Cyfoeth Naturiol Cymru
Natural Resources Wales

Menai Strait and Conwy Bay SAC intertidal monitoring summary, 2010 to 2017

Jon Moore

Report No. 301

Date 27/09/2018

About Natural Resources Wales

Natural Resources Wales is the organisation responsible for the work carried out by the three former organisations, the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales. It is also responsible for some functions previously undertaken by Welsh Government.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future.

We work for the communities of Wales to protect people and their homes as much as possible from environmental incidents like flooding and pollution. We provide opportunities for people to learn, use and benefit from Wales' natural resources.

We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

This Evidence Report series serves as a record of work carried out or commissioned by Natural Resources Wales. It also helps us to share and promote use of our evidence by others and develop future collaborations. However, the views and recommendations presented in this report are not necessarily those of NRW and should, therefore, not be attributed to NRW.

Report Series:	Evidence Report
Report number:	301
Publication date:	September 2018
Contract number:	330 MFG 11 / WDM002
Contractor:	Aquatic Survey and Monitoring Ltd.
Contract Manager:	Paul Brazier
Title:	Menai Strait and Conwy Bay SAC intertidal monitoring summary, 2010 to 2017
Author(s):	Jon Moore
Approved By:	Paul Brazier
Restrictions:	None

Distribution List (core)

NRW Library, Bangor	2
National Library of Wales	1
British Library	1
Welsh Government Library	1
Scottish Natural Heritage Library	1
Natural England Library (Electronic Only)	1

Distribution List (others)

Alun Attwood NRW
Catherine Duigan NRW
Mike Camplin NRW
Huw Jones NRW
Gabrielle Wyn NRW
Kirsten Ramsay NRW

Recommended citation for this volume:

Moore, J. 2018. Menai Strait and Conwy Bay SAC intertidal monitoring summary, 2010 to 2017. NRW Evidence Report No. 301, 50+ix pp, Natural Resources Wales, Bangor

Contents

List of Figures

List of Tables

Crynodeb Gweithredol

Mae'r Gyfarwyddeb Cynefinoedd yn datgan y dylid rheoli Ardaloedd Cadwraeth Arbennig (ACA) gan geisio sicrhau **statws gwarchodaeth ffafriol** y cynefinoedd a'r rhywogaethau a restrir o fewn Atodiad I ac Atodiad II yr AGA dan sylw. Ar gyfer ACA yng Nghymru, mae'n ofynnol i Cyfoeth Naturiol Cymru (CNC), Cyngor Cefn Gwlad (CCG) yng nghynt, lunio adroddiadau'n reolaidd yn nodi a oes gan y nodweddion statws cadwraeth ffafriol ai peidio. Er mwyn gwneud hyn, mae CNC wedi datblygu rhaglen ar gyfer **monitro cyflwr y nodweddion**. Mae *Aquatic Survey & Monitoring Ltd* (ASML) wedi derbyn cytundeb gan CNC i ddatblygu a rheoli'r rhaglen fonitro ar gyfer nodweddion rhynglanwol mewn ACA morol ar gyfer y cyfnod rhwng 2006 a 2019, gan weithio fel tîm gyda staff CNC.

Yn AGA Afon Menai a Bae Conwy y nodweddion cynefin rhynglanwol Atodiad I perthnasol yw *Gwastadeddau llaid a gwastadeddau tywod nad yw dŵr y môr yn eu gorchuddio ar adeg trai* a *Creigresi*. Mae'r mannau penodol sydd o ddiddordeb yn cynnwys darnau o greigwely a chlogfeini mae'r llanw'n llifo drostynt a darnau o *Fucus serratus* mae'r llanw'n llifo drostynt ar waddod cymysg ar hyd Afon Menai. Mae'r adroddiad hwn yn disgrifio arolygon a wnaethpwyd rhwng 2010 a 2017 ac mae'n cynnwys dyddiaduron maes, ystadegau cryno ac amcangyfrif o gyflwr.

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), formerly the Countryside Council for Wales (CCW) is required to report on a regular basis on whether features are in favourable conservation status. To do this NRW has developed a programme of **feature condition monitoring.** Aquatic Survey & Monitoring Ltd. (ASML) have been contracted by NRW to develop and manage the monitoring programme for the intertidal features in marine SACs for the period 2006 to 2019; working as a team with NRW staff.

In Menai Strait and Conwy Bay SAC the relevant Annex I intertidal habitat features are *Mudflats and sandflats not covered by seawater at low tide* and *Reefs*. Specific areas of interest include areas of tide-swept bedrock and boulders and areas of tide-swept *Fucus serratus* on mixed sediment along the Menai Strait. This report describes surveys carried out between 2010 and 2017 and includes field diaries, summary statistics and estimate of condition.

1. Introduction

Menai Strait and Conwy Bay SAC (Figure 1) is designated for five Annex 1 habitats: *Sandbanks which are slightly covered by sea water all the time*, *Mudflats and sandflats not covered by seawater at low tide*, *Reefs*, *Large shallow inlets and bays* and *Submerged or partially submerged sea caves*. Of these mudflats, sandflats and reefs are the main habitats of interest within intertidal areas of Menai Strait and Conwy Bay SAC. Conservation objectives for these habitats are given in the Regulation 33 advice for the SAC (CCW 2009).

Considerable historical data exists on the intertidal habitats and communities present at many sites in the SAC. Earlier reports in this series discuss those historical data that are relevant to the sites and features surveyed in the current survey. Intertidal monitoring began in 2004 and has been refined and developed over the course of the programme. This report describes the survey work carried out between 2010 and 2017 and provides an assessment of the condition of the features surveyed.

1.1. Survey objectives

Survey objectives for the Menai Strait and Conwy Bay SAC intertidal monitoring programme changed each year, but certain features were routinely re-surveyed every year and some others were surveyed at less frequent intervals. The following table gives details of the features and attributes prioritised by NRW:

Feature/attribute	**Sites**	**Purpose / notes**
Boulder community species richness and composition.	Britannia Bridge and Felinheli	Repeat surveys of sites surveyed annually since 2005 to collect monitoring data.
Condition of SLR.FserTX (spp. richness, sediment levels) in the Menai Strait	Castell Gwylan and Llanidan (near Brynsiencyn)	Repeat surveys of sites surveyed annually since 2009 to collect monitoring data.
Distribution and species composition of sediment communities	Traeth Lafan and Y Foryd	Repeat *in situ* surveys of grid stations (previously surveyed in 2007 and 2008 respectively).
Large shallow inlet biotope composition and distribution, incl sandflats	Traeth Lafan and Y Foryd	Repeat core sampling surveys of selected stations (previously sampled in 2007 and 2008 respectively).
Intertidal muddy gravel infauna species composition	Lleiniog (5 stations), Friars Bay (4 stations)	Repeat core sampling surveys (previously sampled in 2004).

The overriding objective of the survey was to establish the reference condition for the Menai Strait and Conwy Bay SAC, using established monitoring stations to describe natural and unnatural changes in the communities. This will enable the development of conservation objectives for the appropriate management of the features of the SAC.

2. Survey planning

2.1. Logistics

One week (5 days) of survey work was organised each year. A Survey Plan and Risk Assessment was prepared in advance of each individual survey and distributed to all the surveyors. It included information on the survey location, personnel, work scope and plan, logistics, tide tables, potential hazards, assessment of risk from those hazards, actions/measures to minimise risk, contact details for emergency services, personnel and next of kin.

Table 1 summarises the survey dates and sites surveyed between 2005 and 2017. Figure 1 shows the locations of all sites and stations. Field logs for the 2010 to 2017 surveys are given in Appendix 1.

Table 1 Summary of survey dates and sites surveyed for each methodology, 2005 to 2017. Low tide heights in metres. BB = Britannia Bridge, FE = Felinheli, CG = Castel Gwylan, LL = Llanidan, TL = Traeth Lafan, FB = Foryd Bay. Numbers of stations surveyed in brackets.

Year	Dates and low tide heights	Boulder stns	FserTX sites	*In situ* sediments	Sediment coring stns	Others
2005	26-29 May	BB(5), FE(5)				
2007	10-14 Sept [0.99 - 1.49m]	BB(5)		TL(100)	TL(7)	TL Zostera
2008	2-6 June [0.8 - 1.0m]	BB(5), FE(5)		FB(45)	FB(8)	FB Zostera
2009	21-26 June [0.6 - 0.92m]	BB(5), FE(5)	CG, LL1			Bait collecting activity
2010	12-16 July [0.56 - 0.83m]	BB(5), FE(5), BB(trials)	CG, LL1, LL2			
2011	1-5 Aug [0.6 - 0.8m]	BB(5)	CG, LL1, LL2			
2012	5-7 July [0.73 - 0.94m]	BB(5), FE(5)				
2013	24-28 June [0.48 - 1.00m]	BB(5), FE(5)	CG, LL1, LL2		Lleiniog(5), Friars Bay(4)	
2014	12-16 July [0.43 - 0.72m]	BB(5), FE(5)	CG, LL1, LL2	FB(50)	FB(7)	
2015	2-6 July [0.76 - 0.9m]	BB(5), FE(5)	CG, LL1, LL2	TL(52)	TL(7)	
2016	5-9 June [0.47 - 1.13m]	BB(5), FE(5)	CG, LL1, LL2		Lleiniog(5), Friars Bay(4)	
2017	23-27 June [0.46 – 0.66m]	BB(5), FE(5)	CG, LL1, LL2			TL Zostera

Detailed methodologies and protocols for each of these intertidal monitoring programmes in the Menai Strait are given in a series of methodology documents. The relevant documents are referenced in the sections below. Each document includes rationales, site and station details, methods, protocols, proformas, equipment lists, QA/QA procedures and modifications that have been made to the methods over the course of the programme up to and including 2016.

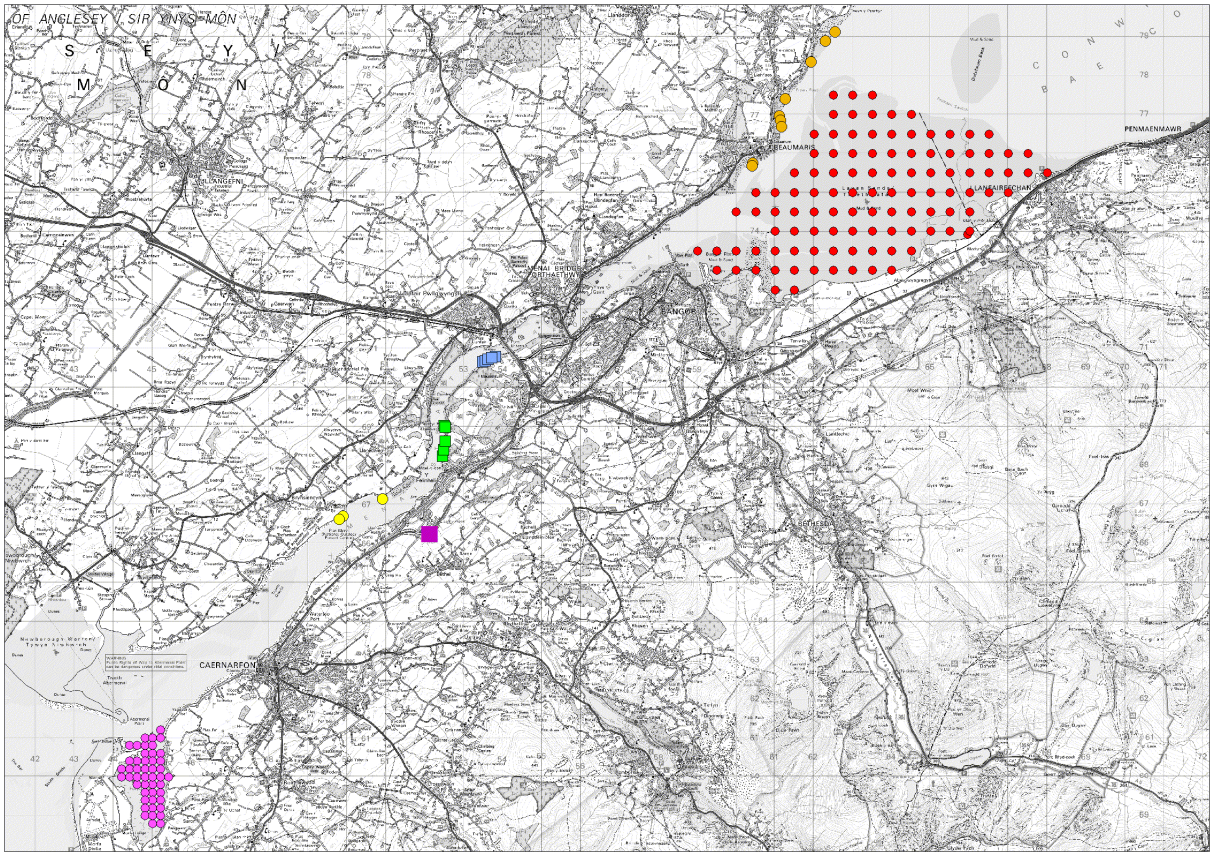

Figure 1 Sites and stations surveyed in the Menai Strait. Britannia Bridge (blue squares), Felinheli (green squares), Castell Gwylan and Llanidan (yellow dots), Traeth Lafan sediments (red dots), Y Foryd sediments (purple dots), Lleiniog and Friars Bay muddy gravels (orange dots).

2.2. QA/QC

Training, identification and recording aids, purpose designed forms, verification procedures and validation procedures have been developed to ensure the quality of the data for the monitoring objectives. Details of these procedures are given in the methodology documents. A number of procedures were strengthened in 2015, including:

- Further development and expansion of the team training and species identification session, carried out on the first morning before going into the field. Surveyors spent at least two hours familiarising themselves with the list of species previously recorded. A slide show of close-up photographs of species, taken during these surveys and representing the majority of species recorded, was used in this session.
- Lists of all species recorded during the program, with numbers of records from each site, was printed onto waterproof paper and given to each pair of surveyors.

- Further emphasis on specimen collection and field lab identification to build up the list of species present at the monitoring sites.
- Completion of a detailed specimen log for all collected specimens.
- On the final day the team held a discussion session to review the detailed protocols and make notes on recommendations for future surveys.

3. Reefs: Tide-swept boulder communities

This program monitors the composition of communities of epibiota present on tide-swept boulders of the lower eulittoral zone (dominated by *Fucus serratus*) at two sites in the Menai Strait: Britannia Bridge and Felinheli.

This program is relevant to the following MSCB SAC attributes (CCW 2009):

Structure and Function: Species composition of reef biotopes in high energy tide-swept wave sheltered locations

Typical Species: Species composition of under-boulder, overhang and crevice reef biotopes

3.1. Monitoring program

Surveys were carried out annually. The program began at both sites in 2005, was repeated at Britannia Bridge in 2007 with some significant modifications and has been repeated every year at both sites from 2008 to 2017. Survey dates ranged from early June to mid-September; now aiming for June or July.

3.1.1 Methodology - summary

Five stations (originally established in 2005) are located on the lower shore at each site: Britannia Bridge stations BB1 to BB5 and Felinheli stations FE1 to FE3, FE5 and FE6. Each station lies at least 50m from the next. Hand held GPS was used to relocate the stations for each survey during a period of low spring tide. Five boulders were selected randomly, within certain criteria, at each station. The size (length and width) of each boulder was measured and recorded. Upward facing surfaces and under boulder surfaces were recorded separately onto a pre-prepared recording form, upward surfaces first. All conspicuous taxa were identified, to species level where possible. The abundances of selected algae (e.g. *Fucus serratus*), space occupying animals (e.g. *Mytilus edulis*) and aggregate taxa (e.g. foliose red algae and barnacles) were recorded as percentage cover. Other taxa were mostly recorded simply as Present (P), or, if their abundance was clearly very low, as Trace (T). See Moore 2016a for more details.

Quality of the data from these surveys is reliant on the surveyors' experience, *in situ* identification skills and thoroughness. Quality assurance procedures have included pre-survey training and familiarisation. The same experienced individuals have carried out most of the surveys. Quality control procedures have included some repeated recording of selected boulders by different surveyors. Significant inconsistencies between surveyors are possible.

3.1.2 Modifications since last reported survey

The methodology was well established and there were no changes that could compromise any comparisons with previous survey data. Moore 2016a describes some the changes that have been applied but it is unlikely they would compromise comparisons between survey years.

The additional abundance category of Trace (T) was applied more thoroughly than previously. It is hoped that data in this category will benefit future interpretation, but backward compatibility is achieved by simply re-assigning the records to Present (P).

The method of data entry into a computer was modified in 2015. A Microsoft Access database, originally designed for data from intertidal monitoring of rocky shore sites in the Pembrokeshire Marine SAC, was adapted to the Menai Strait boulder monitoring program. The data entry front-end to this database includes several auto-validation features which greatly reduces the risks of incorrect data entry.

3.1.3 Analyses

Detailed analysis of the data is not included in this report, but the data have been inspected, summarised and discussed between the experienced surveyors to identify anomalies and highlight notable changes from previous surveys at these sites.

3.2. Results – summary and comparison with previous data

Field logs are given in Appendices A1 to A8. Table 2 summarises the species data from 2007 to 2017.

Characterised by algal dominated communities on the upper boulder surfaces and encrusting invertebrate (sponges, sea-squirts, bryozoa, etc.) dominated communities on the under-boulder surfaces. Generally, there was a high species richness on the underside, except where water flow under the boulder had been restricted (e.g. where the boulder was sitting on muddy sediment) or where boulders had been frequently turned by bait collectors. Felinheli boulder communities were less well developed compared to Britannia Bridge boulders, due to the more gradually sloping shore retaining more mud. There was 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.

A detailed analysis of this data has been deferred to a future report, but some comparisons have been made with previous data for selected taxa and species richness. The occurrence and abundance of most species was within the ranges previously observed on these boulders.

Table 2 Annual fluctuations in percentage occurrence of the most frequently recorded taxa from boulder **tops** (Britannia Bridge and Felinheli records combined). Each value is calculated from presence / absence data from 50 samples (2 sites x 5 stations x 5 replicates), except 2007 and 2011 (*25 samples) when Britannia Bridge only was surveyed. Coloured data bars (using conditional formatting feature from Excel and grouped by phyla) have been added to aid visualisation of changes.

	2007*	2008	2009	2010	2011*	2012	2013	2014	2015	2016	2017
Hymeniacidon perlevis	76	58	50	54	72	58	44	48	48	58	34
Sabellaria	32	16	30	34	68	24	40	52	34	50	58
Spirobranchus	72	42	38	54	60	18	30	28	26	38	56
Spirorbinae	76	54	38	50	80	46	44	30	26	28	34
Cirripedia (juv)		4	86	72		78	94	92	92	96	94
Cirripedia (dead)	76	84	92	98	100	100	98	92	80	86	86
Semibalanus balanoides	64	88	58	84	52	82	62	64	76	36	66
Balanus crenatus	52	34	78	70	100	70	84	72	76	92	68
Austrominius modestus	56	50	36	52	60	64	74	42	68	64	74
Patella vulgata	16	30	22	22	8	28	22	18	18	6	16
Gibbula cineraria	12	18	6	18	12	2	12	2	6	4	6
Gibbula umbilicalis	36	16	14	4	4	4	6		2	6	6
Littorina obtusata (/fabalis)	72	14	30	70	56	44	36	32	18	8	30
Nucella lapillus	20	20	14	18	16	10	24	12	10	20	10
Bryozoa (enc calc)	28	22	14	52	28	32	18	14	20	22	20
Aplidium turbinatum		12	14	4	8	6	18	8	2	2	2
Dendrodoa grossularia	40	30	36	38	48	20	26	18	16	22	16
Rhodophyta (dk.enc)	76	46	80	46	84	76	32		6		
Rhodothamniella floridula	4	6	6	8	8	10	2	22	12	14	18
Palmaria palmata		8	12	4	36	12	20	16	6	8	26
Hildenbrandia	4	32	10	56	84	40	84	20	68	52	52
Corallinaceae (enc)	52	64	50	64	92	56	66	42	40	50	64
Mastocarpus stellatus	8	4	42	10	4		2	4	2	2	8
Chondrus crispus	92	62	52	60	96	68	78	64	70	64	62
Lomentaria articulata	4	6	10	8	16	16	16	18	12	12	14
Ceramium deslongchampsii		6	14	2	28	2	20	34	14	22	36
Membranoptera alata	8	26	22	10	48	16	26	22	16	24	16
Cladostephus spongiosus		4	6	12	32	28	26	18	18	24	24
Fucaceae (sporelings)	24	8	58	56	72	42	80	94	92	86	98
Fucus serratus	100	90	86	96	100	96	98	98	94	82	90
Fucus vesiculosus	24	12	22	22	4	20	26	20	36	16	30
Ulva (tubular)	16	12	4	14	8	22	16	40	24	8	26
Ulva (flat)	76	68	70	54	80	72	76	76	66	60	76
Cladophora rupestris	40	28	20	32	48	24	22	20	24	36	22
Total number of taxa	45*	70	71	89	71*	79	82	77	70	93	73

Table 3 Same as Table 2, for boulder **bottoms**.

	2007*	2008	2009	2010	2011*	2012	2013	2014	2015	2016	2017
Porifera (Agg)	96	80	80	80	84	86	78	78	76	66	80
Leucosolenia	28	38	46	46	32	46	50	56	60	28	48
Halichondria panicea	68	38	46	54	76	56	48	38	30	30	18
Hymeniacidon perlevis	80	58	46	44	68	64	64	54	60	56	54
Ophlitaspongia papilla	0	2	2	10	20	2	8	8	6	6	12
Microciona atrasanguinea	8	2	32	20	40	26	34	44	32	36	52
Halisarca dujardinii	20	48	52	42	56	58	38	40	36	32	40
Polynoidae	12	42	44	54	64	52	50	56	30	26	36
Sabellaria	16	0	6	4	16	6	4	12	8	10	6
Spirobranchus	92	94	72	74	84	82	84	84	86	74	94
Spirorbinae	72	74	68	82	96	86	76	66	70	54	94
Cirripedia (juv)	0	26	84	54	0	66	78	72	88	86	90
Cirripedia (Agg adults)	88	100	88	94	84	98	84	90	90	94	98
Semibalanus balanoides	32	64	34	48	4	54	34	20	32	22	44
Balanus crenatus	60	56	70	70	80	76	76	84	82	82	84
Austrominius modestus	28	32	18	16	16	30	32	20	32	16	46
Porcellana platycheles	52	42	32	38	68	34	40	44	44	38	54
Gibbula cineraria	32	42	40	34	20	26	20	22	32	46	52
Littorina obtusata (/fabalis)	12	8	8	16	16	12	12	6	2	6	2
Nucella lapillus	64	50	34	46	60	44	40	28	24	38	44
Nucella lapillus (eggs)	16	34	30	44	20	36	48	24	44	22	60
Anomiidae	32	28	50	60	60	60	38	58	48	52	78
Bryozoa (enc calc)	80	86	72	72	88	86	84	88	80	78	94
Ophiothrix fragilis	0	12	6	6	40	26	22	22	16	20	22
Clavelina lepadiformis	4	8	16	14	8	14	14	28	14	26	18
Aplidium turbinatum	0	56	64	46	24	50	54	56	40	28	18
Corella eumyota	0	0	4	2	56	54	52	74	60	24	56
Ascidiella scabra	0	34	34	44	0	0	2	0	0	0	0
Dendrodoa grossularia	68	60	50	48	68	50	50	42	46	40	50
Botryllus schlosseri	28	38	16	30	60	14	34	12	24	4	28
Hildenbrandia	0	18	0	36	12	36	40	14	30	40	24
Chlorophyta (Agg)	8	30	8	10	4	22	8	8	6	8	4
Total number of taxa	66*	97	80	105	68*	117	107	113	101	99	89

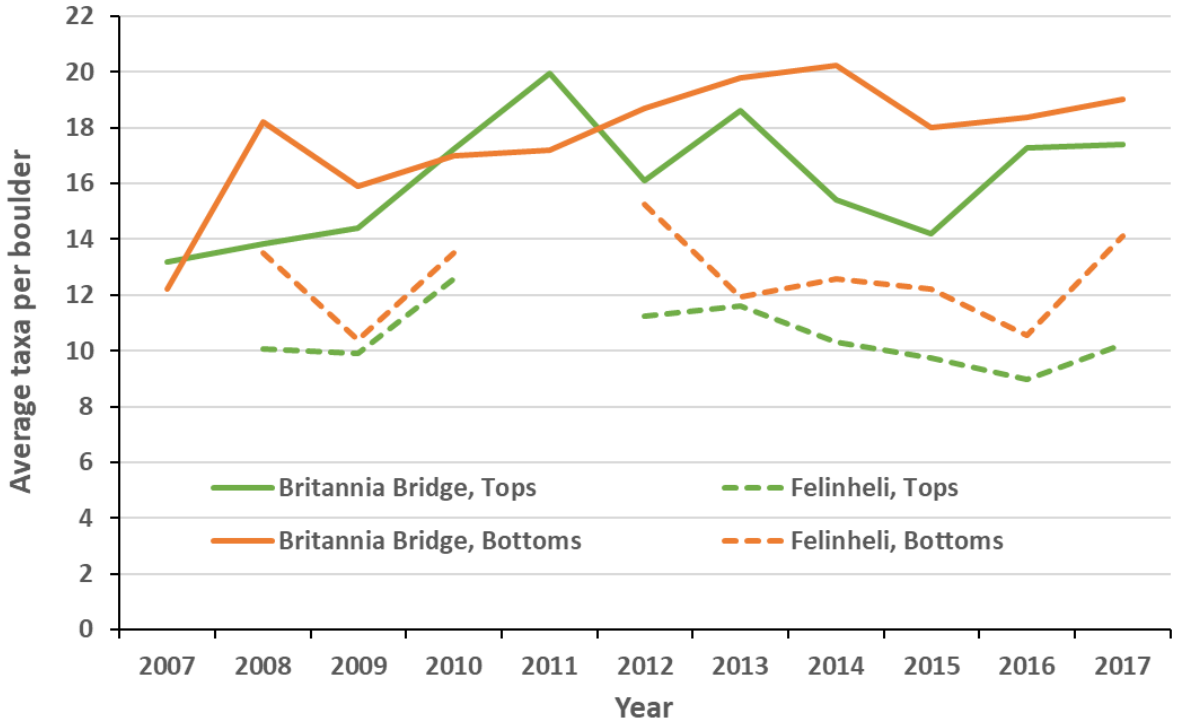

Figure 2 Annual fluctuations in average number of taxa per boulder (combined tops and bottoms).

Figure 2 highlights the difference in species richness between the more steeply sloping shore at Britannia Bridge and the more gradually sloping and muddier shore at Felinheli. It also shows the increase in recorded numbers of taxa over the course of the monitoring programme at Britannia Bridge, due to increasing knowledge and familiarity with the range of species present.

3.3. Condition assessment

Britannia Bridge - **Favourable** - a number of changes have occurred in the monitored communities since the programme began in 2007, but recorded changes in species richness, species composition and abundance appear to be within the normal range of natural fluctuations.

Felinheli – **Unfavourable** - concerns due to impacts of continued bait collection on species richness and composition. Most boulders at this site show evidence of having been repeatedly turned, including the presence of smothered and rotting algae and dead barnacles. It is considered likely that boulder turning was a contributing factor causing the relatively low species richness, compared to Britannia Bridge.

4. Reefs: Epiphytic communities on tide-swept *Fucus serratus*

This program monitors the composition of epiphytic communities present on tide-swept *Fucus serratus* (FserTX biotope) at three sites in the Menai Strait near Brynsiencyn: Castell Gwylan, Llanidan East and Llanidan West.

This program is relevant to the following MSCB SAC attributes (CCW 2009):

Structure and Function: Species composition of reef biotopes in high energy tide-swept wave sheltered locations

Typical Species: Typical epiphytic species (variety and frequency of occurrence)

4.1. Monitoring program

Monitoring began at two sites in 2009, was extended to include Llanidan West in 2010 and repeated at all three sites in 2011 and then in 2013 to 2017. The surveys have been carried out once in each of those years, with dates ranging from late June to early August. This report describes the results from all surveys up to June 2017.

Detailed methodologies, protocols and station locations are given in Moore (2016b), based on the description given in Moore *et al.* (2010) and some changes in 2010.

4.1.1 Methodology - summary

Hand held GPS was used to relocate each site during a period of low spring tide and an area of 5m x 5m was marked out with a tape measure. The percentage cover of *Fucus serratus* in this area was estimated and recorded. A quadrat (0.25 m^2) was randomly placed within the 5m x 5m survey box, using tape measure distance and paces. Estimates of the percentage cover of *Fucus serratus* and the thickness of silt on rocks in the quadrat were recorded. Up to five *Fucus serratus* thalli that had their holdfasts attached within the quadrat were randomly selected. The percentage cover of epibiota on each thallus was estimated and all conspicuous epibiota taxa present were identified and recorded (presence only). This was then repeated for as many quadrats as could be done before the tide covered the survey box. See Moore 2016b for more details.

Quality of the data from these surveys is reliant on the surveyors' experience, *in situ* identification skills and thoroughness. Quality assurance procedures have included pre-survey training and familiarisation. The same experienced individuals have carried out most of the surveys. Quality control procedures have been limited to some repeated recording of quadrats by different surveyors. Significant inconsistencies between surveyors are possible.

4.1.2 Modifications over the course of the monitoring programme

The methodology was well established in 2009 and, apart from the additional site in 2010, changed little in subsequent years. Moore (2016b) describes some small changes but it is unlikely they would compromise comparisons between survey years.

4.1.3 Analyses

Detailed analysis of the data is not included in this report, but the data have been inspected, summarised and discussed between the experienced surveyors to identify anomalies and highlight notable changes from previous surveys at these sites.

4.2. Results from 2009 to 2017

Field logs are given in Appendix A1 to A8. Figure 1 shows the site locations. Table 4 summarises the data from the 3 sites over 8 years. Figure 3 and Figure 4 show the results of multivariate analyses.

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 200 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 bryozoa (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*, the star seasquirt *Botryllus schlosseri*, the erect bryozoan *Amathia imbricata*, the hydroid *Dynamena pumila*, the flat green alga *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 68% of thalli in 2009 to 18% in 2016), a gradually increasing frequency of *Alcyonidium polyoum* / *gelatinosum* (from 24% of thalli in 2009 to 77% in 2016), a gradual increase in *Flustrellidra hispida* to 87% of thalli in 2013 followed by a notable drop and continued decline to 18% in 2017, a similar trend was shown by flat winkles; while *Electra pilosa* decreased gradually to 16% in 2013, then gradually increased back to 49% by 2017. Sea-squirts in general have shown a decline since 2011, most notably by the non-native seasquirt *Corella eumyota* which reached 26% in 2011, but then declined gradually to only 6% in 2017.

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.

Useful further analyses of the data are:

1) Present a summary of % epibiota cover as a table, with further discussion on the difficulty of estimating cover consistently;

2) Evaluate the species richness for each year on each plot, with error bars. Calculate the differences between years and highlight any statistically significant comparisons.

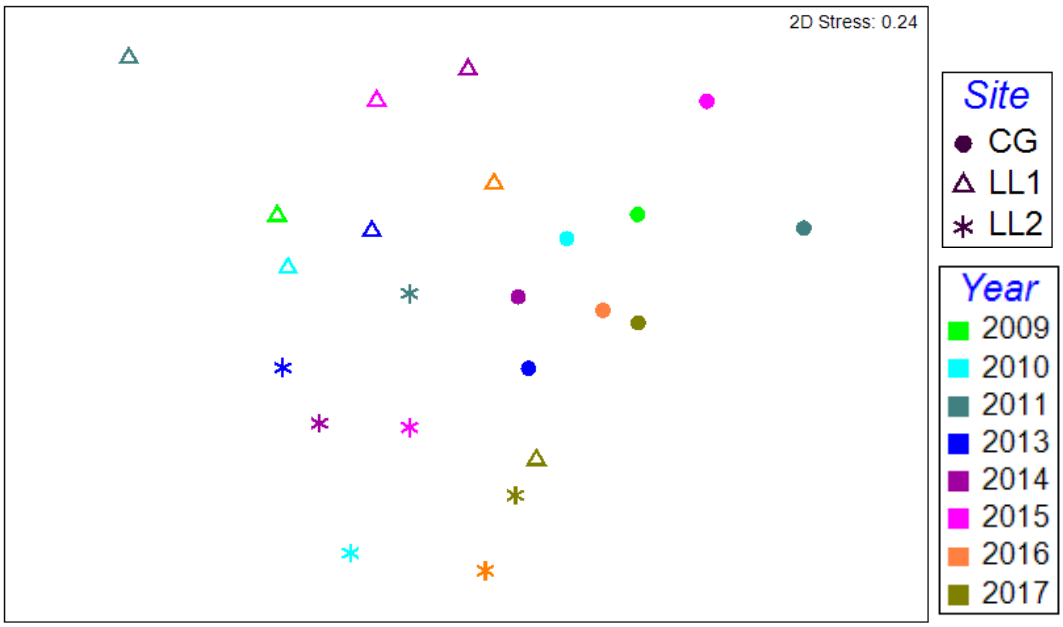

Figure 3 MDS plot showing similarities between epibiota assemblages on *Fucus serratus* thalli from Castell Gwylan, Llanidan 1 and Llanidan 2, 2009 to 2017. All taxa, Bray Curtis similarity. Each point represents average occurrence data from multiple thalli (min 11, max 30).

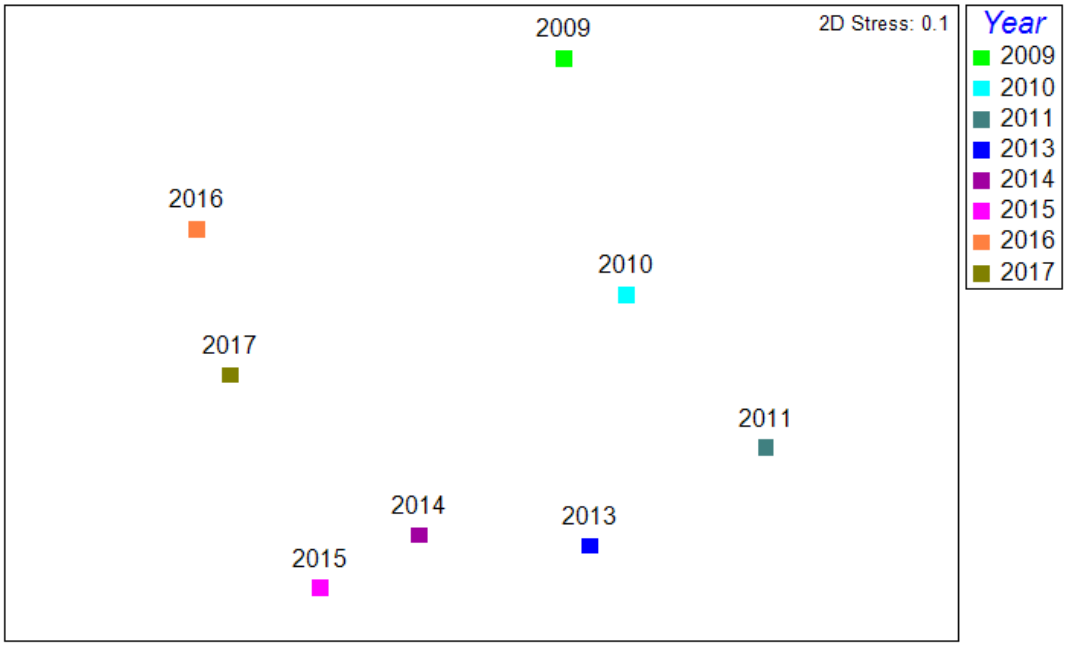

Figure 4 As above, but occurrence data averaged across all sites.

Table 4 Percentage occurrence of most frequently occurring taxa on *Fucus serratus* thalli, from 3 sites, 2009 to 2017.

Site	Castell Gwylan								Llanidan 1								Llanidan 2						
Year	**09**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**09**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**10**	**11**	**13**	**14**	**15**	**16**	**17**
Halisarca dujardinii	83	100	77	50	57	72	27	52	47	21	27	60	67	24	35	36	16	72	27	38		3	10
Dynamena pumila		15	15	19	19	11	18	10		11	13	20	6	6	20	18	36	68	80	17	81	42	10
Campanulariidae				31		61	100					60			70						29		
Spirorbinae	100	100	100	100	95	6	100	95	100	100	100	100	72	88	95	85	100	92	93	66	71	94	95
Balanus crenatus	70	85	8	19	52	28	55	62	73	79	7	53	67	71	70	45	20	52	63	52	10	68	30
Austrominius modestus					24	6	9	24	7			7	83	12	30	45	12		40	76	19	10	50
Amphipoda	13	46	23	44		22	45		7	5	20	7	6			3	40	12		3	10	6	
Littorina littorea		15		6					27	5	20		17	18	15	15		16	17	59	19	13	30
Littorina obtusata (/fabalis)	30	62	77	63	62	28	45	52	73	47	27	67	33	41	40	27	76	96	87	38	71	23	75
Alcyonidium (poly. / gelat.)	39	46	100	75	62	89	100	86		11	13	13	94	53	70	55	16	52	43	52	86	74	65
Alcyonidium hirsutum	48	100		94	76	11	82	5	73	100	67	73		24	60	52	72	80	90		43	65	40
Flustrellidra hispida	4	23	15	100	33				27	68	60	80			10	12	100	92	83	55	62	55	45
Amathia imbricata	96	69	38	38	62	94	73	81	20			7	11	6	5	12		8				10	5
Celleporella hyalina		54	31					67	20						70	24							20
Electra pilosa	35	54		31	29	39	64	48	47	26	13	33	33	47	50	55		36			33	16	40
Aplidium turbinatum	48	69	85	6	5	6			20	5	53	20	67	12	25		4	52	10	31		3	
Corella eumyota	4	15	62	6	29	44	9	24		21		40	22					24	13	14	5		
Botryllus schlosseri	30	92	77	25	48	61	27	19	13	63	100	47	28	47		18	12	68	40	38	33		15
Cystoclonium purpureum	4	46		31	24	39	9		20	16	20	27					8	8	33		24	3	
Lomentaria articulata				6	10	22			7			33	6	18	10	15	12	64	37	24	10		
Ceramium virgatum	4			6	38	44	18	52			60		44	6				16	3		14	3	10
Osmundea oederi				6		17	9				20	53	56	76	45			72	47	34	48	3	
Osmundea truncata								5	60	53	7		6			70	20			21			15
Neosiphonia harveyi			8						13	37	60	60	39	6		9		36	7	10			
Elachista fucicola				19	10	17	9	14	7	26	40	27	61	82	60	24		4	37	14			5
Dictyota dichotoma									73	26	73	13	17	29	5	15		16			5		
Ulva (flat)	13			13	62	50	9	29	13	37	13	33	44	18	10	9	36	56	20	34	43		5
Number of taxa	**34**	**31**	**35**	**40**	**36**	**35**	**32**	**34**	**48**	**50**	**57**	**57**	**55**	**47**	**45**	**54**	**36**	**68**	**60**	**43**	**39**	**39**	**29**
Average taxa per thallus	**8.9**	**12.0**	**10.6**	**12.1**	**9.9**	**9.8**	**10.5**	**9.5**	**11.9**	**10.9**	**16.6**	**14.3**	**12.4**	**10.9**	**10.3**	**9.9**	**9.0**	**16.1**	**13.8**	**9.0**	**9.4**	**8.0**	**8.0**

4.3. Condition assessment

Favourable - A number of changes have occurred in the monitored communities since the programme began in 2009, but those recorded changes in species richness, species composition and frequency of occurrence do not indicate any trends of concern and appear to be within a normal range of natural fluctuations.

Confidence in this conclusion is high; based on the experience of the surveyors (both generally and specifically on this monitoring programme) and a lack of any other known / apparent stresses or mechanisms other than natural fluctuations.

5. Intertidal mudflats and sandflats: Traeth Lafan

This program monitors the distribution and composition of sediment biotopes across the large sand flat of Traeth Lafan. There are two components to the survey – a rapid assessment *in situ* recording methodology that provides qualitative and some quantitative data from large numbers of stations across the whole area; and a conventional methodology of core sampling followed by laboratory analysis that is applied to a small number of representative stations in particular locations.

This program is relevant to the following MSCB SAC attributes (CCW 2009):

Distribution and Extent: Distribution of sediment communities on Traeth Lafan

Distribution and Extent: Variety of mudflat and sandflat communities

Structure and Function: Sediment characteristics of mudflats and sandflats (granulometry)

Typical Species: Typical mudflat and sandflat species (variety abundance, biomass)

5.1. Monitoring program

The monitoring programme is designed for repeat surveys every 3 - 6 years, to check that there has been no notable change in the attributes listed above. This report describes the results from a survey in July 2015. This was the second time that this survey was carried out, the first being in September 2007.

Detailed methodologies and protocols are given in Moore (2016c and d), which are based on the methodologies and protocols described in the first survey report (Moore 2009).

5.1.1 Methodology - summary

Rapid assessment methodology: Hand held GPS is used to relocate each station on a grid of fixed stations distributed across the sand flat, during a period of low spring tide. A single 0.01 m^2 core sample is taken and sieved through a 1 mm mesh (Note: a 0.5 mm mesh was used for the 2007 survey). The contents of the sieve are inspected *in situ*, using a magnifying lens, to identify and count any observed macrofauna. These are recorded, along with a description of the sediment granulometry and other sediment character attributes. Conspicuous animals and plants on the surface, including burrows and tubes, within a radius of 5 metres, are also identified, abundance estimated and recorded. No samples are taken. The survey is carried out by 3 or 4 pairs of surveyors over two days.

Core sampling methodology: Hand held GPS is used to relocate each fixed station, during a period of low spring tide. Five 0.01 m^2 core sample are taken from each station and sieved through a 0.5 mm mesh. Each sample is transferred to a bag or pot, and individually labelled. A sample of sediment is also collected from each station for granulometry analysis. The samples are preserved in formalin and transported to an accredited laboratory for analysis of the infauna and the sediment granulometry.

5.1.2 Modifications since 2007 survey

The conventional core sampling methodology was well established and there were no changes that could compromise any comparisons with the 2007 survey data.

The 2015 methodology for the rapid assessment survey was largely the same as 2007, but core samples taken for *in situ* inspection were sieved over a 1 mm mesh, rather than the 0.5 mm mesh used in 2007. This was to speed up the sieving, reduce the amount of sediment held by the sieve to make *in situ* inspection easier, and because fauna smaller than 1 mm was probably not visible anyway. Comparisons with the 2007 survey data should not be significantly affected.

101 stations were established and surveyed in 2007, but only 52 of those stations were surveyed in 2015. The analyses described in this report have not used any data from the 49 stations that were not surveyed in 2015.

Quality assurance procedures were strengthened, including the use of a waterproof photographic guide to the most commonly occurring sediment macrofauna species which was given to each pair of surveyors.

5.1.3 Analyses

Multivariate analyses, using Primer-E software, were carried out on the detailed infaunal data from the seven fixed sampling stations in 2007 and 2015. Analysis of the *in situ* recorded data from the full grid of stations was mainly limited to summary statistics of species richness and frequency counts, and direct comparison of the 2015 community data with that from 2007.

5.2. Results and comparison with 2007

The survey was carried out in June 2015. Figure 5 shows the locations of the 52 fixed survey stations. A field log is given in Appendix A6.

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 and lugworms; a band of very muddy sand and sandy mud across the sheltered upper shore with ragworm, oligochaetes and amphipod *Corophium*; and an area of mussel beds on soft mud on the very sheltered western flats north of Penrhyn. A variety of other biotopes were sampled incidentally. The seagrass bed present at the back of the sand flats, north of Abergwyngregyn, was not well represented and was surveyed separately. The composition of the infaunal communities were all typical for the area and habitats, with no populations of national scarcity. Species richness was also typical of the habitats present.

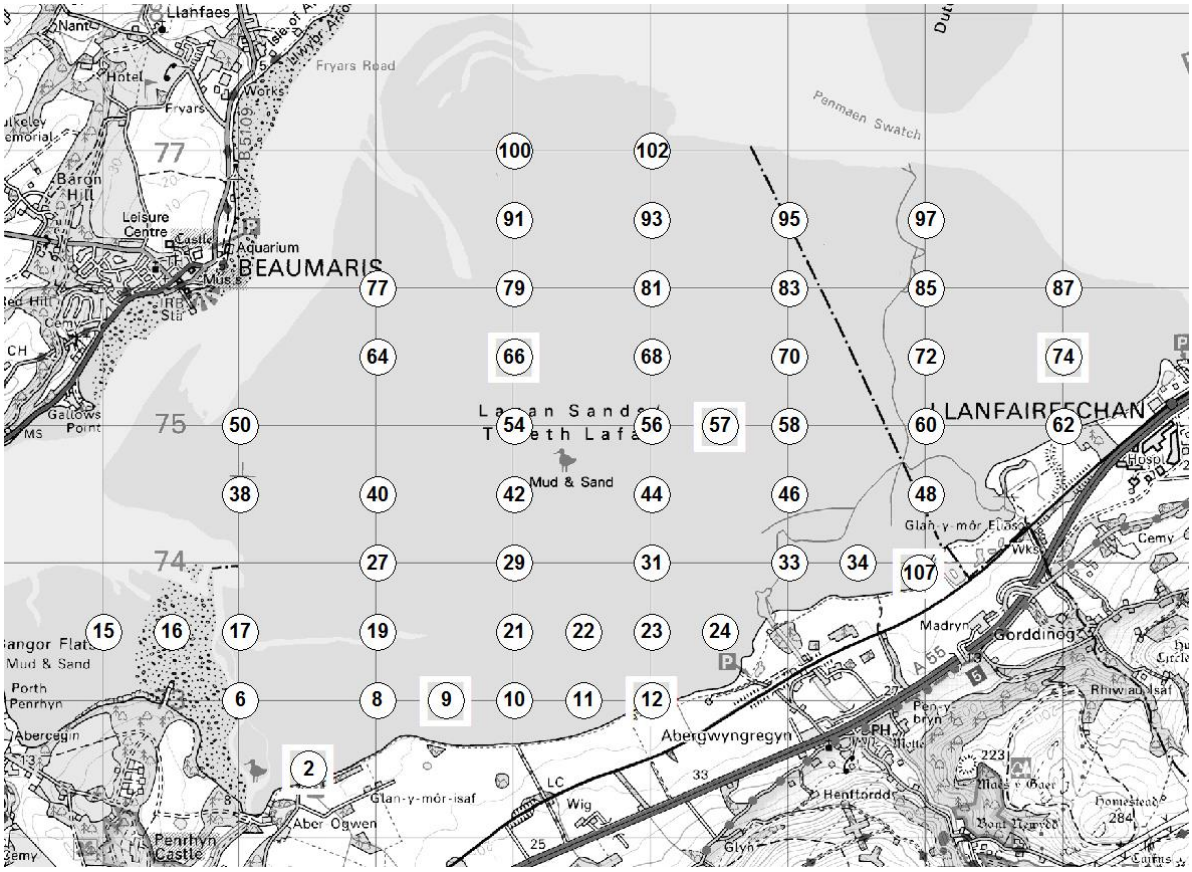

Figure 5 Location of sediment survey stations on Traeth Lafan in 2015. Stations marked with square boxes are those from which core samples were taken for laboratory analysis.

5.2.1 Rapid assessment methodology

Table 5 and Table 6 summarise the data from 52 stations. In the 2015 survey, 24 taxa were recorded *in situ* from the sieved samples and 25 conspicuous taxa were recorded from the sediment surface. This is very like the 2007 survey results. The average number of taxa recorded per core was lower than 2007 and the average number of conspicuous taxa recorded per station was higher than in 2007, but these figures are very sensitive to recorder differences.

Table 5 Frequency of occurrence (Freq) and sum of individuals (Sum) of most frequently occurring taxa identified *in situ* **in sieved core samples** from 52 fixed stations on Traeth Lafan, Sept 2007 and July 2015.

	Freq		**Sum**	
	2007	**2015**	**2007**	**2015**
Polychaeta	9	1	16	1
Hediste diversicolor	7	10	31	49
Nephtys	28	21	37	31
Scoloplos armiger	18	11	34	16
Spionidae (tubes)	18	39		
Spionidae	4	3		
Bathyporeia	11	14	35	35
Corophium	13	9	92	33
Cyathura carinata	1	2	3	2
Carcinus maenas (juv)	6	2	13	3
Peringia ulvae	14	11	60	295
Cerastoderma edule (>20mm)	13	4	20	6
Cerastoderma edule (<20mm)	15	4	39	8
Macomangulus tenuis	2	1	2	1
Limecola balthica	10	4	18	14
Scrobicularia plana	3	7	5	9
Scrobicularia plana (juv)	2	8	3	11
Total taxa (52 stns)	**25**	**24**		
Average taxa per core	**3.52**	**3.06**		

Overall, taxa recorded *in situ* from sieved core samples were similar in 2015 to those recorded in 2007. The most notable difference was a reduction in frequency and overall abundance of four species of bivalves, particularly *Cerastoderma edule* and *Peringia ulvae*, but not *Scrobicularia plana*, which were more abundant. There were also more *Hediste diversicolor* but fewer *Scoloplos armiger* and *Corophium*.

Table 6 Frequency of occurrence (Freq) and sum of individuals (Sum) of most frequently occurring taxa identified *in situ* **on the sediment surface** within a 5m radius at 52 fixed stations on Traeth Lafan, Sept 2007 and July 2015.

	Method	Freq		Sum	
		2007	2015	2007	2015
Hediste diversicolor	per m^2	5	3	168.1	239
Spionidae (tubes)	P	5	17		
Arenicola marina (casts)	per m^2	48	45	384	412
Lanice conchilega	per m^2	22	21	540	109
Carcinus maenas	P		12		
Peringia ulvae	per m^2	5	4	5002	2154
Mytilus edulis	%	3	3	150	450
Cerastoderma edule (>20mm)	P	9	23		
Cerastoderma edule (<20mm)	P		16		
Scrobicularia plana (marks)	per m^2	5	5	14	100
Chlorophyta (film)	%	18	5	668	90
Ulva intestinalis	%	5	1	9	<1
Ulva	%		21		32
Chaetomorpha	%	3		10	
Bacillariophyceae (diatom film)	%	2	3	60	4.5
Total taxa (52 stns)		**26**	**25**		
Average taxa per station		**2.83**	**4.21**		

Records of conspicuous taxa at the Traeth Lafan stations in 2015 were very similar to 2007. However, there were a few changes, including an increase in the frequency of spionid tubes, shore crab *Carcinus maenas* and cockles *Cerastoderma edule*. There were also changes in the records of green algal cover.

5.2.2 Core samples from 7 stations

Laboratory analysis of core samples from seven fixed stations provided infaunal and granulometry data, for comparison with the data from 2007. Summary data are given in Table 7 and Figure 6Figure 7 show the results of multivariate analyses.

Table 7 Average counts of most frequently occurring taxa in core samples from seven stations on Traeth Lafan, Sept 2007 and July 2015. Sediment particle size data (% weight) are also included

Stn	2		9		12		57		66		74		107	
Year	2007	2015	2007	2015	2007	2015	2007	2015	2007	2015	2007	2015	2007	2015
Nemertea			0.4	3.7		0.3					0.2			
Nematoda		0.3	3.8	6.7	0.2								0.2	
Eteone longa	0.4		1.2	1.0	0.8	0.3							1.4	
Nereididae (juv)	2.0		0.6		3.6								0.2	
Hediste diversicolor	8.4	16.3	0.6	2.3	11.6	0.7								10.7
Nephtys (juv)							0.2	0.3	0.2		1.4	0.3		
Nephtys hombergii							1.0	0.3	0.4		0.4		0.2	
Scoloplos armiger	0.2		2.2	5.7			5.0	1.7	1.6	3.7		0.3	0.2	
Pygospio elegans		1.7	0.4	75.7	0.2	104.3	0.8	7.0		1.3	0.2	1.7	6.8	0.7
Spio martinensis									0.8	0.3	1.4	0.3		
Spiophanes bombyx									1.2	1.3	0.2			
Streblospio shrubsolii					3.0									2.0
Tharyx			0.6	13.3						0.3				
Capitella			0.4				0.6		0.2				1.0	
Mediomastus fragilis			1.2	8.0										
Lanice conchilega				4.7										
Tubificoides benedii	0.2		25.4	91.7		21.3							58.4	0.3

Stn	2		9		12		57		66		74		107	
Year	**2007**	**2015**	**2007**	**2015**	**2007**	**2015**	**2007**	**2015**	**2007**	**2015**	**2007**	**2015**	**2007**	**2015**
Tubificoides pseud.			2.4	17.3	0.2									
Bathyporeia sarsi							4.0	16.3	1.2		0.4	2.3		
Corophiidae (juv)	0.2	0.3	11.0	32.3	1.6	0.3							1.6	0.7
Corophium arenarium													6.2	
Corophium volutator	0.4	6.3	13.0	194.7	1.6	1.3								1.3
Cyathura carinata	8.4	9.3			15.0									8.3
Crangon crangon			0.2			0.3			0.2			0.3	0.4	1.0
Peringia ulvae	9.6	30.0	20.8	5.3	2.4	93.0	0.2						67.0	4.0
Cerastoderma (juv)			0.2				0.4		0.2		0.2		0.2	
Cerastoderma edule	0.2		1.4	1.7		0.3	0.2		0.2				2.0	
Limecola balthica		0.7	2.4	1.0	1.8	15.7		0.7					2.2	0.7
Scrobicularia plana	0.4		0.4	5.7	4.6	3.0							0.2	10.3
No. of taxa	**13**	**10**	**24**	**26**	**15**	**15**	**11**	**6**	**12**	**7**	**15**	**11**	**21**	**14**
Sediment particle size analysis (% weight)														
Medium pebble (gravel)					0.6		10.9						0.4	
Small pebble (gravel)				0.2	0.1		0.1		0.2	0.2	0.1		0.3	0.1
Granule		0.0	0.0	0.1	0.3		0.3	0.0	0.1	0.1	0.2	0.1	0.5	0.1
Sand - very coarse	0.0	0.1	0.0	0.0	0.2	0.0	0.1	0.0	0.1	0.2	0.5	0.2	0.3	0.2
Sand - coarse	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.7	0.5	0.3	0.1
Sand - medium	0.5	0.1	0.2	0.1	0.7	0.2	1.0	0.1	0.4	0.4	4.3	6.9	1.3	0.3
Sand - fine	5.2	2.2	10.8	9.4	5.1	1.9	35.0	54.6	41.7	60.6	92.9	88.0	7.8	2.4
Sand - very fine	62.5	39.4	64.4	57.5	46.4	50.9	51.3	41.9	54.9	35.8	1.0	2.7	44.3	27.9
Silt & Clay	31.6	58.1	24.4	32.7	46.4	46.9	1.2	3.4	2.5	2.6	0.3	1.4	44.7	68.9

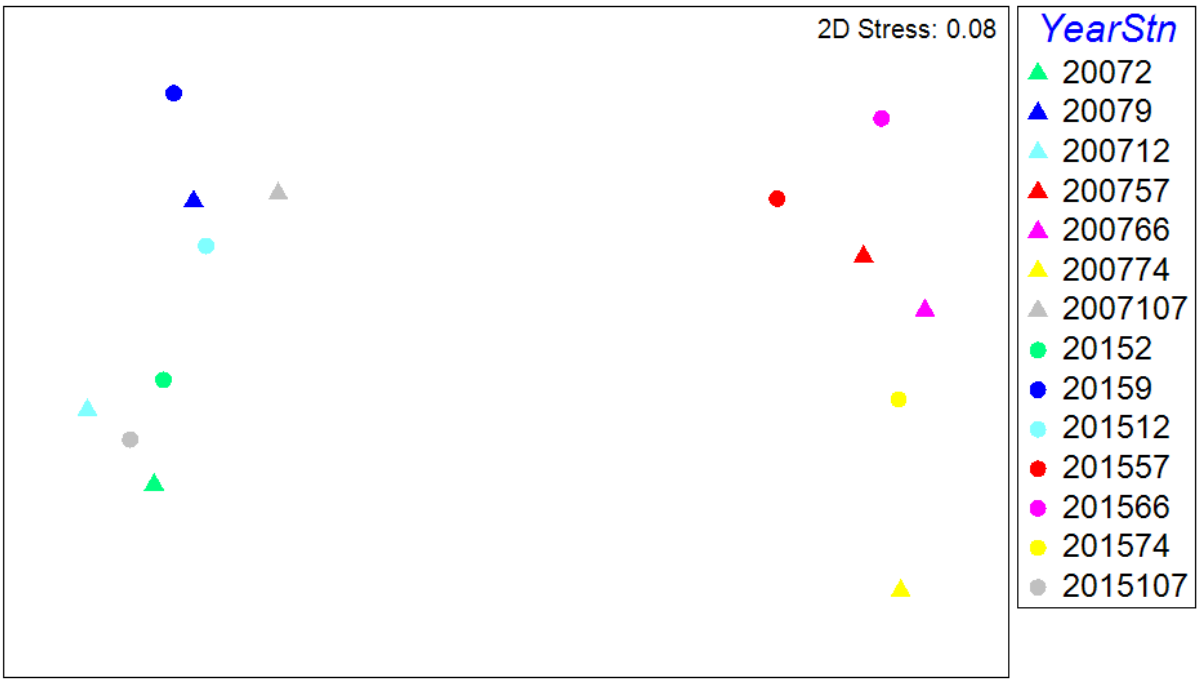

Figure 6 MDS plot showing similarities between infaunal core data from seven stations on Traeth Lafan, 2007 and 2015. All taxa, Bray Curtis similarity. Each point represents average counts from all replicates (5 reps in 2007, 3 reps in 2015) with log(x+1) transformation.

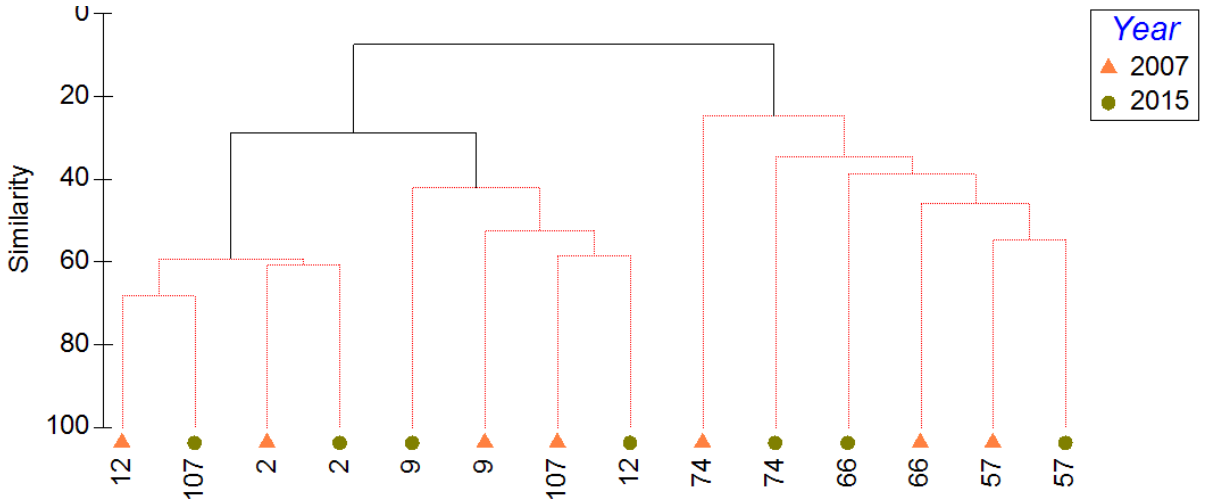

Figure 7 Dendrogram from group average cluster analysis of similarities between infaunal core data from seven stations on Traeth Lafan, 2007 and 2015. All taxa, Bray Curtis similarity. Each point represents average counts from all replicates (5 reps per station in 2007, 3 reps in 2015) with log(x+1) transformation.

The plots highlight the community differences between the muddy stations (2, 9, 12, 107) and the sandy stations (57, 66, 74).

There are notable similarities in the infaunal communities between 2007 and 2015, with many of the stations clustering closely by year. However, there were also notable dissimilarities in community composition between the years in station 107, where the silt and clay % was also higher in 2015 as well as station 12. Direct comparisons between samples from the sandy stations are more difficult due to the relatively sparse infauna.

Species richness was generally similar in 2015 to 2007, but slightly lower at most stations in 2015 and much lower in station 107. Total abundance (sum of individuals of all taxa) was higher in 2015 at all stations except station 107.

The silt and clay % was also notably higher in 2015 at stations 2 and 9, with concomitant reductions in very fine sand %.

5.2.3 Biotope distribution

The 2015 data from both methodologies has been used to assign sediment biotopes to each station. A biotope distribution map is shown in Figure 8. A key to the biotopes is given in Table 8.

The overall distribution is essentially the same as described in 2007, with some small changes in the assignment to specific biotopes including an increase in silt and clay content at some of the upper shore stations.

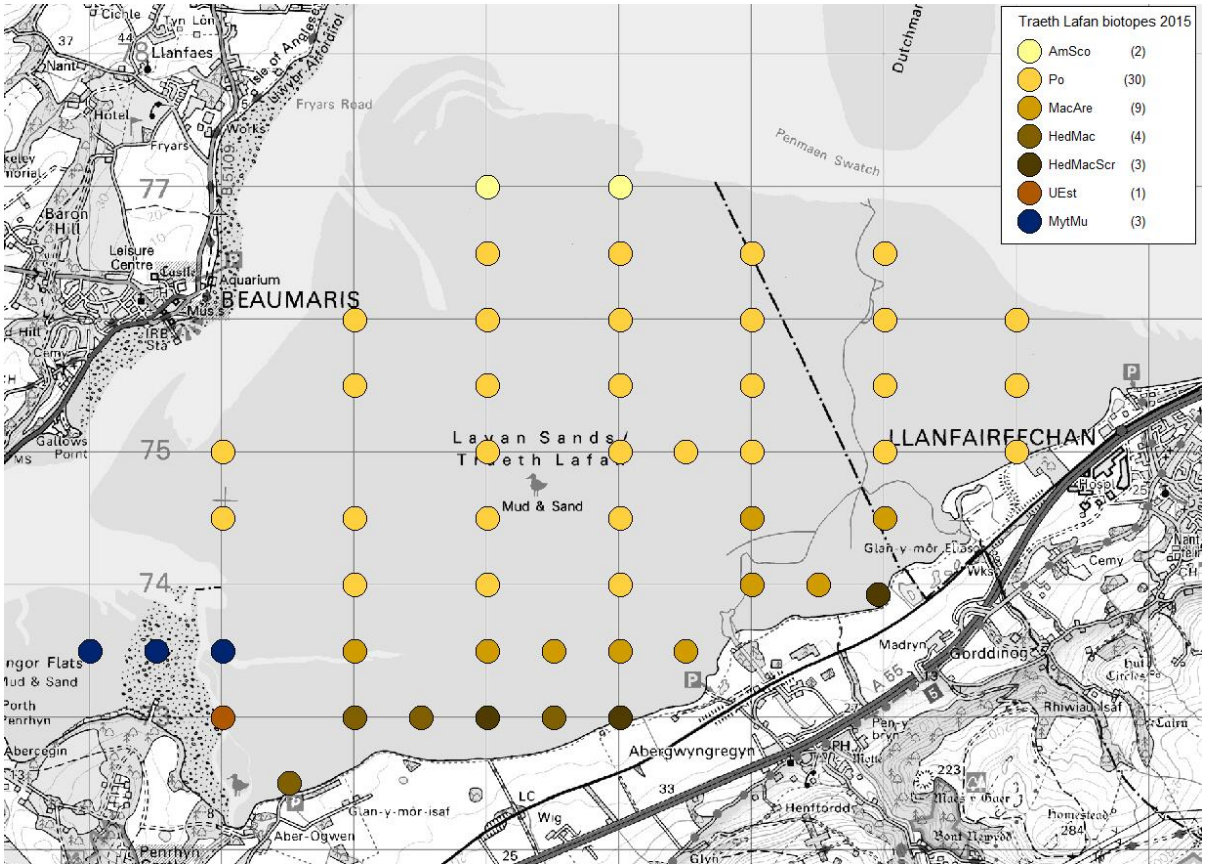

Figure 8 Distribution of sediment biotopes on Traeth Lafan in 2015. See Table 8 for explanation of biotope codes. Number in brackets is the number of stations.

Table 8 Biotopes assigned to stations on Traeth Lafan in 2015. See Figure 8

Biotope	Full code	Description
AmSco	LS.LSa.MoSa.AmSco	Amphipods and *Scolelepis* spp. in littoral medium-fine sand
Po	LS.LSa.FiSa.Po	Polychaetes in littoral fine sand
MacAre	LS.LSa.MuSa.MacAre	*Macoma balthica* and *Arenicola marina* in littoral muddy sand
HedMac	LS.LMu.MEst.HedMac	*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud
HedMacScr	LS.LMu.MEst.HedMacScr	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores
UEst	LS.LMu.Uest	Polychaete / oligochaete dominated upper estuarine mud shores
MytMu	LS.LBR.LMus.Myt.Mu	*Mytilus edulis* beds on littoral mud

5.3. Condition assessment

Favourable - The Traeth Lafan sediment communities in 2015 were very similar to those recorded in 2007 and the recorded changes in biotope richness and distribution, species composition and abundance appear to be within a normal range of natural fluctuations. Species richness was slightly lower in 2015 and is not explained by the changes in sediment granulometry, but this is not considered a trend of concern.

Confidence in this conclusion is high; based on the experience of the surveyors (both generally and specifically on this monitoring programme) and a lack of any other known / apparent stresses or mechanisms other than natural fluctuations.

6. Intertidal mudflats and sandflats: Y Foryd, 2014

This program monitors the distribution and composition of sediment biotopes across the large sand flat of Y Foryd. There are two components to the survey – a rapid assessment *in situ* recording methodology that provides qualitative and some quantitative data from large numbers of stations across the whole area; and a conventional methodology of core sampling followed by laboratory analysis that is applied to a small number of representative stations in particular locations.

This program is relevant to the following MSCB SAC attributes (CCW 2009):

Distribution and Extent: Distribution of sediment communities on Y Foryd

Distribution and Extent: Variety of mudflat and sandflat communities

Structure and Function: Sediment characteristics of mudflats and sandflats (granulometry)

Typical Species: Typical mudflat and sandflat species (variety abundance, biomass)

6.1. Monitoring program

The monitoring programme is designed for repeat surveys every 3 - 6 years, to check that there has been no notable change in the attributes listed above. This report describes the results from a survey in July 2014. This was the second time that this survey was carried out, the first being in June 2008.

Detailed methodologies and protocols are given in Moore (2016c and d), which are based on the methodologies and protocols described in the first survey report (Howson and Moore 2010).

Subsequent surveys have been completed as part of the Water Framework Directive program and the results of the infaunal analysis used to classify the Foryd Bay waterbody using the IQI analysis (Phillips *et al.* 2014).

6.1.1 Methodology - summary

Rapid assessment methodology: Hand held GPS is used to relocate each station on a grid of 47 fixed stations distributed across the sand flat, during a period of low spring tide. A single 0.01 m^2 core sample is taken and sieved through a 1 mm mesh (Note: a 0.5 mm mesh was used for the 2007 survey). The contents of the sieve are inspected *in situ*, using a magnifying lens, to identify and count any observed

macrofauna. These are recorded, along with a description of the sediment granulometry and other sediment character attributes. Conspicuous animals and plants on the surface, including burrows and tubes, within a radius of 5 metres, are also identified, abundance estimated and recorded. No samples are taken. The survey is carried out by 3 or 4 pairs of surveyors on one day.

Core sampling methodology: Hand held GPS is used to relocate each fixed station, during a period of low spring tide. Five 0.01 m^2 core sample are taken from each station and sieved through a 0.5 mm mesh. Each sample is transferred to a bag or pot, and individually labelled. A sample of sediment is also collected from each station for granulometry analysis. The samples are preserved in formalin and transported to an accredited laboratory for analysis of the infauna and the sediment granulometry.

6.1.2 Modifications since 2008 survey

The conventional core sampling methodology was well established and there were no changes that could compromise any comparisons with the 2007 survey data.

The methodology for the rapid assessment survey was largely the same as 2008, but core samples taken for *in situ* inspection were sieved over a 1 mm mesh, rather than the 0.5 mm mesh used in 2008. This was to speed up the sieving, reduce the amount of sediment held by the sieve to make *in situ* inspection easier, and because fauna smaller than 1 mm was probably not visible anyway. The 45 stations that were established and surveyed in 2008 were relocated as closely as possible, but channel shifts required slight changes in location of a small number of stations. Comparisons with the 2008 survey data should not be significantly affected.

Quality assurance procedures were strengthened, including the use of a waterproof photographic guide to the most commonly occurring sediment macrofauna species which was given to each pair of surveyors.

6.1.3 Analyses

Multivariate analyses, using Primer-E software, were carried out on the detailed infaunal data from the seven fixed sampling stations in 2008 and 2014. Analysis of the *in situ* recorded data from the full grid of stations was mainly limited to summary statistics of species richness and frequency counts, and direct comparison of the 2014 community data with that from 2008.

6.2. Results and comparison with 2008

The survey was carried out in July 2014. Figure 9 shows the locations of the 45 fixed survey stations. A field log is given in Appendix A5.

Ten intertidal sediment biotopes, including a *Zostera* 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 and polychaete worms; muddy sands in the middle of the Bay, dominated by cockles and lugworms on both sides of the channel and the seagrass bed on the upper shore of the west side; and some areas of very muddy sediment within the inner parts of the Bay, with ragworm 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 typical of the habitats present.

Figure 9 Location of sediment survey stations in Y Foryd in 2014. Stations marked with square boxes are those from which core samples were taken for laboratory analysis.

6.2.1 Rapid assessment methodology

Table 9 and Table 10 summarise the data from 45 stations. In the 2014 survey, 20 taxa were recorded *in situ* from the sieved samples and 36 conspicuous taxa were recorded from the sediment surface. These are similar to the 2008 survey results. The average number of taxa recorded per core in 2014 was lower than 2007 and the average number of conspicuous taxa recorded per station was also lower, but these figures are very sensitive to recorder differences.

Table 9 Frequency of occurrence (Freq) and sum of individuals (Sum) of most frequently occurring taxa identified *in situ* in sieved core samples from 45 fixed stations in Y Foryd, June 2008 and July 2014. [P] = presence only recorded.

	Freq		**Sum**	
	2008	**2014**	**2008**	**2014**
Hediste diversicolor	6	4	13	15
Nephtys	11	10	16	11
Scoloplos armiger	11	6	29	9
Spionidae (tubes) [P]	25	28		
Bathyporeia	17	10	148	27
Corophium	9	8	53	74
Eurydice	5	2	21	5
Carcinus maenas (juv) [P]		3		5
Peringia ulvae	18	9		
Cerastoderma edule (>20mm)	5	8	9	13
Cerastoderma edule (<20mm)	7	14	22	31
Limecola balthica	5	6	7	6
Scrobicularia plana	2	2	3	3
Total taxa (45 stns)	**21**	**20**		
Average taxa per core	**2.9**	**2.7**		

Overall, taxa recorded *in situ* from sieved core samples were similar in 2014 to those recorded in 2008. The most notable differences were a reduction in frequency and overall abundance of the amphipod *Bathyporeia*, the isopod *Eurydice* and the mud snail *Peringia ulvae*. However, there were more cockles *Cerastoderma edule* recorded.

Table 10 Frequency of occurrence (Freq) and sum of individuals (Sum) of most frequently occurring taxa identified *in situ* on the sediment surface within a 5m radius at 45 fixed stations in Y Foryd, June 2008 and July 2014.

	Method	Freq		Sum	
		2008	2014	2008	2014
Hediste diversicolor	P	5	6		
Spionidae (tubes)	P	18	16		
Arenicola marina (casts)	per m^2	38	32	350	525
Lanice conchilega	per m^2	4	5	43	126
Crangon crangon	P	5			
Carcinus maenas	per m^2	13	7	66	8
Littorina littorea	per m^2	12	5	146	432
Peringia ulvae	P	18	8		
Mytilus edulis	%	7	2	43	130
Cerastoderma edule (>20mm)	per m^2	14	25	550	1297
Cerastoderma edule (<20mm)	per m^2	15	21	1441	983
Limecola balthica	per m^2	5	5	51	256
Scrobicularia plana (marks)	P	8	5		
Vaucheria	%		4		20
Hincksia	%		4		12
Fucus vesiculosus	%	5	8	36	57
Chlorophyta (film/coat)	%	4	9	85	375
Ulva intestinalis	%	32		219	
Ulva	%	2	16	5	91
Ulva lactuca	%		11		37
Chaetomorpha	%	12	1	68	0
Rhizoclonium riparium	%		4		3
Saltmarsh	%	3		70	
Zostera (Zosterella) noltei	%	3	7	75	315
Total taxa (45 stations)		**33**	**36**		
Average taxa per station		**5.4**	**4.9**		

There were a number of changes in conspicuous taxa that live on the sediment surface, including a reduced frequency and abundance of edible winkles *Littorina littorea*, mud snails *Hydrobia ulvae* and mussels *Mytilus edulis*. Cover of algae and saltmarsh plants, including *Zostera noltei*, however, appeared to be greater overall; and there were a number of differences in the species of algae recorded.

Records of most of the conspicuous infauna, including tube worms, lug worm *Arenicola marina* and Baltic tellin *Limecola balthica* were very similar to 2014; but there were notably more records and higher abundance of cockles *Cerastoderma edule*.

6.2.2 Core samples from 7 stations

Laboratory analysis of core samples from seven fixed stations provided infaunal and granulometry data, for comparison with the data from 2008. Summary data are given in Table 11 and Figure 10. Figure 11 show the results of multivariate analyses.

Table 11 Average counts of most frequently occurring taxa in core samples from seven stations in Y Foryd, June 2008 and July 2014. Sediment particle size data (% weight) are also included. No particle size data available for station 10 in 2008.

Stn	**1**		**10**		**11**		**14**		**17**		**19**		**24**	
Year	**2008**	**2014**	**2008**	**2014**	**2008**	**2014**	**2008**	**2014**	**2008**	**2014**	**2008**	**2014**	**2008**	**2014**
Nematoda					0.2		0.2	0.4	7.4	0.2	0.6	3.4	22	0.4
Eteone longa				0.2	1.4				2.2			0.2	0.2	
Nephtys (juv)				0.2	0.2			1.6	0.2		0.4		0.2	
Nephtys cirrosa	1.6	0.8	0.6	0.6	1	0.4								
Nephtys hombergii	0.2		0.2		0.2				0.2		0.8			
Scoloplos armiger	0.2				9	1.2		3.4	4.2	2.8	1	0.2		
Dipolydora quadrilobata.									0.2		0.6	4.6		
Pygospio elegans	5	1.2			67.6			4.8	40.8	9.6	7.6	8.4	3.4	1
Spiophanes bombyx	3.2	2.6	0.4	0.4		1.8		0.2						
Tharyx (Species A)								0.6	106	6.4	2.8	7.8		
Capitella capitata					0.4			1.2	2.2	0.2	0.8	0.6	4.8	
Ampharetidae									2	1.2	9	1.8	0.4	
Ampharete								1	5	9.2	4.4	15.8	0.2	0.2
Fabricia stellaris									25.6	0.4	2.2		6.8	
Manayunkia aestuarina											0.8		1.8	
Baltidrilus costatus										0.6	0.2	0.2	27	0.2
Tubificoides benedii					0.2			9.8	74.6	34.2	41.2	7.2	133	10
Tubificoides pseudo.									3.2		0.2			
Bathyporeia (juv)	0.4		0.6	0.2	4	0.2	2							
Bathyporeia pilosa	0.2						9.6							
Bathyporeia sarsi	0.6	0.2			32.2	0.6		1.4						
Corophiidae					6.8	0.2		10.4						0.2
Corophium arenarium			0.4	0.4	10.6			6.6			0.2			
Eurydice pulchra	0.6						1.8							
Peringia ulvae	2	0.2	0.2	0.2	4	0.2	0.8	9.8	585	473	298	132	370	306
Retusa obtusa					6				0.2				1.4	
Bivalvia (Juvenile)		0.4				0.6		0.8	1.8	0.2	0.6	0.4	0.4	
Mytilus edulis (juv)								0.4	0.6	0.4		0.4		
Cerastoderma edule								1.6	1.4	0.8	2.4	2.2	0.6	1.2
Limecola balthica								1.2	0.4	0.8			0.2	
Scrobicularia plana								0.6	0.8	0.4	0.4	2	0.4	
No. of taxa	**13**	**7**	**10**	**8**	**22**	**11**	**6**	**23**	**31**	**22**	**26**	**26**	**22**	**10**
Sediment particle size analysis (% weight)														
Medium pebble (gravel)						3.8						0.4		
Small pebble (gravel)						0.4		0.1		0.0		0.0		
Granule					0.2	0.3		0.0	0.0	0.0	0.0	0.1		0.2
Sand - very coarse	0.0			0.0	0.2	0.8	0.0	0.7	0.7	0.1	0.1	0.1	0.1	0.1
Sand - coarse	0.0	0.0		0.0	0.1	0.5	0.1	0.0	0.8	0.2	0.2	0.1	0.3	0.1
Sand - medium	0.4	0.2		0.1	0.2	0.6	0.3	0.9	2.6	4.9	2.5	1.2	0.6	0.2
Sand - fine	95.6	61.4		91.8	91.1	84.9	94.7	76.0	41.6	66.0	43.5	35.2	31.5	11.5
Sand - very fine	3.6	4.7		6.7	7.7	6.6	4.8	17.4	17.4	10.2	37.2	32.2	43.9	46.1
Silt & Clay	0.4	33.8		1.4	0.5	2.2	0.1	4.9	36.8	18.6	16.5	30.6	23.7	41.8

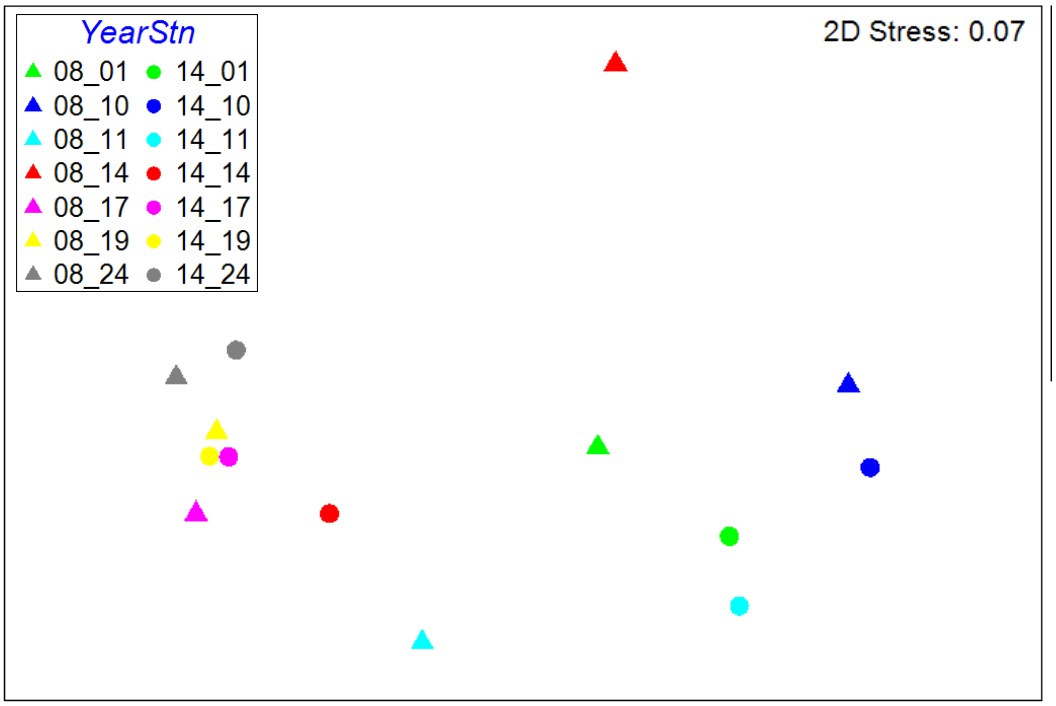

Figure 10 MDS plot showing similarities between infaunal core data from seven stations in Y Foryd, 2008 and 2014. All taxa, Bray Curtis similarity. Each point represents average counts from all replicates (5 reps per station) with log(x+1) transformation.

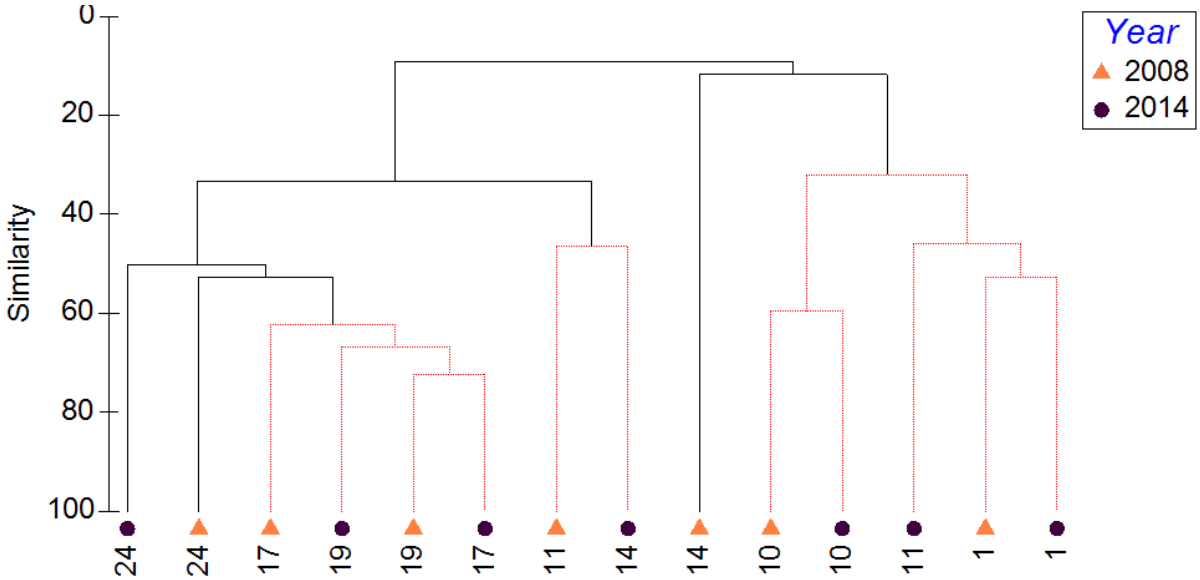

Figure 11 Dendrogram from group average cluster analysis of similarities between infaunal core data from seven stations in Y Foryd, 2008 and 2014. All taxa, Bray Curtis similarity. Each point represents average counts from all replicates (5 reps per station) with log(x+1) transformation.

The plots highlight the community differences between the muddy stations (17, 19 and 24), the sandy stations (1 and 10) and the intermediate stations (11 and 14). The influence of fine particles on the infaunal community is suggested by station 14, which had a notable silt/clay content in 2014, when its infauna was clustered with the muddy stations, but very little silt/clay in 2008, when its infauna was clustered with the sandy stations. However, this relationship does not hold for station 11. Further, the particle size data for station 1 gives a very high silt/clay content in 2014, which is

not suggested by the infaunal data and is anomalous when considering the location of the station at the mouth of the bay.

The silt/clay content of the sediment samples was greater in 2014 than 2008 at most stations.

The infaunal communities in 2014 were very similar to those found in 2008, with many of the stations clustering closely by year. However, as noted above, there were notable dissimilarities in community composition between the years in the intermediate stations 11 and 14. Inspection of the infaunal data shows that station 11 had more species characteristic of muddy sands in 2008, including *Pygospio elegans* and *Corophium arenarium*; while the opposite situation occurred in station 14. It is possible that these two stations are located within a natural boundary zone where silt/clay content can vary to an ecologically significant extent from year to year and influence the infauna.

Species richness was notably lower in 2014 compared to 2008, at most stations; the only increase being at station 14, due to its notable change from sand to muddy sand (muddy sands typically having a higher species richness than clean sands). Part of this decrease appears to be due to a reduced discrimination in the identification of some taxonomic groups from the 2014 samples. For example, six oligochaete taxa were identified in 2008 but only three in 2014, and more individuals were assigned to juveniles in 2008. However, this does not explain all the decreases, which were spread across most taxonomic groups.

Notable increases in 2014 included *Spiophanes bombyx* and *Limecola balthica*.

Notable decreases in 2014 included *Nephtys hombergii*, *Pygospio elegans*, *Fabricia stellaris*, *Baltidrilus costatus*, *Tubificoides benedii*, *Bathyporeia* spp., and *Eurydice pulchra*.

Ampharete spp. were recorded from almost all cores in the muddier stations in both 2008 and 2014, but as *Ampharete grubei* in 2008 and *Ampharete lindstroemi* in 2014. It is thought likely that this was due to misidentification in one of the years, so the records were all assigned to *Ampharete* for the analysis.

6.2.3 Biotope distribution

The 2014 data from both methodologies has been used to assign sediment biotopes to each station. A biotope distribution map is shown in Figure 12.

The overall distribution was essentially the same as described in 2008, with some small changes in the assignment to specific biotopes, particularly in the middle of the Bay where the silt/clay content was higher in 2014.

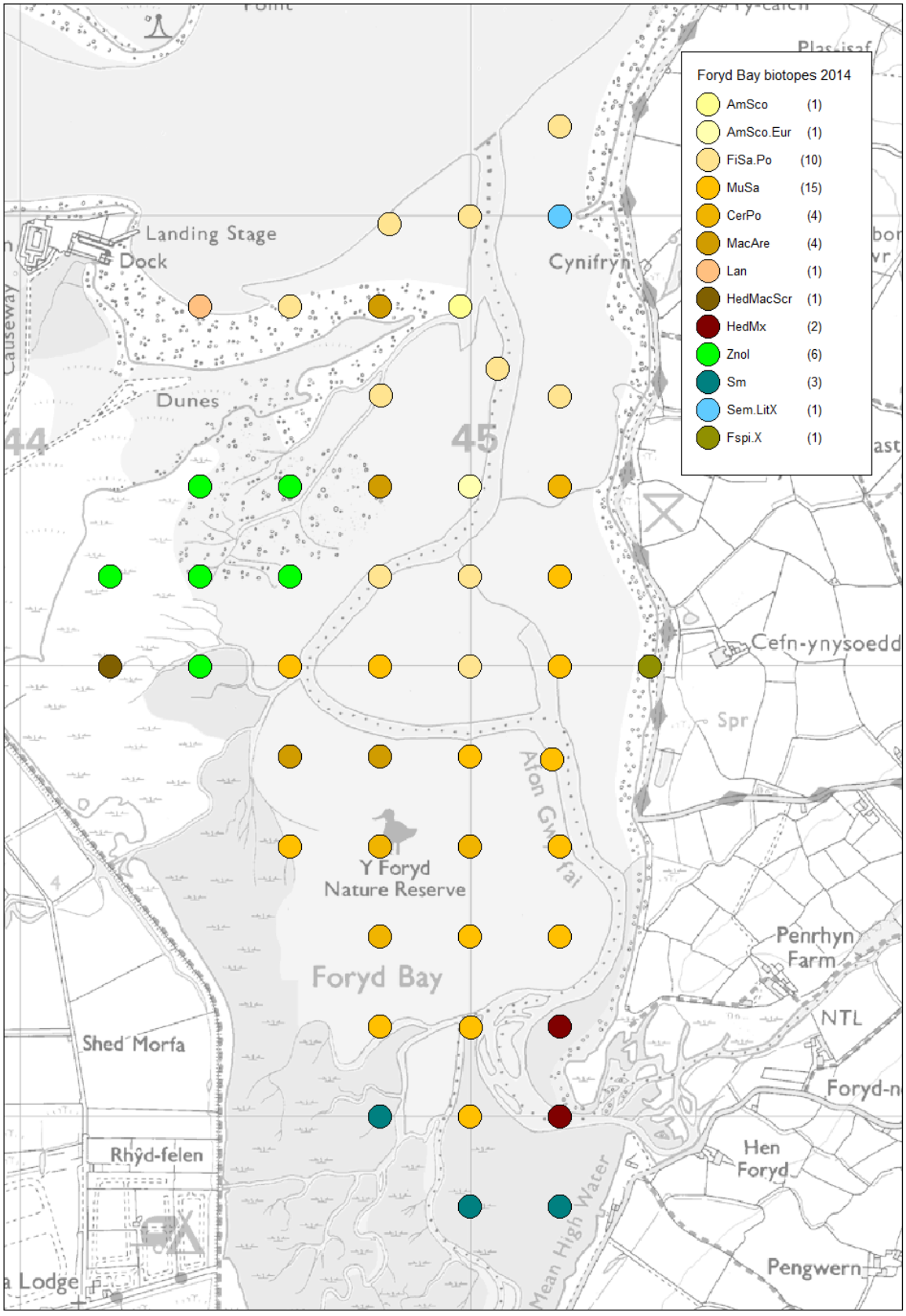

Figure 12 Distribution of sediment biotopes in Y Foryd in 2014. See Table 12 for explanation of biotope codes. Number in brackets is the number of stations.

Infaunal data from the WFD program of work drew similar conclusions, although the absence of data on the conspicuous large or epibenthic biota meant that the biotopes could not be clearly defined.

Table 12 Biotopes assigned to stations in Y Foryd in 2014. See Figure 12

Biotope	Full code	Description
AmSco	LS.LSa.MoSa.AmSco	Amphipods and *Scolelepis* spp. in littoral medium-fine sand
AmSco.Eur	LS.LSa.MoSa.AmSco.Eur	*Eurydice pulchra* in littoral mobile sand
FiSa.Po	LS.LSa.FiSa.Po	Polychaetes in littoral fine sand
MuSa	LS.LSa.MuSa	Polychaete / bivalve dominated muddy sand shores
CerPo	LS.LSa.MuSa.CerPo	*Cerastoderma edule* and polychaetes in littoral muddy sand
MacAre	LS.LSa.MuSa.MacAre	*Macoma balthica* and *Arenicola marina* in littoral muddy sand
Lan	LS.LSa.MuSa.Lan	*Lanice conchilega* in littoral sand
HedMacScr	LS.LMu.MEst.HedMacScr	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores
HedMx	LS.LMx.GvMu.HedMx	*Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud
Znol	LS.LMp.LSgr.Znol	*Zostera noltii* beds in littoral muddy sand
Sm	LS.LMp.Sm	Saltmarsh
Sem.LitX	LR.HLR.MusB.Sem.LitX	*Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles
Fspi.X	LR.LLR.F.Fspi.X	*Fucus spiralis* on full salinity upper eulittoral mixed substrata

6.3. Condition assessment

Favourable - The Y Foryd sediment communities in 2014 were very similar to those recorded in 2008 and most of the recorded changes in biotope richness and distribution, species composition and abundance appear to be within a normal range of natural fluctuations. Species richness was notably lower in 2014 and is not explained by the changes in sediment granulometry, but this is not considered a trend of concern.

Confidence in this conclusion is high; based on the experience of the surveyors (both generally and specifically on this monitoring programme) and a lack of any other known / apparent stresses or mechanisms other than natural fluctuations.

7. Intertidal mudflats and sandflats: Muddy gravel communities

This program monitors the composition of muddy gravel biotopes along the north east shore of the Menai Strait. It uses a conventional methodology of core sampling followed by laboratory analysis that is applied to a small number of representative stations in fixed locations.

This program is relevant to the following MSCB SAC attributes (CCW 2009):

Distribution and Extent: Variety of mudflat and sandflat communities

Structure and Function: Sediment characteristics (granulometry)

Typical Species: Typical mudflat and sandflat species (variety abundance, biomass)

7.1. Monitoring program

The monitoring programme is designed for repeat surveys every 3 - 6 years, to check that there has been no notable change in the attributes listed above. This report describes the results from surveys in June 2013 and June 2016 and compares them with data from August 2004 when the monitoring sites and methodology were established. Some data from a descriptive survey in August 2002 are also given.

Detailed methodologies and protocols are given in Moore (2016d), which are based on the methodologies and protocols described in the 2004 survey report (Allen *et al.* 2004). Station locations are given in the 2004 survey report (Allen *et al.* 2004) and in survey metadata held by NRW.

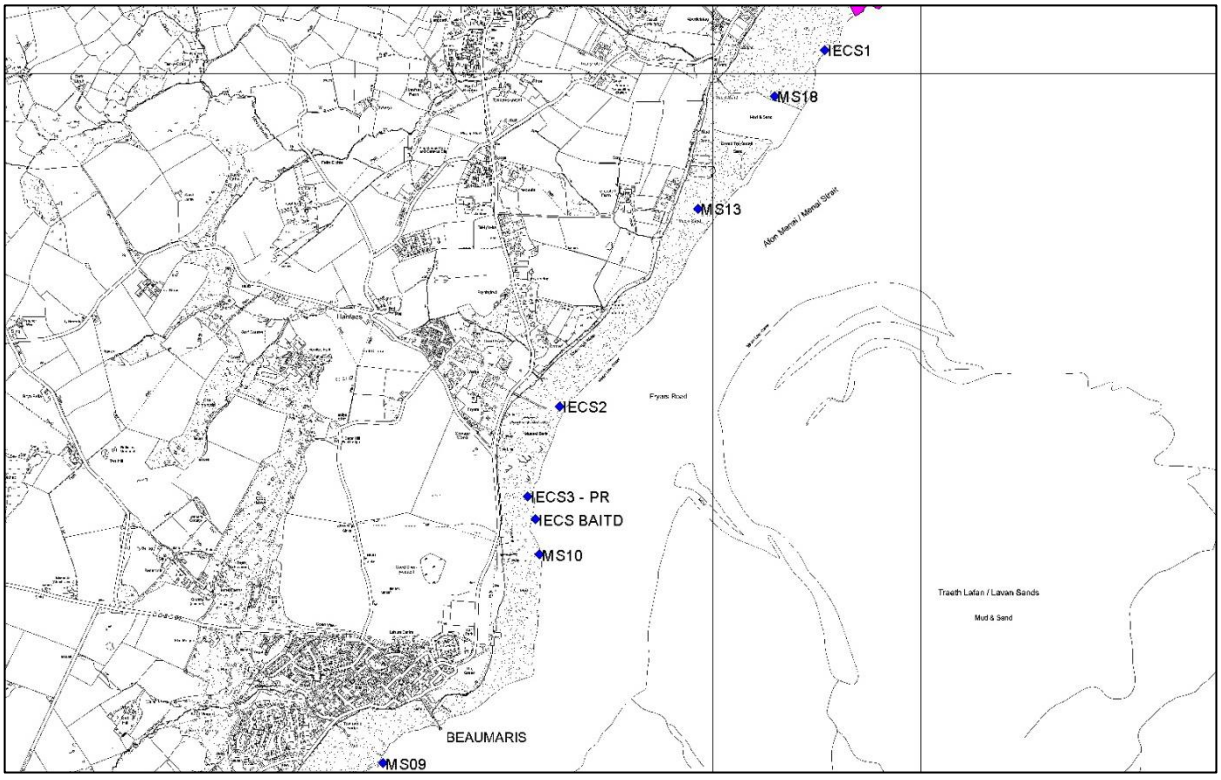

Figure 13 Muddy gravel sediment habitat sampling stations in the Menai Strait.

7.1.1 Methodology - summary

Core sampling methodology: Hand held GPS is used to relocate each fixed station, during a period of low spring tide. Five 0.01 m^2 core sample are taken from each station and sieved through a 0.5 mm mesh. Each sample is transferred to a bag or pot, and individually labelled. A sample of sediment is also collected from each station for granulometry analysis. The samples are preserved in formalin and transported to an accredited laboratory for analysis of the infauna and the sediment

granulometry. Photographs are taken and notes are made on sediment character and conspicuous fauna and flora on the surface.

7.1.2 Modifications since previous surveys

The sites and methodology were established during the 2004 survey and were unchanged for the repeat surveys.

Four of the muddy gravel stations (MS09, MS10, MS13, MS18) were first established and surveyed in August 2002 (as part of a larger descriptive survey), but the sampling methodology was different. 6+ core samples were taken within a fixed radius at each station and bulked to produce a single sample, representing 0.064 m^2. Direct comparison of data with the later surveys is therefore limited. Some of the summary data from that survey are included in Table 13 for general comparison.

7.1.3 Analyses

Multivariate analyses, using Primer-E software, were carried out on the detailed infaunal data from the 8 fixed sampling stations.

7.2. Results and comparison with previous surveys

Figure 1 shows the locations of the 8 fixed survey stations. Field logs are given in Appendices A4 and A7.

Laboratory analysis of core samples from eight stations provided macrofaunal and granulometry data, for comparison with the data from previous surveys. Summary data are given in Table 13 and Figure 14 show the results of multivariate analysis.

Table 13 Percentage occurrence (and average counts) of most frequently occurring taxa in core samples from 8 muddy gravel stations in August 2002*, August 2004, June 2013 and July 2016. Sediment particle size data (average % weight) are also included. *Data from 2002 are not directly comparable with those from the other years, as sampling was limited to only 4 of the stations, with one large sample (representing 0.06 m^2) from each station. Data in red indicate those taxa that were highlighted in SIMPER analysis as contributing the most (cumulative 30%) to the dissimilarity between years (see Figure 14).

Year	2002*	2004	2013	2016
Number of stations	**4**	**8**	**8**	**8**
Number of samples	**4**	**40**	**40**	**40**
Nemertea	50 (0.8)	18 (0.2)	23 (0.3)	20 (0.4)
Nematoda	100 (95)	98 (180)	70 (19)	88 (156)
Pholoe inornata	50 (0.5)	28 (0.3)	25 (0.3)	20 (0.2)
Eteone longa (agg)	100 (4)	40 (1)	73 (2)	83 (3)
Phyllodoce mucosa	75 (1)	65 (1)	65 (4)	83 (11)
Podarkeopsis capensis	100 (2.0)	3 (0.0)	3 (0.0)	13 (0.2)
Parexogone hebes	75 (5)	35 (1)	28 (1)	58 (4)
Exogone naidina	25 (1.0)	38 (1.2)	3 (0.0)	25 (0.5)
Eunereis longissima	25 (0.3)	13 (0.1)	18 (0.2)	23 (0.2)
Nephtys (juv)	50 (0.8)	15 (0.2)	8 (0.1)	38 (0.9)
Nephtys hombergii		10 (0.1)	10 (0.1)	35 (0.5)
Scoloplos armiger	100 (13)	45 (1)	75 (2)	43 (1)
Aricidea (Aricidea) minuta	50 (0.8)	23 (0.5)	5 (0.1)	23 (0.4)

Year	2002*	2004	2013	2016
Aonides oxycephala	75 (2.0)	8 (0.1)	10 (0.1)	33 (0.7)
Dipolydora quadrilobata	25 (0)	13 (0)	63 (9)	53 (5)
Pygospio elegans	50 (5)	40 (1)	15 (0)	60 (2)
Spio decorata	50 (0.8)	43 (0.8)	8 (0.1)	3 (0.0)
Spiophanes bombyx	100 (13)	15 (0)	45 (1)	50 (1)
Chaetozone gibber		15 (0.2)	48 (1.2)	55 (1.2)
Tharyx	25 (4)	88 (36)	33 (4)	
Tharyx (Type A)	100 (129)			75 (21)
Aphelochaeta marioni	50 (15.0)	18 (37.6)	25 (0.7)	28 (1.2)
Capitella (agg)	100 (3)	50 (4)	33 (2)	23 (0)
Mediomastus fragilis	100 (102)	93 (24)	88 (15)	93 (36)
Notomastus	100 (10)	20 (0)	65 (2)	80 (3)
Scalibregma inflatum	25 (0.3)	8 (0.1)	20 (0.4)	40 (0.7)
Galathowenia oculata	100 (8)	35 (1)	23 (0)	38 (1)
Lagis koreni (juv)			78 (3.1)	
Lagis koreni	25 (0.3)	8 (0.1)		48 (1.6)
Ampharete				58 (2.0)
Ampharete grubei	25 (1.0)	38 (0.7)	58 (4.0)	
Lanice conchilega	25 (0)	30 (1)	83 (7)	78 (4)
Tubificoides benedii	100 (392)	88 (29)	78 (56)	85 (68)
Tubificoides pseudogaster (agg)		75 (5)	48 (6)	88 (19)
Balanus crenatus	25	15	43	55
Austrominius modestus	25	10	8	28
Corophium volutator	100 (1)	40 (1)	33 (3)	55 (13)
Pariambus typicus		23 (0.7)	18 (0.3)	28 (0.5)
Crangon crangon	100 (5)	13 (0)	33 (1)	28 (1)
Peringia ulvae	25 (0.3)		13 (1.4)	38 (2.6)
Mytilus edulis (juv)	100 (42)	90 (7)	63 (3)	28 (0)
Kurtiella bidentata	25 (1.0)	10 (0.1)	25 (0.4)	23 (1.5)
Cardiidae (juv)	50 (3.3)	55 (1.0)		
Cerastoderma edule (juv)	50 (1.0)		5 (0.1)	48 (0.9)
Abra alba	50 (0.5)	3 (0.0)	28 (0.6)	45 (0.7)
Summary attributes [excluding colonial epifauna and algae]				
Total number of taxa recorded (all samples). [Total across 4 surveys and 8 stns = 226 taxa]	94	103	129	126
Average number of taxa per sample	43	18	21	25
Average number of individuals per sample	978	345	168	401
Average Evenness (J')	0.546	0.551	0.742	0.660
Average Shannon diversity (H'(loge))	2.028	1.554	2.186	2.090
Sediment particle size analysis (% weight)				
Medium pebble (gravel) (> 8 mm)	9.5	7.9	12.3	6.4
Small pebble (gravel) (4-8 mm)	6.3	7.5	5.9	7.4
Granule (2-4 mm)	5.4	6.8	7.8	8.1

Year	2002*	2004	2013	2016
Sand - very coarse (1-2000 µm)	4.6	4.7	5.8	6.6
Sand - coarse (500-1000 µm)	6.1	5.5	6.3	6.9
Sand - medium (250-500 µm)	24.8	18.5	17.1	19.7
Sand - fine (125-250 µm)	24.9	26.9	24.7	25.3
Sand - very fine (63-125 µm)	13.0	11.2	11.7	11.7
Silt & Clay (< 63 µm)	5.4	10.9	8.4	7.9

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 around 10%, in 2004, 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, prawns, anemones and various algae. Changes in taxonomy and differing levels of differentiation of taxa between analytical laboratories over time appear to influence the Primer analysis.

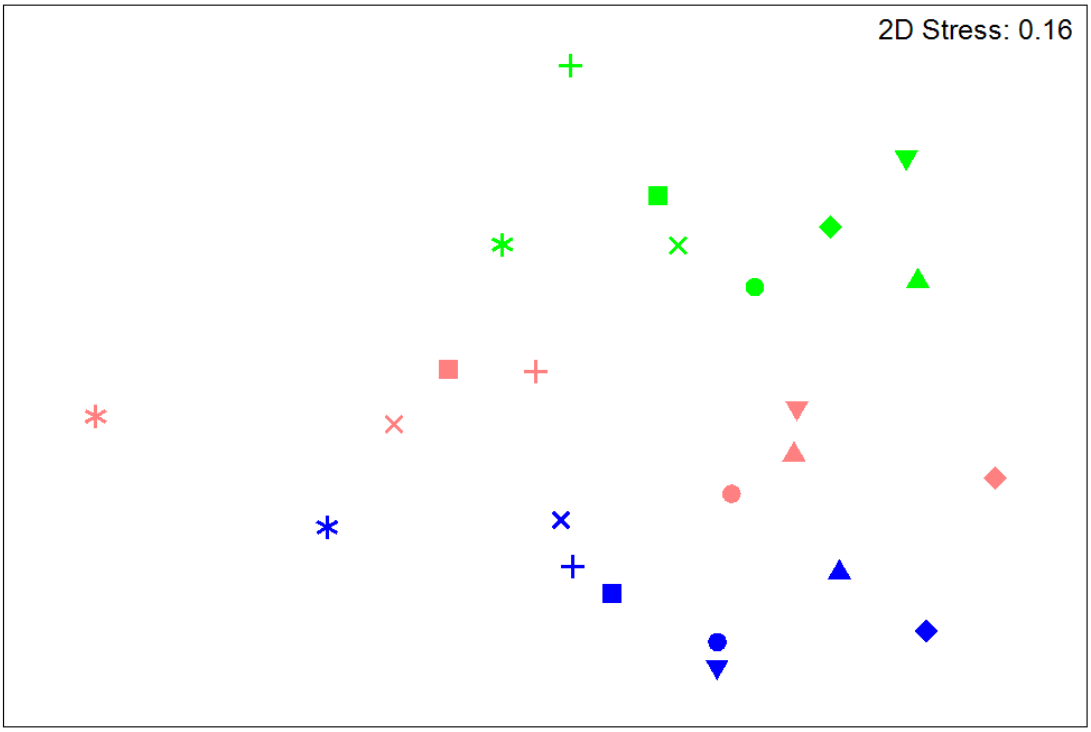

Figure 14 MDS plot, showing similarity of sediment macrofaunal communities from eight muddy gravel stations in 2004 (green), 2013 (pink) and 2016 (blue). Analysis: abundance data (average counts from 5 samples) of all taxa (excluding colonial epifauna and algae), transformed (log(x+1)), Bray Curtis similarity.

Figure 14 highlights the differences in community data between the years, such that the individual stations are not clustering together. ANOSIM analysis shows that the differences between years are significant (0.1%, global R statistic 0.577) and Table 13 shows that the differences are in a wide range of taxa. However, Table 13 also shows that there are many similarities in species composition and sediment character

between the years, and that number of taxa and diversity indices are broadly similar and suggest some increases in taxonomic richness and diversity. Average species richness (of non-colonial animals per 0.01 m^2 core) increased from 18 in 2004, to 21 in 2013 to 25 in 2016.

7.3. Condition assessment

Favourable - The muddy gravel communities in 2013 and 2016 were different from each other and from those of 2004, but those recorded changes in species richness, species composition and abundance do not indicate any trends of concern and appear to be within a normal range of natural fluctuations. The data suggest some possible increases in taxonomic richness and diversity.

Confidence in this conclusion is high; based on the experience of the surveyors (both generally and specifically on this monitoring programme) and a lack of any other known / apparent stresses or mechanisms other than natural fluctuations.

8. Recommendations

The methodologies and protocols applied for these monitoring programmes are still considered appropriate and adequate to fulfil the objectives. Thus, no change in these methodologies or protocols are recommended, but any additional training or aids that can improve the consistency of recording will be useful.

All features, other than the boulder shores near Felinheli, monitored up to 2017 were considered to be in good condition and no changes in management are recommended. Attempts to quantify the levels of boulder turning and the behaviours that bring this about have not been successful. There would be further benefit in encouraging bait and food collectors on the shore of the Menai Strait, as a whole, to settle boulders back to their original location and the correct way up, when foraging.

Continued monitoring is recommended.

9. References

Allen, J.H., Boyes, S. and Burlinson, F., 2004. Intertidal Monitoring of Muddy Gravels (LMX.Psyllid) in the Menai Strait and Conwy Bay SAC in 2004. Institute of Estuarine and Coastal Studies, University of Hull.

CCW 2009 *Advice provided by the Countryside Council for Wales in fulfilment of Regulation 33 of the Conservation (Natural Habitats, &c.) Regulations 1994 for Y Fenai a Bae Conwy / Menai Strait and Conwy Bay European Marine Site*. Issue 2, February 2009. Countryside Council for Wales, Bangor. 70pp.

Howson, C.M. & Moore, J. 2010. Across-Wales intertidal SAC monitoring, Menai Strait and Conwy Bay SAC, June 2008. CCW Marine Monitoring Report No: 70, pp 89 + vi, Countryside Council for Wales, Bangor

Moore, J. 2009. Across-Wales intertidal SAC monitoring, Menai Strait and Conwy Bay SAC, September 2007. CCW Marine Monitoring Report No: 56, 73pp + vi, Countryside Council for Wales, Bangor.

Moore, J. 2016a. Methodologies for intertidal monitoring in Welsh SACs: 2. Tide-swept boulder surveys.

Moore, J. 2016b. Methodologies for intertidal monitoring in Welsh SACs: 3. Epibiota on tide-swept Fucus serratus.

Moore, J. 2016c. Methodologies for intertidal monitoring in Welsh SACs: 4. *In situ* recording of sediment biotopes.

Moore, J. 2016d. Methodologies for intertidal monitoring in Welsh SACs: *7. Sediment core sampling*.

Moore, J., Brazier, D.P., & Hobbs, E. 2010. Across-Wales intertidal SAC monitoring, Menai Strait and Conwy Bay SAC, June 2009. CCW Marine Monitoring Report No: 82, 85pp + vii, Countryside Council for Wales, Bangor

Phillips, G.R., Anwar, A., Brooks, L., Martina, L.J., Miles, A.C., Prior, A. 2014. Infaunal quality index: Water Framework Directive classification scheme for marine benthic invertebrates. Report: SC080016. Environment Agency, Horizon House, Deanery Road, Bristol.

Appendices

Appendix 1 Field log, 11th - 16th July 2010

Survey Team: Jon Moore (JM) (survey leader)
Francis Bunker (FB)
Paul Brazier (PB)
Jen Jones (JJ)
Liz Hobbs (EH)
Daniel Hallam (DH)
Roland Sharp (RS)
Sally Ellis (SE)

Low tide times and heights are for Menai Bridge. All times are BST

11 July (Sun)

Weather: Dry, calm, warm, mostly sunny or bright

pm/eve Travel to Bangor – FB, JM and JJ drive from Pembrokeshire.
Dinner at Indian restaurant near Porthmadog
Arrive at Treborth Hall Farm cottages

12 July (Mon)

Weather: Dry, calm, warm, mostly sunny or bright
Low tide: 0.83m @ 1840

am/pm JM, FB, JJ, PB and EH meet at Treborth cottages. DH arrives from train.
Discussion on survey rationale, methods and recording forms. Preparation for survey.

1500 Drive to Felinheli and walk to survey stations. Wait for low tide.

1600-1900 PB and DH survey station FE1, JM and EH survey station FE3, FB and JJ survey station FE5.
RS joins team on shore

1930 Return to Treborth. Team disperse.

eve JM/FB/JJ have dinner at Greek restaurant, Upper Bangor.

13 July (Tues)

Weather: Mostly dry and cloudy, some light rain, calm.
Low tide: 0.69m @ 1920

am/pm Team meet at Treborth cottages
Data entry, photo download and cataloguing, specimen identification. Preparation for survey.

1630 Drive to Britannia Bridge and walk to survey stations.

1700-2025 JM and DH survey station BB1, FB and EH survey station BB3, PB and JJ survey station BB4.
RS joins team on shore

2045 Return to Treborth. Team disperse.

eve JM/FB/JJ/DH have dinner at Chinese restaurant, Menai Bridge.

14 July (Wed)

Weather: Mostly dry and cloudy, some light rain, calm, chilly
Low tide: 0.56m @ 0750

0600 Team meet at Treborth cottages. JM and JJ dropped off at Britannia Bridge. FB, PB, DH and JJ drive to Felinheli. RS joins JM and JJ.

0620-0900	JM and JJ survey boulders at BB5 and BB2. FB and EH survey boulders at FE2. PB and DH survey boulders at FE6.
0930	Breakfast at Treborth Garden Centre
am / pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification. Preparation for FserTX survey.
1945-2030	FB/PB/JM drive to Britannia Bridge and check Alcyonidium identifications
eve	JM/FB/JJ have dinner at Treborth cottages.

15 July (Thurs)

Weather:	Mostly dry and cloudy, moderate breeze, chilly
Low tide:	0.61m @ 0840
0615	Team meet at Treborth cottages. Drive and walk to sites near Brynsiencyn.
0705-0930	JM/DH/RS survey FserTX study area at Castell-Gwylan. FB and EH survey FserTX study area at Llanidan 1. PB and JJ survey FserTX study area at Llanidan 2.
1000	Breakfast at Hooton's Coffee Shop
am / pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification.
eve	Meet PLAS survey team (Tom Mercer, Christine Howson and Sam Mercer) for dinner at Fu's in Caernarfon.

16 July (Fri)

Weather:	Initially rain, then drying up, moderate breeze and cloudy.
Low tide:	0.83m @ 0930
0700	Team meet at Treborth cottages. Drive and walk to Britannia Bridge. Sally Ellis joins team.
0730-1030	Carry out boulder survey trials on 3 boulders (BBN, BBM and BBS), located between BB2 and BB5
1100	Breakfast at Treborth Garden Centre
pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification.
1500	Team disperse. JM, FB and JJ pack and drive back to Pembrokeshire

Appendix 2 Field log, 1st - 5th August 2011

Survey Team: Paul Brazier (PB) (survey leader)
Jon Moore (JM)
Francis Bunker (FB)
Lucy Kay
Gwen Alun
Clare Davies (Tue and Thu)

Mon 1st August

Weather: Overcast and calm
Low tide: 19:14hrs 0.8 m

am: Team arrive at Treborth and organise equipment for afternoon survey

pm: Survey from 17:45 onwards at Britannia Bridge site, stations 1, 3 and 4.

Tue 2nd August

Weather: Overcast, showers, sunny spells, calm
Low tide: 07:40hrs 0.6 m

am: Survey from 06:15 onwards at Britannia Bridge site, stations 2, 4 and 5.

pm: Sample ID and write up from Mon and Tue.

Wed 3rd August

Weather: Bright and dry. Calm
Low tide: 08:22hrs 0.6 m

am JM/LK/GA completed Carreg Gwylan FserTX station and PB/FB completed the Llanidan first FserTX station. Care must be taken when locating the rock from which the station is measured for the LL1 station.

Thu 4th August

Weather: Overcast and calm
Low tide: 09:05hrs 0.8 m

am JM/FB/PB/LK/CD revisited Llanidan to complete the second station here.

pm: Sample ID and write up

Fri 5th August

am: Validated data, packed up to leave.

Appendix 3 Field log, 4th - 7th July 2012

Survey Team: Jon Moore (JM) (survey leader)
Christine Howson (CH)
Paul Brazier (PB)
Jen Jones (JJ)
Monica Jones (MJ)
Ben Wray (BW)
Lucy Kay (LK)

4 July (Wed)

pm/eve	Travel to Bangor – JJ drive from Pembrokeshire, CH drive from Edinburgh, JM train from London Arrive at Treborth Hall Farm cottages

5 July (Thurs)

Weather:	Mostly dry and cloudy, v. slight breeze
Low tide:	0.73m @ 0710
0530	JM/CH/JJ/PB/BW/MJ meet at Britannia Bridge.
0545-0845	JM and MJ survey boulders at BB1. CH and JJ survey boulders at BB3. PB and BW survey boulders at BB2.
0930	Breakfast at Castle Bakery, Menai Bridge
am / pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification.
eve	JM/CH/JJ have dinner at Dylan's restaurant, Menai Bridge

6 July (Fri)

Weather:	Initially rain, then drying up, cloudy, flat calm.
Low tide:	0.77m @ 0750
0530	JM/CH/JJ/LK/BW/MJ meet at Felinheli.
0600-0915	JM and BW survey boulders at FE6 and FE2. CH and LK survey boulders at FE5. JJ and MJ survey boulders at FE3.
1000	Breakfast at Castle Bakery, Menai Bridge
am / pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification.
eve	Team plus Peter Walker (CCW) meet at Treborth cottage for takeaway Indian.

7 July (Sat)

Weather:	Initially sunny and warm, becoming cloudy and cool, with slight breeze.
Low tide:	0.94 @ 0840
0545	JM/CH/JJ/PB/BW/MJ meet at Treborth cottages. PB and MJ drive to Felinheli, others drive to Britannia Bridge
0620-0910	JM and JJ survey boulders at BB4 and BB3. CH and BW survey boulders at BB5.
0630-0930	PB and MJ survey boulders at FE2 and FE1.
1000	Breakfast at Treborth Garden Centre
am / pm	Treborth cottages. Data entry, photo download and cataloguing, specimen identification.
pm/eve	Team disperse. CH/JM/JJ drive to Pembrokeshire.

Appendix 4 Field log, 23rd – 28th June 2013

Survey Team: Jon Moore (JM) (survey leader)
Francis Bunker (FB)
Paul Brazier (PB)
Jen Jones (JJ)
Natasha Lough (MJ)
Rowland Sharp (BW)
Lucy Kay (LK)

23 June (Sun)

pm/eve	Travel to Bangor – JM, FB and JJ drive from Pembrokeshire Arrive at Treborth Hall Farm cottages. Dinner at Dylan's restaurant, Menai Bridge.

24 June (Mon)

Weather:	Mostly dry and bright, with some sun, but a cold breeze
Low tide:	0.46m @ 1850
0900	JM/FB/JJ/PB/LK/NL/RS meet at Treborth cottage. Familiarisation session – going through methodology, protocols and species for boulder surveys. Look at species on collected boulders and in photographs from previous surveys.
1530	JM/FB/JJ/NL drive to Britannia Bridge. PB/LK/RS drive to Lleiniog
1610-2020	JM and NL survey boulders at BB1 and BB4. FB and JJ survey boulders at BB3 and BB5.
1615-2000	PB/LK/RS collect core samples from muddy gravels at Lleiniog stations MS13, MS18, IECS1, MS09 and MS50.
2045	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner at Bridge restaurant, Menai Bridge

25 June (Tues)

Weather:	Mainly dry and bright, but cool with light breeze.
Low tide:	0.48m @ 1940
am / pm	All meet at Treborth cottage. Data entry, photo download and cataloguing, specimen identification and catalogue.
1530	JM/FB/JJ/NL drive to Britannia Bridge. PB/LK/RS drive to Felinheli
1715-2010	JM and NL survey boulders at BB4 and BB5. FB and JJ survey boulders at BB2.
1650-2030	PB/LK/RS survey boulders at FE6 and FE2
2045	Team disperse.

26 June (Wed)

Weather:	Mainly dry and bright, but cool with light breeze.
Low tide:	0.47m @ 0810
0540	JM/FB/JJ/PB/NL/RS meet at Felinheli and walk to boulder survey stations.
0550-0900	FB and NL survey boulders at FE1 and FE3. JM and RS survey boulders at FE3. PB and JJ survey boulders at FE5.
0930	Breakfast at Ty Golchi café.
am/pm/eve	All return to Treborth. Data entry and collation. Photo download and catalogue. Specimen ID and catalogue.
eve	JM/FB/JJ have takeaway Indian meal at Treborth

27 June (Thurs)

Weather:	Initially grey but dry, becoming wet and cool, with light breeze.
Low tide:	0.68m @ 0900
0600	JM/FB/JJ/PB/NL/RS meet at Treborth cottage. Brief familiarisation session - going through methodology, protocols and species for tide-swept *Fucus serratus* surveys. All drive to Brynsiencyn.
0700-1000	JM and NL survey FserTX study area at Castell-Gwylan. FB and RS survey FserTX study area at Llanidan 1. PB and JJ survey FserTX study area at Llanidan 2
1030	Breakfast at Hooton's Coffee Shop
am	LK works at Treborth cottage to carry out data entry and QA.
am/pm/eve	All return to Treborth. Data entry and collation. Photo download and catalogue. Specimen ID and catalogue.
eve	JM/FB/JJ have dinner at Eastern Origin, Bangor

28 June (Fri)

Weather:	Grey but dry with light winds.
Low tide:	1.00m @ 0950
0730	JM/PB/RS meet at Treborth cottage, then drive to Friars Road.
0800-1045	PB, JM and RS carry out core sampling in muddy gravel at four stations in Friars Bay (IECS2, MS10, IECSB, IECS3).
0830-1000	FB and JJ drive down to Britannia Bridge and carry out photography and sampling of selected sponges (Halichondria / Haliclona / Protosuberites) underboulders between stations BB2 and BB5.
1100	PB, JM and RS go to NRW HQ to preserve and store core samples
1130-1500	All return to Treborth. JJ and FB working through sponge specimens and photographs to identify and catalogue them. All - data collation and validation. Photo and specimen catalogues. Packing up.
1530	Team disperse. JM/FB/JJ drive back to Pembrokeshire

Appendix 5 Field log, 11th - 17th July 2014

Survey Team: Jon Moore (JM) (survey leader)
Francis Bunker (FB)
Paul Brazier (PB)
Jen Jones (JJ)
Lucy Kay (LK)
Rowland Sharp (BW)
Mollie Duggan (MD)

11 July (Fri)

pm/eve	Travel to Bangor – JM and JJ drive from Pembrokeshire, FB from Scotland Arrive at Treborth Hall Farm cottages. Dinner at Bocca, Italian restaurant, Menai Bridge.

12 July (Sat)

Weather:	Mostly dry and overcast, with some showers and increasingly cold breeze
Low tide:	0.72m @ 1800
0900	JM/FB/JJ/PB/LK/MD/RS meet at Treborth cottage. Training / familiarisation session – going through methodology, protocols and species for sediment surveys and boulder surveys. Look at photographs from previous surveys.
1330	Team drive to Foryd Bay in 2 cars. Park on roadside and split into 3 pairs.
1415-1900	PB/JJ survey sediment stations at south end of Bay, JM/RS/MD survey sediment stations in middle section of Bay, FB/LK survey sediment stations at north end of Bay
1900-2000	FB/LK unable to cross channel so walk long way round and picked up by PB.
2030	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner at Spicy Vujon Indian restaurant, Bangor

13 July (Sun)

Weather:	Mostly dry, warm and sunny
Low tide:	0.53m @ 1850
0900	JM/FB/JJ/PB/LK/MD/RS meet at Treborth cottage. Data entry, photo download and catalogue, GPS download. Training / familiarisation session – going through methodology, protocols and species for boulder surveys. Look at photographs from previous surveys.
1500	Team drive to Felinheli in 2 cars. Park in residential estate and walk to boulder survey stations.
1530-1940	Team go through methodology and protocols on example boulder, then split into pairs and walk to stations. PB/JJ survey station FE2, FB/LK survey station FE6, JM/MD/RS survey station FE5 and 2 boulders at FE3.
2030	Return to Treborth cottage (via Britannia Bridge access to pick up gate key). Team disperses.
eve	JM/FB/JJ have dinner at Bridge restaurant, Menai Bridge

14 July (Mon)

Weather:	Beautiful morning – sunny and warm
Low tide:	0.43m @ 0720
0500	JM/FB/JJ/PB/MD/RS meet at Treborth cottage, then drive to Britannia Bridge in 2 cars. Team split into 3 pairs and walk to boulder survey stations.
0540-0840	PB/MD survey station BB2, JM/RS survey station BB4, FB/JJ survey station BB5 and 2 boulders at BB3.
am	Team breakfast at Castle Bakery, Menai Bridge
1030-1900	Return to Treborth cottage. Data entry, photo download and catalogue, GPS download. Specimen identification and cataloguing. Data QA checks.

eve	JM/FB/JJ have dinner in at Treborth

15 July (Tues)

Weather:	Beautiful morning – sunny and warm
Low tide:	0.44m @ 0810
0500	JM/FB/JJ/PB/LK/MD/RS meet at Treborth cottage, then split into 2 teams and drive to Britannia Bridge and Felinheli in separate cars. Teams split into 3 pairs and walk to boulder survey stations.
0540-0850	PB/LK/RS survey stations FE3 and FE1, JM/JJ survey station BB1, FB/MD survey station BB3.
am	Team breakfast at Castle Bakery, Menai Bridge
1030-1900	Return to Treborth cottage. Data entry, photo download and catalogue, GPS download. Specimen identification and cataloguing. Data QA checks.
eve	Team meet up with others for dinner at Eastern Origin.

16 July (Wed)

Weather:	Mixed, with rain and wind at first then clearing up
Low tide:	0.62m @ 0900
0530	JM/FB/JJ/PB/MD/RS meet at Treborth cottage and prepare for survey, then split into 2 teams and drive to Brynsiencyn in separate cars. Teams split into 3 pairs and walk to tide-swept Fucus serratus survey stations and wait for tide to drop.
0700-1000	JM/RS survey Castell Gwylan, FB/JJ survey Llanidan 1, PB/MD survey Llanidan 2.
am	Team breakfast at Hooton's Farm Shop cafe
1130-1800	Return to Treborth cottage. Data entry, photo download and catalogue, GPS download. Specimen identification and cataloguing. Data QA checks.
eve	Team pack up and disperse. JM/FB/JJ have dinner in at Treborth

17 July (Thurs)

am	JM/FB/JJ pack up and drive back to Pembrokeshire in 2 cars.

Appendix 6 Field log, 1st - 7th July 2015

Survey Team: Jon Moore (JM) (survey leader)
Francis Bunker (FB)
Paul Brazier (PB)
Jen Jones (JJ)
Lucy Kay (LK)
Ben Wray (BW)
Natasha Lough (NL)
Eurig Wyn Jones (EJ)

1 July (Wed)

pm/eve	Travel to Bangor – FB, JM and JJ drive from Pembrokeshire Arrive at Treborth Hall Farm cottages. Dinner at Spicy Vujon, Indian restaurant, Bangor.

2 July (Thurs)

Weather:	Dry and bright with fresh south westerly breeze
Low tide:	0.97m @ 1820
0900-1500	JM/FB/JJ/BW/NL/EJ meet at Treborth cottage. Training / familiarisation session – going through methodology, protocols and species for sediment surveys and boulder surveys. LK arrives mid-morning. Look at photographs from previous surveys. Prepare survey equipment etc.
1500	Team drive to Felinheli in 2 cars. Park on roadside and walk to boulder survey station FE5.
1540-1930	Team go through methodology and protocols on example boulder, then split into pairs and walk to stations. JM/NL survey station FE5, FB/LK/EJ survey station FE6, JJ/BW survey station FE2.
2000	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner in cottage at Treborth.

3 July (Fri)

Weather:	Dry, overcast and calm
Low tide:	0.83m @ 1910
0900-1600	JM/FB/JJ/BW/LK/NL/EJ meet at Treborth cottage. JM modifying Access database for species data entry. Data entry, photo download and catalogue. Specimen identification and cataloguing. NL leaves.
1600	Team drive to Britannia Bridge in 2 cars, split into 3 pairs and walk to boulder survey stations.
1630-2000	JM/EJ survey station BB4, then 1 boulder at BB5, JJ/LK survey station BB3, then 1 boulder at BB5, FB/BW survey station BB1.
2000	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner at Greek Taverna Politis restaurant, upper Bangor.

4 July (Sat)

Weather:	Cloudy, dull and calm, with some light rain showers.
Low tide:	0.76m @ 0740
0515	JM/FB/JJ/BW/LK/EJ meet at Treborth cottage meet at Treborth cottage, then split into 2 teams and drive to Britannia Bridge and Felinheli in separate cars. Teams split into 3 pairs and walk to boulder survey stations.
0540-0900	JM/BW survey stations FE3 and FE1, JJ/LK survey 4 boulders at station BB2, FB/EJ survey 3 boulders at station BB5 then 1 boulder at station BB2.
0930	Team breakfast at Castle Bakery, Menai Bridge.
1100-1900	Return to Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing.

	Training / familiarisation session for tide-swept *Fucus serratus* epibiota surveys – going through methodology, protocols and species.
eve	JM/FB/JJ have dinner at Bridge Inn restaurant, Menai Bridge.

5 July (Sun)

Weather:	Dry and bright with light breeze.
Low tide:	0.77m @ 0820
0515	JM/FB/JJ/BW/LK/EJ meet at Treborth cottage and prepare for survey, then split into 2 teams and drive to Brynsiencyn in separate cars. Teams split into 3 pairs and walk to tide-swept Fucus serratus survey stations and wait for tide to drop.
0630-0900	JM/BW survey Castell Gwylan, FB/EJ survey Llanidan 1, JJ/LK survey Llanidan 2.
0930	Team breakfast at Hooton's Farm Shop cafe
1130-1830	Team return to Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing. Training / familiarisation session for Traeth Lafan sediment surveys – going through methodology, protocols and species. Divide up stations for each pair of surveyors.
eve	JM/FB/JJ have dinner in cottage at Treborth.

6 July (Mon)

Weather:	Initially dry, cloudy and warm with light breeze, with some rain after 0900
Low tide:	0.90m @ 0910
0515	JM/FB/JJ/PB/BW/LK/NL/EJ meet at Treborth cottage and prepare for survey, then split into 4 pairs and drive to Traeth Lafan access points in separate cars. JM/EJ to Glan y Mor Elias nature reserve access near Llanfairfechan, FB/NL and PB/JJ to Morfa Aber Nature Reserve access, near Abergwyngregyn, LK/BW to the access near the Spinnies at Aber Ogwen.
0615-1130	FB/NL survey 11 *in situ* sediment stations; PB/JJ survey 14 *in situ* sediment stations and collect core samples from L057; LK/BW survey 9 *in situ* sediment stations; JM/EJ survey 7 *in situ* sediment stations and collect core samples from L074, then return to Treborth cottage to start data entry.
1200	Team breakfast(!) at Treborth Garden Centre café.
1300-2000	Return to Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing. Data QA checks. Team members gradually packing-up and dispersing.
eve	JM/FB/JJ have dinner at Eastern Origin, Chinese restaurant in Bangor.

7 July (Tues)

am	JM/FB/JJ pack up and drive back to Pembrokeshire.
0630	BW/PB/NL/EJ meet at Spinnies car park to complete the remainder of the Traeth Lafan *in situ* and core sediment stations. PB/EJ drive to Aber car park and start at the more eastern stations. BW/NL survey 3 *in situ* stations and collect core samples from TL02, TL09 and TL66. PB/EJ survey 8 *in situ* stations and collect core samples from TL107 and TL12.
1200	BW/PB/NL/EJ arrive back at NRW Maes y Ffynnon and unpack vehicles.

Appendix 7 Field log, 4th – 10th June 2016

Survey Team: Jon Moore (JM) (survey leader)
Francis Bunker (FB)
Jen Jones (JJ)
Lucy Kay (LK)
Paul Brazier (PB)
Tanya Kitteridge (TK)
Liz Jones (LJ)
Laura Grant
Eurig Wyn Jones (EWJ)
Jake Delwyn Davies (JDD)
Amy Salisbury (AS)

4 June (Sat)

pm/eve	Travel to Bangor – FB, JM and JJ drive from Pembrokeshire Arrive at Treborth Hall Farm cottages; staying in Old Coach House. JM collects sample boulder from Britannia Bridge, for training session. Dinner at Harri's Portuguese Kitchen, Menai Bridge.

5 June (Sun)

Weather: Dry and sunny with no wind
Low tide: 0.47m @ 1820

0900-1500	JM/FB/JJ/LK/TK/EWJ/JDD meet at Treborth cottage. Training / familiarisation – going through methodology, protocols and species for boulder surveys. Look at species photographs from previous surveys. Prepare survey equipment etc.
1515	Team drive to Felinheli in 2 cars. Park on roadside and walk to boulder survey stations.
1545-1915	JM/JDD survey station FE5 and 3 boulders at FE3, FB/TK survey station FE2, JJ/LK/EWJ survey station FE6 and 2 boulders at FE3.
2000	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner in cottage at Treborth.

6 June (Mon)

Weather: Mostly dry and sunny with no wind, but also a period of light rain.
Low tide: 0.83m @ 1910

0900-1630	JM/FB/JJ/LK/EWJ/JDD meet at Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing.
1630	Team drive to Britannia Bridge in 2 cars, split into 3 pairs and walk to boulder survey stations.
1645-2015	JM/EWJ survey station BB4, JJ/LK survey station BB3, then repeat 1 boulder at BB4, FB/JDD survey station BB1, then repeat 1 boulder at BB4.
2030	Return to Treborth cottage. Team disperses.
eve	JM/FB/JJ have dinner in cottage at Treborth.

7 June (Tues)

Weather: Mostly dry and sunny with no wind
Low tide: 0.74m @ 1950

0900-1730	JM/FB/JJ/LK/EWJ meet at Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing. PB arrives after lunch. LG visits for briefing on boulder surveys. Team briefing for tide-swept *Fucus serratus* epibiota surveys – going through methodology, protocols and species.
1730	Team drive to Brynsiencyn in 2 cars, split into 3 pairs and walk to tide-swept *Fucus serratus* survey sites.

1810-2040	JM/LK survey Castell Gwylan, FB/JJ survey Llanidan 1, PB/EWJ survey Llanidan 2.
2100	Team disperse.
eve	JM/FB/JJ have dinner at Hydeout Bar-B-Q and Smokehouse, Menai Bridge. AS and JS arrive at Treborth; staying in The Old Granary.

8 June (Wed)

Weather:	Mostly dry and sunny with no wind
Low tide:	0.83m @ 0820
0600	JM/FB/JJ/LK/LJ/LG//EJ/AS meet at Treborth cottage, then split into 3 teams and drive to Britannia Bridge (2 cars) and Felinheli (1 car). Walk to boulder survey stations.
0630-0930	FB/LJ survey station FE1, JM/LK/AS survey station BB2, JJ/LG/EWJ survey station BB5, then 1 boulder (QA repeat) at station BB2.
1015	Team breakfast at Ty Golchi.
1130-1800	Return to Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing. Training / familiarisation session for muddy gravel surveys – going through methodology, protocols and equipment. Divide up stations for each team of surveyors.
eve	JM/FB/JJ/AS/JS have dinner at Bridge Inn restaurant, Menai Bridge.

9 June (Thurs)

Weather:	Dry and sunny with no wind
Low tide:	1.13m @ 0910
0630	JM/FB/PB/JJ/LK/LJ/LG//EJ/AS meet at Treborth cottage and prepare for survey, then split into 3 teams (3 cars) and drive to Menai Strait coast north of Beaumaris.
0730-1030	JM/LJ/EWJ survey muddy gravel stations IECS1, MS18 and MS13 (near Lleiniog); FB/LK/AS survey muddy gravel stations IECS3, IECSB and MS10 (Friars Bay); PB/JJ/LG survey muddy gravel stations IECS2, MS50, MS09.
1045	Team breakfast(!) at Pier café, Beaumaris.
1230-1915	Return to Treborth cottage. Data entry, photo download and catalogue. Specimen identification and cataloguing. Data QA checks. Team members gradually packing-up and dispersing.
eve	JM/FB/JJ have dinner at Neptune Bistro, Beaumaris.

10 June (Fri)

am	JM/FB/JJ pack up and drive back to Pembrokeshire.

Appendix 8 Field log, 23rd – 27th June 2017

Survey Team:	Jon Moore (JM) (survey leader) Tom Mercer (TM) Jen Jones (JJ) Paul Brazier (PB) Laura Grant (LG) Harriet Robinson (HR) Kate Griffiths (KG)

Low tide times and heights are for Menai Bridge. All times are BST

22 June (Thurs)	
pm/eve	Travel to Bangor – JM and JJ drive from Pembrokeshire, TM from County Durham Arrive at Treborth Hall Farm cottages; staying in Old Coach House. Dinner at Hydeout Bar-B-Q and Smokehouse, Menai Bridge.
23 June (Fri)	
Weather:	Grey, but dry with strongish SW wind
Low tide:	0.6m @ 1730
0600	JM collects sample boulder from Britannia Bridge, for training session.
0900-1430	JM/TM/JJ/PB/LG/HR meet at Treborth cottage. Training / familiarisation – going through methodology, protocols and species for boulder surveys. Look at species photographs from previous surveys. Prepare survey equipment etc.
1445	Team drive to Felinheli marina in 2 cars, split into 3 pairs and walk to boulder survey stations.
1520-1830	PB/LG survey station FE5 and then 3 boulders at FE3, TM/JJ survey station FE2 and then 2 boulders at FE3, JM/HR survey station FE6.
1900	Return to Treborth cottage. Team disperses.
eve	JM/TM/JJ have dinner in cottage at Treborth.
24 June (Sat)	
Weather:	Dry and sunny with no wind
Low tide:	0.46m @ 1820
0900-1515	Data entry. Photo download and catalogue. Specimen identification, specimen log and data edits. PB arrives 1000. LG and KG arrive lunchtime. Training / familiarisation for KG. Prepare survey equipment etc.
1515	Team drive to Britannia Bridge in 2 cars, split into 3 pairs and walk to boulder survey stations.
1600-1915	PB/KG survey station BB1 then 2 boulders at BB5, JM/LG survey station BB4 then 2 boulders at BB5, TM/JJ survey station BB3 then 1 boulder at BB5.
2000	Return to Treborth cottage. Team disperses.
eve	JM/TM/JJ have dinner in cottage at Treborth.
25 June (Sun)	
Weather:	Dry and bright with light breeze.
Low tide:	0.47m @ 1910
0900-1630	Data entry. Photo download and catalogue. Specimen identification, specimen log and data edits. PB arrives 1000. KG arrives lunchtime. Team briefing for tide-swept *Fucus serratus* epibiota surveys – going through methodology, protocols and species. Prepare survey equipment etc for boulders and *Fucus serratus* surveys.
1630-2000	TM/KG drive to Felinheli, walk to boulder survey station FE1and survey 7 boulders. JM/JJ drive to Britannia Bridge, walk to boulder survey station BB2 and survey 6 boulders. PB drives to Abergwyngregyn car park, walks to Traeth Lafan *Zostera* bed and maps perimeter of main bed. PB then drives to Felinheli, joins TM/KG at station FE1and surveys 3 boulders by himself.
2030	Team return to Treborth, then disperse.
eve	JM/TM/JJ have takeaway Chinese dinner in cottage at Treborth.
26 June (Mon)	
Weather:	Beautiful morning – sunny and calm, some midges
Low tide:	0.49m @ 0740
0500	JM/TM/JJ/PB/KG meet at Treborth cottage, drive to Brynsiencyn in 2 cars and walk to tide-swept *Fucus serratus* survey sites at Llanidan sites.
0550-0830	PB/JJ/TM survey Llanidan 1, JM/LK survey Llanidan 2.
0900	Team breakfast at Hooton's farm shop.
1000-1900	Return to Treborth cottage. Data entry. Photo download and catalogue. Specimen identification, specimen log and data edits. Data validation.

	JM and PB discuss survey methods, forms and station grid for Traeth Lafan *Zostera* bed survey. JM prepares GIS, forms etc.
	Training / familiarisation session for Traeth Lafan *Zostera* bed survey – going through methodology, protocols and equipment.
eve	JM/TM/JJ have dinner at Dylan's, Menai Bridge.
27 June (Tues)	
Weather:	Grey morning, with some light rain showers but no wind.
Low tide:	0.66m @ 0830
0545	JM/KG meet at Treborth cottage, drive to Brynsiencyn, walk to tide-swept *Fucus serratus* survey site at Castell Gwylan and wait for tide to drop.
0700	PB/TM/JJ meet at Abergwyngregyn car park and walk to *Zostera* bed.
0645-0930	JM/KG survey tide-swept *Fucus serratus* at Castell Gwylan.
0730-1120	PB/TM/JJ survey quadrat stations: TM surveys stations A01 to A31. JJ surveys stations B01 to B31. PB surveys stations C01 to C31.
1000	JM/KG meet Zostera survey team on Traeth Lafan, then return to Treborth cottage to start data entry and specimen identification.
1200	Team breakfast at Ty Golchi.
1300-2000	Return to Treborth cottage. KG leaves. Data entry. Photo download and catalogue. Specimen identification, specimen log and data edits. Data validation.
Eve	Team disperse. TM drives back to County Durham. JM/JJ drive back to Pembrokeshire.

Appendix 9 Data archive

Data outputs associated with this project are archived on server–based storage at Natural Resources Wales (legacy CCW H:\ drive (spreadsheets and images), NRW Y: drive (GIS data) and Marine Recorder.

The data archive contains:

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

[B] Excel spreadsheets of data for each feature as described in this report, including validation, verification and metadata.

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

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

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

[G] A full set of GIS files of any spatial data.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://libcat.naturalresources.wales (English Version) and http://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held within 'intertidal monitoring'.

Recommended citation for this volume:

Moore, J. 2018. Menai Strait and Conwy Bay SAC intertidal monitoring summary, 2010 to 2017. NRW Evidence Report No. 301, 50+ix pp, Natural Resources Wales, Bangor

Published by: Natural Resources Wales
Maes y Ffynnon
Penrhosgarnedd
Bangor
LL57 2DW

03000 653000

Further copies of this report are available from the library

Email: library@cyfoethnaturiolcymru.gov.uk