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Condition Assessments for Estuaries in Welsh Special Areas of Conservation

Report No: 895

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Mawddach Estuary, © 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 aberoedd 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 aberoedd mewn ACAau ledled Cymru

Lleoliad y nodwedd ACA	Asesiad cyflwr	Hyder yn yr asesiad
Glannau Môn: Cors heli	Anffafriol	Isel
Pen Llŷn a'r Sarnau	Ffafriol	Canolig
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 estuaries 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 estuaries in SACs across Wales.

SAC feature occurs in	Condition assessment	Confidence in assessment
Anglesey Coast: Saltmarsh	Unfavourable	Low
Lleyn Peninsula and the Sarnau	Favourable	Medium
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 the habitat description from the JNCC list of Annex I marine, coastal and halophytic habitats.

“Estuaries are habitat complexes which comprise an interdependent mosaic of subtidal and intertidal habitats, which are closely associated with surrounding terrestrial habitats. Many of these habitats, such as mudflats and sandflats not covered by sea water at low tide, saltmarshes, sandbanks which are slightly covered by sea water all the time and reefs, are identified as Annex I habitat types in their own right.

Estuaries are defined as the downstream part of a river valley, subject to the tide and extending from the limit of brackish water. There is a gradient of salinity from freshwater in the river to increasingly marine conditions towards the open sea. The input of sediment from the river, the shelter of the estuary from wave action, and the often low current flows typically lead to the presence of extensive intertidal sediment flats and sediment-filled subtidal channels. There is usually only a limited extent of rocky habitat. In contrast, marine inlets where seawater is not significantly diluted by freshwater are considered as Annex I type large shallow inlets and bays.

The structure of estuaries is largely determined by geomorphological and hydrographic factors.”

3. Estuaries condition assessments

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

- 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.

Estuaries are a physiographic feature that hosts a great variety of habitats. These include other designated features such as reefs, mudflats and sandflats, large shallow inlets and bays, Atlantic salt meadows (ASM) and *Salicornia,* within this report they are called nested features. The estuaries were assessed as a feature in its own right but the results of the relevant nested features were also taken into consideration. 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.

Many of the estuaries have been impacted by land claim and other anthropogenic structures in the past which has affected the natural extent, morphology and hydrodynamics and consequently the habitats present, but these assessments consider condition compared with the estuaries at the time of designation.

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

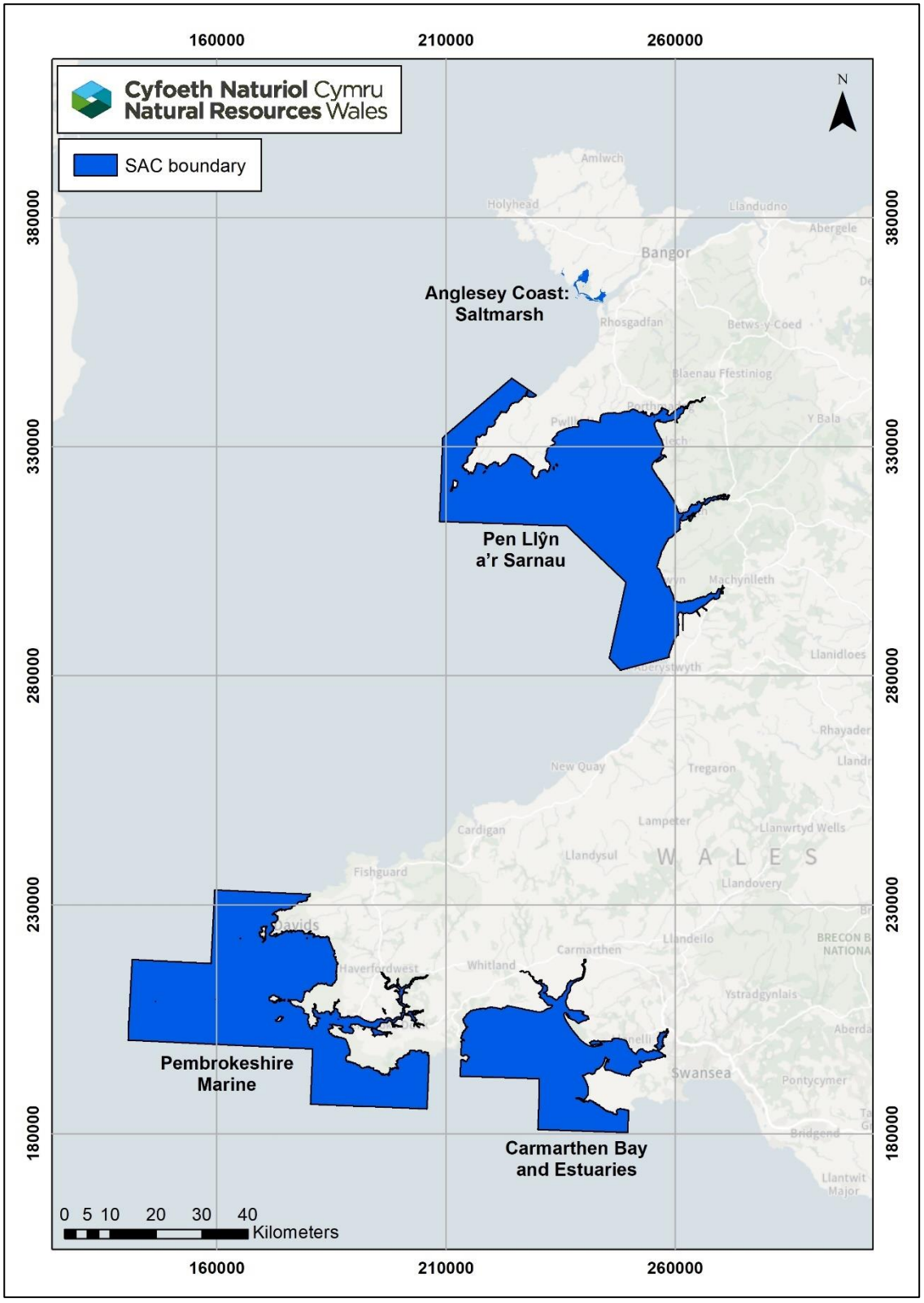
- 2009 cycle 1 classification
- 2015 cycle 2 classification
- 2018 cycle 2 interim classification
- 2021 cycle 3 classification

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

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

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

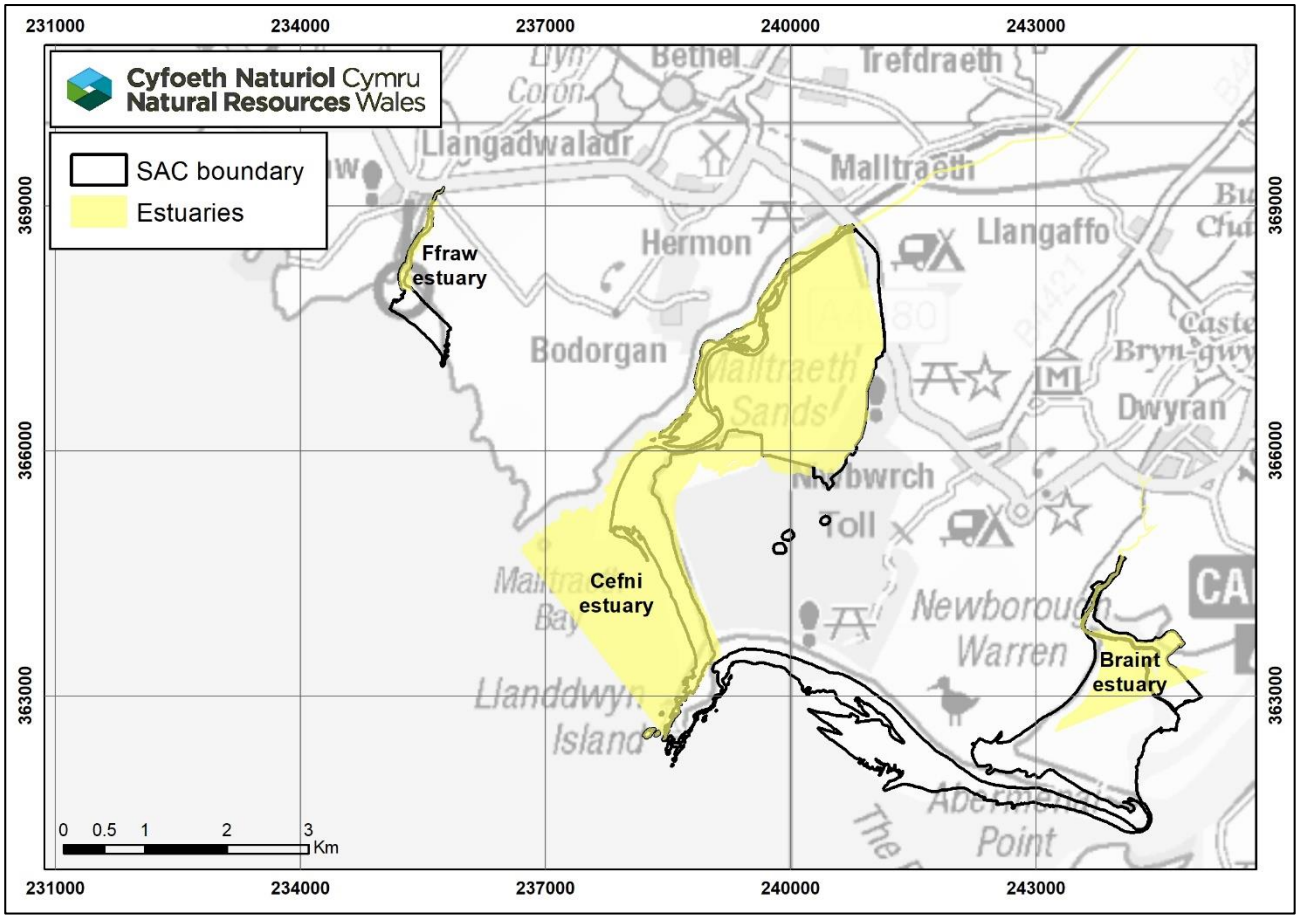
Figure 1. Location of SACs assessed for the estuaries feature.



3.1. Anglesey Coast: Saltmarsh SAC condition assessment

The estuaries feature in the Anglesey Coast: Saltmarsh SAC comprises three estuaries, Braint, Ffraw, and Cefni (also known as Malltraeth) (Figure 2). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 2. Map of the estuaries feature in Anglesey Coast: Saltmarsh SAC.



The estuaries feature in the SAC includes the nested features: mudflats and sandflats, Atlantic salt meadows (ASM) and *Salicornia.* The areas within the estuaries (mainly the estuary channels) that are not covered by the nested features have not been monitored and therefore expert judgment was used in the assessment. Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 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 estuaries 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 extent of estuaries within the SAC, allowing for natural change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the extent of estuaries in the 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 of the feature	Maintain the distribution of the estuaries within the SAC, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution of estuaries in the Anglesey Coast: Saltmarsh SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of estuarine habitats and communities, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution and extent of habitats and communities of estuaries and its nested features in the 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
Morphological equilibrium	Maintain the characteristic physical form and flow of the estuary, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the morphological equilibrium of estuaries in the Anglesey Coast: Saltmarsh SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the estuaries. (S)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the topography of estuaries in the Anglesey Coast: Saltmarsh SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the hydrodynamic and sediment transport processes of the feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: nutrients (Dissolved Inorganic Nitrogen - DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Cefni estuary comprises 86% of the feature, Braint estuary 13% and Fraw 1%.
		• Two WFD waterbodies overlap with the Cefni estuary.
		  ○ The Cefni waterbody was classified as Good status for DIN in the 2024 cycle 3 interim classification, but with an uncertain confidence. It has improved from Moderate status in the 2021 cycle 3 classification, but this may be due to different methodologies used for classification. It is therefore not certain if there has been a true improvement. It overlaps with 83% of the Cefni estuary (71% of the whole feature).
		  ○ The Caernarfon Bay North waterbody was classified with a High status for DIN. This waterbody overlaps with <1% of the Cefni estuary.
		• Two WFD waterbodies overlap with the Braint estuary.
		  ○ The Menai Strait waterbody was classified as High status for DIN. This waterbody overlaps with 85% of the Braint estuary (11% of the whole estuaries feature).
		  ○ The Braint waterbody was classified as Poor status. It overlaps with 10% of the Braint estuary (1% of the whole estuaries feature).
		• One WFD waterbody overlaps with the Ffraw estuary. The Ffraw waterbody was classified as Bad status in the 2024 cycle 3 interim classification. This overlaps with 82% of the Ffraw estuary (1% of the whole feature).
		• Confidence is medium as there is uncertainty in the Cefni waterbody classification, however all three estuaries are considered to fail this indicator.
			Fail	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)	Within the SAC, Cefni estuary comprises 86% of the feature, Braint estuary 13% and Ffraw 1%. • The Menai Strait waterbody was classified as High status for phytoplankton in the 2024 cycle 3 interim classification. This waterbody overlaps with 86% of the Braint estuary (11% of the whole feature). • The other four waterbodies that overlap with the estuaries have not been classified for phytoplankton in any cycles. • The indicator was assessed as unknown as phytoplankton has not been classified in two of the three estuaries.	**Unknown**	N/A
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	Within the SAC, Cefni estuary comprises 86% of the feature, Braint estuary 13% and Ffraw 1%. • Two WFD waterbodies overlap with the Braint estuary. The Menai Strait waterbody was not classified for opportunistic macroalgae. The Braint waterbody was classified with a Moderate status in the 2024 cycle 3 interim classification. This waterbody overlaps with 10% of the Braint estuary (1% of the whole feature). • Two waterbodies that overlap with the Cefni and Ffraw estuaries (Cefni and Ffraw) were classified with High status in the 2024 cycle 3 interim classification. One waterbody (Caernarfon Bay North) was not classified for opportunistic macroalgae. • Confidence is low as the opportunistic macroalgae issues are within only one of the smaller estuaries within the SAC.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Cefni estuary comprises 86% of the feature, Braint estuary 13% and Ffraw 1%. • All five of the WFD waterbodies that overlap with the feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is medium due to samples being taken from the surface of the waterbody which may not detect issues for more demersal habitats within the estuaries feature.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	Within the SAC, Cefni estuary comprises 86% of the feature, Braint estuary 13% and Ffraw 1%. • 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 represent 74% of the whole feature. • The other 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 85% of the Braint estuary (11% of whole feature). • Confidence is low due to the unclassified waterbodies, and the rolled forward classifications.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the estuaries feature in the Anglesey Coast: Saltmarsh SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• There are no data available for infaunal communities in the estuaries feature in the Anglesey Coast: Saltmarsh SAC; there is currently no Habitats Regulation monitoring for this SAC. • There are also limited data on the nested features within the estuaries feature. • One of the three relevant WFD waterbodies that overlap with the estuaries feature, Caernarfon Bay North, was classified as Moderate status for the IQI WFD element in the 2024 cycle 3 interim classification. This waterbody represents 0.2% of the feature. The other two WFD waterbodies were not classified for this WFD element. • The data are insufficient to use for this assessment, resulting in an unknown result.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is limited evidence to suggest that INNS (e.g. the American slipper limpet *Crepidula fornicata*) are currently impacting the condition of estuaries in the SAC. • Confidence is low as the spread and impacts of the INNS present within the feature are not well understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• Recent records of *C. fornicata* have been identified in the SAC, including within the estuaries feature for the first time in 2020. • The red seaweed worm wart weed *Gracilaria vermiculophylla* has been recorded within the last six years within the SAC and covers a large area in the Cefni estuary. • Other records of NNS have been recorded previously including the Pacific oyster *Magallana gigas* in seagrass in the Braint estuary within the estuaries 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 estuaries feature in Anglesey Coast: Saltmarsh SAC has been assessed as being in **unfavourable** condition (low confidence). There were three indicators with failing targets (Table 3). There were also limited or absent data for six key indicators to inform on the condition of the feature (see 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 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 estuaries 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) Water quality: opportunistic macroalgae (S) Non-native species (T)	• There are high nutrient levels in the Cefni, Braint and Ffraw waterbodies. There are also issues with opportunistic macroalgae in the Braint waterbody. • There has been an increase in the number of NNS in the feature SAC, including *C. fornicata, M. gigas* and *G. vermiculophylla*.	• Unconsented infrastructure • INNS • Water quality: contaminants • Climate change

Detailed assessment information

Extent and distribution

The feature extent and the distribution indicators in the Anglesey Coast: Saltmarsh SAC passed their target as since designation in 2004, there are no known anthropogenic impacts that have significantly affected the extent of the estuaries feature. The distribution and extent of habitats and communities indicator also met its target for this reason, and because there are currently no known impacts to the distribution and extent of the nested features. Comparison mapping has not been used to assess the extent and only expert judgment was used to assess communities distribution in the absence of recent data. This has reduced the confidence to medium.

Sediments

There is no sediment monitoring within the SAC therefore the indicators relevant to sediment composition and quality could not be assessed.

Morphological equilibrium, topography and hydrodynamic and sediment transport processes

The morphological equilibrium, topography and hydrodynamic and sediment transport processes are not well researched. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities that are known to have significantly impacted the feature and its nested features since designation in 2004. The freshwater flow indicator could not be assessed due to limited resource.

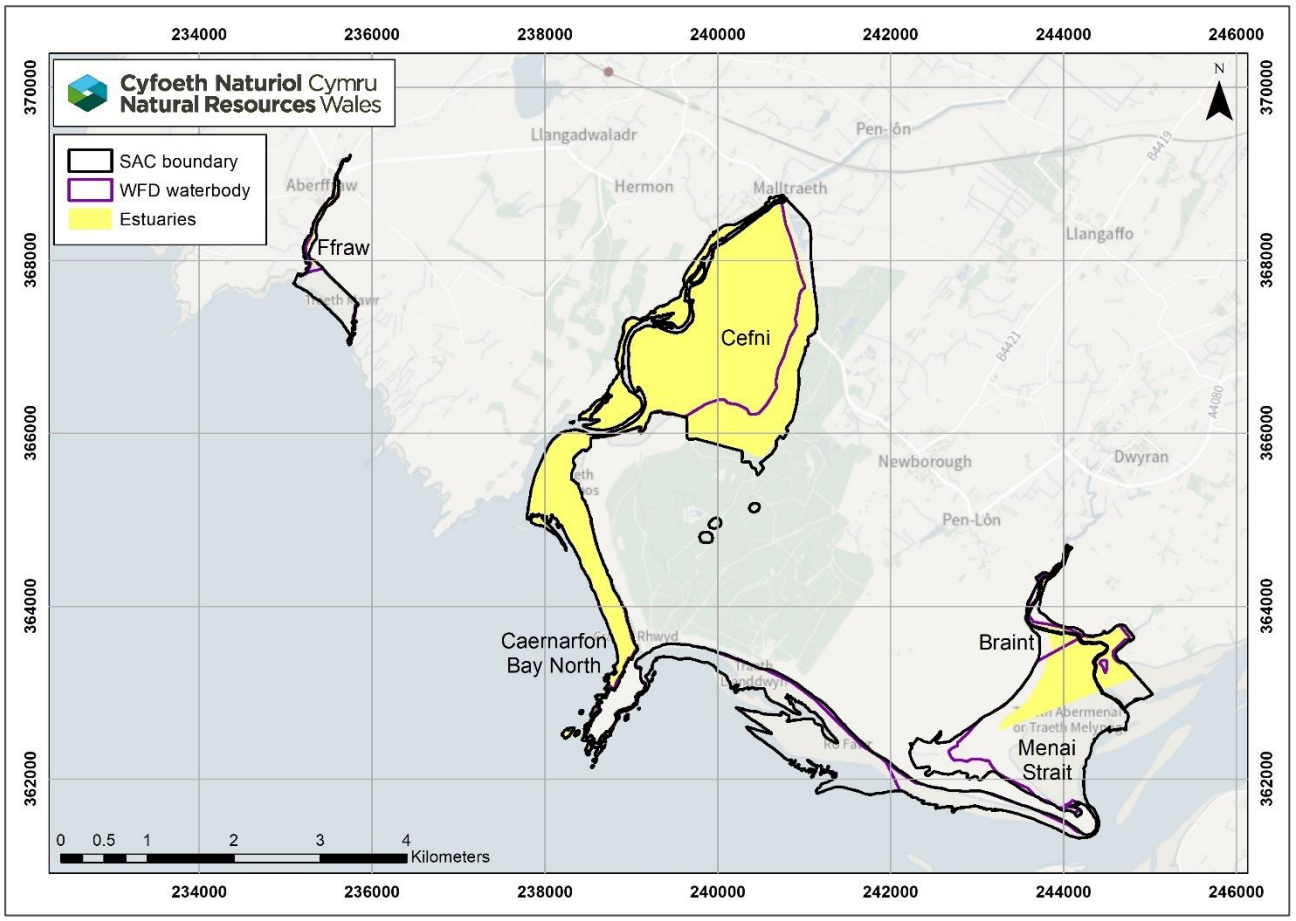
Water quality

It has been estimated that 85% of the estuaries feature falls within five WFD waterbodies (Table 4, Figure 3). These are likely to be a good reflection of the overall effect of water quality on the feature. The Cefni estuary is the largest of the three estuaries within the SAC (85.9% of the estuaries feature). The two smaller estuaries are the Braint and Ffraw (13.0% and 1.0% of the estuaries feature respectively).

Table 4. Designated estuaries within Anglesey Coast: Saltmarsh SAC and the WFD waterbodies that overlap.

Estuary	WFD waterbody	Degree of overlap across indv. estuary (%)	Degree of overlap across estuaries feature (%)
Cefni	Cefni	82.63	71.46
Cefni	Caernarfon Bay North	0.23	0.20
Braint	Menai Strait	85.48	11.22
Braint	Braint	9.51	1.25
Ffraw	Ffraw	81.57	0.86

Figure 3. Map of the WFD waterbodies that overlap with the estuaries feature within Anglesey Coast: Saltmarsh SAC.



Nutrients (DIN only)

The Cefni estuary comprises two WFD waterbodies: the Cefni waterbody and the Caernarfon Bay North waterbody (Table 4). The Cefni waterbody overlaps with a large proportion of the estuary, and it was classified as Good status 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 of the 2024 Good status is uncertain (confidence of Good or better classification: 55%, confidence of Moderate or worse classification: 45%). The 2021 and 2024 dissolved inorganic nitrogen (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 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. The Caernarfon Bay North waterbody was classified with a High status for DIN, however it has not been considered further in the condition assessment due to the small spatial overlap with the feature.

The Braint estuary comprises two WFD waterbodies: the Menai Strait waterbody and the Braint waterbody (Table 4). The Menai Strait waterbody was classified with a High status for DIN in the 2024 cycle 3 interim classification, however the sampling stations were on the other side of the Strait. The Braint waterbody was classified with a Poor status for DIN. The WFD investigation report has confirmed the failure of the DIN classification at stage 1

(Borrowdale and Moore, in draft). This waterbody also failed for the supporting water quality element, opportunistic macroalgae.

The Ffraw estuary comprises one WFD waterbody: the Ffraw waterbody (Table 4). This waterbody was classified with a Bad status in the 2024 cycle 3 interim classification. This 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%). The in draft WFD investigation report confirmed the failure of DIN in the 2021 classification, however there has been no evidence of associated biological failures (Burton, in draft).

Overall, the nutrients indicator (DIN only) was assessed as a fail due to high DIN levels recorded in some of the WFD waterbodies that overlap with all three estuaries. The confidence in the fail was reduced to medium due to the uncertainty of the recorded improvement of the DIN classification in the Cefni waterbody.

Phytoplankton

Only one of the five waterbodies that overlap with the feature in the SAC was classified for the phytoplankton element in the 2024 cycle 3 interim classification. This was the Menai Strait waterbody, which overlaps with the Braint estuary (Table 4). It was classified with a High status, however this classification was rolled forward from the 2018 cycle 2 classification.

All other WFD waterbodies have not been classified for phytoplankton in any WFD cycles. Classification of some WFD waterbodies is not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Overall, the phytoplankton indicator was assessed as unknown because waterbodies that overlap with a large proportion of the feature (75% across the whole SAC) were not classified for this element.

Opportunistic macroalgae

One of the two WFD waterbodies within the Cefni estuary was classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. This was the Cefni waterbody, which overlaps with a large proportion of the estuary (Table 4), and it was classified with a High status. The other waterbody that overlaps with the Cefni estuary, Caernarfon Bay North, has not been classified for this element in any cycles. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Within the Braint estuary, one waterbody, the Braint, was classified with a Moderate status for opportunistic macroalgae in the 2024 cycle 3 interim classification. There are excessive levels of algae in the intertidal area which suggests that nutrient enrichment is causing elevated growth in these species. The other waterbody that overlaps with the Braint estuary, Menai Strait, has not been classified for this element in any cycles.

The one waterbody within the Ffraw estuary (Ffraw) was classified as High status for this element in the 2024 cycle 3 interim classification.

The opportunistic macroalgae indicator was assessed as failing its target due to the Moderate status classification in the Braint waterbody. A low confidence was attributed to this fail as the opportunistic macroalgae issues were only in one of the smaller estuaries of the three within the SAC.

Dissolved oxygen

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

Contaminants

The contaminants indicator met the target as one of the WFD waterbodies that overlaps with the estuaries feature, Menai Strait, has a pass for chemicals in the 2024 cycle 3 interim classification. However, the chemical classifications in the Menai Strait waterbody were rolled forward from the 2018 cycle 2 interim classification. This waterbody overlaps with the Braint estuary. The other four WFD waterbodies were not classified as the chemicals have not been assessed within the last six years. These were the Cefni, Caernarfon Bay North, Braint and Ffraw waterbodies, which combined, represent 74% of the estuaries feature. The confidence in the pass was reduced to low because of this, and due to the rolled forward classification in the Menai Strait waterbody. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Species and communities

Apart from the Infaunal Quality Index (IQI) for Caernafon Bay North waterbody, no data for infaunal communities or estuarine fish are available for Anglesey Coast estuaries and most of its nested features. As a result, the performance indicator for abundance, distribution and species composition of communities have been assessed as unknown.

The Atlantic salt meadows (ASM) feature was assessed as meeting its target with a low confidence as analysis of WFD Regulations monitoring in the Cefni saltmarsh showed that overall plant species richness was good (Jackson-Bué et al., 2025a). This was not enough to assess the estuaries feature of the SAC as it is relevant to a small part of the feature. The mudflats and sandflats feature overlaps with the largest proportion of the estuaries feature (approximately 80%), and there were no data available on this feature.

One of the three relevant WFD waterbodies that overlaps with the estuaries feature, Caernarfon Bay North, was classified as Moderate status for the IQI element in the 2024 cycle 3 interim classification. The WFD investigation report for this waterbody (Moore and Green, 2025) 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. This waterbody represents only 0.2% of the feature and the other two WFD waterbodies were not classified for this element. None of the WFD waterbodies that overlap with the estuaries feature in the SAC have been assessed using the fish tool in the 2024 cycle 3 interim classification.

Invasive non-native species

The red seaweed worm wart weed *Gracilaria vermiculophylla* was recorded in the Cefni estuary within the last six years, but only at a single location (Mercer and Brazier, 2023). Despite being in one location, this species now covers a large area. 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 estuary ecosystems. 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, there has been a minor increase in the number of records for the American slipper limpet *Crepidula fornicata* identified in the SAC. The species was recorded within the feature in the Cefni Estuary for the first time in 2020 and again in 2021 and 2023. Therefore, the tertiary target of the non-native species (NNS) indicator failed with high confidence due to the new NNS recorded in the estuaries feature within the last reporting cycle.

There have also been recent records of the Pacific oyster *Magallana gigas* found in seagrass in Traeth Melynog in the Braint estuary, therefore there is potential for this NNS to spread to other regions in the SAC, including estuaries.

There have been no targeted surveys of these NNS. It is not fully understood how some of these species may spread and impact the condition of estuaries and the nested habitat features within the feature, and effects on the species diversity and composition have not yet been observed. As there is no current impact from the invasive non-native species (INNS) present the primary target of the INNS indicator passed. Confidence is low as the impacts of the INNS present within the feature are not well understood. In addition, further work is required to investigate the impact of *G. vermiculophylla* on the estuaries feature.

Reasons for target failure

The assessment of the estuaries feature in the Anglesey Coast SAC failed one primary target, one secondary 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 in the Braint and Ffraw estuaries, the Braint and Ffraw waterbodies, were

classified with a failing status for the DIN element in the 2024 cycle 3 interim classification. The WFD investigations of the failures in 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 previously Moderate status in the 2021 cycle 3 classification. Different methodologies were used for the assessment of 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).

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. The Braint waterbody was classified as Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. There are excessive levels of algae in the intertidal area which suggests that nutrient enrichment is causing elevated growth in these species. The WFD investigation in this waterbody is ongoing. This failure is localised to the Braint waterbody.

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 within the last six years in the estuaries feature, including *G. vermiculophylla, C. fornicata* and *M. gigas*. There is particular concern about *G. vermiculophylla* as it covers a large part of the Cefni estuary, and as the impacts of the species are not fully understood, however it has a potentially high ecological impact (see further detail in Threats to condition section). Investigation into the management of spread of this species has not been done widely (Maggs and Magill, 2014). Targeted surveys of the species and investigation into its impact are required.

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

Threats to condition

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

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

Invasive non-native species

G. vermiculophylla has been found in the SAC in 2020 and 2023 but only in Cefni estuary. This species has the potential to establish quickly in shallow soft-bottomed bays and estuaries as it has broad environmental tolerances (Maggs and Magill, 2014). *G. vermiculophylla* can have a detrimental impact on the feature as seen in the Carmarthen Bay and Estuaries SAC. *G. vermiculophylla* can alter the sedimentation and topography of estuaries and their associated nested habitat features and could alter the habitat in the long-term if it is in high density (Maggs and Magill, 2014).

There have been recent records of *C. fornicata* in the SAC. This species is commonly found in areas of muddy habitat. At high density, this species could cause an impact on the feature as it and has been shown to alter habitats if it settles in large numbers (Blanchard, 2009). It can also compete with native species for space and food (Frésard and Boncoeur, 2006; Mineur et al., 2012). It may therefore pose a threat to the estuaries feature. However, the spread and impact of this species on the feature are not fully understood.

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 estuaries feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

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

Climate change

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

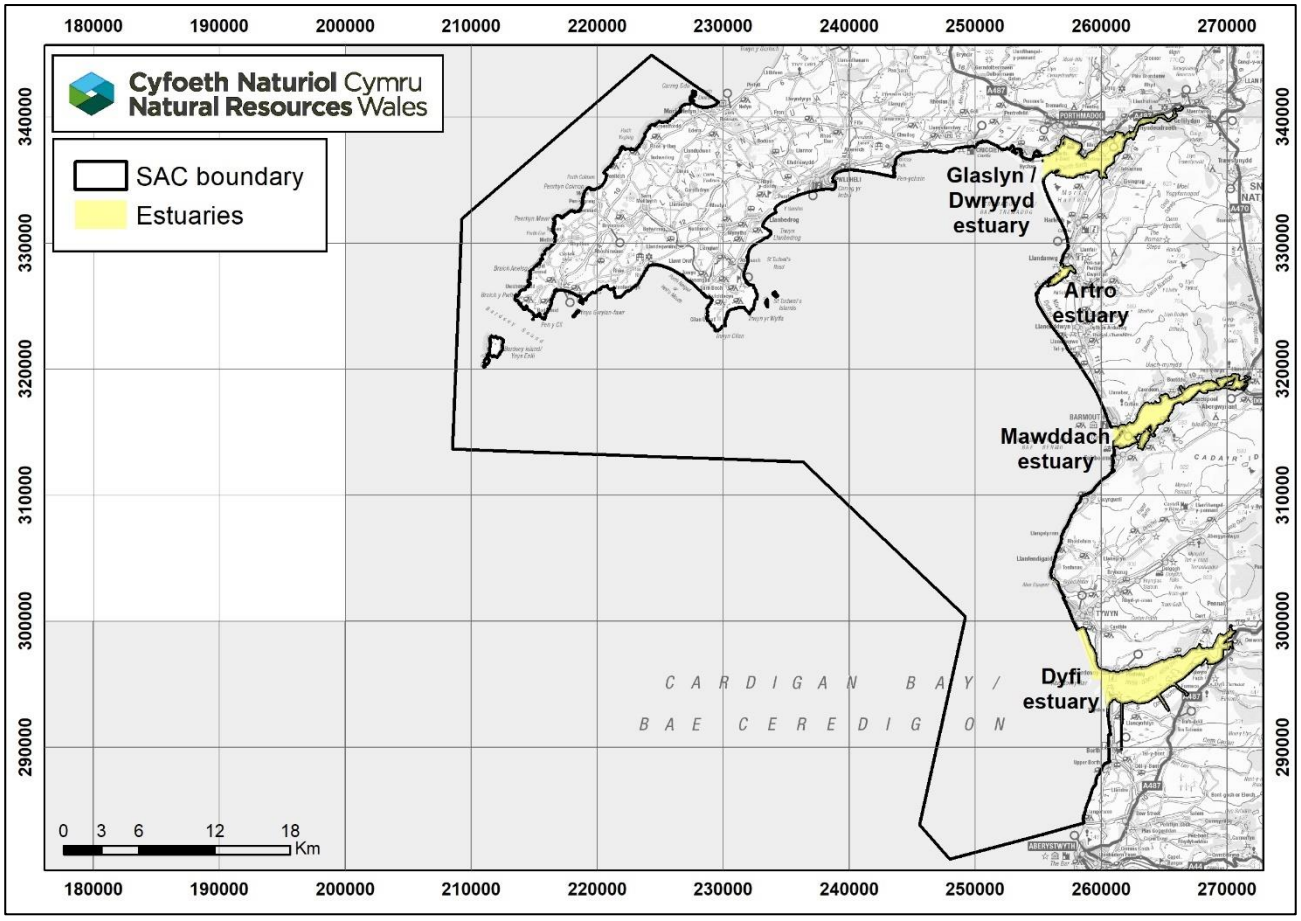
- Sea level rise.
- Changes to wave climate, especially storm frequency and intensity, which may change the topography.

- Changes to freshwater input and flow (i.e. from changes in rainfall).
- Changes in air and sea temperature.
- Changes in ocean acidification.
- Changes in species distribution.

3.2. Pen Llŷn a’r Sarnau SAC condition assessment

The estuaries feature in the Pen Llŷn a’r Sarnau SAC comprises four estuaries, Dyfi, Glaslyn / Dwyryd, Mawddach and Artro (Figure 4). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 4. Map of the estuaries feature in Pen Llŷn a’r Sarnau SAC.



The estuaries features in the SAC includes the nested features: mudflats and sandflats, Atlantic salt meadows (ASM), *Salicornia* and reefs. The areas within the estuaries (mainly the estuary channels) that are not covered by the nested features have not been monitored and therefore expert judgement was used in the assessment. Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 5 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 5. Condition assessment of estuaries in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

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

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

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

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

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence

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

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

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

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

Assessment conclusions

The estuaries feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **favourable** condition (medium confidence). Overall, the lack of any significant anthropogenic impact on this feature in term of extent, hydrodynamic processes, topography, sediment composition and its associated community, have contributed to this favourable assessment outcome. There were two indicators with failing targets (Table 6). There were also limited or absent data for four key indicators to inform on the condition of the feature (see evidence gaps section 4). 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 6 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 6. Summary of the condition assessment for estuaries in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed assessment information

Extent and distribution

Extent and Distribution of the feature

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

Distribution and extent of habitats and communities

Grazing pressure within the SAC could possibly have an impact on the saltmarsh distribution and would be something to pay close attention to in the next assessment (Jackson-Bué et al., 2025a). The indicator was assessed as passing the target but with a medium confidence as the assessment was made using expert judgment.

Sediments

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

Sediments are monitored within the mudflats and sandflats habitat within the estuaries feature. The mudflats and sandflats feature in the SAC overlaps with approximately 50% of the estuaries feature. It was therefore deemed acceptable to use the mudflats and sandflats condition assessment as a proxy for the sediment composition and distribution, and redox layer indicators. Both indicators met their targets with medium confidence for sediment composition and distribution and low confidence in the pass for the redox layer indicator. The intertidal sediments in this SAC should be fairly reflective of the subtidal sediments, therefore the absence of data for subtidal sediments did not reduce the confidence further in the composition and distribution indicator. Low confidence was attributed to the redox layer indicator as further sampling is required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer (Jackson-Bué et al. 2025b).

Organic carbon content and contaminants

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. The data were deemed to be out of date and these indicators were assessed as unknown.

Morphological equilibrium, topography and hydrodynamic and sediment transport processes

The morphological equilibrium, topography and hydrodynamic and sediment transport processes are not well researched. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities known to have

significantly impacted the feature and its nested features since designation in 2004. The freshwater flow indicator could not be assessed due to limited resource.

Water quality

It has been estimated that 70% of the estuaries feature falls within six WFD waterbodies (Table 7, Figure 5). These are likely to be a good reflection of the overall effect of water quality on the feature. The Dyfi estuary is the largest of the four estuaries within the SAC (46.5% of the estuaries feature). The Glaslyn / Dwyryd (26.9%) and Mawddach (24.6%) estuaries also represent a large proportion of the feature, and the Artro is much smaller (2.1%).

Table 7. Designated estuaries within the Pen Llŷn a'r Sarnau SAC and the WFD waterbodies that overlap.

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

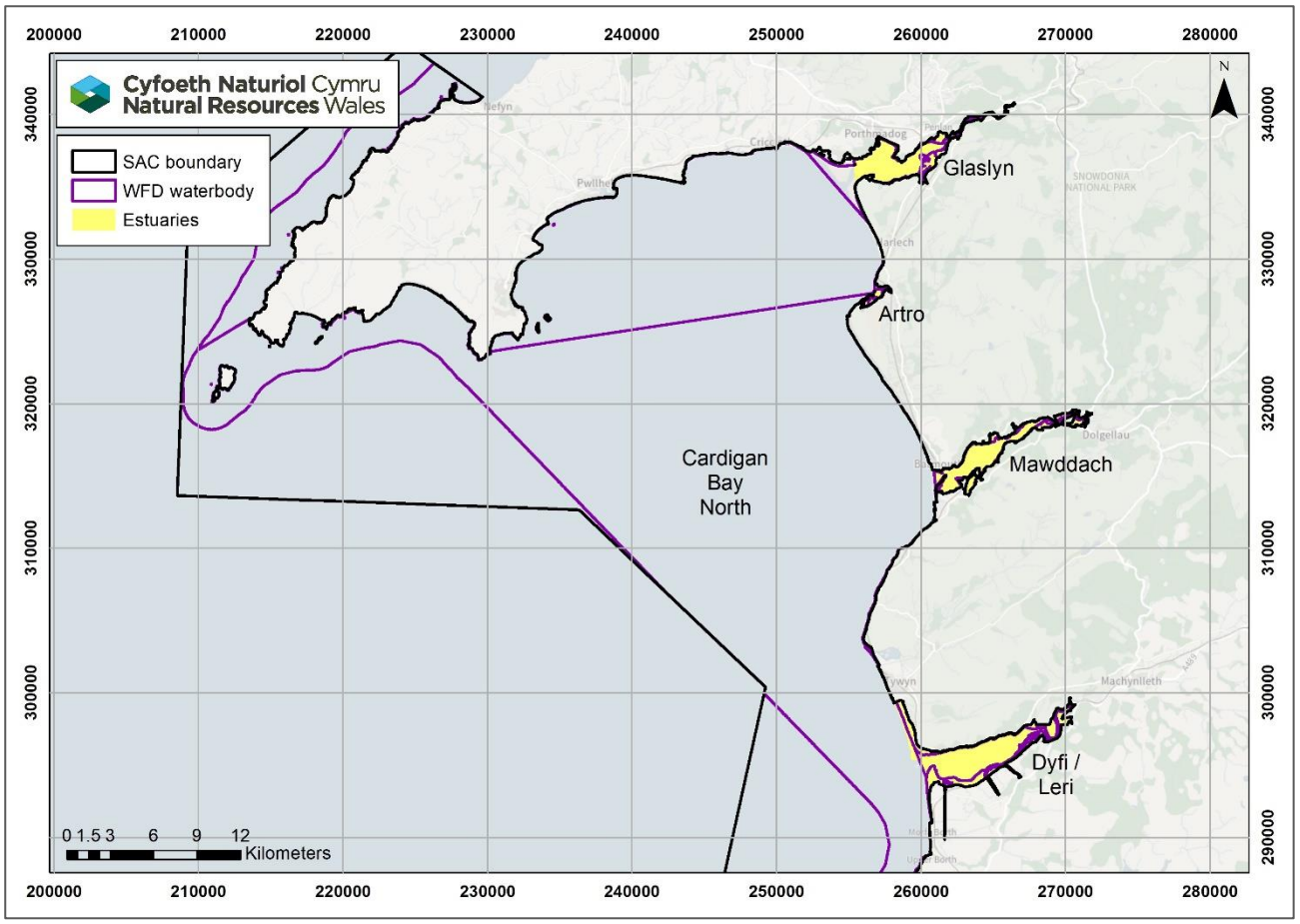
Nutrients (DIN only)

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

Phytoplankton

The phytoplankton indicator was assessed as unknown as a large proportion of the feature overlaps with WFD waterbodies that were not classified for the phytoplankton element in the 2024 cycle 3 interim classification (Dyfi / Leri, Glaslyn, Mawddach and Artro). Combined, these waterbodies represent 68% of the whole feature (Table 7). It should be noted that classification of some of these waterbodies may not be suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels).

Figure 5. Map of the WFD waterbodies that overlap with the estuaries feature within Pen Llŷn a'r Sarnau SAC.



Opportunistic macroalgae

The indicator for opportunistic macroalgae met the target as three of the five overlapping WFD waterbodies were classified with Good or High status in the 2024 cycle 3 interim classification (Dyfi / Leri, Mawddach and Artro). Combined, these waterbodies represent 47% of the whole feature, and overlap with three of the four estuaries within the SAC (Table 7). Confidence was reduced to medium because one of these waterbodies (Mawddach) had a classification that was rolled forward from the 2021 cycle 3 classification. In addition, two WFD waterbodies were not classified for the opportunistic macroalgae element. The unclassified waterbodies represent 23% of the feature (Table 7). Some WFD waterbodies are not assessed for opportunistic macroalgae as they don't have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

Dissolved oxygen

The dissolved oxygen indicator met its target. Two of the five WFD waterbodies that overlap with the estuaries feature were classified as High status for DO. Across the whole estuaries feature, these waterbodies represent only 3%. The other three WFD waterbodies were not classified for dissolved oxygen in the 2024 cycle 3 interim classification, however these were previously classified as High status prior to the 2018 cycle 2 interim classification and are therefore considered low risk. Confidence in the pass was reduced to low because surface sampling of dissolved oxygen may not detect issues for more demersal habitats within the estuaries feature (see further detail in section 3.1), and

because a large proportion of the feature has not been classified for this element. However, they are not deemed to be at risk from failing this element.

Contaminants

Two of the five WFD waterbodies that overlap with the estuaries feature have a fail for chemicals in the 2024 cycle 3 interim classification, which caused the contaminants indicator to fail. The Mawddach waterbody failed for polybrominated diphenyl ethers (PBDE). This is the only waterbody that overlaps with one of the larger estuaries in the SAC, the Mawddach estuary (Table 7). The chemicals in this waterbody however have not been classified in the 2024 cycle 3 interim classification and were rolled forward from the 2021 cycle 3 classification. The PBDE has failed in this waterbody since the 2015 cycle 2 classification. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of estuaries are not fully understood. The Cardigan Bay North waterbody failed for mercury and PBDE. This coastal waterbody overlaps with a small proportion of two estuaries in the SAC (Dyfi / Leri and Artro), and it represents 2% of the whole estuaries feature (Table 7). Some of the chemical classifications in this waterbody were rolled forward from the 2021 cycle 3 classification, including mercury and PBDE. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife).

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

Turbidity and physicochemical properties

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

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

Species and communities

Four of the six overlapping WFD waterbodies were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Cardigan Bay North, Dyfi / Leri, Glaslyn and Mawddach). Combined, these waterbodies represent 68% of the whole

feature. The other two WFD waterbodies with small overlaps (representing <2%) have not been classified for IQI.

The mudflats and sandflats feature overlaps with approximately 50% of the estuaries feature. The condition assessment for the mudflats and sandflats feature concluded that the abundance, distribution and species composition of communities met the criteria for a pass. Some concerns were raised, however, for the Dwyryd estuary due to some changes in infaunal communities and will be something to pay close attention to in the next assessment (Jackson-Bué et al., 2025b).

The Atlantic salt meadows (ASM) feature overlaps with approximately 24% of the estuaries feature. In the ASM feature condition assessment, the species composition of the communities indicator was assessed as unknown due to limited data and available resources. However, recent visual observations made in the Dwyryd and Mawddach estuaries in October 2024 has identified some areas of the saltmarshes that remain heavily grazed (H. Lewis (NRW), pers. comm.) (Jackson-Bué et al., 2025a). Overgrazing is likely to have an impact on the species composition of the ASM feature, however no information is available to confirm this.

The reefs feature overlaps with approximately 1.4% of the estuaries feature. The abundance, distribution and species composition of communities indicator met its target for the intertidal reefs relevant to the estuaries feature (Jackson-Bué et al., 2025c).

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

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

Invasive non-native species

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

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

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

Reasons for target failure

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

Water quality: contaminants

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

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

Non-native species

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

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

Threats to condition

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

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

Unconsented infrastructure

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

Invasive non-native species

G. vermiculophylla has been found in the estuaries feature. This species has the potential to establish quickly in shallow soft-bottomed bays and can have detrimental impact on the feature as seen in the Carmarthen Bay and Estuaries SAC (Jackson-Bué et al., 2025b) (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.

Overgrazing

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

Additionally, sheep grazing and the subsequent wash-off of faecal material from the intertidal saltmarsh may result in episodic events of high bacteria concentrations. A high number of grazing sheep can result in poor water quality, even several kilometres from the grazed marsh (e.g. Burry Inlet).

Water quality: contaminants

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

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

Management of coastal defences

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

Climate change

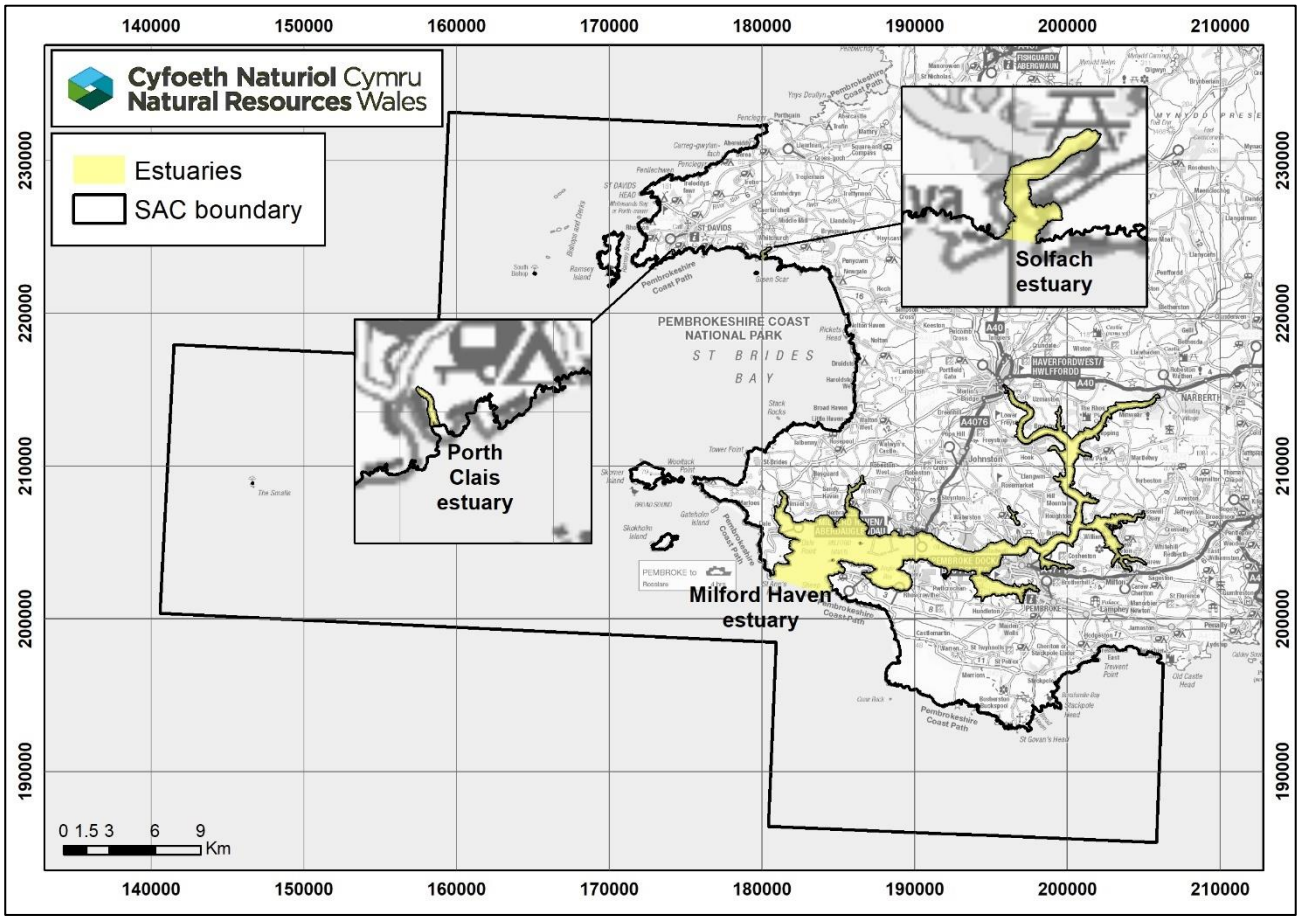
It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Kendon et al., 2023; Kendon et al., 2024; Gihwala et al., 2024; Oaten et al., 2024):

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

3.3. Pembrokeshire Marine SAC condition assessment

The estuaries feature in the Pembrokeshire Marine SAC comprises three estuaries, Milford Haven, Solfach and Porth Clais (Figure 6). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 6. Map of the estuaries feature in Pembrokeshire Marine SAC.



The estuaries feature in the SAC includes the nested features: large shallow inlets and bays, reefs, mudflats and sandflats and Atlantic salt meadows (ASM). Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 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 estuaries in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

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

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

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

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

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais estuary 0.02%.
		• Two WFD waterbodies overlap with the Milford Haven estuary. Both were classified as Poor status in the 2024 cycle 3 interim classification (Milford Haven Inner and Outer). Combined, these waterbodies overlap with 93% of the Milford Haven estuary (92% of the whole feature).
		• Two WFD waterbodies overlap with the Solfach estuary.
		  ○ The Solfach Estuary waterbody was classified as Bad status. It overlaps with 79% of the Solfach estuary (<1% of the whole feature).
		  ○ The Pembrokeshire South waterbody was classified as High status. It overlaps with 4% of the Solfach estuary.
		• One WFD waterbody overlaps with the Porth Clais estuary. This waterbody, Pembrokeshire South, was classified as High status. It overlaps with 92% of the Porth Clais estuary.
		• Confidence is high as the waterbodies with failing DIN status overlap with a large proportion of the feature (93%).
			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)	Within the SAC, Milford Haven estuary comprises nearly 100% of the feature, Solfach estuary 0.2%, and Porth Clais estuary 0.02%. • Three of the four WFD waterbodies that overlap with the estuaries feature in the SAC were High status for phytoplankton in the 2024 cycle 3 interim classification (Milford Haven Outer, Milford Haven Inner, and Pembrokeshire South). Combined these represent 91% of the whole feature in the SAC. • The Solfach Estuary waterbody was not classified for this WFD element. It overlaps with 79% of the Solfach estuary (<1% of the whole estuaries feature). • Confidence is medium due to the unclassified waterbody.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

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

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence

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

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties of the water column	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from intertidal and subtidal temperature loggers were available. Most of these temperature loggers overlap with the estuaries feature. Some temperature loggers in the SAC showed an increase in the number of days with higher temperatures, and potential step change in temperature. • A Pembroke Power Station report indicated a localised increase in temperature, which was deemed unlikely to be of wider ecological significance. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• *Crepidula fornicata* has been recorded in various locations in the SAC starting in 1960 and now reach a high density in some areas, mostly within the Milford Haven estuary. • *C. fornicata* has previously been found in superabundant aggregations across various intertidal and subtidal habitats within the Milford Haven estuary. Where the species dominates, natural habitats have been altered. *C. fornicata* is also found in sensitive habitats (maerl) within the estuary. • Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities. • For these reasons the indicator failed to meet its target. Confidence is medium as there are limited data on the density and distribution of *C. fornicata* within the last six years.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• The carpet sea squirt *Didemnum vexillum* has been recorded on Carr Rocks and on Barnlake Point (Neyland) for the first time, just within the estuaries feature boundary in 2023. • Other NNS have been recorded previously in the SAC within the reefs feature including: brown kelp Wakame *Undaria pinnatifida,* red ripple bryozoan *Watersipora subatra* and San Diego sea squirt *Botrylloides diegensis.* • There have been targeted INNS surveys at intertidal reef sites as part of the MarClim project, 'Rapid Assessment Survey' of marinas and ad-hoc records from the NRW Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The estuaries feature in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of indicators with failing targets (Table 9). All associated failures are localised within Milford Haven estuary, the largest estuary of the three within the SAC. However, it should be noted that there is more monitoring within the Milford Haven estuary. There were also limited or absent data for two key indicators to inform on the condition of the feature (see evidence gaps section 4). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

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

Detailed assessment information

Extent and distribution

Extent and Distribution of the feature

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

Distribution and extent of habitats and communities

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

Sediments

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

Composition and distribution

The sediment composition and distribution indicator in the condition assessment of the nested mudflats and sandflats feature passed its target. Some issues were identified at the Gann, with apparent changes in sediment composition particularly between 2012 and 2018, with an increase of silt and pebble but reduction of fine sand. Although this potentially indicates some disturbance there, this alone was not deemed a large enough impact to fail the nested mudflats and sandflats feature (Jackson-Bué et al., 2025a).

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

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

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

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

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

Oxidation-reduction profile (redox layer)

Quantitative data on the redox layer of sediments has been analysed in the Angle Bay sampling sites only. These data indicated no clear trend over the years. In the wider Milford Haven estuary, there is evidence of opportunistic algae within the site (Lock, 2021a). Excessive opportunistic algal mat growth will quickly smother the sediment, causing anoxic conditions. This has been observed where extensive areas of opportunistic macroalgae growth has been recorded within the Milford Haven estuary, for example within Sandy Haven, where anoxic layers have been observed beneath algal mats (Figure 7). This had led to a failure for the redox layer indicator. The confidence attributed to the failure has been reduced to low as the conclusion has been based on data from a limited spatial coverage, visual observations and expert judgement. The stations assessed for the redox layer are all located within Angle Bay, which is outside the opportunistic macroalgae sampling locations and may explain why there was no clear trend there.

Figure 7. Anoxic layers of sediment beneath opportunistic macroalgae on mudflats in Sandy Haven in 2008, Milford Haven estuary.

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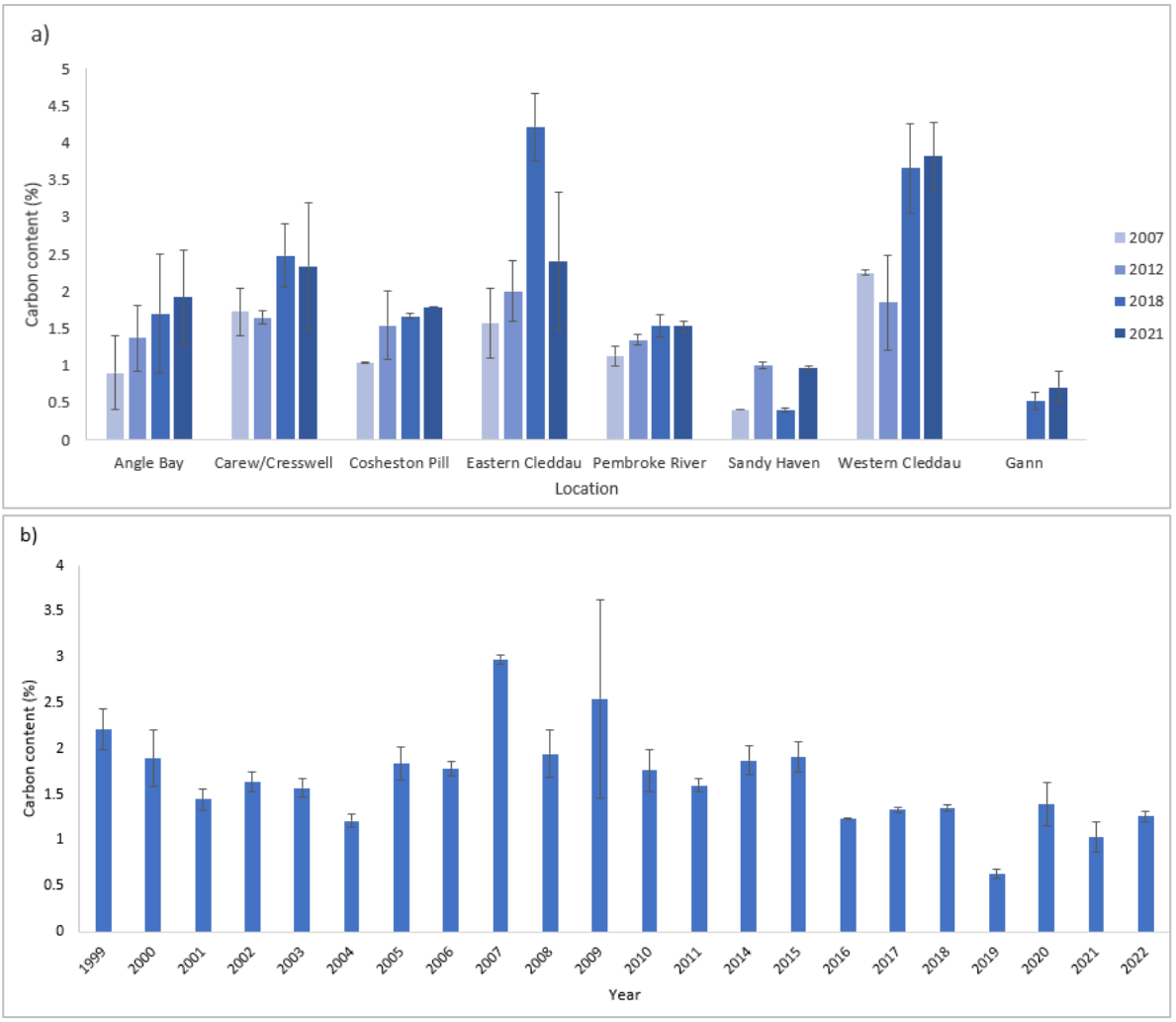
Organic carbon content

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

The organic carbon content at all of the grouped locations has increased over the whole monitoring period (Figure 8a). The location with the highest carbon content in 2021 was the Western Cleddau, where it has increased from 2.3% in 2007 to 3.8% in 2021 (Figure 8a). 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 8b). The carbon content has not been compared against any defined ecological standard as it is highly variable by location, however increases in carbon can be an indicator of organic enrichment and reduced oxygen in the sediment.

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

Figure 8. Average carbon content (±S.E.) from sediment grab samples in Milford Haven estuary. Samples from a) the grouped locations in the Milford Haven estuary in 2007, 2012, 2018 and 2021, and b) the CSEMP location from 1999 to 2022.



Contaminants

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

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

Levels of polycyclic aromatic hydrocarbon (PAH) compounds were recorded at the CSEMP location. Here, the average concentration of Benzo(g,h,i)perylene was above the most stringent ecological guideline (OSPAR effects range low) in all years including 2023. The concentration of this PAH has not changed substantially since earlier years. There

were significant spikes in various PAH concentrations in 2008 and 2011 at the CSEMP site. These peaks are likely due to an increase in dredging activities (Little, 2017; Warwick, 2017). Following these years the concentrations returned to levels similar to those seen before 2008 (NRW unpublished data). PAHs were also recorded at one of the grab sampling locations in the Milford Haven estuary (Pembroke River Upper) in 2021, where concentrations of three of the sampled PAH compounds (anthracene, benzo(a)anthracene and fluoranthene) were above their most stringent ecological guidelines (OSPAR effects range low). Various other PAH concentrations were above the less stringent ecological guidelines (CEQG threshold effect levels) in both the CSEMP and grab sampling locations in the most recent years. In addition, various PAHs were above the most stringent guidelines in 2018 at some of the grab sampling locations over the maerl bed in the Milford Haven estuary. It is not known if the levels still exceed the guidelines at these monitoring sites as they have not been sampled since 2018.

Heavy metal concentrations were also recorded at various locations. The concentration of mercury was above the most stringent guideline (OSPAR effects range low) in 2018 at one of the grab sampling locations over the maerl bed in the Milford Haven estuary. The concentrations of other heavy metals (chromium, arsenic, copper and zinc) were above the less stringent guidelines in some of the sampling locations (CSEMP and grab sampling) in most recent years. There are no OSPAR or CEQG sediment quality guidelines for Tributyltin (TBT) however the average concentration of TBT at the CSEMP location has been above its most stringent ecological guideline (Cefas action level 2) in all years up to 2023. Polychlorinated biphenyls (PCBs) have mostly declined at both the CSEMP and grab sampling stations since earlier years, and all are below the more stringent guidelines in the most recent year of sampling. The concentration of one PCB congener (PCB 118) was above or very close to its most stringent guideline (OSPAR environmental assessment criteria) in seven of the grab sampling locations in 2018, but it has since declined in 2021.

The sediment quality (contaminants) indicator failed to meet the target due to levels exceeding sediment quality guidelines in various contaminants. The impact of the contaminants to the estuaries feature is not fully understood. This caused the confidence to be reduced to medium.

Morphological equilibrium, topography and hydrodynamic and sediment transport processes

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

The hydrodynamic and sediment transport processes indicator met its target as there are no new anthropogenic impacts known to be significantly affecting the hydrodynamic and sediment transport processes of the estuaries feature in the Pembrokeshire Marine SAC. However, historic activities may be continuing to have an effect on the sediment transport,

which may have contributed to an increase in siltation within the Milford Haven estuary. A NRW investigation is ongoing to determine whether an increase in silt may have impacted the maerl bed and whether this is of anthropogenic origin (Ratcliffe, 2025). The confidence in the indicator pass was reduced to low due to this concern, and as the assessment was based on expert judgment.

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

Water quality

It has been estimated that 93% of the estuaries feature falls within five WFD waterbodies (Table 10, Figure 9). These are likely to be a good reflection of the overall effect of water quality on the feature. The Milford Haven estuary is the largest of the three estuaries within the SAC (99.7% of the whole estuaries feature). The Solfach (0.2%) and Porth Clais (0.02%) estuaries are much smaller by size.

Table 10. Designated estuaries within the Pembrokeshire Marine SAC and the WFD waterbodies that overlap.

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

Nutrients (DIN only)

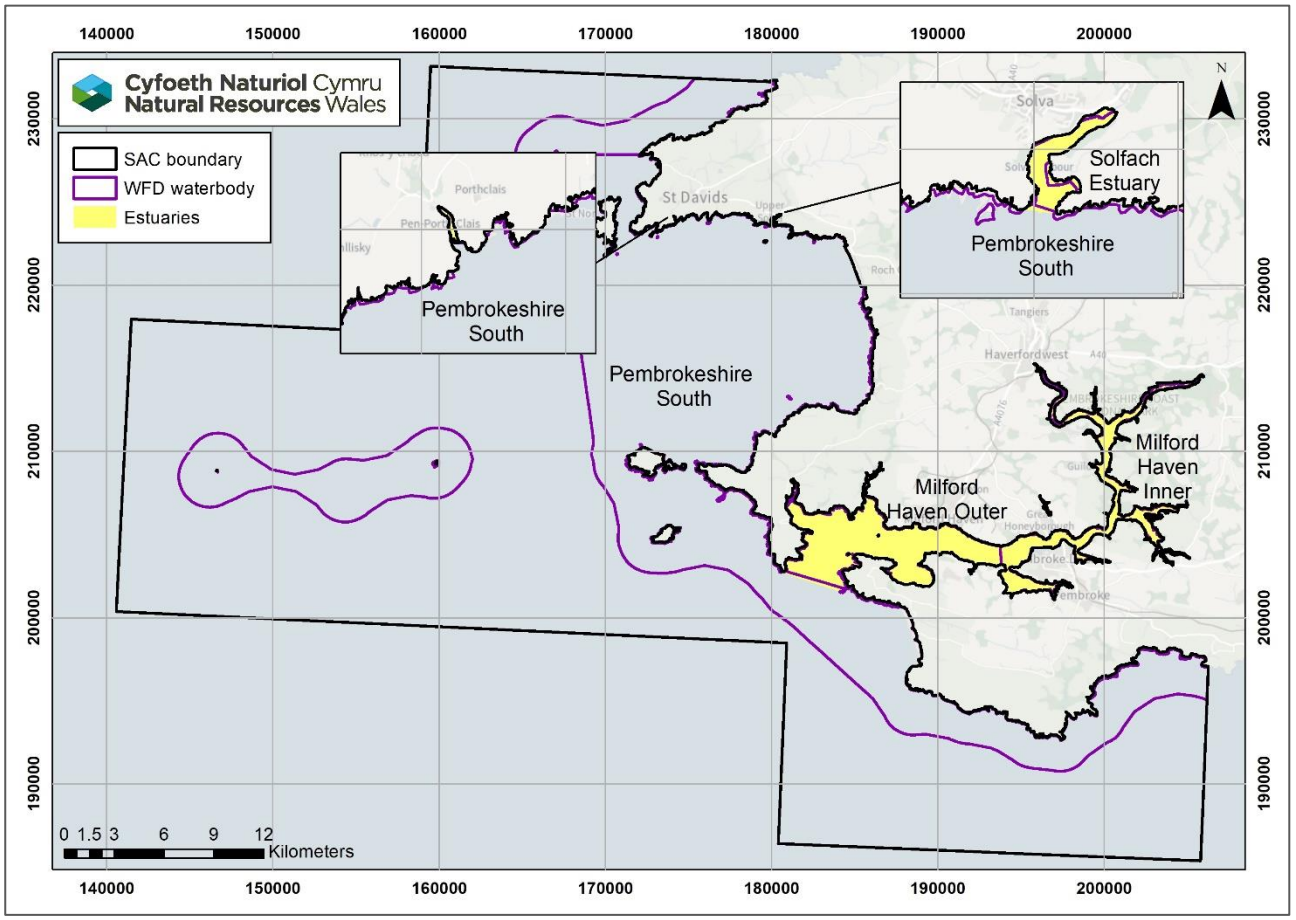
The Milford Haven estuary comprises two WFD waterbodies: the Milford Haven Outer and the Milford Haven Inner waterbodies (Table 10). Both of these waterbodies were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. Combined, these overlap with 93% of the Milford Haven estuary. The Milford Haven Inner and Outer waterbodies also failed in previous cycles, and the Milford Haven Outer waterbody has deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation reports of these waterbodies confirmed the DIN failures in the 2018 cycle 2 interim and the 2021 cycle 3 classifications (Lock, 2021a; Lock, 2021b). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations.

The Solfach estuary comprises two WFD waterbodies: the Solfach Estuary waterbody and the Pembrokeshire South waterbody (Table 10). The Solfach Estuary waterbody overlaps with the largest proportion of this estuary, and it was classified as Bad status for DIN in the 2024 cycle 3 interim classification. The other overlapping WFD waterbody, Pembrokeshire South was classified as High status, however this classification was rolled forward from the 2018 cycle 2 interim classification. The Porth Clais estuary also overlaps with the Pembrokeshire South waterbody.

The nutrients indicator (DIN only) failed to meet the target as high levels of DIN have been recorded in two of the three estuaries, Milford Haven and Solfach. High confidence was

attributed to the failure as the failing WFD waterbodies overlap with a large proportion of the feature, and as the investigations have confirmed nutrient issues in these waterbodies. Confidence was also increased due to the biological response to high nutrient levels in the Milford Haven Inner waterbody, where opportunistic macroalgae was classified with a Moderate status.

Figure 9. Map of the WFD waterbodies that overlap with the estuaries feature within Pembrokeshire Marine SAC.



Phytoplankton

The phytoplankton indicator passed its target as three WFD waterbodies that overlap with a large proportion of the feature (Milford Haven Outer, Milford Haven Inner and Pembrokeshire South) were classified with a High status for the phytoplankton element in 2024 cycle 3 interim classification. Combined, these waterbodies represent 91% of the whole estuaries feature (Table 10). The Milford Haven Outer waterbody improved from Good to High status between the 2021 cycle 3 and the 2024 cycle 3 interim classifications.

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

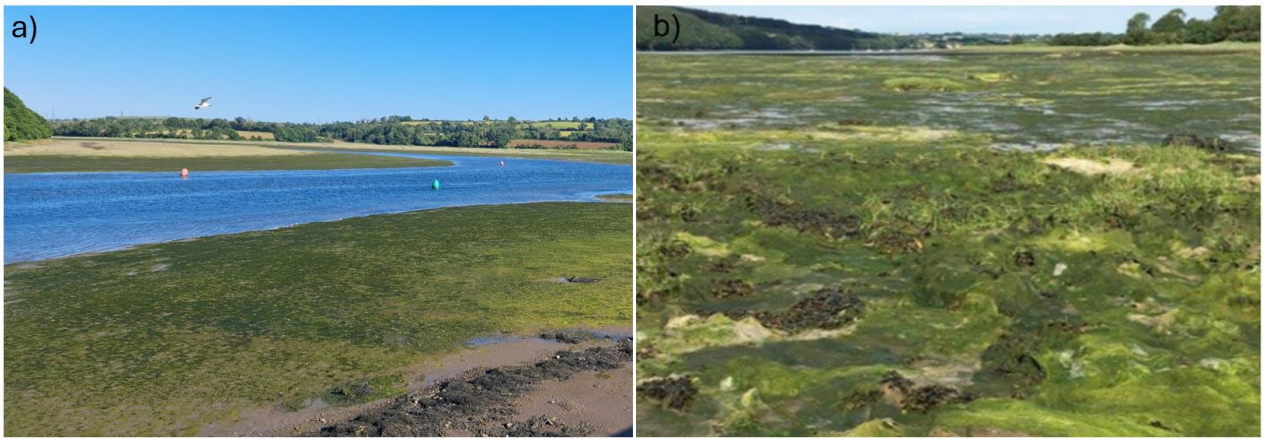
Opportunistic macroalgae

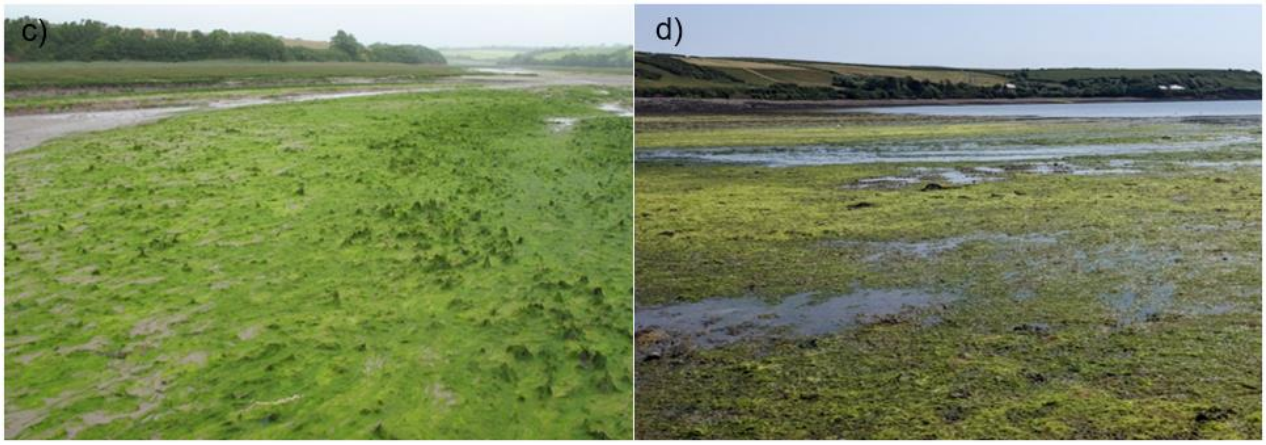
One of the two WFD waterbodies that overlap with the Milford Haven estuary, the Milford Haven Inner waterbody, was classified with a Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure in this waterbody, in which extensive and recurring coverage has been recorded in various locations including Cosheston Pill (Figure 10a), Garon Pill (Figure 10b), and Carew and Cresswell rivers (Lock, 2021a). There has been evidence of opportunistic macroalgae growth since 2007, indicating that this has been a long-lasting issue within the Milford Haven Inner waterbody. The Milford Haven Outer waterbody that also overlaps with the Milford Haven estuary, was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification. Although it is not a failing element for this waterbody, there have been localised issues with opportunistic macroalgae recorded in the more sheltered bays including Angle Bay, Sandy Haven (Figure 10c) and Dale Gann (Figure 10d) (Lock, 2021b).

The WFD waterbodies that overlap with the Solfach and Porth Clais estuaries were not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. Some WFD waterbodies are not assessed for opportunistic macroalgae as they do not have suitable substratum (i.e. areas of intertidal habitat for opportunistic macroalgal growth).

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

Figure 10. Opportunistic macroalgae on saltmarsh and mudflats in the Milford Haven estuary. Photos in a) Cosheston Pill in 2024, b) Garron Pill in 2019, c) Sandy Haven in 2008 and d) Dale in 2023.





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Dissolved oxygen

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

Contaminants

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

Turbidity and physicochemical properties

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

Data from seven NRW monitored subtidal temperature loggers and six NRW monitored intertidal monitoring sites at various shore heights (12 temperature loggers in total) within the SAC were available. Most of these loggers (11 out of the 19) overlap with the estuaries feature. Some of the loggers showed an increase in the number of days with higher

temperatures, and a potential step change in temperature. This is more apparent in the loggers within the Milford Haven estuary. An external report (Sutton, 2023) found localised increase in temperature near the Pembroke Power Station. However, they concluded that this is unlikely to be of wider ecological significance. While localised, warming water can provide a safe haven for NNS, which could then spread further. This will be something to pay close attention to in the next assessment.

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

Species and communities

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

Nested features

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

Although no concern was observed for Angle Bay, the condition of mudflats and sandflats in other parts of the SAC were poor with an increase in opportunistic species which are typically associated with anthropogenic disturbance (e.g. pollution) at several locations during the infaunal Milford Haven estuary grab monitoring surveys (2007-2021) (Jackson-Bué et al., 2025b). From this monitoring, all sampling locations within the estuary indicated large variations in species composition across the monitoring period (NRW unpublished data analysis). Sandy Haven, the Gann, Angle Bay, Cosheston Pill and the Western Cleddau showed large variation in species composition often associated with an increased number of opportunistic species. These locations are known to be impacted by elevated nutrient levels in the Milford Haven Outer and Inner waterbodies (Jackson-Bué et al., 2025b). In addition, bait digging activities in the Gann have been linked with changes in species composition in this area. The observed disturbance was not deemed to be due to natural change. Further analysis on the life histories of species that are driving the observed changes, the broad patterns of tolerant species change, and how these are related to natural versus anthropogenic pressures would help to identify potential reasons for these failures. This resulted in the mudflats and sandflats nested feature to fail for the abundance, distribution and species composition of communities indicator.

The reefs feature overlaps with approximately 35% of the estuaries feature. NRW monitoring data indicated that the intertidal reef communities in the Milford Haven and open coast sampling sites remained stable over time. There was a decline of the knotted wrack *Ascophyllum nodosum* at the Lawrenny Quay and Pembroke Power Station monitoring locations in the Milford Haven estuary which is concerning and warrants further

investigation. This decline was not large enough to fail the abundance, distribution and species composition of communities indicator for intertidal reefs, and the indicator was therefore passed. However, the indicator failed with high confidence for subtidal reefs due to a 50% decrease in mean thickness of cushion and crustose sponge and a small decrease in circumference and height for the mermaid's glove *Haliclona oculata* at Warrior site. In addition, two out of five reef sampling sites (Warrior and Beggars Reach) for the subtidal reef-associated communities showed a change over time, suggesting possible disturbance (Jackson-Bué et al., 2025c).

The ASM feature overlaps with approximately 5% of the estuaries feature. The species composition of the communities indicator for the condition assessment of the ASM feature was assessed as unknown (Jackson-Bué et al., 2025a).

Maerl

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

Subtidal benthic communities

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

Seagrass

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

for *Z. marina* to be light limited at the monitoring site (Unsworth et al., 2017). Epiphytes on *Z. marina* have decreased by 39% since 1999, and wasting disease has increased by approximately 387% since 1999 (Bertelli, 2021a, 2021b). Compared to other sites surveyed in Wales, wasting disease and algae cover was significantly higher in Littlewick Bay. It has been concluded that there may be a system shift from a seagrass dominated to macroalgae-dominated community in Littlewick Bay (Bertelli, 2021a), and reports indicate the seagrass is under light and nutrient stress in the Milford Haven estuary for the majority of the year (Unsworth et al., 2017). There are other known beds of *Z. marina* within the Milford Haven estuary (e.g. in Dale and Angle Point), however long-term data are not available for these other beds of the subtidal seagrass therefore their condition is unknown.

Fish

Although fish within the estuaries are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the estuaries feature. Both the allis and twaite shad, and river and sea lamprey features have been assessed as being in unfavourable condition in Pembrokeshire Marine SAC (Wynter et al., 2025a, 2025b) This was not deemed enough alone to fail the indicator for the estuaries feature because these species represent a small component of the estuarine fish community. In addition to this, shad and lamprey indicator failures were related to wider populations or upstream issues, which are not relevant for the estuaries feature.

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

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

Operational monitoring of fish impingement and entrainment is carried out at Pembroke Power Station's cooling water intake system in the Milford Haven estuaries feature. Further monitoring of the fish community of the Milford Haven commissioned by the operators of the Pembroke Power Station includes subtidal trawls, intertidal seine nets and ichthyoplankton sampling. From the operational monitoring programme data and analysis, decreases, and a negative trend, in impingement numbers of numerous species within the fish community have been observed. The species in question include clupeids, gobies, gadoids, flatfish and sandeels and form over 80% of the recorded impingement abundance. A similar decreasing trend in fish catches was observed in the subtidal trawls. Data from the intertidal seine nets showed variable results with an overall increase in

marine juvenile and estuarine resident species in summer but low abundance in winter catches and no trend was observed for the icthyoplankton community composition, which remained similar throughout the monitoring period (A. Scorey (NRW), pers. comm.). Further investigation is needed into the fish community abundance and structure across the Milford Haven estuaries feature.

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

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

Invasive non-native species

There has historically been a high number of NNS in the Milford Haven estuary. *C. fornicata* has been recorded in various locations within the SAC for many years. The species has been found in superabundant aggregations across various intertidal and subtidal habitat types within the Milford Haven estuary (Figure 11) (Bohn, 2012; 2014), and natural habitats within the estuary have changed where the species dominates (M. Camplin (NRW), pers. comm.). Although no recent survey for *C. fornicata* has been carried out, this species has been found in large numbers during habitat monitoring activities.

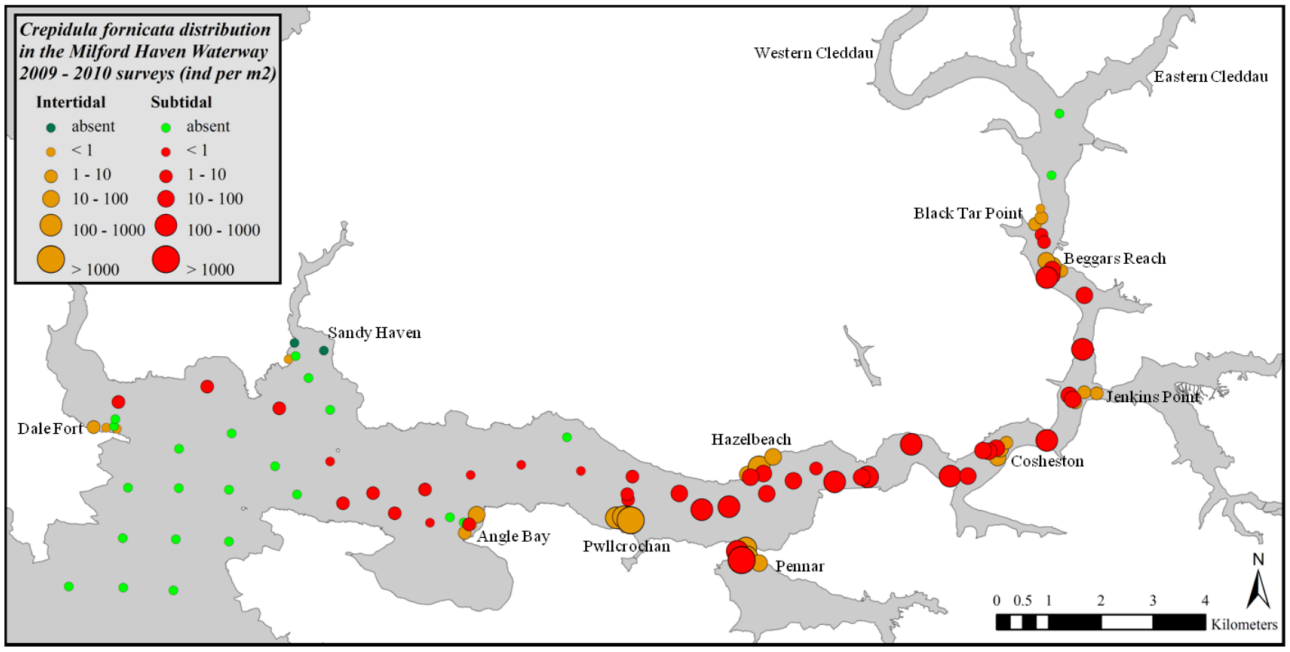
The species has also been found within the maerl bed in the Milford Haven estuary, which may have a potential smothering effect on the maerl (Mercer et al., 2025). Given the high density of *C. fornicata*, including its presence in sensitive habitats (i.e. maerl) and its impact on natural habitats within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

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

Other NNS are known to be present in Pembrokeshire Marine SAC, within the estuaries feature. The large brown kelp wakame *Undaria pinnatifida* has been recorded in the Milford Haven estuary since 2014. First found in 2016, the red ripple bryozoan *Watersipora subatra* has been recorded in large areas in Dale at Jetty Beach in 2023 (Mieszkowska and Sugden, 2023, 2024). *W. subatra* is also known from South Hook Point and Pembroke Power station. Records of the San Diego sea squirt *Botrylloides diegensis* initially

discovered in 2014 has also been found at Pembroke Power station, Pembroke Dock and Neyland (Wood et al., draft). The other NNS previously recorded in the estuaries feature or nearby are the siphoned Japan weed *Dasysiphonia japonica*, pom-pom weed *Caulacanthus ustulatus (okamurae)* and fanworm *Ficopomatus enigmaticus.* The purple fan worm *Bispira polyoma* has been found for the first time in 2023 in the SAC but it is not within the estuaries feature. The spread and full extent of the impact of the NNS recorded in the estuaries feature are currently unknown.

Figure 11. Densities of *Crepidula fornicata* in intertidal and subtidal sites in the Milford Haven estuary, surveyed in 2009 and 2010 (Bohn, 2012).



Reasons for target failure

The assessment of the estuaries feature in the Pembrokeshire Marine SAC failed seven primary targets, three secondary targets, and one tertiary target. All associated failures are localised within Milford Haven estuary, the largest estuary of the three within the SAC. This resulted in the feature to be assessed as being in **unfavourable** condition. The failing indicators and reasons for failure, if known, are stated below.

Distribution and extent of habitats and communities

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

Sediment composition and distribution

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

Sediment quality: carbon

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

Sediment quality: contaminants

This indicator target has a primary weighting. Levels exceeding sediment quality guidelines of PAH compounds and heavy metals have been recorded in sediment samples within the SAC. Contaminants with levels above the more stringent ecological guidelines in some of the most recent sampling years were benzo(g,h,i)perylene, anthracene, benzo(a)anthracene, fluoranthene, mercury and TBT. Various other contaminants including metals had concentrations above the less stringent guidelines in the most recent years of sampling. Investigations into the sources of these contaminants, and the full impact on the feature have not been carried out.

Water quality: nutrients (DIN only)

This indicator target has a primary weighting. Three WFD waterbodies that overlap with the Milford Haven and Solfach estuaries (Milford Haven Inner and Outer, and Solfach Estuary) had failing levels of DIN. The Milford Haven Inner and Outer waterbodies overlap with the largest proportion of the feature. These were classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations. Failure of the supporting water quality elements opportunistic macroalgae in the Milford Haven Inner waterbody further supports the nutrient issues present in this waterbody.

The WFD investigation reports have confirmed elevated nutrients in these waterbodies, where it was concluded that major input of nutrients is likely to be derived from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021a; Lock, 2021b). Further investigation is required to determine the breakdown of nutrient sources from specific agricultural practices and activities into the catchments. Point source continuous sewage discharge from the water industry was confirmed as minor source of nutrients linked to the DIN failures (Haines and Edwards, 2016; Caprez, 2020; Lock, 2021a; Lock, 2021b). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

Abundance, distribution and species composition of communities

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

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

Invasive non-native species; non-native species

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

The failure of the tertiary NNS target is due to the recent arrival of *D. vexillum* within the last six years in the estuaries feature. The full extent of the impact that this species, along with other NNS present within the SAC, may have on the condition of the feature is currently unknown.

A biosecurity plan for INNS has been developed for the SAC. The objective is to manage the key pathways by which marine INNS are introduced and spread at the SAC level through the use of good biosecurity.

Sediment quality: oxidation-reduction profile (redox layer)

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

Water quality: opportunistic macroalgae

This indicator target has a secondary weighting. The Milford Haven Inner waterbody was classified as Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. This waterbody overlaps with a large proportion of the estuaries

feature in the SAC. The WFD investigation report confirmed the opportunistic macroalgae failure in this waterbody. Major input of nutrients was found to be from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021a). In addition, point source continuous sewage discharge from the water industry were confirmed as a major source of nutrients linked to the opportunistic macroalgae failure, but only a minor source for the DIN failure (Haines and Edwards, 2016; Caprez, 2020; Lock, 2021a). Intermittent and domestic sewage are also suspected in the catchment. Further investigation locally is required to confirm these.

Water quality: contaminants

This indicator target has a secondary weighting. One WFD waterbody that overlaps with the Milford Haven estuary (Milford Haven Inner) had failing levels of chemicals. It was classified with fail for chemicals due to PBDE and PAH. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). PAHs can be produced through natural processes, but also arise from anthropogenic sources, for example during combustion of fossil fuels and organic material (Webster and Fryer, 2022).

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

Threats to condition

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

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

Unconsented infrastructure

New unconsented infrastructures 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 been found close to the SAC, in Nevern. This species is not currently within the estuaries feature, but has the potential to establish quickly in shallow

soft-bottomed bays and estuaries and have a detrimental impact on the feature as seen in the Carmarthen Bay and Estuaries SAC (see further detail in section 3.1).

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

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

Water quality: contaminants

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

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

Management of coastal defences

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

Climate change

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

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

- Changes in ocean acidification.
- Changes in species distribution.

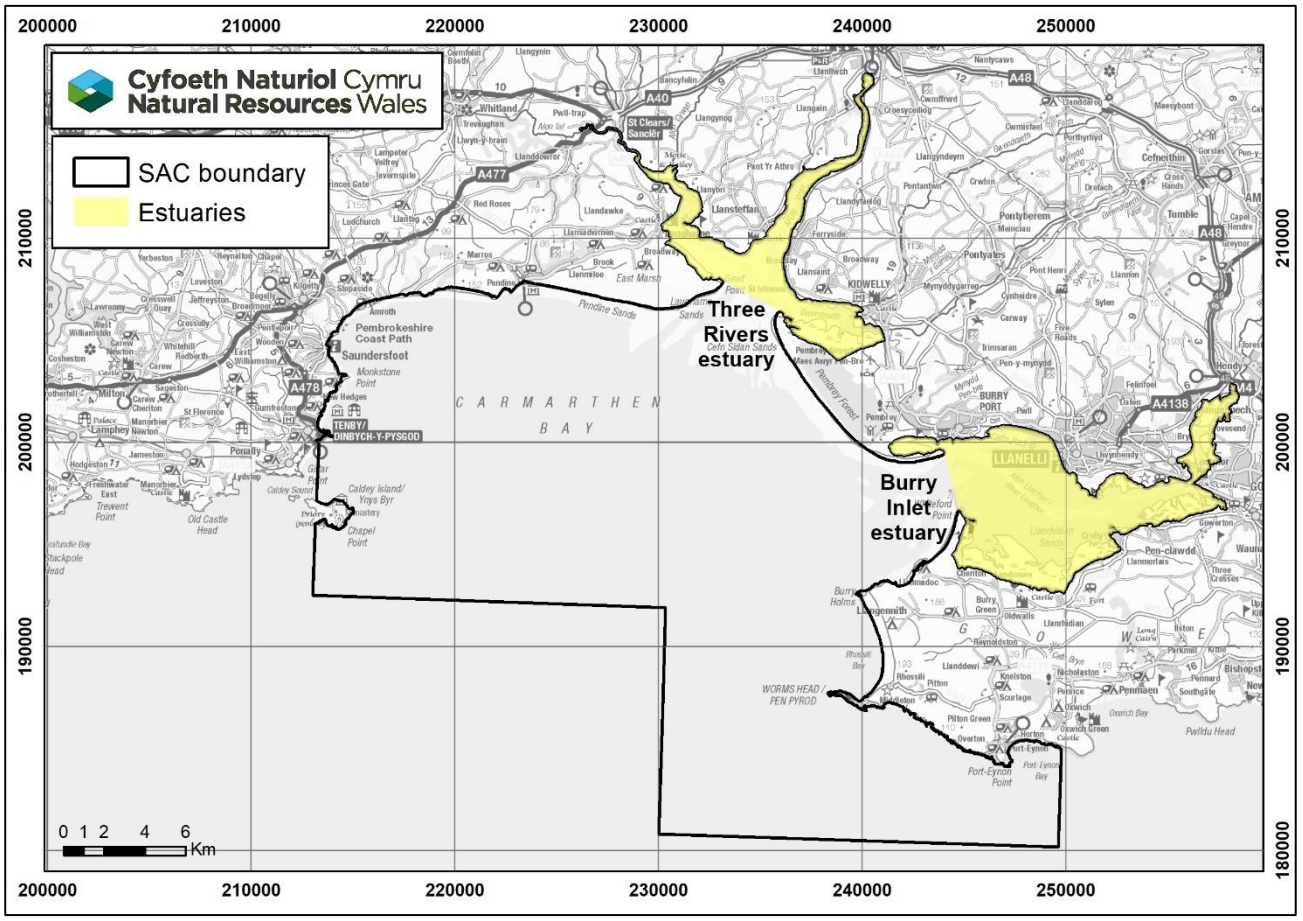
Further threats are associated with the nested features and can be found in the relevant feature reports.

- Recreational access and collection (Jackson-Bué et al., 2025b; 2025c)
- Seabed disturbance (Jackson-Bué et al., 2025c)

3.4. Carmarthen Bay and Estuaries SAC condition assessment

The estuaries feature in the Carmarthen Bay and Estuaries SAC comprises two estuaries, the Three Rivers estuary complex (Tywi, Taf and Gwendraeth) and Loughor estuary commonly called the Three Rivers and Burry Inlet estuaries (Figure 12). The condition assessment was completed using information specific to estuaries in combination with any available data on the nested designated features contained within the estuaries feature.

Figure 12. Map of the estuaries feature in Carmarthen Bay and Estuaries SAC.



The estuaries feature in this SAC includes the nested features: mudflats and sandflats and Atlantic salt meadows (ASM). Estuarine fish communities were only broadly considered due to resource limitations but there is some information included in the detailed assessment section. Each estuary has been assessed separately for each indicator and then combined to produce a single target assessment outcome for the indicator. Table 11 has a summary of the assessment outcome. This outcome and reasons for failure are discussed in more detail in the sections below.

Table 11. Condition assessment of estuaries 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 extent of estuaries within the SAC, allowing for natural change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the extent of estuaries in the 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 of the feature	Maintain the distribution of the estuaries within the SAC, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution of estuaries in the Carmarthen Bay and Estuaries SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of estuarine habitats and communities, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the distribution and extent of habitats and communities of estuaries and its nested features in the Carmarthen Bay and Estuaries SAC. • There are some concerns about overgrazing and spread of *G. vermiculophylla* within the nested habitat features in the estuaries that could impact the distribution and extent of habitats and communities. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment composition and distribution	Maintain composition and distribution of sediment granulometry across the estuaries, allowing for natural change and variation. (P)	• Granulometric analysis of core samples in the condition assessment of the mudflats and sandflats feature in the Burry Inlet and Three Rivers estuaries indicated little variation in sediment composition across the monitoring period. However, there was a sudden and unexplained 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 Gwendraeth and 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
Sediment quality: oxidation-reduction profile (redox layer)	No decrease in the depth of the redox layer from the surface that is considered detrimental to estuarine infaunal communities, allowing for natural change and variation. (S)	• This assessment uses the results of the condition assessment from the mudflats and sandflats feature as a proxy as there were no other data available. The redox layer profile of the monitored mudflats and sandflats indicated no clear trend over the years. • Confidence is low because additional sampling is needed to improve temporal resolution and data continuity, which are required to understand ongoing processes and confirm overall trends.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Sediment quality: organic carbon content	No increase to the organic carbon content considered detrimental to infaunal communities, allowing for natural change. (P)	• Sediment sampling in the SAC has been assessed using sediment grab sample data at 22 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. • In the Taf, the intertidal habitat is highly variable within a small area, therefore repeat sampling is difficult. • For this reason and as there were only three years of data, the confidence is low.	**Fail**	Low
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 22 stations in the Three Rivers estuary (2015, 2018 and 2021). • Contaminants were below the most stringent guidelines in 2021 in all locations. • 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. • The impact of the sediment contaminants on the estuaries feature is not fully understood. In addition, there were only three years of data. This, and as there were some contaminants above the less stringent ecological guidelines caused the confidence in the assessment to be low.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Morphological equilibrium	Maintain the characteristic physical form and flow of the estuary, allowing for natural change and variation. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the morphological equilibrium of estuaries in the Carmarthen Bay and Estuaries SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Topography of the feature	No significant anthropogenic impacts to the small or large scale topography of the estuaries. (S)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the topography of estuaries in the Carmarthen Bay and Estuaries SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• Since designation in 2004, there are no anthropogenic impacts known to have significantly affected the hydrodynamic and sediment transport processes of the feature. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence

Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Burry Inlet estuary comprises 68% of the feature, and Three Rivers estuary 32%.
		• Two WFD waterbodies overlap with the Burry Inlet estuary.
		  ○ The Burry Inlet Outer waterbody was Good status for DIN in the 2024 cycle 3 interim classification. This is an improvement from Moderate status in the 2021 cycle 3 classification. It overlaps with 55% of this estuary (38% of the whole feature).
		  ○ The Burry Inlet Inner waterbody was Moderate status for DIN. This waterbody overlaps with 17% of this estuary (12% of the whole estuaries feature).
		• One WFD waterbody overlaps with the Three Rivers estuary, which was Moderate status for DIN in Cycle 3 (Three Rivers Estuary). This waterbody overlaps with 70% of this estuary (22% of the whole feature).
		• WFD investigations have confirmed nutrient issues and / or biological responses in phytoplankton, however due to the improvement in the Burry Inlet Outer waterbody, confidence has been reduced to medium.
			Fail	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)	Within the SAC, Burry Inlet estuary comprises 68% of the feature, and Three Rivers estuary 32%. • Both WFD waterbodies in the Burry Inlet estuary were Moderate or Poor status for phytoplankton in the 2024 cycle 3 interim classification. Combined, these waterbodies overlap with 72% of this estuary (49% of the whole feature). • The WFD waterbody in the Three Rivers estuary was classified with a Good status for phytoplankton (Three Rivers Estuary). This id an improvement from Moderate status in the 2021 cycle 3 classification. It overlaps with 70% of the Three Rivers estuary (22% of the whole feature). • Confidence is medium due to the improvement in Three Rivers Estuary waterbody.	**Fail**	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)	Within the SAC, Burry Inlet estuary comprises 68% of the feature, and Three Rivers estuary 32%. • None of the 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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (P)	Within the SAC, Burry Inlet estuary comprises 68% of the feature, and Three Rivers estuary 32%. • All three WFD waterbodies that overlap with the feature have been classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is medium due to samples being taken from the surface of the waterbody which may not detect issues for more demersal habitats within the estuaries feature.	**Pass**	Medium
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	Within the SAC, Burry Inlet estuary comprises 68% of the feature, and Three Rivers estuary 32%. • All three WFD waterbodies that overlap with the feature have a pass for chemicals in the 2024 cycle 3 interim classification. However, some or all of the chemicals have not been classified in the 2024 cycle 3 interim classification and were rolled forward from previous cycles. • Confidence is medium due to the rolled forward classifications.	**Pass**	Medium
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (P)	• There are limited data on turbidity for the estuaries feature in the Carmarthen Bay and Estuaries 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)	• All three overlapping WFD waterbodies were classified as Good or High status for the IQI WFD element in the 2024 cycle 3 interim classification. Combined, these waterbodies represent 71% of the feature. • The abundance, distribution and species composition of communities indicator in the condition assessment of the nested mudflats and sandflats feature passed its target. This feature overlaps with 54% of the estuaries feature. • Analysis of grab sampled infaunal communities within the Three Rivers estuary showed high variability in communities during the monitoring period and the causes remain uncertain. • The species composition of communities indicator in the condition assessment of the ASM feature was assessed as unknown due to limited data and resources. Overgrazing, however, is widespread within the ASM feature and is likely to impact the species composition. This feature overlaps with 31% of the estuaries feature. • There have been no confirmed records of allis shad in the Carmarthen Bay and Estuaries SAC and population numbers are thought to be very low. A large reduction of twaite shad returning to the River Severn was also observed. Both river and sea lamprey are common and widespread in the estuaries feature. • Confidence is low as there is limited information on the ASM feature, which overlaps with 31% of the estuaries feature, and there are some concerns with the low abundance of shad species and the lack of fish communities data.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• The establishment of *Gracilaria vermiculophylla* within the last six years has been notably rapid in the Burry Inlet estuary. • This INNS causes sedimentation change and alterations to the topography of the mudflats and sandflats, and is changing mudflat into muddy habitats or mussel beds. It is likely to affect the cockle and mussel fisheries in the area. • Currently the species is impacting only a small proportion of the estuaries feature. Therefore confidence in the assessment is low.	**Fail**	Low
Non-native species (NNS)	No increase in the number of introduced NNS by human activities. (T)	• *G. vermiculophylla* has been recorded in the Burry Inlet estuary within the last six years, where the establishment has been notably rapid compared to other areas. • There have been targeted INNS surveys as part of the MarClim project and ad-hoc records from the NRW Habitats Regulations monitoring. • Confidence is high due to the arrival of NNS within the last six years, and good availability of records.	**Fail**	High

Assessment conclusions

The estuaries feature in Carmarthen Bay and Estuaries SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of indicators with failing targets (Table 12). There were also limited or absent data for two key indicators to inform on the condition of the feature (see evidence gaps section 4). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 12 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 12. Summary of the condition assessment for estuaries 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)	• There has been an increase in carbon content in sediments in various stations, especially in the river Taf. • High nutrient levels have been recorded in the Burry Inlet Inner and Three Rivers Estuary waterbodies. • There has been rapid establishment of *G. vermiculophylla* in the Burry Inlet, which has started to alter the habitat present in the mudflats and sandflats. • Phytoplankton failed in the two Burry Inlet waterbodies.	• Unconsented infrastructure • INNS • Fly ash • Sediment quality: contaminants • Water quality: contaminants • Overgrazing • Management of coastal defences • Climate change

Detailed assessment information

Extent and distribution

Extent and Distribution of the feature

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

Distribution and extent of habitats and communities

Grazing pressure within the SAC could possibly have an impact on the saltmarsh distribution and would be something to pay close attention to in the next assessment (Jackson-Bué et al., 2025a). In addition, the presence of *G. vermiculophylla* within the Burry Inlet has altered the type of habitat to become more muddy (see further detail in Invasive Non-Native Species). There is a need to fully understand the impact this species is causing on the mudflats and sandflats and the estuaries feature as a whole and if the change will be permanent. Evidence from WFD data of seagrass showed fluctuations in *Z. noltei* extent especially in the Burry Inlet Outer waterbody. Some decrease in extent of *Z. noltei* habitat in part of the Burry Inlet estuary resulted in a Moderate status in the two latest WFD classifications, but this is likely due to natural change (Jackson-Bué et al., 2025b).

The indicator was assessed as passing the target but with a medium confidence as it was assessed by expert judgment and as there is an expansion of *G. vermiculophylla* and concerns about grazing.

Sediments

Composition and distribution

Sediment composition has been monitored within the mudflats and sandflats habitat and the subtidal sediments in the main channel within the estuaries feature. The granulometric analysis of the sediment core samples in the mudflats and sandflats habitat in the Burry Inlet and Three Rivers estuaries indicated little variation in sediment composition across the monitoring period. However, there was a sudden unexplained coarsening of sediments in 2019 across all stations (Jackson-Bué et al., 2025b). Further investigation into the cause of this coarse sediment spike is needed.

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 the Gwendraeth with significant fluctuation in silt content (<63 µm) between monitoring years which are a concern. In addition, significant decreases in silt content were observed in a few stations in the 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 investigations.

Overall, the sediment composition and distribution indicator met its target as changes seen 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.

Oxidation-reduction profile (redox layer)

For the redox layer indicator, only sediment data in the mudflats and sandflats feature were available. The mudflats and sandflats feature in the SAC overlaps with approximately 54% of the estuaries feature. It was therefore deemed acceptable to use the mudflats and sandflats condition assessment as a proxy for the redox layer indicator. The indicator met the target but with low confidence as further sampling is required to enhance the robustness and completeness of the dataset, especially important for assessing the redox layer (Jackson-Bué et al., 2025b).

Organic carbon content and contaminants

The assessment of the organic carbon content and contaminants indicators within the Three Rivers estuary used data from NRW Habitats Regulations monitoring sediment sampling at 21 sites in the Three Rivers estuary (Tywi, Taf and Gwendraeth) in 2015, 2018 and 2021. There are no data available on carbon content in the Burry Inlet estuary.

Carbon content has increased over the monitoring period (Figure 13). This is especially notable in the Taf (Figure 13b). 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 from 0.25% to 1.65% at another location (Figure 13b). The carbon levels are not as high as those in Pembrokeshire Marine SAC (maximum of 3.8% in the Milford Haven estuary), 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 are some stations where the carbon content has decreased over the three monitoring years. In the Tywi, two stations with three years of data have decreased (stations Tywi 12 and Tywi 15) (Figure 13a). These stations are in the middle of the central channel. In the Taf, one station (Taf 1) decreased in carbon content over the monitoring period (Figure 13b). This station is the most upstream station in the central channel.

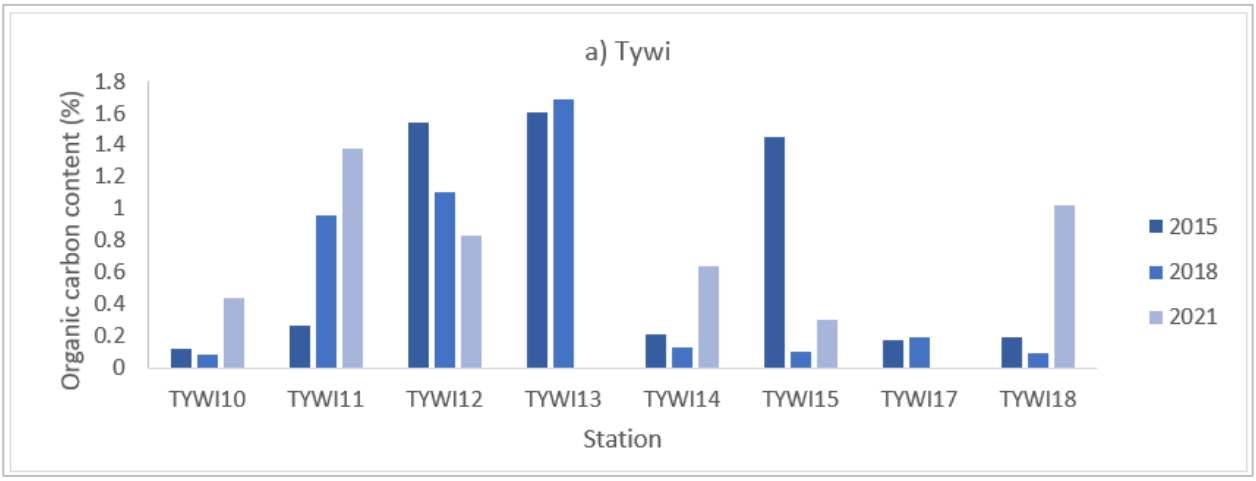
Such increases in carbon content are typically related to agricultural practices (e.g. slurry runoff). This may therefore provide support for evidence of nutrient issues within the Three Rivers estuary (see further detail in the water quality section). The organic carbon content indicator failed to meet the target due to the substantial increases in carbon in some locations in the Three Rivers estuary, especially in the Taf. However, the confidence was reduced to low as the intertidal habitat in the Taf is highly variable within a small area, which makes repeat sampling difficult. In addition, because there were only three years of data available from the sampling.

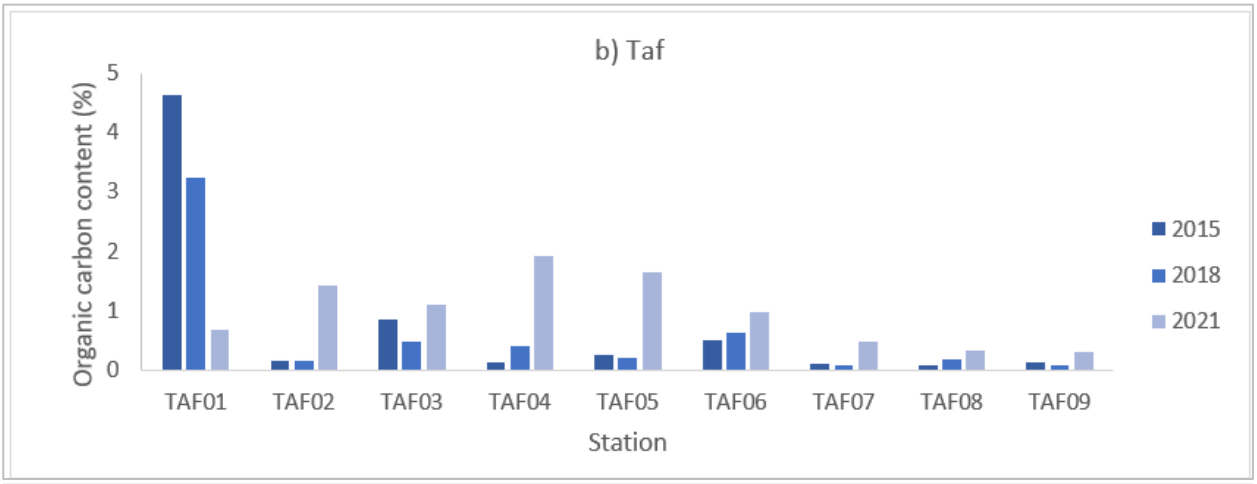
Within the Burry Inlet estuary, there are no available monitoring data on sediment contaminants. However, there may be some residual contamination present as a result of

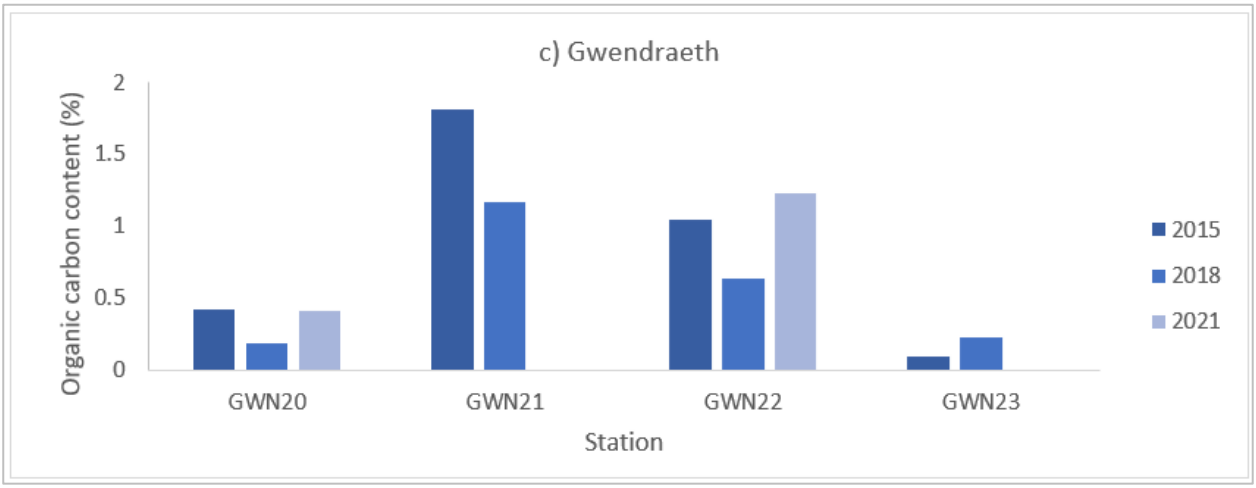
the Llangennech freight train derailment and diesel spill that occurred higher up in the estuary in 2020. There was a large spike in hydrocarbons from the spilled diesel at that location, and high levels at some locations further seaward. The biological impact of the spill at the top of the estuary was 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).

For the Three Rivers estuary data, the concentrations of chemical contaminants were compared against various ecological quality guidelines as outlined in section 3.3. The contaminants were below the most 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 more stringent guidelines. The impact of the contaminants to the estuaries feature is not fully understood. In addition, 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.

Figure 13. Average carbon content (±S.E.) from sediment grab samples in 2015, 2018 and 2021 in Carmarthen Bay and Estuaries SAC. Samples from 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).







Morphological equilibrium, topography and hydrodynamic and sediment transport processes

The morphological equilibrium, topography and hydrodynamic and sediment transport processes are not well researched. These targets passed with medium confidence based on the knowledge that there are currently no anthropogenic activities known to have had significant impact on the feature and its nested features since designation in 2004. The freshwater flow indicator could not be assessed due to limited resource.

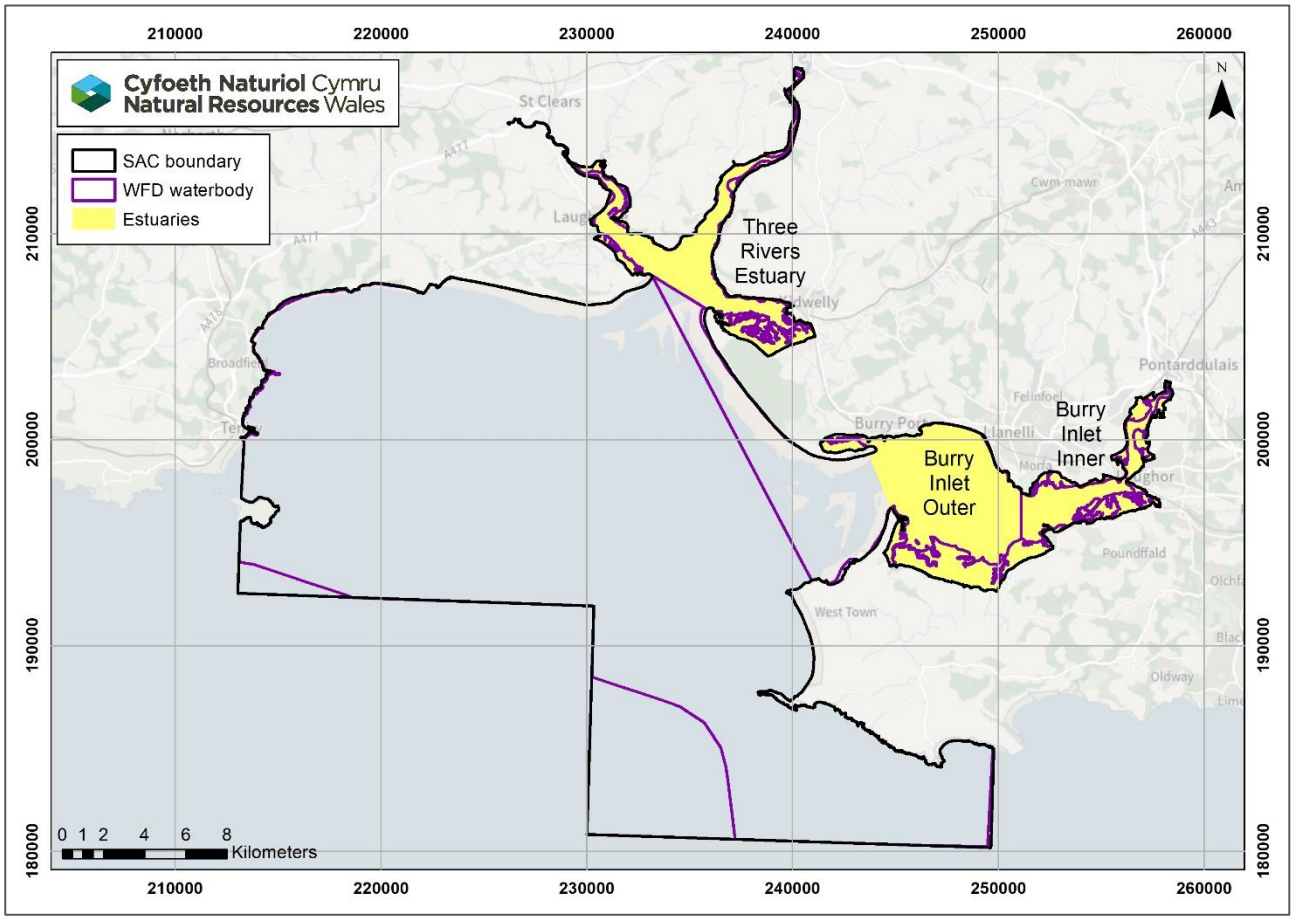
Water quality

It has been estimated that 97% of the estuaries feature falls within four WFD waterbodies (Table 13, Figure 14). These are likely to be a good reflection of the overall effect of water quality on the feature. The Burry Inlet estuary comprises 68.4% of the estuaries feature by area, and the Three Rivers estuary comprises 31.6%

Table 13. Designated estuaries within the Carmarthen Bay and Estuaries SAC and the WFD waterbodies that overlap.

Estuary	WFD waterbody	Degree of overlap across indv. estuary (%)	Degree of overlap across the estuaries feature (%)
Burry Inlet	Burry Inlet Outer	54.86	37.50
Burry Inlet	Burry Inlet Inner	16.84	11.50
Three Rivers	Three Rivers Estuary (Tywi & Taf & Gwendraeth)	70.13	22.20

Figure 14. Map of the WFD waterbodies that overlap with the estuaries feature within Carmarthen Bay and Estuaries SAC.



Nutrients (DIN only)

The Burry Inlet estuary comprises two WFD waterbodies: the Burry Inlet Outer waterbody and the Burry Inlet Inner waterbody (Table 13). The Burry Inlet Outer waterbody was previously Moderate status 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 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, 2021b). The second overlapping WFD waterbody, the Burry Inlet Inner waterbody was classified with a

Moderate status for DIN in the 2024 cycle 3 interim classification. The DIN failure was confirmed by the 2021 WFD investigation report (Jones, 2021c). 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 Three Rivers estuary comprises one WFD waterbody: the Three Rivers Estuary waterbody (Table 13). This waterbody was classified with a Moderate status for DIN in the 2024 cycle 3 interim classification. The DIN failure in this waterbody was confirmed by the 2021 WFD investigation report (Jopson and Newman 2021).

The nutrients indicator (DIN only) failed to meet the target as high levels of DIN have been recorded within waterbodies in both estuaries in the SAC. The confidence in the fail was reduced to medium due to the improvement in DIN in the Burry Inlet Outer waterbody.

Phytoplankton

Both WFD waterbodies that overlap with the Burry Inlet estuary had failing classifications for the phytoplankton element in the 2024 cycle 3 interim classification. The Burry Inlet Outer waterbody was classified with a Moderate status, and the Burry Inlet Inner waterbody with a Poor status. Combined, these waterbodies overlap with 72% of the Burry Inlet estuary (49% of the whole estuaries feature) (Table 13). These waterbodies have had a Moderate or worse status in all cycles. The WFD investigation reports for these waterbodies confirmed the phytoplankton failures in 2021 (Jones, 2021b; Jones, 2021c).

Within the Three Rivers estuary, the one relevant WFD waterbody (Three Rivers Estuary) was Good status for phytoplankton in the 2024 cycle 3 interim classification. This is an improvement from Moderate status in the 2021 cycle 3 classification and cycles prior to this. The previous failure was confirmed in the 2021 WFD investigation report (Jopson and Newman, 2021).

Overall, the phytoplankton indicator failed to meet the target due to the failing WFD waterbodies in the Burry Inlet estuary. The confidence in the fail was reduced to medium because there has been improvement in the Three Rivers Estuary waterbody, meaning the issues are localised to the Burry Inlet only.

Opportunistic macroalgae

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

Dissolved oxygen

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

Contaminants

The contaminants indicator met its target as all three WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification. However, some or all of the chemicals were not classified in the 2024 cycle 3 interim classification and were rolled forward from previous WFD cycles. This caused the confidence to be reduced to medium.

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 three overlapping WFD waterbodies were classified as Good or High status for the IQI element in the 2024 cycle 3 interim classification (Burry Inlet Outer, Burry Inlet Inner and Three Rivers Estuary). Combined, these waterbodies represent 71% of the feature.

The mudflats and sandflats feature overlap with 54% of the estuaries feature. The condition assessment for the mudflats and sandflats feature concluded that the abundance, distribution and species composition of communities meets the criteria for a pass. 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). Some concerns were raised, however, on the impact of mussel removal on infauna, the uncertainties around the moving river channel in Llansteffan, and large shifts observed in communities composition from the grab sample analysis in the Three Rivers estuary (Jackson-Bué et al., 2025b). Some additional stations within the main river channel outside of the mudflats and sandflats feature but within the estuaries feature were analysed and indicated similar patterns. Overall, there are some concerns as the observed large shifts at these stations may not be natural.

Given the observed water quality issues within the Three Rivers estuary and the large shift seen in species composition at these stations, there are concerns that require further investigation. 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.

The Atlantic salt meadows (ASM) feature overlaps with 31% of the estuaries feature. The condition assessment for the ASM feature shows that the species composition of the communities indicator was assessed as unknown due to limited data and available resources. However, evidence of overgrazing is widespread across the SAC and this is likely to have an impact on the species composition of the ASM feature (Jackson-Bué et al., 2025a).

Although fish within the estuaries are an important part of the community, there are limited data and resources to conduct analysis on fish communities for the estuaries feature. Both allis and twaite shad feature have been assessed as being in unfavourable condition in Carmarthen Bay and Estuaries SAC (Wynter et al., 2025a, 2025b). This was not deemed enough to fail the indicator for the estuaries feature because these species represent a small component of the estuarine fish community. In addition, shad indicator failures were related to the wider populations, not necessarily relevant for this feature. Both river and sea lamprey feature have been assessed as being in favourable condition in Carmarthen Bay and Estuaries SAC as they are widespread in the region. Data from wider Irish sea level studies such as International Council for the Exploration of the Sea (ICES) are difficult to relate to the assessment of condition at the SAC and feature level and some species that have been assessed by ICES may not even occur at the individual SAC level. However, populations of various larger-bodied bony fish species in the Irish Sea, such as bass, cod, herring, whiting, plaice and pollack, have declined in recent years (ICES, 2024a, 2024b, 2024c, 2024d, 2024e, 2024f). While there are limited data on the status of other species, the depletion of a number of larger, higher trophic level predatory species in the Irish Sea may have shifted the structure of the wider fish community to an overall lower trophic level with fewer larger predatory fish species. None of the WFD waterbodies that overlap with the estuaries feature in the SAC have been assessed using the fish tool in the 2024 cycle 3 interim classification.

Overall, the abundance, distribution and species composition of communities indicator has passed its target but with low confidence due to uncertainties around the mudflats and sandflats community changes; the overgrazing likely to impact the vegetation composition of the ASM feature; and the concerns with the low abundance of shad species and the lack of fish communities data for the estuaries feature.

Invasive non-native species

G. vermiculophylla has rapidly established in the Burry Inlet (Loughor estuary) across the mudflats (Mercer and Brazier, 2023; Jackson-Bué et al., 2025b). 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. The rapid establishment of *G. vermiculophylla* has resulted in a fail for both the primary and tertiary targets for the INNS and NNS indicators, but with varying confidence. Currently, the extent is thought to be limited to the Loughor estuary and is therefore affecting under 5% of the SAC, resulting in low confidence for the primary target of the INNS indicator. The confidence for the tertiary target of the NNS indicator is high due to the new NNS recorded in the estuaries feature within the last six years.

G. vermiculophylla species has the capacity to spread to other areas and there is a need to better understand the spread and impact of this species. This has been highlighted in the NRW marine evidence needs. *C. fornicata* was found at Burry Port within the estuaries feature in 2008 but there has been no other record since.

Reasons for target failure

The assessment of the estuaries feature in the Carmarthen Bay and Estuaries SAC failed three primary targets, one secondary 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.

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. Two WFD waterbodies that overlap with the Burry Inlet and Three Rivers estuaries (Burry Inlet Inner and Three Rivers Estuary) had failing levels of DIN. 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 2021c; 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 WFD waterbodies (Jones 2021c; 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; non-native species

Both the primary INNS and tertiary NNS 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 within the estuary. The issue is currently limited to the Burry Inlet, but the species may spread to other areas in the future. Investigation into the management of spread of this species has not been done widely (Maggs and Magill, 2014). Targeted surveys of the species and investigation into its impact are required. 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. The WFD waterbodies that overlap with the Burry Inlet estuaries feature were classified with a Moderate and Poor status for the phytoplankton element in the 2024 cycle 3 interim classification. 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). The failure is only relevant to the Burry Inlet as the phytoplankton in the Three Rivers Estuary waterbody has improved.

Threats to condition

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

Activities that go through licencing and permission processes e.g. dredging whereby the impact of the activity on the feature would be assessed have not been included. The threats to the estuaries feature condition in the 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 Three Rivers estuaries 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 estuaries feature as PFAS has been shown to bioaccumulate in marine species, increasing up the trophic levels (Khan et al., 2023). However, the biological impact of PFAS on marine species is not well understood.

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

Overgrazing

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

Additionally, sheep grazing and the subsequent wash-off of faecal material from the intertidal saltmarsh may result in episodic events of high bacteria concentrations. A high number of grazing sheep can result in poor water quality, even several kilometres from the grazed marsh (e.g. Burry Inlet).

Management of coastal defences

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

Climate change

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

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

4. Evidence gaps for the estuaries 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. There are additional evidence gaps concerning the nested features, which can be found in the relevant condition assessment reports. Not all evidence gaps apply to every SAC, see Table 14 for details.

Table 14. Evidence gaps for the estuaries 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
Freshwater inputs (P)	Not assessed	• The freshwater flow indicator could not be assessed in all SACs due to limited resource. There are data available on abstractions and flow levels in estuaries therefore this is something that should be used in future condition assessments.
Sediment composition and distribution (P)	Not assessed	• There is no sediment monitoring within the Anglesey Coast: Saltmarsh SAC.
Sediment quality: organic carbon content (P); contaminants (P)	Not assessed / unknown / low confidence	• Currently, there is no sediment monitoring within the Anglesey Coast SAC. • Within the Pen Llŷn a'r Sarnau SAC, the sediment monitoring ceased in 2015. These data were deemed to be out of date and there are no recent data available. • This indicator was assessed with a low confidence in the Carmarthen Bay and Estuaries SAC as there were some contaminants above the less stringent ecological guidelines. This will be something to pay attention to in the next condition assessments.

Indicator	Assessed status	Comments
Abundance, distribution and species composition of communities (P)	Not assessed / low or medium confidence	• There is currently no NRW Habitats Regulation monitoring in the estuaries of Anglesey Coast: Saltmarsh SAC. Some information can be derived from the IQI WFD element in the 2024 cycle 3 interim classification but currently there are insufficient data to use for this assessment. • Fish communities were broadly discussed for all SACs using reports including ICES data. Although these reports provide an indication of fish numbers, they have certain limitations. The large area covered makes it unsuitable for estuaries or individual SAC. More data would be required to adequately assess fish communities in estuaries. • Further analysis on the life histories of species that are driving the observed changes in the infaunal community in the Pembrokeshire Marine and Carmarthen Bay and Estuaries SACs, 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.
Invasive non-native species (P)	Low confidence (limited data)	• The spread and impact of the NNS currently present on the estuaries feature at all of the SACs are not fully understood. More targeted surveys and investigation on the impact of NNS on estuaries are needed. • Investigation into the use of satellite and or aerial imagery for assessing the extent of *G. vermiculophylla* may be beneficial.
Sediment quality: oxidation-reduction profile (redox layer) (S)	Not assessed / low confidence (limited data)	• Currently, there is no sediment monitoring within 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 hard to confirm any trend. A larger spatio-temporal dataset is required to fully understand what is happening for all SACs. • There is widespread evidence of opportunistic macroalgae in Pembrokeshire Marine SAC, which can lead to anoxia in sediments. Quantification of the redox layers beneath opportunistic macroalgae would be required to strengthen the assessment conclusions.

Indicator	Assessed status	Comments
Water quality: phytoplankton (S)	Unknown	• A large proportion of WFD waterbodies that overlap with the estuaries feature in Anglesey Coast: Saltmarsh and Pen Llŷn a'r Sarnau SACs have not been classified for phytoplankton WFD element in the 2024 cycle 3 interim classification, leading to an unknown assessment. Some WFD waterbodies are not assessed for phytoplankton due to the nature of the waterbodies.
Water quality: opportunistic macroalgae (S)	Unknown	• None of the WFD waterbodies that overlap with the estuaries feature in Carmarthen Bay and Estuaries SAC have been classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification, leading to an unknown assessment. 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 and Carmarthen Bay and Estuaries SACs. • Further evidence in temperature changes is required to adequately assess this indicator in 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.

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