Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Sir Benfro Forol / Pembrokeshire Marine Special Area of Conservation

Report No: 909

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Report series:	NRW Evidence Report
Report number:	909
Publication date:	June 2025
Title:	Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Sir Benfro Forol / Pembrokeshire Marine Special Area of Conservation
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Technical Editor:	Hatton-Ellis, M.
Quality assurance:	Tier 3
Contributors:	Brazier, P., Burton, M., Camplin, M., Green, M., Goudge, H., Hatton-Ellis, T., Lewis, H., Lindenbaum, C., Lock, K., Nielsen, I., Scorey, A., Self, H., Stringell, T., and Woodman, J.
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., Cuthbertson, S. and Hatton-Ellis., M. 2025. Condition Assessments for the Designated Features of Ardal Cadwraeth Arbennig Sir Benfro Forol / Pembrokeshire Marine Special Area of Conservation. NRW Evidence Report No. 909, 359pp, Natural Resources Wales, Cardiff.

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Crynodeb Gweithredol

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

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

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

Crynodeb o asesiadau cyflwr ar gyfer nodweddion dynodedig ACA Sir Benfro Forol.

Nodweddion ACA	Asesiad cyflwr	Hyder yn yr asesiad
Cilfachau a baeau mawr bas	Anffafriol	Canolig
Aberoedd	Anffafriol	Canolig
Riffiau	Anffafriol	Canolig
Morlo llwyd *Halichoerus grypus*	Ffafriol	Canolig
Dolydd ar forfeydd arfordir y gorllewin *Glauco-Puccinellietalia maritimae*	Anffafriol	Isel
Gwastadeddau llaid neu dywod nas gorchuddir gan y môr ar lanw isel	Anffafriol	Canolig
Morlynnoedd neu Lagynau	Anffafriol	Uchel
Ogofâu môr sy’n danforol neu’n lleddanforol	Anhysbys	Ddim yn berthnasol
Ponciau tywod sydd fymryn dan ddŵr y môr drwy’r amser	Ffafriol	Canolig
Herlyn *Alosa alosa*	Anffafriol	Isel
Gwangen Alosa fallax	Anffafriol	Isel
Lamprai’r afon *Lampetra fluviatilis*	Anffafriol	Uchel
Lamprai’r môr *Petromyzon marinus*	Anffafriol	Uchel

Nodweddion ACA	Asesiad cyflwr	Hyder yn yr asesiad
Dyfrgi *Lutra lutra*	Anffafriol	Canolig
Tafolen y traeth *Rumex rupestris*	Anffafriol	Canolig

Executive summary

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

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

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

Summary of condition assessments for the designated features of Pembrokeshire Marine SAC.

Feature	Condition assessment	Confidence in assessment
Large shallow inlets and bays	Unfavourable	Medium
Estuaries	Unfavourable	Medium
Reefs	Unfavourable	Medium
Grey seal *Halichoerus grypus*	Favourable	Medium
Atlantic salt meadows *Glauco-Puccinellietalia maritimae*	Unfavourable	Low
Mudflats and sandflats not covered by seawater at low tide	Unfavourable	Medium
Coastal lagoons	Unfavourable	High
Submerged or partially submerged sea caves	Unknown	Not applicable
Sandbanks which are slightly covered by seawater all the time	Favourable	Medium
Allis shad *Alosa alosa*	Unfavourable	Low
Twaite shad *Alosa fallax*	Unfavourable	Low
River lamprey *Lampetra fluviatilis*	Unfavourable	High

Feature	Condition assessment	Confidence in assessment
Sea lamprey *Petromyzon marinus*	Unfavourable	High
Otter *Lutra lutra*	Unfavourable	Medium
Shore dock *Rumex rupestris*	Unfavourable	Medium

1. Introduction

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

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

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

1.1. Assessment process

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

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

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

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

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

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

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

2. SAC description

The ardal cadwraeth arbennig (ACA) Sir Benfro Forol/ Pembrokeshire marine special area of conservation (SAC) is situated on the southwestern tip of Wales. It is a large designated site covering 138,038 ha and forms part of the UK's National Site Network.

The SAC extends from just north of Abereiddy on the north Pembrokeshire coast to just east of Manorbier in the south. It includes the coast of the islands of Dewi/Ramsey, Sgomer / Skomer, Grassholm, Sgogwm /Skokholm, the Bishops and Clerks and The Smalls. The SAC encompasses a range of marine habitats and species, some of which are unique in Wales. Habitat and biological diversity are of great importance throughout the site, particularly the well documented reef habitats and the Aberdaugleddau/Milford Haven ria-estuary (drowned river valley). The site's location at a boundary between northern and southern species distributions contributes to the biological diversity.

The site was designated in 2004 under Article 4.2 of the Conservation of Natural Habitats and of Wild Fauna and Flora Directive (92/42/EEC) for eight habitat features under Annex I and seven species features under Annex II. It is one of the best areas in the UK for the following features:

- Large shallow inlets and bays
- Estuaries
- Reefs
- Grey seal (*Halichoerus grypus*)

and to supports a significant presence of:

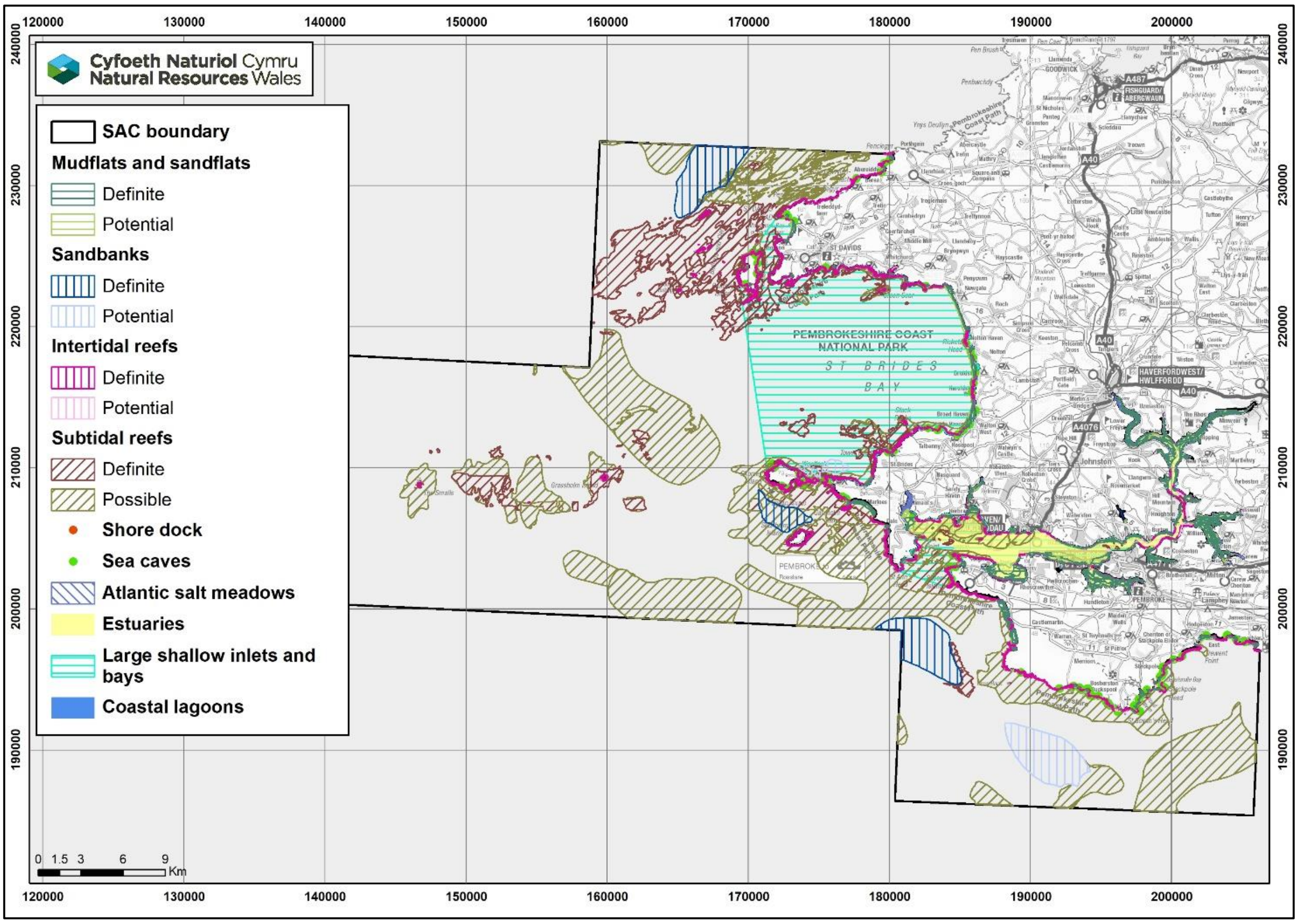
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- Mudflats and sandflats not covered by seawater at low tide
- Coastal lagoons
- Submerged or partially submerged sea caves
- Sandbanks which are slightly covered by seawater all the time
- Allis shad (*Alosa alosa*)
- Twaite shad (*Alosa fallax*)
- River lamprey (*Lampetra fluviatilis*)
- Sea lamprey (*Petromyzon marinus*)
- Otter (*Lutra lutra*)
- Shore dock (*Rumex rupestris*)

The features are distributed throughout the SAC with no single feature occupying the entire SAC and with features overlapping in some locations.

Figure 1 is a map of the location of the designated features within Pembrokeshire Marine SAC. The feature maps in this document are for illustrative purposes only. The extent of most features is not known precisely and some, such as sandbanks, are dynamic and can be highly mobile. Detailed maps for the features in Wales can be found on Data Map Wales.

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

Figure 1. Map of the designated features of the Pembrokeshire Marine SAC.



3. Feature condition assessments for Pembrokeshire Marine SAC

This section contains assessments for the following designated features in Pembrokeshire Marine SAC:

- Large shallow inlets and bays
- Estuaries
- Reefs
- Grey seal *Halichoerus grypus*
- Atlantic salt meadows *Glauco-Puccinellietalia maritimae*
- Mudflats and sandflats not covered by seawater at low tide
- Coastal lagoons
- Submerged or partially submerged sea caves
- Sandbanks which are slightly covered by seawater all the time
- Allis shad *Alosa alosa*
- Twaite shad *Alosa fallax*
- River lamprey *Lampetra fluviatilis*
- Sea lamprey *Petromyzon marinus*
- Otter *Lutra lutra*
- Shore dock *Rumex rupestris*

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

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

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

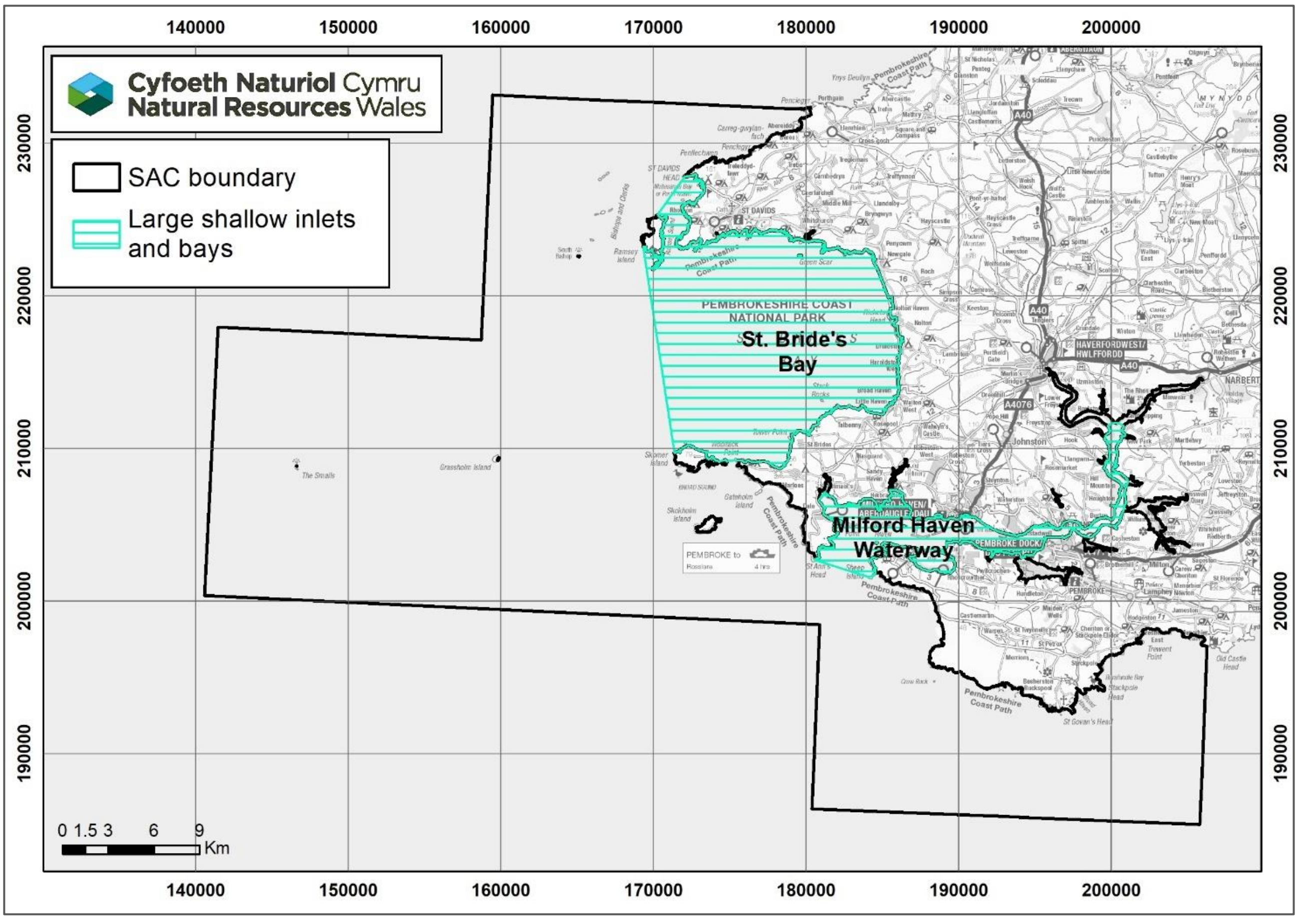
In the WFD classification, results are rolled forward from previous assessments where there is no new monitoring data to provide a new classification. It is used to gap fill and provide a more complete classification. A decision was made to limit roll forward to six years which has been applied to the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

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

3.1. Large shallow inlets and bays condition assessment

The large shallow inlets and bays (LSIB) feature in Pembrokeshire Marine SAC is made of two bays, St Brides Bay and Milford Haven Waterway (Figure 2). The condition assessment was completed using information specific to the LSIB in combination with any available data on the nested designated features contained within the LSIB.

Figure 2. Map of the LSIB feature in Pembrokeshire Marine SAC.



The LSIB includes some nested feature: reefs, estuaries, mudflats and sandflats, sandbanks and Atlantic salt meadows (ASM). Fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section.

Each bay has been assessed separately for each indicator and then combined to produce a single indicator target assessment outcome for the feature. Table 2 has a summary of the assessment outcome. This outcome and reasons of failure are discussed in more detail in the sections below.

Table 2. Condition assessment of LSIB in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature Extent	No significant decrease in extent of LSIB within the SAC, allowing for natural change. (P)	• LSIB are a physiographic feature and the extent of the feature would be unlikely to change. • There are currently no anthropogenic impacts known to be significantly affecting the extent of LSIB in the SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of LSIB habitats and communities, allowing for natural change and variation. (P)	• The extent of the Milford Haven maerl bed within the feature has reduced dramatically between 2005 and 2023 causing the failure of the target. • There are currently no anthropogenic impacts known to have significantly affected the distribution and extent of other habitats and communities of LSIB and its nested features in the Pembrokeshire Marine SAC since designation in 2004. • Confidence is high as the long term monitoring data shows a significant decline in the extent of the maerl bed.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the LSIB, allowing for natural change and variation. (P)	Within the SAC, St Brides Bay comprises 81% of the feature. • The NRW monitoring analysis of the sublittoral soft sediment in St Brides Bay from 2000 to 2022 indicated no concerning change in sediment composition and changes were within bounds of natural variation. Within the SAC, Milford Haven Waterway comprises 19% of the feature. • The Milford Haven inlet sediment monitoring (2007-2021) showed some variation which was deemed likely to be natural. • The maerl bed investigations, and licenced activities assessments within the Milford Haven Waterway indicated no concerns. • Although an issue was identified for sediment composition in the Gann, the overlapping nested mudflats and sandflats feature passed for this indicator. • Post consent monitoring from the Neyland Yacht Haven marina found that the silt content increased significantly across the survey area between 2003 and 2019. This large change in silt content is concerning. • The silt content increase within Milford Haven Waterway has resulted in the fail. • Confidence is low as it is not clear why the silt content has increased and how widespread the issue is within the waterway.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to LSIB infaunal communities, allowing for natural change and variation. (S)	• The stations assessed for the redox layer are all located within Angle Bay. The redox layer indicated no clear trend over the years. • A greater spatial coverage is needed to understand ongoing processes and confirm overall trends. • Opportunistic macroalgae cover has caused anoxic layers in the Milford Haven Waterway sediments. This has led to the indicator failure. However there are limited quantitative data to confirm this. • Confidence is low as the assessment was based on visual observations and expert judgement.	**Fail**	Low
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to LSIB communities, allowing for natural change and variation. (S)	• Organic carbon content has declined within the monitoring period at the Clean Safe Seas Environmental Monitoring Programme (CSEMP) station in the Milford Haven Waterway. • The carbon content at both NRW monitored inlets in the Milford Haven Waterway (Angle Bay and the Gann) has increased across the monitoring period. • The indicator failed to meet the target due to the increase in carbon at the Milford Haven inlet locations. • The confidence has been reduced to low as the assessment has been based on data from a small number of locations.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (S)	• Within Milford Haven Waterway: ○ Polycyclic aromatic hydrocarbons (PAHs) were recorded in the Milford Haven Waterway CSEMP location and NRW monitored grab sampling locations. In the most recent years some PAHs were above the most stringent ecological guidelines. ○ Some heavy metal concentrations were above the less stringent guidelines in CSEMP and NRW monitored grab sampling locations in most recent years. Mercury was above the most stringent ecological guideline in 2018 in one NRW monitored grab sampling site (in the maerl bed). • Within St Brides Bay, at the Skomer Marine Conservation Zone (MCZ) site, the concentrations of chromium and lead were above the most stringent ecological guidelines, and arsenic and copper were above the less stringent ecological guidelines in the most recent sampling years. • The impact of the sediment contaminants on the LSIB feature is not fully understood. In addition, the assessment has been based on data from a small number of locations, leading to a low confidence.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the LSIB. (S)	• Various anthropogenic activities occurring within the LSIB feature have caused changes to the small or large scale topography of the feature. • This includes anchoring in St Brides Bay and other activities such as bait digging at the Gann. • Confidence is low as the damage from anchoring is still under investigation, and there is no recent quantitative measure of the potential damage of this issue.	**Fail**	Low
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are no new anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the LSIB feature in the Pembrokeshire Marine SAC. • However, historic activities may be continuing to have an effect on the sediment transport, which may have contributed to an increase in siltation within the waterway. Levels of silt in the maerl bed are currently under investigation by NRW but no conclusions have been reached yet. • Confidence in this pass is low due to concerns about increased siltation and as the assessment has been based on expert judgment.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
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. (P)	Within the SAC, St Brides Bay comprises 81% of the feature, and Milford Haven Waterway comprises 19%. • The one WFD waterbody that overlaps with St Brides Bay was classified with a High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South). This classification was rolled forward from the 2018 cycle 2 interim classification. The Pembrokeshire South waterbody overlaps with 99% of St Brides Bay • Both WFD waterbodies that overlap with the Milford Haven Waterway were classified with a Poor status for DIN (Milford Haven Inner and Outer). Combined, these waterbodies overlap with 96% of the Milford Haven Waterway (18% of the whole feature). • The failure is localised to the Milford Haven Waterway and confidence is high due to the significant DIN issues there.	**Fail**	High
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• All three WFD waterbodies that overlap with the LSIB feature in the SAC were High status for phytoplankton in the 2024 cycle 3 interim classification (Pembrokeshire South, Milford Haven Outer and Milford Haven Inner). Combined these represent 98% of the whole feature. • Confidence is high as the waterbodies that overlap with a large proportion of the feature were classified with a High status for the phytoplankton element.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	Within the SAC, St Brides Bay comprises 81% of the feature, and Milford Haven Waterway comprises 19%. • The one WFD waterbody that overlaps with St Brides Bay was not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification (Pembrokeshire South). • One WFD waterbody in the Milford Haven Waterway was classified with a Moderate status for this WFD element (Milford Haven Inner). This waterbody overlaps with 20% of the Milford Haven Waterway (4% of the whole feature). • The other WFD waterbody in the Milford Haven Waterway was classified as Good status for this WFD element (Milford Haven Outer). It overlaps with 76% of the waterway (14% of the whole feature). There has been localised growth of opportunistic macroalgae recorded in some of the bays and inlets of the waterbody. • Confidence is medium because the worst affected areas in the Milford Haven Waterway are outside of the LSIB feature, and as the waterbody in St Brides Bay has not been classified for this WFD element.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• All three overlapping WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Pembrokeshire South, Milford Haven Outer and Milford Haven Inner). • Confidence is medium due to samples being taken from the surface of the waterbody which may not detect issues for more demersal habitats within the LSIB feature.	**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)	Within the SAC, St Brides Bay comprises 81% of the feature, and Milford Haven Waterway comprises 19%. • The one WFD waterbody that overlaps with St Brides Bay was not classified as the chemicals have not been assessed within the last six years (Pembrokeshire South). • One WFD waterbody in the Milford Haven Waterway has a fail for chemicals, where it fails for polybrominated diphenyl ethers (PBDE) and PAH (Milford Haven Inner). This waterbody overlaps with 20% of the Milford Haven Waterway (4% of the whole feature). ○ The other WFD waterbody has a pass for chemicals (Milford Haven Outer). This waterbody has improved since earlier cycles. • Confidence is low as the human health standard has been used for PBDE, and as the waterbody that overlaps with a large proportion of the feature was not classified for any relevant chemicals.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the LSIB feature in the Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties of the water column	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from intertidal and 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

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)	St Brides Bay comprises 81% of the feature. • The overlapping WFD waterbody was classified with a Good status for the Infaunal Quality Index (IQI) WFD element in the 2024 cycle 3 interim classification. • The infaunal community in Skomer MCZ was reported to be healthy and species-rich. There were no concerns identified for *Zostera marina* (North Haven) and *Pecten maximus* (Skomer MCZ). • In the nested reefs feature, the indicator failed due to the decline in some subtidal species in the Skomer MCZ. Milford Haven Waterway comprises 19% of the feature. • The IQI, estuarine fish and intertidal seagrass WFD elements in the overlapping WFD waterbodies were assessed with Good or High status in the 2024 cycle 3 interim classification. • A recent study indicated that subtidal benthic communities of the Milford Haven Waterway were in a healthy state. • The indicator failed for the nested mudflats and sandflats and reefs features. • The shoot density of the subtidal seagrass *Z. marina* has declined in Littlewick Bay since 1999. • Percentage cover of live maerl has declined by nearly 80% over the monitoring period. Changes in epibiota, infaunal community composition and species richness have been observed over the survey period. • The herring population in the waterway is in decline. • Confidence is high given the large number of species declines.	**Fail**	High

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)	• The American slipper limpet *Crepidula fornicata* has been recorded in various locations in the SAC starting in 1960 and now reach a high density in some areas, mostly within the Milford Haven Waterway. • *C. fornicata* has previously been found in superabundant aggregations across various intertidal and subtidal habitats within the Milford Haven Waterway. Where the species dominates, natural habitats have been altered. *C. fornicata* is also found in sensitive habitats (maerl) within the waterway. • Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities. • For these reasons the indicator failed to meet its target. Confidence is medium as there are limited data on the density and distribution of *C. fornicata* within the last six years.	**Fail**	Medium

Indicator	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 LSIB feature in 2023. • 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 Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The large shallow inlets and bays (LSIB) feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of indicators with failing targets and most of these are localised within Milford Haven Waterway, the smaller of the two LSIB of the SAC (Table 3). 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 3 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 3. Summary of the condition assessment for LSIB in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Large shallow inlets and bays	**Unfavourable (medium confidence)**	Distribution and extent of habitats and communities (P) Sediment composition and distribution (P) Water quality: nutrients (DIN only) (P) Abundance, distribution and species composition of communities (P) Invasive non-native species (P); non-native species (T Topography of the feature (S) Sediment quality: oxidation-reduction profile (redox layer) (S) Sediment quality: organic carbon (S); contaminants (S) Water quality: opportunistic macroalgae (S) Water quality: contaminants (S)	• There has been a large reduction in live maerl cover. • Silt content has increased in some areas of the Milford Haven Waterway. • There are high nutrient levels in Milford Haven Outer and Inner waterbodies. • There has been an increase in infaunal opportunistic species; declines in live maerl, *Z. marina* shoot density, herring population and sponge thickness; and disturbed reef communities within Milford Haven Waterway; and in some subtidal benthic populations in the Skomer MCZ. • There is an increasing number of *C. fornicata* which has altered habitats. There is an increasing number of other NNS. • There is evidence of seabed disturbance and changes to the topography of the LSIB feature. • Organic carbon content of sediments has increased in the Milford Haven inlet monitoring locations. • Levels of PAHs and heavy metals in sediments are exceeding sediment quality guidelines within Milford Haven Waterway and St Brides Bay. • Opportunistic macroalgae is present in the Milford Haven Inner waterbody, which has led to anoxic layers in sediments. • Levels of PBDE and PAH in the water column in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change • Recreational access and collection • Unconsented infrastructure • Siltation

Detailed assessment information

Extent and distribution

Extent of the feature

The extent of the feature indicator in the Pembrokeshire Marine SAC passed its target as there are currently no known anthropogenic impacts that would significantly affect the extent of the LSIB feature. LSIB are a physiographic feature and the extent of the LSIB feature would be unlikely to change. Comparison mapping has not been used to assess the extent and only expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Distribution and extent of habitats and communities

Investigations on the Milford Haven maerl bed were carried out using a combination of dive surveys and drop-down videos between 2004 and 2023. Results have shown a large reduction in the extent of the maerl bed since 2005 (Mercer et al., 2025). There are concerns that the South Hook jetty refurbishment (2005-2007) have contributed to this decline (Ratcliffe, 2025). There are currently no known anthropogenic impacts that would significantly affect the extent of the LSIB feature and its nested features in other parts of the SAC. Overall, the large decline in the maerl bed extent was deemed enough to fail the distribution and extent of habitats and communities indicator target with high confidence.

Sediments

Composition and distribution

St Brides Bay

The monitoring analysis of the sublittoral soft sediment in St Brides Bay from 2000 to 2014 indicated stable conditions with little variation in sediment composition over time for the stations located in the inner bay. The stations located in the outer bay, however, displayed marked changes between monitoring years. These changes are likely due to natural fluctuations as a result of physical disturbance from exposed prevailing weather systems (Griffin and Clarke, in draft). Additional data up to 2022 further support this with no concerning changes in sediment composition (NRW unpublished data).

Milford Haven Waterway

The sediment composition and distribution indicator in the condition assessment of the nested mudflats and sandflats feature passed its target (see Section 3.6 for further detail). Some issues were identified at the Gann, with apparent changes in sediment composition particularly between 2012 and 2018, with an increase of silt and pebble but reduction of fine sand. Although this potentially indicates some disturbance there, this alone was not deemed a large enough impact to fail the nested mudflats and sandflats feature (see Section 3.6). This feature overlaps with approximately 3% of the LSIB feature.

Granulometric analysis within the Milford Haven inlets monitoring locations (2007-2021) indicated little variation in sediment composition. The majority of stations within the LSIB sediments remained fairly stable across the monitoring period.

The subtidal soft sediments within the LSIB have also been monitored as part of the Milford Haven Waterway Environmental Surveillance Group (MHWESG) surveys, through the maerl bed investigations, and from licenced activities assessments within the Milford Bay. The MHWESG surveys found that sediments are poorly sorted, with the highest silt or clay content in the middle of the estuary channel (Warwick, 2017; Warwick et al., in prep). Due to the methodology used, there was no information on the temporal patterns for these stations, therefore they were considered temporally stable in the report.

Surveys at the maerl bed stations were carried out in 2005, 2010, 2016 and 2023. There was no difference in particle size distribution between years, however it did differ between monitoring sites (Bunker and Ratcliffe, 2025) and diver observations indicated a possible increase in silt at the maerl site.

There is a general concern from NRW experts that the silt content has increased in the Milford Haven estuary. As part of the monitoring for the Neyland Yacht Haven marina, subtidal sediment particle sizes were assessed between 2003 and 2008. Past NRW analyses showed significant increases in silt levels over time from January 2004 to April 2007 at most monitored stations (Camplin, 2005; 2008). Further monitoring was carried out in 2010, 2013, 2016 and 2019. This monitoring further supports the finding of a significant silt content increase across the survey area as a whole (Preen and Mazik, 2019). This large change in silt content is concerning.

The siltation increase within the Milford Haven Waterway contributed to the fail of the sediment composition and distribution indicator for the LSIB feature. A low confidence was attributed to the fail as it is not clear why the silt content has increased and how widespread the issue is within the waterway.

Oxidation-reduction profile (redox layer)

Quantitative data on the redox layer of sediments has been analysed in the Angle Bay sites only. These data indicated no clear trend over the monitoring period. In the wider Milford Haven Waterway, there is evidence of opportunistic algae within the SAC (Lock, 2021a). Excessive growth of opportunistic algal mats will quickly smother the sediment, causing anoxic conditions. This has been observed where extensive areas of opportunistic macroalgae growth has been recorded within the Milford Haven inlets, for example within Sandy Haven, where anoxic layers have been observed beneath algal mats (Figure 3). This had led to a failure for the redox layer indicator. The confidence attributed to the failure has been reduced to low as the conclusion has been based on data from a limited spatial coverage, visual observations and expert judgement. The stations assessed for the redox layer are all located within Angle Bay, which is outside of the opportunistic macroalgae sampling locations and may explain why there was no clear trend there. This indicator also failed for the estuary and mudflats and sandflats features, which overlap with the LSIB Waterway feature. The failure is localised to the Milford Haven Waterway. There are no data on the redox layer within St Brides Bay.

Figure 3. Anoxic layers of sediment beneath opportunistic macroalgae on mudflats in Sandy Haven in 2008, Milford Haven Waterway.

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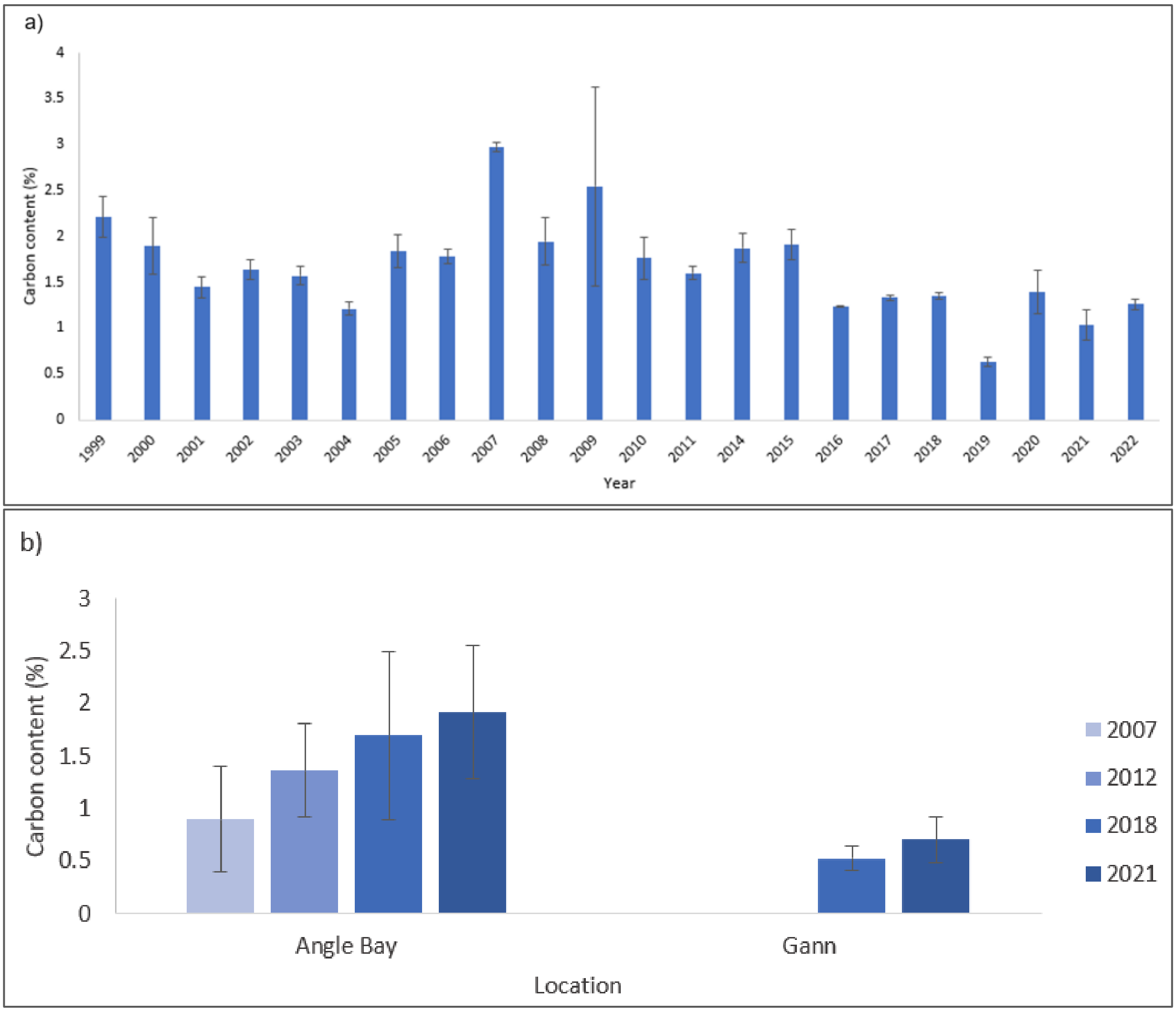
Organic carbon content

The assessment of the sediment quality organic carbon and contaminants indicators used data from NRW monitored sediment contaminants as part of the Clean Safe Seas Environmental Monitoring Programme (CSEMP) sampling in one location in the 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. Additional sediment grab sampling has been carried out in Milford Haven Waterway over four years (2007, 2012, 2018 and 2021). These were grouped into bay locations for analysis. There were two sampling locations that overlap with the LSIB feature which were considered for the assessment of these sediment quality indicators.

At the subtidal CSEMP location the carbon content has decreased over the monitoring period from 2.2% in 1999 to 1.3% in 2022 (Figure 4a). However, the organic carbon content at both of the grouped inlet locations has increased over the monitoring period (Figure 4b). At Angle Bay, the average carbon content has doubled, going from 0.9% in 2007 to 1.9% in 2021 (Figure 4b). The carbon content has not been compared against any defined ecological standard as it is highly variable by location, however, increases in carbon can be an indicator of organic enrichment and reduced oxygen in the sediment.

The indicator failed to meet the target due to the increase in carbon at various monitoring locations within the Milford Haven inlets. While the failure has been based on data from only two stations, evidence from the estuaries condition assessment, which used data from a larger number of monitoring stations, indicates a wider issue with carbon within the Milford Haven Waterway. Additionally, initial outputs of deep cores from the MHWESG show that total organic carbon content has increased over a longer historical time period (i.e. several decades) at some locations in the Milford Haven inlets (e.g. Pembroke River, Boulston and Cosheston Pill) (MHWESG, pers. comm.). The more recent observed increases in carbon are therefore likely a continuation of a long-term trend of increasing carbon at these locations. This will be something to look into in the next assessment when the analysis has been completed. A low confidence was assigned to the failure of the target due to the low number of sampling stations used for the assessment.

Figure 4. Average carbon content (±S.E.) from sediment grab samples in the Milford Haven Waterway. Samples from a) the CSEMP location from 1999 to 2022, and b) the grouped inlet locations in Milford Haven Waterway in 2007, 2012, 2018 and 2021.



Contaminants

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 Environmental Quality Guidelines (CEQG) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) action levels. Further information is available in the IMCA final report.

Within the Milford Haven Waterway, 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). 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. In addition, various PAHs were above the most stringent guidelines in 2018 at some of the grab sampling locations over the maerl bed in the Milford Haven Waterway. It is not known if these levels remain high at these monitoring sites as they have not been sampled since 2018.

Heavy metal concentrations were also recorded at various locations within the Milford Haven Waterway. The concentration of mercury was above the most stringent guideline (OSPAR effects range low) in 2018 at one of the grab sampling locations over the maerl bed in the Milford Haven Waterway. The concentrations of other heavy metals (chromium, arsenic, copper and zinc) were above the less stringent guidelines in some of the sampling locations (CSEMP and grab sampling) in most 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. Polychlorinated biphenyls (PCBs) have mostly declined at both the CSEMP and grab sampling stations since earlier years, and all are below the more stringent guidelines in the most recent year of sampling.

At the one sediment trap sampling location within St Brides Bay (Skomer Island), only heavy metals have been monitored. The concentrations of chromium and lead are both above the most stringent ecological guidelines (CEQG probable effect levels for chromium or OSPAR effects range low for lead) at this monitoring site in the most recent years. In addition, the concentrations of arsenic and copper were above the less stringent ecological guidelines (CEQG threshold effect levels) in the most recent years.

The sediment quality (contaminants) indicator failed to meet the target due to levels exceeding sediment quality guidelines in various contaminants in both the Milford Haven Waterway and St Brides Bay. The impact of the contaminants on the LSIB feature is not fully understood. This reduced the confidence in the assessment. Confidence was further reduced to low as the assessment has been based on data from a small number of locations.

Topography and hydrodynamics

Large vessels commonly use St Brides Bay to anchor whilst awaiting entry to the Milford Haven Waterway. Recently, there has been more frequent anchoring in the south of the bay and areas near Skomer island MCZ. There is some evidence of seabed disturbance and changes to the topography of the seabed from large vessels within St Brides Bay from drop-down video and side scan data in 2008 and 2009 (e.g. Keenan et al., 2012). Research is ongoing to determine the intensity of anchoring events and preliminary results indicated a high number of anchoring events happening within the bay in the last five years. Recreational anchoring occurs within Milford Haven Waterway, which may also affect the topography of the feature. In addition, there have been small scale changes to the topography in the nested mudflats and sandflats feature within the Gann flats in the Milford Haven Waterway. These changes are due to bait digging activities. A national code of conduct for bait collectors has been developed for Wales (code of conduct). It will take time to see if these measures are effective in reducing small scale topography alteration.

The topography indicator failed to meet its target due to the various activities occurring within the LSIB which have altered the topography of the feature at both large and small scale. The confidence has been reduced to low because there is no quantitative measure of the anchoring disturbance in St Brides Bay, and limited information on longevity and extent of any anchoring disturbance, and its impact on the biota within the bay. Investigations into the long term impacts to the seabed and the potential effects of anchoring on biota are required.

The hydrodynamic and sediment transport processes indicator met its target as there are no new anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the LSIB feature in the Pembrokeshire Marine SAC. However, historic activities may be continuing to have an effect on the sediment transport, which may have contributed to an increase in siltation within the Milford Haven waterway. A NRW investigation is ongoing to determine whether an increase in silt may have impacted the maerl bed and whether this is of anthropogenic origin (Ratcliffe, 2025). The confidence in the indicator pass was reduced to low due to this concern, and as the assessment was based on expert judgment.

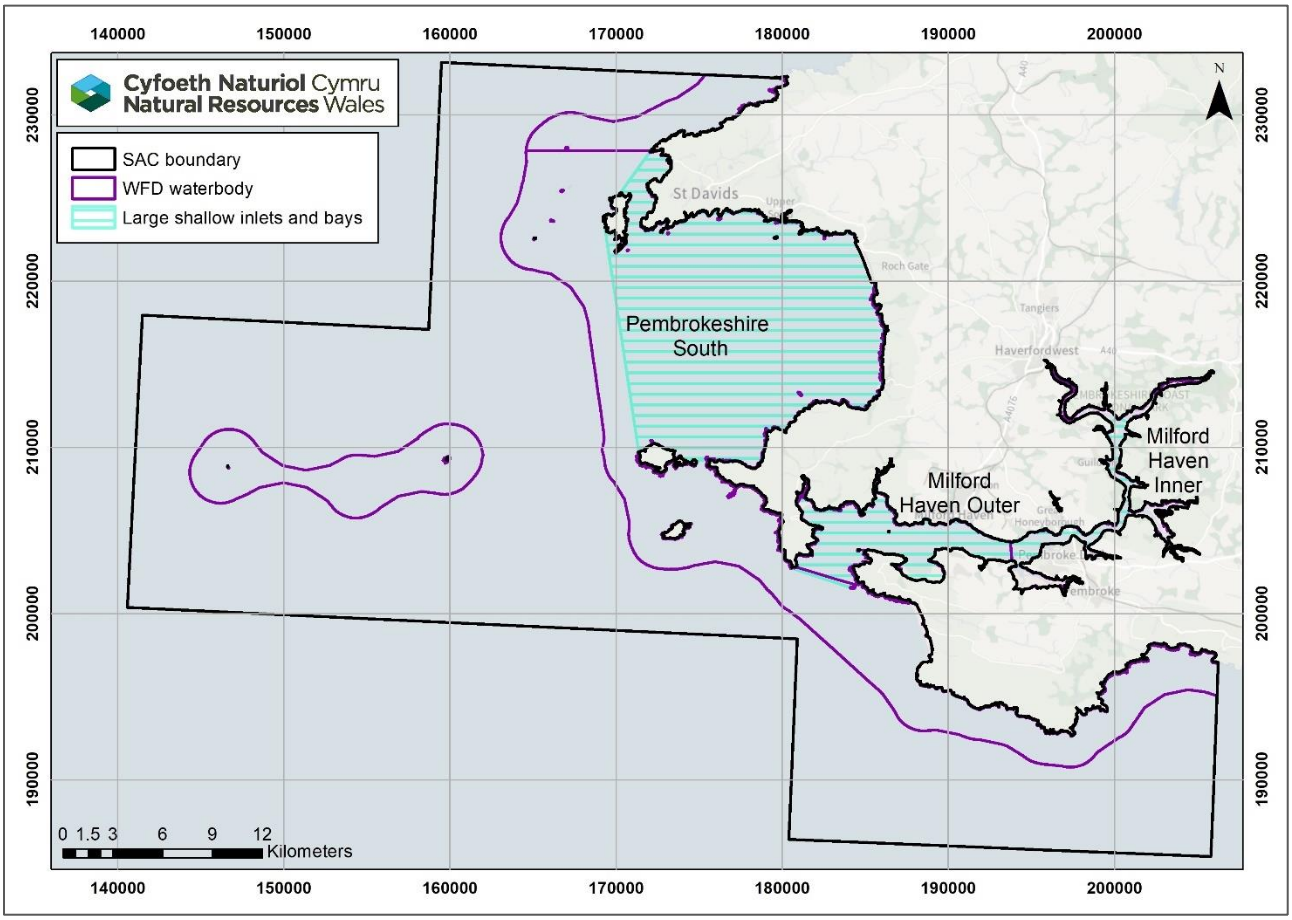
Water quality

It has been estimated that 98% of the LSIB feature falls within three WFD waterbodies (Figure 5), therefore these are likely to be a good reflection of the overall effect of water quality on the feature. St Brides Bay is the largest of the two bays within the SAC (81% of the feature across the SAC), then the Milford Haven Waterway (19%) (Table 4, Figure 5).

Table 4. Designated LSIB within the Pembrokeshire Marine SAC and the WFD waterbodies that overlap.

Bay	WFD waterbody	Degree of overlap across indv. bay (%)	Degree of overlap across whole feature (%)
St Brides Bay	Pembrokeshire South	98.83	80.42
Milford Haven Waterway	Milford Haven Outer	75.82	14.12
Milford Haven Waterway	Milford Haven Inner	20.39	3.80

Figure 5. Map of the WFD waterbodies that overlap with the LSIB feature within Pembrokeshire Marine SAC.



Nutrients (Dissolved Inorganic Nitrogen - DIN only)

St Brides Bay comprises one WFD waterbody, the Pembrokeshire South waterbody (Table 4). This waterbody was classified with a High status for the DIN element in the 2024 cycle 3 interim classification.

The Milford Haven Waterway comprises two WFD waterbodies, the Milford Haven Outer waterbody and the Milford Haven Inner waterbody (Table 4). Both of these waterbodies were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. Combined, these overlap with 96% of the Milford Haven Waterway. The Milford Haven Inner and Outer waterbodies also failed in previous cycles, and the Milford Haven Outer waterbody has deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation reports of these waterbodies confirmed the DIN failures in the 2018 cycle 2 interim and the 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.

The nutrients indicator (DIN only) failed to meet the target as high levels of DIN have been recorded in the Milford Haven Waterway. High confidence was attributed to the failure as the failing waterbodies overlap with a large proportion of the LSIB feature within the Milford Haven Waterway, and as the investigations have confirmed nutrient issues in these waterbodies. Confidence was also increased due to the biological response to high nutrient levels in the Milford Haven Inner waterbody, where opportunistic macroalgae was classified with a Moderate status. There are no recorded issues with nutrients in St Brides Bay, and the nutrients failure is localised to the Milford Haven Waterway only.

Phytoplankton

The phytoplankton indicator passed its target as all three WFD waterbodies that overlap with the feature (Pembrokeshire South, Milford Haven Outer and Milford Haven Inner) were classified with a High status for the phytoplankton element in the 2024 cycle 3 interim classification. Combined, these waterbodies represent 98% of the whole LSIB feature (Table 4). The Milford Haven Outer waterbody improved between the 2021 cycle 3 and the 2024 cycle 3 interim classifications, from Good status to High status. Confidence in the pass is high as the waterbodies that overlap with a large proportion of the feature were classified with a High status for the phytoplankton element.

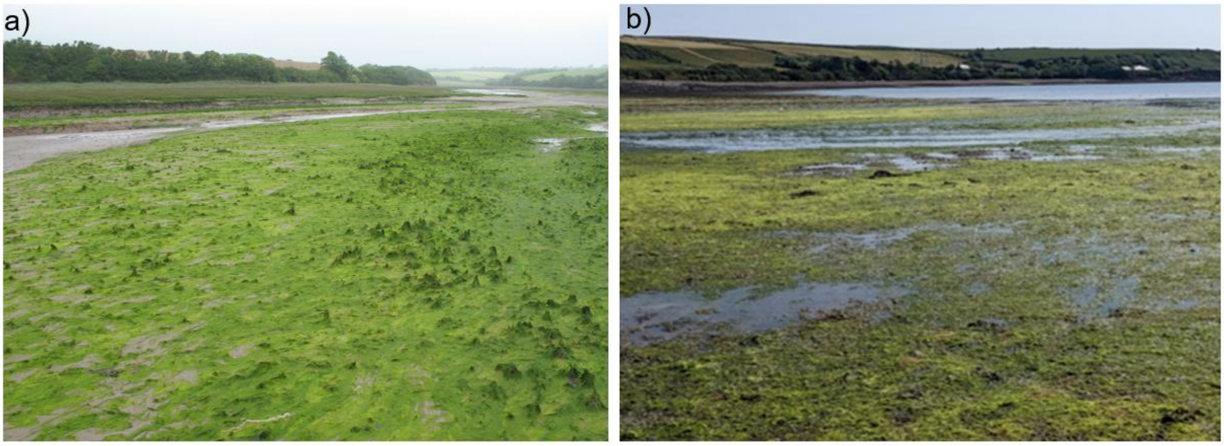
Opportunistic macroalgae

The one WFD waterbody that overlaps with St Brides Bay, Pembrokeshire South, was not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. It should be noted that some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Within the Milford Haven Waterway, one of the two WFD waterbodies was classified with a Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. This was the Milford Haven Inner waterbody, which overlaps with 20% of the Milford Haven Waterway, and represents 4% of the whole feature across the SAC (Table 4). The WFD investigation report confirmed the opportunistic macroalgae failure, in which extensive and recurring coverage has been recorded in various inlets including Cosheston Pill, Garon Pill, and Carew and Cresswell rivers (Lock, 2021a). There has been evidence of opportunistic macroalgae growth since 2007, indicating that this has been a long-lasting issue within the Milford Haven Inner waterbody. The worst areas affected by opportunistic macroalgae are in the inlets of the Milford Haven Waterway, which are not within the LSIB feature. However, the effects of the opportunistic macroalgae may affect downstream areas, and there are also recorded areas with dense macroalgae growth further up the waterway, at Llangwm Pill and Sprinkle Pill which are within the LSIB feature. The Milford Haven Outer waterbody that also overlaps with the Milford Haven Waterway, was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification. Although it 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, which are within the LSIB feature (Figure 6) (Lock, 2021b).

Overall, the opportunistic macroalgae indicator failed to meet the target due to the Moderate status WFD classification for this element in the Milford Haven Inner waterbody. Confidence in the fail was reduced to medium because, although there is extensive evidence of opportunistic macroalgae in the Milford Haven Inner waterway, the worst affected areas are outside of the LSIB feature.

Figure 6. Opportunistic macroalgae on saltmarsh and mudflats within the LSIB feature. a) Sandy Haven in 2008 and b) Dale in 2023, Milford Haven Waterway.



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Dissolved oxygen

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

Contaminants

The one WFD waterbody within St Brides Bay, Pembrokeshire South, was not classified as the chemicals have not been assessed within the last six years.

One of the WFD waterbodies within the Milford Haven Waterway, the Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where polybrominated diphenyl ethers (PBDE) and PAH failed. This caused the contaminants indicator to fail. PBDE has failed in this waterbody in all previous cycles of the WFD assessments. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of LSIB are not fully understood. This reduced the confidence in the fail. 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. The confidence was reduced further to low as a large proportion of the feature overlaps with a waterbody that has not been classified for any chemicals within the last six years. 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. Most of these loggers (18 out of the 19) overlap with the LSIB feature. 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

The assessment of the abundance, distribution and species composition of communities indicator considers data from the Milford Haven Waterway and to a lesser extent St Brides Bay with some reports from the Skomer MCZ. St Brides Bay is the largest of the two bays within the SAC (81% of the feature across the SAC), then the Milford Haven Waterway (19%).

St Brides Bay

There are important intertidal and subtidal reefs within St Brides Bay. The data from the Skomer MCZ monitoring surveys showed that the intertidal reef communities were stable over the monitoring period and in a favourable condition typical of the area. Some subtidal reef species, however, were in decline. There was a decline of the red sea fingers *Alcyonium glomeratum* colony and large loss of the pink sea fan *Eunicella verrucosa* (Section 3.3). This was not deemed large enough to contribute to the overall failure of the feature.

The sublittoral soft sediment infaunal communities of the Skomer MCZ have been surveyed between 1993 and 2020 and showed no concerning change. The last five surveys indicated that the communities were healthy and species rich (Lock et al., 2022). Other species within the boundary of the Skomer MCZ were also reported to be in good condition. This includes the king scallop *Pecten maximus*, surveyed six times since 2020, for which populations appeared healthy with increasing densities (Massey et al., 2023). *Z. marina* was also surveyed every four years since 2006 in North Haven and was also in good condition, as evidenced by an increase in shoot density and stable extent across the monitoring period (Massey et al., 2024).

St Brides Bay sublittoral soft sediment infaunal communities have been surveyed between 2000 and 2016. The report stated that the habitats in St Brides Bay were in good ecological health and have broadly remained so throughout the monitoring period (Griffin and Clarke, in draft). Further analysis using recent data is required to assess the current state of these communities. In addition, the WFD waterbody that overlaps with 99% of the LSIB feature within St Brides Bay (Table 4) was classified as Good status for the Infaunal Quality Index (IQI) element in the 2024 cycle 3 interim classification (Pembrokeshire South). The impacts to the biota from the anchoring of large vessels of St Brides Bay are not currently known.

Milford Haven Waterway

Nested features

The mudflats and sandflats feature overlaps with approximately 3% of the LSIB feature. Infaunal analysis sampled with cores for intertidal Angle Bay infauna showed that communities fluctuated within natural variations (Moore et al., 2021 and NRW unpublished data). In addition, a recent survey by ABPmer has shown no significant impact of bait digging on infaunal communities at Angle Bay (West et al., 2025), but further work is required to confirm this. Although no concern was observed for Angle Bay, the condition of mudflats and sandflats in other part of the SAC were poor with an increase in opportunistic species which are typically associated with anthropogenic disturbance (e.g. pollution) at several locations of the infaunal Milford Haven inlet monitoring. This included two within the LSIB feature (the Gann and Angle Harbour) (see Section 3.6). These locations are known to be impacted by elevated nutrient levels in the Milford Haven Outer waterbody (Section 3.6). In addition, bait digging activities in the Gann have been linked with changes in species composition in this area. The observed disturbance was not deemed to be due to natural change. Further analysis on the life histories of species that are driving the observed changes, the broad patterns of tolerant species change and how these are related to natural versus anthropogenic pressures would help to identify potential reasons for these failures. This resulted in the failure of the abundance, distribution and species composition of communities indicator in the nested mudflats and sandflats feature.

There are important intertidal and subtidal reefs within Milford Haven Waterway. The reefs feature overlaps with approximately 20% (which includes intertidal and subtidal reefs) of the LSIB feature. NRW monitoring data indicated that the intertidal reef communities in the Milford Haven Waterway and open coast sites remained stable over time. There was a decline of knotted wrack *Ascophyllum nodosum* at the Lawrenny Quay and Pembroke Power Station monitoring locations in Milford Haven Waterway which is concerning and warrants further investigation. This decline was not large enough to fail the abundance, distribution and species composition of communities indicator for intertidal reefs, and the indicator was therefore passed. However, the indicator failed with high confidence for subtidal reefs, due in part to a 50% decrease in mean thickness of cushion and crustose sponge and a small decrease in circumference and height for the mermaid’s glove *Haliclona oculata* at Warrior reef, which is within the LSIB feature. In addition, two out of five monitoring sites (Warrior Reef and Beggars Reef) for the subtidal reef-associated communities showed a change over time, suggesting possible disturbance (see Section 3.3 for further detail).

Maerl

The NRW investigation showed that the maerl bed in the Milford Haven Waterway is in poor condition (Ratcliffe, 2025). The cover of live maerl has decreased by nearly 80% from 2005 to 2017 (Mercer et al., 2025). This has resulted in a large shift in epibiota and infauna community composition and changes in infaunal species richness (Bunker and Ratcliffe, 2025).

Subtidal benthic communities

A recent study on the subtidal benthos in the main channel of the Milford Haven estuary indicated that the benthic communities were in a healthy state (Warwick et al., in prep). In addition, the two WFD waterbodies that overlap with 96% of the Milford Haven Waterway, part of the LSIB feature (Table 4) were both classified with a High status for the IQI element in the 2024 cycle 3 interim classification (Milford Haven Outer and Milford Haven Inner). Additional analysis further supports this with no concerning changes in IQI (NRW unpublished data).

Seagrass

The intertidal seagrass *Zostera noltei* within the waterway has increased in extent in recent years and has been assessed as High status in the 2024 cycle 3 interim classification of seagrass in both Milford Haven Inner and Outer waterbodies and particularly in Angle Bay. There are five known subtidal *Zostera marina* seagrass beds in the Milford Haven Waterway, the largest of which is the bed in Littlewick Bay. The subtidal seagrass *Z. marina* has been surveyed between 1986 and 2018 at Littlewick Bay in the Milford Haven Waterway. These surveys indicate that shoot density in 2018 has decreased by 57% since 1986 with a significant decrease since 1999, suggesting localised conditions have changed (Unsworth et al., 2017; Bertelli, 2021a, 2021b). In 2017, *Z. marina* was observed to no longer be continuous and largely fragmented into numerous small, isolated patches. Shoot density within *Z. marina* meadows is a good bioindicator of environmental disturbance, and long-term data at Littlewick Bay indicate anthropogenic impact there (Bertelli, 2021a; 2021b). Poor water quality resulting in hypertrophication or eutrophication has been raised as a possible cause for the decline observed (Bertelli, 2021a, 2021b). Changes in turbidity may also be a cause for declines in shoot density as *Z. marina* is light limited (Bertelli, 2021a; 2021b). Turbidity has not been investigated at Littlewick Bay due to the loss of loggers (Bertelli, 2021a). However, the area is now dominated by the alga *Laminaria saccharina*, and the coverage of attached epiphytic algae was found to be very high, suggesting the potential for *Z. marina* to be light limited at the monitoring site (Unsworth et al., 2017). Epiphytes on *Z. marina* have decreased by 39% since 1999, and wasting disease has increased by approximately 387% since 1999 (Bertelli, 2021a, 2021b). Compared to other monitoring sites surveyed in Wales, wasting disease and algae cover was significantly higher in Littlewick Bay. It has been concluded that there may be a system shift from a seagrass dominated to macroalgae-dominated community in Littlewick Bay (Bertelli, 2021a), and reports indicate the seagrass is under light and nutrient stress in the Milford Haven Waterway for the majority of the year (Unsworth et al., 2017). There are other known beds of *Z. marina* within the Milford Haven Waterway (e.g. in Dale and Angle

Point), however long-term data are not available for these other beds of the subtidal seagrass therefore their condition is unknown.

Fish

Although fish within the LSIB are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the LSIB feature.

The Milford Haven Inner waterbody, which overlaps with the upper Milford Haven Waterway (and represents 3.8% of the whole LSIB feature), was classified as Good status for the WFD estuarine fish tool in the 2024 cycle 3 interim classification. No other WFD waterbodies that overlap with the feature were classified for this element. However, the ability of the WFD fish tool to inform the condition of the LSIB feature is unknown and needs further analysis.

The herring population appears to be in decline in the Milford Haven Waterway. There has been a noticeable decrease in the number of spawning fish since the 1980’s, with higher mortality rates and younger age structure observed in 2018 compared to 1980-1982 (Davies et al., 2020). In addition, no eggs and very few larvae were found on the historic spawning ground despite the presence of spawning adults, supporting the apparent observed decline (Davies et al., 2020). There is an ongoing NRW investigation into this decline.

Data from wider Irish sea level studies such as International Council for the Exploration of the Sea (ICES) are difficult to relate to the assessment of condition at the SAC and feature level and some species that have been assessed by ICES may not even occur at the individual SAC level. However, populations of various larger-bodied bony fish species in the Irish Sea, such as bass, cod, herring, whiting, plaice and pollack, have declined in recent years (ICES, 2024a, 2024b, 2024c, 2024d, 2024e, 2024f). While there are limited data on the status of other species, the depletion of a number of larger, higher trophic level predatory species in the Irish Sea may have shifted the structure of the wider fish community to an overall lower trophic level with fewer larger predatory fish species.

Operational monitoring of fish impingement and entrainment is carried out at Pembroke Power Station’s cooling water intake system in the Milford Haven Waterway. Further monitoring of the fish community of the Milford Haven commissioned by the operators of the Pembroke Power Station includes subtidal trawls, intertidal seine nets and ichthyoplankton sampling. From the operational monitoring programme data and analysis, decreases, and a negative trend, in impingement numbers of numerous species within the fish community have been observed. The species in question include clupeids, gobies, gadoids, flatfish and sandeels and form over 80% of the recorded impingement abundance. A similar decreasing trend in fish catches was observed in the subtidal trawls. Data from the intertidal seine nets showed variable results with an overall increase in marine juvenile and estuarine resident species in summer but low abundance in winter catches and no trend was observed for the icthyoplankton community composition, which remained similar throughout the monitoring period (A. Scorey (NRW), pers. comm.). Further investigation is needed into the fish community abundance and structure across the LSIB feature in the Milford Haven Waterway.

Overall, the poor condition of the maerl bed and certain areas within the Milford Haven inlets, along with concerns over the decline of sponge communities at Warrior Reef, disturbance to subtidal reef-associated communities at Beggars Reach Reef, and the decline in spawning herring and decrease in shoot density of *Z. marina* in Milford Haven Waterway contributed to the abundance, distribution and species composition of communities indicator to fail with high confidence. Most of the issues are localised in the Milford Haven Waterway.

Invasive non-native species

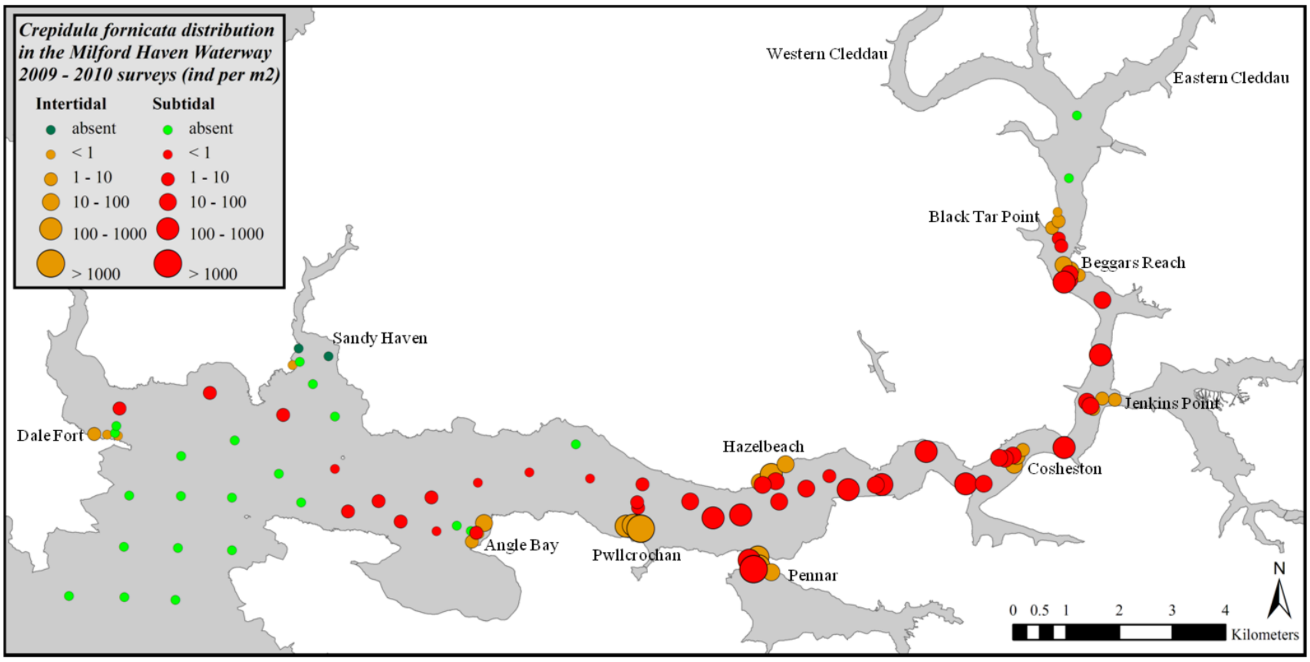
There has historically been a high number of non-native species (NNS) in the Milford Haven Waterway. The American slipper limpet *Crepidula fornicata* has been recorded in various locations within the SAC for many years. The species has been found in superabundant aggregations across various intertidal and subtidal habitat types within the Milford Haven Waterway (Figure 7) (Bohn, 2012; 2014), and natural habitats within the waterway have changed where the species dominates (M. Camplin (NRW), pers. comm.). Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities.

The species has also been found within the maerl bed in Milford Haven Waterway, which may have a potential smothering effect on the maerl (Mercer et al., 2025). Given the high density of *C. fornicata*, including its presence in sensitive habitats (i.e. maerl) and its impact on natural habitats within the Milford Haven Waterway, the primary target of the invasive non-native species (INNS) indicator has failed. Confidence is medium as there are limited data on the density and distribution of *C. fornicata* within the last six years.

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 LSIB feature. The impact of this species on the condition of the LSIB feature is not known, however it is possible for this species to have far reaching implications on native communities (Tillin et al., 2020). The arrival of this species in the LSIB feature within the last reporting cycle has resulted in a fail with high confidence for the tertiary target of the NNS indicator.

Other NNS are known to be present in Pembrokeshire Marine SAC, within the LSIB feature. The large brown kelp wakame *Undaria pinnatifida* has also been recorded within the Milford Haven Waterway since 2014. 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; 2024). *W. subatra* is also known from South Hook Point and Pembroke Power station. Records of the San Diego sea squirt *Botrylloides diegensis,* initially found in 2014, has also been found at Pembroke Power station, Pembroke Dock and Neyland (Wood et al., draft). The other NNS previously recorded in the LSIB feature or nearby are the siphoned Japan weed *Dasysiphonia japonica*, pom-pom weed *Caulacanthus ustulatus (okamurae),* fanworm *Ficopomatus enigmaticus*, red alga harpoon weed *Asparagopsis armata*, wireweed *Sargassum muticum.* The purple fan worm *Bispira polyoma* has been found for the first time in 2023 in the SAC but it is not within the LSIB feature. The spread and full extent of the impact of the NNS recorded in the LSIB feature are currently unknown.

Figure 7. Densities of *Crepidula fornicata* in intertidal and subtidal sites in the Milford Haven Waterway, surveyed in 2009 and 2010 (Bohn, 2012).



Reasons for target failure

The assessment of LSIB feature in the Pembrokeshire Marine SAC failed five primary targets, six 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.

Distribution and extent of habitats and communities

This indicator target has a primary weighting. There has been a dramatic reduction in the extent of maerl since 2005 (Mercer et al., 2025). The clear causes of this observed decline are not yet confirmed. However, from the ongoing NRW investigation it is likely due to the cumulative effects of a combination of pressures. These include disturbance of the seabed surface, sedimentation, pollution and chemical changes, and INNS (Ratcliffe, 2025). There are concerns that the South Hook jetty refurbishment (2005-2007) have contributed to the decline of maerl (Ratcliffe, 2025). The failure is localised to the small maerl bed within the Milford Haven Waterway.

Sediment composition and distribution

This indicator target has a primary weighting. There has been a significant increase in silt content between 2014 and 2019 in some areas within the Milford Haven Waterway. Further investigation is required to determine the causes of this increase and how widespread the issue is within the waterway. Additionally, some changes in sediment composition were identified at the Gann, likely a result of bait digging activities. A national code of conduct for bait collectors has been developed for Wales (code of conduct). The objective is to reduce impacts from bait collection on relevant protected features. The failure of this indicator is localised to some areas within the Milford Haven Waterway.

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. Two WFD waterbodies that overlap with the Milford Haven Waterway (Milford Haven Outer and Inner) had failing levels of DIN. These waterbodies were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. Failure of the supporting water quality elements opportunistic macroalgae in Milford Haven Inner waterbody further supports the nutrient issues present in this waterbody. 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 from specific agricultural practices and activities 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. The failure is localised to the Milford Haven Waterway, and there are no recorded nutrient issues within St Brides Bay.

Abundance, distribution and species composition of communities

This indicator did not meet its primary target for several reasons. These were the poor condition of the maerl bed and its associated epibiota, and large variation in the intertidal infaunal communities within the Milford Haven inlets. In addition, there were the concerns over the decline of sponge communities at Warrior reef, disturbance to subtidal reef-associated communities at Beggars Reach reef, the decline of herring, and a decrease in shoot density of *Z. marina* in the Milford Haven Waterway. There was also a large loss of *E. verrucosa* and decline in *A. glomeratum* colony in the Skomer MCZ, which is within St Brides Bay.

Elevated levels of nutrients and contaminants are likely contributing to the observed changes in the species composition of communities within the Milford Haven Waterway. Other localised issues, e.g. bait digging activities in the Gann, has also contributed to the observed changes in infauna communities. Further investigation is now needed to confirm what the reasons behind these failures are. Identification of the reasons causing these failures will allow management measures to be identified and implemented to allow improvement in the Milford Haven Waterway.

Invasive non-native species; non-native species

This indicator failed to meet its primary and tertiary targets. The primary target failure is due to the increasing number of *C. fornicata*, which has been found in superabundant aggregations across various intertidal and subtidal habitats in the Milford Haven Waterway (Bohn, 2012; 2014). This species has altered natural habitats and is present in sensitive habitats in the waterway (maerl bed) (Mercer et al., 2025). The failure of the primary target is localised to the Milford Haven Waterway.

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.

The failure of the tertiary target of NNS indicator is due to the recent arrival of *D. vexillum* introduced in the LSIB feature. 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.

Topography of the feature

This indicator failed to meet its secondary target due to visual evidence and preliminary results showing damage to the topography of the seabed from anchoring of large vessels in St Brides Bay. Seabed disturbance can result when the anchor drops into the substratum and disturbs sediments within its footprint; whilst at anchor if the vessels move or rotate in different tidal and weather regimes causing the anchor chain to drag; and during anchor retrieval, leaving an anchorage scar. Currently there are no quantitative measures of the damage, and there is a limited understanding of the longevity and extent of any anchoring disturbance, and its potential impact on the biota within the bay. In addition, there have been small scale changes to the topography in the nested mudflats and sandflats feature within the Gann flats in the Milford Haven Waterway. These changes are due to bait digging activities.

Sediment quality: oxidation-reduction profile (redox layer)

This indicator failed its secondary target due to the extensive opportunistic macroalgae growth within the Milford Haven Waterway, and the subsequent anoxic conditions this causes in the sediments. This has been observed where areas of opportunistic macroalgae growth has been recorded within the Milford Haven Waterway. The assessment of this indicator has been based on imagery and expert judgement, with a lack of a long-term quantitative data series. Quantification of the redox layers beneath opportunistic macroalgae would be required to raise the confidence of the failure. The failure is localised to the Milford Haven Waterway.

Sediment quality: carbon

This indicator target has a secondary weighting. The carbon content has increased across the monitoring period at the two Milford Haven inlet monitoring locations within the LSIB feature. Increases in carbon are likely to be from an increase in the amount of organic material being deposited and can be indicative of eutrophication and reduced oxygen in the sediment. The failure is localised to the Milford Haven Waterway.

Sediment quality: contaminants

This indicator target has a secondary weighting. Levels exceeding sediment quality guidelines of PAH compounds and heavy metals have been recorded in sediment samples within both bays in the SAC. Contaminants with levels above the most stringent ecological guidelines in some of the most recent sampling years were benzo(g,h,i)perylene, chromium, lead, mercury and TBT. Various other contaminants including metals had concentrations above the less stringent guidelines in the most recent years of sampling.

Investigations into the sources of these contaminants, and the full impact on the feature have not been carried out.

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. 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. The failure is localised to the Milford Haven Waterway, and there are no recorded nutrient issues within St Brides Bay.

Water quality: contaminants

This indicator target has a secondary weighting. The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification. The failing chemicals were 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 waterbody bed sediments, or point sources from continuous sewage discharge from wastewater treatment. However, an investigation into the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is 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 environmental quality standards (EQS) is based on the most sensitive taxa and may not be applicable to all of the LSIB biota. The impacts of PAH on the LSIB feature are not fully understood. The failure is localised to the Milford Haven Waterway.

Threats to condition

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

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

Unconsented infrastructure

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

Invasive non-native species

The red seaweed worm wart weed *Gracilaria vermiculophylla* has been found close to the SAC, in the Nevern. This species is not currently within the LSIB feature, but has the potential to establish quickly in shallow soft-bottomed bays and estuaries as it has broad environmental tolerances (Maggs and Magill, 2014). *G. vermiculophylla* can have a detrimental impact on the feature as seen in mudflats and sandflats feature in Carmarthen Bay and Estuaries SAC. The species can alter the sedimentation and topography and could alter the habitat in the long-term if at high densities (Maggs and Magill, 2014).

*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 and other features 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 reefs and therefore the LSIB feature.

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

Water quality: contaminants

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

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

Management of coastal defences

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

Where defences continue to be maintained, there are potential impacts on coastal processes and associated habitats and species. Intertidal habitats may also be lost as a result of coastal squeeze (Oaten et al, 2024).

Climate change

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

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

Further threats are associated with the nested features and can be found in the relevant sections of the report.

- Recreational access and collection (reefs condition assessment)
- Seabed disturbance (reefs condition assessment)

Evidence gaps

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

Listed below (There are additional evidence gaps concerning the nested features, which can be found in the relevant sections of this report.

Table 5) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments. There are additional evidence gaps concerning the nested features, which can be found in the relevant sections of this report.

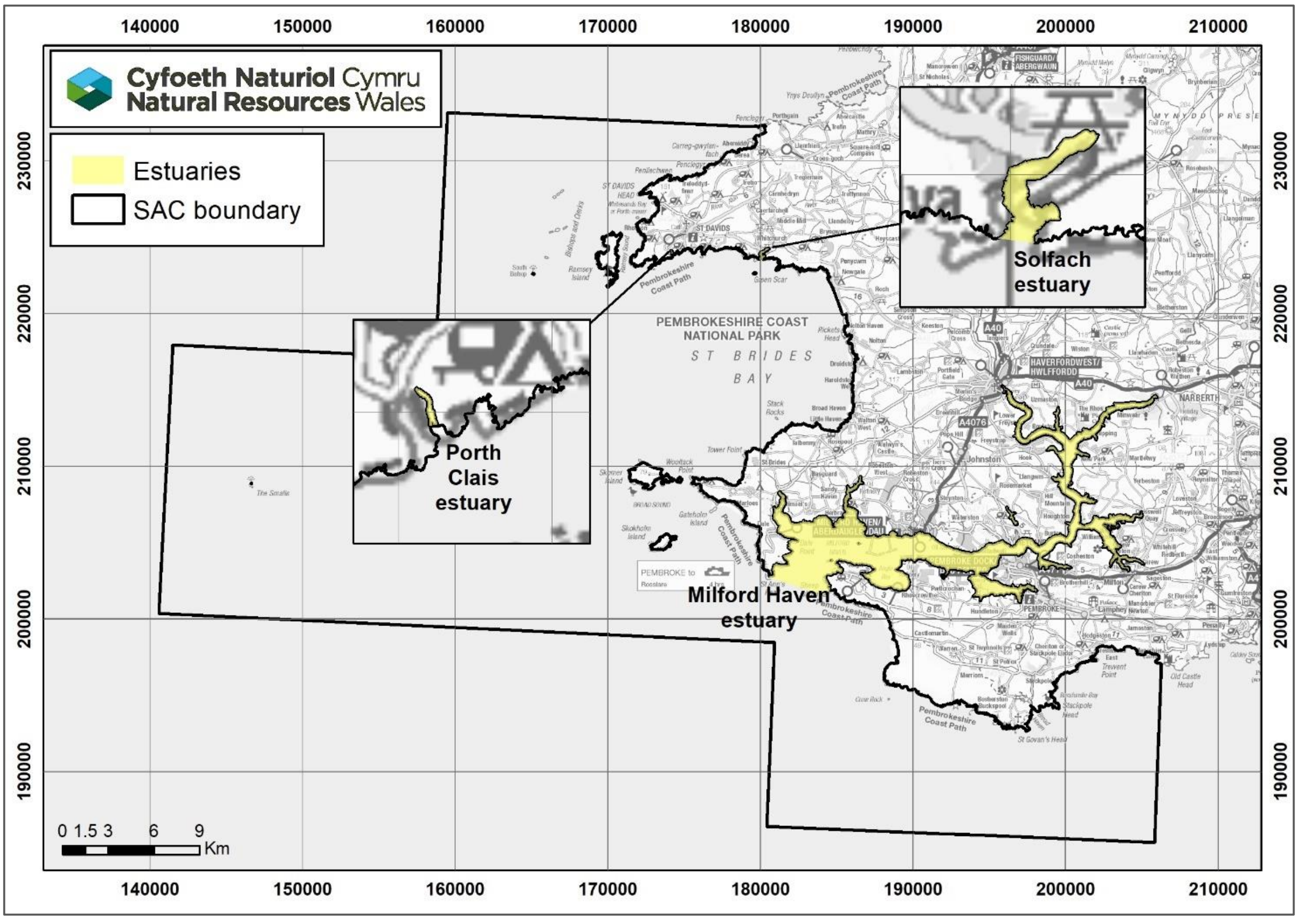
Table 5. Evidence gaps for the LSIB feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Abundance, distribution and species composition of communities (P)	The fish community element did not contribute to the condition outcomes	• Fish communities were broadly discussed for all SACs using reports including ICES data. Although these reports provide an indication of fish numbers, they have certain limitations. The large area covered makes it unsuitable for specific LSIB or individual SACs. More data would be required to adequately assess fish communities in LSIB.
Invasive non-native species (P)	Medium confidence (limited data)	• The spread and impact of the NNS currently present on the LSIB feature within the SAC is not fully understood. More targeted surveys and investigation on the impact of NNS on LSIB are needed.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was difficult to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening for all SACs. • There is widespread evidence of opportunistic macroalgae in Pembrokeshire Marine SAC, which can lead to anoxia in sediments. Quantification of the redox layers beneath opportunistic macroalgae would be required to strengthen the assessment conclusions.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Unknown	• Further evidence on temperature change is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

3.2. Estuaries condition assessment

The estuaries feature in the Pembrokeshire Marine SAC comprises three estuaries, Milford Haven, Solfach and Porth Clais (Figure 8). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 8. Map of the estuaries feature in Pembrokeshire Marine SAC.



The estuaries feature in the SAC includes the nested features: large shallow inlets and bays (LSIB), reefs, mudflats and sandflats and Atlantic salt meadows (ASM). Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 6 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 6. Condition assessment of estuaries in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	No significant decrease in extent of estuaries within the SAC, allowing for natural change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the extent of estuaries in the 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 the distribution of the estuaries within the SAC, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution of estuaries in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of estuarine habitats and communities, allowing for natural change and variation. (P)	• The extent of the Milford Haven maerl bed within the feature has reduced dramatically between 2005 and 2023 causing the failure of the target. • Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution and extent of other habitats and communities of estuaries and its nested features in the Pembrokeshire Marine SAC. • Confidence is high as the long term monitoring data shows a significant decline in the extent of the maerl bed.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the estuaries, allowing for natural change and variation. (P)	• The sediment data from NRW grab surveys within the Milford Haven estuary (2007-2021) showed some variation which was deemed likely to be natural. • The maerl bed investigations, and licenced activities assessments within the Milford Haven estuary indicated no concerns. • Although an issue was identified for sediment composition in the Gann, the nested overlapping mudflats and sandflats feature passed for this indicator. • Monitoring from the Neyland Yacht Haven marina found that the silt content increased significantly across the survey area between 2003 and 2019. This large change in silt content is concerning. • The silt content increase within Milford Haven estuary has resulted in the fail. • Confidence is low as it is not clear why the silt content has increased and how widespread the issue is within the estuary.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to estuarine infaunal communities, allowing for natural change and variation. (S)	• The stations assessed for the redox layer are all located within Angle Bay. The redox layer indicated no clear trend over the years. • A greater spatial coverage is needed to understand ongoing processes and confirm overall trends. • Opportunistic macroalgae cover has caused anoxic layers in sediments in some locations within Milford Haven estuary, however there are limited quantitative data to confirm this. This has led to the indicator failure. • Confidence is low as the assessment was based on visual observations and expert judgement.	**Fail**	Low
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to infaunal communities, allowing for natural change. (P)	• Organic carbon content has declined throughout the monitoring period at the Clean Safe Seas Environmental Monitoring Programme (CSEMP) sampling station in the Milford Haven estuary. • The carbon content at each NRW monitored locations in the Milford Haven estuary (eastern and western Cleddau, Carew / Cresswell, Cosheston Pill, Pembroke River, Sandy Haven, Angle Bay and the Gann) has increased across the period. • The indicator failed to meet the target due to the increase in carbon at the monitored Milford Haven locations. • Confidence is high due to the consistent increase in carbon in each location, and the availability of long term monitoring data with broad spatial cover.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• PAHs were recorded in Milford Haven estuary at the CSEMP sampling location in 2023, and the NRW monitored grab sampling locations in 2021. Some PAHs were above the most stringent ecological guidelines. • Some heavy metal concentrations were above the less stringent guidelines in CSEMP and NRW monitored grab sampling locations in most recent years. Mercury was above the most stringent ecological guideline in 2018 in one grab sampling site (in the maerl bed). • The impact of the contaminants in the sediments on the estuaries feature is not fully understood, leading to a reduced confidence.	**Fail**	Medium
Morphological equilibrium	Maintain the characteristic physical form and flow of the estuary, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the morphological equilibrium of estuaries in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the estuaries. (S)	• Bait digging at the Gann and Angle Bay causes small scale topography alteration. This was not considered to be a large enough effect to fail the whole feature in the SAC. • Since designation in 2004, there are no other anthropogenic impacts known to have significantly affected the topography of estuaries in the Pembrokeshire Marine. • Confidence is medium due to concern of the Gann and as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are no new anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the estuaries feature in the Pembrokeshire Marine SAC. • However, historic activities may be continuing to have an effect on the sediment transport, which may have contributed to an increase in siltation within the estuary. Levels of silt in the maerl bed are currently under investigation by NRW but no conclusions have been reached yet. • Confidence in this pass is low due to concerns about increased siltation and as the assessment has been based on expert judgment.	**Pass**	Low

<table>
<tr><th>Indicator</th><th>Target</th><th>Assessment rationale</th><th>Target assessment</th><th>Target confidence</th></tr>
<tr><td>Water quality: nutrients (DIN only)</td><td>The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)</td><td>Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais estuary 0.02%.
Two WFD waterbodies overlap with the Milford Haven estuary. Both were classified as Poor status in the 2024 cycle 3 interim classification (Milford Haven Inner and Outer). Combined, these waterbodies overlap with 93% of the Milford Haven estuary (92% of the whole feature).
Two WFD waterbodies overlap with the Solfach estuary.
The Solfach Estuary waterbody was classified as Bad status. It overlaps with 79% of the Solfach estuary (<1% of the whole feature).
The Pembrokeshire South waterbody was classified as High status. It overlaps with 4% of the Solfach estuary.
One WFD waterbody overlaps with the Porth Clais estuary. This waterbody, Pembrokeshire South, was classified as High status. It overlaps with 92% of the Porth Clais estuary.
Confidence is high as the waterbodies with failing DIN status overlap with a large proportion of the feature (93%).</td><td>Fail</td><td>High</td></tr>
</table>

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)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais estuary 0.02%. • Three of the four WFD waterbodies that overlap with the estuaries feature in the SAC were High status for phytoplankton in the 2024 cycle 3 interim classification (Milford Haven Outer, Milford Haven Inner, and Pembrokeshire South). Combined these represent 91% of the whole feature in the SAC. • The Solfach Estuary waterbody was not classified for this WFD element. It overlaps with 79% of the Solfach estuary (<1% of the whole estuaries feature). • Confidence is medium due to the unclassified waterbody.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais estuary 0.02%.
		• Two WFD waterbodies overlap with the Milford Haven estuary.
		  ○ The Milford Haven Inner waterbody was classified with a Moderate status for opportunistic macroalgae in the 2024 cycle 3 interim classification. This waterbody overlaps with 33% of the Milford Haven estuary (33% of the whole estuaries feature).
		  ○ The Milford Haven Outer waterbody was classified as Good status for this WFD element. It overlaps with 60% of this estuary (59% of the whole feature). There is evidence of localised opportunistic macroalgae in this waterbody.
		• All other relevant WFD waterbodies in the SAC were not classified for this WFD element. This includes the WFD waterbodies that overlap with the Solfach and Porth Clais estuaries.
		• High confidence has been attributed to the fail as there is extensive evidence of opportunistic macroalgae in the Milford Haven Inner waterbody, and localised evidence of issues in the Milford Haven Outer waterbody.
			Fail	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais 0.02%. • All four overlapping WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is medium due to samples only being taken from the surface of the waterbody which may not detect issues for more demersal habitats within the estuaries feature.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais 0.02%.
		• Two WFD waterbodies overlap with the Milford Haven estuary.
		  ○ The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to PBDE and PAH. It overlaps with 33% of this estuary (33% of the whole estuaries feature).
		  ○ The Milford Haven Outer waterbody has a pass for chemicals. It overlaps with 60% of this estuary (59% of the whole feature).
		• All other relevant WFD waterbodies in the SAC were not classified as the chemicals have not been assessed within the last six years. These waterbodies overlap with a very small proportion of the feature.
		• Confidence is medium as the human health standard has been used for PBDE.
			Fail	Medium

Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the estuaries feature in the Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties of the water column	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from intertidal and subtidal temperature loggers were available. Most of these temperature loggers overlap with the estuaries feature. Some temperature loggers in the SAC showed an increase in the number of days with higher temperatures, and potential step change in temperature. • A 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

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)	• A recent study indicated that benthic communities of the Milford Haven estuary were in a healthy state. • The IQI, estuarine fish and intertidal seagrass WFD elements in the overlapping WFD waterbodies were assessed with Good or High status in the 2024 cycle 3 interim classification. • The indicator failed for the nested features: mudflats and sandflats, and reefs (see detailed text). • Percentage cover of live maerl has declined by nearly 80% over the monitoring period. There have been directional shifts in epibiota and infauna community composition over the survey period, as well as changes to infaunal species richness over time. • The shoot density of the subtidal seagrass *Z. marina* has declined since 1999 in Littlewick Bay, Milford Haven estuary. • The herring population in the Milford Haven estuary is in decline. • Confidence is high given the large number of species declines.	**Fail**	High

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)	• *Crepidula fornicata* has been recorded in various locations in the SAC starting in 1960 and now reach a high density in some areas, mostly within the Milford Haven estuary. • *C. fornicata* has previously been found in superabundant aggregations across various intertidal and subtidal habitats within the Milford Haven estuary. Where the species dominates, natural habitats have been altered. *C. fornicata* is also found in sensitive habitats (maerl) within the estuary. • Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities. • For these reasons the indicator failed to meet its target. Confidence is medium as there are limited data on the density and distribution of *C. fornicata* within the last six years.	**Fail**	Medium

Indicator	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 on Carr Rocks and on Barnlake Point (Neyland) for the first time, just within the estuaries feature boundary in 2023. • 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 Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The estuaries feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of indicators with failing targets (Table 7). All associated failures are localised within Milford Haven estuary, the largest estuary of the three within the SAC. However, it should be noted that there is more monitoring within the Milford Haven estuary. There were also limited or absent data for two key indicators to inform on the condition of the feature (see evidence gaps). 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 7 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 7. Summary of the condition assessment for estuaries in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Estuaries	**Unfavourable (medium confidence)**	Distribution and extent of habitats and communities (P) Sediment composition and distribution (P) Sediment quality: carbon (P); contaminants (P) Water quality: nutrients (DIN only) (P) Abundance, distribution and species composition of communities (P) Invasive non-native species (P); non-natives species (T) Sediment quality: oxidation-reduction profile (redox layer) (S) Water quality: opportunistic macroalgae (S) Water quality: contaminants (S)	• There has been a large reduction in live maerl cover. • Silt content has increased in some areas of the Milford Haven estuary. • Organic carbon content of sediments has increased in some Milford Haven monitoring locations. • Levels of PAHs and heavy metals in sediments are exceeding sediment quality guidelines within the Milford Haven estuary. • There are high nutrient levels in the Milford Haven Inner, Outer, and Solfach Estuary waterbodies. • Infaunal opportunistic species have increased; there have been declines in live maerl, *Z. marina* shoot density, herring population and sponge thickness; and there are disturbed reef communities within Milford Haven estuary. • *C. fornicata* has increased which has altered habitats. There is also an increasing number of NNS (e.g. *D. vexillum*). • Opportunistic macroalgae is present in the Milford Haven Inner waterbody, which has led to anoxic layers in sediments. • Levels of PBDE and PAH in the water column in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change • Recreational access and collection • Unconsented infrastructure • Siltation

Detailed assessment information

Extent and distribution

Extent and Distribution of the feature

The extent and distribution of the feature indicators in the Pembrokeshire Marine SAC passed their target as there are currently no known anthropogenic impacts that have significantly affected the extent of the estuaries feature since designation in 2004. Comparison mapping has not been used to assess the extent and only expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium. There is evidence of localised unconsented construction of artificial structures such as slipways and gabions on the shore and cliff front, which are likely to impact the reef extent, this needs mapping and will be something to pay close attention to in the next assessment.

Distribution and extent of habitats and communities

Investigations on the Milford Haven maerl bed were carried out using a combination of dive surveys and drop-down videos between 2004 and 2023. Results have shown a large reduction in the extent of the maerl bed since 2005 (Mercer et al., 2025). There are concerns that the South Hook jetty refurbishment (2005-2007) have contributed to this decline (Ratcliffe, 2025). There are currently no known anthropogenic impacts that would significantly affect the extent of the estuaries feature and its nested features in other parts of the SAC. Overall, the large decline in the maerl bed extent was deemed enough to fail the distribution and extent of habitats and communities indicator target with high confidence.

Sediments

The assessment of the indicators relevant to sediment composition and quality consider data from the Milford Haven estuary only. There were no data available for the Solfach and Porth Clais estuaries.

Composition and distribution

The sediment composition and distribution indicator in the condition assessment of the nested mudflats and sandflats feature passed its target. Some issues were identified at the Gann, with apparent changes in sediment composition particularly between 2012 and 2018, with an increase of silt and pebble but reduction of fine sand. Although this potentially indicates some disturbance there, this alone was not deemed a large enough impact to fail the nested mudflats and sandflats feature (see Section 3.6).

Granulometric analysis from NRW grab samples from monitored locations within Milford Haven estuary (2007-2021) indicated little variation in sediment composition. The majority of stations in the Milford Haven grab sediments remained fairly stable across the monitoring period.

The subtidal estuary sediments have been monitored as part of the MHWESG surveys, through the maerl bed investigations, and from licenced activities assessments within the Milford Haven estuary. The MHWESG surveys found that sediments are poorly sorted, with the highest silt or clay content in the middle of the estuary channel (Warwick, 2017; Warwick et al., in prep). Due to the methodology used, there was no information on the temporal patterns for these stations, therefore they were considered temporally stable in the report.

Surveys at the maerl bed stations in the Milford Haven estuary were carried out in 2005, 2010, 2016 and 2023. There was no difference in particle size distribution between years, however it did differ between sampling sites (Bunker and Ractliffe, 2025) and diver observations indicated a possible increase in silt at the monitoring site.

There is a general concern from NRW experts that the silt content has increased in the Milford Haven estuary. As part of the monitoring for the Neyland Yacht Haven marina, subtidal sediment particle sizes were assessed between 2003 and 2008. Past NRW analyses showed significant increases in silt levels over time from January 2004 to April 2007 at most monitored stations (Camplin, 2005; 2008). Further monitoring was carried out in 2010, 2013, 2016 and 2019. This monitoring further supports the finding of a significant silt content increase across the survey area as a whole (Preen and Mazik, 2019). This large change in silt content is concerning.

The siltation increase within the Milford Haven estuary contributed to the fail of the sediment composition and distribution indicator for the estuaries feature. A low confidence was attributed to the fail as it is not clear why the silt content has increased and how widespread the issue is within the estuary.

Oxidation-reduction profile (redox layer)

Quantitative data on the redox layer of sediments has been analysed in the Angle Bay sampling sites only. These data indicated no clear trend over the years. In the wider Milford Haven estuary, there is evidence of opportunistic algae within the site (Lock, 2021a). Excessive opportunistic algal mat growth will quickly smother the sediment, causing anoxic conditions. This has been observed where extensive areas of opportunistic macroalgae growth has been recorded within the Milford Haven estuary, for example within Sandy Haven, where anoxic layers have been observed beneath algal mats (Figure 3). This had led to a failure for the redox layer indicator. The confidence attributed to the failure has been reduced to low as the conclusion has been based on data from a limited spatial coverage, visual observations and expert judgement. The stations assessed for the redox layer are all located within Angle Bay, which is outside the opportunistic macroalgae sampling locations and may explain why there was no clear trend there.

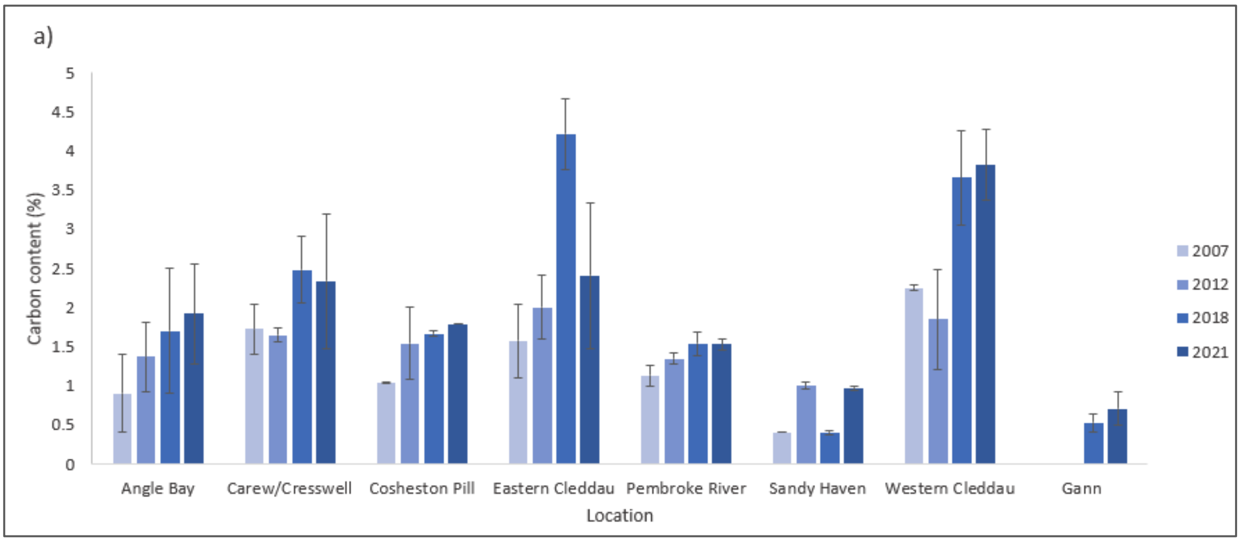
Organic carbon content

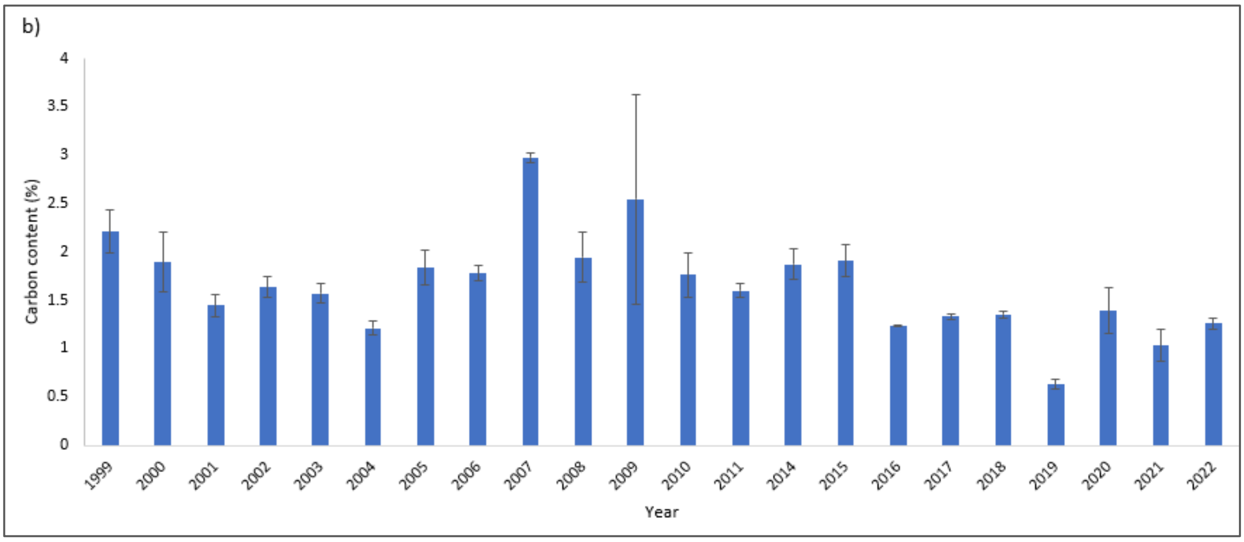
The assessment of the sediment quality (organic carbon and contaminants) indicators used data from NRW monitored sediment contaminants as part of the CSEMP sampling in one location in Milford Haven estuary in various years up to 2023. This location is considered to be representative of the whole estuary as it is upstream of the main industrial areas. Additional sediment grab sampling has been carried out in the Milford Haven estuary over four years (2007, 2012, 2018 and 2021). These were grouped by location for analysis. In total, there were 25 sampling locations that overlap with the estuaries feature which were considered for the assessment of these sediment quality indicators.

The organic carbon content at all of the grouped locations has increased over the whole monitoring period (Figure 9a). The location with the highest carbon content in 2021 was the Western Cleddau, where it has increased from 2.3% in 2007 to 3.8% in 2021 (Figure 9a). At the subtidal CSEMP location the carbon content has decreased over the monitoring period from 2.2% in 1999 to 1.3% in 2022 (Figure 9b). The carbon content has not been compared against any defined ecological standard as it is highly variable by location, however increases in carbon can be an indicator of organic enrichment and reduced oxygen in the sediment.

The indicator failed to meet the target with high confidence due to the increase in carbon at various monitoring locations. Additionally, initial outputs of deep cores from the MHWESG show that total organic carbon content has increased over a longer historical time period (i.e. several decades) at some locations (e.g. Pembroke River, Boulston and Cosheston Pill) (MHWESG, pers. comm.). The more recent observed increases in carbon are therefore likely a continuation of a long-term trend of increasing carbon at these locations. This will be something to look into in the next assessment when the analysis has been completed.

Figure 9. Average carbon content (±S.E.) from sediment grab samples in Milford Haven estuary. Samples from a) the grouped locations in the Milford Haven estuary in 2007, 2012, 2018 and 2021, and b) the CSEMP location from 1999 to 2022.





Contaminants

Historically, there have been various peaks in hydrocarbons and metals in sediments in the Milford Haven estuary, 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 OSPAR guidelines, CEQG and Cefas action levels. Further information is available in the IMCA final report.

Levels of 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 Milford Haven estuary (Pembroke River Upper) in 2021, where concentrations of three of the sampled PAH compounds (anthracene, benzo(a)anthracene and fluoranthene) 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. In addition, various PAHs were above the most stringent guidelines in 2018 at some of the grab sampling locations over the maerl bed in the Milford Haven estuary. It is not known if the levels still exceed the guidelines at these monitoring sites as they have not been sampled since 2018.

Heavy metal concentrations were also recorded at various locations. The concentration of mercury was above the most stringent guideline (OSPAR effects range low) in 2018 at one of the grab sampling locations over the maerl bed in the Milford Haven estuary. The concentrations of other heavy metals (chromium, arsenic, copper and zinc) were above the less stringent guidelines in some of the sampling locations (CSEMP and grab sampling) in most 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. PCBs have mostly declined at both the CSEMP and grab sampling stations since earlier years, and all are below the more stringent guidelines in the most recent year of sampling. The concentration of one PCB congener (PCB 118) was above or very close to its most stringent guideline (OSPAR environmental assessment criteria) in seven of the grab sampling locations in 2018, but it has since declined in 2021.

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 estuaries feature is not fully understood. This caused the confidence to be reduced to medium.

Morphological equilibrium, topography and hydrodynamic and sediment transport processes

The morphological equilibrium, topography and hydrodynamic and sediment transport processes are not well researched. The morphological equilibrium and topography of the feature indicators met their targets with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the feature. Bait digging at the Gann cause small scale topography alteration. This was not considered to be a large enough effect to fail the whole feature in the SAC, however it also contributed to the medium confidence for the topography indicator. A national code of conduct for bait collectors has been developed for Wales (code of conduct). It will take time to see if these measures are effective in reducing small scale topography alteration.

The hydrodynamic and sediment transport processes indicator met its target as there are no new anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the estuaries feature in the Pembrokeshire Marine SAC. However, historic activities may be continuing to have an effect on the sediment transport, which may have contributed to an increase in siltation within the Milford Haven estuary. A NRW investigation is ongoing to determine whether an increase in silt may have impacted the maerl bed and whether this is of anthropogenic origin (Ratcliffe, 2025). The confidence in the indicator pass was reduced to low due to this concern, and as the assessment was based on expert judgment.

The freshwater flow indicator could not be assessed due to limited resource.

Water quality

It has been estimated that 93% of the estuaries feature falls within five WFD waterbodies (Figure 10). These are likely to be a good reflection of the overall effect of water quality on the feature. The Milford Haven estuary is the largest of the three estuaries within the SAC (99.7% of the whole estuaries feature). The Solfach (0.2%) and Porth Clais (0.02%) estuaries are much smaller by size.

Table 8. Designated estuaries within the Pembrokeshire Marine SAC and the WFD waterbodies that overlap.

Estuary	WFD waterbody	Degree of overlap across indv. estuary (%)	Degree of overlap across estuaries feature (%)
Milford Haven	Milford Haven Outer	59.46	59.30
Milford Haven	Milford Haven Inner	33.16	33.07
Solfach	Solfach Estuary	79.27	0.19
Solfach	Pembrokeshire South	4.26	0.03
Porth Clais	Pembrokeshire South	92.28	0.03

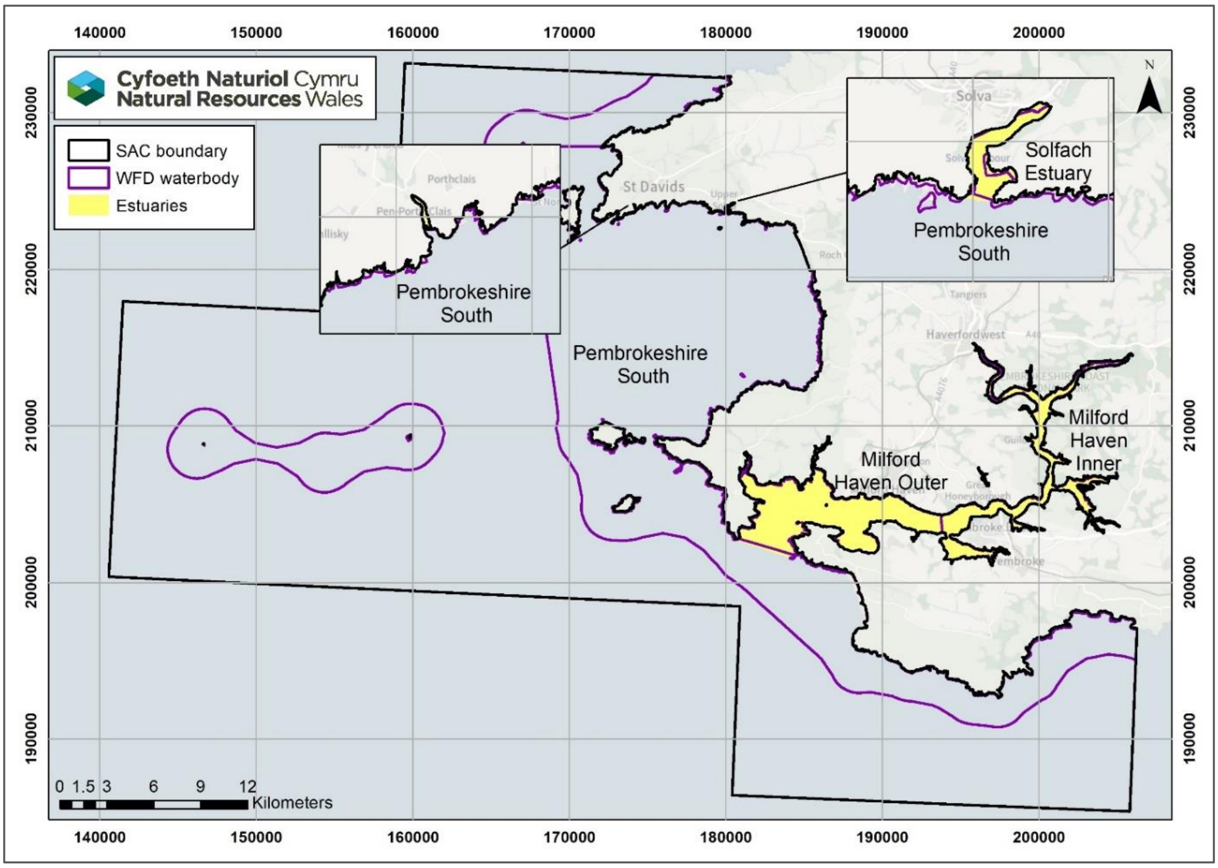
Nutrients (DIN only)

The Milford Haven estuary comprises two WFD waterbodies: the Milford Haven Outer and the Milford Haven Inner waterbodies (Table 8). Both of these waterbodies were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. Combined, these overlap with 93% of the Milford Haven estuary. The Milford Haven Inner and Outer waterbodies also failed in previous cycles, and the Milford Haven Outer waterbody has deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation reports of these waterbodies confirmed the DIN failures in the 2018 cycle 2 interim and the 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.

The Solfach estuary comprises two WFD waterbodies: the Solfach Estuary waterbody and the Pembrokeshire South waterbody (Table 8). The Solfach Estuary waterbody overlaps with the largest proportion of this estuary, and it was classified as Bad status for DIN in the 2024 cycle 3 interim classification. The other overlapping WFD waterbody, Pembrokeshire South was classified as High status, however this classification was rolled forward from the 2018 cycle 2 interim classification. The Porth Clais estuary also overlaps with the Pembrokeshire South waterbody.

The nutrients indicator (DIN only) failed to meet the target as high levels of DIN have been recorded in two of the three estuaries, Milford Haven and Solfach. High confidence was attributed to the failure as the failing WFD waterbodies overlap with a large proportion of the feature, and as the investigations have confirmed nutrient issues in these waterbodies. Confidence was also increased due to the biological response to high nutrient levels in the Milford Haven Inner waterbody, where opportunistic macroalgae was classified with a Moderate status.

Figure 10. Map of the WFD waterbodies that overlap with the estuaries feature within Pembrokeshire Marine SAC.



Phytoplankton

The phytoplankton indicator passed its target as three WFD waterbodies that overlap with a large proportion of the feature (Milford Haven Outer, Milford Haven Inner and Pembrokeshire South) were classified with a High status for the phytoplankton element in 2024 cycle 3 interim classification. Combined, these waterbodies represent 91% of the whole estuaries feature (Table 8). The Milford Haven Outer waterbody improved from Good to High status between the 2021 cycle 3 and the 2024 cycle 3 interim classifications.

The Solfach Estuary has not been classified for this element in any cycles. Classification of some WFD waterbodies is not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Confidence was reduced to medium due to the unclassified waterbody.

Opportunistic macroalgae

One of the two WFD waterbodies that overlap with the Milford Haven estuary, the Milford Haven Inner waterbody, was classified with a 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, in which extensive and recurring coverage has been recorded in various locations including Cosheston Pill (Figure 11a), Garon Pill (Figure 11b), and Carew and Cresswell rivers (Lock, 2021a). There has been evidence of opportunistic macroalgae growth since 2007, indicating that this has been a long-lasting issue within the Milford Haven Inner waterbody. The Milford Haven Outer waterbody that also overlaps with the Milford Haven estuary, was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification. Although it is not a failing element for this waterbody, there have been localised issues with opportunistic macroalgae recorded in the more sheltered bays including Angle Bay, Sandy Haven (Figure 11c) and Dale Gann (Figure 11d) (Lock, 2021b).

The WFD waterbodies that overlap with the Solfach and Porth Clais estuaries 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 do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Overall, the opportunistic macroalgae indicator failed to meet the target due to the Moderate status WFD classification for this element in the Milford Haven Inner waterbody. The confidence in the fail was high due to the extensive evidence of opportunistic macroalgae in the Milford Haven Inner waterbody.

Figure 11. Opportunistic macroalgae on saltmarsh and mudflats in the Milford Haven estuary. Photos in a) Cosheston Pill in 2024, b) Garron Pill in 2019, c) Sandy Haven in 2008 and d) Dale in 2023.

Dissolved oxygen

The dissolved oxygen indicator met its target as all four overlapping WFD waterbodies were classified with a High status for dissolved oxygen 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 habitats within the estuaries feature. This reduced the confidence in the pass to medium.

Contaminants

One of the two WFD waterbodies that overlap with the Milford Haven estuary, the Milford Haven Inner waterbody, has a fail for chemicals in the 2024 cycle 3 interim classification, due to the failure of PBDE and PAH. This caused the contaminants indicator to fail. PBDE has failed in this waterbody in all previous cycles of the WFD assessments. The PBDE failure was 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 estuaries are not fully understood. The Milford Haven Outer waterbody failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals, however TBT, which was previously a failing chemical, is no longer classified. In addition, mercury was not classified in the Milford Haven Outer waterbody in the 2024 cycle 3 interim classification. The WFD waterbodies that overlap with the Solfach and Porth Clais estuaries were not classified as the chemicals have not been assessed within the last six years. The confidence in the fail was reduced to medium because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Data from 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. Most of these loggers (11 out of the 19) overlap with the estuaries feature. 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 estuary. 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

The assessment of the abundance, distribution and species composition of communities indicator considers data from the Milford Haven estuary only. There were no data available for the Solfach and Port Clais estuaries.

Nested features

The mudflats and sandflats feature overlaps with approximately 24% of the estuaries feature. Infaunal analysis sampled by core for intertidal Angle Bay infauna showed that communities fluctuated within natural variations (Moore et al., 2021 and NRW unpublished data analysis). In addition, a recent survey by ABPmer has shown no significant impact of bait digging on infaunal communities at Angle Bay (West et al., 2025), but further work is required to confirm this (see Section 3.6).

Although no concern was observed for Angle Bay, the condition of mudflats and sandflats in other parts of the SAC were poor with an increase in opportunistic species which are typically associated with anthropogenic disturbance (e.g. pollution) at several locations during the infaunal Milford Haven estuary grab monitoring surveys (2007-2021) (Section 3.6). From this monitoring, all sampling locations within the estuary indicated large variations in species composition across the monitoring period (NRW unpublished data analysis). Sandy Haven, the Gann, Angle Bay, Cosheston Pill and the Western Cleddau showed large variation in species composition often associated with an increased number of opportunistic species. These locations are known to be impacted by elevated nutrient levels in the Milford Haven Outer and Inner waterbodies (Section 3.6). In addition, bait digging activities in the Gann have been linked with changes in species composition in this area. The observed disturbance was not deemed to be due to natural change. Further analysis on the life histories of species that are driving the observed changes, the broad patterns of tolerant species change, and how these are related to natural versus anthropogenic pressures would help to identify potential reasons for these failures. This resulted in the mudflats and sandflats nested feature to fail for the abundance, distribution and species composition of communities indicator.

The reefs feature overlaps with approximately 35% of the estuaries feature. NRW monitoring data indicated that the intertidal reef communities in the Milford Haven and open coast sampling sites remained stable over time. There was a decline of the knotted wrack *Ascophyllum nodosum* at the Lawrenny Quay and Pembroke Power Station monitoring locations in the Milford Haven estuary which is concerning and warrants further investigation. This decline was not large enough to fail the abundance, distribution and species composition of communities indicator for intertidal reefs, and the indicator was therefore passed. However, the indicator failed with high confidence for subtidal reefs due to a 50% decrease in mean thickness of cushion and crustose sponge and a small decrease in circumference and height for the mermaid’s glove *Haliclona oculata* at Warrior site. In addition, two out of five reef sampling sites (Warrior and Beggars Reach) for the subtidal reef-associated communities showed a change over time, suggesting possible disturbance (Section 3.3).

The ASM feature overlaps with approximately 5% of the estuaries feature. The species composition of the communities indicator for the condition assessment of the ASM feature was assessed as unknown (Section 3.5).

Maerl

The NRW investigation showed that the maerl bed in the Milford Haven estuary is in poor condition (Ratcliffe, 2025). The cover of live maerl has decreased by nearly 80% from 2005 to 2017 *(*Mercer et al., 2025). This has resulted in a large shift in epibiota and infauna community composition an changes in infaunal species richness *(*Bunker and Ratcliffe, 2025*)*.

Subtidal benthic communities

A recent study on the subtidal benthos in the main channel of the Milford Haven estuary indicated that the benthic communities were in a healthy state (Warwick et al., in prep). In addition, three of the five overlapping WFD waterbodies were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Milford Haven Inner, Milford Haven Outer and Pembrokeshire South). Combined, these waterbodies represent 92% of the feature. The other two WFD waterbodies with small overlaps (<1%) have not been classified for IQI.

Seagrass

The intertidal seagrass *Zostera noltei* within the estuary has increased in extent in recent years and has been assessed as High status in the 2024 cycle 3 interim classification of seagrass in both Milford Haven Inner and Outer waterbodies and particularly in Angle Bay. There are five known subtidal *Zostera marina* seagrass beds in the Milford Haven estuary, the largest of which is the bed in Littlewick Bay. The subtidal seagrass *Z. marina* has been surveyed between 1986 and 2018 at Littlewick Bay in the Milford Haven estuary. The report indicated that shoot density in 2018 has decreased by 57% since 1986 with a significant decrease since 1999, suggesting localised conditions have changed (Unsworth et al., 2017; Bertelli, 2021a, 2021b). In 2017, *Z. marina* was observed to no longer be continuous and largely fragmented into numerous small isolated patches. Shoot density within *Z. marina* meadows is a good bioindicator of environmental disturbance, and long-term data at Littlewick Bay indicate anthropogenic impact there (Bertelli, 2021a; 2021b). Poor water quality resulting in hypertrophication or eutrophication has been raised as a possible cause for the decline observed (Bertelli, 2021a, 2021b). Changes in turbidity may also be a cause for declines in shoot density as *Z. marina* is light limited (Bertelli, 2021a; 2021b). This has not been investigated at Littlewick Bay due to the loss of loggers (Bertelli, 2021a). However, the area is now dominated by the alga *Laminaria saccharina*, and the coverage of attached epiphytic algae was found to be very high, suggesting the potential for *Z. marina* to be light limited at the monitoring site (Unsworth et al., 2017). Epiphytes on *Z. marina* have decreased by 39% since 1999, and wasting disease has increased by approximately 387% since 1999 (Bertelli, 2021a, 2021b). Compared to other sites surveyed in Wales, wasting disease and algae cover was significantly higher in Littlewick Bay. It has been concluded that there may be a system shift from a seagrass dominated to macroalgae-dominated community in Littlewick Bay (Bertelli, 2021a), and reports indicate the seagrass is under light and nutrient stress in the Milford Haven estuary for the majority of the year (Unsworth et al., 2017). There are other known beds of *Z. marina* within the

Milford Haven estuary (e.g. in Dale and Angle Point), however long-term data are not available for these other beds of the subtidal seagrass therefore their condition is unknown.

Fish

Although fish within the estuaries are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the estuaries feature. Both the allis and twaite shad, and river and sea lamprey features have been assessed as being in unfavourable condition in Pembrokeshire Marine SAC (see Section 3.12 and 3.13) This was not deemed enough alone to fail the indicator for the estuaries feature because these species represent a small component of the estuarine fish community. In addition to this, shad and lamprey indicator failures were related to wider populations or upstream issues, which are not relevant for the estuaries feature.

The herring population appears to be in decline in the Milford Haven estuary. There has been a noticeable decrease in the number of spawning fish since the 1980's, with higher mortality rates and younger age structure observed in 2018 compared to 1980-1982 (Davies et al., 2020). In addition, no eggs and very few larvae were found on the historic spawning ground despite the presence of spawning adults, supporting the apparent decline observed (Davies et al., 2020). There is an ongoing NRW investigation into this decline.

Data from wider Irish sea level studies such as International Council for the Exploration of the Sea (ICES) are difficult to relate to the assessment of condition at the SAC and feature level and some species that have been assessed by ICES may not even occur at the individual SAC level. However, populations of various larger-bodied bony fish species in the Irish Sea, such as bass, cod, herring, whiting, plaice and pollack, have declined in recent years (ICES, 2024a, 2024b, 2024c, 2024d, 2024e, 2024f). While there are limited data on the status of other species, the depletion of a number of larger, higher trophic level predatory species in the Irish Sea may have shifted the structure of the wider fish community to an overall lower trophic level with fewer larger predatory fish species.

Operational monitoring of fish impingement and entrainment is carried out at Pembroke Power Station's cooling water intake system in the Milford Haven estuaries feature. Further monitoring of the fish community of the Milford Haven commissioned by the operators of the Pembroke Power Station includes subtidal trawls, intertidal seine nets and ichthyoplankton sampling. From the operational monitoring programme data and analysis, decreases, and a negative trend, in impingement numbers of numerous species within the fish community have been observed. The species in question include clupeids, gobies, gadoids, flatfish and sandeels and form over 80% of the recorded impingement abundance. A similar decreasing trend in fish catches was observed in the subtidal trawls. Data from the intertidal seine nets showed variable results with an overall increase in marine juvenile and estuarine resident species in summer but low abundance in winter catches and no trend was observed for the icthyoplankton community composition, which remained similar throughout the monitoring period (A. Scorey (NRW), pers. comm.). Further investigation is needed into the fish community abundance and structure across the Milford Haven estuaries feature.

The Milford Haven Inner waterbody, which overlaps with the upper Milford Haven estuary (and represents 33% of the whole estuaries feature), was classified as Good status for the WFD estuarine fish tool in the 2024 cycle 3 interim classification. No other WFD waterbodies that overlap with the feature were classified for this element However, the ability of the WFD fish tool to inform the condition of the estuaries feature is unknown and need further investigation.

Overall, the poor condition of the maerl bed and certain areas within the Milford Haven estuary, along with concerns over the decline of sponge communities at Warrior site, disturbances to subtidal reef-associated communities at Beggars Reach, and the decline in spawning herring and decrease in shoot density of *Z. marina* in Milford Haven estuary contributed to the failure of the abundance, distribution and species composition of communities indicator.

Invasive non-native species

There has historically been a high number of NNS in the Milford Haven estuary. *Crepidula fornicata* has been recorded in various locations within the SAC for many years. The species has been found in superabundant aggregations across various intertidal and subtidal habitat types within the Milford Haven estuary (Figure 7) (Bohn, 2012; 2014), and natural habitats within the estuary have changed where the species dominates (M. Camplin (NRW), pers. comm.). Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities.

The species has also been found within the maerl bed in the Milford Haven estuary, which may have a potential smothering effect on the maerl (Mercer et al., 2025). Given the high density of *C. fornicata*, including its presence in sensitive habitats (i.e. maerl) and its impact on natural habitats within the Milford Haven estuary, the primary target of the INNS indicator has failed. Confidence is medium as there are limited data on the density and distribution of *C. fornicata* within the last six years.

Didemnum vexillum was recorded for the first time within the Milford Haven estuary near to Neyland marina on boulder and cobble reefs at Carr Rocks and on Barnlake Point in 2023 and 2024 within the estuaries feature. The impact of this species on the condition of the estuaries feature is not known, however it is possible for this species to have far reaching implications on native communities (Tillin et al., 2020). Therefore, the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the estuaries feature within the last reporting cycle.

Other NNS are known to be present in Pembrokeshire Marine SAC, within the estuaries feature. *Undaria pinnatifida* has been recorded in the Milford Haven estuary since 2014. First found in 2016, *Watersipora subatra* has been recorded in large areas in Dale at Jetty Beach in 2023 (Mieszkowska and Sugden, 2023, 2024). *W. subatra* is also known from South Hook Point and Pembroke Power station. Records of *Botrylloides diegensis* initially discovered in 2014 has also been found at Pembroke Power station, Pembroke Dock and Neyland (Wood et al., draft). The other NNS previously recorded in the estuaries feature or nearby are *Dasysiphonia japonica*, *Caulacanthus ustulatus (okamurae)* and *Ficopomatus enigmaticus. Bispira polyoma* has been found for the first time in 2023 in the SAC but it is not within the estuaries feature. The spread and full extent of the impact of the NNS recorded in the estuaries feature are currently unknown.

Reasons for target failure

The assessment of the estuaries feature in the Pembrokeshire Marine SAC failed seven primary targets, three secondary targets, and one tertiary target. All associated failures are localised within Milford Haven estuary, the largest estuary of the three within the SAC. 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.

Distribution and extent of habitats and communities

This indicator target has a primary weighting. There has been a dramatic reduction in the extent of maerl since 2005 (Mercer et al., 2025). The clear causes of this observed decline are not yet confirmed. However, from the ongoing NRW investigation it is likely due to the cumulative effects of a combination of pressures. These include disturbance of the seabed surface, sedimentation, pollution and chemical changes, and INNS (Ratcliffe, 2025). There are concerns that the South Hook jetty refurbishment (2005-2007) has contributed to the decline of maerl (Ratcliffe, 2025). The failure is localised to a small maerl bed area of the Milford Haven estuary.

Sediment composition and distribution

This indicator target has a primary weighting. There has been a significant increase in silt content between 2014 and 2019 in some areas within the Milford Haven estuary. Further investigation is required to determine the causes of this increase and how widespread the issue is within the estuary. The failure of this indicator is localised to some areas within the Milford Haven estuary.

Sediment quality: carbon

This indicator target has a primary weighting. The carbon content has increased across the monitoring period at various monitoring locations. Increases in carbon are likely to be from an increase in the amount of organic material being deposited and can be indicative of eutrophication and reduced oxygen in the sediment.

Sediment quality: contaminants

This indicator target has a primary weighting. 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 some of the most recent sampling years were benzo(g,h,i)perylene, anthracene, benzo(a)anthracene, fluoranthene, mercury and TBT. Various other contaminants including metals had concentrations above the less stringent guidelines in the most recent years of sampling. Investigations into the sources of these contaminants, and the full impact on the feature have not been carried out.

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. Three WFD waterbodies that overlap with the Milford Haven and Solfach estuaries (Milford Haven Inner and Outer, and Solfach Estuary) had failing levels of DIN. 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. Failure of the supporting water quality elements opportunistic macroalgae in the Milford Haven Inner waterbody further supports the nutrient issues present in this waterbody. 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 from specific agricultural practices and activities 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.

Abundance, distribution and species composition of communities

This indicator did not meet its primary target for several reasons. These were the poor condition of the maerl bed and its associated epibiota, and large variation in the intertidal infaunal communities within the Milford Haven estuary. In addition, there were the concerns over a decline of sponge communities at the Warrior site, disturbances to subtidal reef-associated communities at Beggars Reach, a decline of herring, and a decrease in shoot density of *Z. marina* in the Milford Haven estuary.

Elevated levels of nutrients and contaminants within the Milford Haven estuary are likely contributing to the observed changes in the species composition of communities within the estuaries feature of the Pembrokeshire Marine SAC. Other localised issues, e.g. bait digging activities in the Gann, has also contributed to the observed changes in infauna communities. Further investigation is now needed to confirm what the reasons behind these failures are. Identification of the reasons causing these failures will allow management measures to be identified and implemented to allow improvement in the Milford Haven estuary.

Invasive non-native species; non-native species

This indicator failed to meet its primary and tertiary targets. The primary target failure is due to the increasing number of *C. fornicata*, which has been found in superabundant aggregations across various intertidal and subtidal habitats in the Milford Haven estuary (Bohn, 2012; 2014). This species has altered natural habitats and is present in sensitive habitats in the estuary (maerl bed) (Mercer et al., 2025). The failure of the primary target is localised to the Milford Haven estuary.

The failure of the tertiary target of NNS indicator is due to the recent arrival of *D. vexillum* within the last six years in the estuaries feature. 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.

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.

Sediment quality: oxidation-reduction profile (redox layer)

This indicator failed its secondary target due to the extensive opportunistic macroalgae growth within the Milford Haven estuary, and the subsequent anoxic conditions this causes in the sediments. This has been observed where areas of opportunistic macroalgae growth has been recorded within the Milford Haven estuary. The assessment of this indicator has been based on imagery and expert judgement, with a lack of a long-term quantitative data series. Quantification of the redox layers beneath opportunistic macroalgae would be required to raise the confidence of the failure.

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. The Milford Haven Inner waterbody was classified as Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. This waterbody overlaps with a large proportion of the estuaries feature in the SAC. 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 target has a secondary weighting. One WFD waterbody that overlaps with the Milford Haven estuary (Milford Haven Inner) had failing levels of chemicals. It was classified with fail 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation of the failure in the Milford Haven Inner waterbody is yet to be undertaken. PBDE is 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 estuarine biota. The impacts of PAH on the estuaries feature are not fully understood.

Threats to condition

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

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed, have not been included. The threats to the estuaries feature condition in the Pembrokeshire Marine SAC are stated below.

Unconsented infrastructure

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

Invasive non-native species

Gracilaria vermiculophylla has been found close to the SAC, in Nevern. This species is not currently within the estuaries feature, but has the potential to establish quickly in shallow soft-bottomed bays and estuaries and have a detrimental impact on the feature (see Section 3.1. for further detail).

*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 and other features 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 reefs, it is a threat to the estuaries feature.

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

Water quality: contaminants

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

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

Management of coastal defences

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

Climate change

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

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

Further threats are associated with the nested features and can be found in the relevant sections of the report.

- Recreational access and collection (mudflats and sandflats and reefs condition assessments)
- Seabed disturbance (reefs condition assessment)

Evidence gaps

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

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

Table 9. Evidence gaps for the estuaries feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Freshwater inputs (P)	Not assessed	• The freshwater flow indicator could not be assessed in all SACs due to limited resource. There are data available on abstractions and flow levels in estuaries therefore this is something that should be used in future condition assessments.
Abundance, distribution and species composition of communities (P)	The fish community element did not contribute to the condition outcomes	• Fish communities were broadly discussed for all SACs using reports including ICES data. Although these reports provide an indication of fish numbers, they have certain limitations. The large area covered makes it unsuitable for estuaries or individual SAC. More data would be required to adequately assess fish communities in estuaries.
Invasive non-native species (P)	Medium confidence (limited data)	• The spread and impact of the NNS currently present on the estuaries feature within the SAC are not fully understood. More targeted surveys and investigation on the impact of NNS on estuaries are needed.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was hard to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening for all SACs. • There is widespread evidence of opportunistic macroalgae in Pembrokeshire Marine SAC, which can lead to anoxia in sediments. Quantification of the redox layers beneath opportunistic macroalgae would be required to strengthen the assessment conclusions.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.

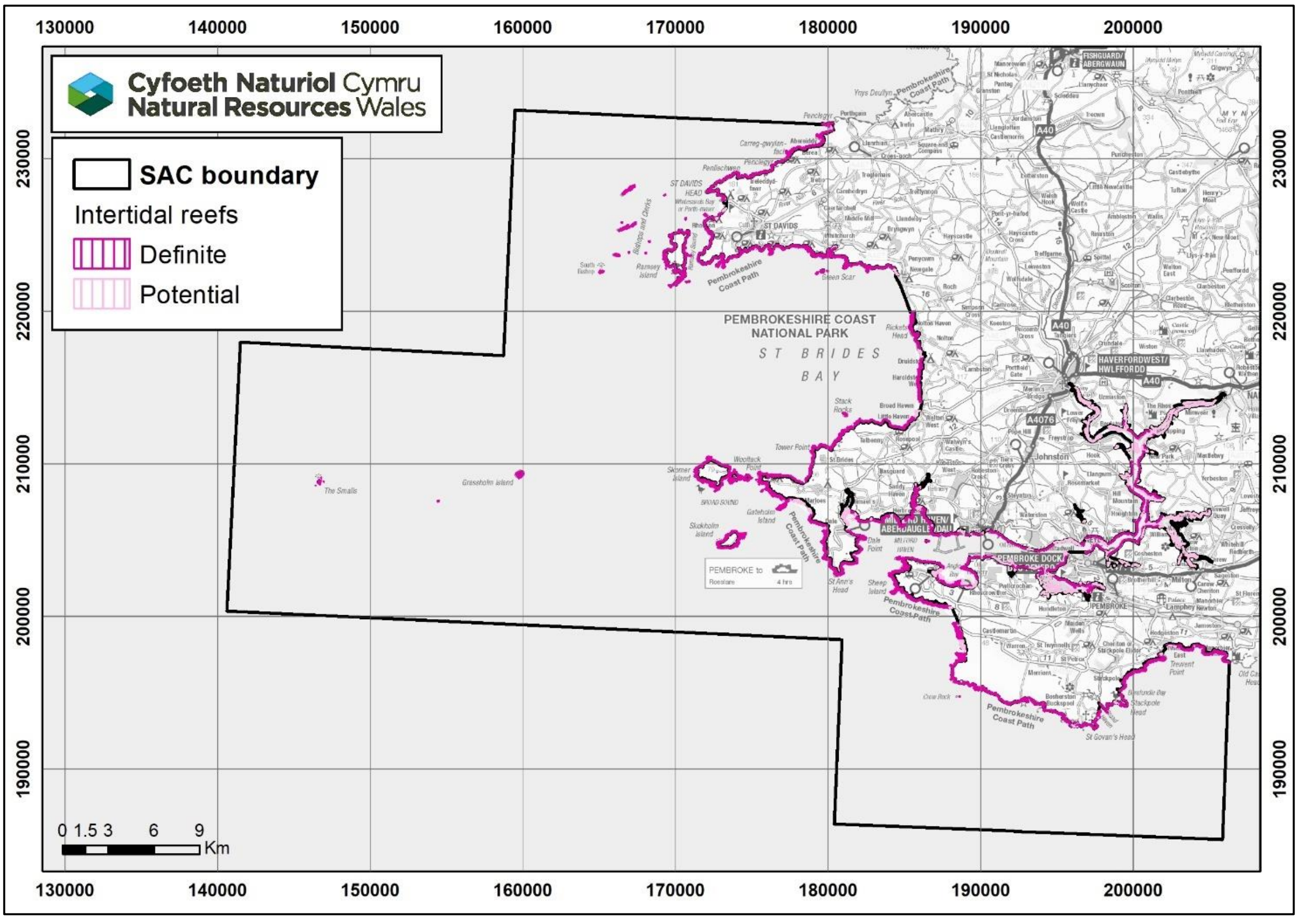
Indicator	Assessed status	Comments
Water quality: physicochemical properties (S)	Unknown	• Further evidence in temperature changes is required to adequately assess this indicator. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some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

3.3. Reefs condition assessment

Intertidal reefs

The reefs feature in the Pembrokeshire Marine SAC comprises of a number of intertidal reefs (Figure 12). 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 12. Map of the intertidal reefs in Pembrokeshire Marine SAC.



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

Table 10. 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

Indicators	Target	Assessment rationale	Target assessment	Target confidence
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
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)	• 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

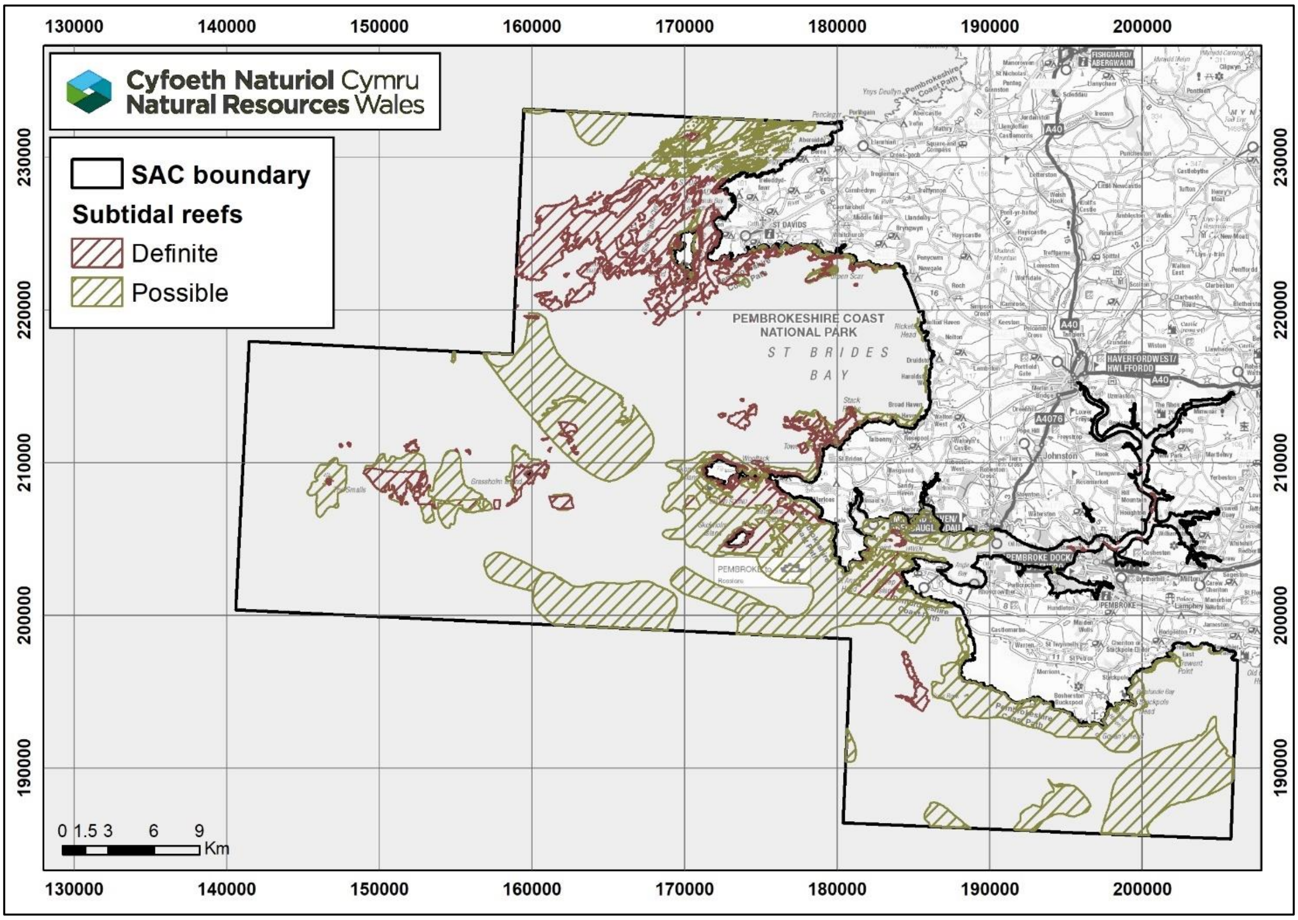
Indicators	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• The recorded changes in species richness and population abundance from the analysis 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. *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 13). 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 13. Map of the subtidal reefs in Pembrokeshire Marine SAC.



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

Table 11. 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)	• PAH were recorded in the Clean Safe Seas Environmental Monitoring Programme (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, a change in community composition was apparent. This may be indicative of anthropogenic impact. • At one of these sites, there was also a 50% decrease in the thickness of cushion and crustose sponges, and a small decrease in the height and circumference of the sponge mermaid's glove *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. • The total number of the ross bryozoan *Pentapora foliacea* colonies recorded between 2019 and 2021 increased 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 has been an increase in *Crepidula fornicata*. • 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 12). 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 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 Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Reefs	**Unfavourable (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 OSPAR guidelines, CEQG and Cefas action levels. Further information is available in the IMCA final report.

Levels of 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 13). 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 13). 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 13). For subtidal reefs, the Milford Haven Outer, Grassholm Island and The Smalls, and Cardigan Bay South waterbodies overlap with a smaller proportion (Table 13). 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 13).

Table 13. 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 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 14)

(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 13). 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 14. Opportunistic macroalgae on reefs in Sandy Haven in 2008, Milford Haven Waterway.

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

Contaminants

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 13). 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 *Mytilus 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 the toothed wrack *Fucus 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 the sponge Mermaid's glove *Haliclona 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

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 15). 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 *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, *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 *Botrylloides diegensis* initially discovered in 2014 has also been found at Pembroke Power station, Pembroke Dock and Neyland (Wood et al., draft). *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). *Crepidula 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 *Dasysiphonia japonica*, *Caulacanthus ustulatus (okamurae), Ficopomatus enigmaticus*, *Botrylloides violaceus* and *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 15. 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.

Threats to condition

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

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

Unconsented infrastructure

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

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 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.

*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.

The various other NNS recorded in the SAC 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 PFAS) to increase. This could affect some of the biota of the reefs feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

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

Management of coastal defences

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

Climate change

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

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

Evidence gaps

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

Listed below (Table 14) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 14. Evidence gaps for the reefs feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Feature extent (P); distribution of the feature (P); distribution and extent of habitats and communities (P); topography of the feature (S); bathymetry of the feature (P); hydrodynamic and sediment transport processes (P)	Medium confidence (proxy data used)	• There are currently no temporal data available to assess changes for these indicators for intertidal and subtidal reefs across all SACs, and assessment was based on expert judgment.
Distribution and extent of the naturally present reef types (P)	Not assessed	• There are currently no temporal data on reef types for the SAC.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present at within the SAC on the reefs feature is not fully understood. More targeted surveys and investigation on the impact of NNS on reefs are needed.
Sediment: composition and distribution (S); availability (S); depth (S)	Not assessed	• There is no current monitoring of the sediment composition, availability and depth over reefs within the SAC.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.

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

3.4. Grey seal condition assessment

Monitoring of the grey seal *Halichoerus grypus* population in Pembrokeshire Marine SAC began in 1974. Monitoring is carried out by a variety of organisations including NRW, the Royal Society for the Protection of Birds (RSPB), the Wildlife Trust of South and West Wales and the Pembrokeshire Coast National Park. A summary of the condition assessment for grey seal in Pembrokeshire Marine SAC can be seen in Table 15. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions.

Table 15. Condition assessment of grey seal in Pembrokeshire Marine 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
Grey seal population size relevant to the SAC	The wider seal population relevant to the SAC is stable or increasing. (P)	• The population relevant to the SAC encompasses all of Wales and the wider Irish and Celtic seas. • A census of grey seals in south-west Britain (including the entire coast of Wales) was done via aerial survey in August 2023. • The population of grey seals in Wales was estimated to be 5,284 seals at the time of the survey. This is a minimum estimate due to cryptic haul outs (e.g. caves). • Pup production models estimate the adult (1 year +) population of Wales to be approximately 5,300. • The population relevant to the SAC was judged to be doing well and assumed to be increasing. • Confidence is medium as updated methods and survey areas in the latest aerial survey make comparisons to previous surveys difficult. The lack of systematic monitoring of seals at the all-Wales scale also lowered the confidence.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Colony pup production	A stable or increasing pup production at the colony level, that support the SAC population, allowing for natural change and variation. (P)	• Data from 1992-2023 showed an increased trend of pup production from all monitored areas in the SAC: • Pup production from 1992 to 2008 was stable in the Skomer MCZ with an increasing trend from 2008 to 2023. The MCZ includes both Marloes and Skomer. • The pup production on Ramsey has been showing an increasing trend between 2010-2023 compared to 1992-2002 (no surveys completed for 2003-2009). • The highest pup production from all monitoring sites was recorded over in the 2023 breeding season. • In south Pembrokeshire the Castlemartin Range site of special scientific interest (SSSI) has pupping data available for 2004-2023 that show an increase in the number of pups born over this period. • Confidence in the pass is high given the long term monitoring of colonies in the SAC.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
SAC pup production	A stable or increasing pup production within the SAC that supports the SAC population, allowing for natural change and variation. (S)	• All monitored colonies in Pembrokeshire Marine SAC have continued to do well since 2005 and have seen an increase in pup production. • There has also been a trend across the UK for increases in the grey seal populations in all regions. • For these reasons it is accepted that production across the SAC has likely remained stable or increasing. • The pups produced in Pembrokeshire Marine SAC represent around 89% of Wales' pup production. This makes the SAC vital in maintaining the wider population. • Confidence in the pass is medium due to the lack of recent data available for the north of Pembrokeshire	**Pass**	Medium
Distribution of grey seal pupping sites within the SAC	The distribution and extent of pupping sites in the SAC is stable or increasing, allowing for natural change and variation. (P)	• Monitored areas in the Skomer MCZ have continued to support pupping with a stable distribution. • South Pembrokeshire has seen an increase in pupping sites from 6 in 2004 to 10 in 2023 (peaking at 12 in 2021). • Data from Ramsey island suggest pupping distribution has been stable for the last 10 years. • There are no recent systematic pupping survey data that apply across the whole SAC and no recent data for north Pembrokeshire. However, anecdotal evidence from north Pembrokeshire suggests that pups are being found in higher numbers in small sites. • Confidence in the pass is medium due to lack of monitoring across the whole SAC.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Accessibility to habitat used by seals	No evidence of significant constraints on grey seal access to habitat within or associated with the SAC. (P)	• There was no knowledge of 'barriers' that would be a concern. • Seal numbers are stable or increasing at regularly monitored sites in the SAC suggesting no significant constraints on seals' access to habitat required to support them. • Confidence is high due to in depth site knowledge and high numbers of seals throughout the SAC.	**Pass**	High
Anthropogenic disturbance	No significant anthropogenic disturbance affecting the grey seal population associated with the SAC. (P)	• Evidence suggests current levels of anthropogenic disturbance are not significantly impacting the seal population associated with the SAC. • Population is known to be doing well in monitored sites. • The confidence in the pass is medium, as while the population is increasing, activity monitoring is only done in the Skomer MCZ.	**Pass**	Medium
Prey availability	Maintain the quality, abundance and diversity of prey species needed to support the grey seal population. (S)	• There is no reason to believe grey seals are prey-limited, that prey availability is limiting the grey seal population, or that there has been a reduction in diversity of available prey species. • Grey seal population is expanding in Wales which strongly suggests prey is abundant enough to support the population. • Confidence in the pass is medium as the assessment is based on proxy data (seal numbers and fisheries data).	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water, sediment and prey contaminants	Ensure water, sediment and prey contaminants are at levels not detrimental to the grey seal population. (S)	• One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody has improved since previous cycles. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. This waterbody is not used by seals as it is high up the estuary. • High concentrations of some heavy metals and PAHs have been identified from sediment sampling in the Milford Haven Waterway and Skomer MCZ in 2022 and 2023. • OSPAR report mercury and lead are above ecological guidelines in the North-East Atlantic region, as is one congener of Polychlorinated biphenyls (PCB). • A study of marine mammals from around the UK found grey seals had the lowest mean concentrations of persistent organic pollutants (POPs) of all 11 species studied, with only 17% above toxicity thresholds. However, the sample size was small. • Seal numbers in the SAC have been increasing since 2008. • Contaminants are deemed not to be having a detrimental impact on seals at present, but confidence is low due to lack of sampling in seals and lack of understanding of the impact contaminants have at the population level.	**Pass**	Low

Assessment conclusions

The condition of the grey seal feature in the Pembrokeshire Marine SAC has been assessed as being in **favourable condition** (medium confidence). All performance indicators targets were met (Table 16). The wider population and pup production data all suggest grey seal numbers have been increasing in recent years. While contaminants are present, they are not thought to be impacting grey seals at a population level at present; however, they remain a threat to future condition. There is significant bycatch of grey seals in net fisheries in the Celtic Seas of the south-west UK and Ireland (SCOS, 2022; Taylor et al., 2022). While seal bycatch is likely to be minimal inside Pembrokeshire Marine SAC, bycatch outside of the SAC affects the wider population, of which the SAC is part. For further information see the threats section.

Table 16. Summary of the condition assessment for grey seal in Pembrokeshire Marine SAC.

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

Detailed assessment information

Grey seal population

Based on pup production, it is estimated that approximately 3-4% of the UK's grey seal population resides in Wales (SCOS, 2022). An estimated 2250 pups are born per year in Wales, of which around 89% (approx. 2000) are born in Pembrokeshire marine SAC (Russell and Morris, 2020). However, there is uncertainty around this estimate given the age and sporadic nature of most of its underlying data (e.g. Baines et al., 1995; Westcott 2002; Westcott and Stringell 2003). This makes Pembrokeshire Marine SAC vital in maintaining the wider population of grey seal in Wales. Pup production at regularly monitored sites in Wales has increased markedly since monitoring began (Bull et al., 2017; Morgan et al., 2018; Strong et al., 2015; Robinson et al., 2023).

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

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

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

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

The aerial survey estimated a 64% increase in the number of hauled-out seals, based on the difference since the last summer composite estimate of 800 hauled-out seals that represented data from 2002-2020 (Thompson, in prep). This increase is likely due to more extensive coverage of mainland and offshore island sites in the aerial survey which were not included in the previous estimate (probably a large under estimation) and the apparent increase in numbers of hauled-out seals at previously included sites (Thompson, in prep). Seals hauled-out at cryptic coastal sites, e.g. caves and overhanging cliffs, however, were not counted by the aerial survey and represent an unknown but possibly large bias. Due to the differences in the way these estimates were produced it is hard to tell how large the increase has been with certainty. The fact that a similar 65% increase is estimated at directly comparable North Wales sites from surveys in August 2002, supports the suggestion of a population increase in Wales (Thompson, in prep).

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

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

Colony pup production

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

Annual pup production data are available from monitored pupping sites within Pembrokeshire Marine SAC. The most detailed data are from the Skomer Marine Conservation Zone (MCZ), where pups are counted at all Skomer Island and mainland (Marloes Peninsula) sites and each pup is tracked up to the point they moult for the first time (Büche and Bond, 2024). Other monitored sites in the SAC are Ramsey Island where pups are counted at nine survey sites and then pup production is modelled for the whole island (Stephens, 2023), and Castlemartin Range site of special scientific interest (SSSI) in South Pembrokeshire where every pup is counted (NRW unpublished data).

Despite declines on Skomer Island between 1992 to 2008, the pup production for the whole Skomer MCZ was stable due to increases in the Marloes peninsula and averaged 208 pups per year (Bull et al., 2021). This highlights the variability that can exist between neighbouring pupping sites and the importance of scale when monitoring (Engbo et al., 2020). Since 2008 there has been an increasing trend at both island and mainland colonies, though this increasing trend is showing signs of levelling off (Büche and Bond, 2024). There were 425 pups born in the MCZ in 2023. This was less than the record years of 2021 and 2022 (446 and 447 births), but in line with 2020 (422 births) (Büche and Bond, 2024).

On Ramsey Island the RSPB has monitored seal pupping in nine sites using consistent methodology since 1992. There was a break in surveying between 2003-2009. The mean pup production for years 1992-1996 was 217 (Morgan et al, 2018). This rose to a mean production of 330 between 2010-2019 (Stephens, 2023). Pupping has continued this increasing trend with a peak pup production in 2023 of 429 pups across the nine monitored sites (Stephens, 2023).

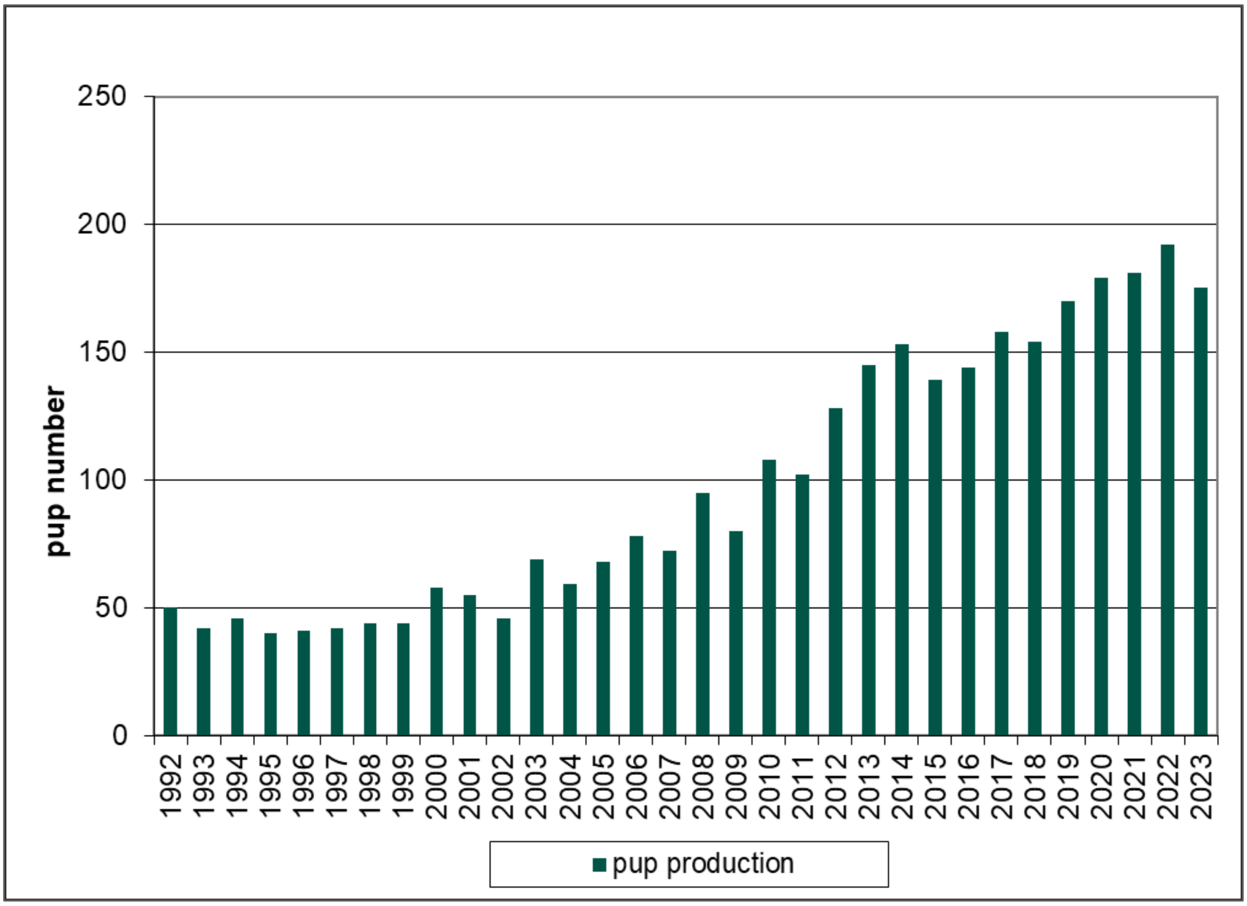
In the Castlemartin Range SSSI, pupping data are available from 2004 to 2023 (NRW unpublished data). There has been a progressive increase in the number of pups born up to 2022, ranging from 21 pups in 2004 to 78 pups in 2022. There were slightly fewer pups born in 2023 (65 births) but this is considered to be within the bounds of natural variation.

There are some breeding sites in North Pembrokeshire that have previously been monitored. Up to 2014, pupping showed an 80% increase in production between 1992 to 2014 (Strong et al. NRW unpublished data), but there has been no monitoring since. However, there is anecdotal evidence that pupping sites in North Pembrokeshire have increased (Pers comm, Pembrokeshire Coast National Park ranger). This allows the assumption that the colonies in the north are following the same increasing trend as those in the south.

The data show that pup production at monitored colonies in Pembrokeshire is healthy. There was an upward trend at Skomer Island up to 2017 but data now show a levelling off. However, grey seals seem to be expanding into the Marloes Peninsula with a steady increase since 1992 (Bull et al., 2017). Mean pup production from 2008-2015 was 119. This has increased to 169 between 2016-2023, peaking at 192 in 2022 (Figure 16).

The high levels of pup production at each monitored colony meant the indicator passed its target. The up-to-date monitoring and long-term nature of the data sets allowed the indicator to pass with high confidence.

Figure 16. Seal pup production at Marloes Peninsula in Pembrokeshire Marine SAC.



SAC pup production and distribution

In 2005, a SAC wide census found pup production across the SAC had increased compared to production between 1992 and 2000 (Strong et al., 2006). While the authors were confident that the increase was real, it was above any predicted increase based on trends seen in the data. There has not been a SAC wide census on pup production since 2005. However, all monitored colonies in Pembrokeshire Marine have continued to do well since then and have seen a continued upward trend in pup production, with signs of stabilising at some sites. There has also been a trend across the UK for increases in the grey seal populations in all regions. The seal population in the UK has increased steadily since the 1960s, though this increase is now slowing (1.4% per year over the last survey interval) (SCOS, 2022).

For these reasons it is accepted that production across the whole SAC is likely to have followed that of monitored colonies and remained stable or increasing. Confidence in this pass is lowered to medium as there can be high variation in pup production between sites, even those near each other (Engbo et al., 2020). There has also been a lack of monitoring in the north of the SAC since 2005.

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

Evidence suggests the distribution of monitored breeding colonies in the Skomer MCZ and Ramsey Island within Pembrokeshire Marine SAC are broadly stable. On Ramsey Island there has been a shift in pupping distribution between 2000-2003. In 2000, pup births were fairly evenly distributed across the 9 monitored sites on the island. By 2023 almost half of all pups were born in one site. However, over the last 10 years the distribution in pupping has been stable (Stephens, 2023).

In South Pembrokeshire (Castlemartin Range SSSI) data show the numbers of sites are growing. The 6 pupping sites recorded in 2004 have grown to 10 sites in 2023, peaking at 12 sites in 2021 (Pers comm, K. Lock (NRW)). However, it is hard to say if this increase in pupping sites applies elsewhere in the SAC as there are limited data for North Pembrokeshire. There is anecdotal evidence from the mainland in the north of the SAC which suggests pups are being found in higher numbers in small sites (Pers comm, Pembrokeshire Coast National Park ranger).

The increase in distribution of pupping sites across the south of the SAC and the stable distribution of sites in other monitored areas, together with evidence that activities occurring in the region are not currently limiting pupping distribution, meant the indicator passed. The confidence was reduced to medium due to lack of recent monitoring of the north mainland coast of the SAC.

Habitat accessibility and disturbance

Grey seals require suitable coastal habitat with which to haul out onto to rest after foraging, to give birth and rear their pups and to moult. In general haul out and breeding sites are undisturbed areas of rock, sandbank or beach with good access to the open sea (JNCC, 2005). In Wales, seals show a strong preference for breeding in sea caves (Baines et al., 1995; Stringell et al., 2014). Seals also require suitable foraging habitat that supports sufficient prey to maintain the population. Seal numbers are stable or increasing at regularly monitored sites in the SAC suggesting no significant constraints on seals' access to habitat required to support them. The habitat accessibility indicator, therefore, met its target with high confidence, supported by good knowledge of the site and high numbers of grey seals.

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

The inaccessibility of many breeding and haul out sites in Pembrokeshire Marine SAC contributes to minimising some types of human disturbance. Airborne noise is known to occur in the SAC from ongoing activity within Castlemartin Range SSSI. The current activity within the SSSI does not appear to be inhibiting increases in pup production or pupping site use, which have occurred alongside these activities since before the designation of the SSSI. There is potential however, for non-routine activities to create greater disturbance, which may result in a detrimental impact on the seals.

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

The Pembrokeshire Coast National Park Authority has published a code of conduct for sea users as have the Skomer Marine Conservation team, to help minimise recreational disturbance. Disturbance in the Skomer MCZ is further controlled through careful management. Industry best practices also help to manage or mitigate disturbance from developments which are robustly assessed when applying for the appropriate permissions.

It is vital that seals have unconstrained access to sufficient suitable habitat both on land and at sea. There is a lack of understanding of the availability of suitable habitat in Pembrokeshire Marine SAC. While disturbance is occurring in the SAC (Castlemartin range SSSI), continued increases in pupping at monitored colonies is evidence that disturbance is currently not adversely affecting the seal population. Therefore the population has been assessed as not being detrimentally affected by significant anthropogenic disturbance. The indicator passed with medium confidence as, with the exception of Skomer MCZ, there is limited monitoring in the SAC of activities that may cause disturbance.

Prey availability

Grey seals are generalist predators and their diet varies depending on their location and the time of year, taking whatever food source is locally abundant (Bowen et al., 2006; Brown et al., 2012; Hammond and Prime, 1990). A study on grey seal diet in Pembrokeshire between 1992 and 1994 found seals ate a wide range of fish species, most of which are not commercially fished, reflecting their opportunistic feeding behaviours. Gadoids and flatfish dominated seal diet (70%) over 3 years in Pembrokeshire (Strong, 1996). Similar results were seen from a more recent comprehensive study of grey seal diet in Wexford Harbour, Southeast Ireland (Gosch et al., 2019) and in small seal diet study on Skomer Island (Lofthouse, 2017). Some commercial species are potentially depleted in the Irish / Celtic Seas (cod, whiting, seabass, herring and plaice which made up 33% of seal diet by weight in the Strong (1996) Pembrokeshire study). However, other commercial species like sole remain abundant, and herring and seabass appear to be making slow recoveries following cessation or restrictions on fishing.

There is no reason to believe that prey is limited or has reduced diversity in the areas of Pembrokeshire Marine that grey seal are using to forage. The grey seal population in Wales has been expanding and pupping has an increasing trend in the SAC. This strongly suggests prey is abundant enough to support a growing population and allowed the indicator target to pass. As there is no targeted surveying of prey abundance or recent seal diet studies, however, the confidence in the pass was reduced to medium.

Contaminants

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

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. 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 grey seals are not fully understood. The Milford Haven waterbody is not regularly used by seals as it is high up the estuary, therefore the failure of this waterbody was not considered in the condition assessment. The Milford Haven Outer waterbody previously failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals in the 2024 cycle 3 interim 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. The four other WFD waterbodies in the SAC were not classified 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).

Sediment sampling at Skomer Island found high levels of chromium and lead, which on average were above the more stringent ecological guidelines in 2022 and have increased since earlier years. Arsenic levels were also high and were above the less stringent ecological guideline in 2022. NRW monitors sediment contaminants as part of the Clean Seas Environment Monitoring Programme (CSEMP). Sediment sampling in Milford Haven Waterway found that the average concentration of one PAH compound was above its most stringent ecological guideline in 2023. Other PAH compounds were below their more stringent guidelines but above their less stringent guidelines in 2023. Other contaminants (including PCBs and heavy metals) were typically below the most stringent ecological guidelines in 2023. Additional sediment sampling in the Milford Haven Waterway found that most stations had contaminant levels below guidelines, however there were a small number of stations with high concentrations of mercury or PAHs. Due to the industrial nature of the Milford Haven Waterway, there is a history of contamination.

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

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

Marine litter is also a concern for seals in the waters around Wales. Litter impacts on seals are monitored at the Skomer MCZ every year. The most obvious marine litter impacts are consistently from monofilament line and netting from fishing activity. In 2023, 29 individual seals were photographed with obvious signs of damage from entanglement with fishing nets. The most common injury is a deep scar on the neck, often with the net still embedded (Lock et al., 2024). Microplastics have also been found in seal stomachs and scat (Hernandez-Milian et al., 2019; Lofthouse, 2017). It is not clear if the microplastics are ingested directly or are present inside their prey (Lofthouse, 2017). Marine litter and microplastics are not currently having an impact on seals at population level but are a threat to future condition if they were to increase significantly. Individual seals entangled with fishing line and net is a welfare issue at the SAC level.

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

Reasons for target failure

The grey seal feature in the Pembrokeshire Marine SAC has been assessed as being in **favourable** condition as none of the targets failed.

Threats to condition

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

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

Disturbance

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

Contaminants

At the time of the assessment, grey seals are thought not to be adversely impacted by contaminants at the population level. However, the high levels of some contaminants within the SAC are cause for concern. While some contaminants like mercury and PBDE are being managed and it is hoped that these levels will reduce in time, there is the potential for unregulated contaminants (such as Per- and polyfluoroalkyl substances (PFAS) and pharmaceuticals) to potentially increase in the future. This could affect grey seals as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). Even though mercury levels are decreasing and the 2024 WFD classification passes for mercury in Milford Haven Outer waterbody, this classification was based on concentrations of mercury in mussels. Due to the bioaccumulation potential of mercury, the levels in top predators such as seals, may still be of some concern. Many contaminants have been shown to have a detrimental impact on reproductive success and can be passed to pups through their mother’s milk (Hammond et al., 2005; Nyman et al., 2003; Robinson et al., 2018). Some persistent chemicals are not measured in every WFD waterbody, and some of the relevant waterbodies have not been classified for any chemicals.

Fisheries bycatch

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

Evidence gaps

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

Listed below (Table 17) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 17. Evidence gaps for grey seal in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comment
Seal population size relevant to the SAC (P)	Medium confidence (proxy data in some cases)	• Regular systematic monitoring at the scale of the SAC and / or regions is needed to inform the condition assessment. • Both pupping and haul out counts are needed across the region to establish whether those sites regularly monitored (e.g. Skomer) are sufficient index sites for the population. • Continued funding for monitoring at key sites (e.g. Skomer) is critical to our understanding of seal status. Only a single systematic survey of hauled out seals has been conducted (in summer 2023) in Wales and should be repeated at regular intervals (e.g. 2-5 years).
Habitat quality and function (S)	Not assessed	• There is a lack of understanding of what is quality habitat for seals and how much is sufficient to support the population using the SAC.
Anthropogenic disturbance (S)	Medium confidence (limited data)	• There is a lack of information on levels of recreational activity in the SAC, their impact on seals and if codes of conduct are being followed. • There is limited information on bycatch in net fisheries in Wales. Some studies are underway to estimate the likely bycatch in parts of Wales, but further work is required to provide robust estimates.
Water, sediment and prey contaminants (S)	Low confidence (limited data)	• There are very little data on the level of contaminants in grey seals. Dead seals are rarely autopsied and sampled for contaminants.

3.5. Atlantic salt meadows condition assessment

The Atlantic salt meadows (ASM) feature, also known as saltmarsh, in Pembrokeshire Marine SAC includes saltmarshes within the Milford Haven Waterway (Figure 17). The ASM feature has been assessed against the performance indicators and an overall condition was assigned for the feature.

Figure 17. Map of the ASM feature in Pembrokeshire Marine SAC.

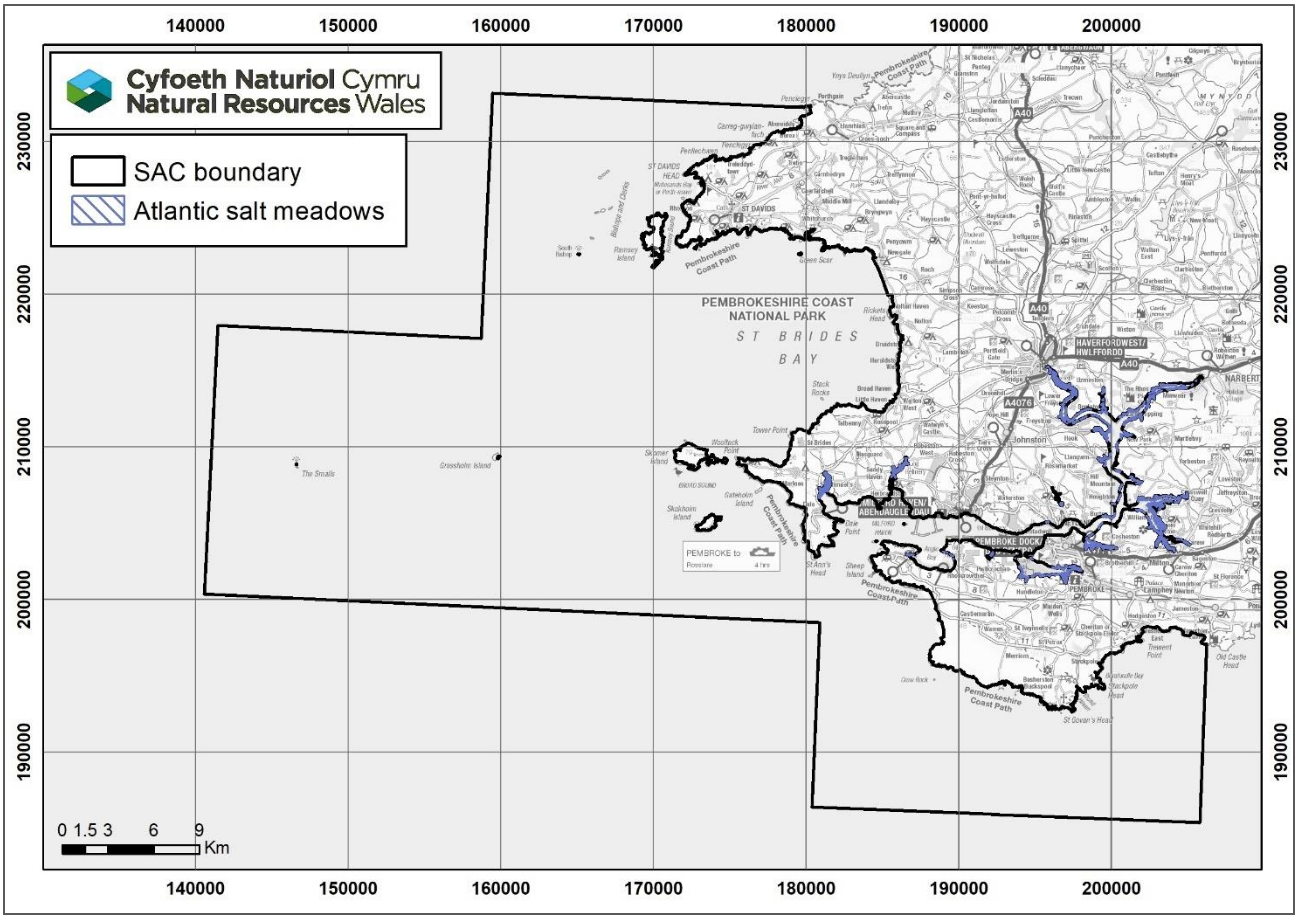


Table 18 has a summary of the assessment outcome against each performance indicator. The outcomes and any reasons for failure are discussed in more detail in the sections below.

Table 18. Condition assessment of the ASM feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Feature extent	The extent of the saltmarsh within the SAC should be stable or increasing, allowing for natural change and variation. (P)	• Between 2000 and 2020, there has been a loss of 0.87 ha (<1%) of saltmarsh extent. This loss is likely within the bounds of natural variation. • The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. Therefore the confidence associated with the pass is medium.	**Pass**	Medium
Distribution of feature	Maintain the distribution of saltmarsh throughout the SAC, allowing for natural change and variation. No significant loss from any of the defined sectors. Significant is defined as loss from any sector not to exceed 20%. (P)	• There has been no significant loss of saltmarsh extent in any of the defined sectors. • 5% loss in the Sandy Haven sector. • The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. Therefore the confidence associated with the pass is medium.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Distribution and extent of habitats and communities	Maintain the distribution and extent of saltmarsh habitats and communities, allowing for natural change. (P)	• The available NVC maps date from 1990-2000 and are too old to use for an assessment of distribution and extent.	**Unknown**	N/A
Physical structure: creeks and pans	Maintain the expected patterns of creeks and pans throughout the SAC, allowing for natural change and variation (P). Artificial drainage channels adversely affecting hydrology are absent or rare. (P)	• There are no anthropogenic impacts known to have significantly affected the creeks and pans in the saltmarsh since SAC designation. • There are currently no known artificial drainage channels that would adversely affect the hydrology within the saltmarsh. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (T)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the saltmarsh. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the saltmarsh. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• One of the three WFD waterbodies that overlaps with the feature was not classified as the chemicals have not been assessed within the last six years (Pickleridge Lagoon). This waterbody overlaps with <1% of the feature. • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 4% of the feature. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. It overlaps with 44% of the feature. • Confidence is medium as the human health standard has been used for PBDE; some waterbodies were not classified for relevant chemicals; and WFD water quality sampling is not focused on saltmarshes.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the three overlapping WFD waterbodies was not classified for the DIN WFD element in the 2024 cycle 3 interim classification (Pickleridge Lagoon). Evidence from the Planned Investigation in Pickleridge Lagoon found that there were elevated nutrients and the waterbody would classify as Bad status in 2023. • The other two WFD waterbodies were classified with a Poor status for DIN (Milford Haven Inner and Milford Haven Outer). Combined, these waterbodies overlap with 48% of the feature. • Confidence is medium as WFD water quality sampling is not focused on saltmarshes.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• One of the three WFD waterbodies was not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification (Pickleridge Lagoon). • One WFD waterbody was classified as Good status for this WFD element (Milford Haven Outer). It overlaps with 4% of the feature. However, there has been localised growth of opportunistic macroalgae recorded in some of the bays and inlets of the Milford Haven Outer waterbody. • One WFD waterbody was classified with a Moderate status (Milford Haven Inner). This waterbody overlaps with 44% of the feature. There are widespread issues with opportunistic macroalgae in this waterbody. ○ The opportunistic macroalgae is outcompeting the saltmarsh within this waterbody. The WFD investigation has confirmed the failure, with widespread issues in the waterbody which correspond to areas within the ASM feature, raising the confidence in the fail. • Confidence is high because the evidence of the opportunistic macroalgae issues in the Milford Haven Inner waterbody is substantial	**Fail**	High
Air quality	Nitrogen deposition should not exceed the critical load range of 10-20 kg N per ha^{-1} per year. (S)	• Nitrogen deposition within the SAC (where data were available) was under 15 kg N per ha per year for all saltmarshes and did not exceeded the upper range of the critical load on average (UK air pollution information system (APIS)). • Confidence is medium as the pass is based on the upper range of the critical load of nitrogen deposition.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, structure and diversity of ASM plant communities within the sectors of the SAC, allowing for natural change and variation. (P)	• Some WFD Regulations monitoring data are available for the Milford Haven Inner and Milford Haven Outer waterbodies but not enough to assess the indicator.	**Unknown**	N/A
Vegetation structure: sward height	Maintain the expected structural variation within the sward height, allowing for natural change and variation. The majority of plants should be able to produce flowers and set seed. (P)	• No significant grazing issues impacting the ASM feature were identified. • The confidence is high due to the availability high quality data.	**Pass**	High
Vegetation structure: zonation of vegetation	Maintain the expected range of saltmarsh zonation for the SAC, allowing for natural change and variation. (P)	• WFD data analysis indicated small changes in zonation, but it was judged to be from natural variation. • Confidence is medium as the changes in zonation were estimated by comparing 2011 and 2019 extents for two of the three relevant WFD waterbodies.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence of INNS presence within the ASM feature. • Confidence is medium as the spread and impacts of any INNS present within the SAC are not well understood, and there have been no targeted surveys of NNS within the ASM feature.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There are no known records of NNS within the ASM feature. • Confidence is medium as there have been no targeted surveys for NNS within the ASM feature.	**Pass**	Medium

Assessment conclusions

The Atlantic salt meadow (ASM) feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (low confidence). There were a number of indicators with failing targets (Table 19). There are serious concerns over the widespread issues with opportunistic macroalgae in the Milford Haven Inner waterbody, and the subsequent impact on the saltmarsh. The substantial evidence and the fact most of the feature is within areas that correspond to the opportunistic macroalgae growth, resulted in an overall unfavourable outcome. There were also limited or absent data for three key indicators to inform on the condition of the feature (see evidence gaps). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 19 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 19. Summary of the condition assessment for the ASM feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Atlantic salt meadows	**Unfavourable (low confidence)**	Water quality: opportunistic macroalgae (S) Water quality: nutrients (DIN only) (T) Water quality: contaminants (T)	• There has been opportunistic macroalgae growth in the Milford Haven Inner waterbody. • Nutrient levels are high in the Milford Haven Inner and Milford Haven Outer waterbodies. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Unconsented infrastructure • INNS • Critical load for nitrogen deposition • Water quality: contaminants • Climate change

Detailed assessment information

Extent and distribution

Saltmarsh extent has been mapped using imagery from 2000 and 2020. The total extent of saltmarsh was measured as 296.17 ha in 2020 compared to 297.01 ha in 2000, indicating a total loss of 0.87 ha (<1%). This loss is likely within the bounds of natural variation, therefore this indicator has been assessed as passing. There has been no significant loss of more than 20% of saltmarsh extent in any of the defined sectors. The extent of the saltmarsh has increased in four of the 12 defined sectors, and there has been no change in four. There has been a minor loss in extent in four sectors. The sector with the largest loss is Sandy Haven which has lost approximately 5% of the extent. Both the feature extent and distribution of the feature indicators met their targets. The mapping is based on high quality imagery, however the changes in extent are indicative only, as there has been no ground truthing. Therefore the confidence associated with the pass is medium.

The distribution and extent of habitats and communities, a key indicator to inform on the condition of the feature, was assessed as unknown as the available NVC mapping dates from 2002 (Prosser and Wallace, 2003). These were deemed too old to be representative of the current situation. The lack of more up to date maps meant change could not be assessed.

Physical structure

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

Hydrodynamic processes and topography

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

Water and air quality

It has been estimated that approximately 49% of the ASM feature within the SAC falls within three WFD waterbodies. The upper marsh areas are above the high-water mark and are therefore outside of the WFD waterbody boundary. However, marine water input to the upper marsh will be from these waterbodies therefore these waterbodies are likely to be a good reflection of the overall effect of water quality on the feature. However, as the WFD water quality classifications are not focused on saltmarshes, the confidence has been reduced in the relevant water quality assessments.

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 the largest proportion of the ASM feature (44%). 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 the ASM feature 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 interim 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. The other WFD waterbody (Pickleridge Lagoon) was 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. The confidence in the fail was reduced to medium because the human health standard has been used for PBDE, and due to the unclassified waterbodies for chemicals. In addition, the impact of the failing contaminants on the feature are not fully understood. The target weighting of the indicator is tertiary to reflect this.

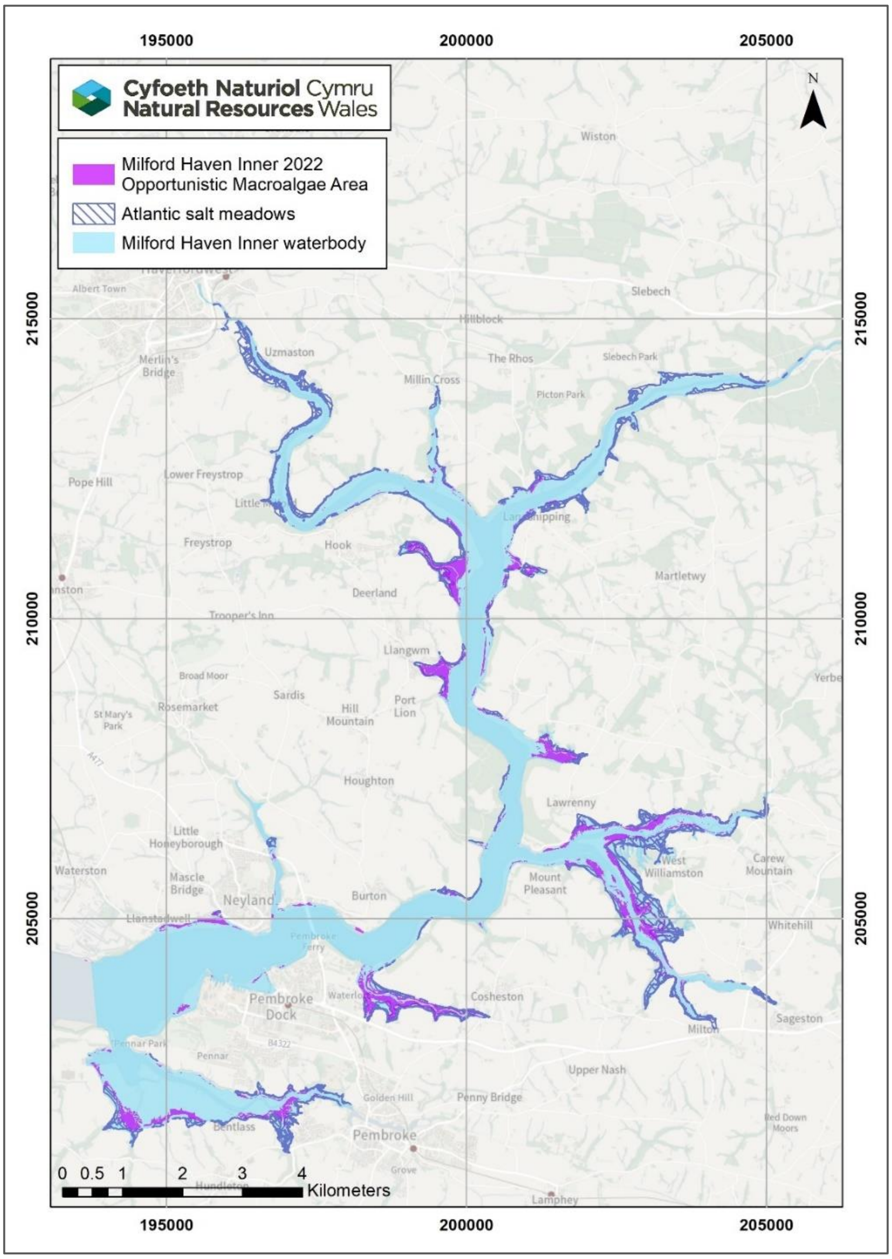
Nutrients (DIN only) and opportunistic macroalgae

The nutrients indicator failed to meet its target as failing levels of DIN have been recorded in two of the three WFD waterbodies that overlap with the ASM feature. The Milford Haven Inner and Milford Haven Outer waterbodies were classified with a Poor status for DIN in the 2024 cycle 3 interim classification. Combined, these overlap with 48% of the feature. These waterbodies also failed in previous cycles, and the Milford Haven Outer waterbody has deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation reports of these waterbodies confirmed the DIN failures in the 2018 cycle 2 interim 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.

The opportunistic macroalgae failure was also confirmed in the WFD investigation of the Milford Haven Inner waterbody (Lock, 2021a). Evidence from a planned investigation concluded that the third WFD waterbody, Pickleridge Lagoon, would classify as Bad status for DIN in 2023 due to elevated nutrients. Nutrient issues have been confirmed from investigations. Confidence in the fail was reduced to medium as WFD water quality sampling is not focused on saltmarshes. The nutrients indicator (DIN only) was given a tertiary weighting as the effects of high nutrient levels on the ASM feature are not fully understood.

The opportunistic macroalgae indicator failed to meet the target 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), in which extensive and recurring coverage has been recorded in various inlets, with many of the areas corresponding to areas within the ASM feature (Figure 18). In some areas, the opportunistic macroalgae is impacting the saltmarsh, growing on pioneer saltmarsh (Figure 19) (Lock, 2021a). There has been evidence of opportunistic macroalgae growth since 2007, indicating that this has been a long-lasting issue within the Milford Haven Inner waterbody. There are no quantitative data available on the anoxic layers from these surveys, however WFD surveyors have noted anoxic layers within 2cm of the surface beneath opportunistic macroalgae (Lock, 2021a). This is indicative of disturbance to the underlying benthos and may impact the ASM feature.

Figure 18. Opportunistic macroalgae cover in Milford Haven Inner waterbody in 2022, mapped against the ASM feature within the waterbody.



waterbody, there have been localised issues recorded in the more sheltered bays and inlets including Angle Bay, Sandy Haven and Dale Gann (Lock, 2021b). The other WFD waterbody (Pickleridge Lagoon) was not classified for this element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Overall, a high confidence was attributed to the failure of this indicator, as the failing WFD waterbody overlaps with the largest proportion of the feature (44%), and because the evidence of the opportunistic macroalgae issues in the Milford Haven Inner waterbody is substantial, especially within the ASM feature.

Figure 19. Opportunistic macroalgae covering pioneer saltmarsh plants in Garron Pill, Milford Haven Waterway in 2018 (Lock, 2021a).

Air quality

High levels of nitrogen (N) deposition from the atmosphere can have detrimental impact on saltmarsh since they are nitrogen limited. The nitrogen deposition within the SAC, where data were available, was under 15 kg N per ha per year for all saltmarshes and therefore did not exceed the upper range of the critical load (20 kg N per ha per year, UK air pollution information system (APIS)). If the assessment was based on the lower range of the critical load (10 kg N per ha per year), the indicator would fail to meet its target. For this reason, confidence was reduced to medium.

Species and communities

Whilst some WFD Regulations monitoring data are available for the Milford Haven Inner and Milford Haven Outer waterbodies, these were not sufficient to assess this indicator as no transect data were available. No further analyses have been carried out to look at distinctive elements such as abundance, distribution and species composition. This is a key indicator to inform on the condition of the feature. As a result, the abundance, distribution and species composition of communities indicator has been assessed as unknown.

Vegetation structure

Both the sward height and zonation of vegetation indicators met their targets. No significant grazing issues were identified (Sherry and Douglas, in draft). There were some local cases of excessive cattle poaching on saltmarshes, but they have all been addressed and the marshes are recovering. For the sward height indicator, the confidence in the pass is high due to the availability of high quality data. WFD data analysis showed small changes in zonation pattern, but this is likely to be natural and of limited concern. The confidence in the assessment for the zonation of vegetation indicator was reduced to medium since the changes in zonation derived from WFD data were estimated by comparing 2011 and 2019 extents for two out of three WFD waterbodies. Further data and ground truthing investigations would be needed to increase confidence.

Invasive non-native species

The saline conditions of saltmarshes prevent the common terrestrial NNS in Wales becoming established. There are no known records of NNS within the ASM feature, resulting in both the primary and tertiary targets for the INNS and NNS indicators to be met.

There were, however, some notable records of NNS within the SAC. The American Skunk cabbage *Lysichiton americanus* has been recorded in the estuary, but this is not yet on the saltmarsh and likely to only reach the margins.

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

Reasons for target failure

The assessment of the ASM feature in Pembrokeshire Marine SAC failed one secondary target and two tertiary targets. Due to the concerns over the failing secondary opportunistic macroalgae indicator, 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.

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. The magnitude of the opportunistic macroalgae issue in the ASM feature was the main reason for unfavourable condition. 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, where it has been photographed and observed on saltmarsh habitats (Lock, 2021a).

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: nutrients (DIN only)

This indicator target has a tertiary weighting. The nutrients indicator failed to meet its target as high levels of DIN have been recorded in all three of the WFD waterbodies that overlap with the ASM 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. A planned investigation in the Pickleridge Lagoon has also found elevated nutrients (Jopson and Lindenbaum, 2024).

Water quality: contaminants

This indicator failed to meet its tertiary target. A large proportion of the ASM feature overlaps with the Milford Haven Inner waterbody, which has a fail 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation of the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is being managed in the UK 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 biota of the ASM feature. The impact of PAH on the condition of the ASM feature is not fully understood.

Threats to condition

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

Unconsented infrastructure

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

Invasive non-native species

The presence of *L. americanus* which can tolerate brackish conditions has been recorded in the estuary but not yet on the saltmarsh. It is possible that this species could establish on the saltmarsh, but this has not happened yet.

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

Critical load for nitrogen deposition

The saltmarsh habitat is sensitive to nitrogen deposition from the atmosphere, so it is important that the current level of nitrogen deposition does not exceed the critical load of 10-20 kg N per ha per year. Although current critical load levels of nitrogen deposition were not exceeded for the ASM feature in the Pembrokeshire Marine SAC, the air quality indicator would fail if it was assessed against the lower range of the critical load (e.g. 10 kg N per ha per year).

Water quality: contaminants

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

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

Climate change

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

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

- Changes in species distribution.

The latest information (Oaten et al, 2024).shows that the ASM feature in this SAC is definitely under threat of coastal squeeze and natural squeeze (loss of habitat against high ground).

Evidence gaps

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

Listed below (Table 20) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 20. Evidence gaps for the ASM feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Distribution and extent of habitats and communities (P)	Unknown	• There are no recent NVC surveys or monitoring aimed at assessing this target for ASM within the SAC. Additional fieldwork would be required to assess this indicator.
Topography of the feature (P)	Medium confidence (proxy data used)	• The topography of the ASM feature is not well monitored in any of the SACs. Repeat Lidar surveys taken at mean low water springs for all saltmarshes within the SAC are required.
Abundance, distribution and species composition of communities (P)	Unknown	• Plant communities are not currently monitored in all of the SACs. Therefore there is a lack of information on the abundance and distribution of plant communities of the ASM feature. • WFD Regulations data could potentially be used further in future assessments, however, additional analysis will be required.
Attributes of local distinctiveness (P)	Not assessed	• There is a lack of information on the named distinctive elements of the ASM feature**.** Additional fieldwork would be required to assess this indicator in all SACs. For further information on what is locally distinctive see relevant Regulation 37 advice packages.
Sediment quality: contaminants (T)	Not assessed	• Currently, there is no sediment monitoring within the ASM feature in all SACs.

Indicator	Assessed status	Comments
Hydrodynamic and sediment transport processes (T)	Medium confidence (proxy data used)	• The hydrodynamic regime of the ASM feature is not currently monitored in all SACs.

3.6. Mudflats and sandflats condition assessment

The mudflats and sandflats feature in the Pembrokeshire Marine SAC is comprised of a number of mudflats and sandflats (Figure 20), but the NRW Habitats Regulations monitoring has been focused on sampling points within mudflats in the Gann, Angle Bay and Milford Haven inlets. As part of the Habitats Regulations monitoring survey, Angle Bay was monitored between 2014 and 2022 using core sampling and Milford Haven inlets were monitored between 2007 and 2021 using grab sampling. Investigation occurred in the Gann flats to assess biological communities and the impact of bait digging activities with targeted monitoring surveys undertaken between 2015 and 2017.

Figure 20. Map of the mudflats and sandflats feature in Pembrokeshire Marine SAC.

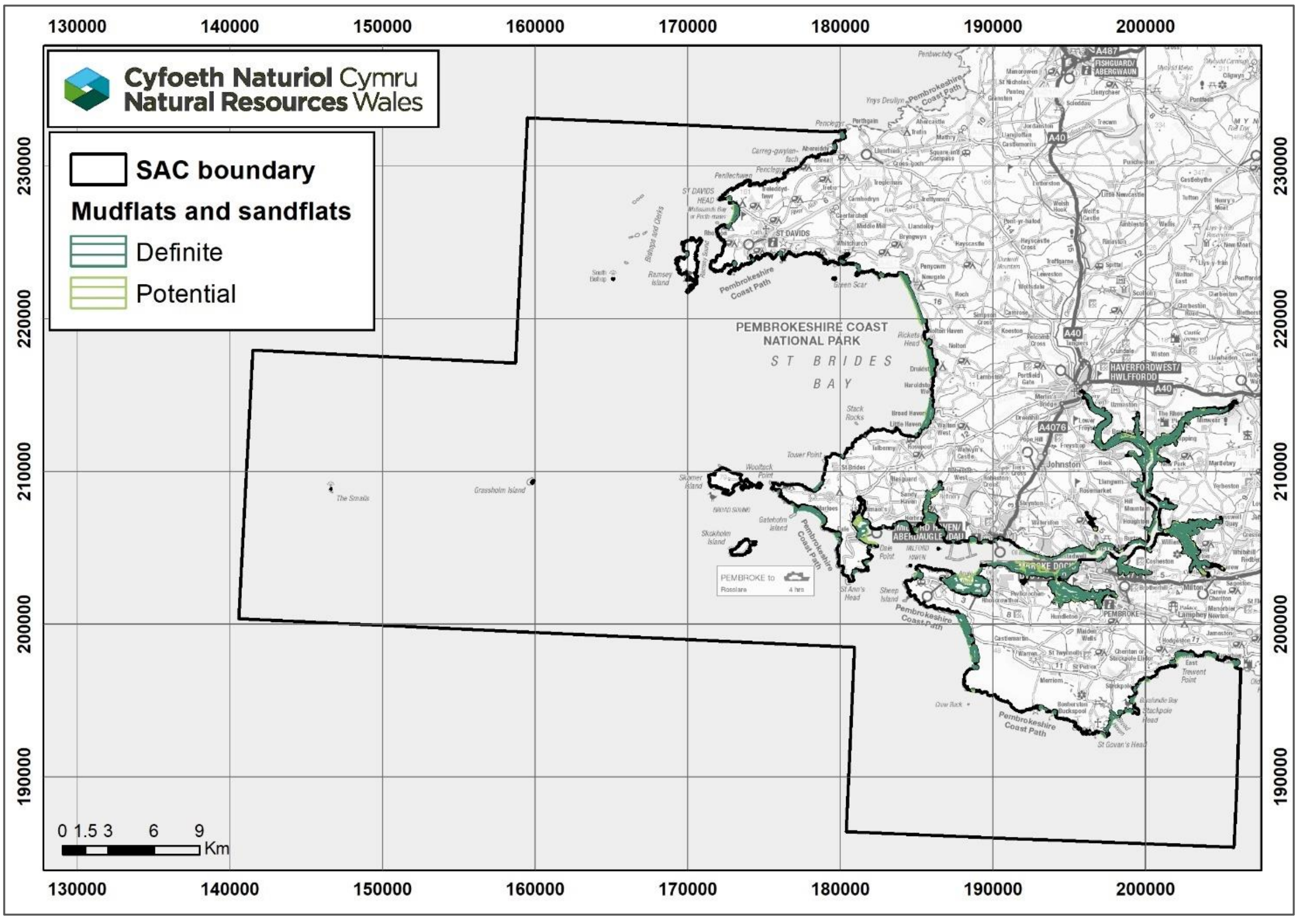


Table 21 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 21. Condition assessment of mudflats and sandflats in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Target**	**Assessment rationale**	**Target assessment**	**Target confidence**
Feature extent	No significant decrease in the extent of mudflats and sandflats within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of the mudflats and sandflats feature in the 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 and extent of habitats and communities	Maintain the distribution and extent of mudflats and sandflats habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of the mudflats and sandflats feature in the Pembrokeshire Marine SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of recent data and, due to the uncertainties around the impact of bait digging activities.	**Pass**	Low
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the mudflats and sandflats. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the mudflats and sandflats feature in the Pembrokeshire Marine SAC. • Bait digging at the Gann, and Angle Bay, cause small-scale topography alteration. This was not considered to be a large enough effect to fail the whole feature in the SAC, however it did reduce the confidence in the assessment to medium.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the mudflats and sandflats feature in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the mudflats and sandflats, allowing for natural change and variation. (P)	• Granulometric analysis for the intertidal monitoring program at Angle Bay showed some variations in sediment composition that are likely to be natural. • With the exception of the Gann, granulometric analysis for the Inlet monitoring program showed some variation in sediment composition, but this is likely to be natural. • The sediment composition at the Gann indicated mixed sediment with large changes, indicating some disturbances. • Confidence is low due to the issue related to the Gann sediment composition.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to mudflats and sandflats infaunal communities, allowing for natural change and variation. (S)	• The stations assessed for the redox layer are all located within Angle Bay. The redox layer indicated no clear trend over the years. • A greater spatial coverage is needed to understand ongoing processes and confirm overall trends. • Opportunistic macroalgae cover has caused anoxic layers in the Milford Haven Waterway sediments, however there are limited quantitative data to confirm this. This has led to the indicator failure. • Confidence is low as the assessment was based on visual observations and expert judgement.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to mudflats and sandflats communities, allowing for natural change and variation. (P)	• Organic carbon content has declined throughout the monitoring period at the Clean Safe Seas Environmental Monitoring Programme (CSEMP) sampling station in the Milford Haven Waterway. • The organic carbon content at each NRW monitored inlet location in the Milford Haven Waterway (eastern and western Cleddau, Carew / Cresswell, Cosheston Pill, Pembroke River, Sandy Haven, Angle Bay and the Gann) has increased across the monitoring period, where some have doubled in carbon content from 2007 to 2021. • The indicator failed to meet its target due to the increase in carbon within the Milford Haven inlets. Increases in carbon can be an indicator of enrichment and reduced oxygen in the sediment. • Confidence is high due to the consistent increase in carbon in each inlet location, and the availability of long term monitoring data with broad spatial cover.	**Fail**	High
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• PAHs were recorded in the Milford Haven Waterway at the CSEMP sampling location and NRW monitored grab sampling locations. In recent years, some PAHs were above the most stringent ecological guidelines. • Some heavy metal concentrations were above the less stringent guidelines in CSEMP and NRW monitored grab sampling locations in recent years (including arsenic, chromium, copper and zinc). • Confidence is medium as the impact of the contaminants to the feature is not fully understood, and as there are no data for other parts of the feature in the SAC.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Two of the five WFD waterbodies that overlap with the feature were classified with a High status for the DIN WFD element in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). These waterbodies overlap with 17% and <1% of the feature.
		  ○ The Pembrokeshire South waterbody classification was rolled forward from the 2018 cycle 2 interim classification.
		• The other three WFD waterbodies were classified with a Poor or Bad status for DIN (Milford Haven Inner, Milford Haven Outer and Solfach Estuary).
		  ○ Milford Haven Inner and Outer waterbodies were classified with Poor status. These waterbodies overlap with 55% and 23% of the feature.
		  ○ The Solfach Estuary waterbody was Bad status. It overlaps with less than 1% of the feature.
		• Confidence is high as the waterbodies with failing DIN status overlap with a large proportion of the feature (79%).
			Fail	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Two of the five WFD waterbodies were not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Solfach Estuary and Cardigan Bay South). However, they overlap with <1% of the feature. • The other three WFD waterbodies were classified with a High status for phytoplankton (Milford Haven Inner, Milford Haven Outer and Pembrokeshire South). Combined, these overlap with 96% of the feature. • Confidence is medium as the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Three of the five WFD waterbodies were not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification (Pembrokeshire South, Solfach Estuary and Cardigan Bay South). Combined, these overlap with 18% of the feature. • One WFD waterbody was classified as Good status for this WFD element (Milford Haven Outer). It overlaps with 23% of the feature. However, there has been localised growth of opportunistic macroalgae recorded in some of the bays and inlets of the Milford Haven Outer waterbody. • One WFD waterbody was classified with a Moderate status (Milford Haven Inner). This waterbody overlaps with 55% of the feature. There are widespread issues with opportunistic macroalgae in this waterbody, leading to high confidence in the fail. • Confidence is high because evidence of the opportunistic macroalgae issues in the Milford Haven Inner waterbody is substantial.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• All five overlapping WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Milford Haven Inner, Milford Haven Outer, Pembrokeshire South, Solfach Estuary and Cardigan Bay South). • Confidence is medium due to samples being taken from the surface of the waterbodies.	**Pass**	Medium

Indicator	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 as the chemicals have not been assessed within the last six years (Pembrokeshire South, Solfach Estuary and Cardigan Bay South). Combined, these overlap with 18% of the feature. • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody overlaps with 23% of the feature. This waterbody has improved since previous cycles. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. It overlaps with 55% of the feature. • Confidence is medium as the human health standard has been used for PBDE, and due to the waterbodies that were not classified for relevant chemicals.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the mudflats and sandflats feature in the Pembrokeshire Marine 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 intertidal and 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

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)	All data listed are within the Milford Haven Waterway. • Four of the five overlapping WFD waterbodies were classified as Good or High status for the IQI WFD element in the 2024 cycle 3 interim classification. Combined, these overlap with 96% of the feature. • Infaunal analysis of the core samples for Angle Bay indicated natural variation in community composition. • The core samples revealed no clear pattern in the abundance of *A. marina,* but no cause for concern. • WFD data indicated that the extent of *Zostera noltei* has expanded in the Milford Haven Inner and Outer waterbodies. • Infaunal analysis of the grab samples for the Milford Haven inlets indicated large variations in community composition across the monitoring period 2007-2021. • There has been an increase in opportunistic species which are typically associated with anthropogenic disturbances (e.g. pollution) at several locations (e.g. Sandy Haven, the Gann, Angle Harbour, Cosheston Pill and Western Cleddau). • The most dominant infaunal species recorded at the Gann Flats in the 2015-2016 surveys were all short-lived species with high dispersal potential and often associated with more disturbed habitats. • Confidence is medium as while evidence indicated poor conditions in the Milford Haven inlets, other data showed natural variability.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of mudflats and sandflats species, allowing for natural change and variation. (S)	• Species richness and diversity from the core samples at Angle Bay were within the bounds of natural variation. ○ One out of three stations monitored (e.g. G14) indicated consistently low species diversity. • A decrease in species richness and diversity in the Milford Haven inlets was observed from the grab sampling at Sandy Haven. Diversity was also low in recent years at Cosheston Pill. • Confidence is low as significant spikes in grab samples infaunal abundance may have influenced the results. There was also a low number of sampling point that showed decreases in diversity.	**Fail**	Low
Taxonomic spread of species	Maintain the expected taxonomic spread of mudflats and sandflats species, allowing for natural change and variation. (S)	• Overall, the average distinctness of the infaunal community of the core samples at Angle Bay mudflats and sandflats remained stable and within the expected values over the monitoring period. • One station (e.g. H18) tended to be mostly outside the expected levels except with some improvement in 2022 with an average taxonomic distinctness within the expected value. • The analysis was not conducted on the grab data for the Milford Haven inlets and will be something to complete in the next assessment.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not adversely altering ecosystems. (P)	• There is limited evidence to suggest that INNS (e.g. *Didemnum vexillum*) are currently impacting the mudflats and sandflats feature 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)	• *D. vexillum* was recorded for the first time in 2023 within the Milford Haven Waterway. • There is a high number of NNS in Milford Haven Waterway especially, and a recent increase of new NNS to the SAC including *Crepidula fornicata* and *D. vexillum* (found in 2023). • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The mudflats and sandflats feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of failing indicators (Table 22). 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 22 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 22. Summary of the condition assessment for mudflats and sandflats in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Mudflats and sandflats	**Unfavourable (medium confidence)**	Sediment quality: carbon (P) Sediment quality: contaminants (P) Water quality: nutrients (DIN only) (P) Abundance, distribution and species composition of communities (P) Water quality: opportunistic macroalgae (S) Sediment quality: oxidation-reduction profile (redox layer) (S) Water quality: contaminants (S) Species richness and diversity (S) Non-native species (T)	• Organic carbon content of sediments has increased in the Milford Haven inlet monitoring locations. • Levels of PAHs and heavy metals are exceeding sediment quality guidelines within Milford Haven sediments. • There are high nutrient levels in the Milford Haven Inner and Outer waterbodies. • The Gann's infauna was dominated by opportunistic species, which is likely due to bait digging activities. High levels of opportunistic species were also found in various locations within the Milford Haven inlets, which is likely due to the elevated levels of nutrients and contaminants within the Milford Haven Waterway. • Opportunistic macroalgae is present in Milford Haven Inner waterbody, which has led to anoxic layers in sediments. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet their relevant EQSs. • A clear decrease in species richness and / or diversity was observed in recent years at Sandy Haven and Cosheston Pill within the Milford Haven inlets. • There has been an increase in the number of NNS in the feature SAC, including *C. fornicata* and *D. vexillum.*	• Unconsented infrastructure • INNS • Recreational access and collection • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

The feature extent and distribution and extent of habitats and communities indicators in the Pembrokeshire Marine SAC passed their targets as there are currently no known anthropogenic impacts that would negatively affect the feature. Comparison mapping has not been used to assess the extent and expert judgement was used to assess this indicator in the absence of recent data. This reduced the confidence in the assessment of both indicators, leading to a medium for the extent indicator.

The confidence in the pass for the distribution and extent of habitats and communities indicator was further reduced to low due to the uncertainties around the impact of bait digging activities. The Gann holds a large proportion of the muddy gravel habitat, which generally supports a high diversity of both infauna and epifauna due to the complex nature of its substratum. Although the impact of bait digging activities in the Gann are long-lasting and it would take time to recover, the extent of the habitat has not decreased as the communities, whilst disturbed, are still present. There is also a recent increase in *Zostera noltei* extent in the west of Angle Bay (West et al., 2025).

Sediment quality; topography; and hydrodynamic and sediment transport processes

Composition

Granulometric analysis within the Milford Haven inlets indicated little variation in sediment composition with the exception of the Gann. The majority of stations in the Milford Haven inlets were dominated by proportions of silt and finer sand fraction (medium and coarse sand for Angle Bay) and this remained fairly stable across the monitoring period. Analysis of the data showed no relationship between infaunal abundance and sediment composition at Angle Bay. Analysis for the Gann, however, indicated changes in sediment composition particularly between 2012 and 2018 with an increase of silt and pebble but reduction of fine sand. This change in sedimentation in one area was not considered to be a large enough impact to fail the whole feature as it represents a small areas in proportion to the feature size. However, these large changes in sediment content suggested some disturbance and therefore would be something to pay close attention to in the next assessment and has reduced the confidence in the pass to low.

Redox layer

Quantitative data on the redox layer of sediments have been analysed in the Angle Bay sites only. These data indicated no clear trend over the years (NRW unpublished data). In the wider Milford Haven estuary, there is evidence of opportunistic algae within the site (Lock, 2021a). Excessive opportunistic algal mat growth will quickly smother the sediment, causing anoxic conditions. This has been observed where extensive areas of opportunistic macroalgae growth has been recorded within the Milford Haven inlets, for example within Sandy Haven, where anoxic layers have been observed beneath algal mats (Figure 3). This had led to a failure for the redox layer indicator. The confidence attributed to the failure has been reduced to low as the conclusion has been based on visual observations and expert judgement, with a lack of a long-term quantitative data series. The stations assessed for the redox layer are all located within Angle Bay, which is outside the opportunistic macroalgae sampling locations and may explain why there were no clear trend there. A greater spatial coverage is needed to understand ongoing processes and confirm overall trends.

Carbon content

The assessment of the sediment quality (organic carbon and contaminants) indicators used data from NRW monitored sediment sampling as part of the CSEMP sampling in one subtidal location in Milford Haven Waterway in various years up to 2023. This location is considered to be representative of the whole estuary as it is upstream of the main industrial areas. Additional sediment grab sampling in Milford Haven Waterway from NRW Habitats Regulations monitoring were also used for the assessment (2007, 2012, 2018 and 2021). These were grouped into inlet locations for analysis. In total, there were 19 sampling locations close to or overlapping with the mudflats and sandflats feature which were considered for the assessment of these sediment quality indicators.

The organic carbon content at all of the grouped inlet locations has increased over the whole monitoring period (Figure 9a). The location with the highest carbon content in 2021 is the Western Cleddau, where it has increased from 2.3% in 2007 to 3.8% in 2021 (Figure 9a). At the subtidal CSEMP location the carbon content has decreased over the monitoring period from 2.2% in 1999 to 1.3% in 2022 (Figure 9b). The carbon content has not been compared against any defined ecological standard as it is highly variable by location, however increases in carbon can be an indicator of organic enrichment and reduced oxygen in the sediment.

The indicator failed to meet its target with high confidence due to the increase in carbon at the Milford Haven inlets locations. Additionally, initial outputs of deep cores from the MHWESG show that total organic carbon content has increased over a longer historical time period (i.e. several decades) at some locations in the Milford Haven inlets (e.g. Pembroke River, Boulston and Cosheston Pill) (MHWESG, pers. comm.). The more recent observed increases in carbon are therefore likely a continuation of a long-term trend of increasing carbon at these locations. This would be something to look at in the next assessment when the analysis has been completed.

Sediment contaminants

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 OSPAR guidelines, CEQG and Cefas action levels. Further information is available in the IMCA final report.

Levels of PAH compounds were recorded at the CSEMP location. 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 Milford Haven Waterway (Pembroke River Upper) in 2021, where concentrations of three of the sampled PAH compounds (anthracene, benzo(a)anthracene and fluoranthene) 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.

Heavy metal concentrations were also recorded at various locations. The concentrations of arsenic, chromium, copper and zinc were above the less stringent ecological guideline at various locations from the CSEMP and grab sampling 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. PCBs have mostly declined at both the CSEMP and grab sampling stations since earlier years, and all are below the more stringent guidelines in the most recent year of sampling. The sediment quality (contaminants) indicator failed to meet its target due to levels exceeding sediment quality guidelines in various contaminants. The impact of the contaminants to the mudflats and sandflats feature is not fully understood. For this reason, the confidence was reduced to medium. In addition, the sampling locations were within the Milford Haven Waterway only and there were no data available for the rest of the feature.

Hydrodynamics and topography

The topography and hydrodynamic and sediment transport processes are not well researched for intertidal mudflats and sandflats. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have a significant impact on the feature. Bait digging at the Gann, and Angle Bay, cause small-scale topography alteration. This was not considered to be a large enough effect to fail the whole feature in the SAC, however it also contributed to the medium confidence for the topography indicator.

Water quality

It has been estimated that approximately 96% of the mudflats and sandflats feature within the SAC falls within five WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Milford Haven Inner waterbody overlaps with the largest proportion of the feature (55%). Two of the five WFD waterbodies, Solfach Estuary and Cardigan Bay South, overlap with a very small proportion of the mudflats and sandflats feature (<0.5%), therefore they have not been considered further in the condition assessment.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target as failing levels of DIN have been recorded in waterbodies that overlap with a large proportion of the mudflats and sandflats feature. The Milford Haven Outer and Inner waterbodies overlap with the largest proportion of the feature (55% and 23% respectively) and were classified as Poor status for DIN 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. 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.

The opportunistic macroalgae failure was also confirmed in the WFD investigation of the Milford Haven Inner waterbody (Lock, 2021a). High confidence has been attributed to the failure of the nutrients indicator 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.

The opportunistic macroalgae indicator failed to meet its target 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, in which extensive and recurring coverage has been recorded in various inlets including Cosheston Pill (Figure 11a), Garon Pill (Figure 11b), and Carew and Cresswell rivers (Lock, 2021a). A high confidence was attributed to this indicator, as the failing waterbody overlaps with the largest proportion of the feature (55%), and because the evidence of the opportunistic macroalgae issues in the Milford Haven Inner waterbody is substantial. The 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 11) (Lock, 2021b). The other three WFD waterbodies were not classified for this 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 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 two overlapping WFD waterbodies were not classified for this element, but they overlap with a very small proportion of the feature, and were therefore not considered in the condition assessment. 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 ecological relationships between phytoplankton and the mudflats and sandflats feature across all SACs are not fully understood, which has reduced the confidence in the assessment to medium.

Dissolved oxygen

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

Contaminants

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 the largest proportion of the mudflats and sandflats feature (55%). 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 mudflats and sandflats 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 interim 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. The other three 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. The confidence in the fail was reduced to medium because the human health standard has been used for PBDE, and due to the unclassified waterbodies or 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 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. None of the loggers overlap with the mudflats and sandflats feature, but some were fairly close. 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

Abundance, distribution and species composition of communities in Milford Haven inlets

Infaunal analysis of the Milford Haven inlets indicated large variations in species composition across the monitoring period (NRW unpublished data). Sandy Haven had the most dramatic change of species composition with the largest variation seen in 2021. This location is known to be one of the most impacted by nutrient levels in the Milford Haven Outer waterbody, with algae covering the mudflats and nearby saltmarsh. Some run-off of algae “liquor” was also observed on the flat (M. Camplin (NRW), pers. comm., Figure 3). This evidence indicated poor condition in this inlet. The infauna at the Gann indicated previous disturbance likely due to historical bait digging activities with elevated numbers of opportunistic species such as *Naididae* and Oligochaetes. A slight reduction of these species was observed in the most recent years, but condition of this inlet remains poor. Species composition at Angle Bay differed greatly between stations, with the one closest to the harbour having many more opportunistic species, including the polychaete *Capitella* spp often linked with pollution (infaunal AMBI group V - species highly sensitive to organic enrichment and present only under severe disturbance, Borja et al., 2000). Survey logs also indicated extensive algae cover resulting in anoxia. WFD surveys also recorded localised opportunistic macroalgae issues at this inlet. This is not surprising since Angle Bay harbour is very sheltered with sewage output and likely to contain high levels of nutrients and contaminants. This inlet is, therefore, in poor condition.

Cosheston Pill is the most impacted inlet by opportunistic macroalgae (M. Camplin (NRW), pers. comm.). Similarly to Sandy Haven, the community composition fluctuated through time with large shifts observed and significant spikes in abundance, often by opportunistic species, which can be indicative of stressed communities. This indicated poor conditions in this inlet. The Western Cleddau appears to be in the worst condition of all inlet monitoring sites, as since 2015 the number of opportunistic species has been rising. Data also showed a large recruitment of the polychaete *Streblospio* spp, a tolerant species (infaunal AMBI group III - tolerant to organic enrichment and typically occur under conditions of moderate disturbance, Borja et al., 2000).

While Pembroke river is known to have some opportunistic macroalgae issues, there is better water flow and it did not appear to be as severe as other inlets (e.g. Sandy Haven and Cosheston Pill) (Lock, 2021a). The infaunal data supported this and did not show anything concerning, resulting in this inlet to be in healthy condition. Data for Carew and Cresswell River showed some shift in species composition especially between 2012 and 2015 but nothing conclusive to whether this is natural or not. Uncertainty remains for this inlet and a deeper look at the analysis might be required. The data for the Eastern Cleddau indicated that a large shift in community composition occurred in 2015 but this appeared to revert to a previous state in recent years. Similarly to the Western Cleddau, *Streblospio* spp appeared to drive this change. While this was not deemed enough to fail this inlet, this shift in 2015 is concerning. Overall, the Milford Haven inlets is in poor condition, as evidenced by concerning patterns in species composition in various inlet locations.

Abundance, distribution and species composition of communities in the Gann flats

The Gann flats have been historically exploited for bait digging activities, resulting in a reduction in long-lived, larger species. As part of the targeted monitoring surveys at the

Gann, infaunal surveys in 2015-2016 indicated a dominance of opportunistic species such as the oligochaete *Tubificoides benedii* and the polychaetes *Pygospio elegans* and *Melinna palmata*. These species are short-lived with high dispersal potential and are often associated with more disturbed habitats (West et al., 2020). In more recent years, a decline in bait digging activities at the Gann (NRW monitoring, pers. comm.), and a decrease of some opportunistic species (e.g. *Naididae* and oligochaetes) were observed from the Milford Haven inlets grab survey. No survey has been conducted to assess the recovery since 2016, but the impacts on communities are still likely to be present. Bait digging activities have also been observed within the *Z. noltei* beds in Kilpaison Bay, which is part of Angle Bay. Bait digging activities have impacted *Z. noltei* cover and limited its expansion in that localised area (Figure 21). This would be something to pay close attention to in the next assessment.

Figure 21. Example of bait digging impact on seagrass *Zostera noltei* at Angle Bay on 11/05/2024.

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Abundance, distribution and species composition of communities in Angle Bay

Other studies and data indicated that the condition of some species composition of communities within the Milford Haven Waterway are in good condition. Infaunal analysis sampled by cores of Angle Bay infauna showed that communities fluctuated within natural variations (Moore et al., 2021 and NRW unpublished data). A recent survey by ABPmer has shown no significant impact of bait digging on infaunal communities at Angle Bay (West et al., 2024), but further work is required to confirm this. In addition, four of the five relevant WFD waterbodies that overlap with the mudflats and sandflats feature were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Milford Haven Inner, Milford Haven Outer, Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 96% of the feature. The other WFD waterbody was not classified for this element (Solfach Estuary). However, it overlaps with less than 0.5% of the feature.

The limited data from the core samples revealed no clear pattern in the abundance of *A. marina,* and was no cause for concern. Evidence suggests that *Z. noltei* extent has increased in recent years in the Milford Haven Outer and Inner waterbodies with possible new patches of *Z. noltei* discovered. Recent surveys at Angle Bay observed widespread *Z. noltei* extent in the east of the Bay (West et al., 2025). While bait digging activities have been observed within the *Z. noltei* in Angle Bay (Figure 21) and are impacting *Z. noltei* cover at this particular location (West et al., 2025), the overall extent of *Z. noltei* for Pembrokeshire Marine SAC has increased (Moore et al., 2021; Moore et al., in draft).

Overall, the poor condition observed at some locations within the Milford Haven inlets, resulting in the abundance, distribution and species composition of communities indicator to fail to meet its target. A medium confidence was given as although evidence suggested poor condition in the Milford Haven inlets, other evidence showed natural variability. Some uncertainties remain and further analysis would be beneficial. Additional analysis on the life histories of species that are driving the observed changes, the broad patterns of tolerant species change, and how these are related to natural versus anthropogenic pressures would raise the confidence in the assessment and help to identify potential reasons for the failures.

Species richness and diversity

Analysis of species richness and diversity of the grab samples taken in the Milford Haven inlets showed a clear decrease at one station in Sandy Haven in both species richness and diversity, however at the other station, these appeared to have increased in 2021. In addition, at Cosheston Pill, there was a decrease in diversity since 2015 at both stations, however it decreased to a lesser extent at one of the two stations. One station in Pembroke River was concerning as there was an overall decrease in diversity in recent years, but with some fluctuation.

Species richness and diversity appeared variable in the Gann, Angle Bay, Carew and Cresswell River, and the Eastern and Western Cleddau locations. These fluctuations were not deemed concerning as there was high variability within grab samples and diversity appeared to have remained stable or increased in recent years.

Species richness and diversity of the core samples at Angle Bay were within the bounds of natural variation (Moore et al., 2021 and NRW unpublished data). One of the stations (G14), however, tended to have low species diversity but as this was seen consistently over time, it was not deemed enough to fail the target.

Overall, the decrease in species richness and diversity at two locations within the Milford Haven inlets (Sandy Haven and Cosheston Pill), and the concern raised for Pembroke River meant the species richness and diversity indicator failed to meet its target. Confidence was reduced to low as large fluctuations in the overall taxa abundance was observed in many locations across the monitoring periods. There was also a low number of sampling points that showed decreases in diversity. A longer dataset would confirm any trend observed.

Taxonomic distinctness

The average taxonomic distinctness indicator was assessed as unknown due to low spatial coverage. Most of the core sampled stations at Angle Bay were within the expected levels across the monitoring period with the exception of some years for one station (H18). Differences observed could be linked with this station being more muddy gravel type habitat with elevated number of polychaetes. Further analysis is needed to assess the taxonomic distinctness with the grab data for the Milford Haven inlets and will be something to pay close attention to in the next assessment.

Invasive non-native species

Didemnum vexillum was recorded for the first time in various locations in 2023 within the Milford Haven Waterway, including within the mudflats and sandflats feature. Therefore the tertiary target of the NNS indicator failed with high confidence due to the new NNS recorded in the mudflats and sandflats feature within the last six years.

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 mudflats and sandflats feature. These include *Magallana gigas*, *Ficopomatus enigmaticus, Undaria pinnatifida, Sargassum muticum* and *Crepidula fornicata*.

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

Reasons for target failure

The assessment of the mudflats and sandflats feature in the Pembrokeshire Marine SAC failed four primary targets, four secondary targets and one tertiary target failed. This resulted in this feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Sediment quality: organic carbon content

This indicator target has a primary weighting. The carbon content has increased across the monitoring period at various monitoring locations within the Milford Haven inlets. Increases in carbon are likely to be from an increase in the amount of organic material being deposited, and can be indicative of eutrophication and reduced oxygen in the sediment.

Sediment quality: contaminants

This indicator target has a primary weighting. 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 and TBT. Various other contaminants including metals 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 as there was no sediment sampling in the mudflats and sandflats feature outside of the waterway. Investigations into the sources of these contaminants, and the full impact on the feature have not been carried out.

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. The nutrients indicator failed to meet its target as high levels of DIN have been recorded in three of the WFD waterbodies that overlap with the mudflats and sandflats 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.

Abundance, distribution and species composition of communities

This indicator target has a primary weighting. Fluctuations and / or large shifts in species composition was observed at several inlets during the monitoring period with significant spikes in abundance, often by opportunistic species. This suggests that communities are unstable and affected by ongoing disturbances. In the Western Cleddau, the abundance of some opportunistic species was on the rise since 2015. These disturbance observed are likely to be linked to high level of nutrients and contaminants recorded in the Milford Haven Waterway. In addition, impacts on infaunal communities at the Gann due to bait digging activities contributed to the failure. A national code of conduct for bait collectors has been developed for Wales. The objective is to reduce impacts from bait collection on relevant protected features.

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. 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.

Sediment quality: oxidation-reduction profile (redox layer)

This indicator failed its secondary target due to the extensive opportunistic macroalgae growth within the Milford Haven Waterway, and the subsequent anoxic conditions this causes in the sediments. This has been observed where areas of opportunistic macroalgae growth has been recorded within the Milford Haven inlets. The assessment of this indicator has been based on imagery and expert judgement, with a lack of a long-term quantitative data series. Quantification of the redox layers beneath opportunistic macroalgae would be required to raise the confidence of the failure.

Water quality: contaminants

This indicator failed to meet its secondary target. A large proportion of the mudflats and sandflats feature overlaps with the Milford Haven Inner waterbody, which has a fail 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation into the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is being managed in the UK 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 mudflats and sandflats biota. The impact of PAH on the mudflats and sandflats feature is not fully understood.

Species richness and diversity

This indicator target has a secondary weighting. A clear decrease in diversity was observed at two locations in the Milford Haven inlets, Sandy Haven and Cosheston Pill. Species richness has also decreased in recent years in Sandy Haven. While reasons for these decrease are not confirmed, it is likely that these issue are linked with the poor water quality and sediment contaminants occurring in the Haven.

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 increase in records of NNS in the mudflats and sandflats feature, including *D. vexillum* and *C. fornicata* within the last six years.

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

Threats to condition

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

Activities that go through licencing and permission processes e.g. cable laying and maintenance whereby the impact of the activity on the feature would be assessed have not been included. The threats to the mudflats and sandflats feature condition in the Pembrokeshire Marine SAC are stated below.

Unconsented infrastructure

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

Invasive Non-Native Species

Gracilaria vermiculophylla has also been found close to the SAC, in Nevern. This species has the potential to establish quickly, and can have a detrimental impact on the feature as seen in in Carmarthen Bay and Estuaries SAC (see further detail in Section 3.1).

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

Recreational access and collection

Bait digging activities can have detrimental effects on the mudflats and sandflats feature by changing the sediment composition and its associated faunal communities and may also affect *Z. noltei* coverage (West et al., 2020; West et al., 2025).

Water quality: contaminants

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

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

Management of coastal defences

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

Climate change

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

- Sea level rise, leading to coastal squeeze and loss of extent.
- Changes to wave climate, especially storm frequency and intensity, which may change the topography.
- Changes in air and sea temperature.
- Changes in species distribution.

The latest information (Oaten et al, 2024) shows that mudflats and sandflats in the SAC is definitely under threat of coastal squeeze and natural squeeze (loss of habitat against high ground).

Evidence gaps

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

Listed below (Table 23) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 23. Evidence gaps for the mudflats and sandflats feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Extent (P)	Medium confidence (proxy data used)	• Currently, the extent of mudflats and sandflat is not accurately measured at any of the SACs and there is no repeated measure taken.
Distribution and extent of habitats and communities (P)	Low confidence (proxy data used)	• Without any recent biotope surveys undertaken, assessing changes in mudflats and sandflats within the SAC is difficult. A new survey is required.

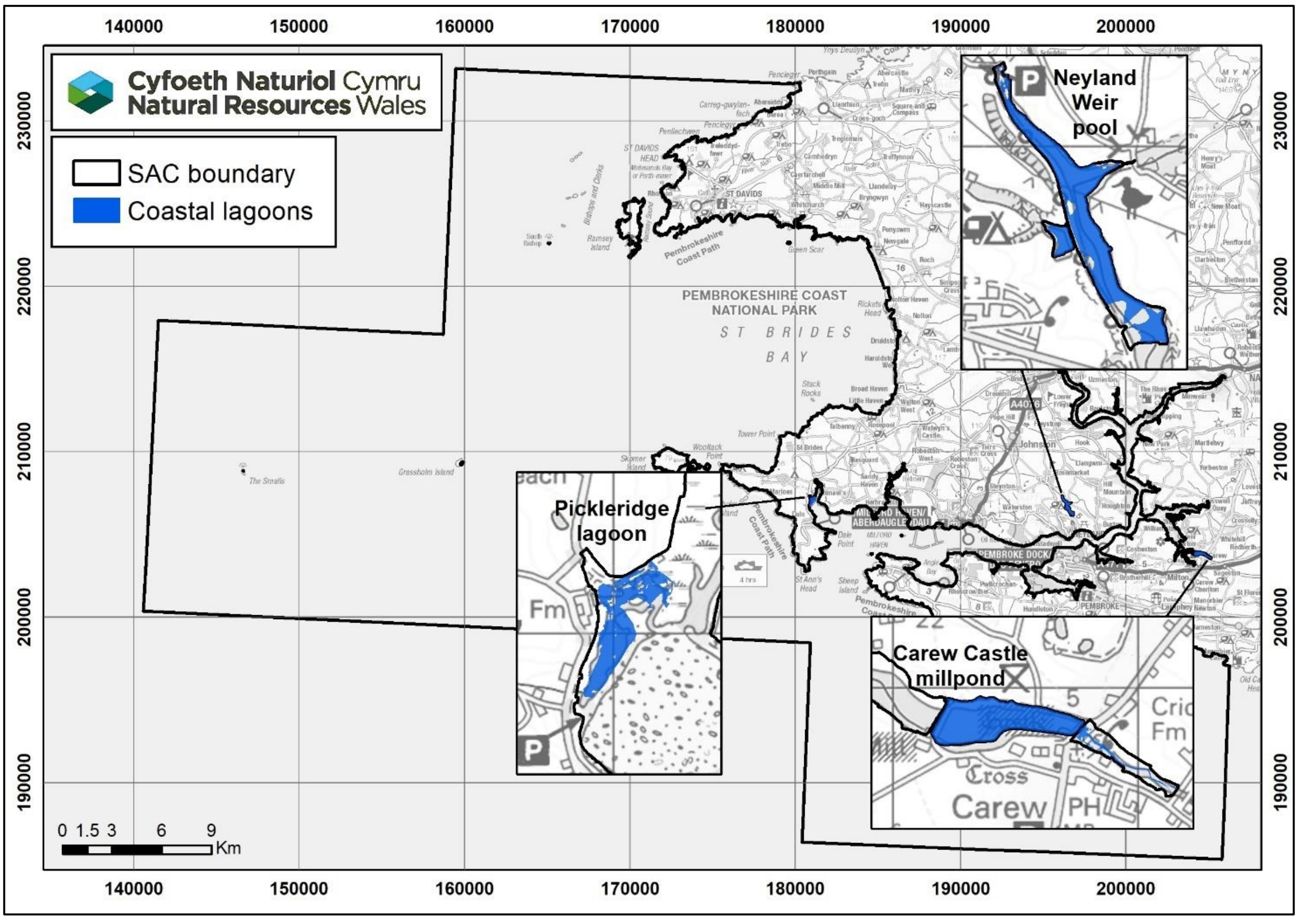
Indicator	Assessed status	Comments
Topography of the feature (P); hydrodynamic and sediment transport processes (P)	Medium confidence (proxy data used)	• The topography and hydrodynamic regime of mudflats and sandflats is not currently monitored in all SACs. • The Wales Coastal Monitoring Centre monitor some sites and are working on a dashboard that will flag up locations with changes outside of natural variability. This could help in assessing in the next cycle of condition assessment.
Abundance, distribution and species composition of communities (P)	Medium confidence (limited data)	• Further analysis on the infaunal species driving observed changes in the infaunal communities in the Pembrokeshire Marine SAC would raise the confidence in the assessment and help to identify potential reasons for the failures. • Available data on the distribution and population structure for some mudflats and sandflats associated species (e.g. cockles) were lacking or insufficient.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present within the SAC on the mudflats and sandflats feature is not fully understood. More targeted surveys and investigation on the impact of NNS on mudflats and sandflats are needed.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Low confidence (limited data)	• The redox layer of sediments was based on current monitoring, but the short time range and small spatial coverage available meant it was difficult to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening.
Sediment quality: dissolved oxygen (S)	Not assessed	• Dissolved oxygen in sediments is not currently monitored in the mudflats and sandflats feature across Welsh SACs, but there is potential for this to be incorporated into granulometric analysis in future.

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

3.7. Coastal lagoons condition assessment

The coastal lagoons feature in Pembrokeshire Marine SAC is comprised of three separate lagoons within the SAC (Figure 22), Pickleridge lagoon, Carew Castle millpond (Carew) and Neyland Weir pool (Neyland). Each lagoon has been assessed separately against the performance indicators and been assigned its own condition. For the assessment of the coastal lagoons feature itself, the three individual lagoon assessments have been brought together into a single condition outcome for Pembrokeshire Marine SAC. Each individual assessment can be seen in the sections below followed by a summary of the overall assessment for the feature in Section 3.7.4.

Figure 22. Map of the coastal lagoons feature in Pembrokeshire Marine SAC.



3.7.1. Pickleridge coastal lagoon in Pembrokeshire Marine SAC

Pickleridge lagoon is located on the Gann estuary which forms part of the Milford Haven Waterway. The lagoon formed behind the shingle storm beach when gravel extraction ceased. Pickleridge lagoon has been monitored annually between 2006-2021 with both net sweep and grab sampling surveys. Table 24 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Pickleridge condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in Section 3.7.4.

Table 24. Condition assessment for Pickleridge lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of coastal lagoon within the SAC, allowing for natural change and variation. (P)	• Extent, determined from aerial imagery, has been judged to be stable. • The lagoon is estimated to have lost 880 m^2 between 2000 and 2022. The minor losses are attributed to natural variation in surrounding vegetation and mostly seasonal. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Distribution of the feature	Maintain the distribution of the three coastal lagoon within the SAC, allowing for natural change and variation (P).	• There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC. • Confidence is high due to the small nature of the lagoons and up to date site knowledge and aerial imagery.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Shape of lagoon	Maintain the shape of coastal lagoon, subject to natural change and variation. (P)	• The shape of the lagoon has been determined from aerial imagery. • The overall shape of the lagoon has remained stable over time. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Isolating barrier integrity	No loss in integrity of any of the lagoons isolating barriers, allowing for natural change and variation. (P)	• Currently, the isolating barrier is judged to have good integrity. • While there is no expectation that the ridge will breach in the short term (10 years), breaches are expected in the medium term with ultimate failure of the barrier at some point in the future if repairs to the barrier stop, and due to the effects of climate change. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Integrity of lagoon banks	No loss in integrity of any of the lagoon’s banks, allowing for natural change and variation. (S)	• Current bank integrity is good and is likely to remain so in the short term if the rock armour is not removed. Though the armour itself will continue to deteriorate over time. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species composition of communities	No modification of the expected composition of lagoon communities, allowing for natural change and variation. (P)	• Infaunal analysis showed changing community composition over the monitoring period (2006-2021). There was no distinct pattern in these changes, and they have been attributed to natural variation. • Confidence is medium as there was a potential disturbance in recent years at one of the sampling stations. A few more years of monitoring data is needed to understand if this is a true disturbance or part of the natural variation at the SAC.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance of lagoon specialists	Maintain the abundance of lagoon specialist species, allowing for natural change and variation. (P) List of species for Pickleridge lagoon: *Chaetomorpha seurati, Ficopomatus enigmaticus* (also considered a NNS), *Cerastoderma glaucum*, *Ectrobia. ventrosa*, , *Monocorophium insidiosum*, *Palaemon varians.*	• There have been no significant declines in lagoon specialist species. • *Conopeum seurati* was not recorded in the sweep net survey of 2019 but was recorded previously in sweep net surveys in 2013 and 2014, and in grab sampling in 2017. • There have been no significant changes in species present at sampling stations between 2006-2021. • *Ficopomatus enigmaticus* has not been sampled at two stations since 2018, but abundance has previously been low so it may have been missed. • Records showed that the size of *Cerastoderma glaucum* may be decreasing over time, however, the number of individuals has increased in recent years. • There was high variation in the size distribution of cockles, but they appeared to follow a cyclical pattern of recruitment. There are no major concerns at present. • *Monocorophium insidiosum* has consistently been recorded at Pickleridge. • *Ectrobia ventrosa* has been recorded at low densities in 2010, 2011, 2013 and 2018. • *Palaemon varians* was recorded throughout the monitoring period (last record in 2019) with sweep net surveys. • Due to the lack of recent records for some species the confidence in the pass in the abundance of lagoon specialist indicator is medium	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of lagoon species, allowing for natural change and variation. (P)	• Analysis of monitoring data from 2006 to 2021 showed no correlation in species richness with year over the period from 2006-2021. • There was a small decline in diversity over time at two of the three sampling stations. • On the whole, there were no clear patterns outside of expected natural change and variation. • Confidence is medium due to the small decline observed.	**Pass**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of lagoon species, allowing for natural change and variation. (P)	• Overall, the average taxonomic distinctness of Pickleridge lagoon infaunal community remained stable and within the expected values over the monitoring period. • Confidence is high due to the availability of long term monitoring data.	**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 no evidence to suggest that INNS are spreading into the lagoon and impacting its conditions. • Confidence is medium as the impacts of INNS present within the feature are not well understood.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• *Pseudopolydora paucibranchiata* is a polychaete species, originally described from Japan. It has been recorded in 2020 in every sample in every station (max 46 individuals. in one station) but it was found in low numbers in 2021. • Confidence is high due to the availability of long term monitoring data.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition of sediment granulometry across the lagoon(s), allowing for natural change and variation. (P)	• Principal component analysis (PCA) showed a shift in sediment composition, with coarse sediment shifting to finer sediments over the years (2006-2021). This can be a natural shift for a lagoon. • Confidence is medium as the rate of change has been fairly rapid (i.e. shift to silt over relatively short space of time). • No significant relationship was detected between sediment composition and abundance of macrofaunal community.	**Pass**	Medium
Water depth	Maintain the expected depth of water within the lagoon(s), allowing for natural change and variation. (P)	• Depth in Pickleridge has been measured with a conductivity, temperature, and depth (CTD) logger since 2008. There have been no extreme low water events since 2010. • Confidence is medium as data collection has not been continuous, and the position of the logger has changed over the years.	**Pass**	Medium
Presence of materials and debris of anthropogenic origin	Anthropogenic material should not be having a detrimental impact on coastal lagoon. (S)	• Anthropogenic materials and debris have not been surveyed in a targeted way but have been counted or weighed as part of the infaunal surveys since 2017, though not consistently. • Microplastic counts took place in 2016 and 2019-2021. • Confidence is low as it is difficult to determine trends due to the short term and sporadic dataset. Large amounts of debris or microplastics have not been seen in available monitoring data.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• The Pickleridge Lagoon waterbody was not classified for the DIN WFD element the 2024 cycle 3 interim classification. However, evidence from a planned investigation in 2023 shows that the status of the Pickleridge Lagoon waterbody would classify as Bad status due to elevated nutrients if assessed under WFD. • The adjacent WFD waterbody that feeds into Pickleridge Lagoon was classified as Poor status for DIN in the 2024 cycle 3 interim classification (Milford Haven Outer). • Confidence is high due to the significant issues with DIN in the recent investigation.	**Fail**	High
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• The Pickleridge Lagoon waterbody was not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification. • The adjacent WFD waterbody that feeds into Pickleridge lagoon was classified with a High status for phytoplankton in the 2024 cycle 3 interim classification (Milford Haven Outer). • Confidence is medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• The Pickleridge Lagoon waterbody was not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. • There was an algal bloom observed in 2013 in the lagoon, however no algal blooms or high opportunistic macroalgae cover has been observed during site visits to the lagoon since 2013. • There have been ongoing observations of opportunistic macroalgae on the Gann mudflats directly adjacent to the lagoon. • The adjacent WFD waterbody that feeds into Pickleridge lagoon was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Milford Haven Outer). However, there has been localised growth of opportunistic macroalgae recorded in some of the inlets of this WFD waterbody, including around the Dale Gann area. • Confidence in the pass is low due to the lack of formal surveys for opportunistic macroalgae within the lagoon.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• The Pickleridge Lagoon waterbody was not classified as the chemicals have not been assessed within the last six years. • The adjacent WFD waterbody that feeds into Pickleridge lagoon has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This WFD waterbody has improved since previous cycles. • Confidence is low as there has been no physical sampling of contaminants in the lagoon.	**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 Pickleridge lagoon 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. (P)	• The seasonal pattern of temperature remained broadly similar across the monitoring period of 2006-2021. Pickleridge lagoon is the most stable for temperature of all the lagoons assessed. • There were no obvious changes in the seasonal pattern of salinity across years. There are no issues with the lagoon barrier (no major modifications or problems), which is key for regulating the salinity at this lagoon. • Confidence is medium as only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.	**Pass**	Medium

Assessment conclusions

The Pickleridge lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were two failing indicators (Table 25). 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 25 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 25. Summary of the condition assessment for Pickleridge lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Lagoon	Overall Condition Assessment	Indicator failures	Reason for indicator failures	Threats to condition
Pickleridge	**Unfavourable (medium confidence)**	Water quality: nutrients (DIN only) (P) Non-native species (T)	• There are high nutrient levels in the Pickleridge Lagoon, and Milford Haven Outer waterbodies. • *P. paucibranchiata* has been introduced in Pickleridge lagoon over the last six years.	• Marine litter • Water quality: contaminants • INNS • Climate change

Detailed Assessment Information

Extent and shape

Aerial imagery has been used to determine changes in the extent and shape of the lagoon. Extent has been judged to be stable, with only minor decreases in extent since 2000. The lagoon is estimated to have lost 880 m^2 between 2000 and 2022. The minor losses have been attributed to natural variation in surrounding vegetation and are mostly related to seasonal changes. There has also been no significant change to the shape of the lagoon during this time. The extent and shape of lagoon indicators were therefore assessed as meeting their targets with a high confidence.

There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC, resulting in a pass for the distribution of the feature indicator with high confidence.

Lagoon barrier and banks

Pickleridge lagoon is isolated from the sea by a shingle ridge. The ridge has been assessed as having good integrity and not in danger of breaching in the short term (next 10 years). The isolating barrier integrity and integrity of lagoon banks indicators therefore met their targets with high confidence.

There has been no active management of the ridge in the last 10 years, except for small repairs to the coast path across the top of the barrier (in 2016 and 2022), therefore the barrier is slowly deteriorating (Pye and Blott, 2023). If repairs to the barrier stop, its integrity will eventually fail. Increased storminess, as a result of climate change, can generate waves with sufficient energy to erode the shingle barrier as they hit and over top it. The intensity and frequency with which waves overtop the barrier is expected to increase with rising levels of storminess and sea level rise due to climate change.

Species and communities

Infaunal analysis showed that the species composition indicator has met its target. There was a potential disturbance in infaunal community in recent years at one of the sampling stations. This reduced the confidence in the species composition indicator to medium. A few more years of monitoring data is needed to understand if this is a true disturbance or part of the natural variation within the lagoon.

The majority of lagoon specialist species have been present at all three sample stations over the monitoring period of 2006-2021. Due to the lack of recent records for some species the confidence in the pass in the abundance of lagoon specialist indicator is medium. *Ficopomatus enigmaticus* has not been seen at two sample stations where it was previously present since 2018. This is not yet of concern as the abundance of *F. enigmaticus* has previously been low and it may not have been picked up in surveys. Its spatial range can be limited by the presence of hard substrate (e.g. rocks provide opportunity to *F. enigmaticus* to settle). This is something to consider in future monitoring, with a possible need for a further investigation to look at the hard substrate. This species is also considered as a non-native species (NNS).

Annual winter sampling was undertaken to assess the dynamics of the *Ceratstoderma glaucum* population at Pickleridge lagoon. Analysis showed that while the size of cockle appears to be decreasing with time, the number of individuals has increased in recent years. The high variation in the size distribution of cockles appears to follow a cyclical pattern of recruitment and because of this there are no concerns over the *C. glaucum* population at present.

Species richness and diversity and taxonomic distinctness were all within the limits of natural variation across the monitoring period of 2006-2021, there was a small decline in species diversity over time. This was most pronounced at two of the three sampling stations (south and middle). This was not deemed to be large enough to fail the species richness and diversity indicator but did reduce confidence in the pass to medium and will be something to pay close attention to in the next assessment. Confidence in the pass of the taxonomic spread of species indicator was high.

Invasive non-native species

Pseudopolydora paucibranchiata, a tube building polychaete originally described in Japan, was present in Pickleridge lagoon in 2020 and 2021. While it has been recorded in 2020 in every monitoring station, it was found in low numbers in 2021. Its arrival in the lagoon within the last six years has resulted in a fail with high confidence for the tertiary target of the NNS indicator.

Three other NNS have been recorded in Pickleridge lagoon across the monitoring period of 2006-2021. *Chaetomorpha caspia*, a freshwater hydroid that originates from the Black Sea, has been recorded in the 2015 grab surveys. *Mya arenaria*, a non-native species that originates from America, was recorded in Pickleridge lagoon in 1998 in low numbers. *Ficopomatus enigmaticus* probably originated in the southern hemisphere. It is an invasive species that dominates and alters habitats, reduces water quality, depletes resources, and causes biofouling (GB non-native species secretariat). It is, however, considered as a lagoon specialist for Pickleridge lagoon and its overall mean abundance during the survey period 2006-2021 was low.

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

Sediments, depth and anthropogenic litter

The sediment composition within the Pickleridge lagoon has varied over the monitoring period of 2006-2021. There has been a general shift from coarser sediments to finer silt over time. This can be a natural progression for a lagoon, however the rate of siltation in recent years has been fairly rapid. As there is no obvious cause, the sediment composition and distribution indicator met its target but the confidence was reduced to medium.

The water depth in the Pickleridge lagoon has been measured with a conductivity, temperature, and depth (CTD) logger since 2008. There were no concerns with the recorded depth from the logger, with no extreme low water events recorded since 2010. The water depth indicator therefore met its target. Confidence was reduced to medium as data collection has not been continuous, and the position of the logger has changed over the years.

The presence of materials and debris of anthropogenic origin indicator met its target. As there has not been a large amount of debris or microplastics found in available monitoring data, anthropogenic material was considered as not having a detrimental impact on the condition of the lagoon. However, there have been no targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This reduced the confidence to low. A longer dataset and appropriate sampling design is required for temporal analysis. A dedicated analysis for plastic should be carried out.

Water quality

There is one WFD waterbody that overlaps with the lagoon feature. This is the Pickleridge Lagoon waterbody, which overlaps with 61% of the lagoon by area. This is likely to be good reflection of the overall effect of water quality on the feature. The adjacent WFD waterbody that feeds into Pickleridge lagoon through the shingle ridge, Milford Haven Outer, has also been used for the water quality assessment.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The Pickleridge Lagoon waterbody has not been classified for the DIN element in the 2024 cycle 3 interim classification. As part of the planned investigation at Pickleridge lagoon, monthly water samples have been collected from various stations across the lagoon. DIN data collected from within the lagoon were analysed using the WFD winter DIN tool (see UKTAG, 2008 for details on how DIN is classified). The current (in draft) results indicate the lagoon would classify as Bad status due to elevated nutrients (Jopson and Lindenbaum, 2024, Figure 23). The adjacent Milford Haven Outer waterbody which feeds into the lagoon was classified as Poor status for DIN in the 2024 cycle 3 interim classification. This WFD waterbody deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation report for the Milford Haven Outer waterbody confirmed the DIN failures in the 2018 cycle 2 interim and 2021 cycle 3 classifications (Lock, 2021b). The nutrients indicator failed to meet its target due to the recorded issues with DIN in the Pickleridge Lagoon and Milford Haven Outer waterbodies. A high confidence has been attributed to the failure as investigations have confirmed the issues.

The phytoplankton indicator passed the target as the adjacent Milford Haven Outer waterbody was classified with a High status for the phytoplankton element in the 2024 cycle 3 interim classification. The Pickleridge Lagoon waterbody was not classified for this 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). Confidence was reduced to medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.

The Pickleridge Lagoon waterbody was not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. There was an algal bloom in the lagoon in 2013, which suggests excessive nutrients at that time (Jopson and Lindenbaum, 2024). However, no algal blooms or high opportunistic macroalgae cover has been observed during site visits to the lagoon since 2013 (Jopson and Lindenbaum, 2024). The opportunistic macroalgae element in the adjacent Milford Haven Outer waterbody was classified as Good status in the 2024 cycle 3 interim classification. Although the opportunistic macroalgae is not a failing element for this WFD waterbody, there have been localised issues recorded in the more sheltered bays and inlets including on the Gann mudflats in 2019, which is directly adjacent to the Pickleridge lagoon (Lock, 2021b). This indicator passed its target as there is no recent evidence of opportunistic macroalgae within the lagoon. A low confidence was attributed to this indicator as there have been no formal surveys of opportunistic macroalgae within the lagoon.

Figure 23. Agricultural land use at Pickleridge. This was found to be a major source of nutrient input into the lagoon.

© Kate Lock, from Jopson and Lindenbaum, 2024

Contaminants

The Pickleridge Lagoon waterbody was not classified as the chemicals have not been assessed within the last six years. The adjacent Milford Haven Outer waterbody passes for chemicals in the 2024 cycle 3 interim classification. This WFD waterbody failed for mercury and tributyltin (TBT) in previous cycles. TBT is no longer assessed, and mercury was not classified in the 2024 cycle 3 interim classification. The contaminants indicator met its target due to the passing Milford Haven Outer waterbody. The confidence in the pass was low because there has been no direct monitoring for contaminants within the lagoon.

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.

Salinity and temperature have been recorded in the lagoon using the loggers. For temperature, the seasonal pattern remained broadly similar across the monitoring period of 2007-2022. The Pickleridge lagoon is the most stable in temperature compared to the others assessed. There were also no clear changes in the seasonal pattern of salinity across the monitoring period. In addition, there have been no major modifications or problems recorded with the lagoon barrier, which is key for regulating the salinity of the lagoon. The physicochemical indicator therefore met its target. Only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.

Reasons for target failure

The assessment of Pickleridge lagoon failed one primary and one tertiary target. This resulted in Pickleridge lagoon to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

This indicator failed to meet its primary target as high levels of DIN have been recorded in both of the relevant WFD waterbodies. Although there is no classification for the DIN element in the 2024 cycle 3 interim classification, a planned investigation found elevated nutrients within Pickleridge lagoon, (Jopson and Lindenbaum, 2024). This investigation concluded that the WFD waterbody would be classified as Bad status based on the samples taken (Jopson and Lindenbaum, 2024). The WFD investigation found that the major cause of nitrogen loading to the lagoon is from diffuse source originating from agricultural land use, with more minor apportionment given to point source sewage discharges (Jopson and Lindenbaum, 2024).

The Milford Haven Outer waterbody was classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. The WFD investigation report confirmed elevated nutrients in this WFD waterbody, 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, 2021b). 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, 2021b). Intermittent and domestic sewage are also suspected in the catchment. Further investigation locally is required to confirm these.

Non-native species

This indicator failed to meet its tertiary target of no increase in the number of introduced NNS by human activities. This is due to the introduction of *P. paucibranchiata* in Pickleridge lagoon over the last six years. While it has been found in low numbers in 2021, this is still a cause for concern.

The potential spread and full extent of the impact that these species, along with other NNS present within the SAC, may have on the condition of the feature is currently unknown. For this reason it did not fail the primary target of the INNS indicator.

3.7.2. Carew Castle Millpond coastal lagoon in Pembrokeshire Marine SAC

Carew Castle Millpond (Carew) lagoon in Pembrokeshire Marine SAC was created during the establishment of the tidal corn mill around 1800. The lagoon is separated from the estuary by a brick dam and sluice gates. Carew lagoon has been monitored annually between 2006-2021 with both net sweep and grab sampling surveys. This data together with data loggers, WFD monitoring, licenced activities assessments and site knowledge have been used to assess Carew lagoon against the performance indicators. Table 26 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Carew lagoon condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in Section 3.7.4.

Table 26. Condition assessment for Carew lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of coastal lagoon within the SAC, allowing for natural change and variation. (P)	• LiDAR surveys, hydrographic surveys and aerial image analysis show the lagoon extent to be stable. • Minor decreases in extent since 2000 have been attributed to natural change. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Distribution of the feature	Maintain the distribution of the three coastal lagoon within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC. • Confidence is high due to the small nature of the lagoons and up to date site knowledge.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Shape of lagoon	Maintain the shape of coastal lagoon, subject to natural change and variation. (P)	• The shape of the lagoon has been determined from aerial imagery. • The overall shape of the lagoon has remained broadly stable over time. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Isolating barrier integrity	No loss in integrity of any of the lagoons isolating barriers, allowing for natural change and variation. (P)	• Water leaks are reported every year through the sluice gates and mortar of the masonry wall despite regular repairs. Even during periods of high input of freshwater from catchment, the lagoon empties in a matter of days during neap tides. • Sluice gates are opened during heavy rainfall to reduce flood risk. These sometimes stay open after the flood risk has ended, allowing the lagoon to drain. • Confidence is high due to the availability of long term monitoring data.	**Fail**	High
Integrity of lagoon banks	No loss in integrity of any of the lagoon's banks, allowing for natural change and variation. (S)	• The banks currently have good integrity. • Confidence is medium because some areas of stabilising saltmarsh have been degraded and eroded in the northern and western areas of the lagoon and almost eroded entirely in the rest.	**Pass**	Medium

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Species composition of communities	No modification of the expected composition of lagoon communities, allowing for natural change and variation. (P)	• There has been large variation in infaunal community composition across monitoring stations and years, with some periods of stabilisation between 2015-2018. Analysis suggests that the observed variation is natural. • Confidence is medium because there were some signs of disturbance at the monitoring station close to the mill.	**Pass**	Medium
Abundance of lagoon specialists	Maintain the abundance of lagoon specialist species, allowing for natural change and variation. (P) List of species for Carew lagoon: *Alkmaria romijni*, *Monocorophium insidiosum*, *Palaemon varians.*	• *M. insidiosum* was recorded in 2011 and has not been recorded since. However, this is of limited concern as the sampling method is unlikely to adequately represent *M. insidiosum* density. • *P. varians* was recorded in low density in the sweep net surveys in 2013 and in 2019. • The tentacled lagoon worm *A. romijni* has shown declines at two of the three sampling stations. These two stations currently dry out when the sluice gates stay open. • Confidence is medium as the sampling method may not be appropriate to detect some of the lagoon specialists.	**Fail**	Medium
Species richness and diversity	Maintain the expected richness and diversity of lagoon species, allowing for natural change and variation. (P)	• Analysis showed no significant decline in species richness or diversity over time. • The patterns seen are within the limits of natural change and variation. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Taxonomic spread of species	Maintain the expected taxonomic spread of lagoon species, allowing for natural change and variation. (P)	• Taxonomic diversity was high. • There were no years between 2006-2021 where the average taxonomic distinctiveness was below what was expected. • Confidence is high due to the availability of long term monitoring data.	**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 no evidence to suggest that INNS (e.g. *Potamopyrgus antipodarum*) are spreading into the lagoon and negatively impacting its condition. • Confidence is medium as the impacts of INNS present within the feature are not well understood.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There has been no increase in the number of NNS in the lagoon within the last six years. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Sediment composition and distribution	Maintain composition of sediment granulometry across the lagoon(s), allowing for natural change and variation. (P)	• Sediment composition and distribution in the lagoon has remained stable across the monitoring period of 2006-2021. • No significant relationship was detected between sediment composition and abundance of macrofaunal community. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Water depth	Maintain the expected depth of water within the lagoon(s), allowing for natural change and variation. (P)	• There are significant leaks in the dam wall and sluice gates. This, combined with delays in closing the gates after flood risk events, has resulted in the water level often being too low. • Silt laden water entering the lagoon during periods of heavy rain have resulted in a slight decrease in water planar area and water volume between 2009-2021. • Confidence is high due to the availability of long term monitoring data.	**Fail**	High
Presence of materials and debris of anthropogenic origin	Anthropogenic material should not be having a detrimental impact on coastal lagoons. (S)	• Anthropogenic materials and debris have not been surveyed in a targeted way but have been counted or weighed as part of the infaunal surveys since 2017, though not consistently. • Microplastic counts took place in 2016 and 2019-2021. • Confidence is low as it is difficult to determine trends due to the short term and sporadic dataset. Large amounts of debris or microplastics have not been seen in available monitoring data.	**Pass**	Low

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• The Milford Haven Inner waterbody that overlaps with the Carew lagoon was classified with a Poor status for the DIN WFD element in the 2024 cycle 3 interim classification. The supporting water quality WFD element, opportunistic macroalgae has also failed in this WFD waterbody. • The river WFD waterbody that inputs directly into Carew lagoon is classified as Good status for the overall waterbody. • There are extensive phosphorus failures in SACs upstream of the Milford Haven Inner waterbody (Afonydd Cleddau SAC), including failures in every WFD waterbody of the Western Cleddau. • Confidence is low as there has been no direct monitoring of nutrient levels within the lagoon.	**Fail**	Low
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)	• The overlapping Milford Haven Inner waterbody was classified with a High status for the phytoplankton WFD element in the 2024 cycle 3 interim classification. • Confidence is medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.	**Pass**	Medium

Attribute	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)	• The overlapping Milford Haven Inner waterbody was classified with a Moderate status for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. There are widespread issues with opportunistic macroalgae in various areas within this WFD waterbody, including within the Carew river inlet. • Confidence is medium as there has been no direct monitoring of opportunistic macroalgae within the lagoon.	**Fail**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• The overlapping Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to PBDE and PAH. • Confidence is low as the human health standard has been used for PBDE, and there has been no monitoring of contaminants within the lagoon itself.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the Carew lagoon in the Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (P)	• There were no clear patterns over time for temperature. • The salinity was very low and highly variable. There was a high number of extreme low salinity events. This caused the failure of the indicator. • Confidence is medium as only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.	**Fail**	Medium

Assessment conclusions

The Carew Castle Millpond (Carew) lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (high confidence). There were a number of failing indicators (Table 27). 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 27 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 27. Summary of the condition assessment for Carew lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Lagoon	Overall Condition Assessment	Indicator failures	Reason for indicator failures	Threats to condition
Carew	**Unfavourable (high confidence)**	Isolating barrier (P) Abundance of lagoon specialist species (P) Water depth (P) Water quality: nutrients (DIN only) (P) Water quality: physicochemical properties (P) Water quality: opportunistic macroalgae (S) Water quality: contaminants (S)	• The fam and sluice gate are leaking. • There has been a decline of *A. romijni* at two of the three sampling stations. • Sluice gates are left open for prolonged periods of time. • There are high nutrient levels in the Milford Haven Inner waterbody. • Salinity is highly variable with an increase in very low salinity events. • Opportunistic macroalgae is present in the Milford Haven Inner waterbody. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Marine litter • Siltation • Water quality: contaminants • INNS • Climate change

Detailed Assessment Information

Extent and shape

LiDAR and hydrographic surveys, and aerial imagery has been used to determine changes in the extent and shape of the lagoon. Extent has been judged to be stable, with only minor decreases in extent since 2000. The minor losses have been attributed to natural change and variation. There has also been no significant changes to the shape of the lagoon during this time. The extent and shape of lagoon indicators were therefore assessed as meeting their targets with a high confidence.

There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC, resulting in a pass for the distribution of the feature indicator with high confidence.

Lagoon barrier and banks

Carew lagoon was originally created to power a tidal mill and the current structure was built in 1801. A brick wall with sluice gates separates the lagoon from the sea. While the dam wall was never constructed to be a watertight barrier, the wall is leaking significantly, despite repair (Bunker and Bunker, 2023). This is causing large volumes of water to drain out, resulting in lack of integrity in the isolating barrier. Extreme surge tides and waves can overtop the dam wall, causing damage to the surface of the causeway. The sluice gates, which are opened during heavy rainfall and high tides to reduce flood risk to the road at the northern end of the lagoon, can lead the lagoon to drain rapidly as river levels drop. This further impacts the integrity of the isolating barrier, causing the failure of the isolating barrier integrity indicator with a high confidence.

The integrity of the lagoon banks is currently intact, however there are signs integrity is starting to reduce. Rock armour in the north and south of the lagoon acts to reduce erosion on the saltmarsh, but it is slowly degrading and becoming less effective (Pye and Blott, 2021). Ad-hoc sections of stone and brick have acted to slow the erosion of the saltmarsh edge but are now of limited effectiveness. Saltmarsh has been degraded and eroded in the northern and western areas of the lagoon and almost eroded entirely in the rest. However, the presence of the stone and brick are not thought to be having a detrimental impact on condition (Pye and Blott, 2021), therefore the integrity of lagoon banks indicator met its target but the confidence was reduced to medium.

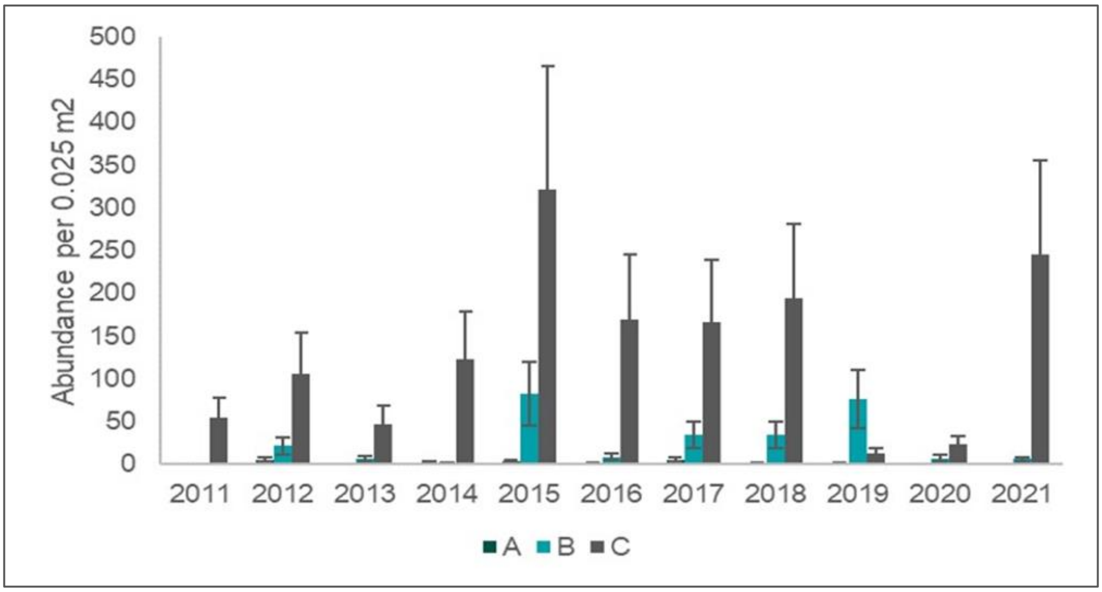
Species and communities

Infaunal analysis showed that the species comprising the communities present in the lagoon vary widely during the monitoring period of 2006-2021. The variation has been judged to be consistent and within the limits of natural change and variation therefore the species composition of communities indicator met its target. However, monitoring station C, the closest station to the mill, has shown signs of disturbance, being dominated by opportunistic species characterised by smaller body sizes and shorter life spans in some years. This is of concern and has lowered the confidence in the indicator pass to medium.

The tentacled lagoon worm *Alkmaria romijni*, a lagoon specialist once present in large densities, has seen significant declines at two of the three sampling stations in recent years (Figure 24). These two stations are within areas that dry out when the sluice gates are left open after the risk of flooding has passed. *A. romijni* is nationally scarce and protected under schedule 5 of the Wildlife and Countryside Act 1981 and Section 7 of the Environment Act (Wales). A specific survey to assess *A. romijni* was undertaken in 2005. This survey should be repeated to look for the species in other areas of the lagoon outside of the sampling stations. The decline in this lagoon specialist caused the abundance of lagoon specialists indicator to fail its target. *Palaemon varians* was recorded in low density in the sweep net surveys in 2013 and in 2019. *Monocorophium insidiosum*, has not been recorded since 2011. This is of limited concern as the sampling method is unlikely to adequately represent *M. insidiosum* density. However, a more targeted survey to look of *M. insidiosum* should be carried out to try and confirm it is still present in the lagoon. Confidence in the fail is medium as the sampling method may not be appropriate to detect some of the lagoon specialists.

The observed changes in species richness and diversity were within the limits of natural change and variation. Taxonomic diversity was high and there were no years between 2006-2021 where the average taxonomic distinctiveness was below what was expected. Therefore the species richness and diversity, and taxonomic spread of species indicators met their targets with high confidence.

Figure 24. Declines of the tentacled lagoon worm *Alkmaria rominji* at Carew lagoon. Mean (±Standard Error) abundance of *A. rominji* per 0.025 m^2 from grab surveys between 2011 and 2021 (5 grabs per station).



Invasive non-native species

Monitoring between 2006-2021 found a small number of NNS present in Carew lagoon. *Mya arenaria* was recorded in Carew lagoon in 1998 in low numbers. *Potamopyrgus antipodarum* has also been recorded. While its density has been increasing in recent years the numbers recorded are still very low.

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

It is not fully understood how some of these species may spread and impact the condition of the coastal lagoons feature, and 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, but confidence in the pass was low.

Sediments, depth and anthropogenic litter

The sediment composition within the Carew lagoon has varied over the monitoring period of 2006-2021, but overall appears to be fairly stable. The sediment composition and distribution indicator target was therefore met with a high confidence.

The leaks in the dam wall and open sluice gates have resulted in the water depth in Carew lagoon lowering significantly. At times when the sluice gate is open, and the tide is out, the area of water remaining is very small. From the photos in Figure 25 it is clear to see that most of the lagoon drains, exposing large areas of sediment. Most of the water left is confined to the channel and around the dam wall and gates. This deeper area of water is where sampling station C, closest to the mill, is located and abundance of *A. rominji* has remained within acceptable levels. To compound the water depth issue further, Carew lagoon has been accreting sediment, as silt laden water enters the lagoon during periods of heavy rain. This siltation has resulted in a slight decrease in water planar area and water volume between 2009-2021. Water depth failed its primary target with high confidence due to the significant drop in water depth and large areas of the lagoon drying out.

The presence of materials and debris of anthropogenic origin indicator met its target. As there has not been a large amount of debris or microplastics found in available monitoring data, anthropogenic material is not thought to be having a detrimental impact on the lagoon. However, there have been no targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This reduced the confidence to low. A longer dataset and appropriate sampling design is required for temporal analysis. A dedicated analysis for plastic should be carried out.

Figure 25. Carew lagoon at low tide when the sluice gates are open

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Water quality

There is one WFD waterbody that overlaps with the lagoon feature. This is the Milford Haven Inner waterbody, which overlaps with 80% of the lagoon by area. Carew lagoon receives water from the Milford Haven Inner waterbody at high tides. This is likely to be good reflection of the overall effect of water quality on the feature.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target as the overlapping Milford Haven Inner waterbody was classified with a Poor status for DIN in the 2024 cycle 3 interim classification. This WFD waterbody also failed in earlier cycles. The WFD investigation report for the Milford Haven Inner waterbody confirmed the DIN failure in the 2018 cycle 2 and 2021 cycle 3 classifications (Lock, 2021a). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations.

There is also a supporting opportunistic macroalgae failure, which was also confirmed in the investigation (Lock, 2021a). The main feeder stream for the lagoon has been classified as Good status overall and there have been no signs of algal growth within the lagoon itself. The nutrients indicator failed due to the issues in the Milford Haven Inner waterbody which enters the lagoon at high tides, but with medium confidence as there has been no direct monitoring of nutrient levels within the lagoon.

The phytoplankton indicator passed the target as the Milford Haven Inner waterbody was classified with a High status for the phytoplankton element in the 2024 cycle 3 interim classification. Confidence was reduced to medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.

The opportunistic macroalgae indicator failed to meet the target 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, in which extensive and recurring coverage has been recorded in various inlets including Carew river (Lock, 2021a). A medium confidence was attributed to this failing indicator as there have been no opportunistic macroalgae surveys within the actual lagoon.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. PBDE has failed in this WFD 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 coastal lagoons are not fully understood. This caused the contaminants indicator to fail as there is a pathway of water exchange into the lagoon from the contaminated waterbody. The confidence in the fail was reduced to low because the human health standard has been used for PBDE, and as there was no direct monitoring of contaminants within the lagoon. 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.

Loggers in the lagoon show that salinity was very low and highly variable through time, with a high number of extreme low salinity events. The physicochemical properties indicator therefore failed to meet its target. For temperature, there were no clear patterns through time therefore this did not contribute to the failure of the indictor. Confidence was reduced to medium as only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.

Reasons for target failure

The assessment of Carew lagoon failed five primary targets and two secondary targets. This resulted in Carew lagoon to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Isolating barrier integrity

This indicator failed to meet its primary target as the dam wall isolating the lagoon from the estuary is leaking, despite repair. This is causing water to drain out constantly. The sluice gates, which are opened during heavy rainfall to reduce flood risk are often left open after the flood risk has ended. This resulting in the isolating barrier not operating as it should for the lagoon to function.

Abundance of lagoon specialist species

This indicator failed to meet its primary target as *A. romijni*, once present in large densities across all three sampling stations, has seen significant declines at two of these in recent years. These two stations are within areas that dry out when the sluice gates are left open after the risk of flooding has passed. More investigation is needed but it is likely the abundance of this species has declined due to water levels dropping. Low water levels would likely lead to increased water temperature and semi-regular periods of sediment exposure and drying.

Water depth

This indicator failed to meet its primary target as the frequency of extreme low water depths at Carew lagoon has increased significantly. This is due to the leaking dam wall and sluice gates being kept open for long periods during flood risk events. Sediment accretion due to sediment laden water entering the lagoon has led to reductions in the water planar area and volume. These issues have led to the water depth being much lower than expected for the lagoon.

Water quality: nutrients (DIN only)

This indicator failed to meet its primary target as the Milford Haven Inner waterbody was classified with a Poor status for DIN in the 2024 cycle 3 interim classification. The WFD investigation report confirmed elevated nutrients in this WFD waterbody, 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). 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). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

Water quality: physicochemical properties

This indicator failed to meet its primary target as the salinity in the lagoon is very low and highly variable. This is highly likely to be caused by the leaking dam wall and the sluice gates failing to close after flood risk events and during spring tides. The incoming tide fills the lagoon with saline water, but this is emptied again during the low tide in periods where the sluice gates are locked open, reducing the salinity.

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target as 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 WFD 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 as the Milford Haven Inner waterbody has a fail 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation of the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is being managed in the UK 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 lagoon biota. The impact of PAH on the coastal lagoons feature is not fully understood.

3.7.3. Neyland Weir pool coastal lagoon in Pembrokeshire Marine SAC

Neyland Weir pool (Neyland) lagoon in Pembrokeshire Marine SAC was established as a saline lagoon in the 1980's being separated from the Cleddau estuary by a concreate bund. Neyland lagoon has been monitored annually between 2011-2021 with both net sweep and grab sampling surveys. Table 28 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Neyland lagoon condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in Section 3.7.4.

Table 28. Condition assessment for Neyland lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of coastal lagoon within the SAC, allowing for natural change and variation. (P)	• Aerial image analysis show the lagoon extent to be stable. • Minor increases and decreases since 2000 are attributed to natural change. • The presence of trees makes it difficult to accurately map the extent reducing the confidence to medium.	**Pass**	Medium
Distribution of the feature	Maintain the distribution of the three coastal lagoon within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC. • Confidence is high due to the small nature of the lagoons and up to date site knowledge.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Shape of lagoon	Maintain the shape of coastal lagoon, subject to natural change and variation. (P)	• The shape of the lagoon has been determined from aerial imagery. • The overall shape of the lagoon has remained broadly stable over time. • The presence of trees makes it difficult to accurately map the extent reducing the confidence to medium.	**Pass**	Medium
Isolating barrier integrity	No loss in integrity of any of the lagoons isolating barriers, allowing for natural change and variation. (P)	• When assessed in 2023, the sluice gate at the lagoon was found to be well maintained. • Confidence is high due to the recent survey of the barrier.	**Pass**	High
Integrity of lagoon banks	No loss in integrity of any of the lagoon's banks, allowing for natural change and variation. (S)	• When assessed in 2023, the lagoon banks were judged to have good integrity. • Confidence is high due to the recent survey of the banks.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Species composition of communities	No modification of the expected composition of lagoon communities, allowing for natural change and variation. (P)	• Community analysis has shown a shift in community composition in recent years. • Since 2017 the variation in community composition has declined, with increasing similarity in the species that make up communities across years and stations. • These results indicate an ongoing disturbance since 2017, with communities being dominated by opportunistic species with smaller body sizes and shorter life spans than previously. • Confidence is medium as the cause of this shift is not known.	**Fail**	Medium

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Abundance of lagoon specialists	Maintain the abundance of lagoon species, allowing for natural change and variation. (P) List of species for Neyland lagoon: *Alkmaria romijni*, *Ecrobia ventrosa*, *Ficopomatus enigmaticus*, *Gammarus chevreuxi*, *Monocorophium insidiosum*, *Palaemon varians*, *Lekanesphaera hookeri*.	• Analysis of lagoon specialists showed that most species (i.e. *Gammarus chevreuxi*, *Palaemon varians*, *Lekanesphaera hookeri*) are present in expected abundance and frequencies. • *Monocorphium insidiosum* and *Ficopomatus enigmaticus* were recorded in low abundance in 2014 with no records in subsequent net sweep surveys. The absence of these species are not concerning as they unlikely to be detected by the sampling methods used. • Whilst the lagoon snail *Ecrobia ventrosa* has not been recorded recently, its abundance was low when recorded prior to 2012. • Confidence is low due to unconfirmed absence of *E. ventrosa* and as the sampling method may not be appropriate to detect some of the lagoon specialists.	**Pass**	Low
Species richness and diversity	Maintain the expected richness and diversity of lagoon species, allowing for natural change and variation. (P)	• Analysis showed increasing species richness over the monitoring period 2011-2021. • For diversity, there was no correlation with time, and the variation between years is within the limits of natural change and variation. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Taxonomic spread of species	Maintain the expected taxonomic spread of lagoon species, allowing for natural change and variation. (P)	• Taxonomic spread of species varied across the monitoring period 2011-2021. • There were no years between 2011-2021 where the average taxonomic distinctiveness was below what was expected. • Confidence is high due to the availability of long term monitoring data.	**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 no evidence to suggest that INNS (e.g. *Potamopyrgus antipodarum*) are spreading into the lagoon and impacting its conditions. • Confidence is medium as the impacts of INNS present within the feature are not well understood.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There has been no increase in the number of NNS in the lagoon within the last six years. • Confidence is high due to the long term monitoring data.	**Pass**	High
Sediment composition and distribution	Maintain composition of sediment granulometry across the lagoon(s), allowing for natural change and variation. (P)	• Sediment composition has remained broadly stable between 2011-2021. • No significant relationship was detected between sediment composition and abundance of macrofaunal community. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Water depth	Maintain the expected depth of water within the lagoon(s), allowing for natural change and variation. (P)	• No depth issues were identified. • With the banks and fish pass in good condition and well maintained the depth is unlikely to drop suddenly. • Confidence is medium as there is a lack of accurate and continuous depth data for the Neyland lagoon therefore the assessment was based on expert judgement.	**Pass**	Medium
Presence of materials and debris of anthropogenic origin	Anthropogenic material should not be having a detrimental impact on coastal lagoon. (S)	• Anthropogenic materials and debris have not been surveyed in a targeted way but have been counted or weighed as part of the infaunal surveys since 2017, though not consistently. • Microplastic counts took place in 2016 and 2019-2021. • Confidence is low as it is difficult to determine trends due to the short term and sporadic dataset. Large amounts of debris or microplastics have not been seen in available monitoring data.	**Pass**	Low
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• The Milford Haven Inner waterbody that overlaps with the Neyland lagoon was classified with a Poor status for the DIN WFD element in the 2024 cycle 3 interim classification. The supporting water quality WFD element, opportunistic macroalgae has also failed in this WFD waterbody. • The river WFD waterbody feeding into the lagoon is classified as Moderate status overall in the 2024 cycle 3 interim classification (the classification is for phosphorous not for DIN as this is not sampled in river waterbodies). • Confidence is medium as there has been no direct monitoring of nutrient levels within the lagoon.	**Fail**	Medium

Attribute	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)	• The overlapping Milford Haven Inner waterbody was classified with a High status for the phytoplankton WFD element in the 2024 cycle 3 interim classification. • The river WFD waterbody that inputs into Neyland lagoon is classified as Moderate status overall. This is based on the macrophyte and phytobenthos, and phosphate elements. (There are no phytoplankton or opportunistic macroalgae elements for river waterbodies). • Confidence is medium as there has been no direct monitoring of phytoplankton within the lagoon, the river waterbody is failing and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.	**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)	• The overlapping Milford Haven Inner waterbody was classified with a Moderate status for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. There are widespread issues with opportunistic macroalgae in this WFD waterbody. • The river WFD waterbody that inputs into Neyland lagoon is classified as Moderate status overall. This is based on the macrophyte and phytobenthos, and phosphate elements. (There are no phytoplankton or opportunistic macroalgae elements for river waterbodies). • Confidence is medium as there has been no direct monitoring of opportunistic macroalgae within the lagoon.	**Fail**	Medium

Attribute	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• The overlapping Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to PBDE and PAH. • Confidence is low as the human health standard has been used for PBDE, and there has been no monitoring of contaminants within the lagoon itself.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the Neyland lagoon, 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. (P)	• There are limited physicochemical data for Neyland lagoon, therefore this target was assessed as unknown.	**Unknown**	N/A

Assessment conclusions

The Neyland Weir pool (Neyland) lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of failing indicators (Table 29). 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 29 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 29. Summary of the condition assessment for Neyland lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Lagoon	Overall Condition Assessment	Indicator failures	Reason for indicator failures	Threats to condition
Neyland	**Unfavourable (medium confidence)**	Species composition of communities (P) Water quality: nutrients (DIN only) (P) Water quality: opportunistic macroalgae (S) Water quality: contaminants (S)	• There is an observed shift in community composition in recent years. This is indicative of ongoing disturbance since 2017. • There are high nutrient levels in the Milford Haven Inner waterbody. • Opportunistic macroalgae is present in the Milford Haven Inner waterbody. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Marine litter • Water quality: contaminants • INNS • Climate change

Detailed Assessment Information

Extent and shape

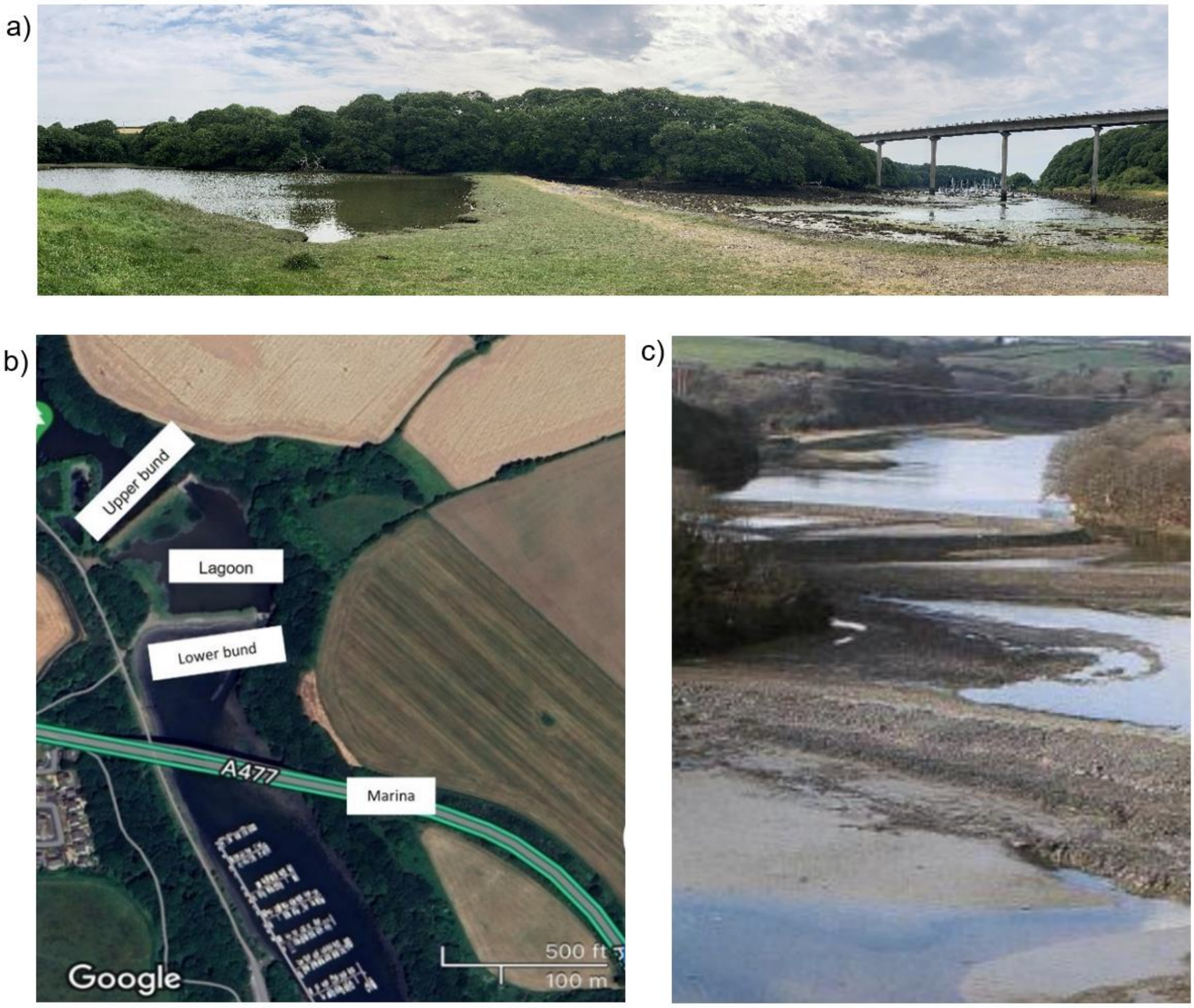
Aerial imagery has been used to determine changes in the extent and shape of the lagoon. Extent has been judged to be stable, with only minor decreases in extent since 2000, however trees surrounding the lagoon make assessing the extent difficult. The minor losses have been attributed to natural change and variation. There has also been no significant change to the shape of the lagoon during this time. The extent and shape of lagoon indicators were therefore assessed as meeting their targets with a high confidence.

There are currently no anthropogenic impacts known to have significantly affected the distribution of the coastal lagoons feature within the Pembrokeshire Marine SAC, resulting in a pass for the distribution of the feature indicator with high confidence.

Lagoon barrier and banks

Neyland is a weir lagoon with a lower bund embankment separating it from the Cleddau estuary (Figure 26). An upper bund splits the lagoon in to two pools. The isolating barrier integrity and integrity of lagoon banks indicators have both been judged to meet their targets with high confidence. At the time of writing there are discussions around creating a woodland buffer around parts of the lagoon to help increase barrier integrity. The seaward face of both bunds and the upstream face of the upper bunds were reinforced with rock. A capping of asphalt was also placed along the down-estuary facing lip of the lower bund to provide additional protection against scour and wave action (Pye and Blott, 2023).

Figure 26. Neyland lagoon upstream of Neyland Marina. a) The lower bund retaining water at low tide is visible in the middle of the picture (© Harriet Robinson NRW). b) Aerial image of Neyland lagoon showing both bunds and the dredged marina to the south (Google Maps, 2023, annotated). c) Aerial image of the lower and upper bunds shortly after construction in the early 1980s (in Pye and Blott, 2023).



Species and communities

Infaunal analysis of the lagoon showed variation in the species that make up the communities present, both across stations and years between 2011 and 2016. Since 2017 the variation in community composition has declined with increasing similarity in the species that make up communities across years and stations. These results indicate an ongoing disturbance since 2017, with communities being dominated by opportunistic species with smaller body sizes and shorter life spans than previously. The species composition indicator therefore failed to meet its target. There is no obvious anthropogenic cause for this shift, which reduced the confidence in the failure to medium.

Analysis of lagoon specialists showed that most species (e.g. *Gammarus chevreuxi, Palaemon varians, Lekanesphaera hookeri*) are present in expected abundance and frequencies. However, the lagoon specialist species *Ecrobia ventrosa* has not been recorded since 2012. Prior to 2012, abundance of this species has been low within the Neyland lagoon. Similarly, *M. insidiosum* and *F. enigmaticus* were recorded in low abundance in 2014 with no records in subsequent net sweep surveys, and all grabs samples. It is challenging to detect these species with the current sampling methods used, and the period of the species being unrecorded has therefore reduced confidence in the pass to low. More targeted sampling for these species is needed to confirm their presence or absence within the lagoon.

There was an increase in species richness over the monitoring period of 2011-2021, and no correlation between species diversity and time. Taxonomic distinctness was variable over the monitoring period, however there were no years between 2011-2021 where the average taxonomic distinctiveness was below what was expected. Therefore the species richness and diversity, and taxonomic spread of species indicators met their targets with high confidence.

Invasive non-native species

Monitoring between 2011-2021 found a small number of NNS present in Neyland lagoon. *Mya arenaria* was recorded in Neyland lagoon in 2006 in low numbers with no records since. *Potamopyrgus antipodarum* was recorded in 2019 in very low numbers. While its density has been increasing in recent years the numbers recorded are still very low. *Cordylophora caspia* was recorded as present in the 2016, 2017 and 2021 grab surveys. *F. enigmaticus* was recorded in the 2014 sweep net survey, but has not been present in recent surveys. It is an invasive species that dominates and alters habitats, reduce water quality, depletes resources, and causes biofouling (GB non-native species secretariat). It is, however, considered as a lagoon specialist.

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

It is not fully understood how some of these species may spread and impact the condition of the coastal lagoons feature, and 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, but confidence in the pass was low.

Sediments, depth and anthropogenic litter

The sediment composition within the Neyland lagoon has varied over the monitoring period of 2011-2021, but overall appears to be fairly stable. The sediment composition and distribution indicator target was therefore met with a high confidence.

There are no accurate and continuous depth data for the Neyland lagoon. However, there are no known depth issues in the lagoon, with the lagoon banks and fish pass present in the lagoon in good condition and well maintained. The depth in the lagoon is therefore unlikely to be impacted based on current knowledge. As a result, the water depth indicator met its target. Confidence is medium as there is a lack of accurate and continuous depth data for the Neyland lagoon therefore the assessment was based on expert judgement.

The presence of materials and debris of anthropogenic origin indicator met its target as there has not been a large amount of debris or microplastics found in available monitoring data. However, there have not been targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This reduced the confidence to low. A longer dataset and appropriate sampling design is required for temporal analysis. A dedicated analysis for plastic should be carried out.

Water quality

There is one WFD waterbody that overlaps with the lagoon feature. This is the Milford Haven Inner waterbody, which overlaps with 76% of the lagoon by area. Neyland lagoon receives water from the Milford Haven Inner waterbody. This is likely to be good reflection of the overall effect of water quality on the feature.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target as the overlapping Milford Haven Inner waterbody was classified with a Poor status for DIN in the 2024 cycle 3 interim classification. This WFD waterbody also failed in earlier cycles. The WFD investigation report for the Milford Haven Inner waterbody confirmed the DIN failure in the 2018 cycle 2 and 2021 cycle 3 classifications (Lock, 2021a). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations.

There is also a supporting opportunistic macroalgae failure, which was also confirmed in the investigation (Lock, 2021a). This primary indicator has failed due to the issues in the Milford Haven Inner waterbody, but with medium confidence as there has been no direct monitoring of nutrient levels within the lagoon.

The phytoplankton indicator passed the target as the Milford Haven Inner waterbody was classified with a High status for the phytoplankton element in the 2024 cycle 3 interim classification. Confidence was reduced to medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.

The opportunistic macroalgae indicator failed to meet the target 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, in which extensive and recurring coverage has been recorded in various inlets including Carew river (Lock, 2021a). A medium confidence was attributed to this failing indicator as there have been no opportunistic macroalgae surveys within the actual lagoon.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. PBDE has failed in this WFD 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 coastal lagoons are not fully understood. This caused the contaminants indicator to fail as there is a pathway of water exchange into the lagoon from the contaminated waterbody. The confidence in the fail was reduced to low because the human health standard has been used for PBDE, and as there was no direct monitoring of contaminants within the lagoon. 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 properties indicator was assessed as unknown as there are limited data available on temperature and salinity and no data on other physicochemical parameters.

Reasons for target failure

The assessment of Neyland lagoon failed two primary targets and two secondary targets.. This resulted in Neyland lagoon to be assessed as being in **unfavourable** condition (low confidence). The failing indicators and reasons for failure, if known, are stated below.

Species composition of communities

This indicator failed to meet its primary target as the variation in the species that make up the communities found in Neyland lagoon has been declining since 2017. Communities are increasingly composed of similar species that are opportunistic, with smaller body sizes and shorter life spans. This indicates that the lagoon has undergone continued disturbance since 2017. There is no obvious cause of disturbance that would lead to a decline in species variation therefore the reason for the failure of this indicator is not clear. There could be links to the high nutrient levels in the surrounding water bodies. However, an investigation would be needed to see what the nutrient levels are within the lagoon itself before any link could be made.

Water quality: nutrients (DIN only)

This indicator failed to meet its primary target. The reasons are outlined in Section 3.7.2 as the same waterbodies apply.

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target. The reasons are outlined in Section 3.7.2 as the same waterbodies apply.

Water quality: contaminants

This indicator failed to meet its secondary target. The reasons are outlined in Section 3.7.2 as the same waterbodies apply.

3.7.4. Overall assessment of the coastal lagoons feature in Pembrokeshire Marine SAC

The condition assessments for each of the three lagoons in Pembrokeshire Marine SAC have been brought together to form one condition outcome for the coastal lagoons feature. The condition of the coastal lagoons feature has been assessed as **unfavourable** (high confidence) (Table 30). All three of the lagoons in the SAC are in unfavourable condition giving us high confidence that the coastal lagoons feature in Pembrokeshire Marine SAC is unfavourable. A summary of condition is in Table 30.

Table 30. Summary of the condition assessment for the coastal lagoons feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failures	Threats to condition
Coastal lagoons	**Unfavourable (high confidence)**	Isolating barrier (P) (Carew) Species composition of communities (P) (Neyland) Abundance of lagoon specialist species (P) (Carew) Water depth (P) (Carew) Water quality: nutrients (P) (all) Water quality: physicochemical properties (P) (Carew) Water quality: opportunistic macroalgae (S) (Carew and Neyland) Water quality: contaminants (S) (Carew and Neyland) Non-native species (T) (Pickleridge)	• Leaking dam and sluice gate and sluice gates left open for prolonged periods of time (Carew). • Shift in community composition in recent years (Neyland). • Decline of *A. romijni* at two of the three sampling stations (Carew). • High nutrient levels in the Pickleridge Lagoon, Milford Haven Outer, and Milford Haven Inner waterbodies (all). • Highly variable salinity with an increase in very low salinity events (Carew). • Opportunistic macroalgae in the Milford Haven Inner waterbody (Carew and Neyland). • Levels of PBDE and PAH in the Milford Haven Inner waterbody failing to meet EQS (Carew and Neyland). • *P. paucibranchiata* has been introduced within the last six years (Pickleridge).	• Marine litter (all) • Water quality: contaminants (all) • INNS (all) • Climate change (all) • Siltation (Carew)

Threats to condition

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

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

Marine litter

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

Siltation (Carew only)

Continued siltation will lead to further reduction in water level and potentially impact some biological communities.

Water quality: contaminants

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

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

Invasive non-native species

All three lagoons sit within the Milford Haven Waterway, which is at high risk of new non-native species introductions due the large number of vessels that enter the waterway from overseas. Lagoons in Pembrokeshire Marine are therefore at risk of non-native species becoming invasive and having a detrimental impact on the condition of the feature.

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

Climate change

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

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

Evidence gaps

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

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

Table 31. Evidence gaps for the coastal lagoons feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Angiosperms (*Ruppia*) (P)	Not assessed	• At the time of assessment, no surveys of *Ruppia* have been carried out in all lagoons. More targeted surveys to look for *Ruppia* are needed
Distribution and extent of habitats and communities (P)	Not assessed	• Biotopes are not well established for lagoons. Current monitoring is not set up to look at this in depth; additional fieldwork would be required.
Sediment quality: organic carbon content (P); sediment quality: contaminants (P)	Not assessed	• This is not monitored but could be incorporated into PSA analysis in lagoons in future.

Indicator	Assessed status	Comments
Water quality: nutrients (DIN only) (P)	Low / medium confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons themselves.
Bathymetry of the feature (S)	Not assessed	• More targeted data would need to be collected to be able to assess changes in bathymetry. There is potential to create continual depth layer for lagoons using LiDAR data.
Hydrodynamic and sediment transport processes (S)	Not assessed	• Lagoon hydrodynamic regimes are not currently monitored.
Presence of materials and debris of anthropogenic origin (S)	Low confidence (limited data)	• Longer datasets and appropriate sampling designs are required for temporal analysis and detecting concerns for the future. A dedicated analysis for plastic should be carried out in a similar fashion to hydrocarbon for sediment. Standardised surveys for large debris are also needed.
Water quality: phytoplankton (S)	Low confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons. Some assessments have relied upon WFD waterbodies that are adjacent to the lagoons only.
Water quality: opportunistic macroalgae (S)	Low / medium confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons. Some assessments have relied upon WFD waterbodies that are adjacent to the lagoons only.
Water quality: dissolved oxygen (S)	Not assessed	• Dissolved oxygen is not currently monitored within lagoons. Once a baseline is established monitoring would take place only when intelligence suggests an impact is occurring from an activity.
Water quality: contaminants (S)	Low confidence (proxy data used)	• Contaminants are mostly measured in Wales as part of WFD monitoring, but there is currently no WFD monitoring of contaminants within any of lagoons themselves.

Indicator	Assessed status	Comments
Water quality: turbidity (S).	Unknown	• Turbidity is measured in WFD sampling, but this is limited to only a few samples per year. Therefore, this cannot be used to adequately assess the turbidity 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.

3.8. Sea caves condition assessment

The sea caves feature in the Pembrokeshire Marine SAC comprises of a number of submerged and partially submerged sea caves (Figure 27). There is no NRW Habitats Regulations monitoring sea caves in this SAC. The summary of the assessment outcome for sea caves is provided in Table 32. This outcome and reasons for failure are discussed in more detail in the sections below.

Figure 27. Location map of the sea caves feature in the Pembrokeshire Marine SAC.

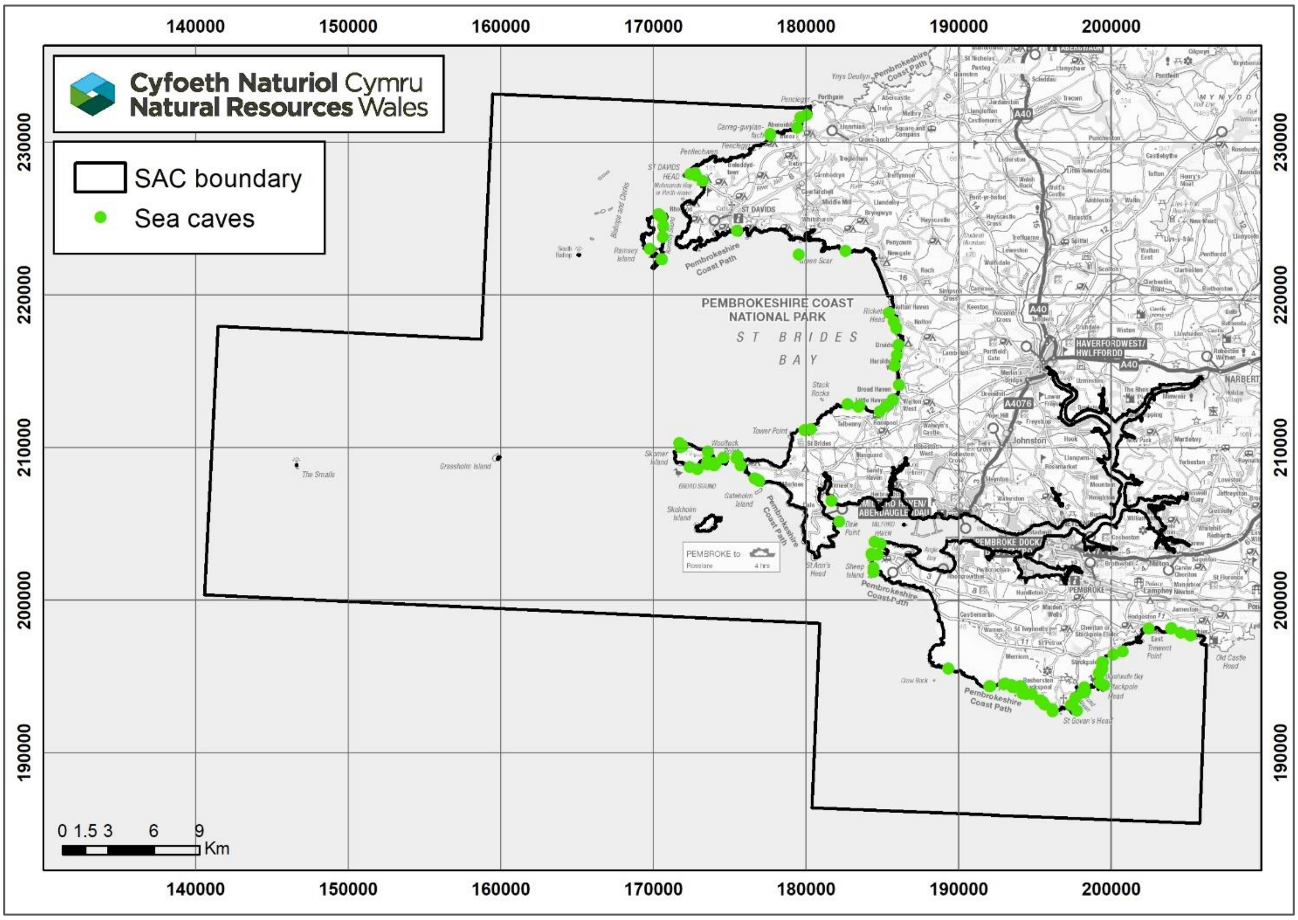


Table 32. Condition assessment of sea caves in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the 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 sea caves, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave 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 sea caves in the Pembrokeshire Marine SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within the sea caves.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within the sea caves.	**Pass**	Low
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (S)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

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. (T)	• Two of the three WFD waterbodies that overlap with the sea caves feature were classified with a High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these overlap with 96% of the mapped sea caves. ○ The classification for the Pembrokeshire South waterbody was rolled forward from the 2018 cycle 2 interim classification. • The other WFD waterbody was classified with a Poor status for DIN (Milford Haven Outer). This waterbody overlaps with 4% of the mapped sea caves. • Confidence is low as the failing waterbody overlaps with a small proportion of the mapped feature and as ecological relationships between DIN and sea caves are not fully understood.	**Fail**	Low
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• 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 8% of the mapped sea caves. • The other two WFD waterbodies were classified with a High status for phytoplankton (Pembrokeshire South and Milford Haven Outer). Combined, these overlap with 92% of the mapped sea caves feature. • Confidence is low as the ecological relationships between phytoplankton and sea caves are not fully understood.	**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. (T)	• All three WFD waterbodies that overlap with the sea caves feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• 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 (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 96% of the mapped sea caves. • 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 the sea caves. • Confidence is low as a large proportion of the feature overlaps with unclassified waterbodies; some waterbodies had rolled forward classifications; and the impact of these contaminants on sea caves is unknown.	**Pass**	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 sea caves feature in 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 intertidal and 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. • A 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
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A

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)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • There is also little information on the impact of any INNS present in the SAC on the condition of sea caves.	**Unknown**	N/A
Non-native Species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• No information on sea cave communities has been collected for this SAC since 2000-2002.	**Unknown**	N/A

Assessment conclusions

The sea caves feature in Pembrokeshire marine SAC has been assessed as being in **unknown** condition (confidence N/A). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps). There was one tertiary failing indicator (Table 33). A summary of the assessment can be seen in Table 33 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Eight indicators were assessed as passing in the assessment of condition for sea caves in the Pembrokeshire Marine SAC including extent and distribution. These can be seen in Table 32. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at low likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment so the confidence was judged to be low (Table 33).

Table 33. Summary of the condition assessment for sea caves in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Sea caves	**Unknown (confidence not applicable)**	**Low (low confidence)**	Water quality: nutrients (DIN only) (T)	• High nutrient levels have been recorded in the Milford Haven Outer waterbody.	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences

Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Pembrokeshire Marine SAC passed their targets as there are currently no known anthropogenic impacts that would negatively affect the sea caves feature. It should be noted that not all sea caves in this SAC have been mapped. Comparison mapping has not been used to assess the extent and expert judgment was used to assess these indicators in the absence of recent data. This has reduced the confidence to medium.

Bathymetry and hydrodynamic processes

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

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within three WFD waterbodies where 88% overlap with the Pembrokeshire South waterbody, 8% with the Cardigan Bay South waterbody and 4% with the Milford Haven Outer waterbody.

Nutrients (DIN only) and phytoplankton

The nutrients indicator failed to meet its target as failing levels of DIN have been recorded in one of the three WFD waterbodies that overlaps with the sea caves feature in the SAC. This waterbody, the Milford Haven Outer, was classified as Poor status for DIN in the 2024 cycle 3 interim classification, and it has deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation report for this waterbody confirmed the DIN failure in the 2018 cycle 2 and 2021 cycle 3 classifications (Lock, 2021b). The other two overlapping WFD waterbodies, Pembrokeshire South and Cardigan Bay South, were classified with a High status for DIN in the 2024 cycle 3 interim classification. Combined, these overlap with 96% of the mapped sea caves. As the failing waterbody overlaps with only 4% of the feature, the confidence in the fail was reduced to low.

There are limited direct impacts of high nutrients in sea caves as they are largely dark environments with limited opportunities for plant growth. There is, however, some potential from indirect effects of increased nutrients. If there is algal growth in waters close to the sea cave environments, this may enter caves and start to decay, resulting in debris collecting in the caves. As the sea caves have not been surveyed, it is unknown whether this is occurring or has occurred.

The phytoplankton indicator passed the target as two of the three WFD waterbodies that overlap with the sea caves feature, Pembrokeshire South and Milford Haven Outer, were classified with a High status for the phytoplankton element in 2024 cycle 3 interim classification. The other overlapping WFD waterbody was not classified for this 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 ecological relationships between phytoplankton and sea caves across all SACs are not fully understood, which has reduced the confidence in the assessment to low.

Dissolved oxygen

The dissolved oxygen indicator also met its target as all three 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 high because sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

The contaminants indicator met the target as there were no recorded failures for chemicals in the relevant overlapping WFD waterbodies. One of the three WFD waterbodies, Milford Haven Outer, passed for chemicals in the 2024 cycle 3 interim classification. However, some of the chemical classification were rolled forward from the 2021 cycle 3 classification. The Milford Haven Outer waterbody failed for mercury and TBT in previous cycles. Although this waterbody now passes for chemicals, TBT, which was previously a failing chemical, is no longer assessed. In addition, mercury was not classified in the 2024 cycle 3 interim classification. Two WFD waterbodies, Pembrokeshire South and Cardigan Bay South, were not classified as the chemicals have not been assessed within the last six years. Combined, these overlap with 96% of the mapped sea caves. The confidence in the pass was reduced to low to reflect this and due to the rolled forward classifications in the Milford Haven Outer waterbody. 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. Most of these loggers (12 out of the 19) are close to some of the mapped sea caves (<1.5 km away). 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

No information on sea cave communities has been collected for this SAC since 2000-2002. The limestone coast of Pembrokeshire had some particularly good examples of un-scoured and species-rich habitats both in the littoral and sublittoral. Ramsey is the largest island in Pembrokeshire Marine SAC and is renowned for its numerous sea caves which are present along every coast (except for the embayment at Abermawr). Little Howler Cave on Ramsey was exceptional in having a cave floor carpeted in cup corals, including *Balanophyllia regia* whereas the floors of most sea caves encountered during the survey were barren and scoured. Also of note in all the Ramsey caves were the variety of encrusting sponges present and the general richness of un-scoured sublittoral biotopes (Bunker and Holt, 2003).

The sea caves of the Skomer Marine Conservation Zone (MCZ) are important habitats both for their attached marine species and as pupping sites for grey seals. Sea caves are found on virtually every part of the MCZ coast, with the highest concentration occurring on the south coast of the Neck and around the Deer Park. They occur in both the littoral and sublittoral zones.

The sublittoral cave at Payne’s rock is composed of basalt and is subject to the strong tidal currents that run past the west coast of Skomer as well as strong wave action. Unusually for such an exposed area, the floor of the cave was not rock or boulder but muddy shell gravel with the burrowing anemone *Cerianthus lloydii*. The cave roof was adorned with the jewel anemone *Corynactis viridis* and the walls studded with Devonshire cup-corals, *Caryophyllia smithii*, mixed with the ascidian *Polycarpa scuba* towards the back of the cave and a turf of *Crisia* sp. and *Bugula plumosa* at the entrance (Bunker and Holt, 2003).

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

Invasive Non-Native Species

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

Reasons for target failure

The assessment of the sea caves feature in Pembrokeshire Marine SAC failed one tertiary target. There were also six targets that were assessed as unknown due to limited data availability. The high level of unknown indicators meant that the features was assessed as being in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

This indicator failed to meet its tertiary target as high levels of DIN have been recorded in one of the three WFD waterbodies that overlap with the sea caves feature, Milford Haven Outer. This waterbody was classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification.

The WFD investigation report has confirmed elevated nutrients in the Milford Haven Outer waterbody, 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, 2021b). 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, 2021b). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

Threats to condition

Part of the condition assessment is to identify threats to the condition of the sea caves. As the threats to sea caves are the similar 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 sea caves feature condition in the Pembrokeshire Marine SAC are stated below.

Recreational access and collection

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

Invasive non-native species

Invasive non-native species are a threat to most of the features in the Welsh SACs. The impact of INNS on the sea caves feature is not well understood, and as they are mostly shady environments many of the invasive seaweeds are unlikely to be an issue. However, some INNS such as the carpet sea squirt *Didemnum vexill*um could have a smothering effect even within sea caves.

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

Management of coastal defences

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

Climate change

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

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

Marine litter

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

Evidence gaps

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

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

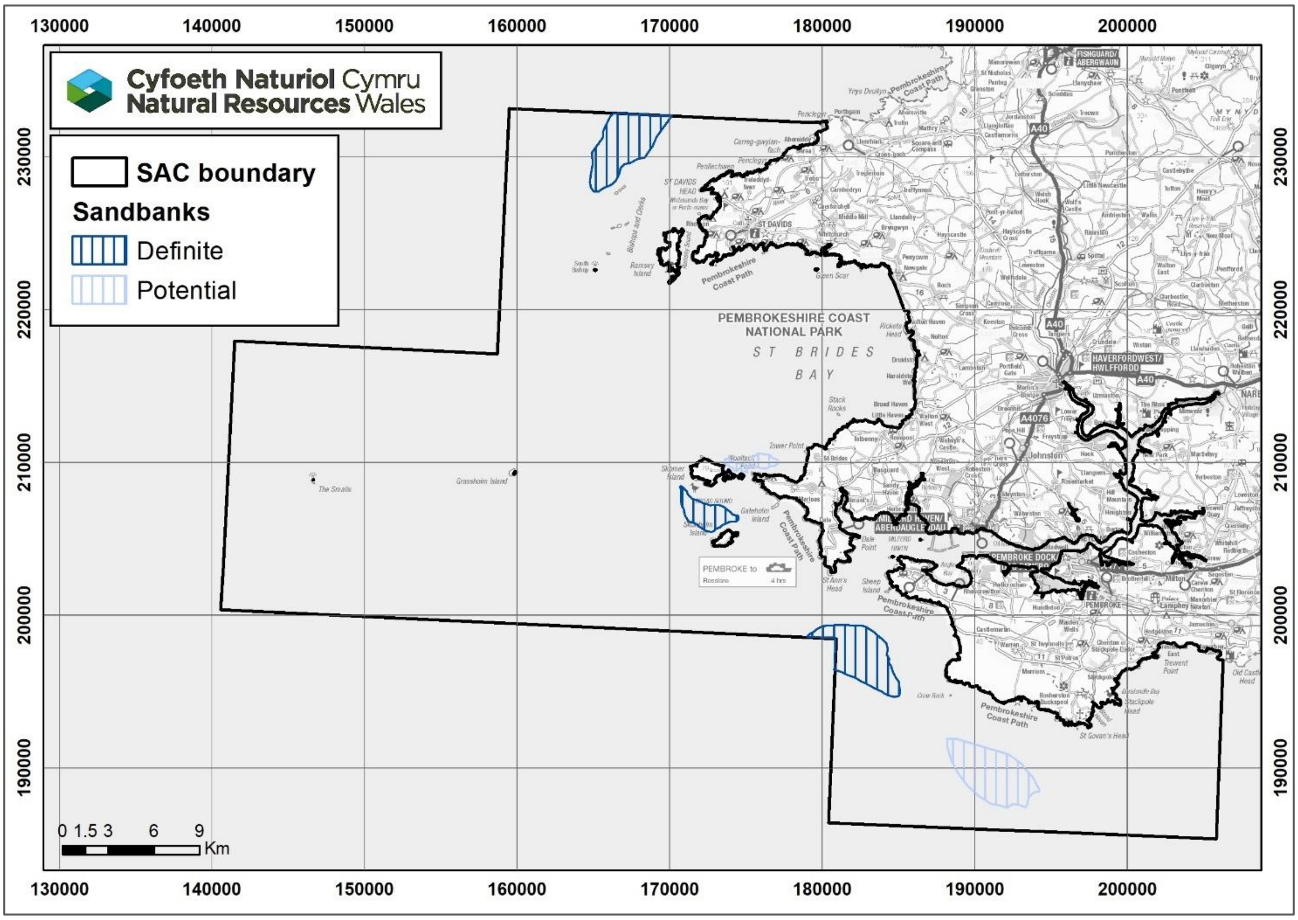
Table 34. Evidence gaps for sea caves in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

3.9. Sandbanks condition assessment

The sandbanks feature in Pembrokeshire Marine SAC comprises a number of sandbanks (Figure 28). The NRW Habitats Regulations monitoring has focussed on three named sandbanks within the SAC: Bais Bank South, Turbot Bank and the Knoll. These sandbanks have been assessed together against the performance indicators and an overall condition was assigned for the feature.

Figure 28. Map of the sandbanks feature in Pembrokeshire Marine SAC.



The summary of the assessment outcome is provided in Table 35. These outcomes and reasons of failure are discussed in more detail in the sections below.

Table 35. Condition assessment of sandbanks in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sandbanks within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sandbanks in the 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 sandbank distribution within the SAC, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sandbanks in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Sediment composition and distribution	Maintain composition of sediment granulometry across the sandbanks, allowing for natural change and variation. (P)	• Granulometric analysis for the monitored sandbanks showed some changes in sediment composition but this is likely to be natural. • Confidence is medium due to concerns around an ongoing trend in reducing coarse material and increasing fine material at the Knoll.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the sandbanks. (P)	• Little change in topography observed (~1 m) between 1980 and 2020 for Bais Bank. • There are currently no anthropogenic impacts known to be significantly affecting the topography of Turbot Bank. • Confidence is medium because there was no evidence available for the other sandbanks in the SAC.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• Modelled data indicated that hydrodynamic and sediment transport processes are functioning as expected for Turbot Bank. • There is no evidence available for the other sandbanks in the SAC. • Confidence is medium because the assessment has been inferred from a model.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Both of the WFD waterbodies that overlap with the sandbanks feature have been classified with High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 26% of the feature. ○ The Pembrokeshire South waterbody classification was rolled forward from the 2018 cycle 2 interim classification. • Confidence is medium due to the rolled forward classification, and as the waterbodies have a low degree of overlap with the feature.	**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. (T)	• One of the two WFD waterbodies was not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Cardigan Bay South). This waterbody overlaps with 7% of the feature. • The other WFD waterbody was classified with a High status for phytoplankton (Pembrokeshire South). This waterbody overlaps with 19% of the feature. • Confidence is medium due to the unclassified waterbody, as the waterbodies have a low degree of overlap with the feature, and because the ecological relationships between phytoplankton and the sandbanks feature are not well understood.	**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)	• Both overlapping WFD waterbodies were classified with High status for dissolved oxygen in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these overlap with 26% of the feature. • Confidence is medium due to samples being taken from surface of the waterbodies, and as the waterbodies have a low degree of overlap with the feature.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Both overlapping WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Pembrokeshire South and Cardigan Bay South). Combined, these overlap with 26% of the feature. • This indicator was therefore assessed as unknown.	**Unknown**	N/A
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the sandbanks feature in the Pembrokeshire Marine 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)	• Both overlapping WFD waterbodies were classified as Good status for the IQI WFD element in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 26% of the feature. • Analysis of macrobenthic infaunal communities for the three monitored sandbanks showed variations across the sampling period. The shift of community composition was smaller in recent years. • Overall, there were no concerns as such variations in community composition are to be expected with ridge sandbanks like Turbot Bank. • Confidence is high due to the availability of long term monitoring data and lack of concerning patterns.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of sandbank species, allowing for natural change and variation. (S)	• Analysis of monitoring data has shown that taxa richness and diversity for the Knoll was not a concern (but not sampled in 2001). • Diversity at Turbot Bank indicated a decline between 2001 and 2013 to rise again subsequently. • There was a decline in diversity for Bais Bank South until 2019 with a slight increase in 2022. • There was a steep decline in taxa richness for Turbot Bank and Bais Bank South after 2001 with better recovery for Turbot Bank. • Confidence in the fail is low due to concern only for a few sampling stations for Bais Bank South and uncertainty around the cause of this decline.	**Fail**	Low
Taxonomic spread of species	Maintain the expected taxonomic spread of sandbank species, allowing for natural change and variation. (S)	• Overall, the average distinctness of infaunal community of the three monitored sandbanks was within the expected values over the monitoring period. • Confidence is high due to the availability of high quality monitoring data and lack of concerning patterns.	**Pass**	High

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 are no records of INNS on any of the three monitored sandbanks. • Confidence is medium because there have been no targeted surveys of NNS.	**Pass**	Medium
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• There were no NNS records across all the three monitored sandbanks. • Confidence is medium because there have been no targeted surveys of NNS on sandbanks.	**Pass**	Medium

Assessment conclusions

The sandbanks feature in Pembrokeshire Marine SAC has been assessed as being in **favourable** condition (medium confidence). Overall, the lack of any significant anthropogenic impact on this feature in terms of extent, hydrodynamic processes, topography, sediment composition and its associated community, have contributed to this favourable assessment outcome. There was a failure for one secondary target (Table 36) and there were limited or absent data for one key indicator to inform on the condition of the feature (see evidence gaps). This reduced the confidence in the assessment.

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

Table 36. Summary of the condition assessment for sandbanks in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Sandbanks	**Favourable (medium confidence)**	Species richness and diversity (S)	• There was a large decline in species richness since 2001 at some sampling stations within Bais Bank South.	• Cable laying and maintenance • INNS • Water quality: contaminants Climate change

Detailed assessment information

Bais Bank South, Turbot Bank and the Knoll, which are part of the sandbanks feature in the Pembrokeshire Marine SAC, were monitored in 2001 and every three years between 2008-2022 using grab sampling surveys.

Extent and distribution

The indicators for extent and distribution of the sandbanks feature in Pembrokeshire Marine SAC pass their targets as there are currently no known anthropogenic impacts that would significantly affect the sandbanks feature. While there is a high confidence in the delineation of Turbot Bank since it was mapped using multibeam in 2012, the other sandbanks have moderate confidence for accurate delineation. A lack of repeat data for some of these sandbanks means it is not possible to calculate changes in extent over time for these features. This has reduced the confidence in both indicators to medium. More resources are needed to accurately and regularly map sandbanks using bathymetry techniques.

Sediment, topography and hydrodynamics

Granulometric analysis indicated some variations in sediment composition especially between 2001 and 2013, fluctuating between 250-500 µm (medium sand) and 500-1000 µm (coarse sand) grain size. This variation was deemed to be natural and could possibly be explained by the topography of a sandbank. Sample stations are in fixed positions but sandwaves move across the bank over time. This means that sometimes samples may be collected from the peak of a sandwave and sometimes from the trough and flanks, which could explain the variation in grain size. Different particle size distribution analysis methods were used during the monitoring period with dry sieving techniques used in 2001 and from 2008 to 2012, while laser diffraction was used from 2013 onwards. Sieve and laser diffraction methods measure particle size differently. Sieving measures a particle using the two shortest dimensions, while laser diffraction measures the particle equivalent to a sphere of the volume measured. For the same particle (unless perfectly round), the sieve weight will be smaller than the laser derived weight. This difference in analysis may have contributed to the variation observed, especially between 2001 and 2013. There was also an ongoing trend in reducing coarse material and increasing fine material at the Knoll. These changes were not deemed to be large enough to fail the sediment composition and distribution indicator target, but did reduce confidence in the pass to medium, and will be something to pay close attention to in the next assessment.

Bathymetry analysis of Bais Bank indicated relatively small changes in topography, with average accretion of 1.3 m (standard deviation 0.6 m) between 1980 and 2020; there was some indication of strong accretion on the northwest flank, possibly related to slight migration of the bank position. There are currently no known anthropogenic impacts that significantly affect Turbot Bank, as suggested by the modelled data issued by contractors. This evidence has resulted in a pass for the topography of the feature target, with a medium confidence score due to variation in data collection, processing methods among years, and the lack of data for the other monitored sandbank (the Knoll).

Hydrodynamic and sediment transport processes are not well researched for sandbanks. Some modelled data issued by contractors in Turbot Bank indicated that natural processes were occurring in this sandbank, and that there are currently no known anthropogenic activities that are known to have a significant impact on the Turbot Bank. For this reason, the hydrodynamic and sediment transport processes indicator met its target, but confidence was reduced to medium due to the lack of evidence for other sandbanks and the inferred nature of a model outcome.

Water quality

It has been estimated that approximately 26% of the sandbanks feature within the SAC falls within two WFD waterbodies, therefore it may not be a good reflection of the overall effect of water quality on feature, this has impacted the confidence of the water quality assessments. These waterbodies are Pembrokeshire South, which overlaps with 19% of the feature, and Cardigan Bay South, which overlaps with 7%.

Nutrients (DIN only) and phytoplankton

The nutrients (DIN only) indicator met its target as both of the WFD waterbodies that overlap with the sandbanks feature were classified with a High status for the DIN element in the 2024 cycle 3 interim classification. However, the classification for the Pembrokeshire South waterbody was rolled forward from the 2018 cycle 2 interim classification. The confidence was reduced to medium to reflect this, and due to the low degree of overlap between the sandbanks feature and the waterbodies within the SAC.

The phytoplankton also met its target as one of the two WFD waterbodies was classified with a High status for phytoplankton in the 2024 cycle 3 interim classification. This was the Pembrokeshire South waterbody, which overlaps with 19% of the feature. The other overlapping WFD waterbody was not classified for this 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). Confidence was reduced to medium due to the low degree of overlap between the sandbanks feature and the waterbodies within the SAC. In addition, the ecological relationships between phytoplankton and sandbanks are not well understood.

Dissolved oxygen

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

Contaminants

Both of the two WFD waterbodies that overlap with the sandbanks feature were not classified as the chemicals have not been assessed within the last six years. This indicator was therefore assessed as unknown.

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

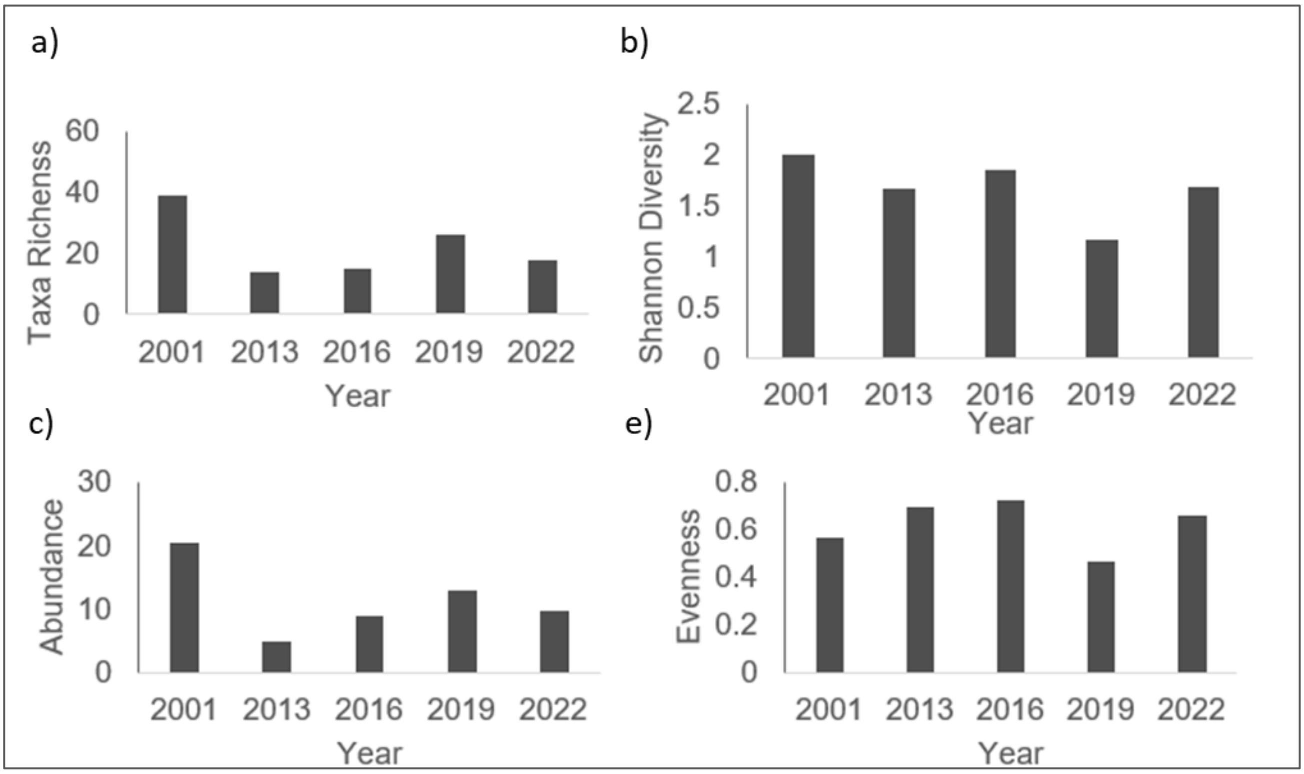
Both WFD waterbodies that overlap with the sandbanks feature were classified as Good status for the IQI element in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 26% of the sandbanks feature.

Infaunal analysis showed that the species comprising the communities present in the three monitored sandbanks varied across the sampling period with many fluctuations. Such variations in community composition are to be expected with ridge sandbanks such as Bais Bank. Depending on where the grab sampling took place, communities could be sampled from a trough, flank or a mobile peak and these tend to move with time, further increasing variations in community composition. The low number of taxa can also accentuate any changes observed in community analysis. Overall, there was no concern with the abundance, distribution and species composition of communities indicator, resulting in a pass with high confidence.

Bais Bank South failed to meet the indicator target for species richness and diversity, resulting in an overall failure for this indicator. Analysis revealed a steep decline in taxa richness since 2001 for Turbot Bank and Bais Bank. Some form of recovery was apparent for Turbot Bank while taxa richness for Bais Bank South had not yet recovered (Figure 29). The decline of taxa richness was observed only at a few stations for Bais Bank South and a further decline in abundance at two stations over time suggested some disturbance. There are no known anthropogenic activities that could significantly impact Bais Bank South. While possible fishing activities could impact sandbanks, the bathymetry and distance from the shore of Bais Bank is not particularly favourable to this type of activity and there is no evidence of impact. There is, therefore, some uncertainty on the causes of these declines seen at only a few stations resulting in a low confidence assessment. There was no concern for the Knoll for taxa richness and diversity, but sampling started after 2001 so a possible decline in taxa observed in the other two sandbanks may be possible but not observed within this timeframe.

The average distinctness of the infaunal community of the three monitored sandbanks remained stable and within the expected values for most of the monitoring period, especially within recent years. A high confidence was attributed to the pass due to the availability of long term monitoring data and lack of concerning patterns.

Figure 29. Diversity indices of macrofauna sampled at Bais Bank South sandbank across the monitoring survey period 2013, 2016, 2019 and 2022 (Van Veen grab 0.1 m^2). a) taxa richness, b) Shannon-wiener diversity (log_e), c) abundance (replicates averaged) and d) Pielou's evenness. Teleost and lancelet are excluded for all indices, sessile epifauna are included in Taxa Richness only.



Invasive non-native species

There has historically been a high number of NNS in other parts of the SAC, especially within the Milford Haven Waterway, but also close to Skomer island. However, there were no NNS found within the three monitored sandbanks, resulting in INNS and NNS indicators to meet both its primary and tertiary targets. Confidence in the pass was reduced to medium as there have been no targeted NNS surveys on sandbanks, which would be required to fully understand the presence and future impacts of any INNS species within the sandbanks feature.

Reasons for target failure

The sandbanks feature Pembrokeshire Marine SAC has been assessed as being in **favourable** condition. However, one secondary target failed to be met and needs to be kept under review.

Species richness and diversity

This indicator target has a secondary weighting. This indicator failed as there has been a large decline of taxa richness since 2001 at some stations in Bais Bank South with little recovery. From the evidence it is not clear what is causing this decline and further investigation will be needed to understand the reason for this failure and allow management measures to be implemented.

Threats to condition

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

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

Invasive non-native species

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

There have been confirmed records of *Crepidula fornicata* within the Pembrokeshire Marine SAC. There are currently no recorded observations of the species on the sandbanks feature. Most records are within the Milford Haven Waterway. There have been three recorded observations of the species near to the Martin’s Haven and Middleholm Bank (2011, 2013 and 2016). At high densities, this species could cause an impact on the feature as it 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). It may therefore pose a threat to the sandbanks feature. However, the spread and impact of this species on the feature is not fully 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. This SAC could be at risk since there are a number of possible pathways of introduction. Further information on introduction pathways can be found on the GB non-native species secretariat website.

Water quality: contaminants

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

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

Climate change

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

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

Evidence gaps

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

Listed below (Table 37) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 37. Evidence gaps for the sandbanks feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

Indicator	Assessed status	Comments
Sediment quality: oxidation-reduction profile (S); volume (S); organic carbon content (S); contaminants (S)	Not assessed	• These aspects are not currently monitored in sandbank sediment particle size analysis (PSA), but could be incorporated into analysis in future.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Not assessed	• There were no temperature, salinity or pH loggers within Pembrokeshire Marine SAC relevant to the sandbanks feature. • Remote sensing data on temperature, salinity and pH could be used in future.

3.10. Allis shad condition assessment

Allis shad *Alosa alosa* has been designated as a qualifying feature in Pembrokeshire Marine SAC as it has been considered an important coastal migration route or feeding ground for this species. There are no known historical spawning grounds in the freshwater catchments which drain into the SAC. A summary of the condition assessment for allis shad in Pembrokeshire Marine SAC can been seen in Table 38. The overall feature condition, a detailed summary of the assessment and threats to condition are discussed in more detail in the sections below.

Table 38. Condition assessment of allis shad in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population variables and data	The wider population of allis shad relevant to the SAC should be stable or increasing in the long-term. (P)	• The historical population of allis shad within the SAC are thought to migrate between spawning grounds in the Rivers Tywi, Wye, Usk and Severn and this marine SAC. Records of the species in these rivers and records within the marine SAC have therefore been considered in the assessment. • There have been no confirmed records of allis shad in the SAC. Population numbers are thought to be very low. • The historical collapse of the allis shad population in the River Severn was linked to weir construction. Barriers in the River Severn, and upstream tributaries in the Usk, are still present and are thought to be limiting the upstream migration of allis shad within these catchments. Within the River Tywi SAC, there have been no confirmed records of allis shad. • Although this indicator was assessed, data on allis shad are very limited and there have been no targeted surveys of the species in any of the marine SACs, therefore confidence is medium.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Habitat connectivity	Maintain safe passage and movement of allis shad in the marine environment into, within and away from the SAC. (P)	• There are no known barriers to marine migration within or into the Pembrokeshire Marine SAC. • There are no known barriers to migration in the Carmarthen Bay and Estuaries SAC and Severn Estuary SAC, and in the Bristol Channel that could impact allis shad in the Pembrokeshire Marine SAC. • Confidence is high as in depth site knowledge was used.	**Pass**	High
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not having a detrimental impact at the population level. (P)	• There are no known records of the INNS that are of particular concern for allis shad within Pembrokeshire Marine SAC. • Confidence is high due to the availability of long term monitoring data on the species of concern to allis shad.	**Pass**	High
Anthropogenic mortality: targeted exploitation	There should be no targeted exploitation of the species. (S)	• No targeted exploitation of allis shad is understood to be occurring. • Under the Wildlife & Countryside Act 1981 (as amended) it is illegal to take, kill or disturb (including fishing for) allis shad without a license. • Confidence is high as the assessment was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Anthropogenic mortality: abstraction and entrapment	Abstraction and entrapment should not adversely affect the viability of the population. (S)	• All licenced abstractions have previously been assessed through the Habitats Regulations Review of Consents (RoC) process, Eel Regulations, or Salmon and Freshwater Fisheries Act (SAFFA) 1975. • All new abstractions are required to go through permitting processes to comply with screening requirements for fish. • There has been no evidence of entrapment of allis shad recorded at Pembroke Power Station. • There are no other major operations within the SAC known to be causing entrapment of allis shad. • Confidence is high as all operations go through permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.	**Pass**	High
Anthropogenic mortality: bycatch	Bycatch of the species should not adversely affect the viability of the population. (S)	• Bycatch of allis shad is thought to be low for the SAC population. • Pelagic fisheries in the Celtic Sea may have bycatch of allis shad but there are no data on the potential impact of this. • The indicator was assessed as unknown as there are no data to assess the extent and impact of bycatch of allis shad.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the six WFD waterbodies in the SAC were not classified 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). • One WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to PBDE and PAH (Milford Haven Inner). • One WFD waterbody has a pass for chemicals (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. • Allis shad are likely to use the coastal areas of the SAC in migration routes, and are unlikely to spend a significant amount of time in the Milford Haven estuary as they do not migrate up the Cleddau Rivers. This indicator was therefore assessed as unknown as the coastal waterbodies have not been classified for this WFD element.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Five of the six WFD waterbodies in the SAC have been classified as High status for dissolved oxygen in the 2024 cycle 3 interim classification. • All WFD waterbodies that have been assessed overlap with an extensive area within the SAC and are therefore considered to be representative of the area that allis shad would use in the SAC. • Confidence is medium as samples have been taken from the surface of waterbodies.	**Pass**	Medium
Water quality: physicochemical properties	Maintain natural physicochemical properties of water subject to natural variation. (T)	• Data from intertidal and 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

Assessment conclusions

The allis shad feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (low confidence). There was one indicator with a failing target (Table 39). The reason for low populations of allis shad in the SAC and across Wales is not known. The species is currently classified as Critically Endangered (presumed extinct) in Wales. The overall confidence was low as the assessment was based on expert judgement as there are limited data within the marine SAC. Further investigation is needed to better understand the failure 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 39 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 39. Summary of the condition assessment for allis shad in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for target failure	Threats to condition
Allis shad *Alosa alosa*	**Unfavourable (low confidence)**	Population variables and data (P)	• There are critically low populations of allis shad across Wales.	• Industry • INNS • Water quality: contaminants • Climate change

Detailed assessment information

Population variables

A Red List Assessment concluded that allis shad are Critically Endangered (presumed extinct) in Wales (Nunn et al., 2023). Although it is possible that allis shad spawn in Wales, numbers are likely to be extremely small and hybridisation with twaite shad may mean that allis shad are functionally extinct in Wales. NRW has records of shad eggs which show that shad are spawning on a regular basis in the relevant river catchments. However, it is not possible to determine what species the eggs are.

There are no known historical allis shad spawning grounds in the freshwater catchments directly upstream of the Pembrokeshire Marine SAC (Cleddau Rivers SAC). The historical population of allis shad within the SAC are thought to migrate between spawning grounds in the Rivers Tywi and Severn (including the important tributaries, rivers Usk and Wye). As the SAC was designated for the species for use as a migration route, records of the species in the rivers that are thought to contribute to the SAC population, and expert judgement of their potential use of the marine SAC has been considered.

There have been no confirmed records of allis shad within the Pembrokeshire Marine SAC, and population numbers are thought to be very low. Detection is hampered by the lack of targeted surveys for this species in the marine environment.

Weir construction was thought to have been a primary reason for the collapse of the allis shad population in the River Severn in England (Aprahamian et al., 1998). The Unlocking the Severn Project has constructed a series of fish passes that open up 254 km of previously inaccessible river to shad, greatly improving the area of available habitat on the river and allowing access along the main Severn as far as Stourport. However, this only amounts to approximately half the distance of river that would previously have been available. Barriers in the Severn, and upstream tributaries in the Usk are still present and are thought to be limiting the upstream migration of allis shad within this catchment. Improvements are planned or in progress at the two weirs on the Usk to progress fish easement as part of the Four Rivers for LIFE project, and works have also been carried out on some of the weirs on the Severn in England as part of the Unlocking the Severn Project. Within the River Tywi SAC, which has historically been an important spawning river for the species, there have been no confirmed records of allis shad.

It should be noted that the shad population on the Tywi shows an unusually high proportion of allis shad haplotypes (72%), likely indicating past hybridisation with allis shad (Hardouin et al., 2013). For the purposes of these assessments, these individuals are considered to be twaite shad as allis shad numbers are very low across Wales. Hardouin et al. (2013) found that in the River Wye, 1% of the eggs studied were assigned to allis shad, compared to 70% for twaite shad, with 29% being hybrids. The Rivers Usk and Tywi had 0% proportions of allis shad.

The indicator linked to population failed to meet its set target primarily due to the lack of records within the Marine SAC, but also due to low populations in the historical spawning populations in the Rivers Tywi and Severn. The assessment was based on expert judgement as there are very limited data within the marine SAC. A medium confidence was therefore assigned to the fail. Although this indicator was assessed, data on allis shad are very limited and there have been no targeted surveys of the species in any of the marine SACs. Surveys of allis shad are therefore required within the SAC.

Habitat connectivity

There are no known marine barriers in the Severn Estuary SAC and the Carmarthen Bay and Estuaries SAC, and along the coast in between that could impact allis shad in the Pembrokeshire Marine SAC. The indicator therefore passed its target with high confidence as there are no known issues with connectivity within the marine migration routes into and through the SAC.

The freshwater flow indicator is not applicable as there are no known spawning populations of allis shad in the freshwater catchments.

Invasive non-native species

The INNS that could significantly impact the allis shad are Chinese mitten crab and Signal crayfish. There have been no known records of these species within the Pembrokeshire Marine SAC. There are no other known INNS considered likely to affect allis shad within the SAC. The INNS indicator therefore passed its target with a high confidence.

Anthropogenic mortality

There is no known targeted exploitation of allis shad within Pembrokeshire Marine SAC therefore this indicator passed its target. Under the Wildlife & Countryside Act 1981 (as amended) it is illegal to take, kill or disturb (including fishing for) allis shad without a license. Any specimens caught unintentionally must be released alive. High confidence was attributed to the indicator pass as it was based on expert judgement and knowledge that there are no fisheries that could capture the species in the site, especially given the low population numbers.

In Wales, all licenced abstractions have been assessed through Habitats Regulations Review of Consents (RoC) process, Eel Regulations, or Salmon and Freshwater Fisheries Act (SAFFA) 1975 to ensure that all permitted abstractions are screened to minimise entrainment of fish. Pembroke Power Station abstracts water from the SAC. Annual impingement and entrainment monitoring conducted at the power station has not recorded any allis shad since the commencement of operation (RWE, unpublished data). The power station may pose a threat due to the abstraction and possibility of entrainment or impingement, but monitoring suggests no current impacts to the species. Therefore, it has been identified as not posing a significant impact to allis shad. There are no other major operations within the Pembrokeshire Marine SAC known to be causing entrapment of allis shad. The abstraction and entrapment target was therefore assessed as passing with high confidence as all operations go through regulated screening permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.

Bycatch of allis shad within the Pembrokeshire Marine SAC is thought to be minimal, particularly given the population levels. There may be some bycatch of allis shad in the pelagic fisheries in the Celtic Sea, however there are no data on the potential impact of this on the SAC population. As there are no data to assess the extent and impact of bycatch of allis shad, the indicator was assessed as unknown.

Water quality

There are six WFD waterbodies within the Pembrokeshire Marine SAC: Pembrokeshire South, Cardigan Bay South, Grassholm Island and the Smalls, Milford Haven Outer, Milford Haven Inner, and Solfach Estuary. The water quality indicator conclusions also apply to twaite shad.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. The Milford Haven Outer waterbody failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals in the 2024 cycle 3 interim 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. The other four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. Allis shad in the SAC are designated for use of the site as a migration route through coastal areas, therefore the species is unlikely to spend a significant amount of time in the Milford Haven estuary. The indicator was therefore assessed as unknown as the coastal waterbodies have not been assessed for the chemicals.

Dissolved oxygen

The dissolved oxygen indicator passed its target as five of the six WFD waterbodies in the SAC were classified as High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. These WFD waterbodies overlap with an extensive area in the coastal part of the SAC and are therefore considered to be representative of the areas potentially used by allis shad in Pembrokeshire Marine SAC. 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 throughout the water column or for more demersal features. This reduced the confidence in the pass to medium.

Physicochemical properties

Data from seven NRW monitored subtidal temperature loggers and six NRW monitored intertidal monitoring sites at various shore heights (12 temperature loggers in total) were available. 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 estuary. 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).

Reasons for target failure

The assessment of allis shad in Pembrokeshire Marine SAC failed one primary target. This resulted in the allis shad feature to be assessed as being in **unfavourable** condition. The failing indicator and reasons for failure, if known, are stated below.

Population variables and data

The population indicator target was not met as there have been no confirmed records of allis shad within the SAC. In the wider region, allis shad are classified as Critically Endangered (presumed extinct) in Wales. Data on allis shad are very limited and there have been no targeted surveys of the species in any of the marine SACs. On the River Severn in England, weir construction was thought to have been a primary reason for the historical collapse of the allis shad population in the river (Aprahamian et al., 1998).

Threats to condition

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

Industry

Any planned installations and projects which could impinge or entrap allis shad, and therefore have the potential to impact the species at a population level, need to be considered carefully, given the low population levels.

Invasive non-native species

There are currently no records of Chinese mitten crab in the Pembrokeshire Marine SAC. However they could be introduced to the area.

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

Water quality: contaminants

At the time of the assessment, allis shad are thought not to be adversely impacted by contaminants at the population level. There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect allis shad as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

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

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counteract each other. However, threats from climate change that could impact the species may include:

- Increasing sea surface and river temperature.
- Changes to prey availability and abundance.

Evidence gaps

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

Listed below (Table 40) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 40. Evidence gaps for the allis shad feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Population variables and data (P)	Medium confidence (limited data)	• Although this indicator was assessed, data on allis shad in the marine environment are limited and there have been no targeted surveys of the species within the marine SACs.
Anthropogenic mortality: bycatch (S)	Unknown	• The extent of bycatch of allis shad in fisheries is uncertain.

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

3.11. Twaite shad condition assessment

Twaite shad *Alosa fallax* has been designated as a qualifying feature in Pembrokeshire Marine SAC as it has been considered an important coastal migration route or feeding ground for this species. There are no known historical spawning grounds in the freshwater catchments which flow into the SAC. A summary of the condition assessment for twaite shad in Pembrokeshire Marine SAC can been seen in Table 41. The overall feature condition, a detailed summary of the assessment and threats to condition are discussed in more detail in the sections below.

Table 41. Condition assessment of twaite shad in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population variables and data	The wider population of twaite shad relevant to the SAC should be stable or increasing in the long-term. (P)	• Data on twaite shad within the Pembrokeshire Marine SAC are very limited. • The population of twaite shad within the SAC are thought to migrate between spawning grounds in the Rivers Tywi, Severn, Wye and Usk and this marine SAC. Records of the species in these rivers and records within the marine SAC have therefore been considered in the assessment. • Monitoring and modelling of the River Severn populations (1991-2024) found large reductions in the number of twaite shad returning to the River Severn. The indicator failed based on this declining population. Confidence was reduced as the relative contribution of each river population to the Pembrokeshire Marine SAC population is unknown. • Some angler data and limited egg counts indicate that the twaite shad population in the Tywi, Usk and Wye may be stable. The absence of population counts on these rivers reduced the confidence, leading to a low confidence.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Habitat connectivity	Maintain safe passage and movement of twaite shad in the marine environment into, within and away from the SAC. (P)	• There are no known barriers to marine migration within or into the Pembrokeshire Marine SAC. • There are no known barriers to migration in the Carmarthen Bay and Estuaries SAC and Severn Estuary SAC, and in the Bristol Channel that could impact twaite shad in the Pembrokeshire Marine SAC. • Confidence is high as in depth site knowledge was used.	**Pass**	High
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not having a detrimental impact at the population level. (P)	• There are no known records of the INNS that are of particular concern for twaite shad within Pembrokeshire Marine SAC. • Confidence is high due to the availability of long term monitoring data on the species of concern to twaite shad.	**Pass**	High
Anthropogenic mortality: targeted exploitation	There should be no targeted exploitation of the species. (S)	• No targeted exploitation of twaite shad is understood to be occurring. • Under the Wildlife & Countryside Act 1981 (as amended) it is illegal to fish for twaite shad without a license. • Confidence is high as the assessment was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Anthropogenic mortality: abstraction and entrapment	Abstraction and entrapment should not adversely affect the viability of the population. (S)	• All licenced abstractions have previously been assessed through the Habitats Regulations RoC process, Eel Regulations, or SAFFA 1975. • All new abstractions are required to go through permitting processes to comply with screening requirements for fish. • There has been no evidence of entrapment of twaite shad recorded at Pembroke Power Station. • There are no other major operations within the SAC known to be causing entrapment of twaite shad. • Confidence is high as all operations go through permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.	**Pass**	High
Anthropogenic mortality: bycatch	Bycatch of the species should not adversely affect the viability of the population. (S)	• Bycatch of twaite shad is thought to be low for the SAC population. • Pelagic fisheries in the Celtic Sea may have bycatch of twaite shad but there are no data on the potential impact of this. • The indicator was assessed as unknown as there are no data to assess the extent and impact of bycatch of twaite shad.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the six WFD waterbodies in the SAC were not classified 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). • One WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, due to PBDE and PAH (Milford Haven Inner). • One WFD waterbody has a pass for chemicals (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody has improved since previous cycles. • Twaite shad are likely to use the coastal areas of the SAC in migration routes, and are unlikely to spend a significant amount of time in the Milford Haven estuary as they do not migrate up the Cleddau Rivers. This indicator was therefore assessed as unknown as the coastal waterbodies have not been classified for this WFD element.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Five of the six WFD waterbodies in the SAC have been classified as High status for dissolved oxygen in the 2024 cycle 3 interim classification. • All WFD waterbodies that have been assessed overlap with an extensive area within the SAC and are therefore considered to be representative of the area that twaite shad would use in the SAC. • Confidence is medium as samples have been taken from the surface of waterbodies.	**Pass**	Medium
Water quality: physicochemical properties	Maintain natural physicochemical properties of water subject to natural variation. (T)	• Data from intertidal and 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

Assessment conclusions

The twaite shad feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (low confidence). There was one indicator with a failing target (Table 42). The confidence was reduced to low as the contribution of twaite shad from the Severn to the SAC population is unknown, and because the state of the twaite shad population in the Tywi, Usk and Wye are unknown but may be stable. Further investigation is needed to better understand the failure 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 42 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 42. Summary of the condition assessment for twaite shad in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for target failure	Threats to condition
Twaite shad *Alosa fallax*	**Unfavourable (low confidence)**	Population variables and data (P)	• The population of twaite shad in the Severn catchment is declining, which is likely to contribute to the Pembrokeshire Marine SAC population, and may be reflective of wider shad population trends.	• Industry • INNS • Water quality: contaminants • Climate change

Detailed assessment information

Population variables

There are no known historical twaite shad spawning grounds in the freshwater catchments directly upstream of the Pembrokeshire Marine SAC (Cleddau Rivers SAC). The historical population of twaite shad within the SAC are thought to migrate between spawning grounds in the Rivers Tywi and Severn (including the important tributaries, rivers Usk and Wye). As the SAC was designated for the species to use as a migration route, records of the species in the rivers that are thought to contribute to the SAC population and expert judgement of their potential use the marine SAC have been considered.

In the River Severn catchment, the population of twaite shad has been modelled from 1991 to 2024, and monitored as part of the Unlocking the Severn project. These have shown a significant decline in the number of returning adult shad (EA, 2020), with the current data indicating that there has been a decline to less than 10% of the pre-2017 adult population (EA, unpublished). The cause of this decline is unclear, and it is also not known whether it is a river-specific issue or is also occurring in the Rivers Wye, Usk and Tywi.

Good juvenile recruitment is heavily dependent on warm, stable flow conditions in the spawning rivers (Aprahamian et al., 2010; Knights, 2014). More extreme weather events such as flooding, especially in summer months, in the last 20 years may have limited the recruitment of twaite shad (EA, 2020). The current British population of twaite shad is substantially lower than it has been historically (Nunn et al., 2023). The spawning run estimates in the Severn Estuary have been considered to be appropriate to use as an index site to assess any changes in the population size regionally. These estimates found that the three-generation percentage change was approximately 41% (Nunn et al., 2023). NRW has records of shad eggs which show that shad are spawning on a regular basis in the relevant river catchments. However, it is not possible to determine what species the eggs are.

Historically, twaite shad ascended the Severn as far as Welshpool (Aprahamian et al., 1998). On the Severn, the Unlocking the Severn Project has constructed a series of fish passes that open up 254 km of previously inaccessible river to shad, greatly improving the area of available habitat on the river and allowing access along the main Severn as far as Stourport. However, this only amounts to approximately half the distance of river that would previously have been available. Barriers in the River Severn, and upstream tributaries in the Usk are still present and are thought to be limiting the upstream migration of shad within this catchment. Improvements are planned or in progress at the two weirs on the Usk to progress fish easement as part of the Four Rivers for LIFE project, and works have also been carried out on some of the weirs on the Severn in England as part of the Unlocking the Severn Project. The indicator linked to population was assessed as failing the set target due to the decline of twaite shad in the River Severn population. The contribution of this population into the Pembrokeshire Marine SAC population is not known.

There has been angler data from the Wye and Usk and egg counts in the three rivers (Tywi, Usk and Wye) which indicate that the population of twaite shad may be stable (NRW, in prep). However, quantification of the population size in these rivers has not been possible using the counter data available. This is because twaite shad migrate in shoals and are therefore difficult to count, and as fish were found to move both up and downstream at the counter location. The lack of direct count data of the twaite shad populations in the Tywi, Usk and Wye reduced the confidence, leading to an overall low confidence assessment. Data on twaite shad in the Pembrokeshire Marine SAC are very limited and there have been no targeted surveys of the species in any of the marine SACs, therefore surveys of the species within the SAC are required.

Habitat connectivity

There are no known marine barriers from the Severn Estuary SAC and Carmarthen Bay and Estuaries SAC, and along the coast and in the Bristol Channel that could impact twaite shad in the Pembrokeshire Marine SAC. The indicator therefore passed its target with high confidence as there are no known issues with connectivity within the marine migration routes into and through the SAC.

The freshwater flow indicator is not applicable as there are no known spawning populations of twaite shad in the freshwater catchments.

Invasive non-native species

The INNS that could significantly impact the twaite shad are Chinese mitten crab and Signal crayfish. There have been no known records of these species within the Pembrokeshire Marine SAC, however, there has been no targeted monitoring of Chinese mitten crab within the area. The INNS indicator therefore passed the target with a high confidence.

Anthropogenic mortality

There is no known targeted exploitation of twaite shad within Pembrokeshire Marine SAC therefore this indicator passed its target. Under the Wildlife & Countryside Act 1981 (as amended) it is illegal to fish for twaite shad without a license. Any specimens caught unintentionally must be released alive. High confidence was attributed to the indicator pass as it was based on expert judgement and knowledge that there are no fisheries that could capture the species in the site.

In Wales, all licenced abstractions have been assessed through Habitats Regulations RoC process, Eel Regulations, or SAFFA 1975 to ensure that all permitted abstractions are screened to minimise entrainment of fish. Pembroke Power Station abstracts water from the SAC. Annual impingement and entrainment monitoring is conducted at the power station has not recorded any twaite shad since the commencement of operation (RWE, unpublished data). The power station may pose a threat due to the abstraction and possibility of entrainment or impingement, but monitoring suggests no current impacts to the species. Therefore, it has been identified as not posing a significant impact to twaite shad. There are no other major operations within the Pembrokeshire Marine SAC known to be causing entrapment of twaite shad. The abstraction and entrapment target was therefore assessed as passing with high confidence as all operations go through regulated screening permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.

Bycatch of twaite shad within the Pembrokeshire Marine SAC is thought to be low. There may be some bycatch of twaite shad in the pelagic fisheries in the Celtic Sea, however there are no data on the potential impact of this on the SAC population. As there are no data to assess the extent and impact of bycatch of twaite shad, the indicator was assessed as unknown.

Water quality

See allis shad water quality in Section 3.10 as it also applies to twaite shad.

Reasons for target failure

The assessment of twaite shad in Pembrokeshire Marine SAC failed one primary target. This resulted the twaite shad feature to be assessed as being in **unfavourable** condition. The failing indicator and reasons for failure, if known, are stated below.

Population variables and data

The historical population of twaite shad in the Pembrokeshire Marine SAC migrate between the Usk, Wye, Severn and Tywi populations, as there has never been a known population of twaite shad in the Cleddau Rivers. Modelling and recent monitoring of twaite shad in the Severn catchment using data from the putcher ranks sampling, Hinkley Point B impingement records and Unlocking the Severn run counts depict a long-term decline of twaite shad. The long-term decline is likely linked to an increase in more extreme weather events, such as summer flooding, which limits the recruitment of twaite shad (EA, 2020). The condition of the twaite shad population in the Tywi, Usk and Wye may be stable.

Threats to condition

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

Industry

Any planned installations and projects which could impinge or entrap twaite shad, and therefore have the potential to impact the species at a population level, need to be considered carefully, given the low population levels.

Invasive non-native species

There are currently no records of Chinese mitten crab in the Pembrokeshire Marine SAC. There is a threat that these could be introduced to the area.

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

Water quality: contaminants

At the time of the assessment, twaite shad are thought not to be adversely impacted by contaminants at the population level. There is the potential for unregulated contaminants (such as PFAS) to increase. This could affect twaite shad as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

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

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counteract each other. However, threats from climate change that could impact the species may include:

- Increasing sea surface and river temperature.
- Changes to prey availability and abundance.

Evidence gaps

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

Listed below (Table 43) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 43. Evidence gaps for the twaite shad feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Population variables and data (P)	Low confidence (limited data)	• Although this indicator was assessed in both SACs, data on twaite shad in the marine environment are limited and there have been no targeted surveys of the species within the marine SACs.

Indicator	Assessed status	Comments
Anthropogenic mortality: bycatch (S)	Unknown	• The extent of bycatch of twaite shad in fisheries is uncertain.
Water quality: physicochemical properties (T)	Not assessed / unknown	• Further evidence in temperature changes is required to adequately assess this indicator in the SAC. • Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. Remote sensing data on temperature, salinity and pH could be used in future.

3.12. River lamprey condition assessment

River lamprey *Lampetra fluviatilis* has been designated as a qualifying feature in Pembrokeshire Marine SAC as it has been considered an important coastal migration route or feeding ground for this species, and as it is adjacent to an important freshwater site for the species (Cleddau Rivers SAC). The Cleddau Rivers were therefore considered as the primary upstream spawning locations for the SAC in this assessment. Other rivers that input into the SAC population (Pembroke river) have also been considered in the assessment. There may be other relevant smaller rivers that contribute to the SAC population. A summary of the condition assessment for river lamprey in Pembrokeshire Marine SAC can been seen in Table 44. The overall feature condition, a detailed summary of the assessment and threats to condition are discussed in more detail in the sections below.

Table 44. Condition assessment of river lamprey in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population variables and data	The population of river lamprey relevant to the SAC should be stable or increasing in the long-term. (P)	• There have been no targeted surveys of river lampreys in the Cleddau Rivers SAC and Pembrokeshire Marine SAC. • The indicator could not be assessed due to the lack of available data for the species.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Habitat connectivity	Maintain safe passage and movement of river lamprey in the marine environment into, within and away from the SAC, including to and from the connected spawning locations. (P)	• There are no known barriers to marine migration within or into the Pembrokeshire Marine SAC that would limit river lamprey migration through the SAC along the coast. • There are two structures that are currently impeding passage of river lampreys between the marine SAC and the connected spawning rivers (Cleddau Rivers SAC): Canaston and Haverfordwest Town weirs. There are currently fish passes at these weirs but they are not yet suitable for river lampreys. • Barriers to migration are also present on the Pembroke river. • Confidence is high as the barriers present are known to be impeding passage of river lamprey.	**Fail**	High
Freshwater flow	Maintain freshwater flow to the estuary / estuaries within the SAC. Regulated rivers meet their minimum flow targets. (P)	• There are no known issues affecting the freshwater flow to the Pembrokeshire Marine SAC that would affect river lamprey migration. • There are no known issues within the Cleddau Rivers SAC affecting flow to the Milford Haven estuary. • Licenced abstractions on the Cleddau Rivers SAC have gone through the RoC process to ensure designated features are adequately protected. • Flow data were not analysed for this assessment therefore confidence is medium.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not having a detrimental impact at the population level. (P)	• There are no known records of INNS which would adversely affect the condition of the river lamprey feature within Pembrokeshire Marine SAC and associated Cleddau Rivers SAC. • Confidence is high due to the availability of long term monitoring data on the species of concern to river lamprey.	**Pass**	High
Anthropogenic mortality: targeted exploitation	There should be no targeted exploitation of the species. (S)	• No targeted exploitation of river lampreys is understood to be occurring in the SAC population. • Confidence is high as the assessment was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.	**Pass**	High
Anthropogenic mortality: abstraction and entrapment	Abstraction and entrapment should not adversely affect the viability of the population. (S)	• All licenced abstractions have previously been assessed through the Habitats Regulations RoC process, Eel Regulations, or SAFFA 1975. • All new abstractions are required to go through permitting processes to comply with screening requirements for fish. • Pembroke Power Station has been identified as not posing a significant impact to river lamprey. • There are no other major operations within the SAC or rivers draining into the SAC known to be causing entrapment of river lamprey. • Confidence is high as all operations go through permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Anthropogenic mortality: bycatch	Bycatch of the species should not adversely affect the viability of the population. (S)	• Bycatch of river lamprey is understood to be low for the SAC population. • Confidence is medium as there are limited data on bycatch.	**Pass**	Medium
Fish Community	The WFD Estuarine Fish tool is at least good. (T)	• There is one transitional WFD waterbody within the SAC that has been assessed using the WFD estuarine fish tool. • The Milford Haven Inner waterbody was classified as Good status for the estuarine fish WFD element in the 2024 cycle 3 interim classification. There has been no change from Good status since previous cycles. • The confidence is medium as the assessment only provides a snapshot of the conditions for estuarine fish.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the six WFD waterbodies in the SAC were not classified 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). • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody has improved since previous cycles. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. • Confidence is low as: the human health standard has been used for PBDE; some waterbodies were not classified for relevant chemicals; and contaminants are not directly monitored in this species.	**Fail**	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. (P)	• Five of the six WFD waterbodies in the SAC have been classified as High status for dissolved oxygen in the 2024 cycle 3 interim classification. • All WFD waterbodies that have been assessed overlap with an extensive area within the SAC and are therefore considered to be representative of the area that river lampreys would use in the SAC. • Confidence is low as samples have been taken from the surface of waterbodies.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain natural physicochemical properties of water subject to natural variation. (T)	• Data from intertidal and 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

Assessment conclusions

The river lamprey feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (high confidence). There were two indicators with failing targets (Table 45). There were limited or absent data for one important indicator to inform on the condition of the feature (see evidence gaps). Further investigation is needed to better understand 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 45 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 45. Summary of the condition assessment for river lamprey in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for target failure	Threats to condition
River lamprey *Lampetra fluviatilis*	**Unfavourable (high confidence)**	Habitat connectivity (P) Water quality: contaminants (S)	• There are barriers within the eastern and western Cleddau Rivers that are affecting lamprey access from the Pembrokeshire Marine SAC into the Cleddau Rivers SAC. • Levels of PBDE and PAH in the Milford Haven Inner waterbody failing are to meet their relevant EQSs.	• Industry • INNS • Water quality: contaminants • Climate change

Detailed assessment information

Population variables

There have been a limited number of recent surveys of river lampreys in the Cleddau Rivers. The acoustic tracking of sea lamprey in the region cannot be used as a proxy for river lampreys as their migration period is different. It is not possible to distinguish between the two *Lampetra* species (river lamprey and brook lamprey) at the ammocoete stage, however there are many records of ammocoetes from NRW monitoring. This may indicate that there is a lot of suitable habitat available for lamprey ammocoetes in the rivers. The indicator linked to population could not be assessed due to the lack of data available for river lamprey. Adaptive resolution imaging sonar (ARIS) tracking would be beneficial in the monitoring of river lamprey in rivers for future condition assessments.

Habitat connectivity and freshwater flow

There are no known barriers to marine migration within the Pembrokeshire Marine SAC that would limit river lamprey migration through the SAC and along the coast.

In contrast, there are issues between the upstream spawning rivers and the marine SAC. There are two weirs present within the Cleddau Rivers SAC which are limiting lamprey access between the Cleddau Rivers and the Pembrokeshire Marine SAC. These are the Canaston weir in the eastern Cleddau and the Haverfordwest Town weir in the western Cleddau, both of which are just above the tidal limit and outside of the Pembrokeshire Marine SAC boundary. There has been no acoustic tracking of river lamprey specifically, however during sea lamprey monitoring in the most recent survey in 2023, there were no lampreys found above the Canaston weir (Griffiths, 2023). Both weirs have fish passes, however they are not yet suitable for river lamprey. Improvements or replacement of the fish passes are currently planned or in progress at these two weirs as part of the Four Rivers for LIFE project, with work due to complete in the summer of 2026. Barriers to migration are also present on the Pembroke river which may benefit lampreys if removed or access via a fish pass installed. The habitat connectivity indicator failed to meet the target due to the presence of barriers that are significantly inhibiting passage between the Pembrokeshire Marine SAC and the Cleddau and Pembroke Rivers. Until work has taken place to improve the passage through these structures and the effects have been observed, this indicator will continue to fail with high confidence.

All licenced abstractions on the Cleddau Rivers SAC went through the RoC process which ensured that designated features, including migratory lamprey, were adequately protected. This indicator in the Pembrokeshire Marine SAC does not include a specific freshwater flow target. Flow data are available at some locations within the contributing rivers. The freshwater flow indicator therefore passed its target as there are no known issues with flow to the Milford Haven estuary or Cleddau Rivers SAC that drains directly into the Pembrokeshire Marine SAC. Confidence in the pass is medium as flow data were not used for the assessment.

Invasive non-native species

The INNS that could significantly impact river lampreys are Chinese mitten crab and Signal crayfish. There have been a small number records of signal crayfish in south Pembrokeshire, but not within the Cleddau Rivers SAC and tributaries. There are no other known records of these species within the Pembrokeshire Marine SAC or the Cleddau Rivers SAC catchment. The INNS indicator therefore passed its target with a high confidence.

Anthropogenic mortality

There is no known targeted exploitation of river lamprey within Pembrokeshire Marine SAC, therefore this indicator was assessed as passing its target. High confidence was attributed to the indicator pass as it was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.

In Wales, all licenced abstractions have been assessed through Eel Regulations, Habitats Regulations RoC process, or SAFFA 1975 to ensure that all permitted abstractions are screened to minimise entrainment of fish. Pembroke Power Station abstracts water from the SAC. Annual impingement and entrainment monitoring conducted at the power station has not recorded any river lampreys since the commencement of operation (RWE, unpublished data). The power station may pose a threat due to the abstraction and possibility of entrainment or impingement, but monitoring suggests no current impacts to the species. Therefore, it has been identified as not posing a significant impact to river lamprey. There are no other major operations within the Pembrokeshire Marine SAC or rivers draining into the SAC known to be causing entrapment of river lamprey. The abstraction and entrapment target was therefore assessed as passing with a high confidence as all operations go through regulated screening permitting processes and as the assessment has been based on up-to-date specialist knowledge and data.

Bycatch of river lamprey within the Pembrokeshire Marine SAC is understood to be low therefore this indicator passed its target. Confidence in this assessment is reduced to medium as there are limited data on bycatch, especially for unregulated fishing.

Fish community

The WFD estuarine fish tool is used as a proxy for habitat quality for fish in general in estuaries. If this element is classified as Good status it is likely that the conditions for fish, and therefore river lamprey, are favourable. The estuarine fish element is assessed in the transitional WFD waterbodies only. Within the Pembrokeshire Marine SAC there is one relevant transitional WFD waterbody, Milford Haven Inner. This was classified as Good status for the fish estuarine element in the 2024 cycle 3 interim classification, therefore the fish community indicator passed its target. It was assessed as Good status in all previous cycles. The confidence of the pass was medium as whilst it covers the main estuary that river lampreys transition through, the tool only provides a snapshot of the suitability of conditions for fish.

Water quality

There are six WFD waterbodies within the Pembrokeshire Marine SAC: Pembrokeshire South, Cardigan Bay South, Grassholm Island and the Smalls, Milford Haven Outer, Milford Haven Inner, and Solfach Estuary. The water quality indicator conclusions also apply to sea lamprey.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. 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 river lampreys are not fully understood. River lamprey potentially use the Milford Haven estuary throughout their adult life stages.

The Milford Haven Outer waterbody failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals in the 2024 cycle 3 interim 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. The other four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. It is not known how river lampreys use and are distributed in the SAC, and therefore how long they spend in the different waterbodies. However, it is likely that river lampreys will stay mainly within the two Milford Haven waterbodies due to the size of the estuary system compared to the river.

The failure of the Milford Haven Inner waterbody caused the contaminants indicator to fail. The confidence in the fail was reduced to low because the human health standard has been used for PBDE, and due to the unclassified waterbodies for chemicals. In addition, the effect of the chemical failure on the species is uncertain, and the contaminants have not been directly monitored in this species.

Dissolved oxygen

The dissolved oxygen indicator passed its target as five of the six WFD waterbodies in the SAC were classified as High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. These waterbodies overlap with an extensive area in the coastal part of the SAC and are therefore considered to be representative of the areas potentially used by the river lampreys in Pembrokeshire Marine SAC. 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 throughout the water column or for more demersal features. This reduced the confidence in the pass to low.

Physicochemical properties

Data from seven NRW monitored subtidal temperature loggers and six NRW monitored intertidal monitoring sites at various shore heights (12 temperature loggers in total) were available. 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 estuary. 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 non-native species (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).

Reasons for target failure

The assessment of river lamprey in Pembrokeshire Marine SAC failed one primary target and one secondary target. This resulted in the river lamprey feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Habitat connectivity

This indicator failed due to the two weirs present within the Cleddau Rivers, the Canaston weir in the eastern Cleddau and the Haverfordwest Town weir in the western Cleddau. Monitoring of sea lamprey has been used as a proxy for river lamprey movement through the weirs, as river lampreys have the same access requirements as sea lampreys. This monitoring found no lampreys above the weir, therefore passage at the weir via the current fish passes is likely to be suboptimal. Improvements or replacement of the fish passes are currently planned or in progress at the two weirs in the Cleddau, with work due to complete in the summer of 2026. However, until the effects of these changes have been observed, this indicator will continue to fail.

Water quality: contaminants

This indicator failed to meet its secondary target due to the chemical failure in the Milford Haven Inner waterbody, 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation of the failure in Milford Haven Inner waterbody is yet to be undertaken. PBDE is being managed in the UK 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 the river lamprey feature. The impact of PAH on the river lamprey feature is not fully understood.

Threats to condition

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

Industry

Any current or planned installations and projects which could impinge or entrap river lampreys, and therefore have the potential to impact the species at a population level, need to be considered carefully.

Invasive non-native species

There have been a small number of records of signal crayfish in South Pembrokeshire (not within the Cleddau Rivers SAC). Signal crayfish would predate on eggs and possibly ammocetes of the river lamprey. There are currently no records of Chinese mitten crab in the Pembrokeshire Marine or Cleddau Rivers SACs. There is a threat that these species could be introduced to the area.

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

Water quality: contaminants

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

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

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counteract each other. However, threats from climate change that could impact the species may include:

- Increasing sea surface and river temperature.
- Changes in precipitation impacting riverine flow in spring and summer, affecting the ability of adults to pass partial barriers and causing washout of eggs and juveniles.
- Changes to prey availability and abundance.

Evidence gaps

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

Listed below (Table 46) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 46. Evidence gaps for the river lamprey feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Population variables and data (P)	Unknown	• Data on river lampreys are very limited and there have been no targeted surveys on the species in any of the marine SACs. There is currently no agreed method of assessment of river lamprey in marine environments.
Water quality: physicochemical properties (T)	Not assessed / unknown	• Further evidence in temperature changes is required to adequately assess this indicator in the SAC. • Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. Remote sensing data on temperature, salinity and pH could be used in future.

3.13. Sea lamprey condition assessment

Sea lamprey *Petromyzon marinus* has been designated as a qualifying feature in Pembrokeshire Marine SAC as it has been considered an important coastal migration route or feeding ground for this species, and as it is adjacent to an important freshwater site for the species (Cleddau Rivers SAC). The Cleddau Rivers were therefore considered as the primary upstream spawning locations for the SAC in this assessment. There may be other relevant smaller rivers that contribute to the SAC population. A summary of the condition assessment for sea lamprey in Pembrokeshire Marine SAC can been seen in Table 47. The overall feature condition, a detailed summary of the assessment and threats to condition are discussed in more detail in the sections below.

Table 47. Condition assessment of sea lamprey in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Population variables and data	The population of sea lamprey relevant to the SAC should be stable or increasing in the long-term. (P)	• There has been no evidence of sea lampreys on the eastern Cleddau over the last 10 years, with no redds observed upstream of the Canaston weir. • Acoustic monitoring on the eastern Cleddau in 2023 found no indications of any sea lampreys during the deployment. • Acoustic monitoring on the western Cleddau in 2014 identified a very small number of migrating adult sea lampreys compared to other regions. • There have been no targeted surveys of sea lampreys in the Pembrokeshire Marine SAC. • Confidence is high due to the very low numbers or absence of sea lampreys within the Cleddau.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Habitat connectivity	Maintain safe passage and movement of sea lamprey in the marine environment into, within and away from the SAC, including to and from the connected spawning locations. (P)	• There are no known barriers to marine migration within or into the Pembrokeshire Marine SAC that would limit sea lamprey migration through the SAC and along the coast. • There are two structures that are currently impeding passage of sea lampreys between the marine SAC and the connected spawning rivers (Cleddau Rivers SAC): Canaston and Haverfordwest Town weirs. • There are current fish passes at these weirs but they are not yet suitable for sea lampreys. • Confidence is high as the barriers present are known to be impeding passage of river lamprey.	**Fail**	High
Freshwater flow	Maintain freshwater flow to the estuary / estuaries within the SAC. Regulated rivers meet their minimum flow targets. (P)	• There are no known issues affecting the freshwater flow to the Pembrokeshire Marine SAC that would affect sea lamprey migration. • There are no known issues within the Cleddau Rivers SAC affecting flow to the Milford Haven estuary. • Licenced abstractions on the Cleddau Rivers SAC have gone through the RoC process to ensure designated features are adequately protected. • Flow data were not analysed for this assessment therefore confidence is medium.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not having a detrimental impact at the population level. (P)	• There are no known records of INNS which would adversely affect the condition of the sea lamprey feature within Pembrokeshire Marine SAC and associated Cleddau Rivers SAC. • Confidence is high due to the availability of long term monitoring data on the species of concern to sea lamprey.	**Pass**	High
Anthropogenic mortality: targeted exploitation	There should be no targeted exploitation of the species. (S)	• No targeted exploitation of sea lamprey is understood to be occurring in the SAC population. • Confidence is high as the assessment was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.	**Pass**	High
Anthropogenic mortality: abstraction and entrapment	Abstraction and entrapment should not adversely affect the viability of the population. (S)	• All licenced abstractions have previously been assessed through the Habitats Regulations RoC process, Eel Regulations, or SAFFA 1975. • All new abstractions are required to go through permitting processes to comply with screening requirements for fish. • Pembroke Power Station has recorded entrapment of 25 sea lampreys since 2012, however the effect at the population level is unknown at present, especially as little is known about the population levels within the SAC. This led to an unknown assessment for this indicator. • There are no other major operations within the SAC or rivers draining into the SAC known to be causing entrapment of sea lamprey.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Anthropogenic mortality: bycatch	Bycatch of the species should not adversely affect the viability of the population. (S)	• Bycatch of sea lamprey is understood to be low for the SAC population. • Confidence is medium as there are limited data on bycatch.	**Pass**	Medium
Fish Community	The WFD Estuarine Fish tool is at least good. (T)	• There is one transitional WFD waterbody within the SAC that has been assessed using the WFD estuarine fish tool. • The Milford Haven Inner waterbody was classified as Good status for the estuarine fish WFD element in the 2024 cycle 3 interim classification. There has been no change from Good status since previous cycles. • The confidence of the pass is medium as the assessment only provides a snapshot of the conditions for estuarine fish.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the six WFD waterbodies in the SAC were not classified 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). • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody has improved since previous cycles. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. • Confidence is low as: the human health standard has been used for PBDE; some waterbodies were not classified for relevant chemicals, and contaminants are not directly monitored in this species.	**Fail**	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. (P)	• Five of the six WFD waterbodies in the SAC have been classified as High status for dissolved oxygen in the 2024 cycle 3 interim classification. • All WFD waterbodies that have been assessed overlap with an extensive area within the SAC and are therefore considered to be representative of the area that sea lampreys would use in the SAC. • Confidence is low as samples have been taken from the surface of waterbodies.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain natural physicochemical properties of water subject to natural variation. (T)	• Data from intertidal and 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

Assessment conclusions

The sea lamprey feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (high confidence). There were three indicators with failing targets (Table 48). Further investigation is needed to better understand 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 48 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 48. Summary of the condition assessment for sea lamprey in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

Feature	Overall Condition Assessment	Indicator failures	Reason for target failure	Threats to condition
Sea lamprey *Petromyzon marinus*	**Unfavourable (high confidence)**	Population variables and data (P) Habitat connectivity (P) Water quality: contaminants (S)	• There is an absence of records of sea lampreys within the Cleddau Rivers in recent years. • There are barriers within the eastern and western Cleddau Rivers that are affecting lamprey access from the Pembrokeshire Marine SAC into the Cleddau Rivers SAC. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet their relevant EQSs.	• Industry • INNS • Water quality: contaminants • Climate change

Detailed assessment information

Population variables

Sea lampreys were historically present and known to spawn in the Cleddau Rivers. These likely contributed most to the Pembrokeshire Marine SAC population of sea lamprey. There has been no evidence of sea lampreys on the eastern Cleddau in the last 10 years, with no redds observed in the reaches upstream of the Canaston weir (Griffiths, 2023). Acoustic monitoring of sea lampreys has been carried out around the Canaston weir in various years. In 2011, DIDSON (dual frequency identification sonar) was deployed upstream of the weir during sea lamprey spawning season (March to June) (Clabburn and Davies, 2011). An additional DIDSON unit was deployed below the weir for one day in May. During the monitoring period, 12 sea lamprey targets were identified, six were found upstream and six downstream. In comparison, sea lamprey numbers associated with the Carmarthen Bay and Estuaries SAC (River Tywi SAC catchment) in 2011 were the highest in any year since deployment began in 2009 (approximately 12,000), therefore the low numbers found in the eastern Cleddau indicate a localised declining population there compared to other regions. CCTV tracking was used in 2012 in the eastern Cleddau (Davies and Bennett, 2013) from April to June, where no sea lampreys were observed migrating up the fish pass. There was, however, one potential sea lamprey, though it may have been a large eel, observed moving down the pass.

The most recent ARIS in 2023 (Griffiths, 2023) monitored the water column directly upstream of the Canaston weir from April to June. There were no sea lampreys observed during this deployment.

DIDSON monitoring has also been carried out in the western Cleddau above the Haverfordwest Town weir in May to June 2014, where a total of 11 adult sea lampreys were recorded (NRW, 2014). As this deployment was shorter than those in the eastern Cleddau, it is likely that there were more sea lampreys present in the western Cleddau than was indicated in the results. However, compared to other regions these numbers were very low.

Based on the tracking data available, the indictor linked to population failed to meet the set target with high confidence due to the very low numbers or absence of sea lampreys within the Cleddau. ARIS tracking will continue to be important in the monitoring of sea lampreys in rivers for future condition assessments. Although this indicator was assessed, there are currently no data available on sea lampreys either in the transitional or coastal areas of the SAC.

Habitat connectivity and freshwater flow

There are no known barriers to marine migration within the Pembrokeshire Marine SAC that would limit sea lamprey migration through the SAC and along the coast.

In contrast, there are issues between the upstream spawning rivers and the marine SAC. There are two weirs present within the Cleddau Rivers SAC which are limiting sea lamprey access between the Cleddau Rivers and Pembrokeshire Marine SAC. These are the Canaston weir in the eastern Cleddau and the Haverfordwest Town weir in the western Cleddau, both of which are just above the tidal limit and outside of the Pembrokeshire

Marine SAC boundary. ARIS was deployed upstream of the Canaston weir in 2023, in which zero sea lamprey were observed during deployment (Griffiths, 2023). The weir currently has a fish pass. However, the lack of adult migrants or redds upstream of the weir suggests this is ineffective for sea lampreys. Improvements or replacement of the current fish passes are currently planned or in progress at these two weirs as part of the Four Rivers for LIFE project, with work due to complete in the summer of 2026. There have been fewer tracking surveys in the western Cleddau, however a DIDSON survey in 2014 was carried out above the Haverfordwest Town weir (NRW, 2014). A total of 11 adult sea lampreys were recorded (10 upstream and 1 downstream), which was low compared to other regions (Tywi). The habitat connectivity indicator failed to meet the target due to the presence of barriers that are significantly inhibiting sea lamprey migration between the Pembrokeshire Marine SAC and the Cleddau Rivers. Until work has taken place to improve the passage through these structures and the effects have been observed, this indicator will continue to fail with high confidence.

All licenced abstractions on the Cleddau Rivers SAC went through the RoC process which ensured that designated features, including migratory lamprey, were adequately protected. This indicator in the Pembrokeshire Marine SAC does not include a specific freshwater flow target. Flow data are available at some locations within the contributing rivers. The freshwater flow indicator therefore passed its target as there are no known issues with flow to the Milford Haven estuary or Cleddau Rivers SAC that drains directly into the Pembrokeshire Marine SAC. Confidence in the pass is medium as flow data were not used for the assessment.

Invasive non-native species

The INNS that could significantly impact sea lampreys are Chinese mitten crab and Signal crayfish. There have been a small number records of signal crayfish in south Pembrokeshire, but not within the Cleddau Rivers SAC and tributaries. There are no other known records of these species within the Pembrokeshire Marine SAC or the Cleddau Rivers SAC catchment. The INNS indicator therefore passed the target with a high confidence.

Anthropogenic mortality

There is no known targeted exploitation of sea lamprey within Pembrokeshire Marine SAC therefore this indicator passed its target. High confidence was attributed to the indicator pass as it was based on expert judgement and knowledge that there are no fisheries that could capture the species in the SAC.

In Wales, all licenced abstractions have been assessed through Eel Regulations, Habitats Regulations RoC process, or SAFFA 1975 to ensure that all permitted abstractions are screened to minimise entrainment of fish. Pembroke Power Station abstracts water from the SAC. Annual monitoring at the power station has recorded entrapment of 25 sea lampreys since 2012 (RWE, unpublished data). In addition, the estimated impingement for the period of 2012-2022 was an average of 53 sea lampreys per year. There are limitations to the monitoring data for sea lampreys because it is not specifically designed for this species. The monitoring does not align with the time of year when they are most abundant, and the screen mesh size may be too large to detect sea lamprey transformers and marine juveniles. The effect of entrapment and impingement at the population level is unknown at present as there are currently no population data available. In addition, little is known about the population level within the Pembrokeshire Marine SAC. However, compared with the estimated sea lamprey numbers from data available from run monitoring on the eastern and western Cleddau, the annual impingement estimates of 53 sea lamprey per year could be significant. The abstraction and entrapment target has been assessed as unknown as the effect at the population level is unknown. There are no other major operations within the Pembrokeshire Marine SAC or rivers draining into the SAC known to be causing entrapment of sea lamprey.

Bycatch of sea lamprey within the Pembrokeshire Marine SAC is understood to be low therefore this indicator passed its target. Confidence in this assessment is reduced to medium as there are limited data on bycatch, especially for unregulated fishing.

Fish community

The WFD estuarine fish tool is used as a proxy for habitat quality for fish in general in estuaries. If this element is classified as Good status it is likely that the conditions for fish, and therefore sea lamprey, are favourable. The estuarine fish element is assessed in the transitional WFD waterbodies only. Within the Pembrokeshire Marine SAC there is one relevant transitional WFD waterbody, the Milford Haven Inner. This was classified as Good status for the estuarine fish element in the 2024 cycle 3 interim classification, therefore the fish community indicator was assessed as passing its target. It was assessed as Good status in all previous cycles. The confidence of the pass was medium as whilst it covers the main estuary that sea lampreys transition through, the tool only provides a snapshot of the suitability of conditions for fish.

Water quality

See river lamprey water quality in Section 3.12 as it also applies to sea lamprey. It is not known how sea lampreys use and are distributed in the SAC, and therefore how long they spend in the different waterbodies. Sea lampreys travel further out to sea compared with river lampreys so it is possible that the contaminants failure in the Milford Haven Inner waterbody has less of an impact. However, as sea lampreys are thought to use the Milford Haven estuary at certain times in their lifecycle, the failure in the Milford Haven Inner waterbody has resulted in a failure for the contaminants indicator.

Temperature is a migratory cue for sea lampreys, where mean daily river temperatures exceeding 12^{o}C have coincided with peaks of sea lamprey migration on the River Tywi during spawning season (Clabburn and Davies, 2011). During monitoring of sea lampreys on the eastern Cleddau in 2011, temperatures only met this level 53% of the time. This may have been due to compensation releases from the Llys Fran reservoir due to low flows during the spring of 2011 (Clabburn and Davies, 2011). The conditions in spring 2011 were not typical, but they could be repeated during dry summers, and could therefore limit the presence and success of spawning of sea lamprey. The physicochemical properties indicator was still assessed as unknown based on the reasons outlined in the river lamprey water quality section in Section 3.12.

Reasons for target failure

The assessment of sea lamprey in Pembrokeshire Marine SAC failed two primary targets and one secondary target. This resulted in the sea lamprey feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Population variables and data

The Cleddau Rivers were considered to be the primary upstream spawning locations for the SAC in this assessment. There has been no evidence of sea lampreys on the eastern Cleddau in the last 10 years, with no redds observed in the reaches upstream of Canaston weir. Acoustic tracking in the most recent study in 2023 recorded zero sea lamprey in the eastern Cleddau. Sea lampreys have historically been present in both the eastern and western Cleddau Rivers. Therefore, the absence of records in recent years indicates a poor population present within the upstream spawning rivers that are connected to the Pembrokeshire Marine SAC due to restricted connectivity.

Habitat connectivity

This indicator failed due to the two weirs present within the Cleddau Rivers, the Canaston weir in the eastern Cleddau and the Haverfordwest Town weir in the western Cleddau. Monitoring of sea lamprey at the Canaston weir in 2023 recorded zero sea lamprey. The weir currently has a fish pass, however the lack of redds upstream of the weir suggests this is suboptimal for sea lampreys. Improvements or replacement of the fish passes are currently planned or in progress at the two weirs in the Cleddau, with work due to complete in the summer of 2026. However, until the effects of these have been observed, this indicator will continue to fail.

Water quality: contaminants

See river lamprey reasons for failure in Section 3.12 as it also applies to sea lamprey.

Threats to condition

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

Industry

Any current or planned installations and projects which could impinge or entrap sea lampreys, and therefore have the potential to impact the species at a population level, need to be considered carefully.

Invasive non-native species

There have been a small number of records of signal crayfish in South Pembrokeshire (not within the Cleddau Rivers SAC). Signal crayfish would predate on eggs and possibly ammocetes of the sea lamprey. There are currently no records of Chinese mitten crab in the Pembrokeshire Marine or Cleddau Rivers SACs. There is a threat that these species could be introduced to the area.

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

Water quality: contaminants

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

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

Climate change

It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counteract each other. However, threats from climate change that could impact the species may include:

- Increasing sea surface and river temperature.
- Changes in precipitation impacting riverine flow in spring and summer, affecting the ability of adults to pass partial barriers and causing washout of eggs and juveniles.
- Changes to prey availability and abundance.

Evidence gaps

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

Listed below (Table 49) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 49. Evidence gaps for the sea lamprey feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Anthropogenic mortality: abstraction and entrapment (S)	Unknown	• Pembroke Power Station has recorded impingement of sea lamprey but better understanding of the structure of the population is required to determine the effect at population level to the sea lamprey in Pembrokeshire Marine SAC.
Water quality: physicochemical properties (T)	Not assessed / unknown	• Further evidence in temperature changes is required to adequately assess this indicator in the SAC. • Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. Remote sensing data on temperature, salinity and pH could be used in future.

3.14. Otter condition assessment

A summary of the condition assessment for otter *Lutra lutra* in Pembrokeshire Marine SAC can be seen in Table 50. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the detailed assessment information.

Table 50. Condition assessment of otter in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Otter population health (hydrometric areas)	Relevant hydrometric areas used for the Otter Survey of Wales have 80% positive sites. (P)	• The relevant hydrometric area for this SAC is the Cleddau. • The Cleddau hydrometric area saw a statistically significant 14% decrease since the last survey. However, 83% of sites were positive so the target passes. • Confidence in the pass is medium due to the age of the survey data.	**Pass**	Medium
Otter population health (wider population)	The wider otter population relevant to the SAC is stable or increasing. (P)	• The relevant wider population is the southwest sub-population which includes the hydrometric areas the Cleddau, Loughour, Tywi and Teifi. • All have seen a statistically significant decline in positive otter sites since the last survey. • The population is not stable or increasing, so the target fails, failing the indicator overall. • Confidence in the fail is medium due to the age of the survey data.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Presence within the SAC	Positive signs otters using sites within the SAC. (P)	There has been periodic surveying of otters in the SAC between 2002-2017. • Sites positive for otter signs increased from 13 to 19 between 2002 and 2012 in the SAC but decreased slightly to 17 in 2017. Overall otter presence was recorded in 26 sites over the 2002- 2017 survey period. • Local Environmental Records Centres (LERC) document 17 records of otter within the SAC boundary or 1 km inland over the last 5 years 2018-2022 and 32 records in the previous 5 years 2017-2013. A total of 49 records in 10 years. • The last available record at the time of assessment in the LERC is from 2022. • No comment can be made on numbers of otter as multiple record signs may have been left by the same otter. • However, there is strong evidence to suggest that otter are using the SAC up until 2022. • Confidence is medium as there have been no targeted surveys of use of the SAC and the last sign was record in 2022.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Habitat quality and function	Maintain quality and functionality of habitat to protect potential foraging, resting and breeding sites relevant to the SAC. (P)	There has been periodic surveying of otters in the SAC between 2002-2017. • In 2012 most resting and breeding site habitats identified during the 2002 survey remained intact. • In 2017 resting and breeding site habitats remained intact with no evidence of human disturbance or damage. • A survey in the Cleddau catchment in 2022 found 8 of 10 potential breeding sites were still viable. This was a subset of all breeding sites. • Confidence is medium due to the scale and date of the last survey.	**Pass**	Medium
Habitat connectivity	No evidence of barriers that impact the safe passage and movement of otters into, within and away from the SAC. (P)	• No evidence of barriers to movement have been noted in Pembrokeshire otter monitoring reports. • No major impacts on otter movement have been identified from development related plans or projects. • No major road schemes planned or under construction. • Confidence is low as there have been no specific surveys to map barriers.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Contaminants within the water column do not exceed the EQS. (S)	• Four of the six WFD waterbodies in the SAC were not classified 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). • One WFD waterbody has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This waterbody has improved since previous cycles. • One WFD waterbody has a fail for chemicals (Milford Haven Inner), due to PBDE and PAH. This caused the indicator to fail. • Confidence was reduced to low as the human health standard has been used for PBDE, and due to the unclassified waterbodies.	**Fail**	Low

Assessment conclusions

The otter feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were two failing indicators (Table 51). 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 51 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 51. Summary of the condition assessment for otter in Pembrokeshire Marine SAC.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Otter *Lutra lutra*	**Unfavourable (medium confidence)**	Otter population health (S) Water quality: contaminants (S)	• Declining wider otter population. • Levels of PBDE and PAH in the Milford Haven Inner waterbody are failing to meet EQS.	• Road traffic collisions • Water quality: contaminants

Detailed assessment information

Otters are a mobile species travelling between resting, foraging and breeding sites over large home ranges. Male otters have larger home ranges than females. In Wales otters have been monitored through the Otter Survey of Wales since the 1970s. The first report was published in 1978 and repeated every 7 years since. The latest report was published in 2021 with the surveys taking place over 2015-2018. Each survey consists of sites across all river catchments (hydrometric areas) in Wales. This equates to 1108 sites over 15 hydrometric areas (see Figure 30). The same sites are revisited during each survey creating a data set currently spanning 40-years of otter occurrence in Wales. Professional surveyors or trained volunteers look for positive signs of otter (e.g. spraints or footprints) at each site. If they are found the site is recorded as positive; if they are not the site is recorded as negative. Comparisons across surveys can then be made to see if there has been a change in the number of positive sites in a hydrometric area. Surveying in this way is considered a good proxy for assessing population size.

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

A genetic study found that otters in Wales are comprised of three genetically distinct subregions; southwest Wales, northwest Wales and mid-east Wales (Hobbs et al., 2011). The Hobbs study recommended each subpopulation be treated as a management unit. The basis for this is that management of the otter population needs to consider gene flow between subregions by understanding what barriers (landscape or anthropogenic features) are creating the population structure within each of the regions. Ideally, gene flow should be re-established between the regions. Therefore, the second target, ‘otter population health’ performance indicator has been set to look at the wider population relevant to the SAC. Any declines in the wider population are likely to impact the number of otters using the SAC.

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

Otter in Pembrokeshire Marine SAC have been assessed against the chosen performance indicators using the Otter Survey of Wales, commissioned SAC surveys, Local Environmental Records Centres (LERC) data, WFD data, licenced activities assessments and expert knowledge.

Otter population health

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

The relevant hydrometric areas for a SAC are those whose boundaries border the SAC boundary. For the Pembrokeshire Marine SAC, the relevant hydrometric area is the Cleddau (Figure 30).

The Cleddau hydrometric area has seen a statistically significant decline of 14% in positive sites in the 6th Otter Survey of Wales compared to the 5th Otter Survey of Wales (Kean and Chadwick, 2021). However, 84% of sites (56 out of 67) were still positive. The sites were surveyed between 2015-2016 with one site surveyed in 2017. As the relevant hydrometric area met the required 80% positive sites, this target passed. However, as the data are now 8-10 years old at the time of publication, the confidence in this pass is reduced to medium, as recovery in declining sites may have occurred.

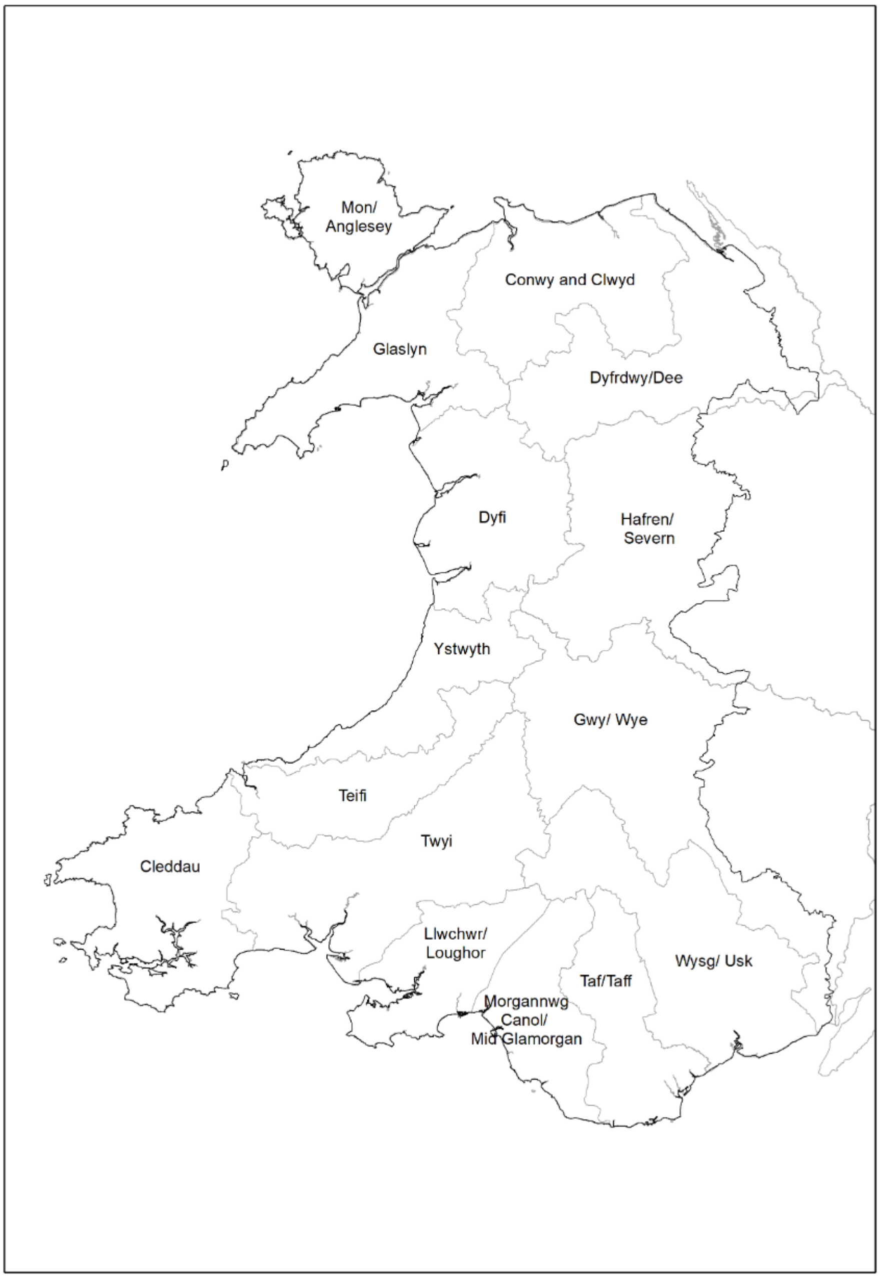
The second indicator for the population heath indicator is around the wider otter population. A genetic study found that otters in Wales are comprised of three genetically distinct sub-groups; southwest Wales, northwest Wales and mid-east Wales (Hobbs et al., 2011). This means that otters within each sub-population are genetically similar, demonstrating a high level of interbreeding within each subregion. This highlights how widely otters move and interact with each other. The Hobbs study recommended each subpopulation be treated as a management unit. Therefore, the performance indicator target has been set to look at the wider population relevant to the SAC for the assessment, as any declines in the wider population are likely to impact the number of otters using the SAC. The relevant subpopulation is the southwest.

The hydrometric areas that cover the southwest population are the Cleddau, Loughor, Tywi and Teifi. All areas have seen declines in the number of positive sites. The largest decline was seen in the at Teifi 48%, followed by the Loughor 37.21%, Tywi 22.32%, and the Cleddau 14%. All were statistically significant declines. The decline on the Teifi was of particular concern as it was nearly a 50% reduction.

Due to the steep declines, the Teifi was resurveyed in 2019-2020 to assess whether volunteer skill in the 6th Otter Survey of Wales contributed to the decline. This resurvey found 74% were positive for otter signs. As this was close to the 6th Otter Survey of Wales results it was deemed volunteer surveying skill were not behind the decline (Kean and Chadwick, 2021). However, it is still important to note the resurvey still showed a significant decline since the 5th Otter Survey of Wales where 95% of sites were positive.

Due to the large declines in these hydrometric areas the wider population was not deemed to be stable, and the target was failed. The fact the survey data ranges from six to ten years old reduces the confidence in the fail to medium. The population may have recovered or may have declined further. The next Otter Survey of Wales is due to take place in 2024-2025.

Figure 30. Hydrometric areas of Wales. Map taken from the 6th Otter Survey of Wales (Kean and Chadwick, 2021).



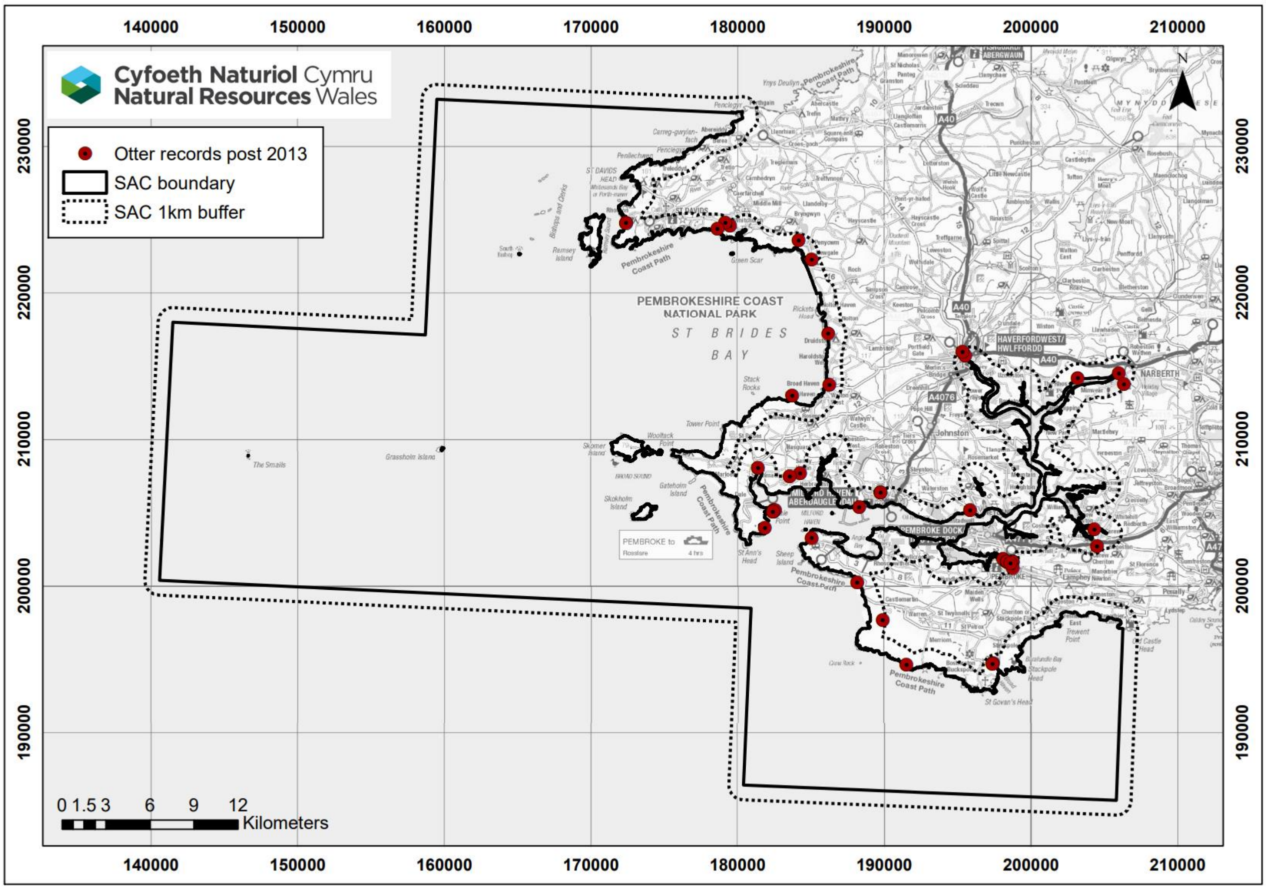
Otter presence in the SAC

Otter presence in the Pembrokeshire Marine SAC has been periodically surveyed. Sites positive for otter signs increased from 13 to 19 between 2002 and 2012 in the SAC but decreased slightly to 17 in 2017. Otter signs were present in 26 sites over the 2002-2017 survey period (Liles, 2017).

LERCs hold records of otter signs (sightings, spraints, footprints, roadkill) and these records include those made as part of the Otter Survey of Wales as well as those submitted directly to the LERC. These records allow an insight into otter usage of the SAC. The LERC data documents 17 records of otter within the SAC boundary or 1km in land over the last 5 years 2018-2022 and 32 records in the previous 5 years 2017-2013. A total of 49 records in 10 years (Figure 31).

The last recorded sign on the LERC when the database was accessed on 22/11/2023 was in 2022. The target for this indicator is met but confidence is reduced to medium as the LERC records are a proxy. An updated survey of otter use of coast in the SAC is needed.

Figure 31. Otter signs in the Pembrokeshire Marine SAC between 2013-2023.



Habitat quality and connectivity

It is known that coastal sites are important to otter in terms of travelling between sites, foraging for food and resting. Therefore, it is important that the habitat quality and functionality is maintained within and around the SAC.

There has been periodic surveying of otters in the SAC between 2002-2017. In 2012 most resting and breeding site habitats related to the SAC (extensive fen, bracken, gorse, bramble scrub, woodland, reed beds and boulder piles) identified during the 2002 survey remained intact with no evidence of disturbance or damage. In the 2017 survey resting and breeding site habitats again remained intact with no evidence of human disturbance or damage (Liles, 2017).

In 2022 a subset of known potential breeding sites in the Cleddau catchment were surveyed. Of the 10 sites investigated, eight were still viable as breeding sites (Liles, 2023). These surveys suggest that otter habitat quality is good within the SAC and surrounding catchment, so the habitat quality and function indicator passed. Due to the age of the data the confidence in the pass was reduced to medium.

As otters are a highly mobile species that have large home ranges, unimpeded movement across their range is vital. None of the otter surveys between 2002-2017 noted any barriers to otter movements within the SAC. Assessors also looked at developments in the area and found no evidence of obvious barriers to otter movement within the SAC or the wider area. Based on this the habitat connectivity indicator passed. However, as there has been no specific surveys of more localised barriers to movement the confidence in the pass is low.

Water quality

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

The water quality target failed to be met for PBDE and PAHs (two groups of POPs) in one WFD waterbody that otters are known to use, the Milford Haven Inner, in the 2024 cycle 3 interim classification. 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 otters are not fully understood. PAH failed due to the maximum allowable concentration (a short term breech) which is based on the most sensitive taxa, which may also be over precautionary for otters. The Milford Haven Outer waterbody previously failed for mercury and TBT in previous cycles. This waterbody now passes for chemicals in the 2024 cycle 3 interim 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. The other four waterbodies in the SAC were not classified as the chemicals have not been assessed within the last six years.

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

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

Reasons for target failure

The assessment of the Pembrokeshire Marine SAC otter feature failed one primary target, and one secondary target. This resulted in feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are summarised below.

Population health

While the Cleddau hydrometric area adjacent to the SAC boundary met the primary target of 80% of survey sites having positive signs for otter, the primary target of the wider population to be stable or increasing failed to be met. The wider otter population relevant to the SAC has seen some large declines in all relevant hydrometric areas. All four hydrometric areas saw statistically significant declines over 10%. The Teifi had between a 22-48% decline since the previous survey.

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

Water quality: contaminants

This secondary target failed due to PBDE and PAH exceeding their EQS in a WFD waterbody otter are likely to use frequently (Milford Haven Inner). 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 waterbody bed sediments, or point sources from continuous sewage discharge from waste water treatment. However, a WFD investigation into the failure in the Milford Haven Inner waterbody is yet to be undertaken. The impact of these chemicals on otter are not understood and further investigation as to the impact of these at a population level is needed. Mercury and PBDE are being managed at the UK and it is hoped levels will reduce over 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 a top predator like otter. The impact of PAH on the otter feature is not fully understood.

Threats to condition

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

Road traffic collisions

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

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

Water quality: contaminants

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

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

Evidence gaps

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

Listed below (Table 52) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 52. Evidence gaps for otter in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
Presence in SAC (P)	Medium confidence	• Sites in the Otter Survey of Wales have not been selected based on their proximity to the coast and other records rely on public sightings.
Water quality: contaminants (S)	Low confidence	• Impacts of contaminants at a population level are not understood. • it is not clear if other chemicals not currently monitored are present and having an impact. More research is needed.

Indicator	Assessed status	Comments
Prey availability (S)	Not assessed	• There is a lack of understanding on the diet of otters foraging in coastal SACs. • This make it difficult to assess if food sources are sufficient to sustain the population. Further research is needed.

3.15. Shore dock condition assessment

Shore dock *Rumex rupestris* has been monitored in the Pembrokeshire Marine SAC (Figure 32) since the year 2000. It was monitored yearly until 2020 when there was a break in monitoring until it resumed in 2024. A summary of the condition assessment for shore dock in Pembrokeshire Marine SAC can be seen in Table 53. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions.

Figure 32. Map of the shore dock feature in Pembrokeshire Marine SAC.

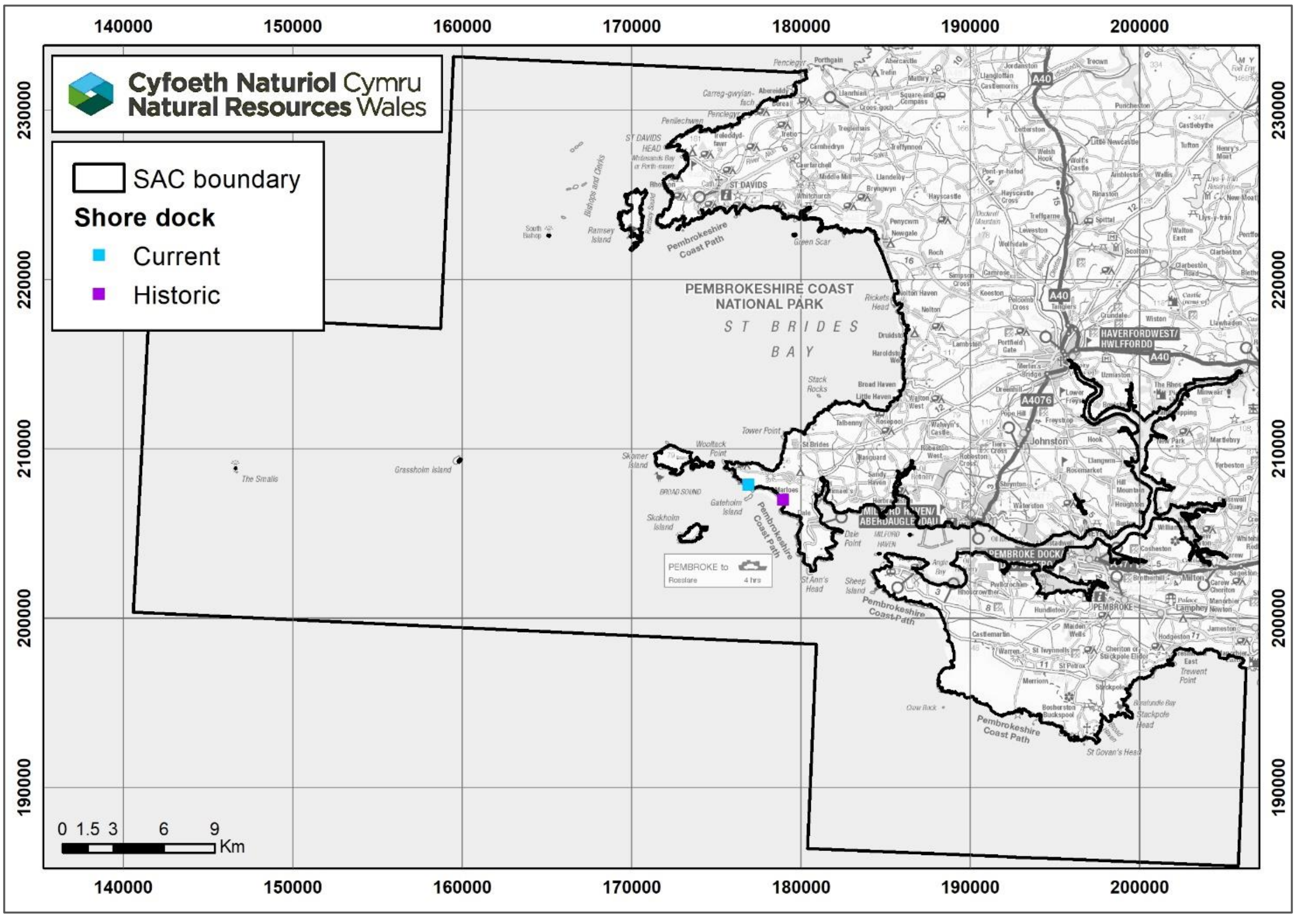


Table 53. Condition assessment of shore dock in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Target**	**Assessment rationale**	**Target assessment**	**Target confidence**
Presence within the SAC	Shore dock present in within the SAC (P)	• In 2024 shore dock was present within Pembrokeshire Marine SAC in good numbers. • There have been no reports of storms or rockfalls that would have impacted the Watery Bay colony, so confidence is high that shore dock remains in the SAC.	**Pass**	High
Distribution	Shore dock present in two colonies in Watery Bay **AND** present in at least one other location within the SAC. (P)	• In 2024 shore dock was still present in the two Watery Bay colonies in good numbers. • No shore dock was present at any other locations within the Pembrokeshire marine SAC. • Confidence is reduced to medium as only a partial systematic survey has been carried out at Marloes beach (to Hoopers Point) in 2024, and it is possible shore dock has recolonised in another area in the SAC.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Total number of shore dock in the SAC	An average of 50 fruiting plants **AND** 20 vegetative plants, with no upper limit, in the past 6 monitoring visits. (P)	• In the last six years there have been two visits that recorded the number of plants (2019 and 2024). • These two visits had an average of 90 fruiting and 30 vegetative plants. • The previous six survey visits took place in 2024, 2019, 2018, 2017, 2016 and 2015. • Over these visits there was an average of 73 fruiting plants and 25 vegetative plants • Only one visit (2015) failed to meet the targets, but the numbers were just below (48 fruiting and 16 vegetative). • The number of shore dock in the SAC met the target. As the latest data is from 2024 the confidence is in the pass is high.	**Pass**	High
Reproductive success	An average 50 fruiting plants **AND** seedlings should be present, with no upper limit, in the past 6 monitoring visits. (P)	• In the last six years there have been two visits that recorded the number of plants (2019 and 2024). • These two visits had an average of 90 fruiting plants and seedling were present on both occasions. • The previous six survey visits took place in 2024, 2019, 2018, 2017, 2016 and 2015. • Seedlings were present in all but one monitoring visit (2016). • The number of shore dock in the SAC met the target. As the latest data is from 2024 the confidence is in the pass is high.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Seed dispersal	No barriers to seed dispersal (S)	• No freshwater or marine barriers to seed dispersal are known. • The indicator assessed with up-to-date site knowledge therefore the confidence is high.	**Pass**	High
Hydrology	There should be lateral water movement across the SAC. There should be continual presence of freshwater within the SAC. (S)	• Freshwater seepages with lateral movement were recorded at both colonies in 2018, 2019 and 2024. • In 2024 Marloes Mere wetland, with some possibly from lateral flow off of fields above, was identified as a key source of freshwater to the Watery Bay colonies. • The age of the latest survey mean the confidence in the pass is high.	**Pass**	High
Water Quality	No evidence of excessive algal growth. (S) No evidence of agricultural runoff (leachate/ slurry) (S)	• Excessive algal growth and agricultural run-off was not identified as a threat on the site in 2018, 2019 or 2024. • Confidence in the pass is medium due to the lack of systematic monitoring for this indicator.	**Pass**	Medium
Vegetation Structure	Shore dock sites within the SAC should have open vegetation with no coarse dominating vegetation. (T)	• Coarse dominating vegetation has not been identified as threat on the site in 2018 or 2024. • The confidence is medium due to the lack of a detailed survey of this indicator at the colony and wider area.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Current colonies and suitable habitat in the SAC are not impacted by INNS caused by human activities. (S)	• No INNS have been reported up to 2024. • Confidence is high due to the recent visit date which indicates that that new INNS have not spread to the colony since the last survey.	**Pass**	High
Disturbance: Coastline	The coastline should not be over-stabilised, nor over-eroded (S)	• The colony site was observed in 2024 with no anthropogenic induced disturbance to cliff erosion or stabilisation reported. • No current or past developments are known to be having an impact on natural erosion, but it is possible some impacts have occurred that have not been reported in the last few years. Therefore the confidence in the pass is medium.	**Pass**	Medium
Disturbance: anthropogenic	No evidence of anthropogenic disturbance to shore dock colonies (S).	• No anthropogenic activities known to be occurring at colony site. • Confidence is medium as while no activities have been observed or reported, unobserved activities could be occurring.	**Pass**	Medium

Assessment conclusion

The condition of Shore dock feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). A summary of this assessment can be seen in Table 54. Of the 11 indicators assessed, one indicator with a primary target failed; distribution. The reason for failure is linked to the lack of colonies within the SAC, having reduced from two to one. A colony on the Marloes Peninsular went extinct after being washed out in a heavy storm. Having only a single remaining colony leaves the species vulnerable to extinction from the SAC completely. The overall confidence in the assessment is medium as there has been no systematic survey of the SAC to look for further shore dock colonies. It is possible another colony has established and is yet to be seen. Threats to the feature have also been identified as part of the assessment (Table 54). More detail on each performance indicator, the reason for failure and threats are provided in the detailed assessment information section below.

Table 54. Summary of the condition assessment for shore dock in Pembrokeshire Marine SAC.

Feature	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Shore dock *Rumex rupestris*	**Unfavourable (medium confidence)**	Distribution	• The distribution of shore dock across the SAC has reduced. This has been attributed to climate change increasing storm severity and frequency.	• Air pollution • Agricultural pollution • Rock falls

Detailed assessment conclusions

Shore dock in Pembrokeshire Marine SAC (Figure 33) has been surveyed by an experience botanical surveyor on a yearly basis between 2001 to 2024 after an initial survey in 2000. Access to the existing colony has been difficult in the recent years due to rock falls making access via land unsafe. The colony can now only be accessed via boat.

There has been a gap in monitoring between 2020-2023. Though a visit to the colony was undertaken in 2020 no information was recorded. There was an attempt to monitor the site in 2023 but seal pupping in the site prevented access. For this assessment, monitoring data, together with casework and SAC knowledge, was used to assess the performance indicators.

Presence and distribution

The last survey of shore dock in Pembrokeshire Marine SAC was undertaken in 2024. The site is located in a remote coastal location at Watery Bay. Access can only be made via boat as land access is now unsafe due to past rock falls. Grey seals use the beach below the colony for pupping, restricting the time of year the colony can be visited. The 2024 survey found two healthy clusters making up the Watery Bay colony. These clusters have been present for many years (first recorded in 2000 but likely to have been present before that). The presence within the SAC indicator therefore passed with high confidence.

Shore dock occurs on cliff faces and cliff bases, a relatively narrow zone above the high-water mark, often where dynamic processes of coastal erosion constantly create new bare ground. As shore dock acts like a pioneer plant, this creation of bare ground is needed to allow the plants to establish. However, this unstable environment makes shore dock vulnerable to erosion and rock falls, which can wipe out colonies. By having multiple colonies within the SAC would make shore dock more resilient to this threat.

Historically shore dock has been present at more than one location within the SAC. The most significant location outside of Watery Bay was at Hoopers point on the Marloes peninsular. The colony was partially destroyed in a rock fall in 2002. Severe storms in 2013-2014 washed out and destroyed what remained of this satellite population. Since 2014 there have been no records of shore dock reestablishing at Hoopers Point or anywhere else in the SAC.

A single storm or rock fall could eradicate the remaining colony in the SAC. This means the feature is currently vulnerable to extinction within the site. Due to the lack of colonies outside of Watery Bay the distribution indicator failed to meet its target. The confidence in the fail was reduced to medium as there have been no targeted surveys within the SAC as a whole to look for a new colony.

Figure 33. Shore dock *Rumex rupestris* in Pembrokeshire Marine SAC.

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Abundance and reproductive success

As of 2024 the Watery Bay shore dock colony was meeting the target number of fruiting and vegetative plants required to be present in the SAC. The target has been chosen to reflect the minimum number of plants needed to maintain a viable population. Over the last six monitoring visits the average number of fruiting plants is 73 and the average number of vegetative plans is 25 (see Table 55). Numbers in 2024 indicated a very healthy population with 90 fruiting plants, with 220 fruiting stems counted, and 30 vegetative plants. This allowed the total number of shore dock in the SAC indicator to be met with high confidence.

Table 55. The number of fruiting and vegetative plants recorded at the Watery Bay colony over the last six monitoring visits.

Monitoring visit	Fruiting plants	Vegetative plants
2015	48	16
2016	53	25
2017	82	21
2018	73	28
2019	83	35
2024	97	25
Average	**73**	**25**

The reproductive success of shore dock is crucial to enable the population to sustain itself. Due to the need for constant fresh water, poor weather conditions, such as prolonged dry weather, can limit seed production in any one year. However, poor fruiting in two or three years in every five is unlikely to be a problem (Bioret and Daniels, 2005). In the last six years there have been two visits that recorded the number of plants (2019 and 2024). These two visits had an average of 90 fruiting plants and seedling were present on both occasions. The previous six survey visits took place in 2024, 2019, 2018, 2017, 2016 and 2015. In these years fruiting plants met the minimum 50 plants in all but one year, 2015, where the count was close at 48. Seedlings were present in all but one monitoring visit over the last 6 monitoring visits (2016). This data shows that the population at watery bay is sustaining itself and reproductively healthy. The reproductive success indicator passed with high confidence.

Supporting habitat

It is important the habitat that supports shore dock within the SAC is of sufficient size, quality and distribution to maintain the existing colony, as well as maximise the chance of further colonies establishing. The assessment concluded that all supporting habitat indicators (seed dispersal, hydrology, water quality, vegetation structure and INNS) met their targets.

A key aspect of supporting habitat is to have a continual presence of fresh water and with lateral water movement. In 2024 an important source of fresh water was identified as Marloes Mere, a wetland situated just inland from the cliff top, above the colony. There is possibly lateral flow of water off of fields above (which slope towards the ditch from the Mere). Water has been observed in the rock crevices where the colonies grow and seedlings have been observed growing there. Any water present for the colony must be free of excessive algal growth to prevent smothering of shore dock. The latest site visit to the Watery Bay colony in 2024 saw no evidence of algal growth or agricultural run-off that may lead to it. Both water quality targets passed. The confidence was reduced to medium as a full scale survey of the area has not be conducted.

As shore dock is a pioneer plant it is a poor competitor with other species. It therefore requires habitat free of coarse dominating vegetation in order to thrive and be able to establish additional colonies. The latest site visit to the colony in 2024 found no evidence of coarse dominating vegetation at the site. The vegetation structure indicator passed but confidence was reduced to medium as there has not been a detailed survey of the wider area to see so if coarse vegetation is hampering the ability of shore dock to colonise elsewhere in the SAC. Species that may be considered coarse and potentially deleterious if dominant are grasses such as Yorkshire fog, cocksfoot and false oat-grass. Some forbs such as other dock species, Bramble, willow’s, rosebay willowherb.

The poor competitive nature of shore dock make it highly vulnerable to invasive non-native species. Due to shore dock being critically endangered it is vitally important that INNS are not allowed to establish in the SAC. The latest site visit found no evidence of INNS at the Watery Bay colony. The recent site visit and experience of the surveyor allowed the INNS indicator to pass with high confidence.

Disturbance

Shore dock occurs on cliff faces where dynamic processes of coastal erosion constantly create new bare ground. Natural erosion and storm events help to maintain and create new colonisation niches. If a cliff was over stabilised, it could prevent this process. However, repeated intense storms or increased erosion would not allow new colonies to establish and can destroy colonies that already exist. As seen in the Marloes peninsula colony that was washed out by severe storms in 2014.

It is important that no anthropogenic development over stabilises, or over erodes the shore dock environment in the SAC. There is currently no evidence that the cliffs in the SAC are being impacted by anthropogenic development. The disturbance: coastline indicator passed. Confidence was reduced to medium as it is possible some impacts have occurred that have not been reported in the last few years.

There is some circumstantial evidence to suggest that visitor pressure may be limiting population size on some sites around the UK (especially those with cliff base colonies). There have been instances of plants / colonies being lost due to dried fruiting stems and whole plants being used as kindling for beach bonfires. Trampling and litter also damaging and killing individuals (King, 2006). The latest site visit found no evidence of impact from anthropogenic disturbance to shore dock in the SAC, allowing the disturbance: anthropogenic indicator to pass. However, activities could be occurring unobserved, limiting the confidence to medium. Disturbance from anthropogenic sources such as recreation remains a threat to shore dock condition. However, the risk to the existing colony is low due to its remote location which is unsafe to access via foot. The threat may be of higher risk to any new colonies that establish in the SAC.

Reasons for target failure

The assessment of the Pembrokeshire Marine SAC shore dock feature failed one primary target. This resulted in feature to be assessed as being in **unfavourable** condition. The failing indicator and reasons for failure, if known, are summarised below.

Distribution

This indicator failed its primary target as shore dock is not present in the SAC outside of Watery Bay. It was previously present at a satellite colony at the Hooper's Point end of Marloes Sands. Therefore the distribution of shore dock across the SAC has reduced.

This failure has been attributed to climate change increasing storm severity and frequency. Early 2014 winter storms were so ferocious that all remaining shore dock at the satellite colony were washed away. Hooper's Point has been revisited regularly between 2014 and 2024 with no sign of shore dock recolonising the area.

Threats to condition

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

Agricultural pollution

Nutrient run off into water courses known to be an issue in many of the surrounding areas.

Climate change

The increasing severity of storms could wash out the existing shore dock colony. Increased rock falls could lead to crushing and burial of the existing colony. Minor rock falls occurred in 2008-2009 at watery bay. These are at risk of increasing with increased storminess due to climate change, threating the extinction of the colony.

Anthropogenic disturbance

Increased recreational use of the coast could impact the existing colony and could reduce the chance of a new colony establishing.

Evidence gaps

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

Listed below (Table 56) are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments.

Table 56. Evidence gaps for shore dock in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	**Assessed status**	**Comments**
Availability of supporting habitat	Not assessed	• There is currently no baseline of suitable supporting habitat for shore dock in the SAC. A comprehensive baseline of suitable habitat is needed. We know we have lost suitable habitat in some locations; however, we do not know if other suitable habitat is present at sites that are inaccessible.
Distribution (P)	Medium confidence	• There is no evidence of additional shore dock outside of the Watery Bay colony. However, there has been no systematic survey of the SAC to look for additional colonies, apart from a partial one of Marloes beach to Hoopers point in 2024 (Woodman, in prep 2025). The remote and inaccessible nature of potential colony sites make surveying difficult. There is a possibility that drones could be used to do this. Though use of drones will be restricted by the grey seal pupping season.

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