Cyfoeth Naturiol Cymru
Natural Resources Wales

Carmarthen Bay and Estuaries SAC, Trevayne rockpool monitoring, 2015-2019

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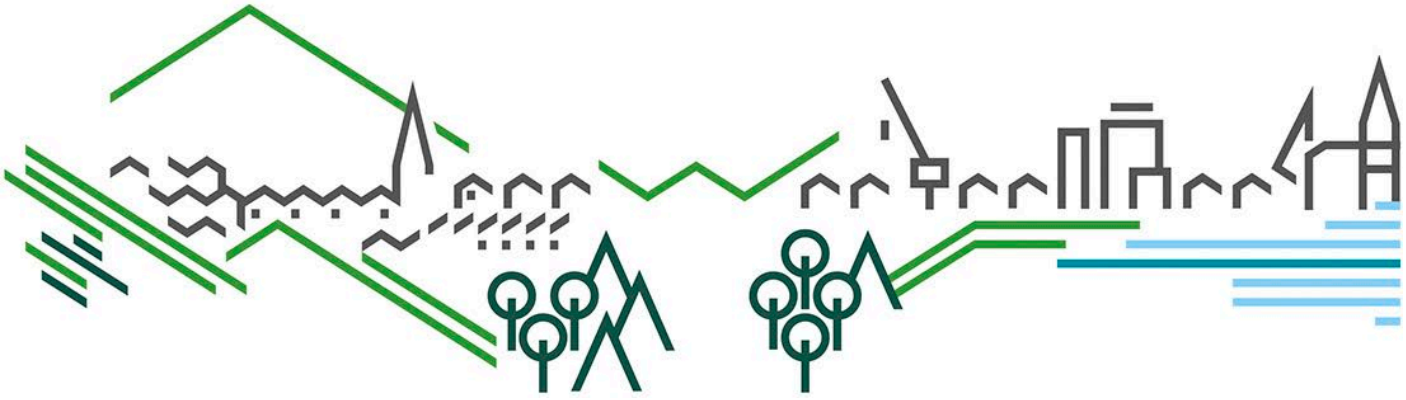
Aquatic Survey & Monitoring Ltd.



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Crynodeb Gweithredol

Noda'r Gyfarwyddeb Cynefinoedd y dylai'r broses o reoli Ardaloedd Cadwraeth Arbennig (ACAau) geisio cyflawni statws ffafriol cadwraeth cynefinoedd a rhywogaethau a nodir yn Atodiad I ac Atodiad II ynddi. Felly, ar gyfer ACAau yng Nghymru, mae angen i Cyfoeth Naturiol Cymru (CNC) adrodd yn rheolaidd ar a yw nodweddion yn meddu ar statws cadwraeth ffafriol. Yn ACA Bae ac Aberoedd Caerfyrddin, mae CNC a'i gontractwyr wedi datblygu rhaglenni monitro cyflwr nodweddion.

Mae *Cilfachau a Baeau Bas* yn un o nodweddion Atodiad I sy'n berthnasol i ddynodiad yr ACA. Ymhlith yr ardaloedd diddordeb penodol ym Mae Caerfyrddin, mae riffau craigwely rhynglanwol gydag is-gynefinoedd megis pyllau glan môr sy'n gwella bioamrywiaeth leol y lan. Disgrifia'r adroddiad hwn raglen fonitro a gynhaliwyd yng nghymunedau pyllau glan môr Tre-faen, a wnaeth ddechrau yn 2015 ac sydd wedi cael ei gynnal bob blwyddyn wedi hynny. Mae'n disgrifio prif nodweddion y cymunedau a chanlyniadau'r dadansoddiadau cyfnodol rhwng 2015 a 2019. Mae dwy elfen i'r gwaith monitro:

i) Arolygwyd deg o byllau glan môr (gyda dynodiad bïotop LR.FLR.Rkp.Cor.Cor) yn y fan a'r lle ar gyfer pob rhywogaeth amlwg. Mae pob pwll glan môr yn cael ei ystyried yn sampl ddyblyg, gan gynrychioli pyllau glan môr rhannau canol y glannau. Rhoddwyd mesurau sicrhau ansawdd a rheoli ansawdd ar waith i leddfu anghysondeb o ran cofnodi. Er hyn, roedd peth anghysondeb yn dal i fod, a nodwyd hyn yn yr adroddiad.

ii) Casglwyd samplau o dyweirch algaidd (*Corallina*), hefyd bob blwyddyn, o byllau glan môr cynrychioliadol eraill yn yr un ardal. Cafodd yr holl ffawna interstitaidd o'r samplau hynny eu dadansoddi mewn labordy er mwyn adnabod a rhifo'r holl rywogaethau macroffawnaidd.

Mae'r data monitro wedi cael eu dadansoddi gydag amrywiaeth o dechnegau unamryweb ac amlamryweb. Dyma'r canlyniadau mwyaf amlwg o'r dadansoddiadau:

i) Cofnodwyd cyfanswm o 122 o dacsonau epibiota o'r deg o byllau glan môr yn y fan a'r lle yn ystod y cyfnod rhwng 2015 a 2019. Cânt eu nodweddu gan algâu cwrelaidd cramennog a *Corallina*, gyda llygaid meheryn, malwod, anemonau, ac amrywiaeth o algâu gwyrdd a choch.

ii) Mae dadansoddiadau amlamryweb o ddata'r gymuned epibiota yn dangos gwahaniaethau sy'n arwyddocaol yn ystadegol rhwng blynyddoedd, ond hefyd rhwng pyllau. Yn fras, mae'r data cymunedol yn rhannu'r pyllau'n dri o grwpiau, sy'n berthnasol i'w dosraniad gofodol ar y lan. Does dim tueddiadau amserol amlwg.

iii) Dangosir gwahaniaethau o ran helaethrwydd (canran gorchudd) neu amlder gwahanol dacsonau epibiota unigol, er nad yw llawer o'r rhain yn cael eu hystyried yn arwyddocaol yn ystadegol neu'n ecolegol.

iv) Cynyddodd helaethrwydd yr algâu coch *Gelidium pulchellum* a *Chondrus crispus* yn 2018 a 2019, ond ystyrir y rhain yn wahaniaethau naturiol.

v) Nodir rhai gwahaniaethau mawr o ran helaethrwydd tyweirch algaidd gwyrdd, yn enwedig *Ulva* (gwastad) a *Chaetomorpha ligustica*, ond ystyrir y rhain yn wahaniaethau naturiol.

vi) Credir bod yr anghysondeb o ran cofnodion canran gorchudd algâu cwrelaidd cramennog yn sylweddol uchel, ac yn debygol o fod oherwydd y ffordd y mae'r arolygwyr yn amcangyfrif helaethrwydd y rhywogaeth benodol honno. Credir bod adolygiad o'r fethodoleg yn briodol.

vii) Roedd cyfoethogrwydd rhywogaethau'r epibiota a gofnodwyd yno'n sefydlog dros y pum mlynedd, gyda chyfartaledd o 28 o dacsonau'n cael eu cofnodi fesul pwll. Doedd dim tueddiadau amlwg.

viii) Ymhlith y cofnodion rhywogaethau nodedig oedd yr *Amathia ?imbricata* bryosoaidd (a oedd yn anarferol yn gorchuddio cyffion y *Corallina*), sawl llyfrothen benddu, yr alga coch *Grateloupia filicina*, a'r alga coch cramennog *Peyssonnelia immersa*.

ix) Cafodd cyfanswm o 126 o dacsonau macroffawnaidd eu hechdynnu (a 90 eu cofnodi'n feintiol) a'u hadnabod o samplau tyweirch algaidd a gasglwyd o byllau Tre-faen rhwng 2015 a 2019. Roeddent yn cynnwys amrywiaeth fawr o fwydod gwrychog, cramenogion bychan, malwod, rhywogaethau dwygragennog, sêr brau, chwistrelliad y môr a thacsonau eraill.

x) Roedd amrywiaeth sylweddol yng nghyfansoddiad y gymuned, rhwng blynyddoedd a rhwng samplau. Doedd dim tueddiadau amserol amlwg.

xi) Roedd cyfoethogrwydd rhywogaethau'r macroffawna tyweirch algaidd yn newid o flwyddyn i flwyddyn, gyda chyfartaledd o 23 o dacsonau (wedi'u cofnodi'n feintiol) yn cael eu cofnodi bob sampl. Doedd dim tueddiadau amserol amlwg.

Mae anghysondeb cofnodi rhwng (ac ymhlith) arolygwyr yn bryder parhaus mewn arolygon monitro yn y fan a'r lle. Fodd bynnag, ystyrir bod y fethodoleg yn ddigonol i ganfod unrhyw newidiadau amserol. Amlygir pa mor bwysig yw parhau i ddefnyddio gweithdrefnau sicrhau ansawdd / rheoli ansawdd.

Aseswyd bod cyflwr y safleoedd monitro yn: Ffafriol – nid yw'r cofnod o newidiadau o ran cyfoethogrwydd rhywogaethau, cyfansoddiad rhywogaethau a helaethrwydd yn tynnu sylw at unrhyw dueddiadau sy'n peri pryder. Ystyrir bod newidiadau a thueddiadau amlwg yn naturiol.

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. In Carmarthen Bay and Estuaries SAC, programmes of feature condition monitoring have been developed by NRW and its contractors.

Shallow Inlets and Bays are one of the Annex I features for which the SAC is designated. Specific areas of interest within Carmarthen Bay include intertidal bedrock reefs with sub-habitats such as rockpools that enhance the local biodiversity of the shore. This report describes a monitoring programme carried out on rockpool communities at Trevayne, which began in 2015 and has been repeated annually. It describes the main characteristics of the communities and the results of temporal analyses for the period 2015 to 2019. There are two components to the monitoring:

i) Ten rockpools (assigned to the LR.FLR.Rkp.Cor.Cor biotope) were surveyed *in situ* for all conspicuous species. Each rockpool is considered a replicate sample, representing the rockpools of the midshore. Quality Assurance and Quality Control procedures were applied to minimise inconsistency of recording, though some inconsistencies remained and are described in the report.

ii) samples of algal (*Corallina*) turf were collected, also annually, from other representative rockpools in the same area. The interstitial fauna within those samples were analysed in a laboratory to identify and enumerate all macrofaunal species

The monitoring data have been analysed with a variety of univariate and multivariate techniques. The most notable results of the analyses were:

iii) A total of 122 epibiota taxa were recorded *in situ* from the ten rockpools over the period 2015 to 2019. They are dominated by encrusting coralline algae and Corallina, with common limpets, snails, anemones and a variety of green and red algae.

iv) Multivariate analysis of the epibiota community data shows statistically significant differences between years, but also between pools. The community data roughly divides the pools into three groups, which relate to their spatial distribution on the shore. No temporal trends are evident.

v) Fluctuations in the abundance (percentage cover) or frequency of occurrence of various individual epibiota taxa are shown, though few are considered statistically and ecologically significant.

vi) Abundance of the red algae *Gelidium pulchellum* and *Chondrus crispus* increased in 2018 and 2019, but are considered to be natural fluctuations.

vii) Some large fluctuations in the abundance of green algal turf, particularly *Ulva* (flat) and *Chaetomorpha ligustica* are shown but are considered to be natural fluctuations.

viii) Inconsistency in percentage cover records for encrusting coralline algae are found to be significantly high and likely due to the way that surveyors estimate that particular species. A review of the methodology is appropriate.

ix) Species richness of the *in situ* recorded epibiota remained steady over the five years, with an average of 28 taxa recorded per pool. No trends were evident.

x) Notable species records included the bryozoan *Amathia ?imbricata* (unusually covering the stems of *Corallina*), numerous Montagu's blenny, the red alga *Grateloupia filicina* and the encrusting red alga *Peyssonnelia immersa*.

xi) A total of 126 macrofauna taxa (90 recorded quantitatively) were extracted and identified from algal turf samples collected from Trevayne pools over the period 2015 to 2019. They comprised a large diversity of polychaete worms, small crustacea, snails, bivalves, brittle stars, sea squirts and other taxa.

xii) There was considerably variability in the community composition, between years and between samples. No temporal trends were evident.

xiii) Species richness of the algal turf macrofauna fluctuated from year to year, with an average of 23 (quantitatively recorded) taxa recorded per sample. No temporal trends were evident.

Inconsistency of recording between (and within) surveyors is a constant concern in *in situ* monitoring surveys. However, it is considered that the methodology is sufficient to detect many temporal changes. The importance of continued application of QA/QC procedures is highlighted.

The condition of the monitoring sites has been assessed as: Favourable - recorded changes in species richness, species composition and abundance do not indicate any trends of concern. Notable changes and trends are considered to be natural.

1 Introduction

The Habitats Directive establishes that the management of Special Areas of Conservation (SACs) should aim to achieve favourable conservation status of habitat and species (*features*) listed within its Annex I and Annex II. Article 17 of the Directive requires reporting of the conservation status of those habitats and species every 6 years. For SACs in Wales, Natural Resources Wales (NRW) is responsible for that reporting. To do this NRW has developed programmes of feature condition monitoring, which include intertidal features of marine SACs. Aquatic Survey & Monitoring Ltd. (ASML) have been contracted by NRW to develop and manage the monitoring programme for these intertidal features for the period 2006 to 2023; working as a team with NRW staff.

Carmarthen Bay and Estuaries Special Area of Conservation (SAC) is designated primarily for sedimentary habitats but is also designated for the Annex I large shallow inlet and bay feature, which includes rocky shore habitats as part of the mix of sub-habitats. Conservation objectives for large shallow inlet and bay habitats are given in the Regulation 37 advice for the SAC (NRW 2018).

Rocky shore areas within the SAC include areas with many rockpools, which are often characterised by a high diversity of species. The mid shore rockpools at Trevayne (Figure 1) were identified as being suitable for monitoring by being numerous, relatively similar in their habitat characteristics, of a size and depth that was manageable for thorough *in situ* recording within a reasonable time and having a diverse community of taxa from multiple phyla. The monitoring site is situated halfway between Tenby and Saundersfoot, but relatively remote from easy access points, so does not receive much visitor pressure. A programme of monitoring began in October 2015 and annual surveys have been carried out every year since then (see table in Appendix 1).

The program objectives are:

- To monitor the composition of communities of conspicuous epibiota present in rockpools of the mid shore at Trevayne.
- To monitor the composition of communities of cryptic / interstitial fauna present within the Corallina turf that is found in those rockpools.

Monitoring methodology and protocols were slightly adapted from ones developed for other monitoring sites and are relevant to the following Carmarthen Bay and Estuaries SAC feature attributes (NRW 2018):

- Structure & Function: Species composition of reef biotopes in high energy locations
- Typical Species: Species composition of rockpool biotopes

The overall aim of the program is to establish reference conditions for the interest features of the SAC and distinguish any deviations from those conditions, using established monitoring sites to describe natural and unnatural changes in the communities. This enables continued development of conservation objectives and informs appropriate management of those SAC features.

This is the first report on the Trevayne rockpool monitoring surveys. It describes the development of the methodology, the characteristics of the rockpool communities and temporal changes up to 2019. It also provides an assessment of the condition of the rockpools in October 2019.

The extent, range and character of rockpools in the Carmarthen Bay and Estuaries SAC were scoped during surveys in 2007 (Moore 2009), prior to establishing the monitoring site at Trevayne Point.

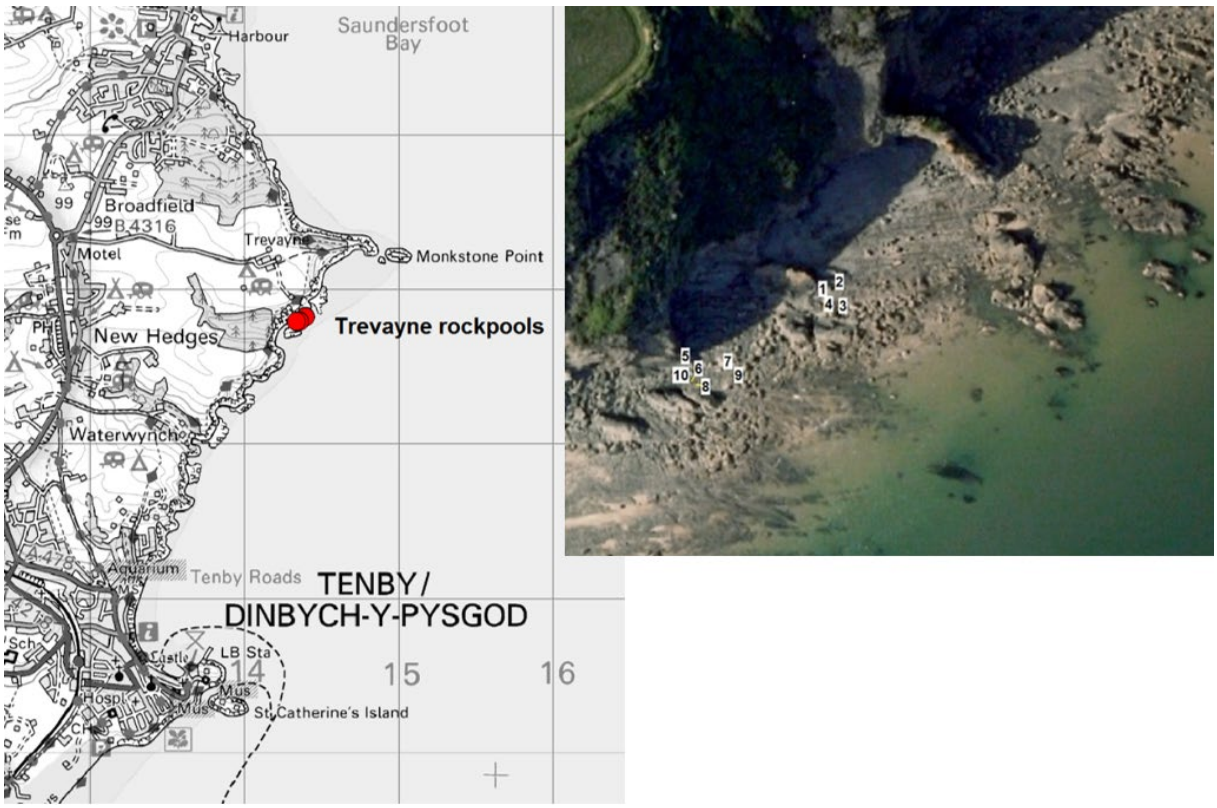
2 Methodology

2.1 Monitoring survey methods - summary

The methodology was initially developed in Cardigan Bay SAC, in rockpools at Aberporth (Moore 2021). Detailed methodologies are given in Moore (2016), including rationales, procedures and protocols, equipment lists and survey forms. No significant modifications to the methodology or protocols have been made since then, though continuous additions to specimen collections, photographs and training does improve species identification, abundance estimation and the overall quality of the data.

Figure 1 shows the locations of Trevayne and the monitored rockpools. More detailed monitoring site location information is given in Appendix 1. Appendix 5 includes photographs of selected rockpools as examples to illustrate the habitat. Survey field logs are held by NRW and ASML and are available on request.

Figure 1 Location of Trevayne rockpools in Carmarthen Bay and Estuaries SAC. Contains OS data © Crown copyright and database right 2021. Scale: 1 kilometre grid squares.



There are two components to the monitoring survey – i) *in situ* recording of all conspicuous epibiota taxa; ii) sampling of *Corallina* turf for laboratory analysis of cryptic / interstitial fauna.

1. *In situ* recording of presence and abundance (% cover) of all conspicuous taxa in 10 fixed rockpools. The majority of the animal taxa were recorded as presence only. Algal taxa and some ground covering animals (various sponges, *Sabellaria* and mussels) were recorded as percentage cover. The following aggregate taxa were additionally recorded as percentage cover: Porifera, Cirripedia, Rhodophyta (enc.), Rhodophyta (turf), Phaeophyceae (turf), Chlorophyta (turf).
2. Two standardised samples of *Corallina* turf, scraped from the side of two other rockpools (not from the *in situ* surveyed pools). Laboratory analysis (identification and enumeration) of all fauna extracted from the turf (and held by 0.5mm mesh). Most taxa recorded as counts, but sessile colonial taxa recorded as presence only, per sample. Laboratory analyses were carried out by Hebog in all years except 2016 when they were carried out by IECS.

Quality Assurance and Quality Control (QA/QC) procedures, including training, identification and recording aids, purpose designed forms, verification procedures and validation procedures have been developed over the course of the monitoring survey programme to ensure the quality of the data for the monitoring objectives. Details of these procedures are given in Moore (2016).

2.2 Data management and analyses

Data from the two monitoring survey components (*in situ* survey records and *Corallina* turf samples) were stored and analysed separately. The *in situ* survey data are stored in an Access database from which they are exported to Excel for selected analyses; while the *Corallina* turf sample data are stored in an Excel spreadsheet. Both datasets include detailed metadata to facilitate extraction of subsets and analyses. Appendix 2 provides a summary of the structure of the datasets and metadata.

Both datasets contain quantitative and qualitative data which require different analytical approaches:

- *In situ* survey records

Quantitative – over half of the records are percentage cover, but nearly 20% are of aggregate taxa (labelled T%) that are analysed separately.
Qualitative – just under half of the records are presence/absence and the percentage cover data can be transformed to presence/absence. Multiple replicates (10 pools) of these data allows for calculation of frequency of occurrence as a surrogate quantitative measure of abundance.

- *Corallina* turf sample records

Quantitative – 70% of the records are counts, though some of them are of juveniles which are excluded from some analyses.
Qualitative – 30% of the records are presence/absence, primarily of sessile colonial taxa that are likely not so consistently recorded from preserved turf samples. No analysis of those data have been included in this report.

In both datasets there are some taxa that are inconsistently recorded. For some taxa the confusing effects of this inconsistency has been reduced by aggregation to higher classifications (e.g. Genus, Family, or Class), using taxonomic classification information in the metadata. Metadata fields have also been applied to both datasets which allow simple selection of taxa that are relatively consistently recorded and suitable for temporal analysis.

Summary statistics and tabulation were prepared in the Access database and typically exported to Excel for further analysis and for preparation and formatting of graphs and tables for use in reports. Tabulated data in Excel formats ready for import into Marine Recorder and PRIMER were also exported from the database. Multivariate analyses were carried out in PRIMER, primarily using non-metric Multi-Dimensional Scaling (nMDS) from matrices of Bray-Curtis similarities:

Univariate analyses (including analysis of variance and Spearman rank correlation) were carried out in the statistical package R.

3 Results

3.1 Epibiota community

3.1.1 General description

The pools are located in the midshore zone and are clearly differentiated from the surrounding open rock habitat. In the national marine habitat classification (JNCC 2015) they can be confidently assigned to the '*Coralline crusts and Corallina officinalis in shallow eulittoral rockpools'* biotope (*LR.FLR.Rkp.Cor.Cor*). They are dominated by encrusting coralline algae and *Corallina*, with common limpets *Patella* spp., edible winkles *Littorina littorea*, purple topshells *Steromphala* (*Gibbula*) *umbilicalis* and beadlet anemones *Actinia equina* and frequent but variable cover of various green and red algae attached to the *Corallina*. Other common taxa include the sponge *Hymeniacidon perlevis*, the serpulid worm *Spirobranchus*, the red algae *Chondrus crispus* and *Gelidium pulchellum*, the brown alga *Dictyota dichotoma* and the green algae *Ulva lactuca*, *Chaetomorpha ligustica* and *Cladophora sericea*. From 2015 to 2019 a total of 122 taxa (not including aggregate taxa) had been recorded from the pools. A complete list is given in Appendix 3.

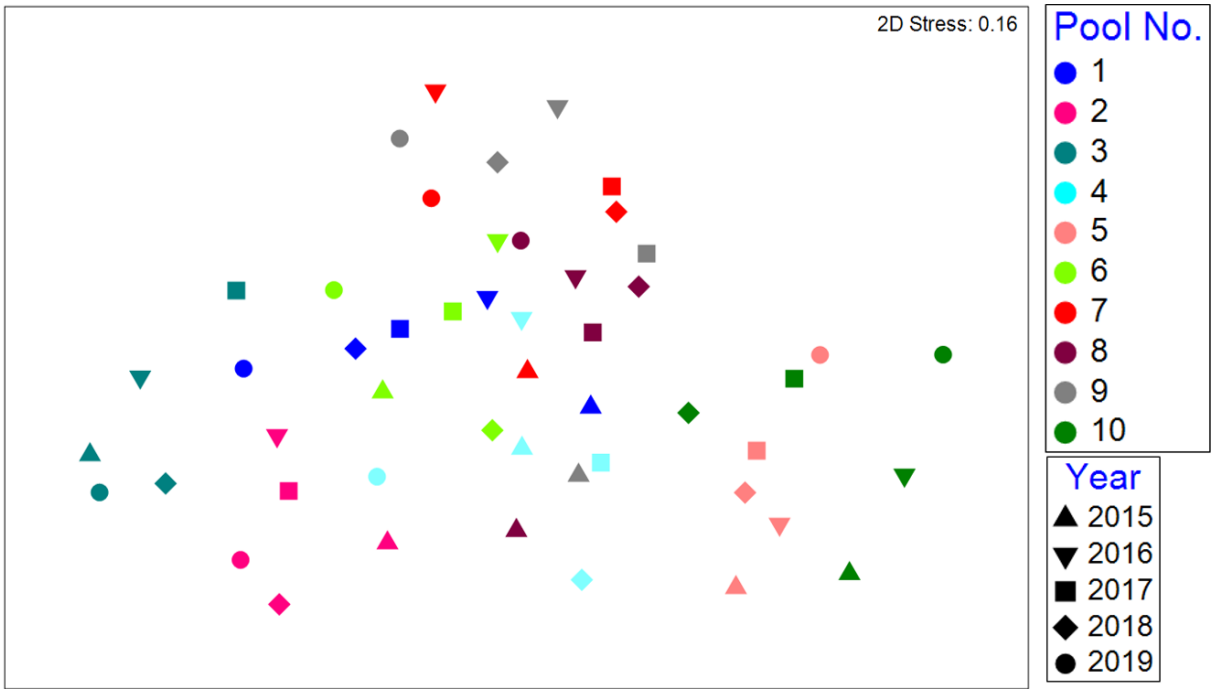
3.1.2 Community data

Multivariate analysis of whole community data shows that there are statistically significant differences between the years and also between the pools (ANOSIM, two-way cross: Year x Pools, testing the null hypothesis that communities are not significantly different, see detailed results in Appendix 4). The percentage cover data and the presence/absence data give similar results, but the presence/absence data give a slightly greater significance to the differences. The difference between pools (PA data: Average Rho 0.277, p=0.1%) is also stronger than the difference between years (PA data: Average Rho 0.285, p=0.5%), so they do not act well as replicates for describing year to year differences.

The MDS plot in Figure 2 shows that while there is some clustering of samples by pool, though with considerable overlaps, there is very little evidence of clustering by years and no obvious temporal trends. Closer inspection of the MDS plot shows that similarities between the pool communities can be partially related to the spatial distribution of the pools on the shore (see Figure 1). They group, roughly, into the following: Pools 1 to 4, Pools 5 and 10, Pools 7 to 9.

Figure 2 is based on percentage cover for the primarily algal taxa. Multivariate analysis of presence / absence for all 96 taxa shows a similar lack of any trends and the clustering of the pools and the years is even less structured. No further multivariate analysis is considered worthwhile.

Figure 2 MDS plot showing similarities (Bray Curtis) between epibiota communities in rockpools at Trevayne, 2015 to 2019. Percentage cover data (square root transformed) for 37 taxa.



3.1.3 Individual taxa

Inspection of data for individual taxa (Figure 3. Annual fluctuations in percentage cover (± Standard Error) of selected taxa in Trevayne rockpools, 2015 to 2019. Each point is the average from ten pools.

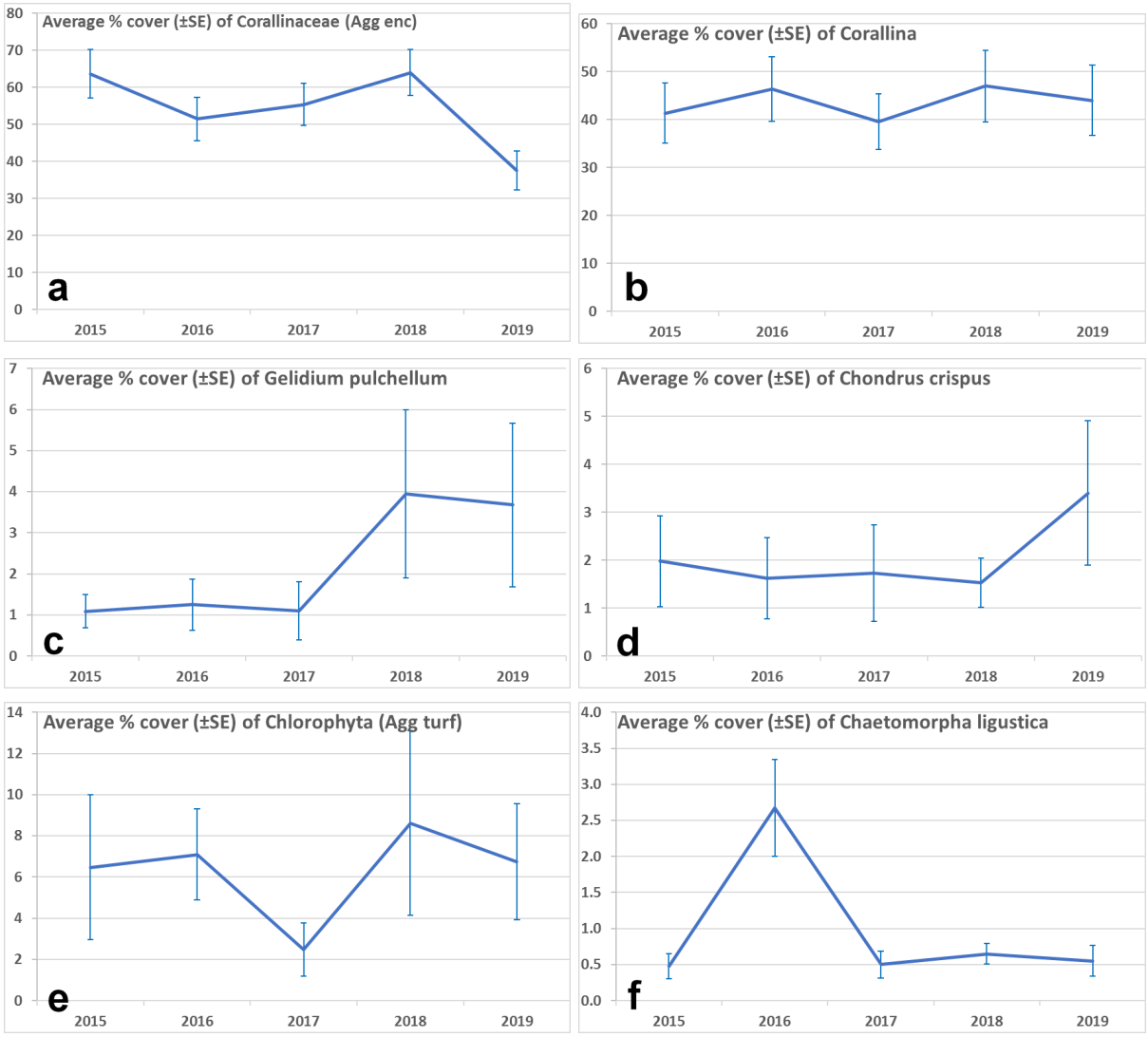


Table 1, Table 3 and Figure 3) shows that there were notable fluctuations in the recorded abundance of many, but few that are considered ecologically significant. Results from a few taxa are discussed below:

Mytilus edulis – relatively large patches of mussels (visible in the photos) have been recorded in only two of the pools (Table 1); and those patches have come and gone, presumably scoured out by storms.

Patella spp – the apparent large temporal variation in frequency of records (Table 3) is likely due more to variation in the identification of these limpets *in situ*. Levering them off the rock, to look at the colour of the foot and tentacles, is not undertaken, because it can damage the animal and thereby reduce survival, which would also influence the quality of the monitoring data.

Littorina saxatilis – the recorded fluctuations in rough periwinkle records (Table 3) is considered real as they have been searched for thoroughly, but numbers are typically low. 2016 appears to have been a bad year for them.

Nucella lapillus – the occurrence of dogwhelks in the pools (Table 3) is likely related to the presence of their prey, particularly mussels; but densities of mussels have been fairly low in most pools, so dogwhelks coinciding with the monitoring survey will be stochastic records and the apparent downward trend is likely due to chance.

Table 1 Percentage cover of the most abundant taxa in Trevayne rockpools, 2015-19. Each value is an average from 10 pools. Coloured data bars (using conditional formatting feature from Excel) have been added to highlight the differences between years within each row (but not between rows as scales vary). ns = not surveyed

	2015	2016	2017	2018	2019
Porifera (Agg)	ns	9.1	11.0	6.5	10.6
Mytilus edulis	1.3	3.0	1.5	1.3	0.2
Bacillariophyceae	ns	3.1	0.1	0.0	1.0
Rhodophyta (Agg enc)	0.7	1.5	1.7	2.6	1.5
Gelidium pulchellum	1.2	1.3	1.4	4.0	3.7
Corallinaceae (Agg enc)	61.5	51.5	52.0	64.0	37.5
Corallina	39.0	46.4	35.5	47.0	44.0
Chondrus crispus	2.2	1.6	2.0	1.5	3.4
Ceramium virgatum	0.3	0.3	0.2	0.4	0.1
Phaeophyceae (Agg turf	1.4	0.4	0.2	0.8	0.7
Dictyota dichotoma	1.4	0.4	0.2	0.7	0.7
Chlorophyta (Agg turf)	7.1	7.1	2.7	8.6	6.8
Ulva (tubular)	0.2	0.6	0.2	0.1	0.4
Ulva (flat)	6.1	4.2	2.3	6.9	5.7
Chaetomorpha ligustica	0.5	2.7	0.6	0.7	0.6
Cladophora	0.2	0.1	0.2	0.4	0.2

Gelidium pulchellum – most abundant in four pools, with notable increase in all four in 2018, persisting through to 2019 (Figure 3c).

Diatoms (Bacillariophyceae) – growths of filamentous diatoms, forming a mat on *Corallina*, are likely present in every pool in every year, but have been conspicuously abundant in some years and not noticed in others (Table 1).

Encrusting coralline algae – an apparent notable drop in cover in 2019 (Figure 3a), which is also shown clearly in Table 2, a table of percentage cover records from the individual pools. However, inspection of the photographs suggests that this may be due more to inconsistency of recording than real change. For example, comparison of the photographs for pool 1 from 2015 and 2019 shows a reduction, but it is clear that the 80% record in 2015 is a large over-estimate, while the 20% value in 2019 is an under-estimate! Over-estimates are surprisingly easy to do for these pink crusts as it is easy to assume that they are present underneath the algal turf.

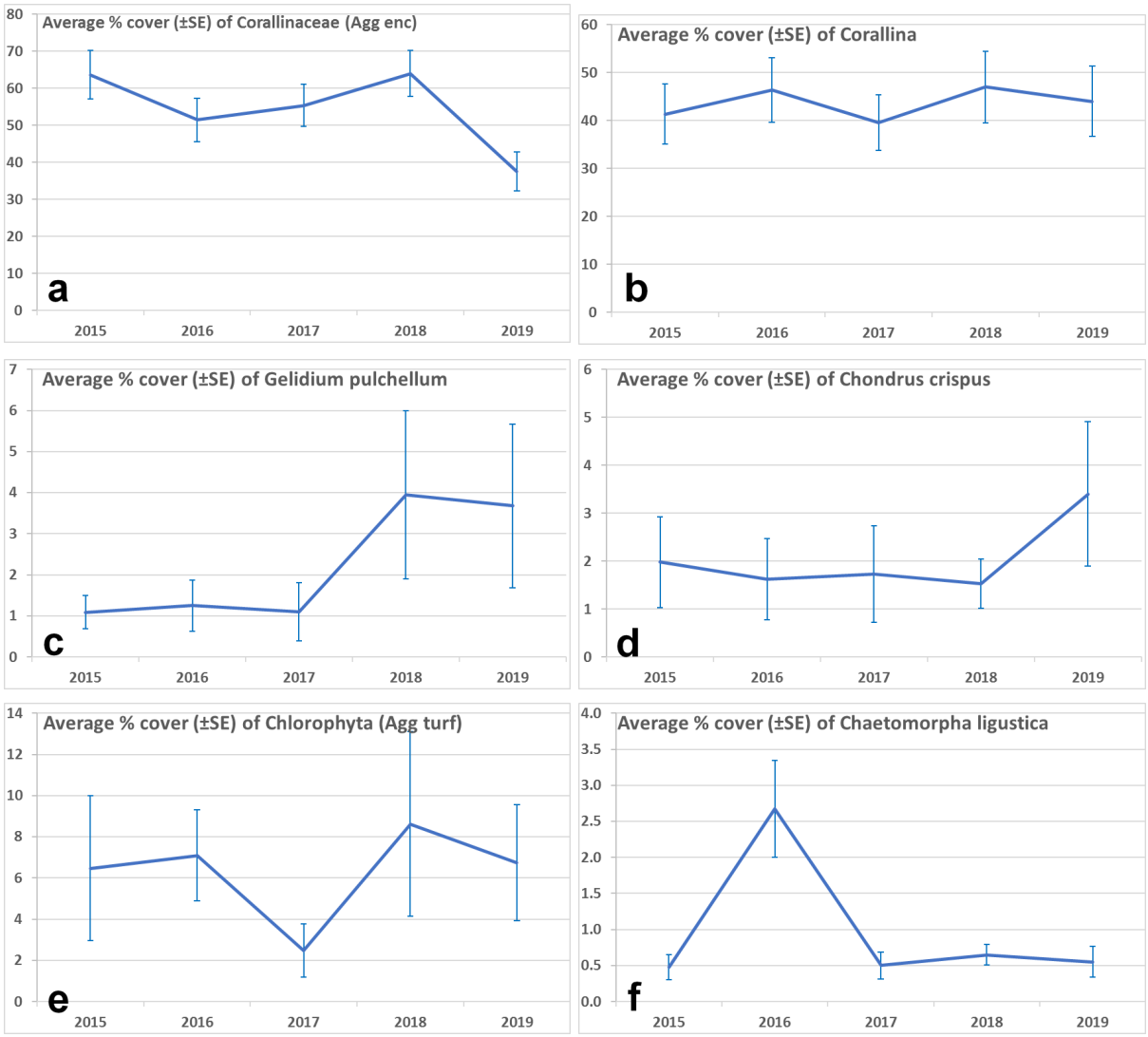
Table 2 Percentage cover of coralline crusts in each pool, 2015-19

Pool No.	1	2	3	4	5	6	7	8	9	10
2015	80	60	15	70	85	50	65	60	50	80
2016	50	40	15	60	70	50	30	70	60	70
2017	30	40	25	70	70	50	50	60	45	80
2018	40	60	20	80	70	70	75	70	75	80
2019	20	30	15	50	60	45	30	30	30	65

Corallina – some fairly large fluctuations within individual pools, but with average cover remaining relatively stable (Figure 3b).

Chlorophyta – some large fluctuations in cover of *Ulva* (flat) in two of the pools, but with no apparent trend (Figure 3e). Similarly, some large fluctuations in *Chaetomorpha ligustica* in four pools, but again no apparent trend (Figure 3f).

Figure 3. Annual fluctuations in percentage cover (± Standard Error) of selected taxa in Trevayne rockpools, 2015 to 2019. Each point is the average from ten pools.



Amathia – the lack of records in 2015 (Table 3) is likely due to identity confusion with *Alcyonidium hirsutum* (see Section 4.2).

Molgula – the large number of records in 2019 (Table 3) may be due to the surveyor(s) getting their eye in for these small cryptic individuals. However, large numbers of *Molgula manhattensis* have been observed more commonly on exposed rocky shores around Tenby in recent years (J. Moore pers. obs).

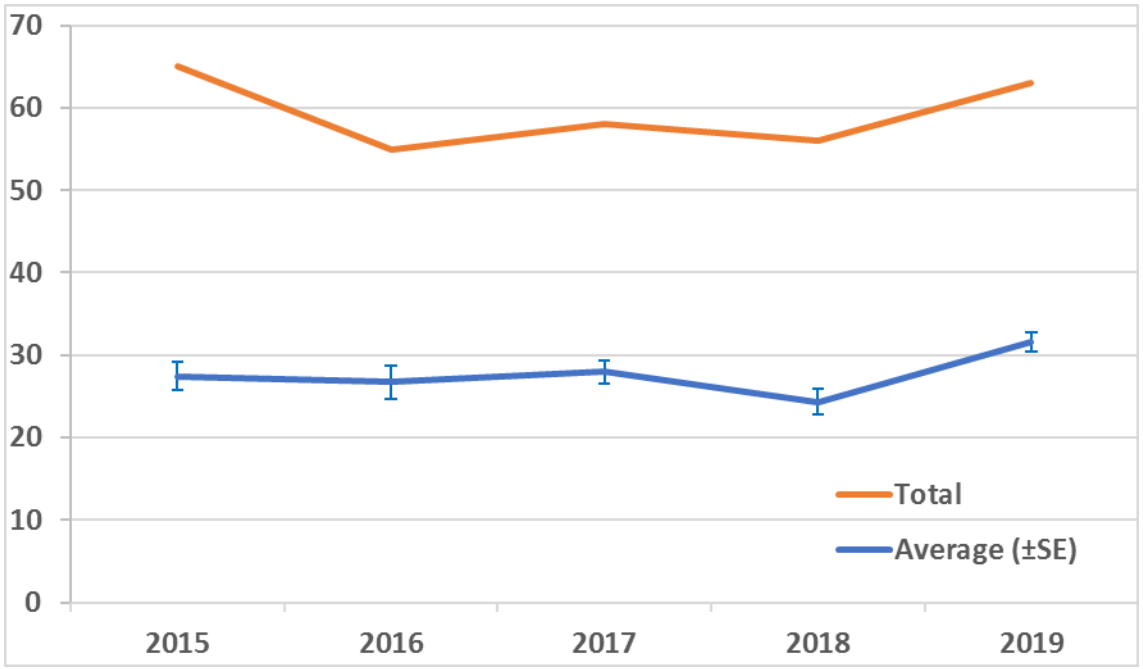
Table 3 Frequency of occurrence of the most commonly recorded taxa in Trevayne rockpools, 2015-19. Each value is the number of pools (out of 10) from which the taxa was recorded. Coloured data bars (using conditional formatting feature from Excel and grouped by phyla) have been added to highlight the differences between years. ns = no survey.

	2015	2016	2017	2018	2019
Microciona atrasanguinea	1	1	7	2	5
Hymeniacidon perlevis	7	7	7	7	7
Sertulariidae	6	1	1	3	5
Actinia equina	9	9	10	8	10
Lanice conchilega	4	4	7	5	5
Spirobranchus	5	6	8	9	4
Semibalanus balanoides	6	6	6	3	9
Austrominius modestus	6	5	5	4	4
Prawns/shrimps	5	8	4	7	8
Anurida maritima	4	7	8	10	8
Patella depressa	3	1	8	1	7
Patella ulyssiponensis	9	8	7	7	8
Patella vulgata	8	4	1	3	5
Steromphala umbilicalis	8	10	10	10	10
Littorina littorea	10	10	10	10	10
Littorina saxatilis	9	2	6	7	6
Nucella lapillus	5	5	6	4	2
Mytilus edulis	6	10	6	5	7
Amathia	1	5	9	7	8
Molgula	2	4	2	1	8
Pisces	5	9	9	5	8
Bacillariophyceae	ns	9	5	0	10
Gelidium pulchellum	9	6	8	8	8
Corallinaceae (Agg enc)	10	10	10	10	10
Corallina	10	10	10	10	10
Chondrus crispus	9	9	10	8	10
Ceramium virgatum	8	7	6	4	5
Osmundea (flat)	6	2	4	6	6
Dictyota dichotoma	9	8	7	5	8
Ulva (tubular)	4	9	6	6	7
Ulva (flat)	6	7	8	7	7
Chaetomorpha ligustica	10	10	8	8	8
Cladophora	7	5	6	7	7

3.1.4 Species richness

Figure 4 shows that the average number of taxa recorded per pool remained fairly steady over the five years and the total number of taxa fluctuated moderately. No trends are evident.

Figure 4. Average number (per pool) (± Standard Error) and total number of taxa (from ten pools) recorded in Trevayne rockpools, 2015 to 2019. Values exclude aggregate taxa.



3.2 *Corallina* turf samples

These sample data (2 samples in each of the 5 years = 10 samples, 126 taxa) include both quantitative (counts, 90 taxa) and qualitative (presence/absence, 36 taxa) records. However, considerable inconsistency is apparent in the qualitative records, so the analyses described here only use the quantitative data.

The 90 counted taxa include 14 categorised as juveniles; these have been included and excluded in various analyses to study patterns present in the data. Analyses in which data were summed to Genus and Family level were also carried out, to reduce the high level of variability in species recorded. Some of that variability comes from differences in the taxonomic level to which the analysts were able to assign some (often many) specimens (i.e. to family or genus rather than species). Some of the species may also be short-lived or with a high turn-over and sporadic recruitment. However, whether the variability is real or methodological, notable changes are still apparent in data summed to the higher taxonomic levels.

Table 4 condenses the count data for the most frequently recorded taxa, summed to family level. It shows that the turf communities comprised a large diversity of polychaete worms and small crustacea (sea spiders, amphipods, isopods), some other worm taxa, a number of small snails and bivalves, some brittle stars and sea squirts. Sample composition was extremely variable, with juvenile mytilid bivalves being the only taxa found in every sample. Other frequently recorded individual taxa were the brittle star *Amphipholis squamata*, nematode worms, the scale worm *Pholoe*

inornata and the nereid worm *Platynereis dumerilii*. However, the abundance of even those species varied dramatically from year to year and often between replicate samples in the same year. There were no obvious temporal trends.

Table 4 Counts of the most frequently recorded taxa (summed to family level) in *Corallina* turf samples from Trevayne rockpools, 2015-19. Values are sums of two samples to highlight the differences between years, although differences between the two samples was often also high. Coloured data bars (using conditional formatting feature from Excel, and grouped by taxonomic group) have been added to highlight the differences between years within each row (but not between rows, as scales vary). Last row: average number of quantitatively recorded taxa per sample.

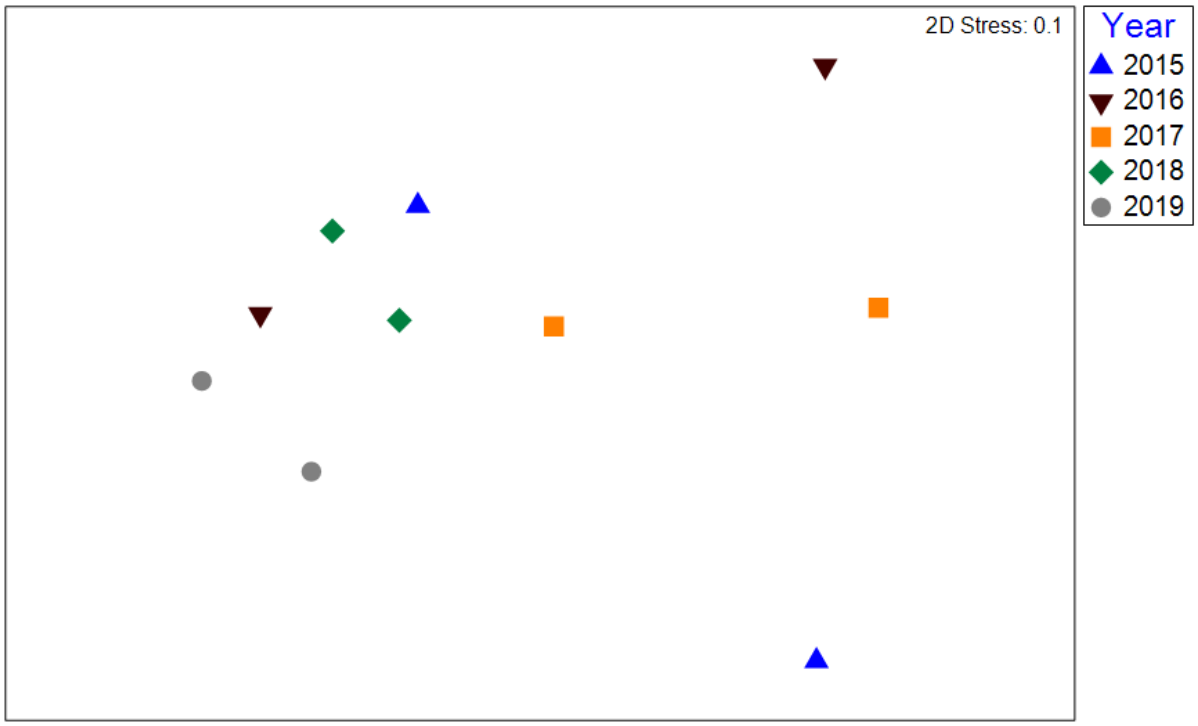
	2015	2016	2017	2018	2019
Platyhelminthes	7	7	0	0	1
Nemertea	4	5	1	30	42
Nematoda	18	115	6	22	73
Pholoidae, Polychaeta	19	10	7	31	27
Phyllodocidae, Polychaeta	7	0	1	0	2
Hesionidae, Polychaeta	3	1	1	3	0
Syllidae, Polychaeta	7	3	2	4	7
Nereididae, Polychaeta	13	9	14	30	8
Spionidae, Polychaeta	2	0	1	1	3
Cirratulidae, Polychaeta	4	1	2	9	3
Fabriciidae, Polychaeta	0	6	1	2	28
Serpulidae, Polychaeta	13	0	5	0	0
Ammotheidae, Pycnogonida	0	13	4	6	12
Phoxichilidiidae, Pycnogonida	0	7	1	2	5
Calliopiidae, Amphipoda	9	13	8	0	2
Stenothoidae, Amphipoda	0	0	18	5	5
Ampithoidae, Amphipoda	5	0	4	0	0
Idoteidae, Isopoda	1	2	2	0	0
Tanaididae, Tanaidacea	1	3	0	1	8
Portunidae, Decapoda	5	4	0	0	3
Chironomidae, Insecta	1	2	1	0	1
Trochidae, Gastropoda	2	1	0	2	0
Littorinidae, Gastropoda	4	4	0	1	0
Rissoidae, Gastropoda	4	9	6	8	0
Runcinidae, Gastropoda	0	1	1	4	12
Limapontiidae, Gastropoda	13	0	0	15	0
Mytilidae, Bivalvia	120	317	74	61	1734
Lasaeidae, Bivalvia	0	0	1	3	1
Veneridae, Bivalvia	14	2	0	0	1
Amphiuridae, Ophiuroidea	67	178	38	183	275
Molgulidae, Ascidiacea	10	0	19	3	2
Average number of taxa	27	20	24	21	23

Species richness (Table 4, bottom row) fluctuated from year to year, but was highest in the first year. However, most samples contained a number of species of

polychaete worms, small crustacea, snails and bivalves, in all years. No temporal trends in species richness were evident.

Multivariate analysis (Figure 5) also highlights the considerable variability in the sample data, sometimes including large differences between replicate samples taken in the same year (e.g. 2015). Again, no temporal trends are evident. It was not possible to test the statistical significance of differences between the years as only two samples were taken on each occasion.

Figure 5 MDS plot showing similarities (Bray Curtis) between *Corallina* turf community samples from rockpools at Trevayne, 2015 to 2019. Analysis data are counts from 89 taxa (including juveniles), summed upwards to 70 genera, then square root transformed.



4 Discussion

All ten rockpools contain a similar community, characterised by a high cover of *Corallina* and encrusting coralline algae. However, while this community remains largely the same, there has been notable variability between rockpools and between years, with, as yet no apparent pattern or trends. The average number of taxa per pool is around half of the total number of taxa for all ten pools (Figure 4). This demonstrates the need to survey all the pools to get an understanding of the flora and fauna of the pools in the area.

No anthropogenic threats to the rockpools have been identified, but sand inundation has occurred in at least some pools and scouring during storm events is also likely.

The Corallina turf sample data shows how important this seaweed is for a diverse range of inconspicuous interstitial fauna.

The natural fluctuations in abundance of some species and the stochastic settlement of other species (e.g. mussels) shows how important it is to maintain a long term data set, so that anthropogenic changes can be separated from natural changes.

4.1 Survey Recommendations

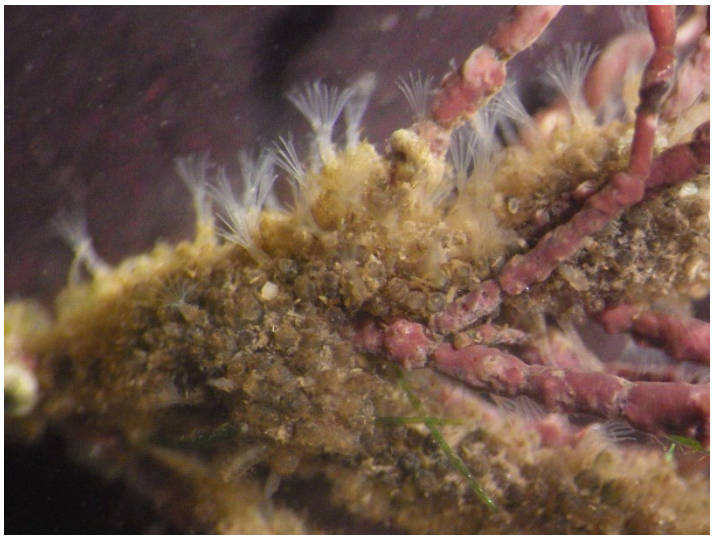
Repeat collection of specimens (ideally from adjacent pools) for confirmation of identification (see Section 4.2) provides some quality control. Repeat monitoring with multiple surveyors, at the same rockpool is useful to identify the variability in estimates of percentage cover, between surveyors. Pre-survey training and partner working can help to reduce inter-surveyor variability, but there still remain some instances, such as with coralline crusts, where estimates of percentage cover vary between surveyors (and by the same surveyor). Further partner working and standardisation of approach is required to improve consistency.

A comparison of the results from rockpool monitoring at Aberporth (Moore 2021) and Pen y Holt (Bunker 2010) could be useful in differentiating local changes from more widespread changes in rockpool communities. Such analyses are beyond the scope of this report, which focuses specifically on the features of Carmarthen Bay and Estuaries SAC

4.2 Notable species

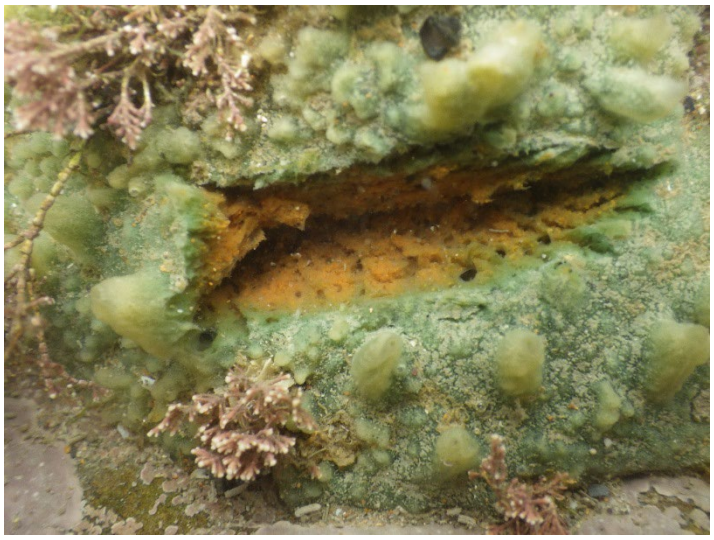
Amathia – an unusual growth of a Ctenostome bryozoan, wrapped around the stems of *Corallina*, has been recorded from most of the pools (Figure 6). It was identified *in situ* in 2015 as *Alcyonidium hirsutum* but has since been identified from microscopic analysis as *Amathia imbricata* (Note: polypide clearly has ten tentacles), though this has yet to be confirmed by a bryozoan expert.

Figure 6 *Amathia imbricata* (unconfirmed ID) growing on *Corallina*.



Hymeniacidon perlevis – in 2015 there was some confusion in the identification of sponges with characters of both *Hymeniacidon perlevis* and *Halichondria panicea*, particularly as they had a strong green colouration. Numerous specimens were checked by Jen Jones and all were confirmed as *H. perlevis*. The image in Figure 7 shows that the typical orange colour of *H. perlevis* is hidden under a green surface colonised by symbiotic algae – a colour more commonly found in *H. panicea*.

Figure 7 *Hymeniacidon perlevis* (identification confirmed from microscopic analysis of spicules by Jen Jones).



Coryphoblennius galerita – while shanny and rock gobies were the most common fish present in the rockpools, a number of Montagu's blenny (Figure 8) have also been recorded.

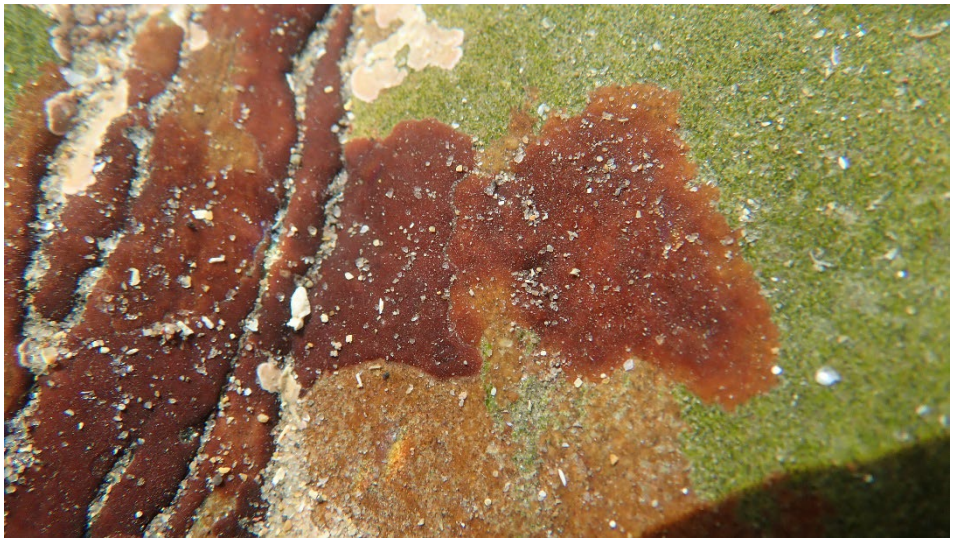
Figure 8 Montagu's blenny, *Coryphoblennius galerita*, occasionally recorded in the rockpools.

Grateloupia filicina – a red alga that is not often recorded but has been found persistently in some of the Trevayne pools (Figure 9).

Figure 9 *Grateloupia filicina*, occasionally recorded in the rockpools (identification confirmed by Francis Bunker).

Peyssonnelia immersa – an encrusting red alga more often recorded from the shallow subtidal, it has been found persistently in some of the Trevayne pools (Figure 10).

Figure 10 Encrusting red algae, *Peyssonnelia immersa*, recorded in some rockpools (identification confirmed by Francis Bunker).



4.3 Condition Assessment

Favourable - recorded changes in species richness, species composition and abundance do not indicate any trends of concern. Notable changes and trends are considered to be natural. There is no evidence of anthropogenic change and no evidence to undermine the conservation objectives for the Large Shallow Inlet and Bay feature.

5 References

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6 Acknowledgements

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Peer review, proof-reading, and some editing of this report was carried out by Paul Brazier and Anne Bunker.

Appendix 1 Monitoring survey dates and pool coordinates

Monitoring survey dates of Trevayne rockpools

Year	Survey dates
2015	14 October
2016	17-18 September
2017	6-7 October
2018	9-10 October
2019	29 September - 2 October

Trevayne rockpool coordinates. Easting / Northings are OS grid references. Lat / Long datum is WGS84.

Description	Easting	Northing	Latitude	Longitude
Pool 1	214388	202831	51.6968	-4.68029
Pool 2	214391	202832	51.6968	-4.68029
Pool 3	214392	202829	51.6968	-4.68029
Pool 4	214388	202829	51.6968	-4.68029
Pool 5	214333	202801	51.6968	-4.68029
Pool 6	214336	202796	51.6968	-4.68029
Pool 7	214349	202804	51.6968	-4.68029
Pool 8	214338	202796	51.6968	-4.68029
Pool 9	214353	202799	51.6968	-4.68029
Pool 10	214333	202798	51.6968	-4.68029

Rockpool relocation sheets, including annotated photographs from various viewpoints, are held by ASML and NRW.

Appendix 2 Database structure

In situ monitoring survey data

The *in situ* survey data are stored in an Access database. A summary of the main data tables and fields is given below:

RockpoolData

Field name	Description
Entity	Accepted name for the taxon, based on WoRMS, plus qualifier
Year	Survey year: 2015 to 2019
SampleCode	Sample code. Year+Pool(+QArepeat), e.g. 15P1.2 = 2015, Pool 1, repeat sample 2
Method	P (=Present), % (=Percentage) or T% (=Percentage of aggregate taxon). The actual method used for this entity in this sample. Not necessarily the default method given in the TaxaList table.
Abundance	A numeric value from 0.01 to 100. If Method = % then Abundance is percentage cover. If Method = P, then Abundance can only be 1 (=Present) or 0.01 (=Trace).

Taxa

Field name	Description
Entity	Accepted name for the taxon, based on WoRMS, plus qualifier
EntCode	Taxonomic code for each entity (=taxon + qualifier), based on Species Directory, e.g. Hymeniacidon perlevis = C005230 and Corallinaceae (enc) = ZM03840.51
AnalysisEntity	Fairly reliable taxonomic entity for use in analyses where identification of Entity is not always reliable
AphiaID	Code for taxon name from WoRMS online database
Authority	Taxonomic authority from WoRMS online database
Kingdom -> Species	Multiple fields – taxonomic classification, from WoRMS online database
PoolChecklist	Tags entities that are listed on the recording form
Method	Default survey method: P (=Presence), % (=Percentage cover), T% (Percentage cover of aggregate taxa)
TemporalAnalysis	Tags entities to include in temporal analysis. Excluded taxa are those that are very inconsistently recorded.
Life form	e.g. Hydroid, Bryozoan turf, Green turf

Samples

Field name	Description
SampleCode	Sample code, as in RockpoolData table
Year	2015 to 2019
Site	Trevayne
Pool	1 to 10
Date	Survey date
Start time & End time	Survey times
Conditions	Environmental conditions during survey, e.g. overcast, windy
Surveyors	Initials of surveyors
Substrata (3 cols)	Tag the presence of Cobbles, Gravel, Sand/Mud and Silt in bottom of pool
Silt	How silted is pool bottom, as judged by surveyor on 5-point scale, 1=low
Scour	How scoured is pool, as judged by surveyor on 5-point scale, 1=low
QA-repeat	1 or 2, where 2 is a repeated sample by another surveyor, for quality control

Pools

Field name	Description
Site	Trevayne
Pool	1 to 10
Depth	Measured depth in centimetres
Length	Measured length in centimetres
Area	Measured area in square metres
Easting / Northing	Ordnance Survey grid reference location for pool
Longitude / Latitude	Pool location coordinates in decimal degrees, with WGS84 datum

Corallina turf sample data

The *Corallina* turf sample data are stored in a spreadsheet. A summary of the main data tables and fields is given below:

Field name	Description
Main matrix	
Column 1: Entity	Accepted name for the taxon, based on WoRMS, plus qualifier
Row 1: Sample code	Code based on year, site, zone and replicate, e.g. 19-Ap.L1
Main body: abundance data	Count data: numeric values >0 Presence data: indicated by numeric value of '-1'
Factors – rows below matrix	
Year	Survey year: 2007 to 2019
Month	Survey month
Date	Survey date
Julian	Day of year, based on Julian year
Zone (Shore height)	U (upper) or L (lower)
Rep	Replicate
OSGB Easting & Northing	Ordnance Survey grid reference location
Sampler	Initials of surveyor who took samples

Analytical lab	Name of laboratory carrying out analysis
Indicators – columns to right of matrix	
Qualifier	e.g. juv, eggs, damaged, bits agg
SDC	Taxonomic code for each entity, based on Species Directory
CategoriesForAnalysis	Categories based on Species type (as below), Qualifier (as above) and Data type (as below), for selection of data for analysis
Data type	Counts or Present
Species type	Infauna, Juveniles, Mobile epifauna, Colonial epifauna, Sessile epifauna, Epiflora
AphiaID	Code for taxon name from WoRMS online database
Authority	Taxonomic authority from WoRMS online database
Kingdom -> Species	Multiple fields – taxonomic classification, from WoRMS online database

Appendix 3 List of taxa

The following table lists all taxa recorded from all Trevayne rockpools, with counts of records by year. Nomenclature is according to the WoRMS database (www.marinespecies.org), current in February 2020. Entity is the taxon and qualifier recorded. AnalysisEntity is that used during many of the statistical analyses described in the report, to merge data for taxa that may have been identified or recorded in different ways by different surveyors or in different years. M is the recording method, where P = presence only, % = percentage cover, T% = percentage cover of aggregate taxa. Taxa have been sorted according to an alphanumeric code based on the Marine Species Directory (Howson & Picton, 1997).

Entity	Entity (analysis)	M	2015	2016	2017	2018	2019
Porifera (Agg)	Porifera (Agg)	T%	0	7	13	8	8
Leucosolenia	Leucosolenia	P	0	1	0	0	0
Halichondria (Halichondria) panicea	Halichondria (Halichondria) panicea	P	3	1	3	0	2
Hymeniacidon perlevis	Hymeniacidon perlevis	P	8	7	8	7	7
Clathria (Microciona) atrasanguinea	Clathria (Microciona) atrasanguinea	P	1	1	10	2	5
Hydrozoa (thecate)	Hydrozoa (thecate)	P	9	0	0	0	0
Kirchenpaueria pinnata	Sertulariidae	P	0	0	0	2	5
Plumularia setacea	Sertulariidae	P	7	1	1	0	0
Sertulariidae	Sertulariidae	P	0	0	0	1	0
Dynamena pumila	Dynamena pumila	P	2	0	1	0	0
Campanulariidae	Campanulariidae	P	0	4	3	1	3
Laomedea flexuosa (or Gonothyraea loveni)	Campanulariidae	P	1	0	0	0	0
Obelia dichotoma	Campanulariidae	P	1	0	0	0	0
Actinia equina	Actinia equina	P	10	9	13	8	10
Anemonia viridis	Anemonia viridis	P	0	0	0	1	1
Urticina felina	Urticina felina	P	0	0	1	2	1
Cereus pedunculatus	Cereus pedunculatus	P	2	3	3	4	4
Eulalia viridis	Eulalia viridis	P	0	0	0	0	1
Polydora	Polydora	P	0	0	1	0	0
Sabellaria	Sabellaria	P	2	3	4	3	3
Lanice conchilega	Lanice conchilega	P	4	4	9	5	5
Serpulidae (round aperture)	Spirobranchus	P	0	0	5	3	0
Spirobranchus	Spirobranchus	P	5	6	11	9	4
Spirorbinae	Spirorbinae	P	0	4	7	3	2
Pycnogonida	Pycnogonida	P	0	0	1	0	0
Cirripedia (Agg)	Cirripedia (Agg)	T%	8	6	11	6	9
Chthamalus montagui	Chthamalus montagui	P	2	1	0	0	0
Chthamalus stellatus	Chthamalus stellatus	P	3	1	1	0	0
Semibalanus balanoides	Semibalanus balanoides	P	7	6	6	3	9
Austrominius modestus	Austrominius modestus	P	7	5	8	4	4
Sphaeromatidae	Sphaeromatidae	P	0	0	1	0	1
Decapoda (prawns/shrimps)	Decapoda (prawns/shrimps)	P	6	8	6	7	8

Entity	Entity (analysis)	M	2015	2016	2017	2018	2019
Pagurus bernhardus	Pagurus bernhardus	P	1	0	0	0	0
Carcinus maenas	Carcinus maenas	P	3	5	4	3	3
Anurida maritima	Anurida maritima	P	4	7	9	10	8
Lepidochitona cinerea	Lepidochitona cinerea	P	0	0	0	1	1
Acanthochitona crinita	Acanthochitona crinita	P	1	0	0	0	0
Patella depressa	Patella depressa	P	4	1	8	1	7
Patella ulyssiponensis	Patella ulyssiponensis	P	10	8	9	7	8
Patella vulgata	Patella vulgata	P	9	4	1	3	5
Phorcus lineatus	Phorcus lineatus	P	2	2	2	1	1
Steromphala umbilicalis	Steromphala umbilicalis	P	9	10	12	10	10
Littorina littorea	Littorina littorea	P	11	10	13	10	10
Littorina saxatilis	Littorina saxatilis	P	10	2	6	7	6
Nucella lapillus	Nucella lapillus	P	6	5	8	4	2
Nucella lapillus (eggs)	Nucella lapillus (eggs)	P	1	0	1	0	0
Mytilus edulis	Mytilus edulis	%	7	10	8	5	7
Modiolus barbatus	Modiolus barbatus	P	0	0	0	1	0
Hiatella arctica	Hiatella arctica	P	0	0	1	0	0
Bryozoa (enc)	Bryozoa (enc)	P	2	0	0	0	0
Alcyonidium hirsutum	Alcyonidium hirsutum	P	8	0	0	2	2
Flustrellidra hispida	Flustrellidra hispida	P	1	0	0	0	0
Walkeria uva	Walkeria uva	P	1	0	0	0	0
Amathia	Amathia	P	0	0	0	0	4
Amathia gracilis	Amathia	P	0	5	0	0	0
Amathia imbricata	Amathia	P	2	0	11	7	4
Cryptosula pallasiana	Bryozoa (enc)	P	0	0	0	2	0
Celleporella hyalina	Bryozoa (enc)	P	1	0	0	0	0
Electra pilosa	Electra pilosa	P	2	0	2	0	2
Asterias rubens	Asterias rubens	P	0	0	0	0	1
Amphipholis squamata	Amphipholis squamata	P	2	0	0	0	2
Psammechinus miliaris	Psammechinus miliaris	P	0	0	0	0	1
Polyclinidae	Polyclinidae	P	0	0	0	2	3
Morchellium argus	Polyclinidae	P	0	0	1	0	0
Didemnidae	Didemnidae	P	0	0	1	0	0
Corella eumyota	Corella eumyota	P	0	0	1	0	0
Botryllus schlosseri	Botryllus schlosseri	P	1	0	0	0	0
Botrylloides leachii	Botrylloides leachii	P	0	1	0	0	1
Molgula	Molgula	P	2	4	3	1	8
Pisces	Pisces	P	0	0	3	1	0
Nerophis lumbriciformis	Nerophis lumbriciformis	P	0	0	0	0	2
Coryphoblennius galerita	Pisces	P	0	2	1	0	2
Lipophrys pholis	Pisces	P	4	9	6	4	5
Gobius paganellus	Pisces	P	3	4	2	0	3
Bacillariophyceae	Bacillariophyceae	%	0	9	0	0	10
Bacillariophyceae (mat on Corallina)	Bacillariophyceae	%	0	0	4	0	0
Bacillariophyceae (film)	Bacillariophyceae	%	0	0	1	0	0

Entity	Entity (analysis)	M	2015	2016	2017	2018	2019
Rhodophyta (dark enc)	Rhodophyta (dark enc)	%	0	0	2	0	0
Rhodophyta (sporeling)	Rhodophyta (sporeling)	%	0	1	0	0	0
Rhodophyta (Agg enc)	Rhodophyta (Agg enc)	T%	9	10	11	10	10
Rhodophyta (Agg turf excl Corallina)	Rhodophyta (Agg turf excl Corallina)	T%	0	0	0	10	10
Rhodophyta (Agg turf incl Corallina)	Rhodophyta (Agg turf incl Corallina)	T%	11	10	13	10	0
Porphyra	Porphyra	%	0	0	3	0	0
Gelidium crinale	Gelidium crinale	%	0	0	0	2	2
Gelidium pulchellum	Gelidium pulchellum	%	9	6	9	8	8
Palmaria palmata	Palmaria palmata	%	2	0	1	0	0
Grateloupia filicina	Grateloupia filicina	%	1	0	3	0	4
Peyssonnelia immersa	Rhodophyta (dark enc)	%	0	0	1	5	5
Hildenbrandia	Rhodophyta (dark enc)	%	0	10	11	9	10
Corallinaceae (Agg enc)	Corallinaceae (Agg enc)	T%	11	10	13	10	10
Corallina	Corallina	%	11	10	13	10	10
Mastocarpus stellatus	Mastocarpus stellatus	%	3	0	0	0	0
Chondrus crispus	Chondrus crispus	%	10	9	13	8	10
Caulacanthus okamurae	Caulacanthus okamurae	%	0	0	0	1	0
Lomentaria articulata	Lomentaria articulata	%	1	0	0	1	6
Ceramium deslongchampsii	Ceramium deslongchampsii	%	0	4	0	0	0
Ceramium virgatum	Ceramium virgatum	%	9	7	8	4	5
Ceramium pallidum	Ceramium pallidum	%	0	1	0	2	6
Apoglossum ruscifolium	Apoglossum ruscifolium	%	0	0	1	0	0
Cryptopleura ramosa	Cryptopleura ramosa	%	2	1	3	1	5
Osmundea (flat)	Osmundea (flat)	%	0	0	0	0	6
Osmundea oederi	Osmundea (flat)	%	0	0	0	6	0
Osmundea hybrida	Osmundea hybrida	%	5	3	3	2	1
Osmundea osmunda	Osmundea (flat)	%	0	0	1	0	0
Osmundea pinnatifida	Osmundea (flat)	%	7	2	5	0	0
Melanothamnus harveyi	Melanothamnus harveyi	%	4	4	3	1	4
Vertebrata fucoides	Vertebrata fucoides	%	1	2	0	0	0
Phaeophyceae (fil)	Phaeophyceae (fil)	%	1	0	0	0	0
Phaeophyceae (Agg turf)	Phaeophyceae (Agg turf)	T%	10	9	8	5	8
Ralfsia (on limpets)	Ralfsia (on limpets)	%	0	0	0	1	0
Dictyota dichotoma	Dictyota dichotoma	%	10	8	8	5	8
Chlorophyta (film)	Chlorophyta (film)	%	0	0	0	0	1
Chlorophyta (Agg turf)	Chlorophyta (Agg turf)	T%	11	10	12	10	10
Ulva (tubular)	Ulva (tubular)	%	1	9	8	6	7
Ulva clathrata	Ulva (tubular)	%	0	1	0	0	0
Ulva intestinalis	Ulva (tubular)	%	4	0	0	0	0
Ulva (flat)	Ulva (flat)	%	4	7	10	7	7
Ulva lactuca	Ulva (flat)	%	2	0	0	0	0
Monostroma grevillei	Monostroma grevillei	%	1	0	0	0	0
Chaetomorpha linum	Chaetomorpha linum	%	2	2	2	0	0
Chaetomorpha ligustica	Chaetomorpha ligustica	%	11	10	11	8	8

Entity	Entity (analysis)	M	2015	2016	2017	2018	2019
Cladophora	Cladophora	%	0	0	9	0	7
Cladophora (On Corallina (c.f. C. hutchinsiae / C. rodolithicola))	Cladophora	%	0	0	9	0	0
Cladophora hutchinsiae	Cladophora	%	0	5	0	0	0
Cladophora sericea	Cladophora	%	8	0	0	7	0
Bryopsis plumosa	Bryopsis plumosa	%	4	1	4	1	3
Codium fragile subsp. fragile	Codium fragile subsp. fragile	%	1	0	2	1	0
Verrucaria	Verrucaria	%	1	1	0	0	0

Appendix 4 Multivariate analyses results

More detailed results from multivariate analyses summarised in Section 3.1.2

ANOSIM: Year x Pool (% cover data)

Analysis of Similarities (see Section 3.1.2)
Two-Way Analysis – Year x Pool No.
Data – Bray-Curtis similarities derived from percentage cover data for 37 taxa.
Factors: Year (ordered): 2015 to 2019 x Pool (unordered): 1 to 10

Tests for differences between ordered Year groups (across all Pool No. groups)
Global Test
Sample statistic (Average R): 0.281
Significance level of sample statistic: 1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Average R: 9

Tests for differences between unordered Pool No. groups (across all Year groups)
No replication so reverting to correlation algorithm
Correlation method: Spearman rank
Global Test
Sample statistic (Average Rho): 0.569
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Average Rho: 0

ANOSIM: Year x Pool (presence / absence data)

Analysis of Similarities (see Section 3.1.2)
Two-Way Analysis – Year x Pool
Data – Bray-Curtis similarities derived from presence/absence data for 96 taxa.
Factors: Year (ordered): 2015 to 2019 x Pool (unordered): 1 to 10

Tests for differences between ordered Year groups (across all Pool No. groups)
Global Test
Sample statistic (Average R): 0.285
Significance level of sample statistic: 0.5%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Average R: 4

Tests for differences between unordered Pool No. groups (across all Year groups)
No replication so reverting to correlation algorithm
Correlation method: Spearman rank
Global Test
Sample statistic (Average Rho): 0.277
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Average Rho: 0

Appendix 5 Rockpool photographs

Figure 11 Photographs of rockpool 2, from 2015 and 2018.

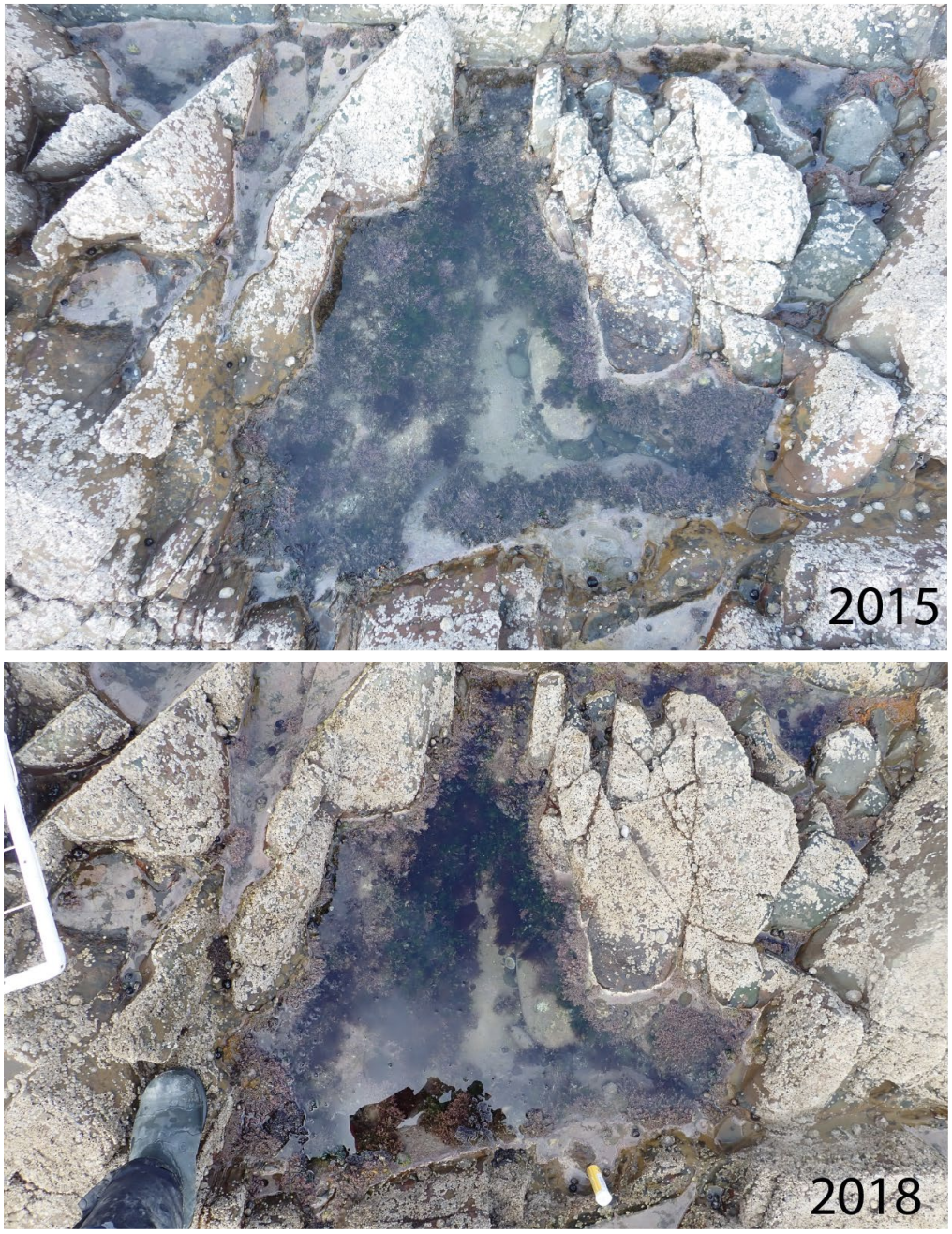
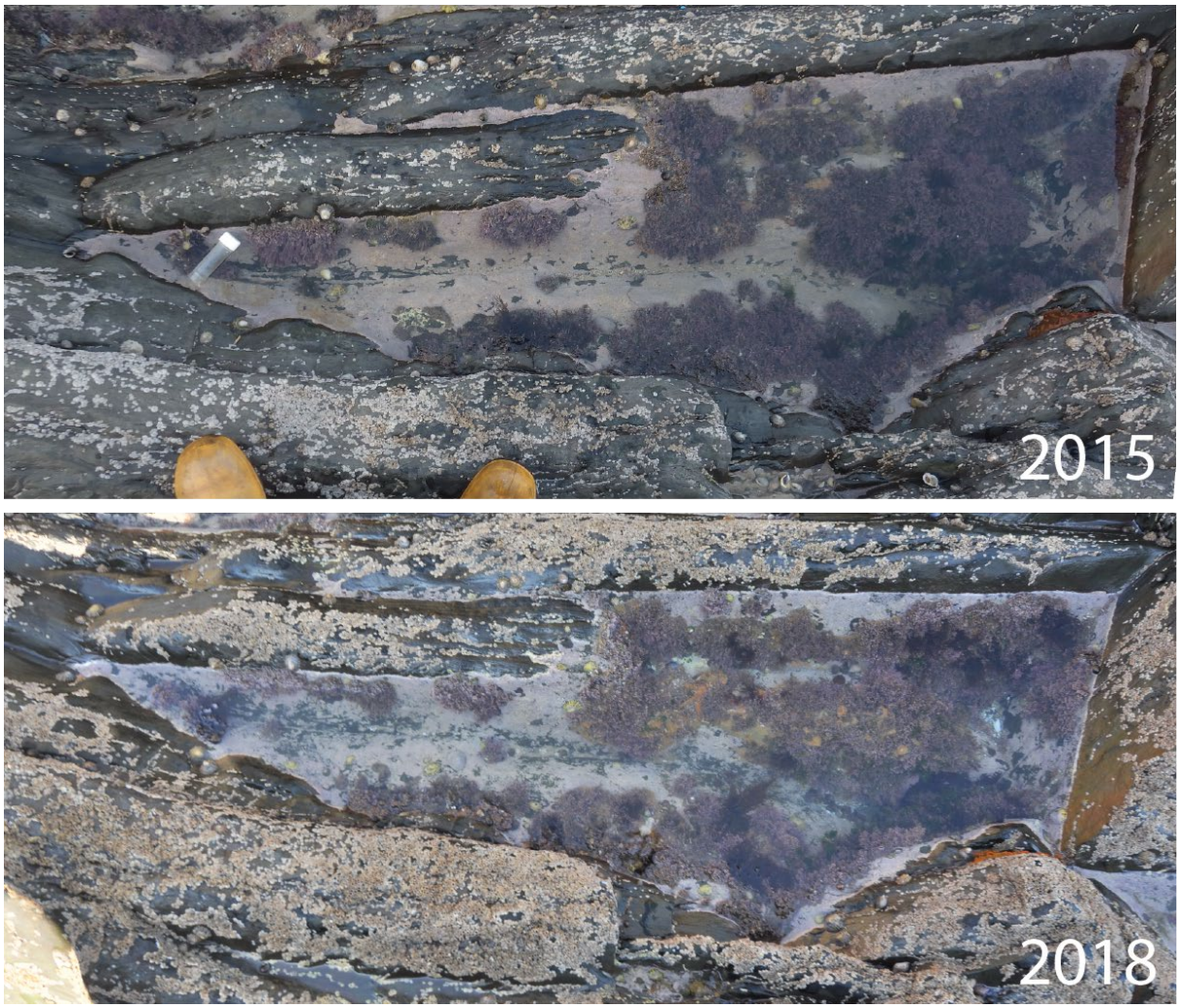


Figure 12 Photographs of rockpool 6, from 2015 and 2018.



Appendix 6 Data archive

Data outputs associated with this project are archived in Document Management System at Natural Resources Wales.

The data archive contains:

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

[B] Excel spreadsheets of data, including validation data, verification data and metadata.

[C] A NBN data file containing the relevant monitoring survey details.

[D] A Marine Recorder snapshot of the monitoring survey for NRW validation purposes.

[E] A full set of images from the monitoring survey, in jpg format.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue Across Wales Intertidal Monitoring Survey (naturalresources.wales) by searching 'Dataset Titles' for 'Intertidal Monitoring'.

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