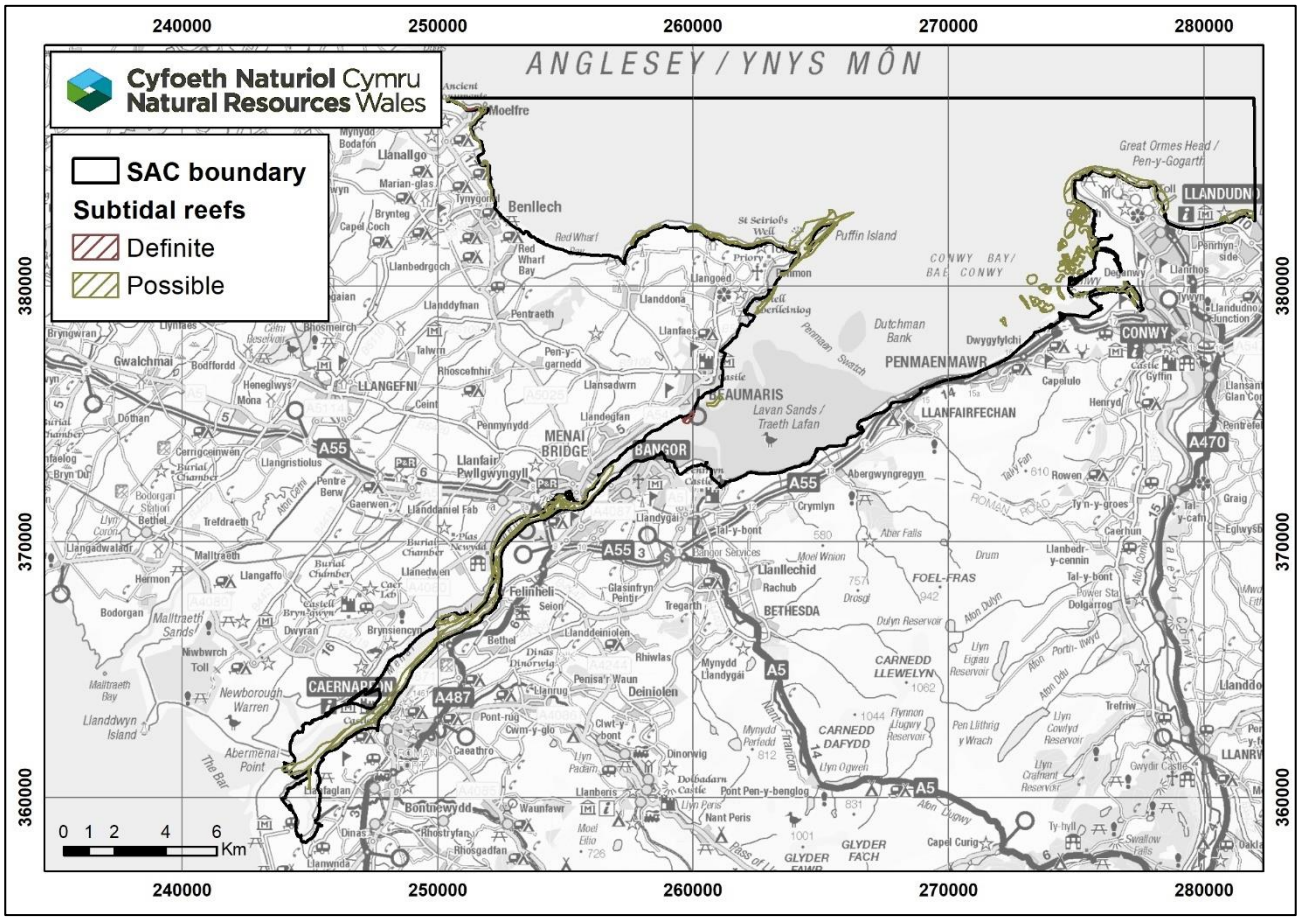
Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• Analysis of the tide-swept *F. serratus* communities data showed that species richness decreased at the Felinheli site between 2015 and 2019, and at the Llanidan site in 2018. The richness at both sites subsequently increased again in 2021 and 2022, but not to levels observed previously. • Analysis of the tide-swept boulder communities data indicated no clear temporal trends in species richness. • There were no clear patterns outside of natural change and variation that is expected. • Confidence is medium due to concerns about the low species richness at Felinheli site.	**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. the American slipper limpet *Crepidula fornicata*) are currently impacting the condition of intertidal reefs in the SAC. • Confidence is low as the spread and impacts of 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)	• *C. fornicata* became established around 2019 in the Menai Strait and numbers are increasing substantially within the reefs feature. • Other NNS have been recorded previously in the Menai Strait within the reefs feature including: Chilean oyster *Ostrea chilensis,* Pacific oyster *Magallana gigas* and wireweed *Sargassum muticum*. • There have been targeted NNS surveys at intertidal reef sites as part of the MarClim project, 'Rapid Assessment Survey' of marinas 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 Menai Strait and Conwy Bay SAC comprises a number of subtidal reefs (Figure 3). The monitored subtidal reefs include sampling sites within the limestone communities at Ynys Moelfre and Bottle Rock (situated off the Southern end of Puffin Island) and the tide-swept sponge communities at the Coleg Normal and Nelson's Column monitoring sites in the Menai Strait. These locations were surveyed between 2005 and 2023.

Figure 3. Map of the subtidal reefs in Menai Strait and Conwy Bay SAC.



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

Table 3. Condition assessment of subtidal reefs in Menai Strait and Conwy Bay 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of subtidal reefs in the Menai Strait and Conwy Bay 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 subtidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of subtidal reefs in the Menai Strait and Conwy Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 subtidal reefs in the Menai Strait and Conwy Bay 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 subtidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this in the absence of recent data.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
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 in the absence of recent data.	**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 subtidal reefs in this SAC. • Confidence is medium as expert judgement has been used to assess this 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. (S)	• One of the six WFD waterbodies that overlaps with subtidal reefs was not classified for the DIN WFD element in the 2024 cycle 3 interim classification (Anglesey North). It overlaps with 17% of the subtidal reefs. • The other five WFD waterbodies were classified as Good or High status for DIN (Conwy Bay, Menai Strait, North Wales, Conwy and Foryd Bay). Combined, these overlap with 83% of subtidal reefs. • 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)	• One of the six WFD waterbodies was classified with a Moderate status for phytoplankton in the 2024 cycle 3 interim classification (North Wales). It overlaps with 11% of subtidal reefs. The failure of this waterbody was considered unlikely to have a significant effect on the feature, especially as the sample locations were not close to the reefs feature. • One WFD waterbody was not classified for phytoplankton (Anglesey North). It overlaps with 17% of subtidal reefs. • The other four WFD waterbodies were classified as Good or High status for phytoplankton (Conwy Bay, Menai Strait, Conwy and Foryd Bay). Combined, these overlap with 72% of subtidal reefs. Two of the waterbody classifications were rolled forward from previous cycles. • Confidence is low due to the failure of one waterbody, one unclassified waterbody and rolled forward classifications.	**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. (S)	• All six WFD waterbodies that overlap with subtidal reefs were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. ○ One of these classifications was rolled forward from the 2021 cycle 3 classification (Anglesey North). • Confidence is medium due to samples being taken from the surface of the waterbody, and due to the rolled forward classification in one waterbody.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Two of the six WFD waterbodies that overlap with subtidal reefs have a pass for chemicals in the 2024 cycle 3 interim classification (Menai Strait and North Wales). In both waterbodies the classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. Combined, these waterbodies overlap with 63% of subtidal reefs. • The other four WFD waterbodies have a fail for chemicals in the 2024 cycle 3 interim classification (Anglesey North, Conwy Bay, Conwy and Foryd Bay). These waterbodies failed for contaminants including mercury, PBDE, PAH and cypermethrin. Combined, these waterbodies overlap with 36% of subtidal reefs. • Confidence is medium as the human health standard has been used for PBDE and due to the 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 Menai Strait and Conwy Bay 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 subtidal temperature loggers from within the SAC were available. Loggers at one monitoring site indicated a potential increase in temperature in recent years. It is not clear if this is a localised change or in line with global trends. • An external report from Bangor University indicates that annual mean sea surface temperature is gradually rising in their Menai Strait temperature logger data. • 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)	• Analysis of subtidal reefs at Ynys Moelfre and Puffin Island indicated stable communities across the monitoring period (2014-2023), with some natural variation. • The sponge morphology data from Ynys Moelfre and Puffin Island did not indicate concern. • The sponge monitoring data from the Coleg Normal monitoring site in the Menai Strait showed a large decline since 2004 which exceeds that expected from natural variation. This caused the indicator to fail its target. An NRW led investigation is ongoing to understand the reasons for this decline. • Confidence is high due to the availability of long term monitoring data and the large decline seen in sponge.	**Fail**	High

Indicator	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)	• At Puffin Island, the recorded changes in species richness and abundance from the analysis of the subtidal reef communities data were small and considered to be natural.
		• Diversity for the sponge morphology data at Ynys Moelfre and Puffin Island appeared stable across time.
		• Data analysis of the Ynys Moelfre and Coleg Normal monitoring sites sponge communities indicate reductions in species richness.
		  ○ At Yyns Moelfre, there has been a 20% decline in reef-associated species richness.
		  ○ The decline in the sponge community at Coleg Normal has led to a decrease in species richness.
		• Confidence is medium as no change in species richness was detected at Puffin Island, and due to the time-limited nature of the sampling methods.
			Fail	Medium

Taxonomic spread of species	Maintain the expected taxonomic spread of reef species, allowing for natural change and variation. (S)	• Overall, the average taxonomic distinctness of the monitored subtidal reefs at Puffin Island remained stable and within the expected values between 2014-2023. • The average taxonomic distinctness at the lower circalittoral zone at Ynys Moelfre was lower in recent years and a reduced number of species was observed. This caused the indicator to fail. • Confidence is low as the analysis is based on data collected in 2014, 2016, 2022 and 2023, making any inference difficult.	**Fail**	Low

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 subtidal 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)	• *C. fornicata* became established around 2019 in the Menai Strait and numbers are increasing substantially within reefs feature. • Other NNS have been recorded previously in the Menai Strait within the reefs feature including: Chilean oyster *Ostrea chilensis,* Pacific oyster *Magallana gigas* and wireweed *Sargassum muticum*. • There have been targeted NNS surveys at intertidal reef sites as part of the MarClim project, 'Rapid Assessment Survey' of marinas 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 Menai Strait and Conwy Bay SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of failing targets (Table 4). There were limited or no data available for some key indicators to inform on the condition of the feature (see evidence gaps section 5). This has contributed to the reduced confidence in the overall 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. 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 Menai Strait and Conwy Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Menai Strait and Conwy Bay	**Unfavourable (medium confidence)**	Abundance, distribution and species composition of communities (P) Water quality: contaminants (S) Species richness and diversity (S) Taxonomic spread of species (S) Non-native species (T)	• Sponges at the Coleg Normal subtidal reefs site are in decline. This has led to a decline in species richness. There was also a 20% decrease in species richness in Ynys Moelfre. • Levels of mercury, PBDE, PAH and cypermethrin in the Anglesey North, Foryd Bay, Conwy Bay and Conwy waterbodies are failing to meet their relevant environmental quality standards (EQS). • Taxonomic distinctness of epibiota has declined in the Ynys Moelfre subtidal reef site. • *C. fornicata* became established around 2019 in the Menai Strait and numbers are increasing substantially.	• Unconsented infrastructure • Recreational access and collection • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Menai Strait and Conwy Bay SAC passed their targets as there are currently no known anthropogenic impacts that would negatively affect the reefs feature. This applies to both intertidal and subtidal reefs. 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.

Sediment and Topography

The sediment quality indicators are relevant to subtidal reefs only. There were no data available on sediment quality within the SAC therefore these indicators were not assessed.

The topography, bathymetry, hydrodynamic and sediment transport processes are not well researched for reefs. 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 intertidal and subtidal reefs.

Water quality

It has been estimated that approximately 95% of intertidal reefs and nearly 100% of subtidal reefs within the SAC fall within seven WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Menai Strait waterbody overlaps with a large proportion of intertidal and subtidal reefs in the SAC (Table 5). For subtidal reefs, the Anglesey North, Conwy Bay and North Wales waterbodies overlap with a smaller but significant proportion (Table 5). The Seiont waterbody overlaps with a very small proportion of intertidal reefs and none of the subtidal reefs (Table 5), and has therefore not been considered further in the condition assessment. Foryd Bay waterbody was not considered further in the assessment of subtidal reefs for the same reason.

Table 5. WFD waterbodies that overlap with intertidal and subtidal reefs within the Menai Strait and Conwy Bay SAC.

WFD waterbody	Degree of overlap with intertidal reefs (%)	Degree of overlap with subtidal reefs (%)
Menai Strait	80.61	52.23
Anglesey North	6.83	16.71
Conwy Bay	0.48	13.30
North Wales	1.70	11.12
Conwy	1.54	6.30
Foryd Bay	3.46	0.17
Seiont	0.07	0.00
All waterbodies combined	94.69	99.83

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The indicators for nutrients and phytoplankton met their targets. The confidence in the pass for the nutrients indicator was medium because one WFD waterbody was not classified for the dissolved inorganic nitrogen (DIN) element in the 2024 cycle 3 interim classification. The confidence in the pass for the phytoplankton indicator was reduced to low because the High status classifications for two WFD waterbodies were rolled forward. This includes the Menai Strait waterbody, which overlaps with a large proportion of the feature (Table 5). In addition, one WFD waterbody (North Wales) was classified as Moderate status, but overlaps with a comparatively smaller proportion (Table 5). It was deemed that the failure of this waterbody was unlikely to have a significant effect on the feature, especially as the sample locations were not close to the reefs feature. Two WFD waterbodies were not classified for the phytoplankton element. Classification of 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 met its target as three of the overlapping WFD waterbodies were classified as Good or High status for this element in the 2024 cycle 3 interim classification (Foryd Bay, Conwy and Seiont). Combined, these waterbodies overlap with a small proportion of the feature (5%), and the classification for one of these was rolled forward from the 2018 cycle 2 interim classification. This reduced the confidence in the pass. There have been observations of nuisance algae in the watercourses that feed into the Foryd Bay waterbody, therefore sampling may not be suitable to pick up issues and this could be something to investigate in future. However, as this waterbody overlaps with a small proportion of the feature (Table 5), this observation did not lead to a failure. The other four WFD waterbodies were not classified for this element in the 2024 cycle 3 interim classification. This includes the Menai Strait waterbody, which overlaps with the largest proportion of intertidal reefs (Table 5). Some 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 low because a large proportion of intertidal reefs overlap with waterbodies that have not been classified for the opportunistic macroalgae element. This indicator is not relevant to subtidal reefs.

Dissolved oxygen

The dissolved oxygen indicator also met its target as nearly all 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, and as there was one WFD waterbody with a rolled forward classification, reduced the confidence in the pass to medium.

Contaminants

Four of the seven WFD waterbodies that overlap with the intertidal and subtidal reefs in the SAC have a fail for chemicals in the 2024 cycle 3 interim classification. This caused the contaminants indicator to fail for both subtidal and intertidal reefs. Combined, these four

WFD waterbodies overlap with approximately 12% of intertidal reefs and 36% of subtidal reefs. The failures were in the Anglesey North (mercury and polybrominated diphenyl ethers (PBDE)), Conwy Bay (polycyclic aromatic hydrocarbons(PAH)), Foryd Bay (mercury), and Conwy (PBDE, mercury, PAH and cypermethrin) waterbodies.

There has been a waterbody status change from pass to fail in the Conwy Bay waterbody between the 2021 cycle 3 classification and the 2024 cycle 3 interim classification, however the failing contaminant (PAH) was not assessed in previous cycles. Similarly, in the Conwy waterbody, two of the failing contaminants (PAH and cypermethrin) were not previously classified. With the exception of the 2021 cycle 3 classification, mercury has failed in this waterbody in all classifications since the 2015 cycle 2 classification. The waterbody status changes for mercury between cycles are likely due to changes in WFD classification methodology. Cypermethrin is a synthetic pyrethroid insecticide and is highly toxic to some aquatic species (EA, 2019), but now has a restricted use in Wales. The EQS for cypermethrin is very low, and in the previous laboratory methodology, it was not possible to detect concentrations below the EQS. There was an additional failure for zinc in the 2021 cycle 3 classification the Conwy waterbody, but this no longer fails in the 2024 cycle 3 interim classification. In the Anglesey North waterbody, mercury has failed since the 2015 cycle 2 classification. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The PBDE failures were based on the value of the human health protection goal as it is the most stringent. This protection goal may be over precautionary as the effect of contaminants on the biota of reefs are not fully understood. The confidence in the fail was reduced to medium to reflect this.

The other two overlapping waterbodies (North Wales and Menai Strait) have a pass for chemicals in the 2024 cycle 3 interim classification. However, in both WFD waterbodies the classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. The Menai Strait waterbody overlaps with the largest proportion of both intertidal and subtidal reefs. This also contributed to the reduced confidence. 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 NRW monitored subtidal temperature loggers from two sites within the SAC were available. However, as loggers from one of the monitoring sites had a large amount of missing data, the observed patterns in temperature are based on data from only one monitoring site which does not overlap with the feature but was less than 500m away. These loggers showed an increase in temperature in more recent years. An external report (Smyth et al., 2022) also found that the annual mean sea surface temperature was gradually rising in the Menai Strait. 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

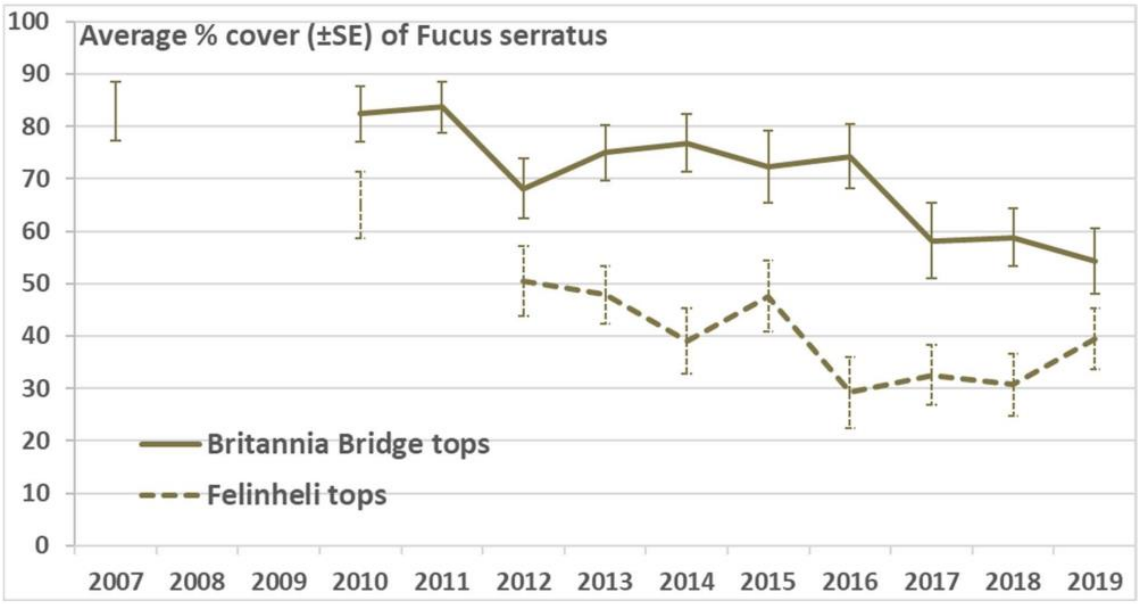
Assessment of the species community indicators for intertidal reefs in Menai Strait and Conwy Bay SAC used data from various monitoring sites. This includes monitoring of sampling sites within the tide-swept boulder communities at Britannia Bridge and Felinheli, and the tide-swept *Fucus serratus* communities in Brynsiencyn (Llanidan and Castell Gwylan sites), from 2007 to 2022. While some of the locations are just outside the SAC boundary they are deemed to be representative of intertidal reefs.

Macrofaunal analysis for the intertidal data showed that there was a change in communities present in the tide-swept boulder locations from 2007 to 2013, with a very similar trajectory at both sites and on both the boulder tops and boulder bottoms. Multiple species contributed to these changes including a decrease in some species of sponges, spirobid, and serpulid worms, barnacles and *F. serratus* and a fluctuation in the abundance of sea squirts (Moore, 2022a). However, these changes may have been partly confounded by differing methodological.

From 2014 to 2022, the community has been more stable (Moore, 2022a; Moore et al., 2023). These changes appeared to reflect the expected level of natural variation and data analysis indicated that the epibiota assemblage was highly variable in both space and time, but with no reason for concern. However, there has been a decrease in the cover of *F. serratus* by almost a third at both sampling sites between 2010 and 2019 (Figure 4) (Moore, 2022a). Interpretation is difficult as boulder selection by the surveyor is inherently influenced by the abundance of *F. serratus.* No local anthropogenic impacts are identified as potential causes for the decline of *F. serratus*. Photographic evidence may indicate that silt levels in 2019 were higher than they were in 2011, but there is no empirical data to confirm this. Another survey focused on the tide swept *F. serratus* communities did not find any notable temporal trends in the overall abundance of *F. serratus*, but its cover was typically patchy at these sampling sites and the number of quadrats surveyed was rarely enough to provide a good estimate of the actual mean (Moore, 2024). Other evidence from the MarClim dataset between 2017 and 2023 suggested that there have been no apparent changes in the SACFOR (Superabundant, Abundant, Common, Frequent, Occasional and Rare) abundance scale of *F. serratus* over this period in all MarClim sites within the SAC (Mieszkowska and Sugden, 2023, 2024). The SACFOR scale is a crude scale to monitor abundance and the decline observed in the boulder surveys may not have been captured by this method. Currently, there is no specific survey designed to monitor the change in abundance of *F. serratus* across the SAC feature. Further investigation is required to understand if the *F. serratus* decline is localised or if it is wider and related to effects of climate change.

Overall, the abundance, distribution and species composition of communities indicator was assessed as passing. The confidence was reduced to medium due to the observed decline in *F. serratus* at the two tide-swept boulder community monitoring sites, and because the sampling areas that the assessment is based upon cover a small proportion of the SAC feature. In addition, there were some concerns raised about the impacts of boulder turning and bait collection on the reef in the Felinheli site.

Figure 4. Average percentage cover (± standard error) of *Fucus serratus*. Each point is calculated from a minimum of 25 boulders (Moore, 2022a).



In general, species richness tended to be higher at Britannia Bridge than Felinheli sites for the tide-swept boulder communities (Moore, 2022a; 2024). The total number of taxa reduced at the Felinheli site between 2015 and 2019, then rose again in 2022, but not to levels observed previously. An large reduction in species richness at Britannia Bridge was observed between 2018 and 2019. This was mainly due to the reduced numbers of sponge taxa (Moore, 2022a). Data from 2021 and 2022 show a large increase in the number of species of sponges, but not to previous levels. There was also a decrease in species richness for the *F. serratus* communities at Llanidan monitoring site up to 2019, however it has increased again in recent years (e.g. 2021 and 2022) suggesting natural fluctuations. Overall, there were no clear temporal trends in species richness for intertidal reefs, and changes tended to be within the bounds of natural variation, resulting in a pass for this indicator. However, there is some concern about the low species richness at Felinheli site, and the unexplained reduction in species richness of sponges at Britannia Bridge in 2018, resulting in medium confidence.

The taxonomic spread of species indicator for intertidal reefs could not be assessed due to insufficient data.

Subtidal reefs

The subtidal reefs assessment included data from various monitoring sites: Ynys Moelfre, situated in the northeast of the Menai Strait and Conwy Bay SAC; Bottle Rock at the southern tip of Puffin Island and Coleg Normal within the Menai Strait. Abundance of different sponge morphologies, as a proxy for sponge species, was assessed using fixed quadrats at Ynys Moelfre (2005-2023) and Bottle Rock (2011-2023) monitoring sites, whilst more recently from 2014 onwards, a more complete suite of reef-associated species were assessed using the same quadrats at these two monitoring sites. Sponge luxuriance, an estimate of both abundance and volume, was assessed along transects at the Coleg Normal monitoring site from 2004 to 2023.

The subtidal reefs analysis of the monitored sites at Puffin Island and Ynys Moelfre indicated small changes in species composition between 2014 and 2023. Several species contributed to these small changes with no pattern detected. Such fluctuations were judged to be within the bounds of natural variation. The sponge morphology at Ynys Moelfre and Puffin Island monitoring sites varied greatly when analysed individually across the monitoring period with no clear pattern. Despite the variation recorded, the mean morphotypes at both monitoring sites was stable over time and thus was considered to be natural.

However, sponge monitoring data at the Coleg Normal site in the Menai Strait indicated a dramatic decline in sponge biomass since 2004 and recent data suggests no improvement (Figure 5 and Figure 6). Sponge luxuriance is used for assessing the health of the sponge community, which is a notable component of the reef feature. The decline in sponge biomass could be an indicator of wider impacts across the whole reefs feature within the SAC. An NRW led investigation is ongoing to understand the reasons for this decline. This decline has resulted in a fail for the abundance, distribution and species composition of communities indicator with high confidence.

The species richness and diversity indicator failed based on a recent 20% decline in reef-associated species richness recorded at Ynys Moelfre monitoring site. Additionally, the decline in sponges recorded at the Coleg Normal site, specifically the loss of the sponge Mermaid's glove *Haliclona oculata* from transects in recent years, has led to a decrease in species richness and therefore contributed to this failure. The confidence in this assessment was lowered to medium as no change in species richness was detected at Puffin Island monitoring site and due to the time-limited nature of subtidal monitoring methods. 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 abundance.

The average taxonomic distinctness was deemed to be within the bounds of natural variation for the reef-associated species at Puffin Island monitoring site. A decrease, however, was detected for the lower circalittoral zone at Ynys Moelfre monitoring site, with lower numbers of species found in more recent years. This finding further supports the evidence of declining species richness at this monitoring site. As a result, the taxonomic spread of species indicator has failed to meet its target. The decreasing trend in taxonomic distinctness at Ynys Moelfre monitoring site, needs confirmation with further sampling. The analysis for this indicator was based on only four data points between 2014-2023 and the failure is localised to a small part of the feature, resulting in a lower confidence.

Figure 5. Measurements of the sponge *Haliclona oculata* along Coleg Normal's 30 m southwest transect in the Menai Strait and Conwy Bay SAC during the monitoring period 2004-2023. a) Percentage occurrence (%) and b) mean size (cm).

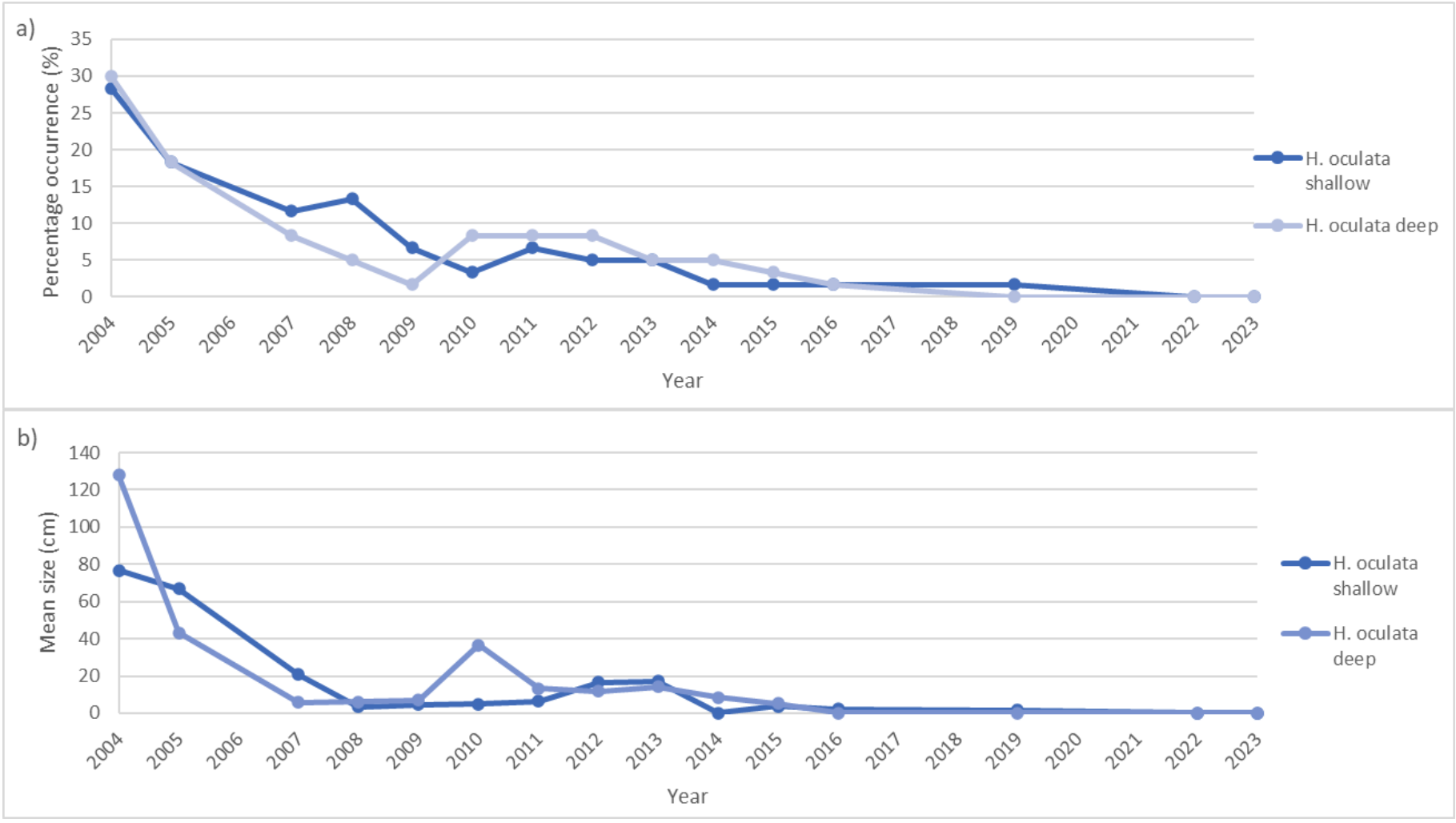
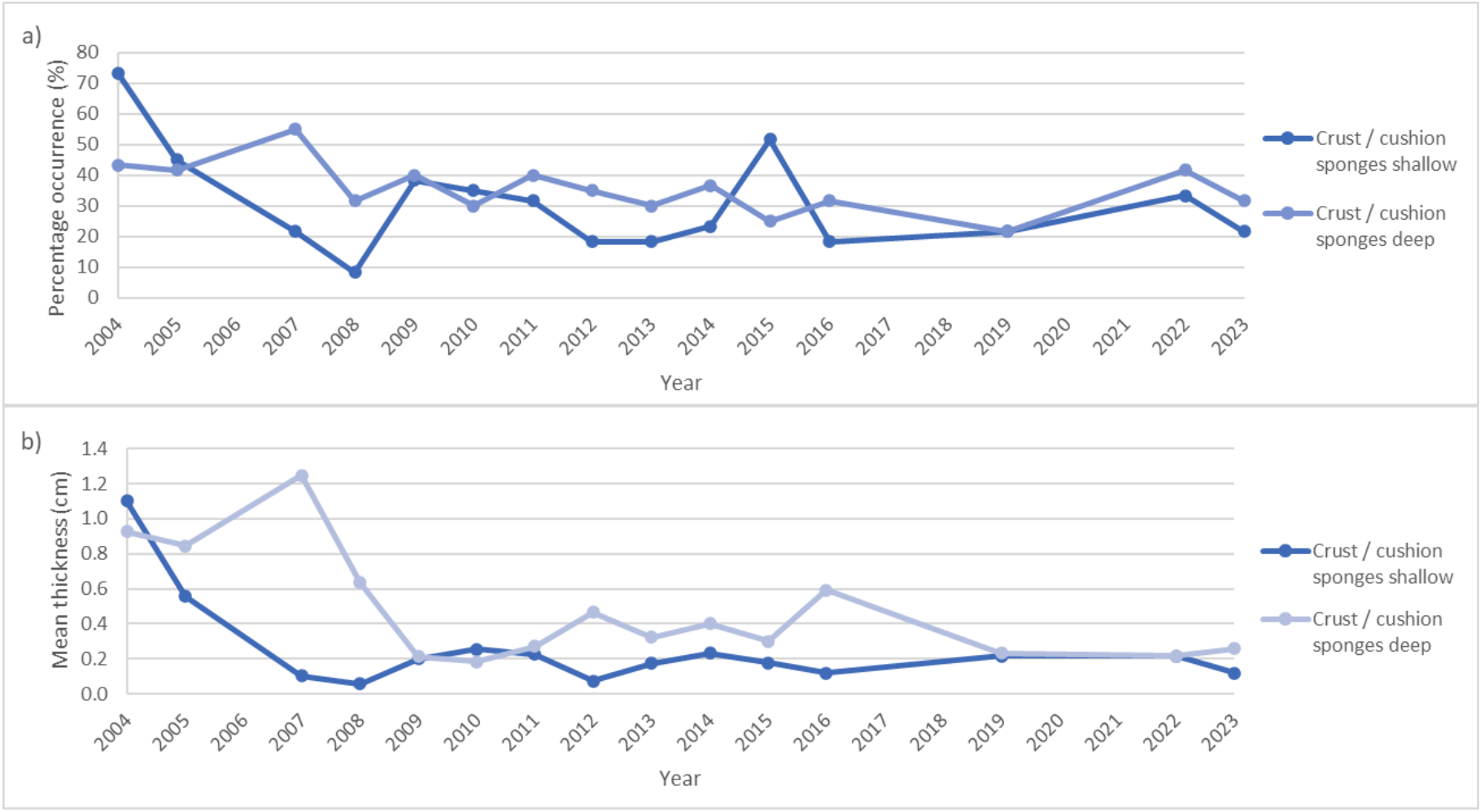


Figure 6. Measurements of crust and cushion sponges along Coleg Normal's 30 m southwest transect in the Menai Strait and Conwy Bay SAC during the monitoring period 2004-2023. a) Percentage occurrence (%) and b) thickness (cm).



Invasive non-native species

There were records of the American slipper limpet *Crepidula fornicata* identified in 2006 in the Menai Strait, however, following an eradication attempt, no records of the species were identified for a number of years. More recently, within the last six years, this species has become established (i.e. since 2019) within the reefs feature in the Menai Strait, and numbers are increasing. 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 Menai Strait (within the reefs feature) including the Chilean Oyster *Ostrea chilensis,* the Pacific oyster *Magallana gigas* and the wireweed *Sargassum muticum*. Limited records have been produced for *O. chilensis,* but it has been known to be present in the Strait for about 30 years. The cover of *S. muticum* is thought to be extensive in the SAC, however this species is no longer consistently recorded. *S. muticum* has replaced the zone of sugar kelp in some areas in the Menai Strait but it is thought that it has not expanded significantly in recent years.

It is not fully understood how some of these species may impact the reef biota and effects on the species diversity and composition have not yet been observed. 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.

Reasons for target failure

The assessment of the reefs feature in the Menai Strait and Conwy Bay SAC failed one primary target, three secondary targets and one tertiary targets. 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.

Abundance, distribution and species composition of communities

This indicator target has a primary weighting. The sponge biomass at Coleg Normal monitoring site has dramatically decreased since 2004 and there is no sign of recovery. As sponge luxuriance is a proxy for assessing the health of the subtidal reef habitat, the sponge biomass decline suggest that the wider reefs feature could be affected. This has resulted in a fail for the abundance, distribution and species composition of communities indicator with high confidence. The reason for this decline is not currently known, but an investigation is underway to help understand the cause of decline and to confirm if it is a localised or wider issue.

Water quality: contaminants

This indicator target has a secondary weighting. The reefs feature is partly within four WFD waterbodies (Anglesey North, Foryd Bay, Conwy Bay and Conwy) which have failed for chemicals due to mercury, PBDE, PAH and cypermethrin. 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). PAHs can be produced through

natural processes, but also arise from anthropogenic sources, for example during combustion of fossil fuels and organic material (Webster and Fryer, 2022). Cypermethrin is an insecticide used for plant protection in crops, in forestry, gardens, homes and businesses. It is also used in veterinary medicine to control pests in livestock and pets (EA, 2019). The application of cypermethrin has been restricted for some uses (sheep dipping and in forestry against the pine weevil).

Some of the contaminants in the water column may be derived from diffuse sources including atmospheric deposition or contaminated waterbody bed sediments. However, WFD investigations of the failures in all four 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. There is currently no specific management in place for PAH in Wales. The PAH EQS is based on the most sensitive taxa and may not be applicable to all of the reef biota. The impacts of PAH on the reefs feature are not fully understood.

Species richness and diversity

This indicator target has a secondary weighting. There has been a 20% decline in species richness in reef-associated species at the subtidal reef site, Ynys Moelfre. While no causes have been identified, such decline is concerning and requires further monitoring to know if this is a persistent and localised issue. There has also been a decline in species richness in the subtidal sponge community at Coleg Normal site in the Menai Strait with no sign of recovery.

Taxonomic spread of species

This indicator target has a secondary weighting. A decline in average taxonomic distinctness and in the number of species was observed since 2016 at the lower circalittoral zone of the subtidal reef site, Ynys Moelfre. While the reason for such a decline is unknown, this is concerning and will require further monitoring.

Non-native species

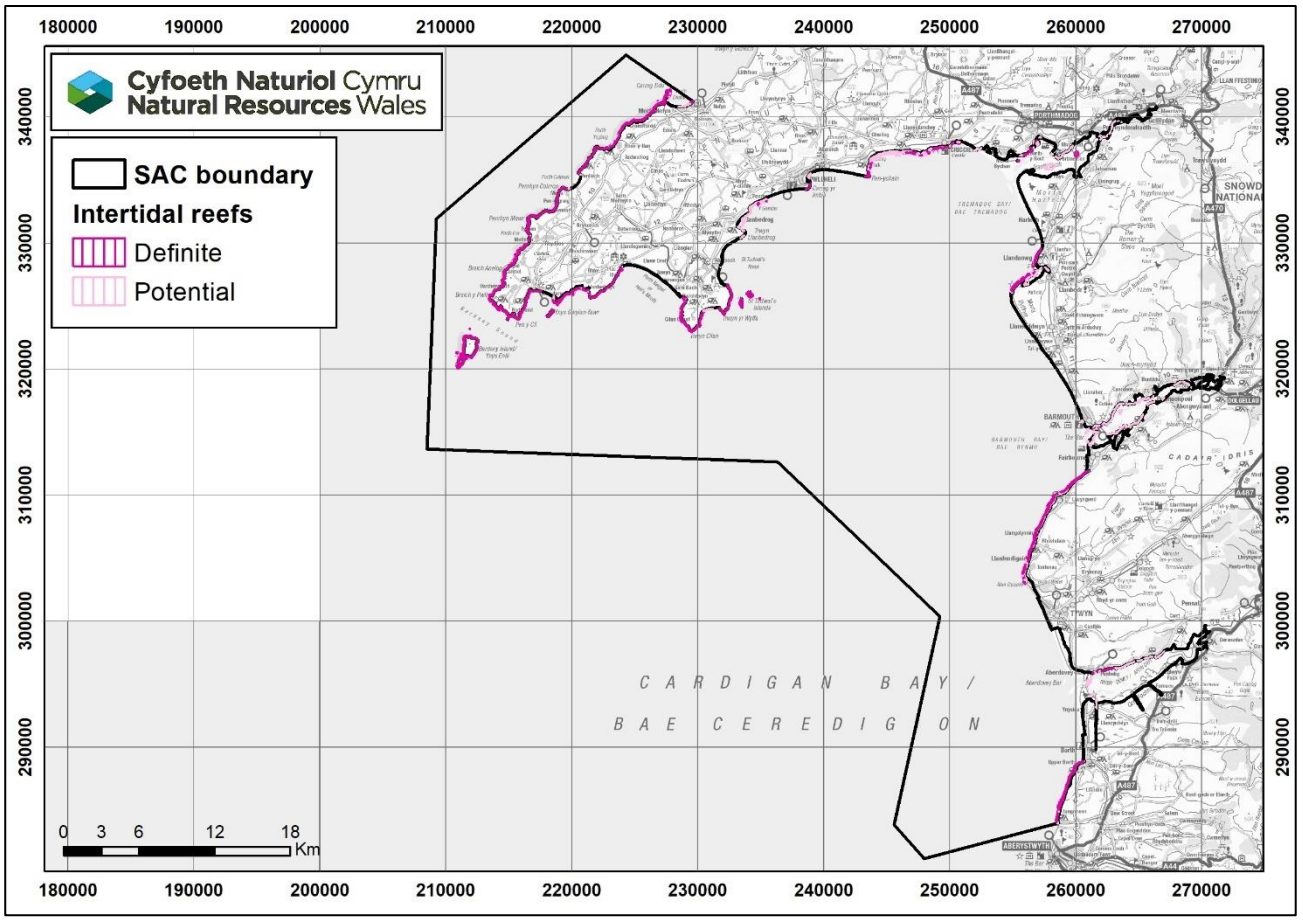
This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to the reappearance of *C. fornicata* within the reefs feature in the Menai Strait within the last six years. It is not fully understood how this species, and the other NNS present within the SAC may spread and impact the reef biota, and any negative 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.

3.2. Pen Llŷn a’r Sarnau SAC

Intertidal reefs

The reefs feature in the Pen Llŷn a’r Sarnau SAC comprises a number of intertidal reefs (Figure 7). 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 7. 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 6. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 6. 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

Indicators	Target	Assessment rationale	Target assessment	Target confidence
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
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 (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 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 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

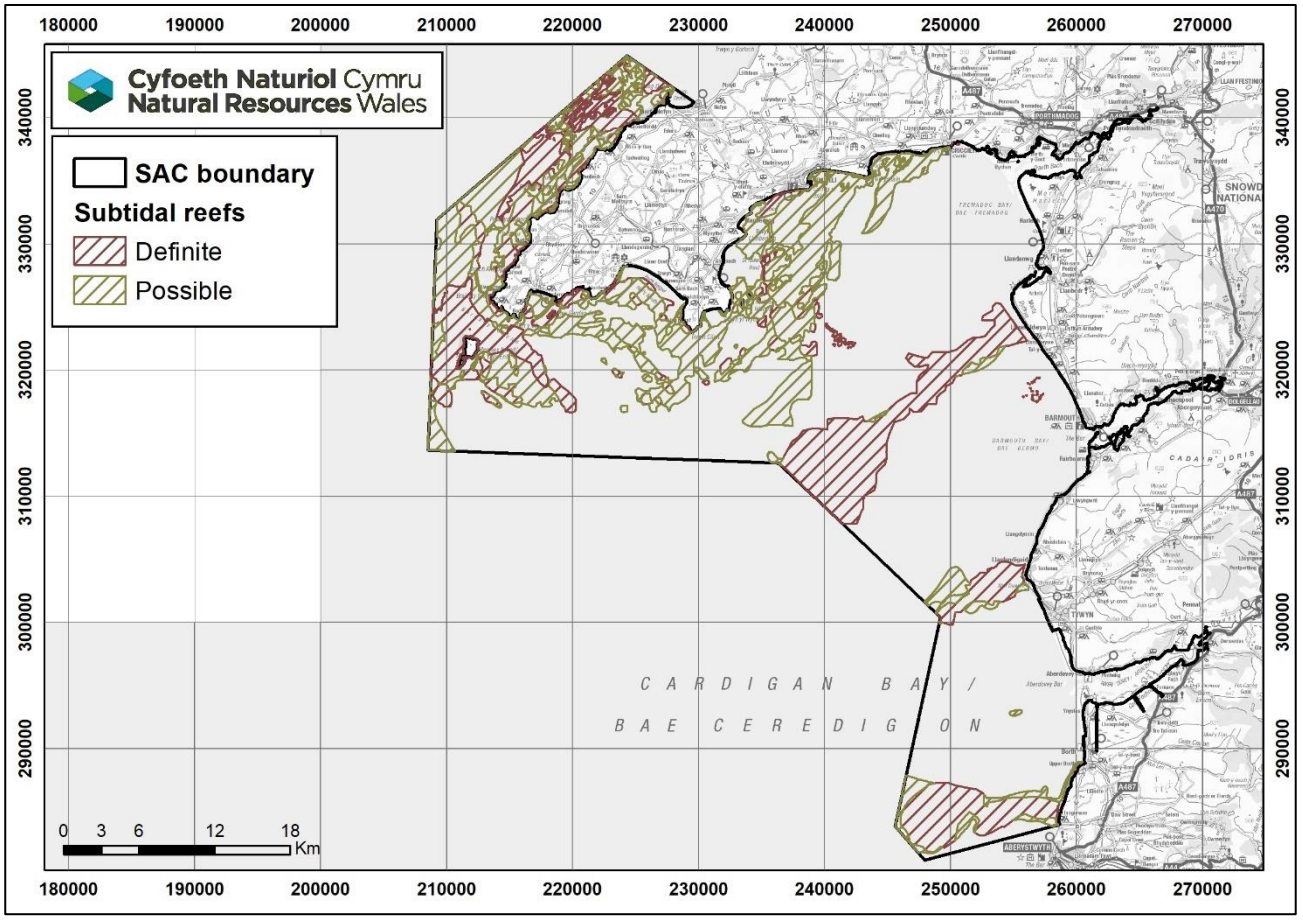
Indicators	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• Analysis 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. *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 *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 8). 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 8. 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 7. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 7. 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 Seas Environment 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

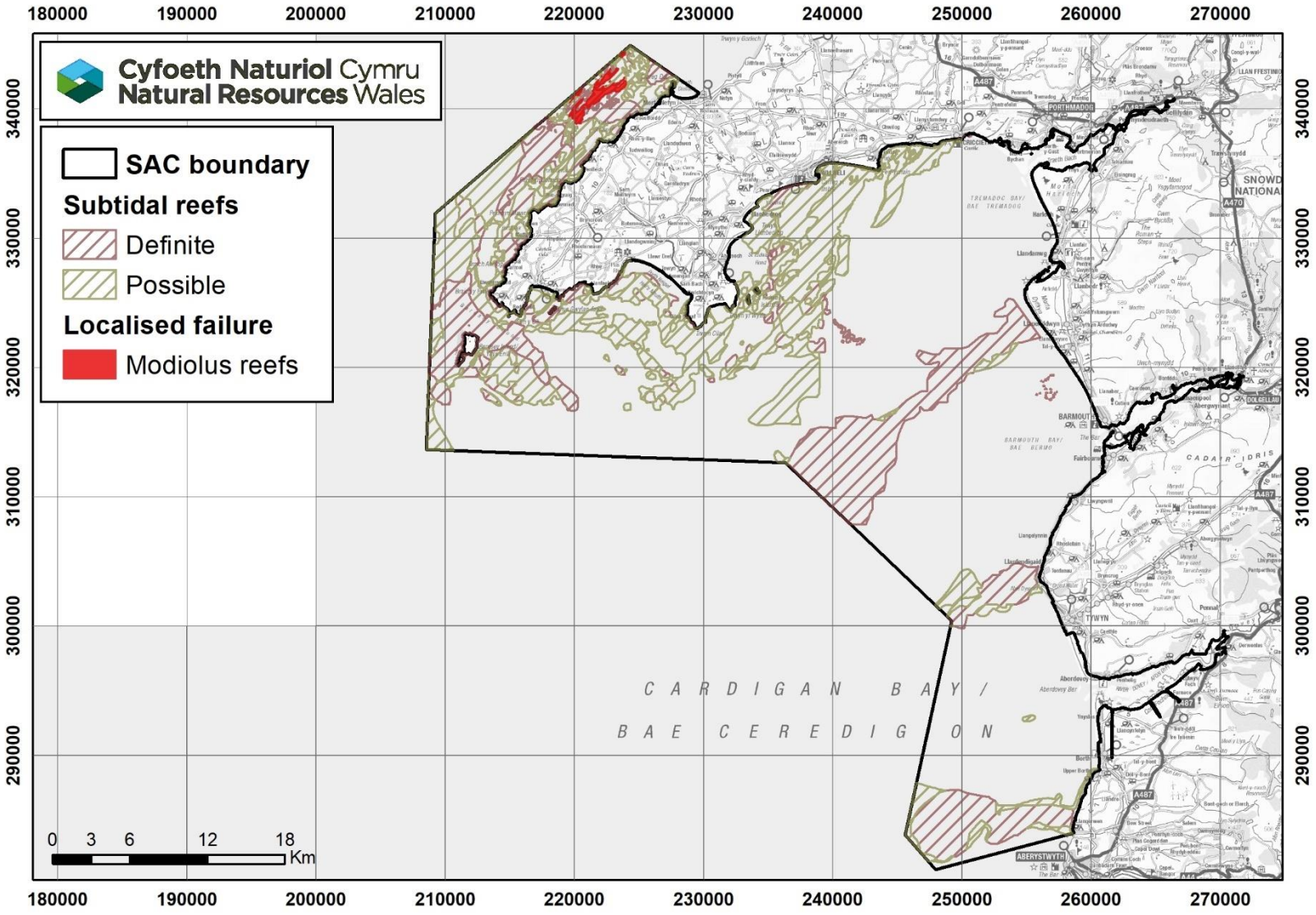
Assessment conclusions

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 8). 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 9). 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 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 reefs in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Pen Llŷn a'r Sarnau	**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 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

Figure 9. Map of the localised failure in the subtidal reefs in Pen Llŷn a'r Sarnau SAC.



Detailed assessment information

Extent and Distribution

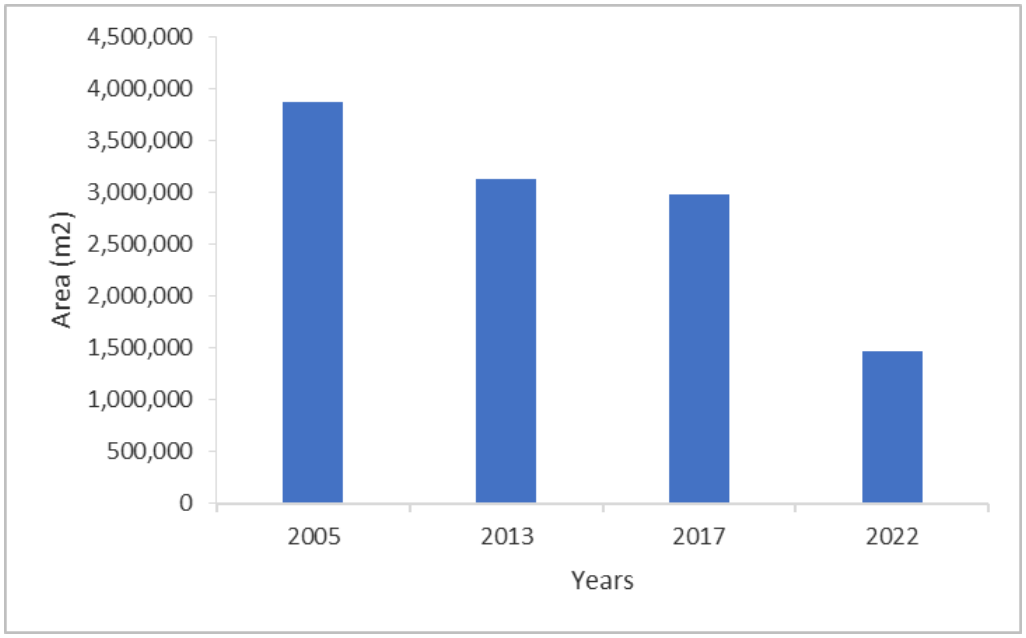
There are no known anthropogenic impacts on intertidal reefs that would significantly affect the extent and distribution indicators for geogenic and biogenic reef types. Comparison mapping has not been used to assess the extent or distribution of geogenic reef types; expert judgment was used in the absence 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 10). 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 9).

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 10. 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 Seas Environment 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 9). 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 9), and have therefore not been considered further in the condition assessment.

Table 9. 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 (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 9). 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. Confidence in the pass was reduced to medium because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in section 3.1).

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 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 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, 2022b; 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 *F. 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 *M. modiolus* reef, the fish communities at Holden's Reef, the reef-associated epibiota at Carreg Y Trai and the unusual *H. 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 10 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 9). 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 *C. 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 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 *S. 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 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

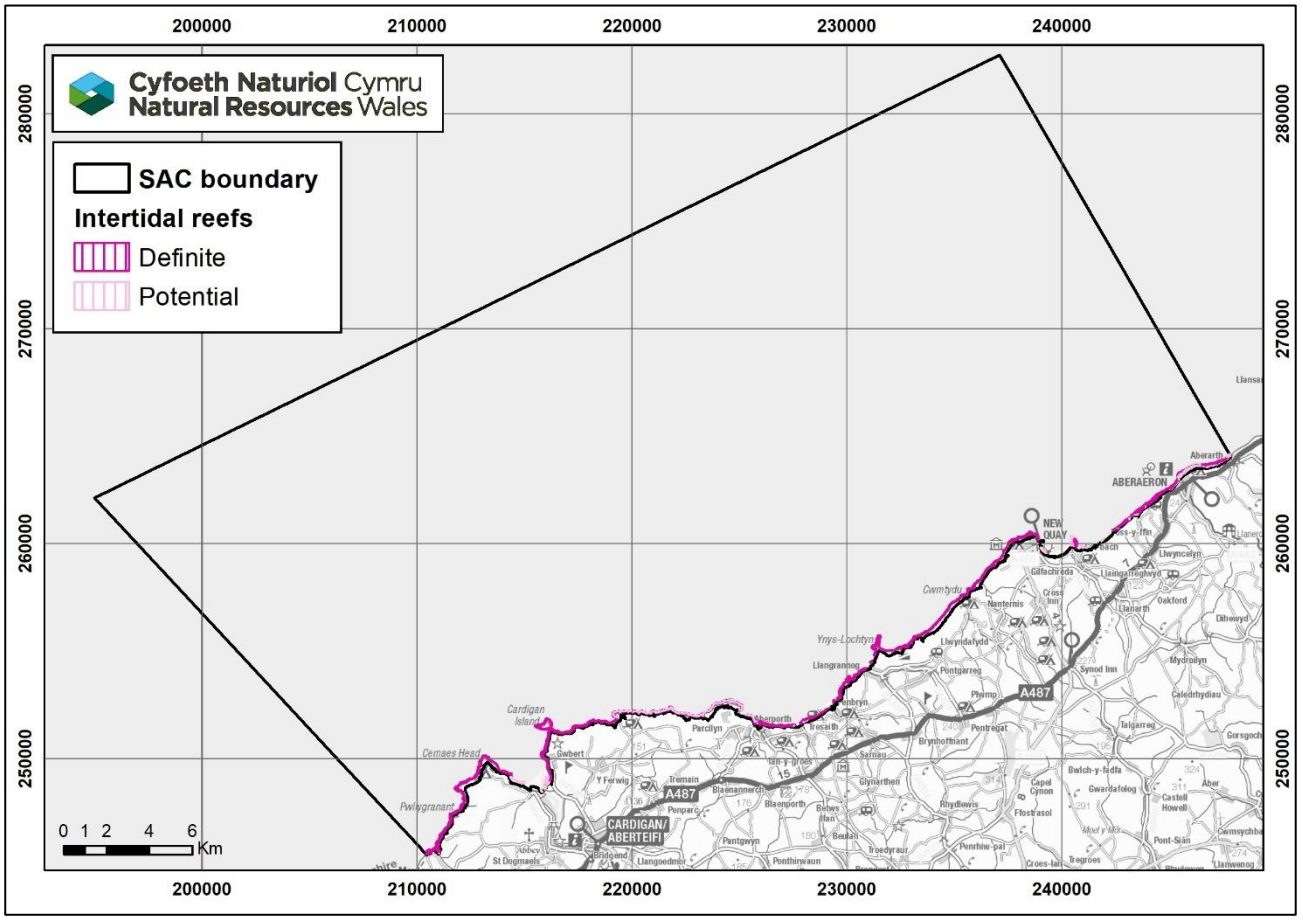
This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to records of *C. fornicata* found in the reef feature within the last six years. It is not fully understood how this species, and the other NNS present within the SAC may 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.

3.3. Cardigan Bay SAC

Intertidal reefs

The reefs feature in the Cardigan Bay SAC comprises a number of intertidal reefs (Figure 11). The NRW Habitats Regulations monitoring of intertidal reefs has focused on sampling sites within the rockpool communities at Aberporth and Cei Bach, the *S. alveolata* reefs at Aberaeron and Cei Bach, and the turf algae communities at Aberporth. These locations were surveyed between 2007 and 2022 using quadrat sampling, scrapes and fixed rockpools as part of the NRW Habitat Regulations monitoring survey.

Figure 11. Map of the intertidal reefs in Cardigan Bay SAC.



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

Table 10. Condition assessment of intertidal reefs in Cardigan Bay 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of intertidal reefs in the Cardigan Bay 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 intertidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of intertidal reefs in the Cardigan Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 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

Indicators	Target	Assessment rationale	Target assessment	Target confidence
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
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 (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)	• Two of the three WFD waterbodies that overlap with intertidal reefs were classified with a High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay Central and Cardigan Bay South). Combined, these waterbodies overlap with 70% of intertidal reefs. • The other WFD waterbody was classified with a Poor status for DIN (Teifi Estuary). It overlaps with 9% of intertidal reefs. • This caused the failure of the target, but with low confidence due to the small spatial overlap.	**Fail**	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. (S)	• One of the three WFD waterbodies was not classified for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay South). This waterbody overlaps with 14% of intertidal reefs in the SAC. • The other two WFD waterbodies were classified with High status for phytoplankton (Cardigan Bay Central and Teifi Estuary). These waterbodies overlap with 56% and 9% of intertidal reefs. ○ The Teifi Estuary waterbody classification was rolled forward from the 2021 cycle 3 classification. This classification may not be a true reflection of phytoplankton in the Teifi Estuary waterbody. • Confidence is low due to the unclassified waterbody, and the uncertainty and rolled forward classification in the Teifi Estuary waterbody.	**Pass**	Low
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)	• Two of the three overlapping WFD waterbodies has not been classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Cardigan Bay Central and Cardigan Bay South). Combined, these waterbodies overlap with 70% of intertidal reefs. • The other overlapping WFD waterbody was classified with a Good status (Teifi Estuary). This waterbody overlaps with 9% of intertidal reefs. ○ The confidence of this classification is uncertain due to outdated available intertidal habitat layers. • Confidence is low as the passing waterbody overlaps with a small proportion of the feature, and as there is some uncertainty in this classification.	**Pass**	Low

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)	• All three WFD waterbodies that overlap with intertidal reefs were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is medium due to samples being taken from the surface of the waterbody.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• One of the three WFD waterbodies was not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Cardigan Bay South). This waterbody overlaps with 14% of intertidal reefs. • One WFD waterbody has a pass for chemicals, however the chemical classifications were rolled forward from the 2018 cycle 2 interim classification (Teifi Estuary). This waterbody overlaps with 9% of intertidal reefs. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Cardigan Bay Central). This waterbody failed for mercury and PBDE and overlaps with 56% 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

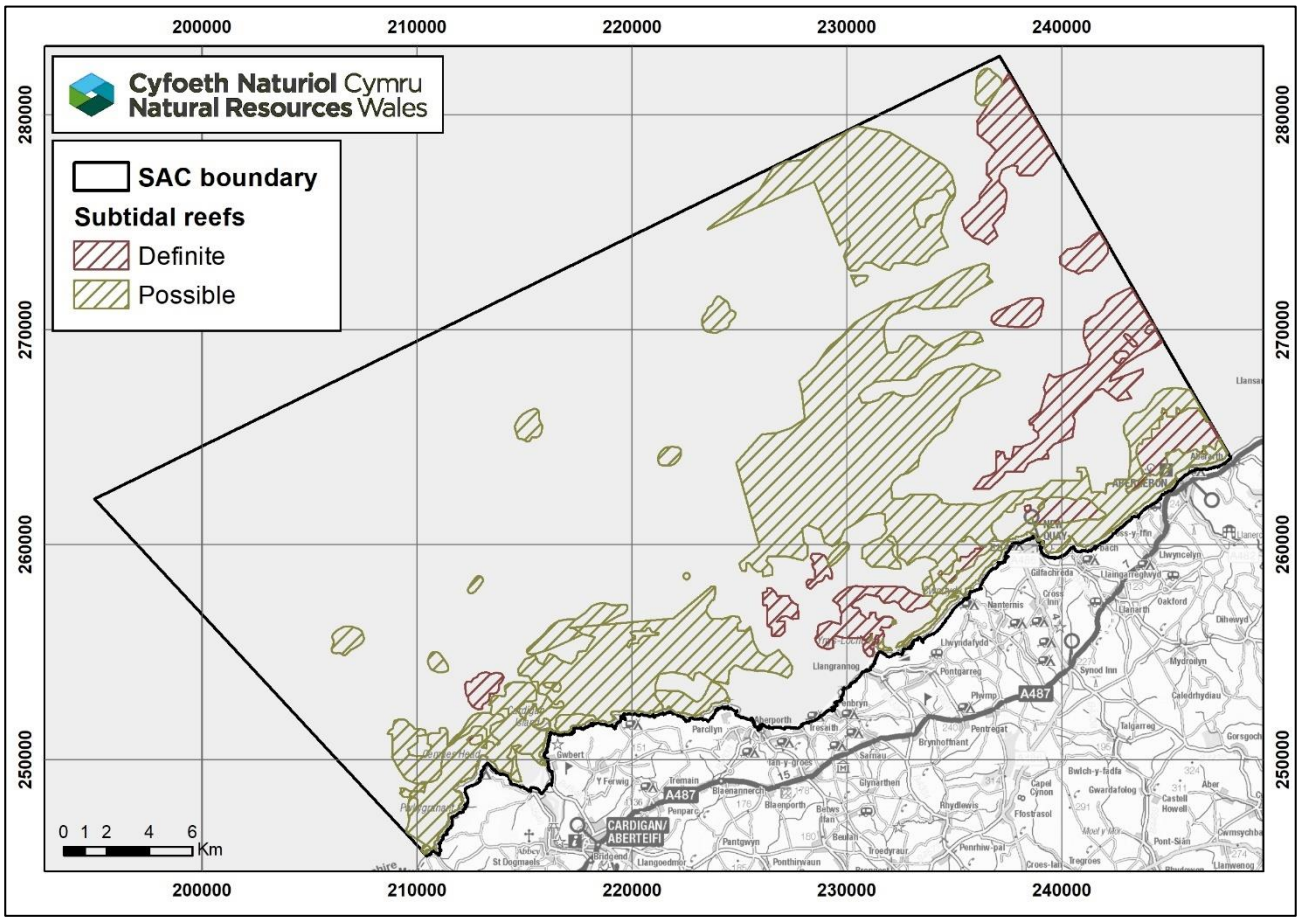
Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the reefs feature in the Cardigan Bay SAC, therefore this target was assessed as unknown.	**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)	• The percentage cover and extent of *Sabellaria alveolata* has fluctuated over the monitoring period at Cei Bach and Aberaeron sites. There was initially a decline in *S. alveolata* cover from 2017 to 2022, which has subsequently increased in 2023 and 2024. Analysis of the *S. alveolata* reef communities indicated a gradual progressive change over the course of the monitoring programme at both sites. This was considered natural. • The occurrence of green algae at Cei Bach site increased in later years, which has raised some concerns. • Analysis of rockpool communities for Aberporth and Cei Bach sites showed natural variation in communities composition across the monitoring period. • Analysis of turf algae at Aberporth site showed no distinct pattern, with sample composition being extremely variable but considered within bounds of natural variation. • The percentage cover of the blue mussel *Mytilus edulis* has fluctuated over the monitoring period which is likely to be part of a natural cycle. • The percentage cover of *Fucus serratus* has increased in recent years at both rockpool and *S. alveolata* reef sites. • Confidence is medium due to the presence of green algae at Cei Bach site within the *S. alveolata* reef.	**Pass**	Medium

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)	• Recorded changes in species richness for both *S. alveolata* reef communities in Aberaeron and Cei Bach sites did not indicate any trends of concern and were considered natural. • Similarly, the species richness for rockpool communities at Aberporth site appear to be within the normally recorded range of such fluctuations and considered natural.	**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 (e.g. *Sargassum muticum*) are currently impacting the condition of 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)	• No new NNS were identified within the last six years within the reefs feature of Cardigan Bay SAC. • *S. muticum* has been previously identified in low abundance in the SAC. • Confidence is low as there have been no targeted INNS surveys in the SAC.	**Pass**	Low

Subtidal reefs

The reefs feature in the Cardigan Bay SAC comprises a number of subtidal reefs (Figure 12). There is currently no NRW Habitats Regulation monitoring programme for the subtidal reefs within the Cardigan Bay SAC, therefore some indicators could not be assessed for subtidal reefs.

Figure 12. Map of the subtidal reefs in Cardigan Bay SAC.



The summary of the assessment outcome for subtidal reefs is provided in Table 11. The outcome and reasons for failure are discussed in more detail in the sections below.

Table 11. Condition assessment of subtidal reefs in Cardigan Bay 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of subtidal reefs in the Cardigan Bay 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 intertidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of subtidal reefs in the Cardigan Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 subtidal reefs in the Cardigan Bay 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 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
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
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 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
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 was classified with a Poor status for DIN in the 2024 cycle 3 interim classification (Teifi Estuary). It overlaps with only 1% of subtidal reefs, and therefore did not cause the indicator to fail. • The other two WFD waterbodies were classified with a High status for DIN (Cardigan Bay Central and Cardigan Bay South). These waterbodies overlap with 24% of subtidal reefs. • Confidence is low due to the failure of the Teifi Estuary waterbody.	**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. (S)	• One of the three WFD waterbodies was not classified for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay South). This waterbody overlaps with 7% of subtidal reefs. • The other two WFD waterbodies were classified with High status for phytoplankton (Cardigan Bay Central and Teifi Estuary). Combined, these waterbodies overlap with 17% and 1% of subtidal reefs. ○ The Teifi Estuary classification was rolled forward from the 2021 cycle 3 classification. • Confidence is medium due to the unclassified waterbody and rolled forward classification.	**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)	• All three WFD waterbodies that overlap with subtidal reefs were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • 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)	• One of the three WFD waterbodies was not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Cardigan Bay South). This waterbody overlaps with 7% of subtidal reefs. • One WFD waterbody has a pass for chemicals, however the chemical classifications were rolled forward from the 2018 cycle 2 interim classification (Teifi Estuary). This waterbody overlaps with 1% of subtidal reefs. • The WFD other waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Cardigan Bay Central). This waterbody failed for mercury and PBDE and overlaps with 17% of subtidal 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 Cardigan Bay SAC, therefore this target was 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 to suggest that INNS (e.g. *Sargassum muticum*) 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 well 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)	• No new NNS were identified within the last six years within the reefs feature of Cardigan Bay SAC. • *S. muticum* has been previously identify in low abundance in the SAC. • Confidence is low as there have been no targeted INNS surveys in the SAC.	**Pass**	Low

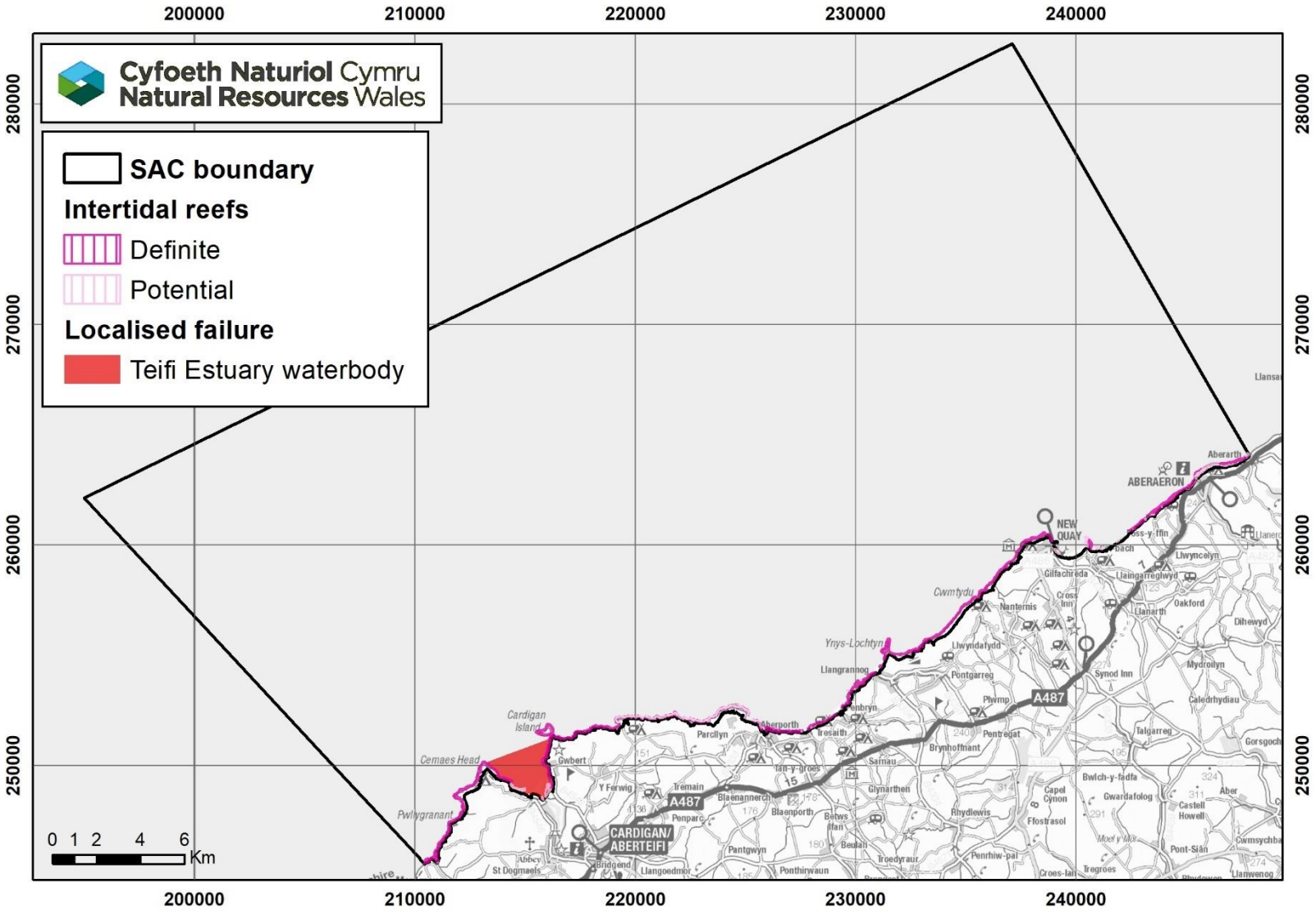
Assessment conclusions

The reefs feature in Cardigan Bay SAC has been assessed as being in **unfavourable** condition (low confidence). There were two failing targets, which were both related to water quality in specific parts of the SAC (Table 12). There were no failures of primary targets. There were limited or no data available for several key indicators to inform on the condition of the feature, especially for subtidal reefs (see eevidence gaps section 5). This has contributed to the reduced confidence in the overall conclusion to low. 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 nutrients failure was localised, it has been mapped to help focus management effort (Figure 13). A summary of the assessment can be seen in Table 12 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 12. Summary of the condition assessment for reefs in Cardigan Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Cardigan Bay	**Unfavourable (low confidence)**	Water quality: nutrients (DIN only) (S) Water quality: contaminants (S)	• High nutrient levels have been recorded in the Teifi Estuary waterbody. This failure is relevant to intertidal reefs only. • Levels of mercury and PBDE in the Cardigan Bay Central waterbody are failing to meet their relevant EQSs.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Figure 13. Map of the localised failure in the intertidal reefs in Cardigan Bay SAC.



Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Cardigan Bay SAC passed their targets as there are currently no known anthropogenic impacts that would negatively affect the reefs feature. This applies to both intertidal and subtidal reefs. 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.

Sediment and Topography

The sediment quality indicators are relevant to subtidal reefs only. There were no data available on sediment quality within the SAC therefore these indicators were not assessed.

The topography, bathymetry, hydrodynamic and sediment transport processes are not well researched for reefs. 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 intertidal and subtidal reefs. Photo monitoring at New Quay confirms no excessive shell fishery waste in the intertidal.

Water quality

It has been estimated that approximately 79% of intertidal reefs and 25% of subtidal reefs within the SAC falls within three WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Cardigan Central waterbody overlaps with a large proportion of intertidal and subtidal reefs in the SAC (Table 13). The Cardigan Bay South and Teifi Estuary waterbodies overlap with a smaller proportion of intertidal and subtidal reefs (Table 13).

Table 13. WFD waterbodies that overlap with intertidal and subtidal reefs within the Cardigan Bay SAC.

WFD waterbody	Degree of overlap with intertidal reefs (%)	Degree of overlap with subtidal reefs (%)
Cardigan Bay Central	56.10	17.40
Cardigan Bay South	13.60	6.70
Teifi Estuary	8.70	1.00
All waterbodies combined	78.4	25.1

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target for intertidal reefs as one of the overlapping WFD waterbodies, the Teifi Estuary, was classified as Poor status for the DIN element in the 2024 cycle 3 interim classification. The Teifi Estuary WFD investigation report confirms the continued failure in DIN (Jopson, Newman and Moore, 2025). This waterbody overlaps with a small proportion of intertidal reefs (Table 13), therefore the confidence in the fail was

low. This waterbody overlaps with a very small proportion of subtidal reefs (Table 13), therefore this indicator did not fail for subtidal reefs, but confidence in the pass was low. The other two WFD waterbodies (Cardigan Bay Central and Cardigan Bay South), were classified with a High status for DIN.

The phytoplankton indicator met its target as two WFD waterbodies which combined overlap with 65% of intertidal reefs and 18% of subtidal reefs, were classified with a High status for this element in the 2024 cycle 3 interim classification. The classification for one of these waterbodies, the Teifi Estuary waterbody, was rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 9% of intertidal reefs and 1% of subtidal reefs. The WFD investigation report for this waterbody states that the phytoplankton WFD element for the 2018 cycle 2 interim and 2021 cycle 3classifications were not a true representation of the phytoplankton in the Teifi Estuary waterbody, but were instead more representative of the Cardigan Bay South waterbody (Jopson, Newman and Moore, 2025). The confidence in the pass was reduced to low for intertidal reefs to reflect this, and because one WFD waterbody was not classified for this element. For subtidal reefs, confidence is medium due to the unclassified waterbody. Classification of 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 met the target as one of the three overlapping WFD waterbodies, the Teifi Estuary, was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification. This waterbody overlaps with 9% of intertidal reefs. The confidence of this classification was uncertain due to outdated available intertidal habitat layers (Jopson, Newman and Moore, 2025). It was therefore concluded that it is possible that a biological response of high nutrient levels has occurred as a result of excess DIN, but it has not been identified through the classification (Jopson, Newman and Moore, 2025). This reduced the confidence in the pass. The other two WFD waterbodies were not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. 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). The confidence is low as a large proportion of intertidal reefs are in unclassified waterbodies, and due to the uncertainty in the Teifi Estuary waterbody classification. This indicator is not relevant to subtidal reefs.

Dissolved oxygen

The dissolved oxygen indicator also met its target as all of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence in the pass was reduced to medium because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in section 3.1).

Contaminants

The Cardigan Bay Central waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where mercury and PBDE failed. This waterbody overlaps with the largest proportion of both intertidal and subtidal reefs. This caused the contaminants indicator to fail in both intertidal and subtidal reefs. 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 reefs are not fully understood.

One WFD waterbody was not classified as the chemicals have not been assessed within the last six years. One WFD waterbody has a pass for chemicals, however the chemical classifications were rolled forward from the 2018 cycle 2 interim classification. Combined, these waterbodies overlap with 22% of intertidal reefs and 8% of subtidal reefs. 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 the unclassified waterbody and rolled forward classification. 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. The physicochemical indicator could not be assessed due to a lack of data.

Species and communities

All species and communities indicators could not be assessed for subtidal reefs in the SAC as there is an absence of data.

Assessment of the species community indicators for intertidal reefs in Cardigan Bay SAC used data from various monitoring sites. This includes monitoring of the rockpools at Aberporth and Cei Bach, the *S. alveolata* reefs at Aberporth and Cei Bach and the turf algae communities at Aberporth from 2007 to 2022.

Species composition analysis indicated that communities associated with rockpools at Aberporth and Cei Bach varied across the monitoring period in a cyclical manner. Rockpool species are known to fluctuate, and since there are no anthropogenic activities known to date that could impact the reef, the variations observed were deemed to be natural. Analysis also showed that whilst communities associated with turf algae at Aberporth were extremely variable, this was considered within the bounds of natural variation.

The cover of *S. alveolata* has fluctuated substantially across the monitoring period, with a noticeable low percentage cover in 2022 (Moore, 2022b). The cover of live *S. alveolata* has been relatively low since 2017 especially at Cei Bach site, however this reestablished in 2023 and 2024. *S. alveolata* cover tends to fluctuate greatly at these sites, with no known reason for the intermittent decline. The distribution of *S. alveolata* reef was assessed by using extent information measured by GPS tracking along the *S. alveolata* reef edge. There was evidence of small changes across the monitoring period with no apparent trend (Moore, 2022b). A gradual progressive change over the course of the monitoring programme was observed for the *S. alveolata* reef communities at Aberaeron and Cei Bach sites and this appeared to be due to small changes in multiple species. These notable changes and trends are considered natural (Moore, 2022b). There was a notable increase in the abundance of green algae (primarily *Ulva spp.*) since 2011 at Cei

Bach site (Moore, 2022b). *Ulva* spp. have the capacity to rapidly expand and can smother the reefs.

Mytilus edulis abundance was recorded at one location at the Aberporth rockpools between 2007 and 2022. *M. edulis* abundance varied through time, with an increase in abundance to up to 50% cover in 2022 in some places following a low percentage cover observed in 2021 (Moore, 2022c; P. Brazier, pers. comm). Such variations are often observed in *M. edulis* and form part of a natural cycle where fast recovery are often observed after storm events (P. Brazier, pers. comm). The abundance of *F. serratus* has been recorded in Aberporth rockpools and in *S. alveolata* reefs at Cei Bach and Aberaeron sites between 2017 and 2019. *F. serratus* increased in 2017, and by 2019 was abundant in lower platform rockpools in Aberporth (Moore, 2022c). Similarly, abundance of *F. serratus* has increased at Cei Bach *S. alveolata* reef since 2015, with an increase to more than a third of quadrats (Moore, 2022b).

Overall, the abundance, distribution and species composition of communities indicator met its target. The occurrence of green algae on Cei Bach *S. alveolata* reef was not deemed to be a large enough impact to fail the target, however it reduced the confidence in the assessment to medium, and will be something to pay close attention to in the next assessment.

The average number of taxa per rockpool has fluctuated with, an overall increasing trend, especially in total number of taxa, which is possibly linked with surveyor skills improvement. There was, however, no clear temporal trend in species richness and diversity at Aberporth and Cei Bach rockpools. Similarly, no clear temporal trend was detected in species richness and diversity for the turf algae sites and *S. alveolata* reef communities. Some increase in the average number of taxa at the *S. alveolata* reef community in Aberaeron was detected but not at Cei Bach site, which is known to be less stable. In addition, the wide-scale survey on *S. alveolata* reefs did not reveal any concerns or highlight any known anthropogenic impacts. The lack of a clear temporal trend and the natural fluctuations observed in species richness and diversity resulted in the target indicator to pass with high confidence.

Invasive non-native species

There have been no new records of NNS in the reefs feature in Cardigan Bay SAC within the last six years. This resulted in a pass for the tertiary target of the NNS indicator. The confidence was reduced to low as there have not been any targeted surveys for INNS within the SAC.

There were two records of *C. fornicata* in 2021 and 2023 from this general area, however, neither were inside the SAC boundary. A small number of records of *S. muticum* have been previously identified within the SAC. The spread and extent of the impacts this species may have on the condition of the reef feature is currently unknown, however there is limited evidence that this NNS is adversely impacting the condition of the feature yet. 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 NNS present within the feature are not well understood.

Reasons for target failure

The assessment of the reefs feature in the Cardigan Bay SAC failed two secondary targets. This resulted in the feature to be assessed as being in **unfavourable** condition. The failures are linked with water quality only, and are limited to the Teifi Estuary waterbody for nutrients, and the coastal Cardigan Bay Central waterbody for contaminants. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

This indicator target has a secondary weighting. High levels of DIN have been recorded in the Teifi Estuary waterbody, which was classified as Poor status for the DIN element in the 2024 cycle 3 interim classification. As this waterbody overlaps with 9% of intertidal reefs, this caused the indicator to fail. Management should be focused on the Teifi Estuary waterbody for this feature. It did not lead to a failure for subtidal reefs due to the small spatial overlap (1%). The WFD investigation report in this waterbody confirms the DIN failure (Jopson, Newman and Moore, 2025). In this report, the likely sources of the nutrients were identified from source apportionment. It found that major input of nutrients is likely to be derived from diffuse sources associated with agriculture and rural land management in the River Teifi catchment (Jopson, 2022; Jopson, Newman and Moore, 2025). Point source continuous and intermittent sewage discharge from the water industry is also likely to be a minor source of nutrients linked to the DIN failure (Jopson, 2022; Jopson, Newman and Moore, 2025). This is a localised issue that is not causing an impact on the rest of the reefs feature.

There has been no biological failure in the phytoplankton or opportunistic macroalgae elements in the Teifi Estuary waterbody. However, due to the issues with the phytoplankton and opportunistic macroalgae classifications (see further detail in water quality section), it is possible that a biological response of high nutrient levels has occurred as a result of excess DIN but it has not been identified through the classification (Jopson, Newman and Moore, 2025).

Water quality: contaminants

This indicator target has a secondary weighting. The Cardigan Bay Central waterbody failed due to mercury and PBDE. 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).

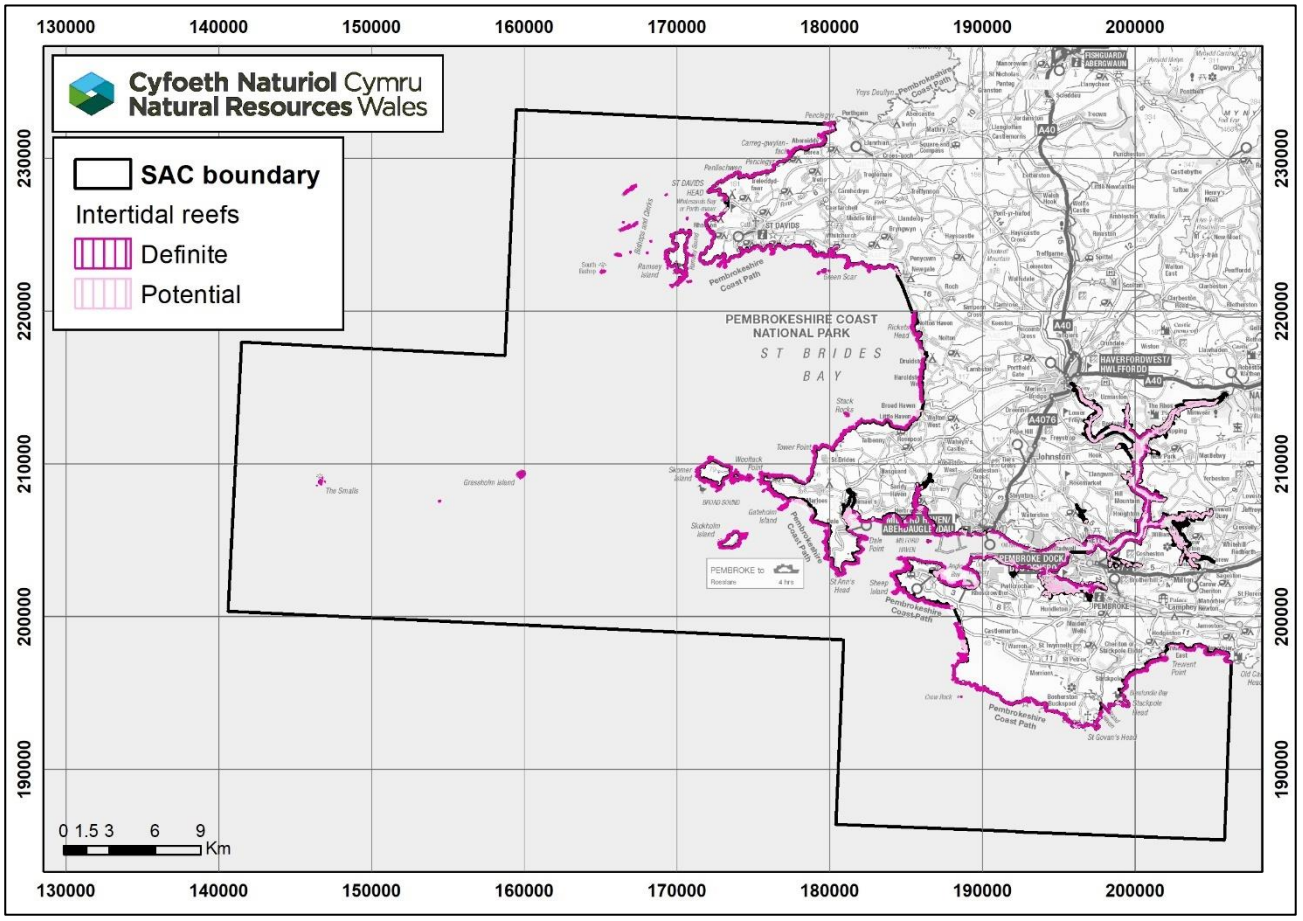
The contaminants in the water column may be derived from diffuse sources from contaminated waterbody bed sediments; or point sources from continuous sewage discharge from wastewater treatment. However, a WFD investigation of the failure in the Cardigan Bay Central waterbody is yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

3.4. Pembrokeshire Marine SAC

Intertidal reefs

The reefs feature in the Pembrokeshire Marine SAC comprises of a number of intertidal reefs (Figure 14). The NRW Habitats Regulations monitoring of intertidal reefs has focused on the rocky shore communities within Milford Haven Waterway (Lawrenny Quay, Pembroke Ferry, Hazelbeach, South Hook, Monk Haven and West Angle Bay) and the open coast (Nolton Haven), and rockpool communities at Pen y Holt. These locations were surveyed between 2007 and 2022 using quadrat sampling, scrapes and fixed rockpools. There are additional monitored sites at the Skomer Marine Conservation Zone (MCZ) for intertidal reef communities.

Figure 14. Map of the intertidal reefs in Pembrokeshire Marine SAC.



The summary of the assessment outcome for intertidal reefs is provided in Table 14. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 14. Condition assessment of intertidal reefs in Pembrokeshire Marine 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of intertidal reefs in the Pembrokeshire Marine 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 intertidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of intertidal reefs in the Pembrokeshire Marine SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 Pembrokeshire Marine 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

Indicators	Target	Assessment rationale	Target assessment	Target confidence
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
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

Indicators	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. (S)	• Two of the six WFD waterbodies that overlap with 36% of intertidal reefs were classified as High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South).
		• One WFD waterbody has not been classified for DIN in any cycles (Grassholm Islands and the Smalls), but overlaps with less than 1% of intertidal reefs.
		• The other three WFD waterbodies were classified with a Poor or Bad status for DIN (Milford Haven Inner, Milford Haven Outer and Solfach Estuary).
		  ○ The Milford Haven Inner and Outer waterbodies were classified with a Poor status. They overlap with 19% and 15% of intertidal reefs respectively.
		  ○ The Solfach Estuary waterbody was classified with a Bad status. It overlaps with <1% of intertidal reefs. This waterbody was not considered further due to small overlap with the intertidal reefs.
		• Confidence in the fail is high due to the significant DIN issues in two of the relevant waterbodies.
			Fail	High

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)	• Three of the six WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay South, Grassholm Islands and the Smalls, and Solfach Estuary). Combined, these waterbodies overlap with 4% of intertidal reefs. • The other three WFD waterbodies were classified with a High status for phytoplankton (Pembrokeshire South and Milford Haven Inner and Outer). Combined, these overlap with 67% of intertidal reefs. • Confidence is high as the majority of the overlapping waterbodies have a High status classification for the phytoplankton element.	**Pass**	High
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 six WFD waterbodies were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Pembrokeshire South, Cardigan Bay South, Grassholm Islands and the Smalls, and Solfach Estuary). Combined, these overlap with 37% of intertidal reefs. • One WFD waterbody was classified with a Good status for this WFD element (Milford Haven Outer). It overlaps with 15% of intertidal reefs. There has been localised growth of opportunistic macroalgae recorded in some of the bays and inlets of the waterbody. • The other WFD waterbody was classified with a Moderate status for opportunistic macroalgae (Milford Haven Inner). This waterbody overlaps with 19% of intertidal reefs. • Confidence is high due to the significant opportunistic issues in the Milford Haven Inner waterbody.	**Fail**	High

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)	• One of the six WFD waterbodies that overlaps with intertidal reefs was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Grassholm Islands and the Smalls). However, it overlaps with less than 1% of intertidal reefs. • The other five WFD waterbodies were classified with a High status for dissolved oxygen. • Confidence is medium due to samples being taken from the surface of the waterbody.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the six WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Pembrokeshire South, Cardigan Bay South, Grassholm Island and the Smalls, and Solfach Estuary). Combined, these waterbodies overlap with 37% of intertidal reefs. • One WFD waterbody has a pass for chemicals, however some of the chemical classifications were rolled forward from the 2021 cycle 3 classification (Milford Haven Outer). This waterbody overlaps with 15% of intertidal reefs. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Milford Haven Inner). This waterbody failed for PBDE and PAH and overlaps with 19% of intertidal reefs. • Confidence is low as the human health standard has been used for PBDE, and due to unclassified waterbodies or rolled forward classifications.	**Fail**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
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 Pembrokeshire Marine 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 intertidal monitoring sites at various shore heights for temperature (12 loggers in total) and seven subtidal temperature loggers were available. Some temperature loggers in the SAC showed an increase in the number of days with higher temperatures, and potential step change in temperature. • Pembroke Power Station report indicated a localised increase in temperature, which was deemed unlikely to be of wider ecological significance. • 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 rocky shore communities up to 2019 in Milford Haven Waterway and open coast monitoring sites indicate that the nature of the communities has remained stable over time. There have been fluctuations in abundance of some species at some sites but most of these were considered to be natural.
		  ○ There has been a decline of *Ascophyllum nodosum* at Lawrenny Quay and Pembroke Power Station in Milford Haven Waterway. This is a concern but the causes are unknown.
		  ○ There has been an increase in abundance of *Ulva spp.* at two sites.
		• Analysis of the Pen-y-Holt rockpools data up to 2020 concluded that the communities of the pools have remained stable over time.
		• Data from algal scrapes within the SAC shows changes in composition and abundance which are considered to be natural.
		• Skomer shore quadrat data shows that communities at the different sites are stable over the time period (2004 – 2023), and in a condition typical of the area.
		• Confidence is low due to the concerns raised about the decline of *A. nodosum* and increase in *Ulva spp.* at some sites, and because it is difficult to determine trends in the algal scrapes data as there is lots of variability.
			Pass	Low

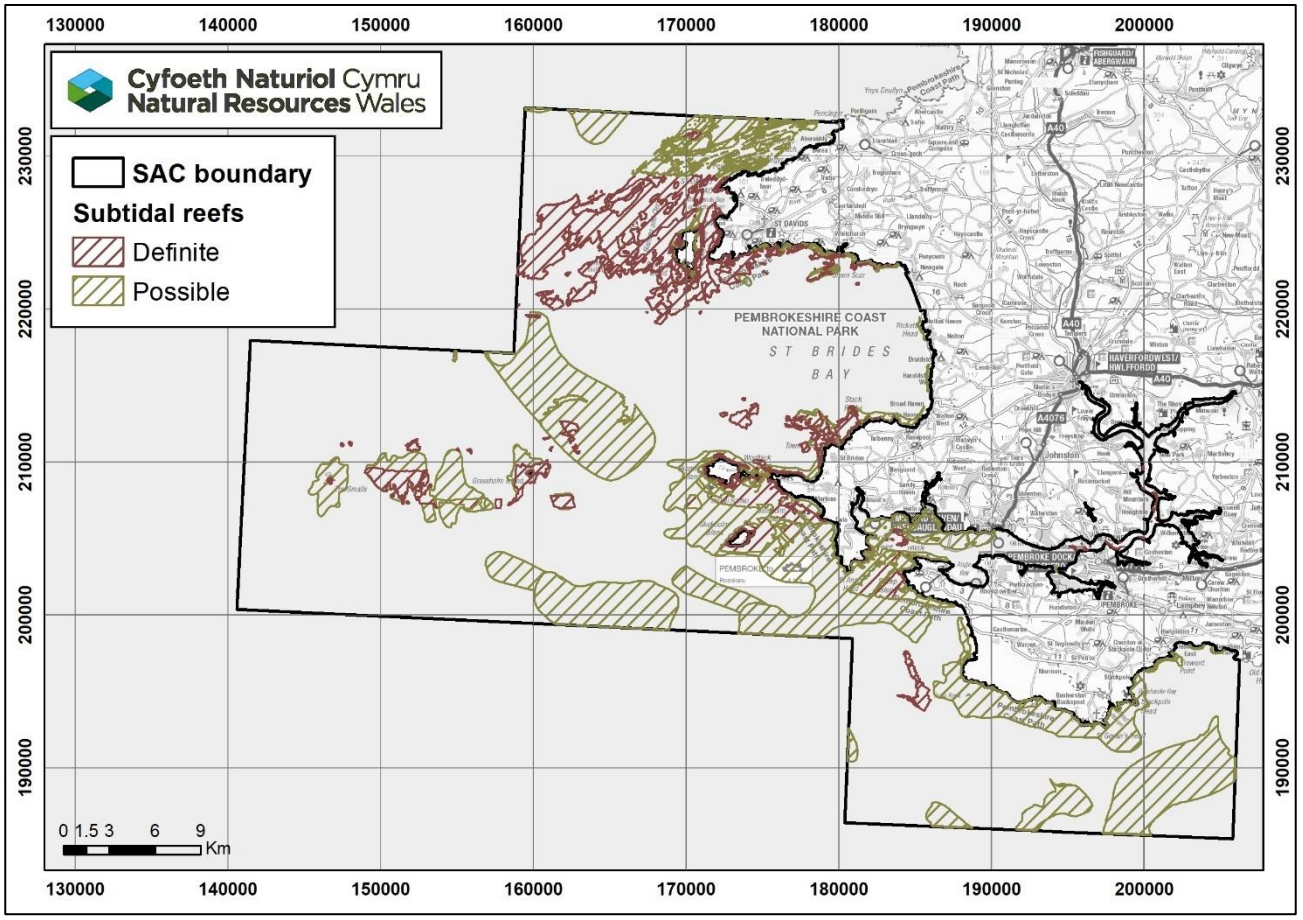
Indicators	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• The recorded changes in species richness and population abundance from the analysis of the rocky shore communities data were considered to be natural at all monitoring sites. • There were limited data on species richness and diversity for the rockpool communities but they were generally found to remain stable. • Data from algal scrapes within the SAC shows changes in species richness which are considered to be natural. • There was no clear discernible trend in species richness or diversity between 2003 and 2023 across all intertidal stations at Skomer Marine Conservation Zone (MCZ). • Confidence is medium due to the limited data specifically on species richness and diversity in the available reports.	**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. the carpet sea squirt *Didemnum vexillum*) are currently impacting the condition of 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

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• The carpet sea squirt *Didemnum vexillum* has been recorded at Carr Rocks and on Barnlake Point (Neyland) for the first time, just within the reef feature boundary in 2023. The impact of this species on the reefs feature at this location is not known. • Other NNS have been recorded previously in the SAC within the reefs feature including: brown kelp Wakame *Undaria pinnatifida,* red ripple bryozoan *Watersipora subatra* and San Diego sea squirt *Botrylloides diegensis.* • There have been targeted INNS surveys at intertidal reef sites as part of the MarClim project, 'Rapid Assessment Survey' of marinas 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 Pembrokeshire Marine SAC comprises of a number of subtidal reefs (Figure 15). The monitored subtidal reefs include five sites within Milford Haven Waterway (Beggars Reach, Warrior, Dockyard Bank, Thorn Island, Chapel Reef) and two sites outside the Haven (Junko's Reef and The Smalls). These sites were surveyed between 2007 and 2023 using quadrat sampling and a point-intercept transect for sponge luxuriance monitoring at Warrior. There are additional monitored sites at the Skomer MCZ for subtidal reef communities.

Figure 15. Map of the subtidal reefs in Pembrokeshire Marine SAC.



The summary of the assessment outcome for subtidal reefs is provided in Table 15. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 15. Condition assessment of subtidal reefs in Pembrokeshire Marine 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 natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of subtidal reefs in the Pembrokeshire Marine 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 subtidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of subtidal reefs in the Pembrokeshire Marine SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 subtidal reefs in the Pembrokeshire Marine 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
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (T)	• Polycyclic aromatic hydrocarbons (PAH) were recorded in the CSEMP location in 2023, with an average concentration of one PAH compound being above the most stringent guideline. PAHs were also recorded at one of the NRW monitored grab sample locations in the Milford Haven Waterway in 2021, with the concentrations of three PAHs being above the most stringent ecological guidelines. Other PAH concentrations were above the less stringent guidelines in both CSEMP and NRW grab sampling locations. • The average concentration of chromium at the two NRW monitored Skomer MCZ locations was above the most stringent ecological guideline in the most recent sampling years, and has been increasing over time. Lead was also at or above the higher guideline in recent years. Other heavy metals were above the less stringent guidelines in all CSEMP, and NRW monitored Skomer MCZ and grab sampling locations in recent years. • Confidence is medium as the impact of the contaminants to the reefs feature is not fully understood.	**Fail**	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 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
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
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 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

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)	• Two of the five WFD waterbodies that overlap with the subtidal reefs were classified with a High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 40% of subtidal reefs.
		  ○ The Pembrokeshire South waterbody classification was rolled forward from the 2018 cycle 2 interim classification.
		• One WFD waterbody was not classified for DIN as earlier risk assessments deemed it unlikely to be impacted by nutrients as it is far from the coast (Grassholm Islands and the Smalls). This waterbody overlaps with 6% of subtidal reefs.
		• The other two WFD waterbodies were classified with a Poor status for DIN (Milford Haven Outer and Milford Haven Inner). These overlap with 4% and 0.05% of the feature. The Milford Haven Inner waterbody was not considered further in the assessment due to small spatial overlap.
		  ○ Subtidal reefs in estuarine environments are not common in the UK. Milford Haven Waterway has been flagged as one of the important examples of this, therefore the value of that habitat in the Milford Haven Outer waterbody is high.
		• Confidence is low because a small proportion of subtidal reefs overlap with the failing waterbodies.
			Fail	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. (S)	• Two of the five WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Grassholm Islands and the Smalls and Cardigan Bay South). Combined, these waterbodies overlap with 7% of subtidal reefs. • The other three WFD waterbodies were classified with a High status for the phytoplankton WFD element (Pembrokeshire South, Milford Haven Inner and Milford Haven Outer). Combined, these overlap with 43% of subtidal reefs. • Confidence is high as the majority of the overlapping waterbodies have a High status classification. As the subtidal reefs that are not overlapped by WFD waterbodies are further offshore, these are less likely to be impacted by water quality issues derived from land.	**Pass**	High
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 five WFD waterbodies that overlaps with subtidal reefs was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Grassholm Islands and the Smalls). This waterbody overlaps with 6% of subtidal reefs. • The other four WFD waterbodies were classified with a High status for dissolved oxygen. • 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)	• Three of the five WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Pembrokeshire South, Cardigan Bay South, and Grassholm Island and the Smalls). Combined, these waterbodies overlap with 46% of subtidal reefs. • One WFD waterbody has a pass for chemicals, however some of the chemical classifications were rolled forward from the 2021 cycle 3 classification (Milford Haven Outer). This waterbody overlaps with 4% of subtidal reefs. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Milford Haven Inner). This waterbody failed for PBDE and PAH and overlaps with 0.05% of subtidal reefs. • Subtidal reefs in estuarine environments are not common in the UK. Milford Haven Waterway has been flagged as one of the important examples of this therefore the value of that habitat is high. • Confidence is low because there is a failure in one of the Milford Haven waterbodies, and due to the unclassified waterbodies.	**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 reefs feature in the Pembrokeshire Marine SAC, therefore this target was 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 intertidal monitoring sites at various shore heights for temperature (12 loggers in total) and seven subtidal temperature loggers were available. Some temperature loggers in the SAC showed an increase in the number of days with higher temperatures, and potential step change in temperature. • Pembroke Power Station report indicated a localised increase in temperature, which was deemed unlikely to be of wider ecological significance. • 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)	Data from seven monitored subtidal reef sites were used (inside and outside of the Milford Haven Waterway) • The community composition at three of these sites fluctuated within the bounds of natural variation. • At two sites in the upper and middle section of Milford Haven Waterway (Beggars Reach and Warrior), a change in community composition was apparent. This may be indicative of anthropogenic impact. • At one of these sites (Warrior), there was also a 50% decrease in the thickness of cushion and crustose sponges, and a small decrease in the height and circumference of *Haliclona oculata*. Monitoring data from subtidal reef sites within the Skomer MCZ were also used. • The frequency of the yellow cluster anemone *Parazoanthus axinellae* and cup coral (*Balanophyllia regia* and *Caryophyllia smithii*) has shown fluctuations year to year at all sites, but overall showed a stable population. • There has been an increase in total number of the ross bryozoan *Pentapora foliacea* colonies recorded between 2019 and 2021 with a slight drop in numbers observed in 2022. • Records of the red sea fingers *Alcyonium glomeratum* colony are in decline at all sites except one. • There have been large losses of the pink sea fan *Eunicella verrucosa*, with no new recruitment recorded. • Confidence is high due to the significant declines in some species.	**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)	• The recorded changes in species richness and abundance from the analysis of the subtidal reef communities data were considered to be natural at all monitoring sites. • Confidence is medium in part due to the time-limited nature of the sampling method.	**Pass**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of reef species, allowing for natural change and variation. (S)	• Overall, the average taxonomic distinctness of the monitored subtidal reefs remains stable and within the expected values over the monitoring period. • Confidence is medium 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. *Didemnum vexillum*) 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 well 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)	• The carpet sea squirt *Didemnum vexillum* has been recorded at Carr Rocks and on Barnlake Point (Neyland) for the first time, just within the reef feature boundary in 2023. The impact of this species on the reefs feature at this location is not known. • Other NNS have been recorded previously in the SAC within the reefs feature including: brown kelp Wakame *Undaria pinnatifida,* red ripple bryozoan *Watersipora subatra* and San Diego sea squirt *Botrylloides diegensis.* • There have been targeted INNS surveys at intertidal reef sites as part of the MarClim project, 'Rapid Assessment Survey' of marinas 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 Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of failing targets (Table 16). 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 16 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 16. Summary of the condition assessment for reefs in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Pembrokeshire Marine	**Unfavourable (medium confidence)**	Abundance, distribution and species composition of communities (P) Water quality: nutrients (DIN only) (S) Water quality: opportunistic macroalgae (S) Water quality: contaminants (S) Sediment quality: contaminants (T) Non-native species (T)	• Disturbance in reef communities was observed at two sites within Milford Haven Waterway. Sponges at the Warrior subtidal reef site are in decline. *E. verrucosa* have been declining at the Skomer subtidal reef sites. This affects the abundance, recruitment, and distribution. There has been a declining trend in the *A. glomeratum* colony frequency at most subtidal reef sites at Skomer. • There are high nutrient levels in the Milford Haven Inner and Outer waterbodies. Opportunistic macroalgae is an issue in the Milford Haven Inner waterbody. • Levels of metals, PAHs and PCBs were above the sediment guidelines in Skomer and Milford Haven monitoring sites. Levels of PBDE and PAH in the water column in Milford Haven Inner waterbody are failing to meet their relevant EQSs. • There has been an increase in the number of NNS in the feature, including *C. fornicata* and *D. vexillum.*	• Unconsented infrastructure • Recreational access and collection • Sea bed disturbance • Nutrient and temperature increases • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Pembrokeshire Marine SAC passed their targets as there are currently no known anthropogenic impacts on the reefs feature that would negatively affect the reefs feature. This applies to both intertidal and subtidal reefs. 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. Additionally, new unconsented infrastructures in the Pembrokeshire Marine SAC could pose a threat to the feature.

Sediment and Topography

The assessment of the sediment quality (contaminants) indicator is relevant to subtidal reefs only. The assessment used data from NRW monitored sediment contaminants as part of the CSEMP sampling in one location in Milford Haven Waterway in various years up to 2023. This location is considered to be representative of the Milford Haven Waterway as it is upstream of the main industrial areas. Two NRW monitoring stations at Skomer MCZ were also used (2013-2022), as well as additional sediment grab sampling in Milford Haven Waterway (2007, 2012, 2018 and 2021). In total, there were 25 sampling locations close to or overlapping with the reefs feature which were considered for the assessment of this indicator.

Historically, there have been various peaks in hydrocarbons and metals in sediments in the Milford Haven Waterway, including as a result of the Sea Empress spill in 1996 (Little, 2017). Sediment contaminant levels have also been moderately high through periods of dredging or construction in the later 2000s (up to 2014) (Little, 2017; Warwick, 2017; Warwick et al., in prep).

There are no defined ecological standards for chemical contaminants within marine sediments agreed within the UK. The concentrations of chemical contaminants were therefore compared against various ecological quality guidelines available including Oslo and Paris Conventions (OSPAR) guidelines, Canadian Environment Quality Guidelines (CEQG) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) action levels. Further information is available in the IMCA final report.

Levels of polycyclic aromatic hydrocarbon (PAH) compounds were recorded at the CSEMP location. Here, the average concentration of Benzo(g,h,i)perylene was above the most stringent ecological guideline (OSPAR effects range low) in all years including 2023. The concentration of this PAH has not changed substantially since earlier years. There were significant spikes in various PAH concentrations in 2008 and 2011 at the CSEMP site. These peaks are likely due to an increase in dredging activities (Little, 2017; Warwick, 2017). Following these years the concentrations returned to levels similar to those seen before 2008 (NRW unpublished data). PAHs were also recorded at one of the grab sampling locations in the Haven (Pembroke River Upper) in 2021, where concentrations of three of the sampled PAH compounds were above their most stringent ecological guidelines (OSPAR effects range low). Various other PAH concentrations were above the

less stringent ecological guidelines (CEQG threshold effect levels) in both the CSEMP and grab sampling locations in the most recent years. PAHs were not assessed in the Skomer MCZ samples.

Heavy metal concentrations were also recorded at various locations. At the two Skomer MCZ sediment trap locations the average concentration of chromium was above the most stringent ecological guideline (CEQG probable effects level) in 2018 to 2022 and has been increasing over time to reach a peak in 2022. At these locations lead was also at or above the most stringent guideline (OSPAR effects range low) in 2021 and 2022. Other heavy metals (including arsenic, copper, mercury and zinc) were above the less stringent ecological guidelines in Skomer, CSEMP or grab sampling locations in recent years. There are no OSPAR or CEQG sediment quality guidelines for Tributyltin (TBT) however the average concentration of TBT at the CSEMP location has been above its most stringent ecological guideline (Cefas action level 2) in all years up to 2023.

The sediment quality (contaminants) indicator failed to meet the target due to levels exceeding sediment quality guidelines in various contaminants. The impact of the contaminants to the reefs feature is not fully understood. These issues have reduced the confidence in the fail to medium.

The topography, bathymetry, hydrodynamic and sediment transport processes are not well researched for reefs. 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 intertidal and subtidal reefs.

Water quality

It has been estimated that approximately 71% of intertidal reefs and 50% of subtidal reefs within the SAC falls within six WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature.

The Pembrokeshire South waterbody overlaps with the largest proportion of intertidal and subtidal reefs in the SAC (Table 17). For intertidal reefs, the Milford Haven Inner and Outer waterbodies overlap with a smaller but significant proportion, and the Cardigan Bay South waterbody overlaps with a small proportion (Table 17). The Grassholm Island and The Smalls, and Solfach Estuary waterbodies overlap with a very small proportion of intertidal reefs and have therefore not been considered further in the condition assessment (Table 17). For subtidal reefs, the Milford Haven Outer, Grassholm Island and The Smalls, and Cardigan Bay South waterbodies overlap with a smaller proportion (Table 17). The other WFD waterbody that overlaps with subtidal reefs, Milford Haven Inner, overlaps with a very small proportion of subtidal reefs and has therefore not been considered further in the condition assessment (Table 17).

Table 17. WFD waterbodies that overlap with intertidal and subtidal reefs within the Pembrokeshire Marine SAC.

WFD waterbody	Degree of overlap with intertidal reefs (%)	Degree of overlap with subtidal reefs (%)
Pembrokeshire South	32.26	39.19
Milford Haven Inner	19.43	0.05
Milford Haven Outer	14.85	4.12
Cardigan Bay South	3.64	1.06
Grassholm Island and The Smalls	0.45	5.96
Solfach Estuary	0.34	0.00
All waterbodies combined	70.97	50.38

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target as failing levels of DIN have been recorded in three of the six WFD waterbodies that overlap with the reefs feature in the SAC. Combined, these waterbodies overlap with 35% of intertidal reefs and 4% of subtidal reefs within the SAC. The Milford Haven Inner and Outer waterbodies overlap with the largest proportion of the feature and were classified as Poor status in the 2024 cycle 3 interim classification. These waterbodies also failed in previous cycles, and the Milford Haven Outer waterbody has deteriorated from Moderate status in the 2021 cycle 3 classification. As subtidal reefs in estuarine environments are not common in the UK, the Milford Haven estuary is one of the important examples of this type of habitat, therefore the value of these reefs is high. The WFD investigation reports of these waterbodies confirmed the DIN failures in the 2018 cycle 2 and 2021 cycle 3 classifications (Lock, 2021a; Lock, 2021b). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations. High confidence has been attributed to the failure of the nutrients indicator for intertidal reefs as the failing waterbodies overlap with a substantial proportion of the feature, and as the investigations have confirmed the nutrient issues in these waterbodies, with the addition of a biological element failure related to nutrients (opportunistic macroalgae) in Milford Haven Inner waterbody. Confidence in the failure was reduced to low for subtidal reefs because a small proportion of the feature overlaps with the failing waterbodies, and two of the failing waterbodies were not considered further in the condition assessment for subtidal reefs due to the small spatial overlap or do not overlap with any of the subtidal reefs.

The opportunistic macroalgae indicator failed to meet the target for intertidal reefs due to the Moderate status classification for this element in the Milford Haven Inner waterbody in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure (Lock, 2021a). A high confidence was attributed to this indicator, as although the failing waterbody overlaps with less than 20% of intertidal reefs, the evidence of the opportunistic macroalgae issues in the Milford Haven Inner waterbody is substantial. Milford Haven Outer waterbody was classified with a Good status in the 2024 cycle 3 interim classification. Although the opportunistic macroalgae is not a failing element for this waterbody, there have been localised issues recorded in the more sheltered bays and inlets including Angle Bay, Sandy Haven and Dale Gann (Figure 16) (Lock, 2021b). The other four WFD waterbodies were not classified for this element in any cycles. 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.

The phytoplankton indicator passed the target as the three WFD waterbodies that overlap with a large proportion of the feature (Milford Haven Inner, Milford Haven Outer and Pembrokeshire South) were classified with a High status for the phytoplankton element in 2024 cycle 3 interim classification. The other overlapping WFD waterbodies were not classified for this element, but they overlap with a small proportion of the reefs feature (Table 17). Classification of 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 confidence in the pass is high as the majority of the overlapping waterbodies have a High status classification for the phytoplankton element. In addition, the subtidal reefs that are not overlapped by WFD waterbodies are located further offshore and are therefore less likely to be impacted by water quality issues derived from the land.

Figure 16. Opportunistic macroalgae on reefs in Sandy Haven in 2008, Milford Haven Waterway.

© NRW monitoring.

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 in the pass was reduced to medium because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in section 3.1).

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. This waterbody overlaps with a substantial proportion of intertidal reefs but a small proportion of subtidal reefs (Table 17). PBDE has

failed in this waterbody in all previous cycles. 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. The Milford Haven Outer waterbody failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals in the 2024 cycle 3 classification, however TBT, which was previously a failing chemical, is no longer assessed. In addition, mercury was not classified in the 2024 cycle 3 interim classification. Four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years.

The failure of the Milford Haven Inner waterbody caused the contaminants indicator to fail for intertidal reefs but not subtidal reefs. Subtidal reefs in estuarine environments are not common in the UK. Milford Haven Waterway has been flagged as one of the important examples of this therefore the value of that habitat is high. For subtidal reefs, the confidence in the pass is low because of the failure in the Milford Haven Inner waterbody, and because of the unclassified waterbodies. For intertidal reefs, confidence in the fail was low as the human health standard has been used for PBDE, and due to the unclassified waterbodies. 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 seven NRW monitored subtidal temperature loggers and six NRW monitored intertidal monitoring sites at various shore heights (12 temperature loggers in total) within the SAC were available. All of the subtidal loggers overlap with subtidal reefs, and all of the intertidal loggers overlap with areas of intertidal reef. Some of the loggers showed an increase in the number of days with higher temperatures, and a potential step change in temperature. This is more apparent in the loggers within the Milford Haven Waterway. An external report (Sutton, 2023) found localised increase in temperature near the Pembroke Power Station. However, they concluded that this is unlikely to be of wider ecological significance. While localised, warming water can provide a safe haven for NNS, which could then spread further. This will be something to pay close attention to in the next assessment.

The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and as further evidence on the apparent temperature change is needed for a comprehensive assessment. In addition because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

Intertidal reefs

Assessment of the species and communities indicators for intertidal reefs in Pembrokeshire Marine SAC used data from various monitoring sites. This includes monitoring at rocky shore sites in Milford Haven Waterway (seven locations) and one open

coast site (Nolton Haven) in various years up to 2019, at one rockpool site at Pen y Holt in various years up to 2020, algal scrapes monitoring from 2007 to 2022 at 11 sites, and intertidal quadrat monitoring at Skomer MCZ from 2004 to 2023.

The recent intertidal rocky shore communities analyses at both the Milford Haven sites and the open coast site in Nolton Haven indicate that the nature of the communities, and recorded changes in species richness and population abundance have remained stable over time (Bunker, 2021). There have been fluctuations in the presence and absence of particular species including the blue mussel *M. edulis* at all sites in Milford Haven Waterway, but changes were considered to be natural. Similarly, recent NRW monitoring data indicated that overall the abundance of *F. serratus* at the two stations where it is abundant within the SAC was consistent with natural variations throughout the monitoring period. Additional data from the MarClim project revealed no clear patterns of change in the abundance of *F. serratus* at the sampling sites within the SAC (Mieszkowska and Sugden, 2023, 2024). There has been an increase in green algae (*Ulva spp.)* since 2015 at two of the monitoring locations that are in close proximity to the Pembroke Power station (Pembroke Ferry and Pembroke Power station). *Ulva spp.* have the capacity to rapidly expand and can smother reefs. This could be a potential concern as it may be linked to the warm outflow from the power station. There were also concerns noted at two of the Milford Haven sites (Lawrenny Quay and Pembroke Power station) due to the decline of the knotted wrack *Ascophyllum nodosum*, where the boundary of *A. nodosum* has retreated (Bunker, 2021). Limpets have been increasing at the stations where *A. nodosum* has declined. The decline may be related to many factors such as climate change and extreme weather, or localised boating or other anthropogenic activity, however the cause is not known and it is not currently possible to rule out that it may be natural. The decline of *A. nodosum* was not considered to be large enough to fail the target for the abundance, distribution and species composition of communities indicator for this SAC, however it has reduced the confidence in the pass to low in the assessment. Continuing monitoring is important to determine if this decline persist and the reasons behind it.

The data analysis for the intertidal rockpool communities at Pen y Holt concluded that the communities of the pools have remained stable over time. There were limited data on species richness and diversity for the rockpool communities but they were generally found to remain stable. Data on algal scrapes communities recorded changes in species richness, composition and abundance, but did not indicate any concerning trends, and appeared to reflect the expected level of natural variation. There is a high degree of variability in the algal scrapes data therefore it was difficult to determine any trends. The data from the Skomer MCZ shore quadrats also found that communities were stable over the monitoring period (2004 - 2023), and in a favourable condition typical of the area. There were no clear discernible trends in species richness or diversity between 2003 and 2023 across all intertidal stations at Skomer MCZ.

Overall, the abundance, distribution and species composition of communities, and species richness and diversity indicators for intertidal reefs met their target as communities were mostly stable with natural variation. Confidence is low due to the potential concerns about the *A. nodosum* decline and the observed increase in *Ulva spp.* at two stations in the rocky shore Milford Haven sites. It is also difficult to determine trends in the algal scrapes data as there is lots of variability. Confidence was also reduced to medium for the species richness and diversity indicator due to limited data on species richness and diversity in the available reports. The taxonomic distinctness indicator was not assessed due to lack of evidence.

Subtidal reefs

The subtidal reefs assessment included data from five sites within the Milford Haven Waterway and two open-coast sites outside the waterway: from the top of the Milford Haven Waterway to the mouth, these included: the tide-swept circalittoral communities at Beggars Reach, the tide-swept communities and tide-swept sponge communities at Warrior, the tide-swept circalittoral communities at Dockyard Bank, the infralittoral communities at Thorn Island, the circalittoral communities at Chapel Reef. Outside the Milford Haven Waterway, the open-coast sites included: the infralittoral and circalittoral communities at Junko's reef and the exposed circalittoral communities at the Smalls. These sites were surveyed between 2007 and 2023. Additionally, monitoring data from sites within the Skomer MCZ were also used, collected from 2004 to 2023.

The subtidal reef analysis of the sponge community at Warrior site showed some decline, with a 50% decrease in mean thickness of cushion and crustose sponge and small decrease in circumference and height for *H. oculata*. In addition, two out of five sites of the subtidal reef-associated communities showed a directional change over time, suggesting potential impact. A directional change in community composition often indicates that the sites have been or are affected by some factors that are not likely to be natural. These sites, Beggars Reach and Warrior, are located at the top of the Haven, and therefore are likely to be the first sites impacted by water quality issues caused by anthropogenic activities. More dispersion of water quality impacts is likely to happen further down the estuary due to dilution effects. While this is concerning, the species composition at the remaining monitored sites appeared to be within the normally recorded range of such fluctuations and was considered natural. The brown algae cover at Thorn Island site was noticeably lower in recent years. While no reason for this decrease was found, this will be something to pay close attention to in the next assessment. Further investigation is required to fully understand the cause of changes in species composition.

Data from the Skomer MCZ indicated that colony frequency of red sea fingers *Alcyonium glomeratum* declined at all sites except Junko's reef site, where it has disappeared from five out of seven sampling sites (Burton et al., 2024). North Wall East and Junko's reef are the only sites left with healthy colonies, however frequency of *A. glomeratum* is showing a decline at North Wall East. No new colonies of *A. glomeratum* have been found during monitoring dives, despite the habitats being suitable (Burton et al., 2024). This indicates a lack of *A. glomeratum* recruitment and raises uncertainty as to whether the observed declines are due to anthropogenic impact. A large number of losses of pink sea fan *Eunicella verrucosa* were also observed, and since 2000 recruitment remains very low (Burton et al., 2024). Several factors might be contributing to the decline of *E. verrucosa*, such as fishing activities, entanglement of bull huss egg cases and tissue necrosis, however, the cause remains unknown. Further data indicated an increase in total number of *Pentapora foliacea* colonies recorded between 2019 and 2021, with a slight drop in numbers observed in 2022. Whilst field and photographic observation provide evidence that fishing pots and angling line can damage *P. foliacea* colonies, there has been a higher number of intact and growing colonies compared to degraded ones (Burton et al., 2024). Potentially damaging anthropogenic activities still remain and this would be something to pay attention to in the future. Other populations of reef species including the yellow cluster anemone *Parazoanthus axinellae* and cup coral (*Balanophyllia regia* and *Caryophyllia smithii*) at the Skomer MCZ reefs were stable.

It is important to note that, historically, the native oyster was widely abundant across Welsh coastal waters. The native oyster population in Milford Haven Waterway declined steeply in the mid-late 1800s, most likely due to overfishing, coupled with the introduction of the oyster disease, *Bonamia* (caused by the parasite *Bonamia ostrea*) and poor recruitment (zu Ermgassen, 2017; 2022). Several surveys have been undertaken to gather evidence on the current status of native oyster in Milford Haven Waterway in 2002 (Emu ltd, 2003), 2011 (Pell, 2011), 2016-2017 (zu Ermgassen 2017; Lock, 2017) as well as a series of surveys conducted by Seasearch (Lock and Bullimore, 2018). Information obtained indicated low densities of native oysters and a patchy distribution at historical areas. Following up on this evidence, a native oyster restoration project (2022 - 2026), from the Natur Am Byth partnership, has been seeding over 40,000 oysters. This project will hopefully contribute towards boosting the natural population. As it is a historical decline, and there is a project planned to restore the oyster population, this has not been considered in the assessment of the abundance, distribution and species composition of communities indicator.

Overall, the abundance, distribution and species composition of communities indicator for subtidal reefs failed to meet its target with a high confidence as concerns have been raised in various subtidal reef sites within the Milford Haven Waterway and in Skomer MCZ.

The species richness and diversity at monitored subtidal reefs were observed to be variable. This is especially the case in the earlier monitoring years (prior to this reporting cycle), but recent data indicated no significant concerns and the pattern was considered to be natural at all monitored sites. For these reasons, the species richness and diversity indicator met its target but with medium confidence. Confidence was reduced due to the time-limited nature of subtidal monitoring methods. 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 abundance.

The average taxonomic distinctness of the monitored subtidal reefs generally remained stable and within the expected values over the monitoring period. There was a slight decrease in taxonomic distinctness at Beggars Reach site in recent years (2022 and 2023), however it was better than the values in previous years (e.g. 2008 and 2011), further supporting the findings of the species composition analysis. The taxonomic distinctness indicator was met as there were no concerning patterns. Confidence is medium, however, due to the time-limited nature of the sampling method.

Invasive non-native species

The carpet sea squirt *Didemnum vexillum* was recorded for the first time within the Milford Haven Waterway near to Neyland marina on boulder and cobble reefs at Carr Rocks and on Barnlake Point in 2023 and 2024 within the reefs feature. The impact of this species on the condition of the reefs feature is not known but could have a smothering effect in some areas (Figure 17). Therefore, the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the reefs feature within the last reporting cycle.

There has historically been a high number of NNS in the Milford Haven Waterway. Some of these species are known to be present within the reefs feature. These include the large

brown kelp wakame *Undaria pinnatifida* which has been recorded in the Milford Haven Waterway since 2014, and has been found attached to boulders for the first time on Skomer and Skokholm shores during the 2018 littoral surveys (Burton et al, 2024). First found in 2016, the red ripple bryozoan *Watersipora subatra* has been recorded in large areas in Dale at Jetty Beach in 2023 (Mieszkowska and Sugden, 2023). *W. subatra* is also known from South Hook and Pembroke Power station. Records of the San Diego sea squirt *Botrylloides diegensis* initially discovered in 2014 has also been found at Pembroke Power station, Pembroke Dock and Neyland (Wood et al., draft). The purple fan worm *Bispira polyoma* was recently found in 2021 on artificial rockpools installed on seawalls at Nelson Quay and Hakin Point Jetty (either side of the entrance to Milford Haven Marina). *C. fornicata* has been recorded in various locations within the SAC for many years and now reaches a high density in some areas. Other NNS recorded within the reefs feature recently include the siphoned Japan weed *Dasysiphonia japonica*, pom-pom weed *Caulacanthus ustulatus (okamurae),* trumpet tube worm *Ficopomatus enigmaticus*, colonial sea squirt *Botrylloides violaceus* and the red alga harpoon weed *Asparagopsis armata.*

It is not fully understood how some of these species may impact the condition of the reefs feature within the SAC, 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.

Figure 17. Carpet sea squirt *Didemnum vexillum* growing on seaweed at Neyland Spit, Milford Haven Waterway.

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Reasons for target failure

The assessment of the reefs feature in the Pembrokeshire Marine SAC failed one primary target, three secondary targets and two tertiary targets. 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.

Abundance, distribution and species composition of communities

This indicator failed to meet its primary target. There was a decline in sponges at Warrior site during the monitoring period. The mean thickness of cushion and crustose sponges has decreased more than 50% since 2005. A small decline in height and circumference was also detected for *H. oculata*. In addition, two out of five sites for the subtidal reef-associated communities showed a change over time, suggesting some disturbance. The reason for this decline is not known.

There was also a decline in abundance of the subtidal species *A. glomeratum* with recent lack of recruits at all monitoring sites at Skomer MCZ except Junko's reef site. In addition, there was a loss in number of the pink sea fan *E. verrucosa* and no new recruits since 2001. Possible damaging activities that could negatively impact pink sea fan in the Skomer MCZ could include commercial fishing, recreational angling, and recreational diving (Burton and Newman, 2020; Macloed and Stevens, 2022). On the other hand, an increase in entanglement of bull huss egg cases and tissue necrosis have also been recently recorded (Burton et al., 2024) and may be a contributing factor to the decline of *E. verrucosa*. The clear causes of the declines of these species remain unknown and more research is needed to fully understand the causes of this decline.

Water quality: nutrients (DIN only)

This indicator failed to meet its secondary target as high levels of DIN have been recorded in three of the WFD waterbodies that overlap with the reefs feature. The Milford Haven Inner and Outer waterbodies overlap with the largest proportion of the feature. These were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. The WFD investigation reports have confirmed elevated nutrients in these waterbodies, where it was concluded that major input of nutrients is likely to be derived from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021a; Lock, 2021b). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations. Further investigation is required to determine the breakdown of nutrient sources into the catchments. Point source continuous sewage discharge from the water industry was confirmed as minor source of nutrients linked to the DIN failures (Haines and Edwards, 2016; Caprez, 2020; Lock, 2021a; Lock, 2021b). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target. The Milford Haven Inner waterbody was classified as Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure in this waterbody. Major input of nutrients was found to be from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021a). In addition, point source continuous sewage discharge from the water industry were confirmed as a major source of nutrients linked to the opportunistic macroalgae failure, but only a minor source for the DIN failure (Haines

and Edwards, 2016; Caprez, 2020; Lock, 2021a). Intermittent and domestic sewage are also suspected in the catchment. Further investigation locally is required to confirm these.

Water quality: contaminants

This indicator failed to meet its secondary target. The contaminants indicator failed to meet its target as intertidal reefs in the SAC is partly within the Milford Haven Inner waterbody, which failed for chemicals due to PBDE and PAH. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). PAHs can be produced through natural processes, but also arise from anthropogenic sources, for example during combustion of fossil fuels and organic material (Webster and Fryer, 2022).

The contaminants in the water column may be derived from diffuse sources from contaminated water body bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, an investigation into the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is being managed and it is hoped that levels will reduce in time. There is currently no specific management in place for PAH in Wales. The PAH EQS is based on the most sensitive taxa and may not be applicable to all of the reef biota. The impacts of PAH on the reefs feature are not fully understood.

Sediment quality: contaminants

This indicator failed to meet its tertiary target. Levels exceeding sediment quality guidelines of PAH compounds and heavy metals have been recorded in sediment samples within the SAC. Contaminants with levels above the more stringent ecological guidelines in the most recent sampling year were benzo(g,h,i)perylene, anthracene, benzo(a)anthracene, fluoranthene, chromium, lead and TBT. Various other contaminants had concentrations above the less stringent guidelines in the most recent years of sampling. All locations with high sediment contaminant levels were within the Milford Haven Waterway or at Skomer MCZ sampling sites. Investigations into the sources of these contaminants, and the full impact on the feature have not been carried out.

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 arrival of *D. vexillum* within the last six years. The full extent of the impact that this 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.

4. Threats to reefs condition

Part of the condition assessment is to identify threats to the condition of the reefs. As the threats to reefs are the same across all the relevant SACs they have been listed here once to avoid repetition. 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 four SACs are stated below.

Unconsented infrastructure

New unconsented infrastructures, especially in the Pembrokeshire Marine SAC, 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.

Recreational access and collection

Access for a variety of recreational and collection activities can have an impact on intertidal reefs including trampling and removal of species. Some bait collectors turn boulders and may neglect to replace them in their original position. This is particularly concerning in the Menai Strait and Conwy Bay SAC. This could have a detrimental impact on the boulder communities. If boulders are displaced, the underboulder community faces challenges such as desiccation, predation, and wave action, while the surface layer of seaweed gets smothered by the displaced boulder.

Sea bed disturbance

Seabed disturbance, likely to occur within the Milford Haven Waterway due to future development plans, can result in increased turbidity and siltation rate. These can have detrimental effect on the reef habitat, affecting the composition, structure and dynamics of reef assemblages. Suspended particles can affect the filter-feeding of benthic invertebrates, while the accumulation of fine sediment may impede settlement, growth and photosynthetic processes of organisms (Airoldi, 2003).

Nutrient and temperature increases

There has been increase in green algae (*Ulva spp*.) since 2015 at two stations within the Milford Haven Waterway. This increase of opportunistic algae may be linked to DIN and could be exacerbated by increases in temperature. Ulva spp. have the capacity to rapidly expand and can smother the reefs, reducing biodiversity. Large blooms of Ulva spp. can pose a threat to the environment.

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.

*D. vexill*um, native from the western Pacific near Japan, is an extremely invasive and harmful species as it can reproduce quickly, has the ability to cover extensive areas of the substratum, outcompete native species and inflict considerable economic damage particularly in relation to mariculture (McKenzie et al., 2017; Tillin et al., 2020). The recent establishment of *D. vexillum* near to Neyland marina and Pembroke Port in Pembrokeshire Marine SAC poses a threat to the reefs feature as it could outcompete native species and alter habitats. Currently, effects on the species diversity and composition have not yet been observed, however as it has the potential to impact the condition of the reefs feature it is a threat.

Future increases in air and water temperatures that are expected with climate change may result in increased occurrence of conditions suitable for spawning and settlement of *M. gigas*. Northward recruitment may be expected (Smyth et al., 2022).

S. muticum has replaced the zone of sugar kelp in some areas in the Menai Strait and has recently spread into Bardsey Island.

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

5. Evidence gaps for the reefs feature

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

Listed below 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. Not all evidence gaps apply to every SAC, see Table 18 for details.

Table 18. Evidence gaps for the reefs feature in Welsh SACs. 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.
Distribution and extent of the naturally present reef types (P)	Not assessed	• There are currently no temporal data on reef types for all SACs except for Pen Llŷn a'r Sarnau SAC where some evidence were available.
Abundance, distribution and species composition of communities (P)	Not assessed	• There are no current data available to assess this indicator for the subtidal reefs within the Cardigan Bay SAC. • To better assess against this indicator, more data are needed on the distribution and population structure, recruitment and larval abundance of species for some intertidal and subtidal reefs.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present at all of the SACs on the reefs feature is not fully understood. More targeted surveys and investigation on the impact of NNS on reefs are needed.

Indicator	Assessed status	Comments
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 / low confidence	• Some or all of the WFD waterbodies that overlap with the feature in the Menai Strait and Conwy Bay, Pen Llŷn a'r Sarnau and Cardigan Bay SACs 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.
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 in any of the SACs. • 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)	Not assessed / unknown	• There were no temperature, salinity or pH loggers within the Cardigan Bay SAC. • Further evidence on temperature change is required to adequately assess this indicator in the other SACs. Some physicochemical parameters such as salinity and pH have not been assessed in any SACs. 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.
Species richness and diversity (S)	Not assessed	• There are no current data available to assess this indicator for the subtidal reefs within the Cardigan Bay SAC.
Taxonomic spread of species (S)	Not assessed	• There are currently no data on the taxonomic distinctness for intertidal reefs in all SACs, and for subtidal reefs in the Cardigan Bay SAC.

Indicator	Assessed status	Comments
Sediment quality: contaminants (T)	Not assessed / unknown	• Currently, there is no sediment monitoring within the Menai Strait and Conwy Bay, and Cardigan Bay SACs. • 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.

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