Cyfoeth Naturiol Cymru
Natural Resources Wales

Skomer Marine Conservation Zone Project Status Report 2019

M. Burton, K. Lock, P. Newman, J. Jones

NRW Evidence Report No. 397

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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.

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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.

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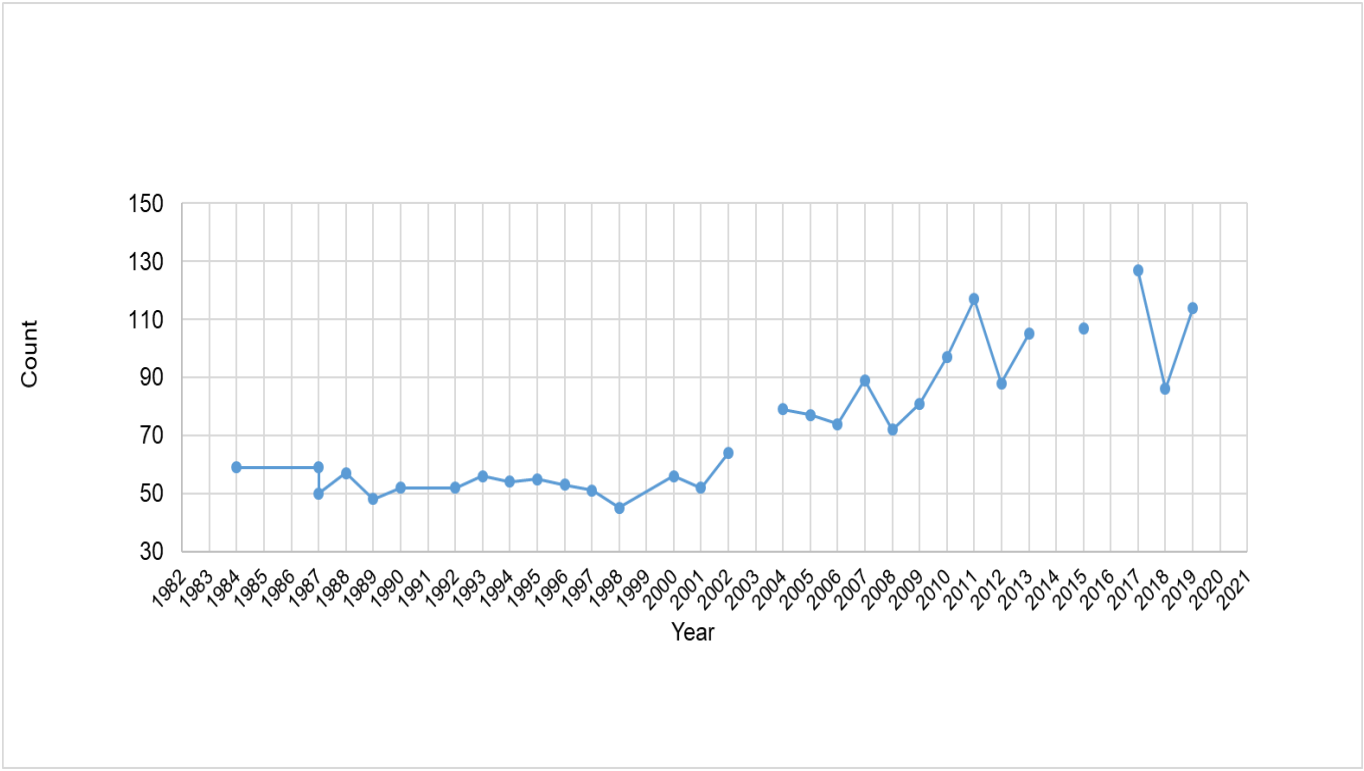


1. Crynodeb Gweithredol

Dyma'r 19eg adroddiad statws prosiect a gynhyrchwyd gan Barth Cadwraeth Forol (PCF) Skomer. Mae'n crynhoi cynnydd a statws cyfredol prosiectau monitro ym Mharth Cadwraeth Forol Skomer yn ystod 2019.

Mae'r prosiectau hyn nid yn unig yn darparu'r dystiolaeth sydd ei hangen i adrodd ar gyflwr PCF Skomer ei hun ond hefyd yn gwneud cyfraniad pwysig i'r dystiolaeth a ddefnyddir wrth asesu cyflwr a statws cadwraeth Ardal Gadwraeth Arbennig Forol Sir Benfro, lle ceir y PCF.

Mae data tymor hir PCF Skomer, defnydd biolegol yn ogystal â defnydd dynol, hefyd wedi cael ei ddefnyddio i sefydlu ac adrodd ar ddangosyddion biolegol ar gyfer gofynion y DU o dan Gyfarwyddeb Fframwaith y Strategaeth Forol.

Ceir manylion achosion penodol lle defnyddiwyd data PCF Skomer i gefnogi mentrau ar wahân i'r rhai sydd â chysylltiad uniongyrchol â'r PCF mewn crynodebau prosiectau unigol.

Mae'r tablau statws prosiect yn Adran 4 yn rhoi crynodeb o'r holl brosiectau monitro sefydledig yn y PCF. Mae Adran 6 yn manylu ar brosiectau biolegol y gweithiwyd arnynt yn ystod 2019 a chrynodeb o'r canlyniadau hyd yma. Mae Adran 7 yn rhoi crynodeb o'r prosiectau gwyliadwriaeth eigionegol a meteorolegol.

Digwyddiadau nodedig yn ystod tymor maes 2019:

Cynhaliwyd yr arolwg draenogod môr a detholiad o rywogaethau o sêr môr gan dîm deifio gwirfoddol dros gyfnod o ddau benwythnos. Cwblhawyd 144 trawslun i gyd dros ardal o 8640 m^2 a chofnodwyd a mesurwyd cyfanswm o 953 o ddraenogod môr.

O ganlyniad i'r arolwg o rywogaethau sbwng cofnodwyd 72 rhywogaeth/endid i gyd: Broad Gully (Thorn Rock) oedd y safle cyfoethocaf o ran amrywiaeth a chofnodwyd cyfanswm o 42 rhywogaeth yno. Yn Dog Leg (Thorn Rock) y cafwyd yr amrywiaeth lleiaf, sef 31 rhywogaeth. Bellach mae cyfanswm o 130 rhywogaeth o sbwng (34 ohonynt wedi'u henwi i lefel genws yn unig) wedi'u cofnodi o Barth Cadwraeth Forol Skomer.

Cwblhawyd yr arolwg geni morloi llwyd ar y safleoedd ar yr ynys a'r tir mawr rhwng mis Awst a mis Rhagfyr a chofnodwyd 408 o forloi bach. Mae nifer y morloi a anwyd ym Mharc Cadwraeth Forol Skomer dros y 5 mlynedd diwethaf wedi dangos y cyfansymiau uchaf a gofnodwyd erioed gyda nifer cyfartalog o 382 o forloi bach ar gyfer 2015-19. Ers 2009, cafwyd cynnydd cyson yn y nifer y morloi ar y safleoedd ar yr ynys a'r tir mawr.

2. Executive Summary

This is the nineteenth project status report produced by the Skomer Marine Conservation Zone (MCZ). It summarises the progress and current status of monitoring projects in the Skomer MCZ during 2019. These projects not only provide the evidence needed to report on the condition of the Skomer MCZ itself but make an important contribution to the evidence used in assessing the condition and conservation status of the Pembrokeshire Marine Special Area of Conservation, within which the MCZ is situated. Skomer MCZ long-term data, biological as well as human use, has also been used in establishing and reporting on biological indicators for UK requirements under the Marine Strategy Framework Directive (MSFD). Specific cases where Skomer MCZ data have been used to support initiatives other than those directly linked to the MCZ are detailed in individual project summaries.

The project status tables in Section 4 provide a summary of all established monitoring projects in the MCZ. Section 6 details biological projects that were worked on during 2019 and a summary of the results to date. Section 7 provides a summary of the oceanographic and meteorological surveillance projects.

Notable events in the 2019 field season:

The common urchin and selected starfish species survey was carried out by a volunteer diving team over two weekends. A total of 144 transects were completed covering an area of 8640 m^2 and a total of 953 urchins were recorded and measured.

The sponge species survey resulted in 72 species/entities being recorded in total: Broad Gully (Thorn Rock) was the richest site in terms of diversity, with a total of 42 species being recorded. Dog Leg (Thorn Rock) was the least diverse, with 31 species. A total of 130 sponge species (34 of which have been named to genus level only) have now been recorded from the Skomer MCZ.

The Grey seal pupping survey was completed at both island and mainland sites from August to December and 408 pups were recorded. Pup production in the Skomer MCZ for the past 5 years has shown the highest totals ever recorded with average production for 2015-19 at 382 pups. Since 2009 there has been a steady increase in pup production at both the island and mainland sites.

3. Skomer MCZ and Sustainable Management of Natural Resources

The Environment (Wales) Act and the Wellbeing of Future Generations (Wales) Act provide the framework for NRW's work to pursue the sustainable management of natural resources as defined in the former while maximising our contribution to the well-being goals set out in the latter.

Sustainable management of natural resources follows nine main principles and the work of Skomer Marine Conservation Zone can be shown to apply (and to have been applying for many years) these principles:

Adaptive management – the management of Skomer MCZ is not set in stone. Our monitoring programme provides the evidence we need to review our management actions and where necessary change them.

Scale – whereas the boundary of the site was decided decades ago, our extensive knowledge of the MCZ allows us to apply aspects of our management to specific and appropriate areas. For instance, we are confident that the seabed in South Haven and parts of North Haven can tolerate current and historical levels of recreational anchoring, but the rest of the site cannot. This allows us to identify areas where recreational anchoring can happen rather than try to impose a blanket ban on anchoring. For the same reason it would be unreasonable to restrict access to the whole coastline of Skomer when it is specific small areas that are more sensitive to disturbance at different times of year. Hence our seasonal access restrictions are designed to protect breeding seals and birds at the most sensitive sites in the autumn and spring respectively.

Collaboration and engagement – this report demonstrates the importance we place upon liaison with academic institutions to increase our knowledge of the site by providing help with research projects. The Skomer MCZ Annual Report further documents our connections with regulatory and recreational organisations to ensure legal and voluntary measures are effective in protecting the site. The Skomer MCZ Advisory Committee is pivotal in this respect.

Public participation – without public participation we would be unable to carry out nearly as much monitoring work as we do. We are dependent on volunteers: from teams of volunteer divers carrying out intensive surveys of species and habitats like scallops and eelgrass, to individuals making up our own dive team to allow work to continue in the absence of staff. Our voluntary controls would be unworkable without public support and the local community provide valuable help in safeguarding the site through their vigilance.

Evidence – NRW is an evidence-based organisation, so evidence is needed to inform policy and underpin operations, whether we are collecting it ourselves or relying on our extensive collaborative network to provide it to us.

Multiple benefits – we are fully aware of the intrinsic value of a site, such as Skomer MCZ, where people can come to enjoy wildlife in as unspoilt a marine area as we are likely to have anywhere in Wales. This is all the more important when the importance

of tourism and recreation to the Welsh economy is considered. We can only theorise on the level of benefits to the wider marine environment of larval export from seabed communities and species deriving a high level of protection as a result of the fishery byelaws we have.

Long term – at Skomer MCZ we are in an almost unique position to be able to report on the long-term consequences of marine conservation management actions taken over two decades ago. This is because we have some of the longest-running time-series data for a marine protected site in the UK.

Preventative action – the site-based nature of the team at Skomer MCZ is a major contributory factor to the protection of the site. We are able to respond quickly to potentially damaging events and intervene. Sometimes this is by our mere presence acting as a deterrent, and sometimes by educating those who might cause harm unknowingly.

Building resilience – by applying nature conservation principles we can help to build diversity, populations, and connectivity; all of which contribute to the maritime ecosystem's resilience in the face of anthropogenic change.

4. Project Status Tables

Table 4.1 Summary of Skomer MCZ Meteorological and Oceanographic Project

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Meteorological data	Wind, rain, sunshine, temperature, humidity, net radiation. Automatic station logging every 10 minutes.	1993 – ongoing	Continuous	No	Yes-SMCZ office
Wave data	Height, period, etc. Automatic station logging every 10mins.	1993-1998 Discontinued	Continuous	No	No - raw only
Seawater data	Temperature, salinity, conductivity, suspended sediment.	1992 – ongoing	Weekly (May - Sept)	No	Yes-SMCZ office
Seawater data	YSI 6600 multi parameter sonde: Temperature, salinity, dissolved O_2, Chlorophyll, turbidity & depth.	2007 – ongoing	Continuous	No	Yes-SMCZ office
Seabed sedimentation	Auto sampler	1994 -1998 Discontinued	Continuous	No	Yes-SMCZ office
Seabed sedimentation	Sediment trap	1994 – ongoing	Every 14 days (April-Oct)	Jones 1998	Yes-SMCZ office
Suspended sediments	Idronaut Turbidity logger	2001 – failed 06	Continuous	No	No - raw only
Suspended sediments	Secchi disc	1992 - onwards	Weekly (seasonal)	No	Yes – SMCZ office

Table 4.2 Summary of Skomer MCZ Activities Project

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Recreation activities	Boats, divers, anglers recorded in the MCZ	1987 - ongoing	Weekly (May - Sept)	Skomer MCZ annual reports	Skomer MCZ annual reports
Commercial fishing activities	Pot buoys and fishing net positions	1989 - ongoing	Weekly (May - Sept)	Burton 2002 SMCZ annual reports	Yes-SMCZ office
Tankers in St Brides bay	Number and names of tankers and movements. Now using AIS system	1994 - ongoing	Daily 24/7 electronic AIS	No	Yes-SMCZ office Yes-SMCZ office

Table 4.3 Summary of Skomer MCZ Biological Project

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Littoral communities: Macro scale	View point time series photographs	1992 - ongoing	Annual	Internal report – Daguet 2000 and Gibbs 2007	Yes-SMCZ office
Littoral communities Meso scale	6 sites with transects. Time series photos.	1992 – ongoing	Annual	Adams 1979/ Bunker 1983/ Crump 1993/96 Hudson 1995.	Yes-SMCZ office
Littoral communities Meso scale	7 sites with permanent marked quadrats, species recording and time series photos. 3 sites with Marclim methodology	2003 - ongoing	Annual	Burton & Crump 2004	Yes-SMCZ office
Sub littoral communities Rocky reef	Time series stereo photos.	1982 - ongoing	Annual	Bullimore1986 & 1987	Yes-SMCZ office
Sub littoral communities Algal	Review of previous surveys and monitoring method development	1999		Brodie & Bunker 1999/2000,	Yes-SMCZ office
Sub littoral communities Algal	Survey completed at selected sites	2005 2007		Maggs & Bunker 2007.	Yes-SMCZ office

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Sub littoral sponge communities	Time series photographs	1994 - ongoing	Annual	No	Yes-SMCZ office
Sub littoral sponge communities	Species recording	2002, 2008 2011,2015,2019	Every 4 years Next survey planned 2023	Bunker & Jones 2005, Jones *et al.* 2012, 2016, 2020	Yes-SMCZ office
Sub littoral sponge communities	Seasonal monitoring from 15 fixed quadrats	2006 – ongoing	Annual	Berman *et al.* 2013.	Yes-SMCZ office
Sub littoral communities Infaunal sediment	Surveys and reports completed	1993/1996/ 1998/ 2003 2007/ 2009 / 2013 & 2016	Every 4 years Next survey planned 2020	Rostron 1994 & 1996, Barfield 1998 & 2003, Barfield 2007 & 2010.	Yes-SMCZ office
Sub littoral communities Epifaunal sediment	Survey and report completed	1995/ 2001 & 2004 Video 2009	Project now combined with Infauna	Rostron 1996, Moore 2002 & 2005.	Yes-SMCZ office
Sub littoral communities Plankton	Zooplankton samples taken with a 200um net. Phytoplankton samples taken with 20um net. Both use vertical haul methods that are comparable to others used in UK.	2009 ongoing	Weekly samples taken during the field season.	Unpublished report with method recommendations Plymouth Marine Laboratories 2015.	Yes-SMCZ office
Zostera marina	Extent of North Haven bed & density distribution.	1997/2002/2006, 2010, 2014, 2018	Every 4 years Next survey planned 2022	Jones & Hodgson 1980 &1981, Jones *et al.* 1983, Lock *et al.* 1998, 2003 & 2006,	Yes-SMCZ office
Zostera marina	Biosonics Acoustic sonar survey	2013, 2014, 2015, 2018 & 2019	Annual	Burton *et al.* 2010, Lock *et al.* 2015. Burton *et al* 2019.	Yes-SMCZ office
Eunicella verrucosa	120 colonies, time series photo	1982- ongoing	Annual	Bunker et al. 1985, Bullimore1986 & 1987, Gilbert 1998.	Yes-SMCZ office

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Alcyonium glomeratum	Time series photo, 5 sites	1984- ongoing	Annual	Bullimore1986 & 1987.	Yes-SMCZ office
Parazoanthus axinellae	Time series photo, 6 sites	2001- ongoing	Annual	Burton *et al.* 2002.	Yes-SMCZ office
Pentapora foliacea	Time series photo, 6 sites	1994- ongoing	Annual	Bullimore1986 & 1987, Bunker & Mercer 1988, Gilbert 1998, Gibbs 2006.	Yes-SMCZ office
Balanophyllia regia	Time series photo, 2 sites	1984 - ongoing	Annual	Bullimore 1986 & 1987.	Yes-SMCZ office
Caryophyllia smithii	Counted from sponge project photo quadrats (	1993 - ongoing	Annual	No	Yes-SMCZ office
Grey seal (H*alichoerus grypus*)	Annual pup production and survival records at Skomer Island and mainland MCZ sites. Site fidelity and other behavioural records for Skomer Island sites.	1976- ongoing	Annual	Grey seal breeding census, Skomer Island 1992-2019, Skomer MCZ project status report 1992-2019.	Yes-SMCZ office
Nudibranch species	Various surveys	1975-1991	Occasional	Hunnam & Brown 1975, Bunker *et al.* 1993,	Yes-SMCZ office
Nudibranch species	MCZ surveys completed:	2002, 2006, 2010, 2014 & 2018	Every 4 years Next survey planned 2022	Luddington 2002, Lock *et al.* 2010, 2014 & 2019.	Yes-SMCZ office
Territorial fish	Survey completed	1997,2002 2005, 2009, 2013, & 2017.	Every 4 years, next survey planned 2021	Lock 1998, Lock *et al.* 2006, Tompsett 2006,	Yes-SMCZ office

Project	Brief description	Year sets	Sampling frequency	Report	Data summary
Territorial fish	Video surveys	2007 & 2009	Occasional	Sweet 2009, Bullimore 2010	Yes-SMCZ office
King scallop *Pecten maximus* (including *Crepidula fornicata*, *Aequipecten opercularis* and *Arctica islandica* from 2008)	Survey completed, 3 sites- 2000 Survey completed, 7 sites 2004, 2008, 2012& 2016	2000, 2004, 2008, 2012, 2016	Every 4 years, next survey planned 2020	Jones 1979 & 1980, Bullimore 1985, Lock 2002, Luddington *et al.* 2004, Lock *et al.* 2009 & 2013, Burton *et al.* 2016.	Yes-SMCZ office
Echinoderm Survey	Abundance of *Echinus esculentus* in Skomer MCZ using volunteer survey methods. Data for *Marthasterias glacialis*, *Crossaster papposus* & *Luidia ciliaris.*	2003,2007 & 2011, 2015, 2019	Every 4 years Next survey planned 2023	Luddington *et al.* 2004, Lock *et al.* 2008, 2011, 2016 & 2019	Yes-SMCZ offic
Commercial Crustaceans	Parlour pot and diving study	2003 & 2011	Aug / Sep 2003 Jul – Oct 2011	Fothergill 2004	Yes-SMCZ office
Commercial Crustaceans	Shell disease survey	2011	Sep – Oct 2011	No	Yes-SMCZ office
Commercial Crustaceans	Crawfish recording	2011 onwards	Continuous	No	Yes-SMCZ office
Cetaceans	Observations of all cetacean species.	2001 onwards	Records from Skomer Island, “Dale Princess” and SMCZ team	No	Yes-SMCZ office

5. Skomer MCZ Sites and codes

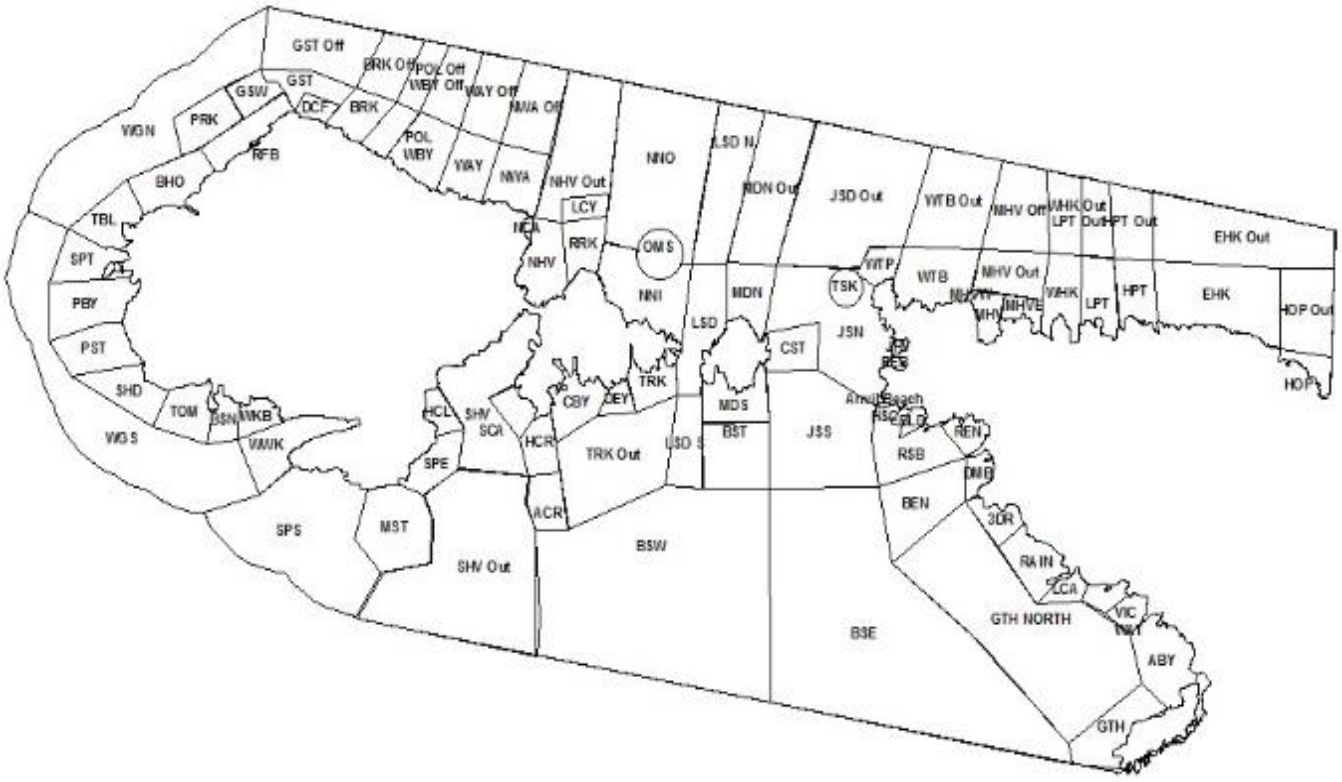


Table 5.1 Skomer MCZ sites and codes

Site code	Site Name	Site Code	Site Name	Site Code	Site Name
ACR	Anchor Reef	JNK	Junko's Reef	SCA	South Castle
ABY	Albion Beach	JHV	Jeffrey's Haven	SHD	Skomer Head
BEN	The Bench	JSD Out/JSN/JSS	Jack Sound /North /South	SHV/SHV Out	South Haven /Outer
BHO	Bull Hole	LCA	Little Castle beach	SPE	South Plateau East
BLD	Boulder Beach	LCY	"Lucy" wreck	SPS	South Plateau South
BRK/BRK Off	Bernie's Rocks/ Offshore	LPT/LPT Out	Low point/Outer	SPT	The Spit
BSE	Broad Sound East	LSD/LSDN/LSDS	Little Sound /North/South	TBL	The Table
BSN	The Basin	MDN/MDS/MDN Out	Middleholm North/South/ North Outer	TOM	Tom's House
BST	Black Stones	MHV/MHVE/ MHVW/MHV Out/MHV Off	Martins Haven/East /West /Outer /Offshore	TRK/Out	Thorn Rock /Outer
BSW	Broad Sound West	MST	Mew Stone	TSK	Tusker Rock
CBY	Castle Bay	NCA	North Castle	VIC	Victoria Bay
CST	Crab Stones	NHV/Out	North Haven/Outer	WAT	Watery Bay
DCF	Double Cliff	NNI/NNO	North Neck Inner/Outer	WAY/Off	Waybench /Offshore
DEY	"Dead Eye" wreck	NWA/NWA Off	North Wall /Offshore	WBY/Off	Waterfall Bay /Offshore

Site code	Site Name	Site Code	Site Name	Site Code	Site Name
DMB	Dead Man's Bay	OMS	Oceanographic Monitoring Site	WGN	
EHK/EHK Out	East Hook/Outer	PBY	Pig Stone Bay	WGS	
GST/GST Off	Garland Stone/Offshore	PEB	Pebbly Beach	WHK/Out	West Hook /Outer
GSW	Garland Stone West	POL/POL Off	The Pool /Offshore	WKB	Wick Basin
GTH/GTH North	Gateholm/North	PST	Pig Stone	WTB/Out	Wooltack Bay /Outer
HCL	High Cliff	RAIN	Rainy Rock	WTP	Wooltack Point
HCR	High Court Reef	REN	Renney Slip	WWK	The Wick
HOP/HOP Out	Hopgang/Outer	RFB	Rockfall Bench	3DR	Three Doors
HPT/HPT Out	High Point/Outer	RRK	Rye Rocks		
HSC	Horseshoe Cave	RSB	Renney Slip Bay		

6. Skomer MCZ Biological Project Summaries

6.1. Littoral Communities
CMS code: RB03/01

6.1.1. Project Rationale
Littoral communities are one of the management features of the Skomer MCZ and are a habitat of principal importance under Section 7 of the Environment (Wales) Act 2016. This project also encompasses intertidal boulder communities, which are a priority habitat under the same Act. They are susceptible to impacts from the water and the air and occupy a harsh niche with an extreme range of environmental conditions. Salt tolerant terrestrial species exist within metres of truly marine species. These factors coupled with the relative ease of fieldwork compared to sub-littoral habitats make littoral communities useful for a wide range of environmental monitoring. There is a wealth of literature on the biology of rocky shores to provide guidance and support information for littoral monitoring projects.

6.1.2. Objectives
To monitor the littoral communities on bedrock shores over the continuum of exposure and aspect ranges.

6.1 3. Sites

	Started	
North Haven	1992	
South Haven	1992	
South Stream	1992	
The Lantern	1992	
The Wick	1992	
Double Cliff	1992	
Pig Stone	2003	
Wooltack	2003	
Martins Haven	2003	
Hopgang	1996	Lichen station only

6.1.4. Methods
Permanent Quadrats (1992 – Ongoing)
Transects with permanent, fixed position quadrats (50 x 50cm) were established in 1992. The quadrats extend from spring low water into the splash zone at regular height intervals. Photographs are taken annually of each quadrat as permanent records.
In 1992 and 1996 a species abundance survey was completed using the semi-quantitative SACFOR abundance scale (Crump 1993 & 1996).

Littoral Community Monitoring (2003 – Ongoing)
In 2003 new methods were developed, these are detailed in Crump & Burton (2004) and summarised as follows:
Sites were divided into 4 zones based on heights on the shore above chart datum (ACD)
Lower shore – 1.8m ACD
Middle shore – 4.2m ACD
Upper shore – 6.0m ACD
Splash zone ~ 9.0m ACD (selected sites only)

At Each Lower, Middle and Upper Shore Zones:
Four 1m^2 quadrats positions are permanently marked. The positions were selected to cover relatively homogenous areas of inclined rock (avoiding rock pools and large fissures). At each position:

- 1m^2 quadrat divided into a 25-cell grid is used to record presence/absence for all species. Some species are aggregated for recording as follows: Rough winkle species, barnacle species, limpets recorded as *Patella spp*., encrusting red algae.
- Four digital photographs are taken using a 50 x50 cm quadrat within each 1m^2 quadrat.
- Limpets are counted in 5 randomly selected grid cells providing 20 samples at each shore height.
- % cover of barnacle species is estimated in 5 randomly selected grid cells and barnacles are photographed within the same 5 grid cells using a 5 x 5cm quadrat. The photographs provide 20 samples from each shore height, these are stored for barnacle species counts for all individuals > 2mm (currently the photos are stored, and counts will be completed when time allows).

Figure 6.1.1. Barnacle 5 x 5cm quadrat

At Middle Shore Zones: Over 100 limpets (*Patella spp.*) from within the quadrats are measured to the nearest mm using callipers. In areas of low density at least 100 limpets were measured.

At Splash Zones: % cover of all lichen species is recorded in 50 x 50cm quadrats at selected sites and a quadrat photograph taken.

*MarClim Methodology (*2003 - Ongoing)
The MarClim project offers an opportunity to compare Skomer MCZ shores to the rest of the UK and contribute to the assessment of the effects of climate change. Martins Haven, North Haven and South Haven were selected as suitable sites for the project (see Mieszkowska *et al.* 2002):

The MarClim method:

- Abundance recording of a selected list of edge of range species.
- Photograph barnacles in 5 x 5cm quadrats to complete barnacle species counts.
- Limpet species counts in 50 x 50cm quadrats

- Timed searches of *Phorcus lineatus* and *Steromphala umbilicalis* and individuals measured to the nearest mm.

Shore Clingfish (Lepadogaster lepadogaster) (2004 - Ongoing)
Timed counts of clingfish are carried out at Martins Haven, North Haven and South Haven together with records of egg masses. Counts started in 2004 at Martins Haven and North Haven and in 2011 at South Haven.

Table 6.1.1. Summary of methods completed at each littoral site.

Site	Permanent Quadrats	Shore zone quadrats, Limpets, Barnacles	Lichen quadrats	MarClim	Shore clingfish
North Haven	No	No	No	Yes	Yes
South Haven	Yes	No	No	Yes	Yes
South Stream	Yes	Yes	Yes	No	No
The Lantern	Yes	Yes	Yes	No	No
The Wick	Yes	Yes	Yes	No	No
Double Cliff	Yes	Yes		No	No
Pig Stone	No	Yes	Yes	No	No
Wooltack	No	Yes	Yes	No	No
Martins Haven	No	Yes	Yes	Yes	Yes
Hopgang	No	No	Yes	No	No

6.1.4. Project history

1982: Bunker *et al.* surveyed twenty-two sites on Skomer as a baseline littoral survey.

1992: Six permanent transects were established on Skomer and surveyed/ photographed (Crump, 1993).

1992 – 2002: Photographs of the six permanent transects were taken and stored.

1996: Following the Sea Empress oil spill (February 1996) the six transects were resurveyed and a lichen monitoring site was set up at Hopgang (Crump, 1996). The littoral shores around Skomer showed no significant changes after the Sea Empress oil spill, with the exception of the lichen community at Hopgang, which showed signs of necrosis.

2001: Slide photographs from 1992 – 2000 were reviewed and abundance estimates from the photographs compared with abundance records from Crump 1993 & 1996 field data. Photograph quality was insufficient to allow accurate abundance estimates.
2001/02: Digital imaging was tested to obtain pictures of permanent quadrats. Image quality was improved; however, estimates of species abundance were still inaccurate due to difficulties with identification of species and individuals from the images. This method cannot replace collection of data in the field for quantitative assessment.

2003: New quantitative methods were tested (Crump & Burton, 2004).

2004: MarClim surveys were started at 3 sites: Martins Haven, South Haven and North Haven.

2007: Temperature loggers were placed at the Martins Haven and South Haven sites.

The survey methods for each site outlined in Table 6.1.1 have been completed in years 2003 to 2019 as shown in Table 6.1.2.

Table 6.1.2. Summary of survey sites completed 2003 – 2019. (Lower shore; LS, Middle shore: MS, Upper shore: US)

Site	North Haven	South Haven	South Stream	Lantern	Wick	Double Cliff	Pig Stone	Wooltack	Martins Haven	Hopgang
2003			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2004	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2005	Yes	Yes	Yes	Yes	Yes	Yes	No LS	Yes	Yes	Yes
2006	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2007	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2012	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2014	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2016	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2018	Yes	Yes	Yes	Yes	Yes	No US/MS	Yes	Yes	Yes	Yes
2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6.1.5. Results

Whole Community Analysis

All the shore zone quadrat data are entered into the PRIMER statistics software for community analysis. The results can be visualised as multi-dimensional scaling (MDS) plots, see Figure 6.1.2

General summary:

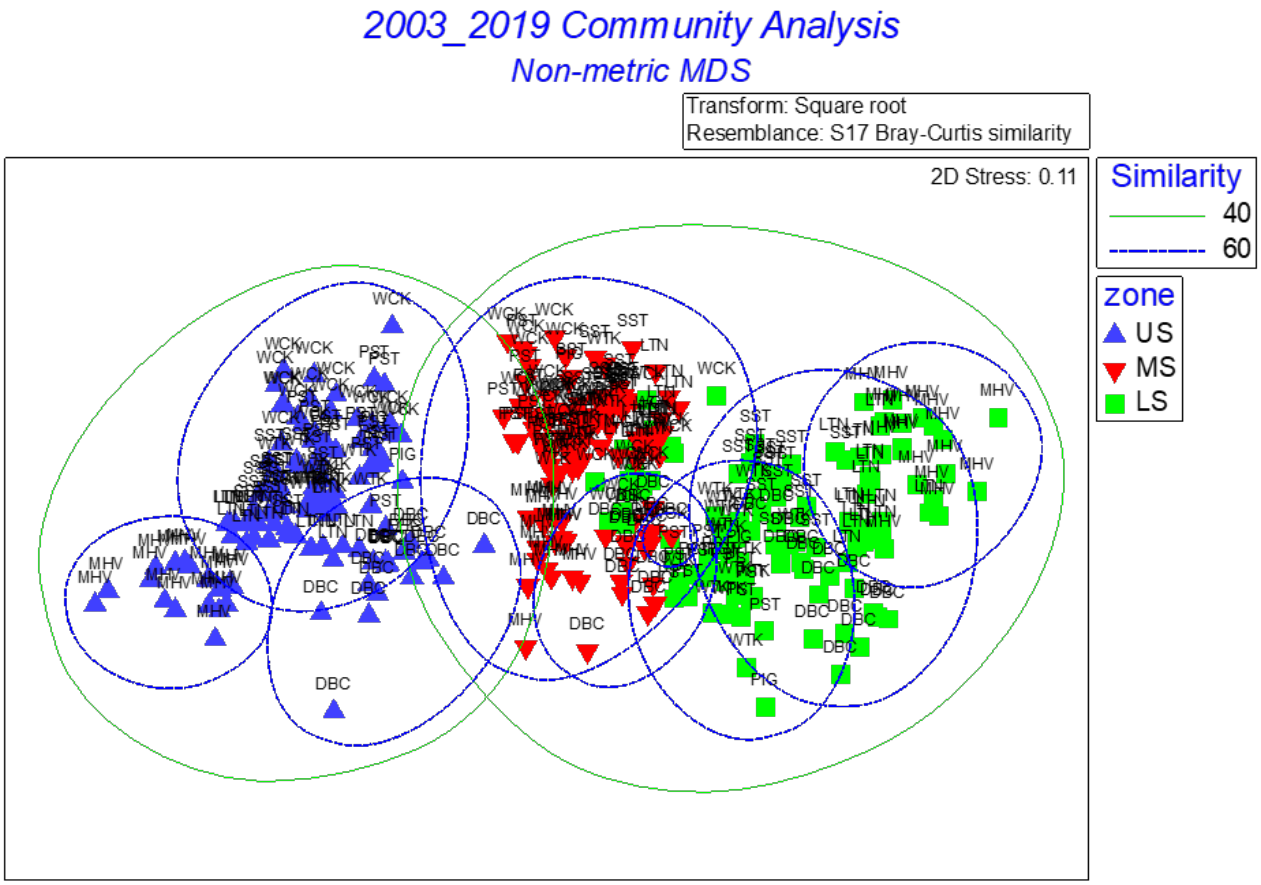
- Upper shore sites group neatly on the left.
- Lower shore sites are much more disparate and grouped on the right.
- Middle shore sites sit in between with some overlap (at 60% similarity) with the lower shores.
- Some sites form distinct clusters e.g. MHV Upper, MHV Lower.
- Some sites are very variable from year to year e.g. PST Lower & WTK Lower.

2019 did not show any major variations from the overall trends seen since 2004.
An “ANOSIM” test for differences between years showed no significant difference between any of the years. Sample statistic (R): -0.014 Significance level of sample statistic: 95%

The communities on the shores have not shown any major changes during the monitoring period 2003 to 2019.

Detailed analysis of some specific groups of species are given below.

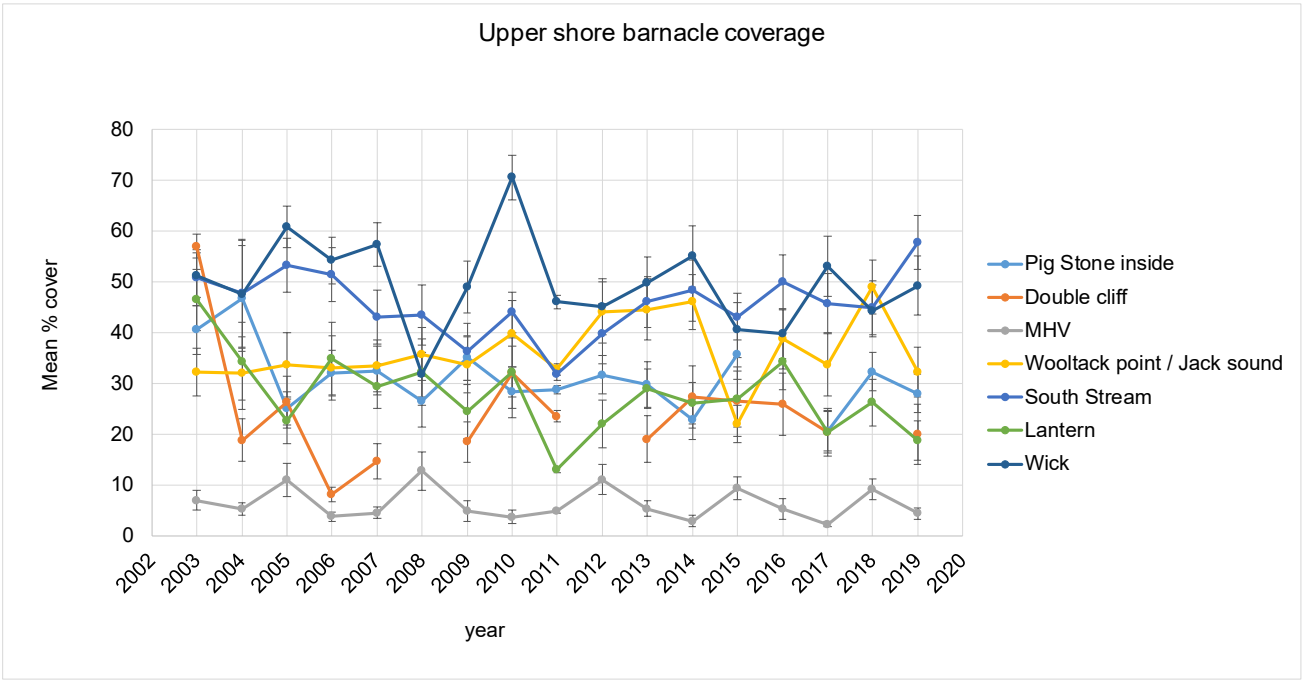
Figure 6.1.2. PRIMER Multi-dimensional scaling (MDS) plot of all littoral community data 2003 – 2019 (Upper shore: US, Middle shore: MS, Lower shore: LS)

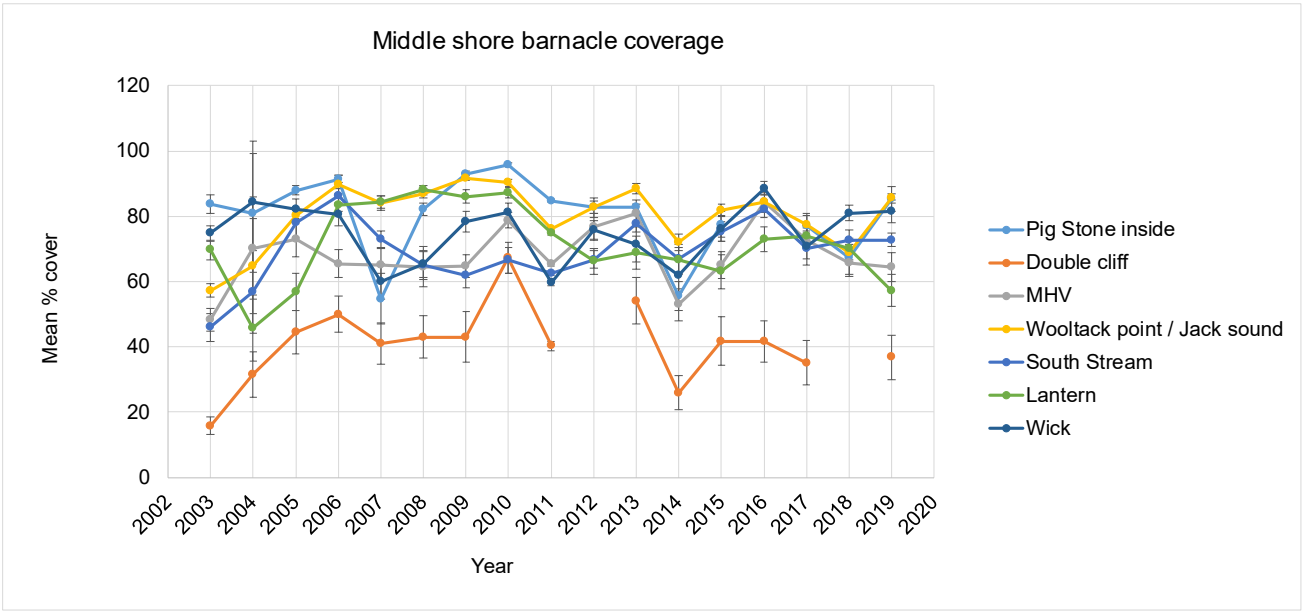


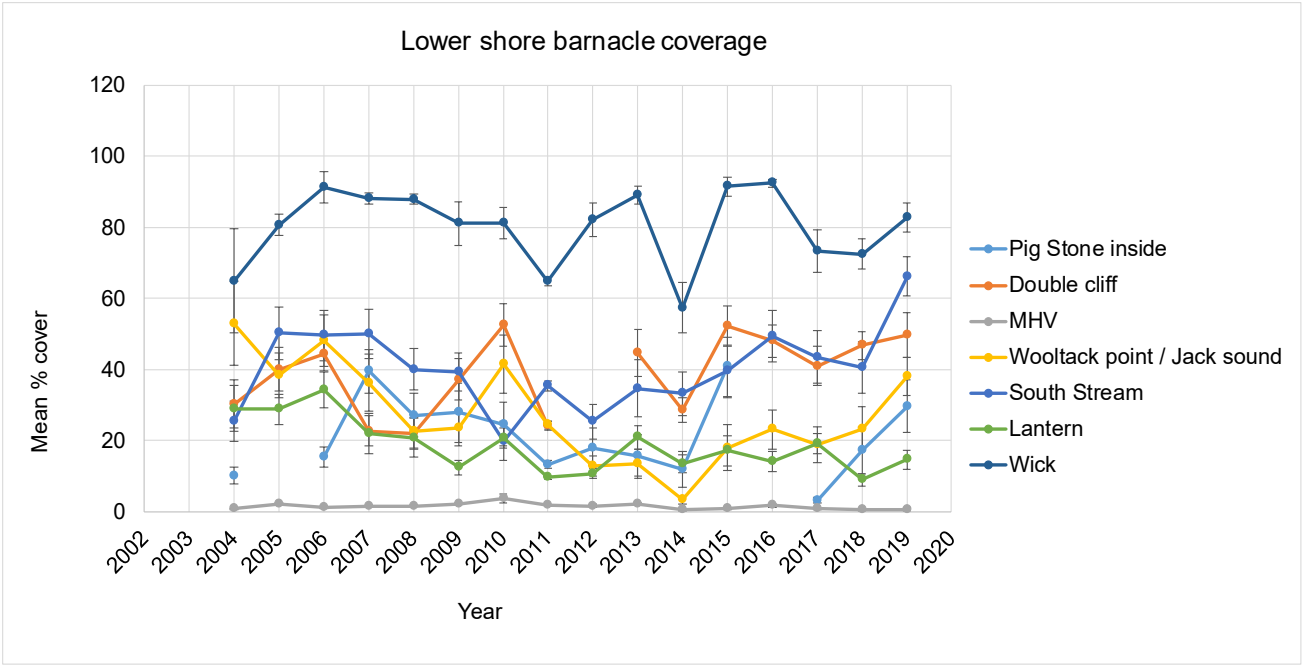
Mean Percentage Cover of Barnacles

Barnacle coverage (all species aggregated together) has been variable between sites over the last 16 years. In 2014 all sites saw a decrease in barnacle cover in the middle and lower shores. This was perhaps due to the extreme weather of the winter of 2013-14. In 2019 the barnacle coverage showed little change.

Figure 6.1.3. Changes in upper, middle and lower shore barnacle coverage 2003 – 2019, with 95% standard error bars.





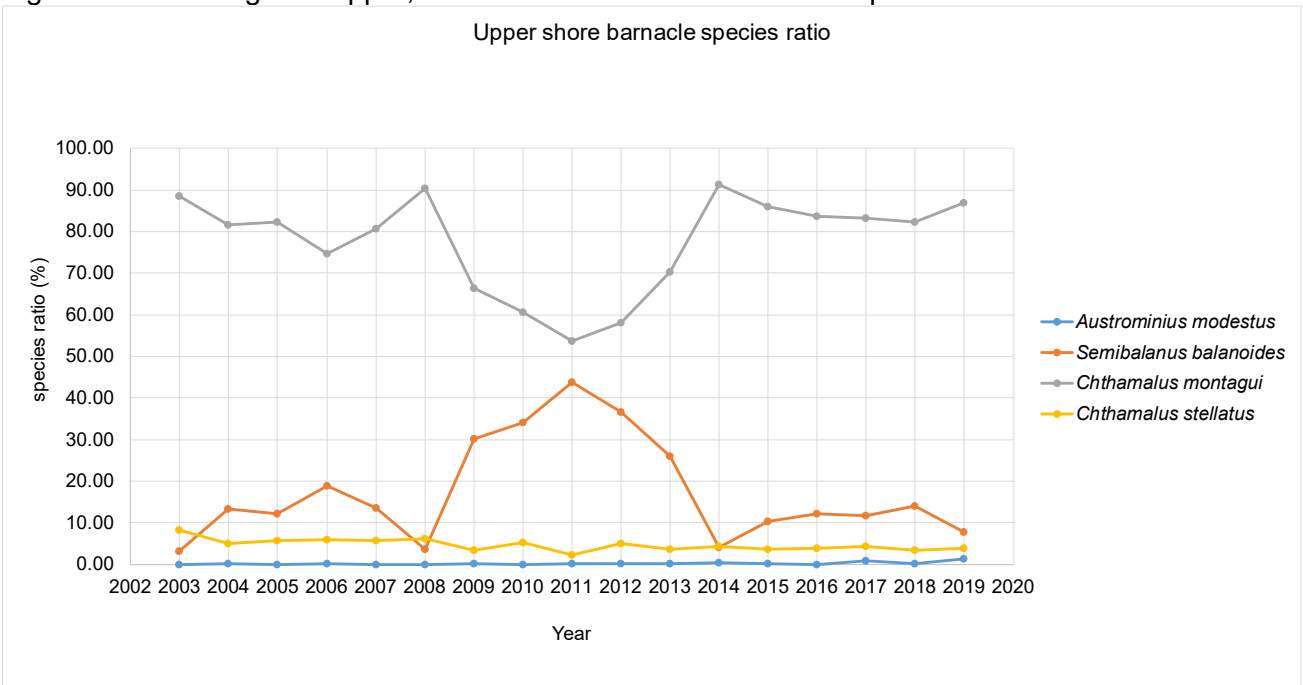


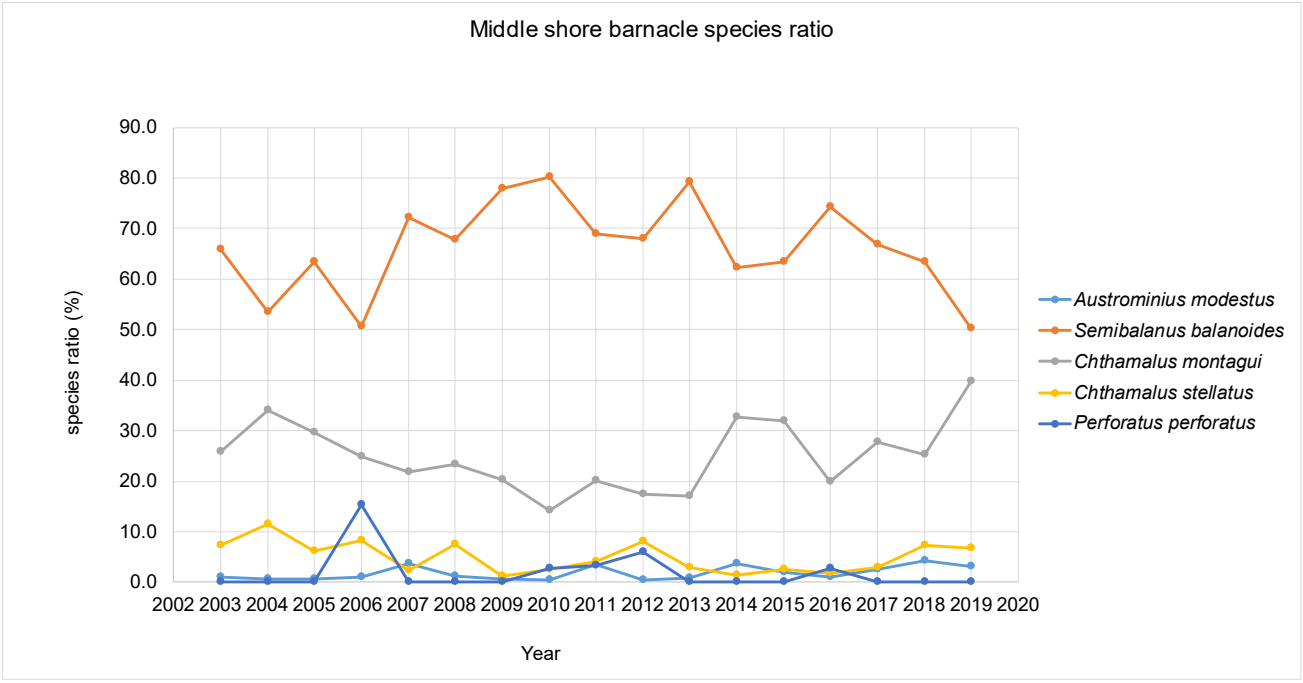
Barnacle Species Ratios

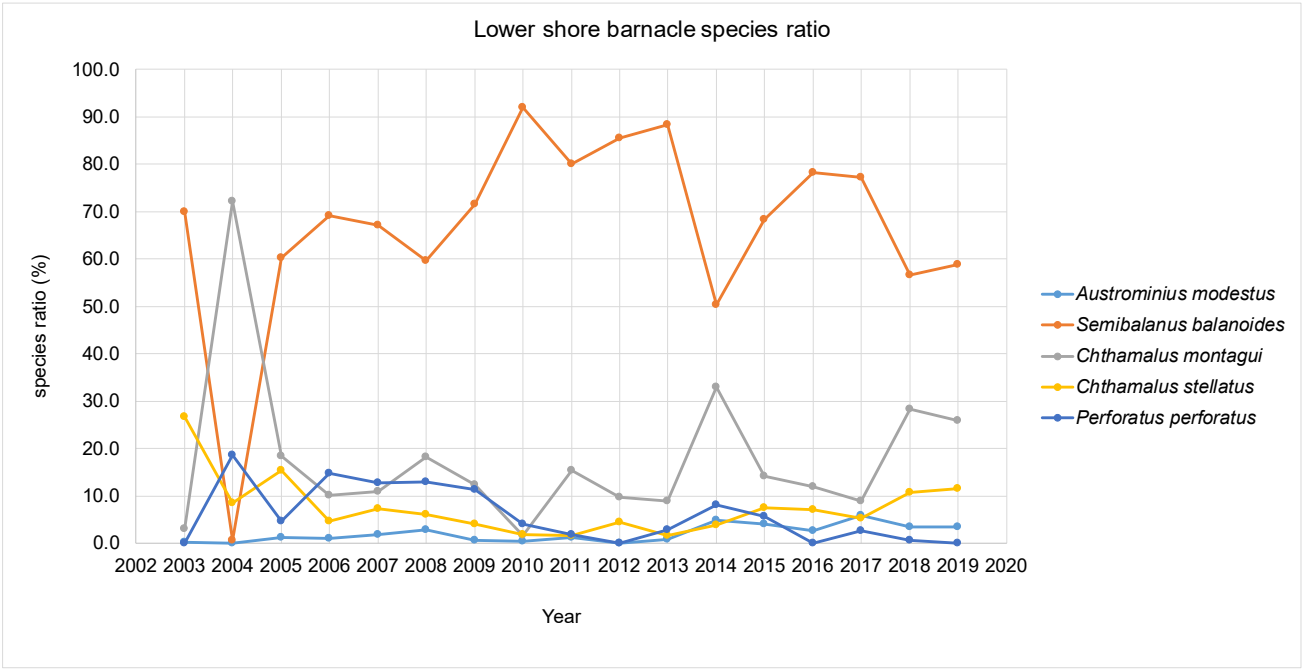
The barnacle species counts have been completed from the photographs of the 5cm x 5cm quadrats at the 3 MarClim Sites: Martins Haven, North Haven and South Haven (photographs taken at the other sites are stored for analysis when time allows).

The lower shore underwent some dramatic changes in 2004 with *Semibalanus balanoides* declining and being immediately replaced by *Chthamalus montagui*. This may be due to a poor settlement of *S. balanoides* spat in the winter of 2002/3 (possibly linked to mild sea temperatures), *C. montagui* individuals would then benefit from a lack of competition. In 2014 there was a significant drop in *S. balanoides* at all shore zones with an increase in *C. montagui*. Since then the proportion of *S. balanoides* has increased.

Figure 6.1.4. Changes in upper, middle and lower shore barnacle species ratios 2003 – 2019







Limpet Size and Counts

The mean limpet size recorded at sites shows a stable trend at most sites, the Lantern shows the greatest fluctuations. In 2019 all four sites had very similar sizes.

Figure 6.1.5. Changes in mean limpet size 2003 – 2019 with 95% standard error bars.

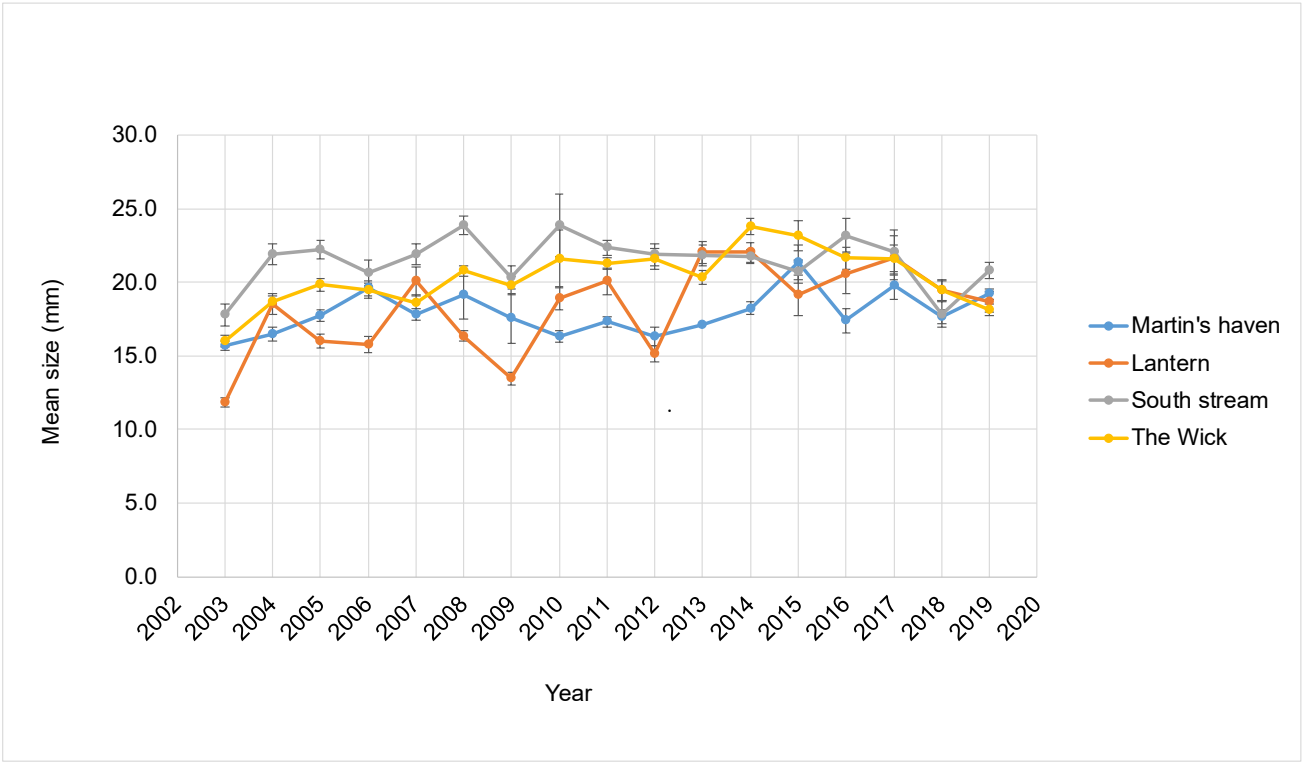
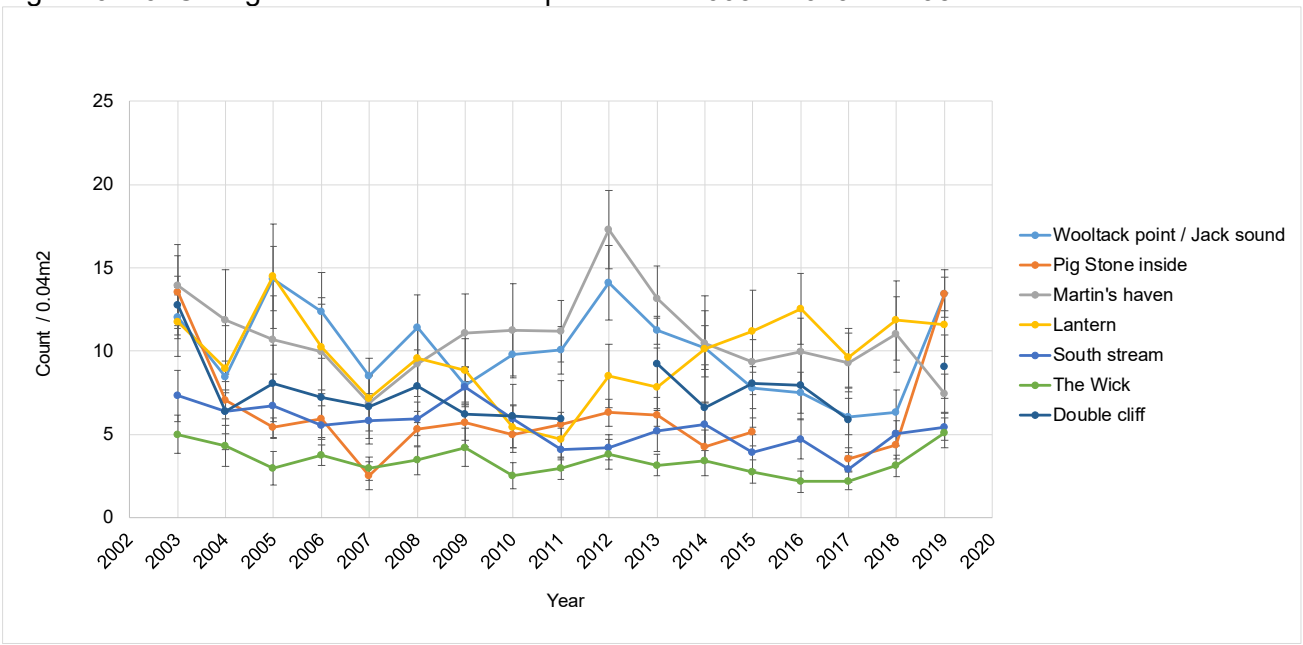


Figure 6.1.6. Changes in middle shore limpet counts 2003 – 2019 with 95% standard error bars.



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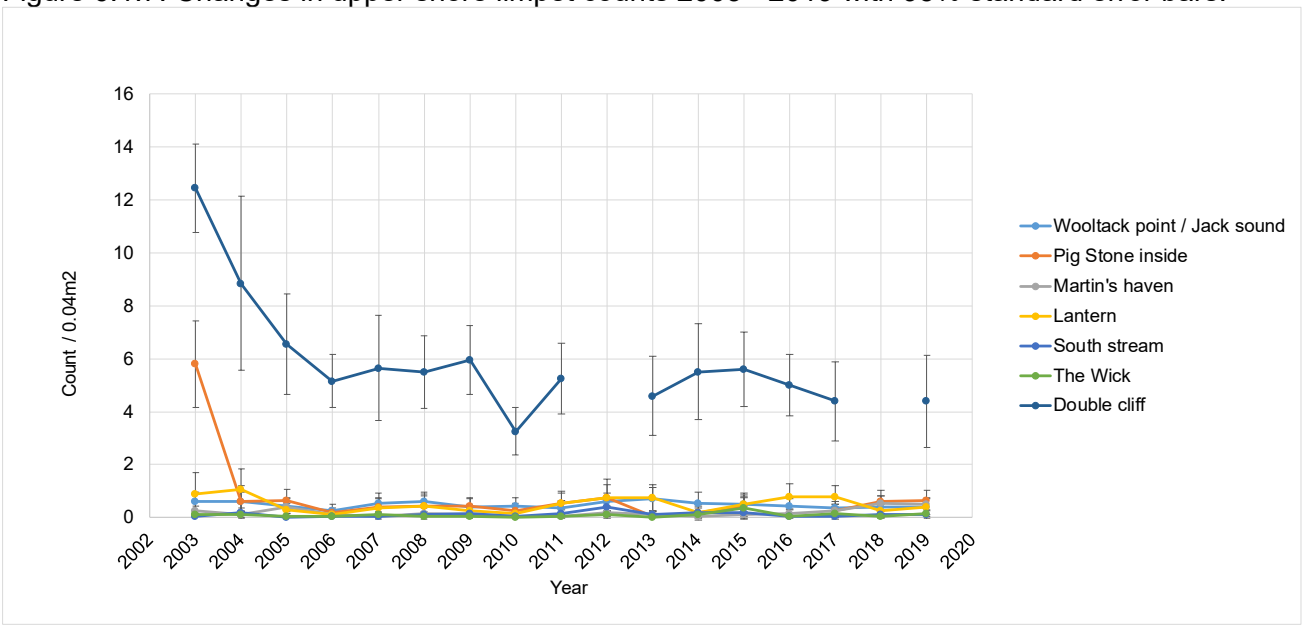
In the middle shore the highest numbers of limpets are found on the north facing shores, but these figures tend to be the most erratic. In 2019 there was an increase in limpet numbers at Pig Stone and Wooltack sites.

Figure 6.1.7. Changes in upper shore limpet counts 2003 - 2019 with 95% standard error bars.



In the upper shore most sites have a low abundance of limpets. Double cliff has significantly more limpets than any other site (north facing shaded cliff) and an interesting declining trend from 2003 – 2006. Double cliff upper shore was not surveyed in 2012 or 2018. All other sites have very similar densities.

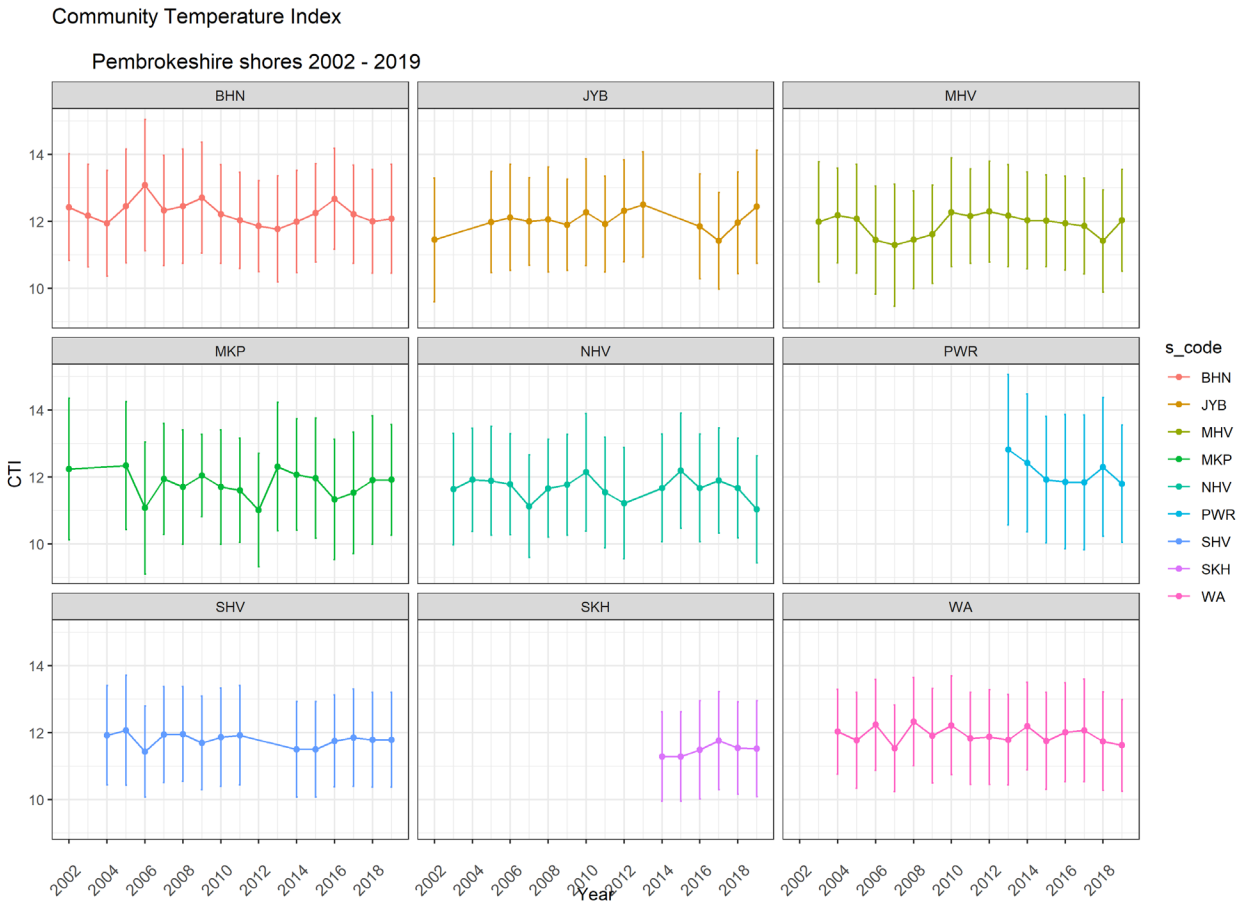
Lichen quadrats
Lichen data have been entered into spreadsheets, and the photographs stored ready for further analysis.

MarClim survey
MarClim data have been entered into spreadsheets and supplied to the MarClim team.

Wakame (*Undaria pinnatifida*) non-native seaweed was found growing for the first time on Skomer and Skokholm shores during the 2018 survey. It was not found at either site in 2019.

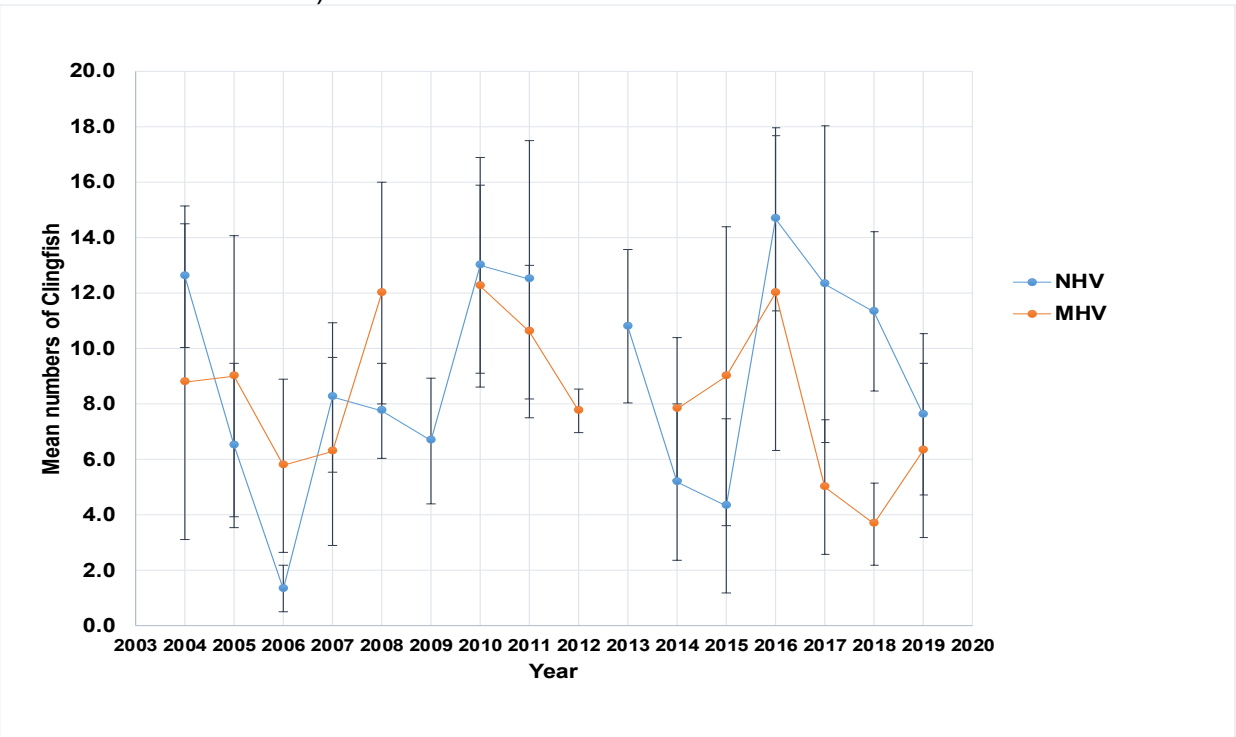
Community Thermal Index (CTI).
CTI is a measure of the status of a community in terms of its species composition of cold- and warm-water species. It is quantitative, easily applied and gives a direct measurement of the response to climate and climate change across all the species in a community (see Burrows 2016 for full description). The MarClim survey data for the Pembrokeshire and Skomer MCZ shores have been used to calculate CTI for the period 2002 – 2019 using species thermal midpoint (STI) values from Burrows (2016).
The CTI scores for the 3 shores surveyed within Skomer MCZ show no significant change averaging a CTI of 11 -12^{o}C which would match the ambient sea surface temperatures for the same period.

Figure 6.1.8. Community Thermal Index Pembrokeshire Marclim shores. Skomer MCZ: Martins Haven - MHV, North Haven - NHV, South Haven - SHV 2002 – 2019 and Skokholm Island - SKH 2014 - 2019 (with 95% standard error bars.).



Clingfish records (*Lepadogaster lepadogaster*).
Timed searches have been completed at North Haven and Martins Haven from 2004 onwards. In 2010 a single clingfish was also found at South Haven beach so this was added as a monitoring site in 2011, and in 2015 and 2016 they were found in greater numbers at South Haven but the presence is erratic with no fish being found in intervening years.

Figure 6.1.9. Average numbers of clingfish 2003 – 2019 at North Haven and Martins Haven (with 95% standard error bars).



Numbers are very variable but there are always clingfish present and eggs are always seen at the time of the survey in various stages of development.

6.1.6. Current Status

The shores appear to be in a condition typical of the area without any unfavourable changes to the shore communities. There is no evidence of any shift in the community due to climate change, in fact the communities on the MarClim shores appear well matched to the ambient sea surface temperatures. Invasive species have been found but so far none are present in large numbers.

6.1.7. Recommendations

Keep current with the development of Community Temperature Index, CTI as an indicator of Good Environmental Status for reporting on littoral communities under the European Marine Strategy Framework Directive: While CTI has been adopted by the European Environment Agency as an indicator of the status of other European terrestrial species (birds and butterflies), it is not yet in widespread use.

Skomer MCZ data could prove valuable in meeting NRW reporting responsibilities as it is shown here to be suitable for CTI calculation.

6.2. Sponge Assemblages
(CMS code: RM13/01)

6.2.1. Project Rationale
The sponge communities at Skomer MCZ have been identified as a management feature due to their rich and diverse nature. Sponges form part of the fragile sponge and anthozoan communities on subtidal rocky habitats, which are of priority importance under Section 7 of the Environment (Wales) Act 2016. Around 130 species have been recorded during this project, some of which are new to science and currently undescribed. Six species are nationally scarce, and eight species are near the limit of their distribution. Sponges are filter feeders and therefore reliant on water quality which makes them susceptible to changes in sediment deposition. They are therefore useful biotic indicators of changes in suspended sediment and surface sedimentation rates, the cause of which might include dredge spoil dumping.

6.2.2. Objectives
- To monitor the sponge assemblages in the MCZ.
- To identify natural and anthropogenically caused fluctuations in the sponge assemblage.
- To identify the presence of rare, scarce and edge of range species in the MCZ.

6.2.3. Sites
- Thorn Rock (annual transects, fixed quadrat and species survey).
- Wick and High Court Reef (species survey)
- MCZ sites, other digital images taken for other projects are used to assess the sponge assemblages around the MCZ. (2009 – ongoing).

6.2.4. Methods
Transects: Four fixed transects are located at Thorn Rock. 1994 to 2008 photographs were taken from fixed positions along the transect using paired cameras set up on a 50 x 70cm frame. The resulting images were analysed using a stereo viewer to count the abundance of sponge species and morphology types. Classifying sponge assemblages into morphology types (Bell & Barnes 2001) has proved to be a quick and simple method to analyse annual photographic datasets, as long as the four-yearly species “inventory” (see below) is used to check that there has been no undetected “drift” in species composition of the assemblage. In 2009, a digital SLR taking high resolution images was substituted for the stereo cameras.

Species survey: In 2003, all sponge species were identified in sixteen 50 x 70cm quadrats positioned close to the four fixed transects at Thorn Rock. From the 2007 survey onwards no quadrats were used, and surveys were completed in the general vicinity of the Thorn Rock transects, with all species being identified if possible. In 2011, the survey was extended to include the Wick with High Court Reef added in 2015. Species photographs were taken in the field and samples taken, where necessary, for spicule preparations.

Seasonal survey from fixed quadrats: In 2005, fifteen 1m^2 quadrats were marked out at three of the four fixed transects locations at Thorn Rock. The quadrats each consist of 25 cells (20 x 20cm). The quadrats are positioned and then “wafted” to clear the surface silt before being photographed with a digital camera fixed to a small camera framer. This is completed at the beginning (April/May) and end of the fieldwork season (Sept/Oct) and where possible in mid-season (July). The digital photographs are then merged together to

form a mosaic of the full 1m^2 quadrats. These data have been stored and supplied to Dr. James Bell, Wellington University, New Zealand for ongoing research and analysis.

6.2.5. Project history

Transects: 1993 to 2019 photo quadrats (samples) taken Thorn Rock

Table 6.2.1. Data gathered from Thorn Rock sponge transects 1993 to 2018
(Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL)

Year	No of samples	Transects WG, SH, BG, DL
1993	24	WG only
1995	77	All completed
1996	72	All completed
1997	20	WG only
1998	60	WG, SH, DL
2000	63	WG, SH, DL
2001	62	WG, SH, DL
2002	81	All completed
2003	79	All completed
2004	80	All completed
2005	80	All completed
2006	79	All completed
2007	81	All completed
2008	0	All completed but the image quality was very poor and no analysis was possible
2009	81	Digital SLR replaced 35mm slide film All completed
2010	81	All completed
2011	81	All completed
2012	81	All completed, poor quality due to lots of sediment on the surfaces
2013	81	All completed
2014	81	All completed – Poor visibility
2015	81	All completed
2016	81	All completed
2017	81	All completed
2018	81	All completed
2019	81	All completed

Species surveys:

Table 6.2.2. Sponge species surveys summary

Year	Thorn Rock	High Court Reef	Wick
2003	Yes	No	No
2007	Yes	No	No
2011	Yes	No	Yes
2015	Yes	Yes	Yes
2019	Yes	Yes	Yes

Sponge samples taken during the 2015 species survey were also supplied to Dr Joanne Preston, University of Portsmouth for DNA research. This is ongoing work and the results will contribute towards the National Gen-bank. Samples have also been supplied to the Natural History Museum (London) and National Museum Wales, to be stored as part of the national sponge collection.

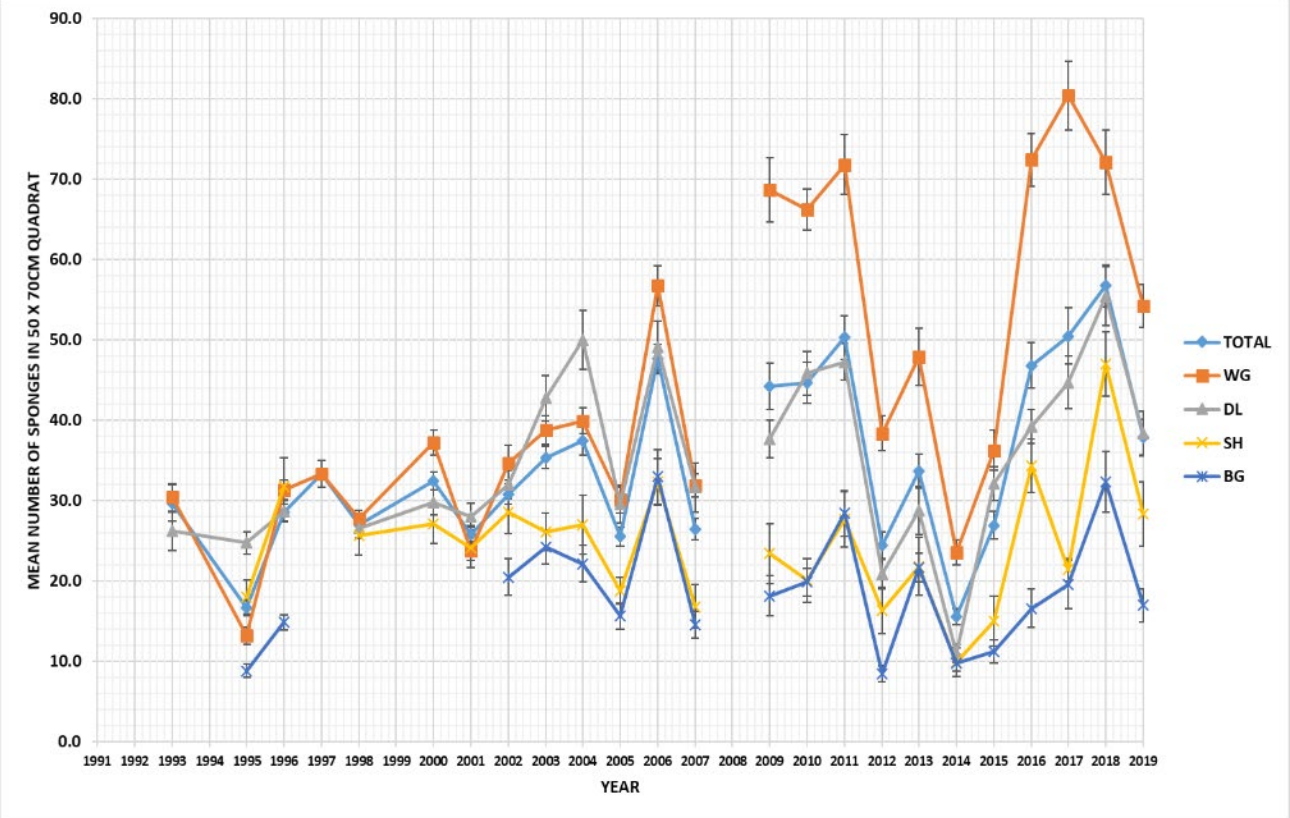
Additionally, to investigate so-called “Black Death” incidents, Boring sponge (*Cliona celata*) samples were collected in 2015 and sent to Dr Preston. Samples were taken of healthy, fouled and diseased sponges for microbial community profiling.

Seasonal survey from fixed quadrats:
The quadrat survey has been completed annually from 2006 to 2019. The frequency of the survey has varied between 1 – 3 survey events in a year, depending on weather and time availability. From 2017 it was decided to reduce the survey to once annually in September.

6.2.6. Results

Transects:
Sponge Morphology Analysis
This method has been used for all the quadrats taken at Thorn Rock, except the “seasonal survey” 1m^2 quadrats (see Recommendations below), and for a series of sites around the MCZ where comparable quadrat photos are taken. The data can then be plotted or analysed using the Primer multivariate analysis software to compare similarity between sites.

Figure 6.2.1. Mean number of sponges counted in each quadrat at 4 sites –Thorn Rock 1993-2019, with 95% confidence intervals. (Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL)

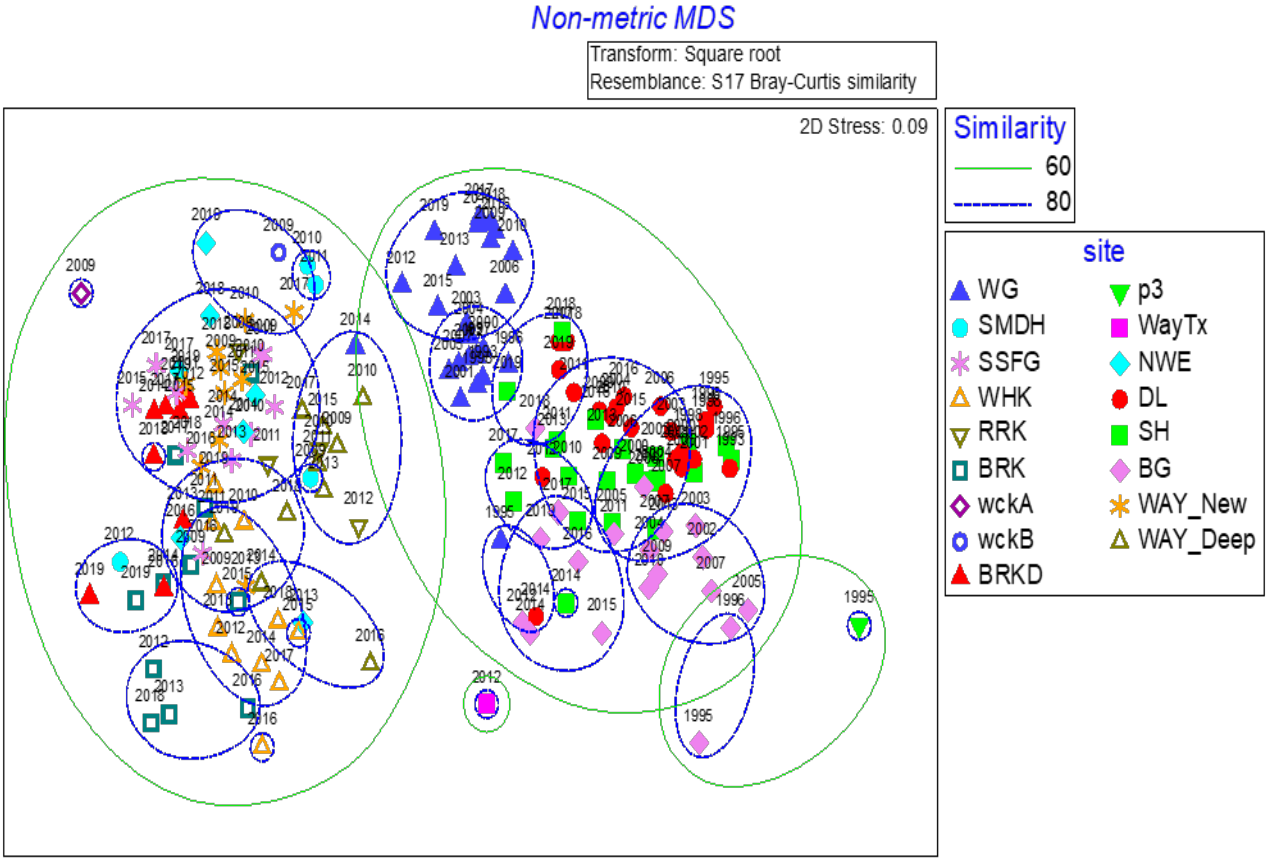


Improvement in image quality and resolution has meant that more sponge entities have been recorded from 2009 onwards than in previous years. However, in 2012 and 2014 there was a noticeable drop in the numbers of sponges across all transects. In 2019 all sites decreased in abundance, despite good image quality.

The morphology method for characterising sponge assemblages has also been applied to suitable monitoring photographs taken from a range of sites around Skomer MCZ. This puts

the Thorn Rock transects into context. The morphology data are entered into the Primer V7 statistics package, averaged to site and year, and a similarity matrix produced using the Bray-Curtis similarity coefficient on the square root transformed data.

Figure 6.2.2. PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data averaged to site and year 1995 – 2019



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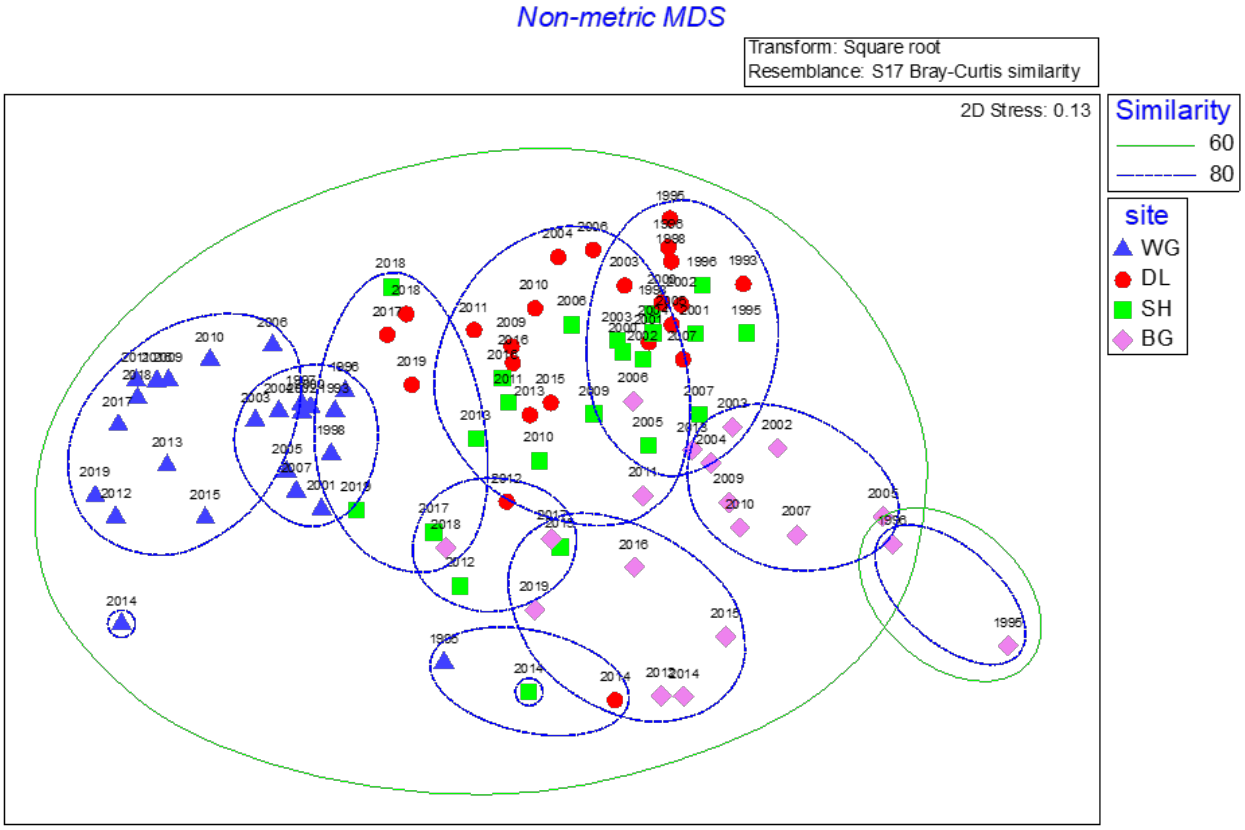
In Figure 6.2.2 the Thorn Rock transects: WG, DL, BG and SH, in all years separate out from the rest of the MCZ sites (see Section 5 map and table for site codes). The longest dataset is at Thorn Rock.

The results for Thorn Rock are analysed separately in Figure 6.2.3 and show that the vertical cliff site of Windy Gully (WG) is consistently different to the flat bedrock sites: Broad Gully (BG), Spongy Hillocks (SH) and Dogleg (DL).

Figure 6.2.3 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data for Thorn Rock transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL.



Species survey:
In 2019 six sites were surveyed on the south side of Skomer Island as part of the continuing full sponge species monitoring programme, completed every 4 years. Four of the sites are located at Thorn Rock, one at The Wick and one at High Court Reef.

Ten dives were undertaken in total during the survey, during which the divers carried out *in situ* recording and photography of sponges. Samples were taken of sponges that were not easily identifiable and these were preserved and later examined in detail.

The survey resulted in 72 species/entities being recorded in total. One of these (*Spongosorites* sp. 'A'), has not been previously recorded from the MCZ, and early findings suggest that it is an undescribed species, although research is currently ongoing. *Spongosorites calcicola*, which is also present in the MCZ, was recorded for the first time during the 2015 species survey and was found again in 2019. Another species of note found in 2019 is a previously un-recorded *Eurypon* sp., bringing the total number of as yet un-named *Eurypon* spp. in the MCZ to 8.

The most frequently recorded species were: *Cliona celata*, *Dysidea fragilis*, *Hemimycale columella*, *Pachymatisma johnstonia*, *Plocamionida ambigua*, *Stelligera stuposa* and *Stelligera montagui (*formerly *Stelligera rigida)*, which were recorded from all six sites.

Broad Gully (Thorn Rock) was the richest site in terms of diversity, with a total of 42 species being recorded. Dog Leg (Thorn Rock) was the least diverse, with 31 species.

A total of 130 sponge species (42 of which have been named to genus level only) have now been recorded from the Skomer MCZ, including records from previous surveys conducted before 2003, when the first of the four-yearly full species surveys took place.

A full report for the 2019 Skomer sponge species survey has been completed (Jones *et al* 2020).

6.2.7. Current status

- The species surveys show that Skomer has a high biodiversity of sponge species, one of the highest in the UK.
- The sponge assemblage at Thorn Rock is a “hot spot” for sponges within the MCZ. The community at Thorn Rock is quite dynamic in terms of total number of sponges visible but the overall community structure appears stable.

6.2.8. Recommendations

- Continue application of morphology method for analysis of photos.
- Expand transect photo-monitoring programme to other sites in the MCZ with good diversity of sponge species.
- Expand transect photo-monitoring programme to sites outside the MCZ to provide contextual data for changes in populations seen at Skomer MCZ and thereby improve knowledge of the diversity of sponge assemblages.
- Work up sponge data from “wafted” 1m quadrats to overcome masking effects of silt (in progress).
- Seasonality patterns need further investigation as seasonal changes in the sponge assemblages have been found. Winter data are needed as samples have only been collected from April to October. Encourage continued research on sponge seasonality in the MCZ.
- Continue sponge species recording every 4 years, next survey due 2023.
- Continue support of sponge research carried out by academic bodies.
- Produce publications in the peer-reviewed scientific literature.

6.3. Plankton Recording
(CMS Code RB04/01)

6.3.1 Project Rationale
Whilst plankton is not identified as a management feature for Skomer MCZ its importance as a vital ecological component of the marine ecosystem makes it a major factor influencing all other MCZ features. Plankton provides primary production to drive the whole system and many feature species have planktonic larval stages. The abundance and species composition of plankton is influenced by available nutrients, water movement, temperature and light.

6.3.2. Objectives
To collect seasonal abundance and species diversity data for zooplankton and phytoplankton.

6.3.3. Sites
- North coast Skomer between OMS site buoy and the Lucy buoy (2008 & 2009)
- North of the Lucy buoy (2010- ongoing)

6.3.4. Method
Zooplankton:
2008 and 2009: A plankton sample was collected once a week using a 63 micron mesh plankton net trawled at less than 2 knots between the OMS and Lucy site markers. Samples were preserved in 2% formalin and seawater.

2010 onwards: A review of the results and objectives called for a change in methods. It was proposed that the sampling from Skomer matched that from other plankton time series projects to make the results comparable. The Plymouth Marine Laboratory (PML) has a plankton sample time series (L4), which would act as a good comparison site. The methods used at L4 are replicated at Skomer and analysis completed by PML.

PML method adopted: A 200 micron mesh net is hauled vertically from 35- 40m depth at approximately 0.2m per second. The sample is collected in the 'cod-end' bottle and this is preserved in 4% formalin. Two samples are taken at each sampling event.

Phytoplankton and chlorophyll:
2011- 2012: A water sample was taken and preserved in Lugol's solution to provide a record of the phytoplankton species present. This can be used to identify species responsible for "blooms". A second water sample was also taken at 1m below the surface. This was then used to filter three 250ml samples over a 0.2 micron filter to estimate chlorophyll content. The chlorophyll samples were analysed by PML. The phytoplankton samples in Lugol's solution were stored as a record of any plankton bloom.
2013 onwards – discontinued due to lack of funding for analysis.

2019 - Phytoplankton sampling was restarted in June. A 20 micron mesh net with a 30cm diameter opening was used. The samples were collected by a vertical haul from 20m with the net attached to a CTD probe. Samples were then stored in 2% formalin.
For the ID and enumeration, the procedure used was:
Formaldehyde was rinsed from the sample using a 20 micron filter and the sample transferred to tap water. The sample was then divided in to eighths with a Folsom splitter. One of the eighths was then made up to 100 ml to dilute it further, agitated vigorously and then a 0.5 ml subsample was taken with a graduated pipette to get a 1600^{th} subsample.

This was then put on a Sedgewick Rafter graduated slide and the cells counted in a series of traverses under the high power of a compound microscope with a mechanical stage.

6.3.5. Project History

2009 - 12 samples were sent to the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) for identification and enumeration by Dr D. Conway. The sample dates were from the 10th May 2009 to the 9th Nov 2009. All zooplankton individuals were identified to species level if possible and counted. Phytoplankton individuals were identified to species level, but their abundance was recorded semi quantitatively, (no report: raw data provided).

2010, 2011 & 2012 - samples were collected from March to November, these have been analysed by the Plymouth Marine Laboratory, (no report: raw data provided).

2013–onwards - Samples were sent to Dr D. Conway (Plymouth Marine Biological Association) for identification and enumeration, (no report: raw data provided).

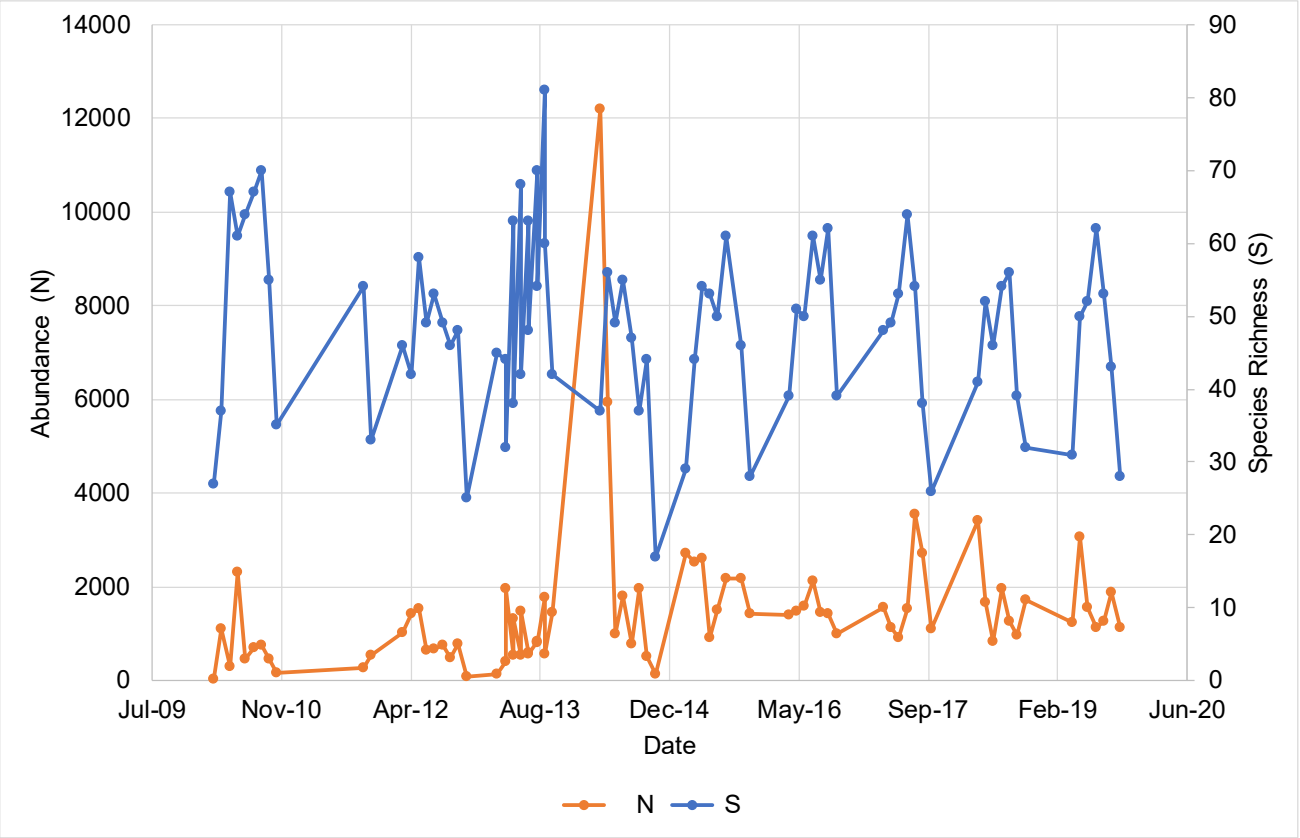
2014 - Plymouth Marine Laboratory reviewed the current dataset, standardised the species list and made recommendations on how the dataset should continue (McEvoy *et al* 2013).

In 2019 - Phytoplankton sampling was restarted. Zooplankton & Phytoplankton samples sent to Dr D. Conway (Plymouth Marine Biological Association) for identification and enumeration, (no report: raw data provided). This is the last year Dr Conway will analyse the plankton samples due to retirement.

6.3.6. Results

Zooplankton:

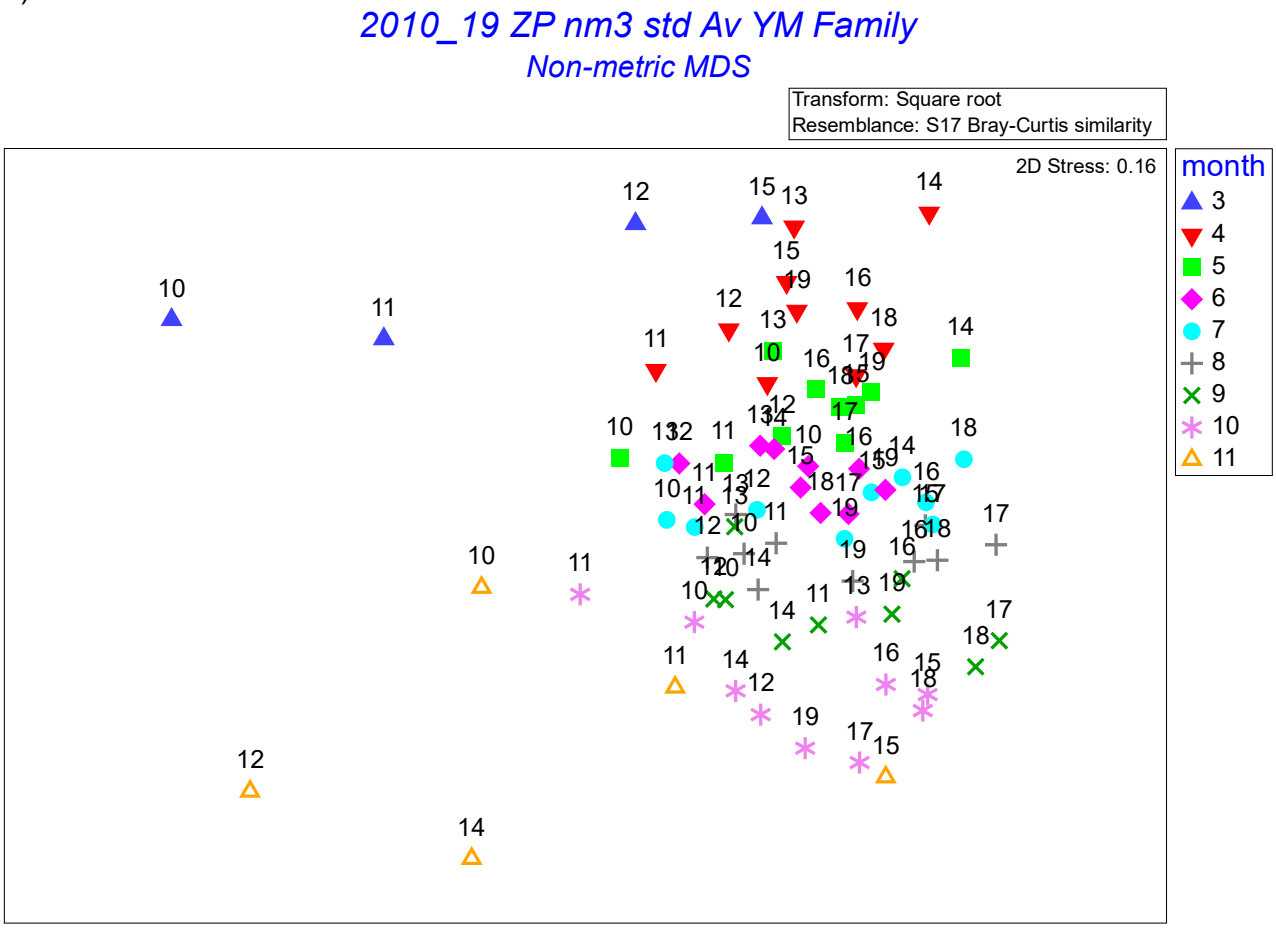
Figure 6.3.1 Average plankton species richness (S) and total number of individuals (N) 2009- 2019



The peak in abundance in April 2014 was due to huge numbers of barnacle larvae in the plankton.

All zooplankton data are held on file at the Skomer MCZ office in spreadsheet format and as Primer files. This allows for a wide range of data analysis: Individual species can be selected, differences between years can be analysed or the whole dataset can be combined to look for seasonal trends.

Figure 6.3.2. PRIMER plot of average plankton species richness (S) and total number of individuals (N) 2009- 2019



Statistical analysis of the differences between datasets shows a strong seasonal pattern with months grouping together. However, these groups are in lines which does suggest inter-annual variability.

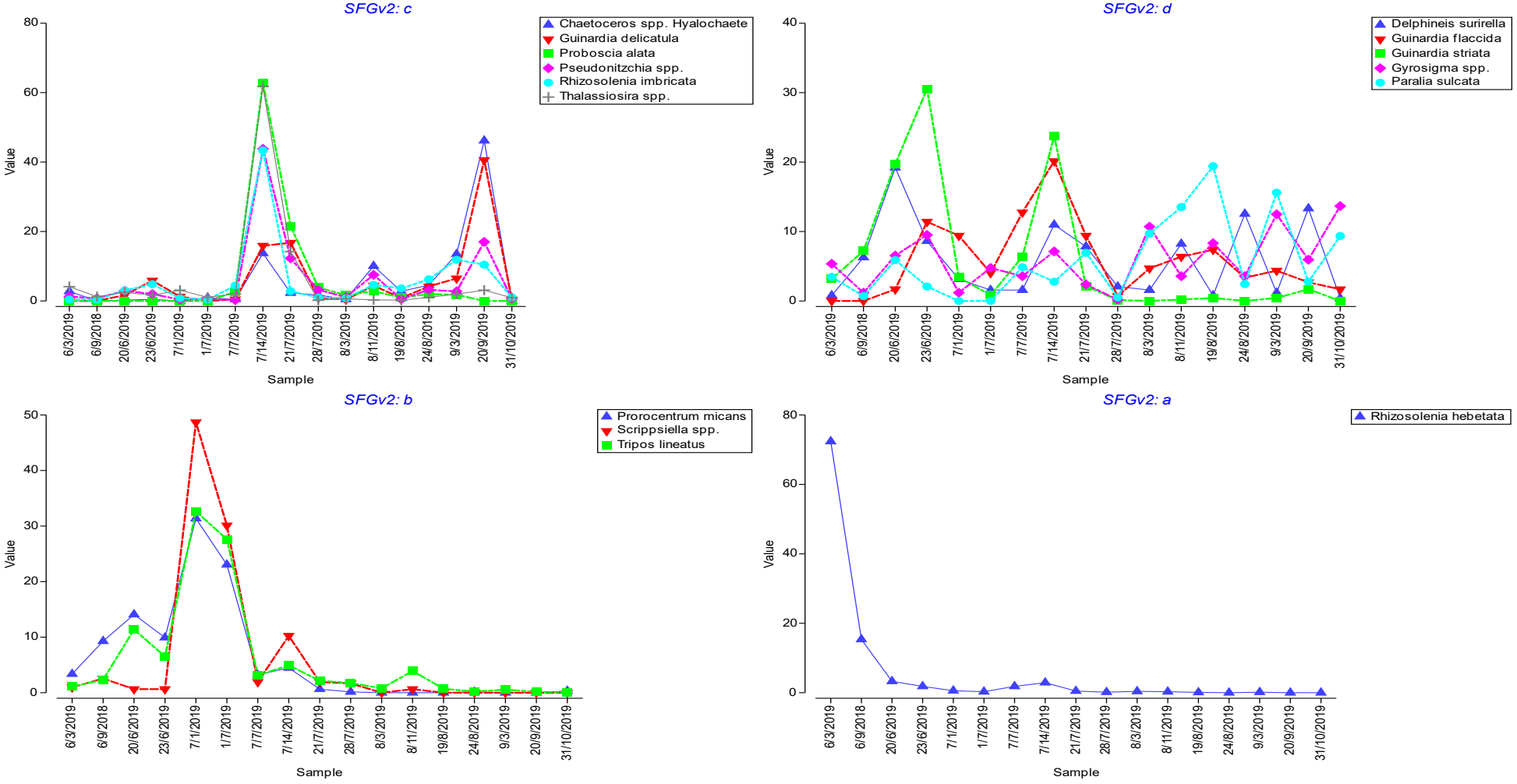
Figure 6.3.3. *Anchovy egg* (D. Conway 2019).

The anchovy egg (14th July 2019) is an interesting record, very few have been recorded in the southwestern approaches. Anchovies tend to spawn in estuaries on the eastern seaboard of the North Sea

Phytoplankton:

Figure 6.3.4. Species coherence plots (Primer7) showing seasonality response for 15 species of phytoplankton.

The 20 micron net collected huge numbers of algae, this meant that in order to enumerate the species a sub sample of 1/1600th was necessary. There was considerable diversity, with 55 species and groups, and seasonal changes in species composition and numbers.



.

Only 1 year of data, starting in June, limits the analysis to being just descriptive. Future years of data with a longer seasonal spread need to be collected

The July 14th 2019 sample was an interesting record with species such as *Leptocylindrus mediterraneus* suggesting an oceanic influence. This coincided with a zooplankton sample containing an anchovy egg (figure 6.3.3) another record that would not normally be found in the coastal waters around Skomer.

6.3.7. Current Status

The status of the plankton at Skomer MCZ is unknown. Further data are required to estimate natural variability.

6.3.8. Recommendations

- Continue to collect further seasonal data for zooplankton and phytoplankton, to assess its variability.
- Restart the water sampling for chlorophyll (planned for 2020).
- Compare datasets to Plymouth Marine Laboratory L4 site to help ascertain natural variability and give geographic context.
- Find a new contractor to identify and enumerate the zoo- and phyto- plankton samples.

6.4. *Eunicella Verrucosa*: Population and Growth Rate
(CMS Code: RM23/01)

6.4.1. Project Rationale
The pink sea fan *Eunicella verrucosa* (Pallas) is a component of the Lusitanian anthozoan management feature of the Skomer MCZ. It is on Schedule 5 of the Wildlife and Countryside Act 1981 and is a species of principal importance under Section 7 of the Environment Act (Wales) 2016. It is also a component of the fragile sponge and anthozoan community habitat of priority importance under Section 7. *E. verrucosa* is a soft coral nearing the northern limit of its distribution in North Pembrokeshire. Sea fans are a slow growing, erect species susceptible to permanent damage. Recovery and reproduction rates are thought to be very slow.

6.4.2. Objectives
To monitor numbers and condition of the recorded pink sea fans in Skomer MCZ and to expand the monitored population.

6.4.3. Sites

North Wall stereo	(1987)
Bernie's Rocks (East and West)	(1994)
Bull Hole	(2002)
The Pool	(1997)
North Wall East	(2000)
Sandy Sea Fan Gully	(1994)
Thorn Rock	(2002)
Way Bench	(1994)
Rye Rocks	(2002)
South Middleholm	(2002)
West Hook	(2005)

6.4.4. Methods
1. Individual pink sea fan colonies are mapped out at each site. The maps are used to navigate to each fan and are expanded when additional mature fans are found in the area. Care is taken to search the area for small, newly established fans which are counted as 'new recruits'.

2. Photographs are taken using a single camera mounted on a 50 x 70 cm frame. Both sides of the sea fan are photographed.

3. Each sea fan is visually inspected for damage, fouling by epibiota, entanglement with man-made materials, necrosis (loss of living tissue) and the nudibranch *Tritonia nilsodhneri* and mollusc *Simnia patula.*

4. The photographs are analysed using image analysis techniques.

Where practicable detached sea fans that are found in the Skomer MCZ are re-attached artificially to the rock substrate at one of the monitoring sites if enough polyps remain alive on the colony for it to recover. These fans are then added to the monitoring programme as 'attached fans'.

6.4.5. Project history

1997 - methods were developed using MapInfo software to study the fan area and branch length to assess growth (Gilbert 1998). This was completed for all fan images taken from1994 to 2000.

2001 - a re-evaluation of methods used for growth assessment was completed and the 1997 method was discontinued due to many inaccuracies, mainly from inconsistencies in the images of individual fans matching between year sets. A method to assess fan condition was developed, this was completed for all photo images in the dataset since 1994.

2002 to date - fan condition assessment has been completed each year using both photo images and supportive field records. In 2008 a new digital SLR camera providing high quality images helped to improve photo analysis.

6.4.6. Results

Table 6.4.1. Skomer MCZ sea fan survey results 1994 -2019

Year	Sites surveyed	Total fans recorded	Total natural fans	Total attached fans	New recruits	Natural fan Losses (confirmed)	Attached fan losses	Missing (to be confirmed)
1994	4	34	34	none	none	none	none	
1995	4	33	33	none	none	1	none	
1996	4	33	33	none	none	none	none	
1997	5	39	39	none	none	none	none	
1998	5	39	39	none	none	none	none	
1999	0	No data	No data	none	none	none	none	
2000	5	54	54	none	none	none	none	
2001	5	55	55	none	none	1	none	
2002	9	86	86	none	none	1	none	
2003	9	99	99	none	1	none	none	
2004	9	101	100	none	none	none	none	
2005	10	114	111	3	1	1	none	
2006	10	119	116	3	7	none	none	
2007	10	121	118	3	1	2	none	
2008	10	126	122	4	none	none	none	
2009	10	128	121	7	none	1	none	
2010	10	126	120	6	none	3	1	
2011	10	126	122	4	none	none	2	
2012	10	126	121	5	none	none	none	
2013	10	129	124	5	none	none	none	
2014	9	124	120	4	none	none	none	
2015	10	125	123	2	none	3	2	
2016	10	118	115	3	1	9	none	
2017	10	114	112	2	none	3	1	
2018	10	110	108	2	1	6	none	
2019	10	104	102	2	none	none	none	7
totals					11	31	6	

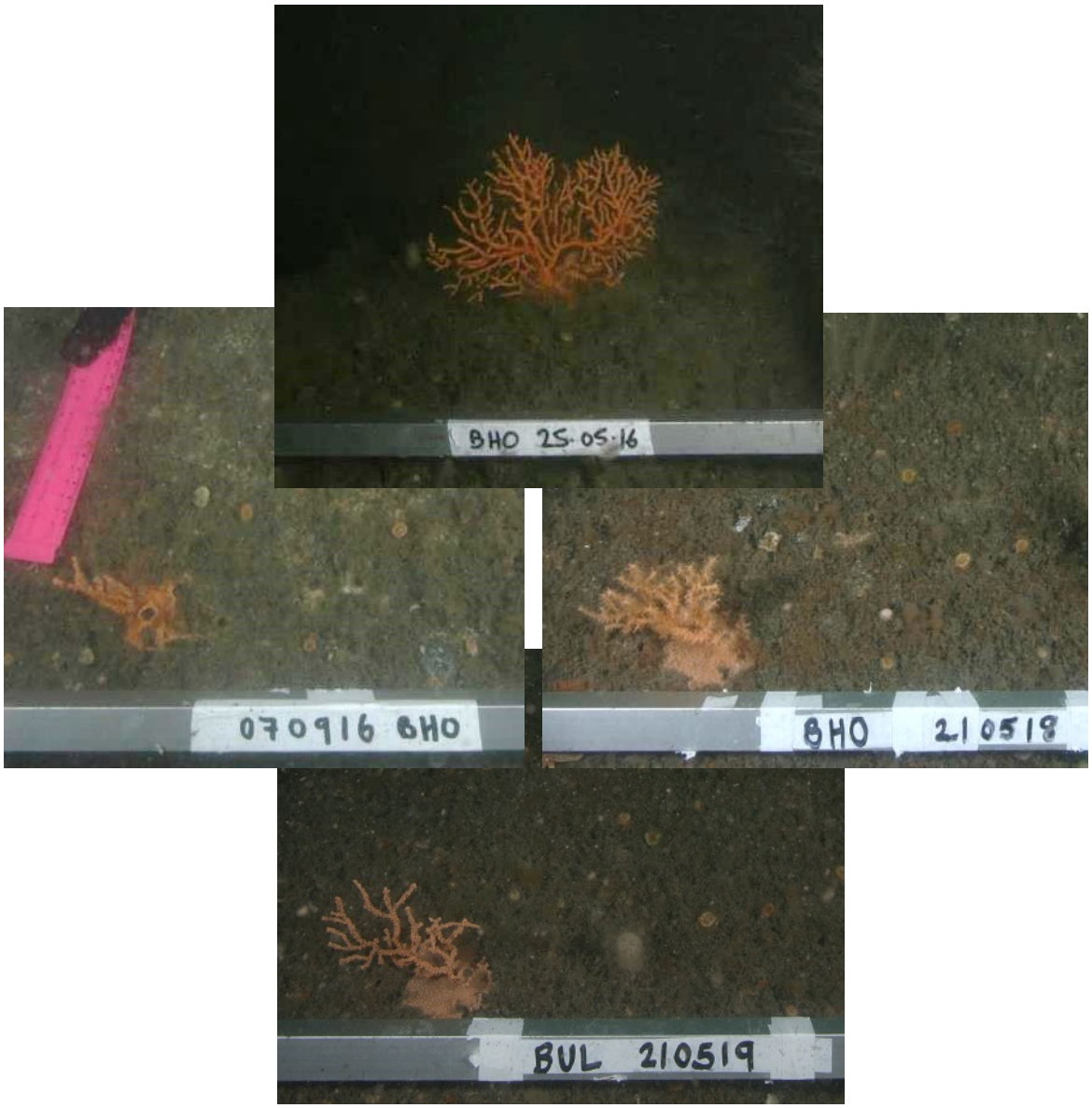
Losses

A total of 31 losses of natural sea fans and 6 losses of artificially attached fans have been recorded throughout the period of this project.

In 2018, 5 natural sea fans (BH8, BH18, BRK7 and POL8 and POL9) and 1 of the cluster of 5 small fans at BH were missing, in 2019 these were all confirmed as losses.

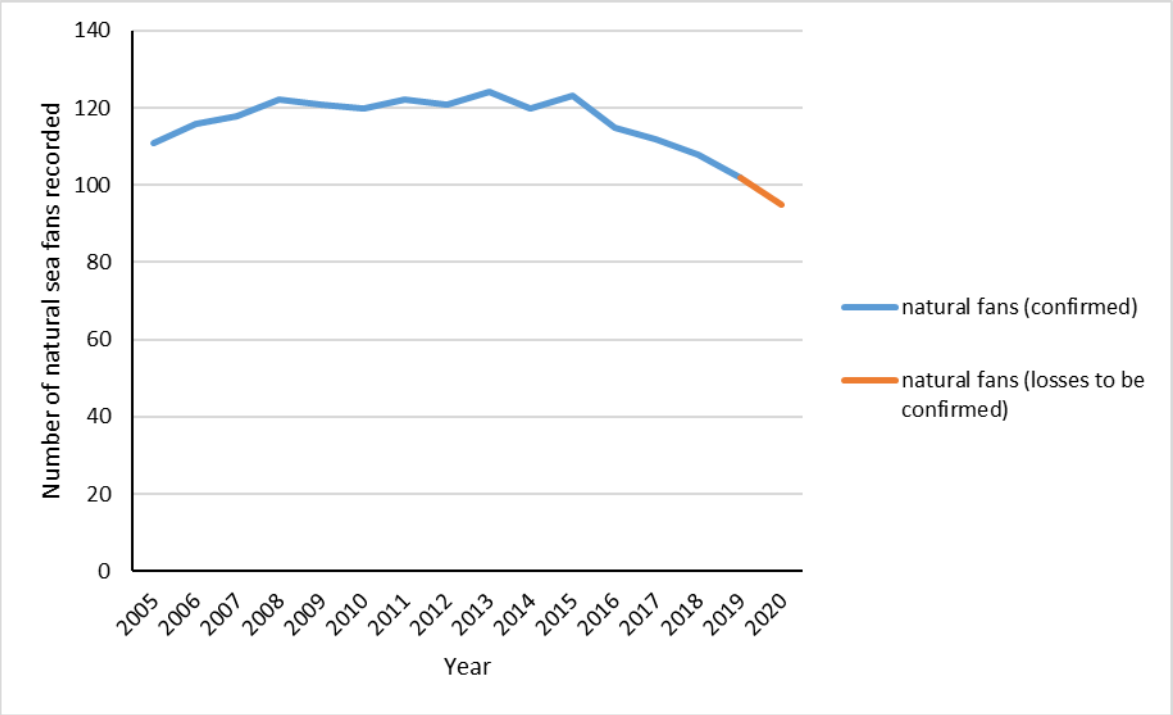
In 2016 BH21, was reduced to a stump, however, new growth was observed in 2018 and this growth has continued in 2019. Other fans which have been lost but where a base or stump is still present are being checked for any new growth.

Figure 6.4.1. Sea fan BH21 May 2016, reduced to stump September 2016, new growth recorded in 2018 and 2019.



Five additional fans were absent in 2019, BH22, WAY7, NWA3, POL10 and RRK25 these will be checked, and their status confirmed in 2020. Only two of the cluster of 5 small fans at Bull Hole were present, one was recorded as lost in 2018 and now a further two are missing.

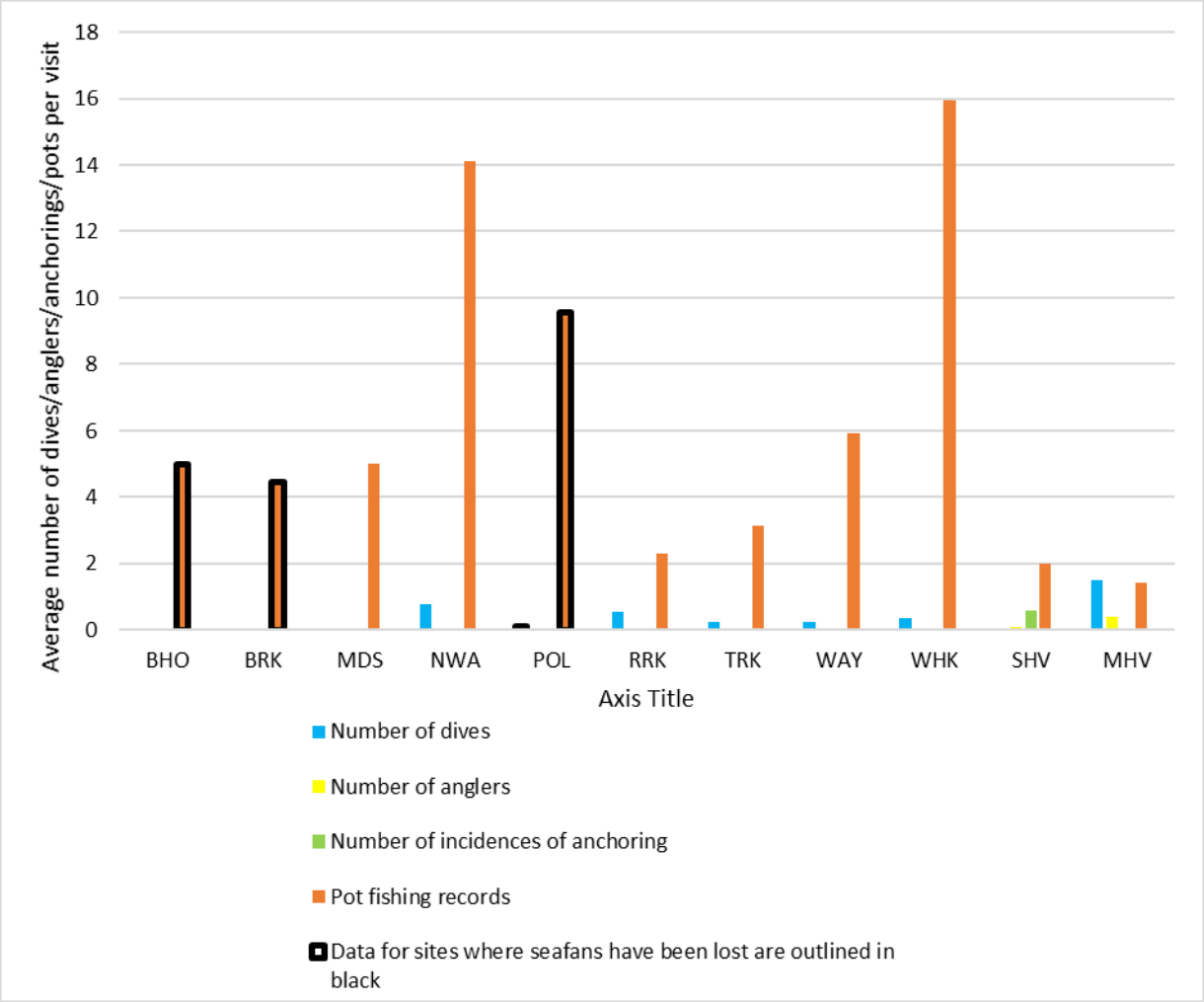
Figure 6.4.2. Total number of natural sea fans recorded 2005 to 2019 (artificially attached sea fans not included in this data)



The loss of natural sea fans has increased in the last 5 years. From 2008 to 2014 the total number of natural sea fans recorded were between 120-124 fans. During this period 4 confirmed losses were made, however since 2015 the losses have significantly increased. Between 2015 and 2019 there have been 21 natural fans and 3 artificially attached fans confirmed missing and a further 5 natural fans and 2 of the cluster of small fans at Bull Hole were absent in 2019 to be confirmed as losses in the 2020 field season.

In an attempt to understand potential causes behind the loss of sea fans at Skomer MCZ human activity data for 2018 (for which sea fan losses are confirmed) has been analysed in more detail (Fig 6.5.2), concentrating on those activities with the potential to make contact with the seabed or sea fans and the sites where sea fans are monitored (see Appendix 1 for human activity recording methodology).

Figure 6.4.3. “Seabed contact” activities at Skomer MCZ sea fan monitoring sites in 2018.



Data presented in Fig 6.5.3 is corrected for differences in the numbers of days on which data were collected for different activities and at different sites to allow comparisons between years to be made. Data for South Haven (SHV) and Martins Haven (MHV) are included for context; neither are sea fan monitoring sites, but one is a highly popular (and permitted) anchorage and the other is popular with divers. Diving numbers include Skomer MCZ monitoring dives.

Of the sites that suffered losses in 2018 (BHO, BRK and POL) most have very low levels of diving (only TRK has dives recorded additional to those carried out by MCZ staff), no anchoring was recorded at any site and angling was only recorded at MDS. The activity most often recorded at all monitoring sites is lobster potting.

It can be seen from the graph that lobster potting is also recorded at sites where there were no sea fan losses, but at these sites there are either very low numbers of sea fans (MDS, TRK, WHK) or the seabed topography may be such that sea fans are protected from “seabed contact” activities by being in gullies or below overhanging rock formations.

It should be noted that all data are likely to be an underestimate of actual activity, but more so for commercial fishing effort, which is only usually recorded once per week between May and September.

Recruitment

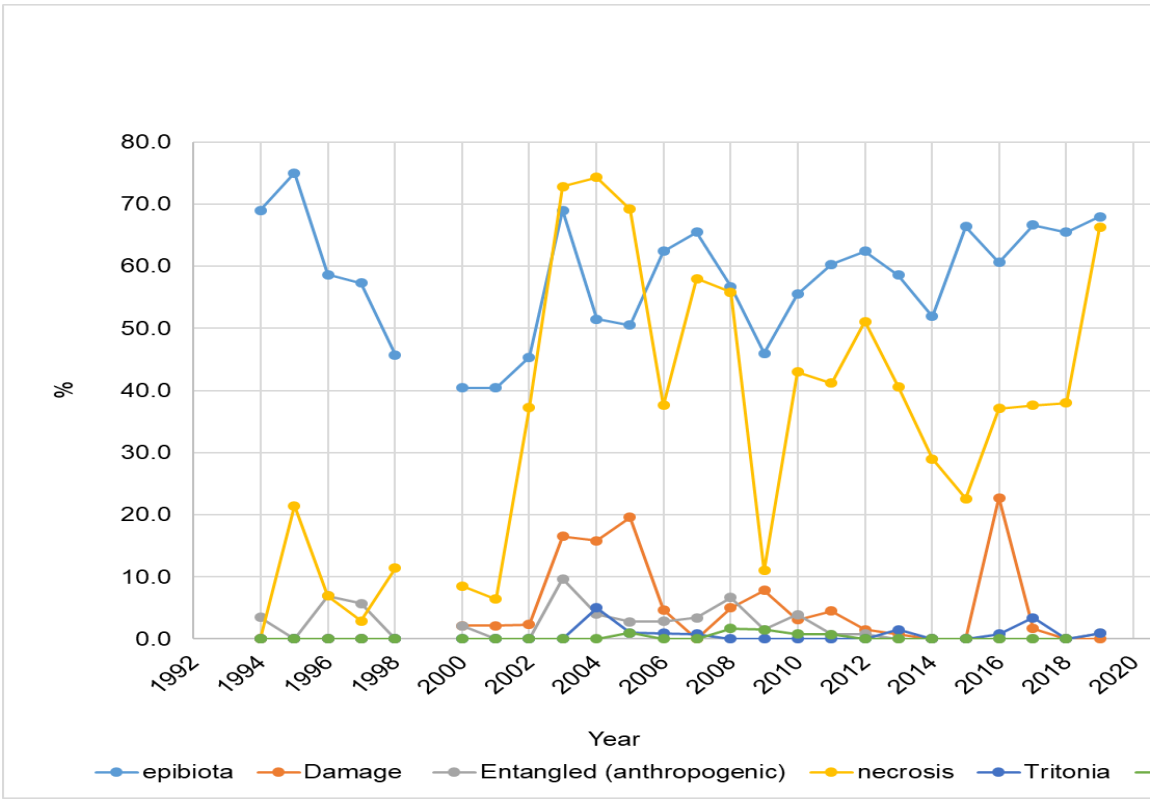
Recruitment has been low relative to losses with a total of only 12 “new recruit” sea fan colonies being recorded at the monitoring sites since 2000. Condition and growth in the recruits has been variable. BHO23 was a confirmed loss in 2010 and the cluster of 5 “new recruits” at BHO have shown no growth in 12 years and in 2019 only 2 were found.

Table 6.4.2. Skomer MCZ sea fan recruitment

Sea fan site and number	Year first found	Description and growth
WAY14	2000	Found close to WAY2. 3 branches in 2000 grown to a small bushy fan in 2018.
BHO23	2003	No growth recorded from 2003 to 2008. Confirmed LOSS in 2010.
SSFG23	2005	Found next to SSFG17. 8 branches in 2008 grown to small bushy fan in 2018.
NWAe15	2005	Found below NWAe13. 3 branches in 2005 grown to 8 branches in 2018.
BHO 5 “new recruits”	2006	A cluster of 5 “new recruit” sea fans on a single boulder, all single or double branched stalks. **No growth** recorded from 2006 to 2018. Only 4 found in 2018.
RRK24	2006	Found next to RRK7. 5 branches in 2006 grown to 18 branches in 2018.
RRK26	2016	Found in gully close to RRK12. 2 branches
MDS7	2018	Found close to MDS 4 and 5. 6 branches

Sea fan condition

Figure 6.5.4. Condition of sea fans in the Skomer MCZ from photographic images (1994-2019) and field data (2002-2019)



Necrosis

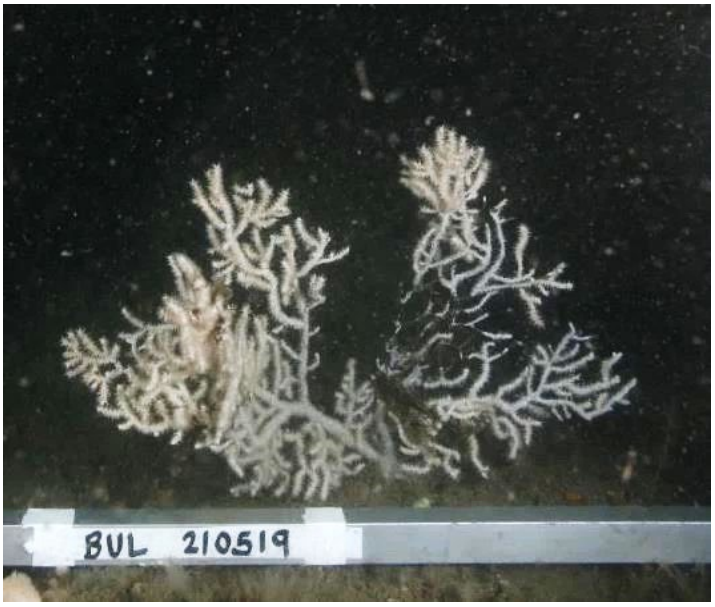
Necrosis is recorded when sea fan soft tissue has died back to leave just the black skeleton showing.

In most cases just tiny tips of necrosis are recorded but, in some cases, larger sections on a fan are seen (this is then also recorded as damage). Dead tips will often fall off, but it is possible for healthy neighbouring tissue to grow over the exposed skeleton, thus a fan may have no necrosis recorded in the following year.

Necrosis recording from photos from 1994 to 2001 was inconsistent due to variable image quality, therefore field recording of necrosis and the other condition parameters started in 2002 to support condition assessment. Since 2008 image quality has significantly improved with the use of a digital SLR camera allowing more accurate assessment of necrosis.

In 2009 a large drop in necrosis was observed with records of its presence in only 12% of the surveyed sea fans. However, the occurrence of necrosis increased in 2010 and then fluctuated between 26% and 55% for the following 8 years. In 2019 necrosis increased to 66.3%, higher than the average level of necrosis since 2002 (18 years) of 46%. Most of the records were of small areas of necrosis on tips, only 8.2% had large areas of necrosis.

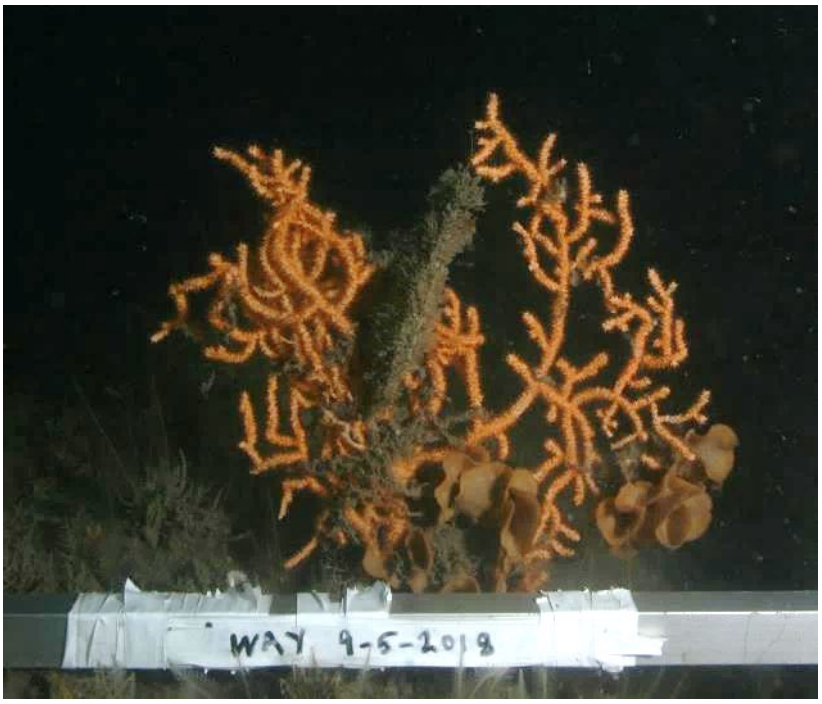
Figure 6.4.5. Sea fan with large area of necrosis.



Epibiota

Epibiota includes tangled and attached dog fish eggs, drift algae, bryozoans and hydroids. On occasion bryozoan sea fingers *Alcyonidium diaphanum*, deadman's fingers *Alcyonium digitatum* and ross coral *Pentapora foliacea,* have been recorded growing on fans. Entanglement with epibiota, and in particular dog fish eggs, if extensive and persistent can cause damage to the sea fan tissues. An annual average of 59% of sea fans have been recorded with attached or entangled epibiota for the last 18 years of surveys. In 2019 this was on 68% of the sea fans, equalling the highest level ever recorded (1995). Also, 8.2% of the sea fans had heavy fouling.

Figure 6.4.5. Epibiota entanglement, dogfish eggs and ross coral *Pentapora foliacea*.



Entanglement (anthropogenic)
Fans have been found with fishing line entanglement, which, if extensive and persistent, has been observed to cause damage to the sea fan tissues. Evidence of damage has been shown in the photographic time series over several years for an individual sea fan. Whenever possible the line is cleaned off the fan to allow recovery. No entanglements were recorded in 2019.

Damage
Damage is recorded when entanglement in fishing line or natural epibiota results in large areas of necrosis. In addition, fans are recorded as damaged when dislodged from the rock. In some cases they are found nearby and an attempt is made to re-attach the colonies artificially.

Tritonia nilsodhneri or Simnia patula
Very low numbers of these species have been recorded over the years. One individual *Tritonia nilsodhneri* was recorded in 2019.

6.4.7. Supported research

- 2002 Reef Research - Sea fan reproductive biology. Small clippings were taken from some fan colonies in Devon and at Skomer. The Skomer clippings showed what was thought to be eggs and sperm, although at lower levels than the Devon population. (Munro & Munro 2004).

- 2007 to 2013 Exeter University: Connectivity between populations of pink sea fans using internal transcriber sequences: Small clippings were taken from some Skomer fans in both 2007 and 2009. The study has recognised genetic variation, with markers showing several distinct groupings across the range of the entire sample collection of Ireland, UK, France and Portugal. The results showed that the Skomer fans are not genetically distinct, but that they form part of a general southwest Britain regional group. (Holland 2013).

- 2016 Cardiff University: Assessing the effects of fouling on the growth rate of pink sea fans in Skomer MCZ. The Skomer MCZ photographic dataset was provided for this study. The branches of 43 colonies (totalling 531 photographs) were counted and each colony was analysed for damage from natural fouling by epibiota and *Scyliorhinus stellaris* eggs. Fouling was found to have a significant negative association with growth with a decline of 0.2% over a twenty years period. This may not seem extreme but the current state of the population along a health spectrum from pristine to system collapse is unknown. (Whittey 2016).

6.4.8. Current status

- Numbers: There have been 31 natural sea fans and 6 artificially attached sea fans confirmed as lost from the monitoring sites between 1994 and 2019. There are 7 further possible losses in 2019 to be confirmed. There were no new recruits in 2019.

- Condition: Necrosis occurrence was found in 68% of the sea fans, which is much higher than the average of 46% recorded for the last 18 years. Epibiota was recorded on 68% of the sea fans, higher than the average of 59% recorded for the last 18 years.

- Repeat surveys carried out in 2016 at the beginning and end of the summer showed sea fans losses at the worst affected sites were not due to storm action.

- From regular observations of human activities that could potentially damage sea fans, lobster pot fishing was the most often recorded in the vicinity of sea fan sites where losses are confirmed. It should be noted that these activities were those that were observed, and it is possible, and indeed likely, that there were further unobserved activities. Physical damage could occur from a single impact, and it is not possible to give a definite cause unless direct observations are made, and no direct observations have been made to suggest the cause of damage. The data on observed activities do give a useful indication of probabilities, however, as well as areas on which to focus improved management.

- Conservation status: As an attribute of the Lusitanian anthozoan assemblages feature for Skomer MCZ, the losses to the sea fan population compared to recruitment means the feature is in unfavourable conservation status.

6.4.9. Recommendations

- Increase photo survey to biannually, complete first survey in May and a repeat survey in September.
- Take close-up photos of all ”new recruits”/small sea fans found;
- Observe persistence of biotic fouling/entanglement e.g. dogfish eggs;
- Monitor sea temperature and suspended turbidity levels to provide background data for the biological monitoring;
- Continue to record fishing, diving, angling and anchoring activity in Skomer MCZ;
- Work with fisheries legislators to better protect sea fans from physical damage; Explore the opportunities to set up a “control area” where no potentially damaging activities take place;
- Support research work on the biology of sea fans and publish results in scientific literature;
- Investigate opportunities for a sea fan restoration project;
- Report status as unfavourable declining.

6.5. *Alcyonium glomeratum* Population
(CMS Code: RM23/03)

6.5.1. Project Rationale
Alcyonium glomeratum (red sea fingers) is a Lusitanian species near to its northern limit of distribution and is a component of the Lusitanian anthozoan management feature of the Skomer MCZ. Colonies are long-lived and possible indicators of climate change.

6.5.2. Objectives
To monitor colony populations and to look for damage and disease.

6.5.3. Sites

North Wall Stereo	(1982)
North Wall main	(2002)
Thorn Rock	(2002)
Sandy Sea Fan Gully	(2002)
North Wall East	(2002)
Rye Rocks	(2003)
Junko's Reef	(2015)

6.5.4. Methods
Each site follows either a sequence of photos or transects that are described in site relocation pro-formas.

North Wall Stereo bar	3 quadrats
North Wall (main)	5 vertical transects
Thorn Rock mooring	2 fixed position quadrats
Sandy Sea Fan Gully	2 vertical transects
North Wall East	2 vertical transects
Rye Rocks	1 transect
Junko's Reef	1 vertical transect

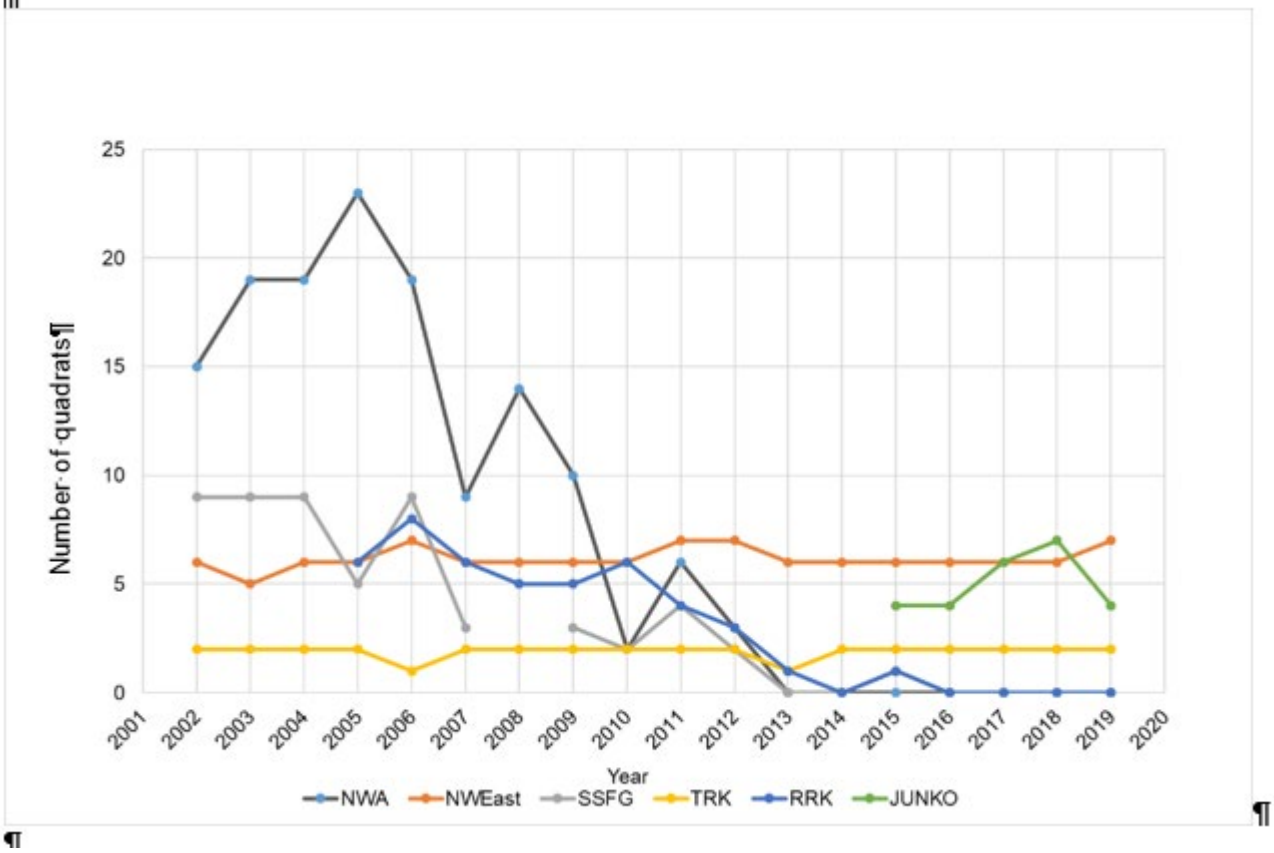
- North Wall Stereo: three quadrats (50 x 40cm) are photographed using stereo or high definition digital SLR photography.
- All other sites: photographs (mono) are taken using a 50 x 70cm framer.

The colonies are gently "wafted" before photographing to make them retract in an attempt to control the variability in colony size. The images are analysed by overlaying a 5 x 5cm grid and recording presence/absence of *A. glomeratum* within the grid squares.

6.5.5. Results

Quadrat results for the following sites are shown in the graph: North Wall main (NWA), North Wall east (NWEast), Sandy Sea fan gully (SSFG), Thorn rock (TRK), Rye Rocks (RRK) and Junko's reef (JUNKO).

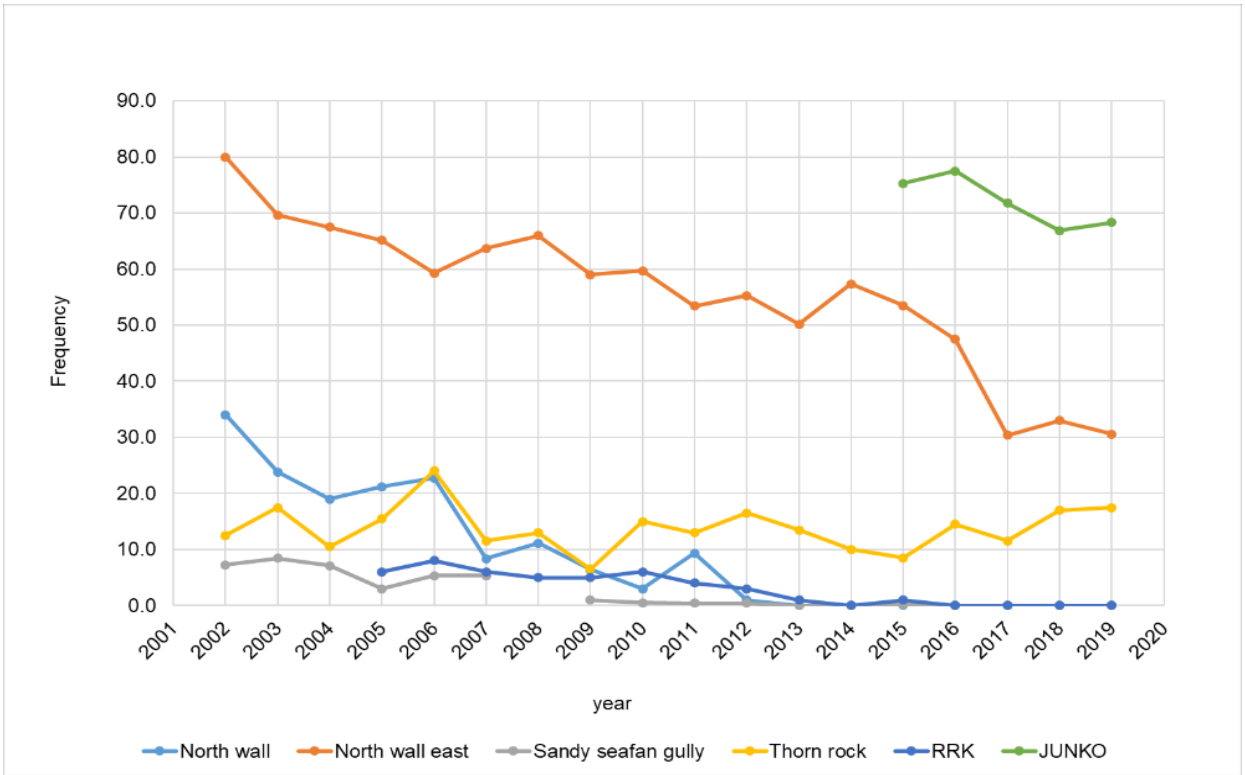
Figure 6.5.1. Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2019.



There has been a decreasing trend in the coverage of *A. glomeratum* colonies at 3 sites with no visible colonies since 2013 at North Wall main and Sandy Sea fan gully, and since 2016 at Rye Rocks.

Alcyonium glomeratum mean frequency count

Figure 6.5.2. Mean frequency of *A. glomeratum* within quadrats Skomer MCZ 2002 – 2019.

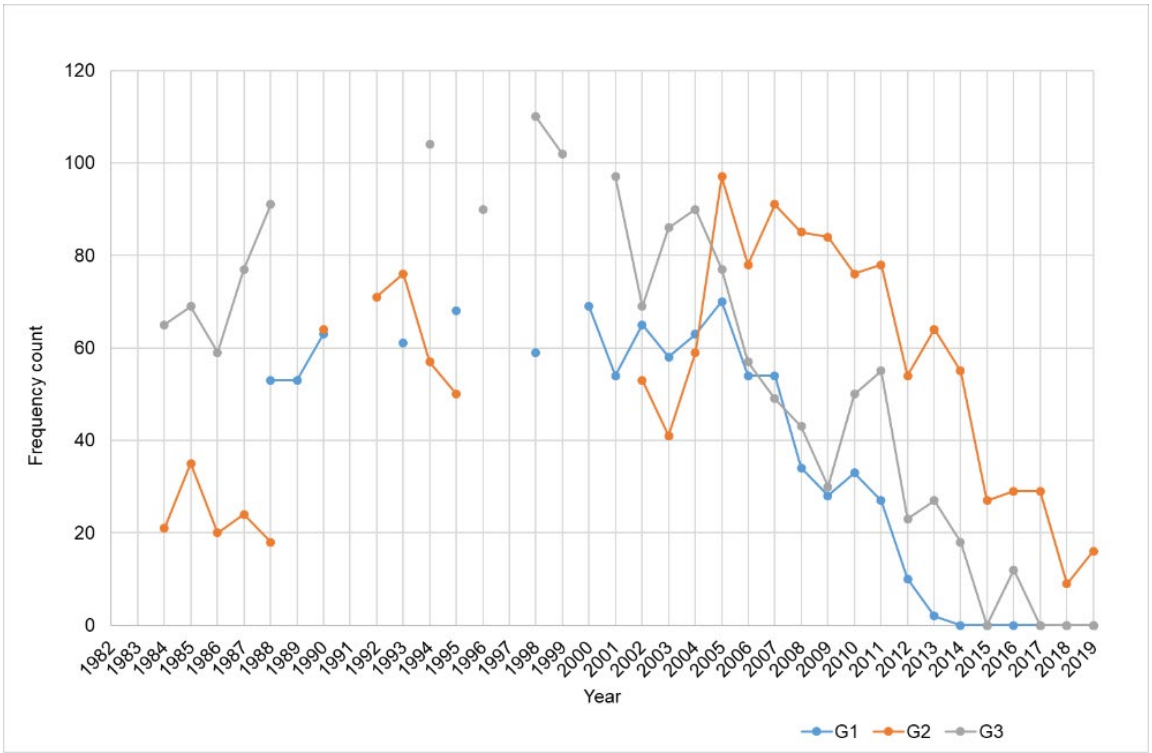


The declining trend or disappearance of *A. glomeratum* has continued at all sites except for Thorn Rock and Junko's reef.

North Wall Stereo colony

The time series for these 3 photo quadrats on the north side of Skomer goes back to the 1980's. The quadrats have been photographed annually for most years since 1988. A frequency count of A. glomeratum for each quadrat is completed using a 120 square grid then presence counted for each square.

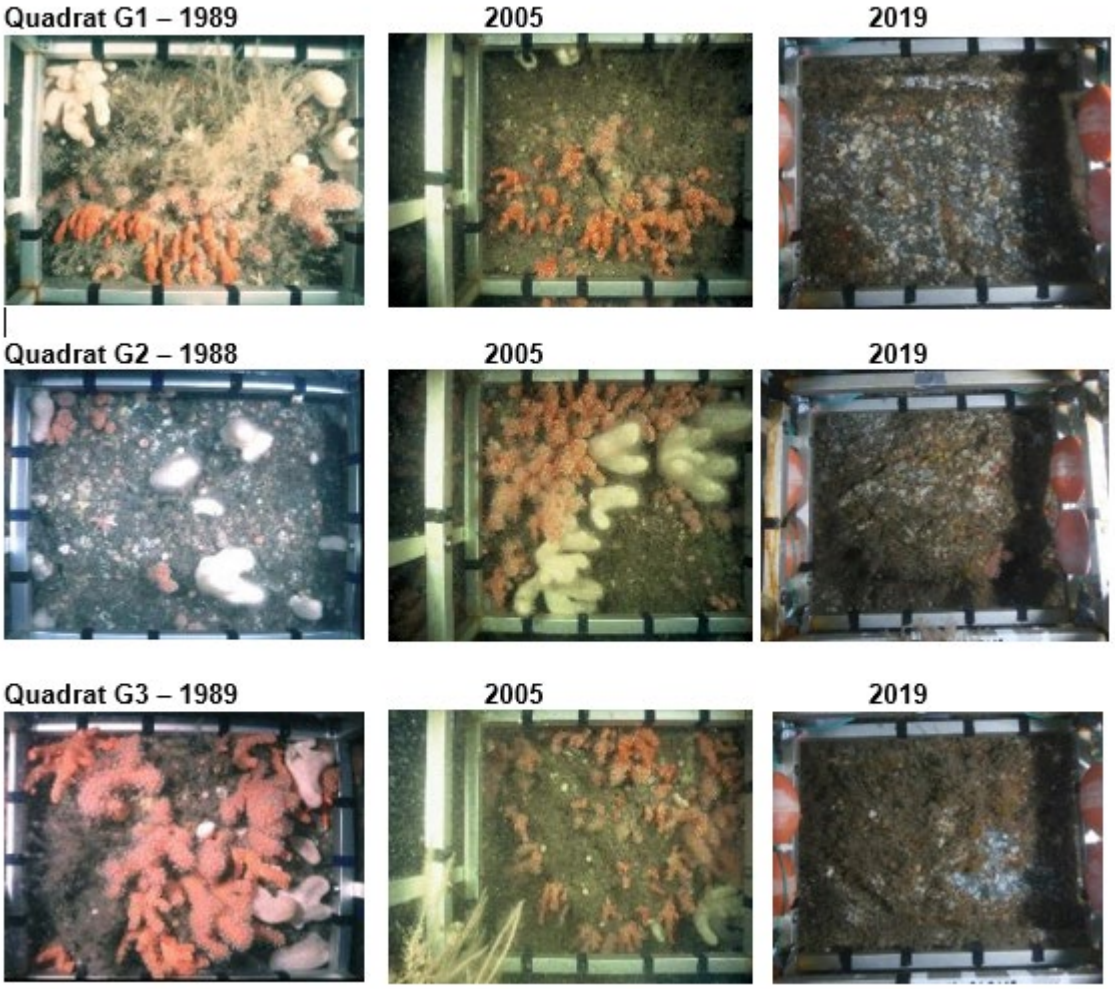
Figure 6.5.3. Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North wall.



All three quadrats show a similar trend of increasing cover peaking in the late 1990's to early 2000's and then declining from 2006 onwards. *A. glomeratum* has now virtually disappeared at this site (2019).

Looking at the "then and now" photographs (Figure 6.6.4) it is interesting to note that *Alcyonium digitatum* (white deadman's fingers) has also reduced significantly in the three quadrats.

Figure 6.5.4. Photographic examples of declining populations of *A. glomeratum* at Skomer MCZ between 1989 and 2019.



6.5.6. Current Status

The abundance of *A. glomeratum* at the monitoring sites is declining: North Wall East and Junko's reef have sizable colonies of *A. glomeratum*, whereas North Wall main, Rye Rocks and Sandy Sea Fan Gully now have no visible colonies.

The reason for this decline is unknown. There is no evidence of disease or mechanical damage at the monitoring sites and changes in environmental conditions are not thought to be significant enough to cause colony loss.

6.5.7. Recommendations

- Search for further colonies in the MCZ and establish new monitoring sites.
- Improve site marking to allow accurate relocation of quadrats.
- Analyse photographs to assess what species have replaced the lost colonies of *A. glomeratum* and establish whether other species (e.g. *Alcyonium digitatum)* have also declined.
- Encourage research to investigate potential reasons for population decline.
- Keep scientific literature under review.
- Report status as declining.

6.6. Parazoanthus axinellae Population
(CMS code: RM23/05)

6.6.1. Project Rationale
The population of *Parazoanthus axinellae* (yellow cluster anemone) is a component of the Lusitanian anthozoan management feature of the Skomer MCZ.
P. axinellae is a Lusitanian species near to the edge of its range and may act as an indicator of climatic change.

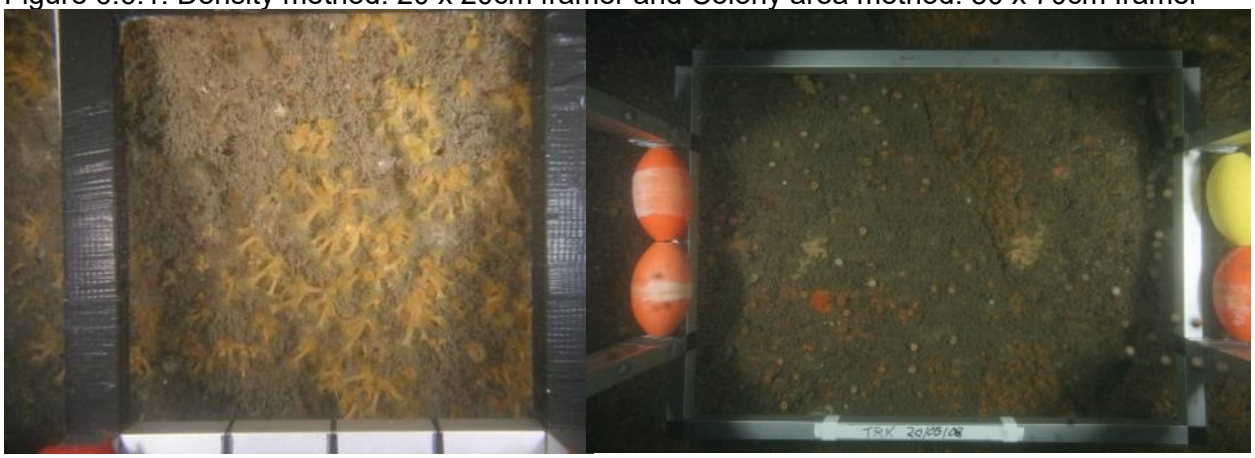
6.6.2. Objectives
Monitor *P. axinellae* colonies for changes in polyp density and colony area.

6.6.3. Sites
- Sandy Sea Fan Gully (2002)
- Sandy Sea Fan Gully Buttress (2015)
- Thorn Rock (3 colonies) (2002)
- Way Bench (2 colonies) (2002)

6.6.4. Methods
Density Estimates
Close-up photographs are taken using a digital camera. The digital camera is mounted on a 20 x 20cm framer. *P. axinellae* polyps are counted in each 20 x 20 cm quadrat.

Area of the Colony
A series of transects are placed through the colonies. Photographs are taken using a 50 x 70cm framer. In 2008 a digital SLR camera replaced the film camera providing high quality images allowing improved photo analysis. The images are analysed by overlaying a 5 x 5cm grid and recording presence/absence of *P. axinellae* within the grid squares. See Burton, Lock & Newman 2002 for details.

Figure 6.6.1. Density method: 20 x 20cm framer and Colony area method: 50 x 70cm framer

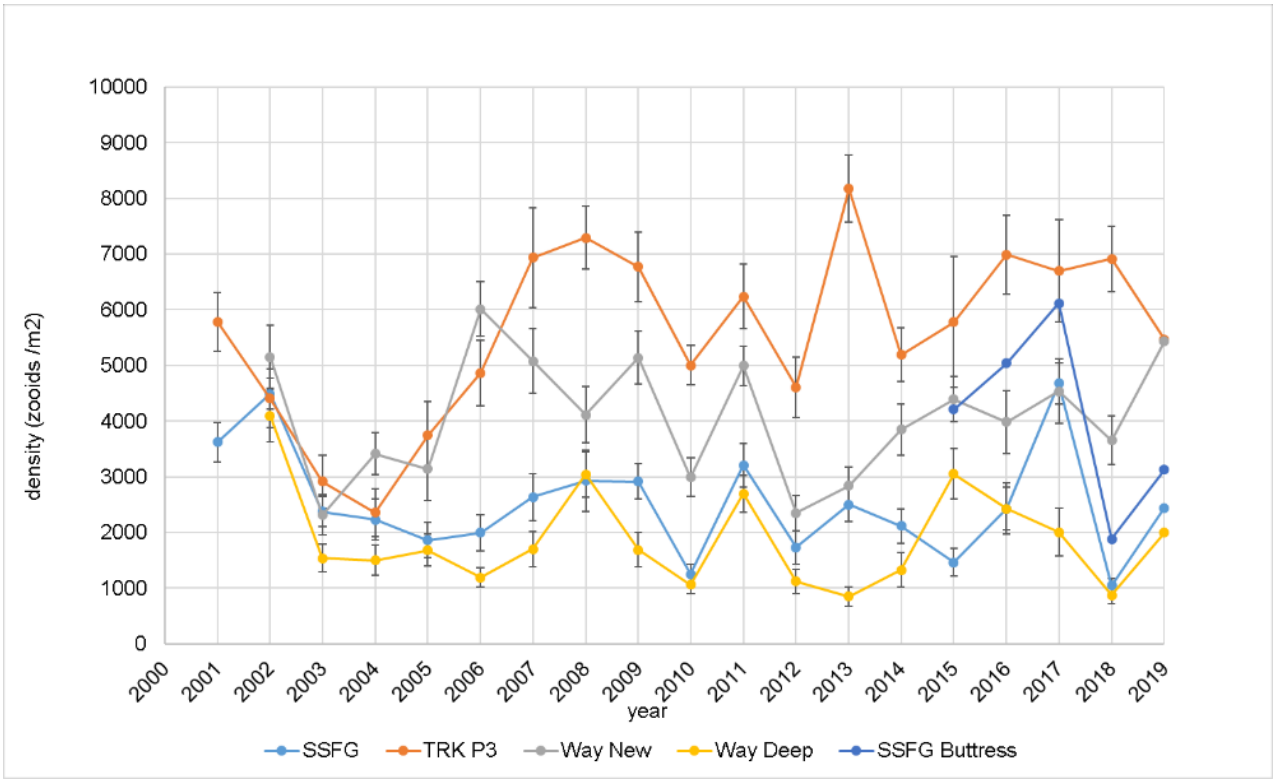


6.6.5. Results

Table 6.6.1 Fieldwork completed at Skomer MCZ in 2019

Site	Colony Area data	Density data
Sandy sea fan gully	5 transects (20 samples)	Yes
Sandy sea fan gully Buttress	2 permanent transects set up 13 quadrats	Yes
Waybench – *New Wall*	9 re-locatable samples	Yes
Waybench – *Deep Wall*	2 transects (8 samples)	Yes
Waybench – *Deep Wall*	New lower transect resurveyed– 6 quadrats	No
Thorn Rock – *Piton 7*	3 re-locatable samples	No
Thorn Rock - *Mooring*	3 re-locatable samples 4 new quadrats west of mooring	No
Thorn Rock – *Piton 3*	3 transects (11 samples)	Yes

Figure 6.6.2. Density of *P. axinellae* polyp (numbers of polyps /m²) at Skomer MCZ sites 2001 – 2019



The mean density of *P. axinellae* polyp (numbers of polyps /m²) at all sites has shown fluctuations year to year, but overall show a stable density.

Figure 6.6.3. Mean frequency of *Parazoanthus axinellae* 2002 – 2019. Thorn Rock (TRK) transects.

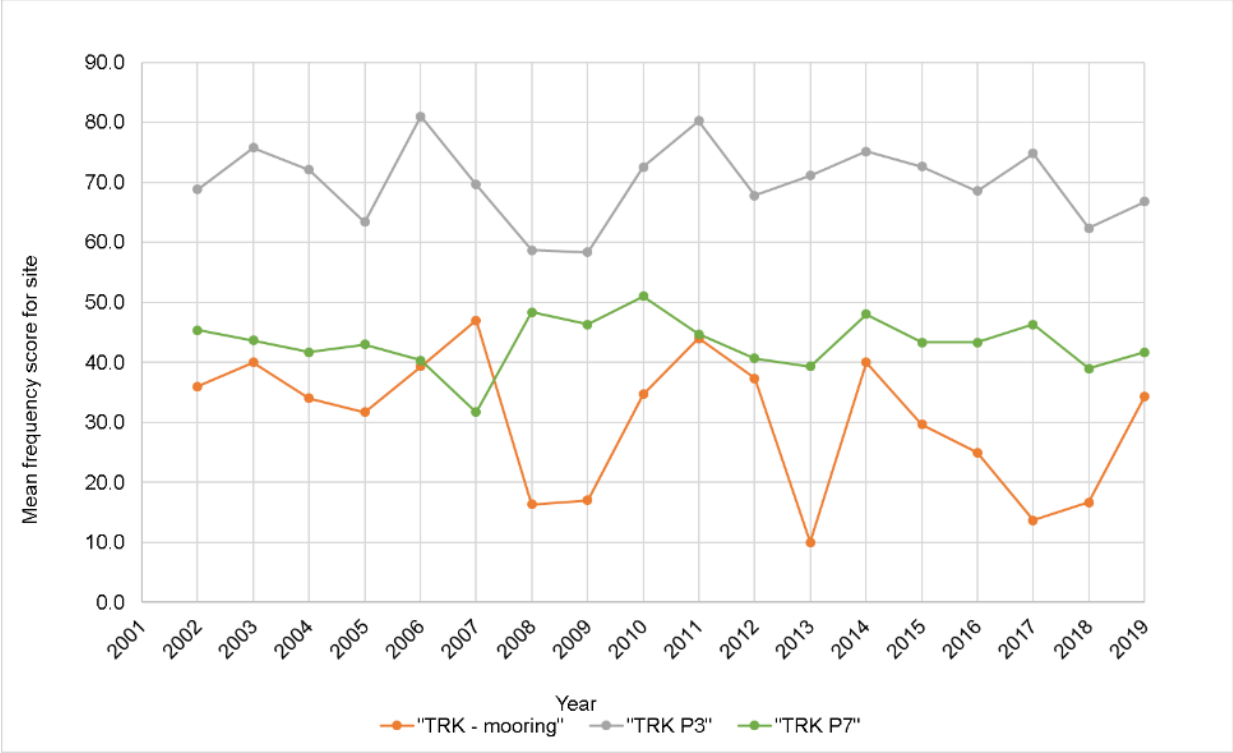
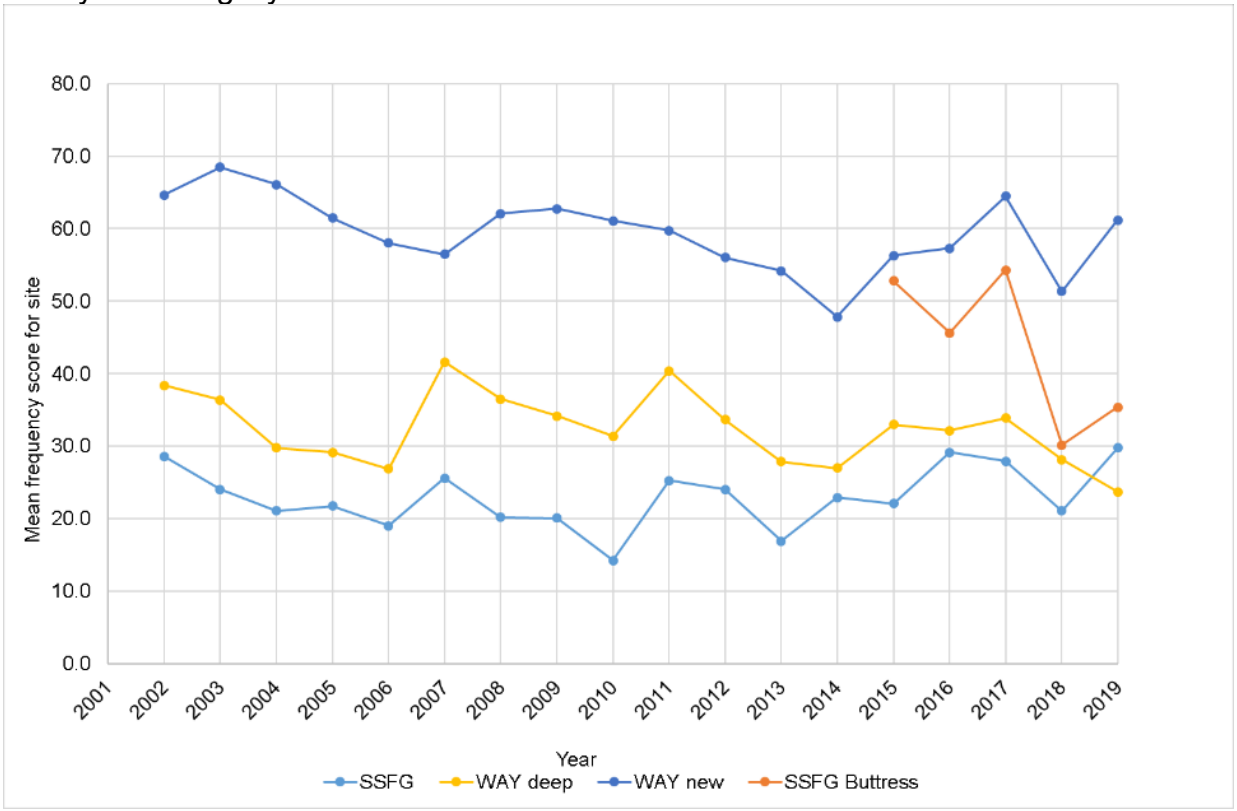


Figure 6.6.4. Mean frequency of *Parazoanthus axinellae* 2002 – 2019. Waybench and Sandy sea fan gully transects



The frequency of *P. axinellae* at all sites has shown fluctuations year to year, but overall show a stable population.

6.6.6. Current Status

All the colonies are still present and populations appear to be stable.

6.6.7. Recommendation

- Search for further colonies in the MCZ and establish new sites.
- Continued research is needed on the biology of *Parazoanthus axinellae.*
- Report status as stable.

6.7. Pentapora foliacea (ross coral) Population

CMS code: RM63/01

6.7.1. Project Rationale

Colonies of the bryozoan *Pentapora foliacea* are fragile structures which are known to survive for many years. They are important microhabitats for mobile species and are regarded as useful indicators of anthropogenic activity such as mobile fishing gear, potting and anchoring (Eno et al 2001, Munro 1996). As such they were selected as a management feature of the Skomer MCZ. They are also a component of the fragile sponge and anthozoan community habitat of priority importance under Section 7 of the Environment Act (Wales) 2016.

6.7.2. Objectives

1. To monitor the numbers and growth rate of colonies.
2. To monitor the amount of damage occurring to the colonies.

6.7.3. Sites

Table 6.7.1 *Pentapora foliacea* monitoring sites at Skomer MCZ in 2019

Site	substrate	dataset
North of the Neck	ground ropes	2002 - onwards
North wall	rock and boulders	1984 – 2002
Way bench	rock and boulders	1993/4 restarted 2002 - onwards
Bernie's Rocks	boulders	1995 onwards
South Middleholm	rock	2003 - onwards
West Hook	rock	2004 - onwards
Pool	boulders	2013 - onwards

6.7.4. Methods

Photographs are taken using a digital camera set up on a 50 x 70 cm frame. Photographs are taken along marked transects at each site following detailed site proforma.

6.7.5. Project History

Growth and community structure

1998: Gilbert tested various image analysis methods for assessing growth rate, but concluded that a three-dimensional method would be most suitable. Colonies were put into size classes using base area (cm^2) however this only provided an approximate measure of colony size. (Gilbert 1998).

2005: the analysis methods were reviewed. The growth of *P. foliacea* colonies were found to vary dramatically; one colony showed an increase in base area of over 800cm^2 in one year, whilst other large colonies had all but disappeared. In general, colonies that survive tend to grow whilst other colonies of all sizes can just disappear in the space of a year. This suggests that some colonies are being physically destroyed or rapidly disintegrate naturally rather than just decrease in size by slow wastage. (Burton *et a*l 2005).

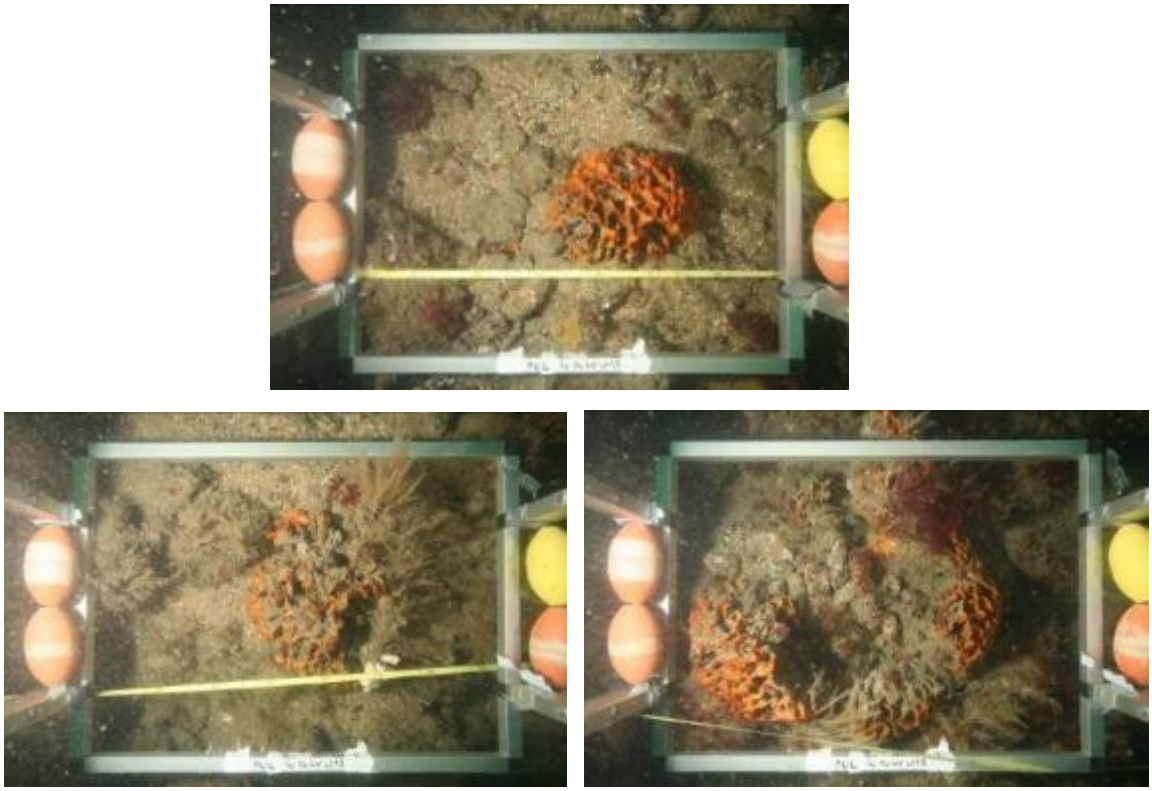
2008: Gibbs developed an empirical calibration method by which a three-dimensional reconstruction of a *P. foliacea* colony may be created from stereo-photographs. This method allows the quantification of the growth of the *P. foliacea* colony over time. A useful qualitative interpretation of some colonies by the creation of time-lapse films (at a rate of 25 days per second) in both monoscopic-colour and dichromatic-stereo was demonstrated.

Sadly, it was found that most of the photo images had insufficient precision of data to apply the method. However, conclusions drawn from study of the films led to the creation of a 5-stage morphological classification system for *P. foliacea*. The system is designed to provide a quick and simple classification of colonies seen during a survey, to give an idea of the state of the population from the distribution of classes within the surveyed population. (Gibbs 2008).

The morphological classification method was applied to the historical photo dataset and continued each year. In 2010 the method was reviewed due to inconsistencies between individuals completing the analysis and revised guidelines were produced (Lock 2013). The revised guidelines were reapplied to the full historical dataset and continued each year.

Morphological classification
Class 1 (single flakes) to class 4 (20cm diameter) relate to size development. Class 5 is not size based but relates to the levels of degradation.
Class 5a is when more than 50% of the colony is covered in epiphytes and class 5b when more than 25% of the colony has broken down. Class 5 can occur at any stage from class 2 to 4.

Figure 6.7.1. *Pentapora foliacea* - examples of Class 4 and Class 5b colonies.



2013: a new site was established at the Pool on the north side of Skomer. The site is a boulder slope and very rich in *P. foliacea* with 250 colonies found.

6.7.6. Results

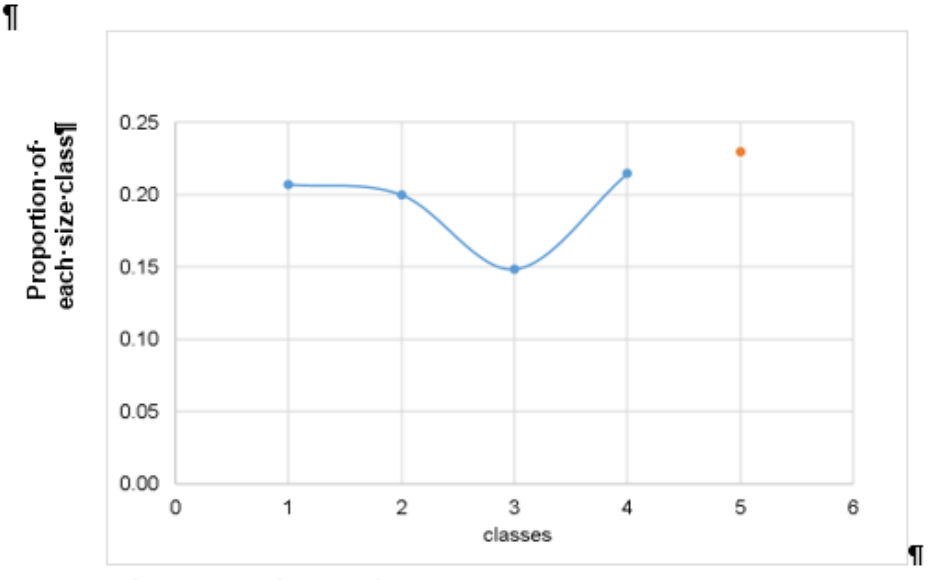
Photo datasets were collected at the following sites in each survey year:

Table 6.7.2. *Pentapora foliacea* photo dataset for Skomer MCZ

Year	North Wall	Waybench	Bernies Deep	Bernies Shallow	North Neck	South Middleholm	West Hook	Pool
1993	**yes**	**yes**	no	no	no	no	no	no
1994	**yes**	no	no	**yes**	no	no	no	no
1995	**yes**	no	**yes**	**yes**	no	no	no	no
1996	**yes**	no	no	no	no	no	no	no
1997	**yes**	no	**yes**	**yes**	no	no	no	no
1998	**yes**	no	**yes**	**yes**	no	no	no	no
1999	**yes**	no	no	no	no	no	no	no
2000	**yes**	no	**yes**	**yes**	no	no	no	no
2001	**yes**	no	no	no	no	no	no	no
2002	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2003	no	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2004	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2005	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2006	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2007	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2008	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2009	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2010	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2011	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2012	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2013	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
2014	no	**yes**	**yes**	**yes**	**yes**	no	**yes**	**yes**
2015	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
2016	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
2017	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**Yes**
2018	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
2019	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**

The following graph for all Skomer sites shows a general pattern of classes 1-4. The population pattern varies between sites as colony development is affected by both substrate and environmental conditions at sites. Class 5 is not connected via the curve as it is not a continuum from class 4 but is related to degradation which can develop directly from class 2, 3 or 4.

Figure 6.7.2. *Pentapora foliacea* - normalised population curve for all Skomer MCZ sites.



Waybench is a large bedrock site, on the north side of the island, and divided into two sections: an exposed rock ridge and a neighbouring boulder area. On the ridge colonies tend to be class 1-3 and rarely reach a class 4, whilst in the more sheltered boulder area high numbers of colonies are found and many of them reach large class 4 before developing into a class 5.

Bernies Rock is located on the north side of the island. There is a shallow site and a deep site, both consisting of boulder substrate. The number of colonies has varied at both sites year by year, with some years no colonies being found. All classes of colonies are found with many developing into a class 4, before progressing to a class 5.

The Pool started in 2013 located on the north side of Skomer. The site is a boulder slope from 10m down to 22m below chart datum. A large survey area is covered, and large numbers of colonies are found (up to 250 individuals) with an even spread of classes present.

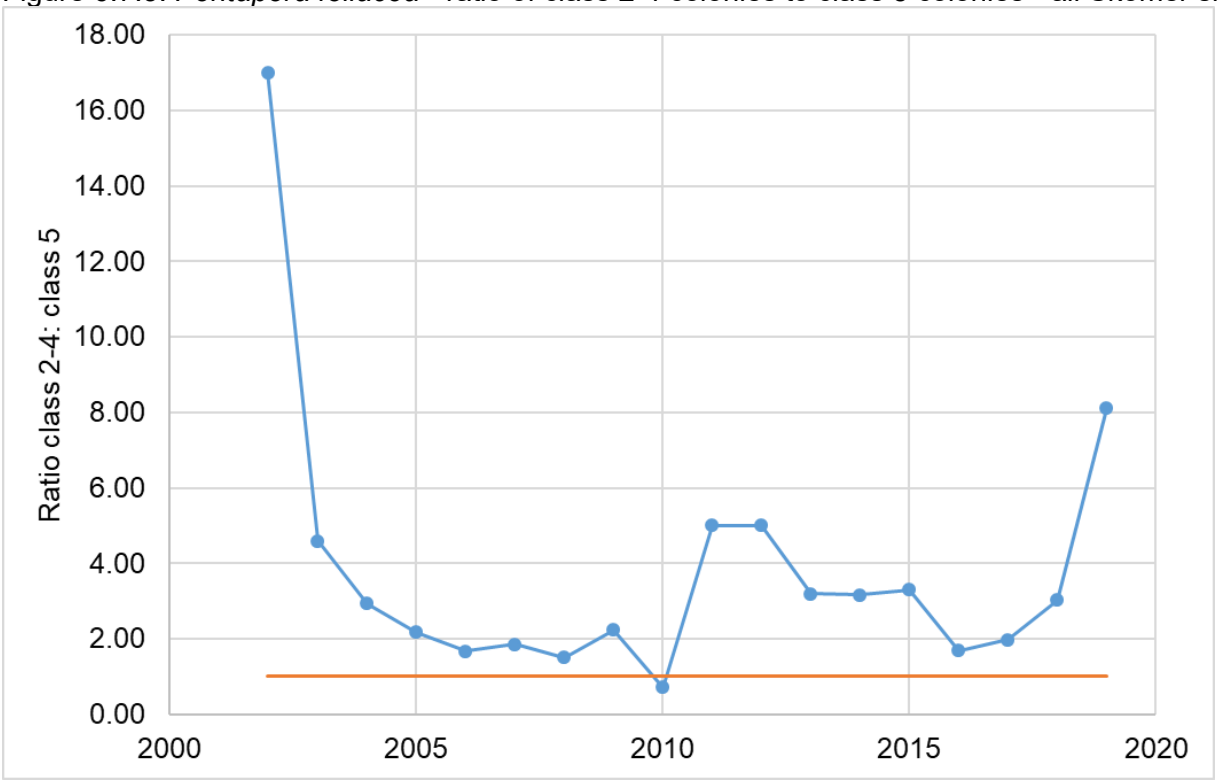
North Neck is unusual as colonies are growing on ground ropes laid upon a mixed sediment seabed. Movement of the ropes due to wave and current action restricts growth of most of the colonies to class 1 and 2. Some individuals grow to class 3 but there are no class 4 individuals.

South Middleholm is a small bedrock site on the south side of the island and subjected to the prevailing south-westerly swell. Class 1 to 3 individuals are the most common, with very few developing into class 4, instead developing directly to class 5.

West Hook is a small bedrock site located on the North Marloes Peninsula, most colonies reach class 4 before developing into class 5.

The ratio between class 2-4 and class 5 colonies at all sites between 2002 and 2019 is shown in the graph below. Class 2-4 colonies represent healthy growing colonies whilst class 5 represent those with deterioration from either natural or anthropogenic factors. The results show that for most years the ratio is greater than 1, therefore there are more healthy growing colonies than degraded colonies.

Figure 6.7.3. *Pentapora foliacea* - ratio of class 2-4 colonies to class 5 colonies - all Skomer sites



The current dataset forms an important baseline for Skomer sites. However, it needs to be remembered that all sites are currently subject to anthropogenic activities including pot fishing, angling and recreational diving, which all have the potential to harm *P. foliacea* colonies.

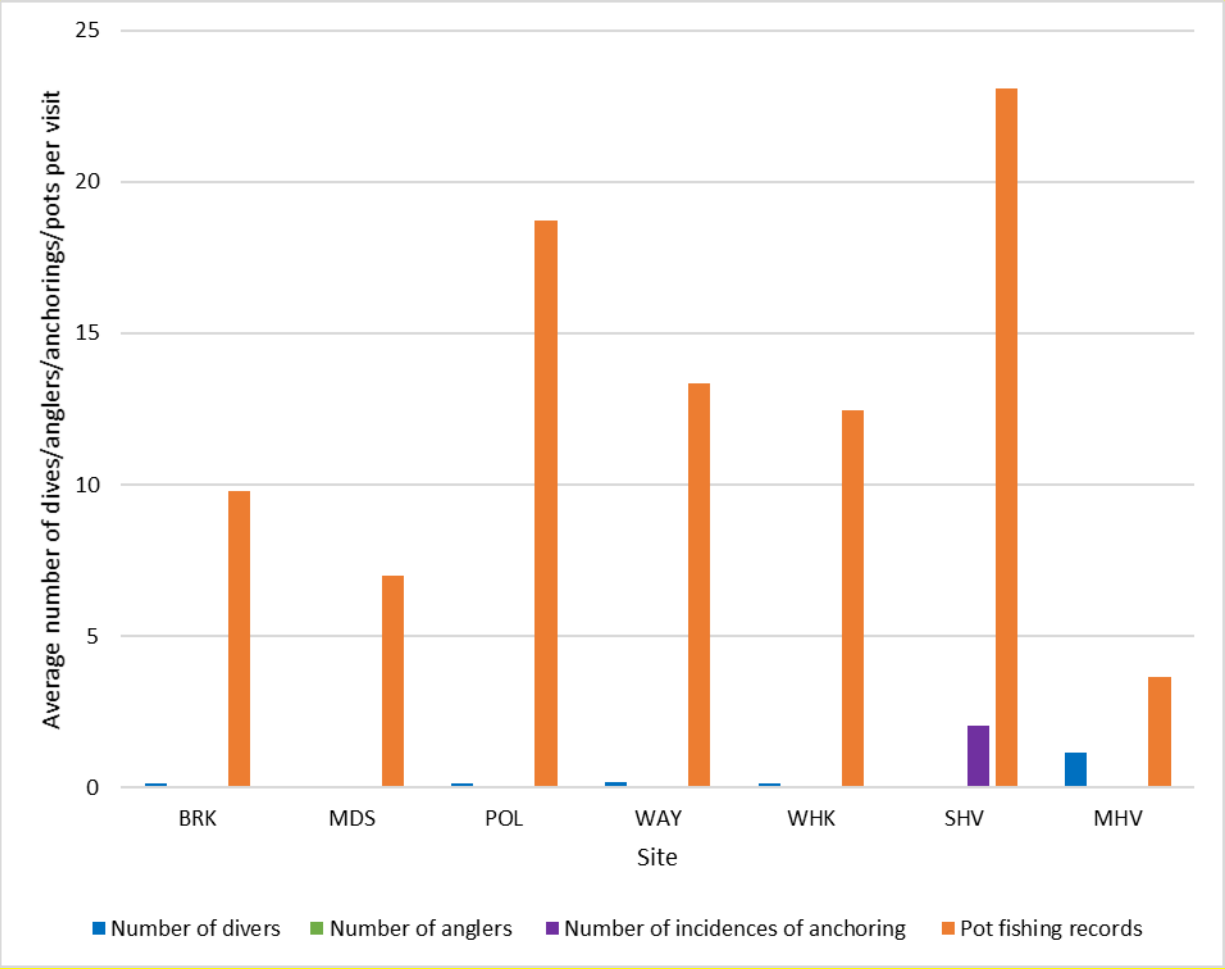
Pot fishing is unrestricted in terms of numbers of pots fished, frequency of fishing or parts of the MCZ that can be fished, although liaison with local fishermen has limited fishing in some of the more sensitive bird nesting areas on a voluntary basis.

Field and photographic observations provide evidence that ropes linking fishing pots lay across the seabed and these, as well as the pots themselves, can damage *P. foliacea* colonies, especially when fished on steeply-inclined seabeds.

Figure 6.7.4. *Pentapora foliacea* – interaction with fishing gear

Other human activities, where contact with the seabed may occur, such as angling, diving and anchoring are regulated by voluntary codes

Figure 6.7.5. “Seabed contact” activities at Skomer MCZ *Pentapora foliacea* monitoring sites in 2019



Levels of these different activities at *P. foliacea* monitoring sites can be seen in Fig 6.7.5. Data for South Haven (SHV) and Martins Haven (MHV) are included for context; neither are *Pentapora foliacea* monitoring sites, but one is a highly popular (and permitted) anchorage and the other is popular with divers. Diving numbers include Skomer MCZ monitoring dives (see Appendix 1 for data collection methodologies).
It should be noted that all data are likely to be an underestimate of actual activity, but more so for commercial fishing effort, which is only usually recorded once per week between May and September.

A study area that excludes all potentially impacting anthropogenic activities is needed to provide an understanding of a normal functioning ecosystem.

6.7.7. Current Status

In most years of recording there has been a higher number of intact and growing colonies (Classes 2-4) compared to “degraded” (Class 5) *P. foliacea* colonies. This proportion of “healthy” colonies increased in 2011 and 2012, and then reduced slightly with the inclusion of a much larger number of colonies from the Pool site in 2013. In 2019 there has been an increase in “healthy” colonies compared to that recorded since 2003. The question still remains however, as to whether this ratio is a “healthy” one, or whether a population not subjected to any anthropogenic activities would demonstrate different characteristics.

Given that some potentially damaging anthropogenic activities are unrestricted and occur in the MCZ, we are unable to judge whether the population exhibits a “healthy” ratio of

degraded to intact colonies, so the condition of this feature is judged to be “unknown” (Alexander, 2005).

6.7.8. Recommendations

- Maintain long-term photographic datasets of individual colonies at a number of different sites to establish the longevity of the colonies and their response to damage.
- Apply the morphological classification system to identify community structure at a number of different sites.
- Establish a totally non-impacted study area. Until all potentially damaging anthropogenic impacts can be removed from the ecosystem, understanding of its normal functioning cannot begin.
- Continued research is needed on the biology of *P. foliacea*.
- Keep literature under review.
- Report status as unknown.

6.8. Cup Coral Populations; *Balanophyllia regia* and *Caryophyllia smithii*
(CMS code: RM23/04*)*

6.8.1. Project Rationale
Cup corals are slow growing filter feeders, which are susceptible to changes in water quality and planktonic food supply.

Balanophyllia regia is a Lusitanian species and Skomer MCZ is close to the northern edge of its range in the UK. It is only found at limited locations within the MCZ.

Caryophyllia smithii is a common species of the sub-littoral benthic community of south-western Britain and is found across the whole MCZ on hard substrates.

Both species are components of the Lusitanian anthozoan management feature of the Skomer MCZ.

6.8.2. Objectives
Monitor the population for changes in densities and to look for evidence of recruitment.

6.8.3. Sites
- Thorn Rock *B. regia* 1985 to current and *C. smithii* 1993 to current
- The Wick *B. regia* 2002 to current

6.8.4. Methods
Balanophyllia regia
- *Thorn Rock:* A fixed position quadrat using a 50 x 40 cm framer at Thorn Rock has been photographed since 1985.
- *The Wick:* Three transects with 51 quadrats were established at the Wick in 2002. A 50 x 40 cm framer was used up until 2008 when it was replaced with a larger 50 x 70cm framer using a digital SLR camera. This provides high quality images allowing improved photo analysis.
- Counts are carried out using GIS techniques described in Burton *et al* 2002.

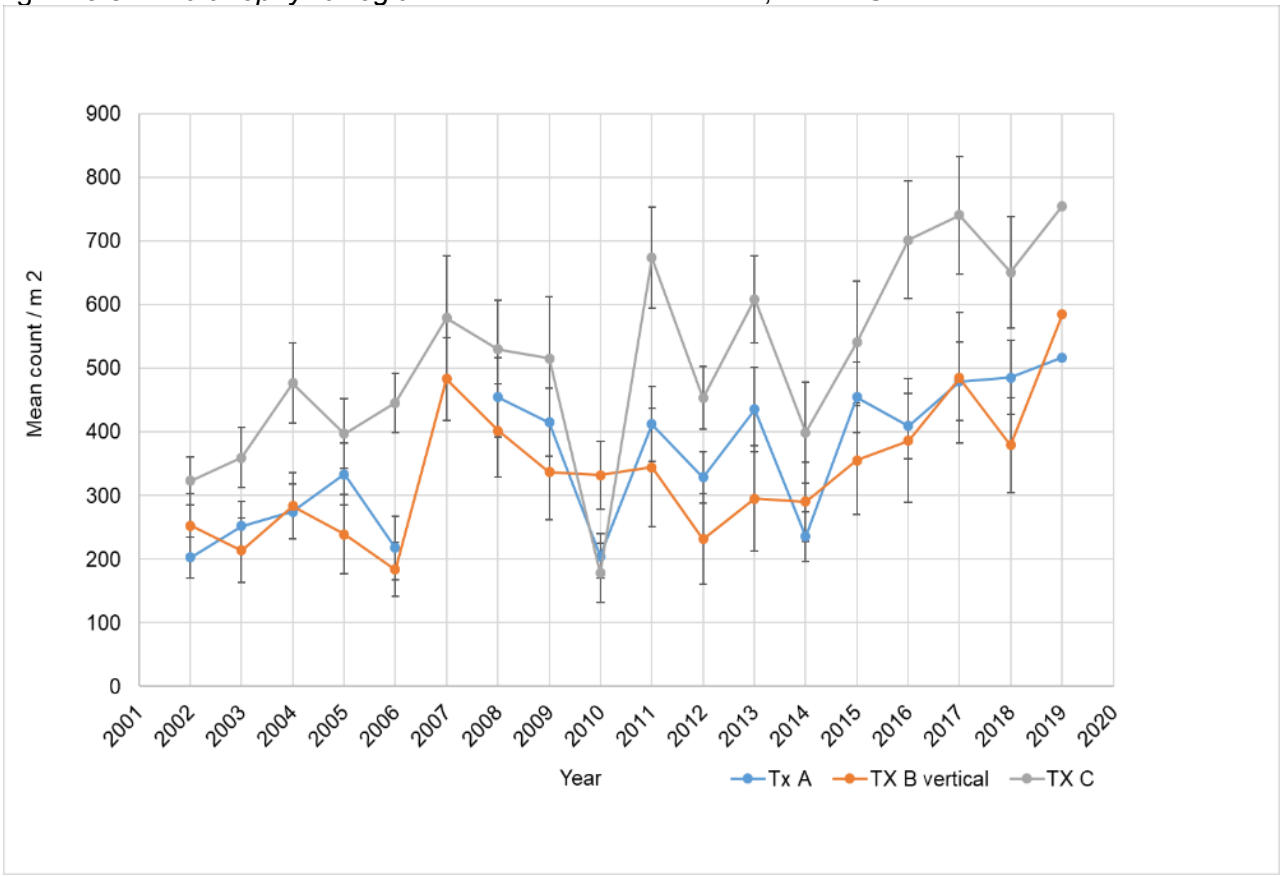
Caryophyllia smithii:
Approximately 70 quadrats have been analysed on an annual basis since 1993 from photographs taken for the sponge community project at Thorn Rock. Photographs are taken using a 50 x 70cm framer and counts are carried out using GIS techniques.

6.8.5. Results
Balanophyllia regia:
At the Wick all data have been adjusted to $1m^2$ to enable the data from the 50 x 40 cm and the 50 x 70 cm framer to be comparable.

Table 6.8.1. Mean abundance (and standard error) of *Balanophyllia regia* in The Wick (adjusted to 1m^2).

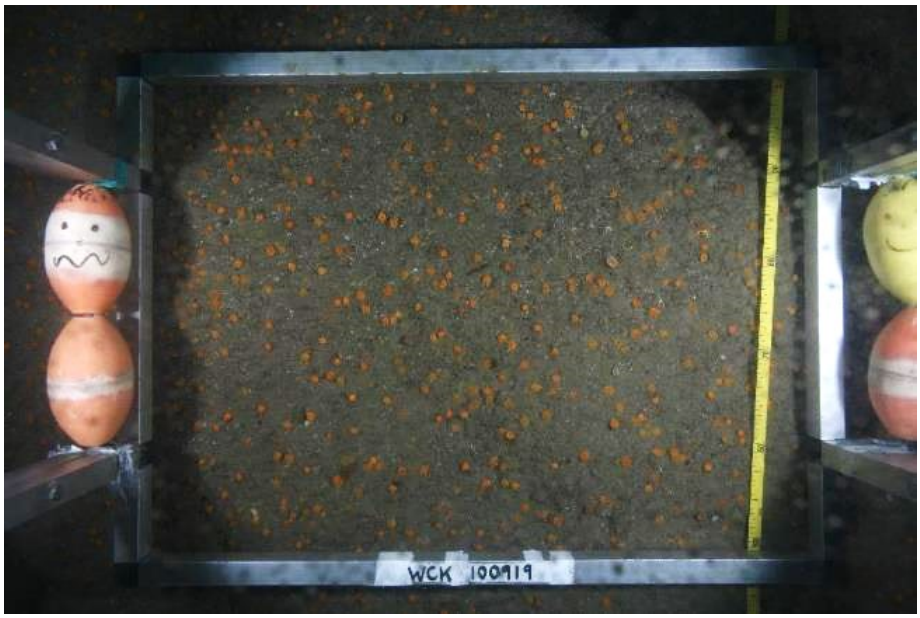
Site	Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
WCK A	Mean	203	252	275	334	218		455	415	205
	S.E.	32	39	43	49	50		62	53	35
WCK C	Mean	323	360	476	397	445	579	530	516	178
	S.E.	50	51	52	62	42	65	73	75	53
WCK B	Mean	253	214	284	239	183	483	402	337	332
	S.E.	38	47	63	55	46	98	76	96	46
Site	**Year**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
WCK A	Mean	412	329	435	236	455	409	479	486	517
	S.E.	59	40	66	39	55	51	62	59	62
WCK C	Mean	674	453	608	399	541	702	259	651	755
	S.E.	93	71	83	62	85	97	36	75	136
WCK B	Mean	344	232	295	291	356	386	170	379	584
	S.E.	79	49	69	80	96	92	32	88	137

Figure 6.8.1. *Balanophyllia regia* abundance at Transects A, B and C at the Wick.



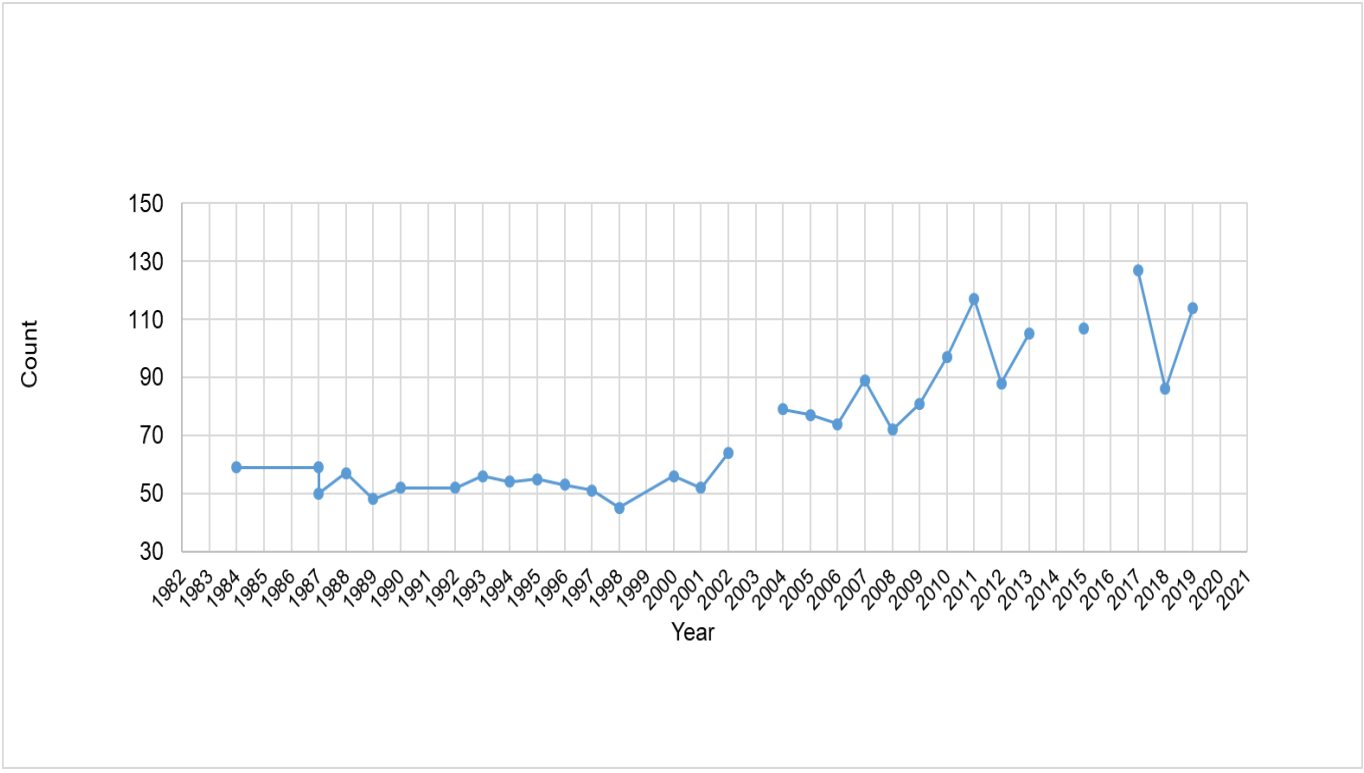
The average number/m^2 of *B. regia* has fluctuated at transects A, B and C. The variability is most likely to be caused by the dense covering of silt that occurs across the site from time to time and occasional very poor photographic conditions (e.g. 2010). In 2019 there was very little silt and the cup corals were visible, even very tiny ones could be seen, which might explain why counts were their highest for each of the transects. A record number of 541 individuals were counted in one 50 x 70cm framer (1546/m^2).

Figure 6.8.2. *Balanophyllia regia* 541 individuals in 1 50x70cm framer, density 1546/m^2 Transect C at the Wick.



At Thorn Rock individual cup corals have been traced for 30 years in a single 40 x 50cm quadrat. Some evidence of recruitment has been observed, numbers have shown a general increase between 1998 and 2019. Variability will occur due to changes in surface sediment which obscures small individuals. Due to very poor photographic conditions no counts were possible in 2014 and 2016.

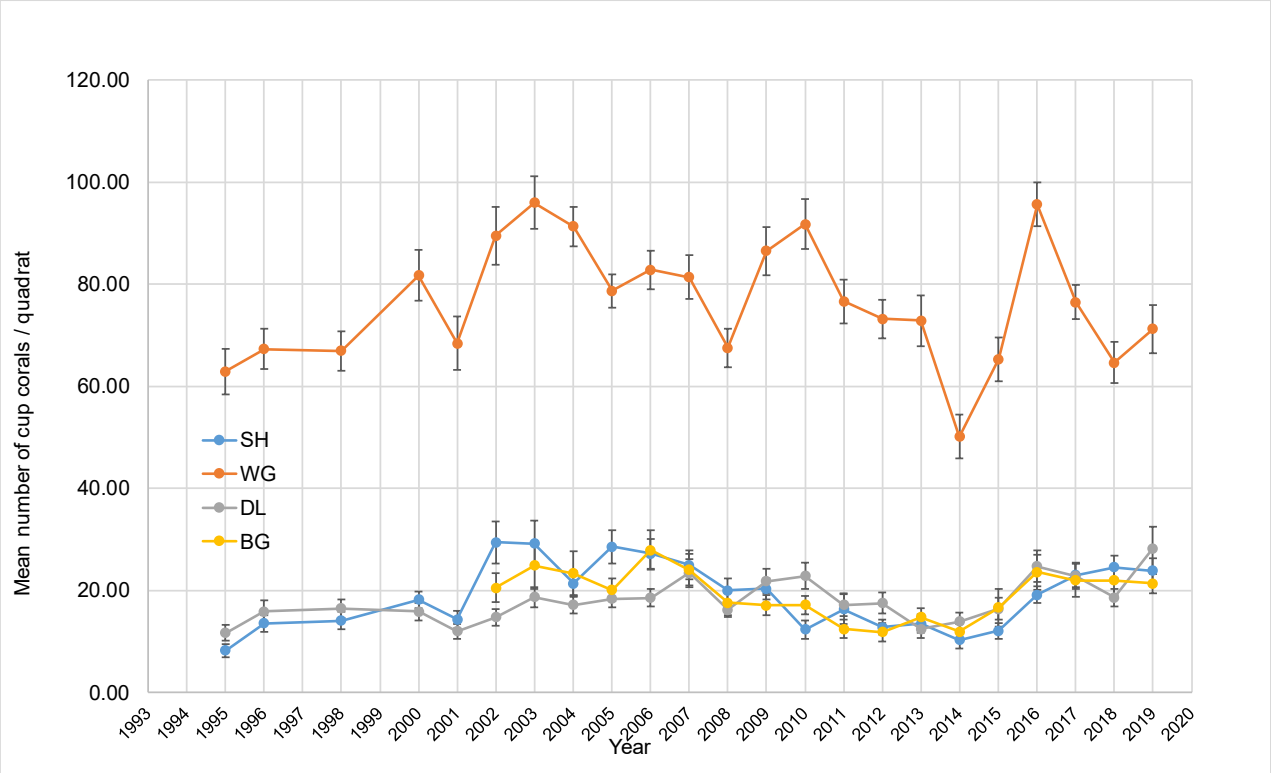
Figure 6.8.3. Thorn Rock boulder *Balanophyllia* regia counts (per 40 x 50cm quadrat)



Caryophyllia smithii
The average number/m^2 of *C. smithii* has fluctuated at each of the Thorn Rock sites. This may be due to variable levels of surface sediment affecting the actual numbers visible during recording.
The Windy gully (WG) quadrats show significantly higher counts compared to the other sites. This is most likely due to it being the only vertical wall site where less surface sediment accumulates. The other three sites are all on horizontal rock.

The abundance has fluctuated at Windy gully (WG) but been reasonably stable at the other three sites. It is not known how long these cup corals live and how variable their numbers are.

Figure 6.8.4. Mean Number of *Caryophyllia smithii* per 50 x 70 cm quadrat at Thorn Rock (4 transects) 1996 – 2019



6.8.6. Current Status
Variability in numbers of both *B. regia* and *C. smithii* is partly due to varying levels of surface sediment. The populations appear stable although there is no firm evidence of recruitment.

6.8.7. Recommendations
- Records of surface sediment levels may help determine whether reduced abundance of cup corals is significant or due to recording inconsistencies.
- Review photographs to test the possibility of tracing individuals from year to year.
- Support research work and publish results in scientific literature.
- Report status as stable.

6.9. Grey Seal (*Halichoerus grypus*) Population
(CMS code: RA03/01)

6.9.1. Project Rationale
Grey seals are a protected species under the Conservation of Seals Act 1970. They live and breed in the Skomer MCZ as part of the west Wales population, which is the largest in south west Britain. Seals are listed under Annex II of the European Union Habitats Directive and one of the features of the Pembrokeshire Marine SAC. Seals are also a management feature of the Skomer MCZ. This project supplies data for reporting on SAC, MCZ and Site of Special Scientific Interest feature condition (Dale and South Marloes coast SSSI, and Skomer island and Middleholm SSSI).

6.9.2. Objectives
To monitor the number and survival rate of seal pups born in the MCZ as an indication of the state of the general seal population.

6.9.3. Sites
All pupping beaches and caves in the MCZ
(Site descriptions in Skomer MCZ and Skomer Island seal management plan, Alexander 2015)

6.9.4. Methods
The pups are recorded from birth through to their first moult using the “Smith 5-fold classification system” (Poole 1996). Reason for death is recorded if possible. Additional behavioural observations are recorded for the Island seals (full method described in Skomer MCZ and Skomer Island seal management plan, Alexander 2015).

Surveys of the Skomer Island sites are completed under contract and a full survey report is produced, whilst the mainland sites are surveyed by MCZ staff. The results are combined to provide the full Skomer MCZ results.

6.9.5. Project History
Regular recording began at Skomer MCZ in 1974 at both mainland and island sites, but effort and methods varied. From 1992 onwards a standard protocol has been adopted to record the pupping success on both the island and the mainland each year, the methods were documented in the Grey Seal Monitoring Handbook (Poole 1996), in 2015 this was revised and updated (Alexander 2015).

Additional Seal Studies carried out at Skomer MCZ
2002 - Methods to study seal disturbance at mainland sites were tested and a further survey done in 2003 by placement students from Pembrokeshire College. A trial MCZ ‘seal watching’ leaflet was produced and distributed at the National Trust car park at Martins Haven. The leaflet included information on how to behave whilst watching seals. The 2003 survey included a questionnaire on the usefulness of the leaflet, which indicated that the leaflet was successful. A professionally produced version was published ready for the 2004 season and a full report on the seal disturbance study was completed (Lock 2004).

2004 - A project to identify individual seals at mainland sites was started by a placement student from Pembrokeshire College. This followed the methods set out in the ‘Grey Seal Monitoring Handbook’ (Poole, 1996 b.) and tested photographic and video methods.

2005 - Photographic methods were introduced to the adult seal identification project on Skomer (Matthews 2006). A Pembrokeshire college student, Liz Coutts, completed a study on the behaviour of bull seals at two island sites (Coutts 2006).

2007 - A project was completed by Dave Boyle studying the bull seals at all Skomer sites during September and October through funding secured by the Wildlife Trust of South and West Wales. The bulls were individually identified by their scars and markings. All bulls were sketched and photographed along with dates, location and dominance being recorded (Matthews & Boyle 2008).

2008 - 2018 - At Skomer sites photography included pupping cows to help increase knowledge of site fidelity, longevity and pupping frequency. In 2011 - 2017 the work also expanded to some cows and bulls from mainland sites. (Matthews 2009, Boyle 2009 - 2012, Buche & Stubbings 2013- 2018).

2010 - 2015 - Collaboration work with Sue Sayer, Cornwall Seal Group, who has maintained extensive catalogues of seals photographed in Cornwall since 2000. In the 'Skomer Seal Photo Identification Project Report 2007 – 2012' photographs taken at Cornwall/Devon and at Skomer sites were compared and 36 seals were identified as having been at both areas. Most of these seals seemed to be spending the breeding season on Skomer, returning to Cornwall for the winter and spring, but disappearing during the summer, presumably going somewhere else to feed up before the next breeding season (Boyle 2011). Between 2007 and 2013 there were a total of 43 "matches" of individual seals in the Cornwall and Skomer MCZ datasets (Sayer *pers. comm*.).

NRW developed an EIRPHOT database called the Wales Seal ID database in collaboration with the Sea Mammal Research Unit. Head and neck profiles of individual seals were extracted from photographs and entered into the database, and "matching" was then carried out on these extracted images. In 2014 a NRW contract allowed all 2007 to 2014 Pembrokeshire photos to be entered, in addition to the North Wales seal ID datasets. 2015 to 2018 photos are stored ready for entry.

2014 - 2016 Collaboration work with Swansea University researchers Dr James Bull and Dr Luca Borger. Long-term Skomer MCZ pup production data from the Marloes Peninsula (1992-2014) has been used to look at temporal trends and phenology in grey seal pups (Bull et al., 2017a). The same team has also used statistical models to look at the long-term datasets (1985-2015) for the Skomer Island sites (Bull et al. 2017b).

2016 - ongoing. PhD student William Kay, co-supervised between Swansea University and NRW, began research on seal movements in the Irish Sea in relation to potential marine renewable energy projects. The research started by mapping the historical Pembrokeshire seal ringing/tagging data collected between the 1950s and the 1970s, including many seal pups from Skomer.

2016- 2017 Callan Lofthouse, a student at Swansea University, completed analyses on seal scat samples collected from Skomer sites in the 2015 and 2016 seasons (Lofthouse 2017).

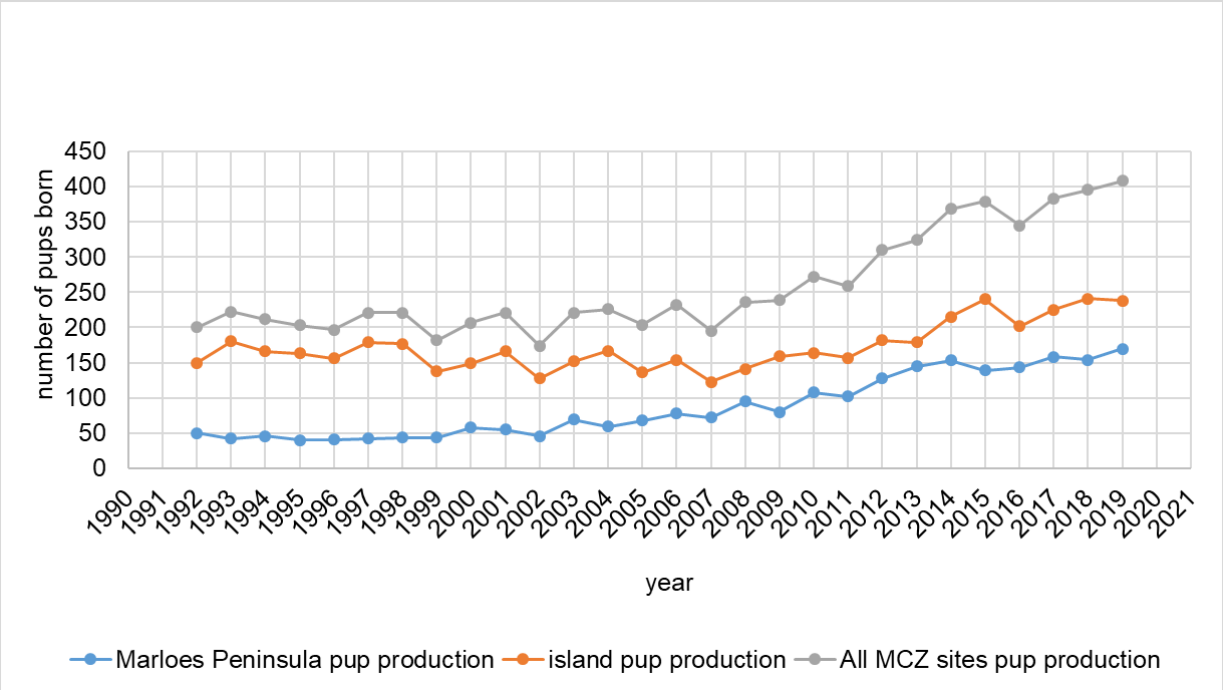
6.9.6. Results

A full report for the 2019 Skomer seal census details the production for the island sites, (Wilkie & Zbijewska 2020). The survey data from the island and mainland sites have been combined to provide data for the whole Skomer MCZ.

Pup production

In 2019, 238 pups were born at Skomer Island sites and 170 pups at mainland sites giving a total of 408 pups born in the MCZ.

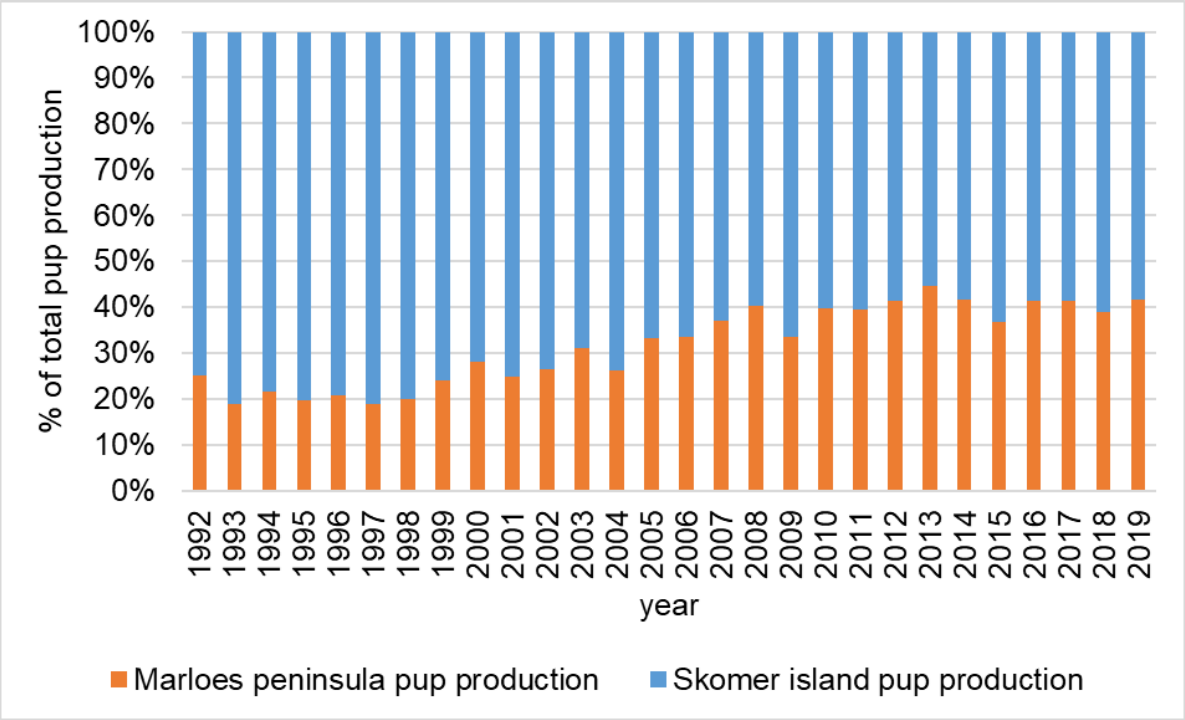
Figure 6.9.1. Skomer MCZ pup production 1992 - 2019



Pup production in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area with average production for 2015-19 at 382 pups. The pup production from 1992 to 2008 remained fairly consistent, within expected natural fluctuations, and with an average of 208 pups. Since 2009 there has been a steady increase in pup production at both the island and mainland sites.

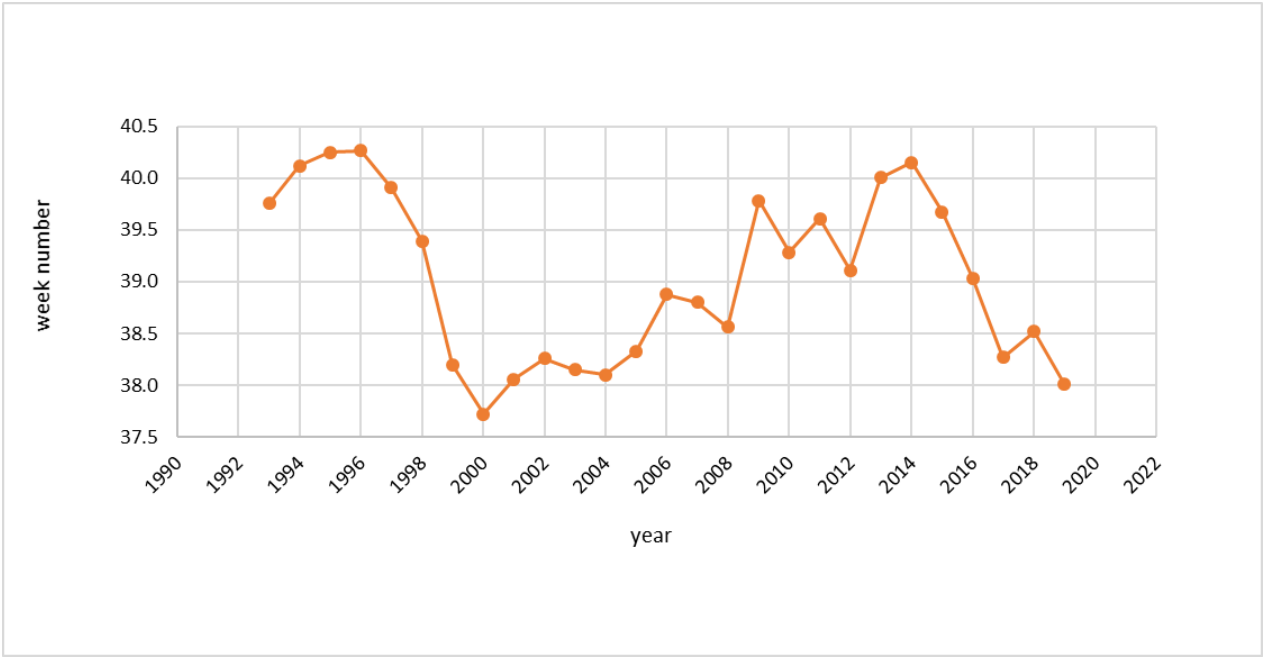
Pup production at the Marloes peninsula sites versus the Skomer island sites expressed as a percentage of the total pup production for the Skomer MCZ is shown in Figure 6.10.2. From 1992 to 2002 Marloes peninsula contributed an average of 22% of total production. This has then gradually increased to a peak of 45% in 2013 and the average over the last five years is 40% of total production.

Figure 6.9.2. Skomer MCZ pup production – proportion born on Island vs. mainland sites



In 2019, 8.5% of pup production occurred in July/August, 64% in September, 26% in October and 1.5% in November. The highest number of births was 80 pups in week 38 (17th – 23rd September). The trend over the last 23 years shows that the mode week of production has fluctuated between weeks 38 to 40 (17th September to 7th October).

Figure 6.9.3. Mode week of seal pup production at Skomer MCZ 1992 – 2019.



Pup survival

In 2019, pup survival through to moult was recorded as 81% for Skomer sites and 78% for Marloes Peninsula sites, with a combined survival for the Skomer MCZ of 79%.

Pup survival assessment is based on the following criteria applied to pups when last seen:

Table 6.9.1. Seal pup survival assessment method

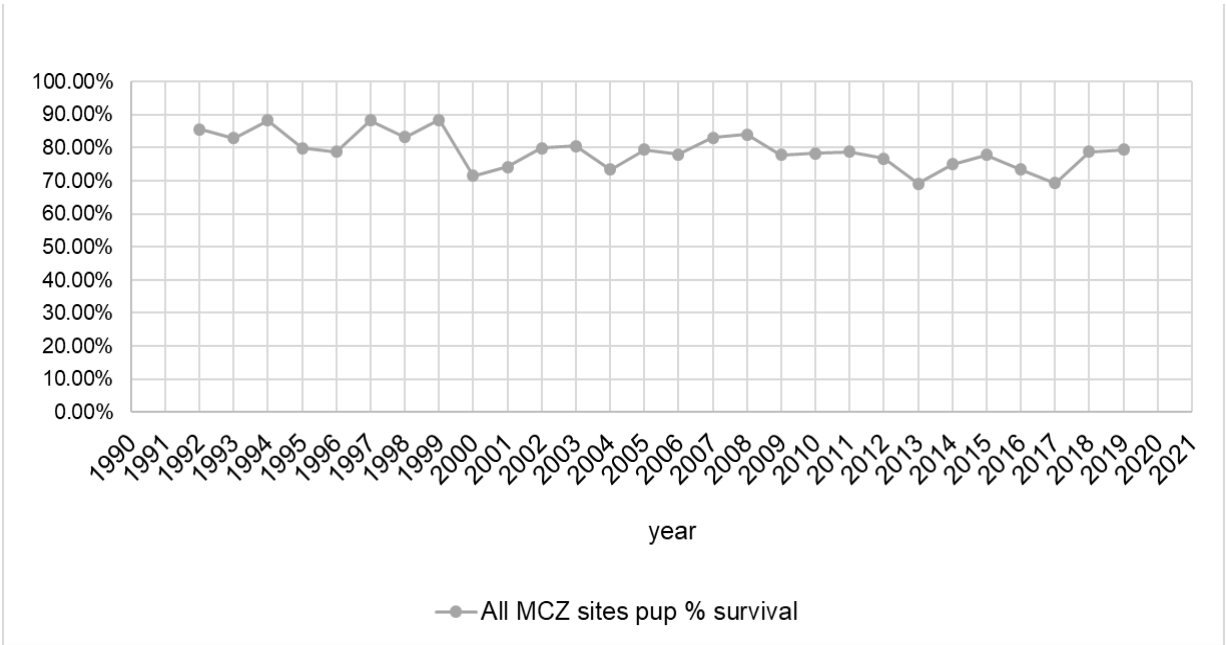
Size	**Assessment**
Very small	Assumed not to survive
Small but healthy	In good condition, reasonable chance of survival
Good size	Most should survive
Very good size	All should survive
Super moulter	All should survive

Mortality will occur for different reasons including still-birth, abandonment, starvation, disease, insufficient growth, injury and severe weather. It is not always possible to know the reason for death so for analysis purposes it has been simplified into three groups:

1. **Stillborn**. These include both stillborn and those that died immediately after birth and were not seen alive.
2. **Died.** All pups seen alive but subsequently recorded dead. These can be from class 1 to 5.
3. **Assumed mortality**. These include pups assessed not to have survived following the survival assessment.

In the Skomer MCZ pup survival from 1992 to 2019 has fluctuated between 69% and 88% with an average of 79%.

Figure 6.9.4. Skomer MCZ pup survival 1992 – 2019



Pollution

Monofilament line and netting were the most obvious pollutants affecting seals. In 2019, 16 seals (9 females, 3 males and 4 immature) were photographed with obvious signs of being entangled in nets at some time in their lives, most commonly a deep scar around their necks, often with netting still embedded. Four seals with scars caused by netting were known from previous years, all of which were adult females.

BK-066 has been recorded most years since she was first recorded in 2011; 2013, 2015, 2017, 2018 and in 2019 was seen in a haul out on Castle Bay.

Figure 6.9.5. Cow BK-066 on Castle Bay 21/10/2019

14.SC-NK-109.MWK which was first recorded in 2014 and subsequently identified around Skomer in 2015, 2017 and 2018, she successfully weaned a pup on Driftwood Bay in 2019.

Figure 6.9.6. Cow 14.SC-NK-109.MWK on Driftwood Bay with pup on 13/10/2019

NK-020 was first recorded in 2008 and has subsequently been identified around Skomer every year except 2013 and 2018. In 2019 she was recorded on Castle Bay.

Figure 6.9.7. Cow NK-020 on Castle Bay 21/10/2019

Seal behaviour
One bull at South Haven (end of 1st week Oct to 3rd week Oct) was observed to be more aggressive towards pups than others. This resulted in many of the pups in South Haven beach having brown bite marks all over their body. It was initially thought to be an illness developed from the unclean beach and the pups being exposed to many storms. Further observations lead to a conclusion that it was a male causing turmoil amongst pups. During that time a number of pups were abandoned by their mothers, but it is difficult to judge whether the male and his aggressive behaviour caused abandonment.

There are clear bite marks on pup 167 shown below. This pup disappeared after the 9th October 2019 and was then found dead on the 14th October 2019.

Figure 6.9.8. Pup 167 on South Haven beach found dead on the 14.10.19

Further Research in 2019
A Seal Mammal Research Unit (SMRU) GPS tracking project (Dr Matt Carter, SMRU, University of St Andrews) was undertaken on Skomer and Ramsey in 2019. Between the 15-18th of April seven GPS devices were deployed on seals caught at sites on Skomer (2 males) and Ramsey (3 males, 2 female). The project is part of a UK-wide project funded by the UK Government's Department for Business, Energy and Industrial Strategy, to investigate the movements and habitat preferences of both grey and harbour seals around the UK. Developing an understanding of important at-sea habitat for marine top predators in the UK is crucial to mitigating any potential impacts of offshore human activities such as oil and gas extraction and the construction of marine renewable energy installations. Compared to seal populations in Scotland and eastern England, relatively little is known

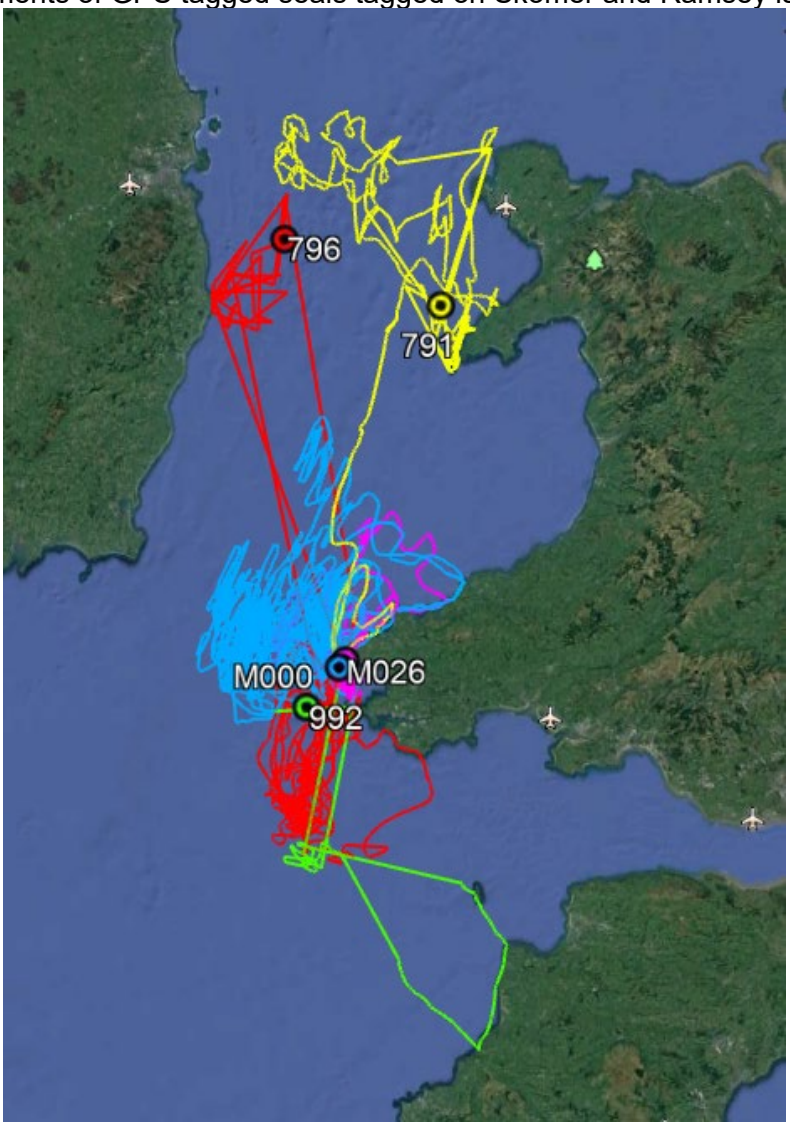
about the at-sea distribution and behaviour of Welsh seals. Therefore, this work is an important step towards understanding regional differences in the movement patterns and habitat requirements of grey seals in the UK.

The tracks of the seals tagged on Skomer and Ramsey will be analysed alongside seals tagged on Bardsey in 2018, and in the Dee Estuary in 2017. An additional aim of the project is to identify the seals' foraging and breeding sites to better understand where seals acquire the food resources required to support breeding. Grey seals are typically capital breeders, meaning that they fast on land during the lactation period and must depend on their energy reserves acquired throughout the summer to feed the pup and sustain themselves. There is evidence that female grey seals return to the colony where they were born to breed as adults, but that they do not necessarily forage in areas adjacent to the breeding colony.

Two different device types (designed and built by SMRU Instrumentation) were used. The first device type, a "GPS phone tag", provides GPS location estimates as well as information on the haul-out and dive behaviour of seals. The data are stored in a buffer memory on-board the tag whilst the seal is at sea and later transmitted via the GSM phone network once the seal hauls out on land within phone coverage. The second device type, a "dual tag", performs the same function but additionally collects temperature readings throughout the water column as the seal dives. These temperature data are then transmitted at sea via polar-orbiting Argos satellites when the seal is at the surface. The data are used by the Met Office in real-time to inform their ocean forecasting models. Therefore, the seals are simultaneously contributing data to ecological and meteorological datasets. The tag is glued to the fur on the seal's neck. This keeps the device streamlined as the seal dives and allows the aerial to be exposed when the seal comes to the surface to breathe, facilitating a connection with satellites. The tags will detach when the old fur is moulted off next spring, leaving no trace on the seal.

Initial results of movements are shown in Fig 6.9.9 Each colour corresponds to an individual seal tagged on either Ramsey or Skomer.

Figure 6.9.9. Movements of GPS tagged seals tagged on Skomer and Ramsey islands in April 2019



M000 (blue track), a female tagged on Ramsey has visited Skomer and later travelled up into Cardigan Bay. M026 (pink track), another female captured on Ramsey has also travelled up into Cardigan Bay. Male 992 (green track) a male captured on Ramsey travelled to Lundy Island and the north Devon coast.

Male 791 (yellow track), a male tagged on Skomer has travelled the furthest, up to the Llyn Peninsula and to the Skerries. Male 796 (red track) tagged on Skomer has travelled all the way to the Irish Sea and stayed around Dalkey Island for a while.

6.9.7. Current Status

Grey seals at Skomer MCZ are considered to be in favourable condition:

- In 2019, pup numbers reached 408, 13 pups higher than the management plan target pup production lower limit of 395 pups (average of last 3 years).

- Pup survival was 79%, 4% above the management plan target percentage survival lower limit of 75% (average of last 10 years).

6.9.8. Recommendations

- To use the combined Marloes peninsula and Skomer island seal survey results to report on the status of seals in the Skomer MCZ using criteria set out in the Skomer MCZ and Skomer Island NNR Seal Management Plan;

- To use the Skomer MCZ seal survey results to report on the status of seals in the Pembrokeshire Marine SAC;

- To continue recording seal disturbance at mainland and island sites;

- Develop a photo database for Pembrokeshire and neighbouring areas. To continue the adult seal identification project and contribute to the development of the Wales Seal ID database. To continue collaboration with the Cornwall Seal Group;

- Provide visitors with information about grey seals both in the visitor centre and through the distribution of the 'seal watching' leaflet developed in 2002 in order to minimise disturbance to breeding seals.

6.10. Cetacean Species Recording
(CMS Code RA01/ 01)

6.10.1. Project Rationale
Cetaceans are regularly recorded in and adjacent to the MCZ.

Harbour porpoise (*Phocoena phocoena*) are most frequently recorded around the island from spring to autumn. However, as individual animals are unidentifiable it is not possible to establish whether the MCZ waters are used regularly by a large number of peripatetic animals or whether a smaller group remains in the immediate area. *P. phocoena* is an internationally protected species listed on: CITES, the Berne Convention, the EC Habitats Directive and under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS). In British waters they are legally protected under the Wildlife and Countryside Act 1981 and species of principal importance in Wales (Environment Act (Wales) 2016, Section 7). The proposed West Wales Marine SAC for harbour porpoise, which includes the waters of the MCZ, became a designated SAC in 2019.
Bottlenose dolphin (*Tursiops truncatus*), Common dolphin (*Delphinus delphis*) and Risso's dolphin (*Grampus griseus*) are occasional visitors to the Skomer MCZ.

This project could potentially provide data for reporting on SAC as well as MCZ feature condition.

6.10.2. Objectives
To record numbers of cetaceans and the locations used by them in the Skomer MCZ.

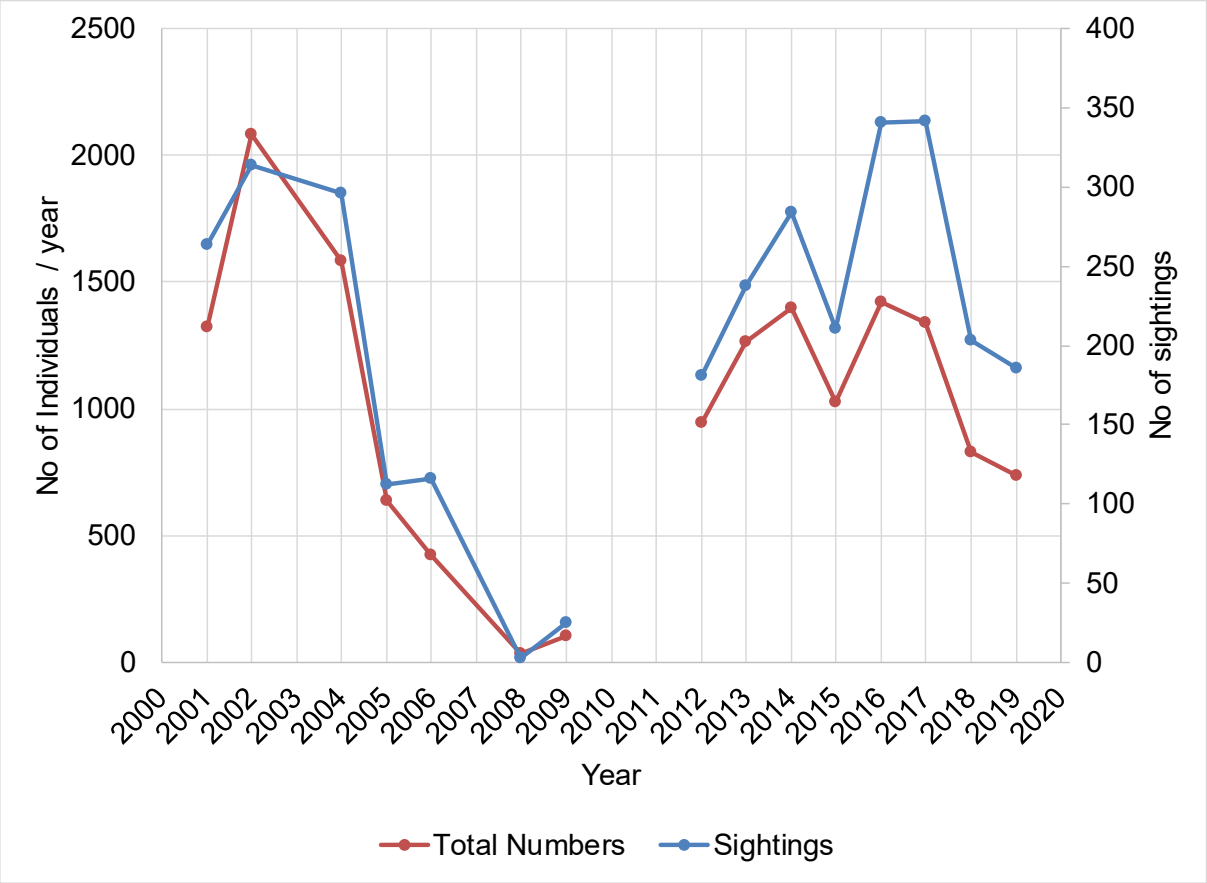
6.10.3. Method
Recording effort varies annually but includes:
- Skomer Island NNR staff and volunteers using binoculars and telescopes from cliff locations around the island.
- Dale Princess crew maintaining records in a diary of sightings during the ferry run between Martins Haven and North Haven and on the round island trips.
- MCZ staff recording all sightings whilst at sea.

Species, numbers, sites, date and time are recorded for each sighting.

6.10.4. Results
All sightings of cetaceans have been collated for the period between 2001 and 2019. There are no records in years 2003, 2007, 2010 & 2011. The effort is variable not just between years but also during the season which makes the data difficult to effort correct.

In 2016 a standard set of site names and recording system was applied to all data collected by Skomer MCZ and Skomer NNR staff. Very few records were received from the Dale Princess in 2017 or 2018. In 2019, regular records from the Dale Princess were received.

Figure 6.10.1. Harbour porpoise sightings within Skomer MCZ 2001 to 2019



These data are not effort corrected and there was a more concerted effort to collate all the records in a consistent way from 2016 onwards.
Harbour porpoise are sighted throughout the whole year and are assumed to be resident or regular users within the MCZ. Common Dolphins are predominantly seen from July to September as shown in Figure 6.10.2.

Figure 6.10.2. Percentage of sightings per month 2001 to 2019. Harbour porpoise & Common dolphin

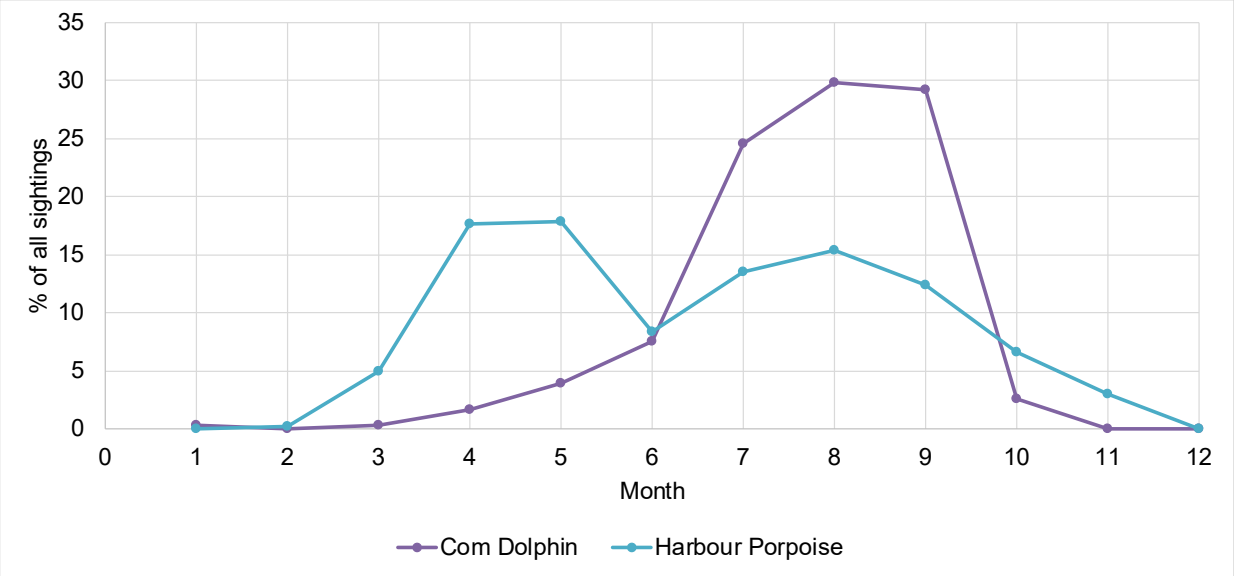


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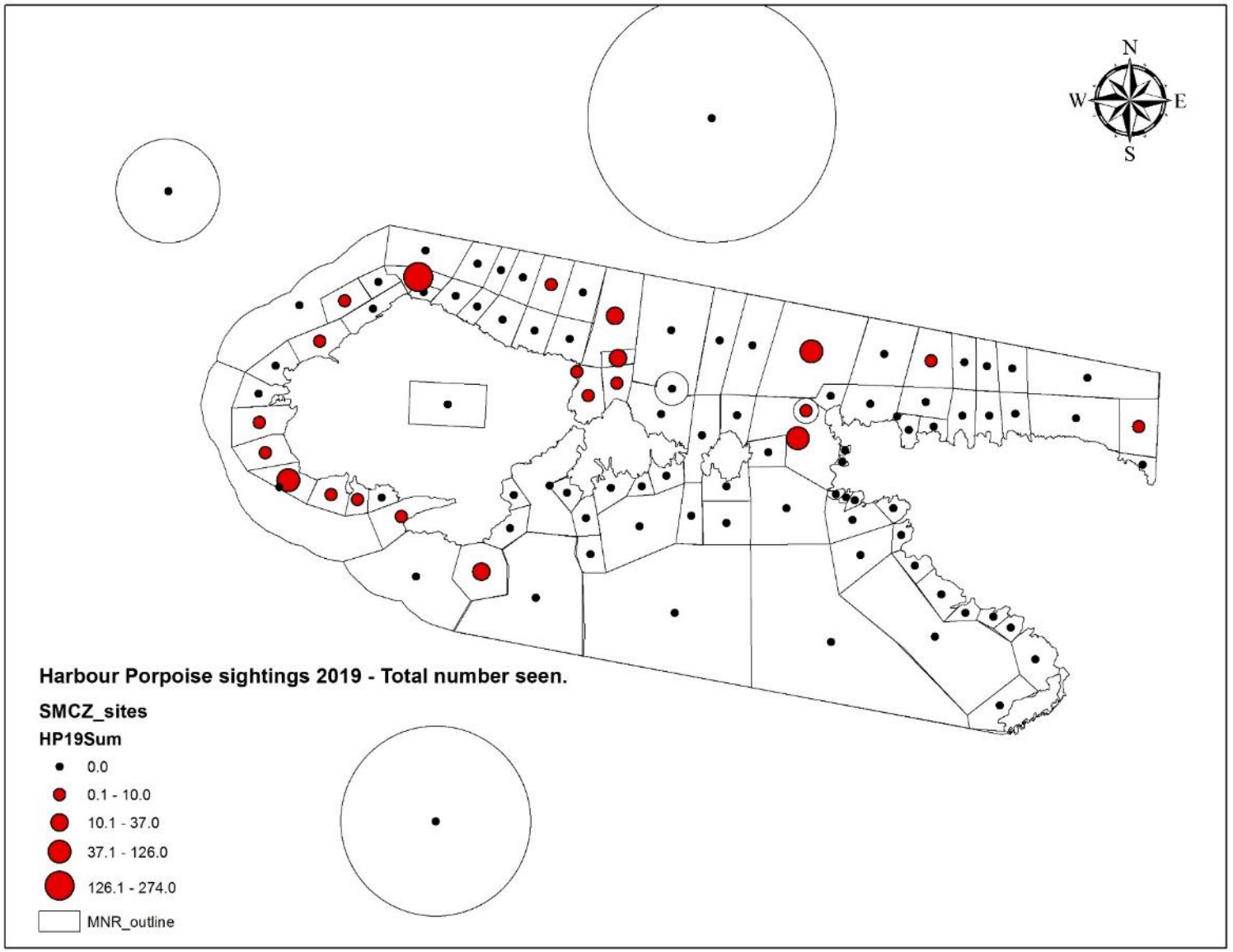
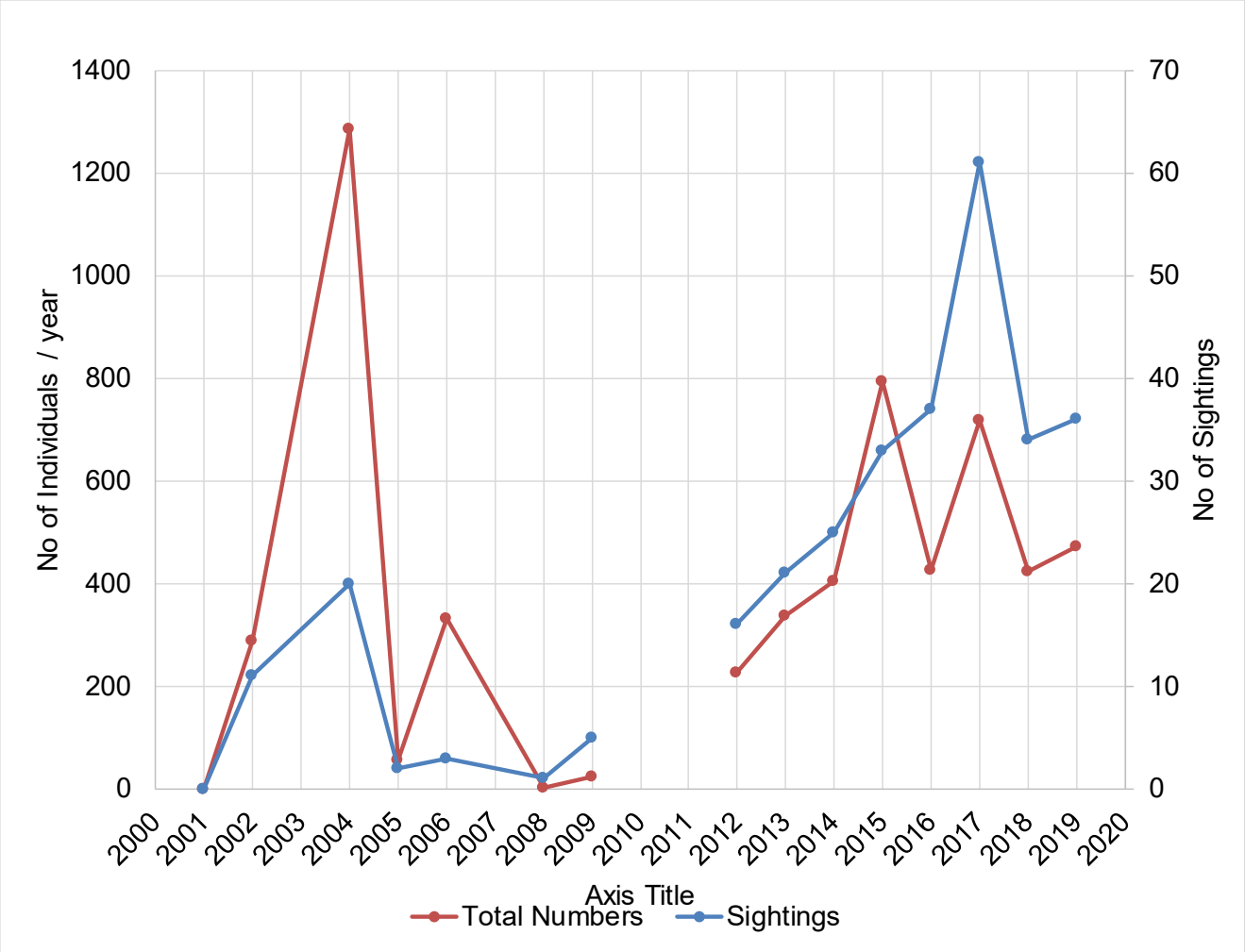
Figure 6.10.3. Harbour porpoise sightings and distribution Skomer MCZ 2019.



This data are not effort-corrected but are useful in showing areas that harbour porpoise frequent. All vagrant and mobile species records are now recorded using this site code format.

Common dolphin (*Delphinus delphis*) use the area infrequently but they can appear in large numbers. There were no observations in 2010 and 2011 but since then they seem to be increasing. These data are not effort corrected but as common dolphin sightings are more unusual, they tend to get recorded when observed. There were more sightings in 2016 but no big pods were seen. In 2019, there was a similar number of sightings compared with 2018 with most seen off the Garland stone and Skomer head.

Figure 6.10.4. Common dolphin sightings within Skomer MCZ 2001 to 2019

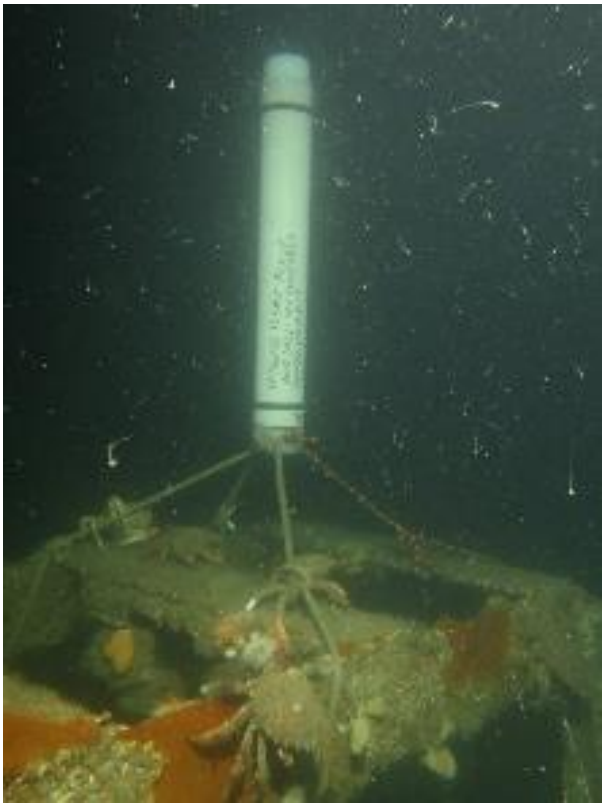


Bottlenose dolphins (*Tursiops truncatus*) are not often seen within the MCZ, but in 2019 there were 2 sightings of individuals off the Garland stone.

Risso's dolphin (*Grampus griseus*) are regularly seen around Ramsey Island, 8 miles to the north but there are only infrequent sightings within the MCZ. However, there were 3 sightings in 2019 including a young animal off North of the Neck in April.

Research Projects 2019.
A static acoustic data logger was placed in the MCZ by the SEACAMS2 research group based at Swansea University, we are currently awaiting results.

Figure 6.10.5. Static acoustic data logger attached to seabed frame located at OMS site.



6.10.5. Current status

Cetaceans continue to be recorded in apparently increasing numbers within Skomer MCZ, although it is unclear whether the increase is an artefact of the lack of consistency of recording in previous years.

6.10.6. Recommendations

- A standardised method of recording needs to be developed and used by all recorders. Standard method needs to include an estimate of days / time spent recording as well as the sightings data.
- Encourage Swansea University to continue to deploy acoustic loggers and provide data to Skomer MCZ.

6.11. General Species Recording

(CMS code: RB06/01)

This section also includes: “vagrant and alien species recording” (CMS code: RB01/01) and “record commercial crustacean populations” (CMS code: RM44/01) projects.

6.11.1. Project Rationale

There are many species in the Skomer MCZ that do not have a dedicated monitoring project. However, it is important that species lists are maintained, particularly for phyla that are under-recorded or of particular conservation importance. Recording of species of principal importance as defined under Section 7 of the Environment Act (Wales) 2016 and ‘Alien’ invasive and non-native species (INNS) are just two examples.

General recording of unusual, rare, scarce or vagrant species is also maintained.

Records are entered into the JNCC-administered Marine Recorder database for access via the National Biodiversity Network on-line gateway.

6.11.2. Crawfish

Crawfish *Palinurus elephas* became a national Biodiversity Action Plan species in 2008 and is an Environment Act (Wales) 2016, Section 7 species of principal importance. From 2009 to 2019 it was recorded in low numbers in Skomer MCZ by staff and volunteers. These records have been submitted to the i-record online recording scheme in an effort to gain better knowledge of the current status of this species in the UK.

Figure 6.11.1. Crawfish, *Palinurus elephas*

6.11.3. Sunfish

Sunfish *Mola mola* is the largest bony fish in the world; they are an ocean vagrant that can be found in both tropical and temperate waters. They feed mainly on jellyfish so are found often when there are jellyfish blooms around the coast. Sunfish are often recorded in the Skomer MCZ in low numbers from July to September when seawater temperatures are around 15ºC or warmer. Sunfish records are from both MCZ staff and from Dale Princess crew. Although they can grow up to 1000kg, those recorded are usually relatively small individuals. Some years several individuals have been spotted whilst in other years there have been no records. In 2019, there were 2 records in August and 2 in September.

6.11.4. Non-native species

Wakame *Undaria pinnatifida*, was found attached for the first time on Skomer and Skokholm shores during the 2018 survey. This is a non-native kelp species from Japan and China, but in recent years it has spread around the world via mariculture and shipping vectors. It first arrived in England in 1994 in the Solent and has since spread around the

UK. In 2019 careful searches were completed at each of the shores during the littoral surveys but it was not found.

A single *Sargassum muticum* plant was recorded at Martins Haven in 2019. It was first found attached to a cobble in 2008 and it has been recorded again on 6 annual surveys over the last 11 years. On each occasion it has just been 1-2 plants.

6.11.5. Notable species recorded in 2019

Portuguese man-o-war *Physalia physalis*, washed up on to Martins Haven beach on 3 occasions following storms during the winter. They were also spotted on Musselwick beach and Marloes sands which are adjacent to the Skomer MCZ.

P. physalis, is a marine hydrozoan of the family Physaliidae found in the Atlantic, Indian and Pacific Oceans. Despite its outward appearance, it is not a jellyfish but a siphonophore, which is a colonial organism made up of specialised polyps. These polyps are specialised for movement, catching prey, feeding and breeding. The individual polyps are dependent on each other for survival, each having a distinct role. A large, purple, gas filled float (the pneumatophore) reaching up to 30 cm in height allows it to float on the surface and the crest running along the top acts as a sail. Its venomous tentacles can deliver a painful sting, which in very rare cases can be fatal.

Figure 6.11.4. Portuguese man-o-war *Physalia physalis*

A record of a crab in the family Atelecyclidae was made by Jon Moore on a night dive at Martins Haven. It was suggested that the crab might be *Atelecyclus undecimdentatus* (Endre Willassen *pers. comm.*) which has a whitish to cream colour carapace with a fringe of long setae and both claws and legs have many bristles. The carapace is wider than it is long growing up to 5cm long and 6.3cm wide. However, it could also have been the more common circular crab *Atelecyclus rotundatus* which has a narrower carapace which is usually reddish brown.

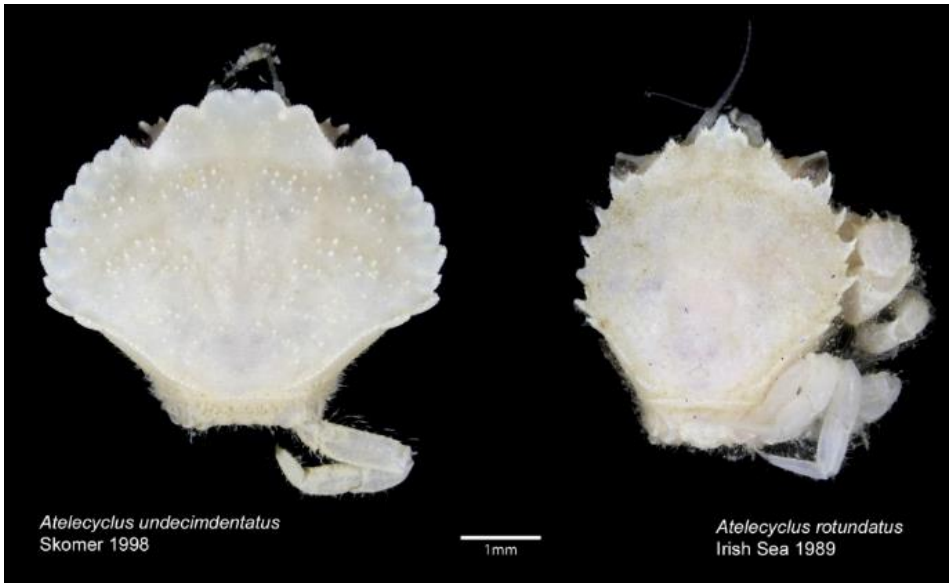
Figure 6.11.5. Crab species, *Atelecyclus sp.(Photo by Jon Moore)*

The angle of the photo and the sand covering the crab makes it difficult to accurately look at the carapace shape and colour which would help confirm the identification. *Atelecyclus undecimdentatus* has a southern distribution in Europe. However, there are records from the Netherlands indicating that it can be found in cooler waters.

Figure 6.11.6. *Atelecyclus undecimdentatus* (Herbst, 1783) in GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 2020-01-29.

There is only one UK record of *Atelecyclus undecimdentatus*, from the north side of Skomer when it was collected during the Skomer MNR sediment infauna survey in 1998, (Barfield 1998). The specimen was preserved and is curated at the National Museum Wales. In order to check the identification of the specimen photographed at Martins Haven, this specimen was photographed by Teresa Darbyshire alongside an *Atelecyclus rotundatus* for comparison (Figure 6.11.7).

Figure 6.11.7. *Atelecyclus undecimdentatus,* Skomer 1998 alongside *Atelecyclus rotundatus,* Irish Sea 1989 photo comparison, National Museum Wales 2020.



These photographs were further examined by Bernard Picton at Ulster museum who took further specimen photographs from voucher samples held there.

Figure 6.11.8. *Cancer pagurus*, 1972 alongside *Atelecyclus undecimdentatus,* Galicia Spain 1978 photo comparison, Ulster museum 2020.

This examination has shown that the 1998 sample is most likely to be a juvenile *Cancer pagurus* (Edible crab) which has rounded evenly spaced teeth between the eyes compared to *Atelecyclus s*pp. which have three close pointed teeth and two outer ones between the eyes.

The 1998 record will be corrected on the National Marine database resulting in no UK records of *Atelecyclus undecimdentatus*.

It is very important that unusual species are verified and checked. This example shows the importance of museum collections, how voucher specimens, photographic or the actual specimen, are important when making records of species, especially at the edge of their ranges.

6.12. Echinoderm populations: *Echinus esculentus, Marthasterias glacialis, Crossaster papposus* and *Luidia ciliaris*

(CMS code: RM73/01)

6.12.1. Project Rationale

Echinus esculentus Linnaeus (1758) is an omnivorous grazer and a key biological structuring factor in sub-tidal communities. The grazing clears space making it available for colonisation by other species. In low numbers this grazing effect is beneficial; in high numbers it can be highly destructive even destroying whole kelp forests (Hagan, 1983). During the 1970s divers targeted the Skomer MNR population for the curio trade and large numbers were removed. Bishop (1982) reported that mean densities of *E. esculentus* in Skomer MNR were not significantly different from densities in a commercially exploited population.

The starfish, *Marthasterias glacialis*, *Crossaster papposus* and *Luidia ciliaris* are easily identifiable and information on their distribution and abundance would be of interest.

6.12.2. Objectives

1. To determine the distribution and abundance of *E. esculentus* and describe their key habitats;
2. To determine the size frequency distribution of *E. esculentus*;
3. To record sunstar, *C. papposus*, spiny starfish *M. glacialis* and seven- armed starfish *L. ciliaris*;
4. To allow a time series of comparable data to develop with surveys completed every 4 years.
5. To determine the distribution and abundance of 'bald' *E. esculentus* and to investigate the cause;
6. To investigate the presence of Echinoderm larvae in plankton samples.

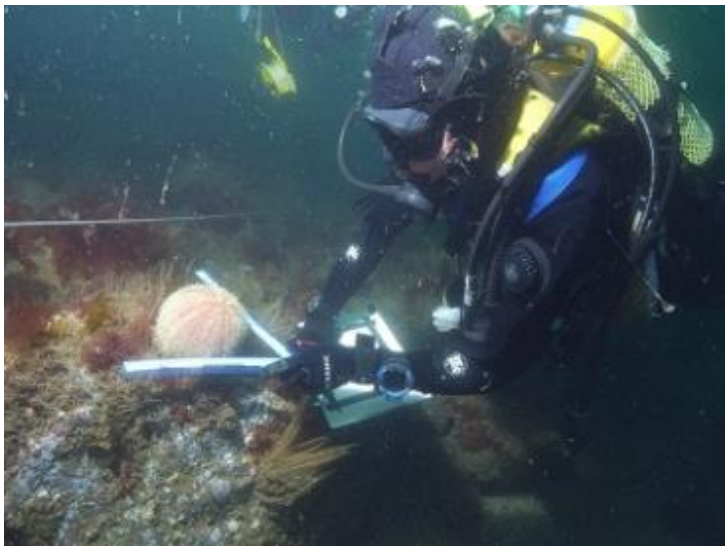
6.12.3. Sites

- North Wall
- Rye Rocks
- Thorn Rock
- Castle Bay
- High Low point
- Martins Haven point

6.12.4. Methods

The methods involve recording sightings of the target species along a 30m transect (from within a 2m wide strip). In addition, the widest diameter of each urchin was measured using callipers and the distance on the tape measure recorded. The method was designed for use with volunteer divers and is described in Luddington & Lock (2004).
In 2007 methods were modified to allow improved statistical analysis and comparison between surveys. The study sites were marked, and GPS positions taken, allowing for relocation of sites in future surveys. Four depth zones were surveyed at 20m, 15m, 10m and 5m below chart datum. *E. esculentus* were measured using a fixed 60 degree divider (the *Gibbs urchin divider*), as this was easier to use and has less error than the sliding callipers.

Figure 6.12.1. Diver measuring sea urchin with 60 degree divider



'Bald' *E. esculentus*, *M. glacialis, C. papposus* and *L. ciliaris* were counted along each completed transect. Seasearch methods were used for recording seabed substrate and habitats present at each site. The revised methods are fully described in Lock *et al.* (2008).

In 2011 one site at Castle Bay was relocated to a new position with more suitable habitat for *E. esculentus.*

A plankton trawl was completed weekly from Easter to the end of October on the north side of Skomer following methods used by Plymouth marine Laboratory (see Section 6.4). Sample species analysis is completed by contractors at the Marine Biological Association.

6.12.5. Results

Echinus esculentus

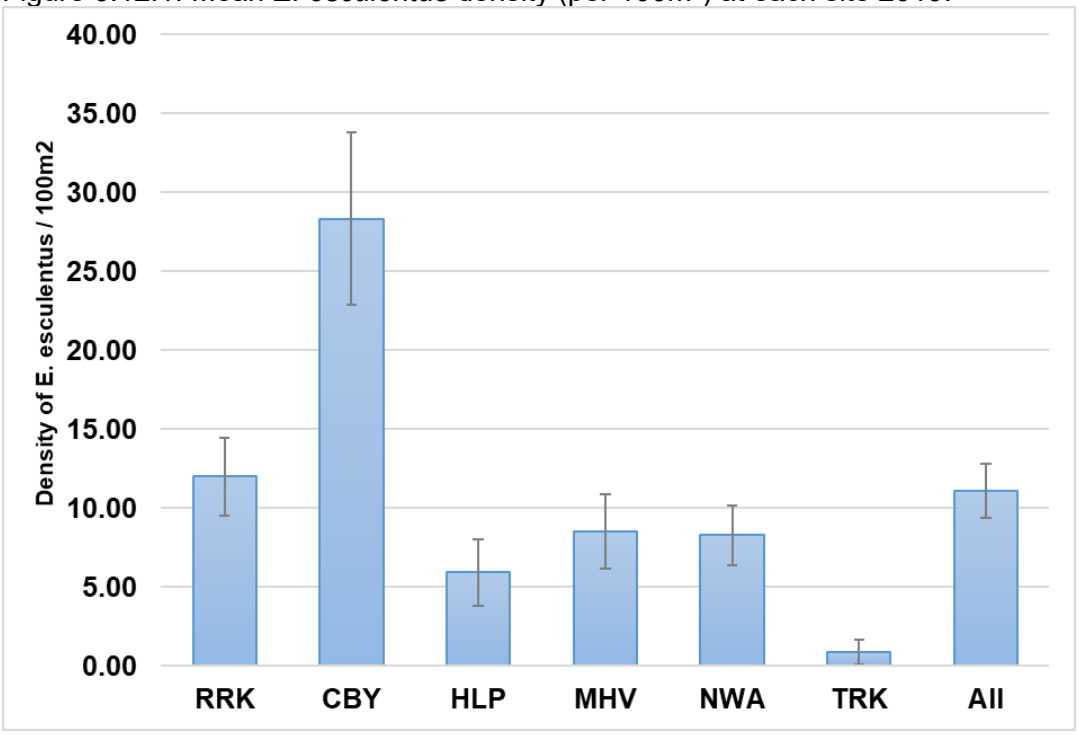
The mean density for the Skomer MCZ for each survey year is shown in Table 6.13.1. A similar number of transects and area surveyed was completed for each survey.

Table 6.12.1. Summary of density results for *Echinus esculentus* in each survey year

	2007	2011	2015	2019
Transects completed	140	139	151	144
Area covered (m^2)	8400	8340	9060	8640
Total number of Urchins	602	755	879	953
Mean density / 100 m^2	6.87	9.05	9.70	11.11

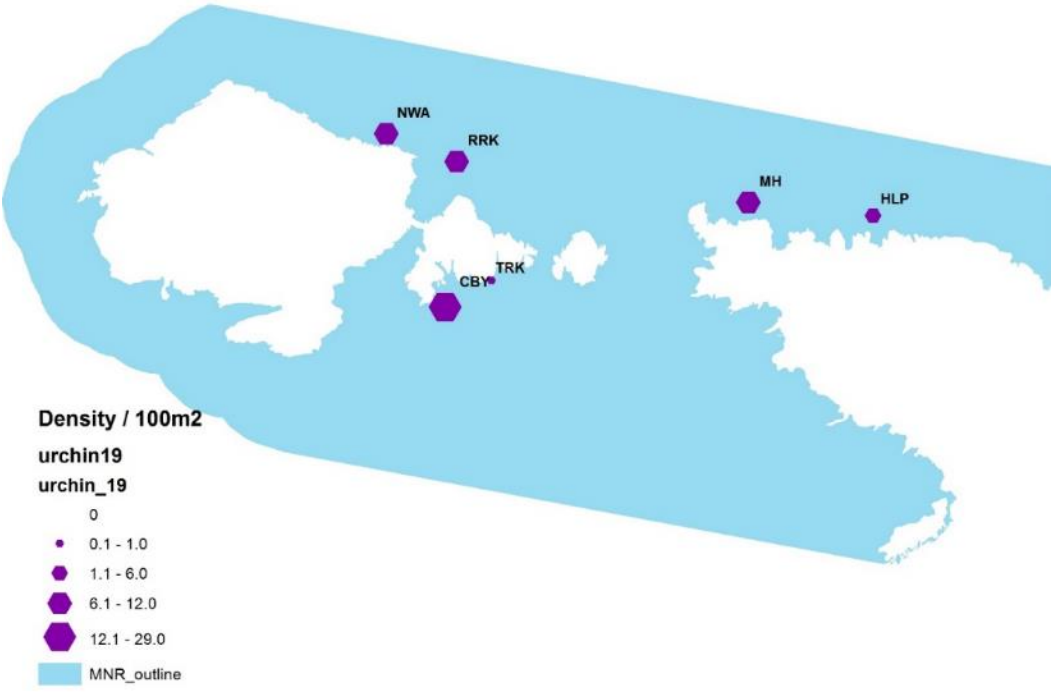
In 2019 the mean density of *E. esculentus* for all sites surveyed was 11.11/100m^2. Density of *E. esculentus* at different sites in 2019 with error bars (95% CI) is shown in Figure 6.12.1. A wide range of mean densities were found at the different sites. The highest mean density of 28.33 per 100m^2 was recorded at Castle Bay and the lowest was 0.9 per 100m^2 at Thorn Rock.

Figure 6.12.1. Mean *E. esculentus* density (per 100m^2) at each site 2019.



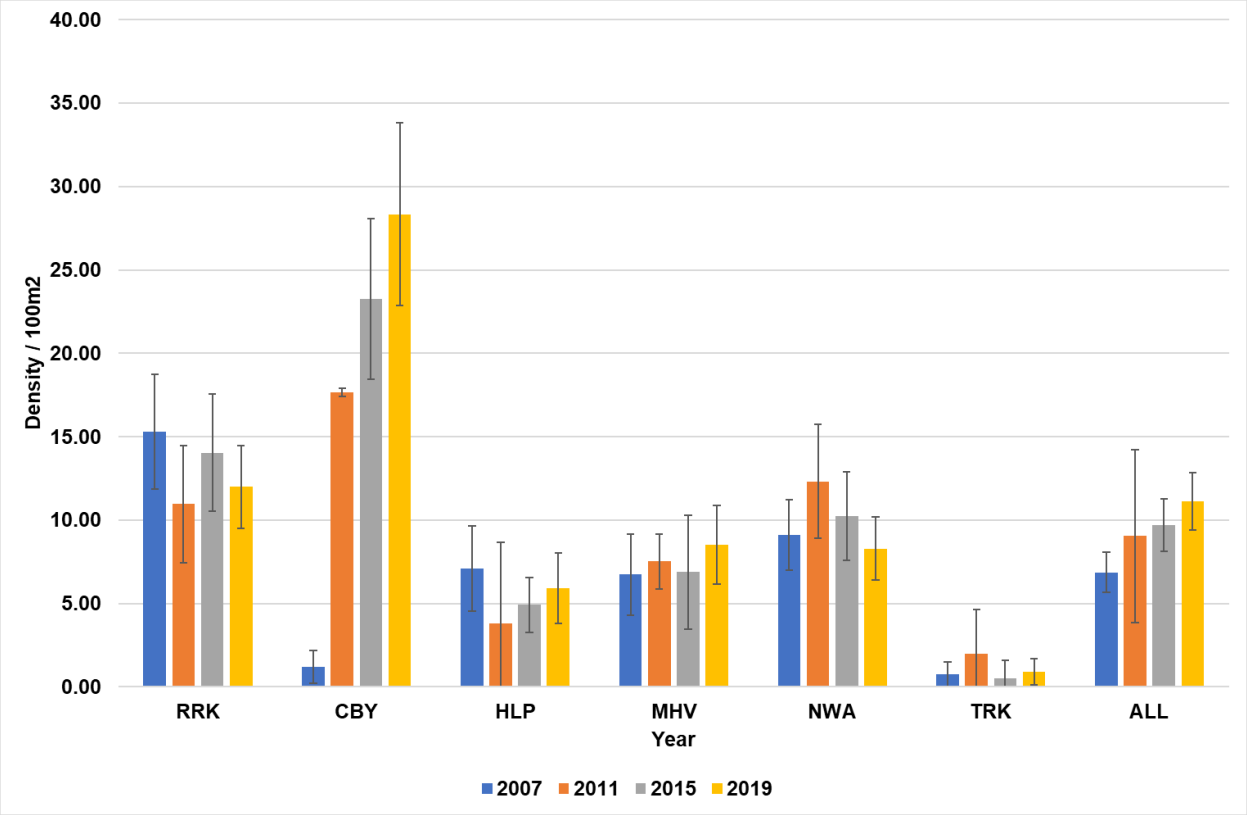
Thorn Rock (TRK), North Wall (NWA), Rye Rocks (RRK), Martins Haven Point (MHV), High/Low Point (HLP) and Castle Bay area (CBY).

Figure 6.12.2. Graduated bubble map of *E. esculentus* density in Skomer MCZ 2019.



These results can be compared to the 2007, 2011 and 2015 surveys.

Figure 6.12.3. Mean *E. esculentus* density (per 100m^2) at each site for 2007, 2011, 2015 & 2019.



Thorn Rock (TRK), North Wall (NWA), Rye Rocks (RRK), Martins Haven Point (MHV), High/Low Point (HLP) and Castle Bay area (CBY).

The pattern of variation in density between the sites has not varied much between the years. It is only the Castle Bay site which has shown any significant change (**p<0.1%).** In 2007 an unsuitable location was used in Castle Bay before relocating it in 2011, this accounts for the comparatively low density recorded in 2007.

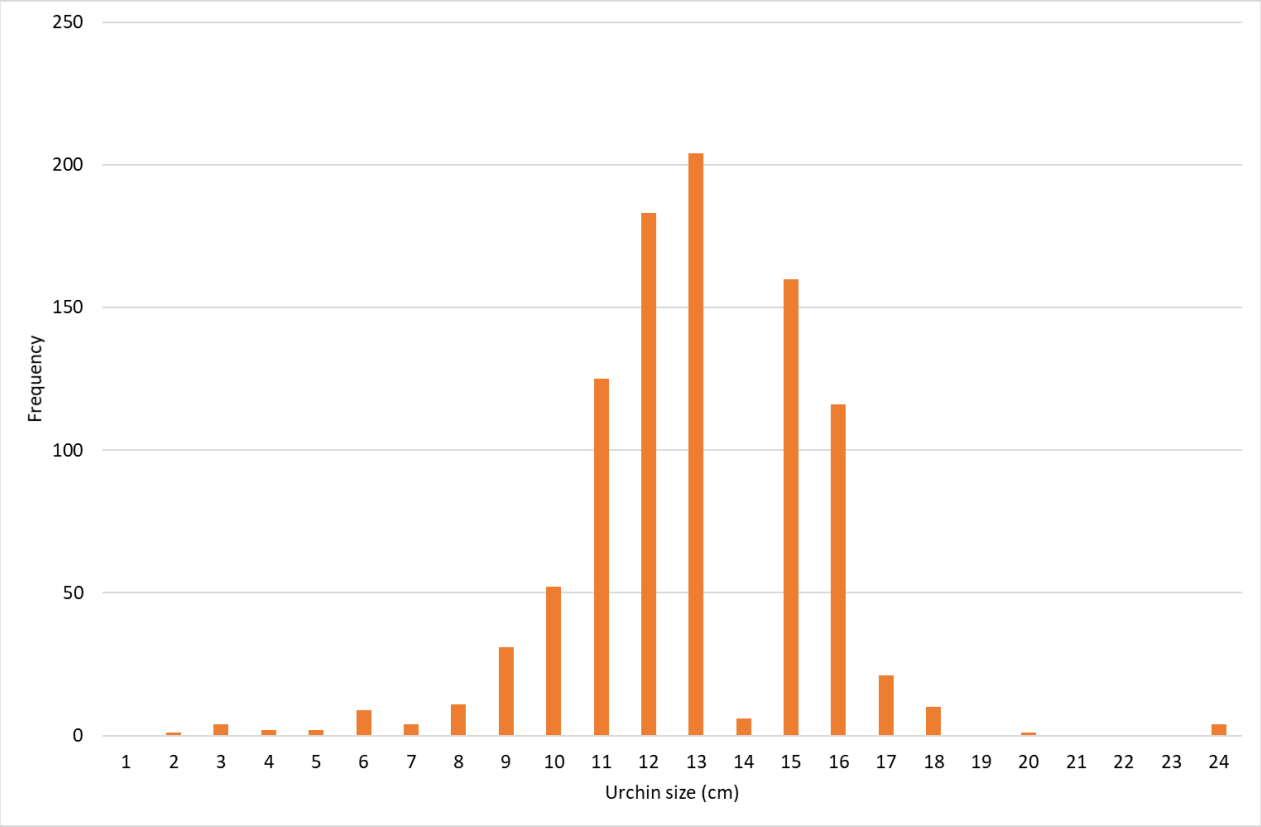
At each of the survey sites transects were completed at 5m, 10m, 15m and 20m depths below chart datum (bcd). The highest number of the transects were conducted at 10m and 15m. A one way ANOVA test showed that there was **no** significant difference between the densities of *E. esculentus* found at each depth zone (F = 1.10 f critc 2.67 **not sig @ p 5%)**. This is consistent with results from the previous surveys (Lock *et al* 2008 & 2012, Burton *et al* 2016).

Table 6.12.2. Summary table of *E. esculentus* density with depth.

Depths	Transects completed	Area covered	Total No of urchins	Mean density per Transect	95%CI (mean / Tx)	Mean Density Per 100m2	95%CI Mean/ 100m2	Mean size	95 % CI
5 M bcd	13	780	75	5.77	2.24	9.62	3.74	13.1	0.5
10 M bcd	64	3840	389	5.98	1.18	9.97	1.96	13.4	0.2
15 M bcd	60	3600	458	7.63	2.01	12.72	3.36	13.5	0.2
20 M bcd	7	420	31	4.43	3.23	7.38	5.38	13.4	0.8

The 'Gibbs urchin divider' data were converted to *E. esculentus* diameter. The population of *E. esculentus* shows a normal size frequency distribution. Mean, maximum and minimum diameters were 13.4 cm, 24.3 cm and 2.3 cm respectively.

Figure 6.12.4. Size frequency distribution for whole MCZ population 2019.



2019 has seen the highest occurrence of 'bald' *E. esculentus* since 2003. One record was from Thorn Rock, three records from Rye Rocks and seventeen records from the Castle Bay site. The numbers found are still very low, accounting for only 2.2% of the total.

Table 6.12.3. Numbers of "bald" *Echinus esculentus* 2003 – 2019

	2003	**2007**	**2011**	**2015**	**2019**
Total *E. esculentus*	505	609	755	869	953
Total "bald" *E. esculentus*	0	2	1	10	21

Starfish Species

In 2019 *Marthasterias glacialis* was the only starfish from the targeted list to be recorded and had a mean density of 2.79/100m^2. There were no records of either *Luidia ciliaris* or *Crossaster papposus. Crossaster papposus* has not been recorded on a survey since 2003. *Luidia ciliaris* was recorded in 2007, 2011 and 2015 but in very low numbers and mainly as juveniles.

Table 6.12.4. Starfish records for Skomer MCZ 2003 – 2019

Year	**2003**	**2007**	**2011**	**2015**	**2019**
C. papposus - counts	21	0	0	0	0
M. glacialis – density / 100m^2	4.98	3.47	4.0	2.17	2.79
L. ciliaris - counts	0	2	10	2	0

Table 6.12.5. Density of *M. glacialis* / 100m^2 at each site 2003 – 2019

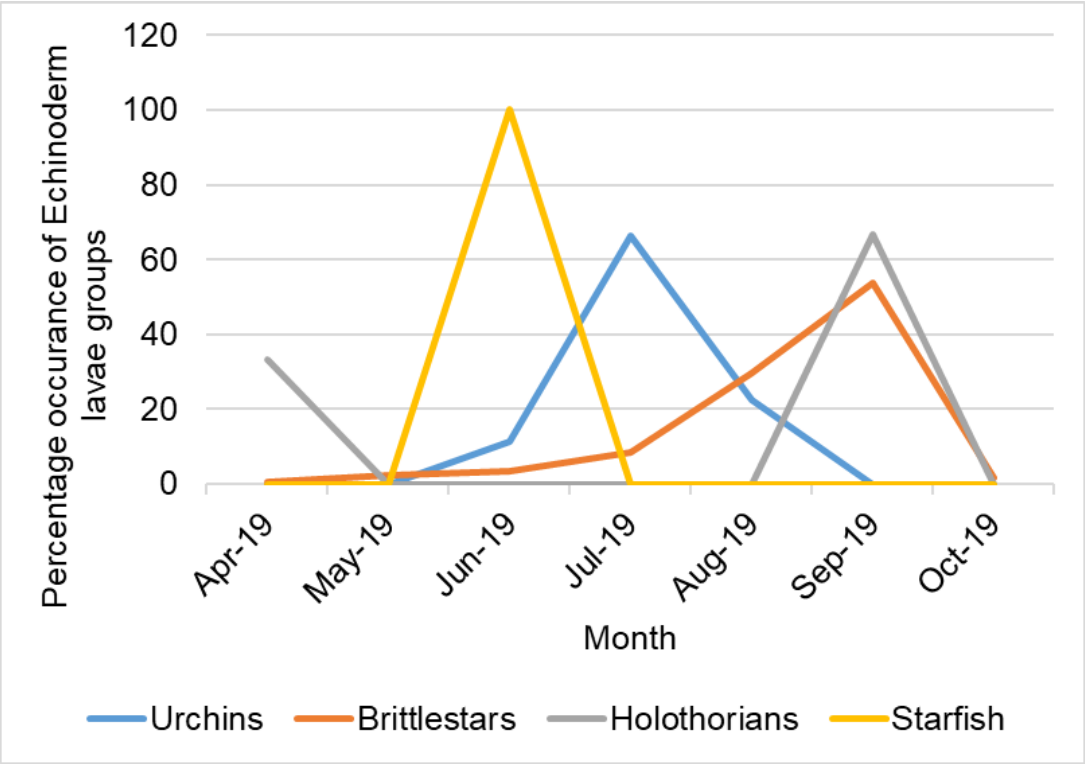
Site	2003	2007	2011	2015	2019
Whole MCZ	4.98	3.47	4	2.17	2.79
HLP	No data	2.9	2.1	1.35	2.5
MHV	No data	2.37	6	0.57	0.77
TRK	No data	1.4	0.6	0.08	0.9
RRK	No data	6.3	6.8	5.48	5.22
NWA	No data	5.3	7.25	4.23	4.44
CBY 2011	No data	No data	1.7	0.58	0.56

Figure 6.12.5. Graduated bubble map of *M. glacialis* density / 100m^2 Skomer MCZ 2019

Plankton

Planktonic echinoderm larvae are seen regularly in the plankton samples taken within Skomer MCZ. In 2019, 4 groups of echinoderm larvae could be identified: echinopluteus (urchins), ophiopluteus (brittlestars), auricularia (Holothurians/sea cucumbers) and brachiolaria (starfish). Their occurrence during the year each peaked at different times. The starfish larvae were found from mid-May to mid-July, peaking in June whilst urchin larvae were found over a longer period from mid-May to mid- September, peaking in July.

Figure 6.12.6. Percentage abundance of echinoderm larvae in plankton samples within Skomer MCZ 2019



6.12.6. Current Status

Surveys completed in 2003, 2007, 2011, 2015 and 2019

6.12.7. Recommendations

- The survey of *E. esculentus* and starfish populations should be repeated every four years, next survey 2023.
- Survey methods should follow those developed in the 2007 survey and used in subsequent surveys to allow comparisons between surveys.
- Increased effort should be made to survey the 5m depth area to record small *E. esculentus*.
- Sites in the Skomer MCZ where *C. papposus* and *L. ciliaris* have been recorded in the past should be targeted. In addition, sightings of these species should be recorded during routine dives.
- Plankton studies should be continued to investigate the presence of echinoderm larvae in the Skomer MCZ.
- 'Bald' *E. esculentus* recording should be continued.

7. Skomer MCZ Meteorological and Oceanographic Project Summaries

7.1. Meteorological Data
CMS Code: RP 04/01

7.1.2. Project Rationale
The weather is an important factor that directly affects species and communities on the shore and in the sub-littoral. Climate change is by definition a change in long-term weather patterns, so it is essential to have meteorological data for the site. Meteorological data are used to improve the interpretation of biological changes seen in monitoring projects by putting them into a climatic context. This application of Skomer MCZ data can also be made for Skomer Island NNR and Pembrokeshire marine monitoring data.

7.1.3. Objectives
To provide continuous meteorological data for the Skomer MCZ.

7.1.4. Sites
Coastguard lookout station, Wooltack Point, Martins Haven.
Grid Ref: SM 7588 0922 (L 51º 44' 78'N 005 º 14' 78'W)

7.1.5. Methods
May 1993 to October 2005. A Fairmount EMS1200 weather station was mounted on the coastguard hut. The station included an anemometer, wind vane, air temperature and humidity sensors, shaded and un-shaded solarimeter, net radiometer, barometric pressure sensor and a tipping bucket rain gauge. The data were automatically downloaded to and stored on a computer in the Skomer MCZ office. An uninterruptible power supply was used, but there were occasional problems with data dropout.

April 2006 – current. A Campbell Scientific Environmental Change Network (ECN) compatible weather station with a CR1000 measurement and control system was installed. Hardware consists of: switching anemometer, potentiometer wind vane, temperature and relative humidity probe, 3 temperature probes (air, ground and below ground), tipping bucket rain gauge, pyranometer, net radiometer, water content reflectometers and barometric pressure sensor.

The CR1000 is capable of storing the data internally, but as with the Fairmount weather station the data are automatically downloaded to a computer in the Skomer MCZ office using "Loggernet" software. The data are saved in three files: daily, hourly and 10 minutes intervals.
In January 2009 a rain collector and ammonia detector were added to the equipment suite. Monthly collections were made for precipitation chemistry and atmospheric ammonia concentration records. A GMS communicator has been added to the CR1000 allowing mobile telephone access to the data. This enabled the data to be automatically updated into an external website.

7.1.6. Project history relevant to data
A continuous dataset has been maintained since May 1993. However, there are some gaps due to equipment failure, these are: March 1994, January 1998 and from November 2005 to April 2006. The Fairmount weather station was already aging before it was replaced and the solarimeter, net radiometer and rain gauge readings were all unreliable during 2005.

In 2010 the weather station and oceanographic buoy data were put onto a website where they could be viewed and downloaded, this was discontinued when Countryside Council for Wales became part of NRW in 2013. The ammonia tubes were discontinued in 2010 due to a lack of funding.

In January 2012, the rain water chemistry sample was reduced to a 250ml sub-sample.
In January 2014, the anemometer failed and there were no data from 2nd -13th Jan 2014. A new anemometer was installed on the 13th January 2014.

The weather station was serviced by Campbell Scientific in 2012 and 2014. Between 2015 and 2017 there was no service contract in place but there were no problems with the station. In 2018 the weather station was serviced (see Appendix for report). The rain gauge had failed and the Pyranometer sensor was reading outside the required tolerance.

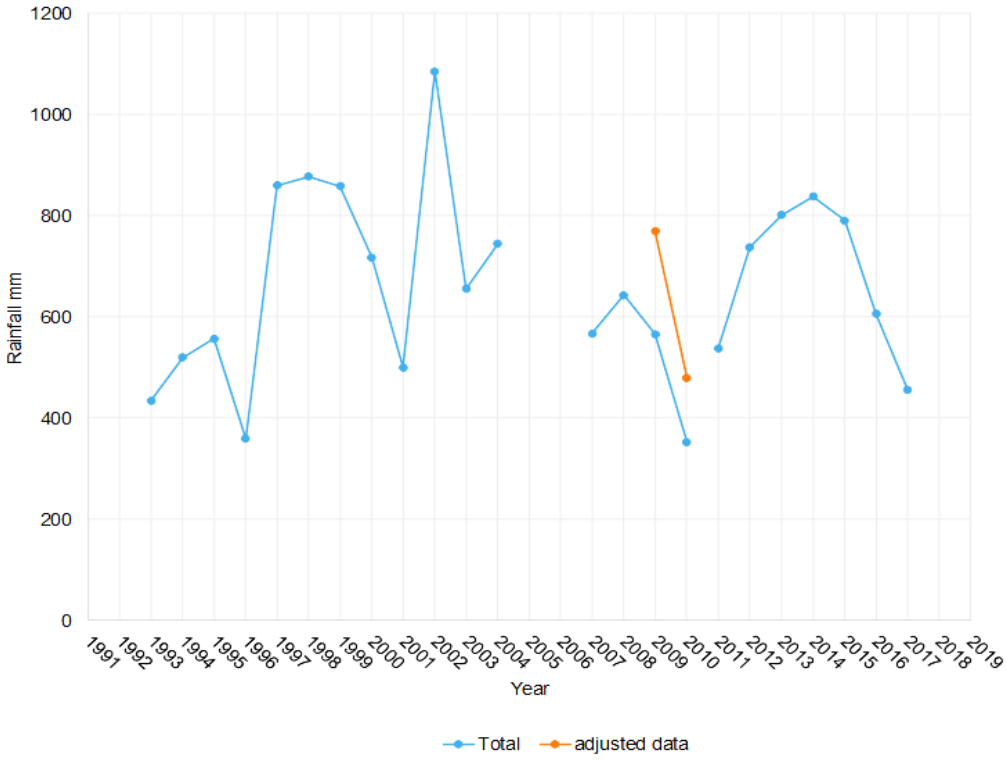
In 2019 the weather station was dismantled between 18th April to May 25th as the Coastguard hut was being renovated. The rain gauge has continued to give unreliable readings in high winds and 2019 rainfall data have been discarded.

7.1.7. Results

Rainfall

The rain gauge was not calibrated properly in 2009 and 2010 so a correction has been added to the records.
In 2019 the rainfall gauge was unreliable in high winds and the data are unusable.

Figure 7.1.1. Skomer MCZ automatic weather station total rainfall (mm) data (incomplete data for 2018 & 2019)

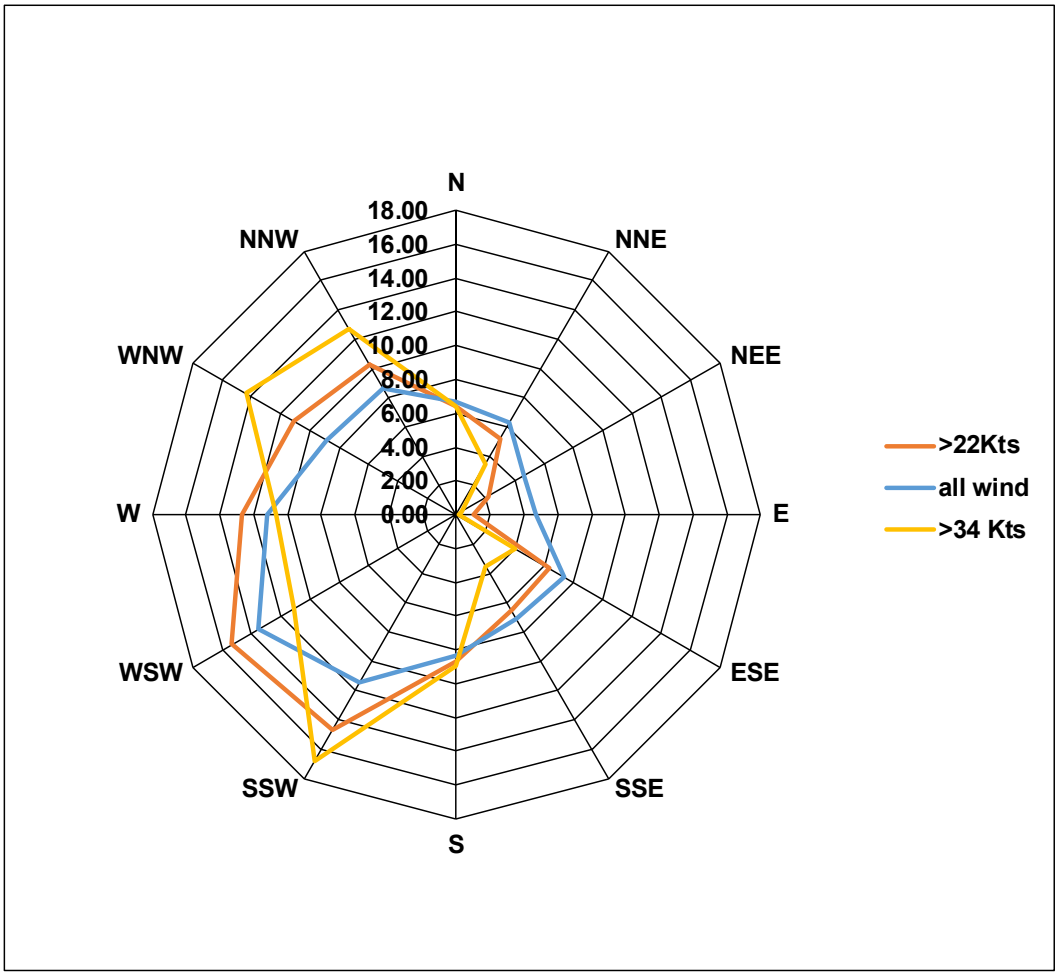


There was some extreme weather in February 2014 with 100mph winds recorded on the 12th Feb 2014. The rain gauge recorded 199mm of rain for that day, but it is likely that this was a false reading, so this has been removed from the data. The winds will have vibrated the rain gauge causing it to "tip" when there was no water in the bucket. To prevent this happening in future the gauge was fixed more securely. However, during routine servicing in 2018 it was discovered that the rain gauge had stopped working during mid- March 2018. A new rain gauge was fitted on the 11th April 2018. Unfortunately, this rain gauge was not robust enough to survive the exposure and was blown off the roof on the 14th October 2018. A more robust rain gauge was fitted on the 21st December 2018. The 2018 and 2019 rain fall data are incomplete and unreliable.

Wind speed and direction

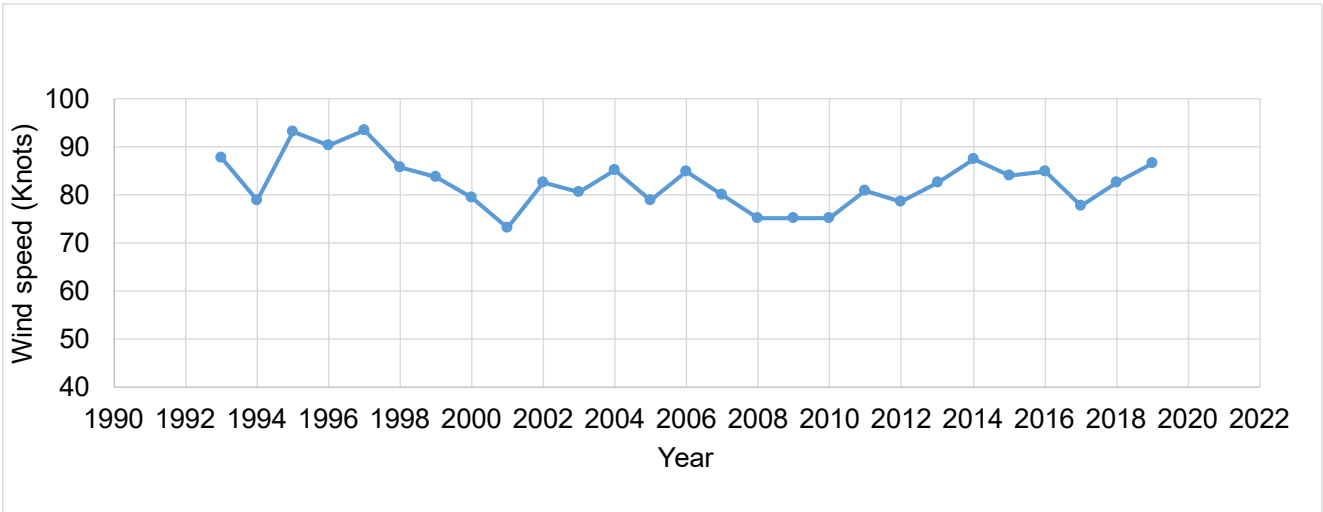
Extreme wind speeds can affect littoral and sublittoral habitats and communities by subjecting them to damaging levels of exposure. Changes in wind direction can also affect normally sheltered habitats

Figure 7.1.2. Skomer MCZ automatic weather station, radar plot average wind direction and strength 1993 – 2019



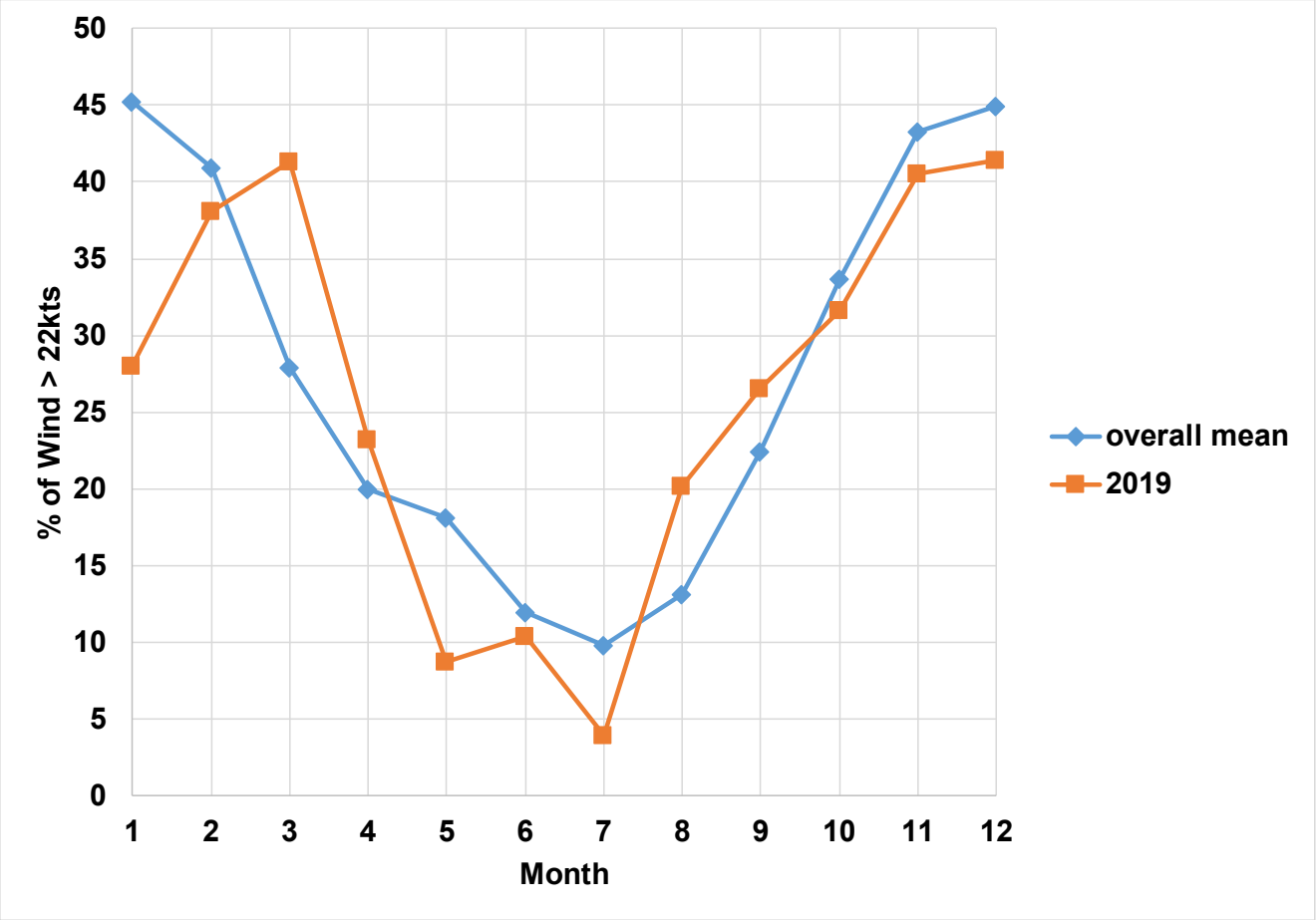
A radar plot of frequency of wind direction shows that the prevailing winds come from the WSW and this has not changed over the period data have been gathered. The stronger winds (>34 knots) are more bimodal in distribution with peaks from the SW and the NW.

Figure 7.1.3. Skomer MCZ automatic weather station data - maximum wind strength (knots) 1993 - 2019



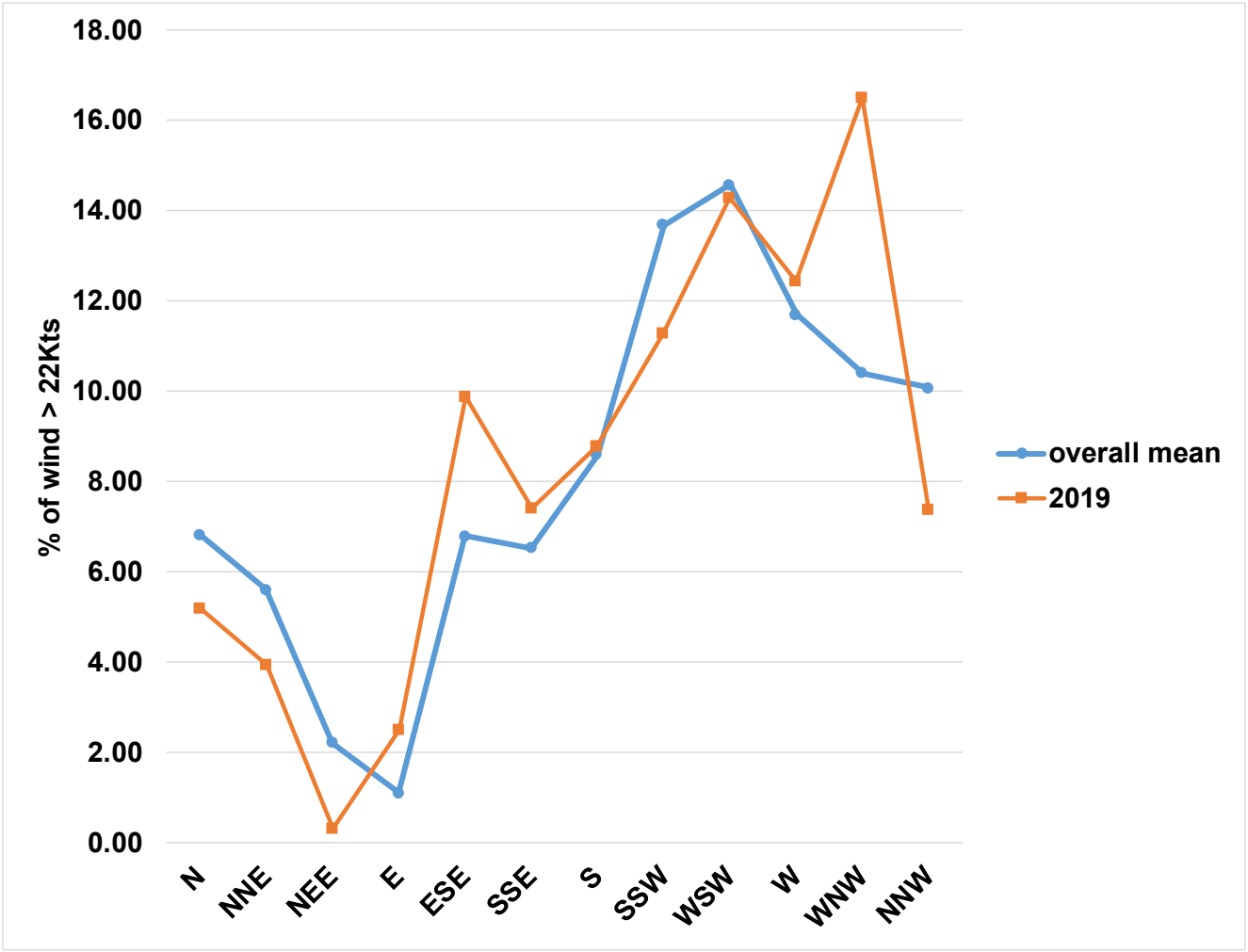
The maximum gust recorded for 2008, 2009 and 2010 was exactly the same (75.28 knots). This led to the suspicion that the anemometer bearings were faulty. After the bearings were replaced in 2011 higher gusts were recorded; 2019 saw a maximum gust of 86.6 knots.

Figure 7.1.4. Skomer MCZ automatic weather station data – percentage of wind greater than 22 knots for each month.



The winter months tend to have the highest percentage of strong winds (Dec 1999: 85% > 22Kts) but it is very variable from year to year.

Figure 7.1.5. Skomer MCZ automatic weather station data – percentage of wind over 22kts from each wind direction.



2019 has a similar distribution of winds compared to the overall mean for 1993 to 2019. Most of the stronger winds come from the SW, WSW & WNW. The east tends to have the lowest percentage of strong winds (Figure 7.1.5).

Another ecologically important measure of exposure is total annual wind, which is a measure of the energy that littoral and sublittoral habitats are subject to. The total amount of wind is calculated from the percentage of wind recorded in each year at each Beaufort force multiplied by the mid wind strength (knots) for that wind force. The windier the year the higher the "total amount of wind".
The amount of wind recorded over 22 knots, less than 10 knots and in between 10 to 22 knots is then shown as a percentage.
2002 was the windiest year with 35% of all the wind greater than 22 knots. 2010 was the calmest year with only 17% of the wind stronger than 22 knots and 33% of the wind less than 10 knots Figure 7.1.6).

Figure 7.1.6. Skomer MCZ automatic weather station data – “total annual wind” 1993 to 2019.

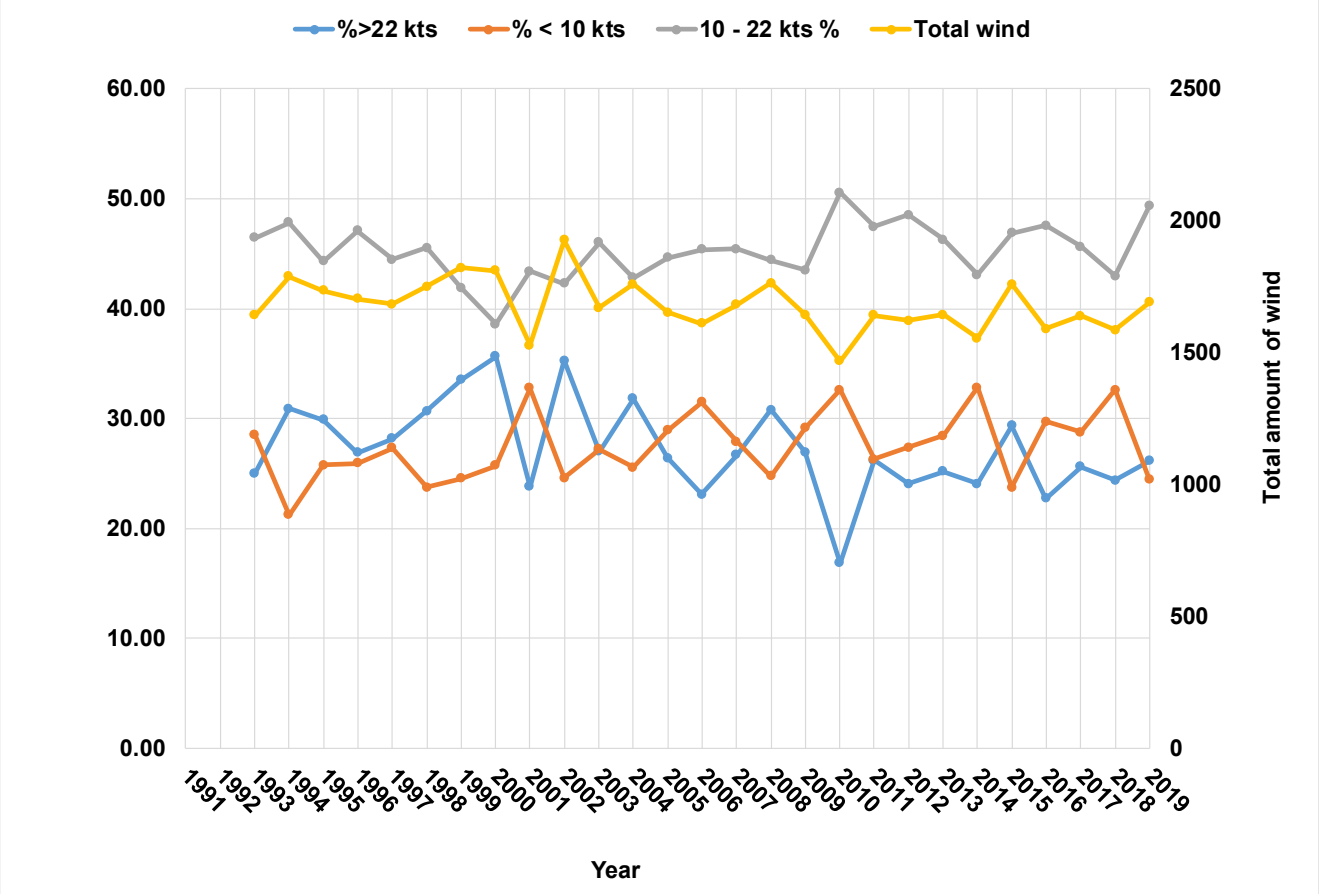


Table 7.1.1 Skomer MCZ automatic weather station – 2019 annual meteorological summary

Natural Resources Wales - Skomer Marine Conservation Zone					YEAR	SUMMARY 2019							
Weather station - Coatguard lookout hut, Wooltack point													
Grid ref: SM75880922													
Geographical position: 51.44.78N 005.14.78W			Height of anonometer above ordinance dat					61.15m					
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AIR TEMP	MEAN	7.4814	8.5942	8.3443	7.8101	12.4	13.24	15.72	16.29	14.92	12.09	9.029	8.8848
T107_1 0c	MAX	10.93	13.15	11.59	15.05	15.54	24.69	22.87	24.57	20.13	16.08	13.89	12.56
	MIN	-0.153	-0.24	3.022	2.319	9.75	9.23	12.13	12.47	10.6	6.218	2.395	2.05
BAROMETRIC PRESS	MEAN	1012.1	1010.4	1008.8	1005.3	1010.4	1007	1010	1006	1010	1003	993.1	1000.1
	MAX	1037	1028	1031	1019	1016	1021	1022	1019	1030	1020	1014	1027
	MIN	0	978	973	979	0	993	995	982	983	985	963	963
RELATIVE HUMIDITY	MEAN	82.04	86.42	86.712	80.972	91.312	87.25	88.31	85.7	85.11	82.54	85.75	84.666
	MAX	100	100	100	100	100	100	100	100	100	100	100	100
	MIN	53.56	45.69	54.99	45.06	-0.017	37.45	55.9	52.01	36.03	50.42	59.94	51.07
RAINFALL	TOTAL(mm)	1852.4	1219.6	4118.5	57.4	5.6	72.7	10	77.3	77.2	100.7	207.4	771.9
SUNSHINE	MEAN(kw/m2)	0.0313	0.0767	0.1165	0.1753	0.2425	0.248	0.269	0.219	0.152	0.081	0.037	0.0277
	sunshine hours	69	161	249	164	74	346	376	329	265	187	79	68
	Sunshine hrs (10m	63.833	156.83	245	163.67	72.167	344.2	374.7	324.2	256.7	180	82	64.333
NET RADIATION	MEAN	-10.413	-1.458	30.152	45.761	129.83	113.6	123.1	91.29	50.48	12.62	-7.42	-19.979
MAX GUST	Knots	40.42	37.92	38.33	26.25	20.83	25	18.33	27.5	27.08	30	33.75	44.58
	direction	327.3	256	284.3	130.2	269.7	131.1	248.2	232.1	219.9	277.7	294	289.3
	Knots	78.52	73.663	74.46	50.993	40.464	48.57	35.61	53.42	52.61	58.28	65.56	86.601
	Days > F7 MEAN	1	1	2	0	0	0	0	0	0	0	3	3
	Days > F7 Gust	18	22	20	7	5	11	6	20	19	22	21	23
	days max hr av>F7	8	5	13	2	0	1	0	1	4	6	12	9
Notes													
Weather station dismantled for hut repairs therefore no data between 18th April - 25th May.													
Rain Guage unreliable in Jan - March													

Summary table shown for information. Contact MCZ staff for more details

Figure 7.1.8. Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2019 with monthly min / max error bars:

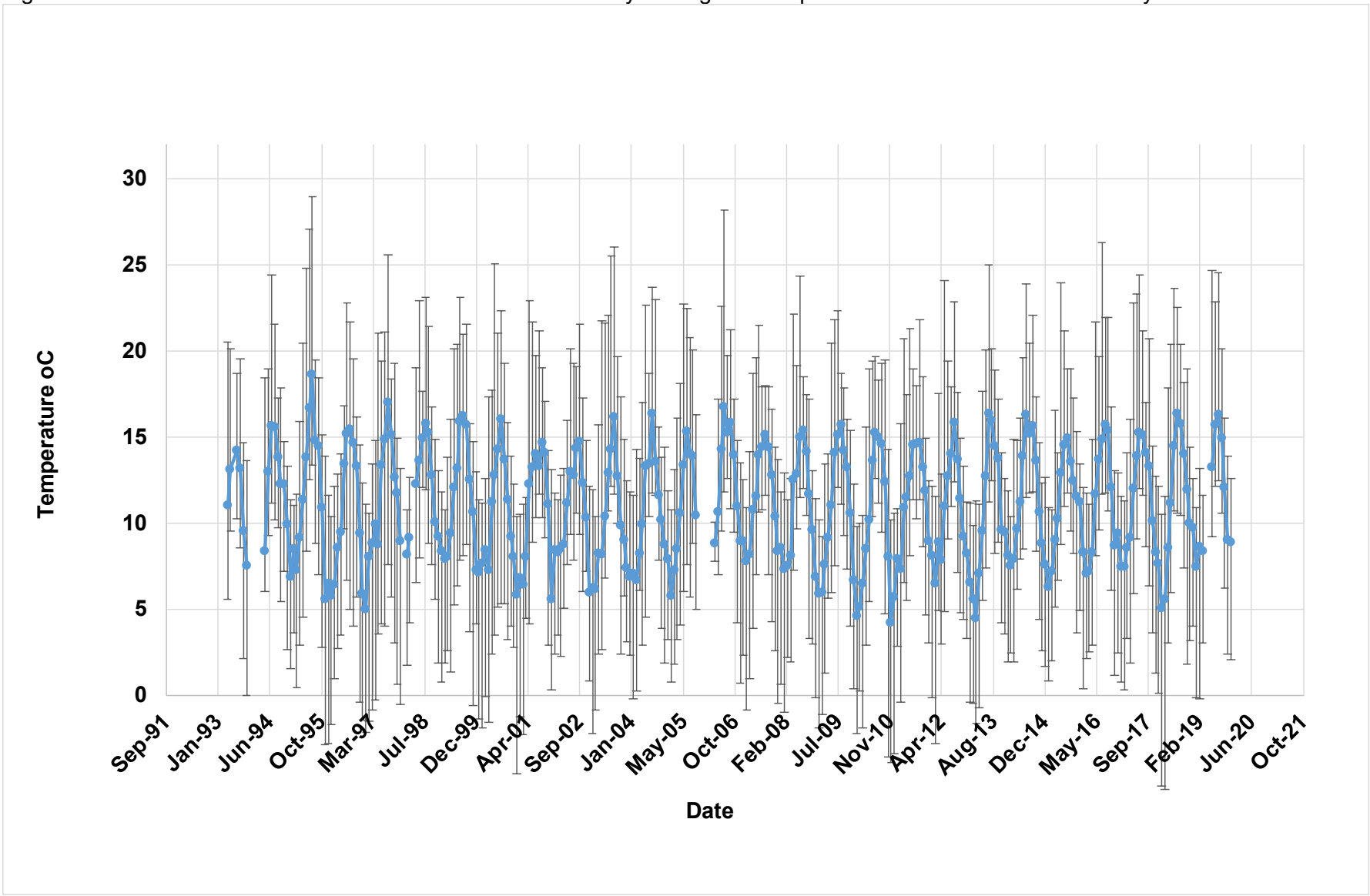


Figure 7.1.9. Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (°C) 2006 – onwards:

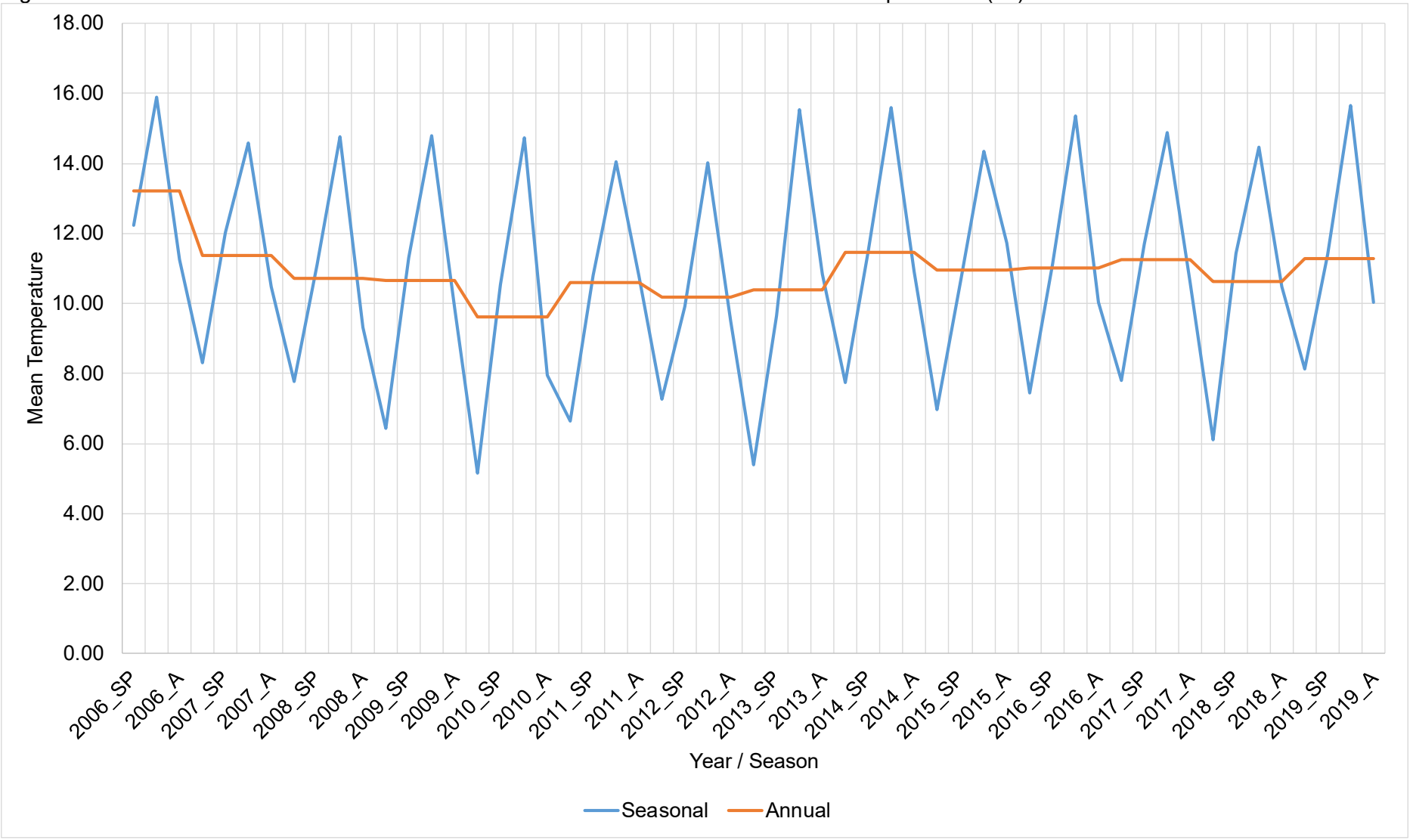
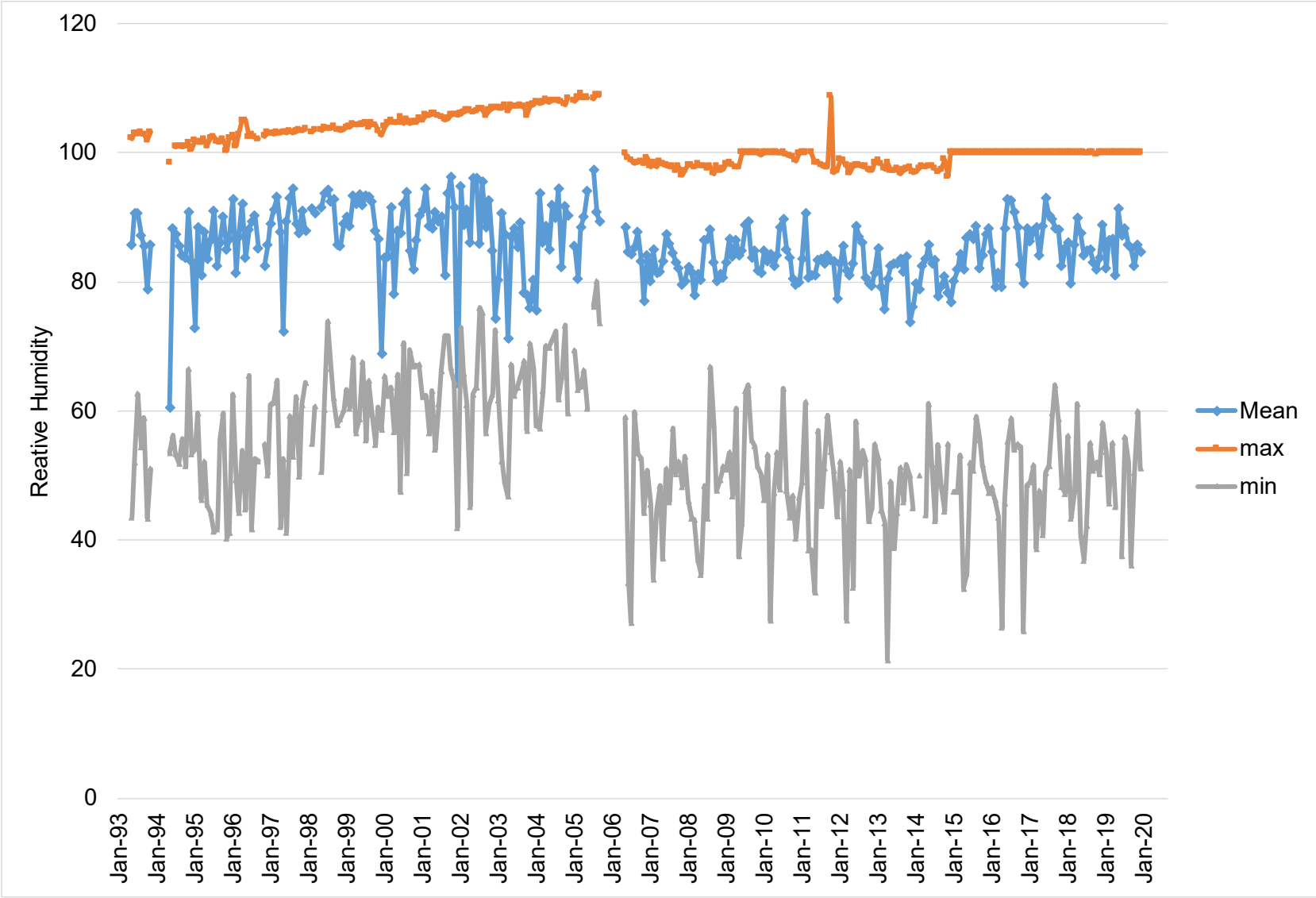
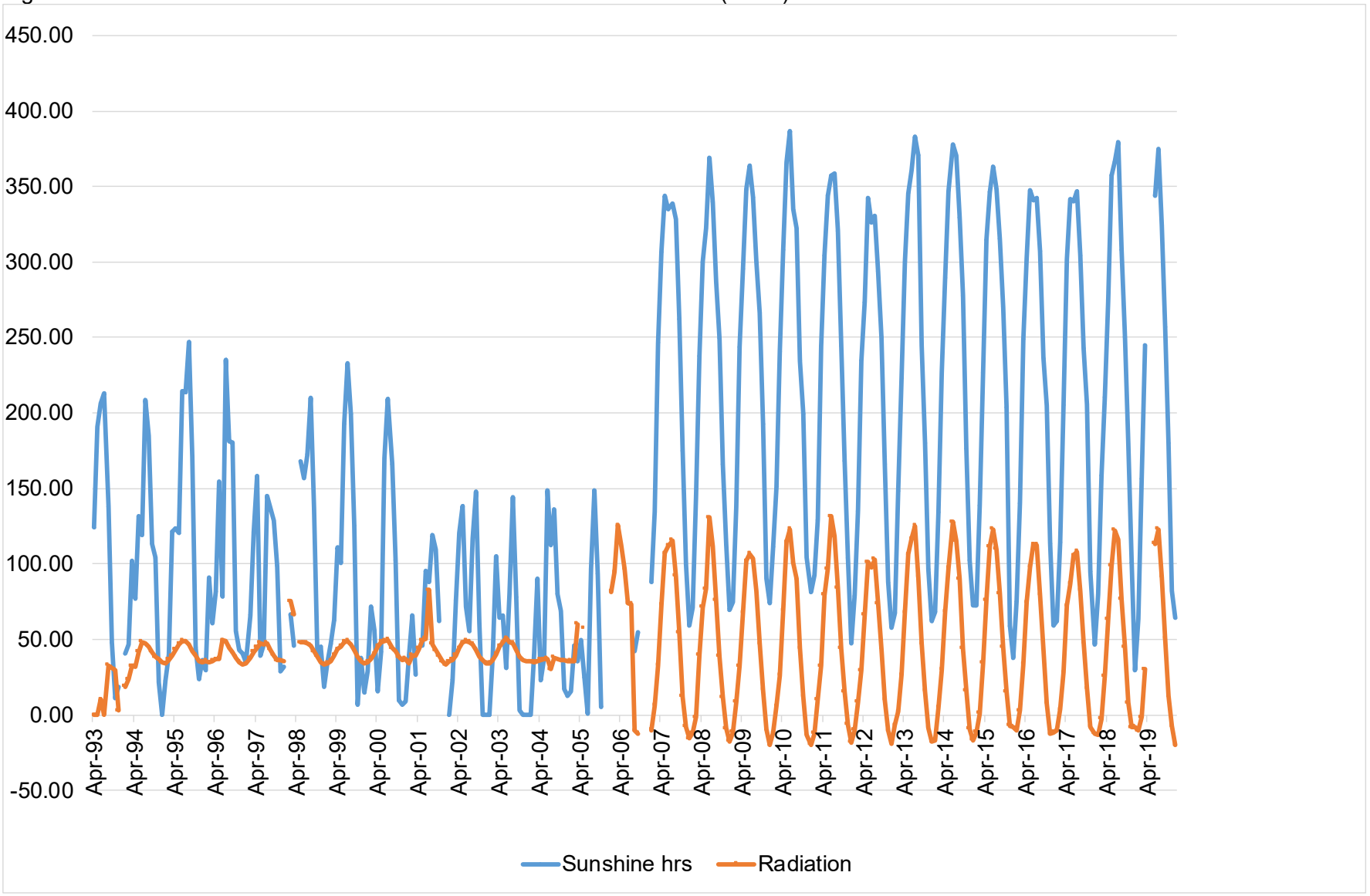


Figure 7.1.10. Skomer MCZ automatic weather station – relative humidity 1993 - 2019



The increasing trend in relative humidity from 1997 to 2005 may well be due to equipment error. From 2006 onwards there is no obvious trend.

Figure 7.1.11. Skomer MCZ automatic weather station – solar radiation (W/m^2) and sunshine hours 1993 - 2018



There was an obvious change in the data when the weather station equipment was changed in 2006. This will be due to a change in the equipment type used.

7.1.8. Current Status

Skomer MCZ weather data demonstrate no significant anomalies other than those attributable to equipment changes or failures

7.1.9. Recommendations

- Keep meteorological equipment maintained and calibrated.
- Change the bearings in the anemometer every 2 years.
- Make Skomer MCZ meteorological data available via the internet.

7.2. Seawater Temperature Recording
(CMS Code: RP64 / 01)

7.2.1. Project Rationale
Temperature is one of the most important physical factors controlling the distribution of living creatures. Climate change has been highlighted as a potential threat to all ecosystems. Data collected at Skomer MCZ are relevant to the Pembrokeshire Marine SAC and potentially to the West Wales Marine SAC for harbour porpoise.

7.2.2. Objectives
- To provide accurate seawater temperature records for near seabed, water column and shore sites.
- To record temperature as continuously as possible to produce an ongoing long-term dataset for the site.

7.2.3. Sites
- Oceanographic Monitoring Site (LL 51.73913 N 5.26976 W).
- Shore sites: Martins Haven, South Haven;
- Non MCZ shore sites: West Angle, Jetty beach, Castle beach and Pembroke power station outfall

7.2.4. Methods
Ocean monitoring site (OMS)
- 1992 onwards: a Valeport series 600 MKII CTD probe has been deployed. A drop down CTD probe is used to take a depth profile of temperature at intervals: 1m, 5m, 10m, 15m below sea level and 2m above seabed. This is completed weekly during the field season (March to October).

- 1993 onwards: a Vemco minilog has been attached to a fixed steel frame on the seabed at 19m below chart datum (BCD). The logger maintains a temperature record every hour and is retrieved every six months to download the data. Two loggers are used alternately at the site to allow uninterrupted data.

- 2007: YSI 6600 multi parameter sonde was attached to a fixed steel frame on the seabed (19m below chart datum). It recorded temperature along with salinity, turbidity, dissolved oxygen, chlorophyll and pressure (=depth).

- 2008: the sonde was linked up to a telemetry buoy to provide live 10 minute readings. The data were sent via VHF to the coastguard look-out hut and then onto the Skomer MCZ office via a fibre- optic link.

- 2010: due to ongoing malfunctions in the readings and high levels of maintenance, the YSI sonde was repositioned onto the telemetry buoy. It recorded from 0.6m below the water surface. The telemetry system was changed to a GSM system to allow remote updates to the ECN website.

- Nov 2013: the data buoy was lost in a storm. A replacement logger (Onset watertemp pro v2) was deployed in Martins Haven for the 2013/14 winter period.

- 2014: a new marker buoy for the OMS site was established and a logger attached at 1m below the sea surface.

Shore Sites

- 2007, Onset “Hobo” pendant temperature loggers have been deployed at: Martins Haven and South Haven shores (lower, middle and upper shore).
- Temperature loggers have been deployed at sites outside of the Skomer MCZ as follows:
  Dale Fort Field Centre: Jetty beach (mid shore) and Castle beach (mid shore).
  West Angle bay: upper shore rock pool.
  Pembroke Power station outfall: middle shore.

7.2.5. Project history

Seabed temperature is not commonly measured in UK waters, sea surface temperatures being the most common records. Since July 1999 only 1 month of data are missing from the temperature logger record and since June 2001 there have been continuous hourly records for seabed temperature. By adding in the water profile records there is a fairly complete sea temperature record going back to 1992. This makes this dataset not only unusual, but highly important not only for putting MCZ/SAC monitoring into context, but also for other applications, including academic and fisheries research.

Valeport series 600 MKII CTD probe water profile records:

1992	Jul – Nov	1999	May – Nov	2006	Mar – Oct	2013	Apr - Oct
1993	Jan – Dec	2000	Mar- Oct	2007	Apr – Oct	2014	Apr - Nov
1994	Feb – Dec	2001	May – Nov	2008	Apr – Dec	2015	Mar - Oct
1995	Jul – Dec	2002	May – Oct	2009	Feb – Oct	2016	Apr - Oct
1996	Mar – Dec	2003	Jun – Sept	2010	Mar – Nov	2017	Apr - Oct
1997	Aug – Dec	2004	May – Oct	2011	Mar – Nov	2018	Apr - Oct
1998	Mar – Nov	2005	May – Oct	2012	Mar – Nov	2019	Apr - Oct

Vemco minilog seabed temperature logger deployment:

- Aug 1993 – Nov 1994
- Dec 1996 – Sept 1997
- Jul 1999 – Apr 2001
- Jun 2001 – 8th May 2002
- 30th May 2002 – ongoing

7.2.6. Results

Oceanographic monitoring site:

Table 7.2.1. Skomer MCZ maximum and minimum annual seabed temperatures 2000 to 2019 at 19m below chart datum

Year	Minimum temperature ºC	Maximum temperature ºC
2000	8.4	16.27
2001	7.27	16.3
2002	8.7	15.6
2003	7.6	17.1
2004	7.7	16. 76
2005	7.36	16.4
2006	7.5	16.3
2007	8.8	16.3
2008	8.4	16.3
2009	7	16.8
2010	6.9	16.8
2011	7.6	15.9
2012	8.0	16.6
2013	6.98	16.82
2014	8.14	16.72
2015	7.8	15.98
2016	8.5	16.8
2017	8.3	16.4
2018	6.6	16.6
2019	8.7	17.2

The air temperature in the winters of 2009, 2010 and 2018 were very cold and the seawater temperature also dropped to below 7 ºC, the coldest recorded this decade. Seabed temperatures in 2012 were mild in the winter and average in the summer. 2013 had a cold April/ May with sea temperatures remaining 1ºC below average temperature. 2015's seawater temperatures were mild both in the winter and the summer. The winter of 2016 was very mild (the mildest December in the MCZ records). The winter for 2017 -2018 has recorded the lowest sea temperature for the last 18 years (6.6ºC) with March temperatures 1ºC below the average. 2019 was much warmer in comparison with a very mild 8.7 ºC in the winter and the warmest summer record since 2003 - 17.2 ºC.

A summary of the seabed temperature (data from Vemco minilog at 19m BCD) is shown in Figure 7.2.1. Monthly means have been calculated from seabed temperature but substituted with the CTD probe seabed temperature data where logger data were absent.

Figure 7.2.1. Skomer MCZ summary of monthly mean seabed temperature (19m BCD) 1992 - 2019

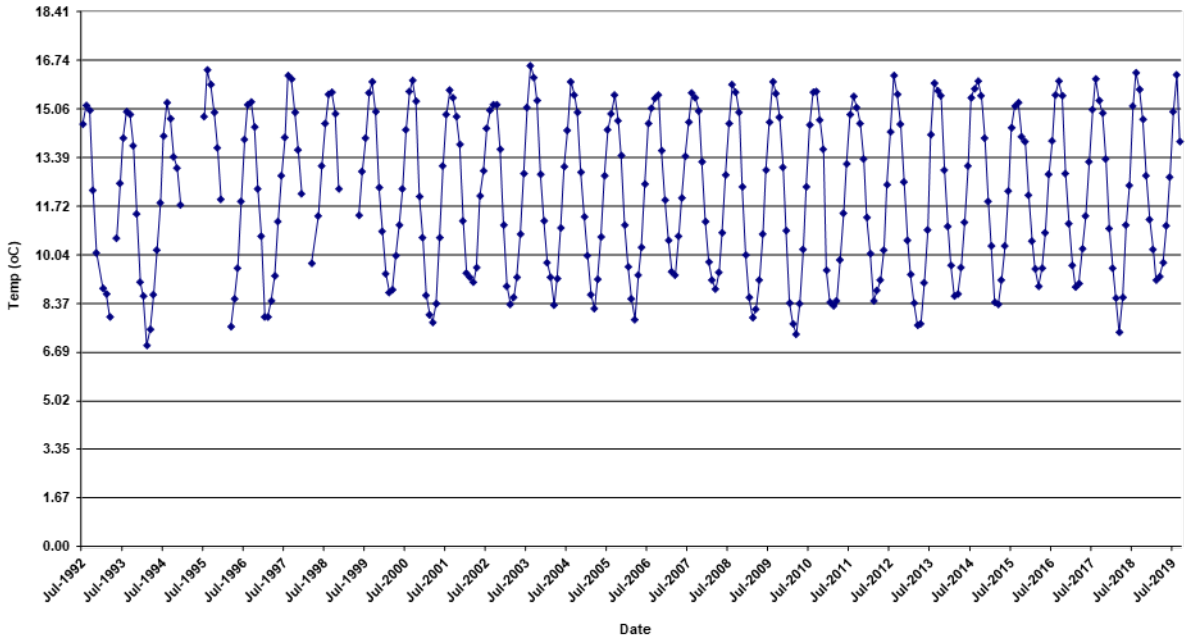
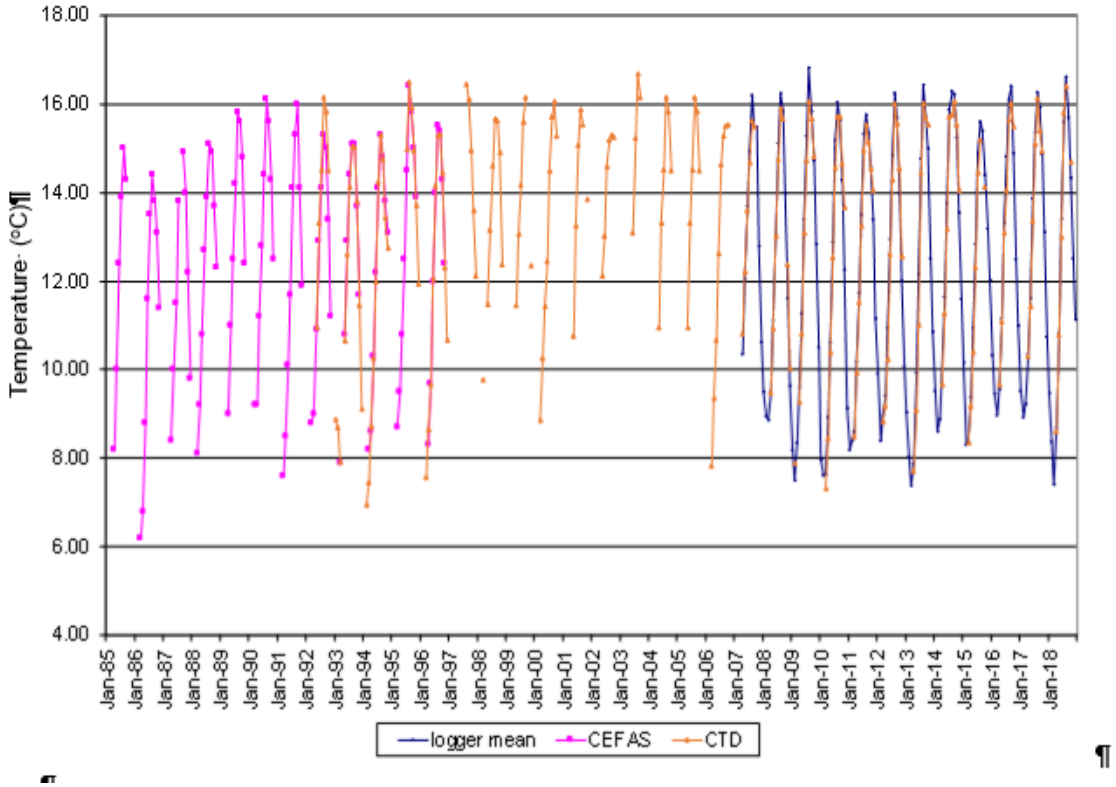


Figure 7.2.2. Skomer MCZ summary of monthly mean sea surface temperature1985 – 2018 (awaiting download of loggers for 2019 data)

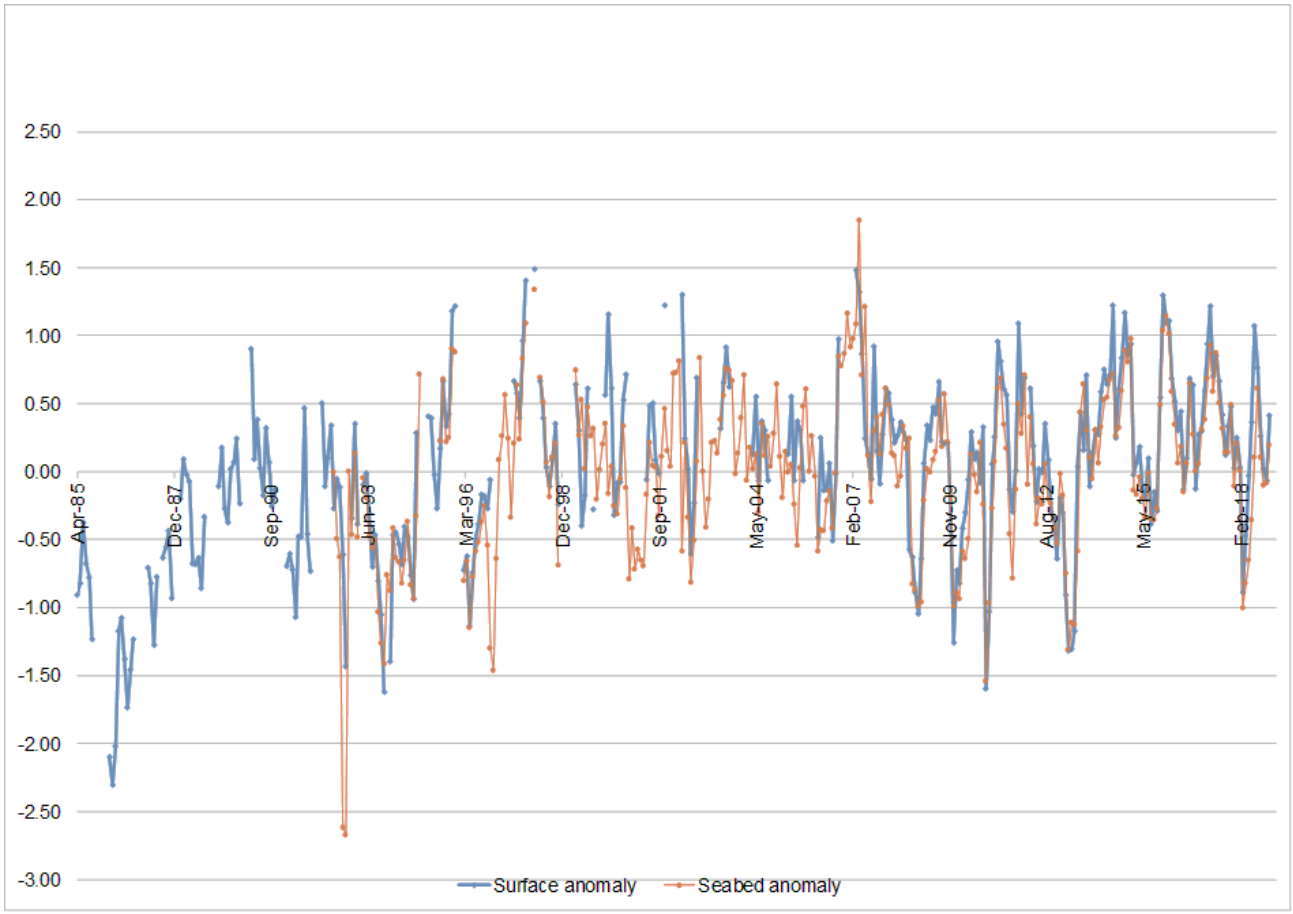


A summary of the sea surface temperature is shown in Figure 7.2.2. This is made up of:

- **CEFAS** data taken from North Haven, Skomer at high tide and only recorded when the Skomer warden was on site;
- Skomer MCZ drop down **CTD** probe data from a depth profile at intervals: 1m, 5m, 10m, 15m below sea level and 2m above seabed. Only 1m and 5m are used as sea surface temperature records;
- Mixture of data from shore loggers (when covered by the tide) and YSI 6600 sonde at the OMS site (**Logger mean**).

Comparing the overall monthly mean with the monthly mean for each year.
By taking the mean for a specific month across the whole dataset (grand monthly mean) and comparing this with the same month's mean for a specific year (specific monthly mean) the "monthly anomaly" can be calculated. Repeating this calculation for each month of each year in the dataset gives an indication of how cold or warm that particular month was compared to the whole dataset (Figure 7.2.3).

Figure 7.2.3. Skomer MCZ sea temperatures – monthly anomaly between the specific monthly mean and the grand monthly mean, surface and seabed temperatures (1985 to 2018 – 2019 data awaiting logger download)



Sea temperatures prior to 1995 were generally colder than average. From 1995 to 2006 there was a warmer period, but from 2006 onwards the data have been very erratic with some very cold winter temperatures but some warm summer temperatures. Due to Covid-19 pandemic lock down data from loggers has not yet been retrieved.

Shore monitoring sites
The loggers provide a record of the temperature regime experienced by sessile organisms in the inter-tidal zone. The data can be split into periods of immersion under water and exposure in the air. The immersed period can be used as a record of sea surface temperature.

7.2.7. Current Status
There does not appear to be any long-term trend in sea water temperatures, which if anything appear to be becoming more erratic. The increase of more extreme weather events may put the marine communities under additional pressure through increases in exposure to wind and wave energy and increases in suspended sediment load.

7.2.8. Recommendations
- Continue dataset to form a long-term record of variation in seabed temperature at Skomer MCZ.
- Keep the dataset as complete as possible. An additional logger running at the same time would add redundancy into the methods should the equipment fail (so far when equipment has failed the data have fortunately been retrievable).

7.3. Seawater Turbidity / Suspended Particulates and Seabed Sedimentation
(CMS CODE RP63/01)/(CMS CODE RP63/04)

7.3.1. Project Rationale
Coastal waters are naturally turbid but this turbidity can change due to anthropogenic activities such as dredge spoil dumping or freshwater run-off from poor land management. Turbidity can also increase due to high phytoplankton levels. Increases in turbidity have the potential to adversely affect many of the species of the Skomer MCZ which depend upon filter feeding strategies that can become "clogged" with metabolically useless material or others that depend on photosynthesis and are affected by lack of light penetration through seawater.
Historically high deposition levels of fine sediments have been observed to partially or completely bury certain sessile life forms, preventing them from feeding and, in the longer term, killing them.

7.3.2. Objectives
The project aims to provide a long-term record of sediment load in the water column in the Skomer MCZ and levels of deposition of sediment on the seabed.

7.3.3. Sites
- Oceanographic Monitoring Site (OMS):
  (51.73913 -5.26976) north side of Skomer (1992)
- Thorn Rock:
  (51.73329 -5.27369) south side of Skomer (2004)

7.3.4. Methods and Project History
- Secchi disk measurements*:* the depth to which a white 30cm "Secchi disc" can be seen through the water column has been recorded during the field season since 1992 at OMS and, since 2004, at Thorn Rock.

- Suspended sediment sampler (pump driven): fixed to the frame on the seabed at OMS site between 1994 and 1997; but with limited success.

- Passive sediment traps: these have been deployed at each site since 1994. Sediment dropping out of the water column is collected into a pot. The sample pots are changed every 2 weeks during the field season and the sediment samples are frozen. These are then analysed for dry weight, organic content, particle size analysis (PSA) and heavy metal content.

- Optical turbidity probe: A Seapoint OEM turbidity probe connected to an Idronaut data logger was fixed to the frame on the seabed at the OMS site from 2002 to 2007. The length of time deployed varied and there were varied levels of success. This was replaced by YSI 6600 multi-parameter sonde in 2007.

- YSI 6600 multi-parameter sonde was fixed to the frame on the seabed at the OMS site in 2007. The sonde includes an optical turbidity probe. This has been deployed several times to date and again, with varying levels of success. From 2010 onwards the YSI sonde was repositioned to a surface mounting on the OMS buoy taking readings 0.6m below the surface. This was discontinued in 2013.

Table 7.3.1. Skomer MCZ sediment trap sampling effort from 1994 to 2019 at OMS and Thorn rock (TRK).

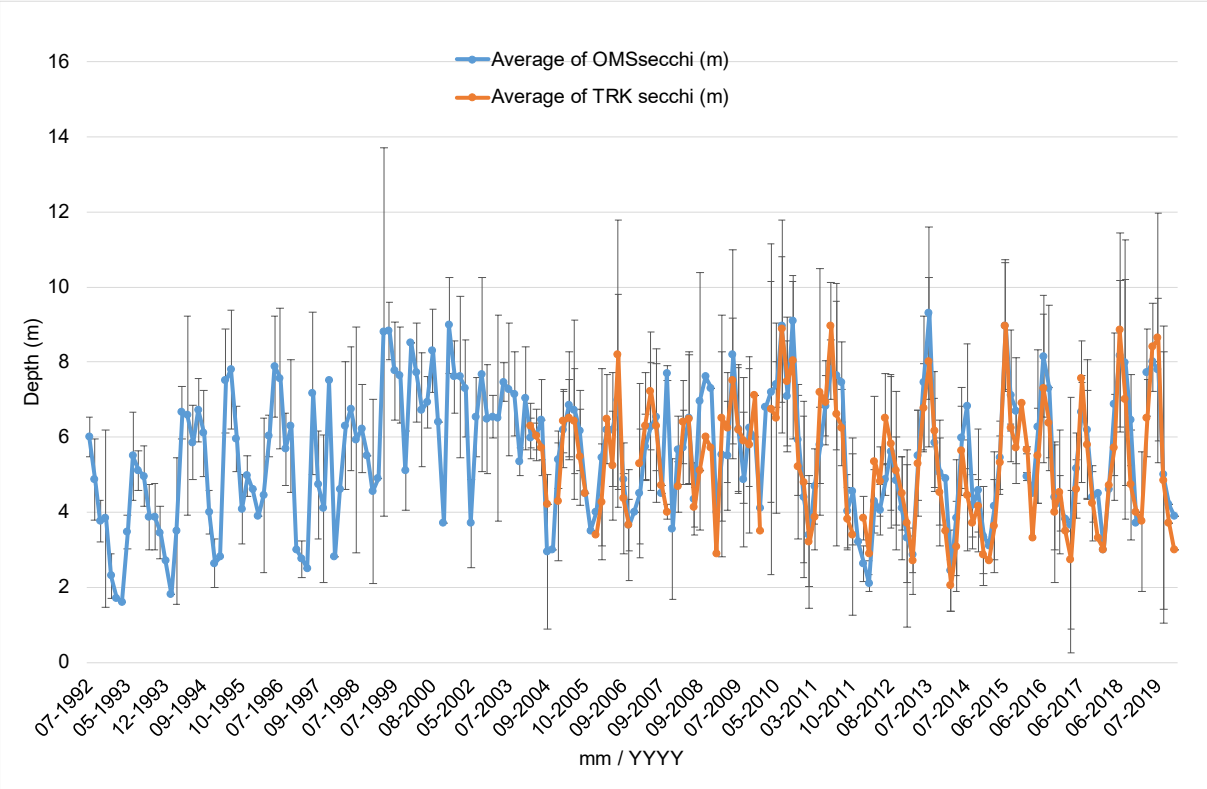
Year	Months with samples	Sites	Notes
1994	Jul – Dec	OMS & TRK	None
1995	Jan – Dec	OMS & TRK	None
1996	Feb – Dec	OMS & TRK	None
1997	Mar – Dec	OMS & TRK	None
1998	Mar – Sep	OMS & TRK	None
1999- 2001	No samples		Re-established 02 Nov 2001
2002	Mar – Nov	OMS & TRK	TRK site damaged
2003	May – Sep	OMS only	None
2004	May – Sep	OMS only	None
2005	Jun- Oct	OMS only	Collector damaged
2006	Jun - Oct	OMS & TRK	Repaired and TRK re-established
2007	May - Sep	OMS & TRK	None
2008	May - Sep	OMS & TRK	None
2009	Apr - Sep	OMS & TRK	Shell fragments in samples.
2010	Apr - Sep	OMS & TRK	None
2011	Apr - Nov	OMS & TRK	None
2012	Apr - Sep	OMS & TRK	None
2013	Apr - Oct	OMS & TRK	New Lab used
2014	Apr - Oct	OMS & TRK	None
2015	Apr - Oct	OMS & TRK	None
2016	Apr - Oct	OMS & TRK	None
2017	Apr - Oct	OMS & TRK	None
2018	Apr - Oct	OMS & TRK	None
2019	Apr - Oct	OMS & TRK	Samples in storage. Will be analysed in 2020

7.3.5. Results

Turbidity

Secchi disc: Measurements have been taken with reasonable consistency for the months of May to October since 1992. The mean monthly Secchi disc readings for OMS and Thorn Rock (TRK) are shown in Figure 7.3.1.

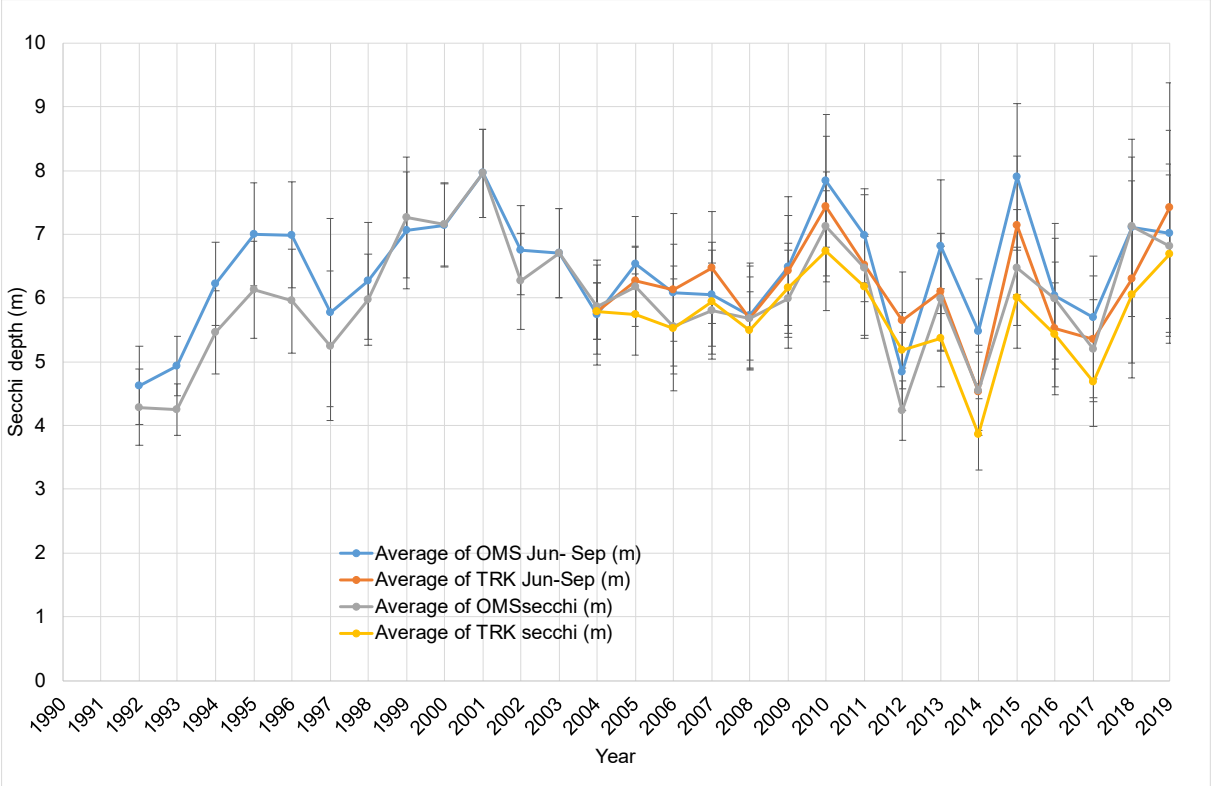
Figure 7.3.1. Skomer MCZ summary of monthly mean Secchi disc data (m) 1992 – 2019 with 95% standard error bars



TRK and OMS follow a very similar trend over time suggesting that the waters on the north and south side of the island are well mixed.

This rather dynamic picture can be simplified by calculating the mean Secchi disk value for each year as shown in Figure 7.3.2.

Figure 7.3.2. Skomer MCZ summary of annual mean Secchi disc data (m) with 95% standard error bars



The Secchi disc readings for Thorn Rock in 2014 are the lowest in the MCZ records. There were very high levels of silt deposited on the south side of the MCZ during the winter storms and it is thought that this silt was continually being re-suspended into the water column throughout the year. In 2015 and 2016 the readings have returned towards average levels but in 2017 there was a drop in water clarity at both OMS and TRK.

Seabed sedimentation

Passive sediment traps

The samples from the sediment traps were analysed for: dry weight, organic content, particle size analysis (PSA) and metal content.

Table 7.3.2. Skomer MCZ sediment trap sample analysis - TRK site (1994 to 1998 % sand data estimated)

TRK	g/day trk	% organic content	% gravel	% sand	% mud
1994	3.32	9.80	0.10	**16.83**	83.07
1995	5.76	8.59	0.41	**55.76**	43.83
1996	3.53	9.90	0.21	**22.56**	77.23
1997	5.81	9.43	no data	**no data**	no data
1998	4.15	10.25	0.23	**23.89**	75.89
2002	2.44	7.61	0.00	61.63	38.36
2006	1.74	8.65	0.00	60.35	39.65
2007	1.54	7.73	0.00	69.81	30.19
2008	1.91	7.13	0.00	78.39	21.23
2009	1.78	8.66	0.00	44.06	55.94
2010	2.73	7.70	3.66	79.47	16.67
2011	1.51	9.31	2.73	68.80	24.61
2012	2.96	7.55	1.43	41.12	57.08
2013	2.53	15.34	3.14	35.04	61.86
2014	2.67	13.33	0.18	31.04	68.77
2015	3.26	11.18	2.23	51.32	46.47
2016	2.01	10.85	1.07	51.33	45.21
2017	2.48	11.12	0.47	39.20	56.07
2018	1.92	10.80	0.93	33.25	62.67

Table 7.3.3. Skomer MCZ sediment trap sample analysis - OMS site site (1994 to 1998 % sand data estimated)

OMS	g/day oms	% organic content	% gravel	% sand	% mud
1995	2.17	9.33	7.37	**18.56**	74.07
1996	2.16	9.95	0.40	**17.08**	82.52
1997	1.69	9.64	0.18	**20.43**	79.40
1998	1.25	9.24	5.08	**42.73**	52.19
2002	1.05	7.91	0.17	73.51	26.32
2003	1.29	8.14	0.37	79.54	20.09
2004	1.91	7.90	0.00	75.27	24.72
2005	2.20	8.80	0.00	76.86	23.14
2006	2.33	8.79	0.00	76.80	23.21
2007	2.94	7.05	0.00	74.93	25.07
2008	0.56	7.34	0.00	81.48	18.23
2009	0.68	8.90	0.00	47.27	52.73
2010	1.75	7.66	4.93	77.99	16.88
2011	1.26	9.73	4.36	60.54	30.81
2012	2.00	7.87	9.12	45.39	45.14
2013	1.01	13.79	26.48	32.25	41.30
2014	2.46	13.57	10.55	48.65	40.11
2015	2.61	13.80	25.94	43.63	30.34
2016	0.79	12.38	5.54	53.42	29.51
2017	1.36	11.72	2.99	47.80	40.50
2018	1.31	13.30	5.00	36.77	35.55

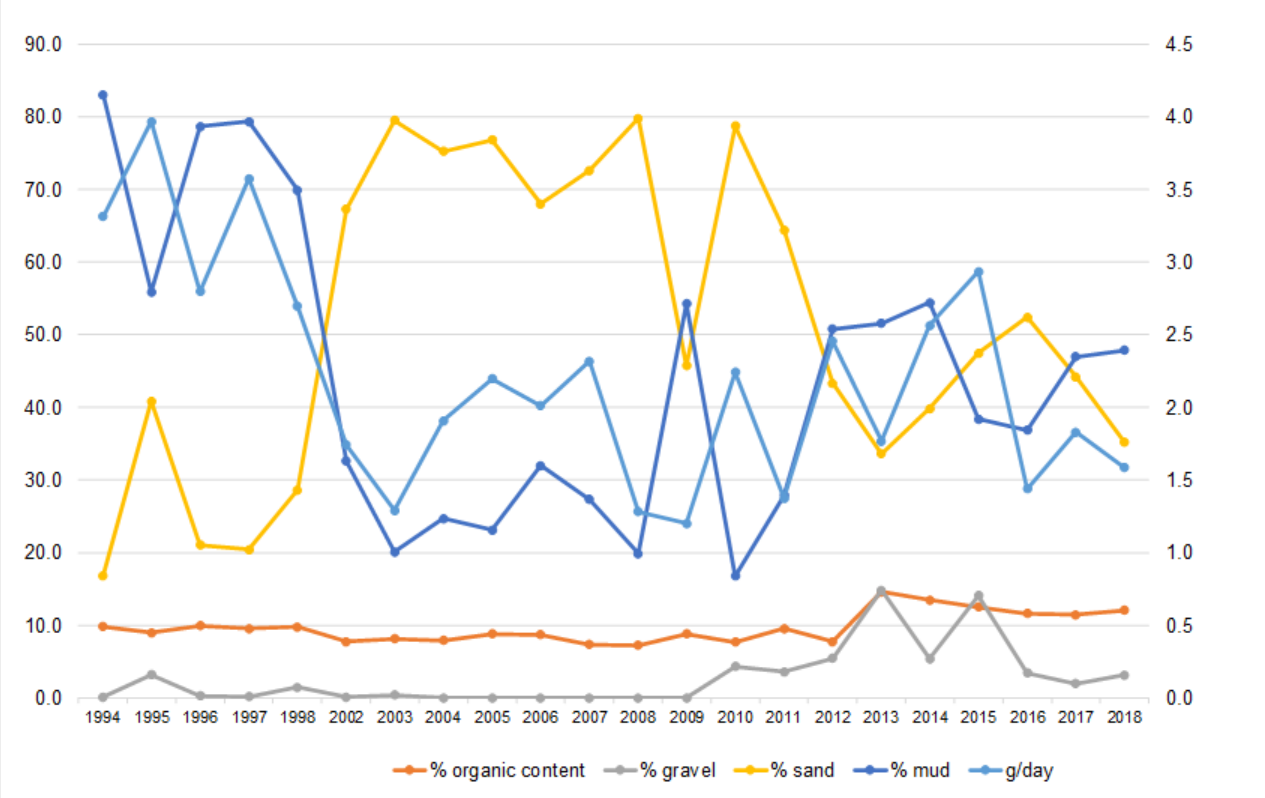
The samples from 2002 to 2012 were analysed by British Geological Society (BGS). In 2013 the sediment samples were sent to the NRW Llanelli laboratories for analysis, using a different set of analysis tools / machines to BGS. Text in red in Tables 7.3.2 and 7.3.3 indicates values were estimated (no data recorded for sand in 1995 – 1998).

Another change in 2013 was that the organic content analysis included heating the sample to 550ºC rather than 450ºC resulting in more carbonates being included in the % organic content. This explains the sudden rise in the 2013 values. The ignition temperature used from 2014 onwards at the NRW laboratories is 480ºC.
The NRW laboratories carry out a slightly different suite of metals analysis, but it is more comprehensive: cobalt and antimony are not done but manganese, mercury, lithium, aluminium, barium, tin and iron are all now added to the metal analysis.

The methodology for quantifying the coarse (gravel) element of the PSA has also changed.

PSA for the sand fraction for 1995 to 1998 is estimated and the 2009 PSA results have been adjusted to remove the effect of large amounts shell fragments contaminating the samples.

Figure 7.3.3. Skomer MCZ sediment trap sample total sediment, PSA and organic content analysis – OMS and Thorn Rock sites combined



General trends: 1994 to1998 samples were characterised by higher mud content to sand content. 2002 to 2008 samples had higher sand content to mud content and a reduced overall sedimentation rate overall, whereas from 2009 the trend has reverted to higher mud content and higher levels of gravel.

7.3.6. Current Status

- Secchi disc method works well and has provided the most reliable and meaningful estimate of turbidity. The dataset will become more useful the longer data are accumulated.

- The passive sediment traps work well and provide a sample that can be analysed in the future (this may be useful in the event of an unforeseen pollution incident).

- The optical turbidity probe has proved unreliable and difficult to interpret. It also lacks the sensitivity needed for the type of sediment load encountered at Skomer.

- Results from the particle size analysis of sediment trap samples reflect the turbidity data from the Secchi disk in that high levels of water turbidity occur in years when finer sediments are being deposited in the sediment traps (and therefore on the seabed).

- In the early 1990s, high sediment deposition and turbidity were of sufficient concern to prompt the re-evaluation of dredge spoil disposal management from Milford Haven and this appeared to have a beneficial effect until recent years. Dredge spoil disposal techniques and locations have not changed again, but sediment deposition and turbidity have occasionally reverted to levels not seen since the early 1990s.

7.3.7. Recommendations

- Continue the Secchi disk readings as often as possible to continue the long-term dataset.
- Restart the water samples for chlorophyll not only to help monitor primary productivity in the plankton (see Section 6.4), but also to enable turbidity due to phytoplankton to be factored into the interpretation of overall turbidity data.

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9. Appendices

Appendix 1.

Methodology used in collecting activity data at Skomer MCZ

Human activity at Skomer MCZ is recorded by staff during all fieldwork days and during weekend liaison patrols. The results are reported in detail in the Skomer MCZ Annual Report each year (Newman, et al. 2019).

Recreational data.

All recreational activity observed within Skomer MCZ is recorded whenever staff are engaged in fieldwork or carrying out on the water liaison "patrols". In order to meet and record as many users as possible, given the restraints on staff resources, these patrols are normally carried out on all Sundays between the early Spring bank holiday and the end of the school summer holiday in early September, together with the Saturdays and Mondays that fall on the bank holiday weekends in this period.

Additional data are provided by Skomer Island NNR staff observing from the island.

Also noted by both NNR and MCZ staff are any infractions of byelaws, or of the voluntary codes of conduct covering, for example, access to sensitive areas or anchoring outside the permitted anchorages in North and South Havens.

All observations are recorded with reference to the site map shown in Section 5.

Recording effort can vary between years due to poor weather or staff occupied away from the site on other duties. For this reason, an estimate of effort is made from the number of days spent at sea, which is routinely recorded as part of MCZ boat operations.

Although the data collected in this way are as complete as possible, it will inevitably be an underestimate as staff cannot be present at all times. By correcting for effort, however, it can give a valuable indication of trends.

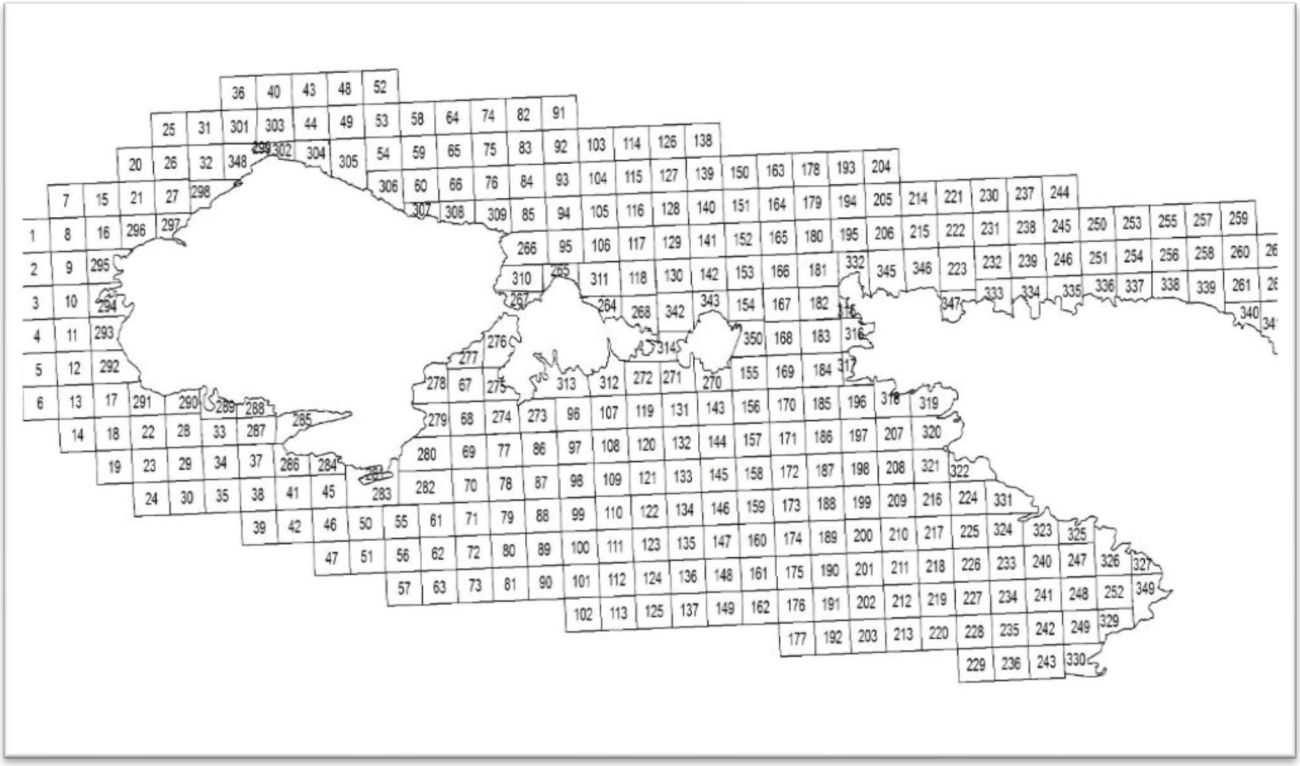
Commercial data.

Commercial vessels, including fishing vessels, diving and angling charter vessels and sightseeing cruises are recorded as part of the process in 9.3.1. In addition, commercial fishing activity (mainly shellfish potting) is recorded in order to estimate relative levels of fishing effort from year to year.

This is done during the same period of the year as recreational activity, but only once per week, usually in combination with the liaison patrols. GPS positions of pot marker buoys are taken and the registration number of the vessel (if marked on the buoy) recorded. The positions are put into Geographical Information System software (GIS) and lines plotted to represent the most likely position of the string of pots between the buoys. Observations of distances between pots along actual strings of pots are used to calculate where pots would most likely occur on the mapped "string". The GIS software is then able to calculate an estimate of the number of pots in each roughly 200m x 200m square (Figure 9.3.1). This is at a finer resolution than the recreational data, particularly for the offshore area, but the inshore squares correspond closely to the site map in Section 5.

As with recreational activity recording effort varies from year to year but is recorded and used to correct data allowing comparisons between years.

Figure 9.1.. Grid used for Skomer MCZ shellfish pot mapping.



Fishing data gathered in this way will underestimate actual fishing effort as it does not record activity outside the MCZ field season, whereas fishing vessels will continue to fish throughout the year depending on the weather. Also, gear would normally be retrieved and reset on the seabed more frequently than once per week. However, the data can demonstrate changes in relative fishing effort between years.

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