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Condition Assessments for Mudflats and Sandflats not Covered by Seawater at Low Tide in Welsh Special Areas of Conservation

Report No: 898

Authors: M. Jackson-Bué, E. Wynter, D.P. Brazier, S. Cuthbertson and M. Hatton-Ellis.

Author Affiliation: Natural Resources Wales

Sandflat in Llansteffan, Carmarthen Bay and Estuaries SAC © Paul Brazier (NRW)

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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 gwastadeddau llaid neu dywod nas gorchuddir gan y môr ar lanw isel o fewn ardaloedd cadwraeth arbennig dynodedig (ACA) ledled Cymru. Mae Adran 1 yn rhoi trosolwg o'r broses asesu ac mae Adran 2 yn darparu disgrifiad a lleoliad y nodwedd(ion).

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

Crynodeb o asesiadau cyflwr ar gyfer gwastadeddau llaid neu dywod mewn ACAau ledled Cymru

Lleoliad y nodwedd ACA	Asesiad cyflwr	Hyder yn yr asesiad
Y Fenai a Bae Conwy	Ffafriol	Isel
Glannau Môn: Cors heli	Anffafriol	Isel
Pen Llŷn a'r Sarnau	Ffafriol	Isel
Sir Benfro Forol	Anffafriol	Canolig
Bae Caerfyrddin ac Aberoedd	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 mudflats and sandflats not covered by seawater at low tide (mudflats and sandflats) within designated special areas of conservation (SACs) across Wales. Cross-border sites are not included in this report but will hopefully be considered in future. Section 1 gives an overview of the assessment process and Section 2 provides a description and location of the feature(s).

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

Summary of condition assessments for mudflats and sandflats in SACs across Wales.

SAC feature occurs in	Condition assessment	Confidence in assessment
Menai Strait and Conwy Bay	Favourable	Low
Anglesey Coast: Saltmarsh	Unfavourable	Low
Lleyn Peninsula and the Sarnau	Favourable	Low
Pembrokeshire Marine	Unfavourable	Medium
Carmarthen Bay and Estuaries	Unfavourable	Medium

1. Introduction

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

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

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

1.1. Assessment process

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

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

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

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

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

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

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

2. Feature description

The following text is adapted from the habitat description of mudflats and sandflats not covered by seawater at low tide (1140) from the JNCC list of Annex I marine, coastal and halophytic habitats.

Mudflats and sandflats not covered by seawater at low tide (mudflats and sandflats) are submerged at high tide and exposed at low tide. The physical structure of the intertidal flats ranges from mobile, coarse-sand beaches on wave-exposed coasts to stable, fine-sediment mudflats in estuaries and other marine inlets. Within this range the plant and animal communities present vary according to the type of sediment, its stability and the salinity of the water. They are of particular importance as feeding grounds for wildfowl and waders. More information on this features associated faunal communities can be found on the JNCC website.

There are three major categories of mudflats and sandflats, although in reality they tend to be present as a continuous gradation between these categories depending on the prevailing conditions:

- Clean sands. These occur particularly on open coast beaches and in bays around the UK where wave action or strong tidal currents prevent the deposition of finer silt.
- Muddy sands. These occur particularly on more sheltered shores of the open coast and at the mouths of estuaries or behind barrier islands, where sediment conditions are relatively stable.
- Mudflats. These form in the most sheltered areas of the coast, usually where large quantities of silt derived from rivers are deposited in estuaries."

Mudflats and sandflats form a major component of two other Annex I habitats (estuaries 1130 and large shallow inlets and bays 1160) but also occur extensively along the open coast and in lagoonal inlets.

3. Mudflats and sandflats condition assessments

This section contains assessments for the mudflats and sandflats not covered by seawater at low tide (mudflats and sandflats) in Welsh only marine ardal cadwraeth arbennig (ACA) / special areas of conservation (SAC). The feature is designated in five SACs in Wales (Figure 1):

- Y Fenai a Bae Conwy / Menai Strait and Conwy Bay
- Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh
- Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau
- Sir Benfro Forol / Pembrokeshire Marine
- Caerfyrddin ac Aberoedd / Carmarthen Bay and Estuaries.

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

Mudflats and sandflats have been assessed against the chosen performance indicators. Any gaps in evidence that would improve the assessment of condition have been identified for each SAC (Section 4).

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

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

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

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

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

The feature maps feature in this document are for illustrative purposes only. Detailed maps for the features in Wales can be found on Data Map Wales.

All maps in this document are copyrighted as follows:
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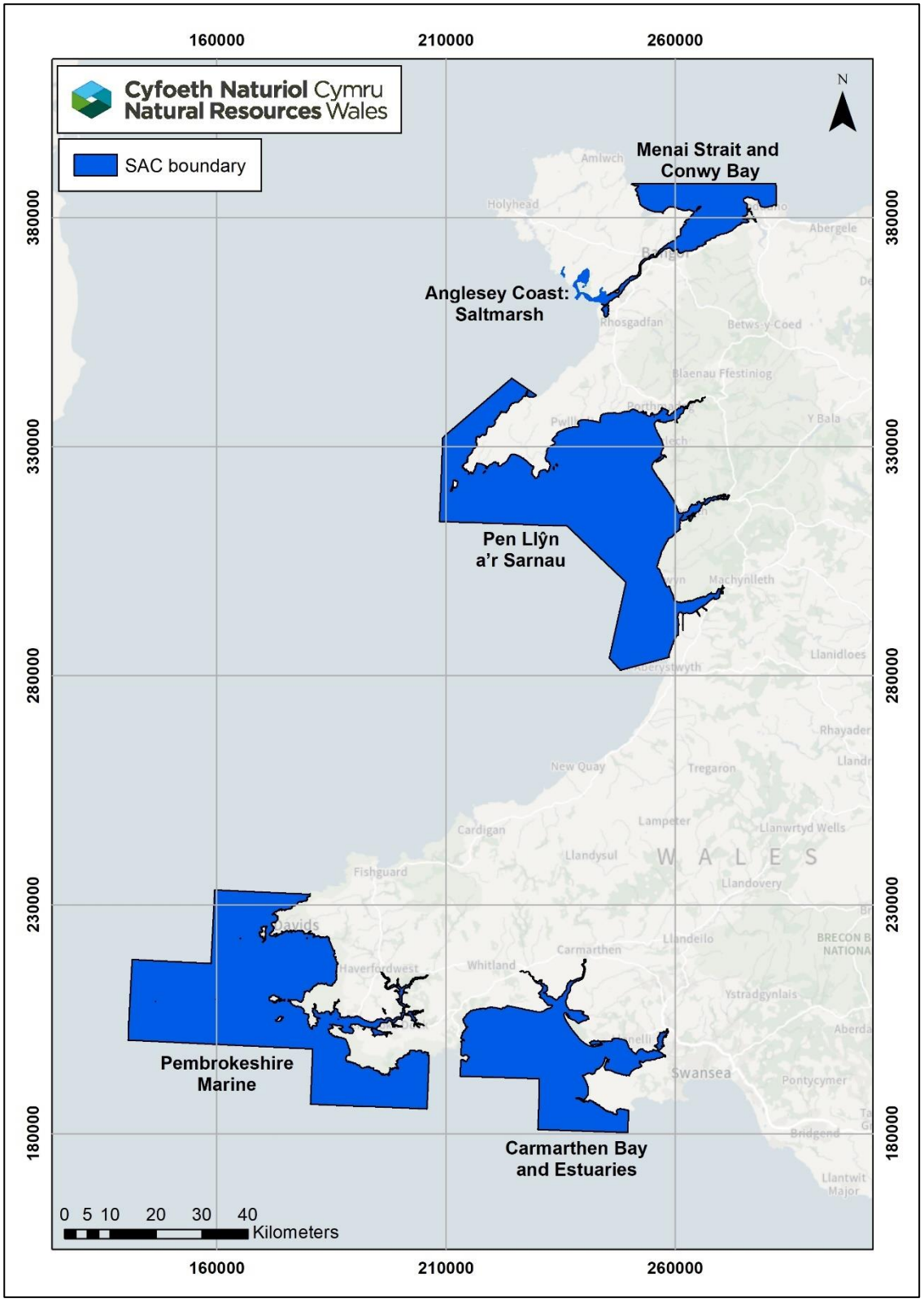
Figure 1. Location of SACs assessed for the mudflats and sandflats feature.



3.1. Menai Strait and Conwy Bay SAC condition assessment

The mudflats and sandflats feature in the Menai Strait and Conwy Bay SAC is comprised of a number of mudflats and sandflats (Figure 2). However, the NRW Habitats Regulations monitoring has been focused on sampling points within muddy gravel sites in Beaumaris, Fryars Bay, Lleiniog, and the mudflats and sandflats in Traeth Lafan and Y Foryd. These locations were surveyed between 2004 and 2022 using core sampling as part of the NRW Habitat Regulations monitoring survey.

Figure 2. Map of the mudflats and sandflats feature in Menai Strait and Conwy Bay SAC.

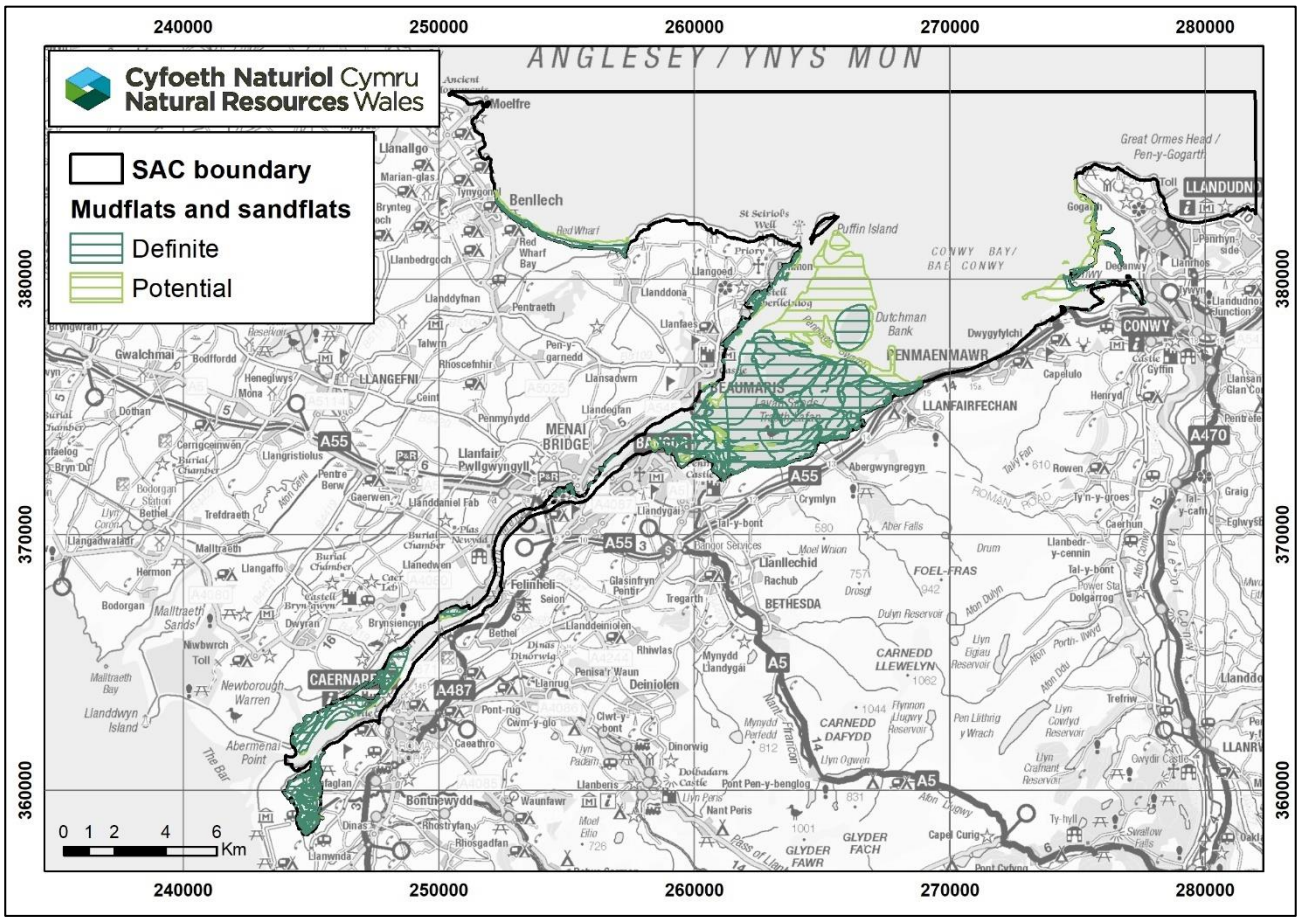


Table 2 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 2. Condition assessment of mudflats and sandflats in Menai Strait and Conwy Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
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 Menai Strait and Conwy Bay SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution 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 Menai Strait and Conwy Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the 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 Menai Strait and Conwy Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium

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 Menai Strait and Conwy Bay SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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 from the Habitats Regulations monitoring program for Traeth Lafan, Beaumaris, Fryars Bay and Lleiniog mudflats and sandflats showed little variation in sediment composition across the monitoring time. • Sediment composition from WFD data indicated very little change at Foryd Bay. • Confidence is high due to the long term data set and knowledge that there were no anthropogenic activities nearby that are known to impact the sediment composition.	**Pass**	High
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to mudflats and sandflats infaunal communities, allowing for natural change and variation. (S)	• The redox layer indicated no clear trend over the years. • There is some evidence the redox layer is decreasing in depth in some monitoring stations. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low

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)	• Six of the seven WFD waterbodies that overlap with the feature were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Conwy Bay, Menai Strait, North Wales, Conwy, Foryd Bay and Seiont). Combined, these overlap with 98% of the feature. • One WFD waterbody was not classified for the DIN WFD element, however it overlaps with only 2% of the feature (Anglesey North). • Confidence is high as the waterbodies that overlap with a large proportion of the feature were classified and there were no failures for the DIN element.	**Pass**	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)	• One of the seven WFD waterbodies was classified with a Moderate status for phytoplankton in the 2024 cycle 3 interim classification (North Wales). However, it overlaps with <1% of the feature. • Two WFD waterbodies were not classified for this WFD element (Anglesey North and Seiont). However, combined these overlap with only 2% of the feature. • The other four WFD waterbodies were classified with Good or High status for phytoplankton (Conwy Bay, Menai Strait, Conwy and Foryd Bay). Combined, these overlap with 98% of the feature. ○ The Menai Strait and Foryd Bay waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to rolled forward classifications, and 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)	• Four of the seven WFD waterbodies have not been classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Menai Strait, Anglesey North, Conwy Bay and North Wales). Combined, these overlap with 95% of the feature. • The other three WFD waterbodies were classified with a Good or High status for opportunistic macroalgae (Conwy, Foryd Bay and Seiont). Combined, they overlap with 5% of the feature. ○ The Seiont waterbody classification was rolled forward from the 2018 cycle 2 interim classification. • Confidence is low as a large proportion of the feature overlap with waterbodies that have not been classified for this WFD element.	**Pass**	Low
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Six of the seven WFD waterbodies that overlap with the feature have been classified with High status for dissolved oxygen in the 2024 cycle 3 interim classification (Menai Strait, Foryd Bay, Anglesey North, Conwy Bay, Conwy and North Wales). Combined, these overlap with nearly 100% of the feature. • One WFD waterbody was not classified, however this waterbody overlaps with <1% of the feature (Seiont). • 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 environmental quality standards (EQS). (S)	• Two of the seven WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification (Menai Strait and North Wales). In both of these waterbodies the classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. The Menai Strait waterbody overlaps with 91% of the feature. • One WFD waterbody was not classified as the chemicals have not been assessed within the last six years (Seiont). This waterbody overlaps with a very small proportion of the feature. • The other four WFD waterbodies have a fail for chemicals (Foryd Bay, Anglesey North, Conwy Bay and Conwy). Combined, these overlap with 9% of the feature. Chemicals that failed were mercury, polybrominated diphenyl ethers (PBDE), polycyclic aromatic hydrocarbons (PAH) and cypermethrin. • Confidence is low as: the failing waterbodies overlap with a small proportion of the feature; the human health standard has been used for PBDE; and due to the roll forward of some chemical classifications.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited turbidity data for the mudflats and sandflats feature in the Menai Strait and Conwy Bay SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from subtidal temperature loggers from within the SAC were available. Loggers at one monitoring site indicated a potential increase in temperature in recent years. It is not clear if this is a localised change or in line with global trends. Loggers at the other monitoring site were missing a large amount of data between 2016 and 2021. • An external report from Bangor University indicates that annual mean sea surface temperature is gradually rising in their Menai Strait temperature logger. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• One of the seven WFD waterbodies, Conwy Bay, was classified as Moderate status for the Infaunal Quality Index (IQI) WFD element in the 2024 cycle 3 interim classification. This waterbody overlaps with a small proportion (1%) of the feature therefore was not considered to fail the feature. Four WFD waterbodies, which overlap with 98% of the feature were classified with a Good or High status. • Analysis of macrobenthic infaunal communities in muddy gravel locations indicated a shift in species composition, with species associated to very muddy gravel habitats in 2004, to species associated with sandier habitats in 2013. Communities have remained more stable in recent years (up to 2022). These trends are unexplained but concern is low as there is no known anthropogenic impact to date and species composition was more stable in the last reporting cycle. • Analysis of macrobenthic infaunal communities for Traeth Lafan showed that communities remained broadly similar over time and within natural fluctuations. • Abundance of cockles *Cerastoderma edule* was assessed to be low during surveys at Traeth Lafan, but biomass was fairly consistent. • WFD data indicated that the extent of seagrass *Zostera noltei* has increased in the Foryd Bay waterbody. • Confidence in this pass is medium due to the unexplained change in species composition in muddy gravel locations since 2004.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of mudflats and sandflats species, allowing for natural change and variation. (S)	• Analysis showed some decrease of taxa richness and diversity at muddy gravel sites. • A decline in taxa richness was also observed at Traeth Lafan sites (e.g. 2018). ○ These decreases were not deemed to be outside of what would be expected from natural change and variation, but some concerns remain. This lowered the confidence of the target assessment pass to medium.	**Pass**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of mudflats and sandflats species, allowing for natural change and variation. (S)	• Overall, the average taxonomic distinctness of the macrofaunal community of Traeth Lafan mudflats remained stable and within the expected values over the monitoring period. • For muddy gravel sites, the results throughout the monitoring period are lower than the expected level of taxonomic spread, however this may be due to natural change. The low values could possibly be explained by the specific nature of the site. The test used, taxonomic average distinctness, might not be suitable for the muddy gravel habitat. • Confidence is low due concerns over the lower taxonomic spread in muddy gravel sites.	**Pass**	Low
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not adversely altering ecosystems. (P)	• There is limited evidence to suggest that INNS (e.g. *Crepidula fornicata*) are currently impacting the condition of the mudflats and sandflats in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• *C. fornicata* became established around 2019 in the Menai Strait and numbers are increasing substantially. Records are within or very close to the mudflats and sandflats feature. • The red seaweed worm wart weed *Gracilaria vermiculophylla* has been recorded within the last six years in the Traeth Lafan sandflats in the Menai Strait, which is within the mudflats and sandflats feature. • Other NNS have been recorded previously including the Chilean oyster *Ostrea chilensis,* Pacific oyster *Magallana gigas* and wireweed *Sargassum muticum* in the Menai Strait (within or close to the feature). • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The mudflats and sandflats feature in Menai Strait and Conwy Bay SAC has been assessed as being in **favourable** condition (low confidence). Overall, the lack of any significant anthropogenic impact on this feature in terms of extent, hydrodynamic processes, topography, sediment composition and its associated communities, have contributed to this favourable assessment outcome. There were two failing indicators, but none with a primary weighting (Table 3). There were also limited or absent data for two key indicators (sediment quality: organic carbon and sediment quality: contaminants) to inform on the condition of the feature (see the evidence gaps section 4). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in Table 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 mudflats and sandflats in Menai Strait and Conwy Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed assessment information

Extent and distribution

The feature extent and the distribution and extent of habitats and communities indicators in the Menai Strait and Conwy Bay SAC passed their targets. There are currently no known anthropogenic impacts that would negatively affect the mudflats and sandflats feature. Comparison mapping has not been used to assess the extent and expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediment quality; topography; and hydrodynamic and sediment transport processes

Overall, sediment composition varied slightly across the monitoring period, but the variation was deemed to be within the expected range of natural variation. There was a recent increase of silt content at Fryars Bay, but this was not considered to be a concern. This target passed with high confidence based on the knowledge that there were no anthropogenic activities nearby that are known to impact the sediment composition of the mudflats and sandflats. Analysis of the data showed that macrofaunal abundance was positively correlated (moderate relationship) to the sediment composition for Traeth Lafan mudflats and sandflats, indicating that communities are to some extent determined by sediment characteristics.

The redox layer profile indicated no clear trend over the surveyed years. An extensive macroalgae layer has been reported in Foryd Bay that could lead to anoxic conditions, but no measurements of the redox layer were taken to confirm this. A long-term data series spanning from 2004 to 2022 is available, but sampling has not been conducted consistently every year. Further sampling is required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer. For this reason the confidence in the pass was reduced to low.

There is no monitoring of sediment contaminants or organic carbon content within the SAC. These indicators were therefore not assessed.

The topography, 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.

Water quality

It has been estimated that nearly 100% of the mudflats and sandflats feature within the SAC falls within seven WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Menai Strait waterbody overlaps with a large proportion of the feature (approximately 91%). Two of the seven WFD waterbodies, North Wales and Seiont, 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 indicators for nutrients (DIN only) and phytoplankton met their targets. For the nutrients indicator (DIN only), a large proportion of the feature (98%) overlaps with WFD waterbodies classified as Good or High status for DIN in the 2024 cycle 3 interim classification. One WFD waterbody (Anglesey North) was not classified for the DIN element in the 2024 cycle 3 interim classification as there were no data collected on this element over the last six years (see Section 3). However, it overlaps with a small proportion of the feature (2%). The Menai Strait waterbody overlaps with the largest part of the feature and was classified as High status for DIN, and it has improved from Moderate and Good status in previous cycles to High status since the 2018 cycle 2 interim classification.

The confidence in the pass for the phytoplankton indicator was reduced to medium. This was because the High status classification in the 2024 cycle 3 interim classification for the Menai Strait waterbody was rolled forward from the 2018 cycle 2 interim classification. In addition, the ecological relationships between phytoplankton and the mudflats and sandflats feature across all SACs are not fully understood. Two WFD waterbodies were not classified for the element, however they overlap with a small proportion of the feature (2%). Classification of some of these waterbodies may not be suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels).

The opportunistic macroalgae indicator met its target as three of the overlapping WFD waterbodies were classified as Good or High status for this element in the 2024 cycle 3 interim classification (Foryd Bay, Conwy and Seiont). Combined, these waterbodies overlap with 5% of the feature. There have been observations of nuisance algae in the watercourses that feed into the Foryd Bay waterbody therefore sampling may not be suitable to pick up issues. This waterbody overlaps with a small proportion of the feature (4%) therefore this observation did not lead to a failure, but will be something to pay close attention to in the next assessment. The other four WFD waterbodies that overlap with the feature were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification. This includes the Menai Strait waterbody, which overlaps with the largest proportion of the feature. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth). The confidence in the pass was reduced to low as the waterbodies classified for the relevant element overlap with a small proportion of the feature.

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

Four of the seven WFD waterbodies that overlap with the mudflats and sandflats feature in the SAC have a fail for chemicals in the 2024 cycle 3 interim classification. Combined, these waterbodies overlap with approximately 9% of the mudflats and sandflats feature. This caused the contaminants indicator to fail. The failures were for the Anglesey North (mercury and polybrominated diphenyl ethers (PBDE)), Conwy Bay (polycyclic aromatic hydrocarbons (PAH)), Foryd Bay (mercury), and Conwy (PBDE, mercury, PAH and cypermethrin) waterbodies.

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

The other two overlapping WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification. However, in both WFD waterbodies the classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. This includes the Menai Strait waterbody which overlaps with the largest proportion of the feature. This also contributed to the reduced confidence. Confidence was further reduced to low as the failing waterbodies overlap with a small proportion of the feature. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Data from NRW monitored subtidal temperature loggers from two sites within the SAC were available. However, as loggers from one of the monitoring sites had a large amount of missing data, the observed patterns in temperature are based on data from only one monitoring site which overlaps with the feature. These loggers showed an increase in temperature in more recent years. An external report (Smyth et al., 2022) also found that the annual mean sea surface temperature was gradually rising in the Menai Strait. It is not

understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

One of the seven relevant WFD waterbodies that overlaps with the mudflats and sandflats feature, Conwy Bay, was classified as Moderate status for the Infaunal Quality Index (IQI) element in the 2024 cycle 3 interim classification. This waterbody overlaps with a very small proportion of the feature (approximately 1%) therefore this has not been considered to fail the feature. Four WFD waterbodies were classified as Good or High status for the IQI element (Menai Strait, Foryd Bay, Anglesey North and Conwy). Combined, these waterbodies overlap with 98% of the mudflats and sandflats feature. The other two waterbodies (North Wales and Seiont) were not classified for this element.

Infaunal analysis showed that whilst communities associated with Traeth Lafan mudflats and sandflats varied across the assessment monitoring period, they remained broadly similar over time with no major shift detected (Moore, 2018 and NRW unpublished data). As a result, the variation in composition of communities was judged to be natural. There have been some noticeable changes with distinct community composition in muddy gravel locations in 2004 compared to more recent years (up to 2022). Species in 2004 tended to belong to very muddy gravel habitat while taxa from recent years and northernmost stations tended to belong to sandier habitat. These trends are unexplained but concerns are low as there is no evidence to suggest the observed changes are attributable to anthropogenic activity. In addition, the species composition was more stable in the last reporting cycle.

Infrequent surveys on cockles *Cerastoderma edule* indicated that while biomass is fairly small, it has remained steady over the years. Evidence suggests that the seagrass *Zostera noltei* extent has increased in recent years in the Foryd Bay waterbody. The seagrass element was consistently given a High status in WFD cycles and remains High in the latest 2024 cycle 3 interim classification for the Foryd Bay waterbody. Other WFD waterbodies were not classified for the seagrass element in the WFD classification.

Overall, the abundance, distribution and species composition of communities indicator met its target. However, the confidence in the pass was reduced to medium due to unexplained changes in muddy gravel species composition. Available data for some mudflats and sandflats associated species on the distribution and population structure were lacking or insufficient. Although these data were not required for the full assessment of the abundance, distribution and species composition of communities indicator, having detailed information on these would strengthen the outcome and could be considered in future.

Small changes at the muddy gravel sites were observed in species richness and diversity with a slight reduction in taxa number in recent years. There was also some decrease of taxa richness at Traeth Lafan sites (e.g. 2018). While the decrease is concerning, there is no evidence to suggest that there is an ongoing decline. Changes in abundance can affect species richness and this could be the case with Traeth Lafan species richness. These declines were not deemed large enough to fail the target but did reduce confidence in the pass and will be something to pay close attention to in the next assessment.

The average taxonomic distinctness of the infaunal community at Traeth Lafan remained relatively stable across the monitoring period. Whilst taxa number was low, the average taxonomic distinctness was within the expected values with the exception of a few stations in 2015 and 2018. The taxonomic distinctness analysis for the muddy gravel sites showed that most of the stations across the monitoring period were below the expected level. This could possibly be explained by the different sediment composition of muddy gravel compared to typical mudflats and sandflats from which the taxonomic aggregation file is compared with (i.e. the main taxonomy of samples was compared with the overall taxonomy of the entire dataset). While the average number of taxa was higher at muddy gravel sites than for other typical muddy / sandy sites, more than half of the taxa belonged to one class (e.g. polychaete) of the total 20 classes. The majority of taxa for a typical muddy / sandy site, like in the Crofty mudflats and sandflats in the Carmarthen Bay and Estuaries SAC, is more evenly spread within three dominant classes (e.g. polychaete, Malacostraca and Bivalvia) of the total of 10 classes. Nevertheless, while below the expected value, the average taxonomic distinctness for muddy gravel remained relatively stable across the monitoring period and for this reason, the indicator met its target but with low confidence.

Invasive non-native species

There were records of the American slipper limpet *Crepidula fornicata* identified in 2006 however, following an eradication attempt, no records of the species were identified for a number of years. More recently, within the last six years, this species has become established (i.e. since 2019) and numbers are increasing. These records are within or very close to the mudflats and sandflats feature. This resulted in a fail for the tertiary target of the NNS indicator. Similarly, the red seaweed worm wart *Gracilaria vermiculophylla* has been recorded within the last six years in the sandflats at Traeth Lafan (Mercer and Brazier, 2023). The tertiary target of the non-native species (NNS) indicator failed with high confidence due to the new NNS recorded in the mudflats and sandflats feature within the last reporting cycle.

Other NNS are known to be present in the Menai Strait (within or very close to the mudflats and sandflats feature) including the Chilean oyster *Ostrea chilensis,* Pacific oyster *Magallana gigas* and the wireweed *Sargassum muticum*. Limited records have been produced for *O. chilensis,* but it has been known to be present in the Strait for about 30 years. The cover of *S. muticum* is thought to be extensive in the SAC, however this species is not consistently recorded. *S. muticum* has replaced the zone of sugar kelp in some areas in the Menai Strait but it is thought that it has not expanded significantly in recent years.

It is not fully understood how some of these species may 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 invasive non-native species (INNS) present the primary target of the INNS indicator passed. Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.

Reasons for target failure

The mudflats and sandflats feature in Menai Strait and Conwy Bay SAC has been assessed as being in **favourable** condition. However, one secondary target and one tertiary target failed to be met and need to be kept under review.

Water quality: contaminants

This indicator target has a secondary weighting. The mudflats and sandflats feature is partly within four WFD waterbodies (Anglesey North, Foryd Bay, Conwy Bay and Conwy) that have a fail for chemicals due to mercury, PBDE, PAH and cypermethrin. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022). PAHs can be produced through natural processes, but also arise from anthropogenic sources, for example during combustion of fossil fuels and organic material (Webster and Fryer, 2022). Cypermethrin is an insecticide used for plant protection in crops, in forestry, gardens, homes and businesses. It is also used in veterinary medicine to control pests in livestock and pets (EA, 2019). The application of cypermethrin has been restricted for some uses (sheep dipping and in forestry against the pine weevil).

Some of the contaminants in the water column may be derived from diffuse sources including atmospheric deposition or contaminated waterbody bed sediments. However, WFD investigations of the failures in all four WFD waterbodies are yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce 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 all of the mudflats and sandflats biota. The impact of PAH on the mudflats and sandflats feature is not fully understood.

Non-native species

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

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

Threats to condition

Part of the condition assessment is to identify threats to the condition of the mudflats and sandflats feature. A threat is defined as an activity that is currently not impacting condition

but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the mudflats and sandflats feature condition in the Menai Strait and Conwy Bay SAC are stated below.

Unconsented infrastructure

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

Invasive non-native species

There have been concerns about the increasing abundance of *C. fornicata* in the SAC. This species is commonly found in areas of muddy gravel habitat. At high density, it could cause an impact on the mudflats and sandflats 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 feature. However, the spread and impact of the species on the feature is not fully understood.

G. vermiculophylla has also been found at Traeth Lafan sandflats within the SAC. *G. vermiculophylla* can have a detrimental impact on the feature as seen in the 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).

Five Chinese mitten crabs *Eriocheir sinensis* have been identified in April 2024 near Deganwy marina, including a berried female. A single record was found in 2010 and 2013 but some uncertainties remain to whether the crab specimen was alive suggesting sign of population being there at the time. This is not currently an issue for the feature in the SAC, however, high numbers in the future may have an impact.

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

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 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 and 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 this SAC is definitely under threat of coastal squeeze and natural squeeze (loss of habitat against high ground).

3.2. Anglesey Coast: Saltmarsh SAC condition assessment

The mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC is comprised of several mudflats and sandflats (Figure 3). No Habitats Regulations monitoring survey for the mudflats and sandflats feature is currently undertaken in this SAC but there are seagrass and cockle surveys periodically undertaken at Traeth Mylenog and Malltraeth which were used for the assessment.

Figure 3. Map of the mudflats and sandflats feature in Anglesey Coast: Saltmarsh SAC.

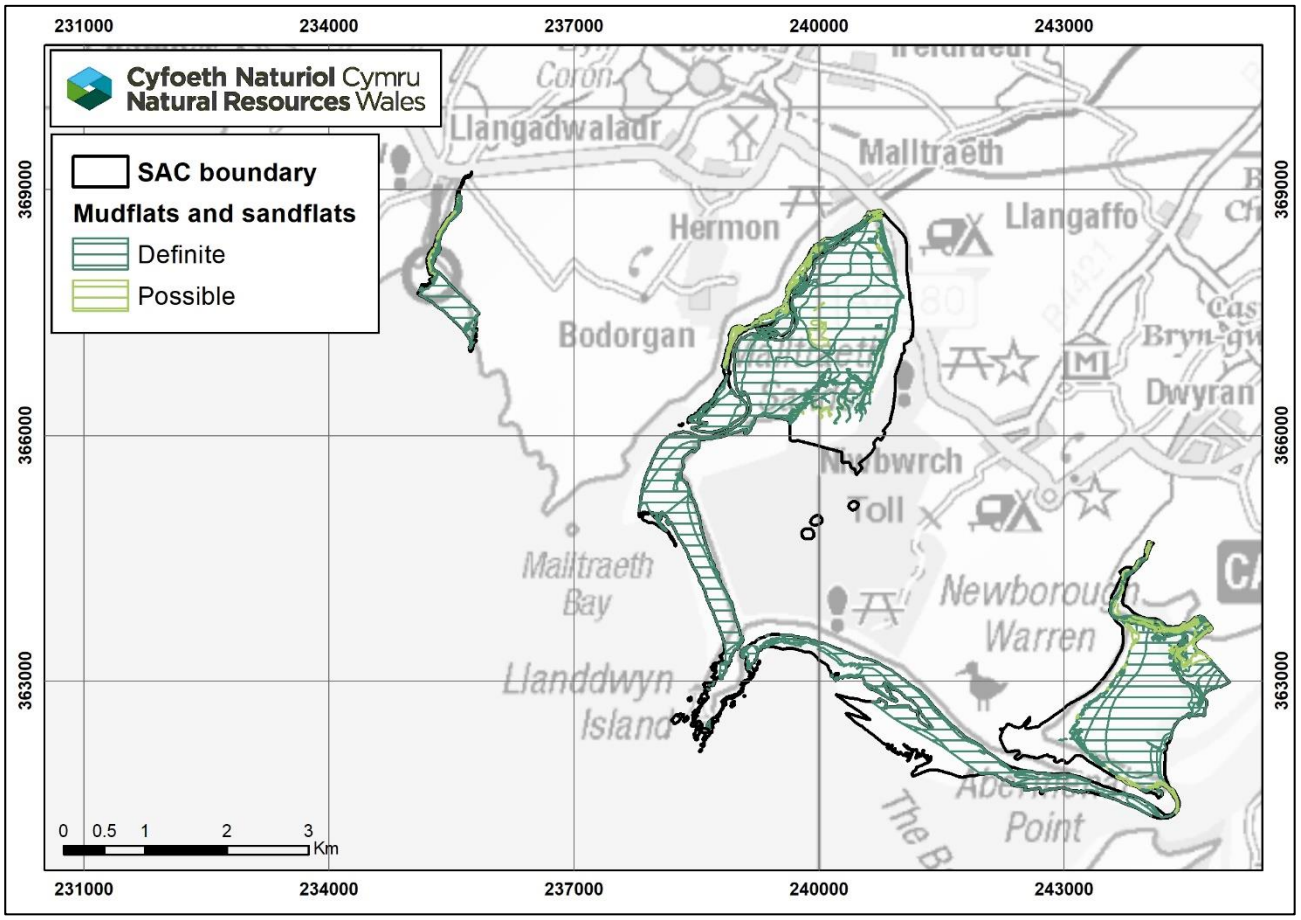


Table 4 has a summary of the assessment outcome. The assessment outcome and any reasons for failure are discussed in more detail in the sections below.

Table 4. Condition assessment of mudflats and sandflats in Anglesey Coast: Saltmarsh 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 Anglesey Coast: Saltmarsh 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 Anglesey Coast: Saltmarsh SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the mudflats and sandflats. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• Two of the five overlapping WFD waterbodies were classified with a High status for DIN in the 2024 cycle 3 interim classification (Menai Strait and Caernarfon Bay Noth). Combined, these overlap with 42% of the feature. • One WFD waterbody was classified as Good status (Cefni). However, the confidence of the classification was uncertain. This waterbody was Moderate status for DIN in the 2021 cycle 3 classification. The reported improvement may be due to the different methodologies used for DIN classification. It is not certain if there has been a true improvement in the DIN levels. This waterbody overlaps with 54% of the feature. • The other two WFD waterbodies were classified with a Poor and Bad status (Braint and Ffraw). Combined, these overlap with 1% of the feature. • Confidence is low as there is uncertainty in the Cefni waterbody classification.	**Fail**	Low

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)	• Four of the five WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Cefni, Caernarfon Bay North, Braint and Ffraw). Combined, these waterbodies overlap with 68% of the feature. • The other WFD waterbody was classified as High status for phytoplankton (Menai Strait). The classification was rolled forward from the 2018 cycle 2 interim classification. This waterbody overlaps with 30% of the feature. • The confidence is low as a large proportion of the feature overlap with waterbodies that have not been classified for phytoplankton, and as the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.	**Pass**	Low
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Two of the five overlapping WFD waterbodies were not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification (Menai Strait and Caernarfon bay North). Combined, these overlap with 42% of the feature. • One WFD waterbody was classified as Moderate status (Braint), however it overlaps with <1% of the feature. • The other two WFD waterbodies were classified with High status (Cefni and Ffraw). These waterbodies overlap with 54% and <1% of the feature respectively. • Confidence is medium as some of the overlapping waterbodies were not classified for the relevant WFD element.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• All five WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Cefni, Menai Strait, Caernarfon Bay North, Braint and Ffraw). • Confidence is medium due to samples being taken from the surface of the waterbodies.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• Four of the five WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Cefni, Caernarfon Bay North, Braint and Ffraw). Combined, these waterbodies overlap with 68% of the feature. • The other WFD waterbody has a pass for chemicals, however all chemical classifications were rolled forward from the 2018 cycle 2 interim classification (Menai Strait). This waterbody overlaps with 30% of the mudflats and sandflats feature. • Confidence is low due to the unclassified waterbodies, and the rolled forward classifications.	**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 mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC, therefore this target was assessed as unknown.	**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)	• One of the five WFD waterbodies that overlap with the mudflats and sandflats feature, Caernarfon Bay North, was classified as Moderate status for the IQI WFD element in the 2024 cycle 3 interim classification. This waterbody overlaps with 12% of the feature. One WFD waterbody was classified with a High status, and the other three WFD waterbodies were not classified for this WFD element. • The 2023 survey indicated an increase in the seagrass *Z. noltei* extent at Traeth Melynog. • Cockle *Cerastoderma edule* stocks appeared to be stable. The data were insufficient to use for this assessment. • No data for infaunal communities are available for the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC as there is currently no Habitats Regulation monitoring for this SAC. • The limited data available on species composition of communities resulted in an unknown assessment.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities is not adversely altering ecosystems. (P)	• There is limited evidence to suggest that INNS (e.g. *Crepidula fornicata*) are currently impacting the condition of the mudflats and sandflats in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• Recent records of *C. fornicata* have been identified in the feature (2023-2024). • *Gracilaria vermiculophylla* has been recorded within the last six years in the Malltraeth estuary (one station only), which is within the feature. • There is also further evidence that there are low numbers of *Magallana gigas* in Traeth Melynog, which is within the feature. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The mudflats and sandflats feature in Anglesey Coast: Saltmarsh SAC has been assessed as being in **unfavourable** condition (low confidence). There were a couple of failing indicators (Table 5). There were also limited or absent data for four key indicators to inform on the condition of the feature (see the evidence gaps section 4). 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 5 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 5. Summary of the condition assessment for mudflats and sandflats in Anglesey Coast: Saltmarsh SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Anglesey Coast: Saltmarsh	**Unfavourable (low confidence)**	Water quality: nutrients (DIN only) (P) Non-native species (T)	• There are high nutrient levels in the Cefni, Braint and Ffraw waterbodies. • There has been an increase in the number of NNS in the feature SAC, including *C. fornicata* and *G. vermiculophylla*.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

The feature extent and the distribution and extent of habitats and communities indicators in the Anglesey Coast: Saltmarsh SAC passed their target as there are currently no known anthropogenic impacts that would negatively affect the mudflats and sandflats feature. Comparison mapping has not been used to assess the extent and expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediment quality; topography; and hydrodynamic and sediment transport processes

There is no monitoring of sediments within the SAC, resulting in all the sediment indicators to not be assessed. A macroalgae layer has been reported in Traeth Melynog and in the Braint estuary. As no measurements were taken, it is not possible to know if the sediment layers were anoxic underneath. These sites, however, are quite sandy and macroalgae move around with wave action, reducing the likelihood that sediments will be anoxic.

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.

Water quality

It has been estimated that approximately 98% 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 Cefni and Menai Strait waterbodies overlap with the largest proportion of the feature (54% and 30% respectively).

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The Cefni waterbody was classified with a Good status for the DIN element in the 2024 cycle 3 interim classification. This is an improvement from Moderate status in all cycles since the 2015 cycle 2 classification. However, the confidence in the 2024 Good status classification is uncertain (confidence of Good or better classification: 55%, confidence of Moderate or worse classification: 45%). The 2021 and 2024 DIN classifications used different methodologies due to changes in the classification process. There has been an improvement in the DIN values recorded between the classifications, however the confidence of the improvement in class for this waterbody is uncertain (54%). The 2021 WFD investigation report (Jones, 2021a) for this waterbody confirmed the DIN failure in the 2021 cycle 3 classification, but found that there has not been a biological response to the elevated nutrients. Most of the sampling locations for this waterbody overlap with the feature. Two WFD waterbodies, Braint and Ffraw, were classified with Poor and Bad status in the 2024 cycle 3 interim classification. The Ffraw waterbody classification has deteriorated from Poor status in the 2021 cycle 3 classification to Bad status in the 2024 cycle 3 interim classification. However, the confidence of the deterioration is uncertain

(52%). These waterbodies overlap with a very small proportion of the feature (1%). The Caernarfon Bay North and Menai Strait waterbodies were classified as High status for DIN, however the sampling locations were not in close proximity to the mudflats and sandflats feature in the SAC. The nutrients indicator (DIN only) failed to meet its target due to the issues with DIN in the Cefni, Braint and Ffraw waterbodies. The confidence was reduced to low as the Cefni waterbody was classified as Good status in the 2024 cycle 3 interim classification but with uncertainty in this classification.

The indicators for phytoplankton and opportunistic macroalgae met their targets. Low confidence was associated to the pass for the phytoplankton indicator as only one WFD waterbody was classified for this element. The Menai Strait waterbody was classified with a High status in the 2024 cycle 3 interim classification but this was rolled forward from the 2018 cycle 2 classification. This waterbody overlaps with 30% of the mudflats and sandflats feature. The remaining WFD waterbodies, which, combined, overlap with approximately 68% of the feature, were not classified for this element in the 2024 cycle 3 interim classification. Classification of some WFD waterbodies may not be suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). The ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood. This also contributed to the low confidence.

For the opportunistic macroalgae indicator, medium confidence was associated to the pass due to two WFD waterbodies not being classified for the relevant opportunistic macroalgae WFD element. 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). In addition, there was one waterbody which was classified with a Moderate status in the 2024 cycle 3 interim classification (Braint). However, as this waterbody overlaps with a very small proportion of the feature (< 1%), it was deemed that the failure was unlikely to have a significant effect on the whole feature.

Dissolved oxygen

The dissolved oxygen indicator met its target. Confidence in the pass was reduced to medium because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in Section 3.1).

Contaminants

The contaminants indicator met its target as one WFD waterbody passed for chemicals in the 2024 cycle 3 interim classification. This waterbody, Menai Strait, overlaps with 30% of the mudflats and sandflats feature. The chemical classifications for this waterbody were rolled forward from the 2018 cycle 2 interim classification. This reduced the confidence in the pass. The confidence was further reduced to low as the other four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. Combined, these waterbodies overlap with 68% of the feature.

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

One of the five relevant WFD waterbodies that overlap with the mudflats and sandflats feature, Caernarfon Bay North, was classified as Moderate status for the IQI element in the 2024 cycle 3 interim classification. This waterbody overlaps with 12% of the feature. The WFD investigation report for this waterbody (Moore, 2023) concluded that the Moderate classification did not adequately represent the whole waterbody. However, there are currently insufficient data to state that the remainder of the waterbody is in a Good ecological status. One WFD waterbody was classified as High status for the IQI element in the 2024 cycle 3 interim classification (Menai Strait). This waterbody overlaps with 30% of the feature. The other three WFD waterbodies were not classified for this element. Combined, these overlap with 56% of the mudflats and sandflats feature.

Recent searches for *C. edule* in August 2023 indicated that the cockle stock appears abundant with plenty of *C. edule* within the sediments and *C. edule* were moving toward the seagrass *Z. noltei* area. There are, however, some concerns about mussel spats settling on cockle bed. In addition, a recent survey in 2023 indicated that *Z. noltei* in Traeth Melynog has been expanding since 1999 (Phase 1 habitat survey).

Apart from the IQI, no data for infaunal communities and limited data on specific species were available for the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC. As a result, the performance indicator for abundance, distribution and species composition of communities has been assessed as unknown, while species richness and diversity and taxonomic spread of species have not been assessed.

Invasive non-native species

G. vermiculophylla has been recorded within the last six years in the Malltraeth estuary but only at a single location (Mercer and Brazier, 2023). Despite being in one location, this species now covers a large area, and is within the mudflats and sandflats feature. This is concerning and will be something to pay close attention to in the next assessment. This species forms algal mats, and in a high biomass can alter the topography of sediments, and therefore has the potential to change the ecology of mudflats and sandflats. Furthermore, once the species is established, it can spread to other areas rapidly. Targeted surveys of *G. vermiculophylla* are needed to assess its spread and possible impact on the feature. In addition, records of *C. fornicata* were found within the last six years including in the SAC within the mudflats and sandflats feature. There have also been recent records of *M. gigas* at Traeth Melynog. This NNS has the potential to spread to other regions in the SAC. The presence of these species in the mudflats and sandflats feature within the last reporting cycle have resulted in a fail with high confidence for tertiary target of the NNS indicator.

It is not fully understood how some of these species may 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. There have been no targeted surveys of these NNS, therefore this is required to fully understand the spread of these

species within the SAC. In addition, further work is required to investigate the impact of *G. vermiculophylla* on the mudflats and sandflats feature.

Reasons for target failure

The assessment of the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC failed one primary target and one tertiary target. This resulted in the feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. Two of the WFD waterbodies that overlap with the feature, the Braint and Fraw waterbodies, were classified with a failing status for the DIN element in the 2024 cycle 3 interim classification. The WFD investigations of the failures for these waterbodies are ongoing, but both have confirmed the failures in the DIN classifications at stage 1 (Borrowdale and Moore, in draft; Burton, in draft). Stage 2 of the investigations to identify potential reasons for failure have not yet been completed.

A third WFD waterbody, Cefni, whilst classified as Good in the 2024 cycle 3 interim classification, remained close to the failure threshold. This waterbody was Moderate status in the 2021 cycle 3 classification. Different methodologies were used for the assessment of the DIN in the 2021 and 2024 classification, therefore there is uncertainty that there has been a genuine improvement in class. The 2021 WFD investigation report for the Cefni waterbody confirmed the DIN failure, but found that there has not been a biological response to the elevated nutrients (Jones, 2021a). It was concluded that the major input of nutrients is likely to be derived from diffuse sources associated with agriculture and rural land management, and point sources from the water industry (Jones, 2021a).

Non-native species

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

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

Threats to condition

Part of the condition assessment is to identify threats to the condition of the mudflats and sandflats feature. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are

unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

Activities that go through licencing and permission processes whereby the impact of the activity on the feature would be assessed have not been included. The threats to the mudflats and sandflats feature condition in the Anglesey Coast: Saltmarsh SAC are stated below.

Unconsented infrastructure

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

Invasive non-native species

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

G. vermiculophylla has also been found at one station in the mudflats and sandflats feature. 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.

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 counteract each other. However, threats from climate change to this feature on this SAC may include (Gihwala 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 species distribution.

3.3. Pen Llŷn a’r Sarnau SAC condition assessment

The mudflats and sandflats feature in the Pen Llŷn a’r Sarnau SAC is comprised of a number of mudflats and sandflats (Figure 4), but the NRW Habitats Regulations monitoring has been focused on sampling points within mudflats at Black Rock Sands, East Criccieth, Dwyryd estuary, Morfa Dyffryn, Morfa Harlech, Mawddach estuary and Dyfi estuary. These mudflats and sandflats were surveyed between 2008 and 2022 using core sampling as part of the Habitats Regulations monitoring intertidal survey.

Figure 4. Map of the mudflats and sandflats feature in Pen Llŷn a’r Sarnau SAC.

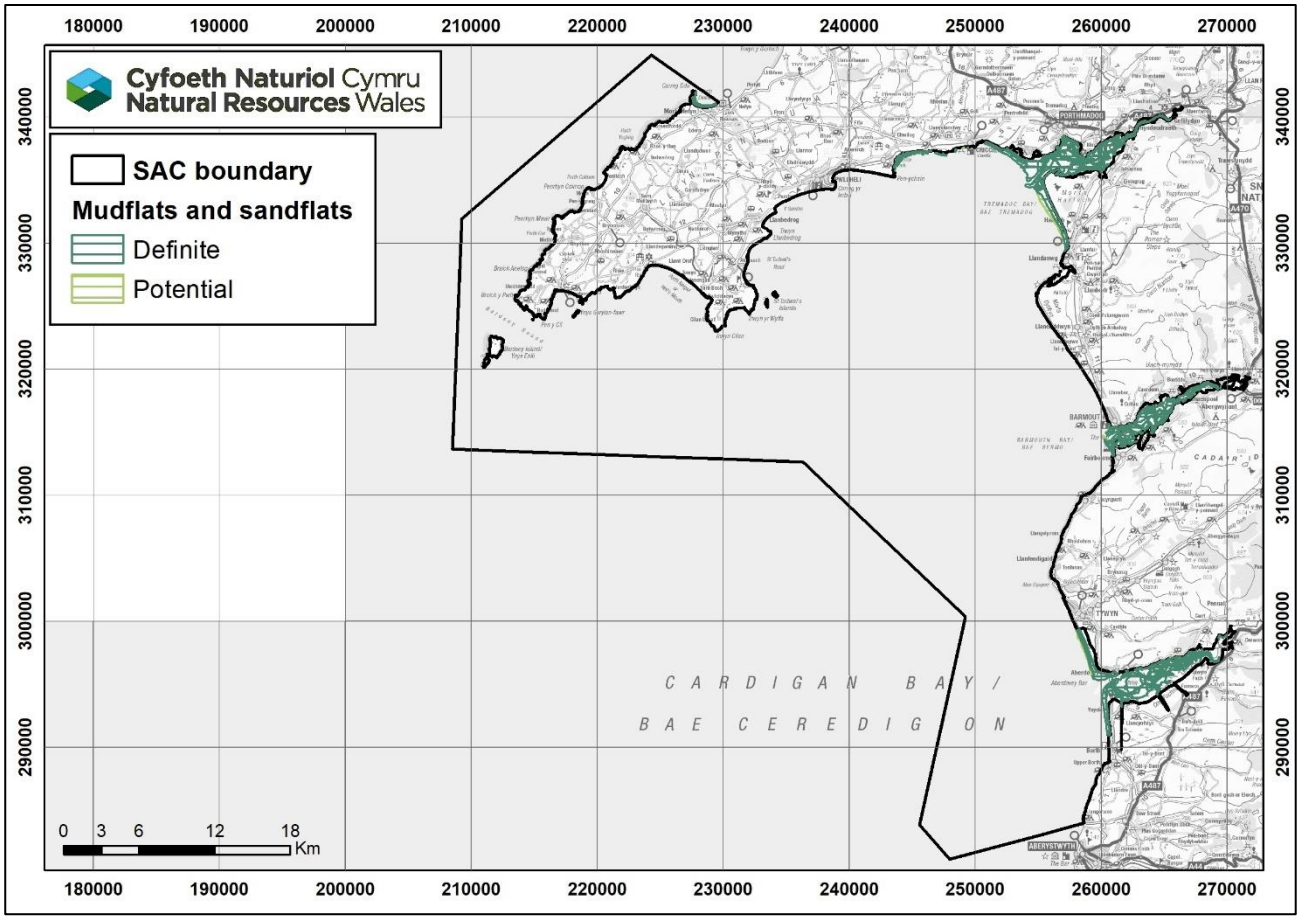


Table 6 has a summary of the assessment outcome. The assessment outcome and any reasons for failure are discussed in more detail in the sections below.

Table 6. Condition assessment of mudflats and sandflats in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the mudflats and sandflats feature in the Pen Llŷn a'r Sarnau SAC. • There is some concern about the ongoing effects from construction of Pont Briwet as there has been no monitoring since the construction. Confidence is low due to this, and as the assessment has been based on expert judgment.	**Pass**	Low
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the mudflats and sandflats, allowing for natural change and variation. (P)	• Granulometric analysis for Criccieth, Black Sand Rocks, Morfa Dyffryn and Harlech mudflats and sandflats showed some variation in sediment composition, but this is likely to be natural. • Sediment composition varied greatly at Mawddach estuary, but this could be explained by the different sampling regime design with the moving channel. • Sediment composition also varied at Dyfi estuary with a decreasing trend of silt fraction resulting in a medium confidence.	**Pass**	Medium
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to mudflats and sandflats infaunal communities, allowing for natural change and variation. (S)	• The redox layer indicated no clear trend over the years. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediments: organic carbon content	No increase to the organic carbon content considered detrimental to mudflats and sandflats communities, allowing for natural change and variation. (P)	• There are no recent data for organic carbon content for the mudflats and sandflats within Pen Llyn a'r Sarnau SAC, as the Clean Seas Environment Monitoring Programme (CSEMP) data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Sediments: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• There are no recent data for sediment contaminants for the mudflats and sandflats within Pen Llyn a'r Sarnau SAC, as the CSEMP data have not been collected here since 2015. • For this reason, this indicator was assessed as unknown.	**Unknown**	N/A
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	• One of the seven WFD waterbodies that overlap with the feature was not classified for DIN in any cycles (Tremadog Bay). It overlaps with 8% of the feature. • The other six WFD waterbodies were classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach, Cardigan Bay North, Caernarfon Bay South and Artro). Combined, these overlap with 86% of the feature. ○ Three of these waterbody classifications were rolled forward from previous cycles. • Confidence is medium due to the one unclassified waterbody and the rolled forward classifications.	**Pass**	Medium

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)	• Five of the seven WFD waterbodies were not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach, Tremadog Bay and Artro). Combined, these waterbodies overlap with 82% of the feature. • The other two WFD waterbodies were classified with a Good or High status for phytoplankton (Cardigan Bay North and Caernarfon Bay South). These waterbodies overlap with 10% and 1% of the feature. • Confidence is low as a large proportion of the feature overlap with unclassified waterbodies, and as the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.	**Pass**	Low
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Four of the seven WFD waterbodies were not classified for opportunistic macroalgae in the 2024 cycle 3 interim classification (Glaslyn, Cardigan Bay North, Tremadog Bay and Caernarfon Bay South). Combined, these overlap with 52% of the feature. • The other three WFD waterbodies were classified with Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach and Artro). Combined, these overlap with 42% of the feature. ○ The Mawddach waterbody classification was rolled forward from the 2021 cycle 3 classification. • Confidence is medium due to the unclassified waterbodies.	**Pass**	Medium

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)	• Four of the seven WFD waterbodies were was not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Glaslyn, Dyfi / Leri, Mawddach and Tremadog Bay). Combined, these overlap with 81% of the feature. • The other three WFD waterbodies were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Cardigan Bay North, Caernarfon Bay South and Artro). Combined, these overlap with 13% of the feature. • Confidence is low due to samples being taken from the surface of waterbodies, and as a large proportion of the feature overlap with unclassified waterbodies.	**Pass**	Low

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

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

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

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

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

Assessment conclusions

The mudflats and sandflats feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (low confidence). Overall, the lack of any significant anthropogenic impact on this feature in term of extent, hydrodynamic processes, topography, sediment quality and its associated community, have contributed to this favourable assessment outcome. There were two failing indicators but none with a primary weighting (Table 7). There were limited or absent data for two key indicators to inform on the condition of the feature (see the evidence gaps section 4). This has reduced the confidence in the assessment conclusion. Further investigation is needed to better understand all of the indicator failures to be able to identify management options.

A summary of the assessment can be seen in Table 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 mudflats and sandflats in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Pen Llŷn a'r Sarnau	**Favourable (low confidence)**	Water quality: contaminants (S) Non-native species (T)	• Levels of mercury and PBDE in the Mawddach and Cardigan Bay North waterbodies are failing to meet their relevant EQSs. • There has been an increase in the number of NNS in the feature SAC, including *C. fornicata* and *G. vermiculophylla*.	• Unconsented infrastructure • INNS • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

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

Sediment quality; topography; and hydrodynamic and sediment transport processes

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

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

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

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

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

Water quality

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

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

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

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

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

Dissolved oxygen

The dissolved oxygen indicator met its target. Confidence in the pass was reduced to low as a large proportion of the feature overlaps with WFD waterbodies that were not classified for DO in the 2024 cycle 3 interim classification (81%). In addition, because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in Section 3.1).

Contaminants

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

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

Turbidity and physicochemical properties

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

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

Species and communities

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

Infaunal analysis showed that communities present in the Dwyryd estuary indicated a directional change through time. A noticeable trend was observed with a decrease of sand-affinity species including some sensitive taxa (e.g. *Bathyporeia* spp) with increases of mud-affinity species and more tolerant species (e.g. *Cerastoderma* spp and *Peringia ulvae*) over the years (2008 to 2020) (Mercer 2016, 2022 and NRW unpublished data). This may indicate a higher level of deposition in the sampled areas.

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

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

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

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

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

Invasive non-native species

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

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

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

Reasons for target failure

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

Water quality: contaminants

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

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

Non-native species

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

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

Threats to condition

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

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

Unconsented infrastructure

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

Invasive non-native species

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

G. vermiculophylla has been found in the SAC and has the potential to establish quickly, and can have a detrimental impact on the feature as seen in the 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.

Water quality: contaminants

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

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

Management of coastal defences

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

Climate change

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

- Sea level rise, in the medium to long term.
- Changes in air and sea temperature.

- Increases in wave climate, especially storm frequency and intensity which may change the topography.
- Changes in species distribution.

3.4. Pembrokeshire Marine SAC condition assessment

The mudflats and sandflats feature in the Pembrokeshire Marine SAC is comprised of a number of mudflats and sandflats (Figure 5), 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 5. Map of the mudflats and sandflats feature in Pembrokeshire Marine SAC.

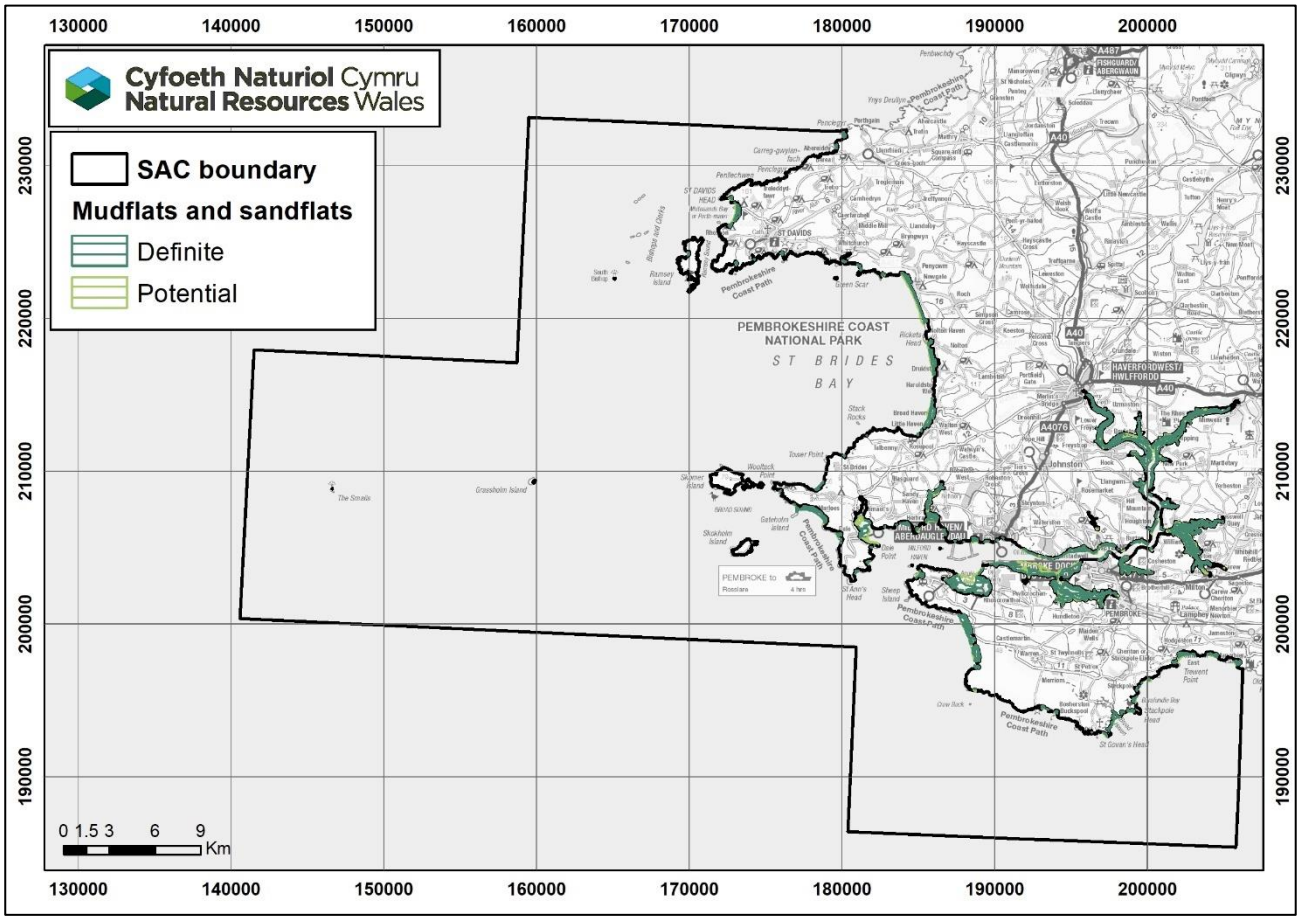


Table 8 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 8. 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
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 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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• Polycyclic aromatic hydrocarbons (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
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
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

Indicator	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 mudflats and sandflats feature in the Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from 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 limited information from 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 *Z. noltei* has expanded in both 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. the carpet sea squirt *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 9). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 9 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 9. 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.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Pembrokeshire Marine	**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 *Z. 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 6). 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.

Figure 6. Anoxic layers of sediment beneath opportunistic macroalgae on mudflats in Sandy Haven in 2008, Milford Haven Waterway.

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Carbon content

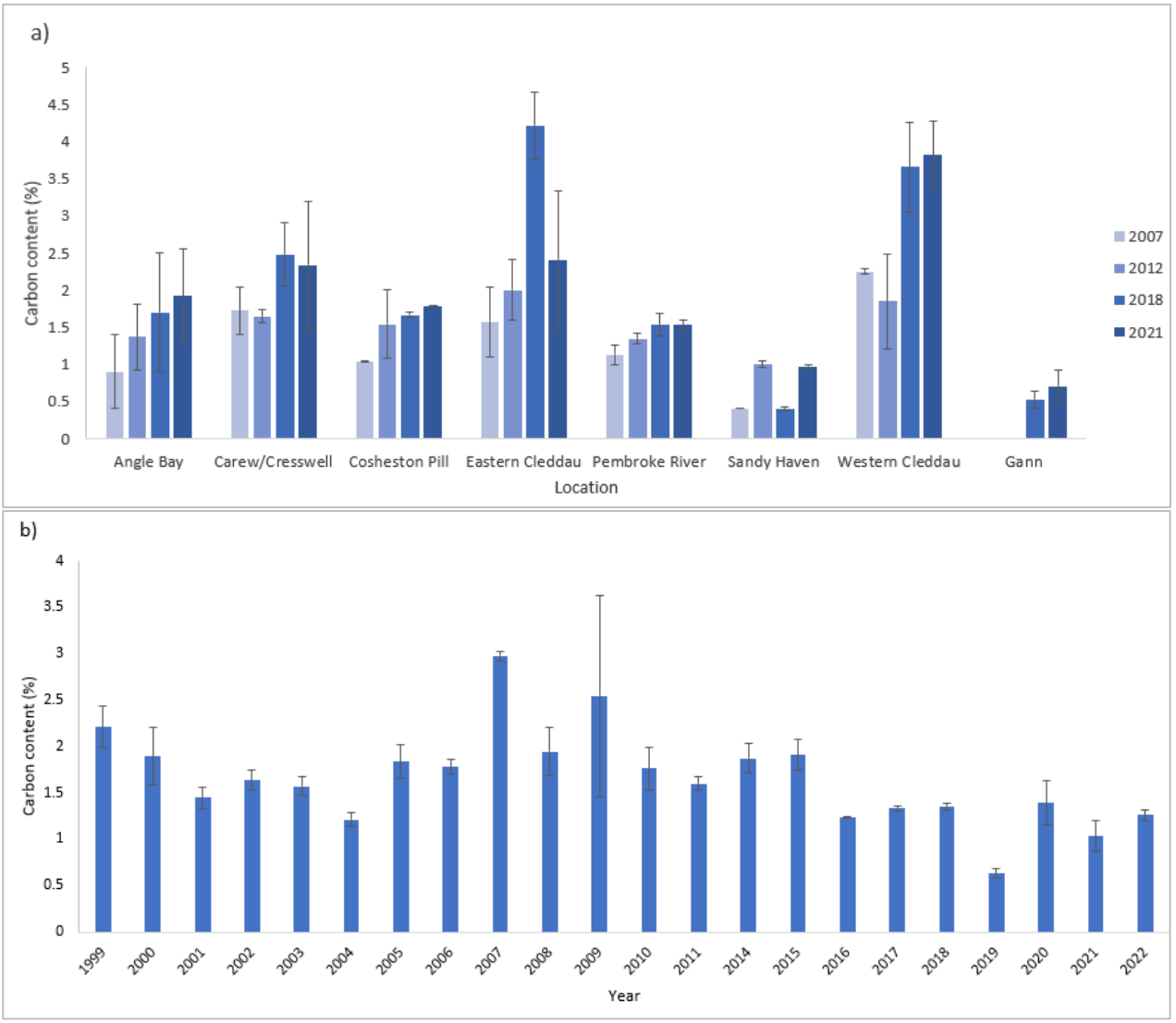
The assessment of the sediment quality (organic carbon and contaminants) indicators used data from NRW monitored sediment sampling as part of the CSEMP sampling in one subtidal location in Milford Haven Waterway in various years up to 2023. This location is considered to be representative of the whole 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 7a). 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 7a). 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 7b). 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 Milford Haven Waterway Environmental Surveillance Group (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.

Figure 7. Average carbon content (±S.E.) from sediment grab samples in the Milford Haven Waterway. Samples at a) the grouped inlet locations in 2007, 2012, 2018 and 2021, and b) the CSEMP location from 1999 to 2022.



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 Oslo and Paris Conventions (OSPAR) guidelines, Canadian Environment Quality Guidelines

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

Levels of polycyclic aromatic hydrocarbon (PAH) compounds were recorded at the CSEMP location. 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 8a), Garon Pill (Figure 8b), 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 8) (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.

Figure 8. Opportunistic macroalgae on saltmarsh and mudflats in the Milford Haven Waterway. Photos from a) Cosheston Pill in 2024, b) Garron Pill in 2019, c) Sandy Haven in 2008 and d) Dale in 2023.

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Dissolved oxygen

The dissolved oxygen indicator met its target. Confidence in the pass was reduced to medium because surface sampling of dissolved oxygen may not detect issues for more demersal features (see further detail in Section 3.1).

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. This waterbody overlaps with 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 8). 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 9). This would be something to pay close attention to in the next assessment.

Figure 9. 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 9) 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

The carpet sea squirt *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 *M. gigas*, the Australian tubeworm *Ficopomatus enigmaticus,* the large brown kelp wakame *Undaria pinnatifida, S. muticum* and *C. 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 especially in the Pembrokeshire Marine SAC, such as private slipways and coastal defences, modify the coastal environment through changes to micro-topography and hydrodynamics and can lead to loss of the feature extent, and impact to the flora and fauna associated with it.

Invasive non-native species

G. 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).

3.5. Carmarthen Bay and Estuaries SAC condition assessment

The mudflats and sandflats feature in the Carmarthen Bay and Estuaries SAC is comprised of a number of mudflats and sandflats (Figure 10), but the Habitats Regulations monitoring has been focused on sampling points within mudflats in the River Loughor (including Burry Port West, Pwll, Machynys and Crofty), Three Rivers (including Black Scar, Llansteffan, Gwendraeth and Laugharne) and open coast locations (Ragwen Point, Wisemans Bridge, Waterwynch and Tenby). These mudflats and sandflats were surveyed between 2007 and 2022 using core sampling.

Figure 10. Map of the mudflats and sandflats feature in Carmarthen Bay and Estuaries SAC.

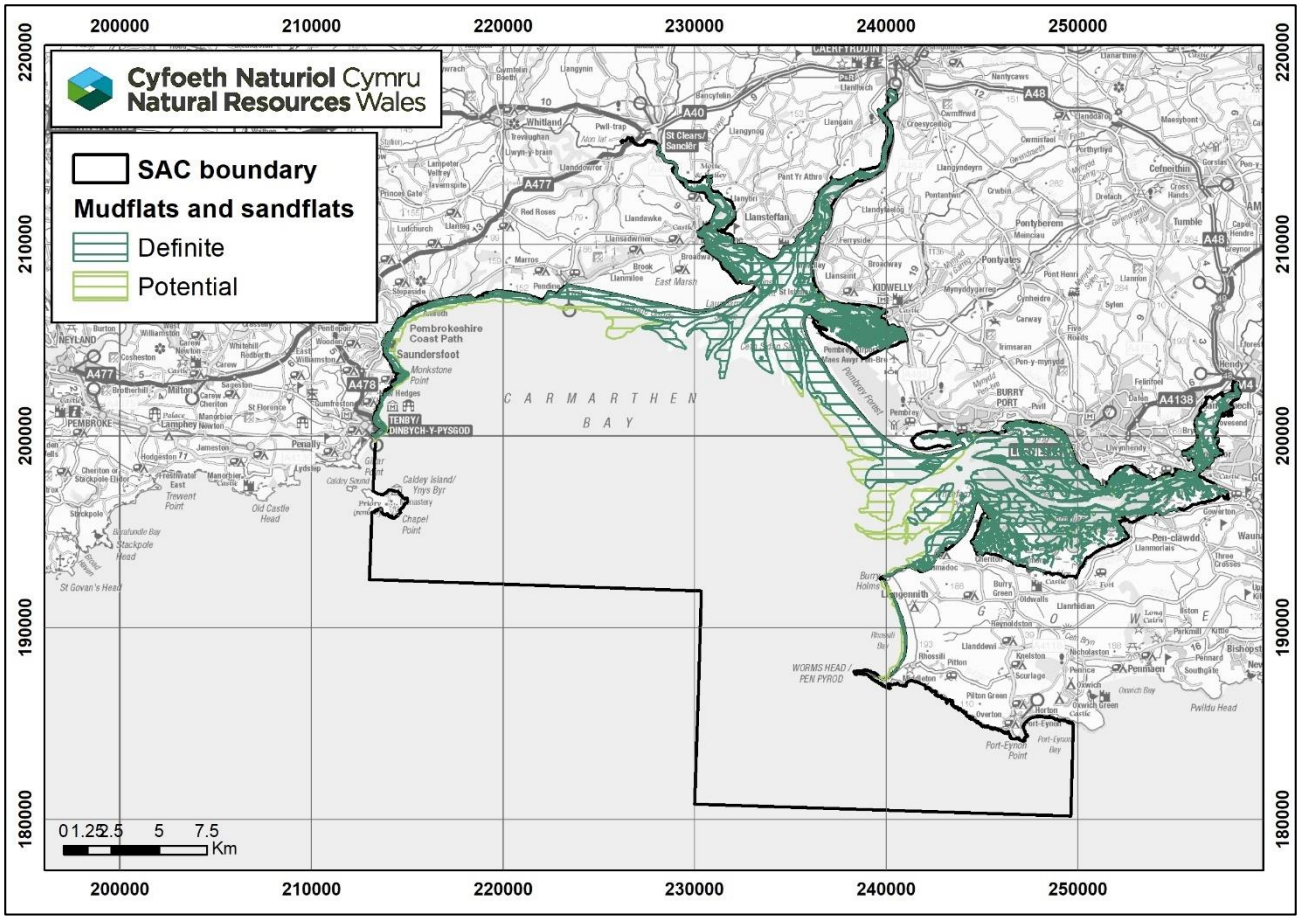


Table 10 has a summary of the assessment outcome. The assessment outcome and any reasons for failure are discussed in more detail in the sections below.

Table 10. Condition assessment of mudflats and sandflats in Carmarthen Bay and Estuaries 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 Carmarthen Bay and Estuaries 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 Carmarthen Bay and Estuaries SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the mudflats and sandflats. (S)	• There are currently no anthropogenic impacts known to be significantly affecting the topography of the mudflats and sandflats feature in the Carmarthen Bay and Estuaries SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the mudflats and sandflats feature in the Carmarthen Bay and Estuaries 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 of core samples in the mudflats and sandflats of the Burry Inlet and Three Rivers estuaries indicated little variation in sediment composition across the monitoring period. However, there was a sudden coarsening of sediments in 2019. • Granulometric analysis of grab samples in the Three Rivers estuary showed variation in sediment composition, but with no overall concerning trend. Some stations in the Gwendraeth and the Tywi had significant changes in silt content between years. This may be due to the dynamic nature of the estuary. • Confidence is medium due to the unexplained coarsening of sediments from core samples, and the large changes in silt content in the grab samples.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to mudflats and sandflats infaunal communities, allowing for natural change and variation. (S)	• The redox layer indicated no clear trend over the years. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low
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)	• Sediment sampling in the SAC has been assessed using sediment grab sample data at 21 stations in the Three Rivers estuary. • There has been an increase in carbon content in 2021 compared to earlier years in various stations, especially in the Taf. Two stations with the largest relative increases went from 0.13% and 0.25% in 2015 to 1.91% and 1.65% in 2021 respectively. • Confidence is medium as the sampling locations are within the Three Rivers estuary only, and as there are only three years of data.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: contaminants	Sediment contaminants not to exceed the quality guidelines. (P)	• Sediment sampling in the SAC has been assessed using sediment grab sample data at 21 stations in the Three Rivers estuary (2015, 2018 and 2021). • The concentration of various heavy metals has increased between 2018 and 2021 (most notable in chromium). Some PAHs and heavy metal concentrations were above less stringent guidelines in 2021. • Contaminants were below the most stringent guidelines in 2021 in all locations. • The impact of the contaminants to the mudflats and sandflats feature is not fully understood. In addition, there were only three years of data, and the sampling locations are within the Three Rivers estuary only. This, and as there were some contaminants above the less stringent ecological guidelines reduced the confidence to low.	**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)	• Two of the four WFD waterbodies that overlap with the mudflats and sandflats feature were classified as Good status for DIN in the 2024 cycle 3 interim classification (Burry Inlet Outer and Carmarthen Bay). Combined, these waterbodies overlap with 72% of the feature. ○ The Burry Inlet Outer waterbody was classified as Moderate status in the 2021 cycle 3 classification, and has fluctuated between Good and Moderate status in previous cycles. • The other two WFD waterbodies were classified with a Moderate status for DIN (Three Rivers Estuary and Burry Inlet Inner). Combined, these overlap with 24% of the feature. • Confidence is medium as a large proportion of the feature overlap with waterbodies that have passed for the DIN WFD element.	**Fail**	Medium
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Two of the four WFD waterbodies were classified with a Good status for phytoplankton in the 2024 cycle 3 interim classification (Carmarthen Bay and Three Rivers Estuary). These waterbodies have improved from Moderate status in the 2021 cycle 3 classification. Combined, they overlap with 38% of the feature. • The other two WFD waterbodies were classified with a Moderate and Poor status (Burry Inlet Outer and Burry Inlet Inner). Combined, these waterbodies overlap with 59% of the feature. • Confidence is medium because the ecological relationships between phytoplankton and the mudflats and sandflats are not fully understood.	**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)	• None of the four WFD waterbodies that overlap with the feature have been classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification.	**Unknown**	N/A
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 four WFD waterbodies that overlap with the feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Burry Inlet Outer, Carmarthen Bay, Three Rivers Estuary and Burry Inlet Inner). • 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 four WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification. In all waterbodies, some or all of the chemical classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. • The other WFD waterbody has a fail for chemicals (Carmarthen Bay). It failed for mercury, PBDE and cypermethrin and overlaps with 21% of the feature. • Confidence is medium as the human health standard has been used for PBDE, and due to the roll forward of some chemical classifications.	**Fail**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for Carmarthen Bay and Estuaries mudflats and sandflats, therefore this target was assessed as unknown.	**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 relevant WFD waterbodies were classified as Good or High status for the IQI WFD element in the 2024 cycle 3 interim classification. • Analysis of grab sampled macrobenthic infaunal communities within the Three Rivers estuary showed high variability in communities during the monitoring period and the causes remain uncertain. • Analysis of core sampled macrobenthic infaunal communities in the River Loughor, Three Rivers and Western part of the SAC were within the limits of natural variation. The infaunal community at Crofty tended to fluctuate and this observation could be due to the transient mussel bed. Some locations have only two stations making the assessment difficult. • Recent cockle stock assessment data indicated a slow recovery and possible longer life expectancy of *C. edule*. • The distribution of *Cerastoderma edule* is patchy but stable. There is some uncertainty on whether the current *C. edule* mortality is natural or not. • *Zostera noltei* cover tended to fluctuate within natural variability. • No clear patterns were observed in the abundance of *A. marina*, *C. edule* and *Corophium arenarium* derived from the limited information of the monitored core samples. • The mudflats and sandflats of the SAC are dynamic, which adds to the uncertainty regarding whether the observed changes in community composition are anthropogenic in origin. This has resulted in a low confidence.	**Pass**	Low

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)	• Some decline in species richness and or diversity was observed for the grab samples across the Three River estuary and the causes remain uncertain.
		• Overall species richness and diversity for the core samples in the monitored mudflats and sandflats in the Carmarthen Bay and Estuaries SAC were within the bounds of natural variation.
		  ○ A decrease of species richness was observed at Crofty, possibly linked with the mussel bed modifying the habitat.
		  ○ Fluctuation as the river channel in Llansteffan can make some stations muddier and could mask underlying impacts.
		  ○ Some locations had only two stations making the assessment difficult.
		• The mudflats and sandflats of the Carmarthen Bay and Estuaries SAC are dynamic, which adds to the uncertainty regarding whether the observed changes are anthropogenic in origin. This has resulted in a low confidence.
			Pass	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 taxonomic distinctness of the infaunal community of the monitored mudflats and sandflats in the Carmarthen Bay and Estuaries SAC remained stable and within the expected values over the monitoring period. • Confidence is high due to the availability of high quality monitoring data and lack of concerning patterns.	**Pass**	High

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)	• The establishment of *Gracilaria vermiculophylla* has been notably rapid in the Loughor estuary (within mudflats and sandflats). • This NNS causes sedimentation change and alterations to the topography of mudflats and sandflats and is changing mudflat into muddy gravel or mussel beds. It is likely to affect the cockle and mussel fisheries in the area. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Fail**	Low
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• *G. vermiculophylla* has been recorded within the last six years in the Loughor estuary, where the establishment has been notably rapid compared to other areas. • Other NNS have been recorded previously including *C. fornicata* within the mudflats and sandflats feature. • Confidence is high due to the recent arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The mudflats and sandflats feature in Carmarthen Bay and Estuaries SAC has been assessed as being in **unfavourable** condition (medium confidence).There were a number of failing indicators (Table 11). 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 11 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 11. Summary of the condition assessment for mudflats and sandflats in Carmarthen Bay and Estuaries SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indicator failure	Threats to condition
Carmarthen Bay and Estuaries	**Unfavourable (medium confidence)**	Sediment quality: organic carbon content (P) Water quality: nutrients (DIN only) (P) Invasive non-native species (P); non-native species (T) Water quality: phytoplankton (S) Water quality: contaminants (S)	• Carbon content in sediments has increased in various stations, especially in the river Taf. • High nutrient levels have been recorded in the Burry Inlet Inner, and Three Rivers Estuary waterbodies. • Phytoplankton failed in the two Burry Inlet waterbodies. • Levels of mercury, PBDE and cypermethrin in the Carmarthen Bay waterbody are is failing to meet their relevant EQSs. • There has been rapid establishment of *G. vermiculophylla* in the Loughor estuary, which has started to alter the habitat present in the mudflats and sandflats.	• Unconsented infrastructure • INNS • Fly ash • Sediment quality: contaminants • Water quality: contaminants • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

The feature extent and the distribution and extent of habitats and communities indicators in the Carmarthen Bay and Estuaries SAC passed their target as there are currently no known anthropogenic impacts that would negatively affect the mudflats and sandflats feature. Comparison mapping has not been used to assess the extent and expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediment quality; topography; and hydrodynamic and sediment transport processes

Composition

Granulometric analysis within Carmarthen Bay and Estuaries SAC indicated little variation in sediment composition over the monitoring period. One station at Crofty showed an increase of silt in recent years, linked with the density of mussels, which are modifying the sediment. A sudden unexplained coarsening of sediment (250 – 500 µm increase) was observed in 2019 across all locations. Further investigation into the cause of this spike of coarse sediments is needed. While this was not deemed enough to fail, this reduced the confidence in the pass to medium. Annual dredging activities are occurring at Tenby Harbour since 2019 and while the impact is very localised and likely to be temporary, this will be something to pay close attention to when interpreting sediment data in future assessments.

Granulometric analysis from sediment grab samples in the Three Rivers estuary showed variation in sediment composition between monitoring years, but with no concerning trend overall. However, there were some stations in Gwendraeth with significant fluctuation in silt content (<63 µm) between monitoring years which are a concern. In addition, significant decrease in silt content were observed in a few stations in Tywi. These changes cannot be explained from the current analysis, and could be a result of moving channels or linked to the dynamic nature of the environment and require further investigation.

Overall, the sediment composition indicator met its target as there were not deemed large enough to fail. Confidence was reduced to medium due to the changes in silt at some Three Rivers stations, and due to the sudden and unexplained coarsening of sediments found in the core samples.

Redox layer

The redox layer indicated no clear trend over the years, resulting in a pass for this indicator. Analysis for the Pwll mudflats and sandflats indicated that the monitoring site was quite anoxic with a 1-5 cm black layer dominating across stations. Layers of green algal mats were observed in this area and could explain the lack of oxygen in the sediment layer. A long-term data series spanning from 2007 to 2022 is available, but for some monitoring sites, sampling has not been conducted consistently every year. Further sampling is required to enhance the robustness and completeness of the dataset,

especially important for assessing the redox layer. For this reason the confidence in the pass was reduced to low.

Carbon content

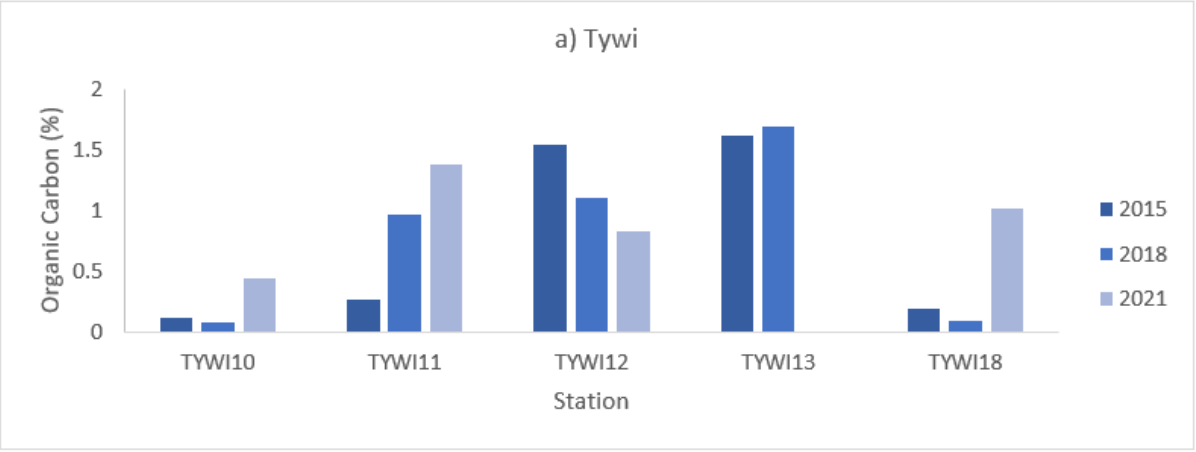
The assessment of the organic carbon and contaminants indicators used data from NRW Habitats Regulations monitoring sediment sampling at 16 sites in the Three Rivers estuary (Tywi, Taf and Gwendraeth) in 2015, 2018 and 2021.

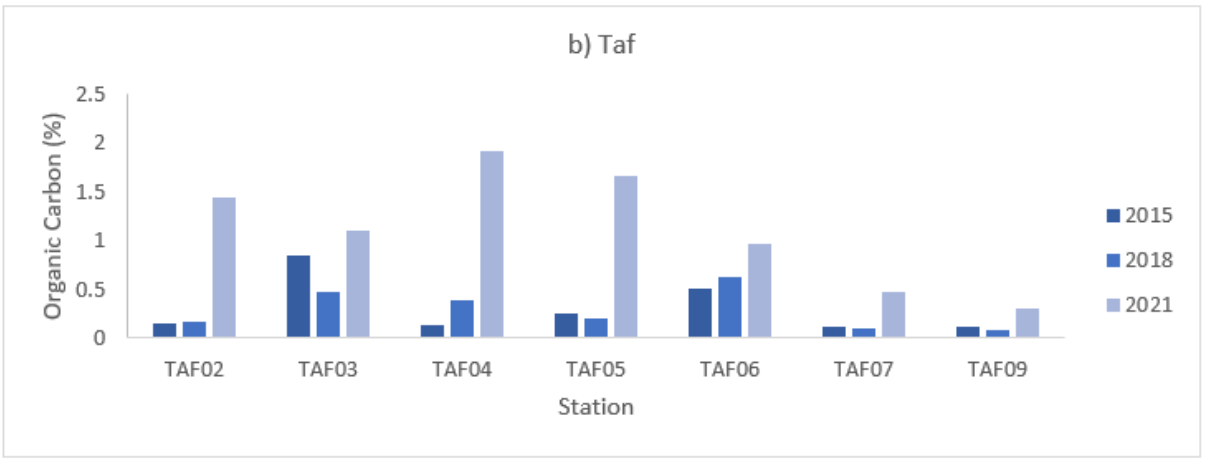
Carbon content has increased over the monitoring period (Figure 11). This is especially notable in the Taf, where all stations that were within the mudflats and sandflats feature increased in carbon (Figure 11b).

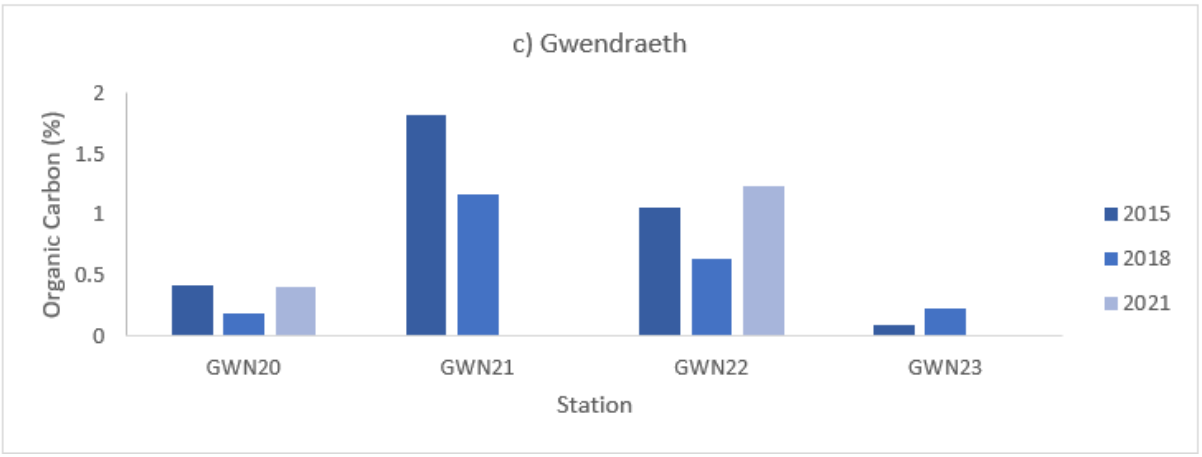
The locations with the highest carbon content in 2021 were in the middle sections of the Taf, where it increased from 0.13% in 2015 to 1.91% in 2021 at one location, and 0.25% to 1.65% at another location (Figure 11b). The carbon levels are not as high as those in Pembrokeshire Marine SAC (maximum of 3.8% in Milford Haven Waterway), but compared to the levels in 2015 or 2018, the 2021 levels are concerning. 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. There was one station in the Tywi (station Tywi 12) where the carbon content has decreased over the three monitoring years (Figure 11a). This station is in the middle the river. It should be noted that one station in the Tywi and two in the Gwendraeth rivers only had carbon data in two years.

Such increases in carbon content are typically related to agricultural practices (e.g. slurry runoff). This may therefore provide support for evidence of nutrient issues within the Three Rivers estuary (see further detail in the water quality section). The organic carbon content indicator failed to meet its target due to the substantial increases in carbon in some locations in the Three Rivers estuary. Confidence was reduced to medium as there were only three years of data. There are no data available on carbon content in other parts of the feature.

Figure 11. Average carbon content (±S.E.) from sediment grab samples in 2015, 2018 and 2021 in Carmarthen Bay and Estuaries SAC. Samples at the Rivers a) Tywi, b) Taf, and c) Gwendraeth in the Three Rivers estuary. There were no data in 2021 for some locations in the Tywi (13 and 17) and Gwendraeth (21 and 23).







Sediment contaminants

The concentrations of chemical contaminants were compared against various ecological quality guidelines as outlined in section 3.4. The contaminants were below the more stringent ecological guidelines in 2021 at all of the locations. There was a concern in 2018 as the concentration of some PAHs were above the most stringent guidelines (OSPAR effects range low) at two of the Taf stations. However, these have since declined to levels below the less stringent guidelines in 2021. The concentrations of chromium, copper and zinc increased between 2018 and 2021, with some stations having concentrations above the less stringent guidelines (CEQG threshold effect level) in 2021. This is most notable in chromium and could be a threat to the feature if it continues to increase. Some of the concentrations of PAHs were above the less stringent guidelines (CEQG threshold effect level) in 2021. The sediment quality (contaminants) indicator was assessed as meeting the target as there were no contaminants with levels above the most stringent guidelines. The impact of the contaminants to the mudflats and sandflats feature is not fully understood. In addition, the sampling locations are within the Three Rivers estuary only and as there were only three years of data. These issues, and because there are some concentrations of contaminants above the less stringent guidelines reduced the confidence in the pass to low.

Within the Burry Inlet estuary, there are no available monitoring data on sediment contaminants. However, there may be some residual contamination present as a result of the Llangennech freight train derailment and diesel spill that occurred higher up in the estuary in 2020. There was a large spike in hydrocarbons from the spilled diesel at the location, and high levels at some locations further seaward. The biological impact of the

spill at the top of the estuary was large, with significant reductions in biota. Due to limited subsequent monitoring in the affected areas, the extent of recovery is unknown, but the residual oil contamination within cockles were within statutory limits (NRW unpublished data).

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.

Water quality

It has been estimated that approximately 97% of the mudflats and sandflats feature within the SAC falls within four WFD waterbodies. These are therefore likely to be a good reflection of the overall effect of water quality on the feature. The Burry Inlet Outer waterbody overlaps with the largest proportion of the feature (51%).

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator (DIN only) failed to meet its target as high levels of DIN have been recorded in two of the four WFD waterbodies that overlap with the mudflats and sandflats feature. Combined, these waterbodies (Three Rivers Estuary and Burry Inlet Inner) overlap with 24% of the feature. The Moderate status for DIN in these waterbodies were confirmed in the 2021 WFD investigation reports (Jones 2021b; Jopson and Newman 2021). There is also a biological response to high nutrient levels in the Burry Inlet Inner waterbody, where phytoplankton was classified with a Moderate status. The other two WFD waterbodies were classified with a Good status for DIN in the 2024 cycle 3 interim classification. These are the Burry Inlet Outer and Carmarthen Bay waterbodies, which combined, overlap with 72% of the feature. The Burry Inlet Outer waterbody was classified as Moderate in the 2021 cycle 3 classification, but has improved to Good status in the 2024 cycle 3 interim classification. The confidence of this improvement is quite certain (79%). The classification of the Burry Inlet Outer waterbody has fluctuated between Moderate and Good status over various cycles. The supporting biological element, phytoplankton, in the Burry Inlet Outer waterbody is still classified as Moderate status in the 2024 cycle 3 interim classification, despite the improved DIN classification. The WFD investigation report for this waterbody confirmed the DIN and phytoplankton failure in 2021 (Jones 2021c). Investigations have confirmed DIN failures and / or biological responses to elevated nutrients in phytoplankton in the relevant waterbodies, however due to the improvement in DIN in the Burry Inlet Outer waterbody, confidence in the fail was reduced to medium.

The phytoplankton indicator failed to meet its target. This element failed in two of the WFD waterbodies that overlap with the mudflats and sandflats feature. The Burry Inlet Outer and Burry Inlet Inner waterbodies were classified with a Moderate and Poor status respectively in the 2024 cycle 3 interim classification. These waterbodies have been Moderate or worse status for phytoplankton in all cycles, and overlap with a large proportion of the feature (59%). The other two WFD waterbodies, Carmarthen Bay and Three Rivers Estuary, were classified with a Good status in the 2024 cycle 3 interim classification, however they were both Moderate status in the 2021 cycle 3 classification. The 2021 WFD investigation reports for the Burry Inlet Outer, Burry Inlet Inner and the Three Rivers Estuary

waterbodies confirmed the phytoplankton failures (Jones, 2021b; Jones, 2021c; Jopson and Newman, 2021). The failure in the Carmarthen Bay waterbody was uncertain in 2021 as the EQR was close to the Good status boundary (Lock, 2021c). Medium confidence has been attributed to the failure of the target due to the improvement in two of the WFD waterbodies, and because the ecological relationships between phytoplankton and the mudflats and sandflats feature are not fully understood.

The indicator for opportunistic macroalgae was assessed as unknown. This was because none of the four WFD waterbodies were classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification, as no data has been collected for this element over the last six years (see Section 3). Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Dissolved oxygen

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

Contaminants

The Carmarthen Bay waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where mercury, PBDE and cypermethrin failed. This waterbody overlaps with 21% of the feature and therefore caused the contaminants indicator to fail. The EQS for cypermethrin is very low, and in the previous lab methodology it was not possible to detect concentrations below the EQS. There has been a waterbody status change between the 2021 cycle 3 classification and 2024 cycle 3 interim classification due to this reason. Cypermethrin is a synthetic pyrethroid insecticide and is highly toxic to some aquatic species (EA, 2019), but now has a restricted use in Wales. Mercury has failed in the waterbody since the 2015 cycle 2 classification. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). 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 mudflats and sandflats are not fully understood. The other three WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification. However, in all three waterbodies, some or all of the chemical classifications were rolled forward from previous cycles as they were not assessed in the 2024 cycle 3 interim classification. The confidence in the fail was reduced to medium due to this and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Species and communities

All four relevant WFD waterbodies were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification. Combined, these overlap with 97% of the feature.

Species composition

Infaunal analysis from core samples showed that communities associated with the surveyed mudflats and sandflats varied across the monitoring period, but with no clear pattern (Moore et al., 2021 and NRW unpublished data). Infaunal communities at Crofty tended to alternate between species with a mud-affinity such as oligochaetes, and species with a sand-affinity such as *Bathyporeia* spp., especially at the two stations furthest from shore. This variation in community composition could be linked with the blue mussel and its removal that occurred there occasionally. Mussels are known to be habitat modifiers by stabilising the substratum and modifying the sedimentary habitat. If the abundance of blue mussels is reduced, muddy substrate can revert back to more sandy substrate, thus impacting the infaunal communities, as seen in Crofty. The transient nature of mussel beds is in part due to its sporadic recruitment which means it is difficult to know if the change seen in the infaunal communities is natural or potentially due to anthropogenic removal. It is likely that both of these contribute to the fluctuations seen in the results. Although the variation in composition of communities for Crofty was judged to be part of natural cycle, this will be something to pay close attention to in the next assessment.

Infaunal communities at Llansteffan also indicated some variation in species composition. These variations are likely due to the impact of the river channel movement, increasing the occurrence of muddier substrate, and the subsequent change in the associated infaunal communities. This, however, creates some uncertainty as it could mask possible underlying effect. There was a limited period of core sampling available for the other stations, making any inferences difficult.

Recent analysis of grab sampled infaunal communities in the Three Rivers estuary showed high variability in communities during the monitoring period of 2007-2021 (NRW unpublished data). Large changes in species composition were detected particularly for the stations in the River Taf. Communities sampled in the middle section of the River Taf, close to the town of Laugharne, were more dominated by species tolerant to pollution (AMBI group III). In addition, some disturbance within the community composition and high levels of ammonia were observed in one of these middle stations, suggesting a possible point source input nearby. Similarly, large changes were observed in species composition in the Rivers Tywi and Gwendraeth, with large changes in species abundance. Abundance of opportunistic species (AMBI group V) and overall species abundance appeared to decrease in recent years at Gwendraeth. The stations located in the mouth of the Three Rivers estuary are subject to a highly dynamic environment (e.g. wave exposure, moving sandbar, increase of sediment movement), and were therefore deemed not suitable to include in the assessment. Overall, there are some concerns as the observed large shifts at these stations may not be natural. Given the large shift seen in species composition at these stations and the observed water quality issues within the Three Rivers estuary, there are concerns that require further investigations. That said, the site is a naturally highly dynamic environment, and it is difficult to disentangle the natural from the anthropogenic causes of the changes to community composition. Consequently, at this stage, without

further analysis and investigation on the grab survey and core survey data, it cannot be ruled out that the observed changes are natural.

Abundance of species

The limited information from the monitored core samples showed no clear pattern in the abundance of *A. marina, C. edule* and *C. arenarium*, but no cause for concern. Evidence from the WFD data of seagrass shows that *Z. noltei* extent declined especially in 2017 in the Burry Inlet Outer waterbody, but increased again in the following years. The most recent WFD classifications in the 2021 cycle 3 and 2024 cycle 3 interim classifications were both Moderate status, however the fluctuations may be natural as some of the patches of *Z. noltei* that appear and disappear are known to be on or close to a moving sandbar. The more established patches of *Z. noltei* tended to remain more stable. The WFD seagrass classification in the Burry Inlet Inner waterbody has been High status since the 2018 cycle 2 interim classification. *Z. noltei* and *C. edule* distribution was patchy but likely due to sediment and topography. The stable populations of *C. edule* were observed all around and outside the Burry Inlet.

The cockle fishery collapsed in Burry Inlet in 2001-2002 with massive mortality of *C. edule* observed. The population grew up to the 1-year class, spawned and died afterward, never reaching larger classes. This decline in 1-year old *C. edule* was unusual and prevented multicohort population. Recent data analysis of the cockle fishery showed a slow recovery in abundance with fluctuations in the number of *C. edule* gathered. Data indicated that a higher proportion of *C. edule* have reached a larger size class (3+ years) compared to the previous decade, suggesting an improvement.

Overall, the abundance, distribution and species composition of communities indicator met its target. Confidence in the pass, however, was reduced to low due to the concern of the impact of mussel removal on infauna, the masking effect of the river channel in Llansteffan, the limited data for other locations, and the large shift in community composition observed from the grab sample analysis. 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 raise the confidence in the assessment.

Species richness and diversity

There was a decline in species richness and diversity for the core sampled infauna at Crofty. However, this could be the result of sporadic mussel bed formation changing the habitat. In later years, the muddier stations changed to sand, similar to the rest of the stations and this could explain the loss of diversity. The impact of the river channel shifting in Llansteffan may also result in fluctuations in species richness and diversity. There were some concerning patterns of decline in species richness and or diversity and some spikes of abundance in few years across the grab monitoring period 2007-2021 for the middle stations of the River Taf. This could potentially be linked with intermittent organic input, but further analysis is required. Although a few stations appeared to have declined in 2021, no clear pattern was apparent but large changes in abundance were recorded for the River Tywi. The stations closer to the shore for Gwendraeth appeared to show declines in diversity in 2021 and large changes in abundance, as with the other rivers. As for abundance, distribution and species composition of communities indicator, it cannot be

ruled out that the changes observed for the core and grab infauna diversity are natural, therefore the species richness and diversity indicator met its target with low confidence.

Taxonomic distinctness

The average taxonomic distinctness indicator met its target as most of the stations were within the expected levels across the monitoring period indicating good mix of taxonomic diversity.

Invasive non-native species

G. vermiculophylla has rapidly established in the Loughor estuary across the mudflats (Mercer and Brazier, 2023). There have been confirmed records of the species since 2017, with the presence of a few scattered plants. In 2022, the extent and density of *G. vermiculophylla* was much greater (Figure 12). The high density of the species has caused the build-up of mud, and settlement of *M. edulis* and *C. edule* spat onto the seaweed. This is transforming the habitat into a mussel bed (Mercer and Brazier, 2023). The build-up of mud in the habitat, the potential smothering effect on cockles, and the difficulty in raking and riddling cockles when mixed in with plant material has made the area unfishable for cockles. The rapid establishment of *G. vermiculophylla* within the last six years has resulted in a fail for both the primary and tertiary targets for the INNS and NNS indicator respectively. Currently, the extent is thought to be limited to the Loughor estuary and is therefore affecting under 5% of the SAC. However, the species has the capacity to spread to other areas. There is a need to better understand the spread and impact of this species. This has been highlighted in the NRW marine evidence needs. For this reason, the confidence in the fail for the primary target of the INNS indicator is low. Other NNS have been recorded previously (e.g. *C. fornicata*) in the SAC, including some within the mudflats and sandflats feature.

Figure 12. Extensive coverage of the red seaweed worm wart weed *Gracilaria vermiculophylla* at Crofty, Loughor estuary, in 2022. a) *G. vermiculophylla* is established on the mudflats and sandflats, b) Example of cockles growing on *G. vermiculophylla*.

Reasons for target failure

The assessment of the mudflats and sandflats feature in the Carmarthen Bay and Estuaries SAC found three indicators with a primary target, two indicators with a secondary target and one indicator with a 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 in the Three Rivers estuary. This was especially notable in the river Taf. Increases in carbon are likely to be from an increase in the amount of organic material being deposited, which may be related to agricultural practices (e.g. slurry runoff).

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. High levels of DIN have been recorded in two of the WFD waterbodies that overlap with the mudflats and sandflats feature. 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 for the Burry Inlet Inner waterbody (Jones 2021b; Jopson and Newman 2021). Point source continuous sewage discharge from the water industry were also confirmed as a source of nutrients linked to the DIN failures for both waterbodies (Jones 2021b; Jopson and Newman 2021). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

Invasive non-native species

Both the primary and tertiary targets failed as there has been rapid establishment of *G. vermiculophylla* in the Loughor estuary within the last six years. This has led to the build-up of mud and is changing the mudflats and sandflats habitat. The issue is currently limited to the Loughor estuary, but the species may spread to other areas in the future. Investigation into the management of spread of *G. vermiculophylla* has not been done widely (Maggs and Magill, 2014). Targeted surveys of the species and investigation into its impact are required. 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.

Water quality: phytoplankton

This indicator target has a secondary weighting. Two of the WFD waterbodies that overlap with the feature were classified with a Moderate and Poor status for the phytoplankton element in the 2024 cycle 3 interim classification (Burry Inlet Outer and Burry Inlet Inner). The WFD investigation reports confirmed the phytoplankton failure in both of these waterbodies, where the sources of nutrients were associated with agriculture and rural land management and the water industry (as described in the nutrient reasons for failure) (Jones, 2021b; Jones, 2021c).

Water quality: contaminants

This indicator target has a secondary weighting. The mudflats and sandflats feature in the SAC is partly within a waterbody that failed for chemicals. The Carmarthen Bay waterbody failed due to mercury, PBDE and cypermethrin. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022). Cypermethrin is an insecticide used for plant protection in crops, in forestry, gardens, homes and businesses. It is also used in veterinary medicine to control pests in livestock and pets (EA, 2019). The application of cypermethrin has been restricted for some uses (sheep dipping and in forestry against the pine weevil).

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

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. dredging 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 Carmarthen Bay and Estuaries 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 further establishment of *G. vermiculophylla* more widely in the Loughor (Three Rivers estuary) is a real concern. The subsequent accumulation of mud and increasing anoxia can directly affect cockle density (see further information 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.

Fly ash

Fly ash (pulverised fuel ash) from the old power station at the west of Burry Port could pose a risk. The power station was immediately adjacent to the estuary and the fly ash was buried along with some asbestos. The shoreline where it is buried is now starting to erode. The impact of fly ash on the estuaries feature is not clear, but if released, fly ash could accumulate in the tissues of marine species, particularly invertebrates (Jenner and Bowmer, 1990 in Robbins, et al. 2023).

Sediment quality: contaminants

The concentration of some sampled PAHs and heavy metals were above the less stringent sediment quality guidelines in the most recent sampling years. The levels of chromium in particular have increased at various locations in the Three Rivers estuary. If the levels were to increase further to above the more stringent ecological guidelines this would cause the indicator to fail its target.

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

4. Evidence gaps for mudflats and sandflats feature

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

Listed below are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments. Not all evidence gaps apply to every SAC, see Table 12 for details.

Table 12. Evidence gaps for the mudflats and sandflats feature in Welsh SACs. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Assessed status	Comments
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 or medium confidence (proxy data used)	• Without any recent biotope surveys undertaken, assessing changes in mudflats and sandflats in all SACs is difficult. A new survey is required.
Topography of the feature (P); hydrodynamic and sediment transport processes (P)	Low or medium confidence (proxy data used)	• The topography and hydrodynamic regime of mudflats and sandflats is not currently monitored 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.
Sediment composition and distribution (P)	Not assessed	• Currently, there is no sediment monitoring within the Anglesey Coast: Saltmarsh SAC.
Sediment quality: organic carbon content (P); contaminants (P).	Not assessed / unknown	• Currently, there is no sediment monitoring within the Menai Strait and Conwy Bay SAC. • Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring ceased in 2015. These data was deemed to be out of date and there are no recent data available.

Indicator	Assessed status	Comments
Abundance, distribution and species composition of communities (P)	Not assessed / low or medium confidence (limited data)	• There is currently no NRW Habitats Regulation monitoring in the mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC. There is currently insufficient data from other sources (e.g. IQI) to use for this assessment. • Further analysis on the infaunal species driving observed changes in the infaunal communities in the Pembrokeshire Marine and Carmarthen Bay and Estuaries SACs 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 at all of the SACs on the mudflats and sandflats feature is not fully understood. More targeted surveys and investigation on the impact of NNS on mudflats and sandflats are needed. • Investigation into the use of satellite and or aerial imagery for assessing the extent of *G. vermiculophylla* may be beneficial.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Not assessed / low confidence (limited data)	• Currently, there is no sediment monitoring within the Anglesey Coast: Saltmarsh SAC. • 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.
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: opportunistic macroalgae (S)	Unknown	• This indicator was assessed as unknown in the Carmarthen Bay and Estuaries SAC due to some or all of the overlapping WFD waterbodies not being classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling. As this is limited to only a few samples per year it cannot be used to adequately assess the turbidity in any of the SACs. • Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.
Water quality: physicochemical properties (S)	Not assessed / unknown	• There were no temperature, salinity or pH loggers within the Anglesey Coast: Saltmarsh and Carmarthen Bay and Estuaries SACs. • Further evidence on temperature change is required to adequately assess this indicator in the other SACs. Some physicochemical parameters such as salinity and pH have not been assessed in any SACs. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.
Species richness and diversity (S); taxonomic spread of species (S)	Not assessed / unknown	• The mudflats and sandflats feature in the Anglesey Coast: Saltmarsh SAC are not currently monitored for infaunal communities with no Habitats Regulations monitoring program taking place.

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