Cyfoeth Naturiol Cymru
Natural Resources Wales

THE MARINE BIOLOGICAL ASSOCIATION

MarClim Annual Welsh Intertidal Climate Monitoring Survey 2013

Dr. N. Mieszkowska

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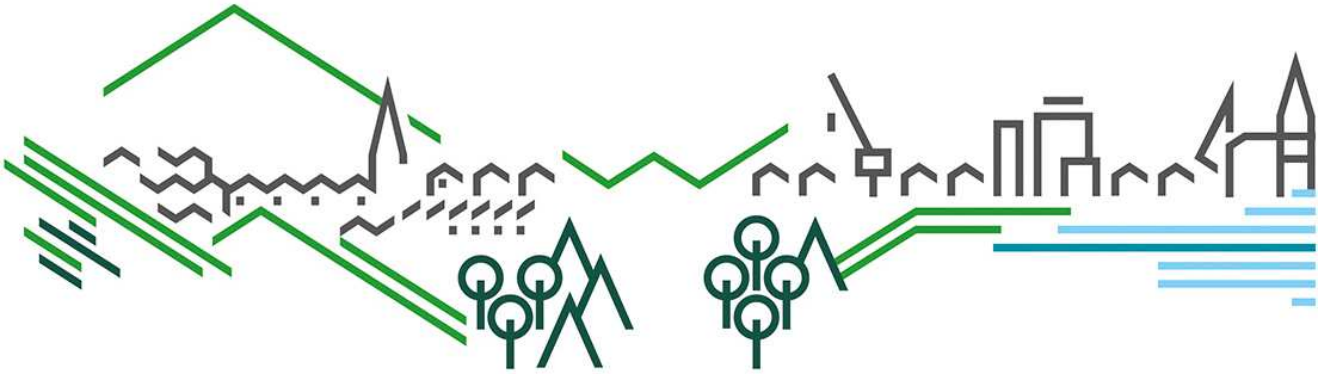

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Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future.

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.

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- 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.

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Crynodeb Gweithredol

Mae'r adroddiad hwn yn rhoi crynodeb o waith, data a dadansoddiad arolwg 2013, a gwblhawyd o dan deitl prosiect MarClim fel y disgrifir yn yr adroddiad gan Mieszkowska (2005) <http://www.mba.ac.uk/NMBL/publications/occpub/occasionalpub20.htm>. Mae'r arolwg blynyddol yng Nghymru yn rhan o arolwg parhaus deuddeg mlynedd y DU. Ymhlith y cwmpas daearyddol mae safleoedd drwy'r gogledd, canolbarth a de-orllewin Cymru ymhle ceir data hanesyddol yn dyddio'n ôl i'r 1950au, a safleoedd ychwanegol lle rhagwelir y bydd tiriogaethau yn ehangu.

Cynhaliwyd arolygon MarClim yn bedwar deg un o safleoedd yn 2013. Arolygwyd deuddeg ar hugain o'r safleoedd yng ngogledd Cymru a naw yn ne Cymru. Gwnaed arolwg yn Llanddulas lle edrychwyd hwnt ac yma am absenoldeb rhywogaethau nodweddiadol ac ychwanegwyd i'r rhestr ar ôl ymddangosiad poblogaeth o *Gibbula umbilicalis* am y tro cyntaf yn 2012, ac mae'r boblogaeth yma dal yno yn 2013 gan ei wneud y lleoliad mwyaf gogleddol yng Nghymru. Fe ychwanegwyd tri safle ar yr amddiffynfeydd arfordirol artiffisial a'r morglawdd artiffisial yn Rhyl a Prestatyn i ganfod a oedd *Gibbula umbilicalis* wedi lledaenu y tu hwnt i Landdulas, ond ni ddaethpwyd o hyd i ddim.

Gall fod yr arafu mewn cynhesu hinsoddol byd eang yn y blynyddoedd diwethaf fod yn ysgogi arafiad helaethrwydd niferoedd mewn cregyn grib a chregyn meheryn dŵr cynnes, fodd bynnag , mae angen dadansoddiad pellach i gadarnhau hinsawdd fel ysgogydd y newidiadau a arsylwyd.

Ni welwyd unrhyw dueddiadau ymledol mewn casgliadau yn ystod cyfres amser 2002-2013, gyda newidiadau bach yn digwydd fesul safleoedd penodol, mwy na thebyg o ganlyniad i amrywiadau naturiol mewn amodau amgylcheddol a ffisegol. Mae llawer o'r rhywogaethau algaidd yng Nghymru yn rhai dŵr oer gogleddol ac mae'r tymheredd yn annhebygol o fod wedi cynyddu digon eto i achosi ansefydlogrwydd yn y lleoliadau lledredau canol, yn annhebyg i safleoedd lledredau isel yn Ewrop lle mae terfynau amrywiaeth môr wiail wedi lleihau wrth i systemau thermol boethi i ganiatáu goroesiad cyfnodau bywyd bregus.

Executive Summary

This report summarizes the 2013 survey work, data and analysis completed under the project title of MarClim as described in the report by Mieszkowska (2005) http://www.mba.ac.uk/NMBL/publications/occpub/occasionalpub20.htm. The annual survey in Wales forms part of a longer, twelve year continuous UK survey. Geographical coverage includes sites throughout north, mid and southwest Wales for which historical data dating back to the 1950s exist, and additional sites where range extensions have been predicted to occur.

MarClim surveys were carried out at forty one sites in 2013. Thirty two sites were surveyed in north Wales and nine sites in south Wales. A survey was carried out at Llanddulas that has been sporadically checked for absence of indicator species and has been added to the list after the appearance of a population of *Gibbula umbilicalis* was found in 2012 for the first time, and this population is still present in 2013 making this the current most northerly location in Wales. Three additional sites on artificial coastal defences and the artificial seawall at Y Rhyl and Prestatyn were added to see if *Gibbula umbilicalis* had spread beyond Llanddulas, but none were found.

The slowdown in global climate warming in recent years may be driving the slowdown in abundance increases in the warm water topshells and limpets, however, further analysis is required to formalize climate as a driver of the observed changes.

No pervasive trends in assemblages were seen across the 2002-2013 time series, with small changes occurring on a site-specific basis, most likely due to natural fluctuations in local environmental and physical conditions. Many of the algal species in Wales are Boreal coldwater in origin and temperatures are unlikely to have increased sufficiently yet to cause mortalities at these mid-latitude locations, unlike low latitude sits in Europe where kelp range limits have retreated as thermal regimes have become hot to allow survival of vulnerable life stages.

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1. INTRODUCTION

The MarClim project was established in 2001 to investigate changes that had occurred in rocky intertidal systems within the last 50 years around the UK. MarClim established a low-cost network of sites covering England, Wales and Scotland which provided subsequent annual updates to track how climate influences the marine biodiversity of the British Isles (Mieszkowska *et al*. 2005). In addition, a comprehensive survey of shores in Ireland and Northern Ireland was undertaken in 2003 (Simkanin *et al*. 2005). Natural Resources Wales (Countryside Council for Wales) has continued to fund annual surveys of the Welsh MarClim sites, including additional sites beyond species distributional limits to track range extensions as they occur.

The main aims at the outset of the MarClim project in 2001 remain as follows:

- To use existing historical information and collect new data on intertidal indicator species from the last 50-100 years to develop and test hypotheses on the impact of climatic change on marine biodiversity in Britain and Ireland.
- To forecast future marine community changes on the basis of the Met Office's Hadley Centre climate change models and the United Kingdom Climate Impacts Partnership's climate change scenarios. The broad range of species known or likely to be temperature sensitive was covered.
- To establish low-cost, fit-for-purpose, methodologies and networks to provide subsequent regular updates and track how climate influences the marine biodiversity of Britain and Ireland.
- To provide general contextual time series data to support reporting on the success or otherwise of the Marine Strategy Framework directive, marine aspects of Biodiversity Action Plans, European initiatives including the Habitats, Birds and Water Framework Directives, and management and monitoring of marine activities and resources, including fisheries and Special Areas of Conservation.
- To evaluate whether the climate indicator species used in this work have a wider contribution to make as part of the sustainability indicators that are needed to underpin the UK sustainable development strategy.
- To disseminate the results widely, and accordingly elucidate the known impact climate has had on marine biodiversity over the last 100 years, and may have in the future.
- To provide a basis for the development of a proposal for European Commission funding to establish a pan-European network with related aims.
- To assess and report on the likely consequences of the predicted changes in response to climate for society, for commercial and non-commercial users of the marine environment and the policies and frameworks that conserve, manage and protect marine biodiversity. To assess whether any more serious impacts can be ameliorated or mitigated.

2. BACKGROUND

Prof. Southward of the Marine Biological Association first spotted the link with climatic fluctuations, prompted in part by his own observations in changes in competing Boreal and Lusitanian species of barnacles along the coastline of the English Channel in the 1950s. The Boreal coldwater species *Semibalanus balanoides* was common in the 1930s and rarer in the warmer 1950s, when the southern species *Chthamalus stellatus* (split into two species, *C. stellatus* and *C. montagui* by Southward in the 1970s) increased in abundance. Following a switch to colder conditions in the 1960s, *S. balanoides* again became more dominant, whereas recent warming from the late 1980s onwards led to an increase in *Chthamalus species*. These changes in barnacles mirrored switches between herring and pilchard and changes in plankton, benthos and demersal fish, but the response of intertidal species was often far quicker than for other components of marine ecosystem, making then early warning indicators of environmental change.

Southward and Prof. Crisp (Bangor University) carried out surveys of barnacles and other rocky intertidal invertebrates and macroalgae around the coastline of Wales, England and Scotland in the 1950s, with ad-hoc resurveys during the 1960s-1980s. Prof. Lewis and his team at the Robin Hood's Bay Laboratory (Leeds University) undertook surveys on the distribution and abundance of rocky intertidal invertebrates in the 1980s, extending the scope to include newly developed quantitative surveys for topshells and limpets and investigations of reproductive cycles in these species.

The MarClim project was established in 2001 to rescue, centrally archive and analyse these data, and to establish a current UK baseline on the distribution and abundance of keystone intertidal invertebrates and macroalgae. MarClim was consortium funded from 2001-2005 by Natural England (then English Nature), Natural Resources Wales (then Countryside Council for Wales), Scottish Natural Heritage, Scottish Government (then Scottish Executive), Defra, JNCC, The Crown Estate, States of Jersey and WWF. The MarClim project has carried out annual surveys at rocky intertidal survey sites where long-term data exists since 2002. MarClim established a low cost network of sites covering England, Wales and Scotland which provided subsequent annual updates to track how climate influences the marine biodiversity of the British Isles (Mieszkowska et al. 2005. The network was downsized at the end of MarClim Phase I in 2005 to a subset of thirty sites in England (due to cessation of funding) and 35 sites in Wales (in conjunction with Countryside Council for Wales). Natural England enabled the restart of eleven additional sites in England in 2010 that have been resurveyed again in each subsequent year to date. This network, together with the baseline information provided by the MarClim project, are being used by scientific and policy communities as key tools to track impacts on biodiversity as climate change.

MarClim surveys around the Welsh coastline are currently funded by Natural Resources Wales with in-kind contributions from the Marine Biological Association of the UK, and academic staff from National University of Ireland Galway University of Newcastle on their own time. These surveys form part of a wider network of long-term MarClim sites in England (funded by Natural England) and France (funded by the Interreg Marinexus project).

The project focuses on a robust set of temperature-sensitive, readily observed, intertidal climate indicator species of invertebrates and macroalgae for which long-term data sets and monitoring sites are available. The MarClim species list includes boreal cold-water and Lusitanian warm-water origins, and non-native species that pose a potential threat to native biodiversity (Appendix 1) in collaboration with the UK Marine Aliens Project http://www.marlin.ac.uk/marine_aliens/. Climate-driven shifts in the biogeographic ranges of these and other species are being tracked by Dr Mieszkowska around northern Europe using the MarClim protocols. Non-natives are also targeted due to their appearance and subsequent impacts on natural communities after introduction via escapes of associated spat from mussel and oyster aquaculture facilities and practices. MarClim data has shown major shifts in biogeographic distributions of both cold and warm water species around the coastline of the UK since the onset of climate warming in the mid-1980s, and associated changes in abundance, population structure and physiological responses across several taxonomic groups (Mieszkowska et al. 2005, 2006, Mieszkowska 2009). These changes are amongst the fastest recorded globally and up to ten times faster than those recorded in terrestrial systems. The methodology is therefore field-tested and proven as a suitable broadscale climate detection tool.

Additional species have been added since 2002 to encompass those shifting distributional ranges into the UK tracking a warming climate, and Invasive Non-Native Species identified as posing a risk to native rocky intertidal communities. To ensure comparability with the historical data the original methodology was retained for ACFOR (now SACFOR) scoring of species abundances and barnacle quadrat counts. Additional quantitative methodology to facilitate robust statistical analysis and modelling has been incorporated since 2002 and is detailed in the Survey Protocols section below.

3. METHODS

The MarClim protocols (Appendix 1) were used as the standard survey methodology. These protocols include additional alien species of concern to NRW or pertinent to the Defra GB Non-Native Species Portal https://secure.fera.defra.gov.uk/nonnativespecies/home/index.cfm. Semi-quantitative SACFOR abundance scores were recorded for a suite of 75 species of invertebrates and macroalgae, including nine non-native invertebrate and nine macroalgal species. Non-native species added to the list in 2013 were the red algae *Heterosiphonia japonica* and *Gracilaria vermiculophylla,* both species thought to be now present in the UK and a potential risk for invasion of natural rocky intertidal communities.

Replicate, quantitative quadrat counts were made for barnacles (10 cm^2) and limpets (0.25m^2). Replicated timed searches were made for topshells (5 x 3 minutes). All data have been submitted to NRW in electronic format. All surveyors had been trained in MarClim methodology and cross-calibrated in the field with Dr Mieszkowska. An additional site at Holyhead was added to the MarClim Wales site network in 2010 and has been re-surveyed annually to track any potential spread of the non-native ascidian *Didemnum vexillum* which has been the subject of an intense eradication program by NRW inside Holyhead marina (http://www.NRW.gov.uk/.../NRW-in-holyhead-harbour.aspx).

MarClim surveys were carried out at forty three sites in 2013 (Table 1, Figure 1). Thirty six sites were surveyed in north Wales and seven sites in south Wales. These included 33 sites that form part of the MarClim/NRW annual long-term monitoring program and three sites where some historical and current data exists. An additional site at Llanddulas which has been sporadically checked for absence of indicator species has been added to the list after the appearance of a population of *Gibbula umbilicalis* was found in 2012 for the first time, and two new locations of artificial habitat at Prestatyn and Y Rhyl checked for the presence of *G. umbilicalis* in 2013 as potential locations for the further spread of this species along the North Wales coastline.

Rocky shores in north Wales were surveyed by Dr. Nova Mieszkowska and Beatriz de Francisco Mora from the Marine Biological Association, Paul Brazier, Kathryn Birch, Ben Wray, Chloe Jennings from Natural Resources Wales, Dr. Heather Sugden from Newcastle University and Dr. Louise Firth from National University Ireland Galway (Figure 2 & 3). Seven sites were surveyed in south Wales including two sites on the Skomer MNR and five on the mainland. These surveys were carried out and cross-calibration exercises undertaken by Mark Burton of NRW and Leoni Adams (MBA). All surveyors have either carried out cross-calibrations with Mieszkowska in several previous years or were trained on site to ensure accurate continuation of sample methodologies and protocols. Data entry was completed by Leoni Adams with a QA by Nova Mieszkowska and Leoni Adams.

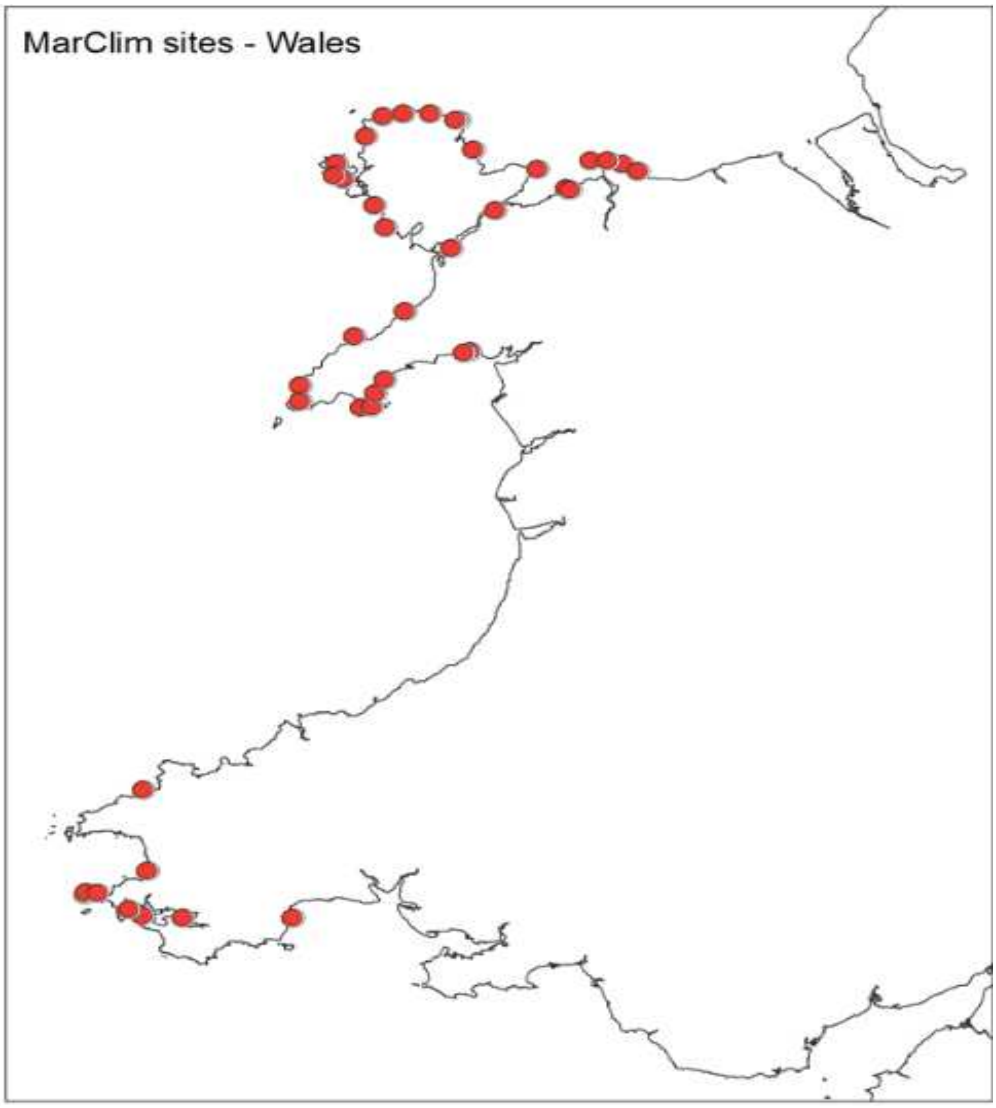

Figure 1. Sites surveyed by MarClim for NRW in 2013

Figure 2. NRW staff, topshell measuring at Moelfre

Figure 3. MarClim & NRW cross-calibrate with limpet quadrat recording at Point Lynas

Table 1. MarClim Survey Site Locations 2013: NM: Nova Mieszkowska, HS: Heather Sugden, LF: Louise Firth, BM: Beatriz de Francisco Mora, LA: Leoni Adams, PB: Paul Brazier, BW: Ben Wray, MB: Mark Burton, CJ: Chloe Jennings

Day	Month	Year	Site	Grid	Lat	Long	Recorder
22	7	2013	Prestatyn artificial sea defences	SJ059839	53.3439	-3.4438	HS, LF
22	7	2013	Rhyl sea wall	SJ021824	-3.4138	-3.4716	HS, LF
22	7	2013	Llanddulas	SH906787	53.2933	-3.6296	HS, LF
22	7	2013	Little Orme	SH812825	53.3260	-3.7852	NM, HS,LF,BM,PB, CJ
22	7	2013	Rhos-on-Sea	SH843805	53.3114	-3.7381	NM, HS,LF,BM, CJ
22	7	2013	South Haven	SM733088	51.7319	-5.2845	MB
22	7	2013	North Haven	SM735093	51.7365	-5.2819	MB
23	7	2013	Penmaenmawr Natural	SH704763	53.2683	-3.9440	HS, BM
23	7	2013	Penmaenmawr Artificial	SH709763	53.1613	-3.5601	HS, BM
23	7	2013	Penmaenmawr Slipway	SH699766	53.2712	-3.9521	HS, BM
23	7	2013	Great Orme Trwynygogarth	SH749834	53.3327	-3.8801	NM, HS,LF,BM
23	7	2013	Great Orme East	SH782832	53.3321	-3.8297	NM, HS,LF,BM
23	7	2013	Trefor	SH376474	52.9992	-4.4215	NM, HS,LF,BM
23	7	2013	Caernarfon (Aber Foreshore Road)	SH521671	53.1374	-4.2897	NM, HS,LF,BM
23	7	2013	Penmon North	SH641813	53.3111	-4.0413	NM, HS,LF,BM
23	7	2013	Menai Bridge	SH555714	53.2207	-4.1643	NM, HS,LF,BM
24	7	2013	Bull Bay	SH427945	53.4238	-4.3688	NM, HS,LF,BM,BW,KB, CJ
24	7	2013	Moelfre	SH513859	53.3490	-4.2354	NM, HS,LF,BM,BW,KB, CJ
24	7	2013	Point Lynas	SH484929	53.4111	-4.2823	NM,LF,KB
24	7	2013	Porth Eilian	SH477929	53.4109	-4.2928	HS,BW, CJ
24	7	2013	Holyhead	SH257825	53.3108	-4.6461	NM, HS,LF,BM
24	7	2013	Porth Swtan	SH298891	53.3713	-4.5598	NM, HS,LF,BM,KB
24	7	2013	Cemlyn	SH337934	53.4146	-4.5112	NM, HS,LF,BM,KB
24	7	2013	Cemaes Bay	SH372944	53.4219	-4.4502	NM, HS,LF,BM, KB
25	7	2013	Rhosneigr	SH315725	53.2233	-4.5253	HS,BM
25	7	2013	Trearrdur Bay	SH252789	53.2790	-4.6231	HS,BM
25	7	2013	Aberffraw (Briach-Lwyd)	SH337674	53.1776	-4.4899	NM, HS,LF,BM
25	7	2013	Porth Dafarch	SH233798	53.2856	-4.6522	NM,LF
25	7	2013	Porth Oer B	SH163297	52.8344	-4.7256	NM, HS,LF,BM,PB,BW, CJ
25	7	2013	Nefyn	SH274415	52.9430	-4.5702	NM, HS,LF,BM
26	7	2013	Porth Neigwl	SH288245	52.7908	-4.5404	NM, HS,LF,BM,BW, CJ
26	7	2013	Aberdaron	SH166260	52.8003	-4.7220	NM, HS,LF,BM
26	7	2013	Llanbedrog	SH335311	52.8516	-4.4742	NM, HS,BM
27	7	2013	Porth Ceriad	SH308247	52.7938	-4.5094	NM, HS,BM
27	7	2013	Abersoch Lifeboat Station	SH317280	52.8232	-4.4993	NM, HS,BM
27	7	2013	Criccieth (East)	SH494376	52.9186	-4.2236	NM, HS,BM
27	7	2013	Criccieth Castle	SH494376	52.9146	-4.2412	NM, HS,BM
19	8	2013	Martin's Haven	SM759091	51.7357	-5.2471	MB, LA
21	8	2013	Pembrokeshire powerstation outflow	SM930032	51.6896	-4.9956	MB
21	8	2013	West Angle	SM848038	51.6916	-5.1151	MB, LA
18	9	2013	Dale	SM822053	51.7041	-5.1533	MB, LA
19	9	2013	Monkstone Point	SN150033	51.6978	-4.6784	MB, LS
20	9	2013	Abercastle	SM851338	51.9610	-5.1294	MB, LS
20	9	2013	Broad Haven	SM859144	51.7871	-5.1057	MB, LA

4. RESULTS

4.1. 2013 Findings

4.1.1. Recent changes in the global and regional climate

The latest findings from the IPCC 5th Assessment Working Group I Report on the Physical Science Basis of Climate Change http://www.ipcc.ch/report/ar5/wg1/#.Uwt9YvYzmlI reveal that the earth's climate has not warmed as rapidly over the last decade compared to the longer-term warming trend, which is tied to natural variability in the earth's climate system. This recent slowdown must be placed into context; each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 and the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years. On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by 0.11 [0.09 to 0.13] °C per decade over the period 1971 to 2010. The UK experienced colder than average winter in 2012/13, and the MarClim data have been analysed to see if any signals of this warming 'hiatus' or the cold weather event (long versus short-term thermal drivers) were evident in terms of responses of species with Boreal coldwater or Lusitanian warm water origins.

Related research being undertaken by an international working group comprised of world-leading climate modellers, ecologists and physiologists (including Mieszkowska) has produced the first monthly air and sea temperature anomaly plots for the west coast of Wales and England at a fine spatial resolution of 10s km using NOAA's National Climatic Data Center at http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily.php. AVHRR-only data were used because it is the only daily SST analysis that extends back to 1981/1982 (Figures 4 & 5). The site numbers are based on MarClim long-term survey sites, with 36 being Monkstone Point, the most southern site in Wales and 71 being Rhos-on-Sea, the most northern site. These plots show how 2007 and 2008 were the warmest years for both sea and air temperatures since the start of the MarClim annual surveys in 2001, with subsequent cooler years more similar to environmental temperatures experienced in the early to mid-1980s.

Ongoing research led by Mieszkowska is looking to build new climate models that use physical data at a spatial and temporal resolution suitable to analyse the MarClim site-specific data and determine species and community level responses to recent change, then forecast future changes based on new IPCC and Met Office/Hadley Centre climate forecasts.

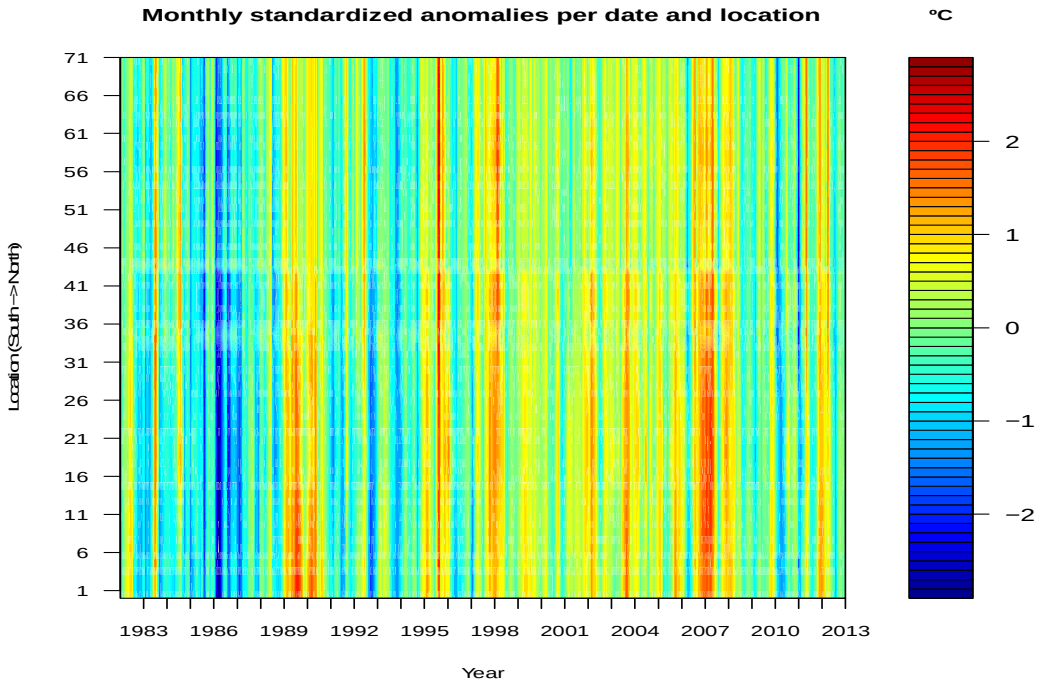

Figure 4. Monthly standardised air temperature anomalies for the west coast of the UK. Data sourced from NOAA's National Climatic Data Center at http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily.php.

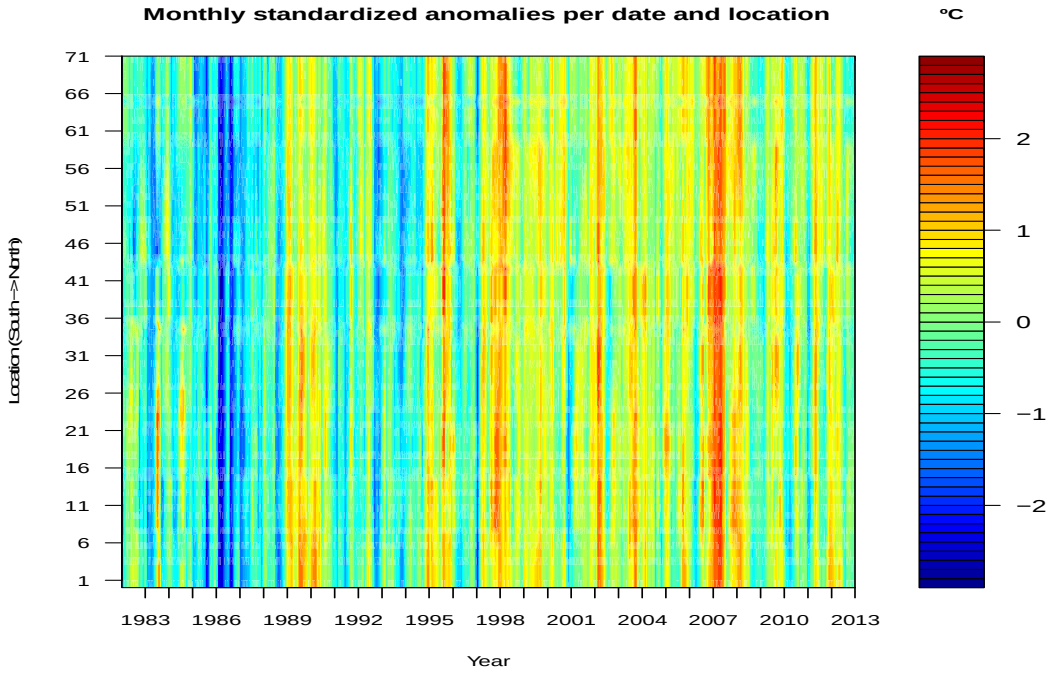

Figure 5. Monthly standardised sea surface temperature anomalies for the west coast of the UK. Data sourced from NOAA's National Climatic Data Center at *http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily.php*.

4.1.2. Lusitanian 'warm water' species

The BAP habitat forming species of polychaete *Sabellaria alveolata* has been recorded around north Wales as both sustained and transient populations in previous MarClim and other surveys (Frost *et al*. 2004). The boulder fields at Criccieth East and Aberystwyth have always had an Abundant population forming flat reefs in the mid to low eulittoral zones since MarClim surveys began in 2002, whereas the populations are ephemeral at Rhosneigr (Not Seen 2002-2005; Rare 2006; Not Seen 2007; Common 2008; Rare 2009; Not Seen 2010-2013) and Little Orme (Not Seen 2002-2006; Rare 2007; Not Seen 2008-2011; Rare 2012; Common 2013) with no obvious pattern within these fluctuating populations linking to the lifecycle or climate dynamics. Isolated records of *S. alveolata* occur from MarClim surveys at Great Orme Trwyn-y-gogarth (2006), Llanddulas (2008) and Abersoch (2008).

A temporal meta-analysis of populations of *S. alveolata* carried out by Firth and Mieszkowska using data from surveys in the 1960s and 1980s (Cunningham *et al*. 1984), and 2000s (Frost *et al*. 2004) and MarClim data 2002-2013 found that for the combined list of survey sites, *S. alveolata* was present in 2012 at most of the sites where it had previously been recorded. The multi-decadal distribution of *S. alveolata* has maintained similar abundances at sites of established populations and increased along the coastline of the north Wales/Wirral region in recent years, facilitated in part by the provision of artificial hard substrata in the form of coastal defence structures in this region (Firth *et al*. in review).

Great Orme East still marks the northern range limit of *Phorcus (Osilinus) lineatus*, which was first recorded as a multi-age population (as opposed to isolated individuals) in 2010, with abundances increasing from Occasional (1 per minute search), 2011 (1.47 per minute search), to Frequent (7 per minute) in 2012 but decreasing back to Occasional (1.4 per minute search) in 2013. Fewer individuals are present on the west coastline of the Great Orme (0.67 per minute search, 2013) and it is likely that these small range edge populations at Great Orme are seeded by larvae from the Caernarfon and Anglesey populations.

Previous searches at Llanddulas, the most north-easterly site for *Gibbula umbilicalis* in Wales have not recorded this warm water topshell until 2008 when it was Frequent (1.75 individuals per minute search). This population had increased to Common in 2012, with an average of 10.67 individuals per minute search but declined to Frequent in 2013 with three individuals per minute search recorded. This location is the last site before a large discontinuity in the biogeographic distribution of *G. umbilicalis*, due to lack of rocky substrate until southwest Scotland, and population dynamics mirror those at true range limits, fluctuating in abundance due to low abundances at the range edge and adjacent sites likely to be the source of larvae to the range edge site. *G. umbilicalis* had not been seen at Rhos-on-Sea since 2009, most likely due to repeated heavy siltation of the site, however, replicated timed counts found an average of 3.13 individuals per minute suggesting that a population has been able to become re-established.

Unlike the topshells, the warm water limpet *Patella depressa* has not shown northern shifts in distributional limits (not recorded north of Porth Neigwl since the 1990s) despite increases in abundance and increases in relative abundance compared to the coldwater limpet *Patella vulgata* throughout the 2000s and 2010s in England and Wales. A population of *P. depressa* was found at Aberdaron, 3km west of Porth Neigwl in Aberdaron Bay in 2012, where previously only a single individual had been recorded in 2007, 2008 and two individuals in 2010. This population was scored as Frequent in 2012 (mean density 4.8 individuals per m^2) but only Occasional in 2013

(mean density 1.6 individuals per m^2) from targeted searches in the midshore region on large, immobile boulders.

The warm water *Saccorhiza polyschides* has shown a rapid increase in the intertidal fringe of kelp forests in France and England, in some places totally excluding native coldwater Laminarians since this species was added to the MarClim list in 2007. Observations from subtidal dive surveys carried out by the Skomer MNR team and MRes student projects in Plymouth supervised by Mieszkowska indicate that *S. polyschides* has been increasing in abundance far more rapidly in subtidal kelp beds along the Atlantic coastline of France and the southern coastline of England during the 2000s. These observations suggest that the colonisation and dominance of kelp forests in the UK is driven by subtidal populations where environmental temperatures are more stable and do not approach lower lethal temperatures, whereas intertidal populations are subject to cold winter air temperatures likely to result in juvenile mortalities within the intertidal fringe.

The pattern of increasing intertidal abundances of *S. polyschides* was observed until 2013, when abundances have declined 2 or more SACFOR abundance categories around the English coastline, and have declined to low densities or were Not Recorded at several sites on Anglesey and the north Wales mainland where this species had previously been recorded (Caernarfon, Cemaes, Porth Swtan, Rhosneigr, Aberffraw, Nefyn, Porth Oer, Aberdaron, Porth Neigwl) and at West Angle Bay and Dale in Pembrokeshire. The sudden disappearance of intertidal individuals may be due to the cold winter in 2012 and/or the slowdown in global warming that has occurred in recent years, resulting in colder intertidal temperatures than in the previous decade.

4.1.3. Boreal 'coldwater' species

Species of UK concern with respect to climate-driven declines in abundance and distribution include the kelp *Alaria esculenta*, fucoid *Pelvetia canaliculata* and the barnacle *Semibalanus balanoides*. None of these species have southern distributional limits currently in Wales and the Welsh MarClim sites show little variation in population abundance across the 2002-2013 time period (Figure 4d-f). Section 4.2.1. investigates long-term patterns in abundance of coldwater macroalgae around the Welsh coastline.

4.1.4. Invasive Non-Native Species

Three Invasive Non-Native Species were recorded in Wales in 2013. The invasive barnacle *Austrominius modestus* has been present in the UK since the 1940s. Within communities that it has invaded, no adverse effects have been recorded and the barnacle seems to achieve densities less than or similar to native barnacles, with no noticeable alteration to ecosystem structure and functioning. It has not been recorded on the east side of Anglesey or the northern coastline of the Llyn Peninsula in recent years and infrequently at sites in Cardigan Bay on the south coastline of the Llyn Peninsula.

The Japanese brown alga *Sargassum muticum* has been present in the UK since the 1970s. Across the 43 MarClim survey sites, only one had a new record of *S. muticum* in 2013*;* Penmon North. Three populations have retained similar densities in 2013 to previous years; Menai Bridge, Trearrdur Bay and West Angle Bay. The new population at Porth Oer that was Abundant in rockpools in 2011, declined to Rare in 2012 and was again Abundant in 2013 (Figure 6). *S. muticum* re-appeared at Dale for the first time in 2011 since 2007, but declined to Rare in 2012 and was Not Seen in 2013. *S. muticum* had disappeared from Aberdaron, Dale and Milford Haven in

2013 and was Not Seen at the other 34 sites where it has not previously been recorded. These data show that for MarClim sites, this INNS is not spreading nor increasing in abundance at sites where it is established.

Figure 6. Abundant *S. muticum* in rockpools at Porth Oer in 2013.

The seasquirt *Corella eumyota* has previously been recorded for Wales (according to the NBN and published research papers) recorded in Milford Haven (Cosheston and Gelliswick) in surveys carried out by the MarClim team in 2010, Victoria Dock, Caernarfon in 2011 and Port Dinorwic, Menai Strait in 2011 (Marine Non-native species records from Countryside Council for Wales (NRW) monitoring research and ad-hoc sightings, NBN database). In 2009 to the present, *C. eumyota* was recorded at low levels near Brynsiencyn (Llanidan pier and Castell Gwylan) and at Britannia Bridge, it was Occasional in 2009 and 2010, becoming Common in 2011 and 2012, during NRW Menai Strait monitoring surveys (Moore *et al*. 2010). In 2012 MarClim surveys found *C. eumyota* on the underside of cobbles and small boulders at Caernarfon (Rare), Menai Bridge (Common), Holyhead (Frequent) and Trefor (Common) (Figure 5). In 2013, *C. eumyota* was not found at any of the sites where it was recorded in 2012 despite targeted searches in areas of suitable underboulder and cobble habitat. These findings suggest that outbreaks of *C. eumyota* may not yet be sufficient to ensure colonisation of natural habitat in current environmental conditions in north Wales. Further NRW monitoring surveys have recorded frequent *C. eumyota* in the Menai Strait and Shore Thing surveys at Church Island also recorded this species.

Holyhead was added as a MarClim site in 2009 to track the potential spread of the invasive colonial ascidian *Didemnum vexillum* from its recorded introduction in Holyhead marina. This adjacent rocky shore has not yet been colonised by *D. vexillum*.

Crassostrea gigas has only been found in a few sites around Wales since 2002; Criccieth East (Rare in 2008, Not Seen since), Great Orme Trwyn-y-gogarth (Rare in 2009 and 2010, Not Seen in 2011 and 2012), Great Orme East (Rare 2010, Not Seen before or after this year), and was Rare in 2012 at Caernarfon and Moelfre. No *C. gigas* individuals were found at any site during the 2013 survey.

The solitary tunicate *Styela clava* is not on the MarClim list, but the surveyors found it to be present in low densities on the concrete supports of the old lifeboat slipway at Abersoch in 2013 (Figure 7).

Figure 7. The invasive *Styela clava* on concrete slipway at Abersoch lifeboat station.

4.2. Spatio-temporal trends

Multidimensional scaling analyses were performed for the macroalgal assemblages present at five sites around the Welsh coastline; Penmon North and Rhosneigr on Anglesey, Porth Oer and Porth Neigwl on the Llyn Peninsula in north Wales, Martin's Haven and West Angle Bay in Pembrokeshire in south Wales (Figure 8-13).

The distance between successive survey years on the plots represents the degree of similarity in the abundance of each species comprising that year's assemblage. None of the sites show a unidirectional trend, which would indicate a long-term pervasive change in conditions. Each site also follows a different trajectory from year to year, indicating that local factors or stochasticity in the local environment is driving changes rather than a pervasive pressure such as climate change that would show similar impacts across large spatial and long temporal scales.

Outlier years at Penmon North (Figure 9) were 2005 and 2009 indicating that in these two years the presence and abundance of algae on the MarClim list were most different from the other years in the time-series. The lack of *Saccharina latissima* in 2005 and 2009, appearance of *Halidrys siliquosa* for the only instance in 2005 and the presence of *Codium* sp. but absence of *Fucus vesiculosus* in 2009 contributed to the dissimilarity.

Rhosneigr had no *Sargassum muticum* present in 2002, 2005 and 2007, *Chondrus crispus* was Not Seen in 2002 and 2007, *Fucus serratus* was Not Seen in 2002 and *Pelvetia canaliculata* had a lower than average abundance in 2007.

At Porth Oer, 2002 and 2004 differed due to the tides not dropping low enough to get around the headland to the large low eulittoral/shallow infralittoral macroalgal beds. In 2009 higher than average abundances were recorded for the kelps *Laminaria hyperborea, Saccharina latissima* and *Himanthalia elongata*.

The years 2008 and 2009 at Porth Neigwl differed due to the kelps observed; this was due to the wave conditions being sufficiently calm compared to previous years that the kelp beds were not covered in the surf and could be properly surveyed. The warm water kelp *Saccorhiza polyschides* was recorded for the first and only time here in 2009. Martin's Haven had no *S. latissima, F. vesiculosus* or *F. spiralis* recorded in 2003 but these species were all present in subsequent years.

None of these site-level changes represent more than a temporary, small change in abundance that are observed in natural communities existing in naturally fluctuating environmental conditions. With the exception of a single record of an individual *S. polyschides* at Porth Neigwl in 2009, no new sightings of warm water species have been recorded yet at MarClim long term sites in Wales.

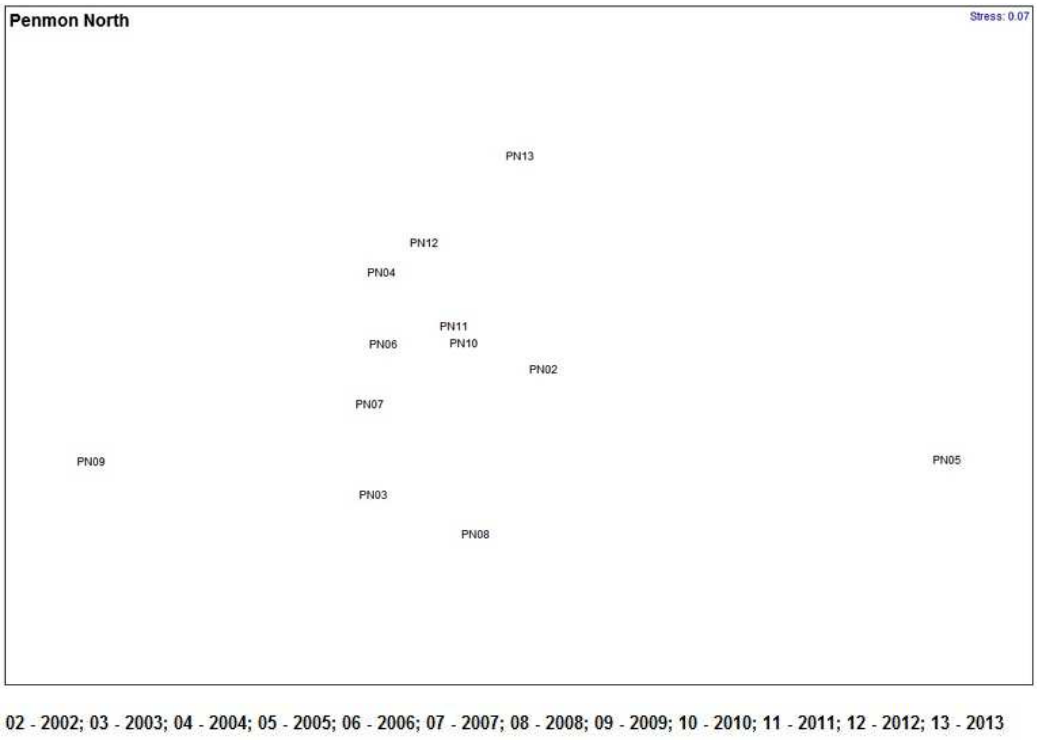

Figure 8. MDS plot of macroalgal assemblages at Penmon North 2002 – 2013.

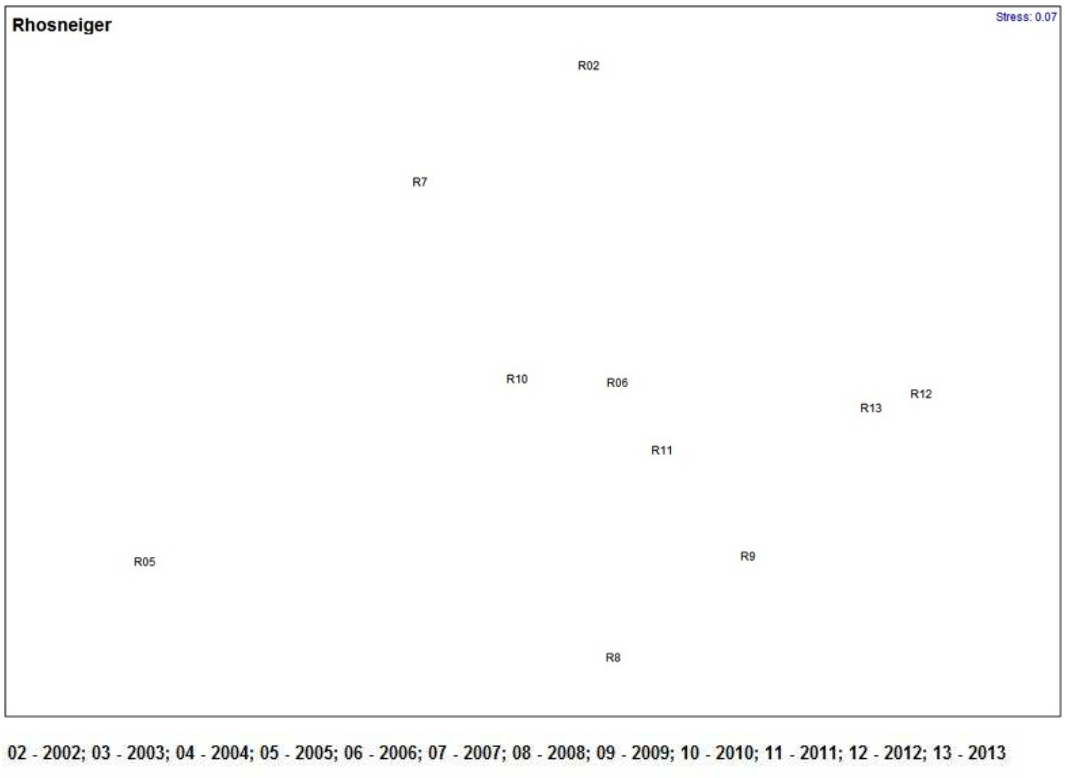

Figure 9. MDS plot of macroalgal assemblages at Rhosneigr 2002 – 2013.

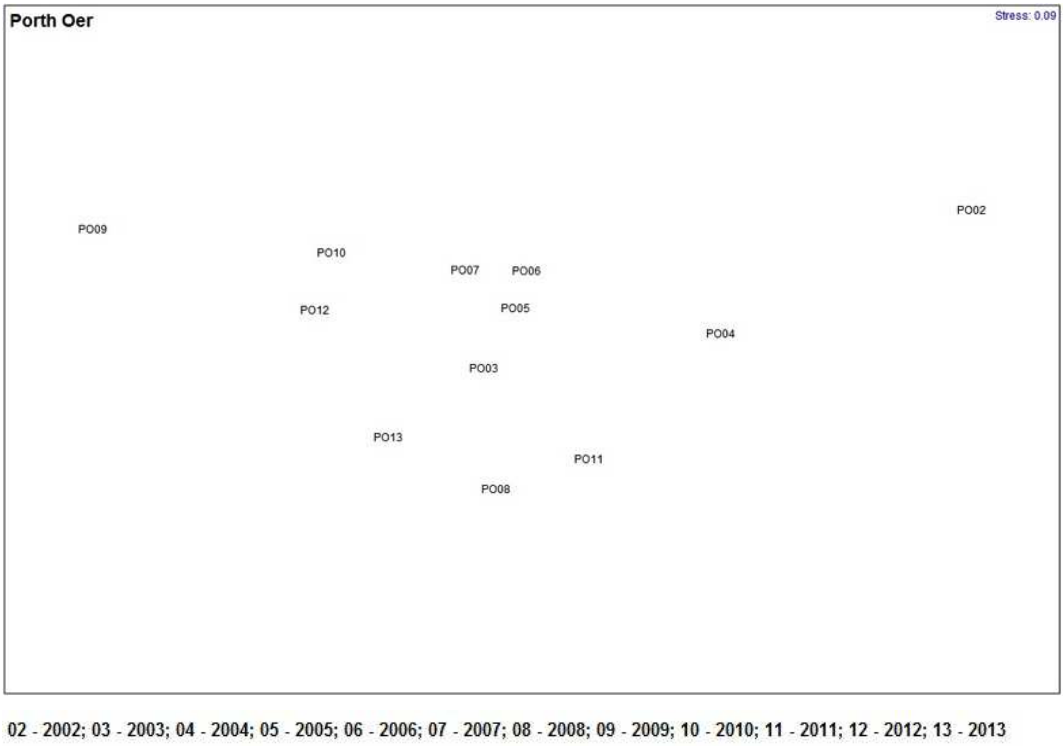

Figure 10. MDS plot of macroalgal assemblages at Porth Oer 2002 – 2013.

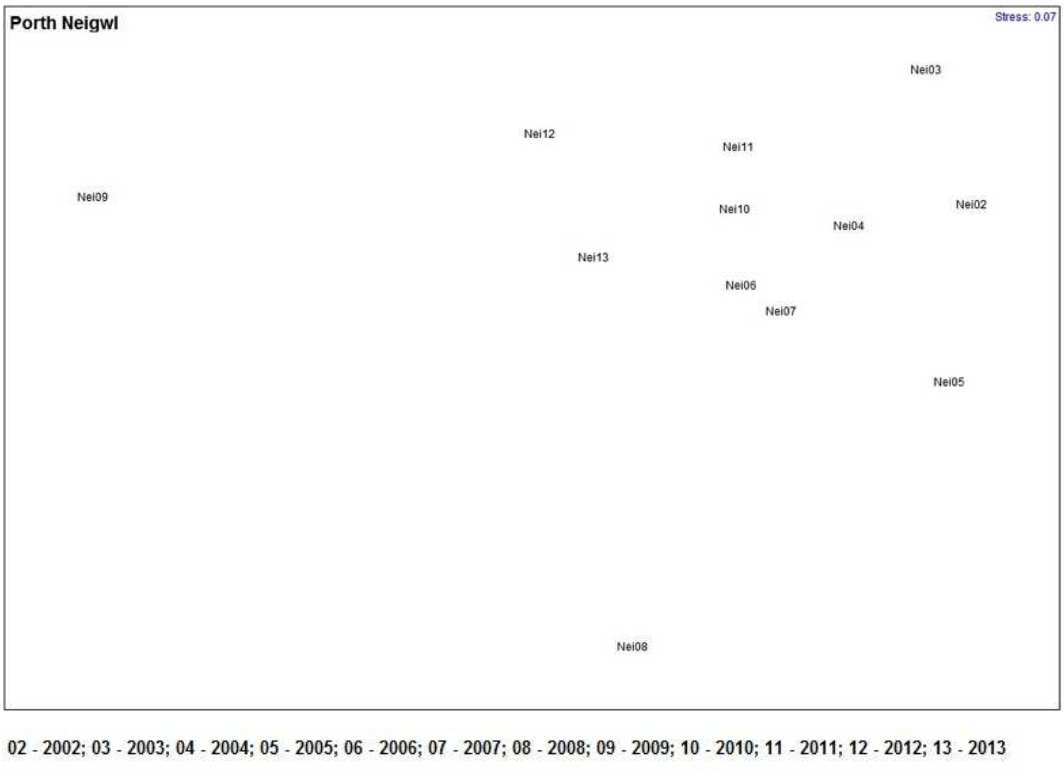

Figure 11. MDS plot of macroalgal assemblages at Porth Neigwl 2002 – 2013.

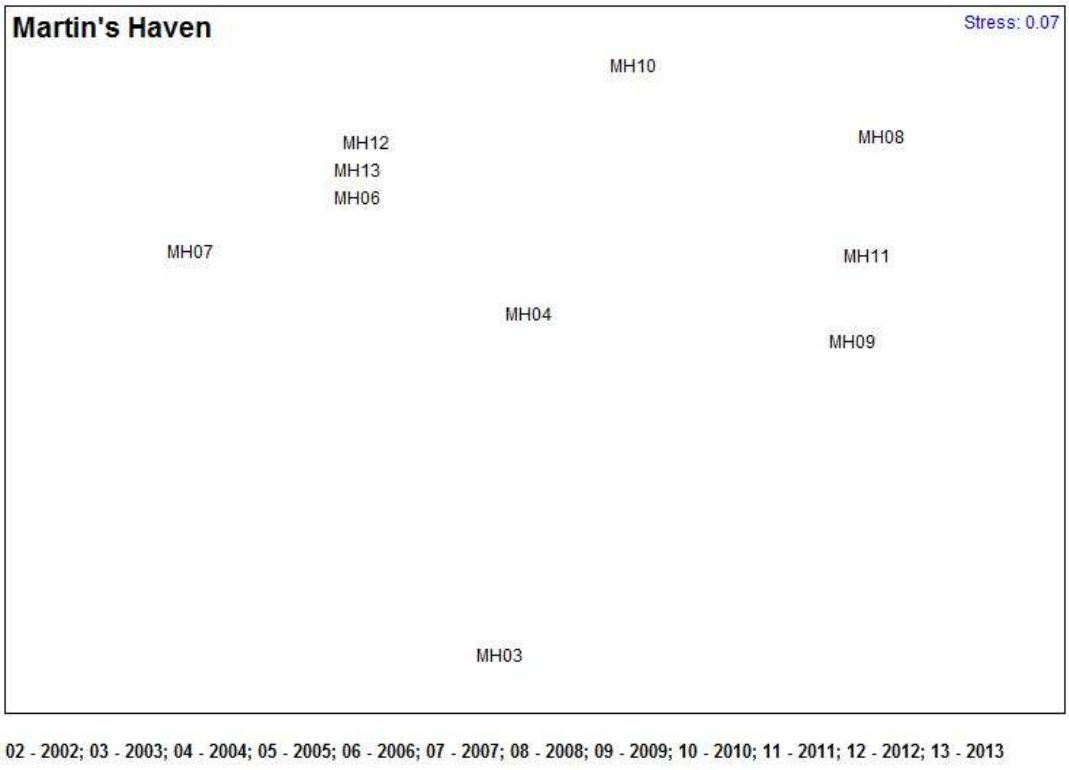

Figure 12. MDS plot of macroalgal assemblages at Martin's Haven 2002 – 2013.

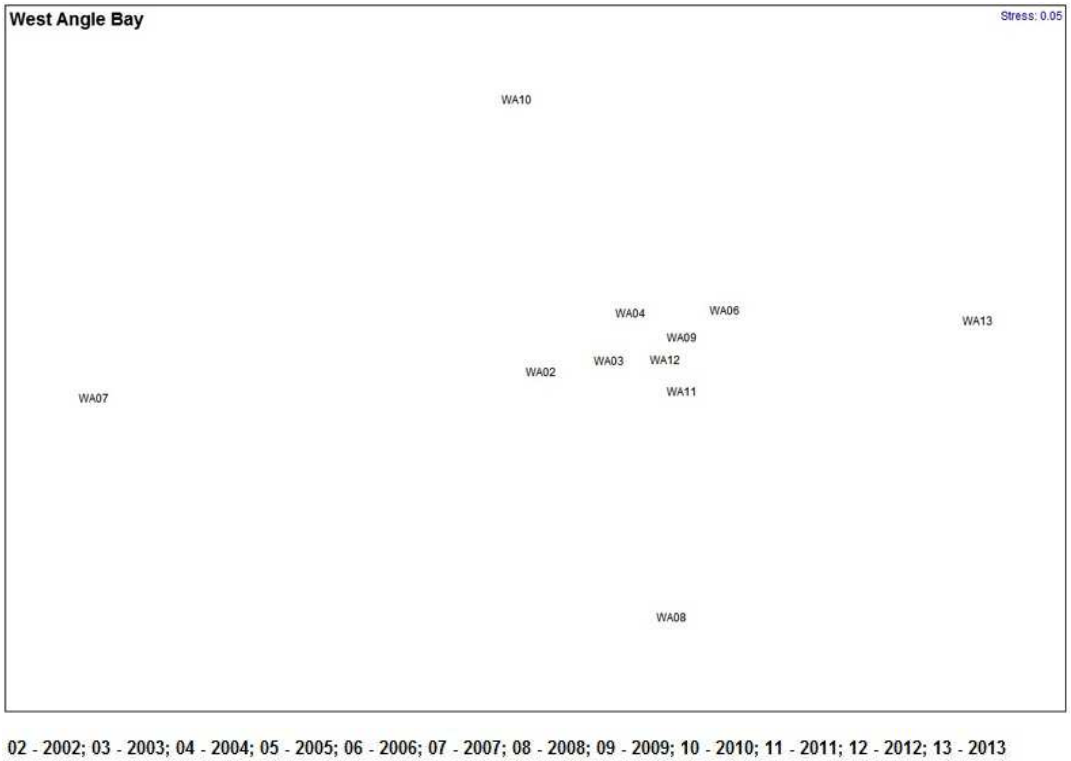

Figure 13. MDS plot of macroalgal assemblages at West Angle Bay 2002 – 2013.

4.3. National trends

4.3.1. North east coastline

Populations of *P. lineatus* across the south and southwest coastlines of England have declined in abundance since the recent 'hiatus' in global warming. Such a widespread response across populations on different coastlines and in different regional seas indicates a large-scale driver such as environmental temperature. The abundance of *P. lineatus* in recent years in North Wales at, and close to northern range limits has shown a slow-down in the increasing trend recorded across the previous decade, but no consistent declines to date (Figure 14). If temperature were a driver of change it would be expected that individuals at the range limit sites that are more frequently exposed to potentially stressful low temperatures would show the most extreme response.

Abundances of *G. umbilicalis* along the coastline of north Wales and Anglesey increased until 2010, when there was a noticeable decline at Great Orme East and Trwyn-y-gogarth and at Moelfre (Figure 15), however, abundances at all sites have increased from 2010 to date across all sites. Again this is in contrast to the trend of reduced abundances across sites in south and southwest England since 2009.

Comparison with SST at these locations (e.g. Little Orme, Figure 16) shows a drop in SST in 2008 that may be reflected in the reduction in densities of both *P. lineatus* and *G. umbilicalis*. This may be due to either individuals at these locations moving to more cryptic habitat in cracks and crevices further down the shore where they were not found during the standard searches, or a decline in recruitment, however, detailed analysis of the individual size data for the entire topshell datasets is beyond the scope of the current contract.

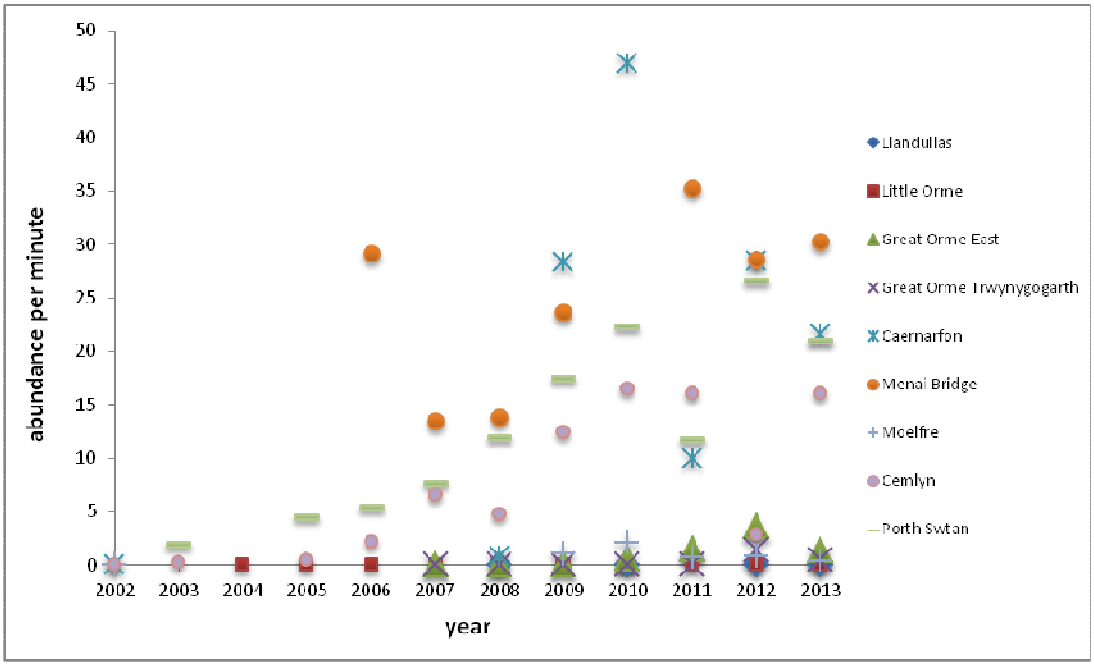

Figure 14. Annual population abundances of *P. lineatus* at the range limit site (Great Orme East) and sites close to the range limit on the north Wales and northern Anglesey coastline.

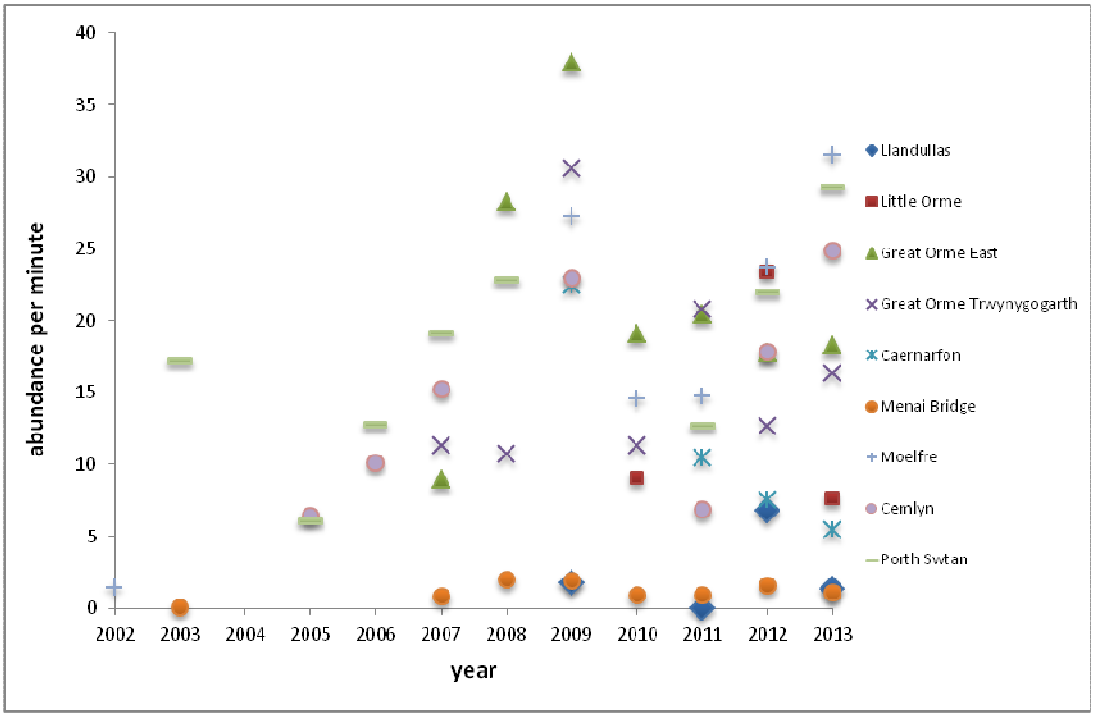

Figure 15. Annual population abundances of *G. umbilicalis* at the range limit site (Llanddulas) and sites close to the range limit on the north Wales and northern Anglesey coastline.

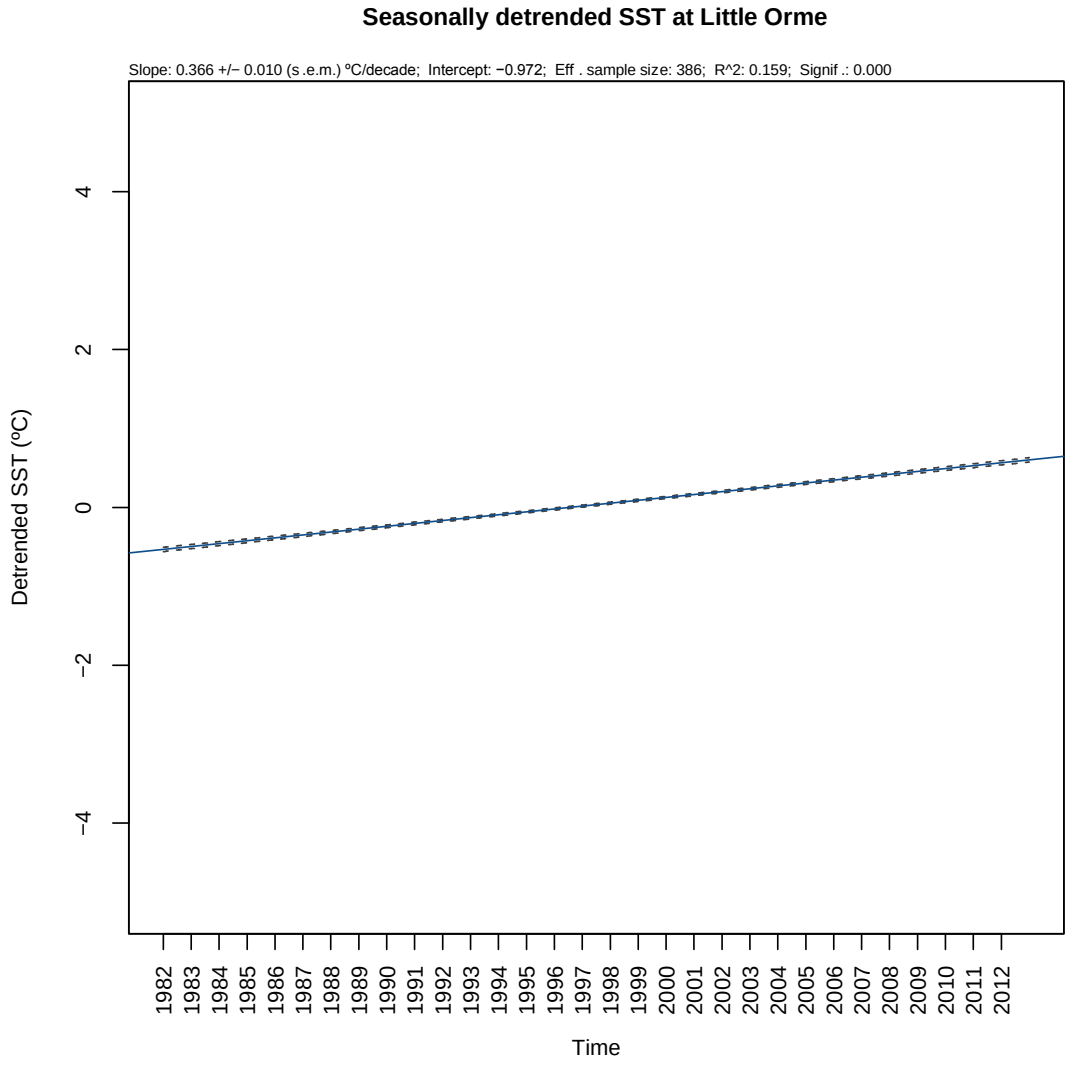

Figure 16. Daily detrended sea surface temperature for Little Orme. Data sourced from NOAA's National Climatic Data Center at *http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily.php*.

4.3.2. Anglesey

Apart from the changes in topshell densities documented above, the intertidal flora and fauna of Anglesey has not fluctuated more than 1-2 SACFOR categories between years across the 2000s and 2010s, indicating natural stochasticity but no pervasive change in community composition at any of the long-term sites. INNS have not increased in abundance at established sites and only one new record, *S. muticum* was recorded in 2013 at Penmon North.

The coldwater kelp *Alaria esculenta* is decreasing in abundance around the UK and undergoing climate-driven retractions of southern range limits. *A. esculenta* is present at Aberffraw, Cemlyn and Porth Dafarch, where abundances fluctuate between Abundant to Not Seen repeatedly between 2002 and 2013, with all sites having recorded *A. esculenta* in 2013.

4.3.3. Llyn Peninsula

Most species have remained stable at sites around the Llyn Peninsula across the 2000s time-series. Some species-specific changes have occurred: *A. esculenta* has remained Common at Nefyn, fluctuated in abundance at Porth Neigwl and declined from Abundant at Porth Oer in 2009 to Not Seen in 2013. The limpet *P. depressa* and barnacle *Chthamalus stellatus* were Not Seen at Porth Neigwl in 2013 but present in low abundances in previous years, the anemone *Anemonia viridis* declined to Occasional and barnacle *C. montagui* declined from Superabundant in 2011 to Common in 2012 and was Not Seen in 2013.

Inter-annual changes observed at Aberdaron, such as the appearance and disappearance of Laminarians intertidally, and fluctuations in abundance of mobile gastropods reflects movement and deposition of soft sediment periodically onto the site. The northern limit of the warm water limpet *Patella depressa*, located at Criccieth in 2002 has extended along the Cardigan Bay coastline of the Llyn Peninsula, establishing a population at Porth Neigwl in 2007 and at Aberdaron in 2012. Abundances of *P. depressa* and the competing coldwater *P. vulgata* have not significantly changed at Criccieth over the past three years.

4.3.4. Pembrokeshire

Most species have not fluctuated more than 1-2 SACFOR categories across the time-series indicating natural stochasticity but no acute impacts or pervasive changes. The warm water kelp *Saccorhiza polyschides* was recorded for the first time at West Angle Bay in 2013 as Occasional. Mytilus edulis appears sporadically at sites, remains for a few years and then disappears again. This is typical of mussel beds that are often the result of a single spatfall that does not successfully recruit in subsequent years.

A new survey station was added at the new Pembroke power station to monitor the potential impacts of warm water outflow on adjacent intertidal habitats, and determine if this warm water plume has any downstream effects.

4.4. Relevance to policy drivers and conservation objectives

Mieszkowska, with the MarClim modeller Burrows (SAMS) and MarClim surveyor Hawkins (University Southampton) have used the MarClim UK time-series to develop indicators designed to address the needs of the Marine Strategy Framework Directive (MSFD). The approach taken reflects discussions that took place at an expert workshop JNCC/Defra-led expert workshop (Birmingham, April 2011) that resulted in the proposals for UK MSFD targets and indicators presented to UK Government. The MarClim indicators use species-level metrics to derive a score that can be compared to a numeric scale to determine the current status and changes between subsequent assessments. An indicator for Climate Change has been developed and tested using metrics based on abundances of warm water and coldwater species to provide information on "prevailing physiographic, geographic and climatic conditions" around the UK and Ireland.

Good Environmental Status for the MSFD relies on eleven descriptors of which four are relevant for these relatively undisturbed and unexploited habitats. The Relevant Descriptors are:

*1. **Biological diversity** is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.*

*2. **Non-indigenous species** introduced by human activities are at levels that do not adversely alter the ecosystems.*

*4. All elements of the marine **food webs**, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.*

*5. Human-induced **eutrophication** is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.*

The findings and final report have been submitted to JNCC and should be available to Natural Resources Wales upon request to JNCC. Until the report is published we are unable to report on details of the indicators or show diagrams of the assessments.

5. SUMMARY

The community composition at the majority of long-term sites did not show major changes in abundance in 2013 compared to recent years. Coldwater macroalgae have not changed in abundance across the sites. Warm water topshells, limpets and barnacles have shown a slight slowdown in the decadal increasing trend, and this will be monitored in future years. Parallel research is developing new climate models to utilise newly released remote sensing data at appropriate spatial and temporal scales to facilitate novel, detailed assessments of species and community level change related to recent climatic fluctuations and provide site-specific forecasts of future abundances and range shifts relevant to management decisions at the national and EU level. It is hoped this research can be applied to the MarClim dataset in the near future.

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Surveyors:

NM Nova Mieszkowska, MBA
LA Leoni Adams, MBA
BM Beatriz de Franciso Mora, MBA
HS Heather Sugden, University of Newcastle
LF Louise Firth, University of Galway
PB Paul Brazier, NRW
KB Kathryn Birch, NRW
BW Ben Wray, NRW
CJ Chloe Jennings, NRW
MB Mark Burton, NRW Skomer MNR

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APPENDIX 1. MarClim Sampling Protocols 2013

Before you start at each site, record:

1. Site name and grid reference
2. County/Area
3. Date
4. Recorder
5. Lat long of access point (e.g. car park) and lat long of centre of survey area (e.g. midshore)
6. Exposure scale of the shore
7. Weather at the time of the survey, especially the visibility
8. Mark site on an OS Map

At each site: Semi-Quantitative Data

1. Identify area to be sampled (this might be up to 100m or more in extent)
2. Photograph approach to site
3. Photograph general view of the sample site
4. Photograph specific features of interest and any rare organisms/new records
5. Walk the whole of the sampling area and using the checklist allocate each of listed species listed to a SACFOR category. Use one or two quick quadrat counts to help in placing in the SACFOR category.
6. It is important to record *apparent* absences and the SACFOR category should be based on the locality in which the species is most abundant, this might be as small as 10m x 10m. DO NOT spend more than 30 minutes searching for species unless at a range edge. If more than 30 minutes is spent searching, record the time.
7. Use the notes section of the form for other species of interest.
8. Use GPS to record
   Midshore of the area sampled/searched
   Location of areas sampled for particular species (if different)
   Location of key features visible in the photographs
9. Note major features of the shore; bedrock, cobbles, boulders, sand scouring etc.

At each site: Quantitative Data

1. Replicated counts of limpets, barnacles, trochids will be made on each shore visit. If time is short and we are visiting a shore that has not been previously surveyed then trochids should only be recorded by SACFOR.
2. Avoid areas of heavy human disturbance.

At each site: Quantitative Barnacle Data Collection

1. Photograph at least ten replicate 5cm x 5cm quadrats containing barnacles at *low, mid* and *high* shore levels. High shore is defined as that area 1m below the very top of the barnacle zone, mid shore in the middle of the barnacle zone, low 1m above the bottom of the barnacle zone
2. Use a 5 x 2cm quadrat frame

Adults	Recruits
Semibalanus (1+ group)	*Semibalanus*
Chthamalus montagui	
Chthamalus stellatus	*Chthamalus* (Total)
Austrominius modestus	*Austrominius modestus*
Perforatus perforatus	
Balanus crenatus	

Counting Limpets and Associated Species

1. Count limpets at both *low* and *mid shore* levels
2. Use a 0.5 x 0.5 m quadrat. Where possible this should be strung at regular intervals to facilitate counting and estimation of % cover of barnacles.
3. Take at least 10 samples but not more than 20 at *each* shore height; the number should be consistent with habitat heterogeneity. True random sampling is unrealistic on a broken rocky shore hence samples should be stratified to encompass the full range of shore slopes
4. Areas with heavy shade, with pools and those that are heavily fissured should be avoided
5. Place the quadrat and record % cover of barnacles, mussels, dominant algae and bare rock. Record the number of individuals of *Osilinus lineatus, Gibbula umbilicalis* and *Nucella lapillus* present in the quadrat.
6. Count the total number of limpets >10mm. Recount to estimate the abundance of the less common species. Ticking animals using chalk is a simple way to ensure that counts and species identification are accurate and consistent. Confirm the identity of *Patella depressa* through checking all features (white tentacles, black foot, shell morphology). Where rare (i.e. at range edges) take reference photographs.

Counting Trochids

1. Count *Phorcus lineatus* and *Gibbula umbilicalis* in the region of the shore that they are most abundant. *Phorcus lineatus* occurs **upshore** of *Gibbula umbilicalis* for a large part of the year.
2. The aim is to record abundance/ structure of populations. As adults and year classes 0-2 often live in slightly different habitats a detailed search is required
3. Make 5 replicated timed counts of 3 minutes duration at each shore.
4. Select a small area in the region of the shore where the species is most abundant. Pick all individuals off visible surfaces and sample under stones and in cracks and crevices for the juveniles. Search using this method for 3 minutes and place all individuals into a bag. Remember to write the length of the search time on the form. Count the number of individuals and measure the basal diameter to the nearest 0.1mm using dial calipers.
5. In shores where there is a relatively uniform distribution of rocks < 30cm it is possible to use a $1m^2$ quadrat to sample trochids. If this sampling method is used the operator moves across the quadrat and collects all animals on the visible surfaces. Once done, each rock is turned over and a separate search is undertaken for the younger animals that seldom move far from damp locations. A substantial proportion of the population may well be under stones. Again count the number of individuals and measure the basal diameter to the nearest 0.1mm. In addition, up to five random 0.5x0.5m quadrats can be thrown randomly to provide backup for SACFOR estimates.

Before leaving, have one last walk around the sample site to confirm first impressions and please check that all equipment and cameras have been collected from the shore

A: MarClim Recording Forms

Site name:	……	Grid reference:	……
County:	……	Lat long of access point:	……
Date:	……	Lat long of centre of survey area:	……
Recorder:	……	Exposure	……
Weather conditions:	……	Low shore availability	……

Species	S	A	C	F	O	R	Not seen	Comments
Codium spp.								
Laminaria hyperborea								
Laminaria digitata								
Saccharina latissima (L. saccharina)								
Laminaria ochroleuca								
Alaria esculenta								
Himanthalia elongata								
Sargassum (Bactrophycus) muticum								
Ascophyllum nodosum								
Pelvetia canaliculata								
Fucus spiralis								
Fucus vesiculosus								
Fucus serratus								
Fucus distichus								
Cystoseira spp.								
Halidrys siliquosa								
Bifurcaria bifurcata								
Mastocarpus stellatus								
Chondrus crispus								
Lichina pygmaea								
Undaria pinnatifida								
Dictyopteris polypodioides								
Calliblepharis jubata								
Chondracanthus acicularis								
Asparagopsis armata								
Colpomenia peregrina								
Saccorhiza polyschides								
Grateloupia turuturu								
Gracilaria vermiculophylla								
Heterosiphonia japonica								
Halichondria panacea								
Hymeniacidon perlevis								
Anemonia viridis								
Aulactinia verrucosa								
Actinia fragacea								
Actinia equina								
Haliplanella lineata								
Sabellaria alveolata								
Chthamalus stellatus								
Chthamalus montagui								
Semibalanus balanoides								
Balanus crenatus								
Perforatus (Balanus) perforatus								
Austrominus (Elminius) modestus								
Pollicipes pollicipes								
Mytilus spp.								
Clibanarius erythropus								
Haliotis tuberculata								
Testudinalia (Tectura) testudinalis								
Patella vulgata								
Patella depressa								
Patella ulyssiponensis								
Patella (Ansates) pellucida								
Gibbula umbilicalis								
Gibbula pennanti								
Gibbula cineraria								
Phorcus (Osilinus) lineatus								
Calliostoma zizyphinum								
Littorina littorea								
Littorina saxatilis agg.								
Melarhaphe neritoides								
Nucella lapillus								
Onchidella celtica								
Crassostrea gigas								
Crepidula fornicata								
Botrylloides violaceus								

Corella eumyota								
Dendrodoa grossularia								
Asterocarpa humilis (cerea)								
Didemnum vexillum								
Asterias rubens								
Leptasterias mulleri								
Paracentrotus lividus								
Strongylocentrotus droebachiensis								
Watersipora subtorquata								

B: Barnacle count

Barnacle Count: Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	PP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	PP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	PP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

C: Limpet Count

Shore height: …… Recorder: ……

Quadrat size: …… Lat long of centre of survey area: ……

Quadrat	x slope	% barnacles	% mussels	% algae	NL	OL	GU	Count		
								P. depressa	***P. vulgata***	***P. ulysipp***
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Shore height: …… Recorder: ……

Quadrat size: …… Lat long of centre of survey area: ……

Quadrat	x slope	% barnacles	% mussels	% algae	NL	OL	GU	Count		
								P. depressa	***P. vulgata***	***P. ulysipp***
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

D: Trochid count

Trochid Count: Recorder: ……

Quadrat/Timed Count: …… Lat long of centre of survey area: ……

Sample	Shore Height	Total Count	
		Phorcus lineatus	*Gibbula umbilicalis*
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Notes:

APPENDIX 2: Data Archive

The report and data collected under Natural Resources Wales contract FC 73-02-359 is archived as Project No 443 Media No 1483 and is maintained on a backed-up server based storage at NRW headquarters.

The data archive consists of:

[A] Digital versions of the contract report: Microsoft Word document(s); and an equivalent Adobe Portable Document Format version

[B] Excel spreadsheets of species records

[C] Some site photographs from each location.

[D]. Marine Recorder file that is held by DASSH

File Path for data:

H:\Science\MFSG\Marine_Habitats_and_Species\Marine Monitoring\Intertidal Climate Change\MarClim 2013

File path for the report:

NRW Ffynnon path: NRW-14-022888

File path for the archive:

Metadata for this project is publicly accessible through the Natural Resources Wales Library Catalogue http://194.83.155.90/olibcgi/ by searching 'Dataset Titles'. The metadata is held as record no 109815.

Date: 05/03/2014