Cyfoeth Naturiol Cymru
Natural Resources Wales

Wales intertidal SAC feature assessment summary 2004-2017

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Crynodeb Gweithredol

Mae'r Gyfarwyddeb Cynefinoedd yn datgan y dylid rheoli Ardaloedd Cadwraeth Arbennig (ACAau) gan geisio sicrhau statws cadwraeth ffafriol y cynefinoedd a'r rhywogaethau a restrir yn Atodiad I ac Atodiad II yr ACA dan sylw. Yng nghyswllt ACAau yng Nghymru, gofynnir i Cyfoeth Naturiol Cymru (CNC) gyflwyno adroddiad yn rheolaidd i nodi a oes gan y nodweddion statws cadwraeth ffafriol. Mae rhaglenni o fonitro cyflwr nodweddion wedi cael eu datblygu gan CNC a'i gontractwyr ar gyfer pob un o'r pum prif ACA morol yng Nghymru – Bae ac Aberoedd Caerfyrddin, Sir Benfro Forol, Bae Ceredigion, Pen Llŷn a'r Sarnau ac ACAau Afon Menai a Bae Conwy. Sefydlwyd y rhaglen fonitro ACA rhynglanwol yn y lle cyntaf yn 2004 a pharhaodd i ddatblygu dros sawl blwyddyn, drwy roi contract i'r Sefydliad Astudiaethau Aberol ac Arfordirol (IECS, Prifysgol Hull) ac Aquatic Survey & Monitoring Ltd. (ASML).

Mae ffocws y monitro ym mhob ACA morol yn ddibynnol ar:

- y rhesymau dros ddynodiad pob ACA,
- nodweddion y Safleoedd o Ddiddordeb Gwyddonol Arbennig (SoDdGA) sylfaenol, i fodloni rhai amcanion monitro SoDdGA,
- nodi lleoliadau y'u hystyrir yn gynrychiadol o'r nodwedd ledled ehangder ehangach yr ACA
- cydnabod yr her o allu darparu sicrwydd digonol ar gyfer pob nodwedd ac is-nodwedd.

Mae'r adroddiad hwn yn cwmpasu'r rhaglen monitro rhwng 2004 a 2017:

- ACA Bae ac Aberoedd Caerfyrddin
  - Amrywiaeth cynefinoedd nodweddion yr aber a'r cilfachau a baeau mawr bas:
    - Cymunedau gwaddodion rhynglanwol yng Nghilfach Tywyn ac aberoedd y tair afon
    - Cymunedau gwaddodion rhynglanwol ar arfordir agored Bae Caerfyrddin (gyda rhai cyfeiriadau at ffynonellau bwyd adar)
    - Poblogaethau pidocau mawn rhynglanwol
    - Gwelyau zostera noltii yng Nghilfach Tywyn
    - Riffau mytilus edulis (gyda chyfeiriad at ffynonellau bwyd adar)
    - Cymunedau glannau creigiog creigwely ym Mhwynt Monkstone
    - Cymunedau pyllau glan môr ym Mhwynt Trevayne
    - Nodweddion glannau creigiog arbennig yng ngorllewin Bae Caerfyrddin
  - - Cymunedau benthig o wastadeddau llaid a gwastadeddau tywod rhynglanwol
    - Cymunedau gwaddodion rhynglanwol yng Nghilfach Tywyn ac aberoedd y tair afon
    - Cymunedau gwaddodion rhynglanwol ar arfordir agored Bae Caerfyrddin (gyda rhai cyfeiriadau at ffynonellau bwyd adar)
- ACA Sir Benfro Forol
  - Cymunedau benthig y nodwedd rîff (gan gynnwys yr aber a'r cilfachau mawr bas)
    - Cymunedau glannau creigiog creigwely yn Aberdaugleddau a Nolton Haven
    - Cymunedau pyllau glan môr ym Mhen y Holt, de Sir Benfro

  - Cymunedau gwaddodion ar nodweddion gwastadeddau llaid a gwastadeddau tywod rhynglanwol ac aberol
    - Cymunedau gwaddodion rhynglanwol ym Mae Angle
    - *Zostera noltii* ym Mae Angle
- ACA Bae Ceredigion
  - Cymunedau benthig y nodwedd rîff
    - Ehangder a chymuned fiolegol riffau *Sabellaria alveolata* yn Aberaeron a Chei Bach
    - Cymunedau pyllau glan môr yn Aber-porth a Chei Bach
- ACA Pen Llŷn a'r Sarnau
  - Cymunedau benthig y nodwedd rîff
    - Ehangder a chymuned fiolegol riffau *Sabellaria alveolata* yn Llandanwg ac i'r gorllewin o afon Dwyfor
    - Cymunedau glannau creigiog creigwely ym Mhorth Oer, Pen Llŷn
  - Cymunedau gwaddodion ar nodweddion gwastadeddau llaid a gwastadeddau tywod rhynglanwol, aberoedd a chilfachau mawr bas
    - Cymunedau gwaddodion rhynglanwol yn aberoedd Dwyryd/Glaslyn, Mawddach a Dyfi
    - Cymunedau gwaddodion rhynglanwol ar arfordir agored Bae Tremadog
    - *Zostera noltii* mewn safleoedd amrywiol ledled Pen Llŷn
  - Cofnodion o rywogaethau prin yn y cilfachau a baeau mawr bas
    - Poblogaeth o *Pectenogammarus planicrurus* ym Mhwllheli
- ACA y Fenai a Bae Conwy
  - Cymunedau benthig y nodwedd rîff
    - Cymunedau biolegol y cynefinoedd clogfaen ym Mhont Britannia a'r Felinheli
    - Cymunedau biolegol y cynefin *Fucus serratus* a ysgubir gan y llanw yn Llanidan, Afon Menai
  - Cymunedau gwaddodion ar nodweddion gwastadeddau llaid a gwastadeddau tywod rhynglanwol a chilfachau a baeau mawr bas
    - Cymunedau biolegol mewn cynefinoedd graean lleidiog yng ngogledd Afon Menai
    - Cymunedau gwaddodion rhynglanwol yn aber y Foryd ac ar wastadeddau Traeth Lafan
    - *Zostera noltii* ar wastadeddau Traeth Lafan.

Mae'r adroddiad hwn yn rhoi crynodeb ar gyfer pob nodwedd/is-nodwedd a fonitrwyd, safleoedd arolwg maes, dyddiadau a dulliau, cyfeiriadau allweddol a disgrifiad o ganlyniad yr arolygon monitro. Mae'r wybodaeth hon yn hanfodol ar gyfer darparu tystiolaeth i lywio'r gwaith o reoli safleoedd yn effeithiol ac ar gyfer adrodd i Ewrop o dan Erthygl 17 y Gyfarwyddeb Cynefinoedd. Mae'r rhan fwyaf o'r data crynodeb yn cael eu cyflwyno'n llawn mewn adroddiadau eraill a ddyfynnwyd, sy'n canolbwyntio ar nodweddion neu leoliadau penodol ac sy'n cynnwys dadansoddiad ystadegol llawn lle bo'n briodol.

Mae'r crynodeb hwn yn cwmpasu'r cyfnod rhwng 2004 a 2017 ac yn cynnwys rhywfaint o waith monitro nodweddion na gafodd ei barhau, gan fod y dadansoddiad

yn dangos nad oedd modd ailadrodd y dull yn ddibynadwy. Roedd y blynyddoedd cynharach o fonitro yn cynnwys sefydlu dulliau a lleoliadau, ac mewn rhai achosion, cafodd dulliau eu haddasu neu eu hehangu, er mwyn gwella canlyniad y data monitro. Darperir cyfeiriadau allweddol, disgrifiad cryno, newidiadau sylweddol a datganiad mewn perthynas â chyflwr pob is-nodwedd. Mae'r adroddiadau bwydo a ddyfynnir yn yr adroddiad hwn yn cynnwys mwy o fanylder ar ddulliau yn ogystal â thablau o ddata crai a ddefnyddiwyd yn y dadansoddiadau, neu ddolenni i'r data gan Cyfoeth Naturiol Cymru.

Ystyrir bod mwyafrif helaeth yr is-nodweddion yn yr ystod o amrywiadau naturioldisgwyliedig. Mae data ar welyau morwellt a gwelyau o gregyn gleision yn amrywiol iawn, ond cadarnhawyd bod y cynefinoedd a'r rhywogaethau hyn yn parhau i fodoli. Yng Nghei Lawrenny yn Aberdaugleddau, mae ehangder Ascophyllum nodosum, rhywogaeth allweddol ar y safle hwn, wedi lleihau, ond mae'n bosibl nad yw hyn yn gyfyngedig i'r safle hwn yn y DU (gohebiaeth bersonol Juliet Brodie). Mae cynnydd nodedig wedi bod mewn rhywogaethau estron sy'n gysylltiedig â glannau creigiog Aberdaugleddau ac Afon Menai. Mewn nifer o safleoedd creigwely, mae stormydd gaeaf wedi symud clogfeini, gan olygu bod mynediad i'r safleoedd monitro cwadrat wedi'i rwystro. Mewn safleoedd pyllau glan môr, mae stormydd gaeaf wedi sgwrio neu siltio'r pyllau glan môr dros dro.

Executive Summary

The Habitats Directive establishes that the management of Special Areas of Conservation (SACs) should aim to achieve the favourable conservation status of habitat and species features listed within its Annex I and Annex II. For SACs in Wales, Natural Resources Wales (NRW) is therefore required to report on a regular basis on whether features are in favourable conservation status. Programmes of feature condition monitoring have been developed by NRW and its contractors for each of the 5 main marine SACs in Wales - Carmarthen Bay and Estuaries, Pembrokeshire Marine, Cardigan Bay, Pen Llŷn a'r Sarnau and Menai Strait and Conwy Bay SACs. The intertidal SAC monitoring program was initially established in 2004 and continued to develop over many years, through contracting the Institute of Estuarine and Coastal Studies (IECS, University of Hull) and Aquatic Survey & Monitoring Ltd. (ASML).

The focus of the monitoring in each marine SAC is dependent on:

- the reasons for designation for each SAC,
- the features of the underlying Sites of Special Scientific Interest (SSSI), to accommodate some SSSI monitoring objectives,
- to identify locations that are considered representative of the feature across the wider extent of the SAC
- recognising the challenge of being able to provide adequate cover of each feature and sub-feature.

This report covers the monitoring program from 2004 to 2017:

- Carmarthen Bay and Estuaries SAC
  - Habitat diversity of the Estuary and the Large Shallow Inlet and Bay (LSIB) features:
    - Intertidal sediment communities in the Burry Inlet and the 3 Rivers estuaries
    - Intertidal sediment communities on the open coast of Carmarthen Bay (with some references to bird food sources)
    - Intertidal peat piddock populations
    - *Zostera noltii* beds in the Burry Inlet
    - *Mytilus edulis* reefs (with reference to bird food sources)
    - Bedrock rocky shore communities at Monkstone Point
    - Rockpool communities at Trevayne Point
    - Special rocky shore features in west Carmarthen Bay
  - Benthic communities of intertidal mudflats and sandflats (IMS)
    - Intertidal sediment communities in the Burry Inlet and the 3 Rivers estuaries
    - Intertidal sediment communities on the open coast of Carmarthen Bay (with some references to bird food sources)
- Pembrokeshire Marine SAC
  - Benthic communities of the Reef feature (incl Estuary and LSIB)
    - Bedrock rocky shore communities in Milford Haven and Nolton Haven
    - Rockpool communities at Pen y Holt, south Pembrokeshire
  - Sediment communities in IMS and Estuary features

        - Intertidal sediment communities at Angle Bay
        - *Zostera noltii* at Angle Bay
- Cardigan Bay SAC
    - Benthic communities of the Reef feature
        - Extent and biological community of *Sabellaria alveolata* reefs at Aberaeron and Cei Bach
        - Rockpool communities at Aberporth and Cei Bach
- Pen Llŷn a'r Sarnau SAC
    - Benthic communities of the Reef feature
        - Extent and biological community of *Sabellaria alveolata* reefs at Llandanwg and West of Afon Dwyfor
        - Bedrock rocky shore communities at Porth Oer, Llŷn Peninsula
    - Sediment communities in IMS, LSIB and Estuary features
        - Intertidal sediment communities in the Dwyryd/Glaslyn, Mawddach and Dyfi estuaries
        - Intertidal sediment communities on the open coast of Tremadog Bay
        - *Zostera noltii* at various sites around the Llŷn Peninsula
    - Rare species recording in the LSIB
        - Population of *Pectenogammarus planicrurus* at Pwllheli
- Menai Strait and Conwy Bay SAC
    - Benthic communities of the Reef feature
        - Biological communities of boulder habitats at Britannia Bridge and Felinheli
        - Biological communities of tide-swept *Fucus serratus* habitat at Llanidan, Menai Strait
    - Sediment communities in IMS and LSIB features
        - Biological communities in muddy gravel habitats in north Menai Strait
        - Intertidal sediment communities in the Y Foryd estuary and on Traeth Lafan flats
        - *Zostera noltii* on Traeth Lafan flats

This report provides a summary for each feature/sub-feature monitored, field survey sites, dates and methods, key references and a description of the outcome of the monitoring surveys. This information is critical in providing evidence to inform effective site management and for reporting to Europe under Article 17 of the Habitats Directive. Most summary data are fully presented in other, cited reports, which focus on specific features or locations and contain full statistical analysis where appropriate.

This summary covers from 2004 to 2017 and includes some feature monitoring that was not continued, due to the analysis demonstrating that the method was not reliably repeatable. The earlier years of monitoring involved the establishment of methods and locations and on occasions, methods were adjusted or expanded on, to improve the monitoring data outcome. Key references, a summary description, notable changes and a statement in relation to the condition of each sub-feature are provided. The feeder reports cited in this report contain greater detail on methods as

well as tables of raw data that were used in the analyses, or links to the data in Natural Resources Wales.

The vast majority of the sub-features are considered to lie within the range of expected natural fluctuations. Data on seagrass beds and mussel beds proves highly variable, but the continued presence of these habitats and species is confirmed. At Lawrenny Quay in Milford Haven, the extent of *Ascophyllum nodosum*, a key species at this site, has declined, although this is possibly not restricted to this site in the UK (pers comm Juliet Brodie). There has been a notable increase in non-native species associated with the rocky shores of Milford Haven and the Menai Strait. At a number of bedrock sites, winter storm action has resulted in boulders being moved, resulting in obstruction of the monitoring quadrat sites. At rockpool sites, winter storms have resulted in the temporary scouring or silting of rockpools.

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1. Introduction

The Habitats Directive establishes that the management of Special Areas of Conservation (SACs) should aim to achieve the favourable conservation status of habitat and species features listed within its Annex I and Annex II (Special Areas of Conservation – overview | JNCC - Adviser to Government on Nature Conservation). For SACs in Wales, Natural Resources Wales (NRW) is therefore required to report on a regular basis on whether features are in favourable conservation status. Programmes of feature condition monitoring have been developed by NRW and its contractors for each of the 5 main marine SACs in Wales - Carmarthen Bay and Estuary, Pembrokeshire Marine, Cardigan Bay, Pen Llŷn a'r Sarnau and Menai Strait and Conwy Bay SACs. The intertidal SAC monitoring program was initially established in 2004 and continued to develop over many years, through contracting the Institute of Estuarine and Coastal Studies (IECS, University of Hull) and Aquatic Survey & Monitoring Ltd. (ASML). A monitoring program has been developed for habitats and species that are representative of Special Area of Conservation (SAC) features in five marine SACs in Wales, as shown in Figure 1 (along with the sampling stations across Wales).

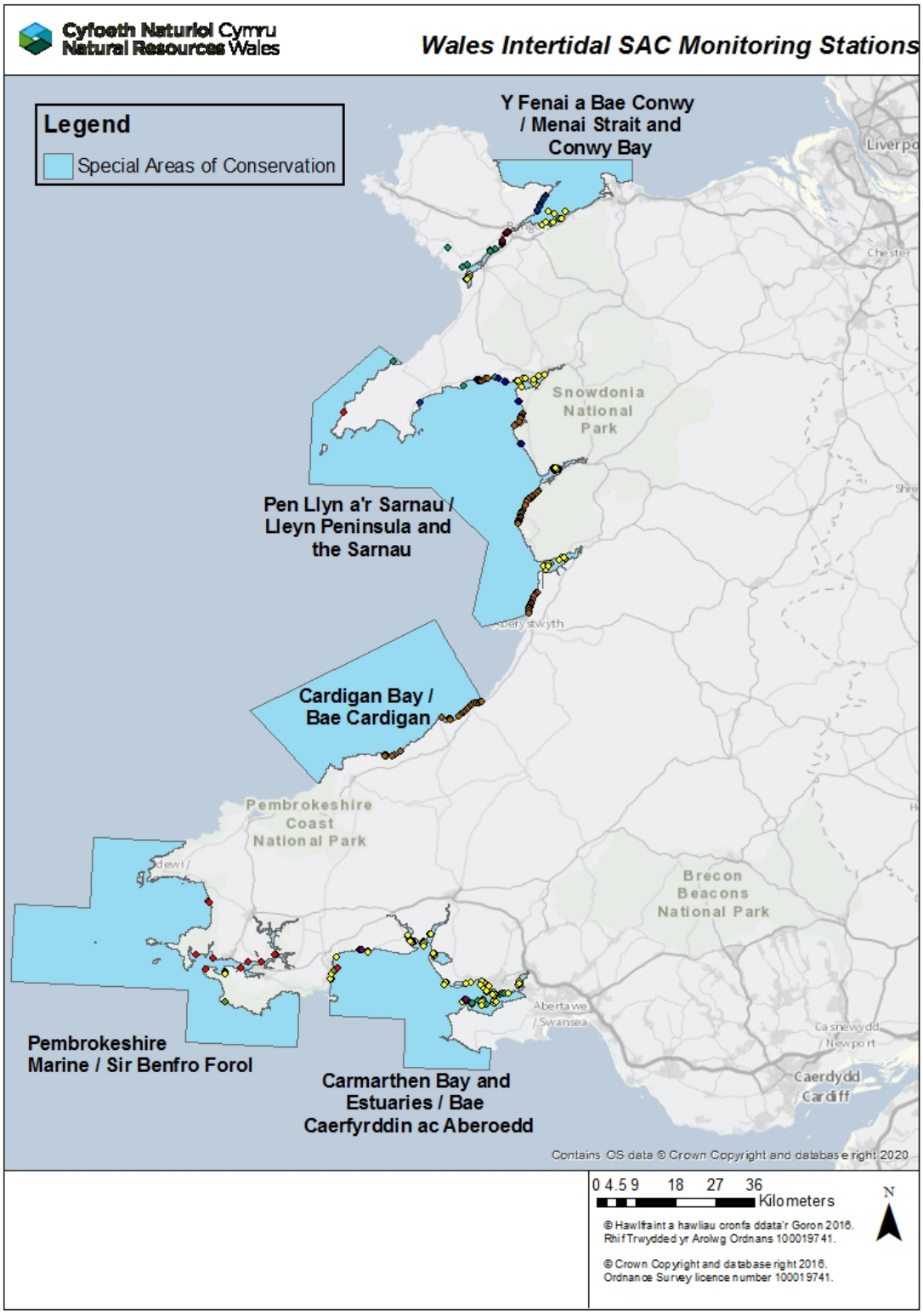
UK Descriptions of each Annex 1 habitat can be found at [ARCHIVED CONTENT] Marine Habitats and Species for SACs (nationalarchives.gov.uk). Table 1 provides a list of monitoring objectives within each of the marine SACs for the period 2004 to 2017. The marine features are very broad in definition (UK Marine SAC project publications: Davison & Hughes 1998; Hill *et al*. 1998; Holt *et al*. 1998; Elliott *et al*. 1998), as well as very extensive across each SAC. The suite of sub-features and their locations that have been identified for intertidal monitoring is derived by consideration of the appropriate features for the SAC, underlying SSSI features, how best to represent the condition of the full breadth of the sub-feature and the level of threat placed on a sub-feature. For each sub-feature, locations have been identified, that are considered representative of the full extent of the sub-feature. In addition, locations where there are greater threats are targeted, whilst remote, apparently less threatened locations (e.g. remote, open coast Reef) are not fully represented. A good knowledge of the distribution of the intertidal habitats and species from the CCW intertidal biotope mapping project (Brazier *et al*. 2007), provides the best opportunity to target the important feature locations. Local knowledge from NRW staff has also been garnered to improve initial site selection.

This report provides a summary of each sub-feature using the following headers:

- Special Area of Conservation Name
- Features in the SAC
- Sampling / Recording site locations
- Years monitored
- Methods
- Key References (mainly feeder reports that provide detailed methodology and the detailed analyses)
- Summary Description of the monitoring events
- Notable changes identified from the data
- Description of the habitat condition

Generic standard operating procedures that apply to all methods are in Moore & Brazier (2016a).

Figure 1 Map of the extent of the intertidal monitoring programme, in 5 SACs in Wales. Also showing the sampling stations across Wales.



1.1. Marine SAC Features and monitoring objectives

1.1.1 Carmarthen Bay and Estuaries SAC

Feature: Habitat diversity of the Estuary and the Large Shallow Inlet and Bay (LSIB) features:

- Intertidal sediment communities in the Burry Inlet and the 3 Rivers estuaries
- Monitoring Objective
- Intertidal sediment communities on the open coast of Carmarthen Bay (with some references to bird food sources)
- Intertidal peat piddock populations
- *Zostera noltii* beds in the Burry Inlet
- *Mytilus edulis* reefs (with reference to bird food sources)
- Bedrock rocky shore communities at Monkstone Point
- Rockpool communities at Trevayne Point
- Special rocky shore features in west Carmarthen Bay

Feature: Benthic communities of intertidal mudflats and sandflats (IMS)

- Intertidal sediment communities in the Burry Inlet and the 3 Rivers estuaries
- Intertidal sediment communities on the open coast of Carmarthen Bay (with some references to bird food sources)

1.1.2 Pembrokeshire Marine SAC

Feature: Benthic communities of the Reef feature (incl LSIB)

- Bedrock rocky shore communities in Milford Haven and Nolton Haven
- Rockpool communities at Pen y Holt, south Pembrokeshire

Feature: Sediment communities in IMS and Estuary features

- Intertidal sediment communities at Angle Bay
- *Zostera noltii* at Angle Bay

1.1.3 Cardigan Bay SAC

Feature: Benthic communities of the Reef feature

- Extent and biological community of *Sabellaria alveolata* reefs at Aberaeron and Cei Bach
- Rockpool communities at Aberporth and Cei Bach

1.1.4 Pen Llŷn a'r Sarnau SAC

Feature: Benthic communities of the Reef feature

- Extent and biological community of *Sabellaria alveolata* reefs at Llandanwg and West of Afon Dwyfor
- Bedrock rocky shore communities at Porth Oer

Feature: Sediment communities in IMS, LSIB and Estuary features

- Intertidal sediment communities in the Dwyryd/Glaslyn, Mawddach and Dyfi estuaries
- Intertidal sediment communities on the open coast of Tremadog Bay
- *Zostera noltii* at various sites around Pen Llŷn

Feature: Rare species recording in the LSIB

- Population of *Pectenogammarus planicrurus* at Pwllheli

1.1.5 Menai Strait and Conwy Bay SAC

Feature: Benthic communities of the Reef feature

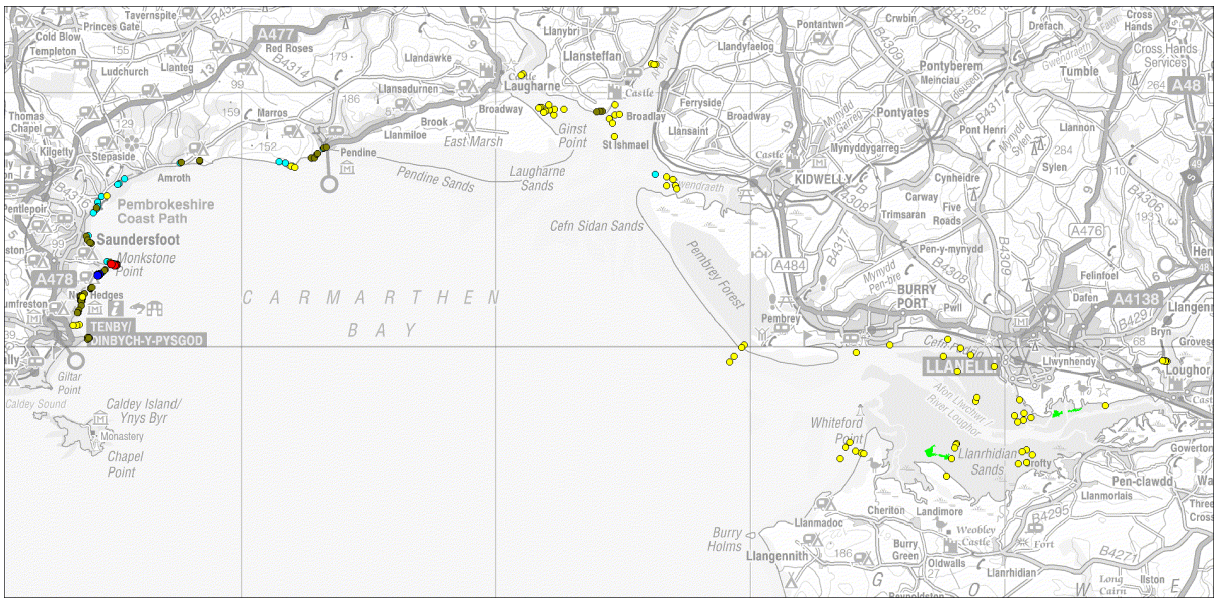
- Biological communities of boulder habitats at Britannia Bridge and Felinheli
- Biological communities of tide-swept *Fucus serratus* habitat at Llanidan

Feature: Sediment communities in IMS and LSIB features

- Biological communities in muddy gravel habitats in north Menai Strait
- Intertidal sediment communities in the Foryd and on Traeth Lafan
- *Zostera noltii* at Traeth Lafan

2. Carmarthen Bay and Estuaries SAC

Figure 2 Locations of intertidal features monitored in Carmarthen Bay SAC. Sediment communities (yellow dots), rockpools (blue dots), caves and overhangs (brown dots), bedrock (red dots), *Zostera* beds (green areas). Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014



2.1. Intertidal sediment communities – Burry Inlet

SAC Annex 1 features: Large shallow inlet and bay, Estuary, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Nine sites are distributed around the Inlet (Figure 2), to represent the range of shores present. Each site consists of multiple stations, representing the various ecological zones and biotopes present. These often take the form of transects down the shore, but elsewhere, cluster in the same habitat, to provide compatibility with the WFD sediment sampling strategy.

Table 1 Numbers of sediment stations sampled by coring in the Burry Inlet

Site	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Burry Port W	0	1	0	0	0	0	1	0	0	0	0	0
Burry Port E	0	1	0	0	0	0	0	0	0	0	0	0
Pwll	0	0	5	0	0	0	0	5	0	5	0	0
Llanelli	3	0	0	0	0	0	0	0	0	0	0	0
Machynys	0	2	5	0	0	0	2	5	0	6	0	0
Penclacwydd	0	1	0	0	0	0	0	0	0	0	0	0
Pencoed-isaf	4	0	0	0	0	0	0	0	0	0	0	0
Crofty	2	0	5	5	5	5	5	5	5	5	3	5
Llanrhidian	5	0	0	0	0	0	5	0	0	5	0	0

Methodologies: A survey at each station is a combination of *in situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (see Moore 2016d) and conventional core sampling (3 or 5 x 0.01 m^2 cores, 0.5 mm mesh, plus sediment sample for particle size analysis) with associated lab analysis (see Moore 2016g). Some stations (additional to those in the table above) are only surveyed *in situ*.

Key references: Annual reports from 2005 (Rowe 2006), 2007 (Moore 2009) and 2008 (Brazier & Bunker 2011). Unpublished spreadsheet data collated from 2005 to 2017.

Summary description and notable changes: A limited analysis of infaunal core sample data and sediment granulometry data has been completed so far.

A range of sediments are represented by the sampling stations in the Burry Inlet, but the majority are dominated by fine sand with some very fine sand and silt/clay and some small amounts of coarser material. Stations within areas where the channel frequently moves around (e.g. Pwll) tend to be more mobile with a greater proportion of medium sand, while those in the more sheltered locations (e.g. Machynys) have a greater proportion of silt/clay, whilst a few very sheltered stations are dominated by silt and clay (e.g. Pencoed-isaf).

The infauna of the fine sand sediments are characterised by cockles *Cerastoderma edule*, Baltic tellin *Limecola balthica*, spionid worms *Pygospio elegans* and laver spire shells *Peringia ulvae*. Species richness (number of taxa per core) typically ranges from 10 to 20. The more mobile medium sands are characterised by lower species richness and more fast burrowing species, like the amphipods *Bathyporeia sarsi* and *Urothoe poseidonis* and the spionid polychaetes *Spio armata* and *Scolelepis squamata*. The muddy sediment stations represent a variety of infaunal communities that are characterised by different species, including the bivalve *Scrobicularia plana*, the ragworm *Hediste diversicolor* and the tube dwelling amphipod *Corophium arenarium*. Large fluctuations in density of individual taxa occur from year to year at all of the monitored stations and fluctuations can also occur in community composition and species richness, but the majority of these changes are considered to be within the normal range for these sediments.

However, particle size analysis of sediments from the five stations at Crofty show some notable changes over the course of the monitoring, with large fluctuations in the finer fractions. At the two lower mid shore stations (CrC2 and CrC4) silt/clay comprised over 30% of the sediment in 2008, but progressively reduced to less than 3% in 2016. This is due to the establishment of a mussel *Mytilus edulis* bed on some former mussel crumble (mussel spat binding empty cockle shells on the sediment surface). The very fine sand fraction also reduced by similar amounts, leaving a sediment comprising 80% fine sand. Associated changes in the infauna are apparent, with notable shifts in the community composition and a large reduction in the total number of individuals by 2016. There was no clear trend in species richness, but the number of species was relatively low in 2017 at those two stations.

Condition (2017): Recorded changes in biotope richness and distribution, species composition and abundance appear to be within the range of natural fluctuations – pending further statistical analysis and comparison.

2.2. Intertidal sediment communities – Three Rivers

SAC Annex 1 features: Large shallow inlet and bay, Estuary, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Five sites are distributed around the three estuaries (Figure 2), to represent the range of shores present. Each site consists of multiple stations, representing the various ecological zones and biotopes present. These

often take the form of transects down the shore, but elsewhere, cluster in the same habitat, to provide compatibility with the WFD sediment sampling strategy.

Table 2 Numbers of sediment stations sampled by coring in the 3 Rivers estuaries.

Site	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Laugharne	0	0	5	0	0	0	0	5	0	0	0	5
Black Scar	1	0	0	0	0	0	0	2	0	0	0	2
Ferry Point	1	0	0	0	0	0	2	0	0	0	0	2
Llansteffan	1	1	5	5	5	5	5	6	5	3	3	5
Gwendraeth	0	3	5	0	0	0	0	5	0	0	0	5

Methodologies: same as Burry Inlet (see Section 2.1)

Key references: same as Burry Inlet (see Section 2.1)

Summary description and notable changes: Limited analysis of core sample data and sediment granulometry data has been completed so far.

A range of sediments are represented by the sampling stations in the Three Rivers, from the mobile sands near the mouths to the cohesive muds in the upper estuaries and saltmarsh areas. As with the Burry Inlet, a large proportion of the monitored stations across the broad tidal flats are dominated by fine sands. Sheltered conditions are also common in the narrower winding channels and here muddy sands occur e.g. Ferry Point, upper shore stations at Gwendraeth. Upper shore stations at Black Scar and Laugharne are very muddy.

A very similar suite of infaunal species is found in the Three Rivers stations to that in the Burry Inlet, with a similar scale of fluctuations in counts of taxa, community composition and species richness. Again, the fluctuations are considered to be within the normal range for these sediments.

The mobile sediments of the lower shore stations at Llansteffan and Laugharne are often characterised by very low species richness and abundance, to the extent that three core samples (a total of 0.03 m^2) sometimes contain insufficient fauna for reliable statistical analysis (No of cores increased to 5 after 2014.

A notable change, over the course of the monitoring programme, has been a large shift in the position of the Taff channel south of Laugharne and erosion of sediment from the south west side of that estuary. In 2008, when survey stations were first sampled, the eroding edge of the channel at low tide was less than 1m high and approximately half way across the estuary. In 2013 the eroding edge, now called the escarpment, was much higher and had moved towards the south west side of the estuary by around 300 m. The edge of the channel, at low tide, had also moved towards the west side, but not as much as the escarpment. In 2017, the escarpment was over 3m high and had eroded by another 80m or more and the channel had also moved further west. The escarpment ran parallel to the channel for many hundreds of metres, dividing the mobile fine sands of the lower shore from a band of muddy upper shore sediments. The latter is backed by saltmarsh, but if the escarpment continues to erode it will eventually reach the marsh edge. Most of the survey stations that were sampled in 2008 are now in the channel or on the east side and no longer accessible from the west side. New stations were established in 2013 and 2017 to replace the lost stations. Direct comparisons with data from most of the original stations is therefore not possible, but there have been large changes in the distribution of the biotopes in this estuary, primarily due to movement of the channel.

Comparison with Phase 1 biotope maps from 1999 (Brazier *et al.* 2007) and the position of the channel in Ordnance Survey maps shows that large changes also occurred prior to 2008. It is assumed that these changes are natural, or at least that local anthropogenic-related causes are not known.

Condition (2017): Recorded changes in biotope richness and distribution, species composition and abundance appear to be within the range of natural fluctuations – pending further statistical analysis of the typical species.

2.3. Intertidal sediment communities – Open coasts

SAC Annex 1 features: Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Six sites are distributed along the open coast from Tenby to Whiteford Point (Figure 2), to represent the range of shores present. Each site consists of multiple stations, representing the various ecological zones and biotopes present. These often take the form of transects down the shore.

Table 3 Numbers of sediment stations sampled by coring on the open coast.

Site	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tenby	3	0	0	0	0	0	3	0	0	0	3	0
Waterwynch	0	1	0	0	0	0	1	0	0	0	1	0
Wisemans Bridge	1	0	0	0	0	0	1	0	0	0	1	0
Ragwen Point	0	1	0	0	0	0	2	0	0	0	2	0
Pembrey	1	0	0	0	0	0	4	0	0	0	0	0
Whiteford Pt	3	0	0	0	0	0	5	2	0	0	0	0

Methodologies: same as Burry Inlet (see Section 2.1)

Key references: same as Burry Inlet (see Section 2.1)

Summary description and notable changes: Limited analysis of core sample data and sediment granulometry data has been completed so far.

The open coast stations are predominantly mixtures of fine and medium sand with some coarse sand, particularly towards the top of the shore and very little finer material. The lower and mid shore stations are often characterised by the bivalve *Macomangulus tenuis*, the polychaete worms *Nephtys cirrosa* and *Spio martinensis* and various fast burrowing amphipods. Species richness is typically less than 15 taxa per core and often much lower in the upper shore stations, which maybe colonised by some of the same worms and amphipods as the lower stations, but in lower densities.

Large fluctuations in counts of individual taxa occur from year to year at all of the monitored stations and fluctuations can also occur in community composition and species richness, but the recorded changes are considered to be within the normal range for these sediments.

Condition (2016): Recorded changes in species composition and abundance appear to be within the range of natural fluctuations.

2.4. Piddock populations

SAC Annex 1 features: Large shallow inlet and bay.

Sites and survey years: Marros Sands (2009, 2014).

Methodologies: Based on methods developed during the 2004 survey (Boyes *et al.* 2009). Mapping the extent of the bed (exposed peat and clay with piddock holes) and recording piddock abundance using quadrats and timed searches. Methods and protocols for selecting survey locations and recording live and dead piddocks have not been fully standardised, so quantitative comparisons are limited. Other conspicuous taxa, including algae, mussels and snails, were also recorded.

Key references: Boyes *et al.* (2009). Unpublished GIS data, spreadsheet data and photographs from 2009 and 2014.

Summary description and notable changes: An area of partially exposed peat and clay in the middle of Marros Sands, colonised by patchy, but in places dense, populations of piddock bivalves (*Pholas dactylus* and *Barnea candida*). The exposed area of peat and clay varies with sand movement, which makes it more difficult to monitor piddock densities in a consistent and unbiased way. The total extent of the beds was higher in 2014 (4.7 hectares) than on previous surveys. Densities of piddock holes (including large adults and small juveniles) ranged from 0 to many hundreds per 0.25 m^2 quadrat, with the highest densities often present on the sides of the peat/clay beds. Densities of confirmed live piddocks was generally low, but they were present in every survey.

This sub-feature has not been further monitored, due to the difficulty of repeat sampling. The extent varies naturally according to sand levels and live piddock numbers will reflect the degree of sand smothering. For fully accurate recording of live piddocks, a destructive method would be necessary and this is not deemed appropriate.

Condition (2014): The extent of the exposed peat/clay was higher in 2014 than previous surveys; areas with high densities of piddock holes, including at least some confirmed live piddocks, were found in all surveys.

2.5. Zostera beds

SAC Annex 1 features: Large shallow inlet and bay, Estuary, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Llanrhidian (2009, 2014) Figure 3, Penrhyn Gwyn (2009, 2014) Figure 4. Grid of stations (with 50 m x 50 m intervals) across each bed.

Methodologies: Mapping the extent of beds using GPS. Recording the abundance (% cover) in one quadrat from each grid station. Frequency of occurrence of *Zostera noltii* and *Spartina* also recorded in 5 quadrats at each station. Other conspicuous taxa, including lugworm *Arenicola marina*, snails, cockles *Cerastoderma edule* and algae, were also recorded.

Key references: Unpublished GIS data, spreadsheet data and photographs from 2009 and 2014.

Figure 3 *Zostera noltii* in 2009 (yellow) and 2014 (green) on Llanrhidian Sands, Burry Inlet in Carmarthen Bay SAC. Aerial image base map.

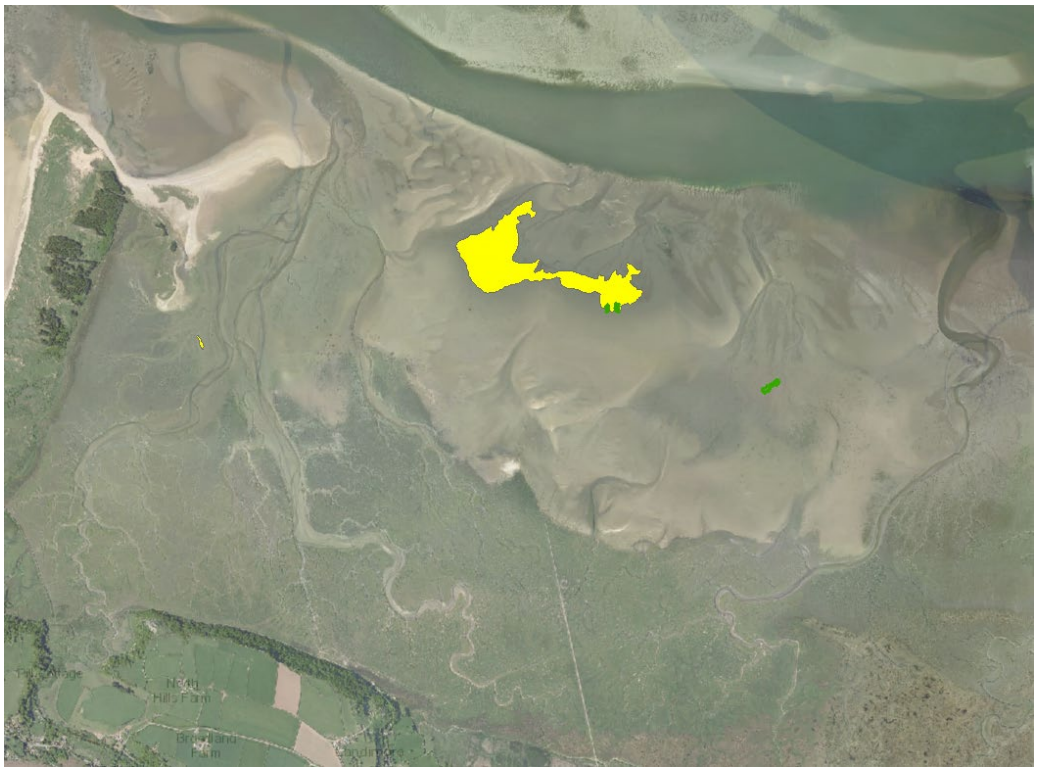
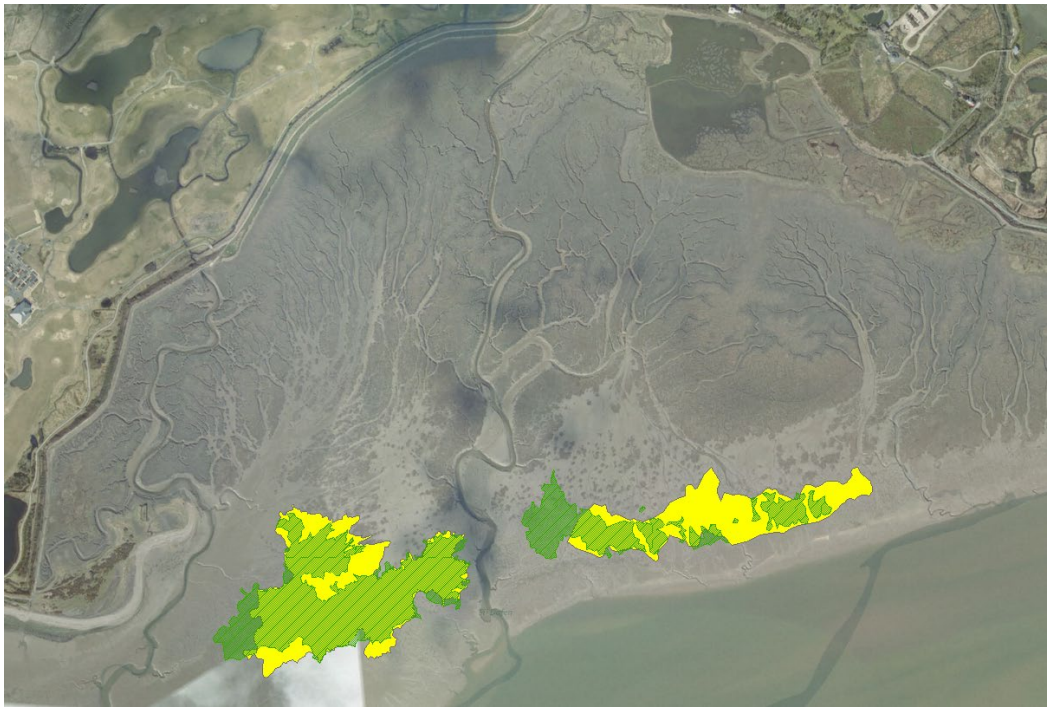


Figure 4 *Zostera noltii* in 2009 (yellow) and 2014 (green) on Penrhyn Gwyn, Burry Inlet in Carmarthen Bay SAC. Aerial image base map.



Summary description and notable changes: The Llanrhidian bed comprises a large area of mostly clean fine sand with very sparse *Zostera noltii*, which was even sparser in 2014. Here, the Z. noltii continues to form widely dispersed, sparse beds, accounting for movements in banks of clean sand across the flats. Penrhyn Gwyn

comprises a large area of muddy fine sand with some relatively dense *Z. noltii*, some of which is sparse. Shoot density was higher in 2014 than 2009.

Condition (2014): The extent of the Llanrhidian bed was considerably diminished in 2014 and the Penrhyn Gwyn bed was slightly less in 2014 than in 2009, whilst average shoot density increased at Penrhyn Gwyn but decreased at Llanrhidian.

2.6. Mussel beds

SAC Annex 1 features: Large shallow inlet and bay.

Sites and survey years: Whiteford Point, Salmon Point, Crofty, Penrhyn Gwyn and Carreg Fach (2013). Figure 5.

Methodologies: Mapping the extent of each bed using GPS. A grid of stations (or three lines of stations) was created across each bed. The percentage cover of mussels and filamentous green algae was recorded from a single quadrat at each station. Size frequency analysis and total weight of mussels was calculated for each station. Methods were based on those from previous mussel stock assessment surveys (Moore 2012, Hartley 2013).

Figure 5 Sampling positions of mussel scars at Salmon Point, Whiteford Point, Crofty and Penrhyn Gwyn in Carmarthen Bay SAC. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014

Key references: Unpublished GIS data, spreadsheet data and photographs from 2013.

Summary description and notable changes: Whiteford Scar and Salmon Point Scar are large beds (50+ hectares and 34 hectares respectively, in 2013), although mapping their extent is made difficult by the variation in cover and character. Both

beds had significant areas of accumulated dead shell that was difficult to distinguish from live mussels without close inspection. The beds also extend into the subtidal, particularly at Whiteford, so an annual measured extent is dependent on the height of the low tide. The other three beds were much smaller (combined area = 12 hectares) and are known to change considerably in extent and sometimes location, from year to year. Percentage cover of mussels is very variable, with percentage cover of greater than 50% only recorded from a proportion of quadrats on the two larger beds. Average cover of mussels on the five beds (in the order listed above) was 49%, 26%, 14%, 5% and 3%. Mussel sizes ranged from 4 mm to 58 mm, with the modal size ranging from 17 mm at Penrhyn Gwyn to 47 mm at Crofty.

Note: *Crepidula fornicata* was searched for but not found on any bed.

These monitoring surveys were initiated to inform work on bird food availability in the SAC and overlapping Carmarthen Bay Special Protection Area (SPA) and Burry Inlet SPA, as well as some pending shellfish fisheries orders. It has not been continued into the full monitoring program.

Condition (2013): Insufficient data were available to assess whether the condition was Favourable or Unfavourable. A large range of mussel sizes was present, including seed mussels, indicating that reproduction, recruitment and growth was apparently occurring.

2.7. Rocky shore communities – open rock

SAC Annex 1 features: Large shallow inlet and bay.

Sites and survey years: Monkstone Point (2015, 2016, 2017). Figure 2.

Methodologies: The methodology is based on that developed for the Pembrokeshire Marine SAC monitoring sites (see Mercer & Brazier 2009). *In situ* recording of abundance (cell frequency counts) of all conspicuous taxa in fixed quadrats; barnacle populations (relative abundance taken from 5cm x 5cm photo quadrats); limpet population size frequencies.

Key references: Unpublished spreadsheet data and photographs from 2009 and 2014.

Summary description and notable changes: The quadrat stations are on south facing, wave exposed bedrock and are colonised by rocky shore communities that are typical for the habitats. The lower shore vertical bedrock community is dominated by a rich assemblage of sponges (particularly *Hymeniacidon perlevis*), hydroids (particularly *Dynamena pumila*), *Spirobranchus*, barnacles (particularly *Perforatus perforatus*), limpets *Patella*, gastropods (particularly *Nucella lapillus*), mussels *Mytilus edulis*, encrusting bryozoan, as well as a large variety of red algae, *Fucus serratus* and green algae (particularly *Ulva* spp. (flat)). Fluctuations in abundance of individual species are considered typical and the average number of taxa recorded per quadrat has been very stable at 45 taxa. The mid shore is upward facing, bedrock community is dominated by barnacles (particularly *Semibalanus balanoides* and *Austrominius modestus*), limpets *Patella*, a variety of small gastropods (incl. *Littorina saxatilis* and *Nucella lapillus*), and juvenile mussels *Mytilus edulis*. Fluctuations in abundance of individual species are considered typical and species richness, generally between 15 and 20 taxa per quadrat, has increased over the

three years. The upper shore is steeply sloping, bedrock and the community is dominated by barnacles (particularly *Chthamalus montagui* and *Austrominius modestus*), limpets *Patella*, a variety of small gastropods (incl. *Littorina saxatilis* and *Melarhaphe neritoides*), encrusting red algae (*Hildenbrandia*), channel wrack *Pelvetia canaliculata* and black lichens *Verrucaria*. Fluctuations in abundance of individual species are considered typical and species richness, generally between 10 and 12 taxa per quadrat, has fluctuated slightly.

Condition (2017): Recorded changes in species richness, species composition, population characteristics and abundances appear to be within the normally recorded range of such fluctuations. Noted changes and trends are also considered to have been natural.

2.8. Rocky shore communities – caves and overhangs

SAC Annex 1 features: Large shallow inlet and bay.

Sites and survey years: Waterwynch to Gwendraeth coast (inventory) (2007), St. Catherine's Island (2008), North Beach Tenby (2008), Waterwynch (2008) and Monkstone Point (2008). Figure 2.

Methodologies: 2007: Inventory and brief Phase 1 style description of 26 caves / overhangs present between Waterwynch and the Gwendraeth estuary. 2008: more detailed Phase 2 style descriptions of 22 overhangs (8 at St. Catherine's Island, 4 at North Beach Tenby, 3 at Waterwynch, 7 at Monkstone Point) and 4 caves (2 at St. Catherine's Island, 2 at Waterwynch). Records were made of the presence of all conspicuous taxa, plus, at 15 of the overhangs and 1 of the caves, of the percentage cover of major taxonomic groups.

Key references: Moore (2009), Brazier & Bunker (2011)

Summary description and notable changes: A large variety of cave and overhang biotopes were present, including one that is considered to be Nationally Important (found in 9 of the caves) and five that are considered Rare or Scarce in Wales (Brazier *et al*. 2007). Many of the overhangs at St. Catherine's Island, Waterwynch and Monkstone Point are characterised by species rich communities of sponges, hydroids, anemones, barnacles, bryozoans, ascidians and red and green algae. 10 of those overhangs have been assigned to the LR.FLR.CvOv.SpR biotope that is considered Rare in Wales, and 14 have been assigned to the LR.FLR.CvOv.SpByAs biotope that is considered Scarce in Wales. This is a single surveying event, so no monitoring data are available to describe temporal changes. Casual observations by F Bunker, particularly at St. Catherine's Island, suggest that the communities there are still characterised by a rich and abundant fauna and flora that is typical of the biotope. A methodology that can provide reliable and repeatable monitoring data on the condition of these communities, within a sustainable budget, has not yet been developed.

Condition (2008): Species rich communities of many rare and scarce biotopes are present, but there are no monitoring data to assess their recent condition.

2.9. Rocky shore communities - rockpools

SAC Annex 1 features: Large shallow inlet and bay

Sites and survey years: Waterwynch to Gwendraeth coast (inventory) (2007), Waterwynch and Monkstone Point (2008), Trevayne (2015, 2016, 2017). Figure 2.

Methodologies: In 2007, an inventory and brief Phase 1 style description of 31 pools present between Waterwynch and the Gwendraeth estuary was undertaken. In 2008: a slightly more detailed description of 2 rockpools (1 at Waterwynch, 1 at Monkstone Point) was undertaken. In 2015, 2016 and 2017 at Trevayne, a well-developed monitoring methodology (Moore 2016f): *in situ* recording of presence and abundance (% cover) of all conspicuous taxa in 10 fixed rockpools on an area of midshore bedrock platform.

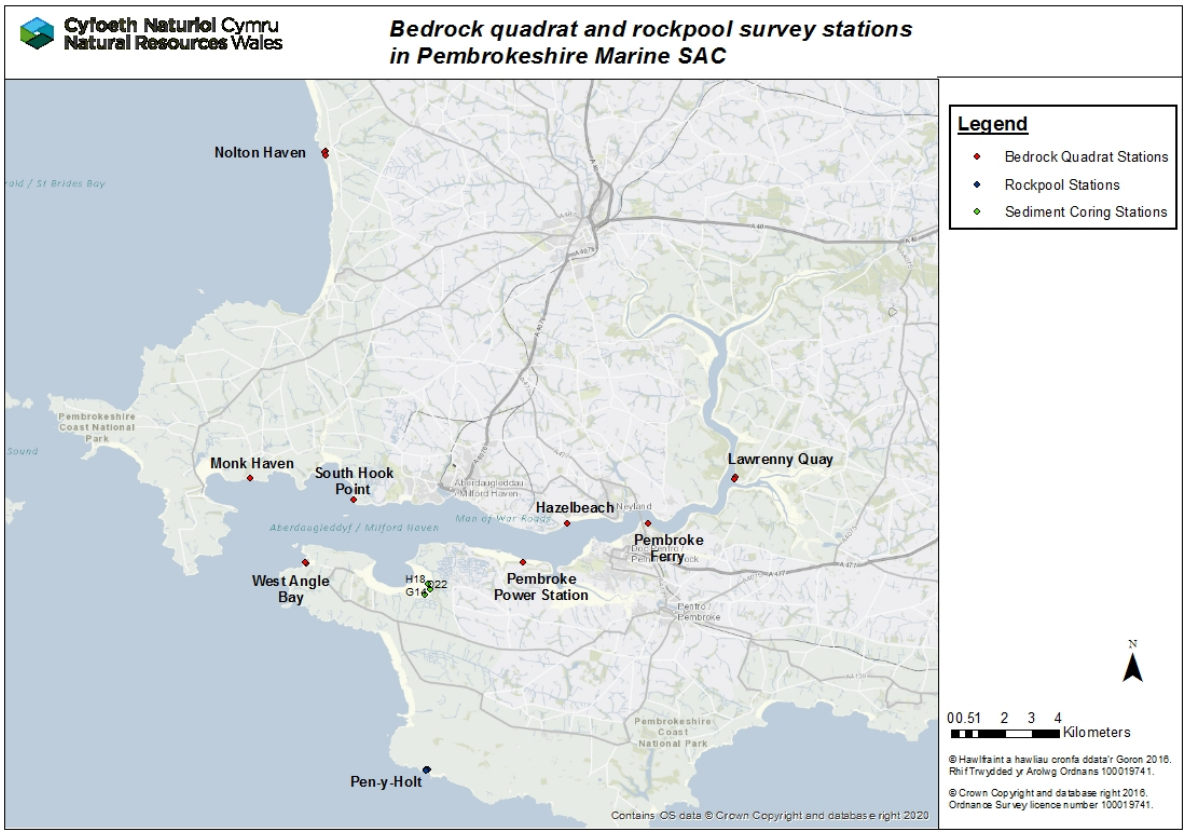
Key references: Annual reports from 2007 (Moore 2009) and 2008 (Brazier & Bunker 2011). Unpublished spreadsheet data from 2015 to 2017.

Summary description and notable changes: A large variety of rockpool biotopes, including two that are considered Rare or Scarce in Wales (Brazier *et al.* 2007). Trevayne monitoring: 10 rockpools with well-developed fauna and flora of moderate species richness, characterised by anemones (e.g. *Actinia equina*), limpets *Patella* spp., snails (e.g. *Gibbula umbilicalis* and *Littorina littorea*), small fish (e.g. *Lipophrys pholis*), coralline algae (encrusting and *Corallina* spp.) and a large variety of red algae (particularly *Gelidium pulchellum*, *Chondrus crispus* and *Ceramium virgatum*) brown algae (e.g. *Dictyota dichotoma*) and green algae (e.g. *Ulva* spp., *Chaetomorpha ligustica* and *Cladophora* spp.). Species richness is fairly stable at around 60 taxa per pool.

Condition (2017): Species richness, species composition and taxa abundances give no indications of stress. These data appear to be in character with the rockpool habitats of the region and changes over the three years of the program appear to be within the normal range of natural fluctuations.

3. Pembrokeshire Marine SAC

Figure 6 Locations of intertidal features monitored in Pembrokeshire Marine SAC. Rocky shore communities in Milford Haven and open coast (red squares), rockpool stations on the open coast (blue squares), *Zostera noltii* monitoring and sediment coring (green squares). Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014



3.1. Rocky shore communities – Milford Haven

SAC Annex 1 feature: Reef, Large shallow inlet and bay.

Sites and survey years: Lawrenny Quay, Pembroke Ferry, Hazelbeach, South Hook, Monk Haven and West Angle Bay (2005-2017). Pembroke Power Station (2012-2017). Figure 6.

Methodologies: *In situ* recording of abundance (cell frequency counts) of all conspicuous taxa in four fixed quadrats in each of the upper shore, middle shore and lower shore (although there is no lower shore station at Pembroke Power Station); barnacle population studies at each shore level estimated from percentage cover of Cirripedia from five randomly placed 0.04 m^2 quadrats and the proportion of different species present obtained from 5cm x 5cm photo quadrats; limpet densities at each shore level obtained from counts in five randomly placed 0.04 m^2 quadrats and size frequencies of middle shore limpets based on measurements of 100+ limpets.

The methodology is described in detail in Mercer & Brazier (2009) and SOP's for recording at the different shores are presented in Bunker (2017).

Key references: Hull *et al.* (2006), Mercer & Brazier (2009), Bunker & Brazier (2013), Bunker (2015), Bunker (in prep (a)).

Summary description and notable changes: There is a clear exposure related change in the shore communities from the shelter of Lawrenny Quay in the Daugleddau to the wave exposed shores, such as Monk Haven, at the entrance to Milford Haven. The nature of the communities at each site has remained stable over time despite fluctuations in the presence and abundance of particular species. How species populations changed over time depended on the shore. There were few overall patterns of change. One change was a decline in mussel *Mytilus edulis* recruitment at all sites in Milford Haven during the course of this study.

Winter storms in 2014 resulted in high suspended sediment loads in the water column throughout the Haven and as a result silt was deposited on lower shore habitats of the intertidal zone. This was particularly noticeable at Lawrenny Quay, which resulted in a lowering of species diversity in 2015. At both Monk Haven and South Hook Point, storms relocated boulders, causing difficulties in recording the quadrats.

Condition (2017):

Lawrenny Quay - recorded changes in species richness, species composition and population abundance appear to be within the normally recorded range of such fluctuations. Most notable changes and trends are also considered to be natural. There is some evidence of a decline in the long-lived brown seaweed *Ascophyllum nodosum* in the middle shore monitoring quadrats. It is also notable that two non-native ascidians have established in the lower shore; *Botrylloides violaceus* in 2009 and *Corella eumyota* in 2010.

Pembroke Ferry - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural. A population of the small non-native sea anemone *Diadumene lineata* has been consistently recorded in the middle and lower shore crevices.

Hazelbeach - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural. A general rise in the population of the non-native slipper limpet, *Crepidula fornicata* has been noted on the lower shore since 2007.

Pembroke Power Station - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

South Hook Point - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural. A general decline in Anthozoa species has been noted since the start of the study. Also, the non-native red seaweed *Caulacanthus okamurae* appeared on the lower shore in 2010 and remains present today.

Monk Haven - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

West Angle Bay - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural. Also, the non-native red seaweed *Caulacanthus okamurae* appeared on the lower shore in 2010 and remains present today.

3.2. Rocky shore communities – Open coast Pembrokeshire

SAC Annex 1 feature: Reef, Large shallow inlet and bay

Sites and survey years: Nolton Haven (2007-2017). Figure 6.

Methodologies: *In situ* recording of abundance (cell frequency counts) of all conspicuous taxa in four fixed quadrats in each of the upper shore, middle shore and lower shore; barnacle population studies at each shore level are estimated from percentage cover of Cirripedia from five randomly placed 0.04 m^2 quadrats and the proportion of different species present obtained from 5 cm x 5 cm photo quadrats; limpet densities at each shore level obtained from counts in five randomly placed 0.04 m^2 quadrats and size frequencies of middle shore limpets based on measurements of 100+ limpets.

The methodology is described in detail in Mercer & Brazier (2009) and SOP's for recording at the different shores are presented in Bunker (2017).

Key references: Mercer & Brazier (2009), Bunker & Brazier (2013), Bunker (2015), Bunker (in prep (a)).

Summary description and notable changes: This exposed shore survey site is situated in two locations, either side of the bay with the upper and middle shore being on the north side and the lower shore being on the south side. The lower shore is subject to sand scour and the communities present reflect this. Settlement of mussels *Mytilus edulis* is frequent on the lower shore and once the seed grows into defined clumps these tend to be torn off the rocks in winter storms leaving bare patches. Colonisation of the middle shore by *Fucus vesiculosus* is also cyclical, as is regular settlement of the barnacle *Perforatus perforatus* on the lower shore.

Condition (2017): Recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

3.3. Rocky shore communities – South Pembrokeshire

SAC Annex 1 feature: Reef

Sites and survey years: Pen y Holt 2007 to 2010, 2013 and 2017. Figure 6.

Methodologies: Two groups of five pools are monitored; a group in the centre of the bay in the mid-lower shore and a group on the west side of the bay on the upper-mid shore. The presence of typical pool taxa ('Aggregate Taxa groups) are searched for and recorded if present. All conspicuous species that can be reliably identified *in situ* are then recorded on pro-forma. Estimates of % cover are made for seaweeds with presence only recorded for animal species. The influence of silt and scour are estimated on a 5-point scale. Specimens are collected of species that could not be reliably identified *in situ* for later identification.

The proportion of different barnacle species present are obtained from 5cm x 5cm photo quadrats and the size frequencies of middle shore limpets are based on measurements of 100+ limpets. Photographs are taken to illustrate the main habitat and community features.

Key references: Bunker (2010) and Bunker (in prep (b)).

Summary description and notable changes: A total of 10 intertidal pools have been studied and despite some variation, analysis of the data has shown differences between the pools not to be significant indicating that the study pools to constitute a good set of replicates. The differences between the pools have often been shown to relate to particular species present in one or two pools but not in others (e.g. the seaweeds *Pterocladiella capillacea* and *Grateloupia filicina* which have been found in rockpool P1 but not in the others). The variation between pools ensures that a wide variety of species are being studied.

Condition (2017): The communities found in the pools have remained remarkably stable over time but with some species disappearing and others making an appearance. Of interest are the populations of blennies in the pools with both the shanny, *Lipophrys pholis* and Montagu's blenny, *Coryphoblennius galerita* found on a regular basis. On two occasions large boulders have moved into pools (one in pool 2 between 2010 and 2013 and one in pool 5 between 2013 and 2017). These events have caused 'natural' disturbance to the pool communities.

3.4. Intertidal sediment communities – Milford Haven

SAC Annex 1 feature: Estuary, Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

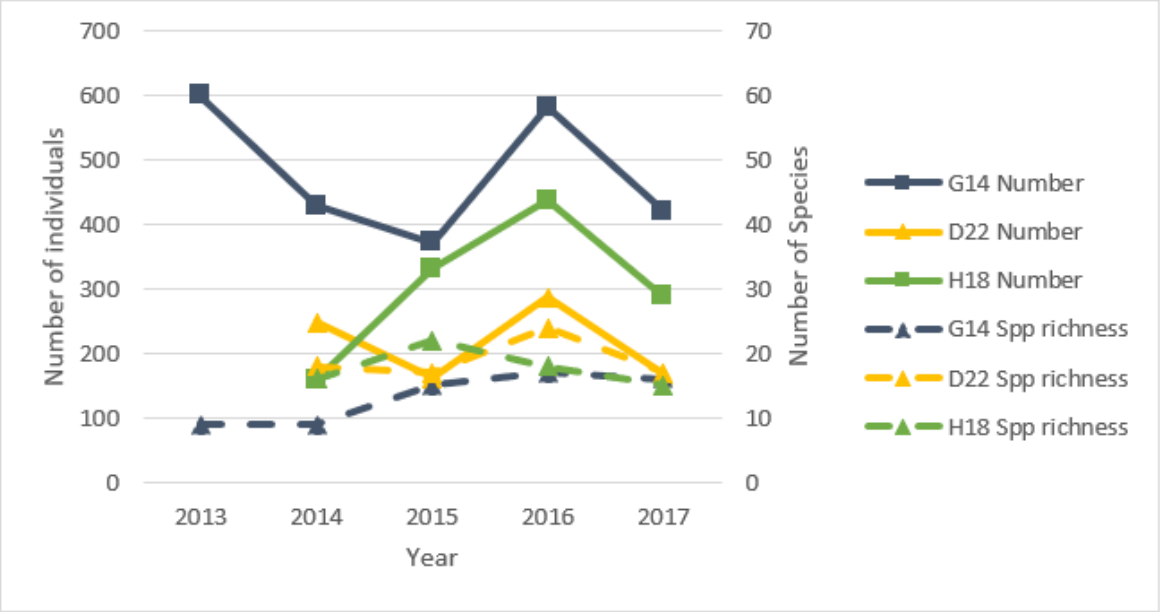
Sites and survey years: Angle Bay 2013 to 2017. Figure 6.

Methodologies: Three stations are located in the mid shore, in coarse gravel sand habitats and close to or in the seagrass *Zostera noltii* bed. A survey at each station is a combination of *in situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (see Moore 2016d) and conventional core sampling (5 x 0.01 m^2 cores, 0.5 mm mesh, plus sediment sample for particle size analysis) with associated lab analysis (see Moore 2016g).

Key references: Moore 2009 (methods only)

Summary description and notable changes: Cluster analysis reveals that 2016 H18 is the only station that is significantly different from the other year-stations. This is due to greater abundance of *Pygospio elegans*, *Streblospio shrubsolii*, *Capitella* sp, *Microphthalmus* and *Tubificoides benedii* and absence of *Idotea* spp. at H18 in 2016. Ecologically, there are no major differences between years, whilst each station shows a slightly different character. H18 has coarser material >15% is >1 mm, compared with G14 and D22 that have <2% of material >1 mm. The latter 2 stations have on average 5% more silt and clay (c. 10%) than station H18 (c. 5%). Figure 7 shows the number of species and individuals for each station.

Figure 7 Number of species and number of individuals for 3 sediment stations in Angle Bay each year.



Condition (2017): No indication of deleterious activities on the sediment infauna, based on the sample stations used. Recorded changes in biotope richness and distribution, species composition and abundance appear to be within the range of natural fluctuations.

3.5. Zostera noltii beds

SAC Annex 1 feature: Estuary, Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Angle Bay 2008 and 2013. Figure 8 .

Methodologies: Surveyors walked along the shore with GPS units in tracking mode and followed the edges of the seagrass bed. Following the survey, the GPS units were downloaded and the tracks incorporated into a GIS software package. The edges of the bed shown by the tracks were then digitally traced to define the area covered by *Zostera noltii* in Angle Bay by a single polygon.

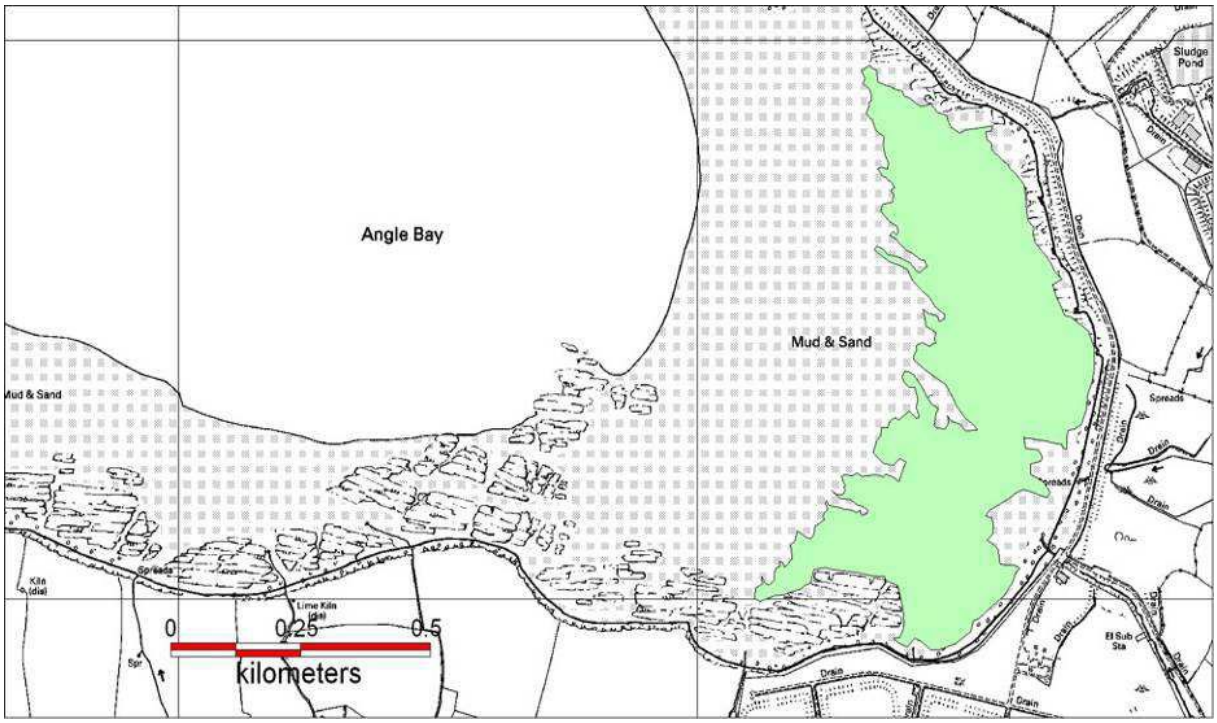
A grid of sampling stations 50 m apart east-west and 100m apart north-south was created over the area colonised by *Zostera noltii* (as determined by the mapping study). Pairs of surveyors were allocated a section of the grid to study, and portable GPS units were uploaded with positions of sampling stations.

At each sampling station, a 0.25 m^2 quadrat with a 0.01 m^2 grid was placed on the seagrass bed and a photograph taken. *In situ* recording of conspicuous plants and animals took place within the whole quadrat. Also, *Cerastoderma edule* counts were made based on numbers found by searching with fingers in decimetre squares per quadrat.

At a single infaunal coring station, 5 replicates of core sediment samples were taken using a 0.01 m^2 corer. The cores were taken within a radius of approximately 5 m from the central mark of the sampling station, and randomly placed without reference to the surface features. Following extraction, each core sample was then sieved over

a 0.5 mm mesh and the sieve contents were identified in the field. In addition, further sediment samples were collected, sieved and placed in containers for laboratory-based macrofauna and granulometric analyses by NRW.

Figure 8 East side of Angle Bay showing the area colonised by Zostera noltii (September 2013) from Duggan-Edwards and Brazier (2015). Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.



Key references: Bunker (2012) and Duggan-Edwards and Brazier (2015).

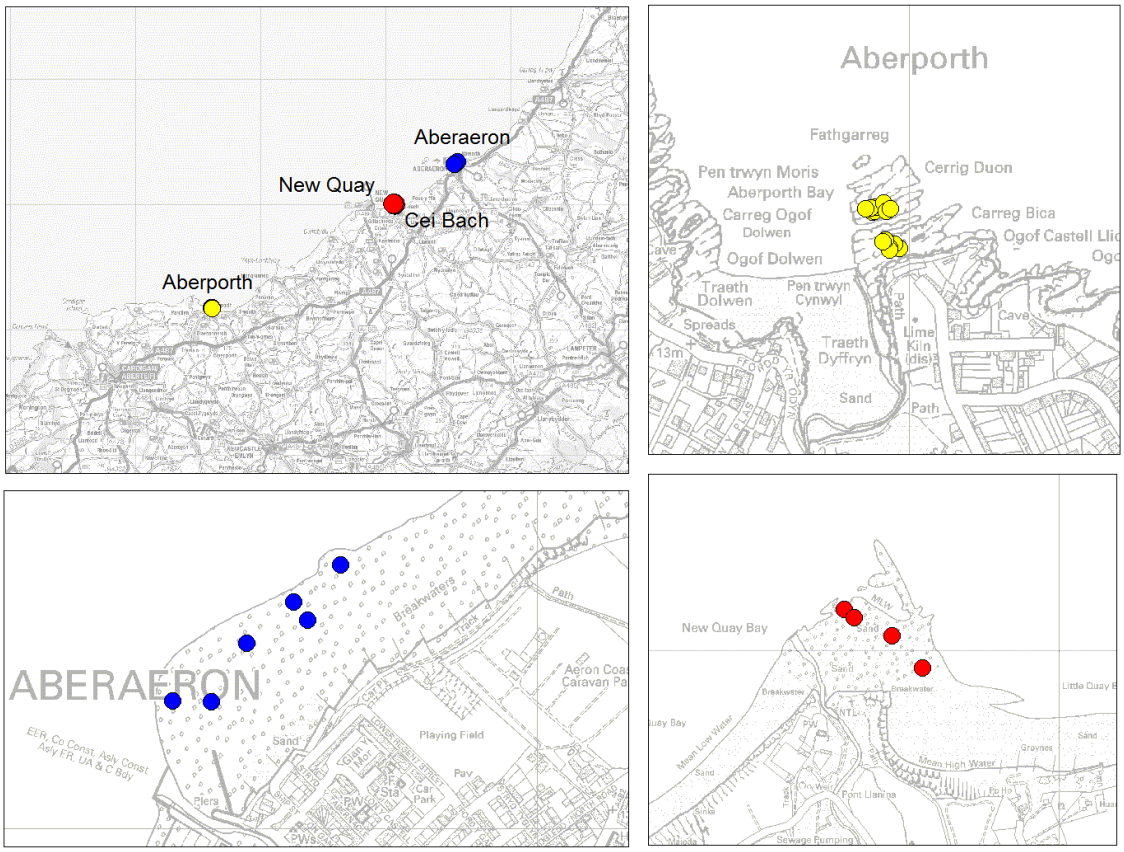
Summary description and notable changes: In 2008 the total area covered by the *Zostera noltii* bed was 19.54 ha, and in 2013 the total area was 31.95 ha. This indicates a percentage extent expansion of 63.5% for the *Zostera* bed over a 5-year period. A map showing the seagrass bed in 2015 is given in Figure 8.

Some of the main impacts on seagrass habitats have been physical damage inflicted by commercial cockling activities (Bunker, A and Camplin, M., NRW unpublished) and bait digging. Numerous locations, particularly on the north side of the seagrass bed, showed evidence of intensive bait digging activities.

Condition (2017): The amount of *Zostera noltii* has been shown to have increased in Angle Bay between 2008 and 2013. Although the mapping survey has not been undertaken since 2013, results from more recent Water Framework Directive surveys by NRW have shown that the *Zostera noltii* population in Angle Bay remains healthy.

4. Cardigan Bay SAC

Figure 9 Locations of intertidal features monitored in Cardigan Bay SAC. *Sabellaria* reef quadrat stations (blue and red dots), and rockpools (yellow dots).



4.1. Sabellaria reef communities

SAC Annex 1 feature: Reef

Sites and survey years: Aberaeron (2007-2017), Cei Bach (2007-2017). Figure 9.

Methodologies: *In situ* recording of presence and abundance (% cover) of all conspicuous taxa in 30 (Aberaeron) and 20 (Cei Bach) randomly placed quadrats within defined areas of *Sabellaria* reef. Plus, recording of abundance (% cover) of *Sabellaria* in an additional 60 (Aberaeron) and 40 (Cei Bach) randomly placed quadrats (Moore 2016e).

Key references: Moore (2010). Unpublished spreadsheet data collated 2007 - 2017.

Summary description and notable changes: Average % cover of *Sabellaria* reef has ranged from 40% to 53%, while live *Sabellaria* cover has ranged from 25% to 44%. No notable changes or trends are apparent, although the lowest values of live *Sabellaria* were in the first and last years (2007 and 2017). Species richness per quadrat (average number of taxa recorded per quadrat) has ranged from 10 to 18 taxa, with slightly greater richness usually recorded at Aberaeron. No notable changes or trends in species richness are apparent. After *Sabellaria*, the most frequently occurring taxa are *Littorina littorea*, *Chondrus crispus*, encrusting coralline algae, *Fucus vesiculosus*, *Gibbula umbilicalis*, green algae, dark encrusting red algae, *Osmundea pinnatifida*, filamentous red algae, *Corallina officinalis*, *Osmundea*

hybrida. No notable changes or trends in these species are apparent. However, interesting trends were apparent in the following species: *Phorcus lineatus* – a notable increase from 2007 to 2010 (reaching 44% occurrence), followed by a notable decline over the following years (only 4% occurrence in 2017). *Dumontia contorta* – a notable reduction in occurrence in 2011 (from 73% in 2010 to 34% occurrence), with some subsequent recovery in following years, but not yet back to the pre-2011 levels. *Cladostephus spongiosus* – a gradual increase from 2007 (16% occurrence) to 2016 (58% occurrence), with a slight reduction in 2017.

Condition (2017): Aberaeron - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

Cei Bach - recorded changes in species richness, species composition and abundance do not indicate any trends of concern and appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

4.2. Rocky shore communities – rockpools

SAC Annex 1 feature: Reef

Sites and survey years: Aberporth (annually, 2007-2017); Cei Bach (2004 ,2007, 2012). Figure 9.

Methodologies: *In situ* recording of presence and abundance (% cover) of all conspicuous taxa in 14 fixed rockpools – 8 on a midshore ('lower') bedrock platform and 6 on an upper shore bedrock platform - Moore (2016f).

Key references: Moore (2010). Unpublished spreadsheet data collated 2007 - 2017.

Summary description and notable changes: The most frequently occurring taxa are encrusting coralline algae, *Corallina, Littorina littorea, Chondrus crispus, Gibbula umbilicalis, Dumontia contorta, Osmundea pinnatifida, Osmundea hybrida, Cladophora sericea, Sabellaria* spp.*, Dictyota dichotoma, Patella ulyssiponensis, Chaetomorpha ligustica,* with some notable differences between the upper and lower platform pools. Some of these taxa, and others, have shown notable changes or apparent trends: *Sabellaria* reef % cover in lower platform pools gradually increased from 16% in 2007 to 68% in 2011, maintained high cover through to 2016, then declined dramatically in 2017 back to 16%, though it is still present in high abundance surrounding the pools. Encrusting coralline algae % cover in those lower pools was high in 2007 and 2008, but then declined as the *Sabellaria* increased and was still only 7% in 2017. *Mytilus edulis* – % cover in lower platform pools reached 12% in 2008, but then gradually declined to 0% in 2014 and has not been recorded since. *Corallina* – % cover in upper shore pools gradually increased from 19% in 2007 to 41% in 2011, then gradually declined again to 20% in 2017. *Osmundea hybrida* – a decrease from 93% frequency occurrence in 2008 to 42% in 2011, followed by a dramatic increase to 100% frequency in 2012 and a modest decrease in 2016. *Gastroclonium ovatum* appeared for the first time in 2011 and its % occurrence increased up to 43% in 2016. Species richness per pool (average number of taxa recorded per pool) has ranged from 17 to 30 taxa, with greater richness usually recorded in the upper platform pools. No notable trends in species

richness are apparent. Scour or silting resulting from winter storms have, on occasion, affected the monitoring data.

Note: Recording rockpool fauna and flora in a large sand-influenced rockpool on the lower shore at Cei Bach in 2004, 2017 and 2012, using 5 random quadrats proved too difficult to achieve repeatable results. Conditions such as weather and water depth made recording very difficult. The surveys did not deliver useful data and this has not been continued.

Condition (2017): Aberporth - recorded changes in species richness, species composition and abundance do not indicate any trends of concern and appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5. Pen Llŷn a'r Sarnau SAC

5.1. *Sabellaria* reef communities

SAC Annex 1 feature: Reef, Large shallow inlet and bay

Sites and survey years**:** Llandanwg and West of Afon Dwyfor.

Methodologies**:** *In situ* recording of presence and abundance (% cover) of all conspicuous taxa in 45 (Llandanwg) and 35 (West of Afon Dwyfor) randomly placed quadrats within defined areas of *Sabellaria* reef. Plus, recording of abundance (% cover) of *Sabellaria* in an additional 90 (Llandanwg) and 70 (West of Afon Dwyfor) randomly placed quadrats (Moore 2016e).

Key references**:** NRW Marine Monitoring Report No: 58 (Mercer 2016a).

Summary description and notable changes**:** Average % cover of *Sabellaria* reef has ranged from 2.5 to 21%, while live *Sabellaria* cover has ranged from 2 to 15%. Most notable changes are that the lowest values of live *Sabellaria* were recorded at West Afon Dwyfor in 2014 after violent winter storms in 2013/14, however recovery appears to be underway with current 2017 levels at 12%. Species richness per quadrat (average number of taxa recorded per quadrat) has ranged from 10 to 13 taxa, with slightly greater richness usually recorded at West of Afon Dwyfor. No notable changes or trends in species richness are apparent. Apart from *Sabellaria*, the most frequently occurring taxa are *Fucus vesiculosus*, *Fucus serratus, Ulva spp*., encrusting Rhodophycota, *Semibalanus balanoides*, *Austrominius modestus*, *Gibbula umbilicalis, Patella spp.* and *Phorcus lineatus*. However, no notable changes or trends were seen in these taxa.

Condition (2017)**:** Llandanwg - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

West of Afon Dwyfor - recorded changes in species richness, species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.2. Intertidal sediment communities – Mawddach

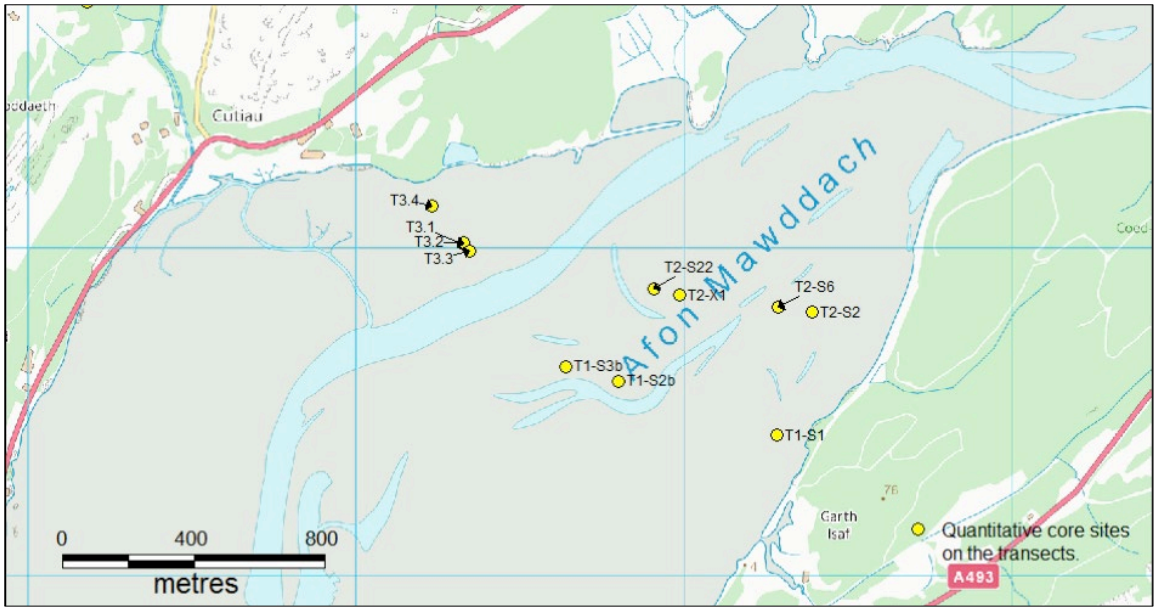
SAC Annex 1 features**:** Estuary, Mudflats and sandflats not covered by seawater at low tide

Sites and survey years**:** Four transects, three of which are shown in Figure 10 (the fourth having been eroded out by the river channel), were established and sampled in 1999 (Wyn *et al*. 2001) and re-sampled in 2004, 2012, 2014 and 2016. Seventeen sites were sampled by coring in 2012 and eleven in 2014. Samples were subject to laboratory taxonomic analysis of the macrofauna.

Methodologies: *In situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (30 stations) (see Moore 2016d), as well as conventional infaunal core sampling with laboratory taxonomic analysis of the macrofauna (9 stations) (see Moore 2016g).

Key references: Wyn *et al.* (2001), CCW MMR No. 102 (Mercer 2013).

Figure 10 The locations of the three Mawddach infaunal transects sampled in 2016. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014



Summary description and notable changes: Seven infaunal biotopes were recorded in 2012 as shown in Table 5. A similar number had been recorded in 2004. In 2014 only 3 transects were sampled and 4 biotopes were recorded.

Transects 3 and 4 have been naturally shortened by channel movements, but this is likely to be cyclical as the meanders of the channel move down the estuary and so the transects may lengthen again in due course. However, the timescale for this is unknown. Between 2012 and 2014, the south side sediments became slightly muddier (5-10%) and the north side sediments slightly (5%) sandier.

Table 4 Mawddach transect stations and their infaunal biotopes in 2012.

Station Code	Full Biotope Code
T1 St1	LS.LMu.UEst.Hed.Cvol
T1 St2	LS.LSa.MoSa.AmSco.Eur
T1 St3	LS.LSa.FiSa.Po
T1 St4	LS.LSa.FiSa.Po.Pful
T ‘R’ St1	LS.LSa.MuSa.HedMacEte
T ‘R’ St2	LS.LMu.MEst.HedMacScr
T ‘R’ St3	LS.LSa.MuSa.MacAre

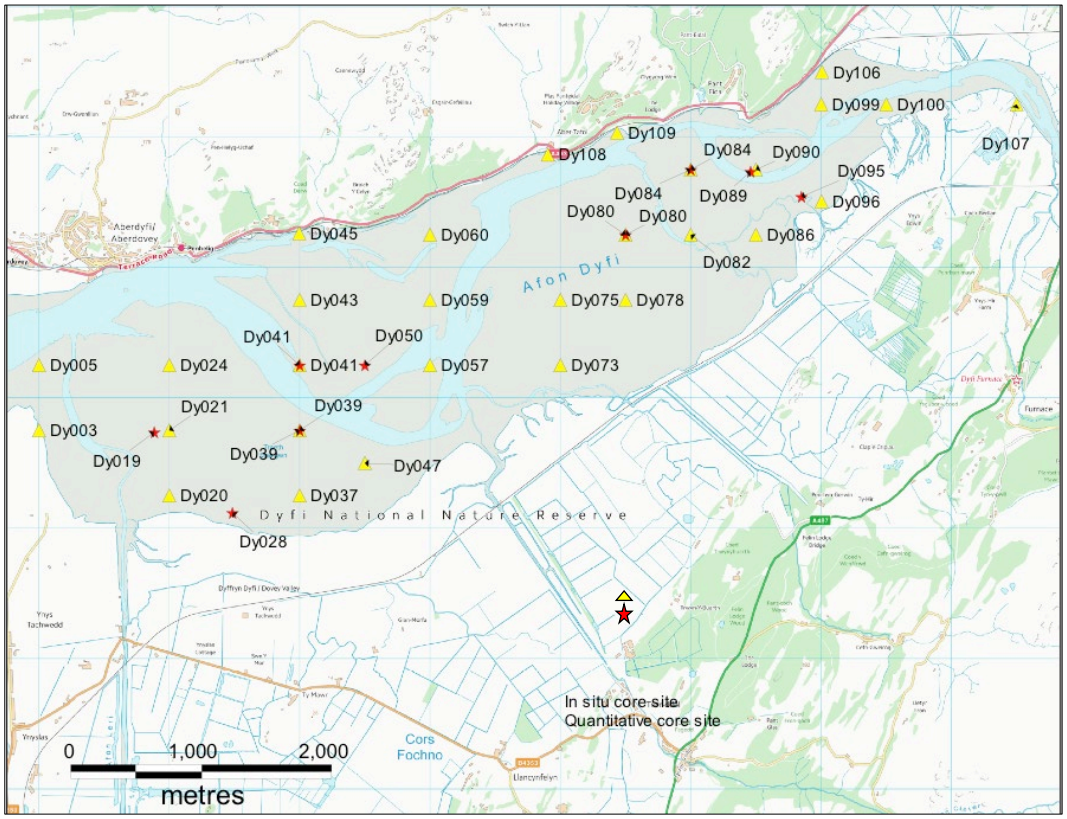
Condition (2017): Recorded changes in species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.3. Intertidal sediment communities – Dyfi

SAC Annex 1 features: Estuary, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years**:** Sampled in 2013 and 2015. Thirty sites were visited to perform *in situ* assessments and 9 sites were sampled quantitatively by coring as shown in Figure 11.

Figure 11 Locations of infaunal sampling in the Dyfi estuary. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.



Methodologies**:** *In situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (30 stations) (see Moore 2016d), as well as conventional infaunal core sampling with laboratory taxonomic analysis of the macrofauna (9 stations) (see Moore 2016g).

Key references**:** NRW Marine Monitoring Report No: 58 (Mercer 2016a)

Summary description and notable changes: Seven intertidal sediment biotopes were noted during the *in situ* assessment these are shown in Table 6 with examples of sites where they were found. Both the *in situ* assessment and the quantitative coring in the Dyfi estuary reveals a low diversity system. This may be due in part to the high sand content of the sediment. No rare or endangered species have been encountered during the monitoring surveys, but the univariate measures calculated for the infaunal cores provide a baseline from which monitoring can take place in the future.

Table 5 Dyfi sediment stations and their infaunal biotopes.

Station Code	Full Biotope Code
Dy57	LS.LSa.MuSa.MacAre
Dy107	LS.LMu.UEst.Hed.Cvol
Dy39	LS.LSa.MuSa.CerPo
Dy3	LS.LSa.MoSa.AmSco.Eur

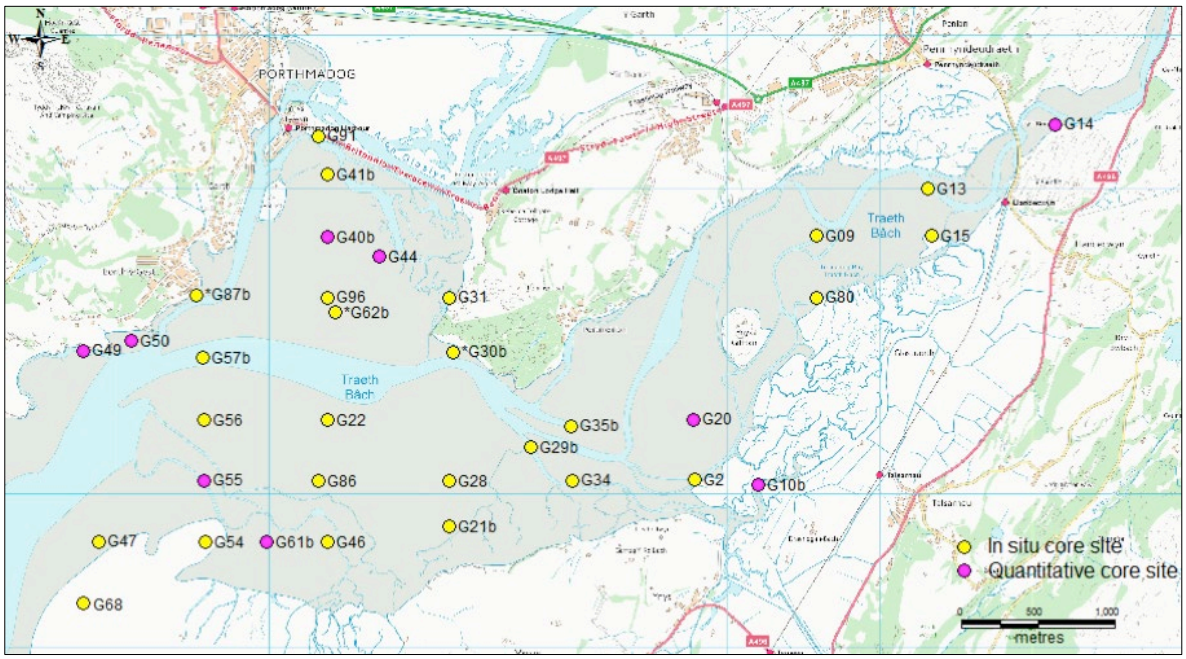
Station Code	Full Biotope Code
Dy99	LS.LMu.MEst.HedMac
Dy109	LS.LSa.MuSa.BatCare
Dy108	LS.LMu.MEst.HedMacScr

Condition (2017)**:** Recorded changes in species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.4. Intertidal sediment communities – Glaslyn and Dwyryd

SAC Annex 1 features**:** Estuary, Mudflats and sandflats not covered by seawater at low tide.

Figure 12 Locations of infaunal sampling in the Glaslyn/Dwyryd system. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.



Sites and survey years**:** Sampled in 2008, 2013, 2014 and 2017. Twenty-five sites were visited to perform *in situ* assessments and 9 sites were sampled quantitatively by coring as shown in Figure 12.

Methodologies**:** *In situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (34 stations) (see Moore 2016d), as well as conventional infaunal core sampling with laboratory taxonomic analysis of the macrofauna (9 stations) (see Moore 2016g).

Key references**:** NRW Marine Monitoring Report No: 75 (Mercer 2016b)

Summary description and notable changes**:** The Glaslyn/Dwyryd infaunal cores reveal a low diversity infaunal invertebrate community, with the greatest number of taxa and individuals in mid-estuary and in the middle shore on the Dwyryd. This community is unsurprisingly dominated by cockles *Cerastoderma edule*, amphipods and spionids. In places at the mouth of the system, where the sands are mobilised daily, they are effectively barren in terms of macrofauna. The 'inner most' site (G14)

is not a truly *euryhaline* / *upper estuary* site as it contains taxa such as *Bathyporeia sp*. The building of the new bridge at Pont Briwet during this period has not immediately affected the macrofaunal communities.

Condition (2017)**:** Recorded changes in species composition and abundance appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.5. Intertidal sediment communities – Open coast

SAC Annex 1 features**:** Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide

Sites and survey years**:** Four sites were sampled in 2014 and 2017. These are shown on Figure 13.

Figure 13 Locations of sediment sites at East Criccieth and Blackrock Sands (top left), Morfa Harlech (top right) and Morfa Dyffryn (bottom left). Aerial image base layer.

Methodologies: Conventional infaunal core sampling followed by laboratory analysis of the macrofauna (Moore 2016g).

Key references: NRW Marine Monitoring Report No: 75 (Mercer 2016b)

Summary description and notable changes: Four sandy beaches were sampled in the mid and lower shore by coring and the infaunal communities were found to be typical for these conditions. Highest diversities were found in the lower shore at each location, with East Criccieth showing the greatest richness and diversity with a

significant bivalve component (*Donax vittatus* and *Macomangulus tenuis*) complementing the polychaetes (*Nephtys cirrosa, Scolelepis squamata*) and amphipods (*Bathyporeia spp*. and *Pontocrates spp*.).

Table 7 presents commonly quoted univariate statistics for the 'open coast' sites for the 2014 results which can be used as a basis for monitoring in the future.

Table 6 Univariate analysis of the infaunal data from the open coast cores in 2014

Station	S	N	d	J'	H'(loge)	1-Lambda'
Morfa Dyffryn-LS	4	5	1.75	0.96	1.22	0.89
Morfa Dyffryn-MS	1	2	0.43	0.36	0.25	0.30
Morfa Harlech -LS	3	4	1.49	0.77	1.01	0.72
Morfa Harlech-MS	2	3	0.86	0.58	0.64	0.52
East Criccieth-MS	2	5	0.99	0.75	0.75	0.61
East Criccieth-LS	10	42	2.36	0.80	1.80	0.79
Black Rock Sands-LS	6	9	2.17	0.94	1.61	0.88
Black Rock Sands-MS	3	14	0.79	0.67	0.71	0.47

- S – Mean number of taxa.
- N – Mean total individuals: The mean number of individuals per core from all three cores per site.
- d – Mean Margalef's richness for all three cores per site. (S-1)/Log(N) - it is a measure of the number of taxa present, making some allowance for the number of individuals.
- J' – Mean Pielou's evenness from all three cores per site - this is a measure of equitability, a measure of how evenly the individuals are distributed among the different taxa.
- H'(loge) – Mean Shannon-Wiener diversity index from all three cores per site.
- 1-Lambda' - Mean Simpson's diversity index from all three cores per site.

Condition (2017): Species composition and abundance reflect the sediment infauna community that would be expected naturally on open coast shores here. Assemblages are considered to be natural.

5.6. Rocky shore communities – open rock

SAC Annex 1 feature: Reef

Sites and survey years**:** Porth Oer (2012 - 2017). Figure 14.

Methodologies**:** *In situ* recording of abundance (cell frequency counts) of all conspicuous taxa in fixed quadrats; barnacle populations (relative abundance from small photo quadrats); limpet size frequencies.

Key references**:** NRW Marine Monitoring Report No: 75 (Mercer 2016b)

Summary description and notable changes: The reef is a typical west-facing, exposed rocky shore dominated by limpet / barnacle biotopes in the upper and middle shore zones and a red algal turf in the lower shore. Populations have remained stable for the most part during the last 5 years, with the exception of the

barnacle community in 2014. This showed a 15-40% decrease following the severe storms of the 2013/14 winter. Approximately 50 taxa have been recorded on this shore in each monitoring survey year.

Figure 14 Location of rocky shore site at Porth Oer. Aerial image base map.

Condition (2014)**:** Recorded changes in species richness, species composition, population characteristics and abundances appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.7. Pectenogammarus population

SAC Annex 1 features**:** Large shallow inlet and bay.

Sites and survey years**:** Marian y De, Pwllheli (2007 - 2010, 2012 - 2017). Figure 15.

Methodologies**:** Multiple *in situ* counts in 'scrapes' at the water's edge on the lower shore.

Key references: CCW Marine Monitoring Reports 40, 59, 73, 78, 88 and 102 (Hemingway *et al.* 2008; Howson *et al*. 2009; Mercer 2010, 2011a, 2011b, 2013) NRW Evidence Reports Nos 58 and 75 (Mercer 2016a, 2016b).

Summary description and notable changes**:** *Pectenogammarus planicrurus* has been present throughout the current monitoring period on the mid and lower shore at Marian y De. The habitat on the shore is a poorly sorted mixed shingle and gravelly sands and the densities of the shrimp appear to vary with localised variations of the sediment's constituents.

Figure 15 Locations of *Pectenogammarus planicrurus* sampling points in 2014. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.

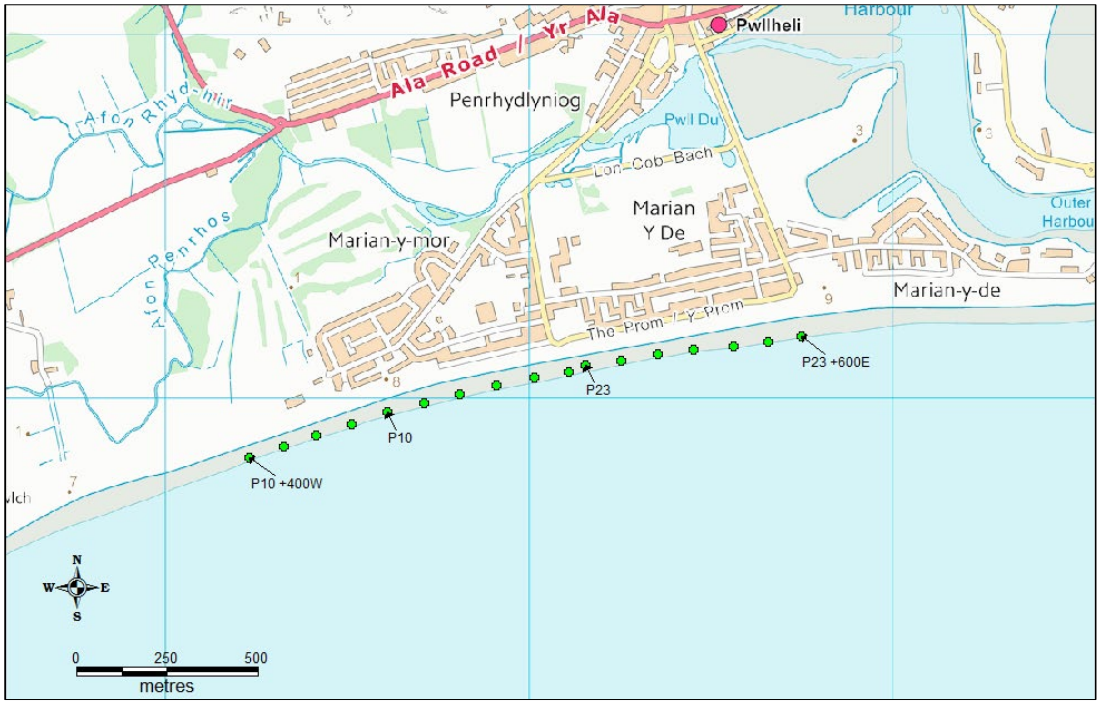


Table 7 Densities of *Pectenogammarus* at Pwllheli stations in 2014

Station	Easting	Northing	No. of *Pectenogammarus* / dm^2	Graphical score
Pec10+400W	236228	333836	None present	0
Pec10+300W	236324	333866	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec10+200W	236413	333897	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec10+100W	236511	333929	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec10	236608	333961	More than 20 *Pectenogammarus* dm^{-2}	25
Pec10+100E	236710	333986	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec10+200E	236806	334010	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec10+300E	236908	334034	10 - 20 *Pectenogammarus* per dm^{-2}	15
Pec10+400E	237014	334055	10 - 20 *Pectenogammarus* per dm^{-2}	15
Pec10+500E	237108	334074	10 - 20 *Pectenogammarus* per dm^{-2}	15
Pec23	237154	334090	10 - 20 *Pectenogammarus* per dm^{-2}	15
Pec23+100E	237251	334101	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec23+200E	237353	334120	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec23+300E	237452	334135	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec23+400E	237560	334143	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec23+500E	237656	334155	Less than 10 *Pectenogammarus* dm^{-2}	5
Pec23+600E	237748	334170	None present	0

The highest density of the shrimps in 2014 appears to lie between Pec10 in the west and Pec23 in the east. This pattern has been repeated in all years since.

Condition (2014)**:** Recorded changes in population abundance appears to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

5.8. Zostera marina beds

SAC Annex 1 feature: Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years**:** Porth Dinllaen (2010, 2016), Pen y chain (2010). Figure 16.

Figure 16 Locations of *Zostera* beds at Porth Dinllaen (left) and Pen y Chain (right). Aerial image base map.

Methodologies: The brief survey of *Z. marina* at Pen y Chain was undertaken in July 2010 at low water. The *Zostera* bed was mapped using the tracking facility on the GPS receivers, however the tide failed to expose more than the uppermost plants in the diffuse bed.

The perimeter of the Porth Dinllaen bed was also mapped by GPS in 2010. Surveyors with quadrats worked north/south transects along the *Z. marina* bed on the beach. The surveyors assessed quadrats at regular intervals noting *Zostera* density, substratum type, abundance of 'core taxa' and presence absence of other taxa. The transects surveyed at Porth Dinllaen were located using handheld GPS receivers. The data were recorded on a form modified from Boyes *et al.* (2005).

Damage and anthropogenic impacts were recorded for the *Z. marina* bed adjacent to Porth Dinllaen in areas of launching and mooring. Position and magnitude of damage was noted.

Key references**:** Boyes *et al.* (2005), CCW Marine Monitoring Report No: 88 (Mercer 2011)

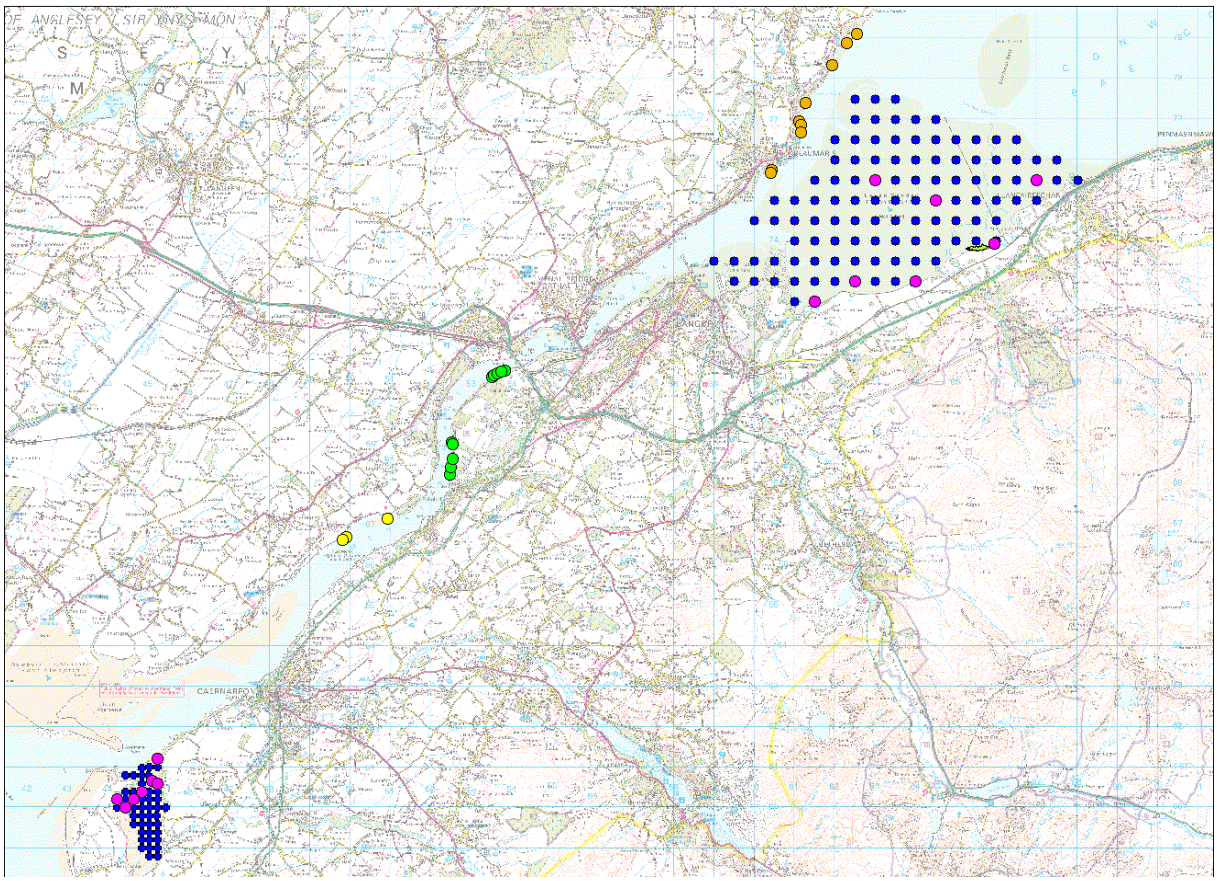
Summary description and notable changes**:** Porth Dinllaen *Zostera* bed was found to have increased in size in respect of the previous monitoring survey (2004). The community of the seagrass bed was dominated by *Zostera marina,* green algae,

Arenicola marina, Lanice conchilega, Anemonia viridis and *Pagurus bernhardus.* Of interest were the patches of *Cereus pedunculatus* noted in the sediment on the lower shore. It was noted that severe damage was caused to the *Z. marina* bed when metal mooring chains were used in contrast to rope moorings.

Condition (2016)**:** Recorded changes in species richness, species composition, population characteristics and abundances appear to be within the normally recorded range of such fluctuations. Notable changes and trends are also considered to be natural.

6. Menai Strait and Conwy Bay SAC

Figure 17 Locations of intertidal features monitored in Menai Strait and Conwy Bay SAC. Tide-swept boulder communities (green dots), tide-swept *Fucus serratus* epibiota communities (yellow dots), *Zostera* beds (green areas), Traeth Lafan and Y Foryd sediment *in situ* recording sites (blue dots), Traeth Lafan and Y Foryd sediment core sampling sites (pink dots), muddy gravel core sampling sites (orange dots). Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.



6.1. Tide-swept boulder communities

SAC Annex 1 feature: Reef.

Sites and survey years: Britannia Bridge (2007-2017), Felinheli (2008–2010, 2012-2017). Figure 17, Figure 18. Note: sites were originally established and surveyed in 2004 and 2005 (Brazier *et al.* 2013), but the survey methodologies were not fully developed.

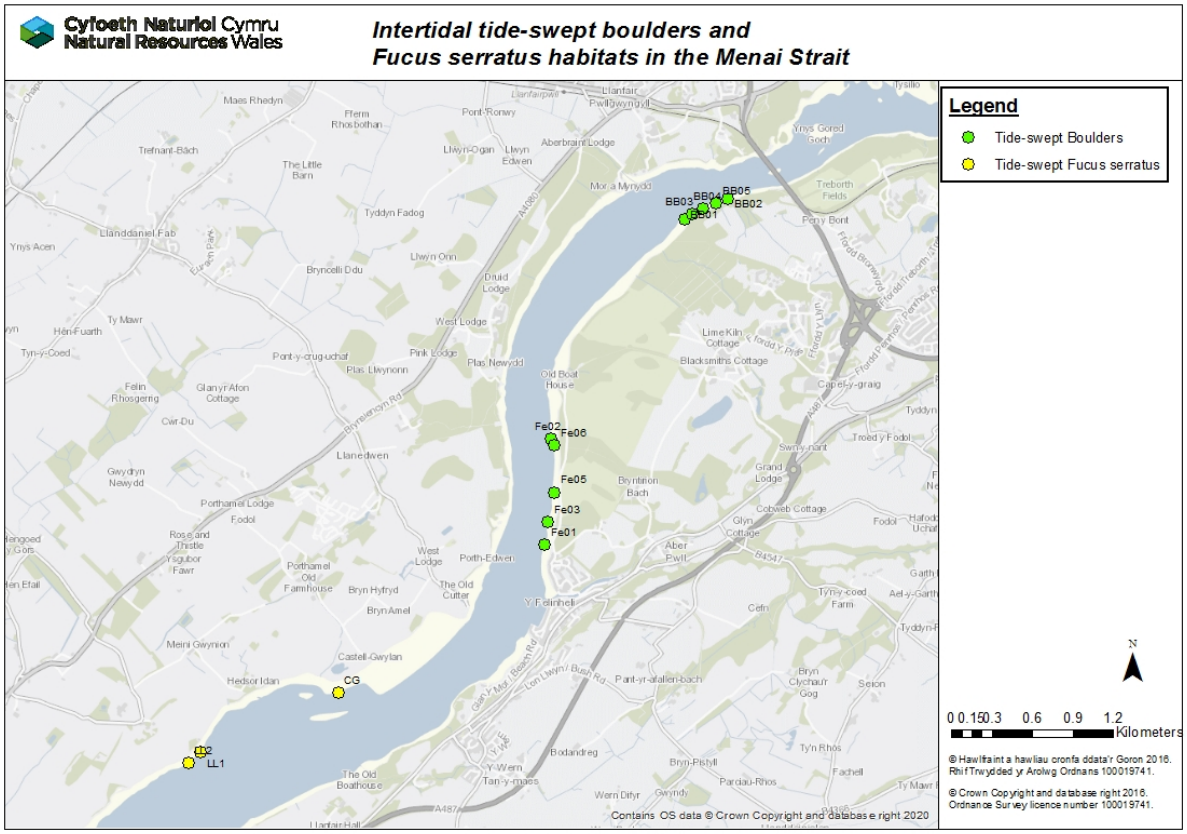
Methodologies: *In situ* recording of presence and abundance (% cover) of all conspicuous taxa on ~25 randomly selected lower eulittoral boulders (that have under-boulder communities) (Moore 2016b).

Key references: Moore *et al.* (2010), Moore (2018)

Summary description and notable changes: Algal dominated communities on the upper boulder surfaces and encrusting invertebrate (sponges, sea-squirts, bryozoans, etc.) dominated communities on the under-boulder surfaces. Generally, there is a high species richness on the underside, except where water flow under the boulder has been restricted (e.g. where the boulder is sitting on muddy sediment) or

where boulders have been frequently turned by bait collectors. Felinheli boulder communities are less well developed compared to Britannia Bridge boulders, due to the more gradually sloping shore retaining more mud. There has been a notable increase in the presence and abundance of the invasive seasquirt *Corella eumyota* at both sites, but so far it appears to be an addition to the fauna with no signs of impact on the native taxa.

Figure 18 Locations of intertidal tide-swept boulder communities (green dots) and tide-swept *Fucus serratus* epibiota communities (yellow dots) in Menai Strait and Conwy Bay SAC. Ordnance Survey material © Crown copyright. All rights reserved. Natural Resources Wales, 100018813 2014.



Condition (2017): Britannia Bridge - Recorded changes in species richness, species composition and abundance appear to reflect the expected levels of natural fluctuations.

Felinheli – concerns due to impacts of continued bait collection on species richness and composition. The majority of boulders at this site show evidence of having been repeatedly turned, including the presence of smothered and rotting algae, dead barnacles and low species richness. The average number of taxa per boulder has gradually declined since 2013. The damage is greatest nearer to the access point at Felinheli, and there is evidence that the damage can persist for some time.

6.2. Tide-swept *Fucus serratus* epibiota communities

SAC Annex 1 feature: Reef.

Sites and survey years: Brynsiencyn (2009-2017) Castell Gwylan and two sites at Llanidan Figure 18 Locations of intertidal tide-swept boulder communities (green

dots) and tide-swept *Fucus serratus* epibiota communities (yellow dots) in Menai Strait and Conwy Bay SAC. Figure 18.

Methodologies: *In situ* recording of conspicuous epibiota on *Fucus serratus* thalli within defined areas of lower eulittoral / sublittoral fringe (mixed boulder / sediment shores). Qualitative recording of all taxa on 20+ replicate thalli, selected randomly using quadrats (Moore 2016c).

Key references: Moore *et al.* (2010), Moore (2018)

Summary description and notable changes: Epibiota cover on the *Fucus serratus* thalli typically varies from thallus to thallus, with some thalli sparsely covered and others heavily covered. Size and age are factors, but the relationship is not always predictable. There have been no notable temporal trends in epibiota cover over the course of the monitoring. A total of 193 taxa have been recorded from the three sites over the course of the monitoring (2009 to 2017). The most frequently occurring colonisers are Spirorbinae worms, encrusting bryozoans (particularly *Flustrellidra hispida*, *Alcyonidium hirsutum*, *Alcyonidium polyoum* / *gelatinosum* and *Electra pilosa*), snails (particularly flat winkles *Littorina obtusata* / *fabalis*), small barnacles *Balanus crenatus*, the slimy brown sponge *Halisarca dujardinii*, star seasquirt *Botryllus schlosseri*, the erect bryozoan *Amathia imbricata*, the hydroid *Dynamena pumila*, sea lettuce *Ulva*, various red algae (particularly *Osmundea oederi*, *Cystoclonium purpureum*, *Neosiphonia harveyi* and *Lomentaria articulata*) and brown algae (particularly *Elachista fucicola* and *Dictyota dichotoma*). There are some notable differences between the sites, with more *Alcyonidium polyoum* / *gelatinosum*, *Halisarca dujardinii* and *Amathia imbricata* at Castell Gwylan, and more red algae at the Llanidan sites. Species richness was also higher at the Llanidan sites. There have been notable fluctuations in various taxa over the course of the monitoring, with some species being particularly abundant in one year (e.g. *Austrominius modestus* in 2014), but infrequent or absent in other years. Some species have also had bad years, e.g. Spirorbinae, which are normally almost ubiquitous, but were only present on 55% of thalli in 2015. There have also been some apparent trends, including a decrease in frequency of the brown sponge *Halisarca dujardinii* (from 65% of thalli in 2009 to 22% in 2016), a gradually increasing frequency of *Alcyonidium polyoum* / *gelatinosum* (from 20% of thalli in 2009 to 81% in 2016), a gradual increase in *Flustrellidra hispida* to 88% of thalli in 2013 followed by a notable drop and continued decline to 22%, a similar trend was shown by flat winkles; while *Electra pilosa* decreased gradually from 38% to 16% in 2011, then gradually increased back to 43% by 2016. Sea-squirts in general have shown a decline since 2011, most notably by the non-native seasquirt *Corella eumyota* which reached 29% in 2011, but then declined gradually to only 3% in 2016. Species richness (the average number of taxa per thallus) peaked at 14 taxa in 2011, but has mostly stayed around 10 taxa, with no apparent trend.

Condition (2017): Recorded changes in species richness, species composition and frequencies do not indicate any trends of concern and appear to reflect the expected levels of natural fluctuations.

6.3. Sediment communities – Foryd Bay

SAC Annex 1 features: Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: *Rapid Assessment:* A grid of 48 stations designed to represent the range of, primarily sediment, biotopes present in Y Foryd Bay.

Conventional coring: 8 stations, selected from the 48 to represent key biotopes, for more detailed sampling and analysis. Established and surveyed in 2008; resurveyed in 2014 (45 stations common to both surveys). Figure 17.

Methodologies: *Rapid Assessment: In situ* recording of sediment biota (epibiota and infauna) and habitat characteristics (see Moore 2016d). *Conventional coring:* core sampling (5 x 0.01m^2 cores per station, sieved over 0.5 mm mesh, plus 1 sample for particle size analysis) and lab analysis (see Moore 2016g).

Key references: Howson & Moore (2010), Moore (2018).

Summary description and notable changes: Ten intertidal sediment biotopes, including a *Zostera noltii* biotope, and two mixed hard substratum biotopes were described. The latter were incidental, represented by only one station each. The sediment biotopes ranged from fairly mobile fine sand at the entrance to the Bay, characterised by fast burrowing amphipods e.g. *Bathyporeia* and polychaete worms; muddy sands in the middle of the Bay, dominated by cockles *Cerastoderma edule* and lugworms *Arenicola marina* on both sides of the channel and the seagrass bed *Z. noltii* on the upper shore of the west side; and some areas of very muddy sediment within the inner parts of the Bay, with ragworm *Hediste diversicolor* and oligochaetes. The composition of the infaunal communities were all typical for the area and habitats, with no populations of national scarcity. Species richness was also fairly typical of the habitats present.

The distribution of biotopes was much the same in 2014 as it had been in 2008, but the silt/clay content was higher in 2014, at most stations, particularly in the middle of the Bay, resulting in some shifts in the biotopes. A number of changes in the infaunal communities were recorded between 2008 and 2014, including higher abundances of cockles, the spionid polychaete *Spiophanes bombyx* and the Baltic tellin *Limecola balthica*, but decreases in various other polychaetes, oligochaetes and mobile crustacea. Species richness was also lower in many stations, though much of this was due to reduced discrimination in the identification of some taxa.

Condition (2014): Recorded changes in biotope richness and distribution, species composition and abundance do not indicate any trends of concern and appear to reflect the expected levels of natural fluctuations.

6.4. Sediment communities – Traeth Lafan

SAC Annex 1 features: Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: *Rapid Assessment:* Grid of 101 stations designed to represent the range of, primarily sediment, biotopes present on Traeth Lafan. *Conventional coring:* 7 stations, selected from the 101 to represent key biotopes, for more detailed sampling and analysis. Established and surveyed in 2007; resurveyed in 2015 (52 stations common to both surveys). Figure 17.

Methodologies: As for Y Foryd Bay (see Section 6.3).

Key references: Moore (2008), Moore (2018).

Summary description and notable changes: Nine intertidal sediment biotopes were described. The sediment biotopes ranged from mobile medium sand along the wave exposed northern edge of the sand flat, characterised by fast burrowing amphipods and polychaete worms; clean fine sands across a large expanse of the central sand flats, characterised by spionid tube worms and the amphipod *Bathyporeia*; a wide band of muddy fine sand across the upper mid shore, dominated by cockles *Cerastoderma edule* and lugworms *Arenicola marina*; a band of very muddy sand and sandy mud across the sheltered upper shore with ragworm, oligochaetes and mud shrimp *Corophium*; and an area of mussel beds *Mytilus edulis* on soft mud on the very sheltered western flats north of the Penrhyn estate. A variety of other biotopes were sampled incidentally. The seagrass *Z. noltii* bed present at the back of the sand flats, north of Abergwyngregyn, was not well represented and was monitored on a separate occasion. The composition of the infaunal communities were all typical for the area and habitats, with no populations of national scarcity. Species richness was also fairly typical of the habitats present and was much the same in 2015 as in 2007.

The distribution of biotopes was essentially the same in 2015 as in 2007, although there had been an increase in silt and clay content at some of the upper shore stations. A number of changes in the infaunal communities were recorded, including lower abundances of cockles, some other bivalves and *Corophium* in 2015, but increases in the polychaetes *Scoloplos armiger* and the ragworm *Hediste diversicolor*.

Condition (2015): Recorded changes in biotope richness and distribution, species composition and abundance do not indicate any trends of concern and appear to reflect the expected levels of natural fluctuations.

6.5. Sediment communities – Muddy gravels

SAC Annex 1 features: Large shallow inlet and bay, Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Beaumaris to Lleiniog (9 stations, selected to represent muddy gravel biotopes) (2004, 2013 and 2016). Figure 17.

Methodologies: Conventional core sampling (5 x 0.01 m^2 cores per station, sieved over 0.5mm mesh, plus 1 sample for particle size analysis) and lab analysis, with some *in situ* recording and photography (see Moore 2016g). The extent of the muddy gravel habitat was also monitored in 2004.

Key references: Allen *et al*. (2004), Moore (2018). Unpublished spreadsheet data 2013 - 2016.

Summary description and notable changes: The muddy gravel stations were characterised by very poorly sorted mixtures of silt and clay, sand, granules and pebbles. Silt and clay content of sediment samples averaged 10%, in both 2013 and 2016. The infaunal communities were dominated, numerically and to a large extent in biomass, by polychaete, oligochaete and nematode worms. Species richness amongst the polychaetes was high, representing many families. The most abundant polychaete taxa included *Mediomastus fragilis, Tharyx, Phyllodoce mucosa, Aphelochaeta marioni, Polydora ciliata* and *Lanice conchilega*. Other infaunal groups included bivalves and amphipods, with various taxa represented. Epibiota included

barnacles, littorinid snails, *Crangon crangon*, anemones and various algae. Species composition was similar in all three monitoring surveys. Average species richness (of non-colonial animals per 0.01 m^2 core) increased from 17.3 in 2004, to 20.3 in 2013 to 24.8 in 2016; but this may be influenced by differences in analytical protocols (to be investigated further).

Condition (2016): Recorded changes in species richness, species composition and abundance do not indicate any trends of concern and appear to reflect the expected levels of natural fluctuations.

6.6. Zostera noltii beds

SAC Annex 1 features: Mudflats and sandflats not covered by seawater at low tide.

Sites and survey years: Traeth Lafan (2005, 2007, 2009, 2010, 2011, 2012, 2017), Y Foryd (2005).

Methodologies: Mapping extent, using GPS (Traeth Lafan: approx. annually, 2005 to 2017; Y Foryd: 2005). *In situ* recording of abundance (% cover) and other records of conspicuous biota, habitat and condition in quadrats (Traeth Lafan: 2005 and 2017; Y Foryd 2005). With patchy seagrass, such as at Traeth Lafan, the ability to record a representative *Z. noltii* density for the whole bed is difficult. Random sampling and a grid sampling strategy have both been trialled – the former providing a representative but highly variable result and the latter providing a measure across the whole seagrass bed, but is not statistically representative. In 2012, CCW trialled the effectiveness of the use of a drone to map the *Z. noltii* at Traeth Lafan (Brazier 2013).

Key references: Boyes *et al*. (2004), Boyes & Mazik (2005). Unpublished GIS data, spreadsheet data and photographs from 2007 to 2017.

Summary description and notable changes: Three seagrass beds (one larger (approx. 14 hectares) and two smaller (combined area approx.1 hectare)) have been monitored in Y Foryd, and on Traeth Lafan, one extensive, but very patchy area of seagrass (eastern bed: approx. 24 hectares) has been monitored. Monitored extent of the beds has varied considerably between surveys, reflecting natural patchiness of the beds and some differences in survey protocols, which have proved difficult to standardise for patchy beds. The surveyed extent of the densest area of the Traeth Lafan bed, north of Abergwyngregyn, has varied by up to 25% between 2007 and 2017, with no obvious temporal trend. Plotting the extent of dense *Z. noltii* illustrates that no real changes in extent have occurred.

Patchiness is highlighted by the variability in % cover data (measured in quadrats placed at intervals along transects), with cover on the Y Foryd beds varying from 0 to 100%, even across the densest parts. Percentage cover on the Traeth Lafan bed was also patchy but did not reach more than 50%. A detailed analysis has not been carried out yet.

Condition: (2017) Traeth Lafan - Recorded changes in extent do not indicate any trends of concern and appear to reflect the expected levels of natural fluctuations. No negative indicators of seagrass condition (disease, bait digging or other physical damage) were recorded in 2017.

Y Foryd – insufficient data available from recent years.

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A3 Data archive

Data outputs associated with this project are archived in the NRW Document Management System on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

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