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Condition Assessments for Coastal Lagoons in Welsh Special Areas of Conservation

Report No: 894

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Pickleridge Lagoon. © Kate Lock (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 morlynnoedd neu lagynau 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 morlynnoedd neu lagynau mewn ACAau ledled Cymru

Lleoliad y nodwedd ACA	Asesiad cyflwr	Hyder yn yr asesiad
Bae Cemlyn	Anffafriol	Uchel
Pen Llŷn a'r Sarnau	Anffafriol	Isel
Sir Benfro Forol	Anffafriol	Uchel

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 coastal lagoons within designated special areas of conservation (SACs) across Wales. 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 coastal lagoons in SACs across Wales

SAC feature occurs in	Condition assessment	Confidence in assessment
Cemlyn Bay	Unfavourable	High
Lleyn Peninsula and the Sarnau	Unfavourable	Low
Pembrokeshire Marine	Unfavourable	High

1. Introduction

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

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

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

1.1. Assessment process

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

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

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

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

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

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

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

2. Feature description

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

Annex I coastal lagoons are areas of shallow, coastal salt water, wholly or partially separated from the sea by sandbanks, shingle or, less frequently, rocks. Lagoons show a wide range of geographical and ecological variation. Five main sub-types have been identified in the UK as meeting the definition of the Annex I habitat type and are listed below. More information on each sub type can be found on the JNCC website.

1. Isolated lagoons - separated completely from the sea by a barrier of rock or sediment.
2. Percolation lagoons - normally separated from the sea by shingle banks.
3. Silled lagoons - water is retained at all states of the tide by a barrier of rock (the 'sill').
4. Sluiced lagoons – natural movement of water between the lagoon and the sea is modified by artificial structures, such as a culvert under a road or valved sluices.
5. Lagoonal inlets – seawater enters the inlet on each tide and salinity is usually high.

The water in lagoons can vary in salinity from brackish (i.e. dilution of seawater by freshwater) to hypersaline (i.e. more salty than seawater as a result of evaporation). The biological communities of lagoons vary according to the physical characteristics and salinity regime of the lagoon, leading to significant differences between sites. Compared to other marine habitats, there is usually only a limited range of species present which are especially adapted to the varying salinity of lagoons, with some unique to lagoon habitats.

Coastal lagoons are a relatively uncommon habitat in the UK and are defined as a priority habitat within the habitat regulations. Priority habitats are those that are particularly vulnerable and are mainly found within Europe.

3. Coastal lagoons condition assessments

This section contains condition assessments for all designated coastal lagoons in Welsh only marine ardal cadwraeth arbennig (ACA) / special areas of conservation (SAC). The feature is designated in three SACs. Table 2 lists the lagoons found in each SAC. Where there are multiple lagoons within a SAC all lagoons form part of the feature.

Table 2. Coastal lagoons in their designated sites in Wales.

SAC	Lagoon name and subtype
Bae Cemlyn / Cemlyn Bay	Cemlyn Bay lagoon (sluiced)
Pen Llŷn a`r Sarnau / Lleyn Peninsula and the Sarnau	Morfa Gwyllt lagoon (percolation)
Sir Benfro Forol / Pembrokeshire Marine	Pickleridge lagoon (silled) Carew Castle millpond (sluiced) Neyland Weir pool (silled)

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

There are five coastal lagoons across three SACs in Wales. Three lagoons are in the Pembrokeshire Marine SAC which together make up the coastal lagoons feature. In this case each lagoon has been assessed individually then brought together to give an overall assessment for the lagoons feature itself.

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 each assessment.

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

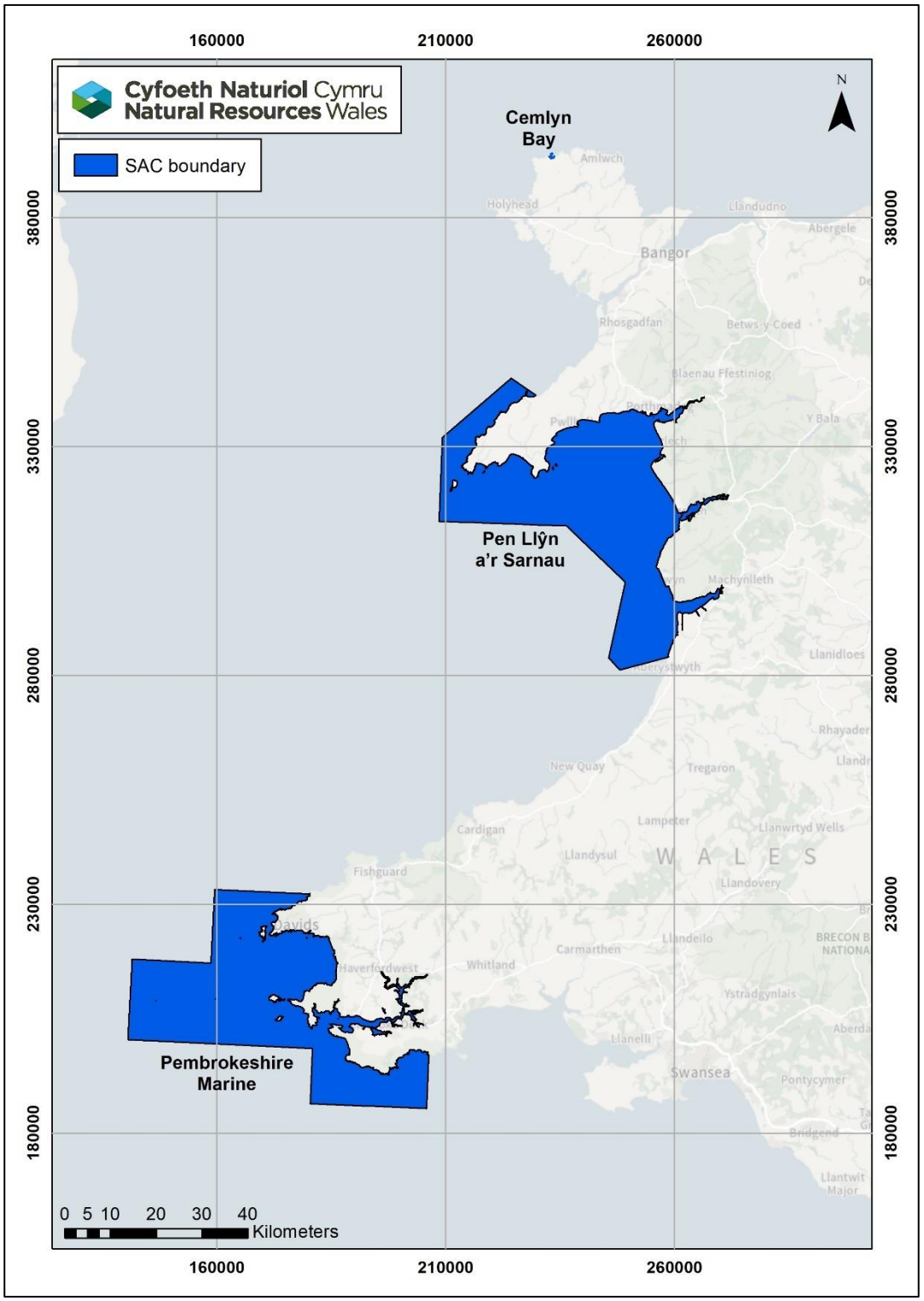
- 2009 cycle 1 classification
- 2015 cycle 2 classification
- 2018 cycle 2 interim classification
- 2021 cycle 3 classification

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

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

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

Figure 1. Location of SACs assessed for the coastal lagoons feature.



3.1. Cemlyn Bay SAC condition assessment

The coastal lagoons feature in Cemlyn Bay SAC is comprised of a single lagoon located on the Island of Anglesey (Figure 2). The lagoon is separated from the sea with a shingle ridge and sluice built over the narrow channel at the western end. Monitoring data collected between 2006-2021, with both net sweep and grab sampling surveys, together with other relevant evidence has been used to assess the performance indicators.

Figure 2. Map of the coastal lagoons feature in Cemlyn Bay SAC.

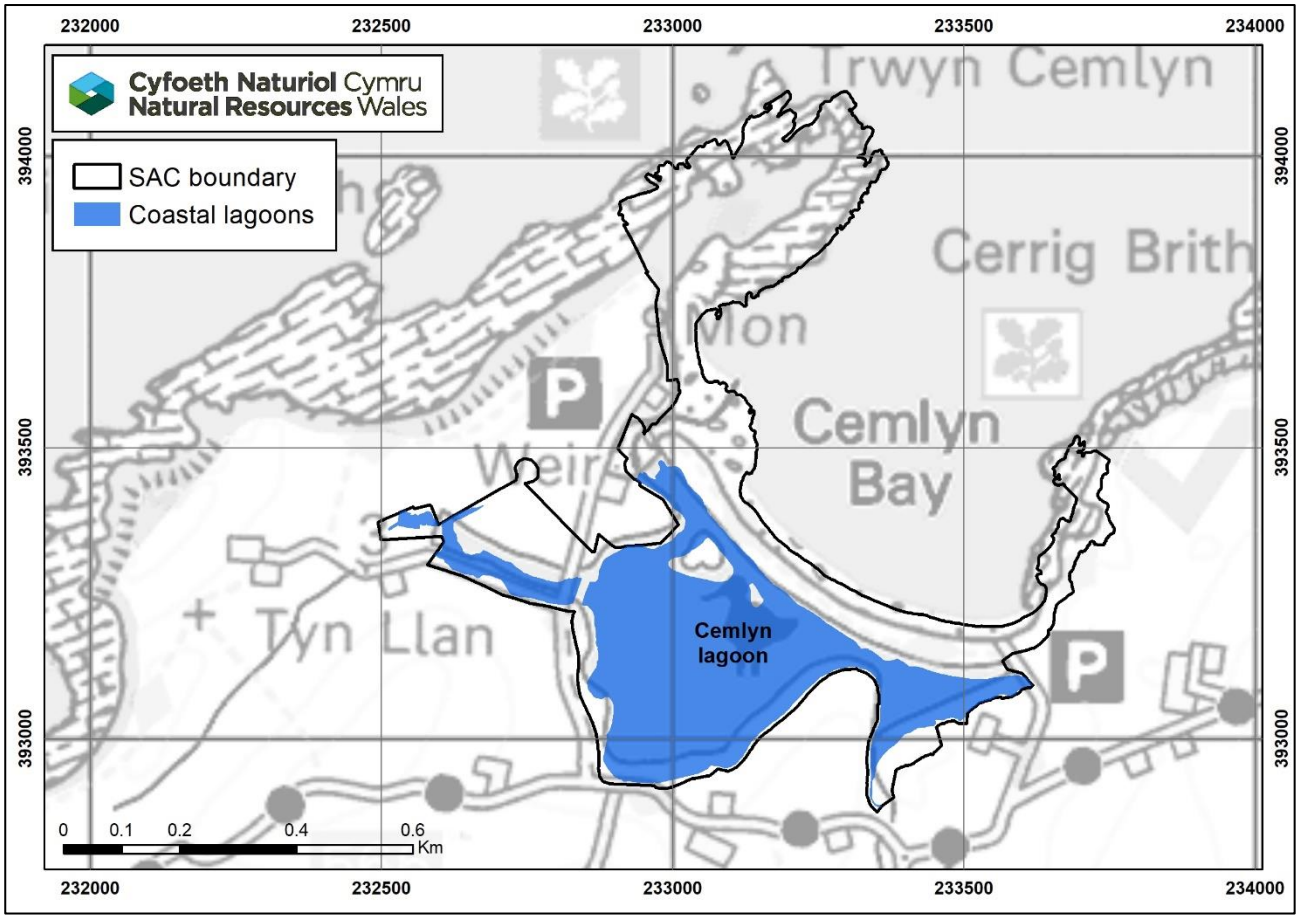


Table 3 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the sections below.

Table 3. Condition assessment of Cemlyn Bay Lagoon. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of coastal lagoon within the SAC, allowing for natural change and variation. (P)	• Extent, determined from aerial imagery, indicates an apparent loss of 727 m^2 between 2000-2022. • The most notable loss of extent is at the northern end of the shingle barrier. It is estimated that 630 m^2 has been lost between 2000-2022 due to the barrier encroaching westward into the lagoon and makes up most of the extent lost. • This is not considered to be a significant loss to extent and within natural variation. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High
Shape of lagoon	Maintain the shape of coastal lagoon, subject to natural change and variation. (P)	• The shape of the lagoon has been determined from aerial imagery. • Very shallow wetting pools beyond the western lagoon extend into the neighbouring field. These areas are clearly drying parts of the lagoon and are subject to seasonal changes. The shingle barrier has also encroached westwards into the lagoon by 4-5 m. • These small changes are considered natural and the shape of the lagoon across the SAC remains broadly consistent. • Confidence is high due to the availability of long term aerial imagery.	**Pass**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Isolating barrier integrity	No loss in integrity of any of the lagoon isolating barriers, allowing for natural change and variation. (P)	• Waves over topping the barrier in stormy conditions over the last 20 years has caused a lowering of the shingle ridge along the western section. All Wales light detection and ranging (LiDAR) data shows the over topped areas are approximately 0.8 m lower than the natural mean height of the barrier. • The reduction in barrier height is not considered significant. The barrier currently has good integrity. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Integrity of lagoon banks	No loss in integrity of any of the lagoon's banks, allowing for natural change and variation. (S)	• Nearby livestock have been impacting bank integrity through grazing and trampling. • A vegetation survey by the National Trust in 2016 shows that several of the feeder streams to the lagoon are used by livestock, and are causing heavy poaching of the banks, reducing vegetation cover. • The integrity of the lagoon banks has been significantly compromised. • Confidence in the fail is high as damage to the banks was still evident in 2023.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Angiosperms (*Ruppia*)	No loss of *Ruppia* extent from the lagoon, allowing for natural change and variation. (P)	• A 2019 aquatic macrophyte survey of Tyn Llan pool to the West of Cemlyn's main lagoon showed that both Beaked Tasselweed *Ruppia maritima* and Spiral Tassleweed *Ruppia cirrhosa* (syn. *R. spiralis*) were present and formed a major component of the submerged macrophyte community. • There are historical records of *Ruppia* spp. in the main lagoon, though no recent surveys have confirmed if presence in the main pool has been maintained. This caused the confidence to be medium.	**Pass**	Medium
Species composition of communities	No modification of the expected composition of lagoon communities, allowing for natural change and variation. (P)	• Monitoring data has been collected between 2006-2021. Community analysis found a clear change in community composition in recent years (2016-2021). This relatively large change can be seen across all 3 sampling stations in the lagoon. • This shift has been driven by a decline in the gastropod *Ecrobia ventrosa*, a lagoon specialist, and increases in more opportunistic species. • Confidence is high due to the significant shifts toward opportunistic species seen in recent years which are strongly indicative of environmental disturbance.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Abundance of lagoon specialists	Maintain the abundance of lagoon specialist species, allowing for natural change and variation. (P) List of species for the SAC: *Cerastoderma glaucum, Chaetomorpha linum, Conopeum seurati, Ecrobia ventrosa, Gammarus chevreuxi, Gammarus insensibilis, Idotea chelipes, Monocorophium insidiosum, Ruppia maritima.*	• There were no concerns for the following lagoon specialists. ○ *Monocorophium insidiosum* abundance has varied greatly throughout the monitoring period. ○ *Idotea chelipes* was recorded in low numbers by grab samples but high numbers by sweep net surveys in 2015. • Declines in the following species are cause for concern, based on medium confidence data collected between 2006-2021. ○ *Ecrobia ventrosa* has seen significant declines in abundance since 2016. The decline has been consistent across all sampling stations. ○ *Gammarus chevreuxi* and *G. insensibilis* have not been recorded in sweep net surveys since 2013. ○ *Cerastoderma glaucum* was recorded previously in low numbers (typically 4-8 per m^2). There have been no recent records, despite additional effort to specifically search for it. • Other species have not been sampled in recent years but are hard to detect with standard survey methods. ○ *Conopeum seurati* was recorded previously in 1998 and 2000, and in the sweep net survey in 2014. It has not been recorded since 2017. ○ *Chaetomorpha linum* has not been recorded since 2013. • Confidence is medium due to inadequate sampling method and the boom-and-bust nature of some populations making drawing any conclusion difficult.	**Fail**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Species richness and diversity	Maintain the expected richness and diversity of lagoon species, allowing for natural change and variation. (P)	• Analysis of monitoring data collected between 2006-2021 showed changes in species diversity which were within the expected range of natural variation. • However, there was a decline in species richness in recent years (2016-2021) across all three sampling stations. There has also been a significant decline in the abundance of species at each sampling station. • The decline is potentially linked to water quality, but more investigation is needed. • Confidence is medium as it is not clear what has caused the decline in species richness.	**Fail**	Medium
Taxonomic spread of species	Maintain the expected taxonomic spread of lagoon species, allowing for natural change and variation. (P)	• Analysis of monitoring data showed a high mix of taxonomic diversity across the dataset. • However, there was a low number of taxa in 2021. This, together with declining species richness (see above), suggests there could be a decline in taxonomic spread of species in years to come. • This caused the confidence in the pass to be low.	**Pass**	Low
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• There is no evidence to suggest that INNS are spreading into the lagoon or impacting its condition. • Confidence is medium as the impacts of INNS present within the feature are not well understood.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Non-native species (NNS)	No increase in the number of introduced non-native species (NNS) by human activities. (T)	• There has been no increase in NNS species introduced to the lagoon within the last six years. • Confidence is high due to the availability of long term monitoring data.	**Pass**	High
Sediment composition and distribution	Maintain the composition and distribution of sediment granulometry across the lagoon, allowing for natural change and variation. (P)	• Principal component analysis (PCA) showed a shift in sediment composition, with coarse sediment shifting to finer sediments over the years (2006-2021). This can be a natural shift for a lagoon. • However, the rate of recent change (silt increase) is a concern. This caused the confidence to be low. No significant relationship was detected between sediment composition and abundance of macrofaunal community.	**Pass**	Low
Water depth	Maintain the expected depth of water within the lagoon, allowing for natural change and variation. (P)	• Water depth in the lagoon is managed via sluice gates. Stop logs reduce the peak flow of seawater into the lagoon in summer to protect the nesting tern colony. • Water depth has been measured sporadically since 2010 and seems to be stable (possible declines in recent years). • Confidence is medium due to a lack of consistent data and natural water depth variability creating uncertainty.	**Pass**	Medium

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Presence of materials and debris of anthropogenic origin	Anthropogenic material should not be having a detrimental impact on coastal lagoon. (S)	• Anthropogenic materials and debris have not been surveyed in a targeted way but have been counted or weighed as part of the infaunal surveys since 2017, though not consistently. • Microplastic counts took place in 2016 and 2019-2021. • Confidence is low as it is difficult to determine trends due to the short term and sporadic dataset. Large amounts of debris or microplastics have not been seen in available monitoring data.	**Pass**	Low
Water quality: nutrients (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)	• The Cemlyn Lagoon waterbody was classified with a Bad status for the DIN WFD element in the 2024 cycle 3 interim classification. • The adjacent WFD waterbody, the Skerries, has not been classified for the DIN WFD element in any cycles. • Confidence is high due to the recent monitoring within the lagoon.	**Fail**	High

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• Neither of the WFD waterbodies that input water into the Cemlyn lagoon have been classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. • There have been direct observations of nuisance algae growth in the lagoon every year since 2020. • Confidence is high due to the observed extent of the macroalgae cover in the lagoon in recent years.	**Fail**	High
Water quality: contaminants	Water column contaminants not to exceed the environmental quality standards (EQS). (S)	• Both of the relevant WFD waterbodies were not classified as the chemicals have not been assessed within the last six years (Cemlyn Lagoon and Skerries). • There is no monitoring of chemicals within the lagoon itself. This indicator was therefore assessed as unknown.	**Unknown**	N/A
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the coastal lagoons feature in Cemlyn Bay SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (P)	• Temperature and salinity loggers within the lagoon showed no concerning changes. • Confidence is medium as there are large gaps in the data series as the loggers have not been recording continuously due to technical issues. In addition, only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.	**Pass**	Medium

Assessment conclusions

The coastal lagoons feature in Cemlyn Bay SAC (Cemlyn) has been assessed as being in **unfavourable** condition (high confidence). There were a number of failing indicators (Table 4). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

A summary of the assessment can be seen in Table 4 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 4. Summary of the condition assessment for the coastal lagoons feature in Cemlyn Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Indicator failures	Reason for indictor failures	Threats to condition
Cemlyn Bay	**Unfavourable (high confidence)**	Species composition of communities (P) Abundance of lagoon specialist species (P) Species richness and diversity (P) Water quality: nutrients (DIN only) (P) Water quality: opportunistic macroalgae (S) Integrity of lagoon banks (S)	• There has been a decline in the lagoon specialist *E. ventrosa* and increases in opportunistic species. • There are high nutrient levels in the Cemlyn Lagoon waterbody. • There is growth of opportunistic macroalgae within the lagoon. • Livestock is damaging bank integrity.	• Marine litter • Increased siltation • Water quality: contaminants • Climate change

Detailed assessment information

Extent and shape

The extent and shape of the lagoon has remained relatively stable over the monitoring period. Initial extent analysis showed a decrease of 727 m^2 between 2000-2022, equating to a 0.45% loss. Storm waves breaking over the top of the shingle barrier have washed down shingle into the lagoon. This is most pronounced at the northern end of the barrier and has changed the perimeter line in this area inwards by 4-5 m. This inward encroachment equates to a 630 m^2 loss of lagoon extent, accounting for most of the overall loss seen. These losses are relatively small and have been attributed to natural change. The shape of the lagoon across the SAC also remains broadly consistent. The extent and shape of lagoon indicators were therefore assessed as meeting their targets with a high confidence.

Lagoon barrier and banks

Cemlyn lagoon is isolated from the sea by the shingle ridge. Storm waves have over topped this ridge, but it still has good integrity and is currently functioning as a barrier. The isolating barrier integrity indicator target was therefore met with a high confidence. Although the barrier has good integrity, there is a lack of data and concerns over its long-term security. Surveying the ridge itself for change would improve assessment of this indicator. There is an expectation that as climate change brings about increased storminess and sea level rise, over topping events will occur more frequently. This will eventually result in a catastrophic breach of the barrier unless it is managed. The area of low-lying coast cliff retaining the sea from the field above Tyn Llan is also eroding and is thought to be a potential breach area in the future.

The banks of the lagoon on the landward side have been judged to lack integrity, causing the integrity of lagoon banks indicator to fail its target with a high confidence. Several areas of the banks of the lagoon have been identified as being affected by livestock from neighbouring fields. Several of the retaining field boundaries around the lagoon are compromised. A vegetation survey by the National Trust in 2016 showed livestock using feeder streams to the lagoon are heavily poaching the banks, reducing vegetation cover (A. Lewis (NRW), pers. comm.), particularly by the stream to the south and the shallow pools to the west. Lack of vegetation can increase runoff and livestock can cause the banks to erode. A project between NRW and the National Trust was carried out in 2022. The aim was to re-establish fences around field boundaries, completely excluding the cattle from the lagoon. Feeding stations and water troughs were moved to the centre of the field to limit cattle proximity to the lagoon and reduce trampling of the banks. The field near the western end of the lagoon that often gets wet has been fenced off to stop grazing. The National Trust have excluded stock from the majority of the feeder streams on their land (A. Lewis (NRW), pers. comm.), and also plan on planting more apple trees and hedges to create a more permanent buffer. While it is felt appropriate management has been carried out, it will take time to see if these measures are effective in allowing the banks to recover and regain integrity.

Species and communities

The angiosperms (*Ruppia*) within the Cemlyn lagoon were assessed as part of a 2019 aquatic macrophyte survey of Tyn Llan pool in the west of the main lagoon. This survey found that both Beaked Tasselweed (*Ruppia maritima*) and Spiral Tassleweed (*Ruppia cirrhosa* (syn. *R. spiralis*) were present and formed a major component of the submerged macrophyte community. The angiosperms indicator therefore met its target but confidence was reduced to medium as there are no routine surveys of *Ruppia*. There is a threat that the opportunistic macroalgae present in the lagoon (see below) could restrict light availability to the *Ruppia* species.

Cemlyn lagoon failed to meet indicator targets for species composition of community, species richness and diversity and abundance of lagoon specialists. Failure of these indicators suggests there has been a decline in lagoon condition that is impacting the species present.

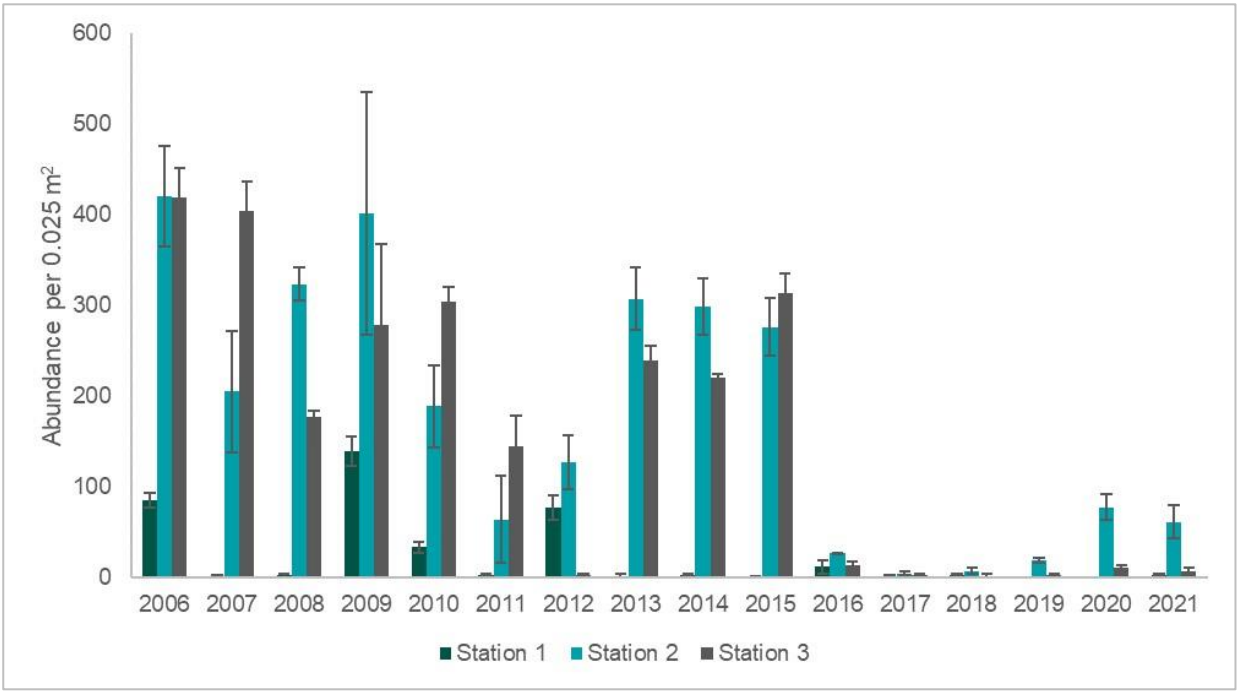
Community composition, species richness and taxonomic spread

Analysis showed a relatively large shift in community composition since 2016. This shift has been driven by a decline in the Spire snail *Ecrobia ventrosa*, a lagoon specialist, and increases in more opportunistic species (i.e. smaller body sizes and shorter life spans). *E. ventrosa* was the most abundant lagoon specialist at Cemlyn with high densities in the past, before starting to decline in 2016 as seen in Figure 3. Confidence in the fail is high due to the significant shifts toward opportunistic species seen in recent years, which are strongly indicative of environmental disturbance.

Analysis of species richness and diversity also revealed a decline over time at all three sampling stations. Species abundance was significantly lower in 2016-2021 compared to 2006-2015. The decline in species richness caused the species richness and diversity indicator to fail its target. Confidence was reduced to medium as it is not certain what has caused the decline, however it may be related to water quality. Observations of algal mats in recent years has prompted a water quality investigation. Nutrient levels were found to be very high (see below). It is possible that algal blooms resulting from high nutrients have negatively impacted the species richness and abundance. The sinking and subsequent decay of dying algal blooms can result in anoxic conditions on the surface of sediments which can lead to benthic biota death.

While the taxonomic spread indicator was deemed to meet its target, the data suggested there has been a decline in recent years. This caused the confidence in the taxonomic spread of species indicator to be reduced to low. The potential decline in taxonomic spread may be related to the decline in species richness, and may be further evidence of disturbance and loss of biodiversity within the lagoon.

Figure 3. Declines of the Spire snail *Ecrobia ventrosa* at Cemlyn lagoon. Mean (± Standard Error) abundance of *E. ventrosa* per 0.025 m^2 from grab surveys between 2006 and 2021 (5 grabs per station).



Lagoonal specialists

Other lagoon specialists besides *E. ventrosa* have also declined in abundance over the monitoring period. The amphipods *Gammarus chevreuxi* and *G. insensibilis* have not been recorded in sweep net surveys since 2013. The lagoon cockle *Cerastoderma glaucum* was recorded previously, up to 2007, in low numbers, but has not been recorded recently. This is despite additional targeted surveys to specifically search for the species.

Two lagoon specialists, the spaghetti algae *Chaetomorpha linum* and bryozoan *Conopeum seurati* have also not been observed in recent years. *C. linum* has not been recorded since 2013 (further surveys in 2014, 2015 and 2019). *C. seurati* has not been recorded since 2017. Both species are hard to sample with grab and sweep net methods. *C. seurati,* for example, is an encrusting bryozoan commonly inhabiting pebbles on the lagoon floor making them unlikely to be sampled. This means *C. seurati* and *C. linum* may be present and not being picked up by monitoring. While it is a concern that these species have not been recorded in recent years, it is not certain that they have been lost from the lagoon. The abundance of other lagoon specialists, such as the amphipod *Monocorophium insidiosum* and the isopod *Idotea chelipes*, varied greatly depending on the sampling methods and throughout the monitoring period, making it difficult to draw conclusions. These caused the confidence of the abundance of lagoon specialists indicator to be medium.

Invasive non-native species

Monitoring between 2006-2021 found some non-native species (NNS) present in Cemlyn lagoon. However, numbers recorded have been very low. The sand gaper *Mya arenaria*, a non-native species originating from America, was first recorded in the Cemlyn lagoon in 1998 and consistently in grab surveys since 2013. The overall mean abundance of this

species from sweep net surveys over the monitoring period was low, with a high abundance in 2014, but just one record in 2015, and no records in 2019.

Two further NNS have been recorded over the monitoring period of 2006-2021. The Ponto-Caspian freshwater hydroid *Cordylophora caspia* is a non-native freshwater hydroid that originates from the Black Sea. Presence of *C. caspia* has been recorded in the 2017 pre-term raft survey but not in the grab or sweep net surveys. The Jenkins' spire snail *Potamopyrgus antipodarum* is a freshwater mud snail that originates from New Zealand. It was only recorded in small numbers in 1998, with no records of the species since.

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

It is not fully understood how some of these species may spread and impact the condition of the coastal lagoons feature, and effects on the species diversity and composition have not yet been observed.

As there is no current impact from the invasive non-native species (INNS) present the primary target of the INNS indicator passed. Confidence is medium as the impacts of the NNS present within the feature are not well understood.

Sediments, depth and anthropogenic litter

While both the sediment composition and distribution, and water depth indicators met their targets, analysis showed some concerns. Sediments have been shifting from coarser sediments to finer silts over the period of 2006-2021. This can be a natural progression for a lagoon, however the rate of siltation at Cemlyn in recent years has been rapid. As there is no obvious anthropogenic impact the target passed but the confidence was reduced to low due to concerns over the increased rate of siltation seen. A similar scenario was seen with water depth. From the data available, the water depth appears to be stable, though there is evidence of slight declines in recent years. The lack of continuity in water depth data, combined with natural variability in water depth makes it difficult to determine if the recent decline is an issue. Therefore, the indicator has passed but with medium confidence.

The presence of materials and debris of anthropogenic origin indicator met its target. As there has not been a large amount of debris or microplastics found in available monitoring data, anthropogenic material was considered as not having a detrimental impact on the condition of the lagoon. However, there have not been targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This reduced the confidence to low. A longer dataset and appropriate sampling design is required for temporal analysis as well as dedicated analysis of plastics.

Water quality

There is one WFD waterbody that overlaps with the lagoon feature. This is the Cemlyn Lagoon waterbody, which overlaps with 97% of the lagoon by area. This is likely to be good reflection of the overall effect of water quality on the feature. Cemlyn is isolated from the sea by the shingle ridge, but receives some water from the adjacent WFD waterbody,

the Skerries, which was used as part of the water quality: contaminants indicator assessment.

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

In the 2024 cycle 3 interim classification, the Cemlyn Lagoon waterbody was classified with a Bad status for the DIN element. This caused the nutrients (DIN only) indicator to fail with a high confidence as the monitoring has been done within the lagoon itself. The adjacent WFD waterbody, the Skerries, has not been classified for the DIN element in any cycles.

The nutrient levels in the lagoon could possibly have been elevated for a long time due to excrement from the breeding tern colony nesting on islands in the lagoon. Terns have been recorded nesting at Cemlyn for over 40 years but there has been no evidence collected to support this.

The opportunistic macroalgae indicator was assessed as failing to meet its target with high confidence due to observations of opportunistic macroalgae since 2020 (Figure 4). There were no reports of nuisance algae prior to 2020, suggesting new inputs of nutrients are increasing levels to a point that produces a biological response.

Neither of the relevant WFD waterbodies have been classified for the phytoplankton element in the 2024 cycle 3 interim classification. Therefore, this indicator could not be assessed. Classification of some WFD waterbodies are not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels).

Figure 4. Algal mats at Cemlyn lagoon in 2020.

Contaminants

The contaminants indicator has been assessed as unknown as the two relevant WFD waterbodies were not classified as the chemicals have not been assessed within the last six years.

Turbidity and physicochemical properties

The turbidity indicator was assessed as unknown due to insufficient data.

Temperature and salinity loggers in the lagoon did not indicate any concerning changes over the sample period therefore the physicochemical properties indicator met its target. Medium confidence has been attributed to the pass as the loggers in the lagoon have not been recording continuously due to technical issues, and as there are some gaps in the data series. In addition, only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future. The salinity, temperature, and water level in Cemlyn are closely linked to tidal and meteorological parameters, the degree of runoff into the lagoon, and the presence of the weir at the seaward entrance of the lagoon. Any changes in the runoff entering the lagoon, e.g. through artificial diversion or blocking of drainage ditches and streams, could tip the delicate balance of seawater and freshwater inputs to result in either a mainly fresh or mainly saltwater lagoon.

Reasons for target failure

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

Species composition of communities

This indicator failed to meet its primary target due to a significant shift in community composition in recent years (2016-2021). The shift has been driven by declines in the once abundant lagoon specialist *E. ventrosa* and increases in short lived, opportunistic species. The shifts in community composition are indicative of disturbance in the lagoon ecosystem, although it is not clear what is causing this disturbance. The declines may be related to the high level of nutrients and opportunistic macroalgae growth within the lagoon. However, further investigation will be needed to understand the reason for this failure and allow management measures to be implemented.

Abundance of lagoon specialist species

This indicator failed to meet its primary target due to significant declines in some of the specialist lagoon species. Of the nine specialist lagoon species seven have seen declines. Some of these such as *G. chevreuxi*, *G. insensibilis, C. linum* and *C. seurati* may be due to not being easy to detect with current sampling methods and locations, or the boom-and-bust nature of some populations. More targeted investigations to find these species should be carried out. In the case of *E. ventrosa* and *C. glaucum*, it is certain that these species have seen real and significant declines. *E. ventrosa*, a once abundant gastropod in the lagoon has declined significantly since 2016. The lagoon cockle *C. glaucum* seems to

have disappeared from Cemlyn lagoon, with an absence of records of the species during targeted surveys in recent years. From the evidence it is not yet clear what is driving the declines of these lagoon specialists. Declines may be due to water quality issues, as high levels of nutrients and algae have been recorded. However, further investigation will be needed to understand the reason for this failure and to allow management measures to be implemented.

Species richness and diversity

This indicator failed to meet its primary target due to a significant decline in species richness and abundance in the years 2016-2021 compared to years 2006-2015. Declines in species richness can indicate a change in environmental conditions. While taxonomic spread was deemed to meet its target, the data suggested there has been a decline in recent years. If this trend continues it would be further evidence for disturbance and loss of biodiversity within the lagoon. As with previous indicators these declines may be linked to the water quality issues in the lagoon, but it is not yet clear what is driving the declines of species richness and abundance and further investigation is needed.

Water quality: nutrients (DIN only)

This indicator failed to meet its primary target as the WFD waterbody that overlaps with the Cemlyn lagoon was classified with a Bad status for the DIN element in the 2024 cycle 3 interim classification (Cemlyn Lagoon waterbody).

The nutrient levels in the lagoon could possibly have been elevated for a long time due to excrement from the breeding tern colony nesting on islands in the lagoon. Terns have been recorded nesting at Cemlyn for over 40 years but there has been no evidence collected to support this. However, the reports of nuisance macroalgae have only been reported since 2020, suggesting new inputs of nutrients are increasing levels to a point that produces a biological response. Other sources of nutrients are most likely coming from agricultural land use in the surrounding area. Cattle are grazed in the fields surrounding the lagoon. Though management is now in place to prevent them getting close to the lagoon itself, runoff will still be an issue. There are also concerns of the impact of waste spreading on land adjacent to the lagoon. It is likely some point source pollution from leaking sewage is occurring, as large quantities of kiwi and tomato seeds have been found in grab samples (C. Lindenbaum, pers. comm.).

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target as a large accumulation of green algae has been observed in the lagoon since 2020. The large algae mats present are a result of high levels of nutrients in the lagoon and are now considered to be abundant enough to have a detrimental impact (see above).

Integrity of lagoon banks

This indicator failed to meet its secondary target due to bank integrity being significantly impacted by cattle from neighbouring farmland. Trampling and poaching of vegetation have led to bank erosion and instability in many areas. Management measures have been put in place to deal with this issue. Fencing has been erected to prevent cattle from accessing the banks; feed stations have been moved to keep cattle away; and trees are being planted to create natural long lasting buffer zones around the lagoon. It is hoped that

with this management in place the integrity of the lagoon banks can start to recover. The level of recovery will not be clear until the next condition assessment.

Threats to condition

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

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

Marine litter

Marine litter (e.g. microplastics) are increasing and could threaten condition.

Increased siltation

Increasing levels of silt in the lagoon can lead to decreases in water depth, increased turbidity (limiting light and clogging feeding apparatus) and change substrata, which can negatively impact those species that require less silty environments.

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

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

Climate change

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

- Increased storminess which will put pressure on the barrier through over topping events and storm wave damage.
- Coastal squeeze from sea level rise will increase flooding events on high tides changing the hydrodynamic and physical conditions of the lagoon.

3.2. Pen Llŷn a’r Sarnau SAC

The coastal lagoons feature in the Pen Llŷn a’r Sarnau SAC comprises of a single lagoon, Morfa Gwyllt. The lagoon is a small percolation lagoon that consists of a depression in a shingle bar across the mouth of the Afon Dysynni in mid Wales (Figure 5). Monitoring data collected between 2006-2021, together with other relevant evidence has been used to assess the performance indicators.

Figure 5. Map of the coastal lagoons feature in Pen Llŷn a’r Sarnau SAC.

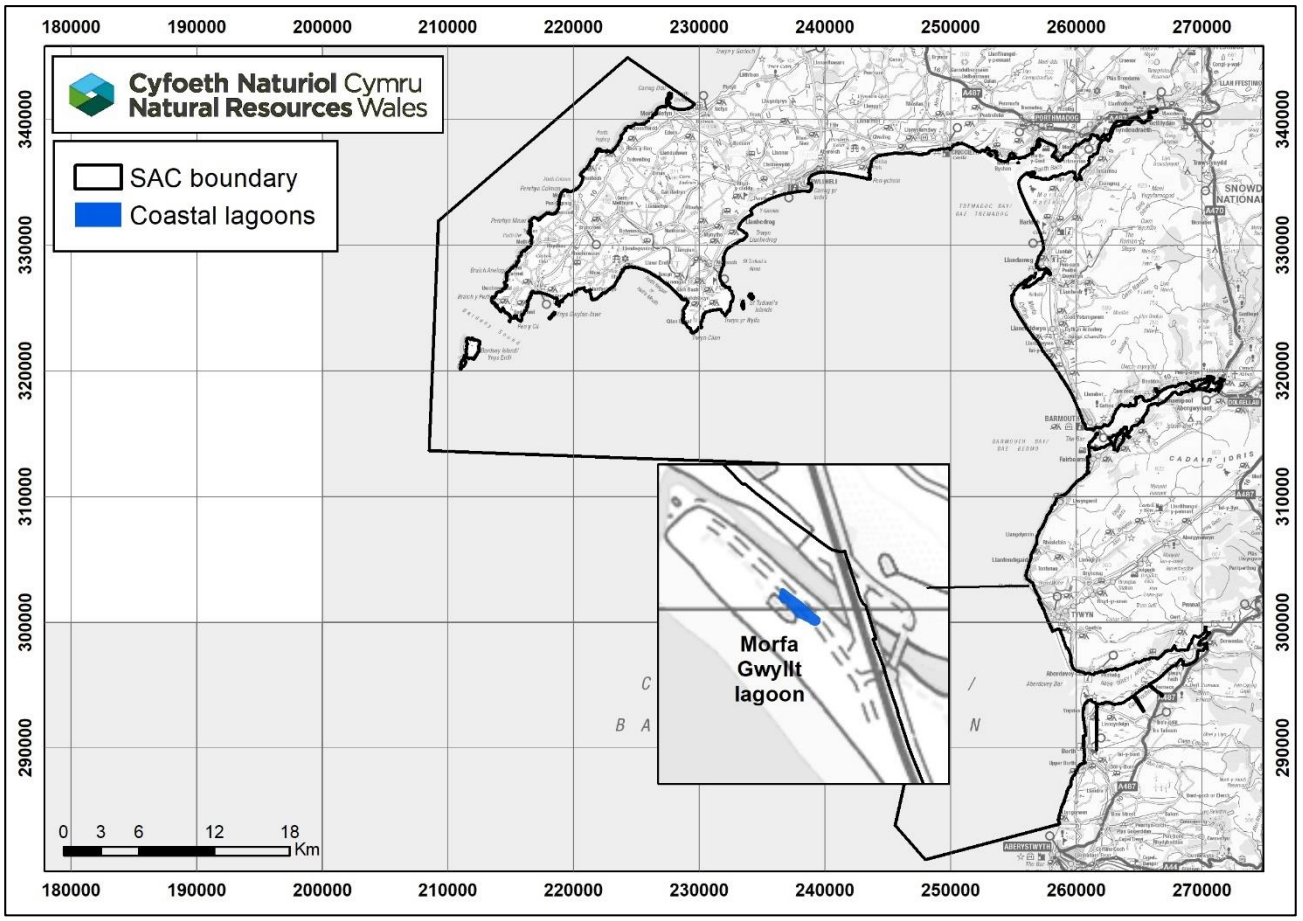


Table 5 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions.

Table 5. Condition assessment for Morfa Gwyllt lagoon in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

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

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

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

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

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

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

Assessment conclusion

The coastal lagoons feature in Pen Llŷn a'r Sarnau SAC (Morfa Gwyllt) has been assessed as being in **unfavourable** condition (low confidence). There were a number of failing indicators (Table 6). 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 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 the coastal lagoons feature 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 failures	Threats to condition
Pen Llŷn a'r Sarnau	**Unfavourable (low confidence)**	Abundance of lagoon specialist species (P) Species richness and diversity (P) Water depth (P) Water quality: physicochemical properties (P)	• There has been a decline in lagoon specialist species and species richness and diversity. • There is decreasing water depth and increasing salinity, potentially linked to the excavation of the channel entrance of the Dysynni river to manage flooding.	• Physical disturbance • Flood defences • Marine litter • Water quality: contaminants • Climate change

Detailed assessment information

Extent and shape

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

Lagoon barrier and banks

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

Species and communities

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

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

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

species are truly absent the population is unlikely to repopulate. More targeted surveys are needed.

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

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

Invasive non-native species

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

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

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

Sediments, depth and anthropogenic litter

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

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

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

Water quality

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

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

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

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

Contaminants

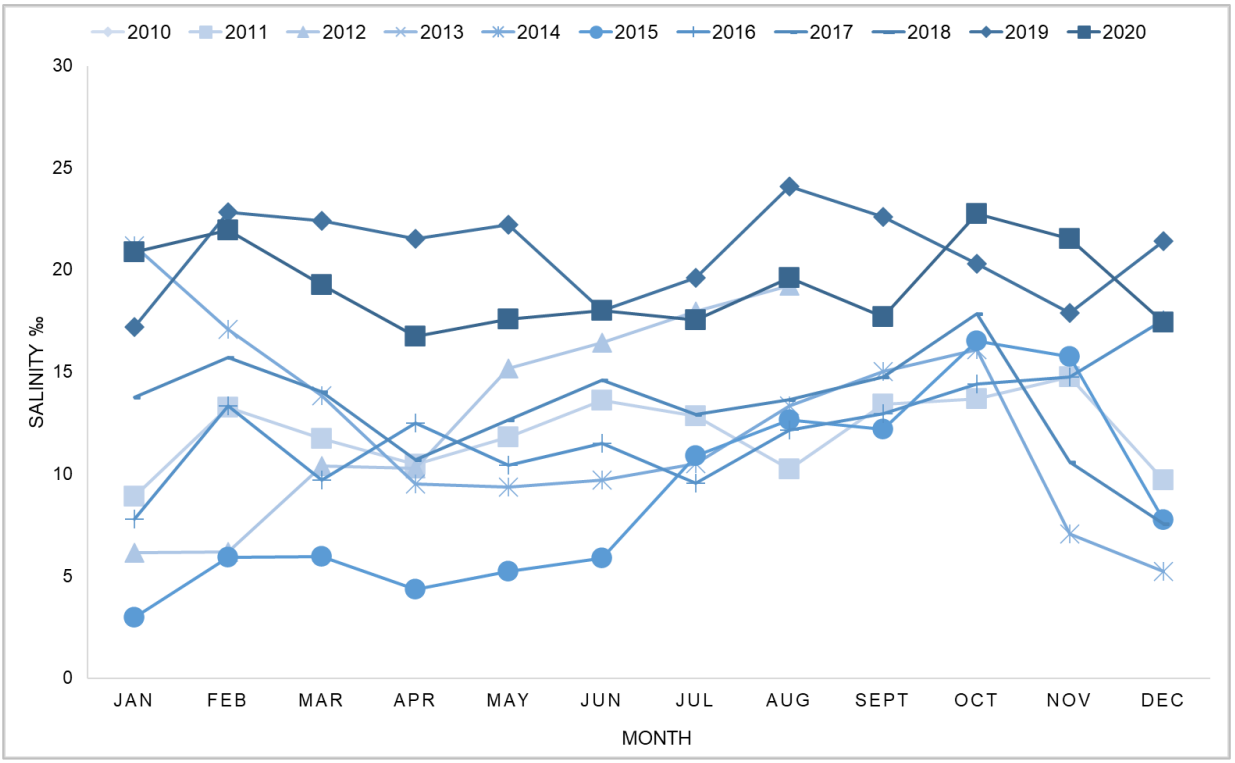
One of the WFD waterbodies adjacent to the lagoon, Cardigan Bay North, has a fail for chemicals in the 2024 cycle 3 interim classification. It failed for mercury and polybrominated diphenyl ethers (PBDE). Cardigan Bay North is a large coastal waterbody, and previous failing sample locations were collected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

Turbidity and physicochemical properties

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

Salinity loggers in the lagoon indicated that the salinity increased in 2019 and 2020 (Figure 6). The physicochemical properties indicator therefore failed to meet its target. This increase may be due to the small nature of the lagoon and its low flushing rates, or it could be related to the excavation of the entrance of the Dysynni river channel (last excavated in October 2018). Excavation of the river channel could lower the freshwater table, therefore reducing the freshwater input into the lagoon. Changes in salinity could have consequences for the biota that live within a specific salinity range. Low confidence has been attributed to the failure of the physicochemical properties indicator as there were no salinity data post 2020 available, and because not all physicochemical parameters have been assessed (e.g. pH). There were no concerning changes observed from the temperature loggers in the lagoon.

Figure 6. Average monthly salinity at Morfa Gwyllt lagoon between 2010 and 2020. Some months had incomplete data due to technical issues with the salinity logger.



Reasons for target failure

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

Abundance of lagoon specialist species

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

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

Species richness and diversity

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

Water depth

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

Water quality: physicochemical properties

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

Threats to condition

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

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

Physical disturbance

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

Flood defences

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

Marine litter

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

Water quality: contaminants

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

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

Climate change

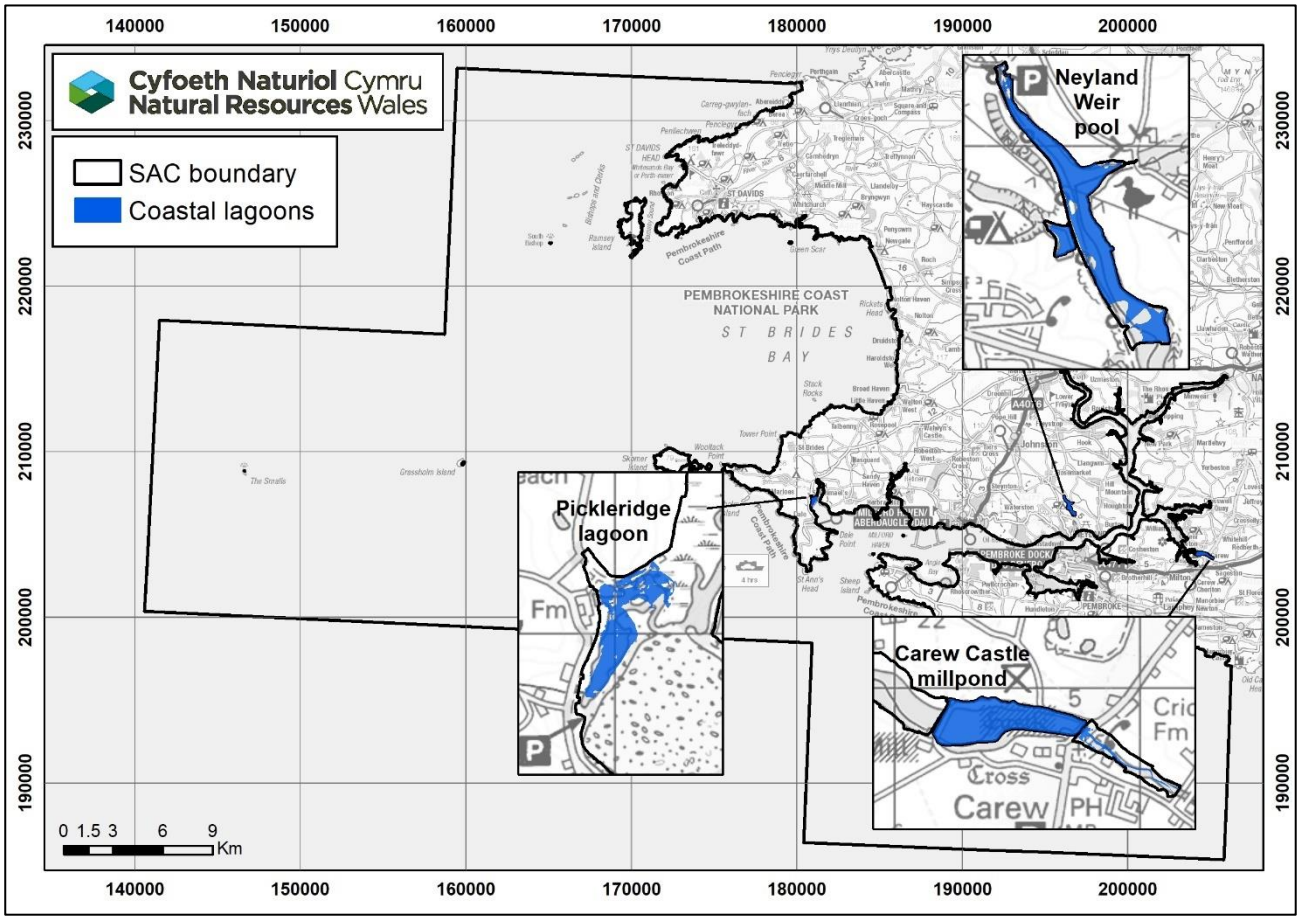
It is not yet clear what pressures we will see from climate change at the SAC level or how different pressures will counter act each other. However, threats from climate change may include (Gihwala et al., 2024):

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

3.3. Pembrokeshire Marine SAC

The coastal lagoons feature in Pembrokeshire Marine SAC is comprised of three separate lagoons within the SAC (Figure 7), Pickleridge lagoon, Carew Castle millpond (Carew) and Neyland Weir pool (Neyland). Each lagoon has been assessed separately against the performance indicators and been assigned its own condition. For the assessment of the coastal lagoons feature itself, the three individual lagoon assessments have been brought together into a single condition outcome for Pembrokeshire Marine SAC. Each individual assessment can be seen in the sections below followed by a summary of the overall assessment for the feature in section 3.3.4.

Figure 7. Map of the coastal lagoons feature in Pembrokeshire Marine SAC.



3.3.1. Pickleridge coastal lagoon in Pembrokeshire Marine SAC

Pickleridge lagoon is located on the Gann estuary which forms part of the Milford Haven Waterway. The lagoon formed behind the shingle storm beach when gravel extraction ceased. Pickleridge lagoon has been monitored annually between 2006-2021 with both net sweep and grab sampling surveys. Table 7 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Pickleridge condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in Section 3.3.4.

Table 7. Condition assessment for Pickleridge lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

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

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

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

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

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

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

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: opportunistic macroalgae	The WFD classification achieved for opportunistic macroalgae should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• The Pickleridge Lagoon waterbody was not classified for the opportunistic macroalgae WFD element in the 2024 cycle 3 interim classification. • There was an algal bloom observed in 2013 in the lagoon, however no algal blooms or high opportunistic macroalgae cover has been observed during site visits to the lagoon since 2013. • There have been ongoing observations of opportunistic macroalgae on the Gann mudflats directly adjacent to the lagoon. • The adjacent WFD waterbody that feeds into Pickleridge lagoon was classified with a Good status for opportunistic macroalgae in the 2024 cycle 3 interim classification (Milford Haven Outer). However, there has been localised growth of opportunistic macroalgae recorded in some of the inlets of this WFD waterbody, including around the Dale Gann area. • Confidence in the pass is low due to the lack of formal surveys for opportunistic macroalgae within the lagoon.	**Pass**	Low
Water quality: contaminants	Water column contaminants not to exceed the EQS. (S)	• The Pickleridge Lagoon waterbody was not classified as the chemicals have not been assessed within the last six years. • The adjacent WFD waterbody that feeds into Pickleridge lagoon has a pass for chemicals in the 2024 cycle 3 interim classification (Milford Haven Outer). However, some of the chemical classifications were rolled forward from the 2021 cycle 3 classification. This WFD waterbody has improved since previous cycles. • Confidence is low as there has been no physical sampling of contaminants in the lagoon.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the Pickleridge lagoon in the Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (P)	• The seasonal pattern of temperature remained broadly similar across the monitoring period of 2006-2021. Pickleridge lagoon is the most stable for temperature of all the lagoons assessed. • There were no obvious changes in the seasonal pattern of salinity across years. There are no issues with the lagoon barrier (no major modifications or problems), which is key for regulating the salinity at this lagoon. • Confidence is medium as only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.	**Pass**	Medium

Assessment conclusions

The Pickleridge lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were two failing indicators (Table 8). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

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

Table 8. Summary of the condition assessment for Pickleridge lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed Assessment Information

Extent and shape

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

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

Lagoon barrier and banks

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

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

Species and communities

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

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

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

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

Invasive non-native species

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

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

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

Sediments, depth and anthropogenic litter

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

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

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

Water quality

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

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The Pickleridge Lagoon waterbody has not been classified for the DIN element in the 2024 cycle 3 interim classification. As part of the planned investigation at Pickleridge lagoon, monthly water samples have been collected from various stations across the lagoon. DIN data collected from within the lagoon were analysed using the WFD winter DIN tool (see UKTAG, 2008 for details on how DIN is classified). The current (in draft) results indicate the lagoon would classify as Bad status due to elevated nutrients (Jopson and Lindenbaum, 2024, Figure 8). The adjacent Milford Haven Outer waterbody which feeds into the lagoon was classified as Poor status for DIN in the 2024 cycle 3 interim classification. This WFD waterbody deteriorated from Moderate status in the 2021 cycle 3 classification. The WFD investigation report for the Milford Haven Outer waterbody confirmed the DIN failures in the 2018 cycle 2 interim and 2021 cycle 3 classifications (Lock, 2021a). The nutrients indicator failed to meet its target due to the recorded issues with DIN in the Pickleridge Lagoon and Milford Haven Outer waterbodies. A high confidence has been attributed to the failure as investigations have confirmed the issues.

The phytoplankton indicator passed the target as the adjacent Milford Haven Outer waterbody was classified with a High status for the phytoplankton element in the 2024 cycle 3 interim classification. The Pickleridge Lagoon waterbody was not classified for this element. Classification of some WFD waterbodies are not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Confidence was reduced to medium as there has been no direct monitoring of phytoplankton within the lagoon, and as the ecological relationships between phytoplankton and the lagoons feature are not fully understood.

The Pickleridge Lagoon waterbody was not classified for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. There was an algal bloom in the lagoon in 2013, which suggests excessive nutrients at that time (Jopson and Lindenbaum, 2024). However, no algal blooms or high opportunistic macroalgae cover has been observed during site visits to the lagoon since 2013 (Jopson and Lindenbaum, 2024). The opportunistic macroalgae element in the adjacent Milford Haven Outer waterbody was classified as Good status in the 2024 cycle 3 interim classification. Although the opportunistic macroalgae is not a failing element for this WFD waterbody, there have been

localised issues recorded in the more sheltered bays and inlets including on the Gann mudflats in 2019, which is directly adjacent to the Pickleridge lagoon (Lock, 2021a). This indicator passed its target as there is no recent evidence of opportunistic macroalgae within the lagoon. A low confidence was attributed to this indicator as there have been no formal surveys of opportunistic macroalgae within the lagoon.

Figure 8. Agricultural land use at Pickleridge. This was found to be a major source of nutrient input into the lagoon.

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Contaminants

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

Turbidity and physicochemical properties

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

Salinity and temperature have been recorded in the lagoon using the loggers. For temperature, the seasonal pattern remained broadly similar across the monitoring period of 2007-2022. The Pickleridge lagoon is the most stable in temperature compared to the others assessed. There were also no clear changes in the seasonal pattern of salinity across the monitoring period. In addition, there have been no major modifications or

problems recorded with the lagoon barrier, which is key for regulating the salinity of the lagoon. The physicochemical indicator therefore met its target. Only temperature and salinity have been considered. Other physicochemical parameters such as pH should be considered in future.

Reasons for target failure

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

Water quality: nutrients (DIN only)

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

The Milford Haven Outer waterbody was classified with a Poor status for the DIN element in the 2024 cycle 3 interim classification. The WFD investigation report confirmed elevated nutrients in this WFD waterbody, where it was concluded that major input of nutrients is likely to be derived from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021a). Further investigation is required to determine the breakdown of nutrient sources into the catchments. Point source continuous sewage discharge from the water industry was confirmed as minor source of nutrients linked to the DIN failures (Haines and Edwards, 2016; Caprez, 2020; Lock, 2021a). Intermittent and domestic sewage are also suspected in the catchment. Further investigation locally is required to confirm these.

Non-native species

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

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

3.3.2. Carew Castle Millpond coastal lagoon in Pembrokeshire Marine SAC

Carew Castle Millpond (Carew) lagoon in Pembrokeshire Marine SAC was created during the establishment of the tidal corn mill around 1800. The lagoon is separated from the estuary by a brick dam and sluice gates. Carew lagoon has been monitored annually between 2006-2021 with both net sweep and grab sampling surveys. This data together with data loggers, WFD monitoring, licenced activities assessments and site knowledge have been used to assess Carew lagoon against the performance indicators. Table 9 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Carew lagoon condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in section 3.3.4.

Table 9. Condition assessment for Carew lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

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

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

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

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

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

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

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

Assessment conclusions

The Carew Castle Millpond (Carew) lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (high confidence). There were a number of failing indicators (Table 10). 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 10 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

Table 10. Summary of the condition assessment for Carew lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed Assessment Information

Extent and shape

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

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

Lagoon barrier and banks

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

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

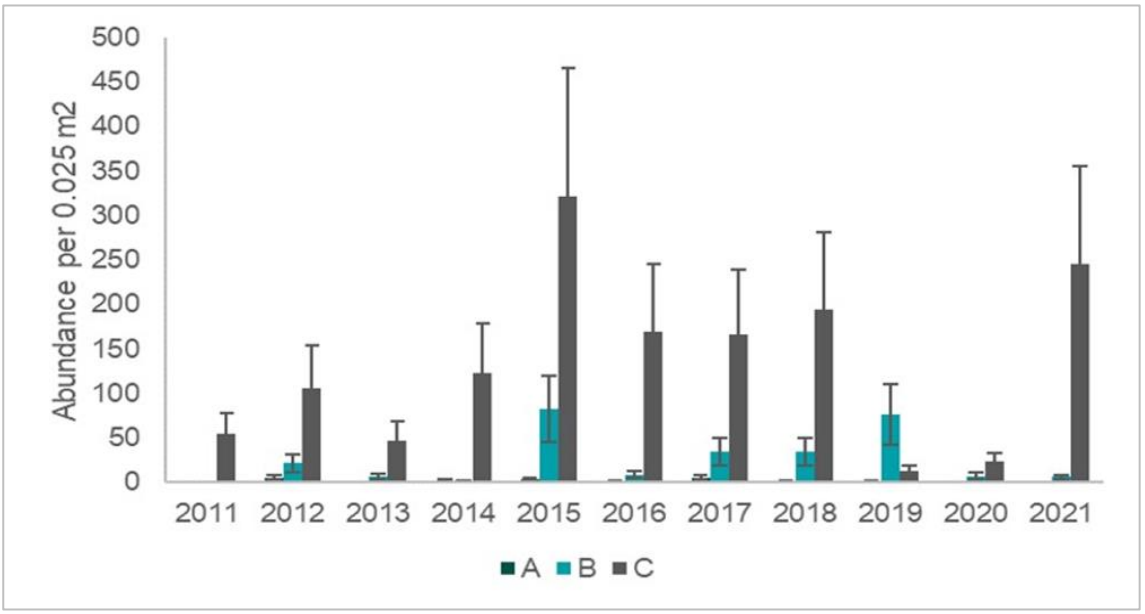
Species and communities

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

The tentacled lagoon worm *Alkmaria romijni*, a lagoon specialist once present in large densities, has seen significant declines at two of the three sampling stations in recent years (Figure 9). These two stations are within areas that dry out when the sluice gates are left open after the risk of flooding has passed. *A. romijni* is nationally scarce and protected under schedule 5 of the Wildlife and Countryside Act 1981 and section 7 of the Environment Act (Wales). A specific survey to assess *A. romijni* was undertaken in 2005. This survey should be repeated to look for the species in other areas of the lagoon outside of the sampling stations. The decline in this lagoon specialist caused the abundance of lagoon specialists indicator to fail its target. *Palaemon varians* was recorded in low density in the sweep net surveys in 2013 and in 2019. *Monocorophium insidiosum*, has not been recorded since 2011. This is of limited concern as the sampling method is unlikely to adequately represent *M. insidiosum* density. However, a more targeted survey to look of *M. insidiosum* should be carried out to try and confirm it is still present in the lagoon. Confidence in the fail is medium as the sampling method may not be appropriate to detect some of the lagoon specialists.

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

Figure 9. Declines of the tentacled lagoon worm *Alkmaria rominji* at Carew lagoon. Mean (±Standard Error) abundance of *A. rominji* per 0.025 m^2 from grab surveys between 2011 and 2021 (5 grabs per station).



Invasive non-native species

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

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

It is not fully understood how some of these species may spread and impact the condition of the coastal lagoons feature, and effects on the species diversity and composition have not yet been observed. For this reason, it did not fail the primary target of the INNS indicator, but confidence in the pass was low.

Sediments, depth and anthropogenic litter

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

The leaks in the dam wall and open sluice gates have resulted in the water depth in Carew lagoon lowering significantly. At times when the sluice gate is open, and the tide is out, the area of water remaining is very small. From the photos in Figure 10 it is clear to see that most of the lagoon drains, exposing large areas of sediment. Most of the water left is confined to the channel and around the dam wall and gates. This deeper area of water is where sampling station C, closest to the mill, is located and abundance of *A. rominji* has remained within acceptable levels. To compound the water depth issue further, Carew lagoon has been accreting sediment, as silt laden water enters the lagoon during periods of heavy rain. This siltation has resulted in a slight decrease in water planar area and water volume between 2009-2021. Water depth failed its primary target with high confidence due to the significant drop in water depth and large areas of the lagoon drying out.

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

Figure 10. Carew lagoon at low tide when the sluice gates are open.

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Water quality

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

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

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

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

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

The opportunistic macroalgae indicator failed to meet the target due to the Moderate status classification for this element in the Milford Haven Inner waterbody in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure, in which extensive and recurring coverage has been recorded in various inlets including Carew river (Lock, 2021b). A medium confidence was attributed to this failing indicator as there have been no opportunistic macroalgae surveys within the actual lagoon.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and polycyclic aromatic hydrocarbons (PAH) failed. PBDE has failed in this WFD waterbody in all previous cycles. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of coastal lagoons are not fully understood. This caused the contaminants indicator to fail as there is a pathway of water exchange into the lagoon from the contaminated waterbody. The confidence in the fail was reduced to low because the human health standard has been used for PBDE, and as there was no direct monitoring of contaminants within the lagoon. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

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

Reasons for target failure

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

Isolating barrier integrity

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

Abundance of lagoon specialist species

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

Water depth

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

Water quality: nutrients (DIN only)

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

Water quality: physicochemical properties

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

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target as the Milford Haven Inner waterbody was classified as Moderate status for the opportunistic macroalgae element in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure in this WFD waterbody. Major input of nutrients was found to be from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021b). 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, 2021b). Intermittent and domestic sewage are also suspected in the catchment. Further investigation locally is required to confirm these.

Water quality: contaminants

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

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

3.3.3. Neyland Weir pool coastal lagoon in Pembrokeshire Marine SAC

Neyland Weir pool (Neyland) lagoon in Pembrokeshire Marine SAC was established as a saline lagoon in the 1980's being separated from the Cleddau estuary by a concreate bund. Neyland lagoon has been monitored annually between 2011-2021 with both net sweep and grab sampling surveys. Table 11 has a summary of the assessment against the performance indicators. The overall feature condition, a detailed summary of the assessment and threats to condition can be found in the assessment conclusions. The Neyland lagoon condition assessment has been combined with the two other lagoons in the SAC to give an overall condition for the coastal lagoons feature in section 3.3.4.

Table 11. Condition assessment for Neyland lagoon in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see Section 1.1).

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

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

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

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

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

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

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

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

Assessment conclusions

The Neyland Weir pool (Neyland) lagoon in Pembrokeshire Marine SAC has been assessed as being in **unfavourable** condition (medium confidence). There were a number of failing indicators (Table 12). Further investigation is needed to better understand all of the failures to be able to identify management options that can bring the feature back into favourable condition.

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

Table 12. Summary of the condition assessment for Neyland lagoon, part of the coastal lagoons feature of Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed Assessment Information

Extent and shape

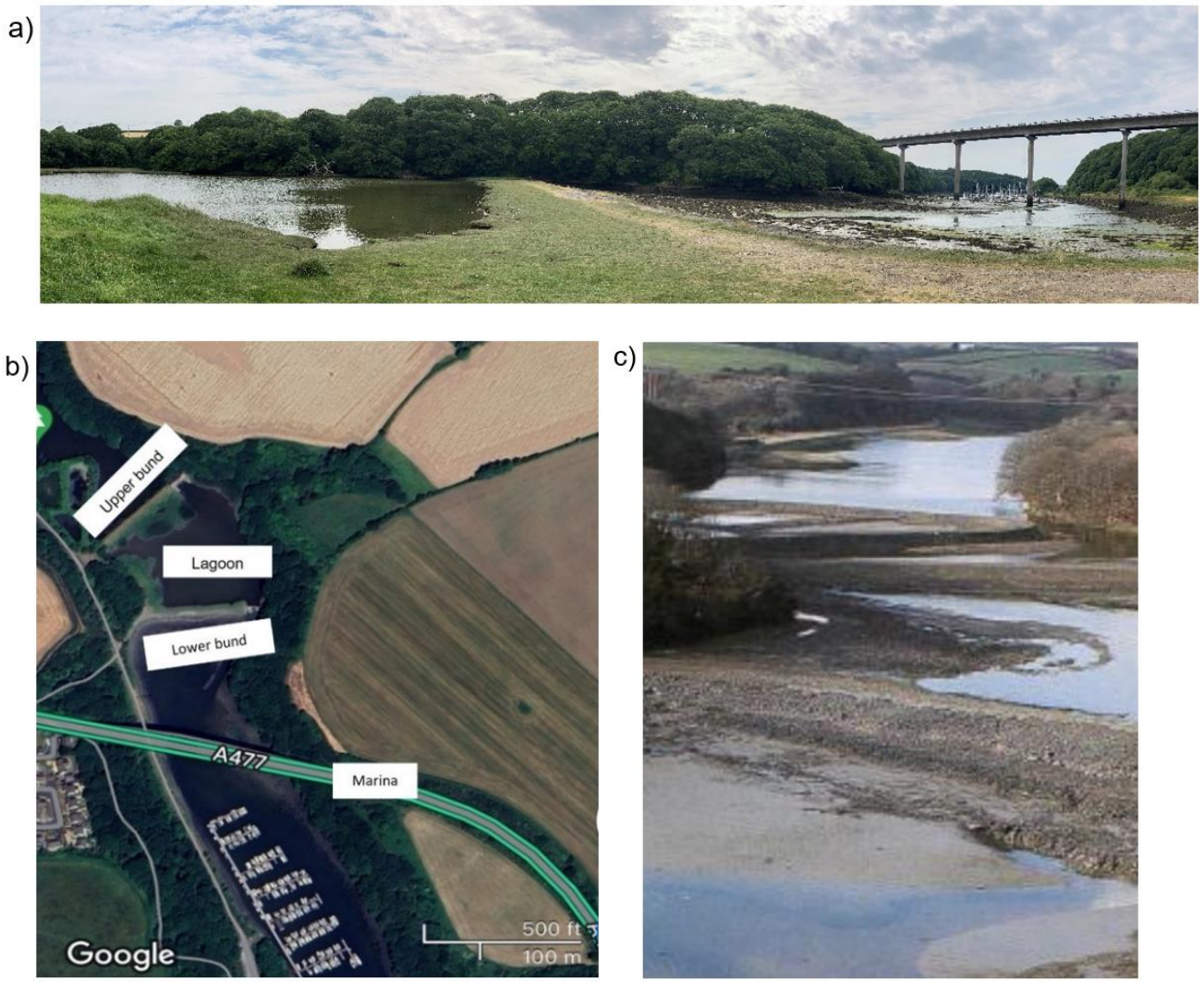
Aerial imagery has been used to determine changes in the extent and shape of the lagoon. Extent has been judged to be stable, with only minor decreases in extent since 2000, however trees surrounding the lagoon make assessing the extent difficult. The minor losses have been attributed to natural change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

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

Lagoon barrier and banks

Neyland is a weir lagoon with a lower bund embankment separating it from the Cleddau estuary (Figure 11). An upper bund splits the lagoon in to two pools. The isolating barrier integrity and integrity of lagoon banks indicators have both been judged to meet their targets with high confidence. At the time of writing there are discussions around creating a woodland buffer around parts of the lagoon to help increase barrier integrity. The seaward face of both bunds and the upstream face of the upper bunds were reinforced with rock. A capping of asphalt was also placed along the down-estuary facing lip of the lower bund to provide additional protection against scour and wave action (Pye and Blott, 2023).

Figure 11. Neyland lagoon upstream of Neyland Marina. a) The lower bund retaining water at low tide is visible in the middle of the picture (© Harriet Robinson NRW). b) Aerial image of Neyland lagoon showing both bunds and the dredged marina to the south (Google Maps, 2023, annotated). c) Aerial image of the lower and upper bunds shortly after construction in the early 1980s (in Pye and Blott, 2023).



Species and communities

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

Analysis of lagoon specialists showed that most species (e.g. *Gammarus chevreuxi, Palaemon varians, Lekanesphaera hookeri*) are present in expected abundance and frequencies. However, the lagoon specialist species *Ecrobia ventrosa* has not been recorded since 2012. Prior to 2012, abundance of this species has been low within the Neyland lagoon. Similarly, *Monocorophium insidiosum* and *Ficopomatus enigmaticus* were

recorded in low abundance in 2014 with no records in subsequent net sweep surveys, and all grabs samples. It is challenging to detect these species with the current sampling methods used, and the period of the species being unrecorded has therefore reduced confidence in the pass to low. More targeted sampling for these species is needed to confirm their presence or absence within the lagoon.

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

Invasive non-native species

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

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

It is not fully understood how some of these species may spread and impact the condition of the coastal lagoons feature, and effects on the species diversity and composition have not yet been observed. For this reason, it did not fail the primary target of the INNS indicator, but confidence in the pass was low.

Sediments, depth and anthropogenic litter

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

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

The presence of materials and debris of anthropogenic origin indicator met its target as there has not been a large amount of debris or microplastics found in available monitoring data. However, there have not been targeted surveys of anthropogenic materials within the lagoon, and instead ad-hoc data has been obtained as part of the infaunal surveys. This

reduced the confidence to low. A longer dataset and appropriate sampling design is required for temporal analysis. A dedicated analysis for plastic should be carried out.

Water quality

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

Nutrients (DIN only), phytoplankton and opportunistic macroalgae

The nutrients indicator failed to meet its target as the overlapping Milford Haven Inner waterbody was classified with a Poor status for DIN in the 2024 cycle 3 interim classification. This WFD waterbody also failed in earlier cycles. The WFD investigation report for the Milford Haven Inner waterbody confirmed the DIN failure in the 2018 cycle 2 and 2021 cycle 3 classifications (Lock, 2021b). The Milford Haven Inner waterbody has also been designated by Welsh Government as a sensitive area (eutrophic) under the Urban Wastewater Treatment Regulations. There is also a supporting opportunistic macroalgae failure, which was also confirmed in the investigation (Lock, 2021a). This primary indicator has failed due to the issues in the Milford Haven Inner waterbody, but with medium confidence as there has been no direct monitoring of nutrient levels within the lagoon.

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

The opportunistic macroalgae indicator failed to meet the target due to the Moderate status classification for this element in the Milford Haven Inner waterbody in the 2024 cycle 3 interim classification. The WFD investigation report confirmed the opportunistic macroalgae failure, in which extensive and recurring coverage has been recorded in various inlets including Carew river (Lock, 2021b). A medium confidence was attributed to this failing indicator as there have been no opportunistic macroalgae surveys within the actual lagoon.

Contaminants

The Milford Haven Inner waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where PBDE and PAH failed. PBDE has failed in this WFD waterbody in all previous cycles. The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of coastal lagoons are not fully understood. This caused the contaminants indicator to fail as there is a pathway of water exchange into the lagoon from the contaminated waterbody. The confidence in the fail was reduced to low because the human health standard has been used for PBDE, and as there was no direct monitoring of contaminants within the lagoon. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

The physicochemical properties indicator was assessed as unknown as there are limited data available on temperature and salinity and no data on other physicochemical parameters.

Reasons for target failure

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

Species composition of communities

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

Water quality: nutrients (DIN only)

This indicator failed to meet its primary target. The reasons are outlined in section 3.3.2 as the same waterbodies apply.

Water quality: opportunistic macroalgae

This indicator failed to meet its secondary target. The reasons are outlined in section 3.3.2 as the same waterbodies apply.

Water quality: contaminants

This indicator failed to meet its secondary target. The reasons are outlined in section 3.3.2 as the same waterbodies apply.

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

The condition assessments for each of the three lagoons in Pembrokeshire Marine SAC have been brought together to form one condition outcome for the coastal lagoons feature. The condition of the coastal lagoons feature has been assessed as **unfavourable** (high confidence) (Table 13). All three of the lagoons in the SAC are in unfavourable condition giving us high confidence that the coastal lagoons feature in Pembrokeshire Marine SAC is unfavourable. A summary of condition is in Table 13.

Table 13. Summary of the condition assessment for the coastal lagoons feature in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Threats to condition

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

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

Marine litter

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

Siltation (Carew only)

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

Water quality: contaminants

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

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

Invasive non-native species

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

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

Climate change

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

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

4. Evidence gaps for the coastal lagoons feature

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

Listed below are current indicators that were either assessed as unknown, not assessed, or assessed with a lower confidence. This was due to either limited data availability, outdated data, or a lack of information. Some indicators are not currently monitored but should be ideally considered in future condition assessments. Not all evidence gaps apply to every SAC, see Table 14 for details.

Table 14. Evidence gaps for the coastal lagoons 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**
Angiosperms (*Ruppia*) (P)	Not assessed	• At the time of assessment, no surveys of *Ruppia* have been carried out in all lagoons except for Cemlyn. More targeted surveys to look for *Ruppia* are needed
Distribution and extent of habitats and communities (P)	Not assessed	• Biotopes are not well established for lagoons. Current monitoring is not set up to look at this in depth; additional fieldwork would be required.
Sediment quality: organic carbon content (P)	Not assessed	• This is not monitored but could be incorporated into PSA analysis in lagoons in future.
Sediment quality: contaminants (P)	Not assessed	• This is not monitored but could be incorporated into PSA analysis in lagoons in future.
Water quality: nutrients (DIN only) (P)	Low confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons themselves.
Bathymetry of the feature (S)	Not assessed	• More targeted data would need to be collected to be able to assess changes in bathymetry. There is potential to create continual depth layer for lagoons using LiDAR data.

Indicator	Assessed status	Comments
Hydrodynamic and sediment transport processes (S)	Not assessed	• Lagoon hydrodynamic regimes are not currently monitored.
Presence of materials and debris of anthropogenic origin (S)	Low confidence (limited data)	• Longer datasets and appropriate sampling designs are required for temporal analysis and detecting concerns for the future. A dedicated analysis for plastic should be carried out in a similar fashion to hydrocarbon for sediment. Standardised surveys for large debris are also needed.
Water quality: phytoplankton (S)	Low confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons. Some assessments have relied upon WFD waterbodies that are adjacent to the lagoons only.
Water quality: opportunistic macroalgae (S)	Low confidence (proxy data used)	• These elements are not currently monitored in some of the lagoons. Some assessments have relied upon WFD waterbodies that are adjacent to the lagoons only.
Water quality: dissolved oxygen (S)	Not assessed	• Dissolved oxygen is not currently monitored within lagoons. Once a baseline is established monitoring would take place only when intelligence suggests an impact is occurring from an activity.
Water quality: contaminants (S)	Low confidence (proxy data used)	• Contaminants are mostly measured in Wales as part of WFD monitoring, but there is currently no WFD monitoring of contaminants within any of lagoons themselves.
Water quality: turbidity (S).	Unknown	• Turbidity is measured in WFD sampling, but this is limited to only a few samples per year. Therefore, this cannot be used to adequately assess the turbidity in any of the SACs. Investigation of the use of remote sensing data to assess turbidity could be carried out in the future. External data from other organisations could also be used.

5. References

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