Cyfoeth Naturiol Cymru
Natural Resources Wales

Skomer Marine Conservation Zone Project Status Report 2018

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

NRW Evidence Report No. 324

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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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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.

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Contents

1. Crynodeb Gweithredol

Dyma'r deunawfed adroddiad statws prosiect a luniwyd gan Barth Cadwraeth Forol (PCF) Sgomer. Mae'n crynhoi cynnydd a statws prosiectau monitro ym Mharth Cadwraeth Forol Sgomer yn ystod 2018. Mae'r prosiectau hyn nid yn unig yn darparu'r dystiolaeth sydd ei hangen i adrodd ar gyflwr PCF Sgomer ei hun, maent yn gwneud cyfraniad pwysig at y dystiolaeth a ddefnyddir i asesu cyflwr a statws cadwraeth Ardal Cadwraeth Forol Arbennig Sir Benfro, y mae'r PCF wedi'i leoli ynddi. Defnyddiwyd hefyd ddata hirdymor PCF Sgomer, gan gynnwys defnydd biolegol a dynol, i ganfod ac adrodd ar ddangosyddion biolegol ar gyfer gofynion y DU o dan Gyfarwyddeb Fframwaith y Strategaeth Forol. Mae manylion achosion penodol pan fo data PCF Sgomer wedi'u defnyddio i gefnogi mentrau ar wahân i'r rhai sy'n uniongyrchol gysylltiedig â'r PCF i'w cael mewn crynodebau prosiect unigol.

Mae'r tablau statws prosiect yn Adran 4 yn grynodeb o bob prosiect monitro a sefydlwyd yn y PCF. Mae Adran 6 yn nodi'r prosiectau biolegol y gweithiwyd arnynt yn 2018 ynghyd â chrynodeb o'r canlyniadau hyd yma. Mae Adran 7 yn darparu crynodeb o'r prosiectau gwyliadwriaeth eigionegol a meteorolegol.

Dyma ddigwyddiadau pwysicaf tymor maes 2018:

- Cafodd arolwg gwellt y gamlas, *Zostera marina*, ei gwblhau gan dimau o ddeifwyr gwirfoddol dros dri phenwythnos. Cafodd data'r arolwg eu cymharu â chanlyniadau arolygon blaenorol.

- Cwblhawyd arolwg rhywogaethau noethdagellogion ar 16 o safleoedd a oedd yn cynrychioli amrywiaeth o gynefinoedd, gan arwain at gyfanswm o 58 o rywogaethau. Ymysg y rhywogaethau noethdagellogion a gofnodwyd oedd llawer a ystyrir yn rhai prin yn genedlaethol neu sydd wedi'u dosbarthu i raddau cyfyngedig yn Ynysoedd Prydain.

- Cwblhawyd yr arolwg morloi llwyd bach ar safleoedd ar yr ynys a'r tir mawr rhwng mis Awst a mis Rhagfyr, a chofnodwyd 395 o loi bach. Dros y pum mlynedd ddiwethaf cofnodwyd y cyfansymiau uchaf erioed o forloi'n cael eu geni ym Mharth Cadwraeth Forol Sgomer: 374 o loi bach oedd cyfartaledd geni 2014-18.

2. Executive Summary

This is the eighteenth 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 2018. 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 has 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 2018 and a summary of the results to date. Section 7 provides a summary of the oceanographic and meteorological surveillance projects.

Notable events in the 2018 field season:

- The eelgrass, *Zostera marina* survey was completed by teams of volunteer divers over three weekends. The survey data was compared to previous survey results.

- Nudibranch species survey was completed at 16 sites representing a range of habitats resulting in a total of 58 species. Nudibranch species recorded include several classed as nationally scarce or with limited national distribution in the British Isles

- The Grey seal pupping survey was completed at both island and mainland sites from August to December, and 395 pups were recorded. Pup production in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area with average production for 2014-18 at 374 pups.

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

	Brief description	Year sets	Sampling frequency	Report	Data summary
PHYSICAL					
Meteorological data	Wind, rain, sunshine, temperature, humidity, net radiation. Automatic station logging 10 minute means. New met station (2006) is compatible with the ECN and logs files daily, hourly and (since Oct 06) every ten minutes.	1993 – ongoing (Old station removed Oct 05) New Met station installed 25 /04 2006 - 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
	YSI 6600 multi parameter sonde: Temperature, salinity, dissolved O_2, Chlorophyll, turbidity & depth. OSIL buoy automatically transmitting data from YSI 6600 sonde.	2007 – 2013	Temp (since 99) Hourly	No	Yes-SMCZ office
	Buoy redeployed 2010		Hourly samples		
	Buoy lost Nov 2013 Onset logger re-deployed Apr 2014 (no telemetry)	2014 - ongoing	Hourly samples		

	Brief description	Year sets	Sampling frequency	Report	Data summary
Seabed sedimentation	Auto sampler	1994-1998 Discontinued	Continuous	No	Yes-SMCZ office
	Sediment trap	1994 – ongoing 1995 to1998 2002 to 2018	Every 14 days (April-Oct)	Jones 1998	Yes-SMCZ office
Suspended sediments	Idronaut Turbidity logger	2001 – failed 06	Continuous	No	No - raw only
	Secchi disc	1992 - onwards	Weekly (seasonal)	No	Yes – SMCZ office
	YSI 6600 multi parameter sonde – now stopped	2007 - 2013	Hourly	No	Yes-SMCZ office
ACTIVITY					
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
BIOLOGICAL					
Littoral communities:					
Macro scale (view point photographs)	Time series photos/digitised.	1992 - ongoing	Annual	Internal report – Daguet 2000 and Gibbs 2007	Yes-SMCZ office
Meso scale (transects)	6 Transects. Time series photos/digitised.	1992 – 2002	Annual	Adams 1979/ Bunker 1983/ Crump 1993/96 Hudson 1995.	Yes-SMCZ office
		2003 - ongoing	Annual	Burton & Crump 2004	Yes-SMCZ office

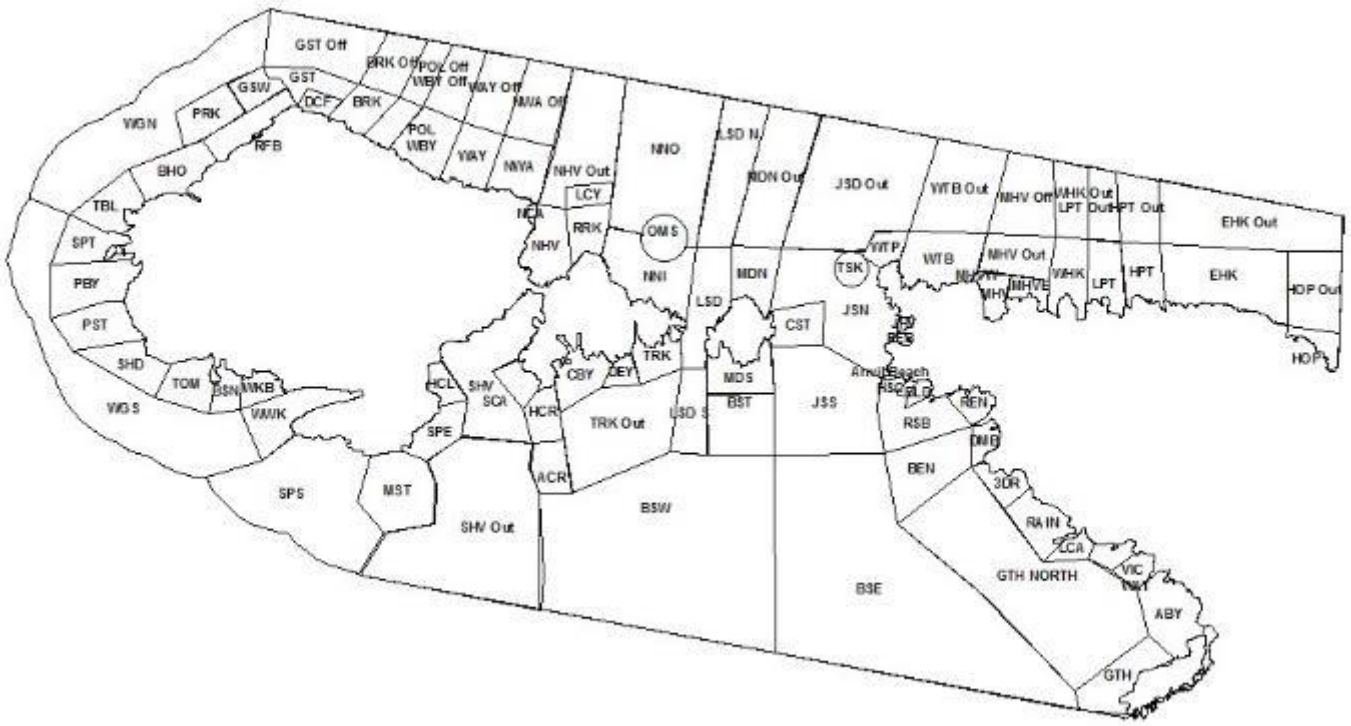
	Brief description	Year sets	Sampling frequency	Report	Data summary
	9 sites established in 2003 including 3 Marclim sites. Site marking completed in 2004.				
Sub littoral communities:					
Rocky reef communities	Time series stereo photos.	1982 - ongoing	Annual	Bullimore1986 & 1987	Yes-SMCZ office
Algal communities	Survey and report completed Survey completed report in preparation Full survey and method development	1999 2005 2007		Hiscock, S 1983 & 1986, Scott 1994, Brodie & Bunker 1999/2000, Maggs & Bunker 2007.	Yes-SMCZ office
Sponge assemblages	Time series mono-photo/digitised. Species recording at TRK Seasonal monitoring from 15 fixed quadrats – Dr J Bell	1994 - ongoing 2002/3, 2007/8 2011, 2015 2006 – ongoing	Annual Every 4 years Next survey planned 2019	Bunker & Jones 2008 & 2012, Bell *et al.* 2012, Jones *et al.* 2012 & 2015, Berman *et al.* 2013.	Yes-SMCZ office
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
Epifaunal sediment	Survey and report completed	1995/ 2001 & 2004 Video 2009	Project now combined with Infauna	Rostron 1996, Moore 2002 & 2005.	Yes-SMCZ office

	Brief description	Year sets	Sampling frequency	Report	Data summary
Plankton communities	Zooplankton samples taken with a 200um net. Vertical haul using methods that are comparable to others used in UK.	2009 ongoing	Weekly samples taken during the field season.	Unpublished report with method recommendations and links to data spreadsheets – Plymouth Marine Laboratories 2015.	Yes-SMCZ office
Flora:					
Zostera marina	Extent of North Haven bed & density distribution. Biosonics Acoustic sonar survey	1997/2002/2006, 2010, 2014, 2018 (Boundary maps for 2000, 2002 & 2004) 2013, 2014 & 2015, 2018	Every 4 years Next survey planned 2022 Annual	Jones & Hodgson 1980 &1981, Jones *et al.* 1983, Lock *et al.* 1998, 2003 & 2006, Burton *et al.* 2010, Lock *et al.* 2015. Burton *et al* 2019.	Yes-SMCZ office
Fauna:					
Eunicella verrucosa	101 colonies, time series mono-photo/digitised. 4 colonies stereo-photo.	1993- ongoing 1982- ongoing	Annual	Bunker et al. 1985, Bullimore1986 & 1987, Gilbert 1998.	Yes-SMCZ office
Alcyonium glomeratum	Time series stereo-photo/digitised. North wall 5 transects (% frequency) North wall East, Thorn rock &Rye rocks.	1984- ongoing 2002 new transects	Annual	Bullimore1986 & 1987.	Yes-SMCZ office
Parazoanthus axinellae	6 sites, time series mono-photo/digitised.	2001- ongoing	Annual	Burton *et al.* 2002.	Yes-SMCZ office

	Brief description	Year sets	Sampling frequency	Report	Data summary
Pentapora foliacea	3 sites, time series mono-photo/digitised. New sites established 2002 & 2003.	1994- ongoing	Annual	Bullimore1986 & 1987, Bunker & Mercer 1988, Gilbert 1998, Gibbs 2006.	Yes-SMCZ office
Balanophyllia regia	Time series at Thorn Rock stereo-photo/digitised The Wick. 3 transects	1984 – 2002 - ongoing 2002 - ongoing	Annual	Bullimore 1986 & 1987.	Yes-SMCZ office
Caryophyllia smithii	Counted from sponge project quadrats (stereo-photo/digitised)	1993 - ongoing	Annual	No	Yes-SMCZ office
Grey seal (*Halichoerus 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 1992-2017, Skomer MCZ annual reports 1992-2018.	Yes-SMCZ office
Nudibranch species	Various surveys MCZ survey completed.	1975-1991 2002, 2006, 2010, 2014 & 2018.	Every 4 years Next survey planned 2022	Hunnam & Brown 1975, Bunker *et al.* 1993, Luddington 2002, Lock*et al.* 2010, 2014 & 2019.	Yes-SMCZ office
Territorial fish	Survey methods developed. Survey completed. N. Sweet drop down video survey R. Bullimore video survey	1997,2001/2002 2005, 2009, 2013,2007, 2009, 2013 & 2017.	Every 4 years Next survey planned 2021	Lock 1998, Lock *et al.* 2006, Tompsett 2006, Sweet 2009, Bullimore 2010.	Yes-SMCZ office

	Brief description	Year sets	Sampling frequency	Report	Data summary
King scallop *Pecten maximus* (including *Crepidula fornicata*, *Aequipecten opercularis* and *Arctica islandica* from 2008)	UCS survey, Survey completed, 3 sites- 2000 Survey completed, 7 sites 2004, 2008, 2012& 2016	1979/80, 1979-82 2000, 2004, 2008, 2012, 2016	Every 4 years Next survey planned 2020	Bullimore 1985, Jones 1979 & 1980, 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 ciliate.*	2003,2007 & 2011, 2015	Every 4 years Next survey planned 2019	Luddington *et al.* 2004, Lock *et al.* 2008, 2011 & 2016.	Yes-SMCZ office
Commercial Crustaceans	Parlour pot and diving study (Plymouth student project) Parlour pot study – MCZ Shell disease survey Crawfish recording	2003 2011 2011 2011 onwards	Aug / Sep 2003 Jul – Oct 2011 Sep – Oct 2011 SMCZ team	Fothergill 2004 No 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



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
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).

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 are 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 *Phorcas 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.

Site	Permanent Quadrats	Shore zone quadrats, Limpets, Barnacles	Lichen quadrats	MarClim	Shore clingfish
North Haven				Yes	Yes
South Haven	Yes			Yes	Yes
South Stream	Yes	Yes	Yes		
The Lantern	Yes	Yes	Yes		
The Wick	Yes	Yes	Yes		
Double Cliff	Yes	Yes			
Pig Stone		Yes	Yes		
Wooltack		Yes	Yes		
Martins Haven		Yes	Yes	Yes	Yes
Hopgang			Yes		

Table 6.1.1 Summary of methods completed at each littoral site.

6.1.5. 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 at the six original sites and four additional sites were established, (Crump & Burton, 2004).

2004: Methods established in 2003 were continued. All site marking was completed, and all results collected. Marclim surveys were started at 3 sites: Martins Haven, South Haven and North Haven.

2005: All the sites established in 2003 were resurveyed except for the lower shore at Pig Stone.

2006: All sites were completed.

2007: All sites were completed, and temperature loggers were placed at the Martins Haven and South Haven sites.

2008: All sites resurveyed except for Double cliff, upper shore.

2009 - 2011: All sites completed.

2012: All sites complete except Double cliff (no data for any shore height).

2013 - 2015: All sites completed.

2016: All sites completed except for Pig Stone – no landing was possible (no data).

2017: All sites completed.

2018: All sites complete except for Double cliff Upper & Middle shore (no data)

6.1.6. Results

Whole Community Analysis

All the shore zone quadrat data is entered into the PRIMER statistics software for community analysis. The results can be visualised as MDS plots.

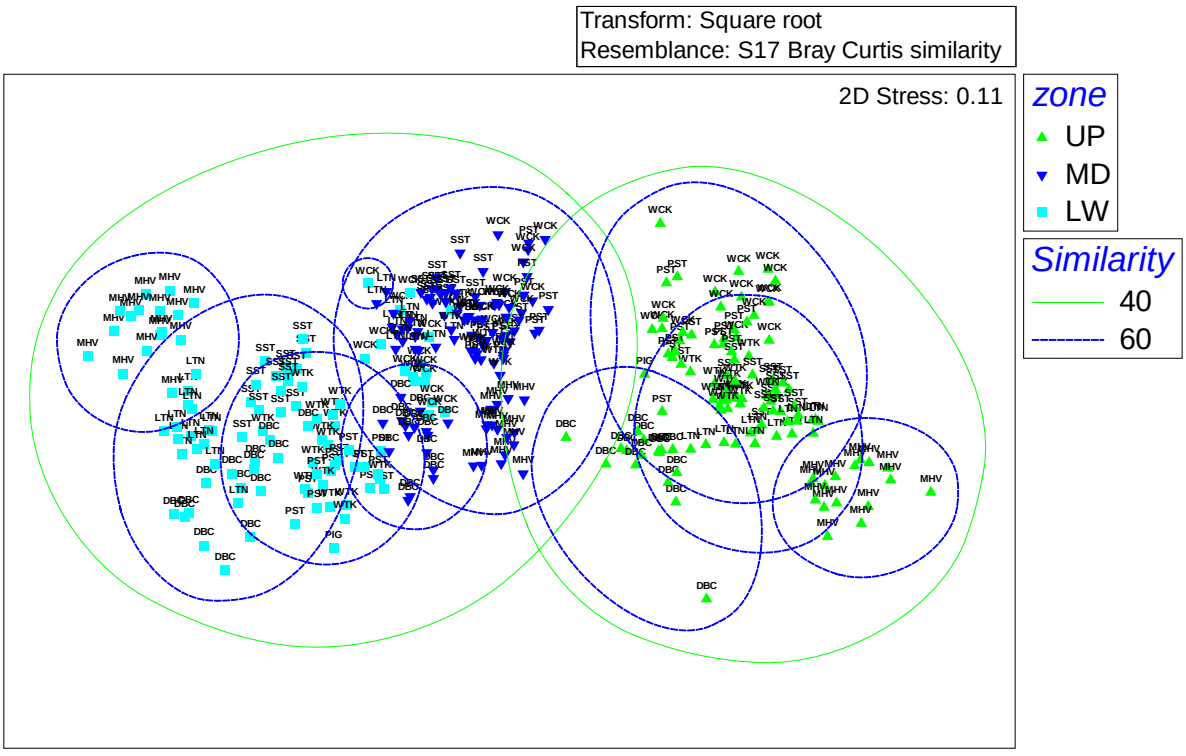


Fig. 6.1.1 PRIMER Multi-dimensional scaling (MDS) plot of all littoral community data 2003 – 2018

General summary:

- Upper shore sites group neatly on the right.
- Lower shore sites are much more disparate and grouped on the left.
- Middle shore sites sit in between with some overlap (at 60% similarity) with the lower shores.

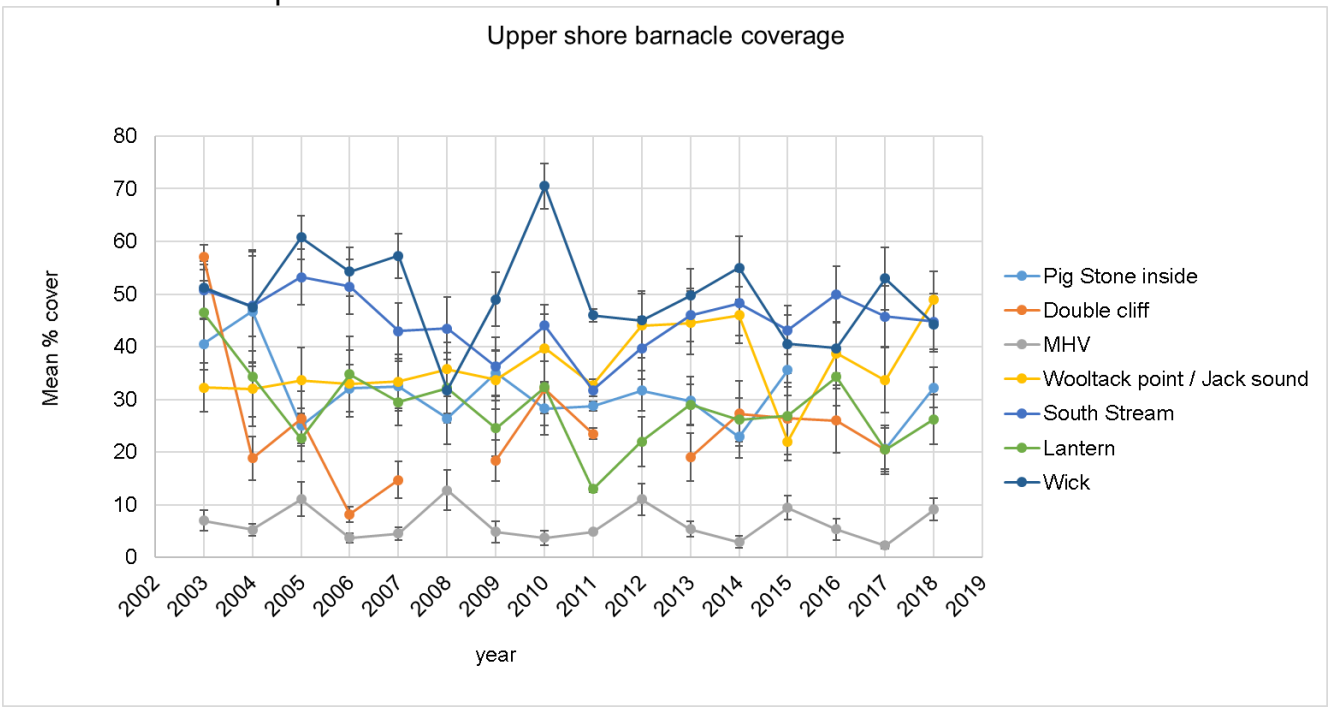
- Some sites form distinct clusters e.g. MHV Upper, MHV Lower.
- Some sites are very variable from year to year e.g. PST Lower & WTK Lower.

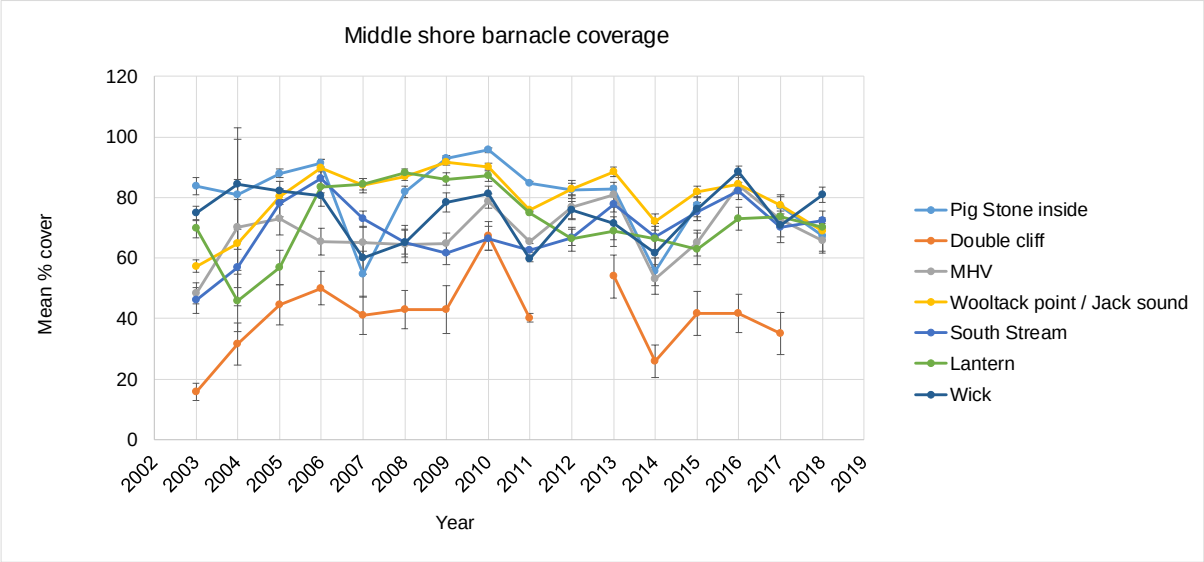
2018 did not show any major variations from the overall trends seen since 2004.
An “ANOSIM” test for differences between years showed no significant difference between any of the years.
Global Test
Sample statistic (Global R): -0.024
Significance level of sample statistic: 100%

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

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

Mean Percentage Cover of Barnacles
Barnacle coverage has been variable between sites over the last 15 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 2018 the barnacle coverage showed little change. There was an increased across most upper shores, a slight decrease in the middle shore and a mixed picture in the lower shores.





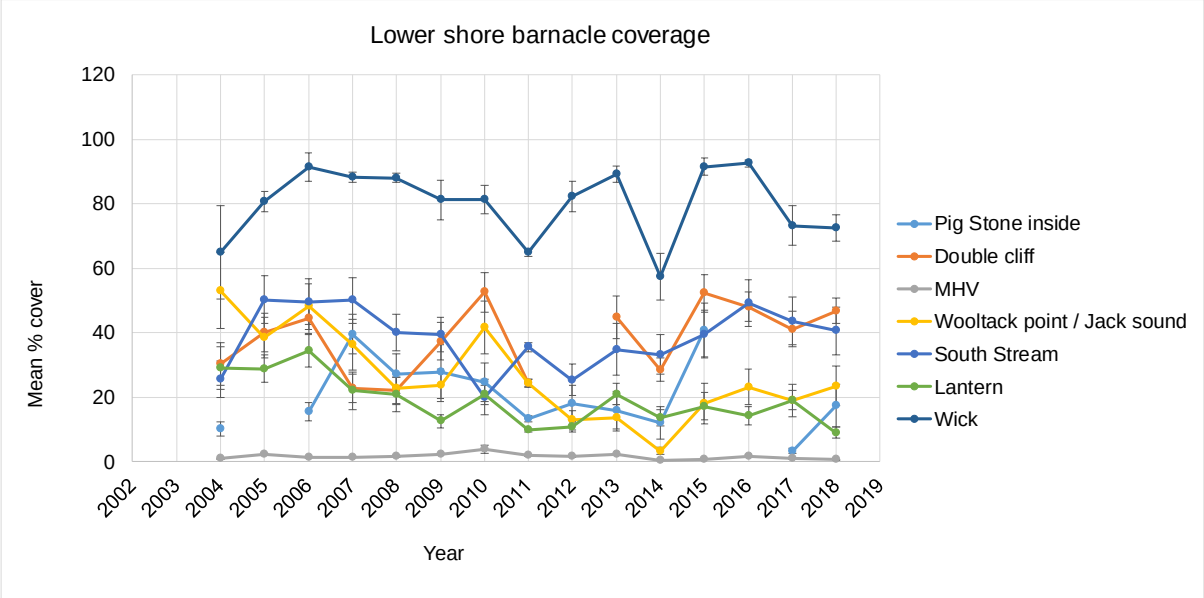
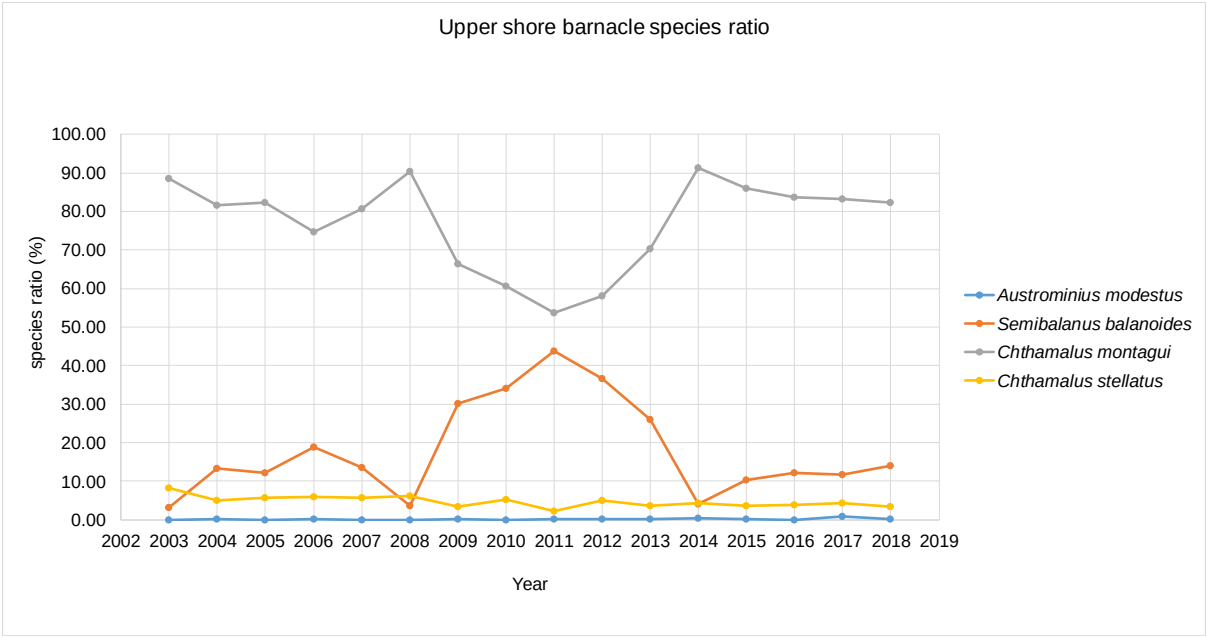


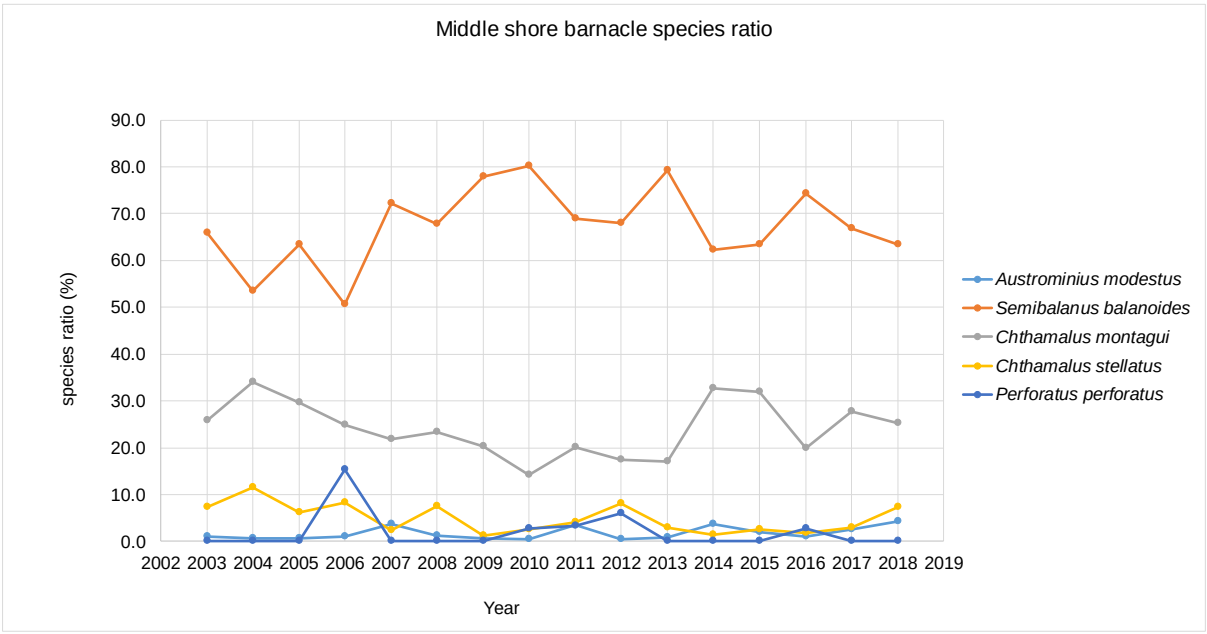
Fig. 6.1.2 Changes in upper, middle and lower shore barnacle coverage 2003 – 2018 95% S.E.

Barnacle Species Ratios

The barnacle species counts have been completed from the photographs of the 5cm X 5cm quadrats at the 3 MarClim Sites, (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.


Upper shore barnacle species ratio
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
species ratio (%)
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Year
Austrominius modestus
Semibalanus balanoides
Chthamalus montagui
Chthamalus stellatus


Middle shore barnacle species ratio
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
species ratio (%)
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Year
Austrominius modestus
Semibalanus balanoides
Chthamalus montagui
Chthamalus stellatus
Perforatus perforatus

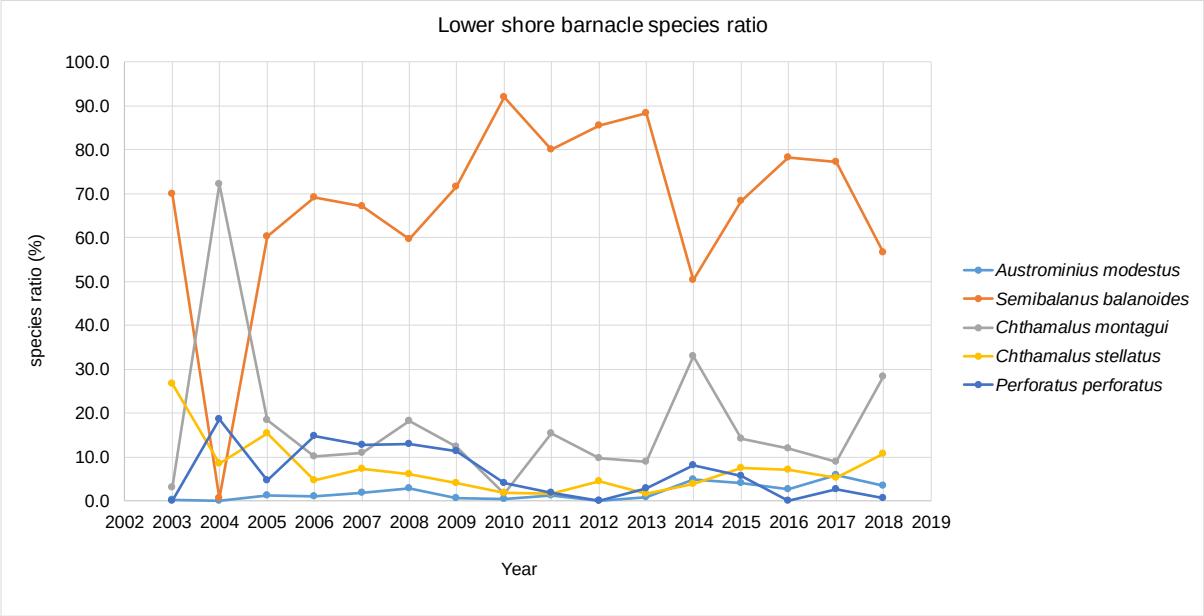


Fig. 6.1.6 Changes in upper, middle and lower shore barnacle species ratios 2003 – 2018

Limpet Size and Counts

The mean limpet size recorded at sites shows a stable trend at most sites, the Lantern shows the greatest fluctuations.

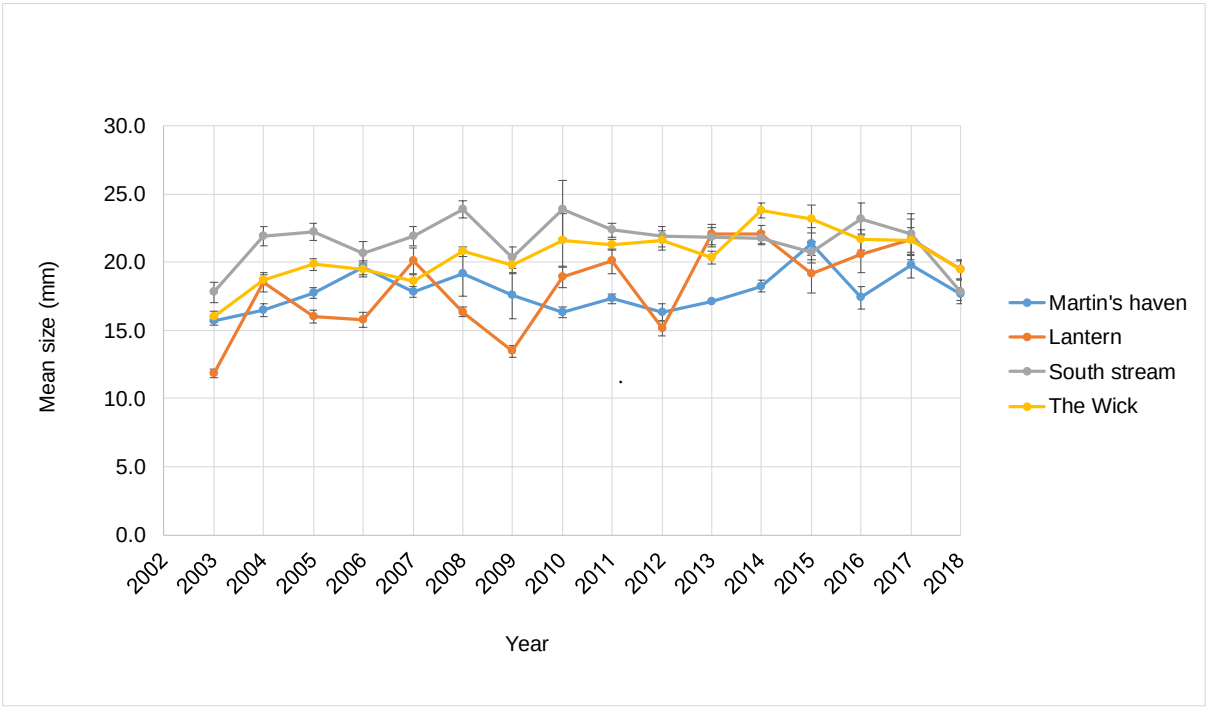


Fig. 6.1.3 Changes in mean limpet size 2003 – 2018 95% S.E.

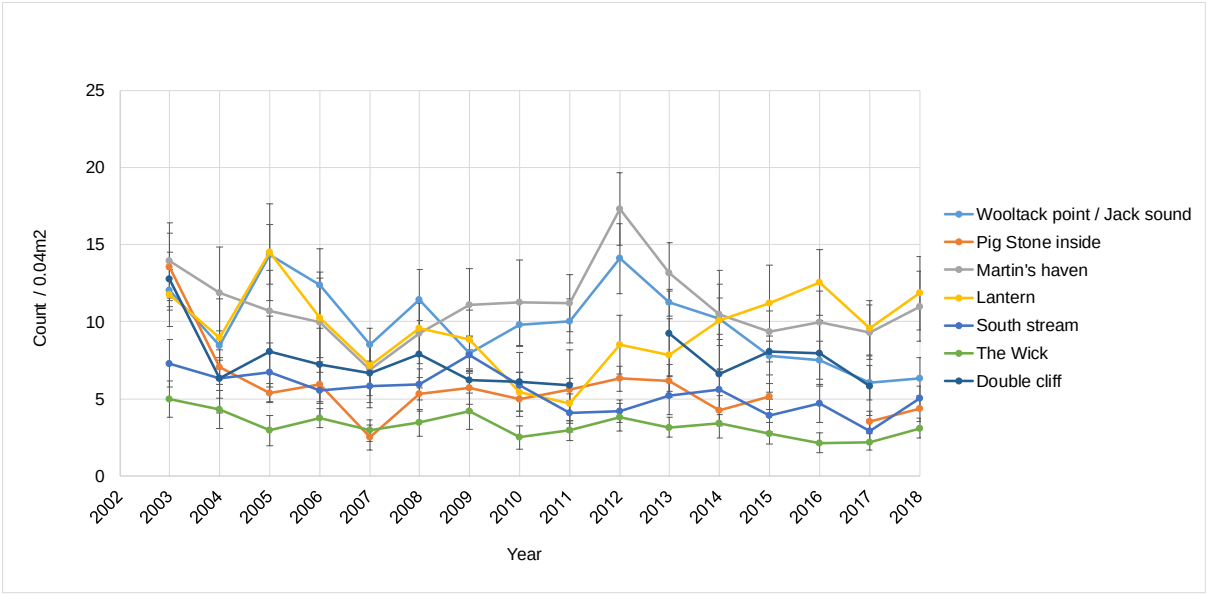


Fig. 6.1.4 Changes in middle shore limpet counts 2003 – 2018 95% S.E.

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. 2007 appears to have had a dip in numbers at six of the sites, which all showed an increase the following year. On the middle shore the numbers have been stable from 2009 onwards with an increase in numbers at all sites in 2012 followed by a slight decrease in 2013 & 2014.

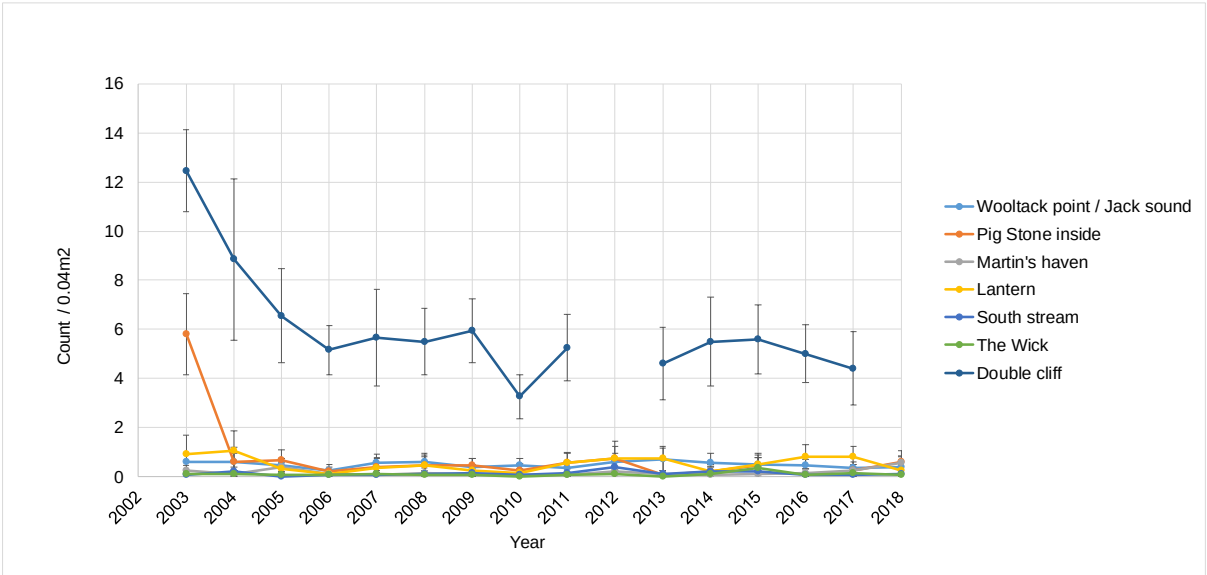


Fig. 6.1.5 Changes in upper shore limpet counts 2003 - 2018 95% S.E.

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. The site was not visited in 2018.

Lichen quadrats

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

MarClim survey

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

Wakame (*Undaria pinnatifida*) was found 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. It first arrived in England in 1994 in the Solent and has since spread around the UK. It is found mixed in with native kelp species and looks similar to sugar kelp (*Saccharina latissima*), but can be distinguished by its distinct midrib with a frilly corrugated frond either side.

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 2003 – 2018 using species thermal midpoint (STI) values from Burrows 2016.

The CTI scores for the 3 shores surveyed at Skomer 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 6.1.6 Community Temperature Index - Skomer shores 2002 – 2018 (95% S.E. 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 & 2016 they were found in greater numbers at South Haven but the presence is erratic with no fish being found in intervening years.

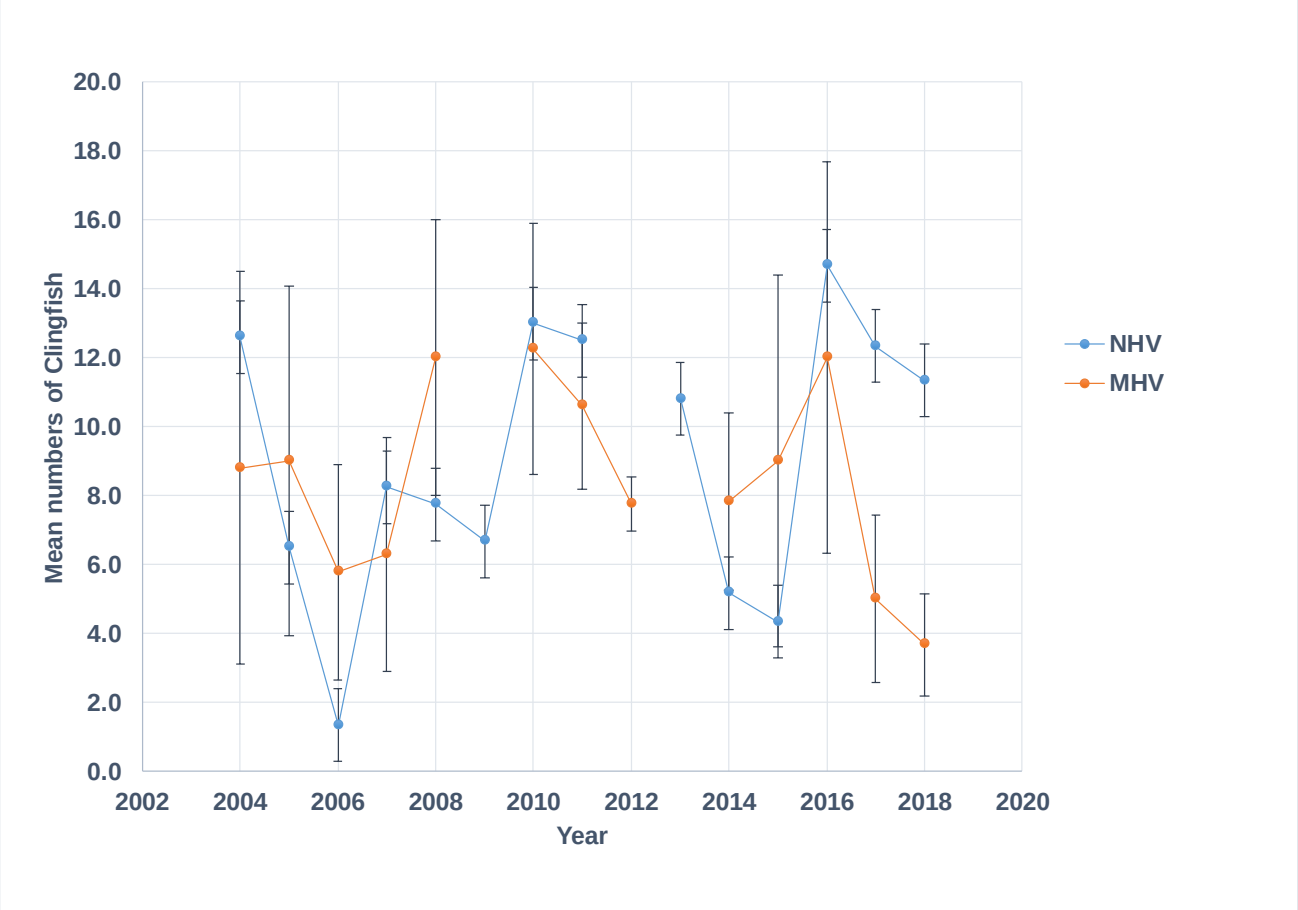


Figure 6.1.7 Average numbers of clingfish 2003 – 2018 at North Haven and Martins Haven

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.

6.1.7. 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.

6.1.8. Recommendations

Keep current with the development of 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 2011, 2015).
- 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. Until 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 and 2015 the survey was additionally completed at the Wick and High Court Reef sites. 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 in May and October and if time allows also in 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

Year	No of samples	Transects
1993	24	WG
1995	77	WG, SH, BG, DL
1996	72	WG, SH, BG, DL
1997	20	WG
1998	60	WG, SH, DL
2000	63	WG, SH, DL
2001	62	WG, SH, DL
2002	81	WG, SH, BG, DL
2003	79	WG, SH, BG, DL Species survey
2004	80	WG, SH, BG, DL
2005	80	WG, SH, BG, DL
2006	79	WG, SH, BG, DL
2007	81	WG, SH, BG, DL
2008	0	Transects were completed but the image quality was very poor and no analysis was possible
2009	81	Digital SLR used – not stereo 35mm Results very good – better resolution than the 35mm system
2010	81	Digital SLR used
2011	81	Digital SLR used Species survey
2012	81	Digital SLR used – lots of sediment on the surfaces
2013	81	Digital SLR – good conditions
2014	81	Digital – Poor visibility
2015	81	Digital SLR – good conditions Species Survey
2016	81	Digital SLR – good conditions
2017	81	Digital SLR – good conditions
2018	81	Digital SLR – good conditions

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

The 2015 species survey brought the total number of sponge species and entities recorded in the MCZ to 129 (of which 31 have yet to be described or identified to species level).

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, to be stored as part of the national sponge collection. Additionally, to investigate so-called "Black Death" incidents, Boring sponge (*Cliona celata*) samples were also collected in 2015 and sent to Dr Preston. Samples were taken of healthy, fouled and diseased sponges for microbial community profiling.

6.2.6. Results

Species surveys: Next species survey planned for 2019.

Transects:

Sponge Morphology Analysis

This method has been used for all the quadrats taken at Thorn Rock 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.

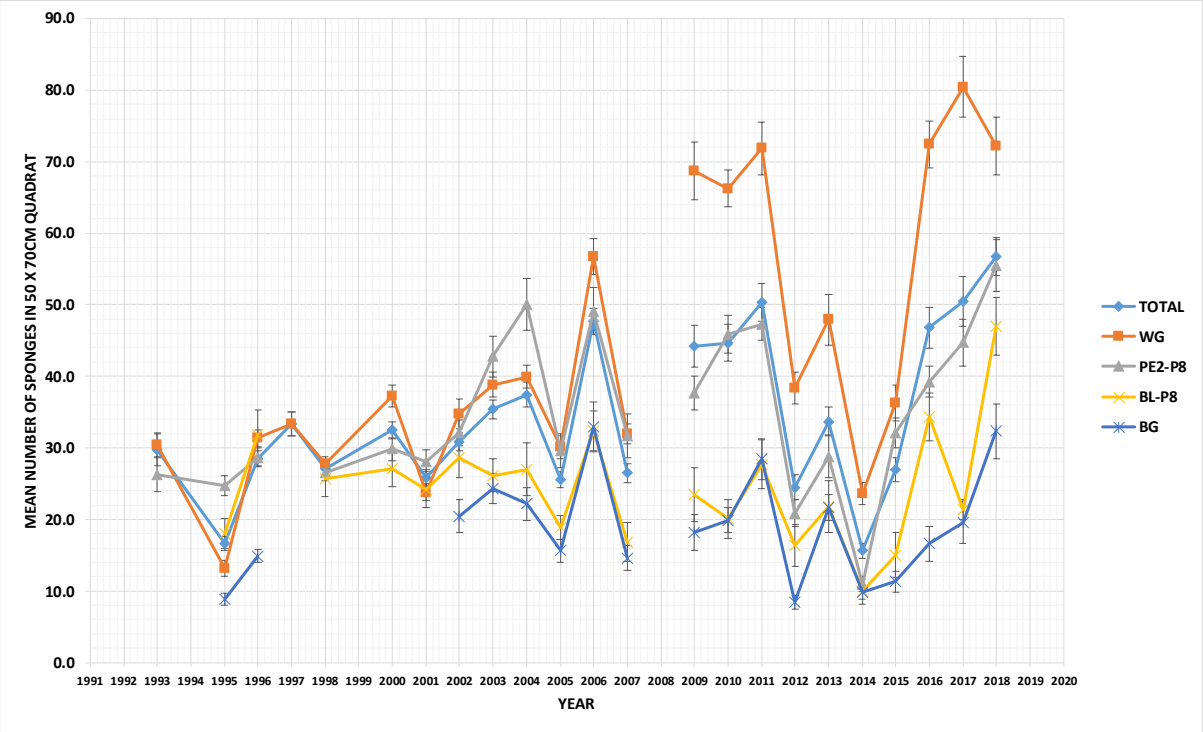


Figure 6.2.1 Mean number of sponges counted in each quadrat at 4 sites –Thorn Rock 1993-2018

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 2018 all sites increased in abundance except for Windy gully. Image quality was good and there was very little silt on the seabed when the photographs were taken.

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 is entered into the Primer V6 statistics package, averaged to site and year, and a similarity matrix produced using the Bray-Curtis similarity coefficient on the square root transformed data.

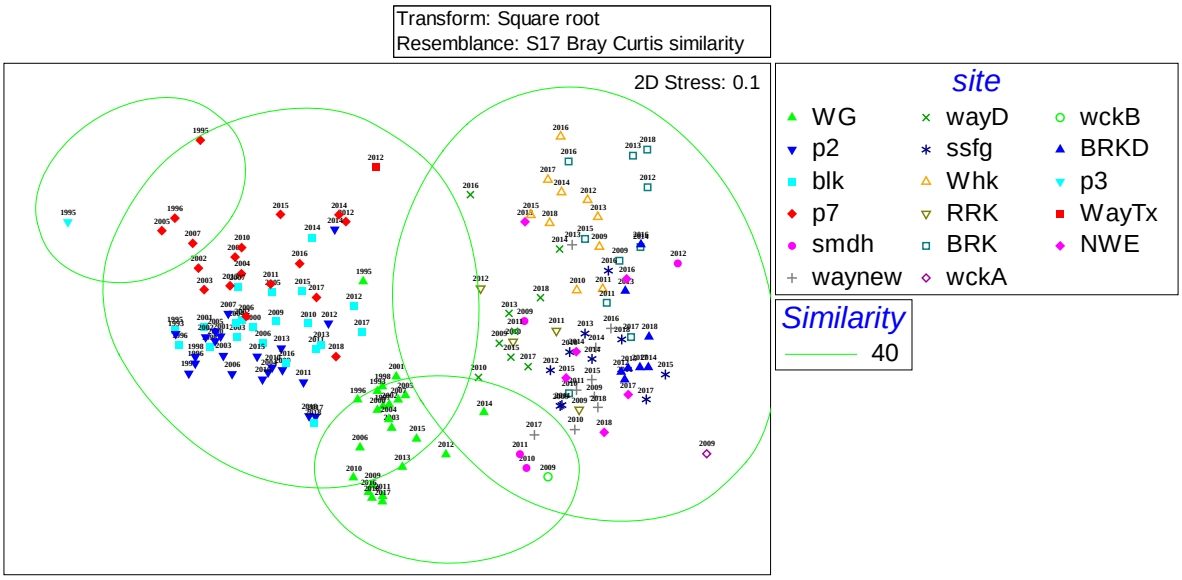


Figure 6.2.2 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data averaged to site and year 1995 – 2018.

The sites in Figure 6.2.2 with a solid colour fill are the Thorn Rock (TRK) transects, the rest of the sites are spread around the MCZ (see section 5 map). In all years, the TRK transects separate out from the rest of the MCZ. To test if this separation is significant the data were labelled with “TRK” or “MCZ” (Figure 6.2.3).

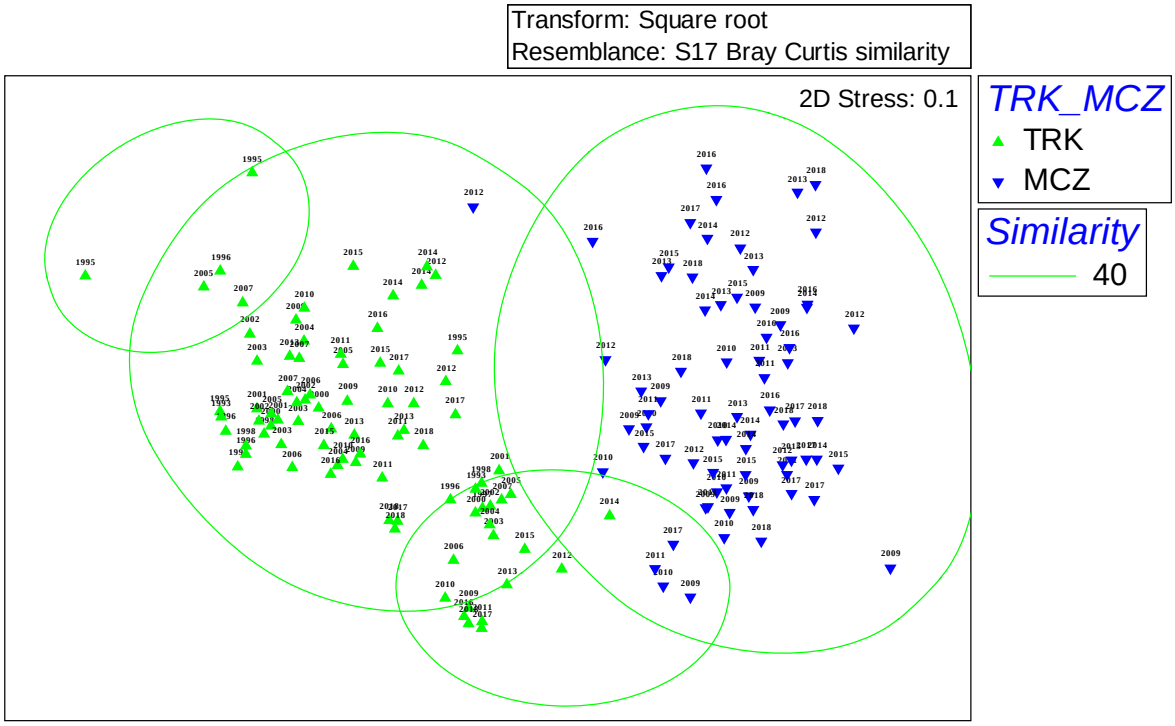


Figure 6.2.3 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data labelled with “TRK” or “MCZ”.

A 2 way ANOSIM test was applied to the Bray-Curtis similarity matrix Testing for differences between area & year.

```
TESTS FOR DIFFERENCES BETWEEN TRK_MCZ GROUPS
(across all year groups)
Global Test
Sample statistic (Global R): 0.898
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

TESTS FOR DIFFERENCES BETWEEN year GROUPS
(across all TRK_MCZ groups)
Global Test
Sample statistic (Global R): 0.06
Significance level of sample statistic: 1.8%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 17
```

These results suggest that there is very little difference between the years but that there is a very significant difference between the Thorn Rock (TRK) quadrats and quadrats from the rest of the MCZ.

A SIMPER analysis describes what these differences are:

```
Groups TRK  &  MCZ
Average dissimilarity = 59.06
```

Species	Group TRK Av.Abund	Group MCZ Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
AR	3.71	0.49	19.59	2.64	33.17	33.17
EN	2.08	2.92	11.24	1.54	19.03	52.20
PA	1.34	0.05	8.08	1.97	13.68	65.89
PE	1.25	0.04	7.42	1.59	12.56	78.44
MA	1.90	1.51	5.51	1.34	9.33	87.78
OTHER	0.34	0.21	2.33	1.01	3.94	91.71

In summary:
Arborescent (AR) Papillate (PA) & Pedunculate (PE) sponges are much more abundant at Thorn Rock. The total number of sponges (all groups) is higher at Thorn Rock. Encrusting sponges are more abundant in the rest of the MCZ.

The Thorn Rock sponge assemblage is much more diverse in its morphology types and has a higher number of sponges. The number of sponges at Thorn Rock do seem to vary a lot between years. Silt levels and photograph quality do affect the number of sponges visible. In 2014 there was a noticeable drop in the number of sponges visible and this was probably due to high silt levels and poor photo quality.

6.2.7. Current status

The species surveys show that Skomer has a very biodiverse range 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.
- 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 2019.
- Continue support of sponge research carried out by academic bodies.
- Produce publications in the peer-reviewed scientific literature.

6.3. Nudibranch species diversity

(CMS Code: RM54/01)

6.3.1. Project Rationale

Nudibranchs are predators on a wide range of species. Most are seasonal and reliant on their prey for food, shelter and a place to lay their eggs. Being near the top of the food chain they can act as an indicator of the health of the communities they rely on. The Skomer MCZ nudibranch population has for many years been identified as being rich and diverse including nationally rare and scarce species (Bunker, Picton & Morrow 1993).

6.3.2. Objectives

- To produce a species list for Skomer MCZ on a 4-yearly basis.
- To record a nudibranch species, check list annually.

6.3.3. Sites

All of the Skomer MCZ

6.3.4. Methods

- Full survey: Surveys are carried out in early summer. Sites from around the whole Reserve are chosen to provide a range of habitat types. The sub-littoral habitat found at each site is described briefly and associated nudibranch species recorded as a list for each site. In addition, an overall list of species is compiled for the Skomer MCZ and species recorded photographically.
- Annual check list : Species from the checklist are recorded along with other notable observations during other monitoring dives throughout the season, sites are not targeted specifically for nudibranch records.

6.3.5. Project History

Between 1975 and 1991 sixty-two species of nudibranchs were recorded during a total of 99 dives at 44 Skomer sites (Bunker *et al*., 1993).

2002 – full survey completed. Twenty dives at 16 sites representing a range of habitats were surveyed for nudibranch species resulting in a total of 32 species. A check list of 16 species was selected for annual monitoring with a target of observing 80% of these species annually, and it was recommended that a full species survey was carried out every 4 years. (Luddington 2002).

Checklist species:

Acanthodoris pilosa	*Facelina auriculata*
Archidoris pseudoargus	*Flabellina pedata*
Crimora papillata	*Janolus cristatus*
Diaphorodoris luteocincta	*Limacia clavigera*
Doto fragilis	*Polycera faeroensis*
Doto pinnatifida	*Polycera quadrilineata*
Eubranchus farrani	*Tritonia lineata*
Facelina annulicornis	*Tritonia nilsodhneri*

2003 and 2004 all 16 species from the checklist were recorded in both years. A notable record was *Tritonia nilsodhneri* on the pink seafan, *Eunicella verrucosa*. *T. nilsodhneri* is a nationally scarce species (Moore 2002).


Tritonia nilsodhneri

2006 – full survey completed. 13 sites representing a range of habitats for nudibranch species were surveyed. Thirty-five species were recorded during 21 dives. Notable records were *Doris sticta* a nationally scarce species (Moore, 2002) and three species not previously recorded in the historical data set, *Cadlina laevis, Doto eireana* and *Onchidoris pusilla* (Burton *et al* 2007).


Trapania tartanella DK

2007 and 2009 - 14 of the 16 species from the check list were recorded in 2007 and 15 of the 16 species in 2009. Notable records in 2009 were *Trapania tartanella,* a new record for both Skomer and Wales, *Doto hystrix* and *Cuthona caerulea* which had not been not found on either the 2002 or 2006 surveys. These were recorded and photographed at Rye Rocks by diving volunteers Sarah Bowen and David Kipling (Lock *et al* 2011).

2010 – full survey completed. A nudibranch species identification course was provided by specialist Bernard Picton. 14 sites were surveyed resulting in a total of 55 species of nudibranchs. The number of species were significantly higher than the 2002 or 2006 surveys, this may have been due to improved identification skills and also to extra efforts made to target a wider range of habitats including mixed sediment sites. Two species not previously recorded in the Skomer MCZ were *Eubranchus vittatus* and *Trapania pallida*.

2013 - 15 of the 16 species from the check list were recorded, including *Tritonia nilsodhneri* on pink sea fan, *E. verrucosa* at Rye Rocks. *Onchidoris pusilla* was recorded at the Mewstone and *Okenia elegans* at the Pool and Thorn Rock. A notable record was *Lomanotus marmoratus* at High Point by David Kipling which had not been recorded at Skomer since 1991.

2014 – full survey completed. 13 sites were surveyed, and 49 nudibranch species recorded. Three species had not been recorded since 1992: these were *Cuthona concinna, Eubranchus doriae* and *Doto floridicola*. *Doto floridicola* had previously been recorded as *Doto sp 'A'* in 1990 (Bunker *et a*l, 1993), its identification was confirmed in 2002 (Picton *pers. comm.*).

2015, 2016 and 2017 - In 2015 15 of the 16 species from the annual check list were recorded, and in both 2016 and 2017 14 species. *Tritonia nilsodhneri* was recorded in 2016 at North Wall east and in 2017 at Rye Rocks during pink sea fan, *Eunicella verrucosa* monitoring dives. Other notable records include: *Doris sticta* at Thorn Rock in 2015, *Lomanotus genei* at Junko's Reef and *Facelina bostoniensis* at North of the Neck in 2016 and *Okenia elegans* at Martins Haven West in 2017.

6.3.6. Results

A total of 58 nudibranch species were recorded at 16 survey sites in the Skomer MCZ during the 2018 survey.

30 dives targeting nudibranch recording were completed at 15 sites by the Skomer MCZ team and volunteers between 18th and 29th June 2018. Additional sites were also explored during other Skomer MCZ monitoring dives.

In 2010, 2014 and 2018 a weekend each year was organised for Seasearch volunteer divers to complete a nudibranch "Bioblitz" at Martins Haven. Between 20 and 34 divers took part in each survey and were assisted by specialist Bernard Picton. The results were impressive with 31 species recorded in 2010, 33 species in 2014 and 29 species in 2018. Combining these records gives a total of 44 species for Martins Haven.

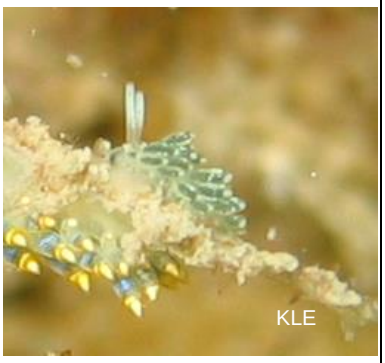
A review was completed of all records for surveys between 1975 and 2018 including sediment infauna surveys. A total of 79 nudibranch species have been recorded in the Skomer MCZ.

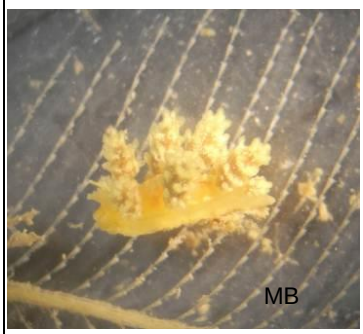
69 species have been found on those surveys carried out between 2002 and 2018, of these, 9 species, *Cadlina laevis, Doto eireana, Onchidoris pusilla, Eubranchus vittatus, Trapania pallida, Palio nothus, Fjordia chriskaugei, Doto hydrallmaniae and Eubranchus linensis* had not been recorded before the 2002 survey. Nudibranch species recorded include several classed as nationally scarce or with limited national distribution in the British Isles, these are listed in the table below:

Table 6.31 Notable nudibranch records for diving surveys 2002-2018

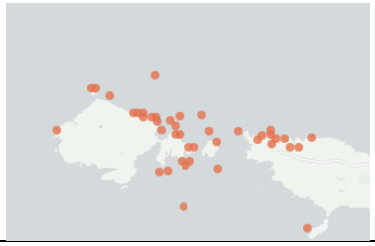
(Maps sourced through the NBN atlas www.species.nbnatlas.org.uk The recorders, data provider[1] and the NBN Trust bear no responsibility for any further analysis or interpretation of the data)

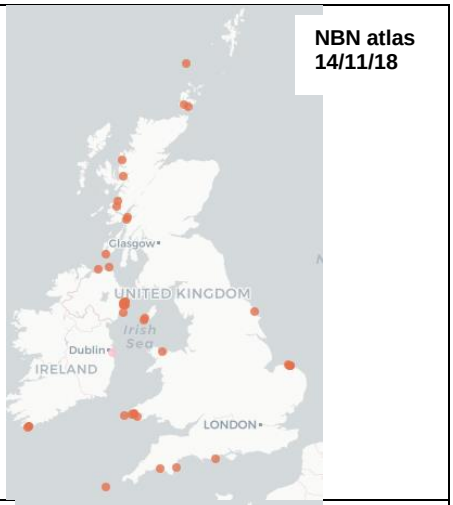
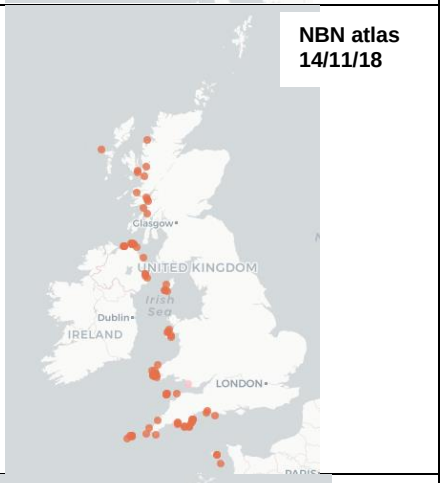
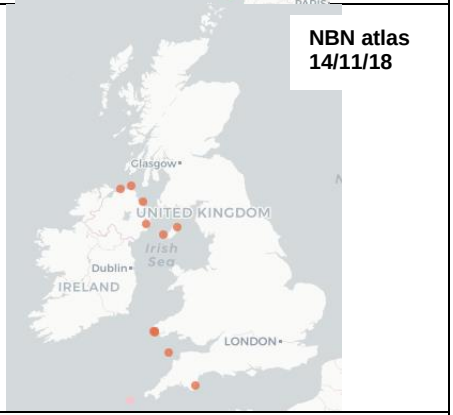
SPECIES	COMMENTS (Bunker *et al* 1993, Picton & Morrow 1994, www.habitas.org.uk)	DISTRIBUTION MAP (NBN Gateway www.data.nbn.org.uk)
Cuthonella concinna	This is a northern species with sparse records at Skomer and the south coast. It feeds on the hydroid *Sertularia argentea* which is usually found in strong tidal flows or wave action, Recorded in 1989 and 1992. First record on a survey in 2014.	

Diaphoreolis viridis  	Found all around the British Isles, however records are sparse as it can often be highly camouflaged. It feeds on *Sertuarella* hydroids. First record for Skomer in 2010 and again in 2013 AND 2018	
Diaphorodoris alba 	First record for Skomer in 2002 and on several occasions since.	
Doris sticta  	A nationally scarce species found on the west of Ireland and south west Britain (Moore, 2002). Feeds on sponges but it is unknown which species. Recorded in 1975, 1990 and 1991. Found on both 2006 and 2014 surveys and in 2015.	
Doto cuspidata  	An uncommon species that feeds exclusively on *Nemertesia ramosa*. It is found in the south of Britain but more regularly in the north. Found in 1988, 1999 and all the Skomer surveys.	

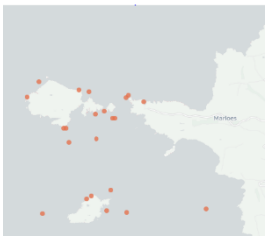
Doto eireana  	Found on the west coast of Britain, however records are few due to its separation from *Doto coronata*. It feeds exclusively on *Amphisbetia operculata*. New record for Skomer in 2006, recorded again in 2010, 2014 and 2018.	**NBN atlas 14/11/18** 
Doto floridicola  	First recorded at Skomer as "*Doto sp A"* in 1990. In 2002 Picton confirmed it to be "*Doto floridicola"*. It is a southern species found in the Azores and Mediterranean. In Britain it feeds on *Aglaophenia kirchenpaueri.* Recorded in 2014 survey at 2 sites and 2018 at 3 sites.	**NBN atlas 14/11/18** 
Doto hydrallmaniae  	Recently described from the Isle of Man in 1992. Feeds on the hydroid *Hydrallmania falcata*, found mainly on rocks, stones and pebbles in areas subject to scour. First record for Skomer in 2018.	**NBN atlas 14/11/18** 
Doto hystrix  	A scarce species found in deep waters below 25m found on the hydroid *Schizotricha frutescens.* A north west species with occasional records at Skomer and Lundy. Recorded in 1988 and on the 2010 and 2018 surveys.	**NBN atlas 14/11/18** 

Doto koenneckeri	A widely distributed animal recorded from Spain to Scotland. Feeds on the hydroid *Aglaophenia pluma* which grows on the seaweed *Halidrys siliquosa.* Recorded on the 2002 and 2010 surveys.	 **NBN atlas 14/11/18**
Eubranchus doriae 	This is a very small camouflaged species. Few records exist however it has been found on the west and south coasts of Britain. It feeds on the plumularian hydroid *Kirchenpaueria similis.* Recorded in 1997 and on the 2014 and 2018 surveys.	 **NBN atlas 14/11/18**
Eubranchus linensis 	This species was first described in 1990 in Spain and has been recorded in Portugal and the Netherlands. It was first recorded in the UK in 2015. In Wales it was first recorded in Brides Bay in 2017 and was found at 5 sites during the 2018 survey.	Distribution map not available
Eubranchus vittatus 	A frequent species in the north west of Britain but scarcer in the south. It feeds on the hydroid *Kirchenpaueria pinnata*. New record for Skomer in 2010 and found again in 2018.	 **NBN atlas 14/11/18**

Facelina annulicornis  	An uncommon species but with a wide spread distribution in Britain. It feeds on a variety of hydroids and has been known to attack and eat other nudibranchs. It is particularly common at Skomer. 	**NBN atlas 14/11/18** 
Favorinus blianus  	Distributed along the north and west coasts of Britain. It eats other nudibranch spawn. Collected in 1972 and subsequently described in 1974 as a new species with Martins Haven the type locality for the species, Hunnam & Brown (1975). Recorded in 1975, 1989 and on the 2010 and 2018 surveys.	**NBN atlas 14/11/18** 
Fjordia chriskaugei  	Recently described in 2017 in Norway. Previously confused with *Fjordia lineata*. It feeds on the hydroid *Tubularia indivisia* as adults and on hydroids with smaller polyps as juvenilles. Currently known from southern Norway to Croatia including all around Britain and Ireland. Recorded in the 2010 survey.	Distrubution map not available
Lomanotus genei  	A scarce species with sporadic records but with a wide distribution from the west coast of Scotland to the Mediterranean. It feeds on *Nemertesia ramosa.* Found in 1988, on the 2010 survey and at one site in 2016.	**NBN atlas 14/11/18** 

Lomanotus marmoratus 	This is a highly camouflaged species and most likely under-recorded. It has been found all around the British isles. It feeds on *Nemertesia antennina.* Found in 1989 and 2013.	
Okenia aspersa 	A scarce burrowing nudibranch that feeds on the ascidian *Molgula occulta*. *M. occulta* live buried in muddy sand and often the only clue to *O. aspersa's* presence is the distinct spawn shaped like coiled springs. Found in 1989 and on the 2010 survey and egg masses were recorded in both 2014 and 2018.	
Okenia elegans 	A nationally scarce species that feeds on *Polycarpa sp.* Found at scattered locations on the south and west coasts of Britain. (Moore, 2002) Found in 1991 and the 2010, 2014 and 2018 surveys. It is regularly found in the MCZ.	
Onchidoris oblonga 	It is found at scattered on the south and west coasts of Britain but rarely recorded. It is very small and well camouflaged on its food *Cellaria fistulosa.* Found in 1987, 1989 and on the 2010, 2014 and 2018 surveys.	
Onchidoris pusilla		

	Found all around the coast of Britain but rarely recorded as it is particularly well camouflaged. Feeds on encrusting bryozoans. New record for Skomer in 2006 and again in 2013. Found on the 2018 survey.	 **NBN atlas 14/11/18**
Palio nothus 	This species is found all around the UK and the north to the Arctic circle. It feeds on Bowerbankia bryozoans. It was first recorded at Skomer during the 2018 survey.	 **NBN atlas 14/11/18**
Thecacera pennigera 	A species that is confined to the south and west coasts of Britain. It feeds on the bryozoan *Bugula plumosa*. It is regularly recorded at Skomer.	 **NBN atlas 14/11/18**
Trapania tartanella 	Found on the Atlantic coasts of Spain and Portugal. A rare species first recorded in Britain at the Manacles, Cornwall in 2007. First record for both Wales and Skomer in 2009, by David Kipling and Sarah Bowen.	 **NBN atlas 14/11/18**

Trapania pallida 	A scarce species found from west Scotland to the Atlantic coast of Spain. It feeds on kamptozoan. First record for Skomer in 2010.	**NBN atlas 14/11/18** 
Trinchesia caerulea 	Found all around the British Isles but most frequently on the west coast of Scotland. It feeds on *Sertularella* hydroids. Recorded in 1975 ,1989, 2009 2013 and 2018	**NBN atlas 14/11/18** 
Tritonia nilsodhneri 	A nationally scarce species (Moore, 2002) found in the south west of Britain. Feeds on the Pink sea fan, *Eunicella verrucosa*. Present in small numbers around Skomer and monitored on the Pink sea fan surveys.	**NBN atlas 14/11/18** 
Zelentia pustulata 	A northern species but regularly found around Skomer.  It feeds on the hydroid *Halecium muricatum.* Recorded on the 2006, 2010 and 2018 surveys.	**NBN atlas 14/11/18** 

6.3.7. Current Status

A total of 79 nudibranch species have been recorded in the Skomer MCZ between 1975 and 2018 from both diving and sediment infauna surveys. Sixty-nine species have been found on those surveys carried out between 2002 and 2014, of which 9 species were unrecorded in the MCZ before 2002. Nudibranch species recorded include several classed as nationally scarce or with limited national distribution in the British Isles.

The diversity of nudibranch species in the Skomer MCZ is very high with 70% of UK species represented in an area of 13.2 square kilometres. This high diversity is a reflection of the diversity of habitats and environmental conditions found in the MCZ and the rich communities that this support. As specialised predators nudibranch species have a very selective choice of prey organisms, they are therefore a good indicator of the overall ecosystem health.

Fifty-eight species were recorded on dives during 2018, representing 84% of the nudibranch species that have been recorded on dives in the Skomer MCZ. This is higher than in 2014 (49 species) and 2010 (54 species). The lower number of species in 2014 was most likely due to the survey sites being covered in a thick layer of silt which buries many of the sessile filter feeding animals: hydroids, bryozoans, sponges and ascidians which are food sources for the different nudibranch species. In contrast there were low levels of silt on the reefs and good diving visibility in both 2010 and 2018 surveys.

6.3.8. Recommendations

- Complete the annual check list;
- Photograph and collect any unusual species for identification;
- Complete a nudibranch species survey in the Skomer MCZ every 4 years.

6.4. Plankton Recording
(CMS Code RB04/01)


Phoronid actinotrocha larvae (D. Conway 2018)

6.4.1. 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.

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

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

6.4.4. Method
Zooplankton:
2008 & 2009: A plankton sample was collected once a week using a 63um 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 200um 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 0.2um 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.

6.4.5. 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 data set, standardised the species list and made recommendations on how the data set should continue (McEvoy *et al* 2013).

6.4.6. Results

Zooplankton:

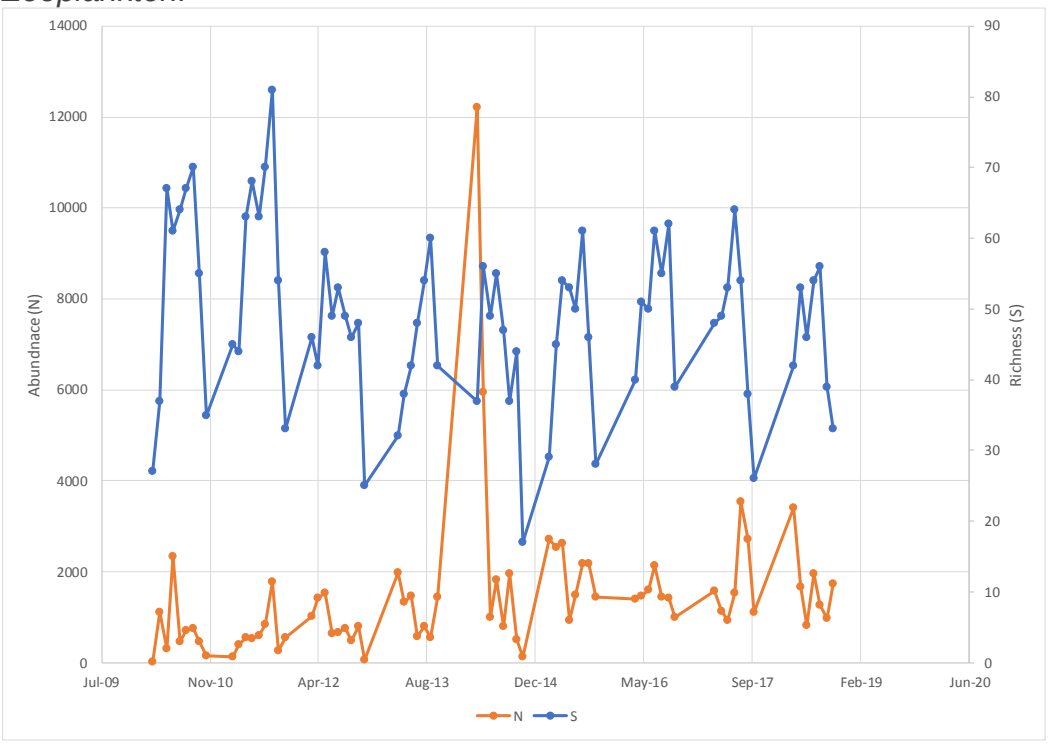


Figure 6.4.1 Average plankton species richness (S) and total number of individuals (N) 2009- 2018

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 data set can be combined to look for seasonal trends.

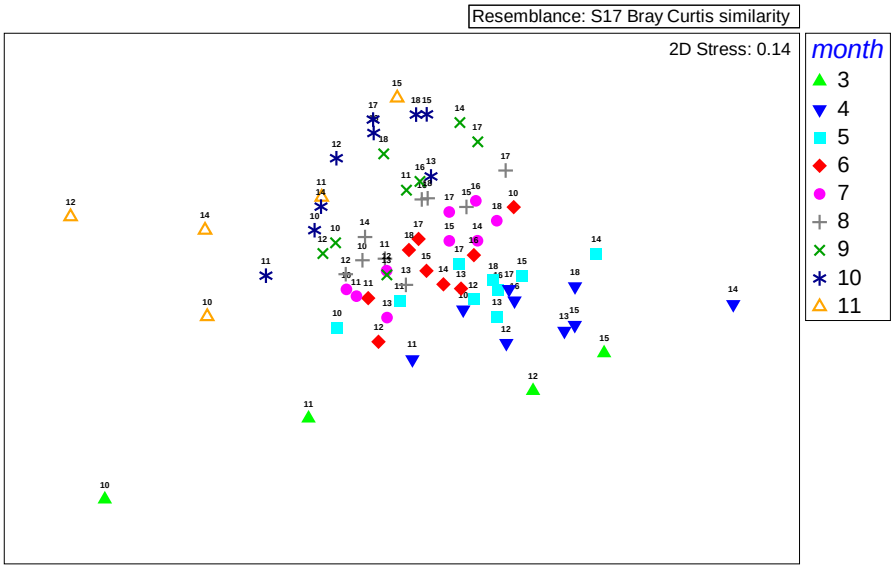


Figure 6.4.2 PRIMER MDS Plot of the whole Skomer MCZ zooplankton data set – symbols denote month, figures denote year.

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. 2018 points appear very close to 2015/16.

There were some notable species recorded in the 2018 samples (D Conway *pers. comm.*): There was a swap-over in chaetognath (Arrow worm) species from *Parasagitta elegans* to *P. setosa* in July, indicating a change in water mass. The only time *Calanus finmarchicus* was found was during this period, at all other times there were low numbers of *C. helgolandicus*. These 2 copepod species have shown dramatic changes in distribution in the North Sea and are indicator species of changes in water temperature. *C. finmarchicus* in a northern species whereas *C. helgolandicus* is suited to warmer waters and has been expanding its range.

There was an obvious intrusion of oceanic water in August/September indicated by the arrival of the pelagic tunicate *Dolioletta gegenbaurau* and the oceanic medusa *Solmaris corona*.

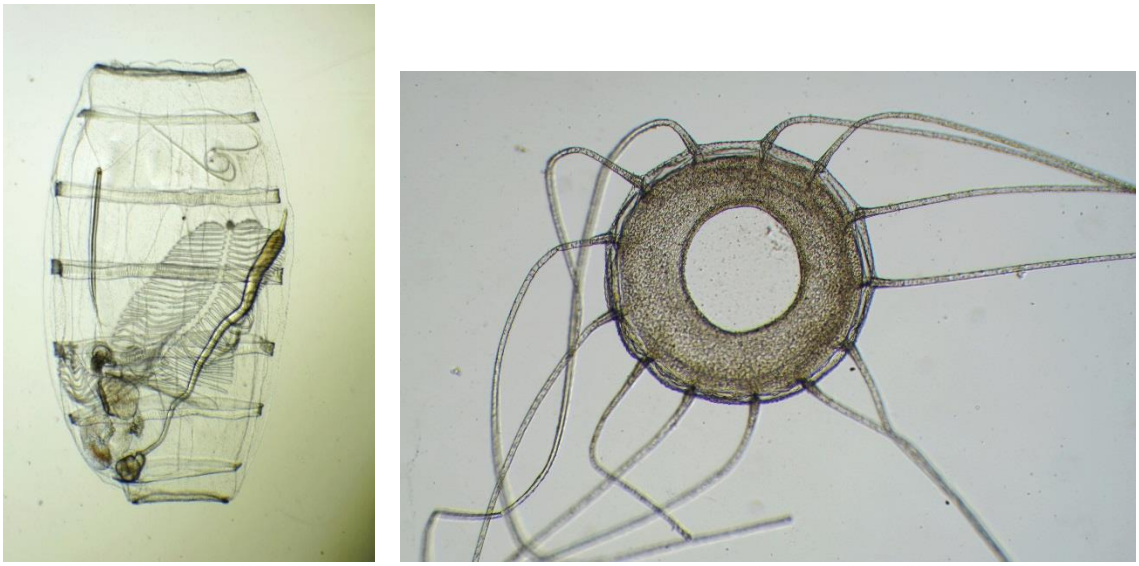


Figure 6.4.3 *Dolioletta gegenbaurau* (left) and *Solmaris corona* (photographs -D. Conway 2018).

6.4.7. Current Status

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

6.4.8. Recommendations

- Continue to collect further seasonal data for zooplankton, to assess its variability.
- Restart the water sampling for chlorophyll or phytoplankton.
- Compare data sets to Plymouth Marine Laboratory L4 site to help ascertain natural variability and give geographic context.
- Publish a descriptive paper with Plymouth Marine Laboratory.

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

6.5.1. 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.

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

6.5.3. Sites

	Date started
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)

6.5.4. Methods
- 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'.
- Photographs are taken using a single camera mounted on a 50 x 70 cm frame. Both sides of the sea fan are photographed.
- 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.*
- 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.
- The photographs are analysed using image analysis techniques.

6.5.5. Project history

Image analysis

- 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.

6.5.6. Results

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					
1995	4	33	33			1		
1996	4	33	33					
1997	5	39	39					
1998	5	39	39					
1999	0							
2000	5	54	54					
2001	5	55	55			1		
2002	9	86	86			1		
2003	9	99	99		1			
2004	9	101	100					
2005	10	114	111	3	1	1		
2006	10	119	116	3	7			
2007	10	121	118	3	1	2		
2008	10	126	122	4		1		
2009	10	128	121	7				
2010	10	126	120	6		3	1	
2011	10	126	122	4			2	
2012	10	126	121	5		1		
2013	10	129	124	5				
2014	9	124	120	4				
2015	10	125	123	2		3	2	
2016	10	118	115	3	1	9		
2017	10	114	112	2		3	1	
2018	10	110	108	2	1			6
totals					11	26	6	

Table 6.5.1 Skomer MCZ sea fan survey results 1994 -2018

Losses

A total of 26 losses of natural sea fans and 6 of artificially attached fans have been recorded throughout the period of this project.

In 2017, 4 natural sea fans (BH25, BRKw2, RRK14 and MDS5) and 1 artificially attached fan (POL4) were missing, of these only MDS5 was found again in 2018, the others confirmed as losses.

One sea fan lost in 2016, BH21, was reduced to a stump, however, new growth was observed in 2018 and the fan has been added back onto the total numbers in the survey. Other fans which have been lost but where a base or stump is still present are being checked for any new growth.

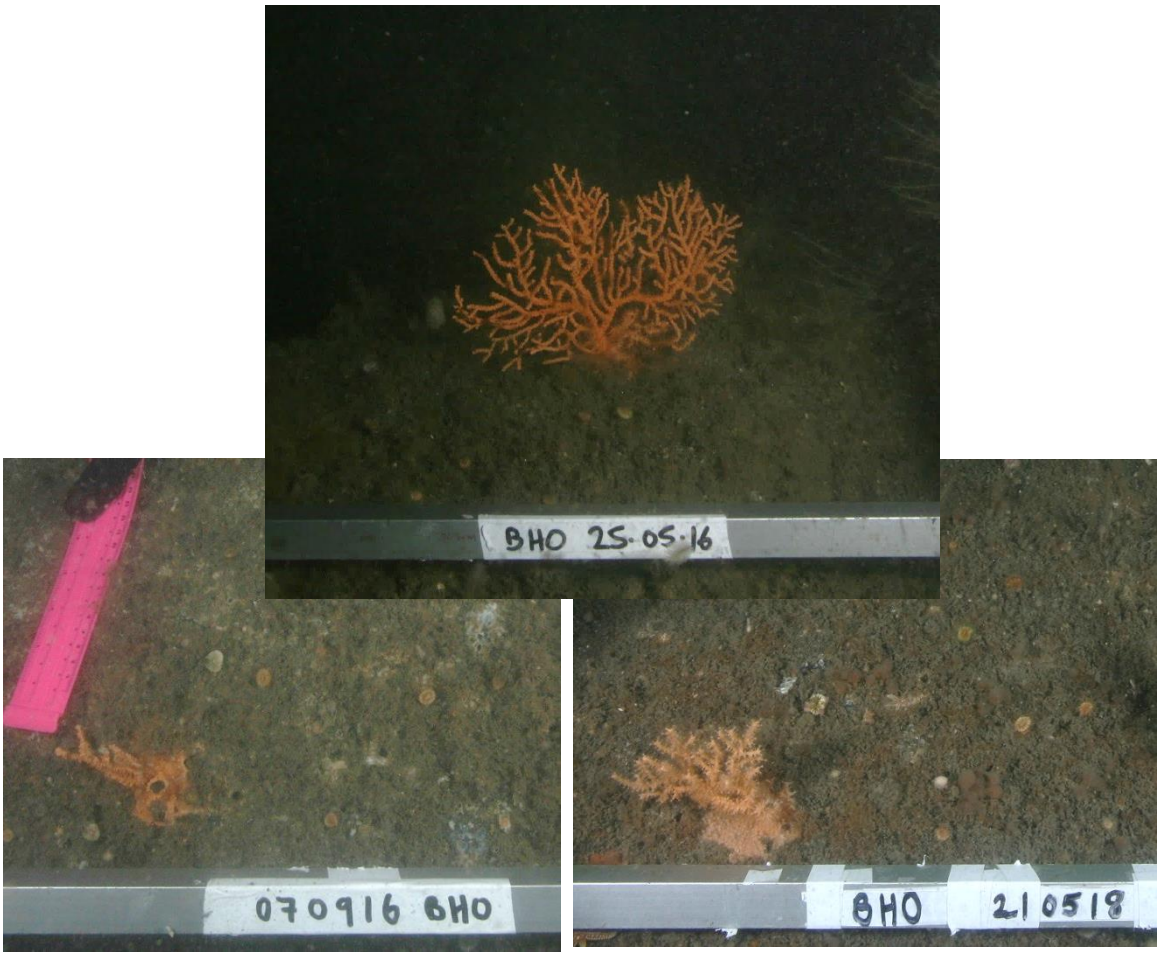


Figure 6.5.1 Sea fan BH21 May 2016, reduced to stump September 2016, new growth recorded in 2018.

Five additional fans were absent in 2018, BH8, BH18, BRK7, POL8 and POL9, these will be checked, and their status confirmed in 2019. Only four of the group of 5 small sea fans at Bull Hole was present and this will be checked again in 2019.

Between 2015 to 2018 there has been an unusually high number of losses with 15 natural fans and 3 artificially attached fans confirmed as gone and further 5 fans absent in 2018 to be confirmed as losses.

In an attempt to understand potential causes behind the loss of sea fans at Skomer MCZ human activity data for 2017 (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).

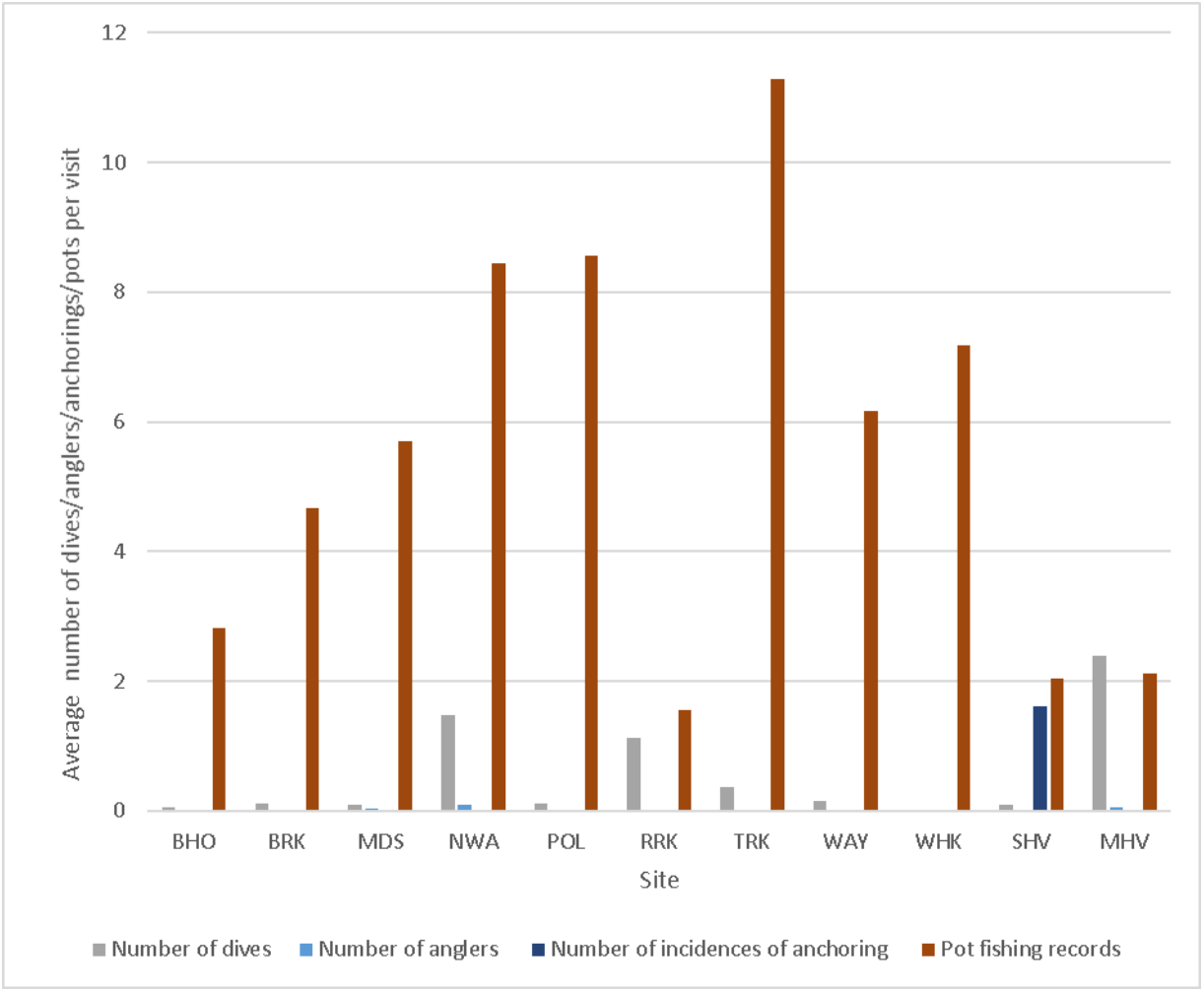


Figure 6.5.2 “Seabed contact” activities at Skomer MCZ sea fan monitoring sites in 2017.

Data presented in Fig 6.5.2 is corrected for differences in the numbers of days on which data was 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 2017 (BHO, BRK, RRK, 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 should be noted that all data is 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 11 years and in 2018 only 4 were found. There was 1 recorded recruitment in 2018.

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

Table 6.5.2 Skomer MCZ sea fan recruitment

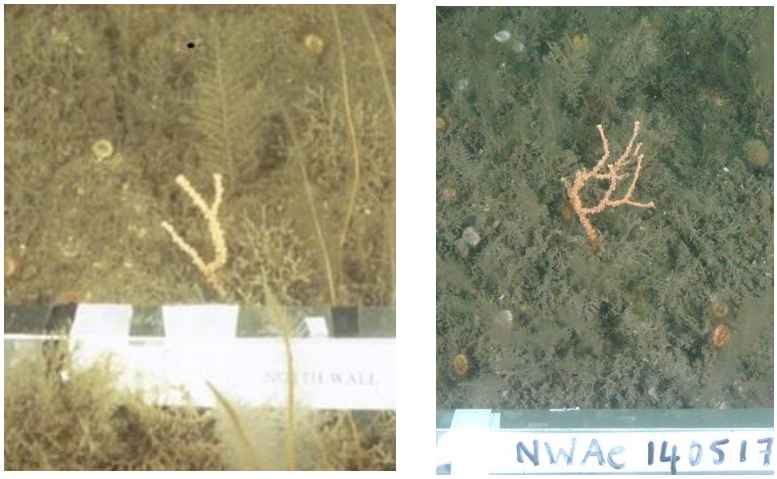


Figure 6.5.3 Pink sea fan, *Eunicella verrucosa,* NWAe15, 2005 and 2018.

Sea fan condition

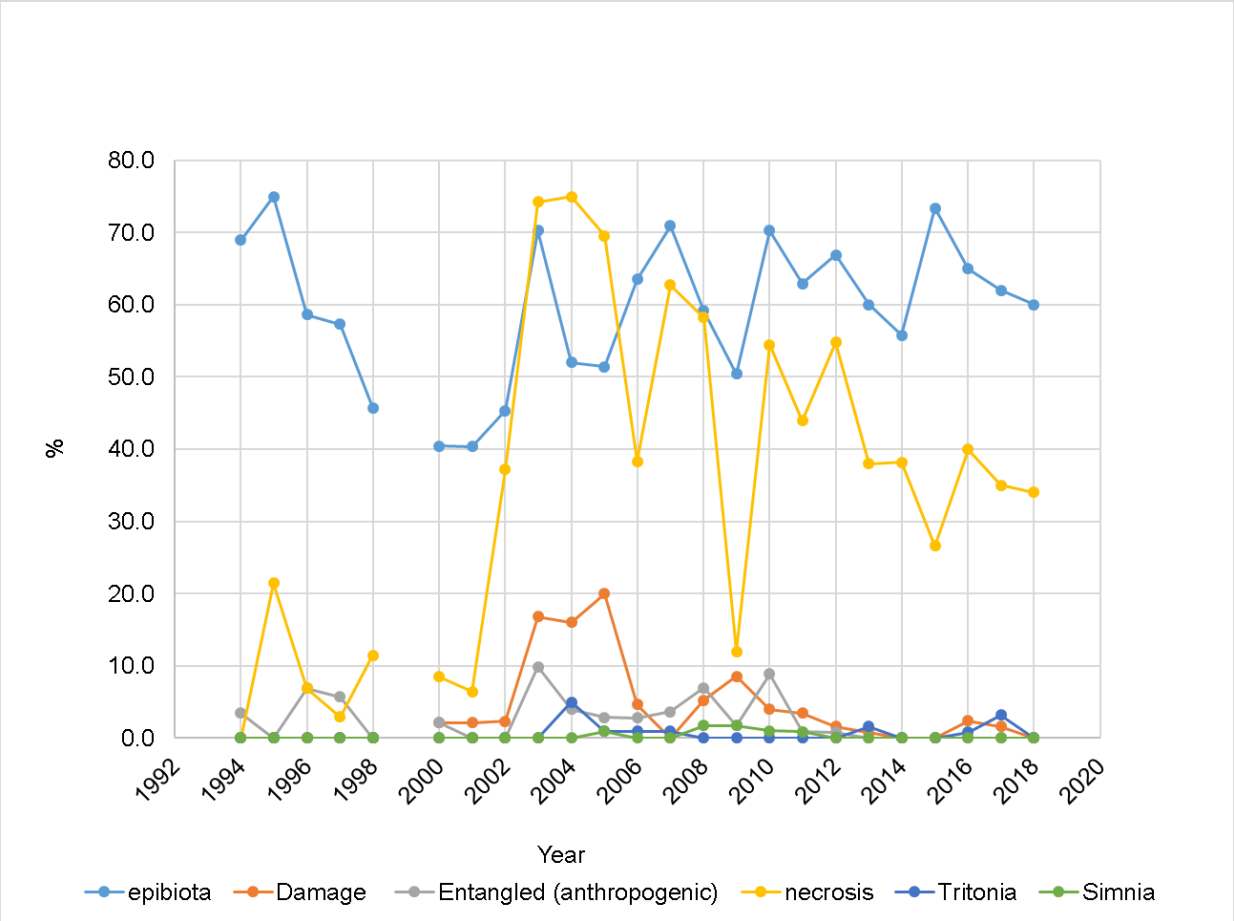


Figure 6.5.4 Condition of sea fans in the Skomer MCZ from photographic images (1994-2018) and field data (2002-2018).

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 7 years - in 2018 necrosis was 34%, lower than the average level of necrosis since 2002 (17 years) of 47%.

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 a fan.
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 61% of sea fans have been

recorded with attached or entangled epibiota for the last 17 years of surveys. In 2018 this was on 60% of the fans.

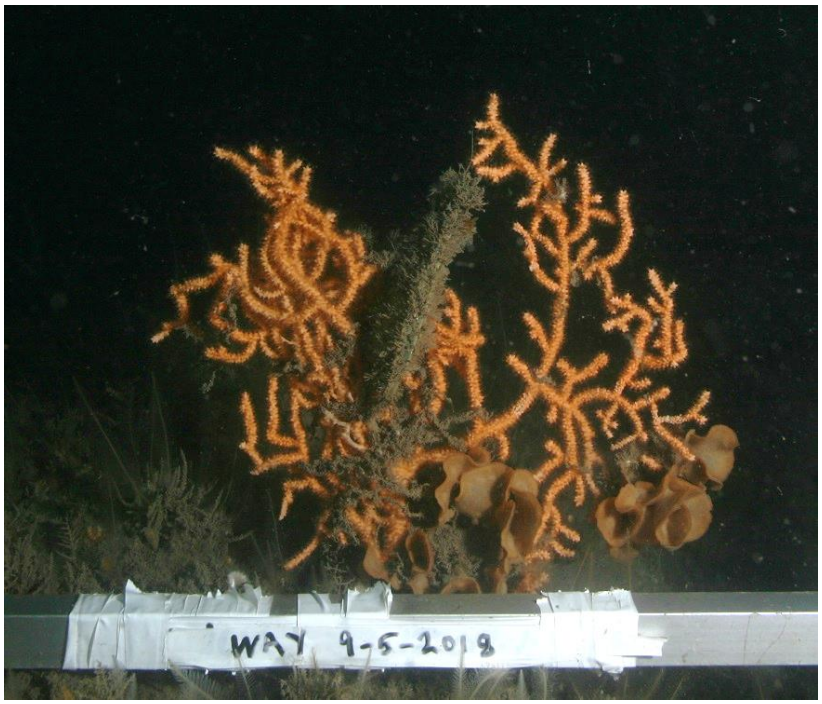


Figure 6.5.5 Epibiota entanglement, dogfish eggs and ross coral *Pentapora foliacea*.

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 between years of individual sea fan. Whenever possible the line is cleaned off the fan to allow recovery. No entanglements were recorded in 2018.

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 2018 on a fan at Highpoint, not on one of the monitored fans.

6.5.7. Supported research

- 2002 Reef Research - Sea fan reproductive biology. Small clippings were taken from some fans 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).

6.5.8. Current Status

- Numbers: There have been 32 confirmed sea fans lost from the monitoring sites between 1994 and 2018 and there are 5 further possible losses in 2018.
- 3 naturally attached and 1 artificially reattached sea fans missing in 2017 have been confirmed as lost.
- There was one new recruit in 2018.
- Condition: Necrosis occurrence was found in 34% of the sea fans, which is lower than the average of 47% recorded for the last 17 years. Epibiota was recorded on 60% of the sea fans; close to the average of 61% recorded for the last 17 years.
- Losses during 2018 have yet to be confirmed.
- 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.

6.5.9. Recommendations

- Observe persistence of biotic fouling/entanglement e.g. dogfish eggs;
- Take close-up photos of all ”new recruits”/small sea fans found;
- 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;
- Report status as unfavourable declining.

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

6.6.1. 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.

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

6.6.3. Sites

	Date started:
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)

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

	Sequence
North Wall Stereo bar	3 quadrats
North Wall (main)	five vertical transects
Thorn Rock mooring	two fixed position quadrats
Sandy Sea Fan Gully	two vertical transects
North Wall East	two vertical transects
Rye Rocks	one transect
Junko's Reef	one 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.

6.6.5. Results

Quadrat results for the following sites are shown in the table and 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).

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NWA	15	19	19	23	19	9	14	10	2	6	3	0	0	0	0	0	0
NWEast	6	5	6	6	7	6	6	6	6	7	7	6	6	6	6	6	6
SSFG	9	9	9	5	9	3		3	2	4	2	0	0	1	0	0	0
TRK	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2
RRK				6	8	6	5	5	6	4	3	1	0	1	0	0	0
JUNKO														4	4	6	7

Table 6.6.1 Number of quadrats with *A. glomeratum* present.

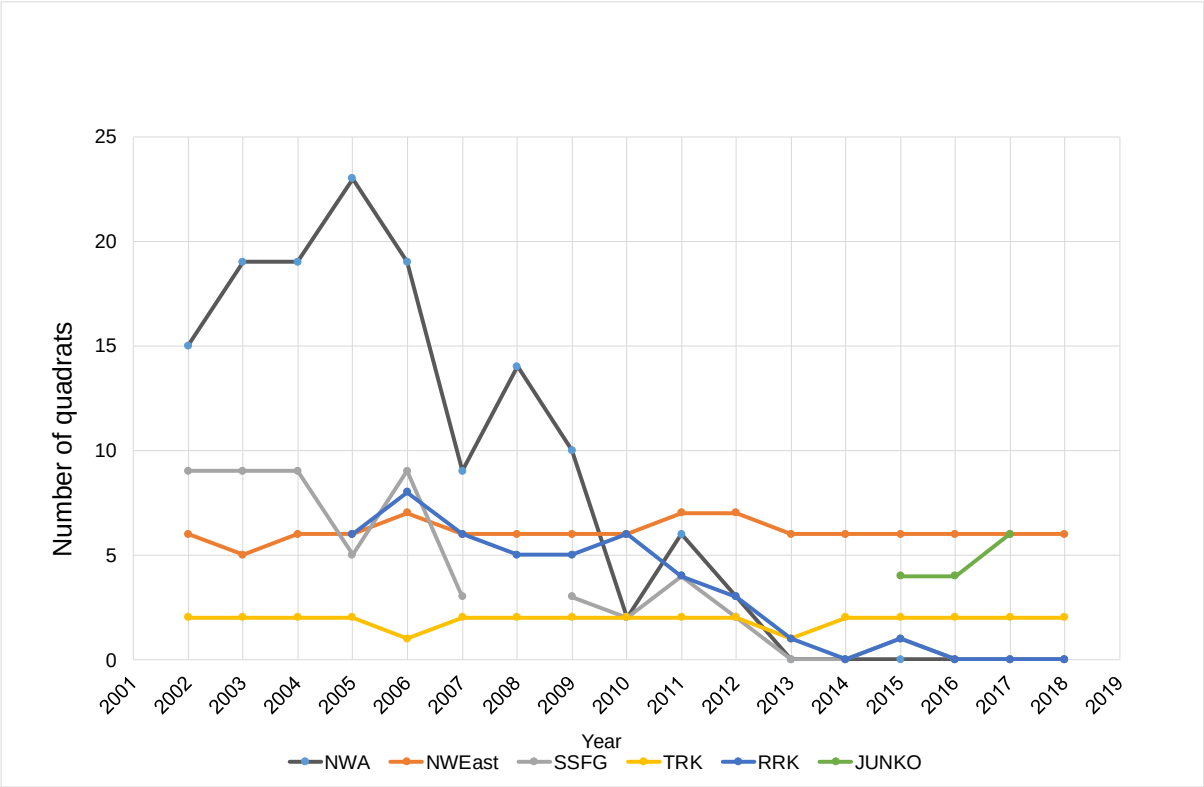


Figure 6.6.1 Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2018.

All sites except NWA East show a decreasing trend in the coverage of *A. glomeratum* colonies. From 2013 onwards North Wall and Sandy Sea fan gully have had no visible colonies of *A. glomeratum*.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NWA	34.0	23.8	19.0	21.2	22.7	8.3	11.1	6.4	3.0	9.3	1.0	0.0	0.0	0.0	0.0	0.0	0
NWEast	80.0	69.6	67.5	65.2	59.3	63.7	66.0	59	59.7	53.4	55.3	50.2	57.3	53.5	47.5	30.4	33
SSFG	7.2	8.4	7.1	3.0	5.3	5.3		1.0	0.5	0.4	0.4	0.0	0.0	0.2	0.0	0.0	0
TRK	12.5	17.5	10.5	15.5	24	11.5	13	6.5	15.0	13.0	16.5	13.5	10.0	8.5	14.5	11.5	17
RRK				5.3	10.3	8.0	9.8	10.0	7.2	4.8	3.3	14.0	0.0	0.1	0.0	0.0	0
JUNKO														75.3	77.5	71.8	66.9

Table 6.6.2 Mean Frequency count from Skomer MCZ quadrats with *A. glomeratum* occurring

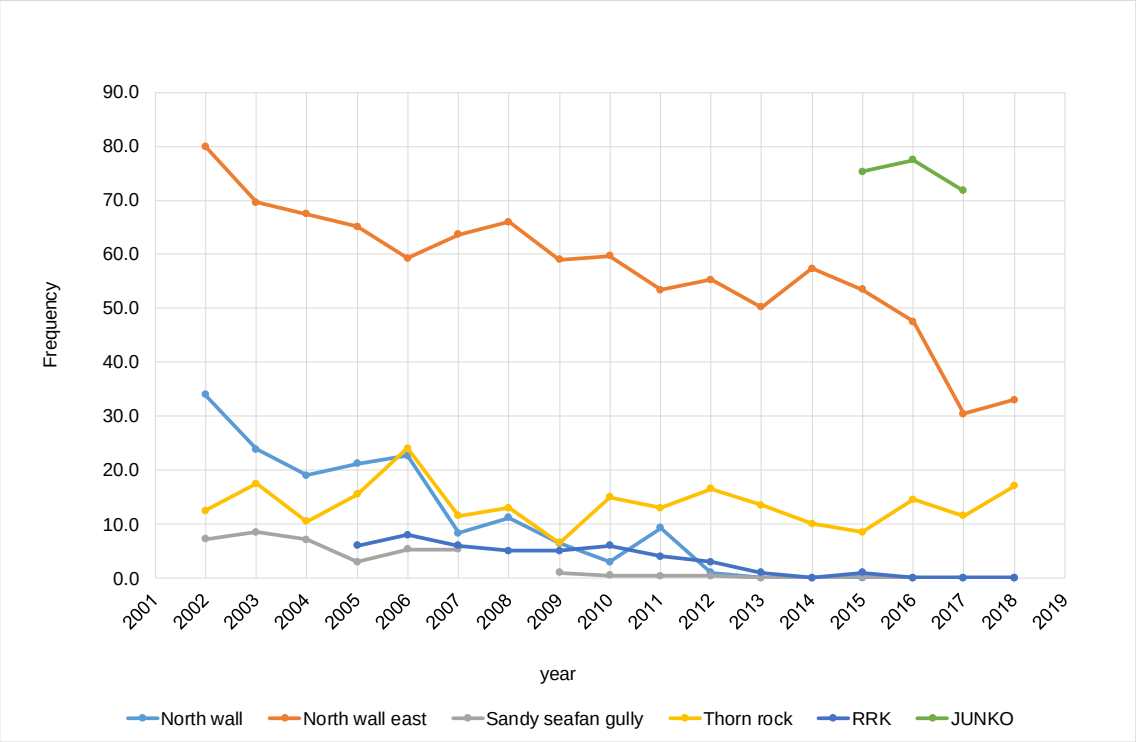


Figure 6.6.2 Mean frequency of *A. glomeratum* within quadrats Skomer MCZ 2002 – 2018.

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 quadrats on the north side of Skomer runs back to the 1980's. The quadrats have been photographed annually for most years since 1988.

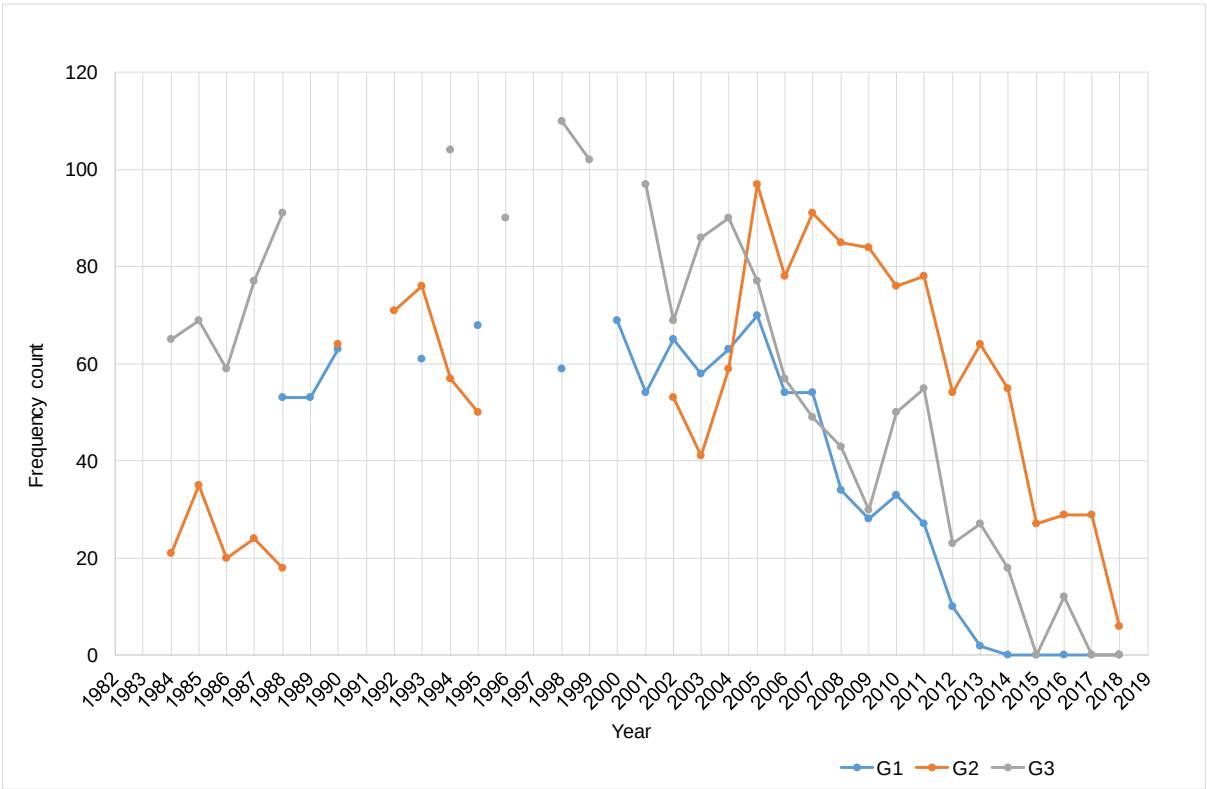


Figure 6.6.3 Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North wall – Skomer MCZ

All three quadrats show a similar trend of increasing cover peaking in the late 90's- early 2000's and then declining from 2006 onwards. *A. glomeratum* has now virtually disappeared at this site (2018).

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

Example photographs of "then and now"

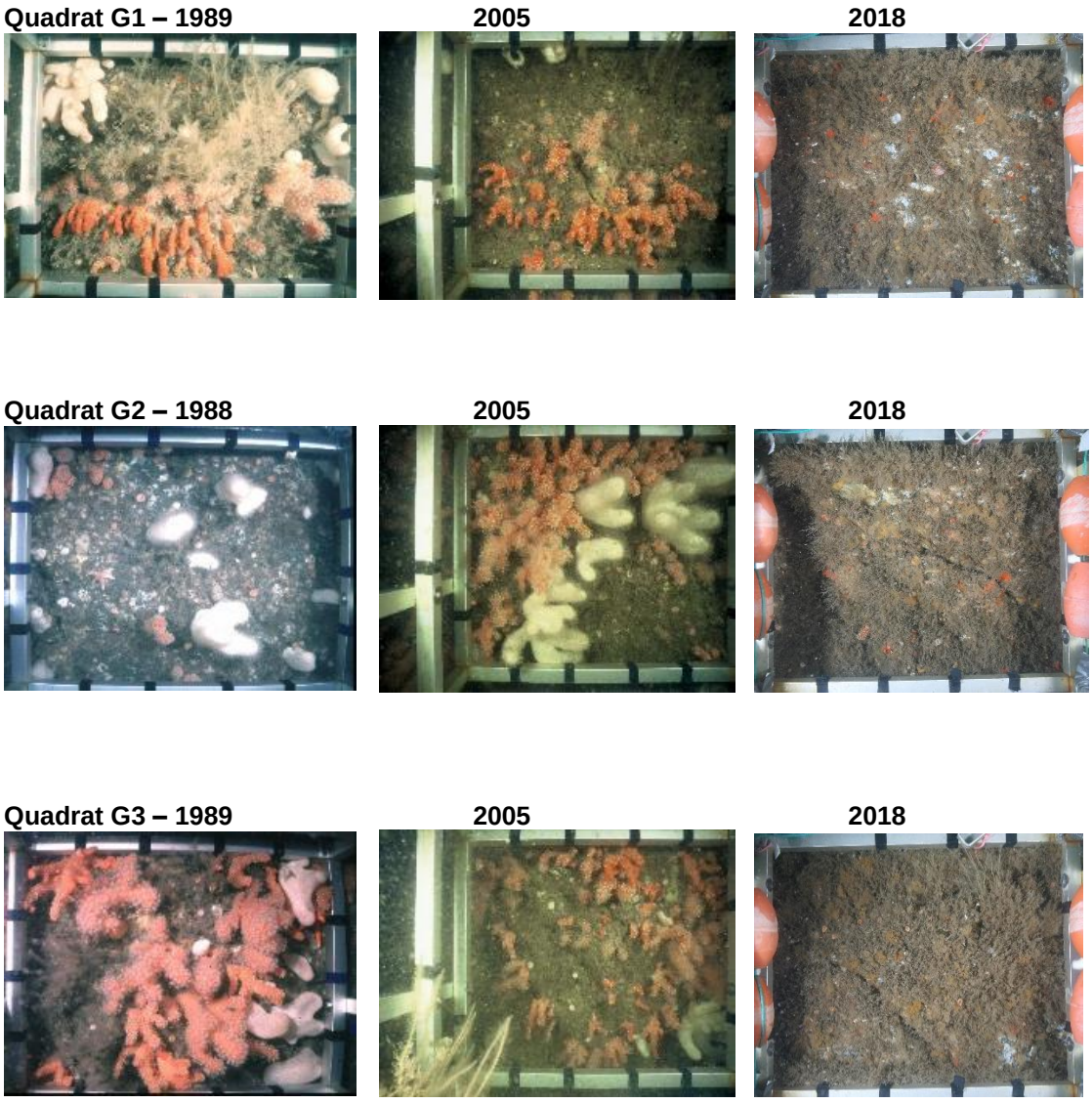


Figure 6.6.4 Photographic examples of declining populations of *A. glomeratum* at Skomer MCZ between 1989 and 2018.

6.6.6. 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*. 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.

6.6.7. 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.

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

6.7.1. 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.

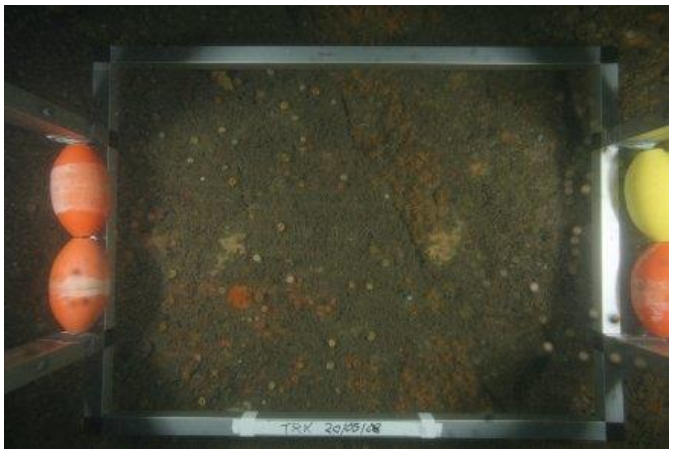
6.7.2. Objectives
Monitor *P. axinellae* colonies for changes in polyp density and colony area.

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

6.7.4. 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 6.7.1 Density: 20 x 20cm framer



Colony area: 50 x 70cm framer

6.7.5. Results

Colony area		**Density**
Site	**Index of Area**	**Close up photographs**
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

Table 6.7.1 Fieldwork completed at Skomer MCZ in 2018

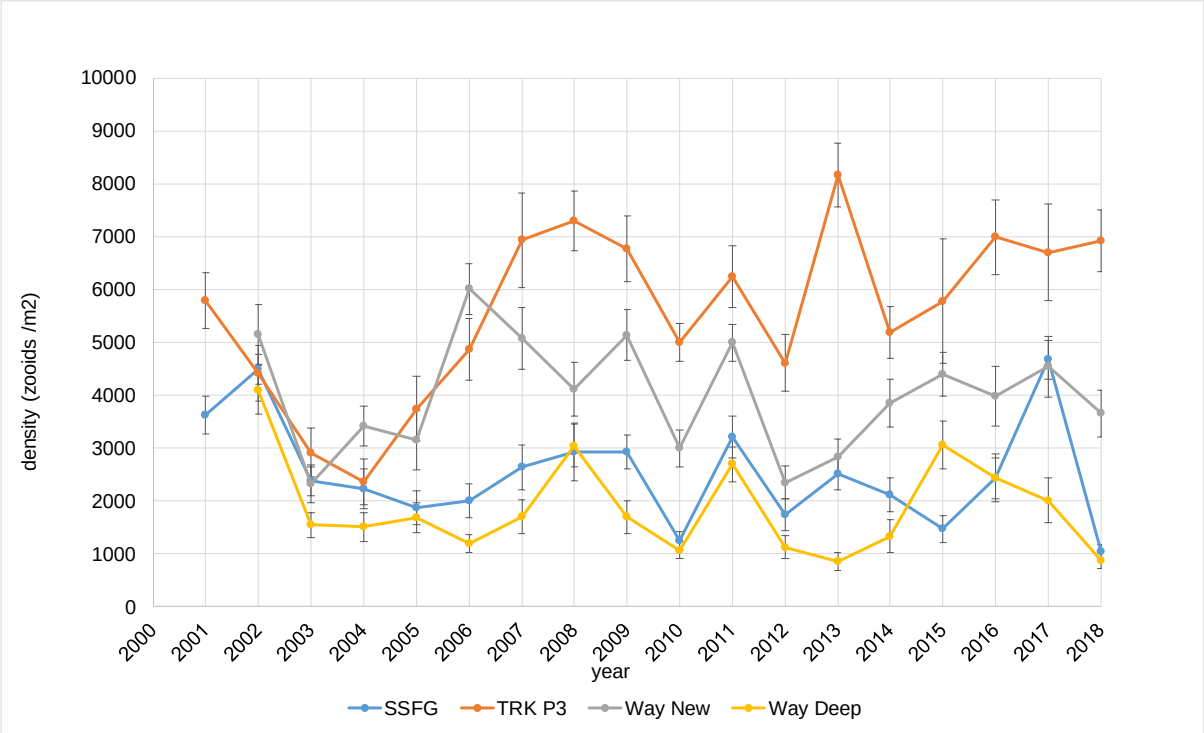


Figure 6.7.2 Density of *P. axinellae* polyp (numbers of polyps /m^2) at Skomer MCZ sites 2001 – 2018

TRK and Way New sites showed little change in density but SSFG and Way Deep both had a significant drop in density.

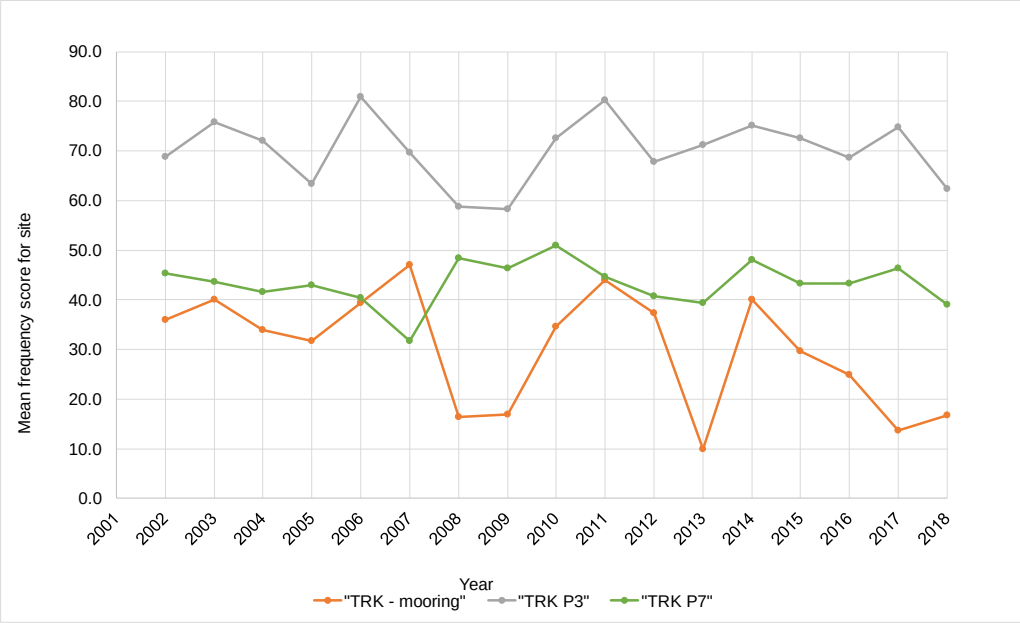


Figure 6.7.3 Mean frequency of *Parazoanthus axinellae* 2002 – 2018. Thorn Rock (TRK) transects.

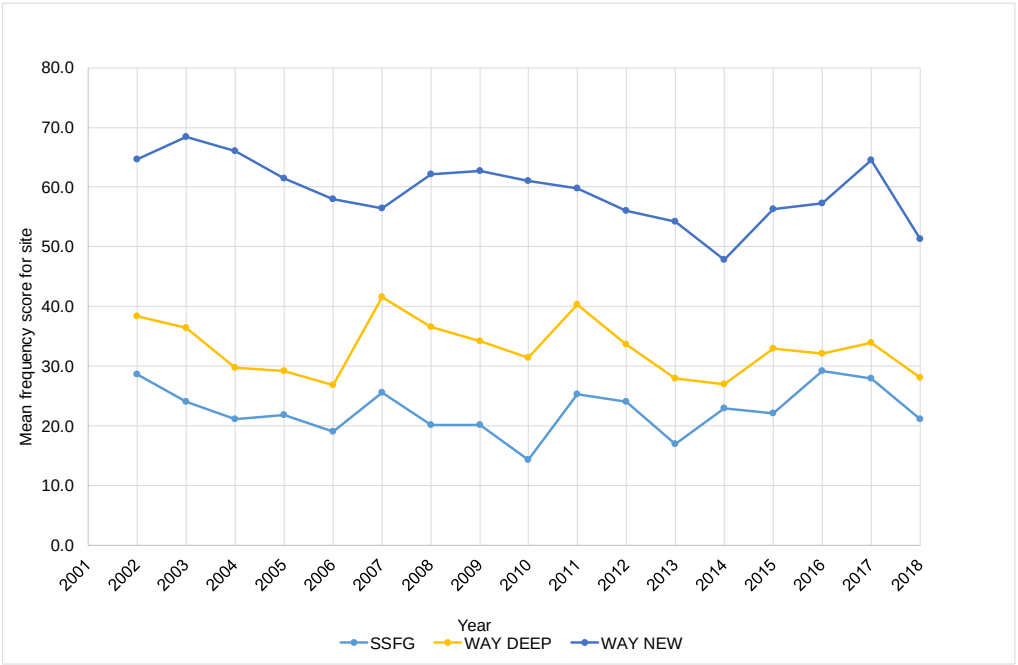


Figure 6.7.4 Mean frequency of *Parazoanthus axinellae* 2002 – 2017. Other Skomer MCZ sites

All sites except TRK-mooring declined in coverage in 2018.

6.7.6. Current Status

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

6.7.7. 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.

6.8. *Pentapora foliacea* (ross coral) Population

CMS code: RM63/01

6.8.1. 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.

6.8.2. Objectives

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

6.8.3. Sites

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

Table 6.8.1 *Pentapora foliacea* monitoring sites at Skomer MCZ in 2017

6.8.4. 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.

6.8.5. 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.

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.

Year	North Wall	Waybench	Bernies Deep	Bernies Shallow	North Neck	South Middlehom	West Hook	Pool
1993	yes	yes						
1994	yes			yes				
1995	yes		yes	yes				
1996	yes							
1997	yes		yes	yes				
1998	yes		yes	yes				
1999	yes							
2000	yes		yes	yes				
2001	yes							
2002	yes	yes	yes	yes	yes	yes		
2003		yes	yes	yes	yes	yes		
2004		yes	yes	yes	yes	yes	yes	
2005		yes	yes	yes	yes	yes	yes	
2006		yes	yes	yes	yes	yes	yes	
2007		yes	yes	yes	yes	yes	yes	
2008		yes	yes	yes	yes	yes	yes	
2009		yes	yes	yes	yes	yes	yes	
2010		yes	yes	yes	yes	yes	yes	
2011		yes	yes	yes	yes	yes	yes	
2012		yes	yes	yes	yes	yes	yes	
2013		yes	yes	yes	yes	yes	yes	yes
2014		yes	yes	yes	yes		yes	yes
2015		yes	yes	yes	yes	yes	yes	yes
2016		yes	yes	yes	yes	yes	yes	yes
2017		yes	yes	yes	yes	yes	yes	Yes
2018		yes	yes	yes	yes	yes	yes	yes

Table 6.8.2 *Pentapora foliacea* photo dataset for Skomer MCZ

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.

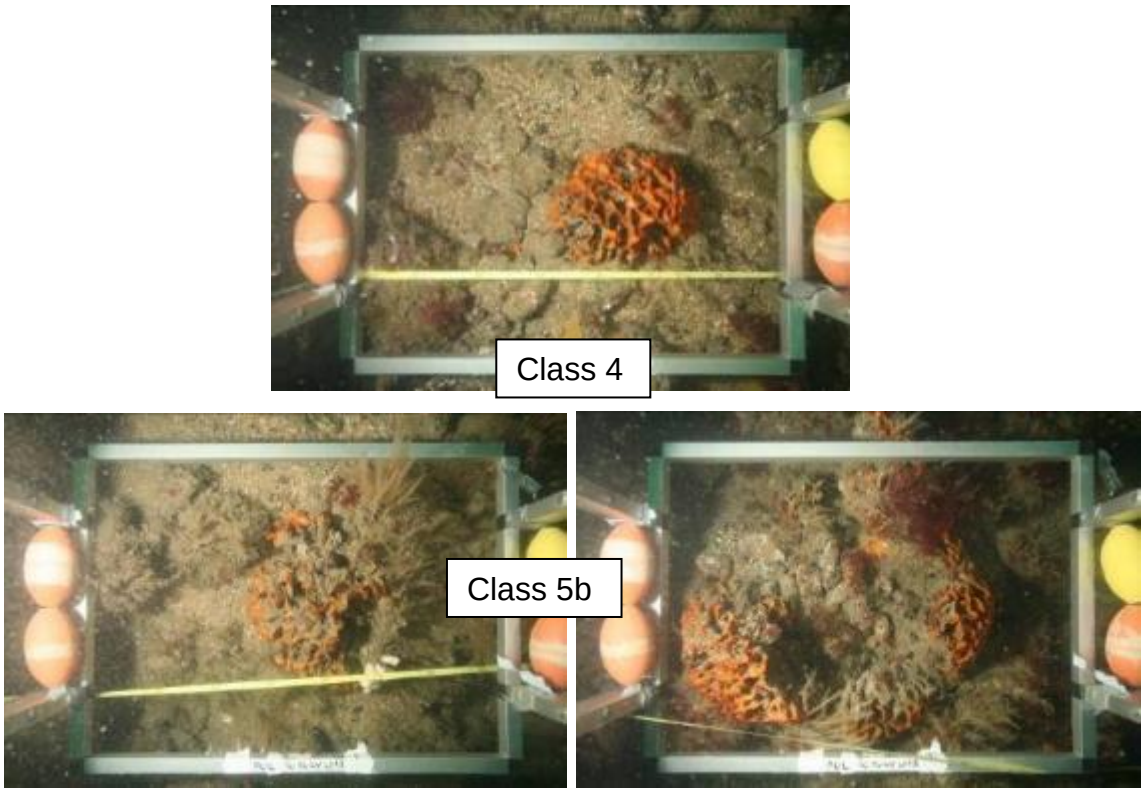


Figure 6.8.1 *Pentapora foliacea* - examples of Class 4 and Class 5b colonies.

6.8.6. Results

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.

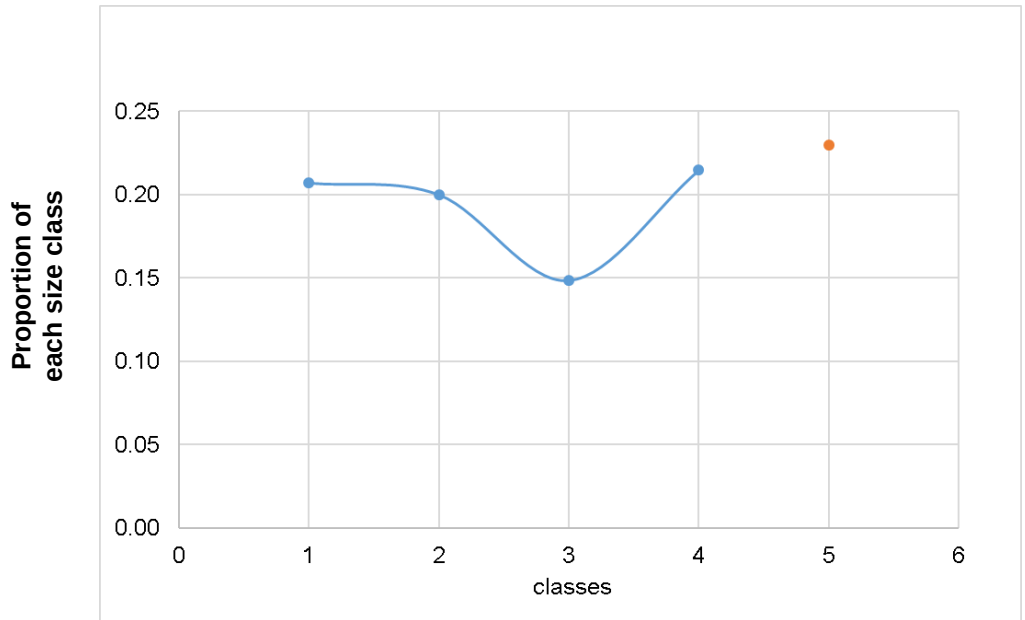


Figure 6.8.2 *Pentapora foliacea* - normalised population curve for all Skomer MCZ sites

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 2018 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.

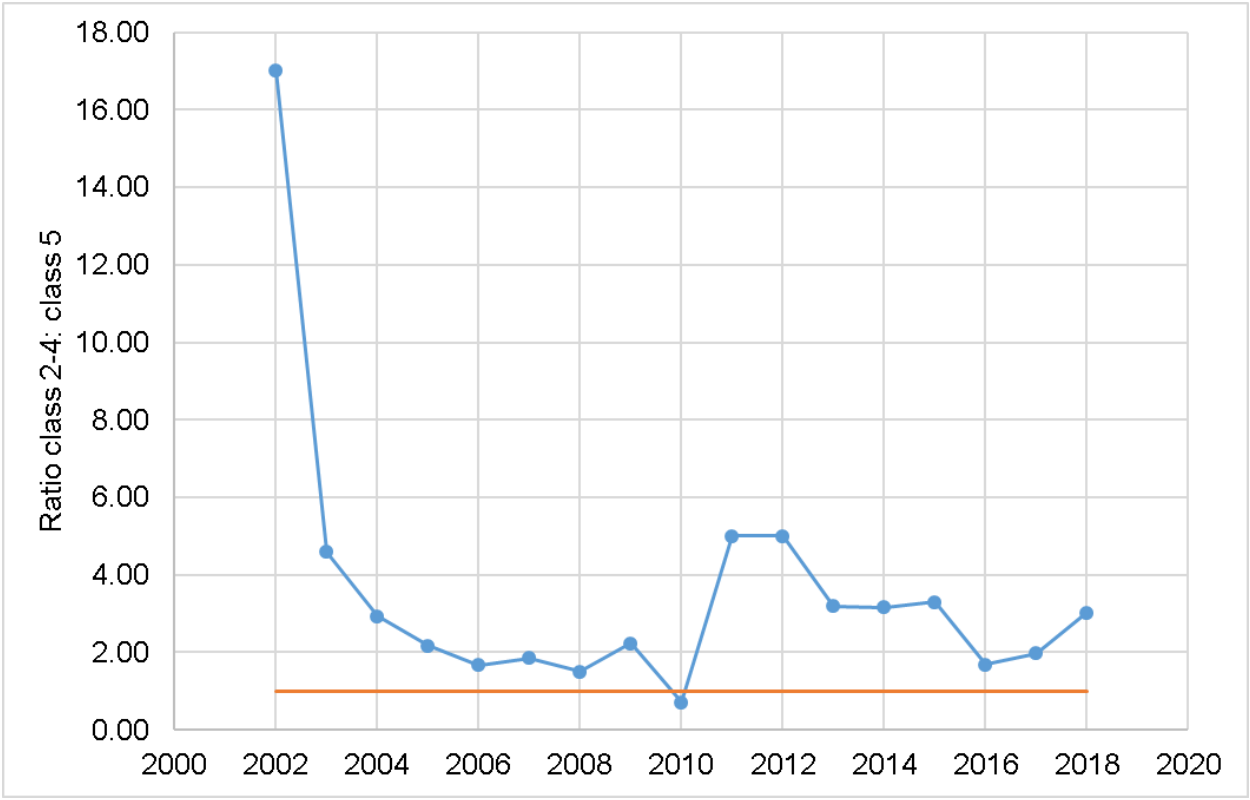


Figure 6.8.3 *Pentapora foliacea* - ratio of class 2-4 colonies to class 5 colonies - all Skomer sites

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.

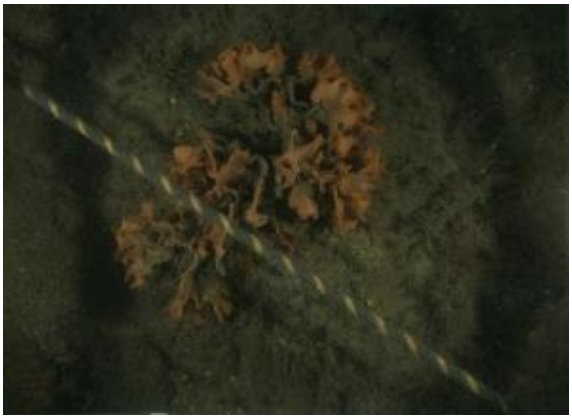


Figure 6.8.4 *Pentapora foliacea* – interaction with fishing gear

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

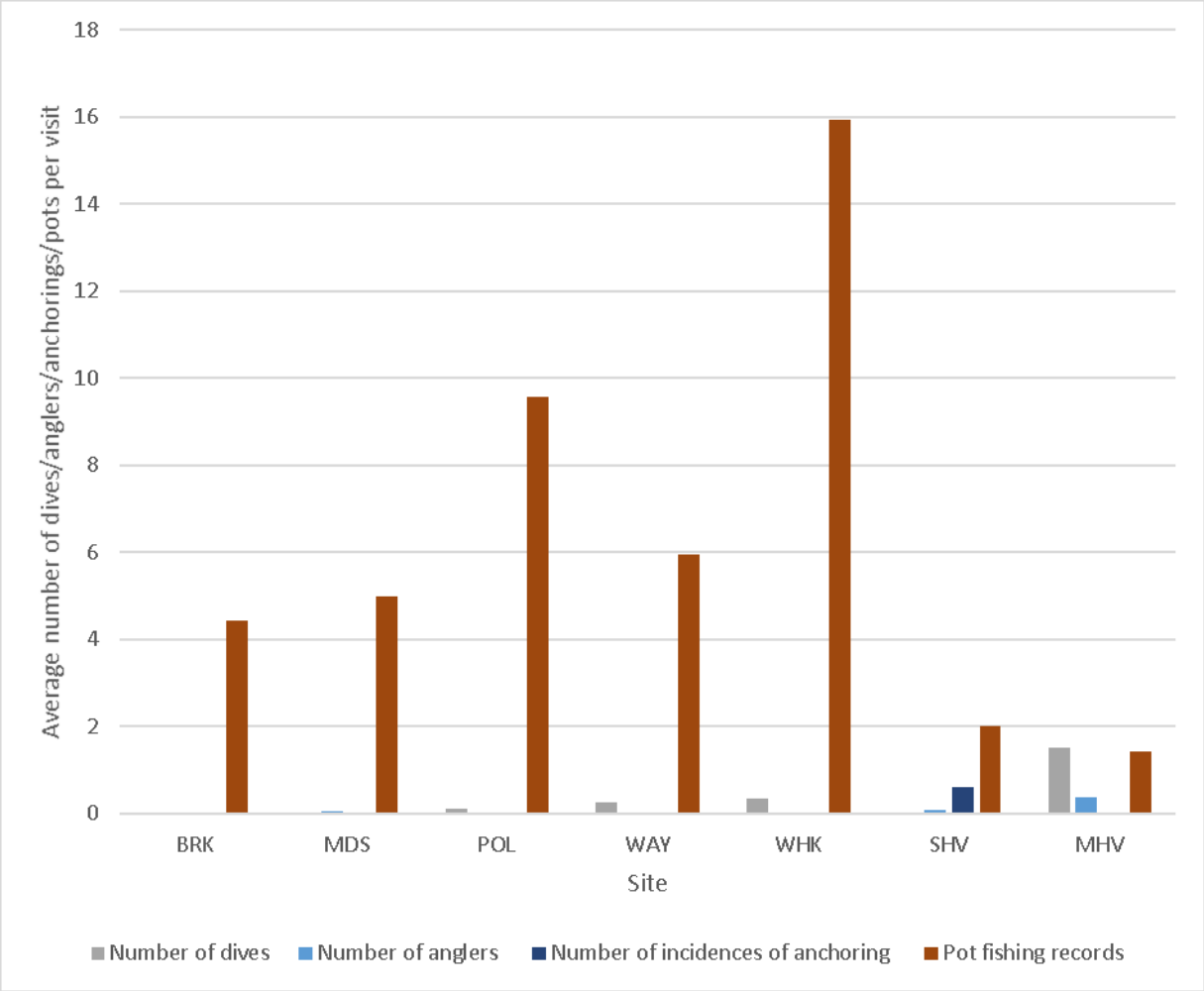


Figure 6.8.4 "Seabed contact" activities at Skomer MCZ *Pentapora foliacea* monitoring sites in 2018

Levels of these different activities at *P. foliacea* monitoring sites can be seen in Fig 6.8.4. 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.

6.8.7. 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. After three years of apparent stability the proportion of "healthy" colonies has slightly decreased again, but remains higher than the proportion of "degraded" colonies. The question remains 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).

6.8.8. 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.

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

6.9.1. 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.

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

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

6.9.4. 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.

6.9.5. Results
Balanophyllia regia:
At the Wick all data has 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.

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
WCK A	Mean	412	329	435	236	455	409	479	486
	S.E.	59	40	66	39	55	51	62	59
WCK C	Mean	674	453	608	399	541	702	259	651
	S.E.	93	71	83	62	85	97	36	75
WCK B	Mean	344	232	295	291	356	386	170	379
	S.E.	79	49	69	80	96	92	32	88

Table 6.9.1 Mean abundance (and standard error) of *Balanophyllia regia* in The Wick (adjusted to 1m^2).

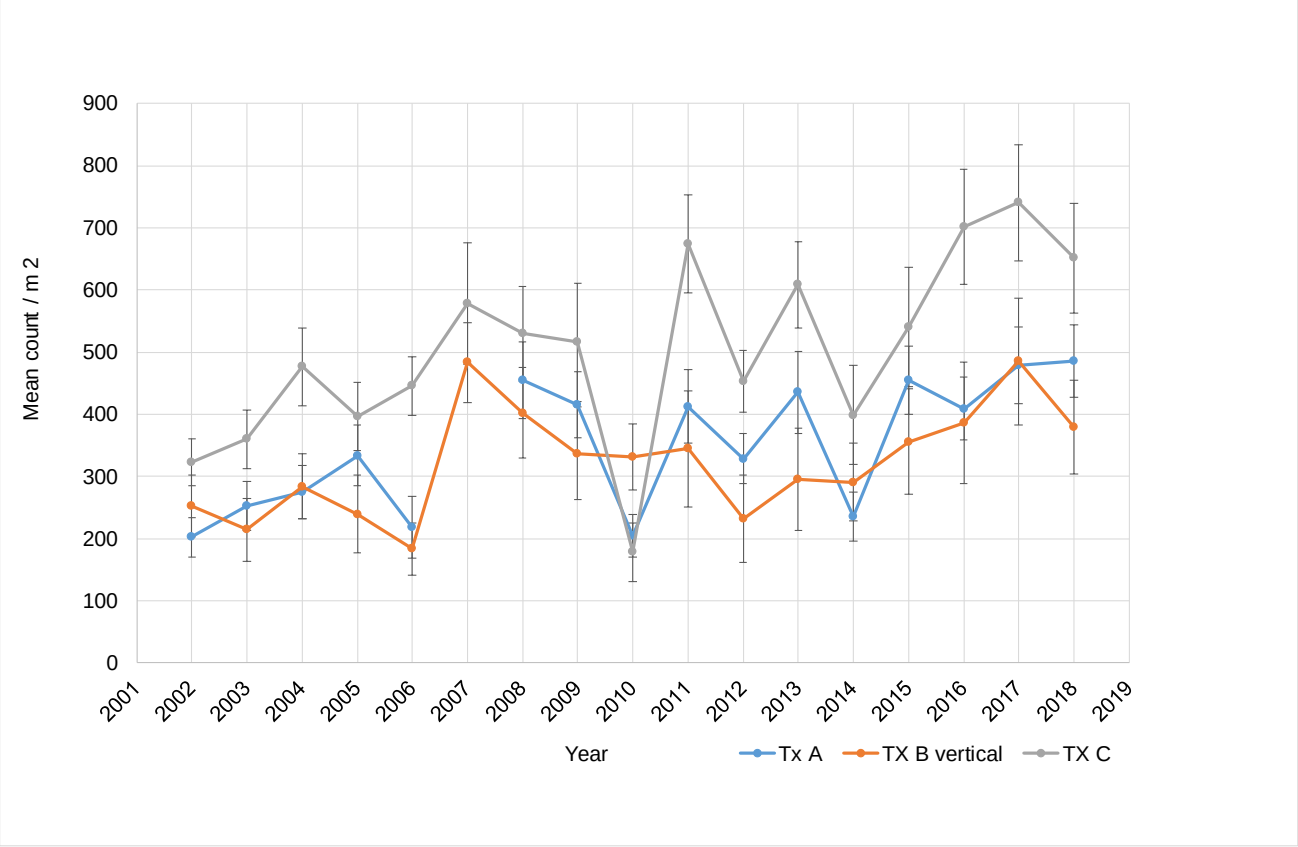


Figure 6.9.1 *Balanophyllia regia* abundance at Transects A, B and C at the Wick.

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). This might explain why counts were higher in 2018 when silt was reduced and more cup corals were visible. 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 2018. 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.

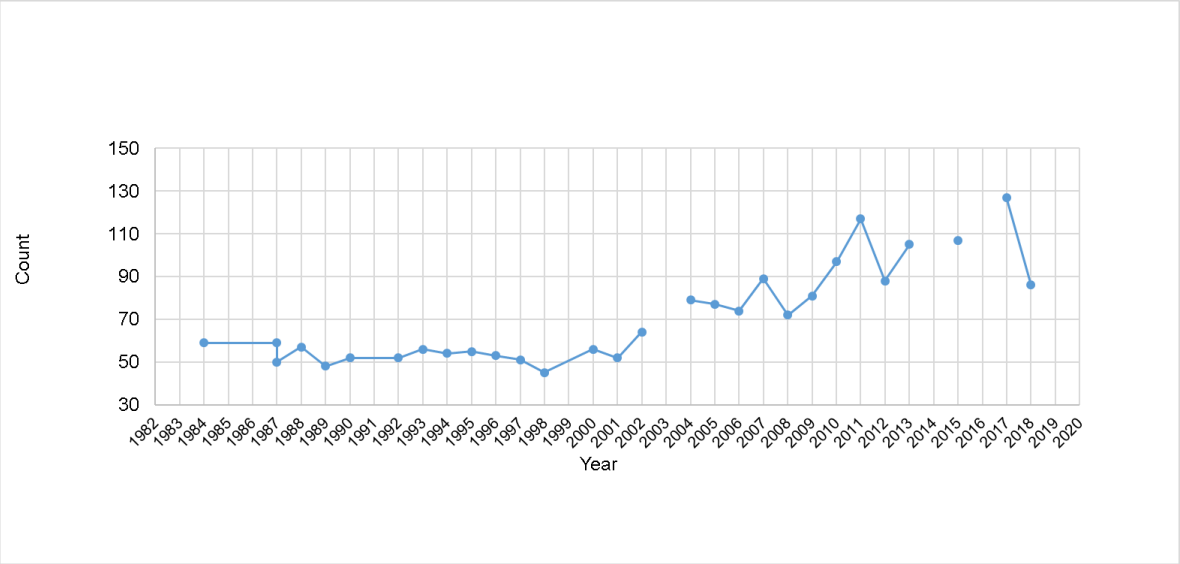


Figure 6.9.2 Thorn Rock boulder *Balanophyllia* regia counts (per 40 x 50cm quadrat)

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 drop in abundance in 2018 is interesting as the silt levels were very low and the photograph quality was very good. It isn't known how long these cup corals live and how variable their numbers are.

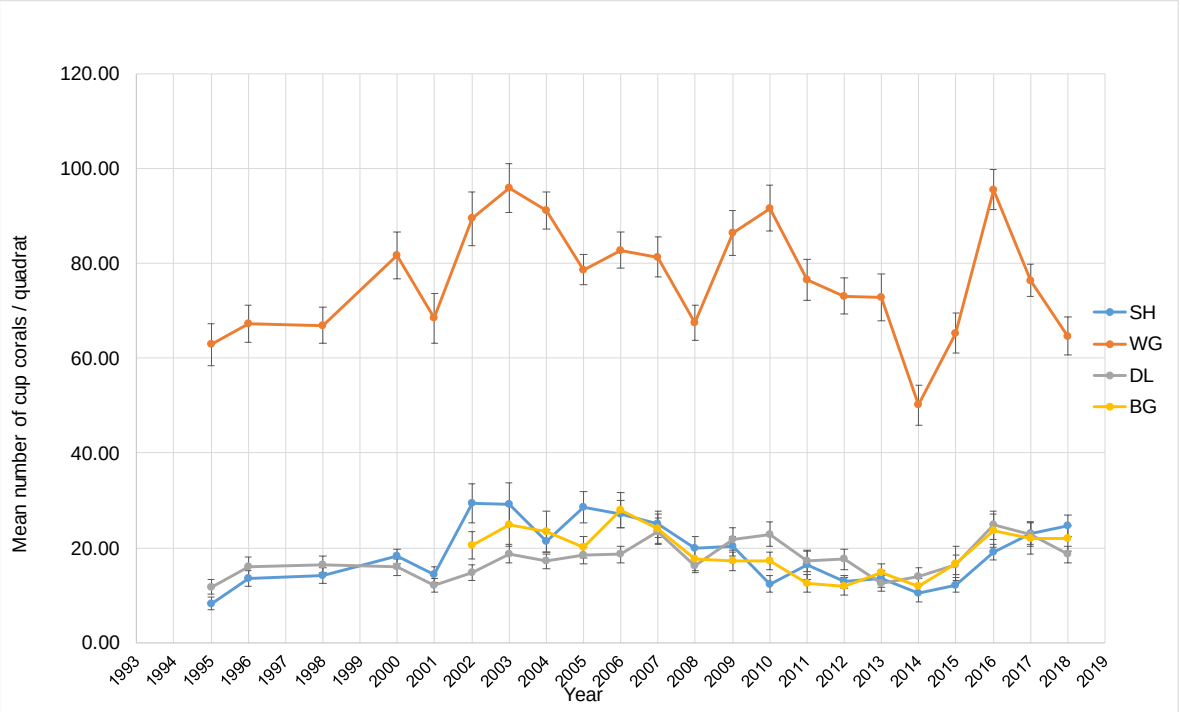


Figure 6.9.3 Mean Number of *Caryphyllia smithii* per 50 x 70 cm quadrat at Thorn Rock (4 transects) 1996 – 2018

6.9.6. 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.

6.9.7. 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.

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

6.10.1. 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).

6.10.2. 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.

6.10.3. Sites
All pupping beaches and caves in the MCZ.

6.10.4. 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).

The Skomer sites are completed through a contract and a full survey report is produced, the mainland sites are completed by MCZ staff. The results are combined to provide the full Skomer MCZ results.

6.10.5. Project History
Regular recording began at Skomer MCZ in 1974. From 1992 onwards a standard protocol has been adopted to record the pupping success on both the island and the mainland each year.

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 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 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 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 - 2017 - At Skomer sites photography included pupping cows to help increase knowledge of site fidelity, longevity and pupping frequency. In 2011 - 2015 the work also expanded to some cows and bulls from mainland sites. (Matthews 2009, Boyle 2009, 2010, 2011 & 2012, Buche & Stubbings 2013, 2014, 2015, 2016 & 2017).

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 have 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 are extracted from photographs and entered into the database, and "matching" is 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 and 2016 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 data sets (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).

6.10.6. Results

In 2018 241 pups were born at Skomer Island sites and 154 pups at mainland sites giving a total of 395 pups born in the MCZ.

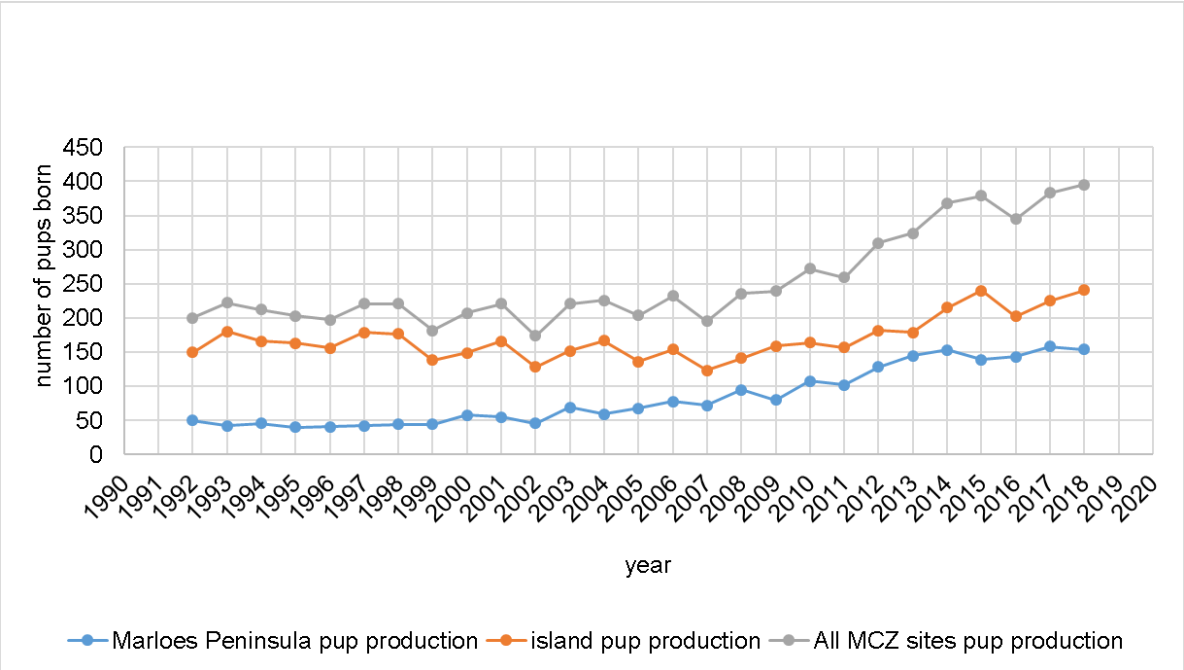


Figure 6.10.1 Skomer MCZ pup production 1992 - 2018

Pup production in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area with average production for 2014-18 at 374 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.

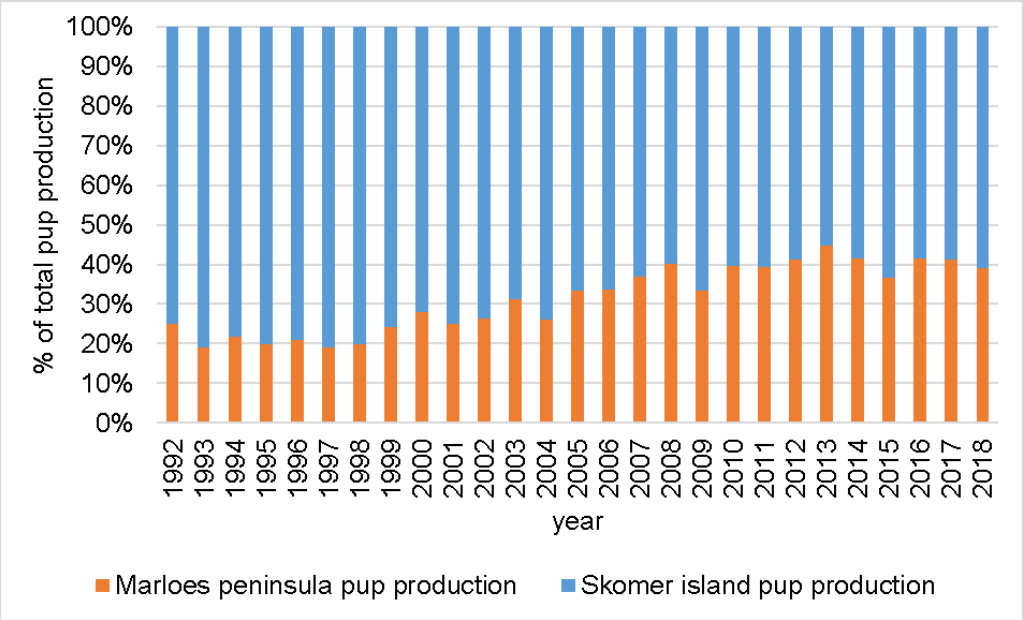


Figure 6.10.2 Skomer MCZ pup production – proportion born on Island vs. mainland sites

In 2018 10% of pup production occurred in August, 60% in September, 28% in October and 1% in November, and the peak week of production was week 38 (17th – 23rd September). The trend over the last 23 years shows that the peak week of production has fluctuated between weeks 38 to 40 (17th September to 7th October).

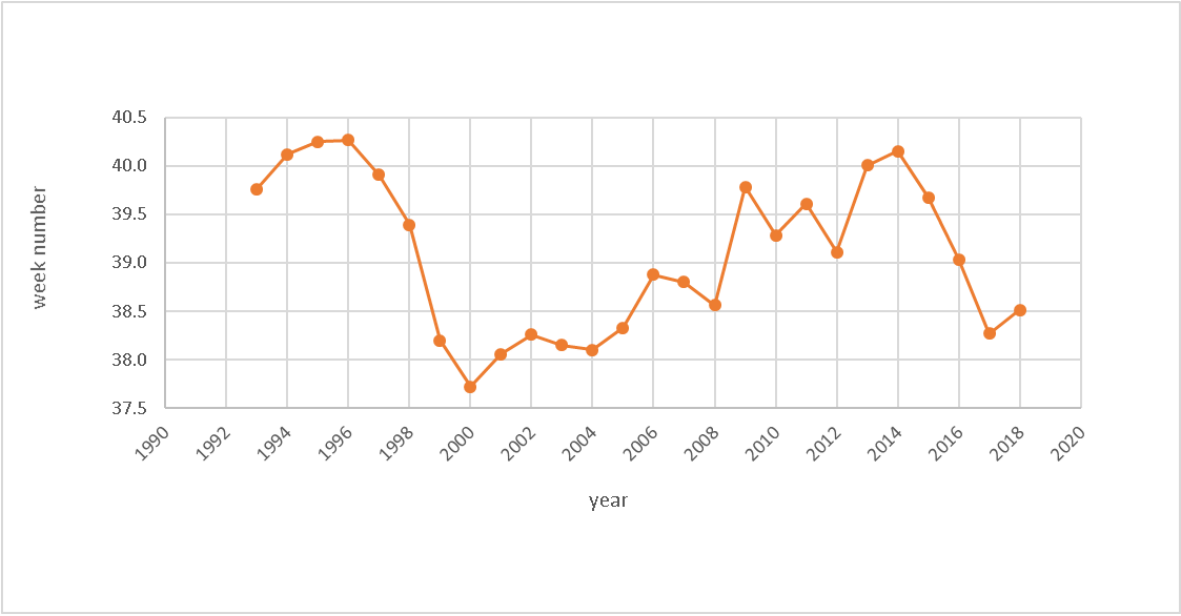


Figure 6.10.3 Skomer MCZ pup production – peak seal birth number seasonality

In 2018 pup survival through to moult was recorded as 78% for Skomer sites and 81% for Marloes Peninsula sites, with a combined survival for the Skomer MCZ of 79%.

Pup survival assessment is based on the following:

Size	E. A Smith's age classification	Assessment
Very small	Class 1 or 2	Assumed not to survive
Small but healthy	Class 2, 3, 4 or 5	In good condition, reasonable chance of survival
Good size	Class 3, 4 or 5	Most should survive
Very good size	Class 3, 4 or 5	All should survive
Super moulter	Class 4 or 5	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:

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

In the Skomer MCZ pup survival from 1992 to 2018 has fluctuated between 69% and 88% with an average of 79%. The low survival of 69% in 2017 was due to the severe storms in October killing many of the pups on the beaches at the time of the storms.

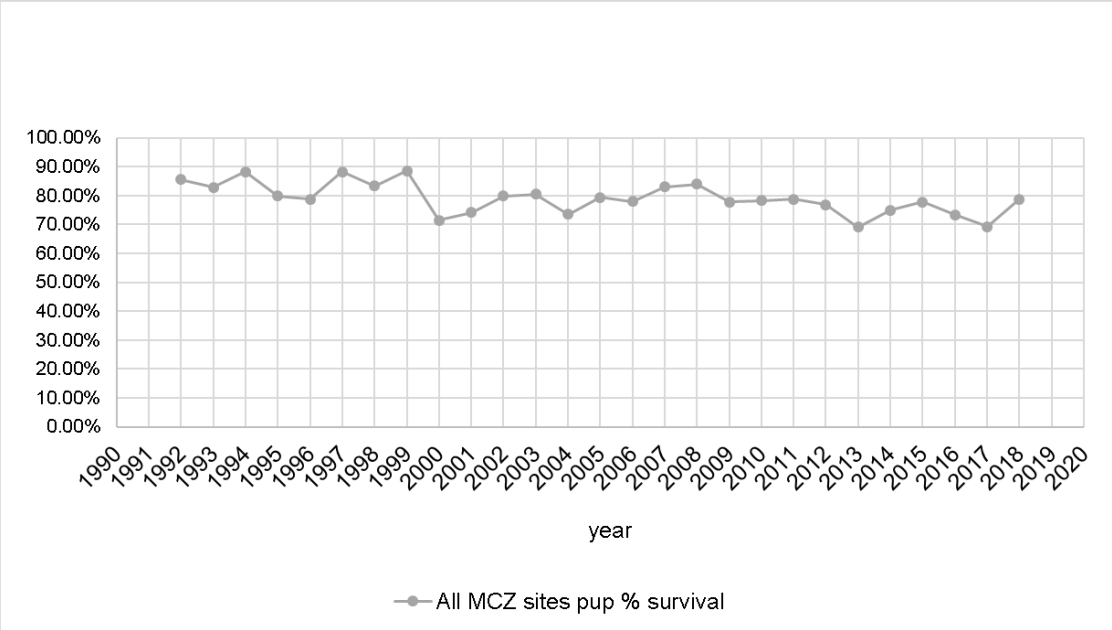


Figure 6.10.4 Skomer MCZ pup survival 1992 - 2018

A full report for the 2018 Skomer seal census details the production for the island sites (Buche & Stubbings, 2017).

Pollution
Monofilament line and netting were the most obvious pollutants affecting seals. In 2018 28 animals (18 females, 3 males, 7 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. Seven of the animals were known from previous years. (Buche & Stubbings 2018). The problem with netting entanglement is of growing concern especially with the high numbers of entanglements and neck scars recorded each year.

6.10.7. Current Status

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

- In 2018 pup numbers reached 395, 21 pups higher than the management plan target pup production lower limit of 374 pups.
- Pup survival was 79%, 4% above the target percentage survival lower limit of 75%.

All Skomer and Marloes Peninsula adult seal photos are stored ready for entry into the NRW Wales Seal ID database.

6.10.8. 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.

6.11Cetacean Species Recording
(CMS Code RA01/ 01)

6.11.1 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.

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

6.11.3 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.

6.11.4 Results
All sightings of cetaceans have been collated for the period between 2001 and 2017. 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.

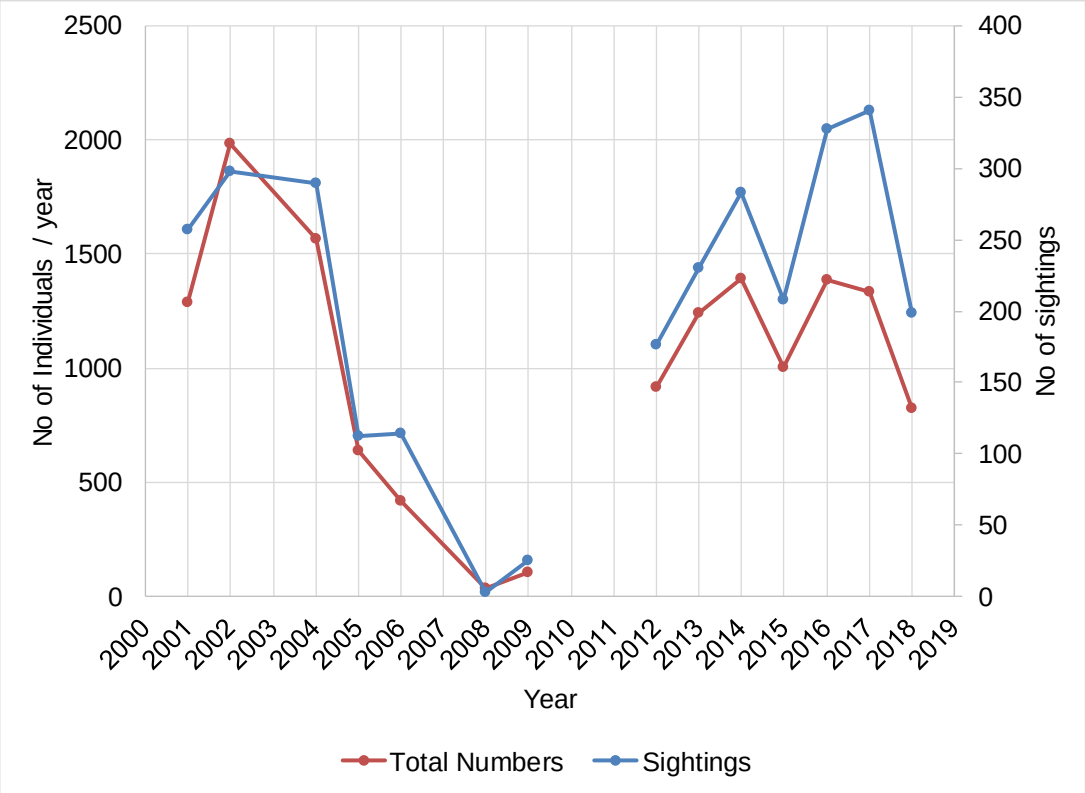


Figure 6.11.1 Harbour porpoise sightings within Skomer MCZ 2001 - 2018

This data is not effort corrected and there was a more concerted effort to collate all the records in a consistent way in 2016.
Harbour porpoise are sighted throughout the whole year and are assumed to be resident / regular users within the MCZ. Common Dolphins are predominantly seen in July – September (fig 6.11.2).

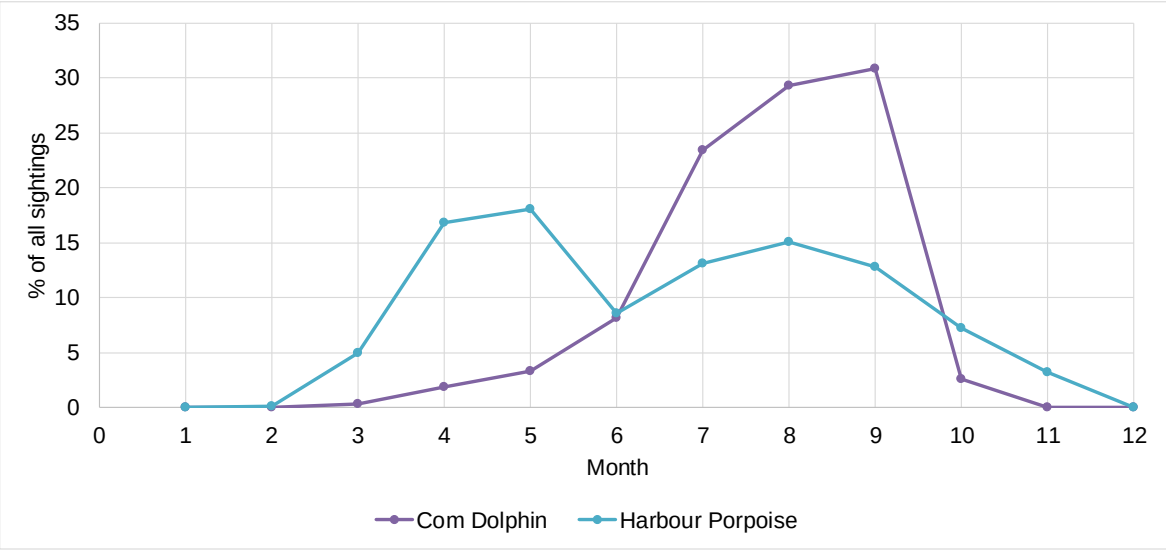


Figure 6.11.2 % of sightings / month 2001 – 2018. Harbour porpoise & Common dolphin.

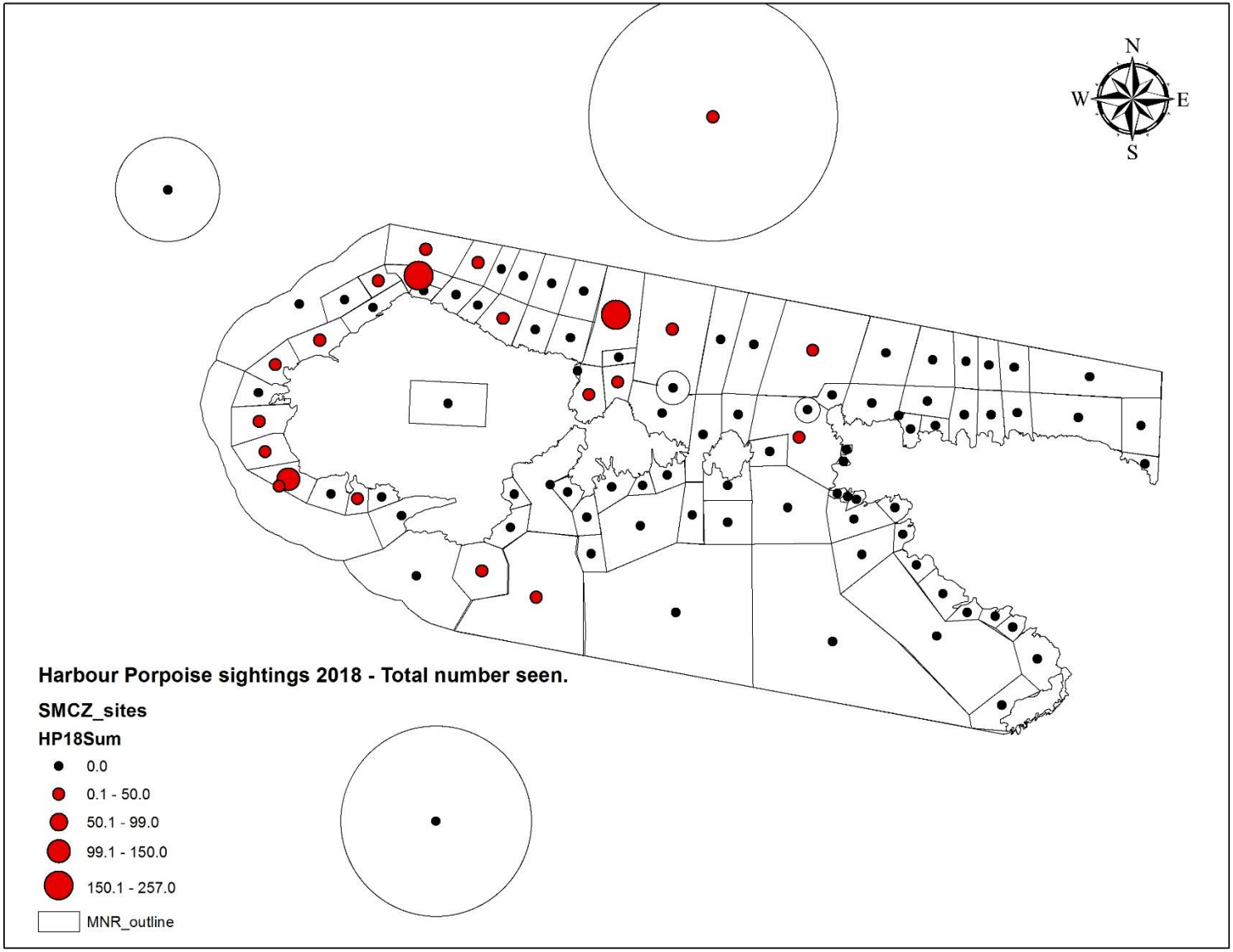


Figure 6.11.3 Harbour porpoise sightings Skomer MCZ 2018.

This data is not effort-corrected but is 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 common dolphin sightings are much more unusual and tend to get recorded. There were more sightings in 2016 but no big pods were seen. In 2018 there were fewer sightings (34) than in 2017 (61) with most seen off the Garland stone and Skomer head. – see fig 6.12.2.

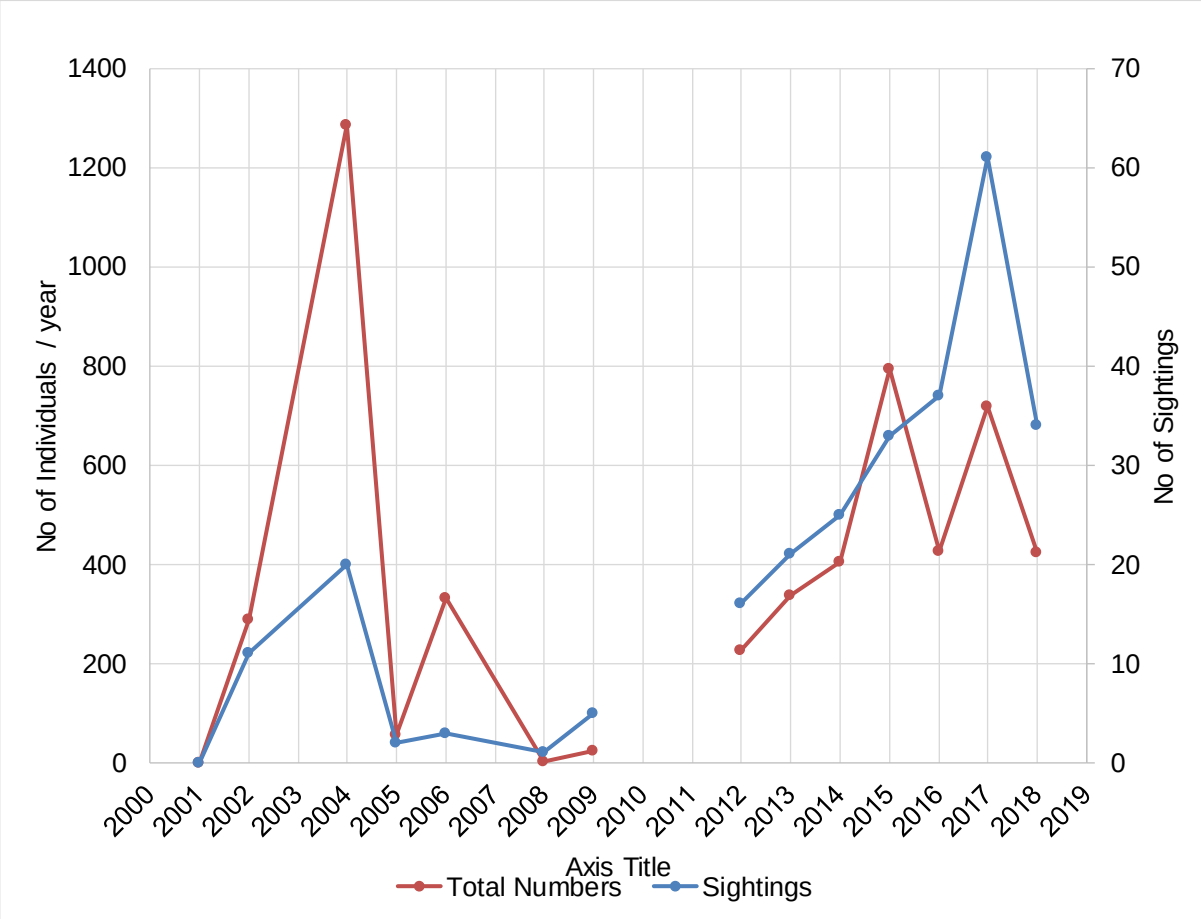
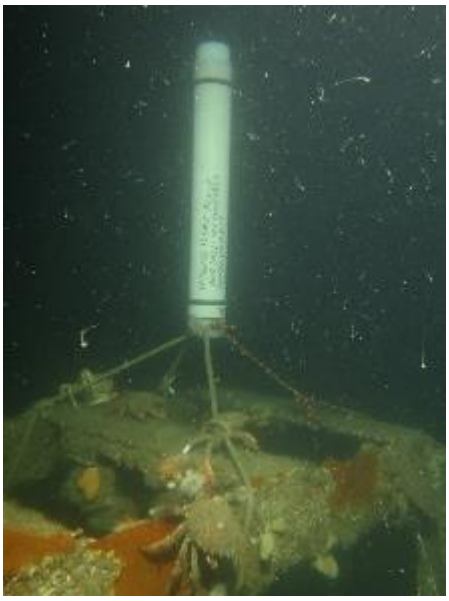


Figure 6.11.4 Common dolphin sightings within Skomer MCZ 2001 - 2018

Bottlenose dolphins (*Tursiops truncatus*) are not often seen within the MCZ, but in 2018 there was a sighting of 13 individuals off the Garland stone and 3 off Rye Rocks in May.

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 4 sightings in 2018 (including a pod of 8 at the Mew Stone) within the MCZ and a pod of 12 seen in St Brides Bay.

Research Projects 2018.
In 2018 a static acoustic data logger was placed in the MCZ by the SEACAMS2 research group based at Swansea University.



6.11.5 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.

6.11.6 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.

6.12 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.

6.12.1 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.

6.12.2 Crawfish


Crawfish *Palinurus elephas* became a national Biodiversity Action Plan species in 2008,and is now an Environment Act (Wales) 2016, Section 7 species of principal importance. From 2009 to 2018 it was recorded in low numbers in Skomer MCZ by staff and volunteers. These records have been submitted to the recording scheme set up by Seasearch (www.seasearch.org.uk) in an effort to gain better knowledge of the current status of this species in the UK.

6.12.3 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 2018 only one sunfish was recorded in July.

6.12.4 Notable species that were recorded in 2018

Wakame (*Undaria pinnatifida*) was found 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.

The ocean quahog (*Arctica islandica*) and ross worm, *Sabellaria spinulosa* were both recorded at a mixed sediment site north of the Marloes Peninsula. The ocean quahog is a round clam that is found in sandy and muddy seabeds. It builds up a very thick shell as it grows, which can be used to age it: One individual has been reported to have lived for 507 years, making it one of the longest lived individual animals. The dead shells in the sediments provide a structure for other creatures to hide in like small octopus, or structures to settle on like sponges, bryozoans and tube worms. The ross worm builds sand tubes and was found growing on old quahog shells. *Arctica islandica* is on the Environment Act (Wales) 2016: Section 7 list of habitats and species of principal importance for Wales whilst the reef building *Sabellaria spinulosa* is on the EU Habitats Directive: Marine habitats Annex 1 reefs – biogenic reef.

6.13. Zostera marina
(CMS code: RF23/01)

6.13.1. Project Rationale
Zostera marina is the only flowering plant within the British Isles that grows and produces seed entirely submerged by seawater. *Z. marina* populations are highly productive habitats and they provide an important stabilising function for the mobile marine sediments. The maintenance of *Z. marina* populations directly influences the associated algal and invertebrate communities that it supports**,** which are an important source of food for birds. *Z. marina* is one of two seagrass species which are listed as nationally scarce. In 1994 the UK government published the UK Biodiversity Action Plan(BAP) for species and habitats that were identified as being threatened. Intertidal and subtidal seagrasses were both included as threatened habitats. BAP was superseded by the NERC Act (2008) and further by the Environment (Wales) Act, 2016, where seagrass beds are listed as a Section 7 habitat due to the declines and level of threat to this habitat.

6.13.2. Objectives
1. To map the boundaries of the *Z. marina* bed.
2. To determine and identify changes in its distribution and abundance.
3. Record conspicuous organisms associated with the *Z. marina* population.

6.13.3. Site
North Haven

6.13.4. Methods
Permanent markers define the corners of a survey plot of 60 x 65 m^2 in North Haven and lead lines marked every 5m are laid for the survey duration. Within the plot area transects are completed every 5m. Every 5 metres along each transects *Zostera* shoot counts are taken in six 25 x 25 cm^2 quadrats. The transect lines are continued outside the survey plot where *Z. marina* is present. Quadrat counts are completed along these transects at 5 metres out to 60m.
A boat-based GPS unit was used to electronically record the boundary of the *Z. marina* bed as divers with a surface marker buoy (SMB) swam the edge of the *Z. marina* bed.
For detailed methodology see Burton *et al* 2019.

6.13.5. Results
The first mapping studies were completed in 1979, 1980 and 1981 by divers swimming on compass bearings and taking abundance readings at 20m intervals. The results were sparse and patchy and comparison between years was difficult.

1982 A detailed method was devised based on a fixed grid area and used a defined abundance scale to complete a full survey of the bed.

1997 Permanent plot markers were established (using the grid area devised in 1982), and methods developed for *Z. marina* shoot density and boundary maps (Lock 1998).

1997 Student project was completed by Joanne Trigg: Temporal changes in distribution and abundance of *Z. marina* and possible effects on benthic community structure.

2000 *Z. marina* bed boundary map was completed using GPS.

2002 *Z. marina* shoot density and boundary map was completed following the method established in 1997 and compared maps with those from 1997 (Lock 1003).

2003 A study on the epiflora in *Zostera* beds in Wales, including North Haven was completed (Edwards et al 2003).

2004 A *Z. marina* bed boundary map was completed using GPS.

2006 A *Z. marina* shoot density and boundary map was completed following the method established in 1997 with additional transects every 5m out to the east and west.

2010 A repeat survey of *Z. marina* shoot density and boundary using the 2006 methodology.

2013 An acoustic survey of the extent of the eel grass bed using a Biosonics DT-X split beam echo sounder.

2014 A repeat survey of *Z. marina* shoot density and boundary using the 2006 methodology and an acoustic survey of extent. See Burton *et al* 2014 for full report.

2015 An acoustic survey of the extent of the eel grass bed using a Biosonics DT-X split beam echo sounder.

2018 A repeat survey of *Z. marina* shoot density and boundary using the 2006 methodology and an acoustic survey of extent. See Burton *et al* 2019 for full report.

2018 Density Results

The central bed has been surveyed consistently from 1997 to 2018 but the outer transects (north, south, east and west) were only partly done in 1997 and 2002. To account for this only transect stations which were completed on all of the surveys have been included in the density calculations.

	1997	2002	2006	2010	2014	2018
Mean	**36.2**	**53.6**	**48.0**	**41.1**	**35.1**	**59.2**
Std Dev	27.3	38.5	31.4	30.6	23.3	38.7
Variance	746.0	1478.4	987.8	933.6	544.4	1498.7
95%Std error	3.1	4.4	3.6	3.5	2.7	4.5
n	289	288	289	289	289	289
min	0	0	0	0	0	0
max	104.0	156.0	128.7	182.7	104.7	162.0

Figure 6.13.1 Comparison of overall shoot density (per m^2) for all years 1997 - 2018 (Only using data from sample stations with replicates in every sampling year)

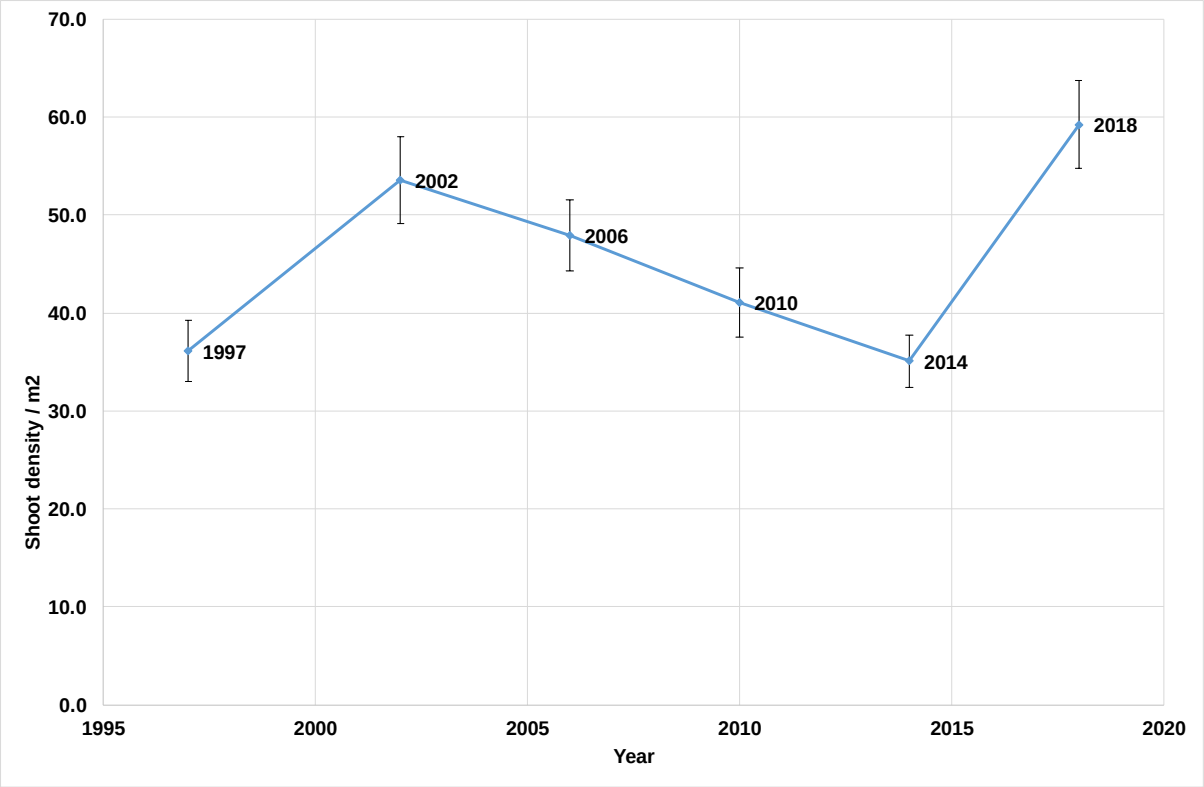


Figure 6.13.2 Graph of overall shoot density (per m^2) for 1997 – 2018
(Using comparable data from Figure 3.4 - Shown with 95% S.E of mean error bars).

Figure 6.13.2 highlights the decline in overall shoot density from 2002 - 2014 with a significant increase in 2018.

A one-way ANOVA test between years on (logx+1) transformed data showed a significant difference in shoot density between years P<0.01% with 2018 being significantly higher than 1997, 2010 and 2014.

Density map of 2018 survey

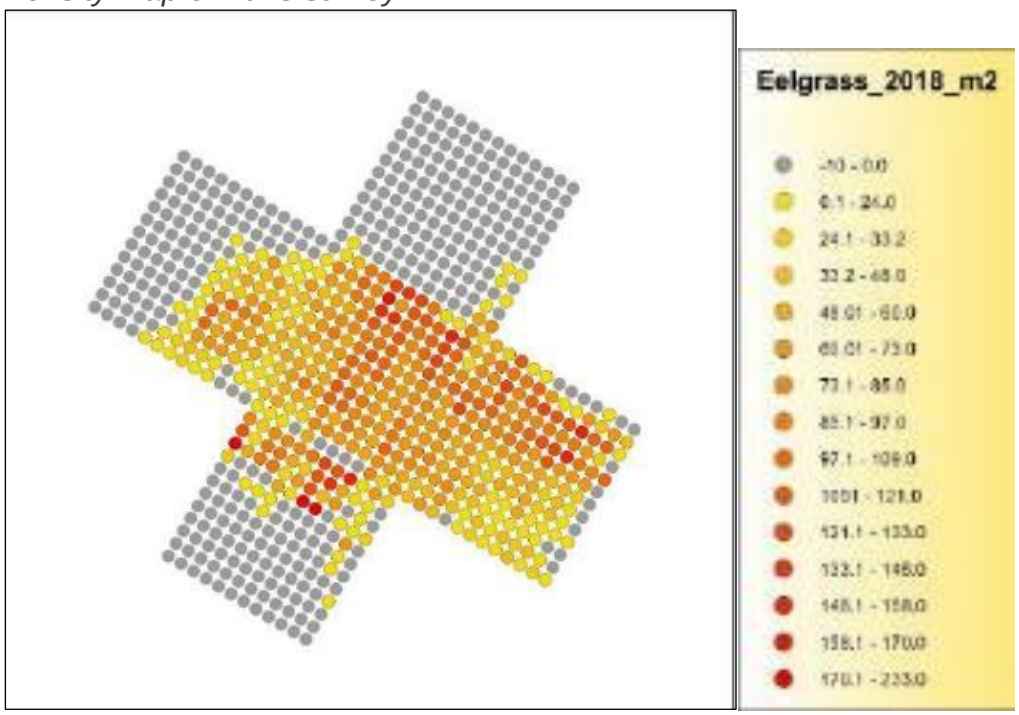


Figure 6.13.3 Density map from 2018 survey (shoots / m^2)

Differences between the last 2 surveys (2014 and 2018) can be mapped by plotting a function of; diff = 2018 density – 2014 density. A negative value means a decrease in density in 2018 compared to 2014 see Figure 6.13.4.

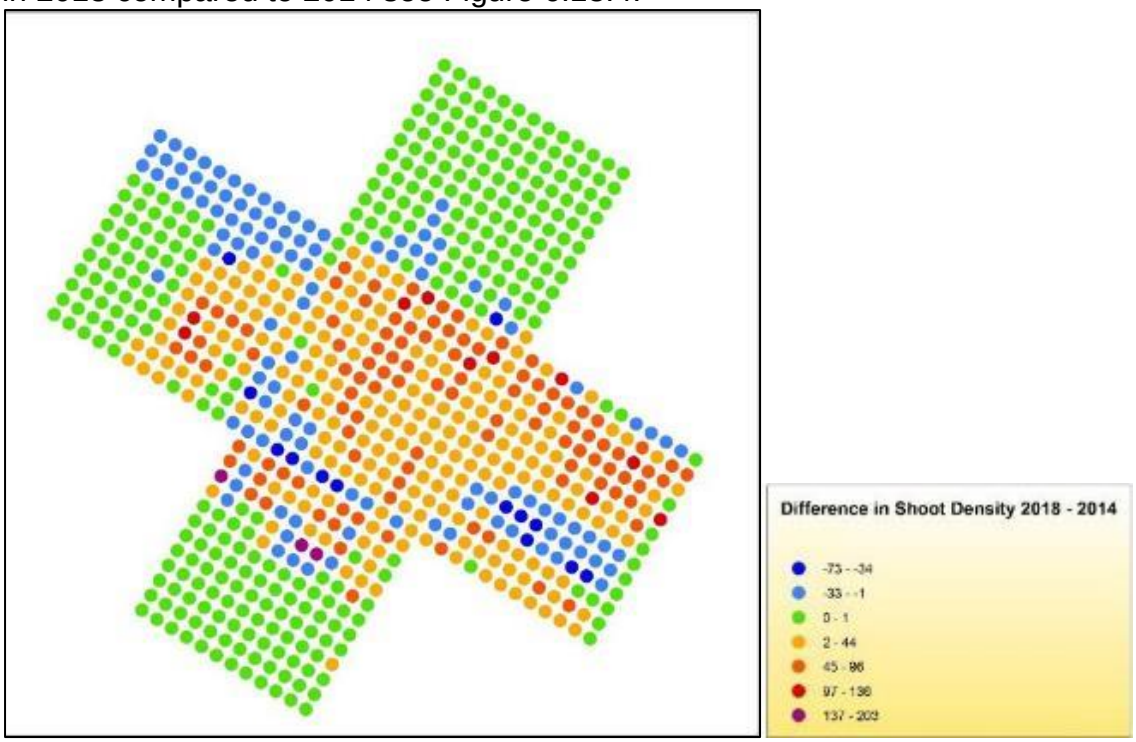


Figure 6.13.4 Comparison between 2018 and 2014 shoot density data (/m^2).
Blue areas show a decrease in density in 2018, compared with 2014. Red areas show an increase in density in 2018 and green highlights areas of little or no change.

Area of extent results

Seagrass bed extent polygons from the density survey records 1982 – 2018 shown all together.

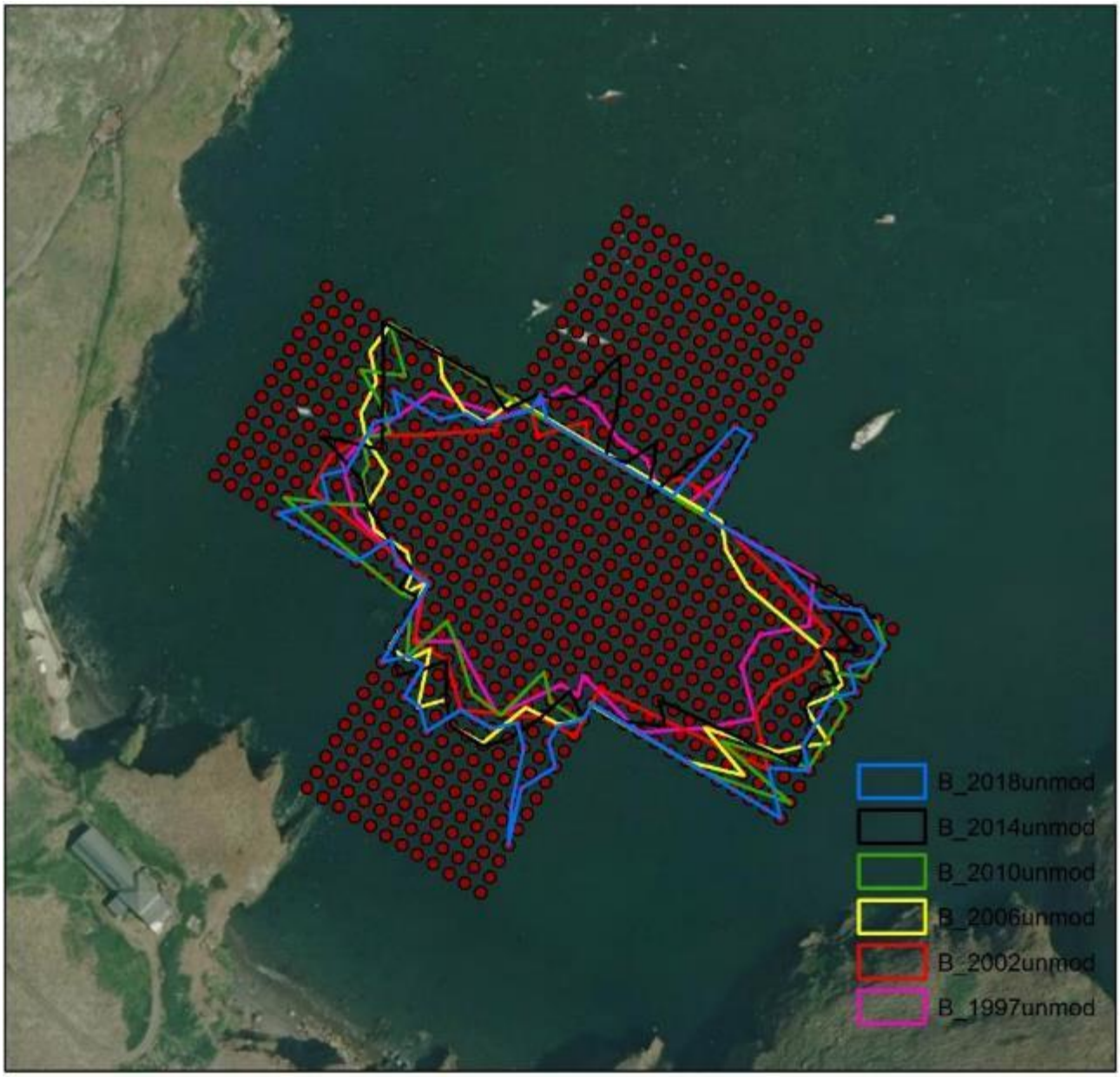


Figure 6.13.5 Area of extent polygons 1997 – 2018.

The expansion into the eastern area is notably from 2010 onwards otherwise the bed extends over a similar area and it has probably reached the physical limits of available habitat.

Year	Area Estimate m^2 (from survey grid) MapInfo	Area Estimate m^2 (from survey grid) ArcGIS	Area Estimate m^2 (from swim)	Area Estimate (Biosonics acoustic survey 60-70 PAI)
1982	3788			
1997	6333.4	6484.2		
2000	No survey		7007.8	
2002	6569.5	6439.6	7683.20	
2004	No survey		6817.5	
2006	7336.6	7587.2		
2010	7980.6	8044.0		
2013				8290
2014		8224.6		8621
2015				6133
2018		8567.6		8244

Figure 6.13.6 Estimated area of extent (m^2) 1982 – 2018 all survey methods.

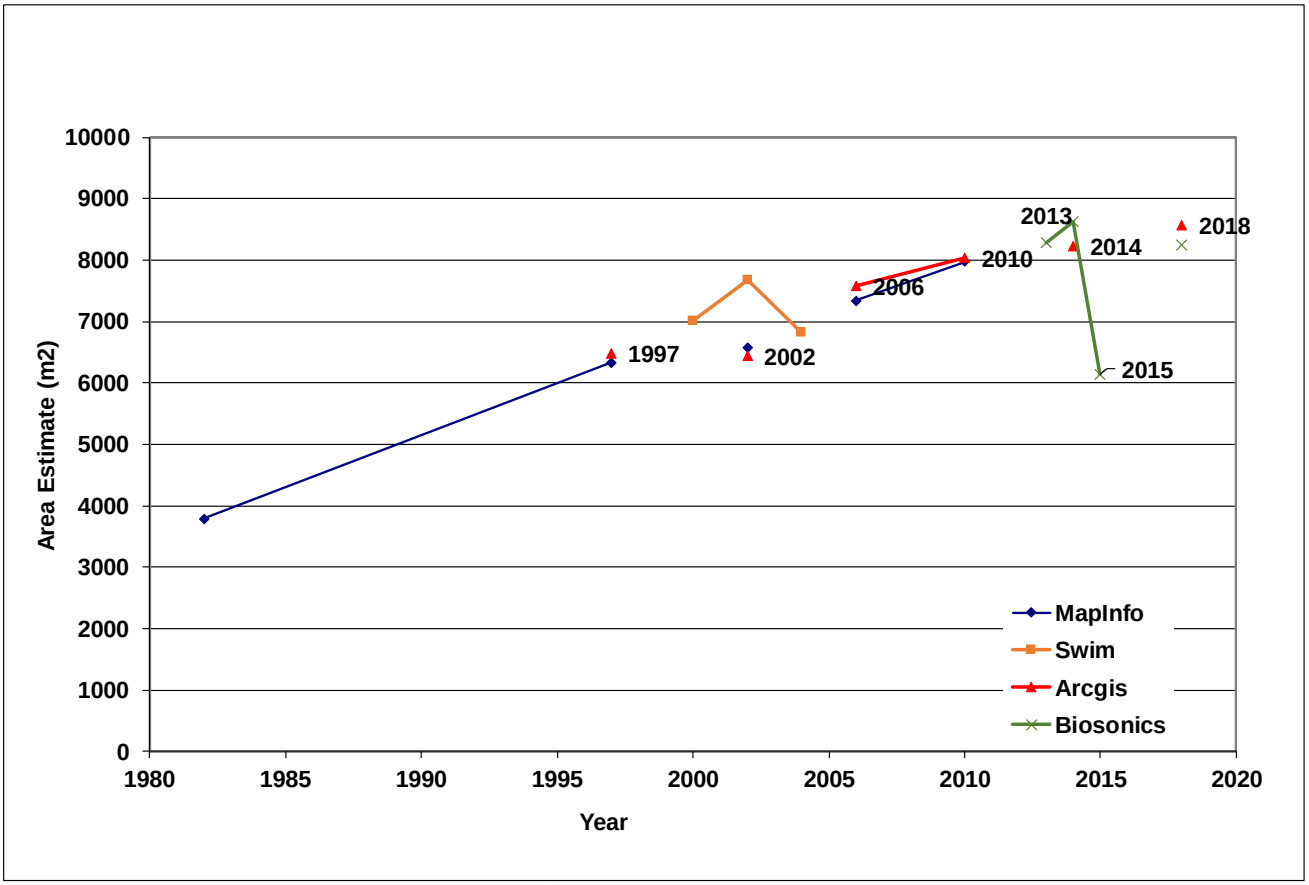


Figure 6.13.7 Graph of area estimates (m^2).

The two different GIS methods (MapInfo and ArcMap) using two different projections (WGS 84 & British National Grid) give similar results.
The area of extent appears to be increasing and in 2018 the area estimate of 8567.6 m^2 is well above the lower specified limit of 5500 m^2 as defined in the Skomer Marine Nature Reserve Management Plan 2000.

Acoustic Survey Results – 2013 - 2018

In 2013,2014, 2015 & 2018 the *Z. marina* in North Haven was surveyed by the NRW Fisheries Assessment Team using a Biosonics DT-X split beam echo sounder, with a 7^{O} circular 200 khz transducer, from the vessel "Skalmey". The transducer was mounted vertically from the port side of the vessel and suspended 50cm below the water surface. The DT-X's transmit power was set to -221.0dB, pulse width 0.1ms, ping rate 10ings per second and raw data was collected at -130dB.

GPS data were logged using a Garmin 72 GPS, which was linked to the Biosonics system, and the boat speed for the survey was approximately $10kmh^{-1}$.

% Area Inhabited Contour	2013 Area Estimate (m^2)	2014 Area Estimate (m^2)	2015 Area Estimate (m^2)	2018 Area Estimate (m^2)
90	6140.2	6282.1	3833	6086
80	7126.0	7329.4	4910	7004
70	7742.1	8041.8	5572	7589
60	8290.1	8621.1	6133	8244

Figure 6.13.8 Estimated area of extent from acoustic survey data 2013-2018.

Comparison of Acoustic and In-situ Diver Survey Data 2018.

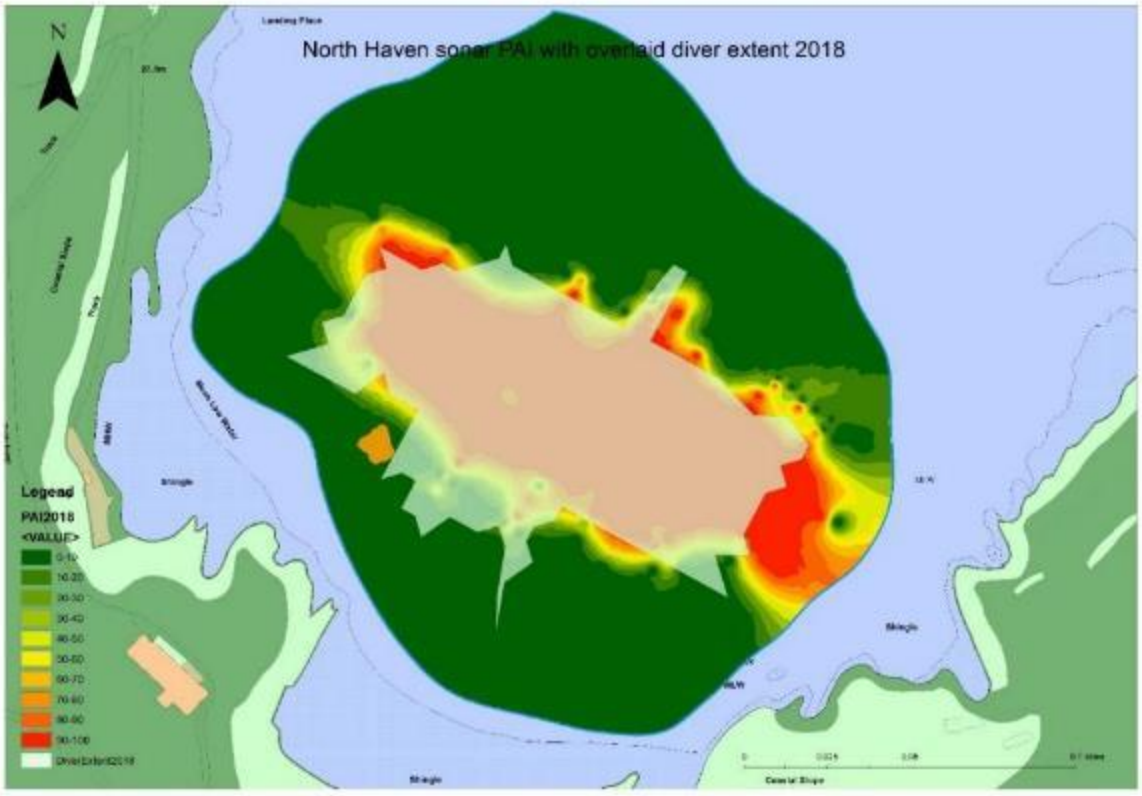


Figure 6.13.9 2018 Interpolated plot of percentage area inhabited (PAI 0-100%) overlaid with the diver survey estimate.

The 2 areas match up very well. The acoustic survey will only ever be as good as the amount of data points used in the interpolation but the general shape is a good fit to the in- situ diver survey. The extended area out to the east, shown in the acoustic survey will need confirming as the diver survey suggested that this area was kelp with no eelgrass present.

Stand Height of Eelgrass 2018

The Sonar 5 Pro software also allows the user to estimate “bio-height” from the acoustic data. This measures the height of the *Z. marina* acoustic signal above the seabed which provides an estimate of stand height of the *Z. marina* blades.

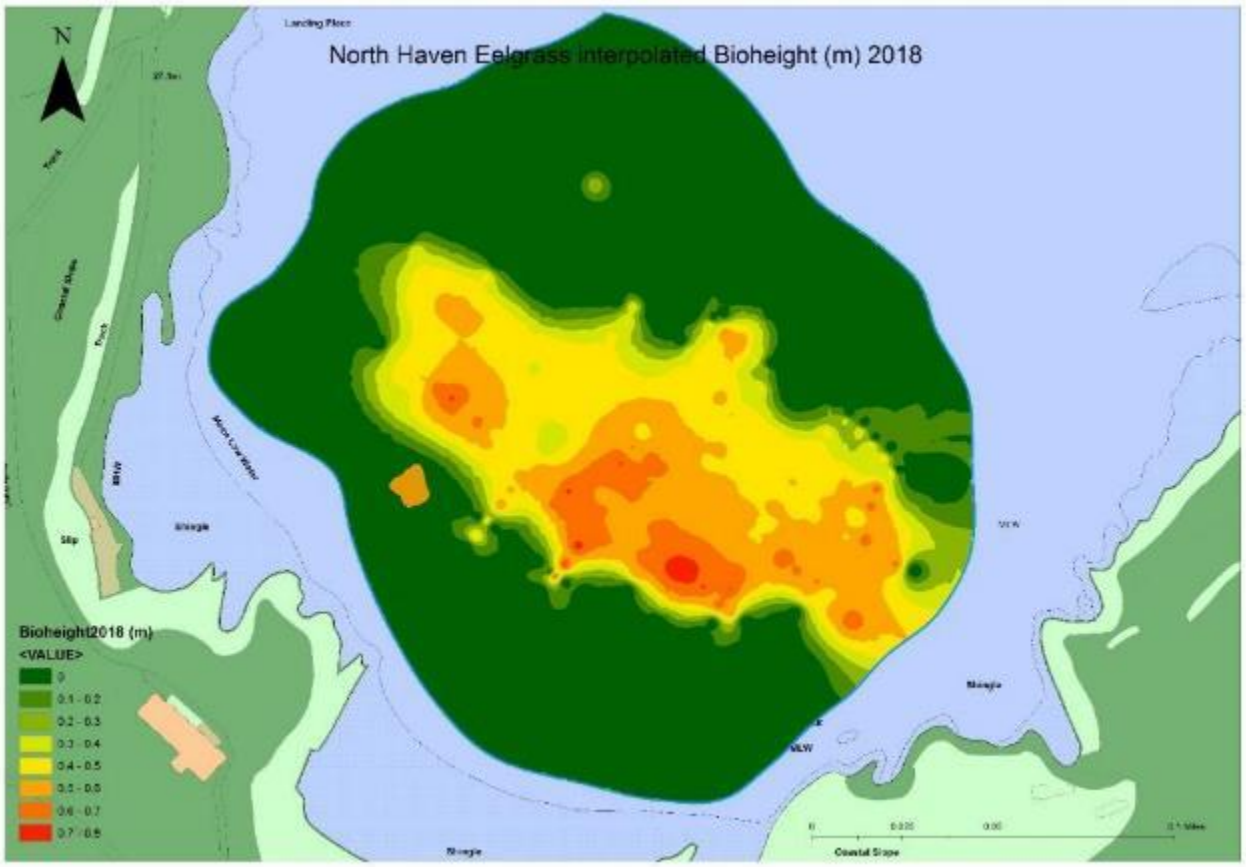


Figure 6.13.10 Bio- Height (m) of *Z. marina*, 2018.

The values of 70 - 80cm need ground truthing as no physical measurements of stand height were taken during the diver survey. From these results it appears that the seagrass is taller in the shallower (southern) areas.

6.13.6. Targets

The Skomer MCZ management plan objectives for the population of *Z. marina* in North Haven is to maintain it in favourable condition where:

The extent of the *Z. marina* bed:

Upper Specified limit: No limit set

Lower Specified limit: 5500 m^2 (from original1982 estimated level)

In 2018 the extent is **8567.6 m^2** and is therefore in favourable condition.

The mean density of the *Z. marina* bed:

Upper Specified limit: No limits set

Lower Specified limit: comparable mean density $^{>}/_{=}$ 36 shoots/ m^2 (from 1997 level)

In 2018 the comparable mean density is **59.2 shots /m^2** and is therefore in favourable condition.

6.13.7. Recommendations

- Continue the 4 yearly *in situ* volunteer diver survey and maintain the continuity of data.
- The current monitoring target for the lower specified limit of mean shoot density is set from the 1997 survey. The methods have changed since 2006 and the survey now has a more comprehensive coverage of the whole area of suitable habitat. In order to get a value for the current shoot density a subset of survey points are used which match to the 1997 survey (see Fig 3.4). These survey points are mainly in the densest part of the seagrass bed and therefore give artificially high shoot density results when compared with density values that encompass the whole area of suitable habitat. Therefore:
  Amend the lower specified limit for *Z. marina* mean density in the Skomer MCZ management plan. New limits to be set based on the survey data points used since 2006 and the lower limit set from results in the 2014 survey (lowest density since 2006). These would be as follows:
  The mean density of the *Z. marina* bed:
  Upper Specified limit: No limits set
  Lower Specified limit: comparable mean density $^{>}/_{=}$ 35.1 shoots/ m^2 (from 2014 level).

- Continue with an annual acoustic survey of the eelgrass bed for area of extent and check the boundary areas of the bed with a drop-down video or divers to confirm acoustic results.
- Ground-truth the bio-height results from the acoustic survey with *in situ* records.
- Develop a project to monitor shoot density, plant health and surveillance of environmental factors to allow some conclusions to be drawn about changes in shoot density. Ideally this would be an annual survey.
- Link in with other research and monitoring projects for eelgrass around Wales and the UK (see Unsworth et al. 2014).
- Start monitoring C: N, ^{15}N and C:P ratios along with measurements of leaf biometrics.

7 Skomer MCZ Meteorological and Oceanographic Project Summaries

7.11Meteorological Data

CMS Code: RP 04/01

7.11.1 Project Rationale

The weather is an important factor that directly affects species / 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 is 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.

7.11.2 Objectives

To provide continuous meteorological data for the Skomer MCZ.

7.11.3 Sites

Coastguard lookout station, Wooltack Point, Martins Haven.
Grid Ref: SM 7588 0922 (LL 51.44.78N 005.14.78W)

7.11.4 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 minute 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.

7.11.5 Project history relevant to data

A continuous data set 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.
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 – 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.

7.11.6 Results

Rainfall

The rain gauge was not calibrated properly in 2009 and 2010 so a correction has been added to the records.

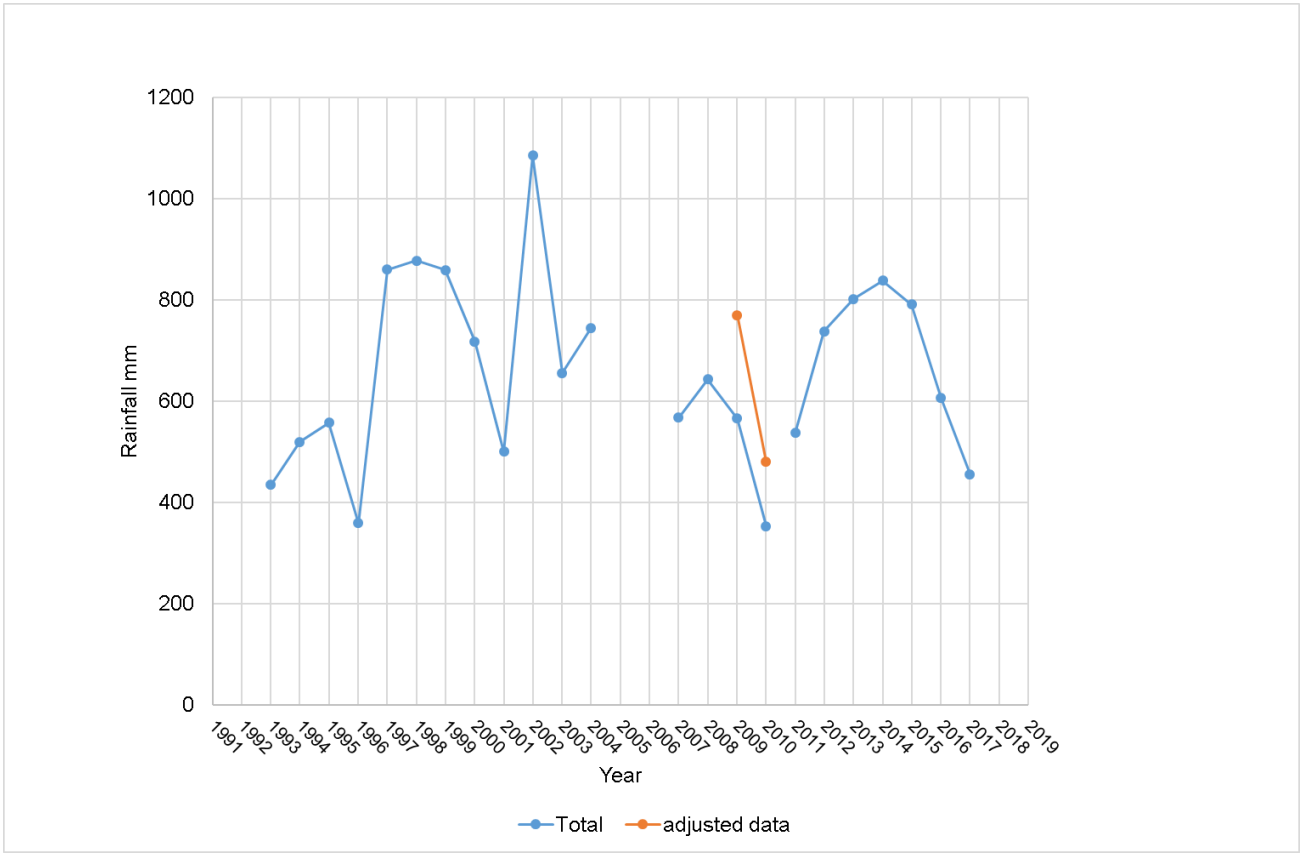


Figure 7.1.1 Skomer MCZ automatic weather station total rainfall (mm) data – incomplete data for 2018

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 and 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 rain fall data are incomplete.

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

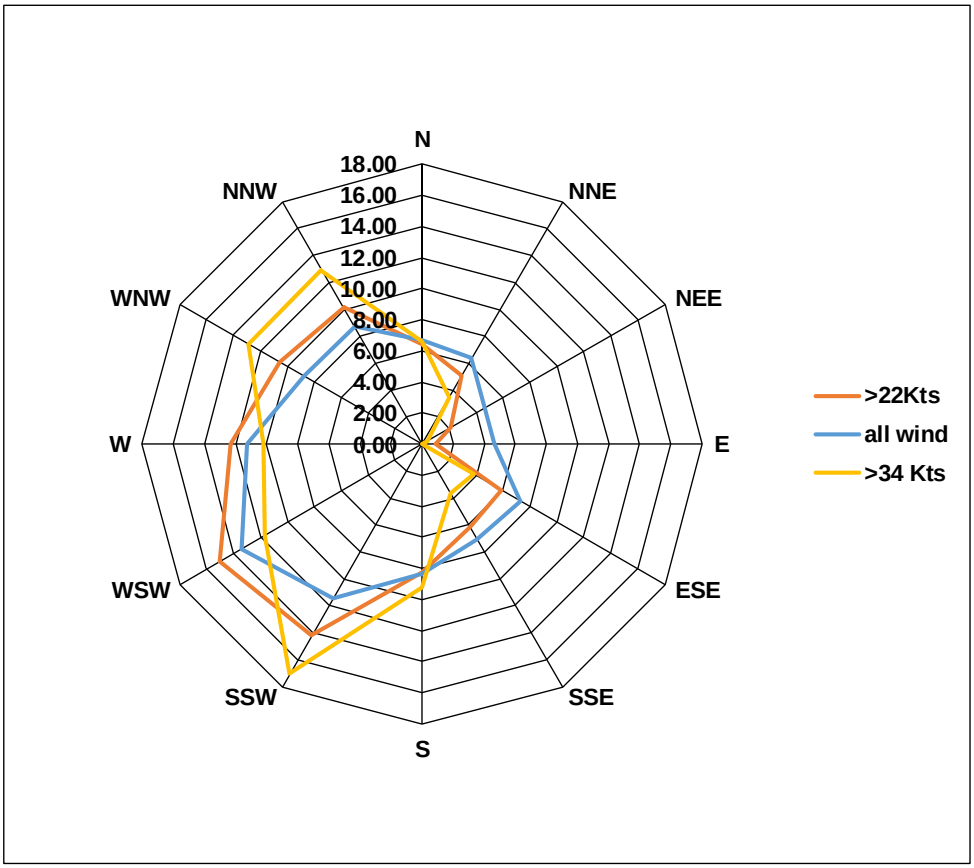


Figure 7.1.2 Skomer MCZ automatic weather station – average wind direction 1993 - 2018

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 has been gathered. The stronger winds (>34 knots) are more bimodal in distribution with peaks from the SW and the NW.

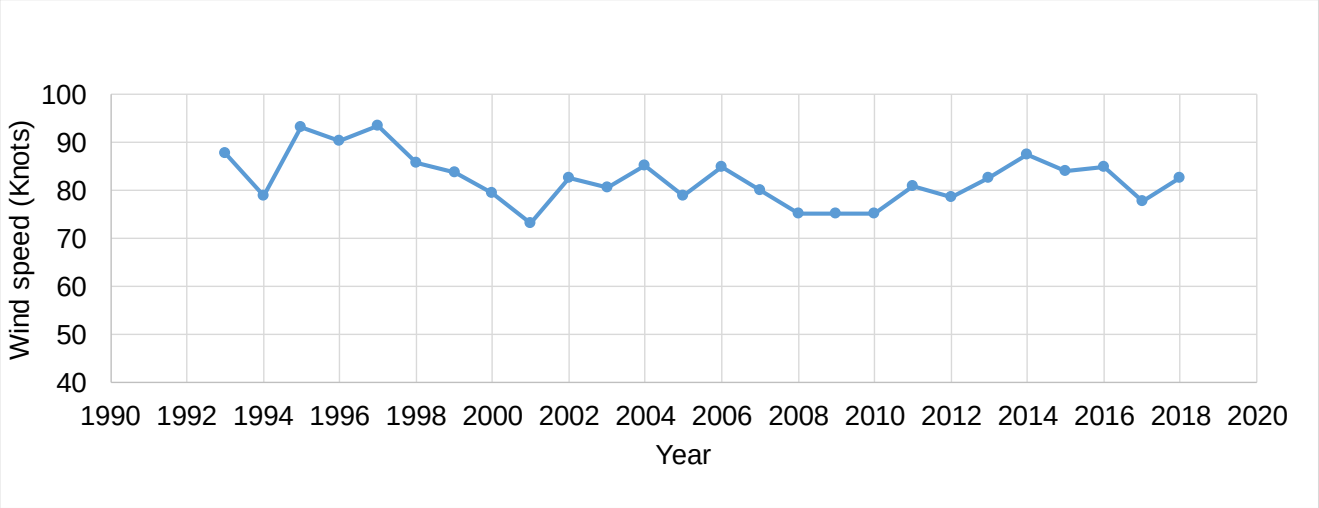


Figure 7.1.3 Skomer MCZ automatic weather station – maximum wind strength (knots) 1993 - 2017

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; 2018 saw a maximum gust of 82.56 knots.

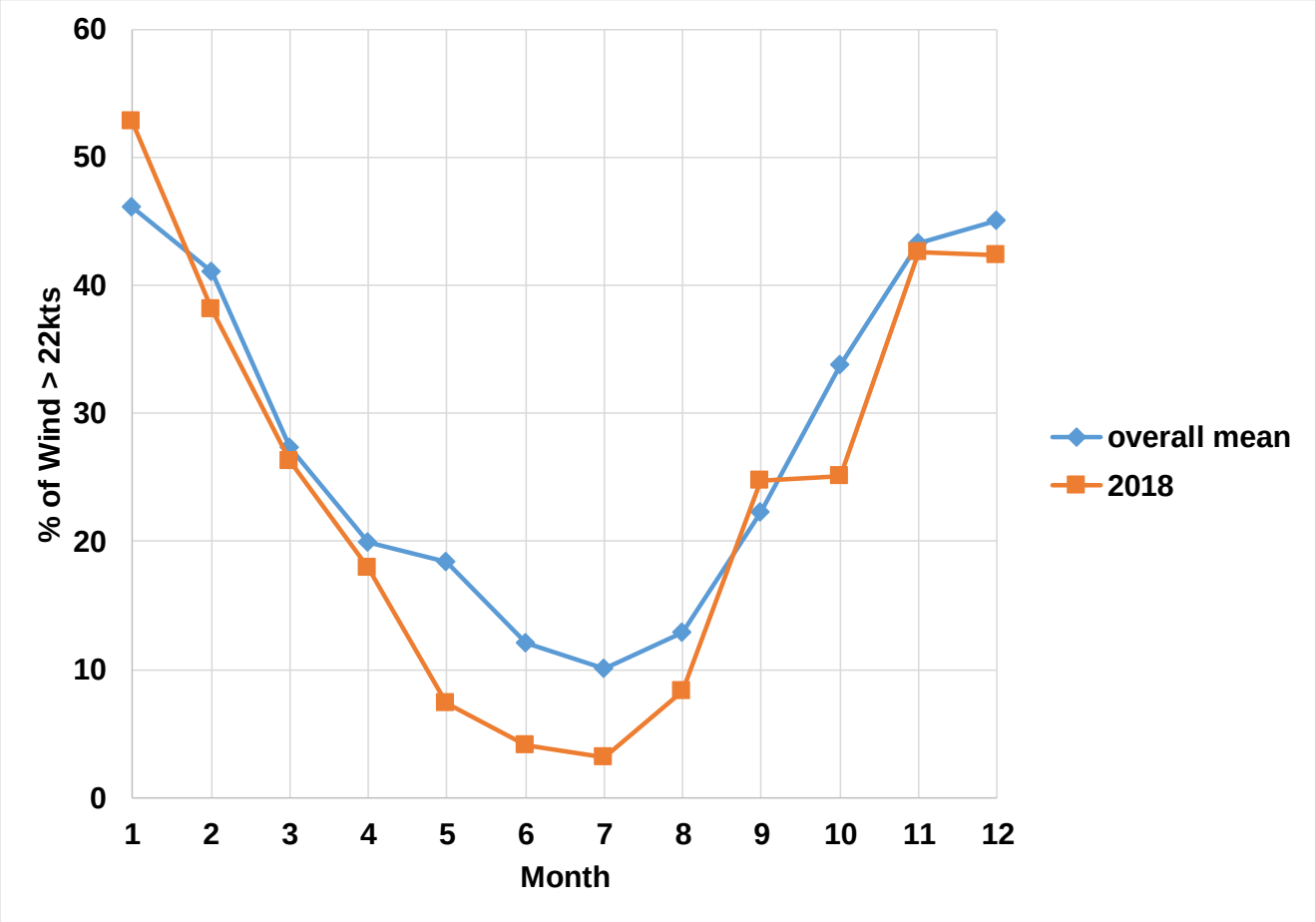


Figure 7.1.5 Skomer MCZ automatic weather station – percentage of wind greater than 22 kts for each month.

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.

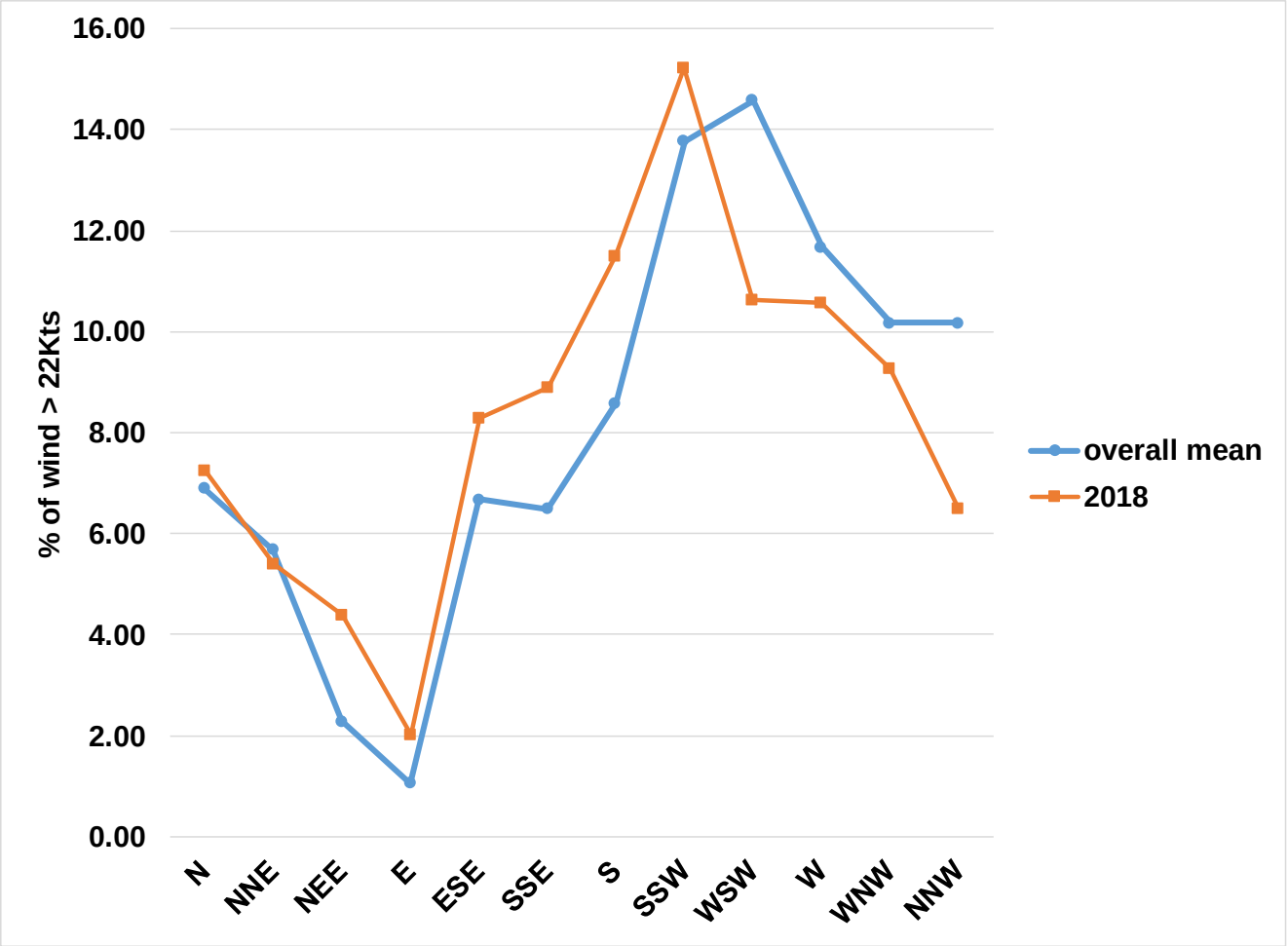


Figure 7.1.6 Skomer MCZ automatic weather station – percentage of wind over 22kts from each wind direction.

2018 has a similar distribution of winds compared to the overall mean for 1993 to 2017. Most of the stronger winds come from the SW, WSW and W. The east tends to have the lowest percentage of strong winds (Fig. 7.1.6).

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 Fig. 7.1.7).

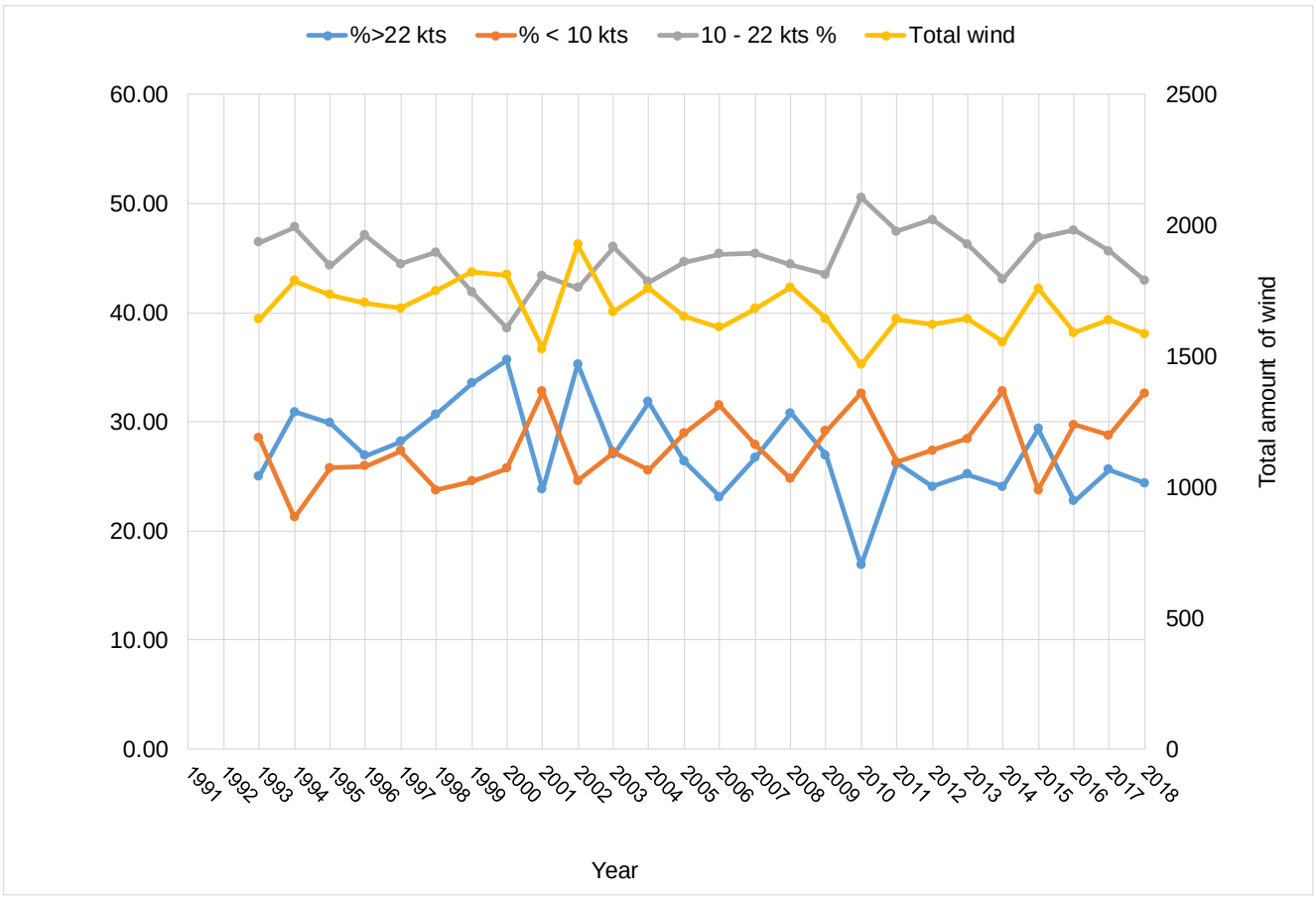


Figure 7.1.7 Skomer MCZ automatic weather station – “total annual wind” 1993 to 2018.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AIR TEMP	MEAN	7.6	5.1	5.6	8.6	11.2	14.5	16.3	15.8	14.0	12.0	10.0	9.7
T107_1 0c	MAX	12.1	10.5	11.5	17.8	20.4	23.6	22.5	20.4	18.2	19.0	14.4	12.6
	MIN	0.1	-5.3	-5.5	3.0	6.0	10.7	10.6	10.4	7.4	1.8	3.2	4.0
BAROMETRIC PRESSU	MEAN	1002.7	1010.0	993.3	1002.2	1011.4	1012.9	1010.0	1010.2	1013.7	1011.2	1000.8	1007.4
	MAX	1026.0	1024.0	1028.0	1020.0	1022.0	1027.0	1022.0	1020.0	1034.0	1034.0	1019.0	1030.0
	MIN	977.0	0.0	974.0	0.0	990.0	998.0	986.0	994.0	986.0	0.0	976.0	0.0
RELATIVE HUMIDITY	MEAN	86.1	79.7	85.8	89.9	87.5	84.0	84.7	85.0	82.9	82.0	83.7	88.8
	MAX	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	100.0	99.7	100.0	100.0
	MIN	56.1	43.3	47.5	61.1	40.8	36.8	42.2	55.0	50.7	52.1	50.2	58.1
RAINFALL	TOTAL(mm)	55.8			272.0	180.7	32.4	125.2	70.3	1303.8	2119.6		5.2
SUNSHINE	MEAN(kw/m2)	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.0	0.0
	sunshine hours	81.0	162.0	212.0	279.0	365.0	370.0	378.0	316.0	254.0	179.0	105.0	30.0
	Sunshine hrs (10min)	80.0	158.5	210.5	274.5	357.5	366.7	379.7	308.0	250.5	180.0	101.2	29.5
NET RADIATION	MEAN	-12.8	-2.5	26.0	63.1	98.7	122.4	116.1	76.5	45.2	8.1	-8.2	-7.9
MAX GUST	M/S	42.5	35.8	27.5	28.8	23.8	22.5	37.1	22.9	32.1	36.7	35.0	42.5
	direction	234.7	302.1	133.0	179.9	206.7	250.6	230.1	295.5	215.9	188.0	203.3	165.1
	Knots	82.6	69.6	53.4	55.8	46.1	43.7	72.0	44.5	62.3	71.2	68.0	82.6
	Days > F7 MEAN	3	1	0	0	0	0	0	0	0	1	1	2
	Days > F7 Gust	29	18	20	14	8	4	3	11	17	15	24	23
	days max hr av>F7	13	10	2	4	2	0	0	0	0	0	0	0
Notes													
Rain guage failed therefore no records from 16th Feb-11th April													
Rain guage blew off roof in October, no reliable data from 14th													
New rain gauge installed 21 Dec 2018 - CR1000 programme updated													

Table 7.1.8 Skomer MCZ automatic weather station – 2018 annual meteorological summary

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

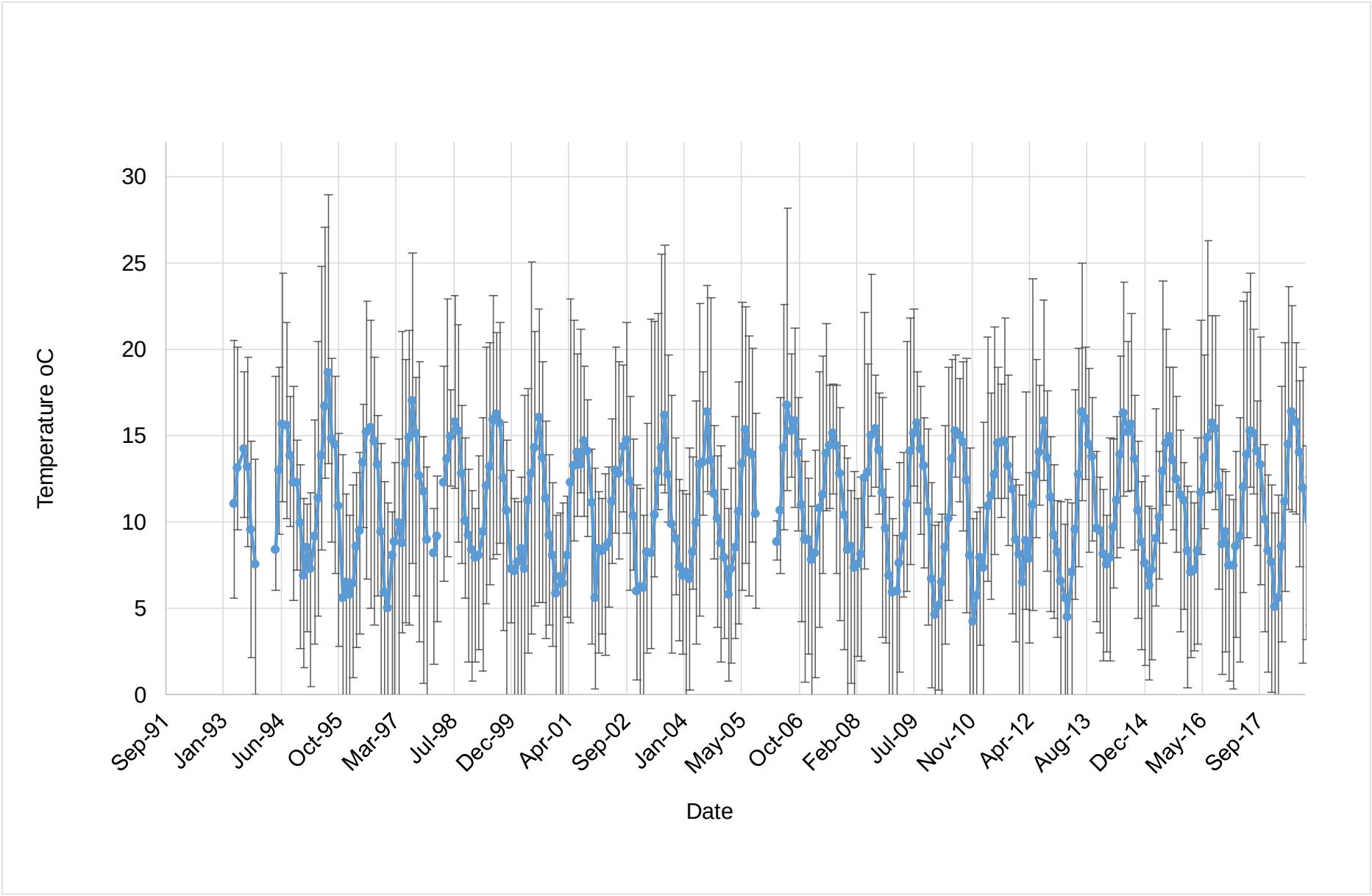


Figure 7.1.9 Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2018 with monthly min / max error bars:

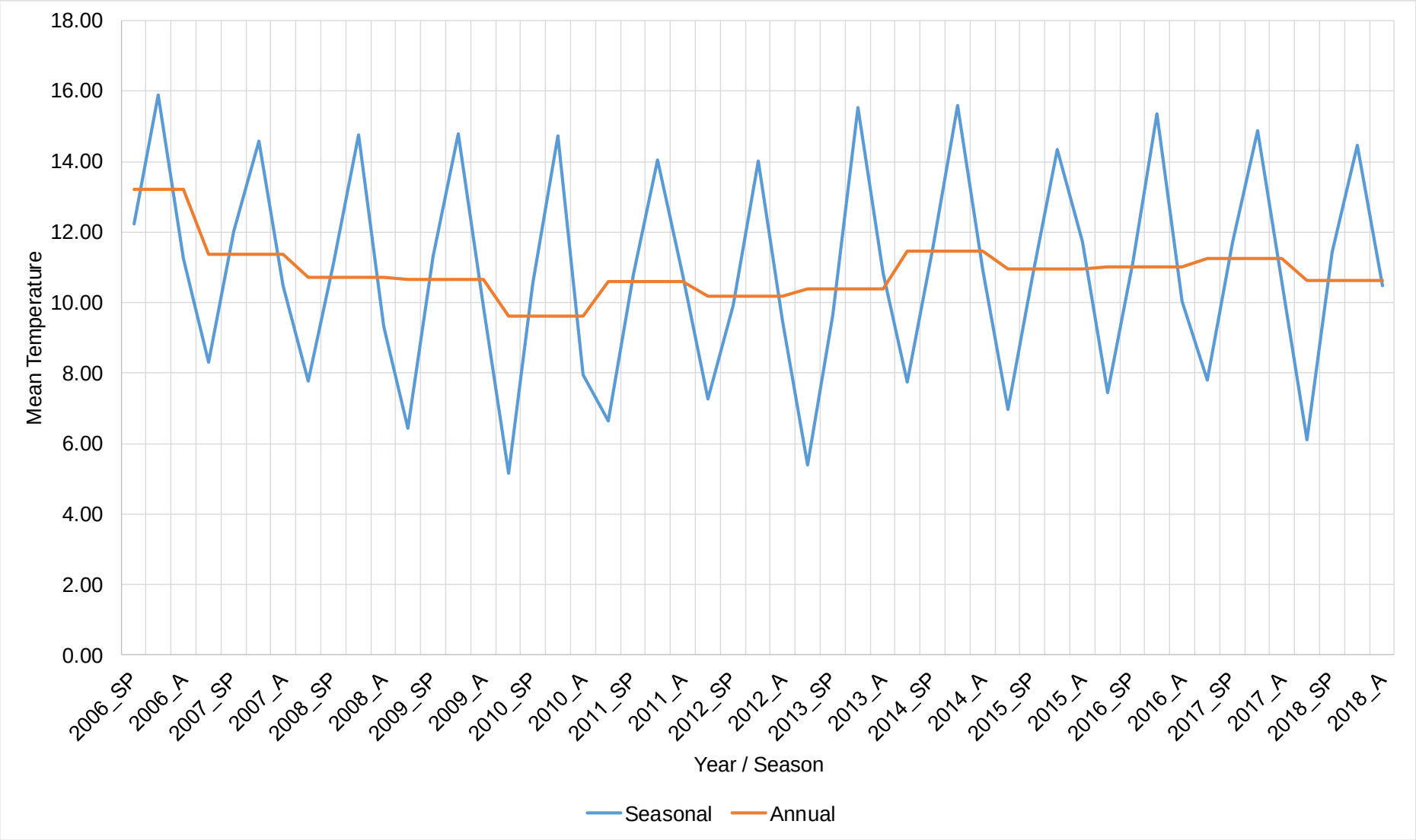


Figure 7.1.10 Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (ºC) 2006 – onwards:

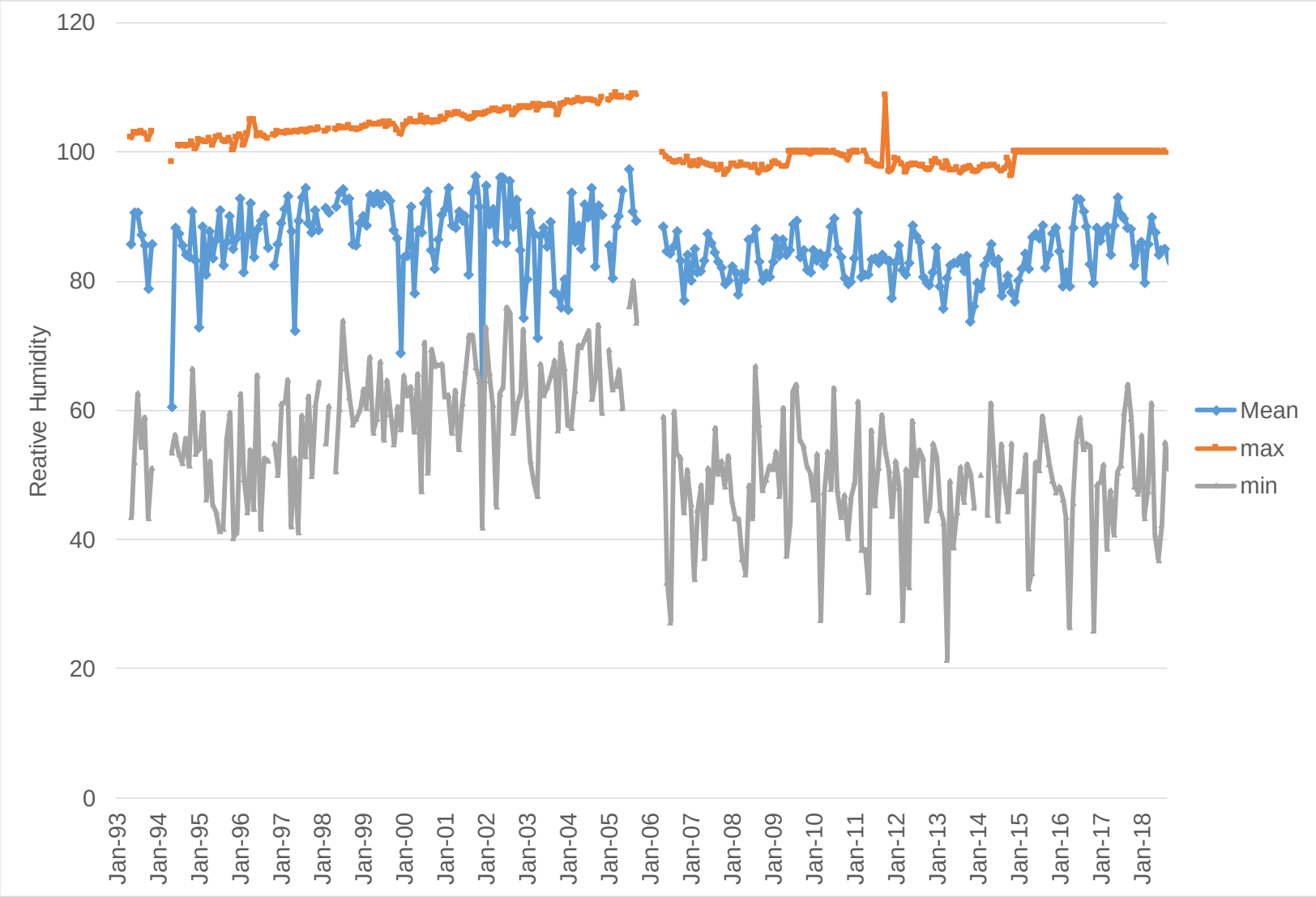


Figure 7.1.11 Skomer MCZ automatic weather station – relative humidity 1993 - 2016:

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.

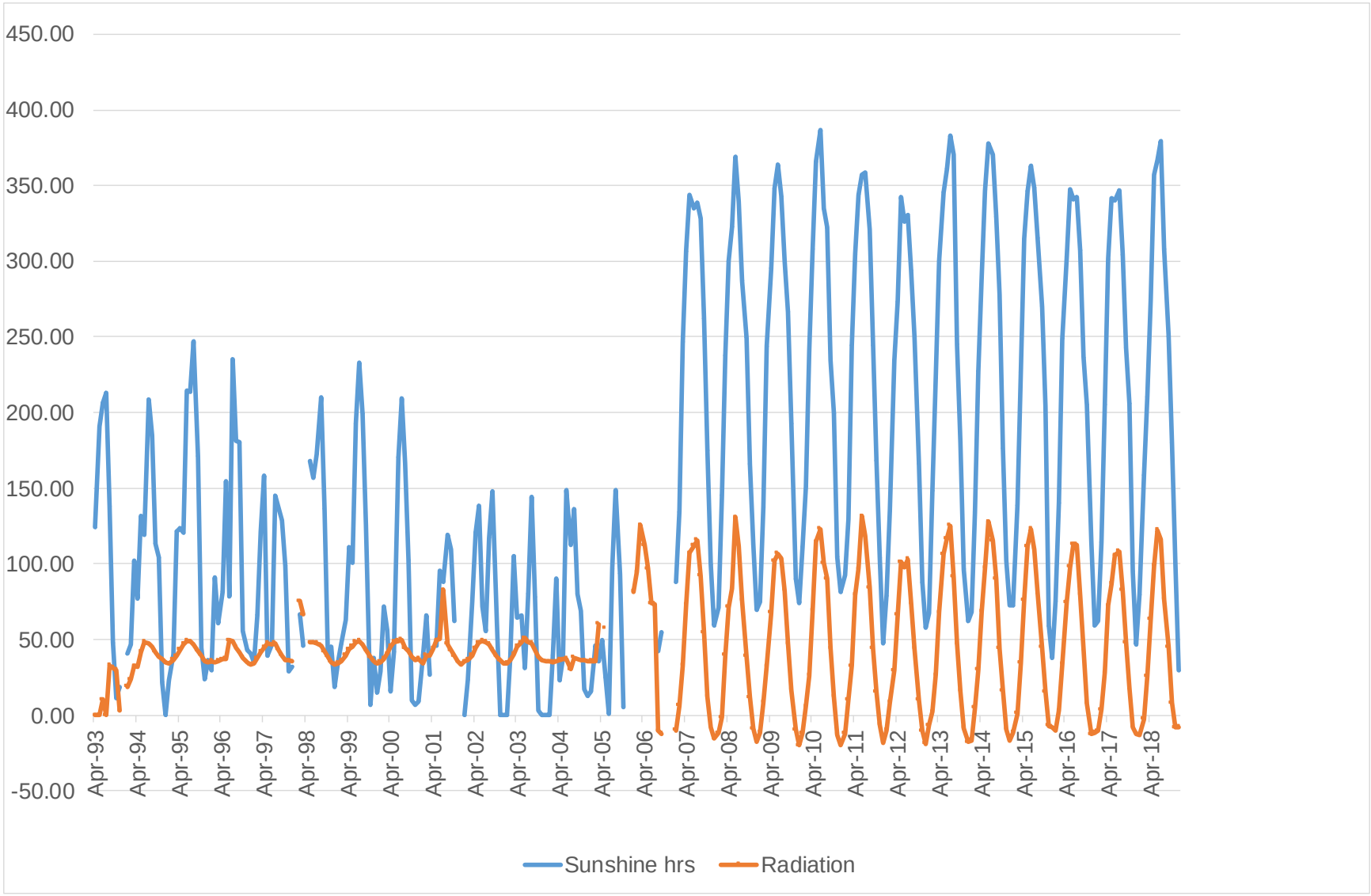


Figure 7.1.12 Skomer MCZ automatic weather station – solar radiation (W/m^2) and sunshine hours 1993 - 2018

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.

7.11.7 Current Status

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

7.11.8 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.

7.12Seawater Temperature Recording

(CMS Code: RP64 / 01)

7.12.1 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 is relevant to the Pembrokeshire Marine SAC and potentially to the West Wales Marine SAC for harbour porpoise.

7.12.2 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 data set for the site.

7.12.3 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

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

7.12.5 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 is 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		
1998	Mar – Nov	2005	May – Oct	2012	Mar – Nov		

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

7.12.6 Results

Oceanographic monitoring site:

Temperature °C	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Minimum	8.4	7.27	8.7	7.6	7.7	7.36	7.5	8.8	8.4	7	6.9
Maximum	16.27	16.3	15.6	17.1	16.76	16.4	16.3	16.3	16.3	16.8	16.8
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**			
Minimum	7.6	8.0	6.98	8.14	7.8	8.5	8.3	6.6			
Maximum	15.9	16.6	16.82	16.72	15.98	16.8	16.4	16.6			

Table 7.2.1 Skomer MCZ maximum and minimum annual seabed temperatures 2000 – 2018 (19m BCD)

The air temperature in the winters of 2009, 2010 and 2018 were very cold and the seawater temperature also dropped to below 7 °C, 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 1^{o}C 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 (6.6^{o}C) with March temperatures 1^{o}C below the average.

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.

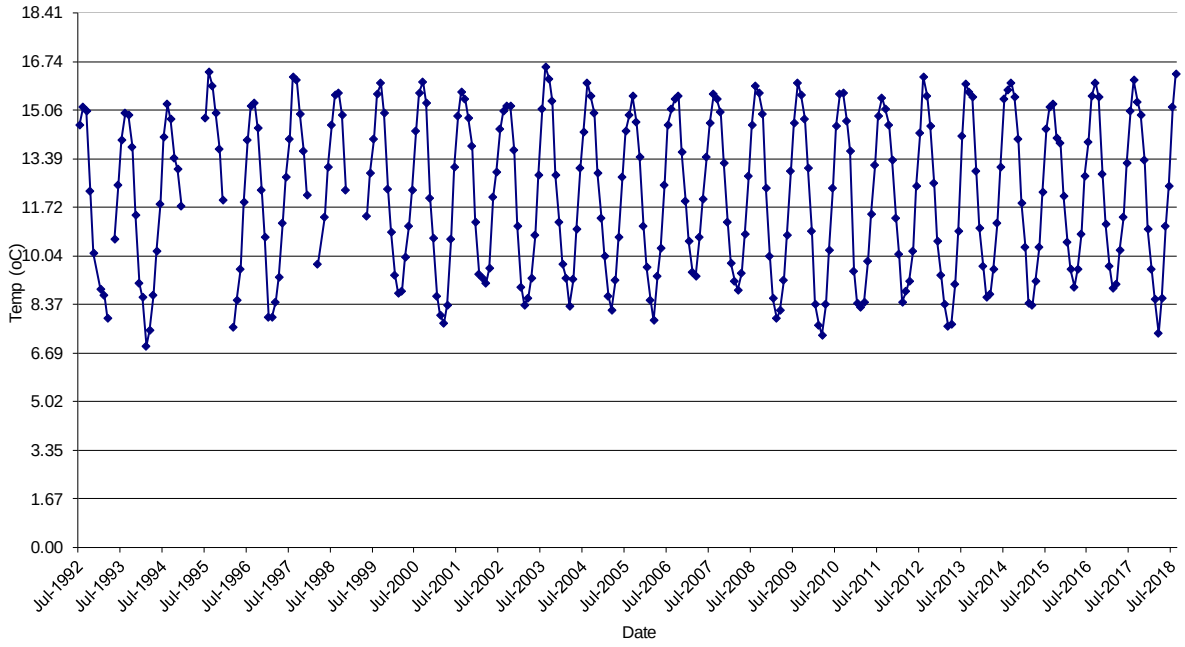


Figure 7.2.1 Skomer MCZ summary of monthly mean seabed temperature (19m BCD) 1992 - 2018

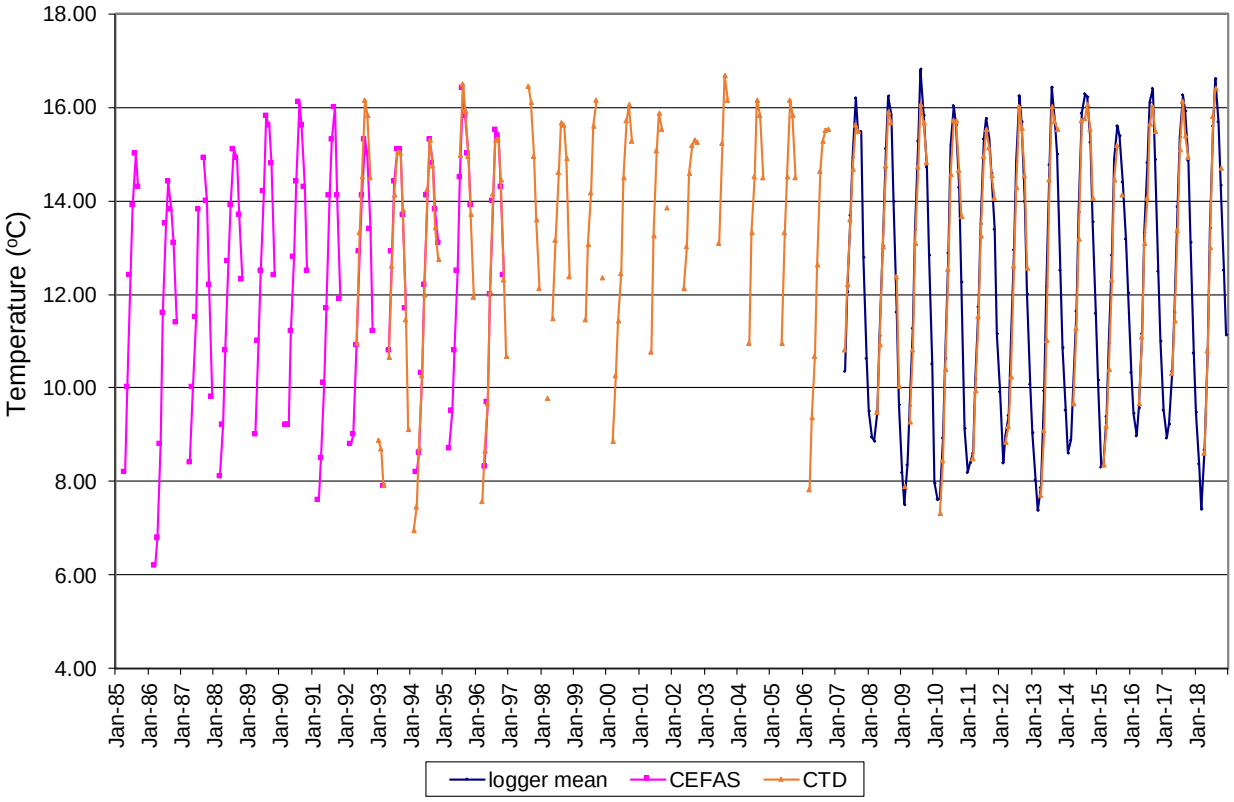


Figure 7.2.2 Skomer MCZ summary of monthly mean sea surface temperature1985 – 2018

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 data set (Figure 7.2.3).

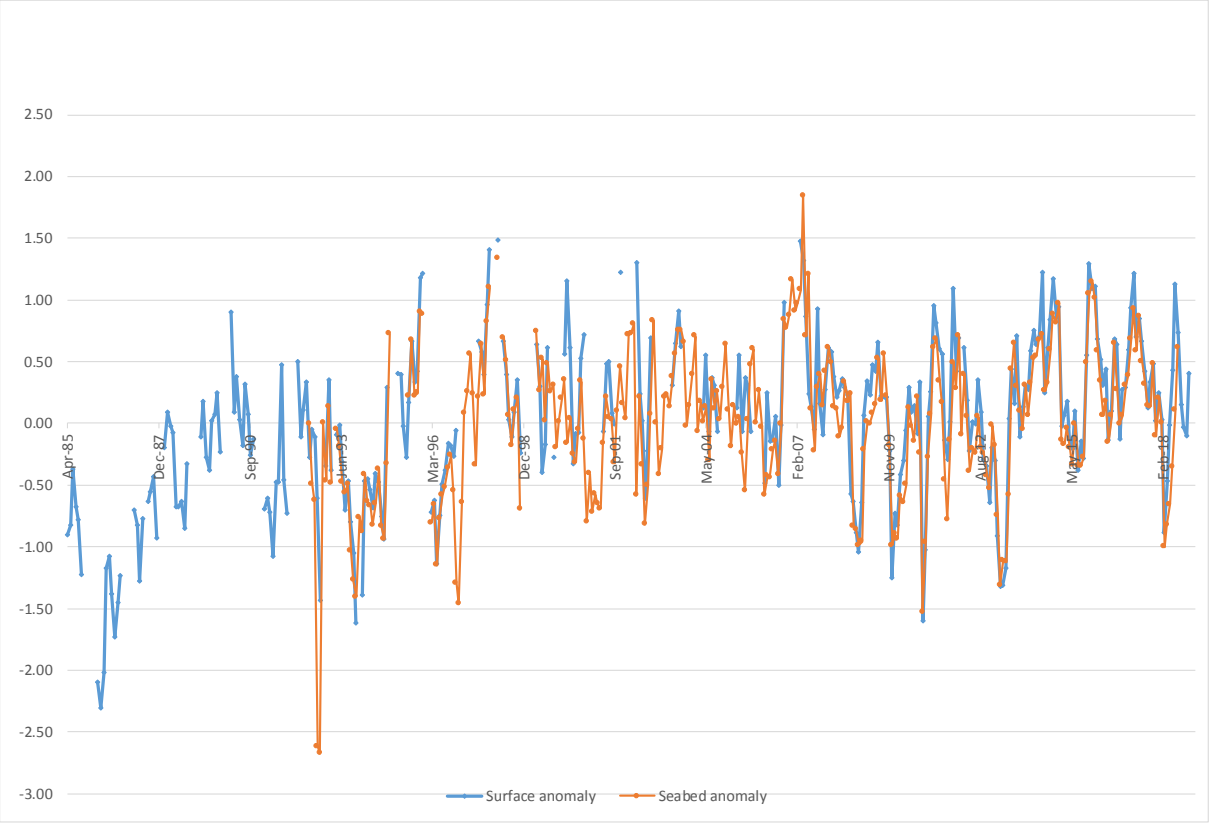


Figure 7.2.3 Skomer MCZ sea temperatures – monthly anomaly between the specific monthly mean and the grand monthly mean, surface and seabed temperatures (1985 to 2018)

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 has been very erratic with some very cold winter temperatures but some warm summer temperatures. In 2018 March – May were unusually cold.

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.

7.12.7 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.

7.12.8 Recommendations

- Continue data set to form a long-term record of variation in seabed temperature at Skomer MCZ.
- Keep the data set 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).

7.13Seawater Turbidity / Suspended Particulates and Seabed Sedimentation *(CMS CODE RP63/01)/(CMS CODE RP63/04)*

7.13.1 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.

Passive sediment trap on seabed at Skomer MCZ

7.13.2 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.

7.13.3 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)

7.13.4 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.

Year	Months with samples	Sites	Notes
1994	Jul – Dec	OMS & TRK	
1995	Jan – Dec	OMS & TRK	
1996	Feb – Dec	OMS & TRK	
1997	Mar – Dec	OMS & TRK	
1998	Mar – Sep	OMS & TRK	
1999- 2001	No samples		Re-established 02 Nov 2001
2002	Mar – Nov	OMS & TRK	TRK site damaged
2003	May – Sep	OMS only	
2004	May – Sep	OMS only	
2005	Jun- Oct	OMS only	Collector damaged
2006	Jun - Oct	OMS & TRK	Repaired and TRK re-established
2007	May - Sep	OMS & TRK	
2008	May - Sep	OMS & TRK	
2009	Apr - Sep	OMS & TRK	Shell fragments in samples.
2010	Apr - Sep	OMS & TRK	
2011	Apr - Nov	OMS & TRK	
2012	Apr - Sep	OMS & TRK	
2013	Apr - Oct	OMS & TRK	New Lab used
2014	Apr - Oct	OMS & TRK	
2015	Apr - Oct	OMS & TRK	
2016	Apr - Oct	OMS & TRK	
2017	Apr - Oct	OMS & TRK	
2018	Apr - Oct	OMS & TRK	

Table 7.3.1 Skomer MCZ sediment trap sampling effort from 1994 to 2017 at OMS and Thorn rock (TRK).

7.13.5 Results

Turbidity

Secchi disc: Measurements have been taken with reasonable consistently 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.

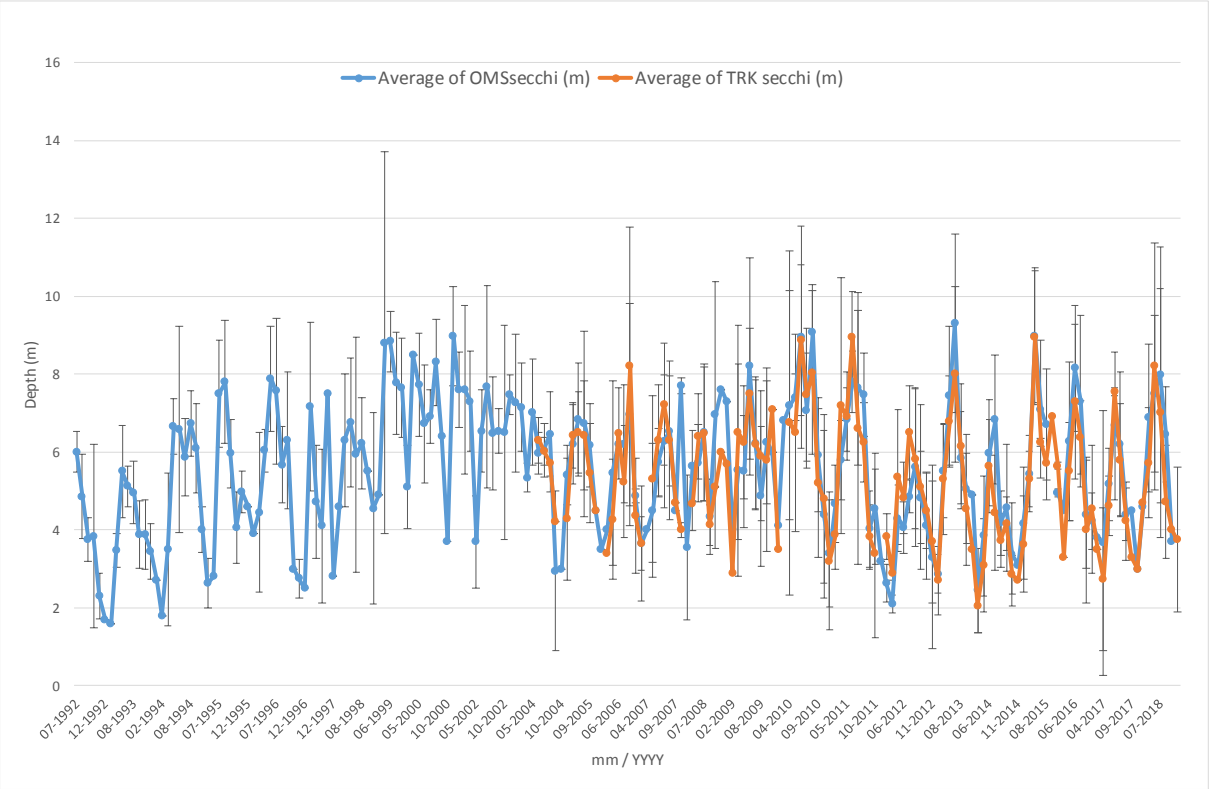


Figure 7.3.1 Skomer MCZ summary of monthly mean Secchi disc data (m) 1992 – 2018 with 95% standard error bars

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.

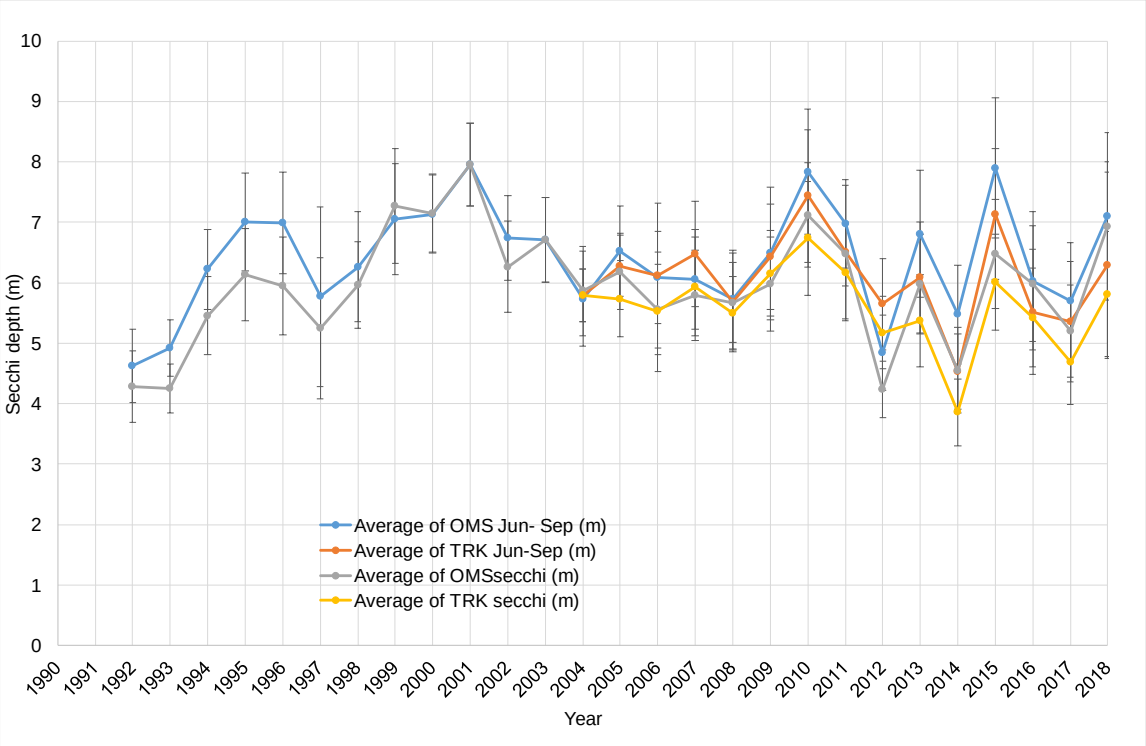


Figure 7.3.2 Skomer MCZ summary of annual mean Secchi disc data (m) with 95% standard error bars

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.

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			
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

Table 7.3.2 Skomer MCZ sediment trap sample analysis - TRK site

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	49.45	40.50

Table 7.3.3 Skomer MCZ sediment trap sample analysis - OMS site

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.

Another change in 2013 was that the organic content analysis included heating the sample to 550°C rather than 450°C 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 480°C.
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.

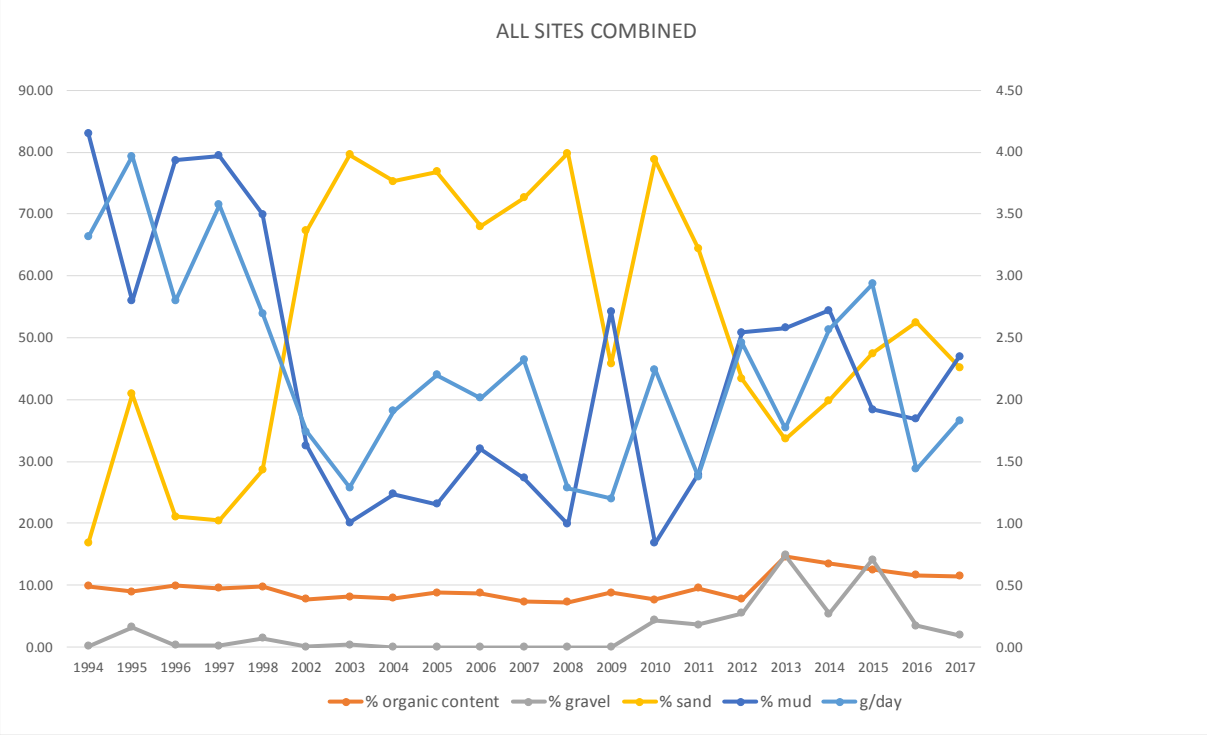


Figure 7.3.3 Skomer MCZ sediment trap sample total sediment, PSA and organic content analysis – both sites combined

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.

7.13.6 Current Status

- Secchi disc method works well and has provided the most reliable and meaningful estimate of turbidity. The data set 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 seen since the early 1990s.

7.13.7 Recommendations

- Continue the Secchi disk readings as often as possible to continue the long-term data set.
- 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

9.11 Appendix 1 Note on 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).

9.11.1 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.

9.11.2 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 (Fig. 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.

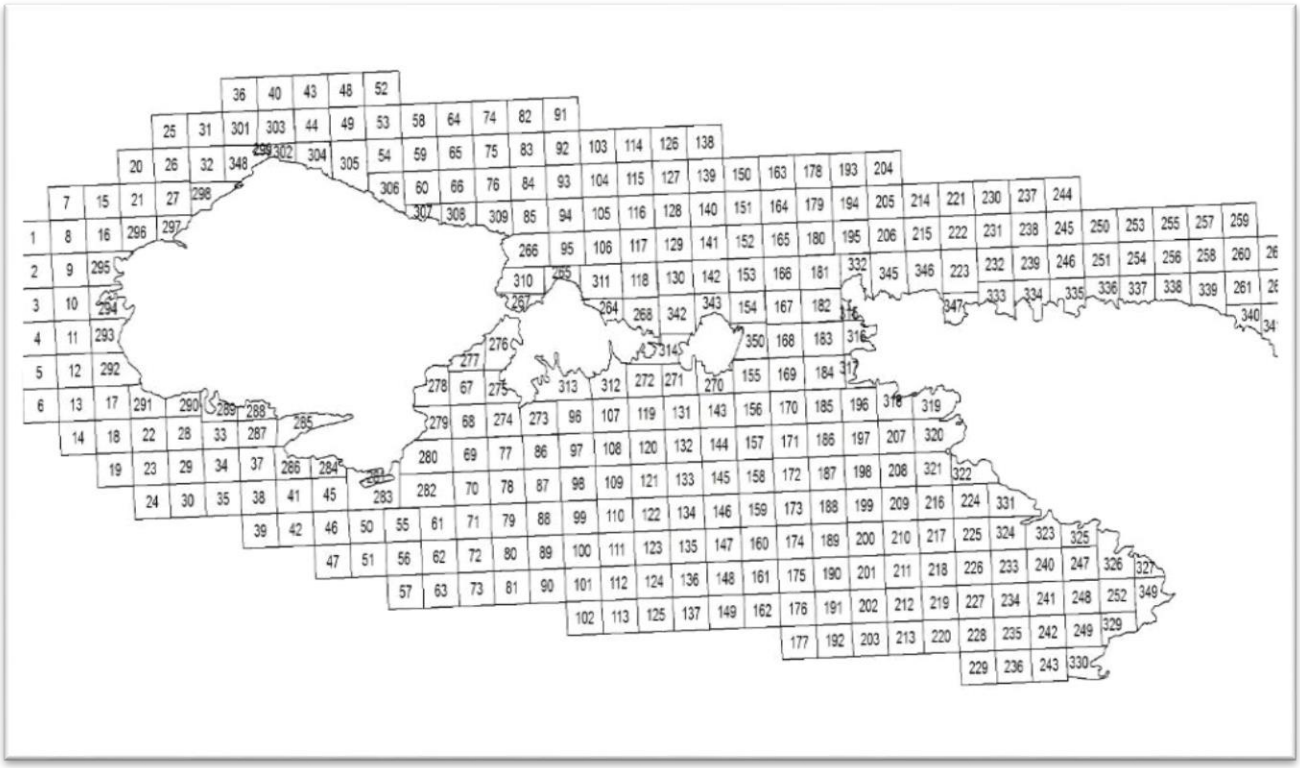

Figure 9.3.1 Grid used for Skomer MCZ shellfish pot mapping.

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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