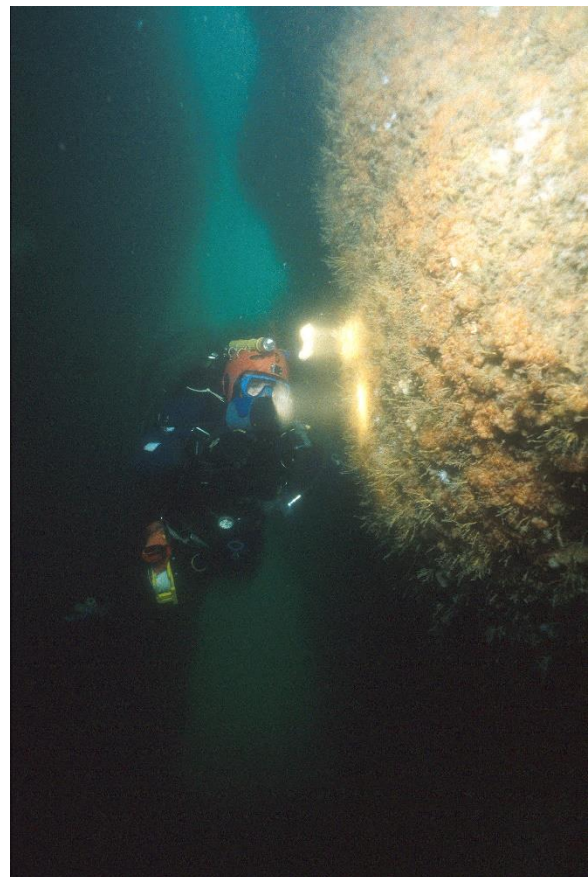# Condition Assessments for submerged and partially submerged Sea Caves in Welsh Special Areas of Conservation

Report No: 903

Author Name: M. Hatton Ellis, S. Cuthbertson, M. Jackson-Bué and E. Wynter

Author Affiliation: Natural Resources Wales

Welsh sea caves, © Rohan Holt

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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 ogofâu môr sy'n danforol neu'n lleddanforol 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 ogofâu môr mewn ACAau ledled Cymru

Lleoliad y nodwedd ACA	Asesiad cyflwr	Hyder yn yr asesiad	Lleoliad y nodwedd ACA	Asesiad cyflwr
Y Fenai a Bae Conwy	Anhysbys	Ddim yn berthnasol	Isel	Canolig
Pen Llŷn a'r Sarnau	Anhysbys	Ddim yn berthnasol	Canolig	Isel
Bae Ceredigion	Anhysbys	Ddim yn berthnasol	Isel	Isel
Sir Benfro Forol	Anhysbys	Ddim yn berthnasol	Isel	Isel
Arfordir Calchfaen de Orllewin Cymru	Anhysbys	Ddim yn berthnasol	Isel	Isel

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 submerged and partially submerged sea caves within designated special areas of conservation (SACs) across Wales. Cross-border sites are not included in this report but will hopefully be considered in future. Section 1 gives an overview of the assessment process and Section 2 provides a description and location of the feature(s).

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

Summary of condition assessments for sea caves in SACs across Wales.

SAC feature occurs in	Condition assessment	Confidence in assessment	Likelihood of unfavourable condition	Confidence
Menai Strait and Conwy Bay	Unknown	Not applicable	Low	Medium
Lleyn Peninsula and the Sarnau	Unknown	Not applicable	Medium	Low
Cardigan Bay	Uknown	Not applicable	Low	Low
Pembrokeshire Marine	Unknown	Not applicable	Low	Low
Limestone coast of South west Wales	Unknown	Not applicable	Low	Low

1. Introduction

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

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

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

1.1. Assessment process

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

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

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

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

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

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

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

2. Feature description

The following text is the habitat description from the JNCC list of Annex I rocky habitats and caves.

"This Annex I type includes submerged sea caves and also partially submerged caves which are only exposed to the sea at high tide (sea caves). Caves vary in size, from only a few metres to more extensive systems, which may extend hundreds of metres into the rock. There may be tunnels or caverns with one or more entrances, in which vertical and overhanging rock faces provide the principal marine habitat. They are typically associated with 1170 Reefs.

Sea cave communities vary considerably depending on the structure and extent of the cave system, their degree of submergence and of exposure to sand scour and wave-surge, and their geology. Caves are typically colonised by encrusting animal species but may also support shade-tolerant seaweeds near their entrances. Physical conditions, such as inclination, wave surge, scour and shade, change rapidly from cave entrance to the inner parts of a cave, and this often leads to a marked gradation in the communities present."

3.   Sea caves condition assessments

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

- Y Fenai a Bae Conwy / Menai Strait and Conwy Bay
- Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau
- Bae Ceredigion / Cardigan Bay
- Sir Benfro Forol / Pembrokeshire Marine
- Arfordir Calchfaen de Orllewin Cymru / Limestone Coast of South West Wales

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

The indicators were assessed using a combination of NRW Habitats Regulations monitoring, Water Framework Directive (WFD) Regulations 2017 (WFD Regulations) monitoring, scientific literature, commissioned evidence reports, plan and project assessments, and expert judgement. As sea caves are related to intertidal and subtidal reefs, the outcomes of those assessments were also interrogated during the sea cave assessment. The outcome of the assessment and any reasons for failure are discussed in more detail in the sections below.

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

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

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

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

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

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Figure 1. Location of SACs assessed for the sea caves feature.
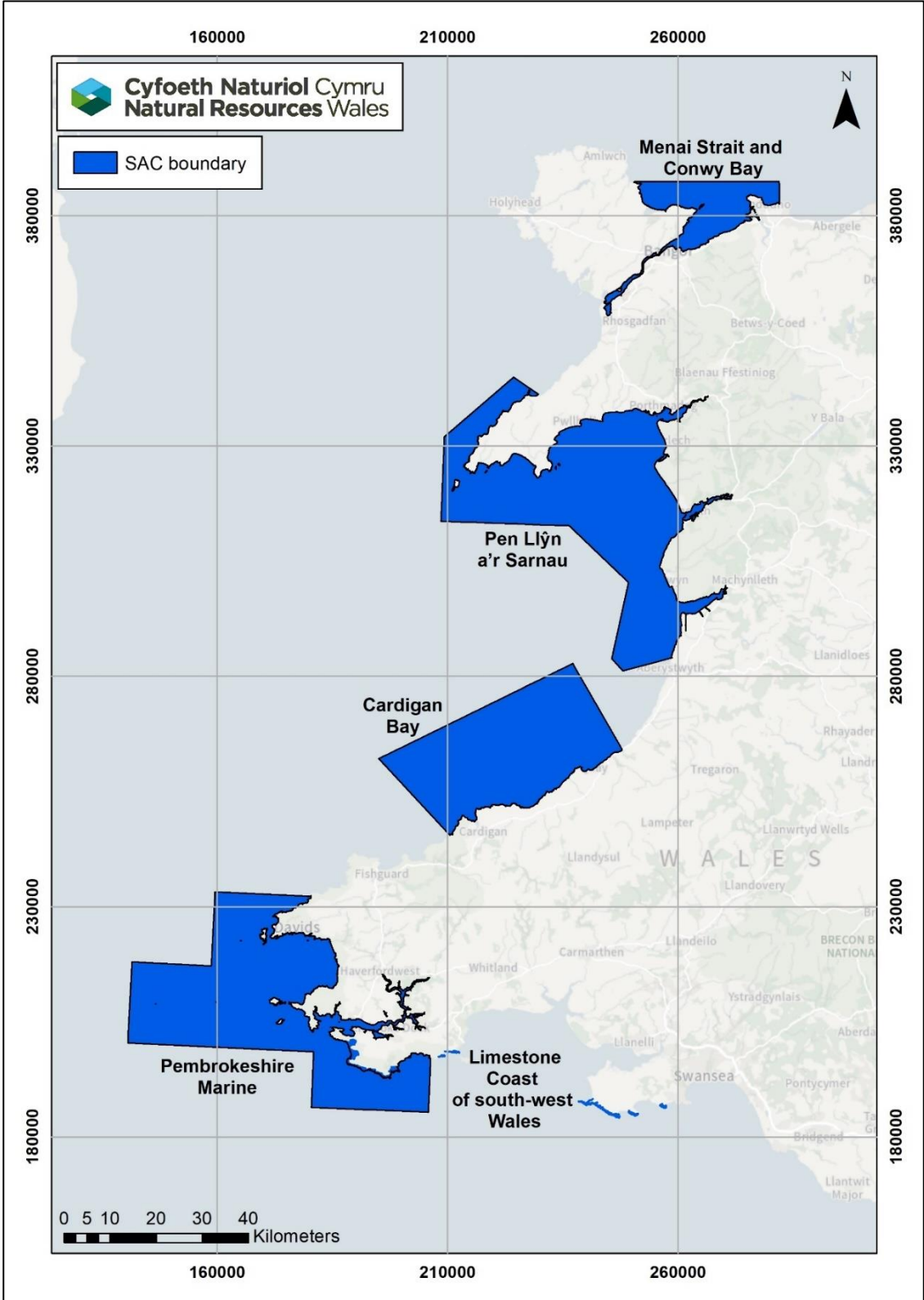
3.1. Menai Strait and Conwy Bay SAC condition assessment

The sea caves feature in the Menai Strait and Conwy Bay SAC comprises a number of sea caves most of which are along the north Wales coast area of the SAC with only a few within the Menai Strait itself (Figure 2). The summary of the assessment outcome for sea caves is provided in Table 2. These outcomes and any reasons for failure are discussed in more detail in the sections below.

Figure 2. Location map of the sea caves feature in the Menai Strait and Conwy Bay SAC.
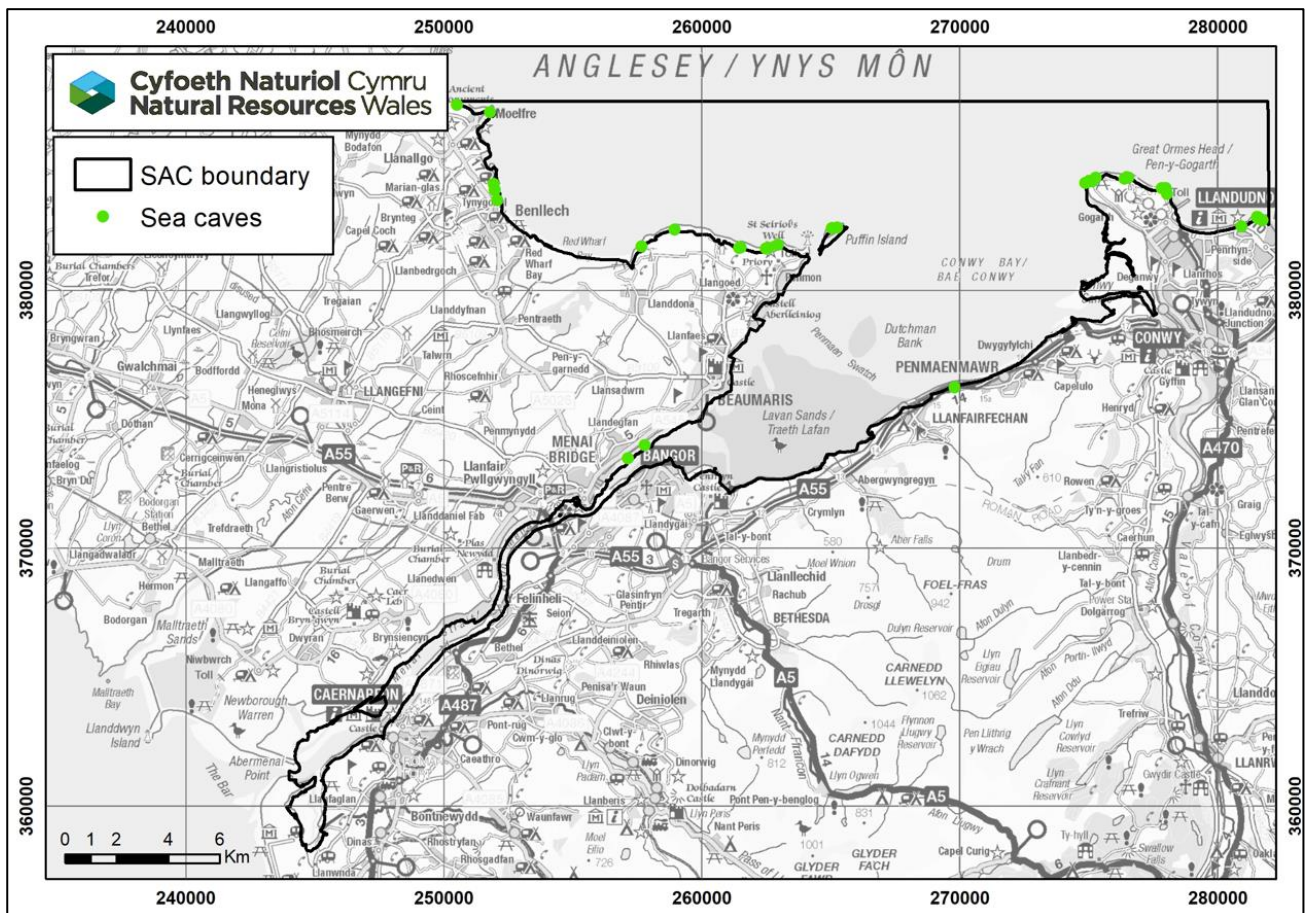
Table 2. Condition assessment of sea caves in Menai Strait and Conwy Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Menai Strait and Conwy Bay SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of sea caves allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Menai Strait and Conwy Bay SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of sea caves in the Menai Strait and Conwy Bay SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (S)	• No anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
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. (T)	• Two of the WFD waterbodies that overlap with the mapped sea caves feature have been classified as Good or High status for DIN in the 2024 cycle 3 interim classification (Menai Strait and North Wales). • The Anglesey North waterbody was not classified for this WFD element. • Low confidence as one of the waterbodies was not assessed, and as ecological relationships between DIN and sea caves are not fully understood.	**Pass**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the three WFD waterbodies that overlaps with the mapped sea caves was not classified for the phytoplankton WFD element in the 2024 cycle 3 interim classification (Anglesey North). It overlaps with approximately 38% of the mapped sea caves within the SAC. • One WFD waterbody was classified with a High status for phytoplankton (Menai Strait). This classification was rolled forward from the 2018 cycle 2 interim classification. It overlaps with 5% of the mapped sea caves. • The final WFD waterbody was classified with a Moderate status for phytoplankton (North Wales). This waterbody overlaps with the largest proportion of the mapped sea caves (57%). • Confidence is low as one waterbody which overlaps with a large proportion of the feature has not been classified for the phytoplankton WFD element, and as ecological relationships between phytoplankton and sea caves are not fully understood.	**Fail**	Low

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All three WFD waterbodies that overlap with the mapped sea caves feature have been classified with High status for dissolved oxygen in the 2024 cycle 3 interim classification. • One WFD waterbody classification was rolled forward from the 2021 cycle 3 classification which affected the confidence. • Confidence is high as most sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High
Water quality: contaminants	Water column contaminants not to exceed the environmental quality standards (EQS). (T)	• Two of the three overlapping WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification (North Wales and Menai Strait). In both waterbodies the classifications were rolled forward from previous cycles. Combined, they overlap with 62% of the mapped sea caves. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Anglesey North). This waterbody failed for mercury and polybrominated diphenyl ethers (PBDE). It overlaps with 38% of the mapped sea caves. • Confidence is low because the human health standard has been used for PBDE, and the impact of these contaminants on sea caves is unknown.	**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 sea caves feature in Menai Strait and Conwy Bay SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicator	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (T)	• Data from subtidal temperature loggers from within the SAC were available. Loggers at one monitoring site indicated a potential increase in temperature in recent years. It is not clear if this is a localised change or in line with global trends. • An external report from Bangor University indicates that annual mean sea surface temperature is gradually rising in their Menai Strait temperature logger. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A

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

Assessment conclusions

The sea caves feature in Menai Strait and Conwy Bay SAC has been assessed as being in **unknown** condition (N/A confidence). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps section 5). There were two tertiary failing indicators (Table 3). A summary of the assessment can be seen in Table 3 with more detail on each performance indicator, and the reasons for indicator failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Seven indicators were assessed as passing in the assessment of condition for sea caves in the Menai Strait and Conwy Bay SAC including extent and distribution. These can be seen in Table 2. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at low likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment but there was good local knowledge of the SAC so the confidence was judged to be medium (Table 3).

Table 3. Summary of the condition assessment for sea caves in Menai Strait and Conwy Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Menai Strait and Conwy Bay	**Unknown (Confidence not applicable)**	**Low (medium confidence)**	Water quality : phytoplankton (T) Water quality: contaminants (T)	• Phytoplankton failed in the North Wales waterbody. • Levels of mercury and PBDE in the Anglesey North waterbody are failing to meet their relevant environmental quality standards (EQS).	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences • Metal mines

Detailed assessment information

Extent and Distribution

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

Bathymetry and hydrodynamic processes

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

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within three WFD waterbodies where 57% of sea caves overlap with the North Wales waterbody, 38% with the Anglesey North waterbody and 5% with the Menai Strait waterbody.

Nutrients (Dissolved Inorganic Nitrogen - DIN only) and phytoplankton

The nutrients (Dissolved Inorganic Nitrogen - DIN only) target was met as two of the relevant overlapping WFD waterbodies were classified with a Good or High status for the DIN element in the 2024 cycle 3 interim classification. These were the Menai Strait and North Wales waterbodies. These waterbody DIN classifications have improved or been maintained. The Anglesey North waterbody was not classified for the DIN element in the 2024 cycle 3 interim classification. This waterbody overlaps with approximately 38% of the mapped sea caves, therefore confidence in the indicator pass was reduced. There is also a lack of knowledge on the impact of nutrients on the sea caves feature, therefore the confidence was reduced to low.

The phytoplankton indicator failed to meet its target as the North Wales waterbody, which overlaps with the largest proportion of the mapped sea caves in the SAC, was classified with a Moderate status for the phytoplankton element in the 2024 cycle 3 interim classification. This waterbody has had a Moderate status for this element since the 2018 cycle 2 interim classification. The Anglesey North waterbody overlaps with the next largest proportion of the mapped sea caves, and has not been classified for phytoplankton in the

2024 cycle 3 interim classification. Classification of some WFD waterbodies is not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). Confidence in the fail is low as one waterbody which overlaps with a large proportion of the feature has not been classified for the phytoplankton element, and as the ecological relationships between phytoplankton and sea caves are not fully understood.

Dissolved oxygen

The dissolved oxygen indicator met its target as all three relevant WFD waterbodies were classified as High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Sea caves are high energy environments so likely to have high oxygen levels in general, therefore the confidence in this indicator is high.

Contaminants

One of the three WFD waterbodies that overlap with the mapped sea caves feature in the SAC, Anglesey North, has a fail for chemicals in the 2024 cycle 3 interim classification due to mercury and polybrominated diphenyl ethers (PBDE). This waterbody overlaps with approximately 38% of the feature, which caused the contaminants indicator to fail. In this waterbody, mercury has failed since the 2015 cycle 2 classification. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The PBDE failures were based on the value of the human health protection goal as it is the most stringent. This protection goal may be over precautionary as the effect of contaminants on the biota of sea caves are not fully understood. The confidence in the fail was reduced to reflect this, and as the impact of the failing contaminants on sea cave biota is unknown. The other two overlapping WFD waterbodies have a pass for chemicals in the 2024 cycle 3 interim classification. However, in both waterbodies the classifications were rolled forward from previous cycles as they were not classified in the 2024 cycle 3 interim classification. This also contributed to the low confidence outcome. 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 for the sea caves feature.

Data from NRW monitored subtidal temperature loggers from two monitoring sites within the SAC were available. However, as loggers from one of the sites had a large amount of missing data, the observed patterns in temperature are based on data from only one site which does not overlap with the feature but was less than 1km away. These loggers showed an increase in temperature in more recent years. An external report (Smyth et al., 2022) also found that the annual mean sea surface temperature was gradually rising in the Menai Strait. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

No information on sea cave communities has been collected for this SAC since 2000-2002. The majority of caves within the Menai Strait and Conwy Bay SAC occur along the limestone coast of the Great Orme's Head and Little Orme's Head, however there are shallow intertidal caves in several other locations including the north side of Puffin Island and the mainland coast of Anglesey between Puffin Island and Llanddonna.

The cliffs of the Great and Little Orme's headlands are composed of carboniferous limestone, as is the area around Puffin Island. Wave action on the limestone here has formed cave and overhang features both in the intertidal and subtidal. The caves range from wave-cut indentations in the base of the cliffs to fully formed caves and tunnels, some over 30 m long.

The cave floors are typically scoured smooth and barren and the upper parts of the walls at the cave rear are covered in a thin brown biotic film with a few small mussels *Mytilus edulis* and barnacles occurring in algal crusts and films dominate the main part of the cave walls. Below these crusts are dense zones of barnacles, tubeworms and mussels. In places the vertical walls descend to overhangs dominated by large clumps of mussels with barnacles and the plumose anemone *Metridium senile*. Beneath the overhangs, a scour zone at the base of the rock walls has sparse barnacles and tubeworms often with an overlying short turf of the hydroid *Obelia dichotoma* (Bunker and Holt, 2003).

The biotopes and their characterising species found in the cave systems in the Menai Strait and Conwy Bay SAC are highly representative of the limestone substrata/habitat and the turbid waters. The most abundant species are those resilient to high and almost constant turbidity and the effects of sand-scour, and as such assemblages of species not often recorded in the rest of the Wales and the UK occur here (Bunker and Holt, 2003).

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

Invasive non-native species

There is no information available on the establishment or impact of non-native species (NNS) in sea caves in this SAC as there have been no surveys within the sea caves since 2000-2002. For this reason the invasive non-native species (INNS) and NNS targets were assessed an unknown.

There has been an increase in the number of records for the American slipper limpet *Crepidula fornicata* identified in the Menai Strait and Conwy Bay SAC. Other non-native species (NNS) are known to be present in the Menai Strait (within the reefs feature) including the Chilean Oyster *Ostrea chilensis*, the Pacific oyster *Magallana gigas* and the wireweed *Sargassum muticum*. Limited records have been produced for *O. chilensis*, but it has been known to be present in the Menai Strait for about 30 years. It is not fully understood how any NNS present could impact the sea cave biota and any potential effects on the species diversity and composition are unknown.

Reasons for target failure

The assessment of the sea caves feature in Menai Strait and Conwy Bay SAC failed two tertiary targets. There were also six targets that were assessed as unknown due to limited data availability. Overall the feature was assessed to be in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: phytoplankton

This indicator target has a tertiary weighting. The failure of the phytoplankton indicator is due to the Moderate status classification for this element in the North Wales waterbody in the 2024 cycle 3 interim classification. The 2021 WFD investigation of the failures in this waterbody has been carried out and concluded that the 2021 cycle 3 classification was likely a result of diatom blooms in the first part of 2016, and the pattern of high phytoplankton was not repeated in subsequent years. There are mitigation measures in place in catchments adjacent to the North Wales waterbody, but it has not been possible to determine if these have reduced nutrient inputs into the waterbody recently.

Water quality: contaminants

This indicator target has a tertiary weighting. The sea caves feature is partly within one WFD waterbody, Anglesey North, which has failed for chemicals due to mercury and PBDE. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

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

3.2. Pen Llŷn a'r Sarnau SAC condition assessment

The sea caves feature in Pen Llŷn a'r Sarnau SAC includes a number of submerged and partially submerged sea caves (Figure 3). The summary of the assessment outcome for sea caves is provided in Table 4. This outcome and reasons for failure are discussed in more detail in the sections below.

Figure 3. Location map of the sea caves feature in the Pen Llŷn a'r Sarnau SAC.
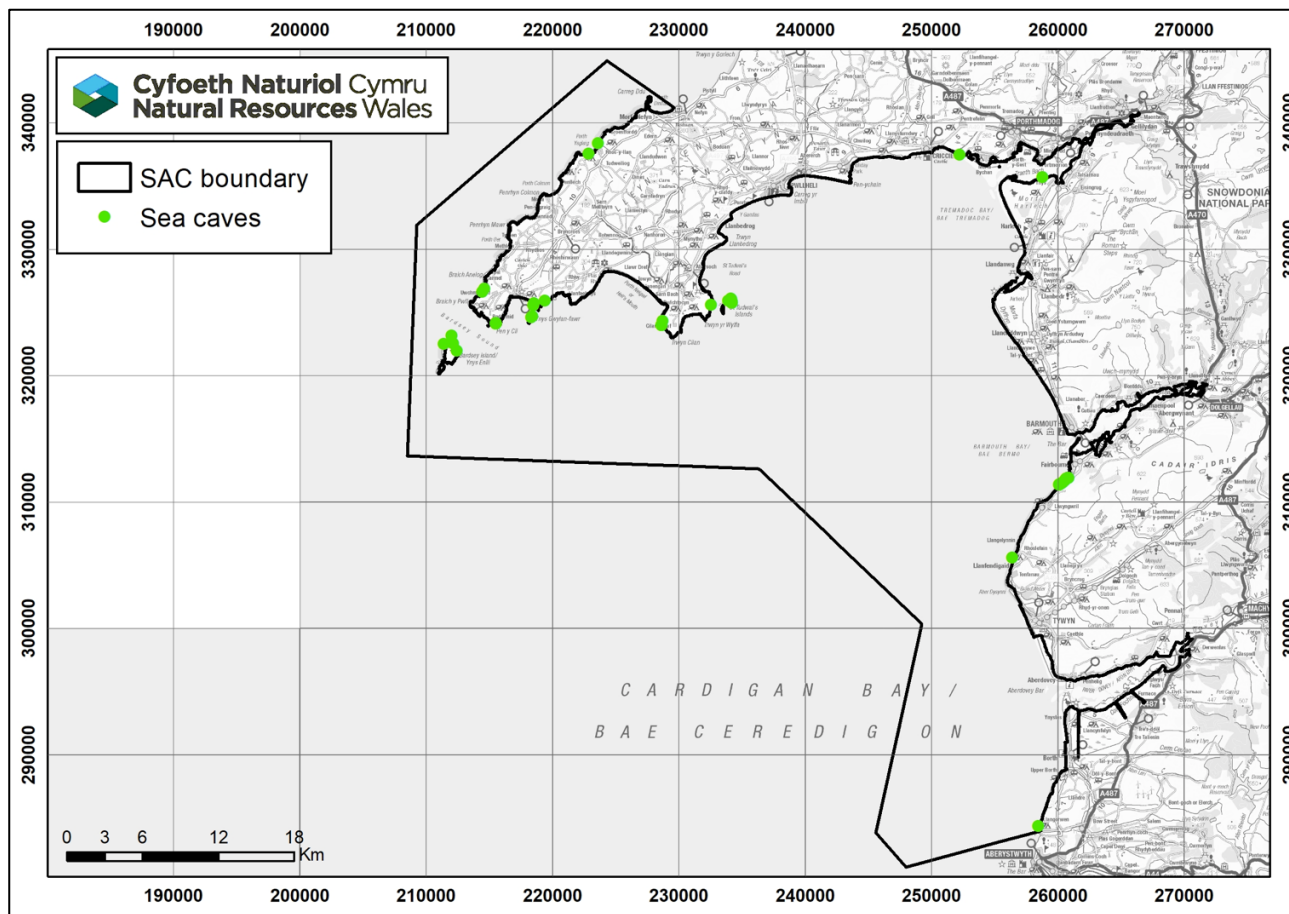
Table 4. Condition assessment of sea caves in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of sea caves allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Pen Llŷn a'r Sarnau SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of sea caves communities in the Pen Llŷn a'r Sarnau SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves on this site.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves on this site.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the four WFD waterbodies that overlaps with the sea caves feature was not classified for DIN in any cycles (Tremadog Bay). It overlaps with 29% of the mapped sea caves. • The other three WFD waterbodies were classified with a High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay North, Caernarfon Bay South and Glaslyn). Combined, these waterbodies overlap with 71% of the mapped sea caves. ○ One of these waterbody classifications was rolled forward from the 2018 cycle 2 interim classification. • Confidence is low due to the one unclassified waterbody and as ecological relationships between DIN and sea caves are not fully understood.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the four WFD waterbodies were not classified for phytoplankton in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). Combined, these overlap with 31% of the mapped sea caves. • The other two WFD waterbodies were classified with a Good status for phytoplankton (Cardigan Bay North and Caernarfon Bay South). Combined, these overlap with 69% of the mapped sea caves. • Confidence is low due to the unclassified waterbodies, and as ecological relationships between phytoplankton and sea caves are not fully understood.	**Pass**	Low
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the four WFD waterbodies that overlap with the sea caves feature were not classified for dissolved oxygen in the 2024 cycle 3 interim classification (Tremadog Bay and Glaslyn). Combined, these overlap with 31% of the mapped sea caves. • The other two WFD waterbodies were classified with High status for dissolved oxygen (Caernarfon Bay South and Cardigan Bay North). Combined, these overlap with 69% of the mapped sea caves. • Confidence was high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Three of the four WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Tremadog Bay, Caernarfon Bay South and Glaslyn). Combined, these waterbodies overlap with 36% of the mapped sea caves. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification due to mercury and PBDE (Cardigan Bay North). It overlaps with 64% of the mapped sea caves. • Confidence is low as the human health standard has been used for PBDE, some waterbodies were not classified, and the impact of these contaminants on sea caves is unknown.	**Fail**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (T)	• There are limited data on turbidity for the sea caves feature in Pen Llŷn a'r Sarnau SAC, therefore this target as assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from the six subtidal temperature loggers from within the SAC were available. Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. • It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• No information on sea cave communities has been collected for this SAC since 2000-02. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • There is also little information on the impact of any INNS present in the SAC on the condition of sea caves.	**Unknown**	N/A
Non-native species (INNS)	No increase in the number of introduced NNS by human activities. (T)	• No information on sea cave communities has been collected for this SAC since 2000-2002.	**Unknown**	N/A

Assessment conclusions

The sea caves feature in Pen Llŷn a'r Sarnau SAC has been assessed as being in **unknown** condition (N/A confidence). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps section 5). There was one tertiary failing indicator (Table 5). A summary of the assessment can be seen in Table 5 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Eight indicators were assessed as passing in the assessment of condition for sea caves in the Pen Llŷn a'r Sarnau SAC including extent and distribution. These can be seen in Table 4. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at medium likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment but the confidence was judged to be low (Table 5).

Table 5. Summary of the condition assessment for sea caves in Pen Llŷn a'r Sarnau SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Pen Llŷn a'r Sarnau	**Unknown (confidence not applicable)**	**Medium (low confidence)**	Water quality: contaminants (T)	• Levels of mercury and PBDE in the Cardigan Bay North waterbody are failing to meet their relevant EQSs.	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences

Detailed assessment information

Extent and Distribution

The extent, distribution of the feature, and the distribution and extent of habitats and communities indicators in the Pen Llŷn a'r Sarnau SAC passed their targets as there are no known anthropogenic impacts that would negatively affect the sea caves feature at the present. Although there were concerns about infilling of sea caves in one part of the SAC for coastal infrastructure that happened in the past, it was not felt to be enough to fail this indicator. It should be noted that not all sea caves in this SAC have been mapped. Comparison mapping has not been used to assess the extent and expert judgment was used to assess these indicators in the absence of recent data. This has reduced the confidence to medium.

Bathymetry and hydrodynamic processes

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

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within four WFD waterbodies where 64% overlap with the Cardigan Bay North waterbody, 29% with the Tremadog Bay waterbody, 5% with Caernarfon Bay South waterbody and 2% with the Glaslyn waterbody.

Nutrients (DIN only) and phytoplankton

The indicators for nutrients and phytoplankton met their targets. Some of the relevant WFD waterbodies were not classified for the DIN and phytoplankton element. This includes the Tremadog Bay waterbody, which overlaps with a significant proportion of the mapped sea caves. This caused the confidence in the assessments to be reduced to low. Classification of phytoplankton for some WFD waterbodies are not suitable or possible for this element due to WFD classification methodology, or due to the nature of the waterbodies (e.g. turbidity levels). For phytoplankton, there has been a deterioration from High status prior to the 2021 cycle 3 classification to Good status thereafter in the Cardigan Bay North waterbody. This waterbody overlaps with the largest proportion of the feature. This also contributed to the low confidence outcome. In addition, the ecological relationships between DIN and phytoplankton, and the sea caves feature across all SACs are not fully understood.

Dissolved oxygen

The dissolved oxygen indicator also met its target as most of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence was high as sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

One of the four WFD waterbodies that overlaps with the sea caves feature in the SAC, Cardigan Bay North, has a fail for chemicals in the 2024 cycle 3 interim classification due to mercury and PBDE. This waterbody overlaps with the largest proportion of the mapped sea caves (64%), which caused the contaminants indicator to fail. There was no change in the failure since the 2021 cycle 3 classification. The Cardigan Bay North waterbody failed for tributyltin (TBT) in previous cycles. This chemical is no longer assessed. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of sea caves are not fully understood. Three WFD waterbodies that overlap with the sea caves feature were not classified as the chemicals have not been assessed within the last six years. Overall, the confidence in the failure was reduced to low to reflect that the PBDE failure uses a protection goal which may be over precautionary, and due to some waterbodies being unclassified for chemicals. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Data from six NRW monitored subtidal temperature loggers within the SAC were available. Three of the loggers are close to some of the mapped sea caves (<1km away). Some of the loggers indicated an increase in the number of days with higher temperatures, and some showed no clear pattern. It is not understood if the observed increases in temperature are localised to the SAC, or if they are consistent with the effects of climate change. The physicochemical indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).

Species and communities

No information on sea cave communities has been collected for this SAC since 2000-2002. It should also be noted that not all sea caves have been mapped on this SAC. Along the south coast of Pen Llŷn, Two-levels cave on East St Tudwal's Island had exceptional examples of species-rich un-scoured littoral and sublittoral biotopes. Of special note were the encrusting sponges, the large patch of the anemone *Epizoanthus couchii* and the presence of the rare red seaweed *Schmitzia hiscockiana*. The complex tunnel at Pen-y-Cil had extensive areas of rich, tide-swept but un-scoured sublittoral biotopes and included species not commonly encountered in other caves studied including the ascidian *Polysyncraton lacazei* and many large growths of the sponge *Tethya aurantium*. The large-scale rock architecture of this tunnel was not encountered elsewhere in the 2000-2002 surveys (Bunker and Holt, 2003).

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

Invasive non-native species

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

Reasons for target failure

The assessment of the sea caves feature in Pen Llyn a'r Sarnau SAC failed one tertiary target. There were also six targets that were assessed as unknown due to limited data availability. Overall the feature was assessed to be in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: contaminants

This indicator target has a tertiary weighting. A large proportion of the sea caves feature in the SAC overlaps with one WFD waterbody, Cardigan Bay North, which has failed for chemicals due to PBDE and mercury. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

The sources of mercury and PBDE into the Cardigan Bay North waterbody are unknown. The WFD investigation of the failures is yet to be undertaken. Mercury and PBDE are being managed in the UK and it is hoped that these levels will reduce in time.

3.3. Cardigan Bay SAC condition assessment

The sea caves feature in the Cardigan Bay SAC comprises a number of submerged and partially submerged sea caves (Figure 4). There is currently no NRW Habitats Regulation monitoring programme for the sea caves within the Cardigan Bay SAC, therefore some indicators could not be assessed. The summary of the assessment outcome for sea caves is provided in Table 6. The outcome and reasons for failure are discussed in more detail in the sections below.

Figure 4. Location map of the sea caves feature in the Cardigan Bay SAC.
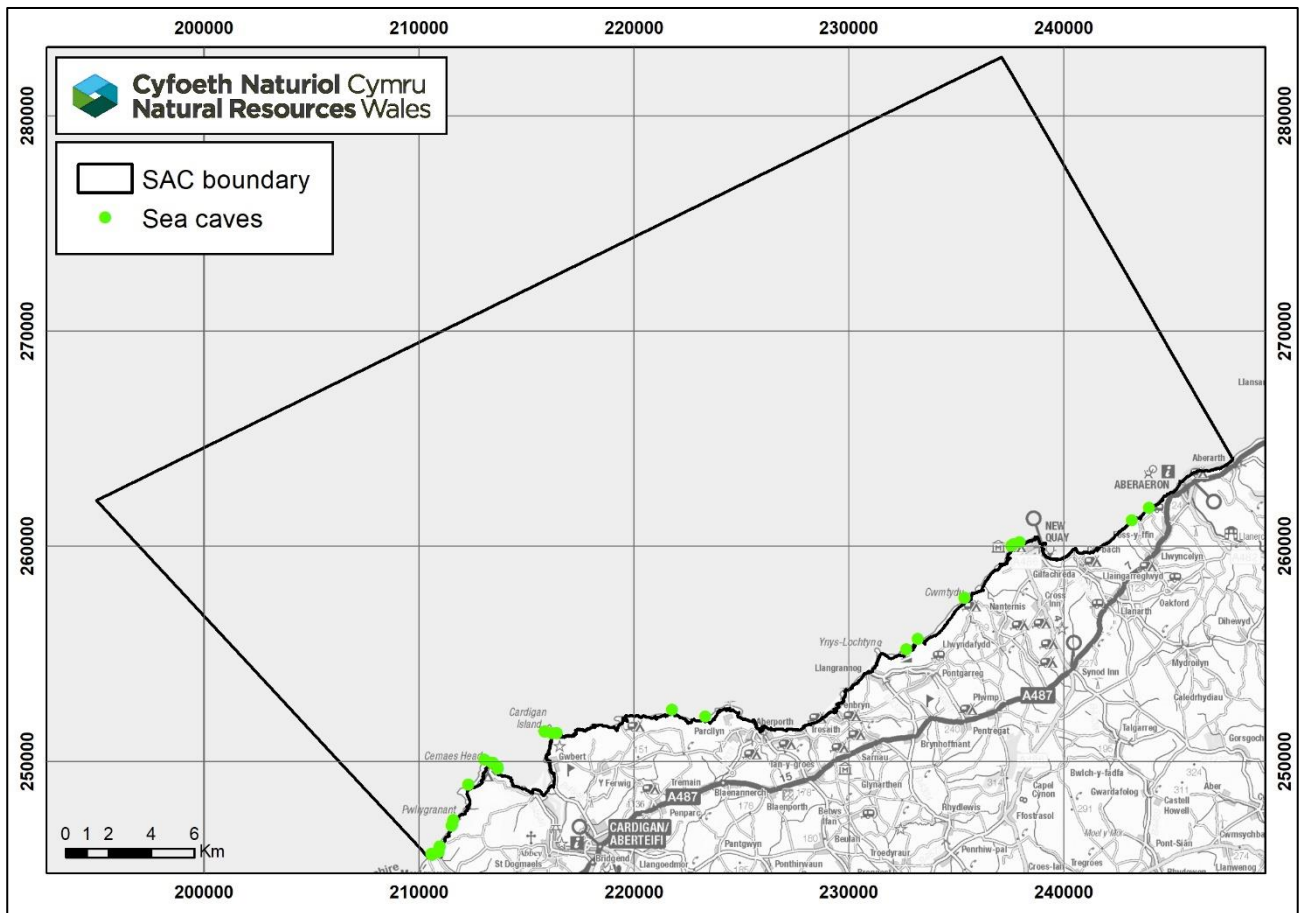
Table 6. Condition assessment of sea caves in Cardigan Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of natural reef within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Cardigan Bay SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of intertidal reef, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Cardigan Bay SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of reef habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of sea caves in the Cardigan Bay SAC. • Confidence was reduced as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the reef(s), allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence was reduced as expert judgement has been used to assess this indicator in the absence of any recent data from within sea caves.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (P)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the three WFD waterbodies that overlap with the sea caves feature in the SAC were classified with a High status for DIN in the 2024 cycle 3 interim classification (Cardigan Bay Central and Cardigan Bay South). Combined, these waterbodies overlap with 78% of the mapped sea caves. • The other WFD waterbody was classified with a Poor status for DIN (Teifi Estuary). It overlaps with 22% of the mapped sea caves. • Confidence is low as a large proportion of the feature overlap with waterbodies classified as High status and as ecological relationships between DIN and sea caves are not fully understood.	**Fail**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the three WFD waterbodies was not classified for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay South). This waterbody overlaps with 55% of mapped sea caves feature. • The other two WFD waterbodies were classified with High status for phytoplankton (Cardigan Bay Central and Teifi Estuary). Combined, these waterbodies overlap with 45% of the mapped sea caves. ○ The Teifi Estuary waterbody classification was rolled forward from the 2021 cycle 3 classification. • Confidence is low due to the unclassified waterbody, rolled forward classification, and as ecological relationships between phytoplankton and reefs are not fully understood.	**Pass**	Low
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (S)	• All three WFD waterbodies that overlap with the sea caves feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• One of the three WFD waterbodies was not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Cardigan Bay South). This waterbody overlaps with 55% of the mapped sea caves. • One WFD waterbody has a pass for chemicals, however the chemical classifications were rolled forward from the 2018 cycle 2 interim classification (Teifi Estuary). This waterbody overlaps with 22% of the mapped sea caves. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Cardigan Bay Central). This waterbody failed for mercury and PBDE and overlaps with 24% of the sea caves. • Confidence is low as the human health standard has been used for PBDE; some waterbodies are unclassified or had rolled forward classifications; and the impact of these contaminants on sea caves is unknown.	**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 sea caves feature in Cardigan Bay SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • There is also little information on the impact of any INNS present on the condition of sea caves.	**Unknown**	N/A
Non-native species (INNS)	No increase in the number of introduced NNS by human activities. (T)	• No information on sea cave communities has been collected for this SAC since 2000-2002.	**Unknown**	N/A

Assessment conclusions

The sea caves feature in Cardigan Bay SAC has been assessed as being in **unknown** condition (confidence N/A). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps section 5). There were two tertiary failing indicators (Table 7). A summary of the assessment can be seen in Table 7 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Seven indicators were assessed as passing in the assessment of condition for sea caves in the Cardigan Bay SAC including extent and distribution. These can be seen in Table 6. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at low likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment so the confidence was judged to be low (Table 7).

Table 7. Summary of the condition assessment for sea caves in Cardigan Bay SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Cardigan Bay	**Unknown (confidence not applicable)**	**Low (low confidence)**	Water quality: nutrients (DIN only) (T) Water quality: contaminants (T)	• High nutrient levels have been recorded in the Teifi Estuary waterbody. • Levels of mercury and PBDE in the Cardigan Bay Central waterbody are failing to meet their relevant EQSs.	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences • Metal mines

Detailed assessment information

Extent and Distribution

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

Bathymetry and hydrodynamic processes

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

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within three WFD waterbodies where 55% overlap with the Cardigan Bay South waterbody, 24% with the Cardigan Bay Central waterbody and 22% with the Teifi Estuary waterbody.

Nutrients (DIN only) and phytoplankton

The nutrients indicator failed to meet its target as one of the overlapping WFD waterbodies, the Teifi Estuary, was classified as Poor status for the DIN element in the 2024 cycle 3 interim classification. The draft WFD investigation report for the Teifi Estuary waterbody confirms that the waterbody is at least Moderate or worse status for DIN (Jopson et al., in draft). This waterbody overlaps with approximately 22% of the mapped sea caves. The other two WFD waterbodies, Cardigan Bay Central and Cardigan Bay South, were classified with a High status for DIN. The confidence in the pass was reduced to low as a large proportion of the feature overlap with waterbodies that were classified with a High status for DIN and as the relationship between DIN and sea caves is poorly understood.

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

The phytoplankton indicator met its target as two of the overlapping WFD waterbodies were classified with a High status for this element in the 2024 cycle 3 interim classification. These are the Cardigan Bay Central and Teifi Estuary waterbodies, which combined overlap with 45% of the mapped sea caves. The confidence in the pass was low because one waterbody was not classified for this element, and because the High classification in the Teifi Estuary waterbody was rolled forward from the 2021 cycle 3 classification. 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). In addition, the ecological relationships between phytoplankton and the sea caves feature across all SACs are not fully understood.

Dissolved oxygen

The dissolved oxygen indicator also met its target as all of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence in the pass was high as sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

The Cardigan Bay Central waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where mercury and PBDE failed. This waterbody overlaps with 24% of the mapped sea caves. This caused the contaminants indicator to fail. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The human health protection goal that is used for PBDE may be considered as over precautionary as the effect of contaminants on the biota of sea caves are not fully understood. One WFD waterbody, Cardigan Bay South, was not classified as the chemicals have not been assessed within the last six years. One WFD waterbody, Teifi Estuary, has a pass for chemicals, however the chemical classifications were rolled forward from the 2018 cycle 2 interim classification. Combined, these waterbodies overlap with 77% of the mapped sea caves. Overall, the confidence in the failure was reduced to low to reflect that the PBDE failure uses a protection goal which may be over precautionary and due to the unclassified waterbody and rolled forward classification. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Species and communities

No information on sea cave communities has been collected for this SAC since 2000-2002. Stable boulders and bedrock on the lower shore portions of the cave floors in the Cardigan area were colonised by *Sabellaria alveolata*. Although not found in the large hummocks of honeycomb-like tubes found on the open coast in this area, the fresh growth of tubes in several of the caves reflected the turbid and sand-scoured conditions not found in caves in the other SACs in Wales (Bunker and Holt, 2003).

Above the low water mark deep inside the caves the walls support little other than biotic films grazed by small molluscs such as *Otina ovata* and small *Patella vulgaris*. This apparently barren zone of bedrock continues along the walls out towards the entrance of the caves just above the mobile boulder floor. Spirorbid worms and barnacles with patchy thin crusts of sponge including *Halichondria panicea*, *Myxilla incrustans* and other yellow encrusting sponge species and sparse anemones *Actinia equina* cover the less scoured intertidal parts of the cave walls towards the backs of the caves. Barnacles, anemones and limpets are more common towards the cave entrance (Bunker and Holt, 2003).

Where cave walls have a lower shore and shallow subtidal section, for example in caves on the south-west side of Cardigan Island and the east side of Cemaes Head, the sea-squirt *Dendrodoa grossularia* is occasionally found at high densities, mixed with smaller patches of the white lace sponge *Clathrina coriacea* – both highly characteristic of wave-surge conditions. The most species-rich sections of the cave on the south-west side of Cardigan Island occurred just below chart datum between 10 and 30 m back into the cave. Patches of bright yellow sponge *Aplysilla sulfurea* and red *A. rosea* and *Ophlitaspongia seriata* are found on the walls, interspersed with colonial ascidians *Botrylloides leachii* and encrusting bryozoans such as *Flustrellidra hispida*. Towards the entrance of the cave, these short faunal turfs become more species-rich with other hydroids, ascidians and bryozoans (Bunker and Holt, 2003).

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

Invasive non-native species

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

Reasons for target failure

The assessment of the sea caves feature in Cardigan Bay SAC failed two tertiary targets. There were also five targets that were assessed as unknown. Overall the feature was assessed to be in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

This indicator target has a tertiary weighting. High levels of DIN have been recorded in the Teifi Estuary waterbody, which was classified as Poor status for the DIN element in the 2024 cycle 3 interim classification. As this waterbody overlaps with 22% of the sea caves, this caused the indicator to fail. A WFD investigation of the nutrient failure in this waterbody is currently underway, but the draft report confirms the DIN failure (Jopson, et al., in draft). In this draft report it is concluded that major input of nutrients is likely to be derived from diffuse sources associated with agriculture and rural land management (Jopson, 2022; Jopson, et al., in draft). Point source continuous and intermittent sewage

discharge from the water industry is also likely to be a minor source of nutrients linked to the DIN failure (Jopson, 2022; Jopson, et al., in draft).

There has been no biological failure in the phytoplankton or opportunistic macroalgae elements, however sampling for these elements in the Teifi Estuary waterbody was suspended in earlier years. There is some evidence of phytoplankton blooms which may indicate a localised issue in the estuary. It is possible that the lack of biological response observed could be due to dilution of water. The sources likely to be responsible for increased nutrient loading have been identified from source apportionment. A significant contribution of nitrogen loading is from diffuse sources in the catchment. In addition, a major source of the loading is likely from landward sources which is suggestive that the nutrient input may be from freshwater inputs. There may also be minor point-source inputs from continuous and intermittent sewage discharges from the water industry, and from unsewered domestic discharges by the general public.

Water quality: contaminants

This indicator target has a tertiary weighting. The Cardigan Bay Central waterbody failed due to mercury and PBDE. Historically, the main source of PBDE is as flame retardants in a variety of materials (Viñas et al., 2022). Mercury has been used in many industries, but today the primary sources are burning of coal and artisan mining for mercury (Larsen and Hjermann, 2022).

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

3.4. Pembrokeshire Marine SAC condition assessment

The sea caves feature in the Pembrokeshire Marine SAC comprises of a number of submerged and partially submerged sea caves (Figure 5). There is no NRW Habitats Regulations monitoring sea caves in this SAC. The summary of the assessment outcome for sea caves is provided in Table 8. This outcome and reasons for failure are discussed in more detail in the sections below.

Figure 5. Location map of the sea caves feature in the Pembrokeshire Marine SAC.
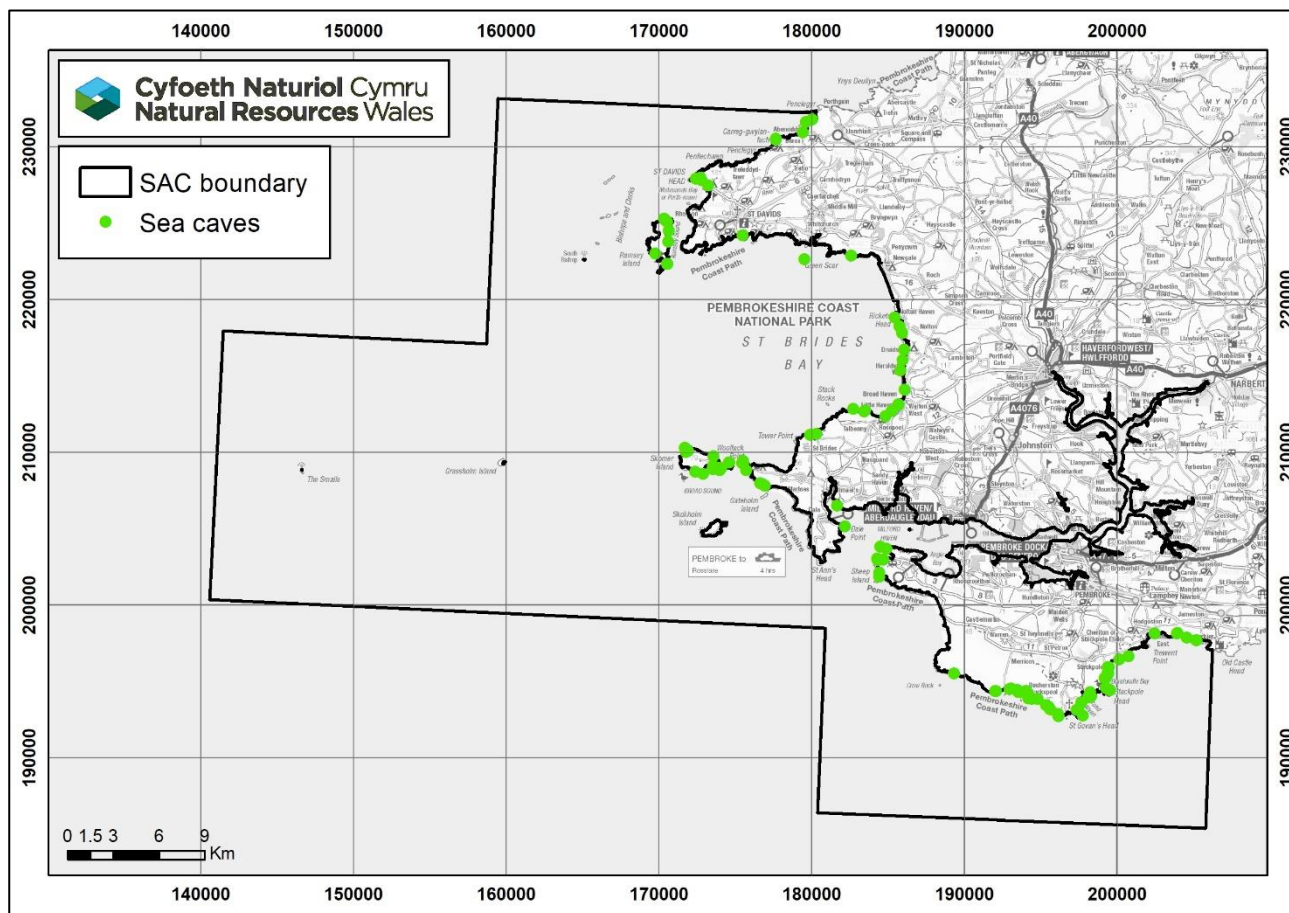
Table 8. Condition assessment of sea caves in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of sea caves, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Pembrokeshire Marine SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of sea caves in the Pembrokeshire Marine SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within the sea caves.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data from within the sea caves.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (S)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the three WFD waterbodies that overlap with the sea caves feature were classified with a High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Cardigan Bay South). Combined, these overlap with 96% of the mapped sea caves. o The classification for the Pembrokeshire South waterbody was rolled forward from the 2018 cycle 2 interim classification. • The other WFD waterbody was classified with a Poor status for DIN (Milford Haven Outer). This waterbody overlaps with 4% of the mapped sea caves. • Confidence is low as the failing waterbody overlaps with a small proportion of the mapped feature and as ecological relationships between DIN and sea caves are not fully understood.	**Fail**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• One of the three WFD waterbodies was not classified for phytoplankton in the 2024 cycle 3 interim classification (Cardigan Bay South). This waterbody overlaps with 8% of the mapped sea caves. • The other two WFD waterbodies were classified with a High status for phytoplankton (Pembrokeshire South and Milford Haven Outer). Combined, these overlap with 92% of the mapped sea caves feature. • Confidence is low as the ecological relationships between phytoplankton and sea caves are not fully understood.	**Pass**	Low
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All three WFD waterbodies that overlap with the sea caves feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification. • Confidence is high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Two of the three WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Pembrokeshire South and Cardigan Bay South). Combined, these waterbodies overlap with 96% of the mapped sea caves. • One WFD waterbody has a pass for chemicals, however some of the chemical classifications were rolled forward from the 2021 cycle 3 classification (Milford Haven Outer). This waterbody overlaps with 4% of the sea caves. • Confidence is low as a large proportion of the feature overlaps with unclassified waterbodies; some waterbodies had rolled forward classifications; and the impact of these contaminants on sea caves is unknown.	**Pass**	Low
Water quality: turbidity	Maintain expected levels of turbidity, allowing for natural change and variation. (S)	• There are limited data on turbidity for the sea caves feature in Pembrokeshire Marine SAC, therefore this target was assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: physicochemical properties	Maintain expected physicochemical properties of the water, allowing for natural change and variation. (S)	• Data from intertidal and subtidal temperature loggers were available. Some temperature loggers in the SAC showed an increase in the number of days with higher temperatures, and potential step change in temperature. • A Pembroke Power Station report indicated a localised increase in temperature, which was deemed unlikely to be of wider ecological significance. • This indicator was assessed as unknown due to a lack of understanding of the cause of the temperature patterns, and because there are currently insufficient data on other physicochemical parameters (e.g. salinity and pH).	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A
Species richness and diversity	Maintain the expected richness and diversity of reef species, allowing for natural change and variation. (S)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs at this SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Invasive non-native species (INNS)	Spread and impact of INNS caused by human activities should not adversely affect the condition of the feature. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • There is also little information on the impact of any INNS present in the SAC on the condition of sea caves.	**Unknown**	N/A
Non-native species (INNS)	No increase in the number of introduced NNS by human activities. (T)	• No information on sea cave communities has been collected for this SAC since 2000-2002.	**Unknown**	N/A

Assessment conclusions

The sea caves feature in Pembrokeshire marine SAC has been assessed as being in **unknown** condition (confidence N/A). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps section 5). There was one tertiary failing indicator (Table 9). A summary of the assessment can be seen in Table 9 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Eight indicators were assessed as passing in the assessment of condition for sea caves in the Pembrokeshire Marine SAC including extent and distribution. These can be seen in Table 8. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at low likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment so the confidence was judged to be low (Table 9).

Table 9. Summary of the condition assessment for sea caves in Pembrokeshire Marine SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

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

Detailed assessment information

Extent and Distribution

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

Bathymetry and hydrodynamic processes

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

Water quality

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

Nutrients (DIN only) and phytoplankton

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

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

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

Dissolved oxygen

The dissolved oxygen indicator also met its target as all three WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence in the pass was high because sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

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

Turbidity and physicochemical properties

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

Data from seven NRW monitored subtidal temperature loggers and six NRW monitored intertidal monitoring sites at various shore heights (12 temperature loggers in total) within the SAC were available. Most of these loggers (12 out of the 19) are close to some of the mapped sea caves (<1.5 km away). Some of the loggers showed an increase in the number of days with higher temperatures, and a potential step change in temperature. This is more apparent in the loggers within the Milford Haven Waterway. An external report (Sutton, 2023) found localised increase in temperature near the Pembroke Power Station. However, they concluded that this is unlikely to be of wider ecological significance. While localised, warming water can provide a safe haven for NNS, which could then spread further. This will be something to pay close attention to in the next assessment.

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

Species and communities

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

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

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

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

Invasive non-native species

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

Reasons for target failure

The assessment of the sea caves feature in Pembrokeshire Marine SAC failed one tertiary target.There were also six targets that were assessed as unknown due to limited data availability. The high level of unknown indicators meant that the features was assessed as

being in unknown condition. The failing indicators and reasons for failure, if known, are stated below.

Water quality: nutrients (DIN only)

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

The WFD investigation report has confirmed elevated nutrients in the Milford Haven Outer waterbody, where it was concluded that major input of nutrients is likely to be derived from diffuse sources associated with farm infrastructure and probable losses from agricultural land (Haines and Edwards, 2016; Lock, 2021). 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, 2021). Intermittent and domestic sewage are also suspected in the catchments. Further investigation locally is required to confirm these.

3.5. Limestone Coast of south-west Wales SAC condition assessment

The sea caves feature in Limestone Coast of south-west Wales SAC comprises of a number of partially submerged sea caves (Figure 6). There is no NRW Habitats Regulations monitoring sea caves in this SAC. The summary of the assessment outcome for sea caves is provided in Table 10. This outcome and reasons for failure are discussed in more detail in the sections below.

Figure 6. Location map of the sea caves feature in the Limestone Coast of south-west Wales SAC.
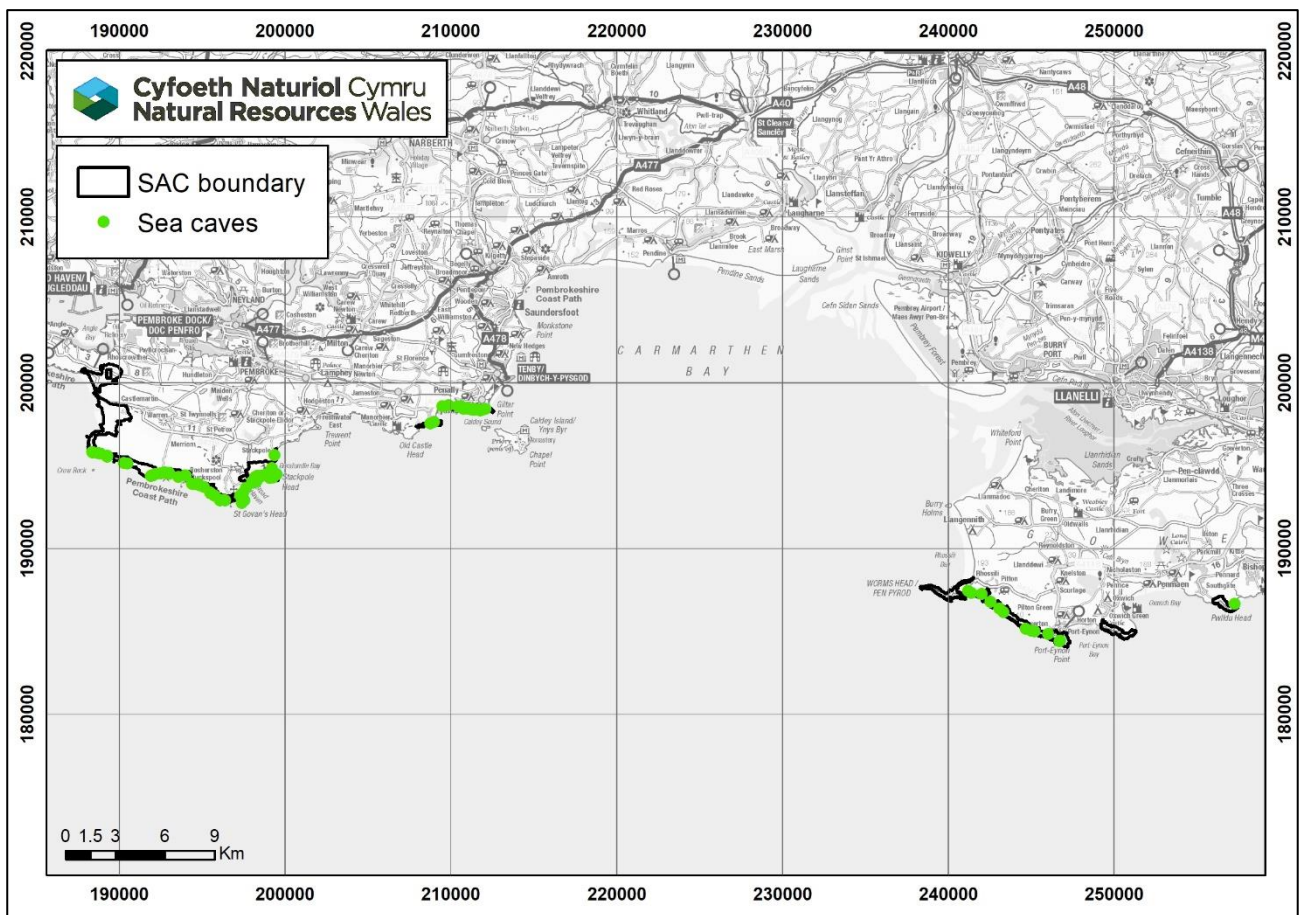
Table 10. Condition assessment of sea caves in Limestones coast of south-west Wales SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Extent	No significant decrease in the extent of sea caves within the SAC, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the extent of sea caves in the Limestone Coast of south-west Wales SAC. • Confidence is medium as the assessment has not been based on comparison mapping of the feature and expert judgment was used.	**Pass**	Medium
Distribution of the feature	Maintain distribution of sea caves, allowing for natural change. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution of sea caves in the Limestone Coast of south-west Wales SAC. • Confidence is medium as the assessment has been based on expert judgment.	**Pass**	Medium
Distribution and extent of habitats and communities	Maintain the distribution and extent of sea cave habitats and communities, allowing for natural change and variation. (P)	• There are currently no anthropogenic impacts known to be significantly affecting the distribution and extent of habitats and communities of sea caves in the Limestone Coast of south-west Wales SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data within sea caves.	**Pass**	Low
Bathymetry of the feature	Maintain bathymetry of the sea caves, allowing for natural change and variation. (S)	• There are currently no anthropogenic impacts known to significantly affect the bathymetry of the sea caves at this SAC. • Confidence is low as expert judgement has been used to assess this indicator in the absence of any recent data within sea caves.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Hydrodynamic and sediment transport processes	Maintain hydrodynamic and sediment transport processes, including connectivity, allowing for natural variation and change. (S)	• There are currently no anthropogenic impacts known to significantly affect the hydrodynamic and sediment transport processes of the sea caves at this SAC. • Confidence is medium as expert judgement has been used to assess this indicator in the absence of recent data.	**Pass**	Medium
Water quality: nutrients (DIN only)	The WFD classification achieved for winter DIN should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• Two of the three WFD waterbodies that overlap with the sea caves feature in the SAC were classified with a Good or High status for DIN in the 2024 cycle 3 interim classification (Pembrokeshire South and Carmarthen Bay). Combined, these waterbodies overlap with 99% of the mapped sea caves. ○ The Pembrokeshire South waterbody classification was rolled forward from the 2018 cycle 2 interim classification. • The other WFD waterbody was classified with a Moderate status for DIN (Bristol Channel Outer North). However, as it overlaps with only 1% of the mapped sea caves this did not cause the indicator to fail. • Confidence is low due to the failure in the Bristol Channel Outer North waterbody and as ecological relationships between DIN and sea caves are not fully understood.	**Pass**	Low

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: phytoplankton	The WFD classification achieved for phytoplankton should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All three WFD waterbodies were classified with a Good or High status for phytoplankton in the 2024 cycle 3 interim classification (Pembrokeshire South, Carmarthen Bay and Bristol Channel Outer North). • Confidence is medium because the ecological relationships between phytoplankton and the sea caves are not fully understood.	**Pass**	Medium
Water quality: dissolved oxygen	The WFD classification achieved for dissolved oxygen should be Good or High status in WFD waterbodies that overlap with the feature, and there should be no deterioration between status classes. (T)	• All three WFD waterbodies that overlap with the feature were classified with a High status for dissolved oxygen in the 2024 cycle 3 interim classification (Pembrokeshire South, Carmarthen Bay and Bristol Channel Outer North). • Confidence is high as sea caves are high energy environments so likely to have high oxygen levels in general.	**Pass**	High

Indicators	Target	Assessment rationale	Target assessment	Target confidence
Water quality: contaminants	Water column contaminants not to exceed the EQS. (T)	• Two of the three WFD waterbodies were not classified in the 2024 cycle 3 interim classification as the chemicals have not been assessed within the last six years (Pembrokeshire South and Bristol Channel Outer North). Combined, these waterbodies overlap with 72% of the mapped sea caves. • The other WFD waterbody has a fail for chemicals in the 2024 cycle 3 interim classification (Carmarthen Bay). This waterbody failed for mercury, PBDE and cypermethrin and overlaps with 28% of the sea caves. • Confidence is low as the human health standard has been used for PBDE; some waterbodies are unclassified; and as the impact of these contaminants on sea caves is unknown.	**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 sea caves feature in Limestone Coast of south-west Wales SAC, therefore this target was assessed as unknown.	**Unknown**	N/A
Abundance, distribution and species composition of communities	Maintain the abundance, distribution, and diversity of species within communities and component habitats, allowing for natural change and variation. (P)	• No information on sea cave communities has been collected for this SAC since 2000-2002. • Intertidal reefs for the adjoining Pembrokeshire marine SAC passed for this indicator which may give an indication of how sea caves might be doing in the SAC. • Intertidal reef was not used as a proxy so this indicator has been assessed as unknown.	**Unknown**	N/A

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

Assessment conclusions

The sea caves feature in Limestone Coast of south-west Wales SAC has been assessed as being in **unknown** condition (confidence N/A). This was due to the fact that there were very important indicators that could not be assessed as the data were over twenty years old. Two of these indicators were on species composition and species richness (see evidence gaps section 5). There was one tertiary failing indicator (Table 11). A summary of the assessment can be seen in Table 11 with more detail on each performance indicator, and any reasons for failure, provided in the sections below.

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

This simple assessment for sea caves looked at:

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

Eight indicators were assessed as passing in the assessment of condition for sea caves in the Limestone Coast of south-west Wales SAC including extent and distribution. These can be seen in Table 10. The assessment of pressures which might affect the condition of sea caves in the SAC was based on expert judgement.

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

The sea caves were assessed as being at low likelihood of being in unfavourable condition. The risk assessment was based solely on expert judgment so the confidence was judged to be low (Table 11).

Table 11. Summary of the condition assessment for sea caves in Limestone Coast of south-west Wales SAC. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting.

SAC	Overall Condition Assessment	Likelihood of unfavourable condition	Indicator failures	Reason for indicator failure	Threats to condition
Limestone Coast of south-west Wales	**Unknown (confidence not applicable)**	**Low (low confidence)**	Water quality: contaminants (T)	• Levels of mercury, PBDE and cypermethrin in the Carmarthen Bay waterbody are is failing to meet their relevant EQSs.	• Marine Litter • INNS • Recreation • Climate change • Management of coastal defences

Detailed assessment information

Extent and Distribution

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

Bathymetry and hydrodynamic processes

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

Water quality

The assessment has considered the sea caves which have been mapped within the SAC however there may be a large number of sea caves which have not been mapped. This affects the WFD waterbodies which have been included, and the proportion of sea caves within those waterbodies, and therefore lowers the confidence in the water quality assessment for this feature. For the mapped sea caves, it has been estimated that all of them fall within three WFD waterbodies where 71% overlap with the Pembrokeshire South waterbody, 28% with the Carmarthen Bay waterbody and 1% with the Bristol Channel Outer North waterbody.

Nutrients (DIN only) and phytoplankton

The nutrients indicator (DIN only) met its target as two of the three WFD waterbodies that overlap with the sea caves feature were classified with a Good or High status for DIN in the 2024 cycle 3 interim classification. The Pembrokeshire South waterbody was classified as High status, however this was rolled forward from the 2018 cycle 2 interim classification. This waterbody overlaps with the largest proportion of the mapped sea caves. The Carmarthen Bay waterbody was classified as Good status. This waterbody overlaps with 28% of the mapped sea caves. The other overlapping WFD waterbody, Bristol Channel Outer North, was classified with a Moderate status for DIN in the 2024 cycle 3 interim classification. As this waterbody overlaps with only 1% of the feature, it did not cause the indicator to fail, but it did reduce the confidence in the pass. Confidence was also reduced due to the rolled forward classification in the Pembrokeshire South waterbody, leading to a low confidence overall.

The phytoplankton indicator passed the target as all three WFD waterbodies that overlap with the sea caves feature were classified with a Good or High status for the phytoplankton element in 2024 cycle 3 interim classification. The ecological relationships between phytoplankton and sea caves across all SACs are not fully understood, which has reduced the confidence in the assessment to medium.

Dissolved oxygen

The dissolved oxygen indicator also met its target as all of the relevant WFD waterbodies were classified with a High status for the dissolved oxygen element in the 2024 cycle 3 interim classification. Confidence in the pass was high because sea caves are high energy environments so likely to have high oxygen levels in general.

Contaminants

The Carmarthen Bay waterbody has a fail for chemicals in the 2024 cycle 3 interim classification, where mercury, PBDE, and cypermethrin failed. This waterbody overlaps with 28% of the mapped sea caves and therefore caused the contaminants indicator to fail. The EQS for cypermethrin is very low, and in the previous lab methodology it was not possible to detect concentrations below the EQS. There has been a waterbody status change (pass to fail) between the 2021 cycle 3 classification and 2024 cycle 3 interim classification due to this reason. Cypermethrin is a synthetic pyrethroid insecticide and is highly toxic to some aquatic species (EA, 2019), but now has a restricted use in Wales. Mercury has failed in the Carmarthen Bay waterbody since the 2015 cycle 2 classification. The EQS for mercury is based on the secondary poisoning protection goal (for wildlife). The PBDE failure was based on the value of the human health protection goal as it is the most stringent. This protection goal may be over precautionary as the effect of contaminants on the biota of sea caves are not fully understood. The other two WFD waterbodies, Pembrokeshire South and Bristol Channel Outer North, were not classified as the chemicals have not been assessed within the last six years. Combined, these overlap with 72% of the mapped sea caves. The confidence in the pass was reduced to low to reflect this, and because the human health standard has been used for PBDE. In addition, the impact of the failing contaminants on the feature are not fully understood.

Turbidity and physicochemical properties

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

Species and communities

No information on sea cave communities has been collected for this SAC since 2000-2002 and only one part of the SAC was covered. The characteristic and rich marine habitats of this coast have been documented by several studies over the years. Caves have formed in many locations along the coast and some are known to be important as winter roosts for the rare greater horseshoe bat *Rhinolophus ferrumequinum* which is also a feature of the SAC. The caves are of many different structures and sizes, ranging from the huge cavernous 'Witches Cauldron' by Stack Rocks to small caves such as those found on the north side of Broadhaven (Bunker and Holt, 2003). One limestone cave at Broadhaven is known for its population of the nationally rare lagoon snail *Paludinella litorina* (Killeen and Light, 1994).

The supralittoral rocky ceiling and upper walls of the Barafundle Bay and Broadhaven caves were characterised by black Verrucaria lichens and a green algal film together with

patches of the red velvet seaweed *Rhodothamniella purpurea*. Where rock was regularly inundated with sea water, barnacles and limpets were present sometimes with patches of encrusting sponges and a thin coat of crustose Corallinaceae. The lower walls were often overhanging and where shade-tolerant red algal species such as *Lomentaria articulata* and *Plumaria plumosa* were present. Sponge growths characterised the overhangs with the species *Hymeniacidon perleve* and *Halichondria panicea* being prominent together with the barnacle *Balanus perforatus*. Several other species of sponge and ascidian were recorded in lower abundance. A number of the rarely recorded sea anemone *Anthopleura thallia* were recorded in May 2002 (Bunker and Holt, 2003).

Intertidal reefs are not a feature of this SAC but intertidal reef in the adjoining Pembrokeshire Marine SAC passed for this indicator which may give an indication of how sea caves might be doing for this element in this SAC. However, intertidal reef was not used as a proxy so this indicator has been assessed as unknown.

Invasive non-native species

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

Reasons for target failure

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

Water quality: contaminants

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

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

4.   Threats to sea caves condition

Part of the condition assessment is to identify threats to the condition of the sea caves. As the threats to sea caves are the similar across all the relevant SACs they have been listed here once to avoid repetition. A threat is defined as an activity that is currently not impacting condition but has the potential to do so over the next reporting cycle, if activity levels increase or are unmanaged. It is important to identify these threats to be able to put pre-emptive management in place to prevent declines in condition.

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

Recreational access and collection

Access for recreational activities particularly coasteering can have a trampling effect on intertidal sea caves. This is particularly concerning in the Pembrokeshire Marine SAC and Limestone Coast of south-west Wales SAC. This could have detrimental impact on the sea cave communities.

Invasive non-native species

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

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

Management of coastal defences

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

Climate change

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

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

Marine litter

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

Historic Metal Mines

In the Menai Strait and Conwy Bay SAC there are historic metal mines which could have an effect on the sea cave communities. This is due to leaching from the old mines in the back of sea caves. More information on this issue would be useful.

5. Evidence gaps for sea caves feature

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

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

Table 12. Evidence gaps for sea caves in Welsh SACs. Each indicator target has a primary (P), secondary (S) or tertiary (T) weighting (see section 1.1).

Indicator	Assessed status	Comments
Distribution and extent of habitats and communities (P)	Low confidence (proxy data used)	• There are currently no data available to assess changes for these indicators from within sea caves across all SACs. Assessment was based on expert judgment.
Abundance, distribution and species composition of communities (P); species richness and diversity (P)	Unknown	• There are no current data available to assess this indicator for sea caves across all SACs.
Invasive non-native species (P) ; non-native species (T)	Unknown	• Investigations into the impact of the recorded NNS on sea caves is required. • There have been no targeted surveys for NNS in sea caves across all SACs.
Water quality: turbidity (S)	Unknown	• Turbidity is measured in WFD sampling, but this is limited to only a few samples per year. Therefore, this cannot be used to adequately assess the turbidity 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.

Indicator	Assessed status	Comments
Water quality: physicochemical properties (S)	Unknown / Not assessed	• There were no temperature loggers in the Cardigan Bay and Limestone Coast of south-west Wales SACs. • Further evidence on temperature change is required to adequately assess this indicator in other SACs. Some physicochemical parameters such as salinity and pH have not been assessed. These could be considered in future as some monitoring data are available. • Remote sensing data on temperature, salinity and pH could be used in future.

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