Skomer Marine Conservation Zone Project Status Report 2021

NRW Evidence Report 589

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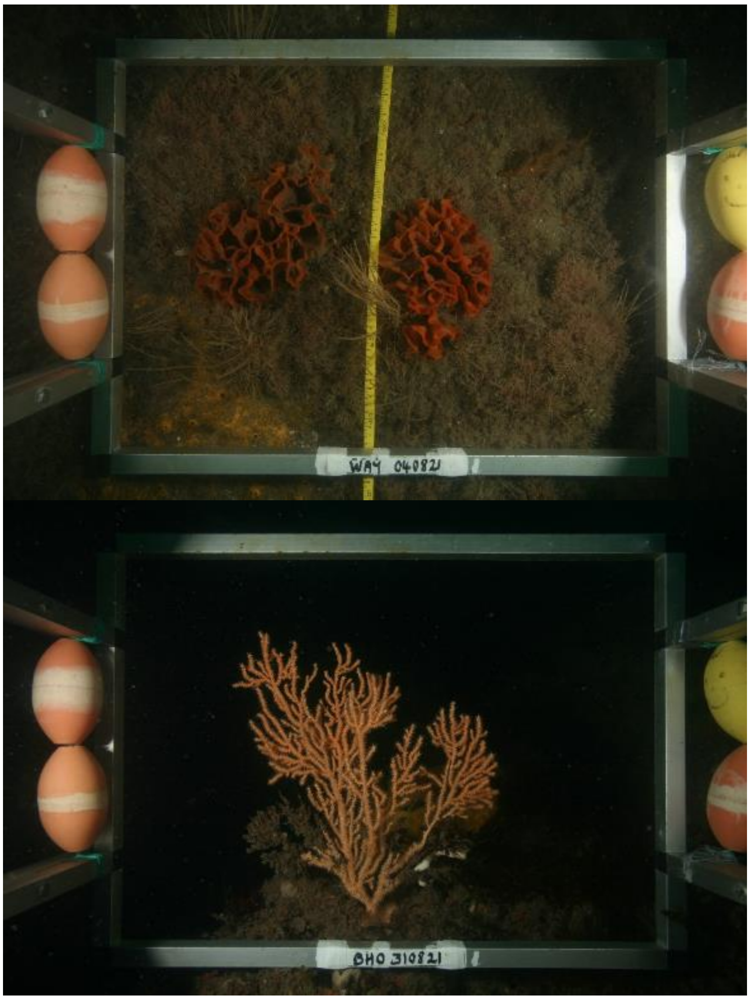

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Dyma'r ugeinfed adroddiad ar statws prosiectau y mae Parth Cadwraeth Morol (PCM) Sgomer wedi'i gynhyrchu. Mae'n crynhoi cynnydd a statws presennol prosiectau monitro yn PCM Sgomer yn ystod 2021. Mae'r prosiectau hyn nid yn unig yn darparu'r dystiolaeth sydd ei hangen i adrodd ar gyflwr PCM Sgomer ei hun ond hefyd yn gwneud cyfraniad pwysig i'r dystiolaeth a ddefnyddir wrth asesu cyflwr a statws cadwraeth Ardal Cadwraeth Arbennig Forol Sir Benfro, y mae'r PCM wedi'i lleoli ynddi. Mae data hirdymor PCM Sgomer, sef biolegol yn ogystal â'r defnydd gan bobl, wedi'i defnyddio hefyd i sefydlu ac adrodd ar ddangosyddion biolegol ar gyfer gofynion y DU o dan Gyfarwyddeb Fframwaith y Strategaeth Forol (MSFD). Ceir manylion am achosion penodol lle defnyddiwyd data PCM Sgomer i gefnogi mentrau heblaw'r rhai sy'n uniongyrchol gysylltiedig â'r PCM yng nghrynodebau'r prosiectau unigol.

Mae tablau statws y prosiectau yn Adran 2 yn rhoi crynodeb o'r holl brosiectau monitro sydd wedi'u sefydlu yn y PCM. Mae Adran 4 yn manylu ar brosiectau biolegol y gwnaed gwaith arnynt yn ystod 2021 a chrynodeb o'r canlyniadau hyd yma. Mae Adran 5 yn rhoi crynodeb o'r prosiectau gwyliadwriaeth eigionegol a meteorolegol.

Cofnodion nodedig yn 2021:

Mae cyfanswm nifer y cytrefi o Gwrel rhosliw, *Pentapora foliacea* a gofnodwyd yn y safleoedd mwyaf, Waybench, Pool a Bernies Rock i gyd yn dangos cynnydd sylweddol. Dengys canlyniadau o bob safle fod mwy o gytrefi iach sy'n tyfu na chytrefi sydd wedi dirywio. Sefydlwyd safleoedd monitro newydd yn riff dwyreiniol Martin's Haven.

Cofnodwyd rhagor o golledion ymysg môr-wyntyllau pinc, *Eunicella verrucosa*, yn 2021. Datblygwyd gwell dulliau dadansoddi delweddau i alluogi asesiad manylach o gyflwr presennol y môr-wyntyllau. Cofnodwyd wyau morgwn brych *Scyliorhinus stellaris* ar 62% o fôr-wyntyllau ac mae necrosis lefel 4 (epiffytau'n tyfu ar ran helaeth o'r môr-wyntyll) wedi cynyddu o 2.4% o fôr-wyntyllau yn 2002 i 20% yn 2021.

Cwblhawyd yr arolwg o loi Morloi llwyd ar safleoedd yr ynys a'r tir mawr o fis Awst i fis Rhagfyr a chofnodwyd 446 o loi. Dros y tair blynedd diwethaf, gwelwyd y cyfansymiau uchaf erioed o ran genedigaethau morloi llwyd yn PCM Sgomer, gyda chyfartaledd o 425 o loi ar gyfer 2019-21. Ers 2009 bu cynnydd cyson yn y lloi sy'n cael eu geni ar safleoedd yr ynys a'r tir mawr.

Executive summary

This is the twentieth 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 2021. These projects not only provide the evidence needed to report on the condition of the Skomer MCZ itself but make an important contribution to the evidence used in assessing the condition and conservation status of the Pembrokeshire Marine Special Area of Conservation, within which the MCZ is situated. Skomer MCZ long-term data, biological as well as human use, has also been used in establishing and reporting on biological indicators for UK requirements under the Marine Strategy Framework Directive (MSFD). Specific cases where Skomer MCZ data have been used to support initiatives other than those directly linked to the MCZ are detailed in individual project summaries.

The project status tables in Section 2 provide a summary of all established monitoring projects in the MCZ. Section 4 details biological projects that were worked on during 2021 and a summary of the results to date. Section 5 provides a summary of the oceanographic and meteorological surveillance projects.

Notable records in 2021:

The total numbers of Ross coral*, Pentapora foliacea* colonies recorded at the largest sites, Waybench, Pool and Bernies Rock all show significant increases. Results from all sites show there are more healthy growing colonies than degraded colonies. A new monitoring site was established at Martins Haven east reef.

Pink sea fan, *Eunicella verrucosa*, monitoring recorded further losses in 2021. Improved photo analysis methods were developed to enable a more detailed assessment of the current condition of the individual sea fans, bull huss *Scyliorhinus stellaris* eggs were recorded on 62% of sea fans and necrosis level 4 (epiphytes growing on extensive area of the sea fan) has increased from 2.4% of fans in 2002 to 20% in 2021.

The Grey seal pupping survey was completed at both island and mainland sites from August to December and 446 pups were recorded. Pup production in the Skomer MCZ for the past 3 years has shown the highest totals ever recorded with average production for 2019-21 at 425 pups. Since 2009 there has been a steady increase in pup production at both the island and mainland sites.

1. 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 public access to the whole coastline of Skomer when it is specific small areas that are more sensitive to disturbance at certain 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 from 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 can 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.

2. Project Summary Tables

2.1 Physical data projects

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Meteorological data	Automatic station logging 10 mins mean for wind, rain, sunshine, temperature, humidity, net radiation New met station (2006) compatible with the ECN and logs files daily, hourly and every ten minutes.	1993 to ongoing (Old station removed October 2005 and new station installed April 2006)	Continuous	No	Yes, Skomer MCZ office
Wave data	Height, period, etc. Automatic station logging every 10mins.	1993-1998 Discontinued	Continuous	No	No, raw data, paper format only
Seawater data	Temperature, salinity, conductivity	1992 to ongoing	Weekly (April to Oct)	No	Yes, Skomer MCZ office
Seawater data	YSI 6600 multi parameter sonde: Temperature, salinity, dissolved O_2, Chlorophyll, turbidity & depth. OSIL buoy automatically transmitting data from YSI 6600 sonde.	2007 to 2013 Discontinued	Hourly samples	No	Yes, Skomer MCZ office
Seawater data	Temperature onset logger	2014 to ongoing	Hourly samples	No	Yes, Skomer MCZ office
Seabed sedimentation	Auto sampler	1994 to1998 Discontinued	Continuous	No	Yes, Skomer MCZ office
Seabed sedimentation	Sediment trap	1994 – ongoing	Every 14 days (April to Oct)	Jones 1998	Yes, Skomer MCZ office
Suspended sediments	Idronaut Turbidity logger	2001-2006 Discontinued	Continuous	No	No, raw data only
Suspended sediments	Secchi disc	1992 to ongoing	Weekly (April to Oct)	No	Yes, Skomer MCZ office
Suspended sediments	YSI 6600 multi parameter sonde	2007 to 2013 Discontinued	Hourly	No	Yes, Skomer MCZ office

2.2 Activity projects

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Recreation activities	Numbers and locations of Boats, divers, anglers	1987 to ongoing	Weekly (May -Sept)	Skomer MCZ annual reports	Yes, Skomer MCZ office
Commercial fishing activities	Date and location of fishing boats	1987 to ongoing	Weekly (May -Sept)	Skomer MCZ annual reports	Yes, Skomer MCZ office
Commercial fishing activities	Mapping of Pot buoys and fishing net positions	1989 to ongoing	Weekly (May -Sept)	Burton 2002, Skomer MCZ annual reports	Yes, Skomer MCZ office
Tankers in St Brides bay	Number and names of tankers and movements.	1994 to ongoing	Daily	No	Yes, Skomer MCZ office
Tankers in St Brides bay	Automatic Identification System (AIS)	2013 to ongoing	Continuous	No	Yes, Skomer MCZ office

2.3 Biological projects

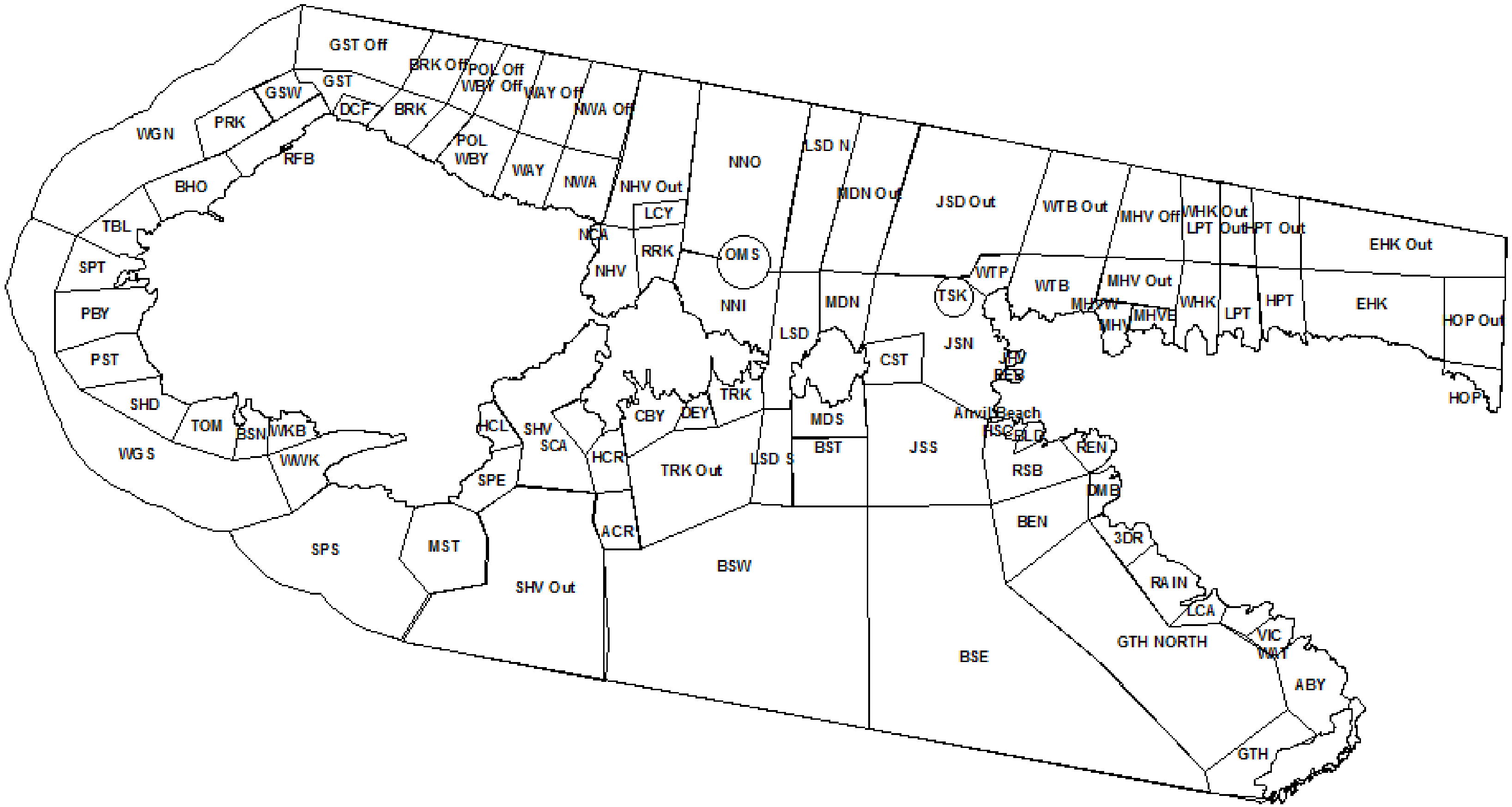
Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Littoral Community Macro scale	Viewpoint photos/digitised to form time-series dataset	1992 to ongoing	Annual	Internal reports: Daguet 2000, Gibbs 2007	Yes, Skomer MCZ office
Littoral Community Meso scale	6 Transects, photos/digitised to form time-series dataset	1992 to ongoing	Annual	Adams 1979, Bunker 1983, Crump 1993/96, Hudson 1995.	Yes, Skomer MCZ office
Littoral Community Meso scale	7 sites, quadrats at lower, middle, upper shores and lichen zone. 3 sites MarClim methods	2003 to ongoing	Annual	Crump & Burton 2004	Yes, Skomer MCZ office
Sub-Littoral Rocky reef communities	Stereo photos/digitised to form time-series dataset	1982 – ongoing	Annual	Bullimore 1986 & 1987	Yes, Skomer MCZ office

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Sub-Littoral Algal communities	Algae species and community survey	1983, 1986,1994, 1999, 2007	No current planned survey	Hiscock,S 1983 & 1986, Scott 1994, Brodie & Bunker 1999/2000, Maggs & Bunker 2007.	Yes, Skomer MCZ office. Algae herbarium stored at National Museum Wales.
Sub-Littoral Sponge assemblages	4 transects, photos/digitised to form time-series dataset	1994 to ongoing	Annual	Bunker & Jones 2008 & 2012	Yes, Skomer MCZ office.
Sub-Littoral Sponge assemblages	Species recording	2002/3, 2007/8 2011, 2015, 2019	Every 4 years, next planned 2025	Jones *et al.* 2012, 2016, 2020.	Yes, Skomer MCZ office.
Sub-Littoral Sponge assemblages	15 fixed quadrats, photos/digitised to form time-series dataset	2006 to ongoing	Annual	Berman *et al.* 2013.	Yes, Skomer MCZ office.
Sub-Littoral Infauna sediment	12 sampling stations. Grab sampling: 5 biological replicas, 1 PSA and 1 metals sample.	1993,1996, 1998, 2003, 2007, 2009, 2013, 2016, 2020	Every 4 years, next survey planned 2024	Rostron 1994 & 1996, Barfield 1998 & 2003, 2007 & 2010.	Yes, Skomer MCZ office.
Sub-Littoral Epifaunal sediment	2 sampling stations. Diver species recording, suction sampling collection.	1995, 2001 & 2004, 2009 video only.	Project now combined with Infauna	Rostron 1996, Moore 2002 & 2005.	Yes, Skomer MCZ office.
Plankton communities	Zooplankton samples taken with a 200um net. Vertical haul methods comparable to others used in UK.	2009 ongoing	Weekly (April to Oct)	Unpublished report with method recommendations Plymouth Marine Laboratories 2015.	Yes, Skomer MCZ office.
Plankton communities	Phytoplankton samples taken with 20um net. Vertical haul methods comparable to others used in UK.	2009 – 2012 Restarted 2019	Weekly (April to Oct)	No	Yes, Skomer MCZ office.
Zostera marina	Extent of North Haven bed & density distribution.	1997, 2002, 2006, 2010, 2014, 2018 2013, 2014, 2015, 2018, 2019 & 2021	Every 4 years Next survey planned 2023	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, Skomer MCZ office.

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Zostera marina	Biosonics acoustic sonar survey	2018, 2019 & 2021	Annual if possible	Skomer MCZ annual reports	Yes, Skomer MCZ office.
Eunicella verrucosa	10 sites. Colonies photographed to form time-series dataset	1993 to ongoing	Annual	Bunker et al. 1985, Bullimore1986 & 1987, Gilbert 1998, Skomer MCZ annual reports	Yes, Skomer MCZ office.
Alcyonium glomeratum	4 sites. Colonies photographed to form time-series dataset	1984 to ongoing	Annual	Bullimore1986 & 1987.	Yes, Skomer MCZ office.
Parazoanthus axinellae	6 sites. Colonies photographed to form time-series dataset	2001 to ongoing	Annual	Burton *et al.* 2002.	Yes, Skomer MCZ office.
Pentapora foliacea	6 sites, Colonies photographed to form time-series dataset	1994- ongoing	Annual	Bullimore1986 & 1987, Bunker & Mercer 1988, Gilbert 1998, Gibbs 2006.	Yes, Skomer MCZ office.
Balanophyllia regia	2 sites, Colonies photographed to form time-series dataset	TRK, 1984 to ongoing, WCK 2002 to ongoing	Annual	Bullimore 1986 & 1987.	Yes, Skomer MCZ office.
Caryophyllia smithii	Counted from sponge project photo quadrats	1993 to ongoing	Annual	No	Yes, Skomer MCZ office.
Grey seal *Halichoerus grypus*	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 1992-2021, Skomer MCZ annual reports.	Yes, Skomer MCZ office.
Nudibranch species	Species recording.	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, Skomer MCZ office. NBN database.
Territorial fish	Counts completed along transects at 15m, 10m & 5m depths at sites on the North sides Skomer and Marloes Peninsula.	1997, 2001/2002 2005, 2009, 2013, 2007, 2009, 2013 & 2017.	Every 4 years No new survey planned	Lock 1998, Lock *et al.* 2006, Tompsett 2006 .	Yes, Skomer MCZ office.
Territorial fish	Drop-down video surveys	2009, 2010	Student projects	Sweet 2009, Bullimore 2010	Yes, Skomer MCZ office.

3. Skomer MCZ Sites and codes

3.1 Map of Skomer MCZ divided into site code areas (see 3.2 for site names)



3.2 Site codes with corresponding site names.

Site code	Site Name
ACR	Anchor Reef
ABY	Albion Beach
BEN	The Bench
BHO	Bull Hole
BLD	Boulder Beach
BRK / BRK Off	Bernie's Rocks / Offshore
BSE	Broad Sound East
BSN	The Basin
BST	Black Stones
BSW	Broad Sound West
CBY	Castle Bay
CST	Crab Stones
DCF	Double Cliff
DEY	"Dead Eye" wreck
DMB	Dead Man's Bay
EHK / EHK Out	East Hook / Outer
GST / GST Off	Garland Stone / Offshore
GSW	Garland Stone West
GTH / GTH North	Gateholm / North
HCL	High Cliff
HCR	High Court Reef
HOP / HOP Out	Hopgang / Outer
HPT / HPT Out	High Point / Outer
HSC	Horseshoe Cave
JNK	Junko's Reef
JHV	Jeffrey's Haven
JSD Out/ JSN / JSS	Jack Sound / North / South
LCA	Little Castle Beach
LCY	"Lucy" wreck
LPT / LPT Out	Low Point / Outer
LSD / LSDN / LSDS	Little Sound /North/South
MDN / MDS / MDN Out	Middleholm North / South / North Outer
MHV / MHVE / MHVW / MHV Out / MHV Off	Martins Haven / East / West / Outer / Offshore

Site code	**Site Name**
MST	Mew Stone
NCA	North Castle
NHV / Out	North Haven / Outer
NNI / NNO	North Neck Inner / Outer
NWA / NWA Off	North Wall / Offshore
OMS	Oceanographic Monitoring Site
PBY	Pig Stone Bay
PEB	Pebbly Beach
POL / POL Off	The Pool / Offshore
PST	Pig Stone
RAIN	Rainy Rock
REN	Renney Slip
RFB	Rockfall Bench
RRK	Rye Rocks
RSB	Renney Slip Bay
SCA	South Castle
SHD	Skomer Head
SHV / SHV Out	South Haven / Outer
SPE	South Plateau East
SPS	South Plateau South
SPT	The Spit
TBL	The Table
TOM	Tom's House
TRK / Out	Thorn Rock / Outer
TSK	Tusker Rock
VIC	Victoria Bay
WAT	Watery Bay
WAY / Off	Waybench / Offshore
WBY / Off	Waterfall Bay / Offshore
WGN	Wild goose north
WGS	Wild goose south
WHK / Out	West Hook / Outer
WKB	Wick Basin
WTB / Out	Wooltack Bay / Outer
WTP	Wooltack Point
WWK	The Wick
3DR	Three Doors

4 Skomer MCZ Biological Project Summaries

4.1. Littoral Communities

4.1.1. 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 which provide guidance and supporting information for littoral monitoring projects.

4.1.2. Objectives

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

4.1 3. Sites

Table 1 Survey site names, site code and start date.

Site Name	Site code	Start of survey
North Haven	NHV	1992
South Haven	SHV	1992
South Stream	SST	1992
The Lantern	LTN	1992
The Wick	WCK	1992
Double Cliff	DCF	1992
Pig Stone	PST	2003
Wooltack	WTK	2003
Martins Haven	MHV	2003
Hopgang	HOP	1996 Lichens only

4.1.4. 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 shore height 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:

- 1m2 quadrat divided into a 25-cell grid is used to record presence/absence of all species. Some species are aggregated for recording as follows: Rough winkle species, barnacle species, limpets (recorded as *Patella spp*.) and encrusting red algae.
- Four digital photographs are taken of a 50 x50 cm quadrat, placed within each 1m2 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 (Figure 1). The photographs provide 20 samples from each shore height, these are stored for barnacle species counts of all individuals > 2mm (currently the photos are stored, and counts will be completed when time allows).

Figure 1 Barnacle 5 x 5cm quadrat

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

At Splash Zones:
% cover of all lichen species is recorded in 50 x 50cm quadrats at selected sites and a quadrat photograph taken.*MarClim Methodology (*2003 - Ongoing):
The MarClim project offers an opportunity to compare Skomer MCZ shores to the rest of the UK and contribute to the assessment of the effects of climate change. Martins Haven, North Haven and South Haven were selected as suitable sites for the project (see Mieszkowska *et al.* 2002).The MarClim methods:

- Abundance recording of a selected list of edge-of-range species.
- Photograph barnacles in 5 x 5cm quadrats to complete barnacle species counts.
- Limpet species counts in 50 x 50cm quadrats
- Timed searches of *Phorcus lineatus* and *Steromphala umbilicalis* and individuals measured to the nearest mm.

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

Table 2 Summary of methods completed at each littoral site.

Site	**Permanent Quadrats pre-2003**	**Shore zone quadrats 2003 onwards**	**Lichen quadrats**	**Marclim**	**Shore Clingfish**
North Haven	No	No	No	Yes	Yes
South haven	Yes	No	No	Yes	Yes
South Stream	Yes	Yes	Yes	No	No
The Lantern	Yes	Yes	Yes	No	No
The Wick	Yes	Yes	Yes	No	No
Double Cliff	Yes	Yes	No	No	No
Pig Stone	No	Yes	Yes	No	No
Wooltack	No	Yes	Yes	No	No
Martins haven	No	Yes	Yes	Yes	Yes
Hopgang	No	No	Yes	No	No

4.1.5. 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, except for the lichen community at Hopgang, which showed signs of necrosis.

2001: Slide photographs from 1992 – 2000 were reviewed and abundance estimates from the photographs compared with abundance records from Crump 1993 & 1996 field data. Photograph quality was insufficient to allow accurate abundance estimates.

2001/02: Digital imaging was tested to obtain pictures of permanent quadrats. Image quality was improved; however, estimates of species abundance were still inaccurate due to difficulties with identification of species and individuals from the images. This method cannot replace collection of data in the field for quantitative assessment.

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

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

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

2020: No field work was completed due to Covid restrictions.

2021: Only Marclim field work was completed.

The survey methods for each site outlined in Table 1 have been completed in years 2003 to 2021 as shown in Table 2.

Table 3 Summary of survey sites completed 2003 – 2021. (Lower shore: LS, Middle shore: MS, Upper shore: US)

Site	North Haven	South haven	South Stream	The Lantern	The Wick	Double Cliff	Pig Stone	Wooltack	Martins haven	Hopgang
2003	Marclim	Marclim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2004	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2005	Yes	Yes	Yes	Yes	Yes	Yes	No LS	Yes	Yes	Yes
2006	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2007	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2012	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2014	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2016	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2018	Yes	Yes	Yes	Yes	Yes	No US / MS	Yes	Yes	Yes	Yes
2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2020	No	No	No	No	No	No	No	No	Marclim	No
2021	Marclim	Marclim	No	No	No	No	No	No	Marclim	No

4.1.6. Results

Whole Community Analysis

All the shore zone quadrat data are entered into the PRIMER statistics software for community analysis. The results can be visualised as multi-dimensional scaling (MDS) plots, see Figure 2.

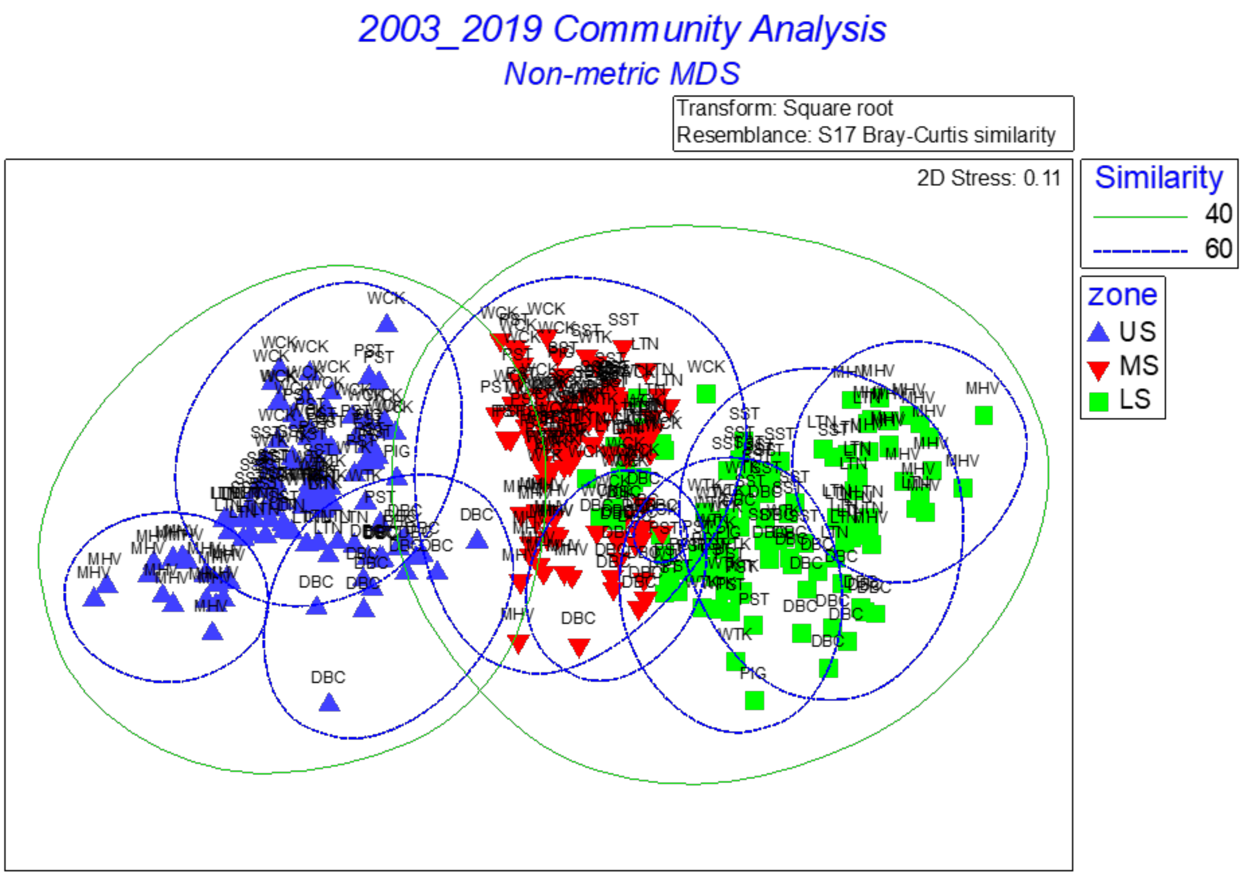
General summary:

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

2019 did not show any major variations from the overall trends seen since 2004.
An "ANOSIM" test for differences between years showed no significant difference between any of the years. Sample statistic (R): -0.014   Significance level of sample statistic: 95%
The communities on the shores have not shown any major changes during the monitoring period 2003 to 2019. The shores were not surveyed in 2020 or 2021.

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

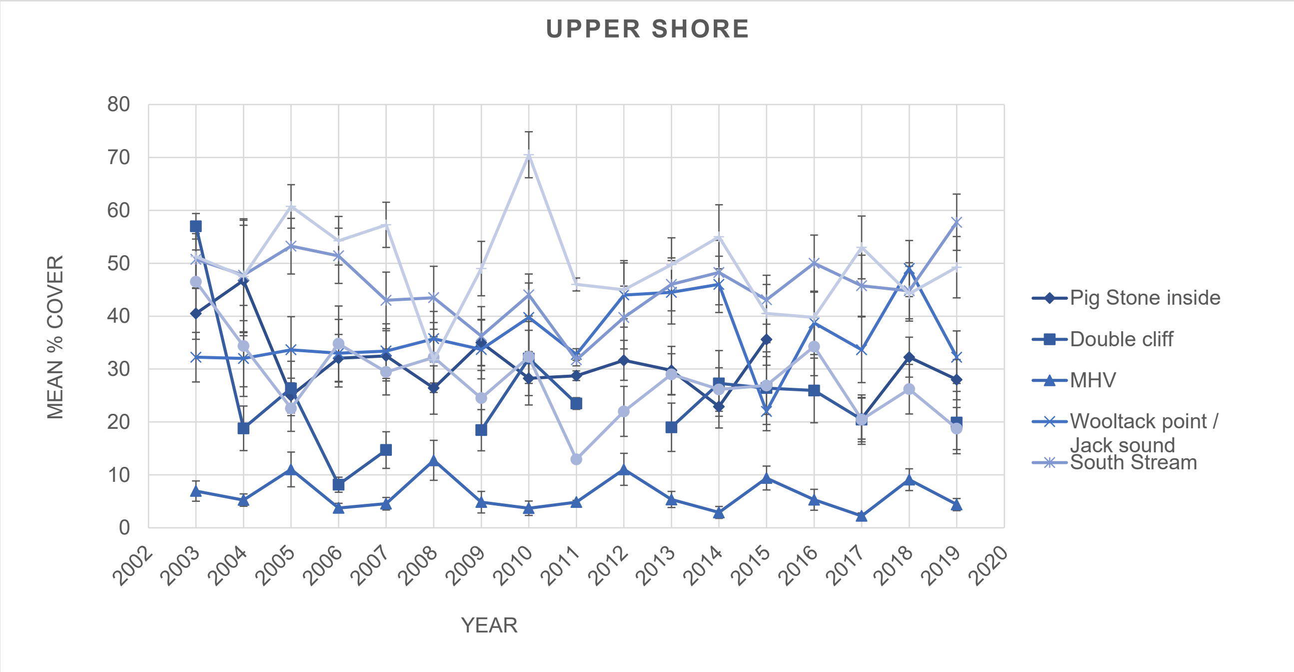
Figure 2 PRIMER Multi-dimensional scaling (MDS) plot of all littoral community data 2003 – 2019 (Upper shore: US, Middle shore: MS, Lower shore: LS)

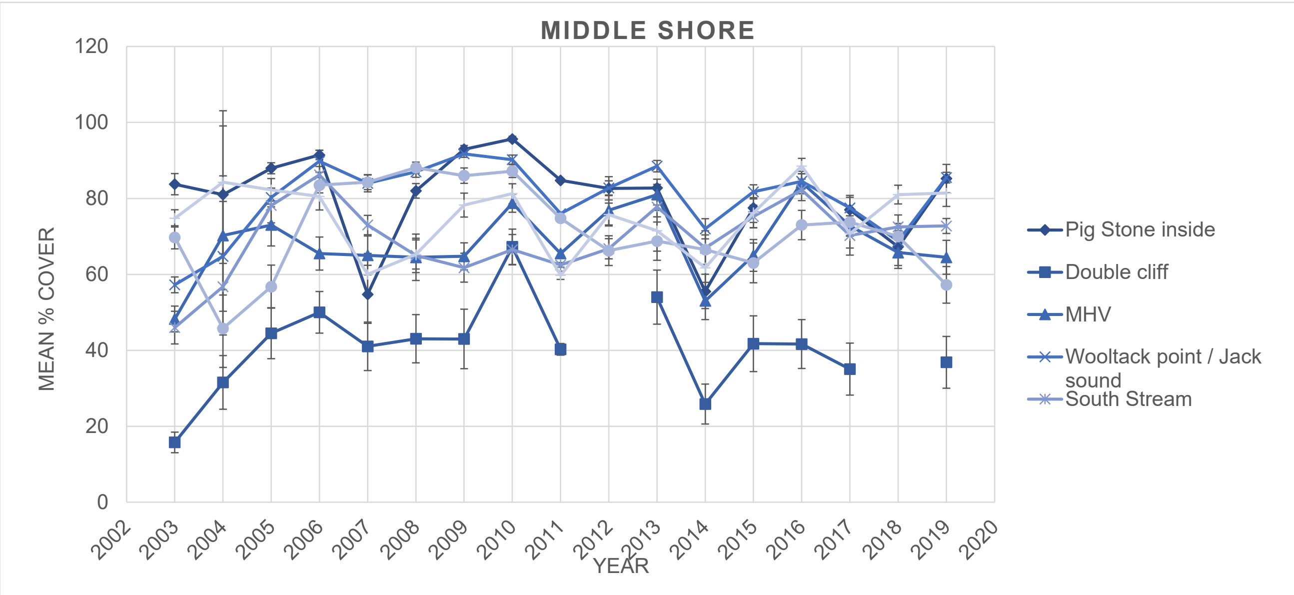


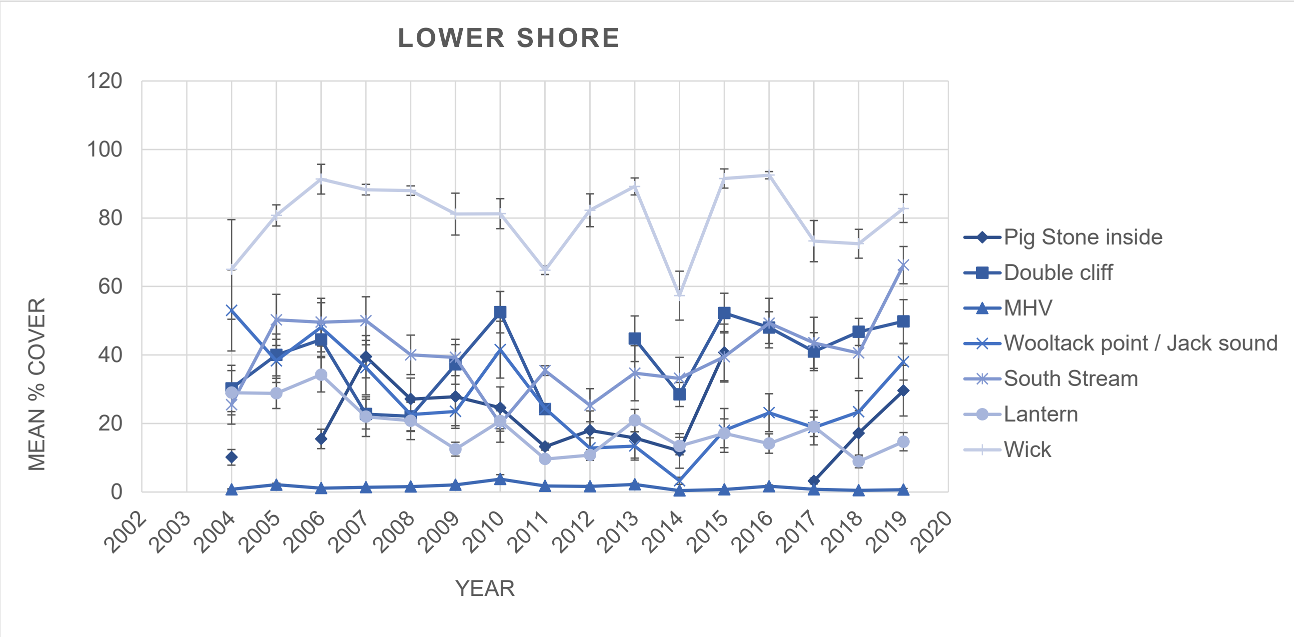
Mean Percentage Cover of Barnacles

Barnacle coverage (all species aggregated) has been variable between sites over the last 16 years. In 2014 all sites saw a decrease in barnacle cover in the middle and lower shores. In 2019 the barnacle coverage showed little change (Figure 3).

Figure 3 Changes in upper, middle and lower shore barnacle coverage 2003 – 2019, with standard error bars.





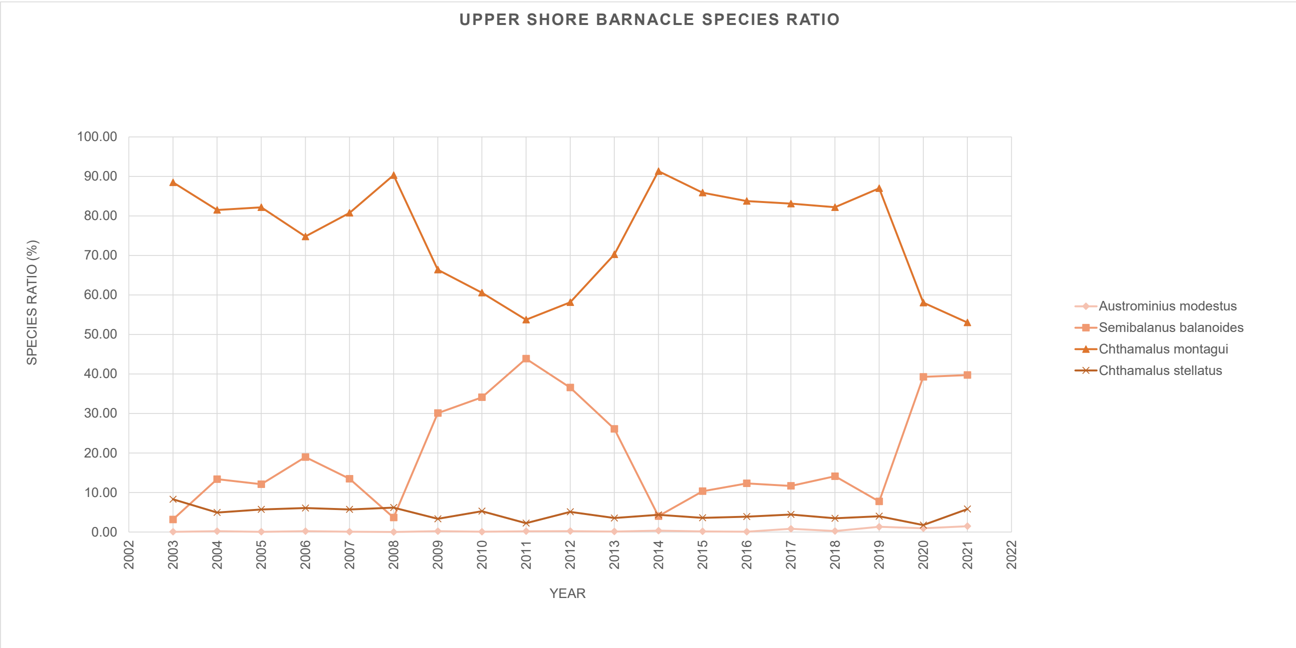


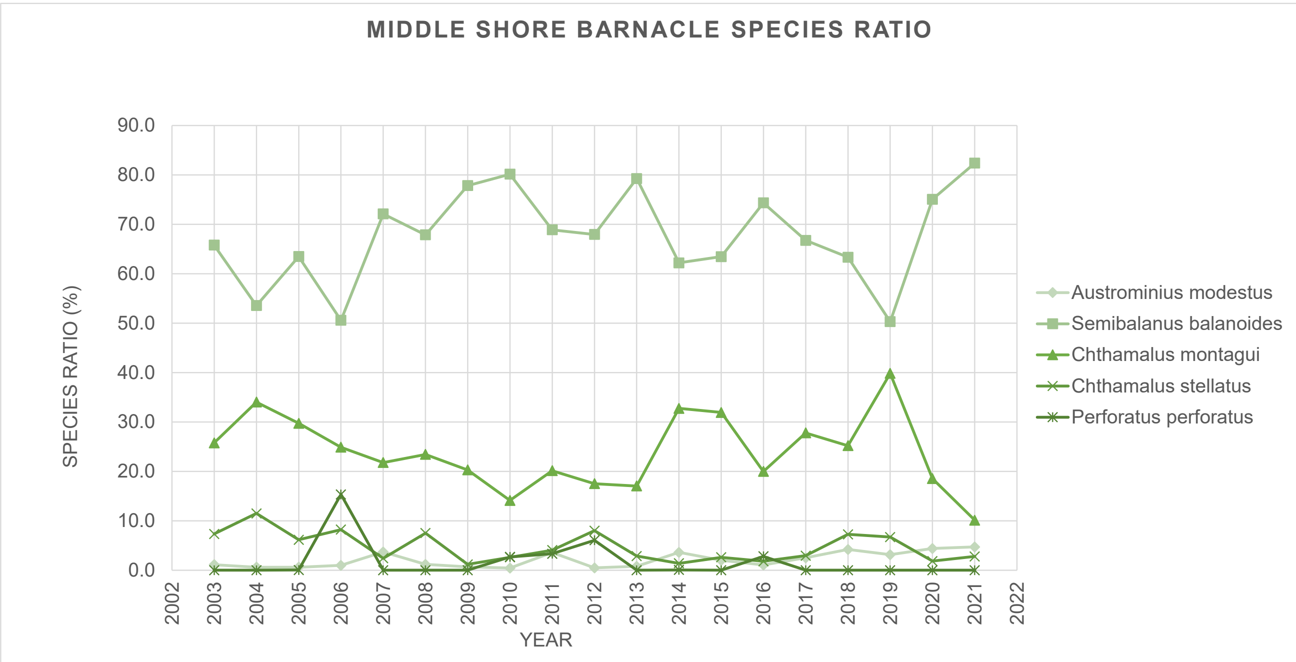
Barnacle Species Ratios
The barnacle species counts have been completed from the photographs of the 5cm x 5cm quadrats at the 3 MarClim Sites: Martins Haven, North Haven and South Haven (photographs taken at the other sites are stored for analysis when time allows).

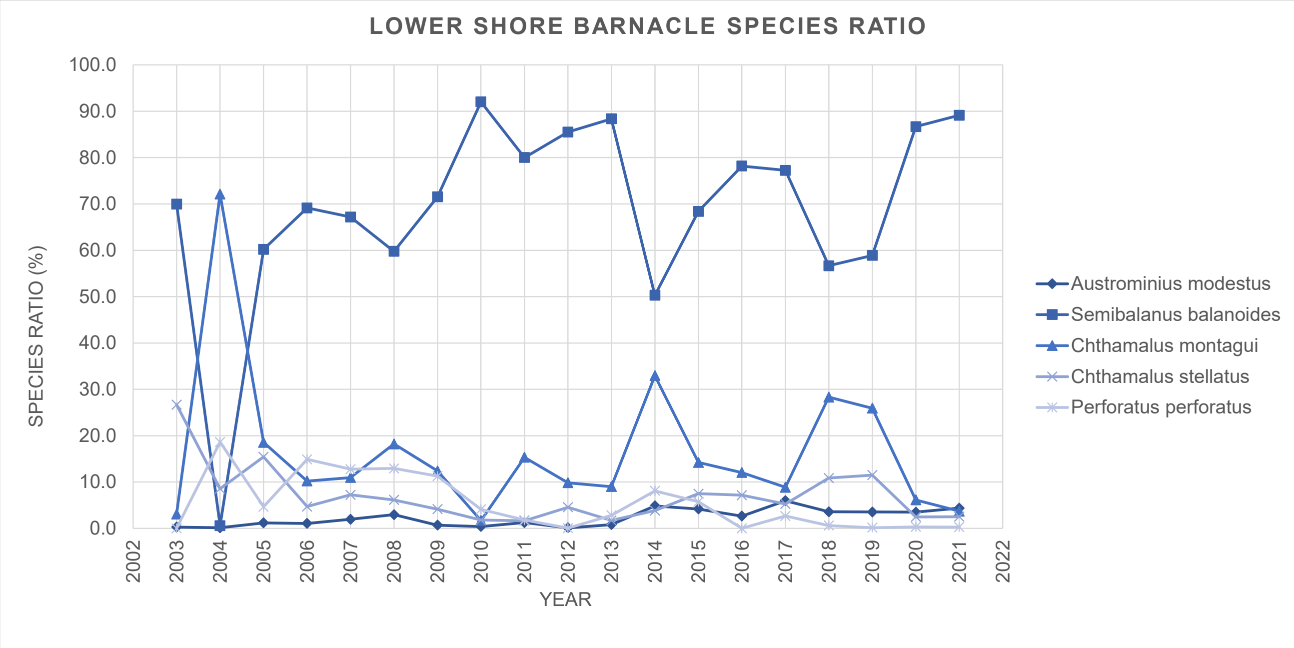
The lower shore underwent some dramatic changes in 2004 with *Semibalanus balanoides* declining and being immediately replaced by *Chthamalus montagui*. This may be due to a poor settlement of *S. balanoides* spat in the winter of 2002/3 (possibly linked to mild sea temperatures 8.7°C compared to an average of 7.8°C), *C. montagui* individuals would then benefit from a lack of competition. In 2014 there was a significant drop in *S. balanoides* at all shore zones with an increase in *C. montagui*. Since then, the proportion of *S. balanoides* has increased (Figure 4).

Barnacle species ratios were collected in 2020 and 2021 for the Marclim sites (Figure 4).

Figure 4 Changes in upper, middle and lower shore barnacle species ratios 2003 – 2021







Limpet Size and Counts
The mean limpet size (mm) recorded shows a stable trend at most sites, the Lantern showing the greatest fluctuations. In 2019 all four sites had very similar sizes. No recording was completed in 2020 and 2021 (Figure 5).

Figure 5 Changes in mean limpet size 2003 – 2019 with standard error bars.

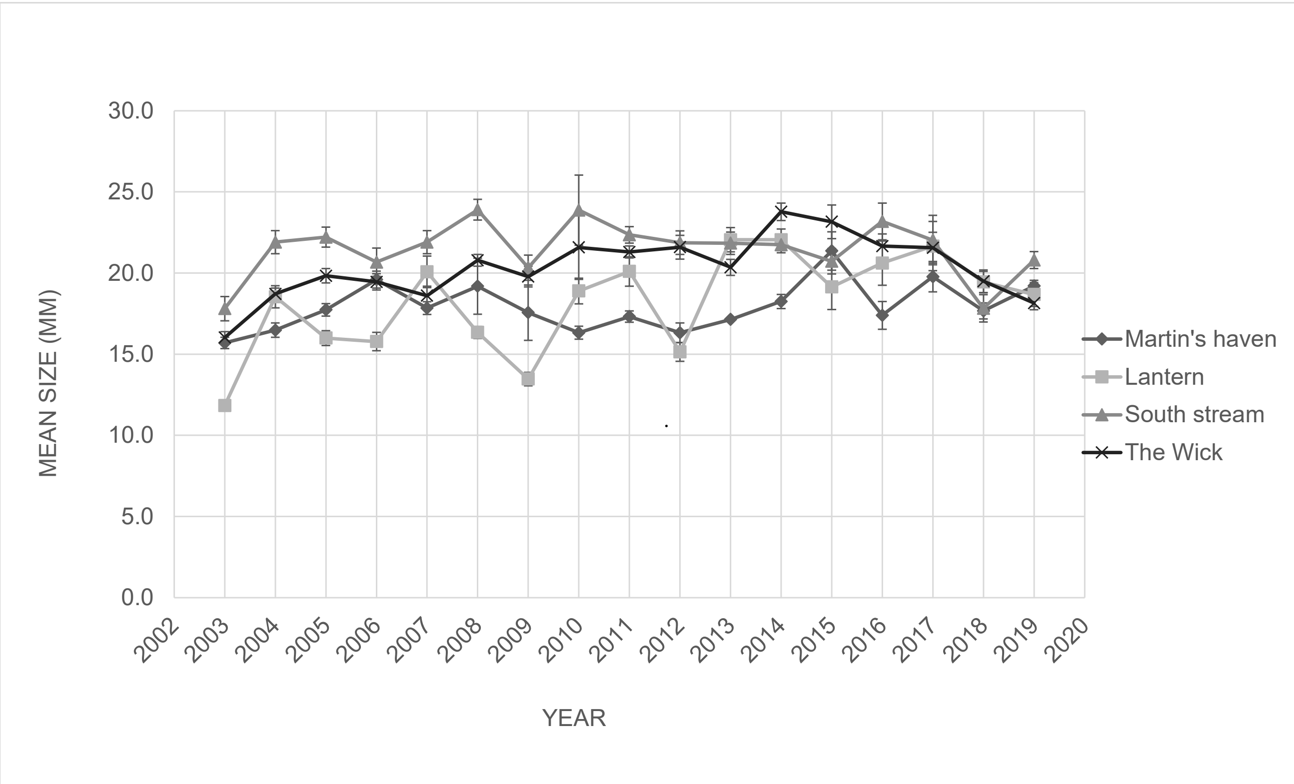
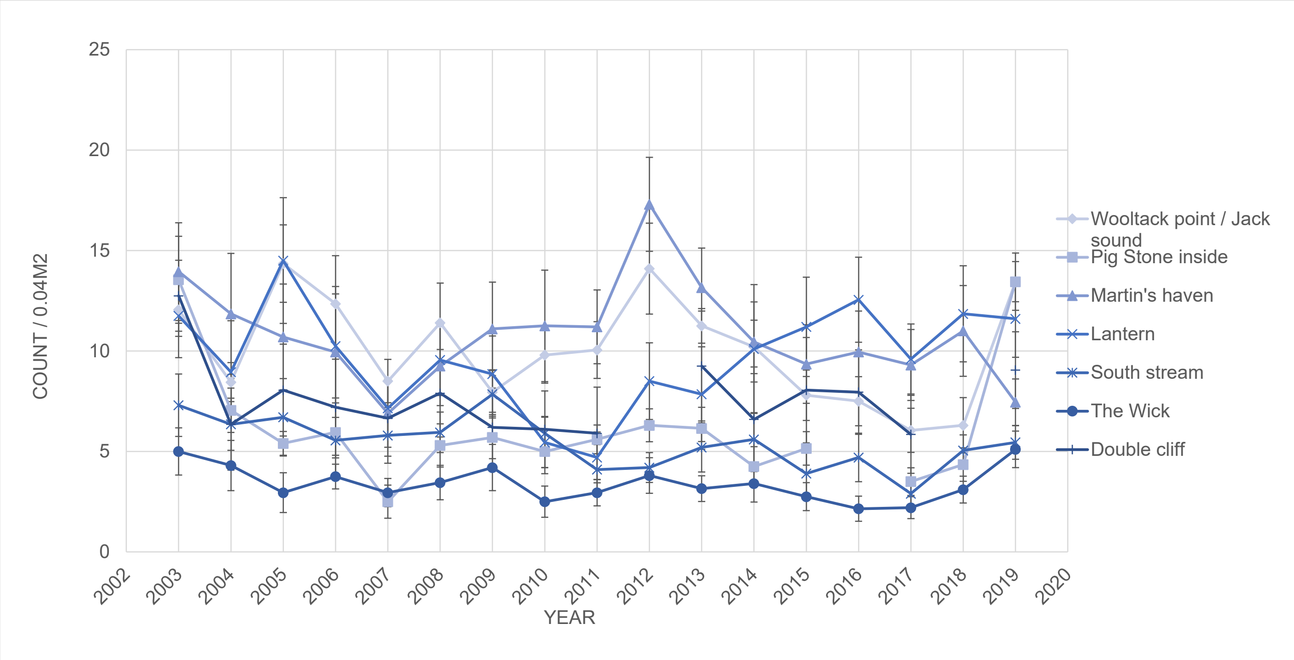
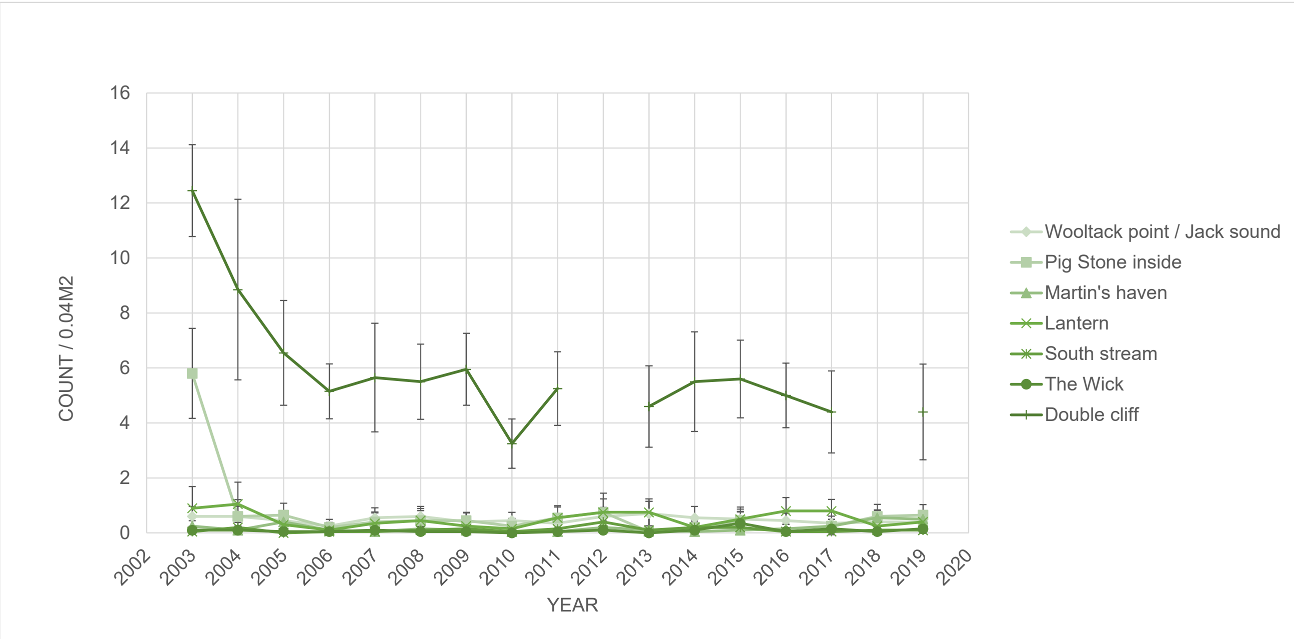


Figure 6 Changes in middle shore limpet counts 2003 – 2019 with standard error bars.



In the middle shore the highest numbers of limpets are found on the north facing shores, but these figures tend to be the most erratic. In 2019 there was an increase in limpet numbers at Pig Stone and Wooltack sites (Figure 6).

Figure 7 Changes in upper shore limpet counts 2003 - 2019 with standard error bars.



Most upper shore sites have a low abundance of limpets. Double cliff has significantly more limpets than any other site (north facing shaded cliff) which interestingly declined in numbers between 2003 – 2006 after which numbers stabilised at around 4-6 per 0.04m2. Double cliff upper shore was not surveyed in 2012 or 2018. All other sites have very similar limpet densities (Figure 7).

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

MarClim survey
MarClim data have been entered into spreadsheets and supplied to the MarClim team. Wakame (*Undaria pinnatifida*) non-native seaweed was found growing for the first time on Skomer and Skokholm shores during the 2018 survey but has not been found again.

Community Temperature Index (CTI).
CTI is a measure of the status of a community in terms of its species composition of cold- and warm-water species. It is quantitative, easily applied and gives a direct measurement of the response to climate and climate change across all the species in a community (see Burrows 2016 for full description). The MarClim survey data for the Pembrokeshire and Skomer MCZ shores have been used to calculate CTI for the period 2002 – 2021 using Species Thermal Midpoint (STM) values from Burrows (2016) (Figure 9).

The CTI scores for the 3 shores surveyed within Skomer MCZ show no significant change averaging a CTI of 11 -12ºC which would match the ambient sea surface temperatures for the same period (Figure 8).

Figure 8 Community Thermal Index (CTI) Pembrokeshire Marclim shores. Skomer MCZ: Martins Haven - MHV, North Haven - NHV, South Haven - SHV 2002 – 2021 and Skokholm Island - SKH 2014 - 2019 (with standard error bars).

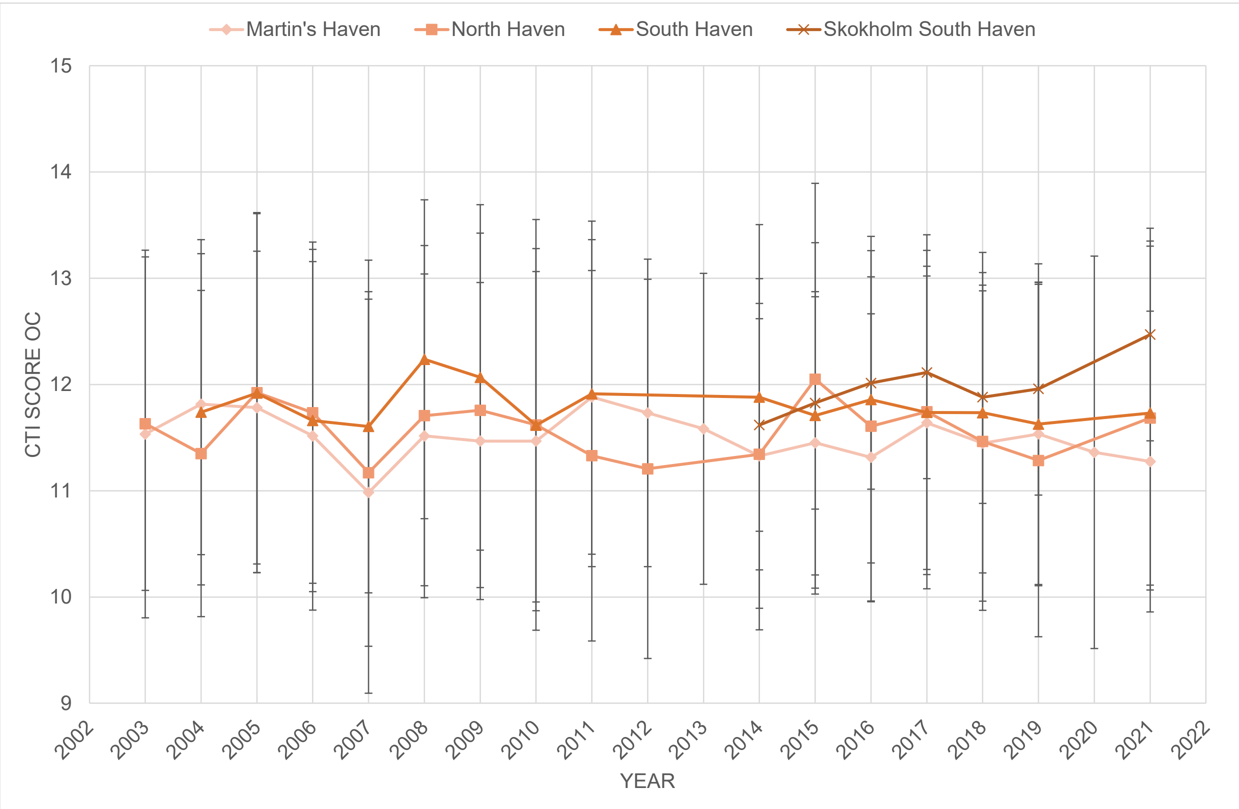
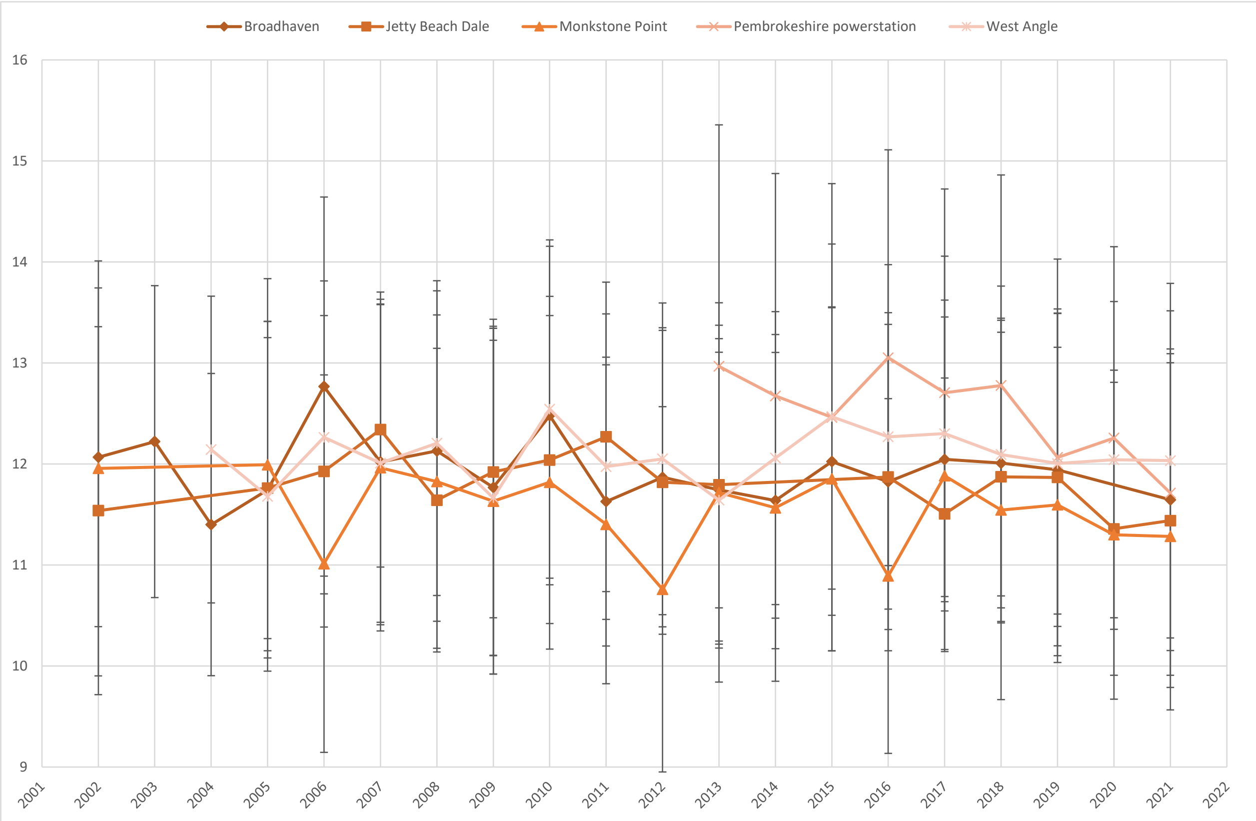


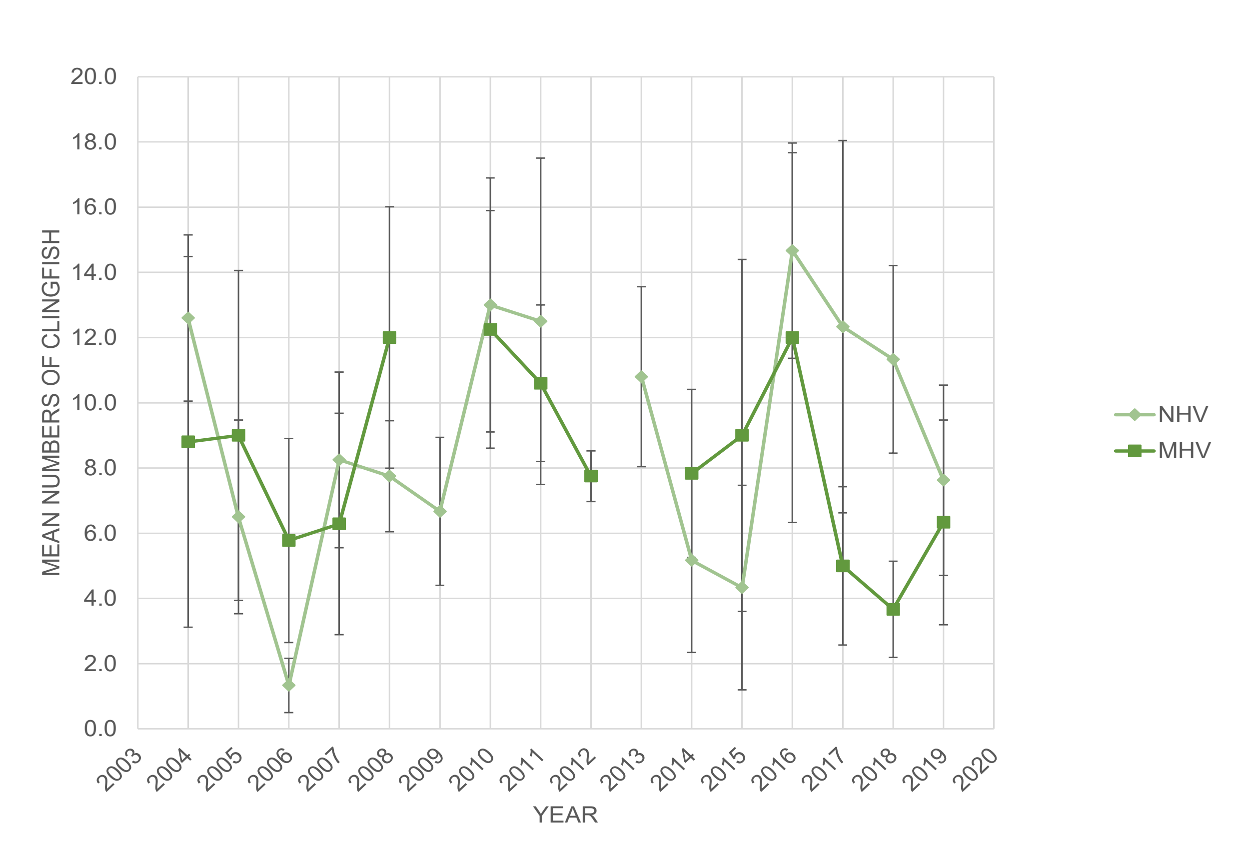
Figure 9 Community Thermal Index (CTI) Pembrokeshire Marclim shores 2002 - 2021(with standard error bars).



Clingfish records (Lepadogaster lepadogaster).

Timed searches have been completed at North Haven (NHV) and Martins Haven (MHV) (Figure 10) from 2004 onwards. In 2010 a single clingfish was found at South Haven beach, so this was added as a monitoring site in 2011. In 2015 and 2016 clingfish were found in greater numbers at South Haven but presence is variable with no fish being found in intervening years.

Figure 10 Average numbers of clingfish 2003 – 2019 at North Haven (NHV) and Martins Haven (MHV) (with standard error bars).



Numbers are very variable, as shown by high standard error values in Figure 10, but there are always clingfish present and eggs are always seen at the time of the survey in various stages of development.

4.1.7. 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. There hasn't been a full species survey of the Skomer intertidal sites for 2 years, so every effort will be made in 2022 to complete a full species and quadrat survey of all sites.

4.1.8. Recommendations

- Continue littoral monitoring programme
- Continue Marclim survey methodology.
- Keep current with the development of Community Temperature Index, CTI as an indicator of Good Environmental Status for reporting on littoral communities under the European Marine Strategy Framework Directive. Historical and ongoing Skomer MCZ data is demonstratably suitable for CTI calculation and this could provide added value to NRW by helping meet our statutory reporting responsibilities.

4.2. Sponge Assemblages

4.2.1. 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 susceptible to changes in water quality and sediment deposition. They are therefore useful biotic indicators of changes in rates of suspended and deposited sediments (sedimentation). Dredge spoil dumping has previously been attributed to increases in sedimentation at Skomer. Other sources of sedimentation could include riverine inputs, increased storminess or towed fishing gear.

4.2.2. 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.

4.2.3. Sites

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

4.2.4. Methods

Transects: Four fixed transects are located at Thorn Rock. 1994 to 2008 photographs were taken from fixed positions along the transect using paired cameras set up on a 50 x 70cm frame. The resulting images were analysed using a stereo viewer to count the abundance of sponge species and morphology types. Classifying sponge assemblages into morphology types (Bell & Barnes 2001) has proved to be a quick and simple method to analyse annual photographic datasets, if 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 specimens identified to the greatest possible taxonomic resolution. In 2011, the survey was extended to include The Wick, with High Court Reef added in

2015. Species photographs are taken in the field and samples collected, where necessary, for spicule preparations and microscopic analysis to confirm identification.

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

4.2.5. Project history

Transects: 1993 to 2021 photo quadrats taken at Thorn Rock (Table 3).

Table 4 Data gathered from Thorn Rock sponge transects 1993 to 202. Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL.

Year	Sample Number	Transects WG,SH,BG,DL
1993	24	WG Only
1995	77	All completed
1996	72	All completed
1997	20	WG Only
1998	60	WG, SH & DL
1999	0	No fieldwork
2000	63	WG, SH & DL
2001	62	WG, SH & DL
2002	81	All completed
2003	79	All completed
2004	80	All completed
2005	80	All completed
2006	79	All completed
2007	81	All completed
2008	0	All completed but image quality very poor no analysis possible
2009	81	Digital SLR replaced 35mm slide film All completed
2010	81	All completed
2011	81	All completed
2012	81	All completed- lots of surface sediment
2013	81	All completed
2014	81	All completed - poor visibility
2015	81	All completed
2016	81	All completed
2017	81	All completed
2018	81	All completed
2019	81	All completed
2020	81	No fieldwork
2021	81	All completed

Species surveys:

Table 5 Sponge species surveys summary

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

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

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

Seasonal survey from fixed quadrats:

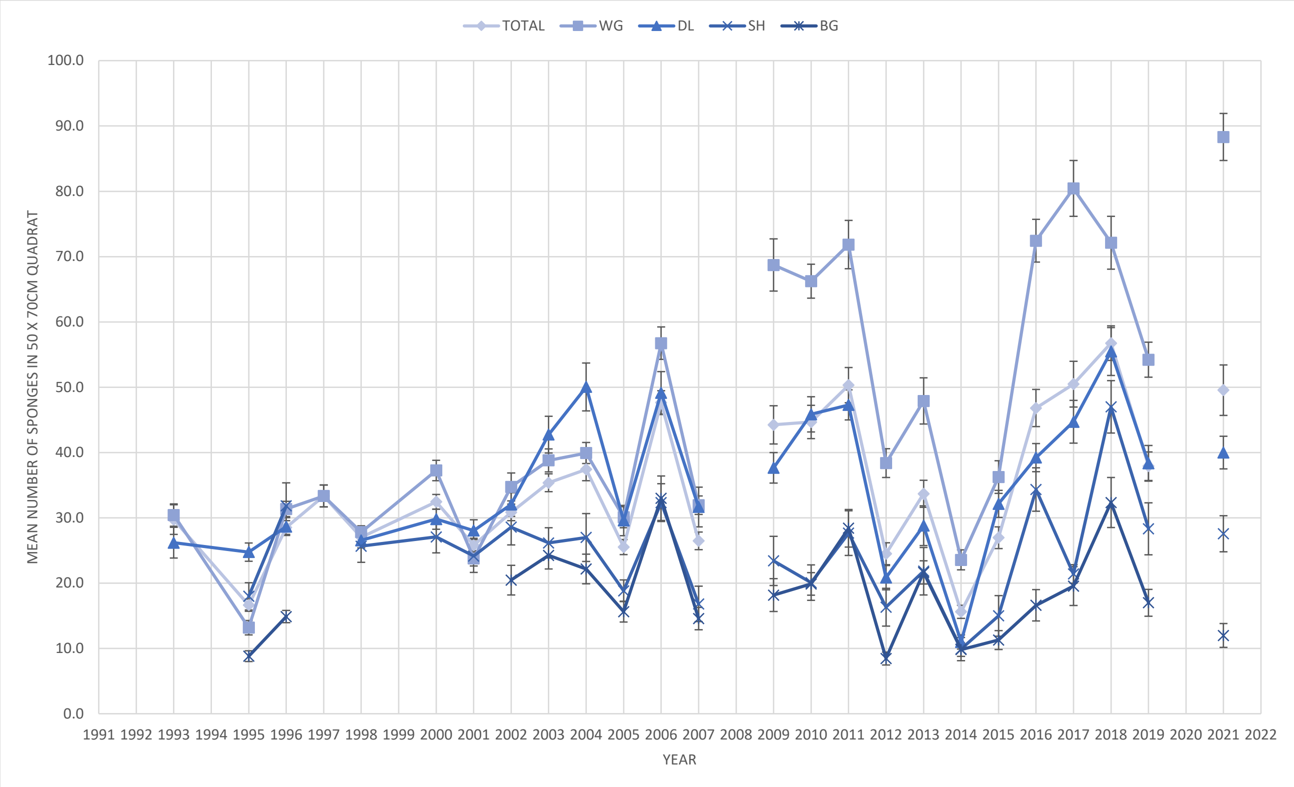
The quadrat survey has been completed annually from 2006 to 2019. The frequency of the survey has varied between 1 – 3 survey events in a year, depending on weather and resources. Following the publication of Berman *et al* 2013 the seasonal variability had been successfully identified. Since 2017 it was decided to reduce the survey to once annually in September to concentrate on annually variability and reduce the amount of fieldwork required.

4.2.6. Results

Transects:

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

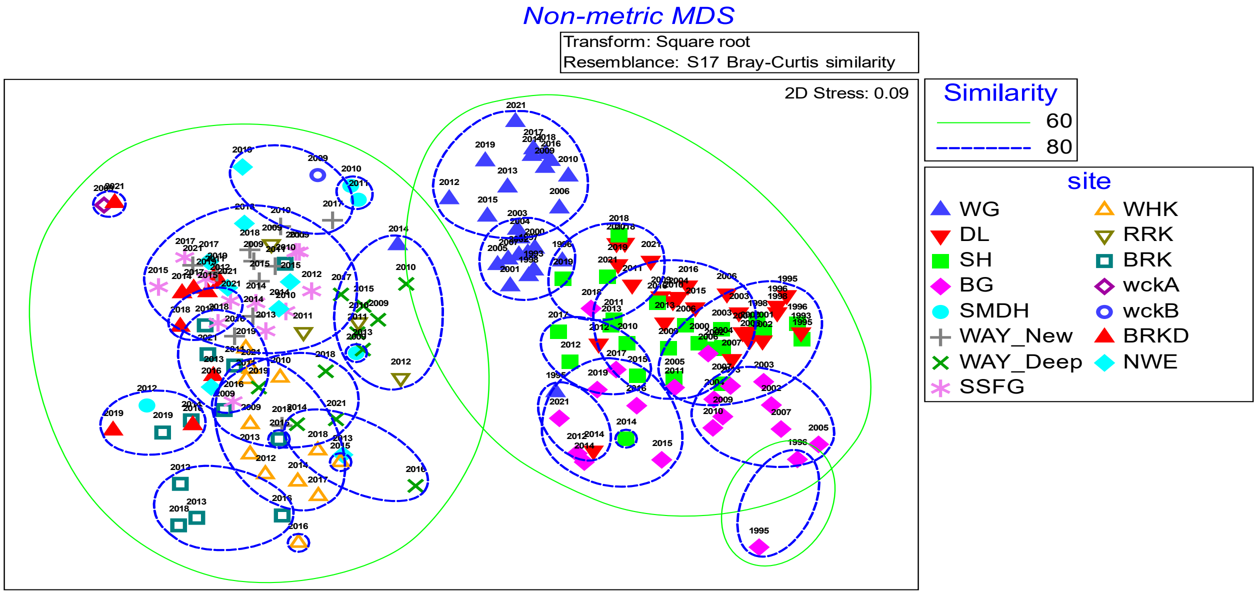
Figure 11 Mean number of sponges counted in each quadrat at 4 sites –Thorn Rock 1993-2021, with standard error bars. (Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL)



Improvement in image quality and resolution has meant that more sponge entities have been recorded from 2009 onwards compared to previous years. However, in 2012 and 2014 there was a noticeable drop in the numbers of sponges across all transects. In 2019 all sites decreased in abundance, despite good image quality and this lower number was again recorded in 2021 (Figure 11).

The morphology method for characterising sponge assemblages has also been applied to suitable monitoring photographs taken from a range of sites around Skomer MCZ. This puts the Thorn Rock transects into context. The morphology data are entered into the Primer V7 statistics package, averaged to site and year, and a similarity matrix produced using the Bray-Curtis similarity coefficient on the square root transformed data (Figure 12).

Figure 12 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data averaged by site and year 1995 – 2021.

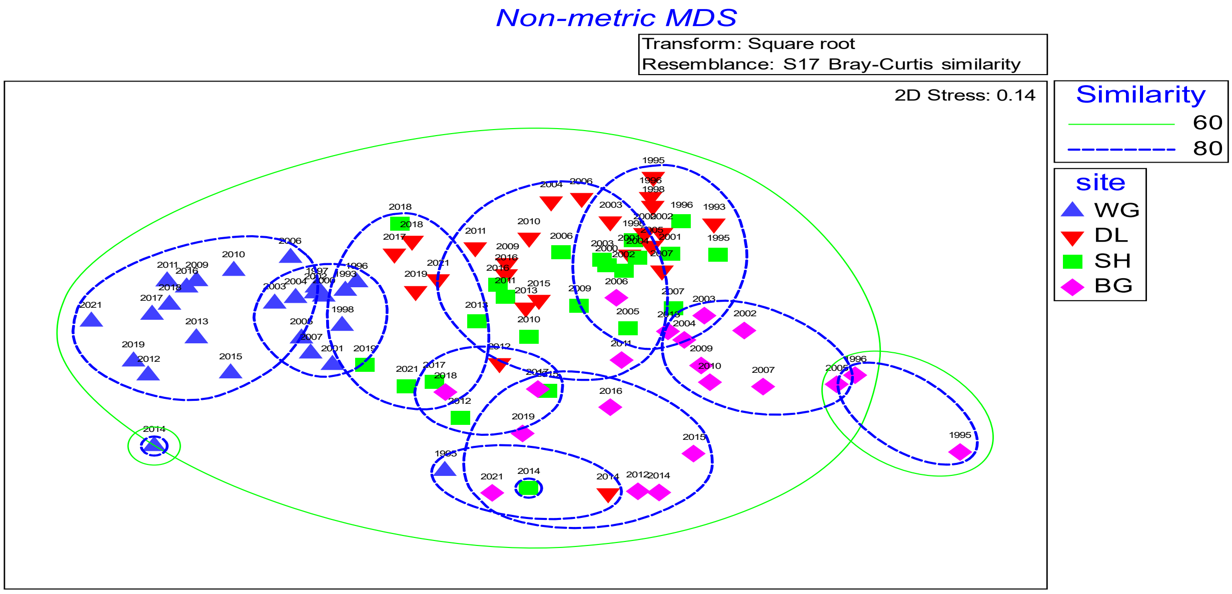


Site codes: WG,DL,SH & BG are all sites at Thorn Rock. All the other sites are located along the north side of Skomer island and the north Marloes peninsula.

In Figure 12 the Thorn Rock transects: Broad Gully (BG), Spongy Hillocks (SH) and Dogleg (DL), in all years separate out from the rest of the MCZ sites (see Section 2 map and table for site codes). The longest dataset is at Thorn Rock. The differences between sponges communities at Thorn rock compared to other sites within the MCZ are a great number of individuals and a greater diversity of morphology types at Thorn Rock.

The results for Thorn Rock are analysed separately in Figure 13 and show that the vertical cliff site of Windy Gully (WG) is consistently different to the flat bedrock sites: WG, DL, BG and SH.

Figure 13 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data for Thorn Rock transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL.



4.2.7. Current status

The species surveys show that Skomer has a high biodiversity of sponge species. 42 of the 130 species recorded at the MCZ are new to science or need further investigation (Jones 2020).

- The community at Thorn Rock is quite dynamic in terms of total number of sponges visible but the overall community structure appears stable.

4.2.8. Recommendations

- Continue application of morphology method for analysis of photos.

- 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 1m fixed quadrat photos (in progress).

- Seasonality patterns need further investigation as seasonal changes in the sponge assemblages have been found. Winter data are needed as samples have only been collected from April to October. Encourage continued research on sponge seasonality in the MCZ.

- Continue sponge species recording every 4 years, next survey due 2023.

- Continue support of sponge research carried out by academic bodies.

4.3. *Eunicella Verrucosa*: Population and Growth Rate

4.3.1. Project Rationale

The pink sea fan *Eunicella verrucosa* (Pallas) is a component of the Lusitanian anthozoan management feature of the Skomer MCZ. It is listed in 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. The pink sea fan is a soft coral nearing the northern limit of its distribution in North Pembrokeshire, they are slow growing, erect species and reproduction rates are also thought to be very slow. Damage can be caused through changes in water temperature, poor water quality and possibly from extensive entanglement in biota. Pink sea fan has the potential to be damaged by anthropogenic physical seabed activities.

4.3.2. Objectives

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

4.3.3. Sites

Table 6. Pink sea fan sites names, codes and survey start date.

Site name	**Site code**	**Started survey**
North Wall stereo	NWA	1987
Bernie's Rocks (East and West)	BRK	1994
Bull Hole	BHO	2002
The Pool	POL	1997
North Wall East	NWAe	2000
Sandy Sea Fan Gully	SSFG	1994
Thorn Rock	TRK	2002
Way Bench	WAY	1994
Rye Rocks	RRK	2002
South Middleholm	SMD	2002
West Hook	WHK	2005

4.3.4. Methods

- Individual 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 presence of predatory molluscs *Duvaucelia odhneri* and *Simnia patula.*

- Where practicable, and if enough polyps remain alive on the colony for it to recover, detached sea fans are re-attached artificially to the rock substrate at one of the monitoring sites. These fans are then added to the monitoring programme and called ‘attached fans’.

- The photographs are analysed for entanglement of small-spotted catshark *Scyliorhinus canicula* and bull huss *Scyliorhinus stellaris* eggs, entanglement of other biota, attached epibiota, necrosis, damage and presence of the molluscs *Duvacelia odheri* and *Simnia patula*.

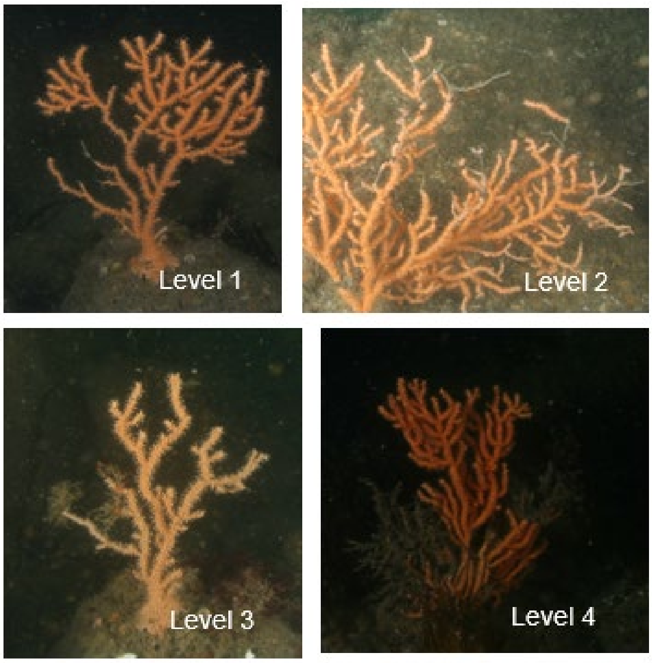
- Missing sea fan are recorded, these are searched for the following year to confirm that they are losses.

In 2021 a review was made on the photo analysis method used to access the condition of sea fans. Improved methods were developed to enable a more detailed assessment of the current condition of the individual sea fans. Necrosis is recorded when sea fan soft tissue has died back to leave just the black skeleton showing. Previous analysis recorded only that necrosis was present, whereas the new method records levels of necrosis on a level 1 to 4 rating (Table 5 and Figure 14).

Table 7. Sea fan condition necrosis levels 1 to 4.

Level of necrosis	Description
Level 1	Less than 5 tips
Level 2	Multiple tips, more than 5 tips
Level 3	Epiphyes growing from tips
Level 4	Full branches/extensive epiphytes

Figure 14 Sea fan necrosis levels 1 to 4.



4.3.5. Project history

1997: methods were developed using MapInfo software to study the sea fan area and branch length to assess growth (Gilbert, 1998). This was completed for all sea fan images taken from 1994 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 sea fans matching between year sets. A method to assess sea fan condition was developed, this was completed for all photo images in the dataset since 1994.

2002 to 2021: sea fan condition assessments were completed each year using both photo images and supportive field records. In 2008, a new digital SLR camera provided higher quality images and this helped to improve photo analysis.

2018 to 2021: To help understand potential causes of sea fan losses at Skomer MCZ, human activity data has been analysed in more detail, concentrating on activities with the potential to make contact with the seabed or sea fans, and the sites where sea fans are monitored. This data is available in the Skomer MCZ Annual reports 2018 – 2021. Natural Resources Wales / Marine and coastal evidence reports.

2020: no field work was completed due to Covid restrictions.

2021: a re-evaluation of methods used to assess sea fan condition was completed. This aims to provide a more detailed assessment of the condition of sea fans ranging in scale from the whole Skomer MCZ, to site level and even for each individual sea fan.

4.3.6. Results

The numbers of sites surveyed, total number of sea fans recorded, confirmed losses and missing sea fans to be confirmed are summarised for each survey year in Table 8..

Table 8. Skomer MCZ sea fan survey results 1994 -2021.

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	0	0	0	0	0
1995	4	33	33	0	0	1	0	0
1996	4	33	33	0	0	0	0	0
1997	5	39	39	0	0	0	0	0
1998	5	39	39	0	0	0	0	0
1999	0	no data	no data	no data	no data	0	0	0
2000	5	54	54	0	0	0	0	0
2001	5	55	55	0	0	1	0	0
2002	9	86	86	0	0	1	0	0
2003	9	99	99	0	1	0	0	0
2004	9	101	100	0	0	0	0	0
2005	10	114	111	3	1	1	0	0
2006	10	119	116	3	7	0	0	0
2007	10	121	118	3	1	2	0	0
2008	10	126	122	4	0	0	0	0
2009	10	128	121	7	0	1	0	0
2010	10	126	120	6	0	3	1	0
2011	10	126	122	4	0	0	2	0
2012	10	126	121	5	0	0	0	0
2013	10	129	124	5	0	0	0	0
2014	9	124	120	4	0	0	0	0
2015	10	125	123	2	0	3	2	0
2016	10	118	115	3	1	9	0	0
2017	10	114	112	2	0	3	1	0
2018	10	110	108	2	1	6	0	0
2019	10	105	103	2	0	5	0	0
2020	no data	no data	no data	no data	no data	no data	no data	no data
2021	10	88	86	2	0	0	0	16
totals	n/a	n/a	n/a	n/a	12	36	6	n/a

Losses

A total of 36 losses of natural sea fans and 6 losses of artificially attached sea fans have been recorded throughout the period of this project.

In 2019, 6 natural sea fans (BHO22, WAY7, NWAe6, POL10, RRK25, RRK19) and 2 of the cluster of baby fans at BHO were not found. In 2021, BHO22, NWAe6, RRK19 and the 2 BHO baby fans were confirmed as losses. WAY7, POL10, RRK25 were refound.

16 additional fans were not found in 2021: NWAe3, NWAe15, BHO10, BHO20, BHO24, BHO30, RRK8, RRK15, BRK4, BRK5, BRK6, SMD1, WAY15, WAY16 and the last 2 of the original 5 BHO baby fans. These will be checked, and their status confirmed in 2022.

In 2016, BHO21, was reduced to a stump, however, new growth was observed in 2018 and this growth has continued in 2021. Other sea fans which have been lost but where a base or stump was still present, are being checked for any new growth (Figure 15).

Figure 15 Sea fan BHO21 May 2016, reduced to stump September 2016, new growth recorded from 2018 to 2021.

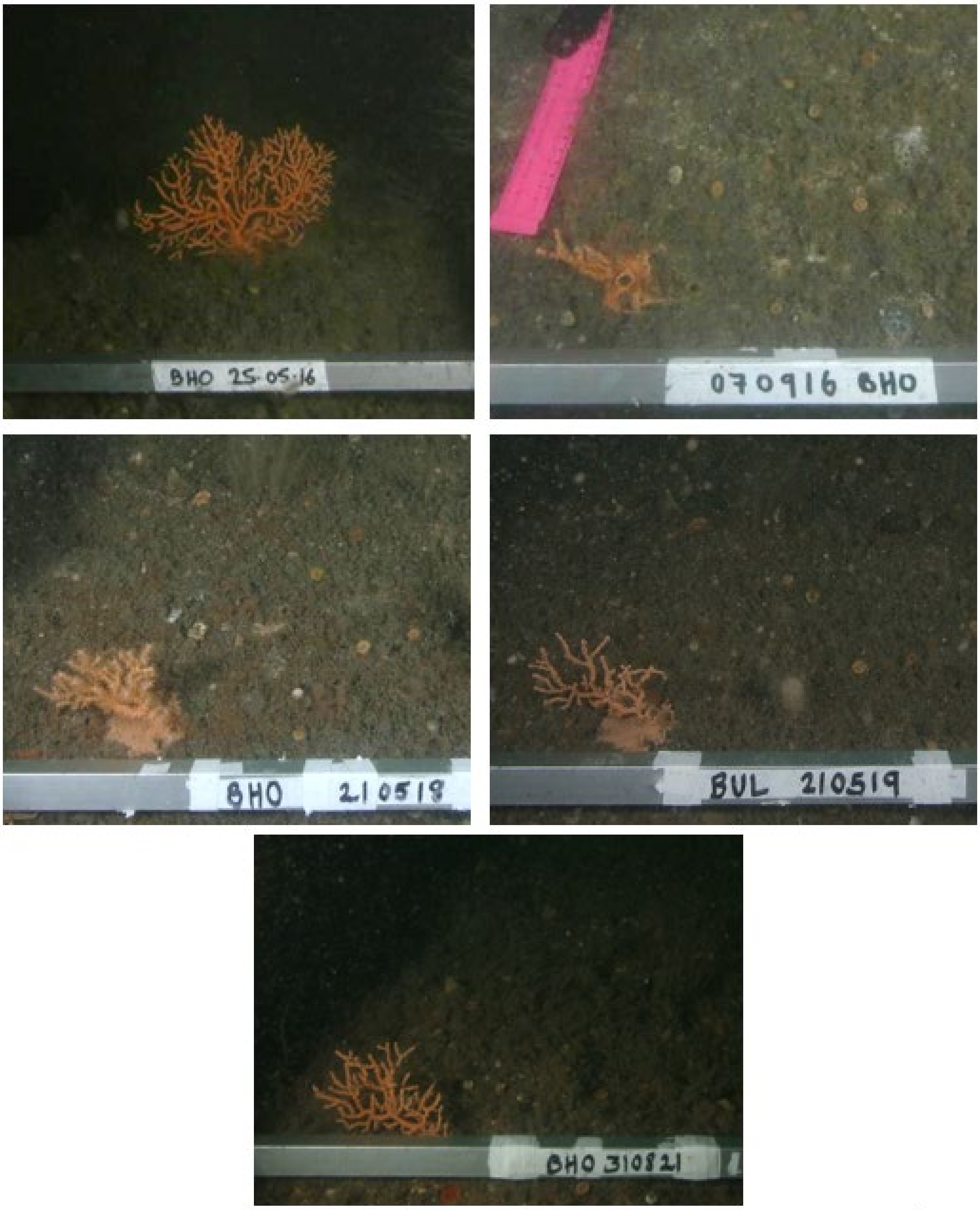
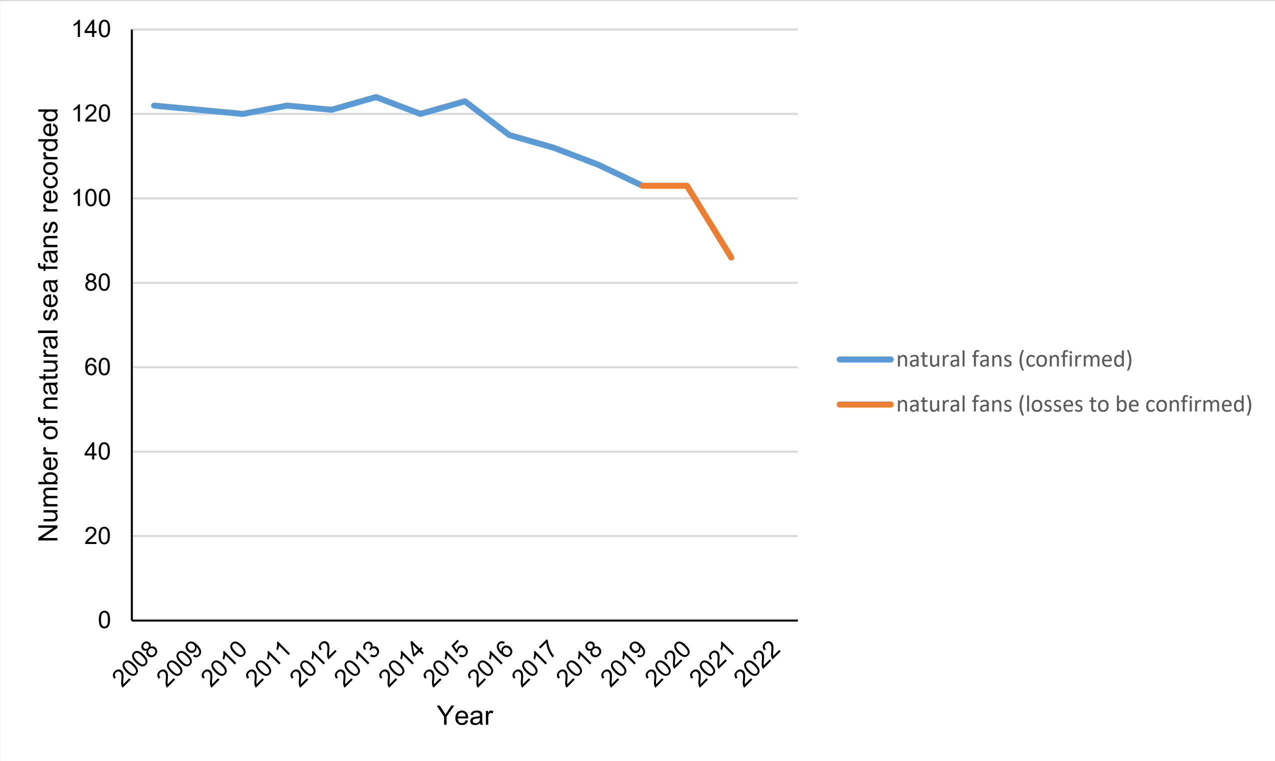


Figure 16 Total number of natural sea fans recorded 2005 to 2021 (artificially attached sea fans not included in this data).



The rate of 'natural' sea fan losses has increased in the last 7 years. In the six year period from 2008 to 2014, the total number of natural sea fans recorded were between 120-124 fans. During this period 4 confirmed losses were recorded (0.03 losses per recorded sea fan). Since 2015 the losses have increased. During the six year period from 2015 to 2021 there have been 26 'natural' fans and 3 artificially attached fans confirmed as missing '. A further 14 'natural fans' and 2 from the cluster of small fans at Bull Hole, were absent in 2021, to be confirmed as losses in the 2022 field season (Figure 16).

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 as described in Table 9. BHO23 was a confirmed loss in 2010 and the cluster of 5 "new recruits" at BHO showed no growth in 12 years and in 2021 were not found (Table 9). NWAe15 was first found in 2005 with 3 branches grown to 8 branches in 2017 but reduced to single stick in 2019 and was missing in 2021 (Figure 17).

Table 6 Skomer MCZ sea fan recruitment

Sea fan site and number	Year first found	Description and growth
WAY14	2000	Found close to WAY2. 3 branches in 2000 grown to a small bushy fan in 2019.
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 2019.
NWAe15	2005	Found below NWAe13. 3 branches in 2005 grown to 8 branches in 2018 and then reduced to 2 branches in 2019.
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 2019. Only 2 found in 2019.
RRK24	2006	Found next to RRK7. 5 branches in 2006 grown to 18 branches in 2019.
RRK26	2016	Found in gully close to RRK12. 2 branches
MDS7	2018	Found close to MDS 4 and 5. 6 branches

Figure 17 Sea fan NWAe15 2005,2012, 2017 and 2019.

Sea fan condition
In 2021 all sea fan photos have been revisited to assess sea fan condition in detail for:

1. Small-spotted catshark *S. canicula* and bull huss *S.stellaris* eggs, numbers of eggs and % entanglement of sea fan.

Figure 18 Proportion of sea fans at Skomer MCZ entangled in *S. canicula* eggs.

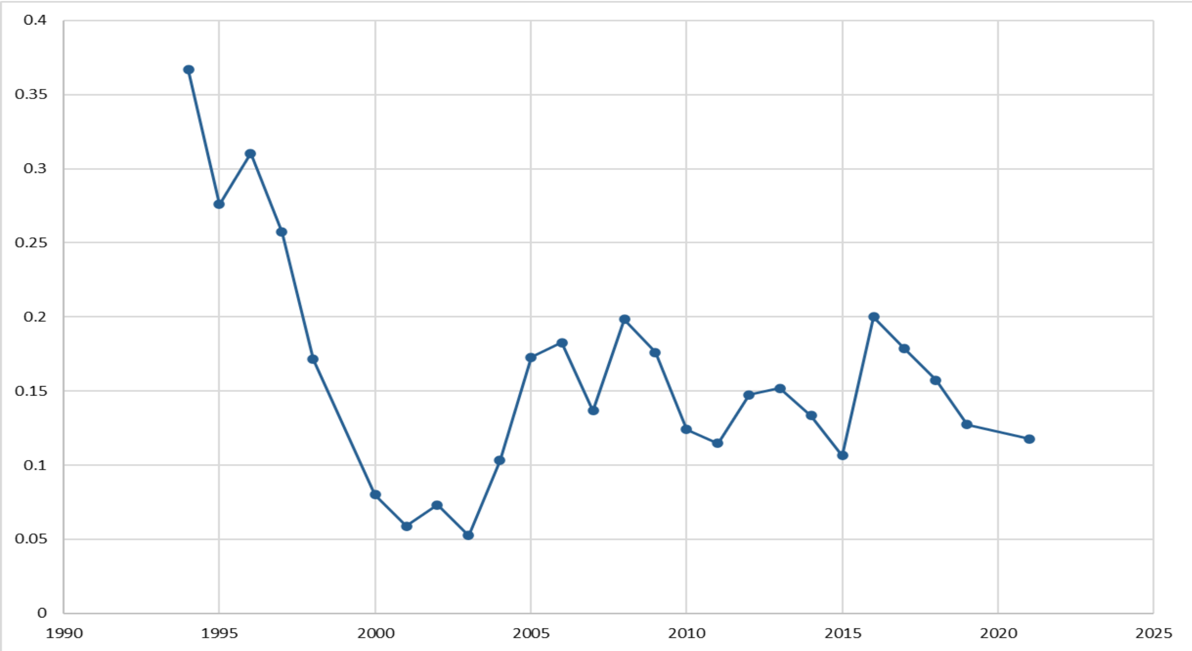
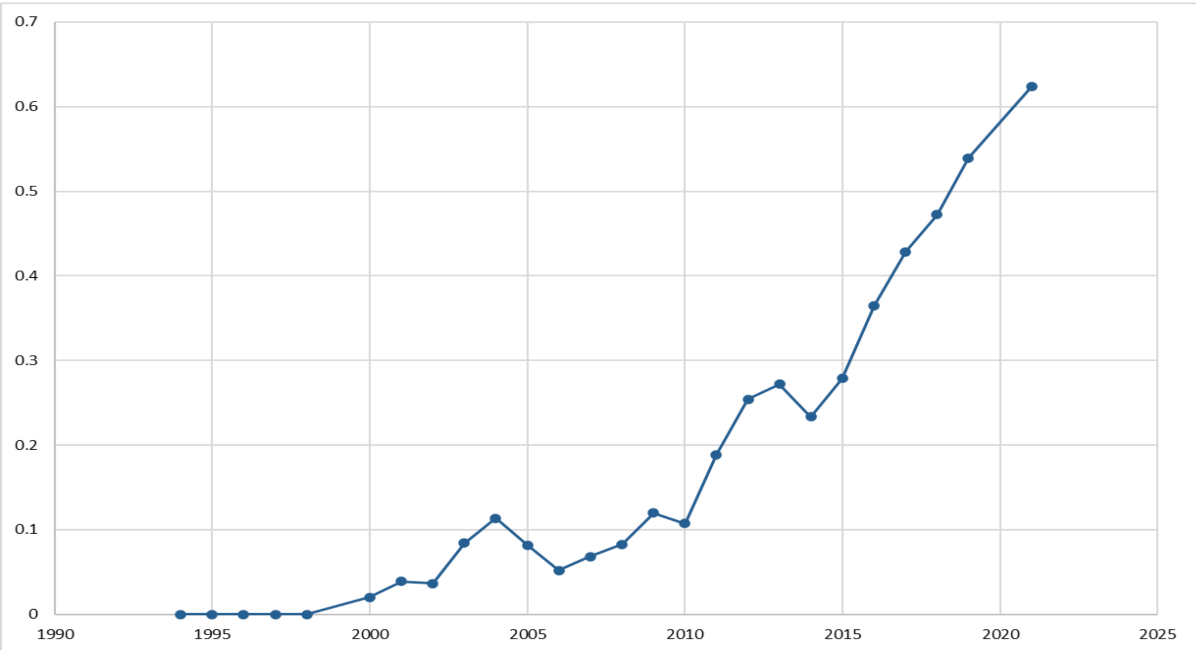


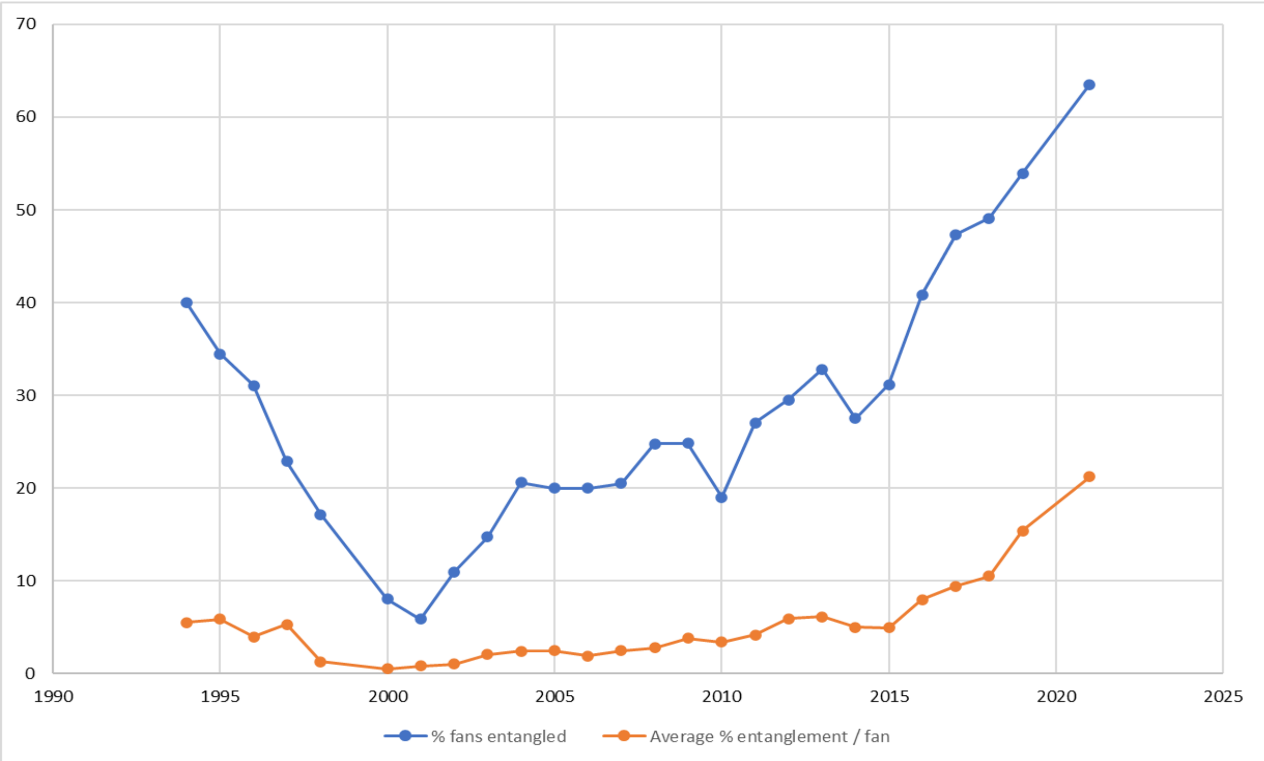
Figure 19 Proportion of sea fans at Skomer MCZ entangled in *S. stellaris* eggs.



S. canicula eggs were found on 25-35% of recorded sea fans between 1994 to 1997, since then it has fluctuated between 5 and 20% of sea fans from all sites, in 2021 this was 11% of sea fans (Figure 19). *S. stellaris* eggs were first recorded on a sea fan in 2000 and up to 2010 was found on less than 12% of sea fans. In 2012, 25% of sea fans had *S. stellaris* eggs and this has steadily increased each year with 62% of sea fans recorded with these eggs in 2021 (Figure 20).

2. Biota entanglement - tangled *S. canicula* eggs and *S.stellaris* eggs, squid eggs, drift algae, bryozoans and hydroids. Entanglement with epibiota, and in particular eggs, if extensive and persistent can cause damage to the sea fan tissues (Figure 21).

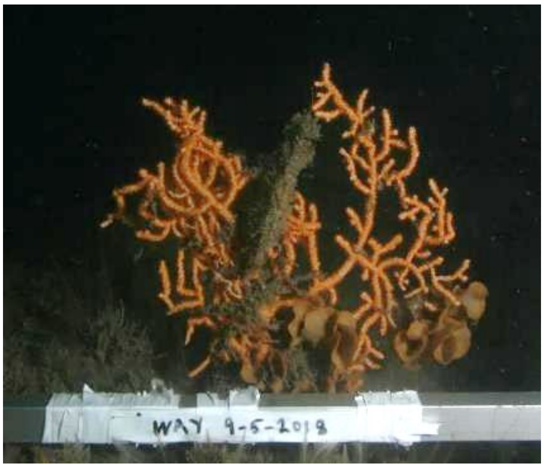
Figure 20 Percentage of sea fans at Skomer MCZ entangled in biota and the average percentage of entaglement per sea fan.



S. canicula eggs and *S. stellaris* eggs make up the bulk of the entangled biota and the pattern of entanglement reflects the percentage of sea fans entangled in eggs as shown in figures 19 & 20. There has been an increase in entanglement since 2011 from 27% to 64% of sea fans in 2021 (Figure 21, top line). Opportunistic bryozoan and hydroid species are regularly found growing on the egg cases or on the curly tendrils tightly entangled around the sea fan branches (Figure 21).

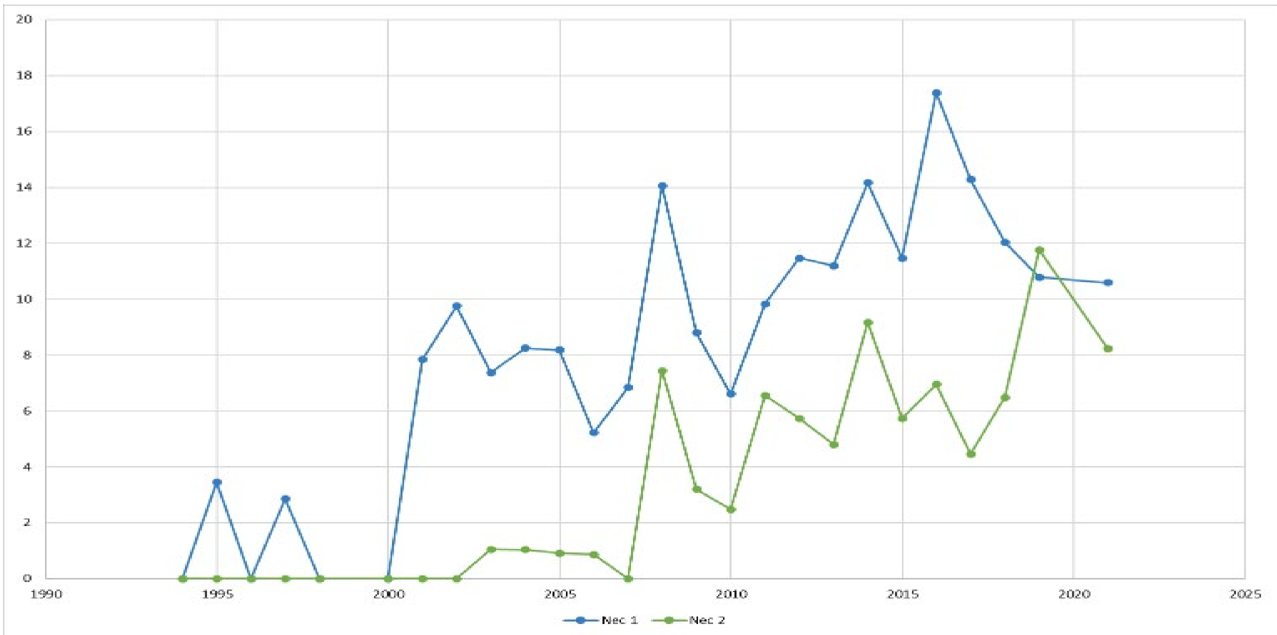
Between 1994 to 2015, those sea fans with entanglement averaged between 0.5 to 6% cover and in 2016 this increased to 8%, increasing again in 2021, to 21% (Figure 21, bottom line).

Figure 21 Sea fan with *S.stellaris* egg covered in bryozoan turf and *Pentapora foliacea*, an epiphytic species growing on the sea fan (necrosis level 4).



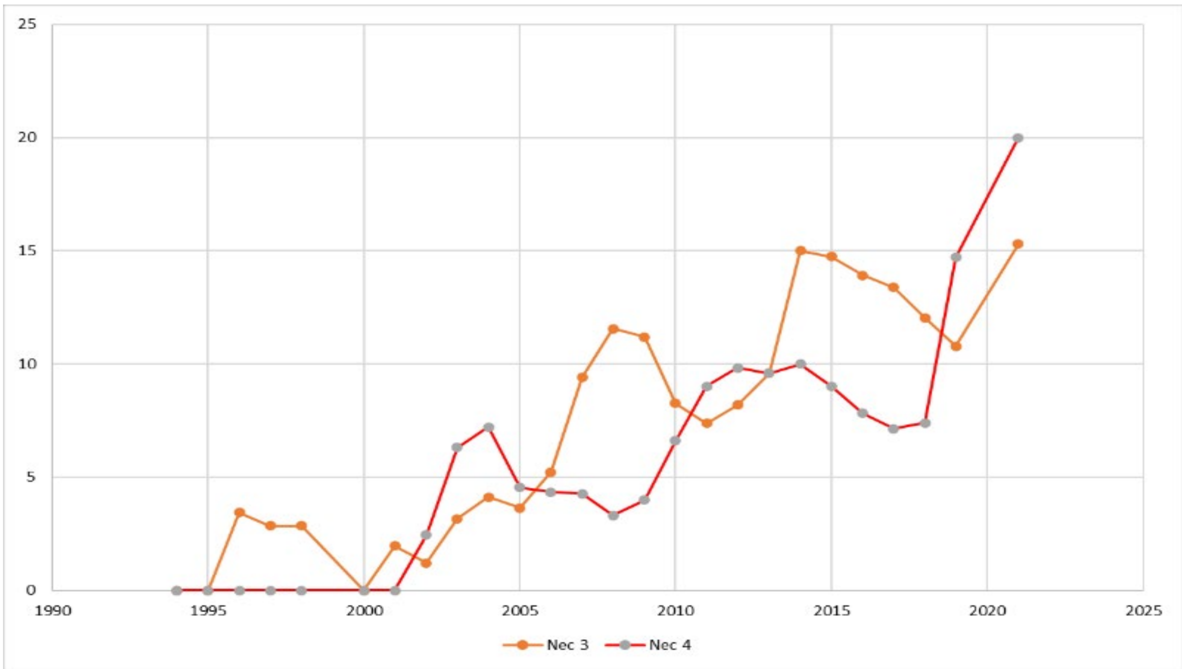
3. Necrosis is assessed for each sea fan and recorded on a scale from level 1 to 4. Both levels 3 and 4 have opportunistic epiphytes growing on the sea fan, which can include bryozoan, hydroids and small red algae (Figure 21). On occasion bryozoan sea fingers *Alcyonidium diaphanum*, deadman's fingers *Alcyonium digitatum* and ross coral *Pentapora foliacea,* have been recorded growing on fans.

Figure 22 Percentage of sea fans at Skomer MCZ with necrosis level 1 and 2.



Necrosis level 1 (less than 5 tips necrosed) was recorded on 0 to 17.4% of sea fans since 1994 and in 2021 was recorded on 10.5% of sea fans. Necrosis level 2 (more than 5 tips necrosed, but no epiphytes) was not recorded until 2002, after which it was found on 1% or less of sea fans until 2006. Since 2007 necrosis level 2 has increased, fluctuating between 2.5 and 11.7%, and in 2021 was recorded on 8.3% of sea fans.

Figure 23 Percentage of sea fans at Skomer MCZ with necrosis level 3 and 4.

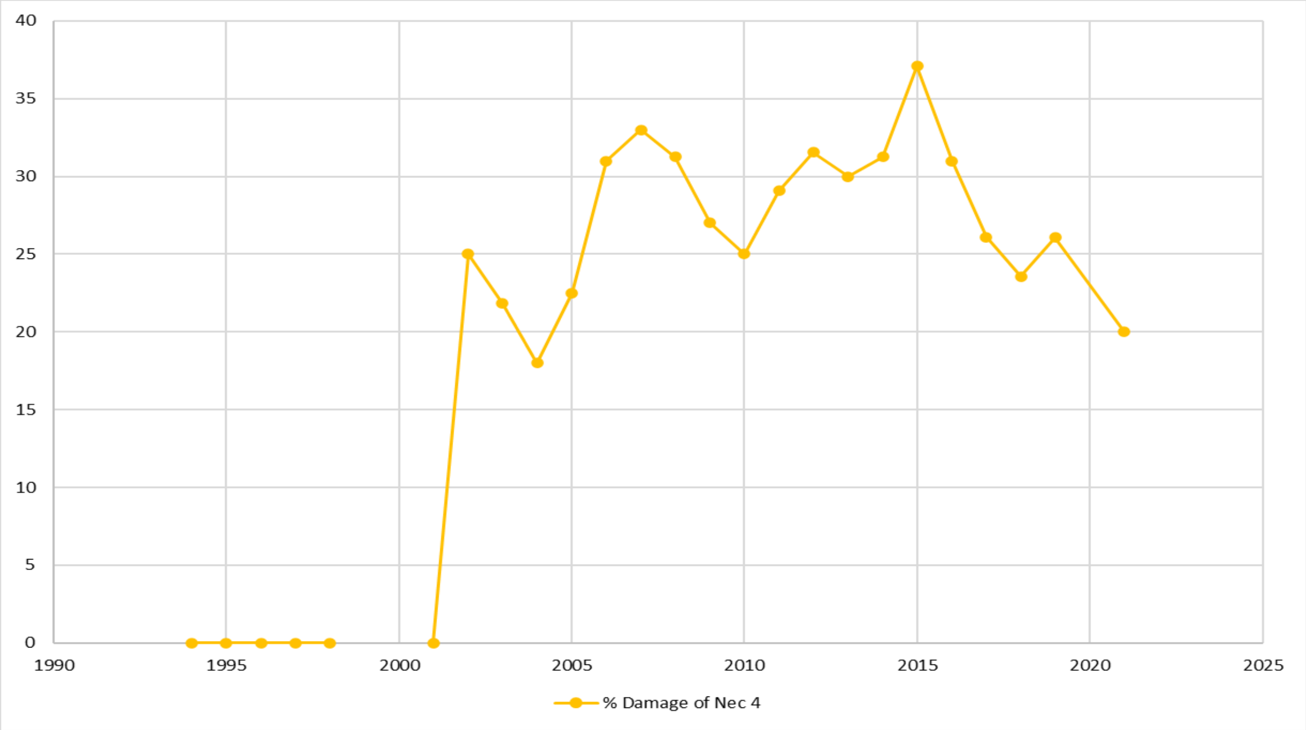


Necrosis level 3 (epiphytes growing on tips) was found on 0 to 5% of sea fans between 1994 and 2006 and since 2007 increased, varying between 7.3 and 15.3% of sea fans. 2021 saw the highest recorded percentage of level 3 necrosis at 15.3%. Necrosis level 4 (extensive areas of bare necrosis or epiphytes growing on sea fan) was not recorded on any sea fans until 2001, in 2002 it was 2.4% and by 2012 fluctuated around and increased to 10%. 2019 and 2021 both recorded large increases with 14.7% and 20% of sea fans respectively.

4. Damage is recorded as the percentage of level 4 necrosis on each sea fan. This can be caused from persistent biota entanglement or attached epibiota (Figure 24).

Figure 24 Sea fan with 30% level 4 necrosis damage

Figure 25 The average percentage of level 4 necrosis per sea fan



The average percentage of level 4 necrosis damage per sea fan (for those with it recorded), has fluctuated from 18 to 37% since it was first observed in 2002, and in 2021 was recorded as 20% damage per sea fan (Figure 25).

Sea fans are also recorded as damaged when losses of branches are recorded or if the sea fan is dislodged from the rock, this is recorded in the individual data files for each sea fan.

5. Nudibranch *D. odhneri* and mollusc *S. patula* presence is recorded. Very low numbers of these species have been found over the years, none were recorded in 2021.

6. Anthropogenic entanglement is recorded when sea fans have been found entangled with angling line, which, if extensive and persistent, has been observed to cause damage to the sea fan tissues. Whenever possible the line is cleaned off the fan to allow recovery. No entanglements were recorded in 2021.

4.3.7. Supported research

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

- 2007 to 2013 Exeter University: Connectivity between populations of pink sea fans using internal transcriber sequences: Small clippings were taken from some Skomer sea fans in 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 sea 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 *S. stellaris* eggs. Fouling was found to have a significant negative association with growth with a decline of 0.2% over a twenty-year 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).

4.3.8. Current status

- Conservation status: This Lusitanian anthozoan assemblages feature for Skomer MCZ is in unfavourable conservation status due to a negative trend in sea fan population resulting from further increases in losses recorded compared to recruitment.

- There have been 36 natural sea fans and 6 artificially attached sea fans confirmed as lost from the monitoring sites between 1994 and 2021. There are 16 further possible losses in 2021 to be confirmed. There were no new recruits recorded in 2021.

- Biota entanglement has increased on sea fan from 27% in 2011 to 64% in 2021. *S. canicula* eggs were found on 11% of sea fans and *S. stellaris* eggs were recorded on 62% of sea fans. Opportunistic species grow on the egg cases and on the tendrils, tightly entangled in the sea fan branches. For sea fan recorded with entanglement, the average percentage of entanglement was 21% in 2021.

- Necrosis was recorded on 54% of sea fans in 2021, of this 15.3% was at level 3 (epiphytes growing on tips) and 20% at level 4 (extensive areas of bare necrosis or epiphytes growing on sea fan). Level 4 was not recorded on any sea fans from 1994 to 2001, between 2002 and 2018 it peaked at 10% but in 2019 this increased to 14.7% and then to 20% in 2021.

- The average percentage of level 4 necrosis damage per sea fan for those with it recorded, has fluctuated since it was first observed in 2002, from 18 to 37% and in 2021was recorded as 20%.

4.3.9. Recommendations

- Increase photo survey frequency to biannually, firstly in May and repeated in September each year.

- Take close-up photos of all ”new recruits”/small sea fans found.

- Observe persistence of biotic fouling/entanglement e.g., catshark eggs.

- Continue to record fishing, diving, angling and anchoring activity in Skomer MCZ.

- Explore the opportunities to set up an “exclusion zone ” where potentially damaging activities are excluded.

- Support research work on the biology of sea fans and publish results in scientific literature.

- Investigate opportunities for a sea fan restoration project, expanding current restoration activities into a fully funded and long-term project.

- Report pink sea fan status at Skomer MCZ as unfavourable, declining.

4.4. *Alcyonium glomeratum* Population

4.4.1. 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.

4.4.2. Objectives

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

4.4.3. Sites

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

4.4.4. Methods

Each site follows either a sequence of photo-quadrats or transects that are described in site relocation pro-formas.

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

North Wall Stereo: three quadrats (50 x 40cm) are photographed using stereo or high definition digital SLR photography.

All other sites: photographs (mono) are taken using a 50 x 70cm framer.

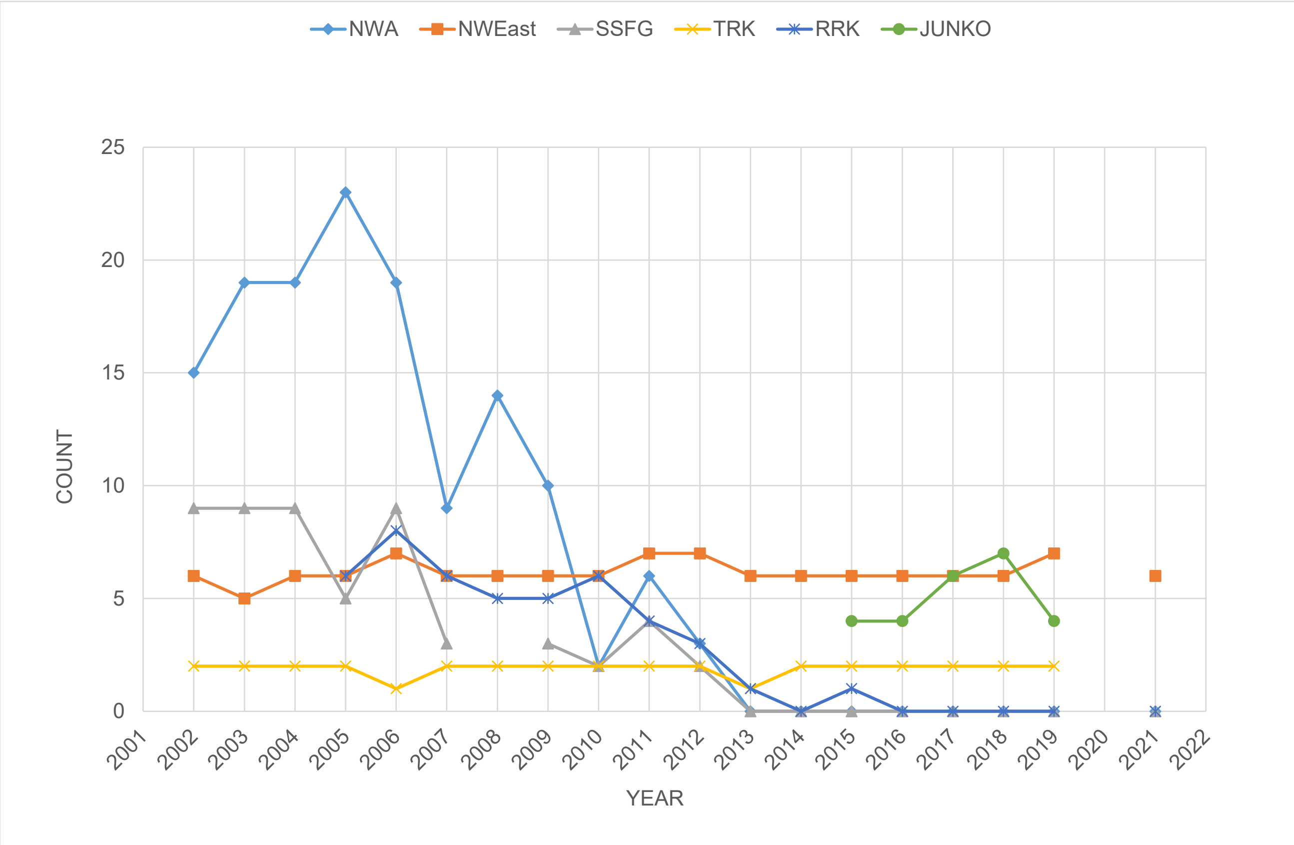
The colonies are gently "wafted" before photographing to make them retract in an attempt to control the variability in colony size. The images are analysed by overlaying a 5 x 5cm grid and recording presence/absence of *A. glomeratum* within each grid square.

There photographs are analysed for presence of A. glomeratum and a frequency count is completed for each quadrat using a 5 x 5cm grid (140 squares) for the 50 x 70cm frame.

4.4.5. Results

Quadrat results for the following sites are shown in Figures 26 to 30

Figure 26 Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2021.

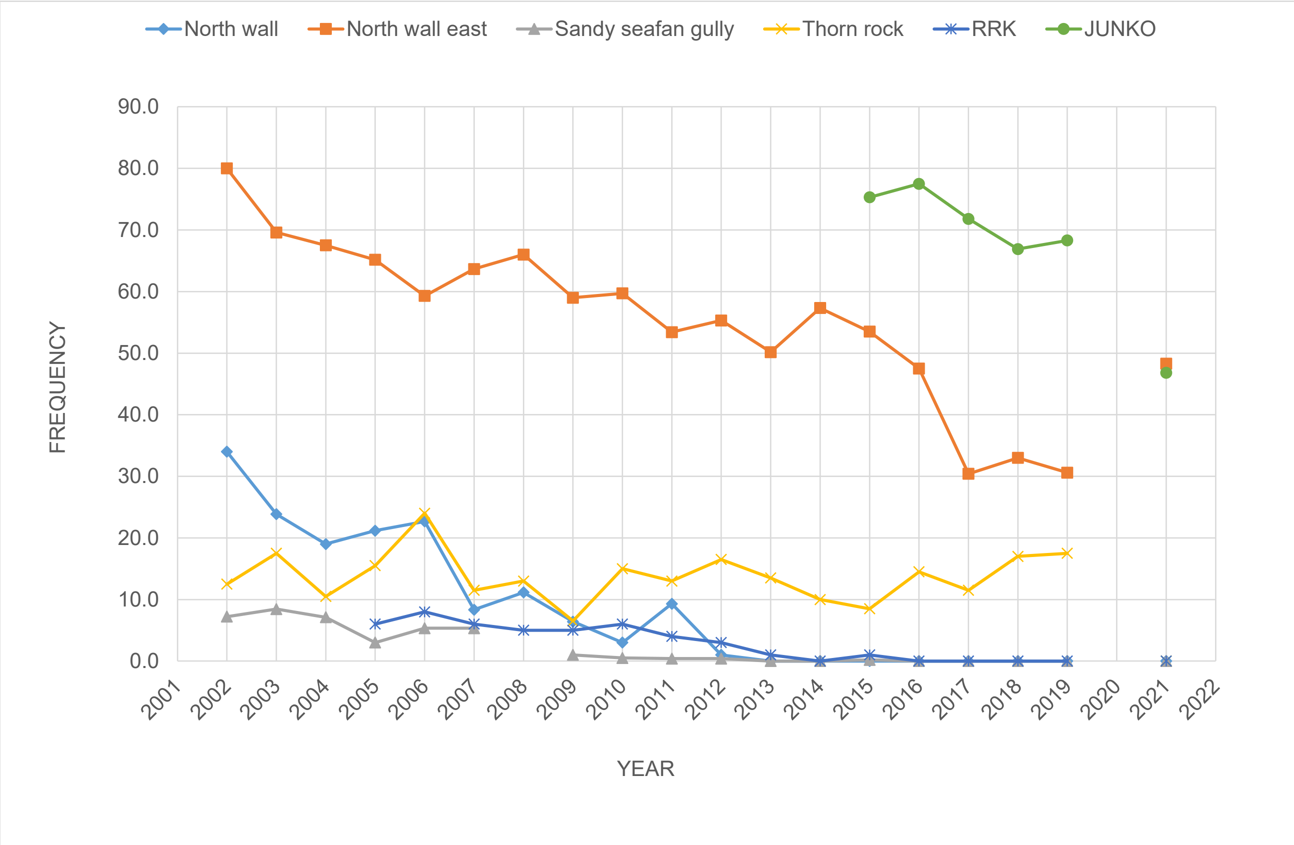


Legend: North Wall main (NWA), North Wall east (NWAe), Sandy Sea fan gully (SSFG), Thorn rock (TRK), Rye Rocks (RRK) and Junko's reef (JUNKO).

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

Alcyonium glomeratum mean frequency count

Figure 27 Mean frequency of *A. glomeratum* per quadrat Skomer MCZ 2002 – 2021.

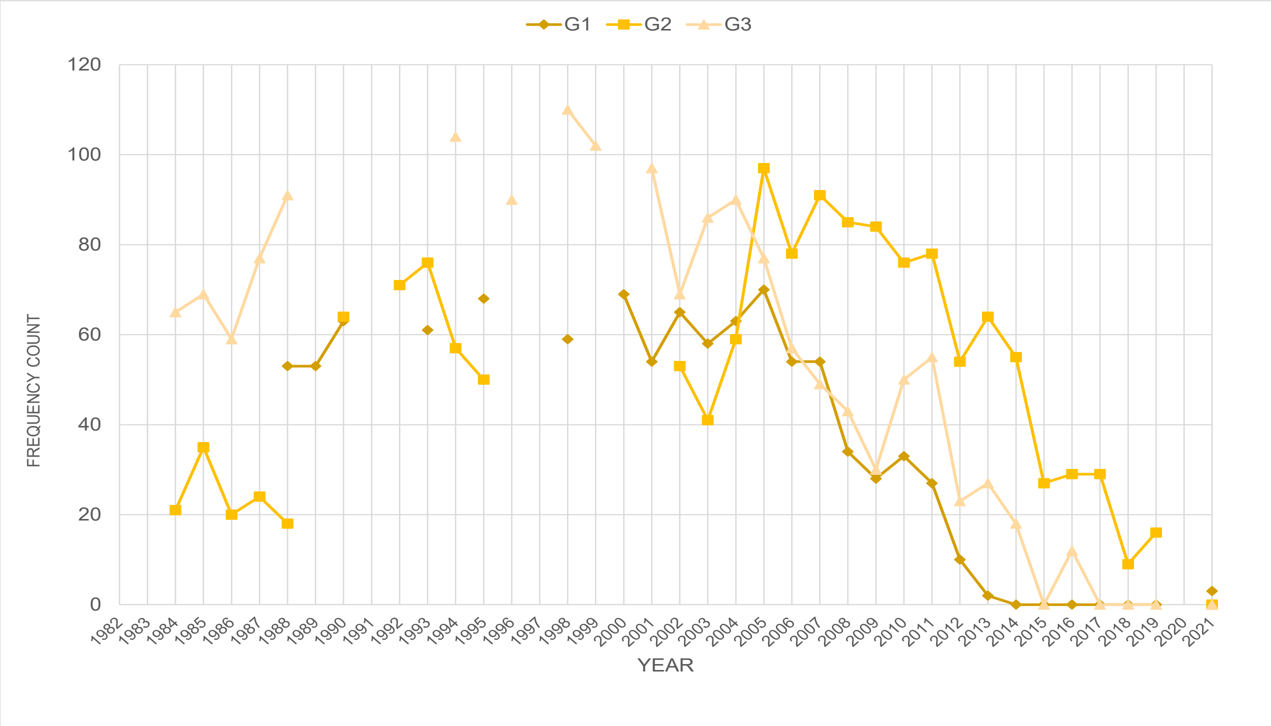


The declining trend or disappearance of *A. glomeratum* has continued at all sites except for Thorn Rock (Figure 27).

North Wall Stereo colony

The time series for these 3 photo quadrats on the north side of Skomer goes back to the 1980's. The quadrats have been photographed at least once a year for most years since 1988. A frequency count of *A. glomeratum* for each quadrat is completed using a 120 square grid (4 X 4cm squares) then presence counted for each square (Figure 28).

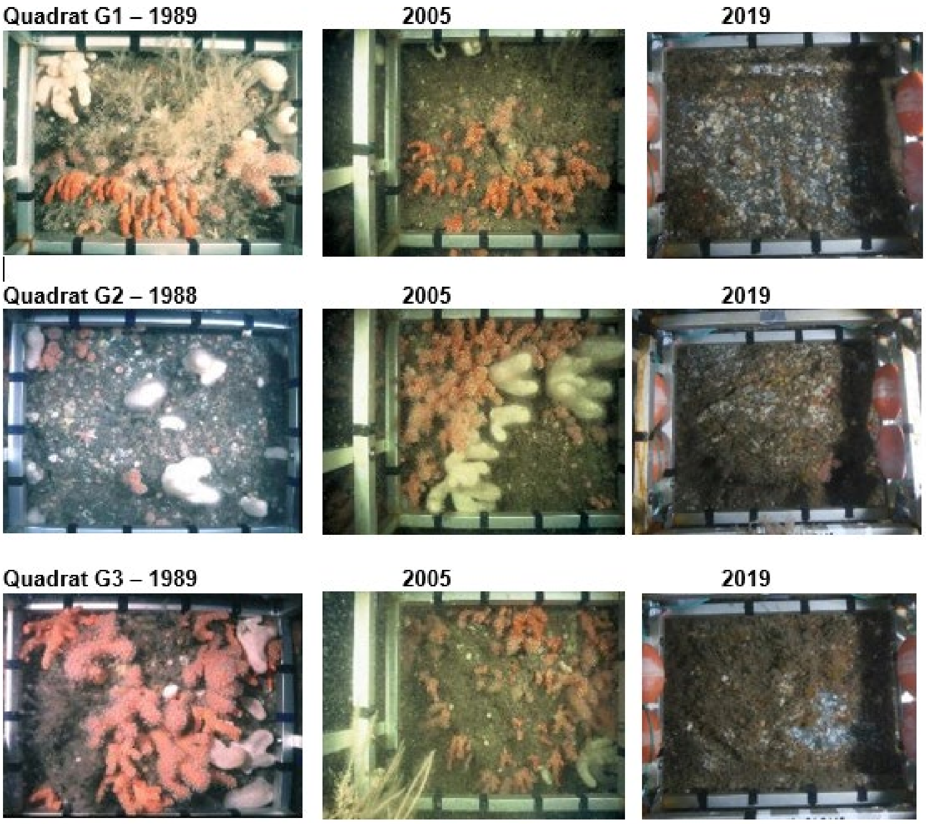
Figure 28 Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North wall.



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

Looking at the "then and now" photographs (Figure 29) it is interesting to note that *Alcyonium digitatum* (white deadman's fingers) has also reduced significantly in the three quadrats.

Figure 29 Photographic examples of declining populations of A. glomeratum at Skomer MCZ between 1989 and 2019.



4.4.6. Current Status

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

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

4.4.7. Recommendations

- Search for further colonies in the MCZ and establish new monitoring sites.
- 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 and to look at the wider picture across the SAC.
- Keep scientific literature under review.
- Report feature as declining.

4.5. *Parazoanthus axinellae* Population

4.5.1. 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.

4.5.2. Objectives

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

4.5.3. Sites

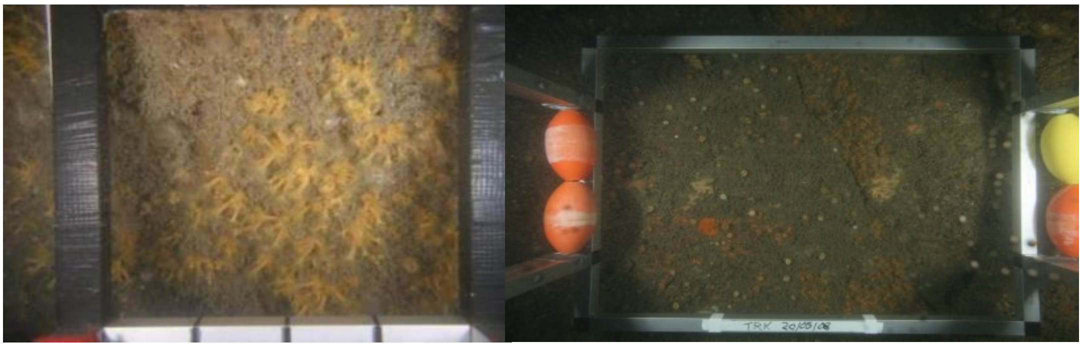
- Sandy Sea Fan Gully (2002)
- Sandy Sea Fan Gully Buttress (2015)
- Thorn Rock (3 colonies) (2002)
- Way Bench (2 colonies) (2002)

4.5.4. 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 (Figure 30, left).

Coverage 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 (Figure 30, right). See Burton, Lock & Newman 2002 for details.

Figure 30 Left: density method using a 20 x 20cm framer; and right: colony coverage method using a 50 x 70cm framer.

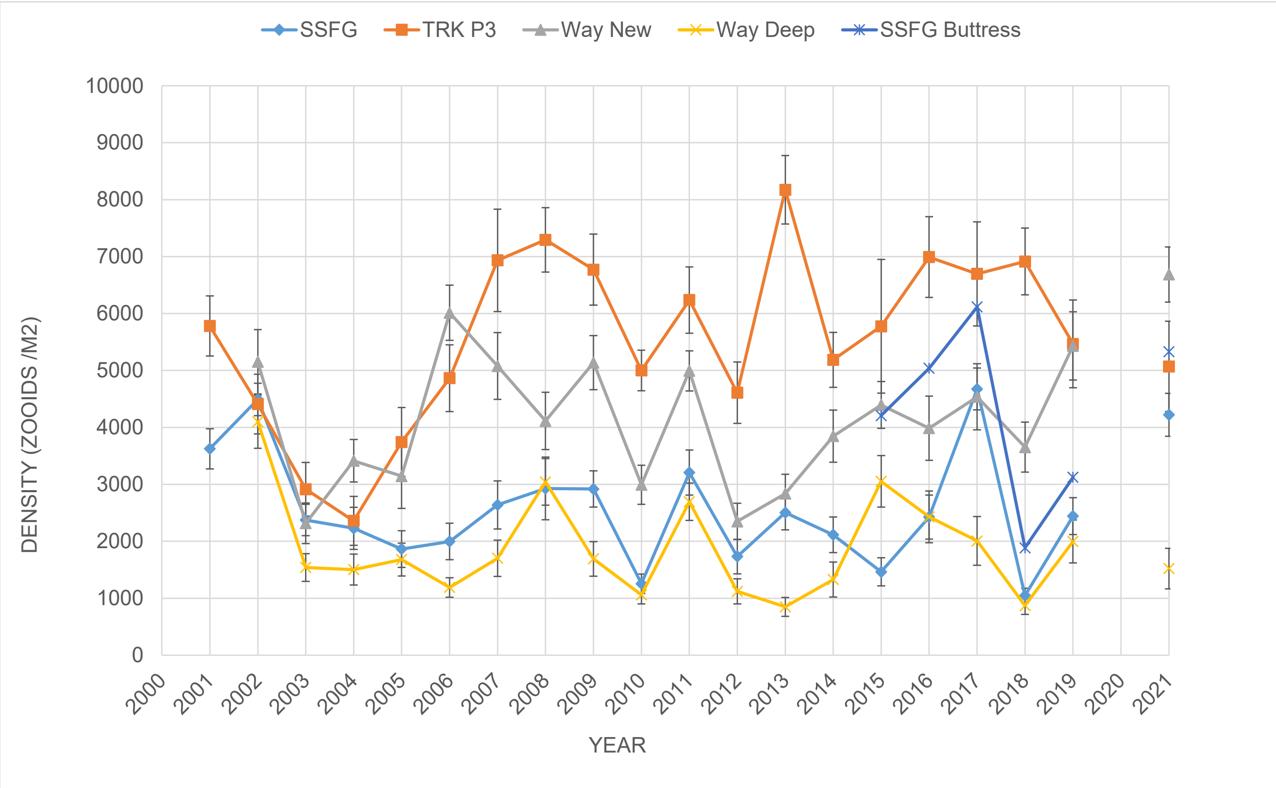


4.5.5. Results

Table 7 *Parazoanthus axinellae* fieldwork completed at Skomer MCZ in 2021.

Site	Site Code	Colony coverage	Density data
Sandy sea fan gully (SSFG)	SSFG	5 transects (20 quadrats)	Yes
Sandy sea fan gully Buttress (SSFG Buttress)	SSFG Buttress	2 permanent transects set up 13 quadrats	Yes
Waybench – *New Wall*	Way New	9 re-locatable quadrats	Yes
Waybench – *Deep Wall*	Way Deep	2 transects (8 quadrats)	Yes
Waybench – *Deep Wall*	Way Deep	New lower transect resurveyed– 6 quadrats	No
Thorn Rock – *Piton 7*	TRK P7	3 re-locatable quadrats	No
Thorn Rock - *Mooring*	TRK Mooring	3 re-locatable quadrats 4 new quadrats west of mooring	No
Thorn Rock – *Piton 3 (TRK P3)*	TRK P3	3 transects (11 quadrats)	Yes

Figure 31 Mean density of *P. axinellae* (number of zooids /m2) at five Skomer MCZ sites 2001 – 2021 with S.E bars.



The mean density of *P. axinellae* (number of polyps /m^2) at all sites has shown fluctuations from year to year, but overall shows a stable trend (Figure 31).

Figure 32 Mean frequency of *Parazoanthus axinellae* 2002 – 2021. Thorn Rock (TRK) transects.

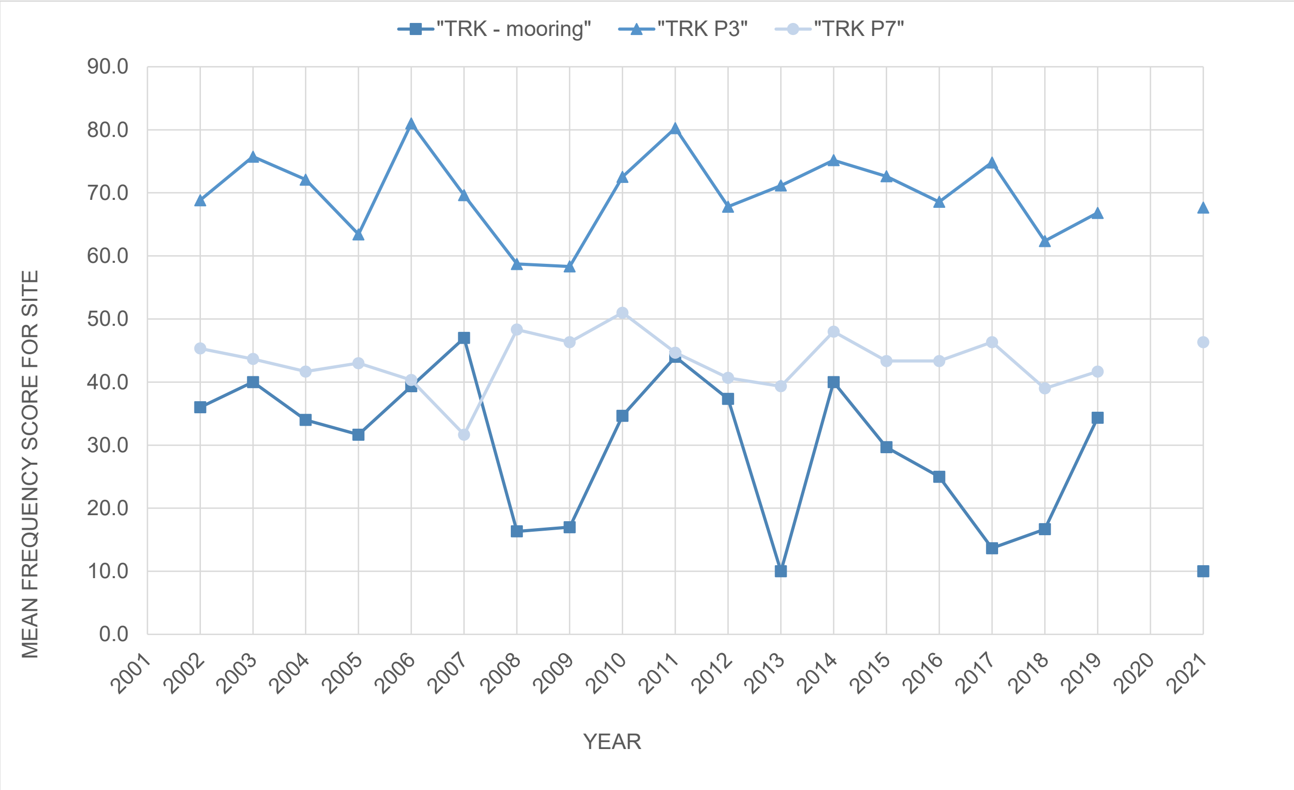
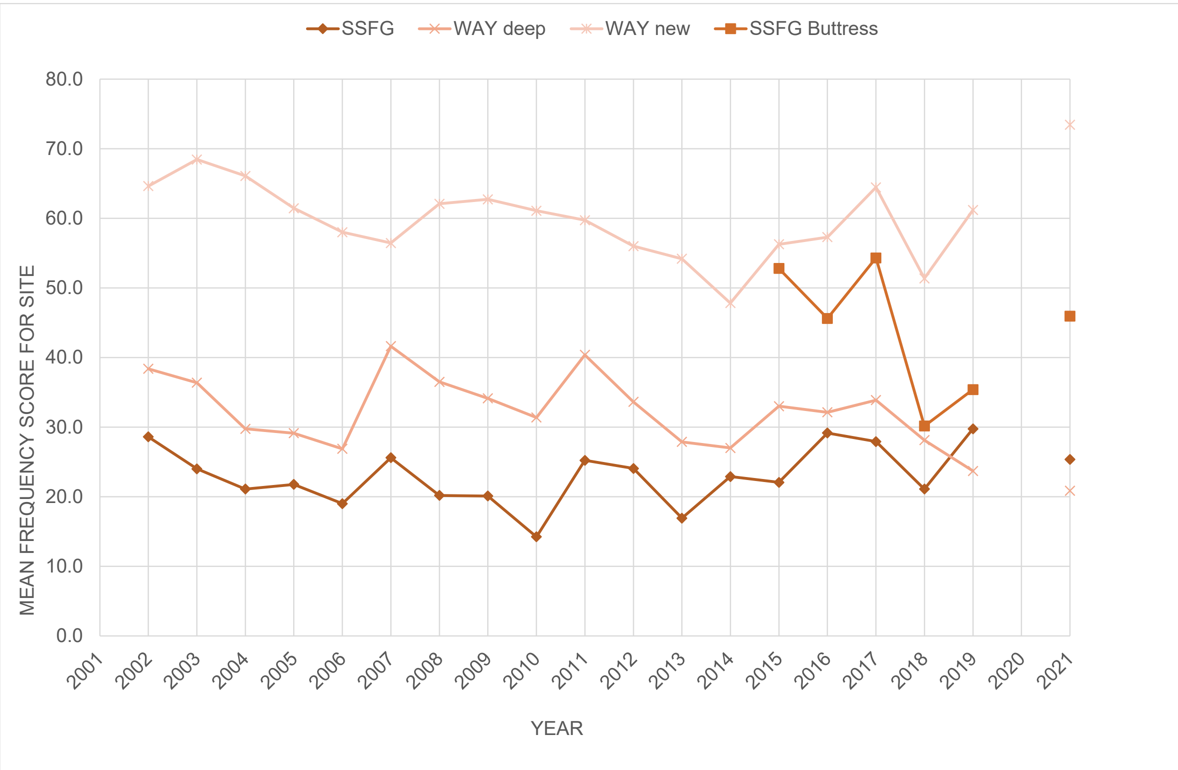


Figure 33 Mean frequency of Parazoanthus axinellae 2002 – 2021. Waybench and Sandy sea fan gully transects.



The frequency of *P. axinellae* at all sites has shown fluctuations year to year, but overall show a stable population (Figure 32 and 33).

4.5.6. Current Status

All previously recorded colonies are still present and population trends appear stable.

4.5.7. Recommendation

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

4.6. *Pentapora foliacea* (ross coral) Population

4.6.1. 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 physical disturbance. 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.

4.6.2. Objectives

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

4.6.3. Sites

Table 8 *Pentapora foliacea* monitoring sites at Skomer MCZ in 2021.

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
Martins Haven East	rock and boulders	2021

4.6.4. 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.

4.6.5. 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. Sadly, it was found that most of the photo images had insufficient precision of data to apply the method. However, conclusions drawn from study 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 2007).

2010: 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 2013b). 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.

2021: A new site was established at Martins Haven east rocky reef on the north side of the Marloes Peninsula.

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 34).

Figure 34 *Pentapora foliacea* - examples of Class 4 (top) and Class 5b (bottom) colonies.

4.6.6. Results

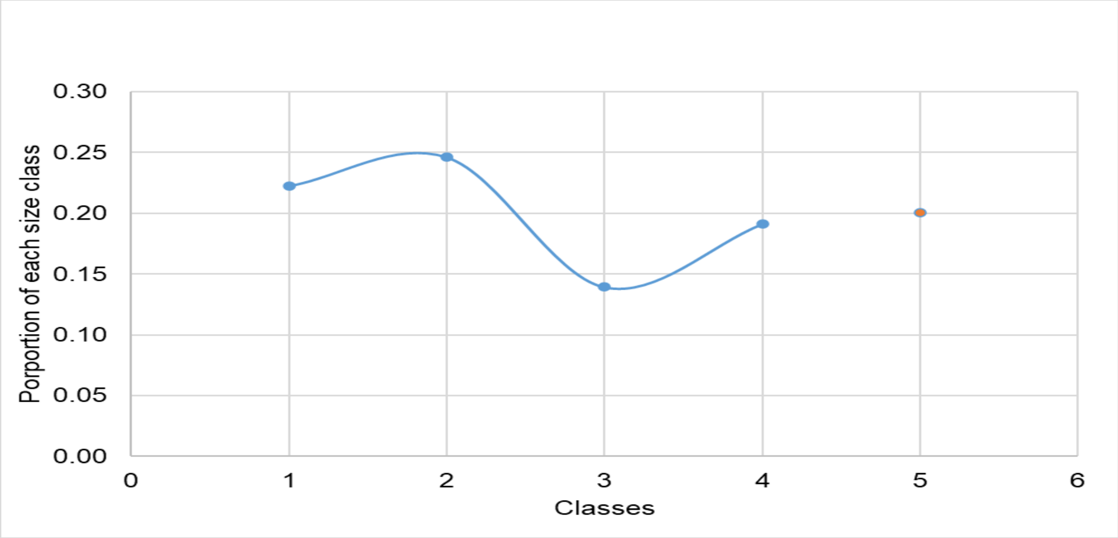
Photo datasets collected each year for each survey sites are shown in table 9.

Table 9 *Pentapora foliacea* photo dataset for Skomer MCZ.

Year	North Wall	Waybench	Bernies Deep	Bernies Shallow	North Neck	South Middleholm	West Hook	Pool	Martins Haven E
1993	**yes**	**yes**	no	no	no	no	no	no	no
1994	**yes**	no	no	**yes**	no	no	no	no	no
1995	**yes**	no	**yes**	**yes**	no	no	no	no	no
1996	**yes**	no	no	no	no	no	no	no	no
1997	**yes**	no	**yes**	**yes**	no	no	no	no	no
1998	**yes**	no	**yes**	**yes**	no	no	no	no	no
1999	**yes**	no	no	no	no	no	no	no	no
2000	**yes**	no	**yes**	**yes**	no	no	no	no	no
2001	**yes**	no	no	no	no	no	no	no	no
2002	**yes**	**yes**	**no**	**no**	**yes**	**yes**	no	no	no
2003	no	**yes**	**yes**	**yes**	**yes**	**yes**	no	no	no
2004	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2005	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2006	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2007	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2008	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2009	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2010	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2011	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2012	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no	no
2013	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2014	no	**yes**	**yes**	**yes**	**yes**	no	**yes**	**yes**	no
2015	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2016	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2017	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2018	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2019	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	no
2020	no	no	no	no	no	no	no	**no**	no
2021	no	**yes**	**yes**	**yes**	**yes**	no	**yes**	**yes**	**yes**

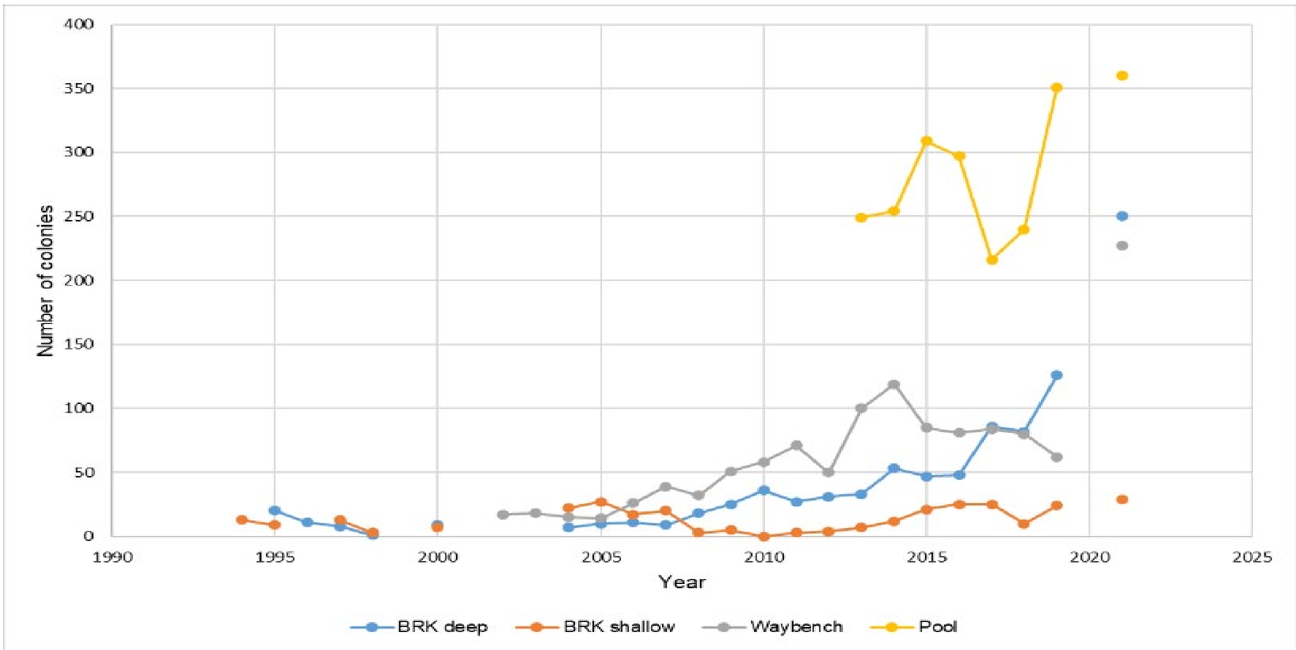
The normalised population curve in Figure 36 shows the proportions of each size class (1-4) across all Skomer sites and gives an overall pattern of size-class distribution. Class 5 is not connected via the curve as it is not a continuum from class 4 but is related to degradation which can develop directly from class 2, 3 or 4. The population pattern varies between sites as colony development is affected by both substrate, environmental conditions, disease and recruitment at sites.

Figure 35 *Pentapora foliacea* - normalised population curve for all Skomer MCZ sites.



Waybench, Pool and Bernies Rock are the largest sites surveyed, the total number of colonies (all classes) recorded in each survey year is shown in Figure 36. The total numbers recorded at each of these sites increased between 2019 and 2021.

Figure 36 Total number of *Pentapora foliacea* colonies (all classes) recorded each year surveyed at Waybench, Pool and two sites at Bernies Rock.



Waybench is a large bedrock site, on the north side of the island, and is divided into two areas: an exposed rocky ridge and a neighbouring boulder area. Ridge colonies tend to be recorded as class 1-3 and rarely reach class 4, whilst in the more sheltered boulder area higher numbers of colonies are found and many of them reach the larger class 4, before developing into a class 5. Between 2002 and 2014 a steady increase in colony numbers was recorded from 17 to 119, numbers then dropped over the following years to 62 in 2019, however, in 2021 a significant increase was recorded with 227 colonies with all classes represented (Figure 36).

Bernie's 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 present. All classes of colonies are found with many developing into a class 4, before progressing to a class 5. In 2021, 29 colonies were recorded at the shallow site, similar to previous years (Figure 37). At Bernie's rock deep, colony numbers had fluctuated between 0 to 50 colonies between 1994 and 2016, however, over the next 3 years this increased to 126 colonies in 2019, and a further increase to 250 colonies were found in 2021 with all classes represented (Figure 36).

The Pool monitoring was 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 area is surveyed, and large numbers of colonies are found with an even spread of classes present. Between 2013 and 2018, total numbers fluctuated between 216 to 309 colonies, in 2019 this increased to 351 colonies and in 2021, 360 colonies were recorded with all classes represented (Figure 36).

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.

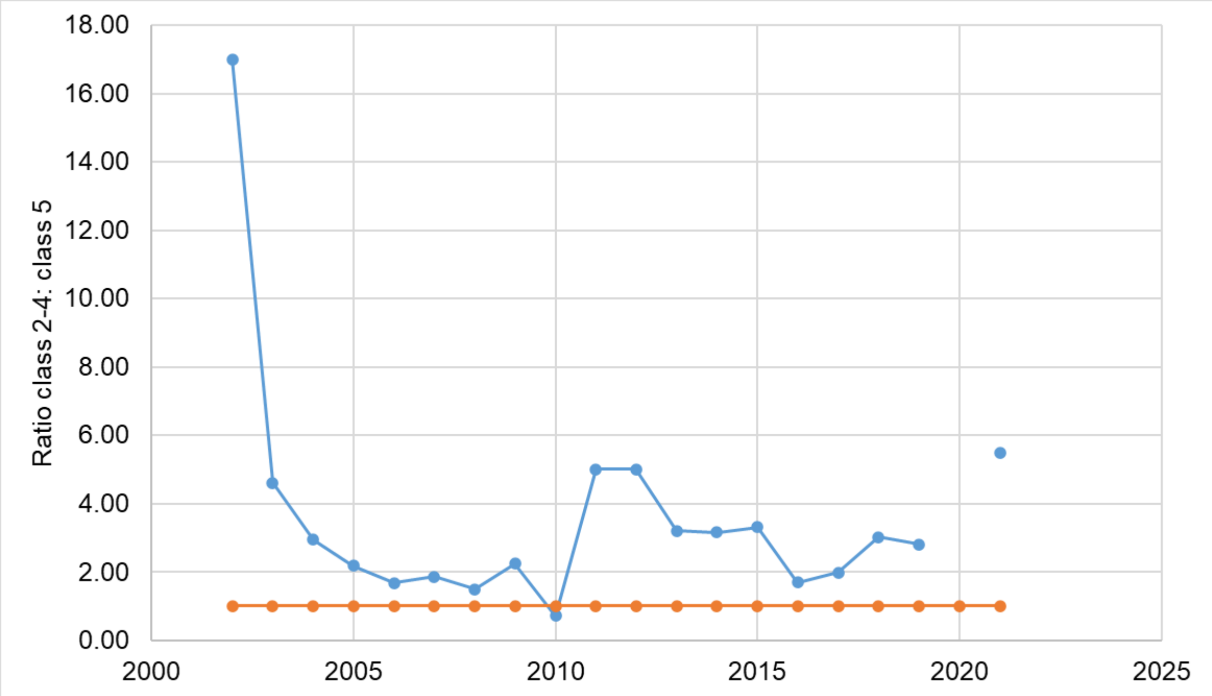
South Middleholm is a small bedrock site on the south side of the island and subjected to the prevailing south-westerly swell. Class 1 to 3 individuals are the most common, with very few developing into class 4, instead developing directly to class 5.

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

Martins Haven East is a small bedrock site located on the North Marloes Peninsula established in 2021. A range of class 1 to 4 colonies were recorded in addition to class 5. Angling line was found wrapped around several colonies.

The ratio between class 2-4 and class 5 colonies at all sites between 2002 and 2021 is shown in figure 38. Class 2-4 colonies represent healthy growing colonies whilst class 5 represents those with natural or anthropogenic damage and deterioration. The results show that for most years the ratio is greater than 1 (shown as straight line in Figure 37), therefore there are more healthy growing colonies than degraded colonies.

Figure 37 *Pentapora foliacea* - ratio of class 2-4 colonies to class 5 colonies - all Skomer sites



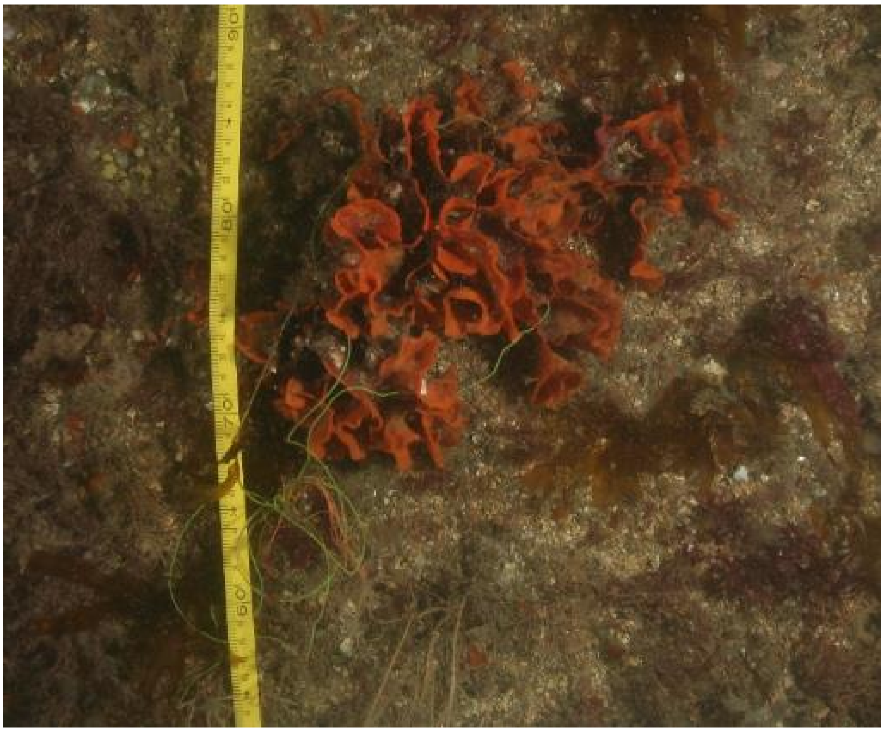
The current dataset forms an important baseline for Skomer sites. However, it needs to be remembered that all sites are currently subject to anthropogenic activities including pot fishing, angling and recreational diving, which all have the potential to harm *P. foliacea* colonies.

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 seabed (Figure 38).

Figure 38 *Pentapora foliacea* – interaction with fishing gear

Evidence of damage from angling line was also observed in 2021 tangled in *P.foliacea* at the new Martins Haven east survey site, this location is popular with shore angling (Figure 39).

Figure 39 *Pentapora foliacea* – interaction with angling line



Human activities, where contact with the seabed may occur, such as pot fishing, angling, diving and anchoring, are recorded at Skomer MCZ. These data have been analysed in more detail for monitoring sites and are available in the Skomer MCZ Annual reports 2018 – 2021. [Natural Resources Wales / Marine and coastal evidence reports]

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

4.6.7. Current Status

- An increase in total numbers of colonies (all classes) was recorded in 2021 at the largest survey sites: Waybench, Pool and Bernies Rock.

- In most years of recording there has been a higher number of intact and growing colonies (Classes 2-4) compared to "degraded" (Class 5) *P. foliacea* colonies. This proportion of "healthy" colonies increased in 2011 and 2012, and then reduced slightly with the inclusion of a much larger number of colonies from the Pool site in 2013. In 2021 there has been an increase in "healthy" colonies compared to the previous 10 years.

- The question still remains however, as to whether this ratio is a "healthy" one, or whether a population not subjected to any anthropogenic activities would demonstrate different characteristics. Given that some potentially damaging anthropogenic activities are unrestricted and occur in the MCZ, we are unable to judge whether the population exhibits a "healthy" ratio of degraded to intact colonies, so the condition of this feature is judged to be "unknown".

4.6.8. 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*.

- Report status as unknown.

4.7. Cup Coral Populations; *Balanophyllia regia* and *Caryophyllia smithii*

4.7.1. 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.

4.7.2. Objectives

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

4.7.3. Sites

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

4.7.4. Methods

Balanophyllia regia

1. Thorn Rock Boulder: A fixed position quadrat using a 50 x 40 cm framer at Thorn Rock has been photographed since 1984

2. 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.

3. 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 Burton et al 2002.

4.7.5. Results

Balanophyllia regia

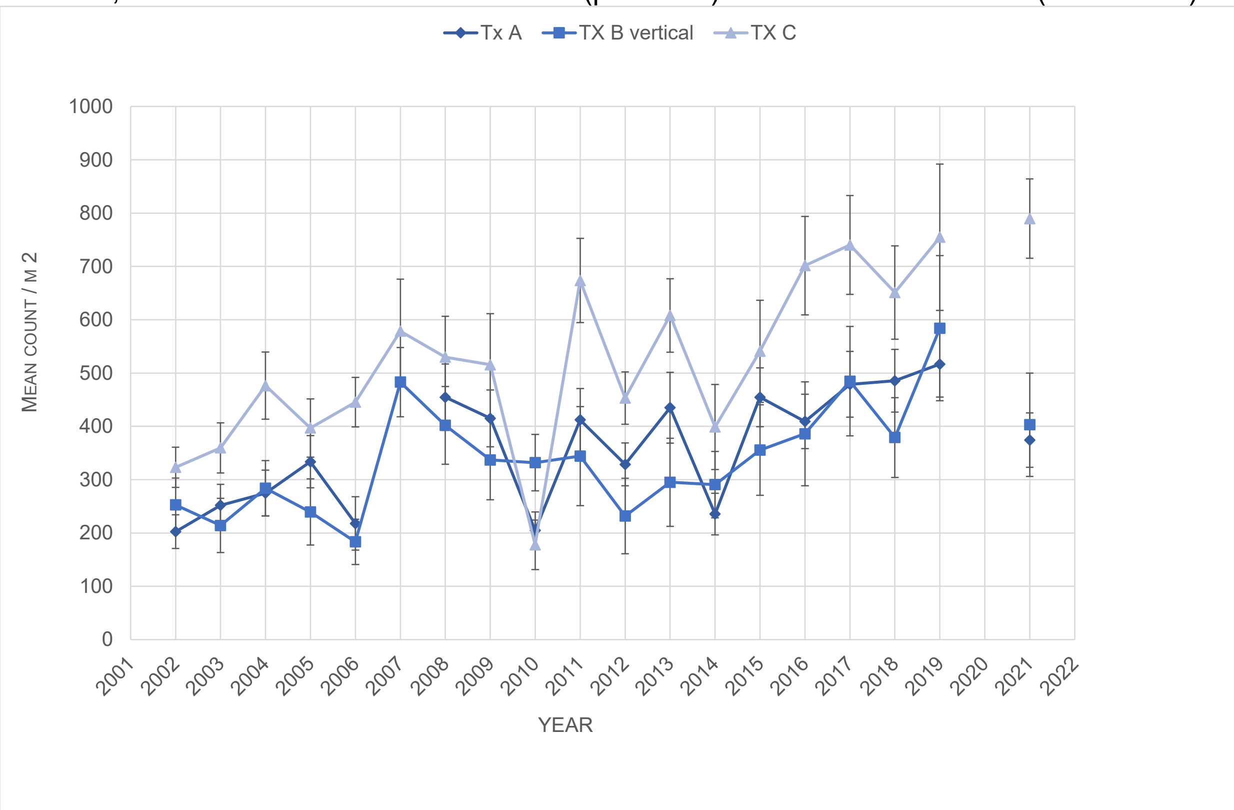
At the Wick, all data have been standardised abundance per 1m^2 to enable comparison between the 50 x 40 cm and the 50 x 70 cm framers (Table 10).

Table 10 Mean abundance (and standard error) of *Balanophyllia* regia in The Wick (standardised to 1m^2).

Site	Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
WCK A	Mean	203	252	275	334	218	no data	455	415	205	412
WCK A	S.E.	32	39	43	49	50	no data	62	53	35	59
WCK C	Mean	323	360	476	397	445	579	530	516	178	674
WCK C	S.E.	50	51	52	62	42	65	73	75	53	93
WCK B	Mean	253	214	284	239	183	483	402	337	332	344
WCK B	S.E.	38	47	63	55	46	98	76	96	46	79

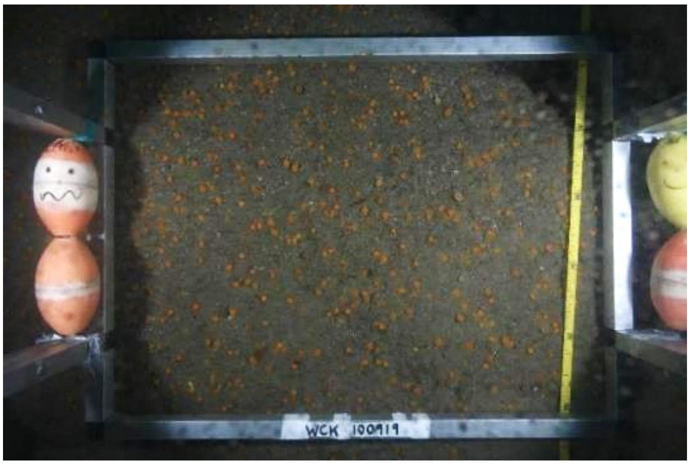
Site	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
WCK A	Mean	329	435	236	455	409	479	486	517	no data	374
WCK A	S.E.	40	66	39	55	51	62	59	62	no data	51
WCK C	Mean	453	608	399	541	702	259	651	755	no data	790
WCK C	S.E.	71	83	62	85	97	36	75	136	no data	97
WCK B	Mean	232	295	291	356	386	170	379	584	no data	403
WCK B	S.E.	49	69	80	96	92	32	88	137	no data	74

Figure 40 Mean abundance (and standard error) of *Balanophyllia* regia at Transects A, B and C at the Wick, counted within 50 x 40 cm framers (pre-2008) and 50 x 70cm framers (since 2008).



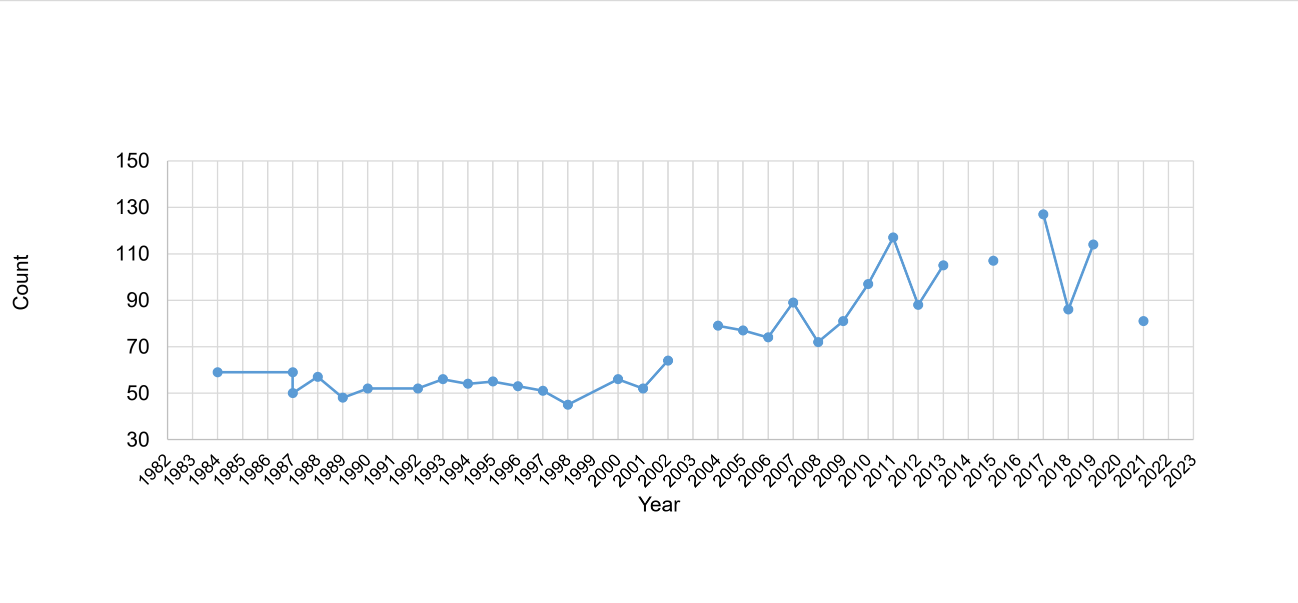
The average count /m² of *B. regia* has fluctuated at transects A, B and C at the Wick. The variability is most likely to be caused by the dense covering of silt that occurs across the site from time to time and occasional very poor photographic conditions (e.g., 2010). In 2019 there was very little silt, and the cup corals were visible, even very tiny ones could be seen, which might explain why counts were their highest for each of the transects (Figure 40). A record number of 541 individuals were counted in one 50 x 70cm framer (1546/m^2) (Figure 41).

Figure 41 *Balanophyllia regia* (individuals 541) in 1 50x70cm framer at the Wick, representing a density of 1546/m^2



At Thorn Rock individual cup corals have been traced for 30 years in a single fixed-position 40 x 50cm quadrat. Numbers have shown a general increase between 1998 and 2021 which suggests recruitment could have occurred. Variability in abundance counts can 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 and no survey was completed in 2020due to Covid restrictions (Figure 42).

Figure 42 Thorn Rock *Balanophyllia regia* counts (within a single 40 x 50cm quadrat).



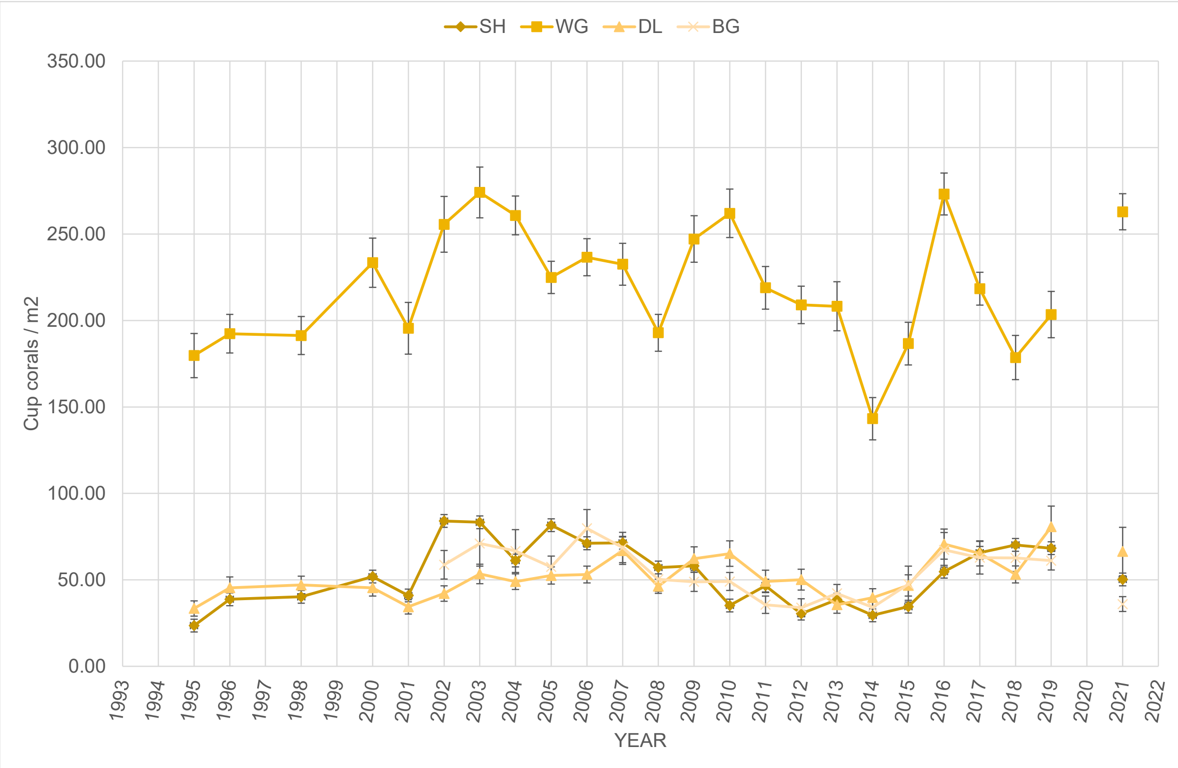
Caryophyllia smithii

The average density of *C. smithii* has fluctuated at each of the Thorn Rock sites (Figure 43). 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 (Figure 43). This is most likely due to it being the only vertical wall site where less surface sediment accumulates. The other three sites are all on horizontal rock.

The abundance has fluctuated at Windy gully (WG) but been reasonably stable at the other three sites. It is not known how long these cup corals live (Biotic Database suggests a life span of 11-20 years [BIOTIC (marlin.ac.uk)](marlin.ac.uk)) and what variability in their numbers would be natural.

Figure 43 Mean Number of *Caryophyllia smithii* /m^2 quadrat at Thorn Rock (4 transects) 1995–2021.



4.7.6. 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.

4.7.7. Recommendations

- Records of surface sediment levels may help determine whether reduced abundance of cup corals is significant or due to recording inconsistencies.
- Support research work.
- Report feature component as stable.

4.8. Grey Seal (*Halichoerus grypus*) Population

4.8.1. 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 EC 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).

4.8.2. 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.

4.8.3. Sites

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

4.8.4. Methods

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

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

4.8.5. Project History

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

Additional Seal Studies carried out at Skomer MCZ

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

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

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

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

2008 - 2019 - At Skomer, sites photography included pupping cows to help increase knowledge of site fidelity, longevity and pupping frequency. In 2011 - 2017 the work also expanded to some cows and bulls from mainland sites. Matthews & Boyle 2008, Boyle 2009 - 2012, Buche & Stubbings 2013- 2019).

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

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

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

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

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

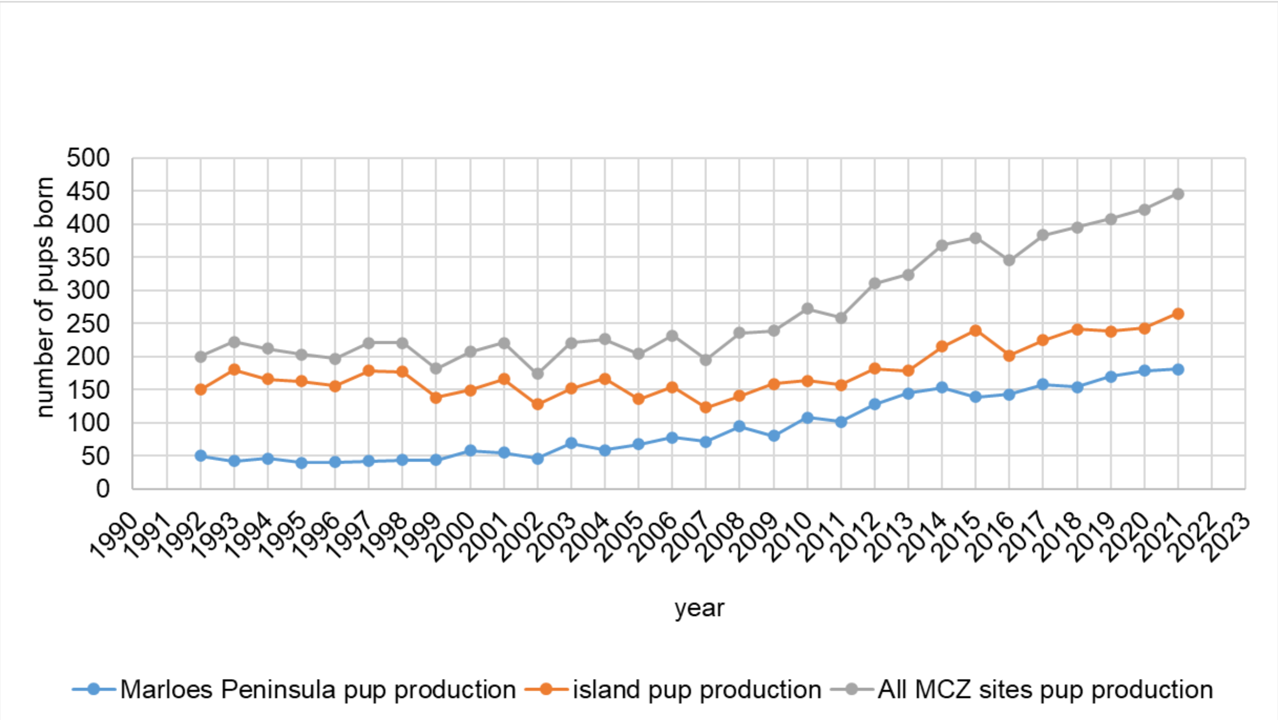
4.8.6. Results

A full report for the 2021 Skomer seal census details the production for the island sites, (Buche 2022). The survey data from the island and mainland sites have been combined to provide data for the whole Skomer MCZ.

Pup production

In 2021, 265 pups were born at Skomer Island sites and 181 pups at mainland sites giving a total of 446 pups born in the MCZ (Figure 44).

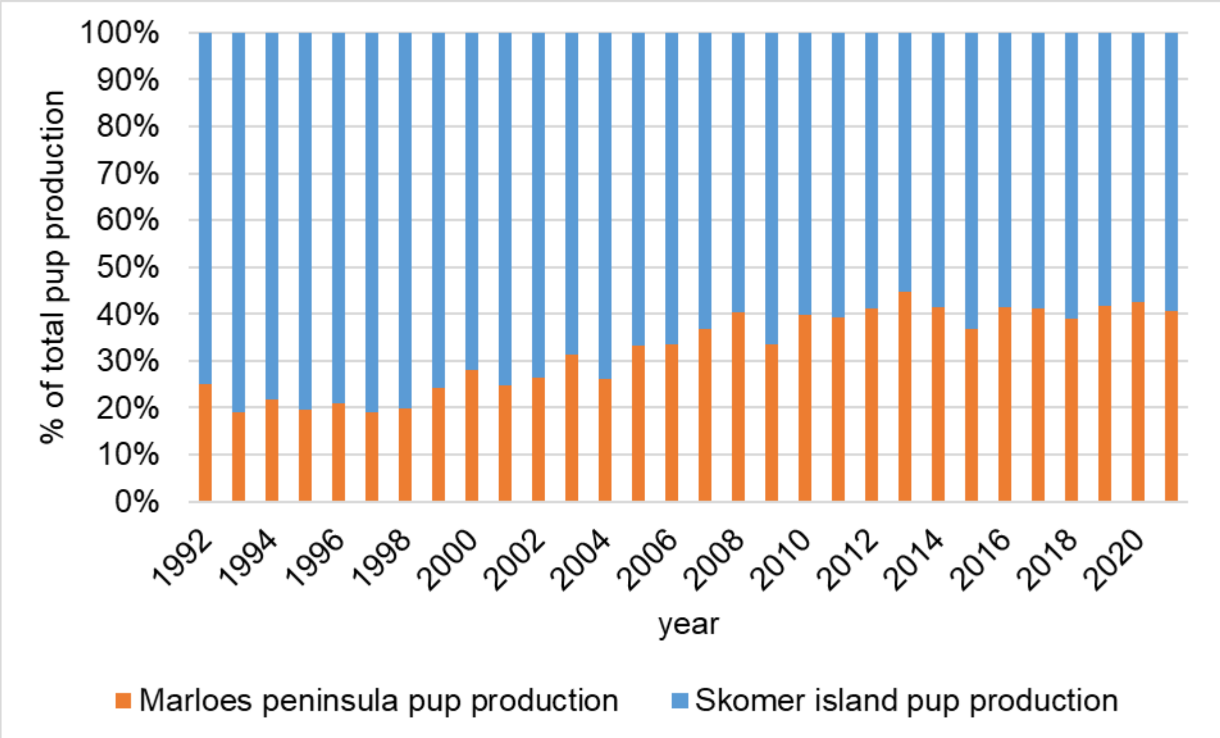
Figure 44 Skomer MCZ pup production 1992 - 2021.



Pup production from all sites in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area, with production averaged for 2017-21 being 410 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 (Figure 44).

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 46. From 1992 to 2002 Marloes peninsula contributed an average of 22% of total production. This has gradually increased to a peak of 45% in 2013 and the average over the last five years is 40% of total production.

Figure 45 Skomer MCZ pup production – percentage born on Island vs. mainland sites



In 2021, 12.2% of pup production occurred in August, 65.8% in September, 21% in October and <1% in November. The highest number of births was 94 pups in week 37 (10th to 16th September). The trend over the last 23 years shows that the mode week of production has fluctuated between weeks 37 to 40 (10th September to 7th October) (Figure 46).

Figure 46 Mode week of seal pup production at Skomer MCZ 1992 – 2021.

Pup survival

In 2021, pup survival through to moult was recorded as 74% for Skomer sites and 79% for Marloes Peninsula sites, with a combined survival for the Skomer MCZ of 76%.

Pup survival assessment is based on the following criteria applied to pups when last seen (Table 11):

Table 11 Seal pup survival assessment method

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

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

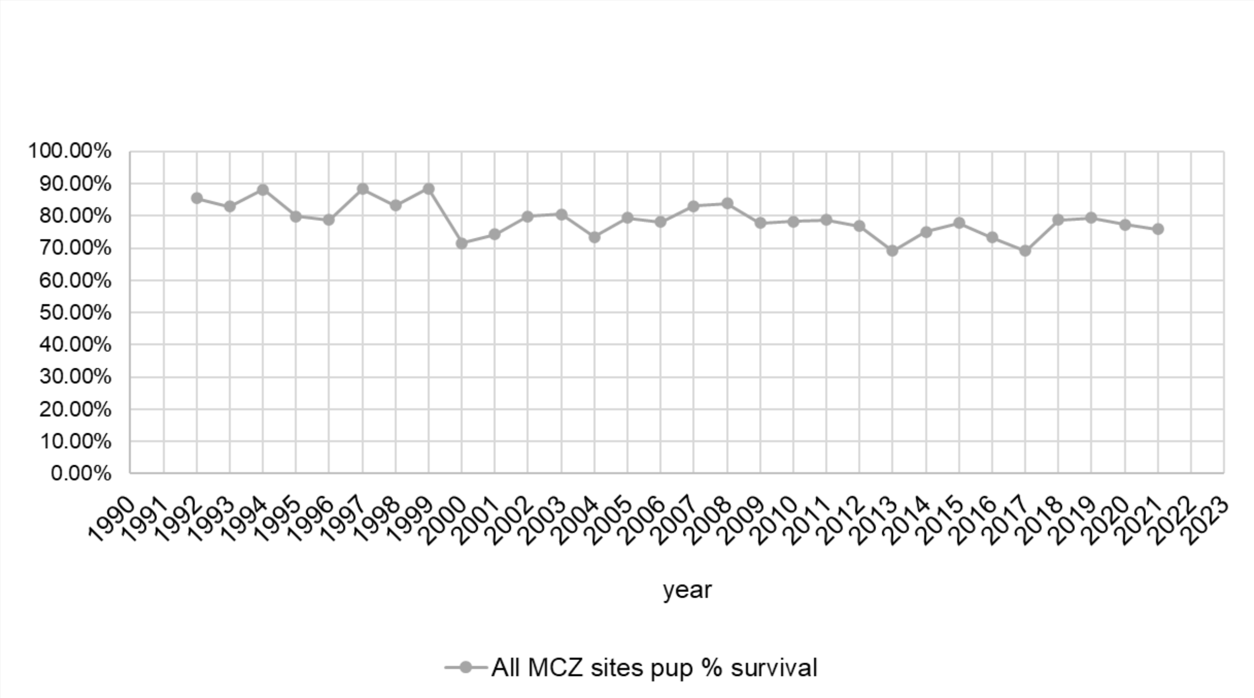
Stillborn. These include both stillborn and those that died immediately after birth and were not seen alive.

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 2021 has fluctuated between 69% and 88%, with an average of 79% (Figure 47).

Figure 47 Skomer MCZ pup survival 1992 – 2021.



Pollution and Litter

Monofilament line and netting were the most visible pollutants affecting seals in 2021. 40 individual seals on Skomer (four males, 32 females and four immatures) 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.

In 2020 only 16 seals with scars from netting were observed. It is unknown whether the increase in 2021 mirrors a rise in pollution or whether it is due to observer effort. Photographing netted seals relies on good weather and time spent in the field so will vary from year to year. Furthermore, some seals might get counted twice as it is not always possible to photograph both sides of a seal during one session. If the same seal gets photographed the next day from the other side it might not be possible to match the animal, hence the seal gets counted again.

In order to increase accuracy and comparability a more systematic approach to monitoring netted seals is recommended by the Skomer seal worker. During the quieter period (August, mid-October until the end of November) all seals hauled-out on North Haven beach and Castle Bay which are fully visible, and all netted animals should be counted regularly. This way a percentage of netted seals can be calculated which does not rely on identifying individual animals. This figure can then be compared throughout the years to determine a trend.

Skomer MCZ beaches remain relatively clean, no pollution by oil or tar was observed in 2021.

Seal behaviour

In 2021, as in most years, females were observed nursing other's' young. On South Haven, Driftwood Bay as well as Matthew's Wick, females were observed fighting over pups and suckling not only their own pups but others as well.

Seal disturbance

Only one significant disturbance to seals was recorded on Skomer during the 2021 pupping season. At the end of August several snorkelers were seen swimming very close to South Haven beach which had several females with pups on it. The next day one of the pups which had been attended by its mum had disappeared. Several minor disturbances to seals were recorded and boats were regularly observed within the voluntary no access zone (Table 12).

Table 12 Seal disturbance (records by Skomer Island staff) on Skomer Island in 2021.

Level of disturbance: 1 = little disturbance (lifting of heads); 2 = Seals enter water in response to perceived threat; 3 = major disturbance involving abandonment of pup or similar

Date	Time	Location	Type	Severity	Comment
27/8/21	14:33	RRK	RIB	1	disturbed seals hauled-out on RRK
22/8/21	13:47	CBY	Airplane	1	disturbed seals hauled-out on CBY
20/8/21	12:00	RRK	Diving boat	2	8 snorkelers went through the middle of RR at low tide
29/8/21	16:36	SHV	Snorkelers	1-3	5 snorkelers very close to SHV beach with pups, females in water, next day a pup on W-side was gone
9/9/21	13:30	RRK	Kayak	2	2 kayaks
14/9/21	16:19	RRK	Kayak	2	2 Kayaks disturbing haul-out, seals enter water in panic

4.8.7. Current Status

- In 2021, pup numbers reached 446, 21 more pups than the management plan target pup production lower limit of 425 pups (average of last 3 years).
- Pup survival was 75%, equal to the management plan target percentage survival lower limit of 75% (average of last 10 years).
- Grey seals at Skomer MCZ are considered to be in favourable condition.

4.8.8. 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.
- To continue to contribute seal ID photos to collaborative projects in South West Britain.
- 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.

4.9. Cetacean Species Recording

4.9.1. 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 currently unidentifiable, it is not possible to establish whether the MCZ waters are regularly used by a large number of peripatetic animals, or whether a smaller group remains in the immediate area and are seen more frequently. *P. phocoena* is an internationally protected species listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (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.

4.9.2. Objectives

To record numbers of cetaceans and their distribution within the Skomer MCZ.

4.9.3. Method

Recording effort varies annually but includes:

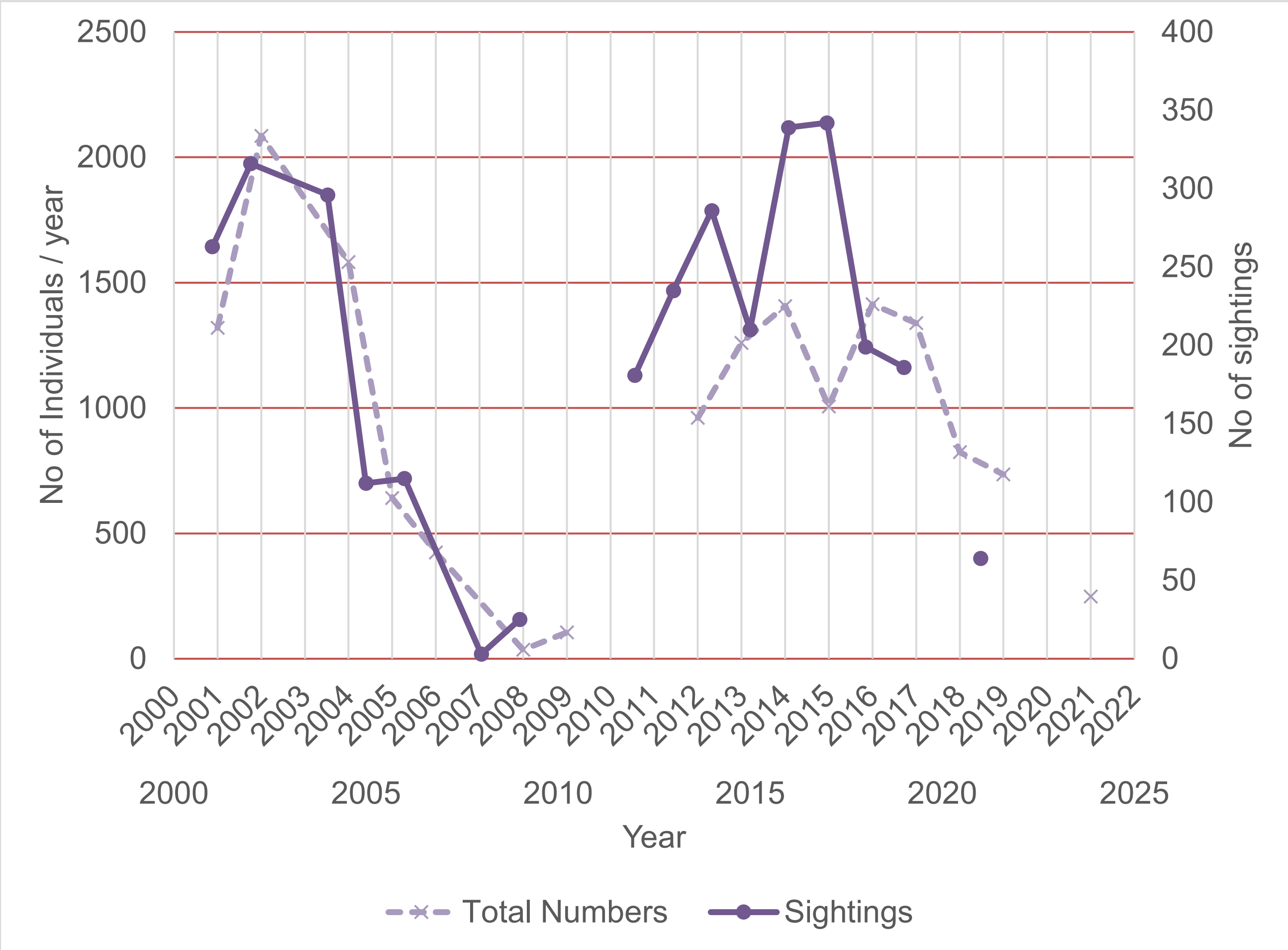
- Species, numbers of individuals, sites, date and time are recorded for each sighting.
- Skomer Island NNR staff and volunteers using binoculars and telescopes from cliff locations around the island.
- Dale Princess crew maintaining records in a diary of sightings during the ferry run between Martins Haven and North Haven and on the round island trips.
- MCZ staff recording all sightings whilst at sea.

4.9.4. Results

All sightings of cetaceans have been collated for the period between 2001 and 2021. There are no records in years 2003, 2007, 2010, 2011 and in 2020 (Figure 49). The effort is variable not just between years but also during the season which makes the data difficult to effort correct. Very few records were received from the Dale Princess in 2017 or 2018, records were received in 2019 but none for 2020 or 2021. As several cetaceans are frequently seen together during the same sighting, total numbers of cetaceans reported are higher than total sightings reported.

In 2016 a standard set of site names and recording system was applied to all data collected by Skomer MCZ and Skomer NNR staff & volunteers (Wildlife Trust of South & West Wales).

Figure 48 Harbour porpoise sightings and total numbers of individuals seen per year within Skomer MCZ 2001 to 2021. No recording occurred in 2010, 2011 and 2020.

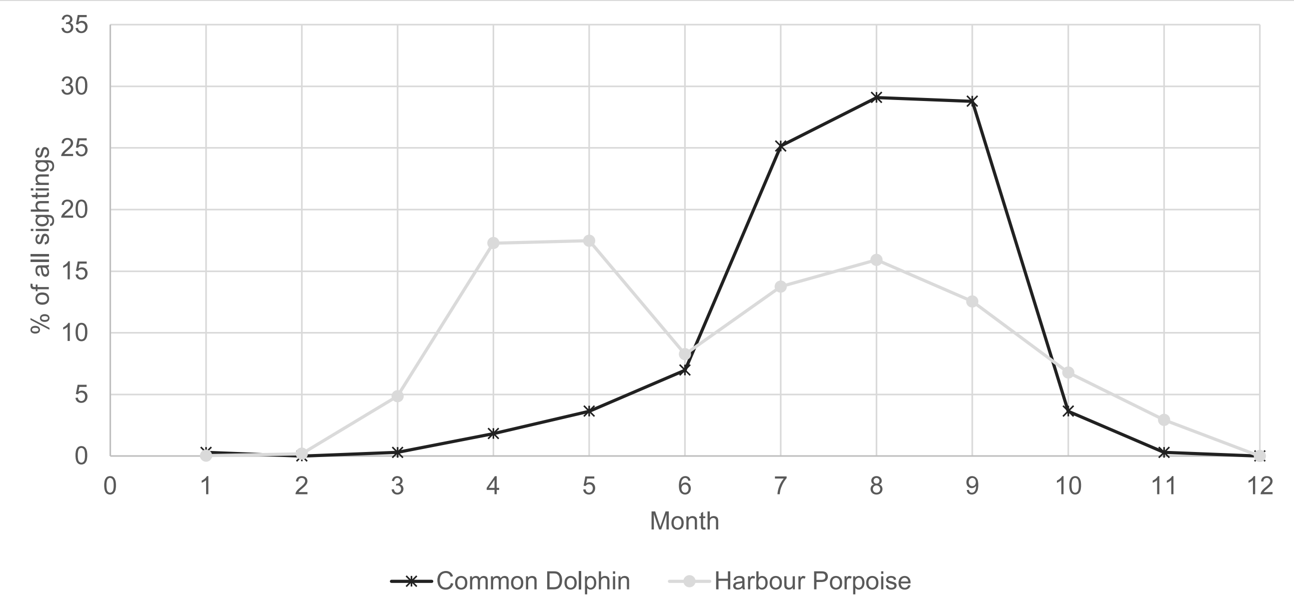


A “Sighting” refers to a single event when 1 or more cetacean is recorded from a specific location. “Total numbers” is the sum of all the counts of a specific cetacean species for the whole year.

These data are not effort corrected and there was a more concerted effort to collate all the records in a consistent way from 2016 onwards. In 2020 there were no records collected. In 2021 the amount of recording effort was reduced especially from Skomer NNR due to lower numbers of researchers and volunteers.

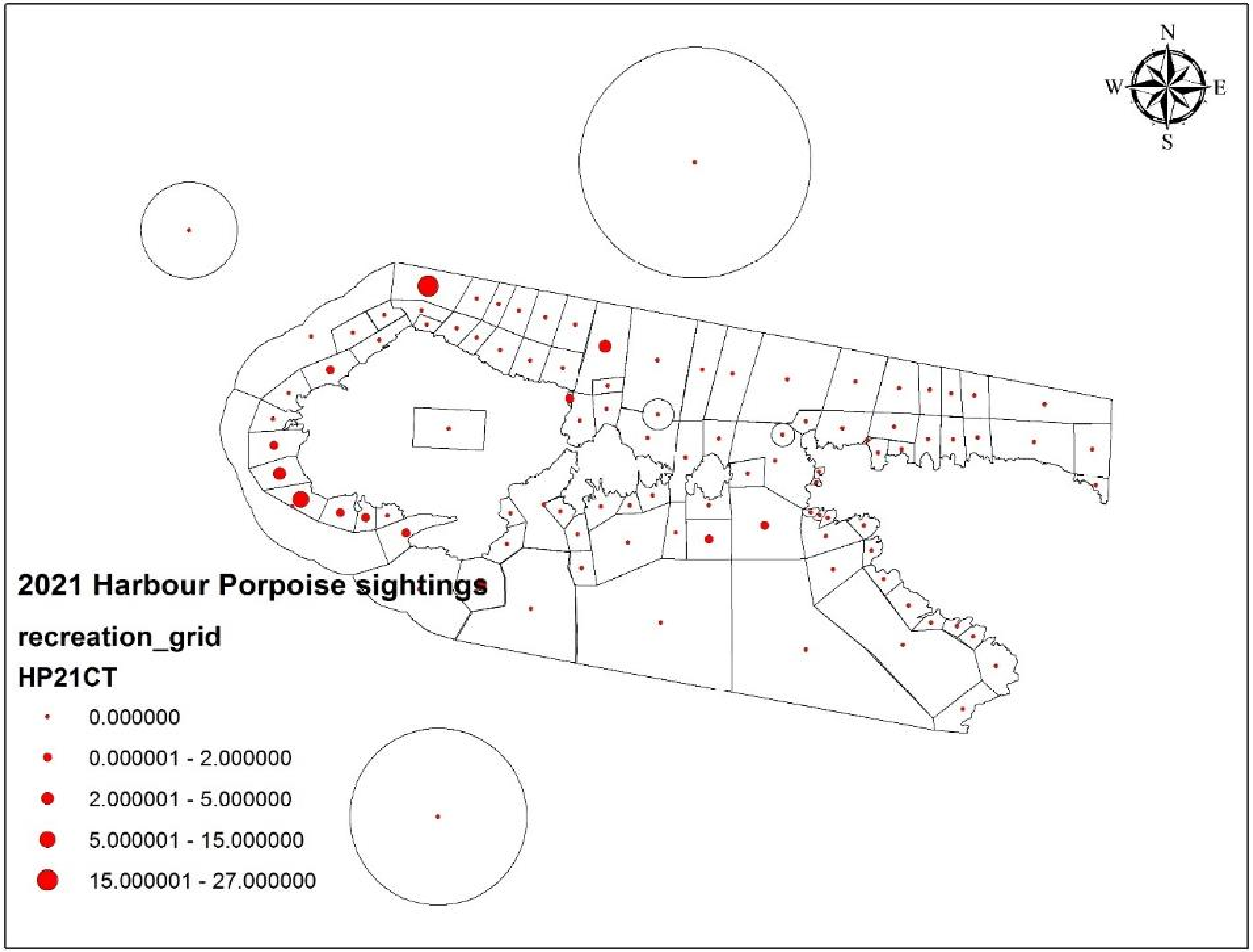
Harbour porpoise are sighted throughout the whole year and are assumed to be resident or regular users within the MCZ. Common Dolphins (*Delphinus delphis*) are predominantly seen from July to September as shown in Figure 49.

Figure 49 Percentage of sightings per month 2001 to 2021 Harbour porpoise & Common dolphin.



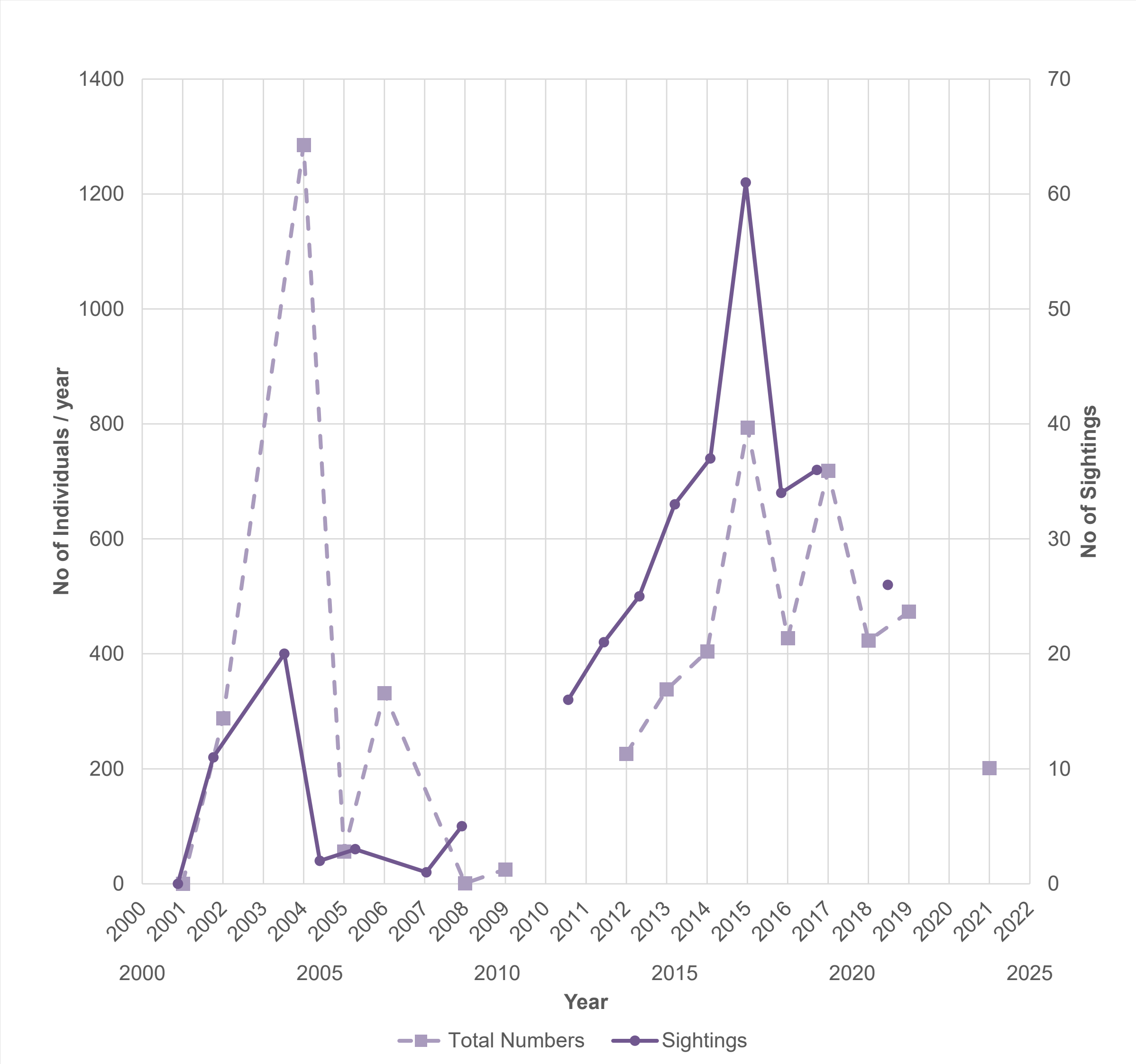
Common dolphins use the area infrequently, but they can appear in large numbers. There were no observations in 2010 and 2011 but since then their numbers seem to be increasing. These data are not effort corrected but as common dolphin sightings are more unusual, they tend to get recorded when observed. There were more sightings in 2016 but no big pods were seen. In 2019, there was a similar number of sightings compared with 2018, with most seen off the Garland Stone and Skomer Head (Figure 50).

Figure 50 Harbour porpoise sightings and distribution Skomer MCZ 2021.



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

Figure 51 Common dolphin sightings within Skomer MCZ 2001 to 2021.



Bottlenose dolphins (*Tursiops truncatus*) are not often seen within the MCZ, but in 2019 there were 2 sightings of individuals off the Garland stone. There were no sightings in 2021.

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. In 2019 there were 3 sightings including a young animal off North of the Neck in April and in 2021 there was a sighting of 3 Rissos from High Court Reef.

4.9.4.2 Further research

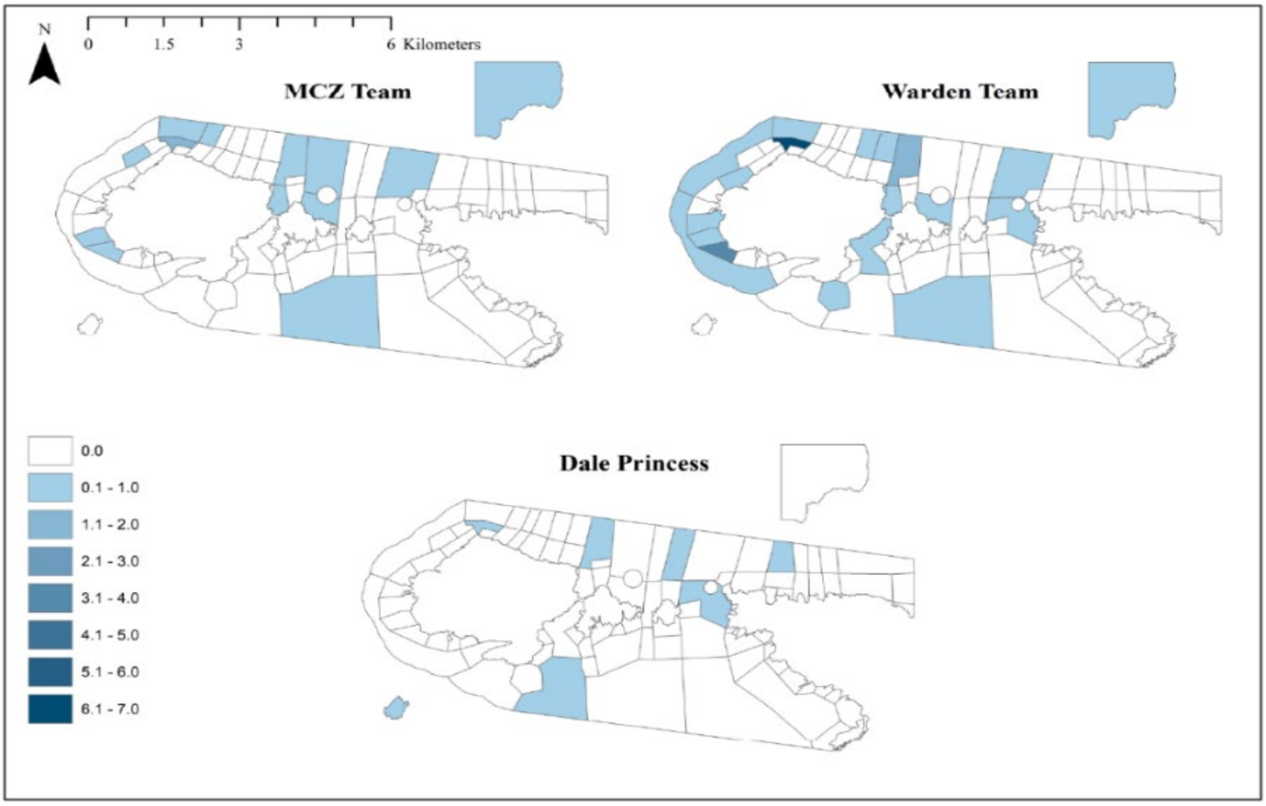
In 2020 James Middleton, an undergraduate student from Cardiff University collated all the cetacean records from the MCZ from 3 sources: Skomer MCZ staff, Skomer NNR and Dale Princess records. The data was corrected for observer effort and analysed for temporal and spatial trends.

Project summary:

The distribution of *P. phocoena* around the Skomer Marine Conservation Zone was described on a temporal and spatial scale. Sightings from the two main survey teams indicated that annual species abundance increased from 2008-2019 reported by greater detection of harbour porpoise across survey months and higher sighting frequency. Intra-annual trends were varied, but displayed a typical annual pattern centred around high sighting frequency in April and May, and July and August, with abundance showing a marked decline in June. The species was observed in varied pod sizes, most commonly in groups of three to five individuals, while calves and juveniles were relatively uncommon, but were observed throughout the season, preventing conclusive links with breeding or nursing seasons being drawn.

The spatial distribution of *P. phocoena* indicated that sightings occurred most frequently at four key sites: Garland Stone, Skomer Head, North Haven, Jack Sound. This agreed with the three high density sighting areas hypothesised with the addition of Jack Sound. Key sites were considered widespread enough to provide an overview of *P. phocoena* distribution within the MCZ, while acknowledging that temporal trends were undeniably biased towards these sectors. The location of sightings also provided an insight into survey effort, which was not recorded on a spatial scale, as it was understood that the high-density areas could not be solely attributed to *P. phocoena* distribution. Significant seasonal changes in *P. phocoena* distribution could not be determined; temporal patterns described for the species were reflected by an increase in abundance at key sites. Calves and juveniles were observed most frequently at Garland Stone and Jack Sound (Outer) and other key sites, indicating the distribution of neonates and juveniles were not limited to an exclusive area of the MCZ (Figure 52).

Figure 52 Average annual *P. Phocoena* sighting events, 2008 to 2019, reported by the MCZ Team, Skomer Warden Team and Dale Princess at sites around Skomer Island.



The unit of effort employed in the study, survey time, was deemed a weak measure of surveillance effort; too many factors which might have affected sighting *P. phocoena* were not accounted for, which introduced a high rate of uncertainty into the data. Annually, findings were biased towards the working season in the MCZ – March to October – which prevented species distributions in winter months from being described. A weak relationship between survey hours and sighting events reported by the MCZ highlighted the unreliability of incidental sightings in defining confident species abundance, while a stronger relationship observed for the parameters by dedicated volunteer watches indicated that survey time was a more reliable measure of effort in dedicated surveillance practices. While the process of normalisation showed that survey time did not have a significant influence of sighting frequency it also emphasised that there were unknown factors affecting the detection of the species which had not been corrected for. Key uncertainties were believed to be weather and sea state, activity type during survey time, and sites where survey time was spent. Suggested improvement methods within the methodologies for collecting these data were more specifically recording time where sightings were possible (i.e., during downtime or transit time when not undertaking work), reporting weather and sea state conditions to inform the impact of visibility, and reporting visitation periods at sites for spatial effort corrections.

D. delphis and *P. phocoena* displayed markedly different temporal distributions; dolphin abundance was highest in August and September and the species was largely absent at the beginning of the season in April and May, while porpoise was sighted frequently throughout. The species were observed at similar sites within the MCZ with the only notable differences being higher dolphin abundance at offshore sites, St Brides and Grassholm, reflecting its ecology as a primarily offshore species. Lack of confidence in the above distributions due to uncertainty in surveillance practice and low sighting frequency of *D. delphis* prevented a causal relationship between the two species' distributions being drawn.

In summary, given the scope of work conducted around the Skomer MCZ, cetacean monitoring data enabled the distributions of *P. phocoena* to be described. However, the incidental sighting methodologies were exposed as relatively unreliable, introducing a significant rate of uncertainty, and reducing the level of confidence and reliability in the distributions shown. This made it especially difficult to suggest possible causes for the observed abundance of harbour porpoise, but these findings could be used in conjunction with other studies as supporting material. Continued monitoring of cetaceans around Skomer Island, increasing the quantity of data for the region, will provide further insights into the distributions of the species. However, alternative monitoring practices can aid this research such as acoustic monitoring, which has been trailed within the MCZ. This study highlights how essential it is to identify sources of uncertainty affecting cetacean monitoring and develop robust methodologies to examine species distributions reliably.

4.9.5. 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.

4.9.6. 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 and support Dale Sailing to record sightings

- Encourage and support volunteers based at the Deer Park coastguard hut to record sightings.

- Encourage Swansea University to deploy acoustic loggers and provide data to Skomer MCZ.

4.10. General Species Recording

This section also includes: “vagrant and alien species recording” and “record commercial crustacean populations” projects.

4.10.1. 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 (INNS) and non-native species (NNS) 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.

4.10.2. Crawfish

Crawfish *Palinurus elephas* (Figure 54) became a national Biodiversity Action Plan species in 2008 and is an Environment Act (Wales) 2016, Section 7 species of principal importance. From 2009 to 2021 it was recorded in low numbers in Skomer MCZ by staff and volunteers. These records have been submitted to the i-record online recording scheme in an effort to gain better knowledge of the current status of this species in the UK.

Figure 53 Crawfish, *Palinurus elephas*

4.10.3. Sunfish

Sunfish *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 15°C 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. In some years several individuals have been spotted whilst in other years there have been no records. In 2021, there was 1 record in August.

4.10.4. Non-native species

Wakame *Undaria pinnatifida*, was found attached to boulders for the first time on Skomer and Skokholm shores during the 2018 littoral surveys. 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 into the UK in England in 1994, in the Solent and has since spread around the UK. In 2021 careful searches were completed at each of the shores during the MarClim surveys but it was not found.

Sargassum muticum was first found in the MCZ attached to a cobble in 2008 and it has been recorded again on 6 annual surveys over the last 11 years. On each occasion it has just been 1-2 individuals. It was not recorded in 2021.

4.11. Sediment Infauna Communities

4.11.1 Project Rationale

Sediment infauna and epifaunal communities are recognized as management features of the Skomer MCZ. The sediments studied at Skomer also include several of the priority sediment habitats identified in Section 7 of the Environment (Wales) Act 2016. Despite the relatively high number of surveys carried out in Skomer MCZ much remains unknown about the sediment communities. Sediments can accumulate pollutants and toxins and the faunal communities living within them have been shown to respond to these pollutants. The seabed within the MCZ has a byelaw preventing the use of all dredges and trawls, which makes it one of the most protected areas in the UK. The sediment communities within the MCZ can be thought of as recovering to a natural state and this makes them a useful control area. This aspect of Skomer MCZ sediment communities has been used by NRW in its investigation into the effects of commercial ship anchoring in St Brides Bay and in academic studies comparing “fished” and “unfished” seabed biota.

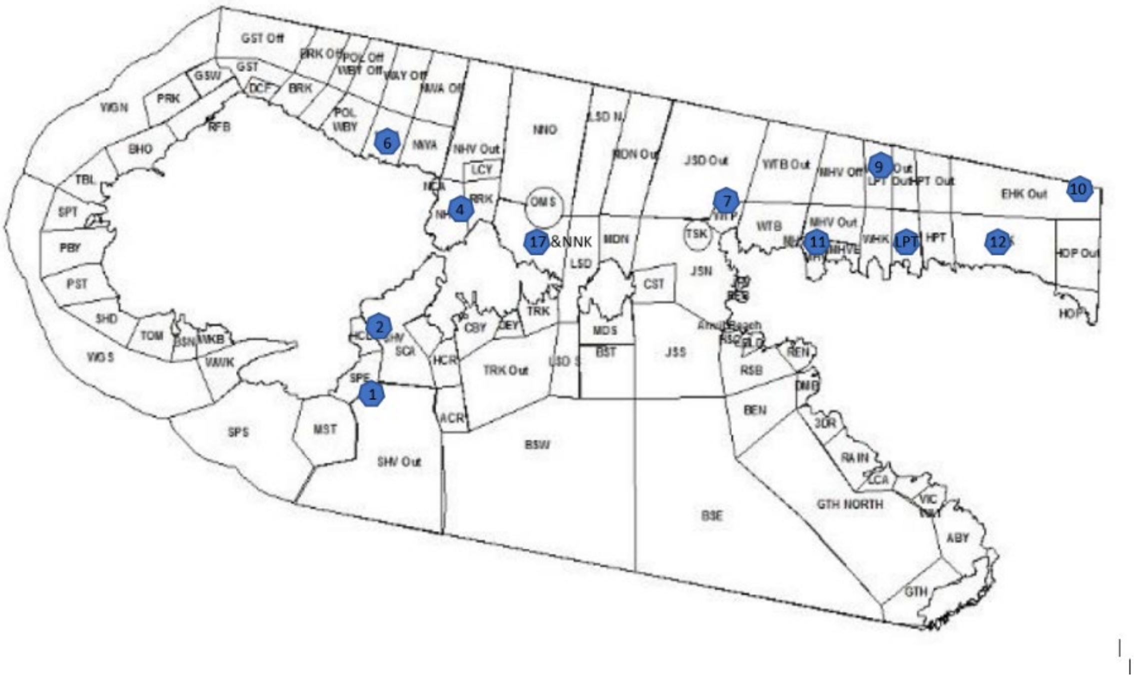
4.11.2 Objectives

To assess species richness and diversity and to measure inorganic pollutant concentrations.

4.11.3 Sites

Nineteen sample stations in Skomer MCZ were sampled in the first survey in 1993. This was reduced to ten stations in subsequent surveys (eight on the north side of Skomer and the Marloes peninsula and two in South Haven). In 2009 two extra stations were added to include those from the epifauna study project.

Figure 54 Map of the sample stations used from 1996 onwards.



4.11.4 Methods

1. Two replicate samples are taken at each station using a 0.1m^2 day grab, sieved with a 0.5mm sieve and preserved on site for biological analysis. The faunal content of these samples is then identified and enumerated by a specialist contractor.

2. A third grab sample is taken at each site and two sub samples are taken and stored. These are sent to specialist laboratories for sediment grain size analysis and hydrocarbon content analysis.

4.11.5 Project history

Surveys were completed in 1993, 1996, 1998, 2003, 2007, 2009, 2013, 2016 & 2020. The aim of the survey in 1996 was to assess the effect of the Sea Empress oil spill. The average number of individuals, species richness and taxonomic diversity was significantly lower in 1996 than all other years but it was not clear if that was a direct effect of the oil spill or a combined effect of the oil spill and an exceptional storm (16m wave height) a month before sampling.

4.11.6 Results

This time series has shown a very dynamic range in type and number of species recorded each year and it is very hard to analyse the data using univariate methods. The data set spans nearly 2 decades and infaunal taxonomy has changed a lot in that time which makes it difficult to compare species lists from 1993 to those from 2020, especially when different taxonomists have been used over the time series. These changes in identification of species are likely to confound any results when assessing temporal variation. When all of the data from 1993 – 2020 are combined there is a total of 2590 different taxa records, many of which would be duplicates due to changes in how species have been recorded over time.

To mitigate issues described above, a data truncation has been undertaken. The basic objective of the truncation was to maintain the most precise quantification and highest taxonomic resolution possible, with the greatest degree of consistency between data sets. This was conducted by infauna taxonomic experts from APEM environmental consultancy in accordance with the NMBAQC scheme.

Two truncations were completed; the full truncation resulted in a list of 802 taxa which can be confidently attributed to distinct entities over the whole time series. Many of these taxa are higher than species or genus level but this higher order truncation was necessary to overcome changes in identification techniques over the 20 years.

A second truncation was made for biodiversity assessments rather than temporal analysis. This was not as strict in the full truncation method and resulted in a list of 1035 taxa which gives a better indication of the diversity of species recorded each year. This biodiversity truncation is not as reliable when looking at temporal changes.

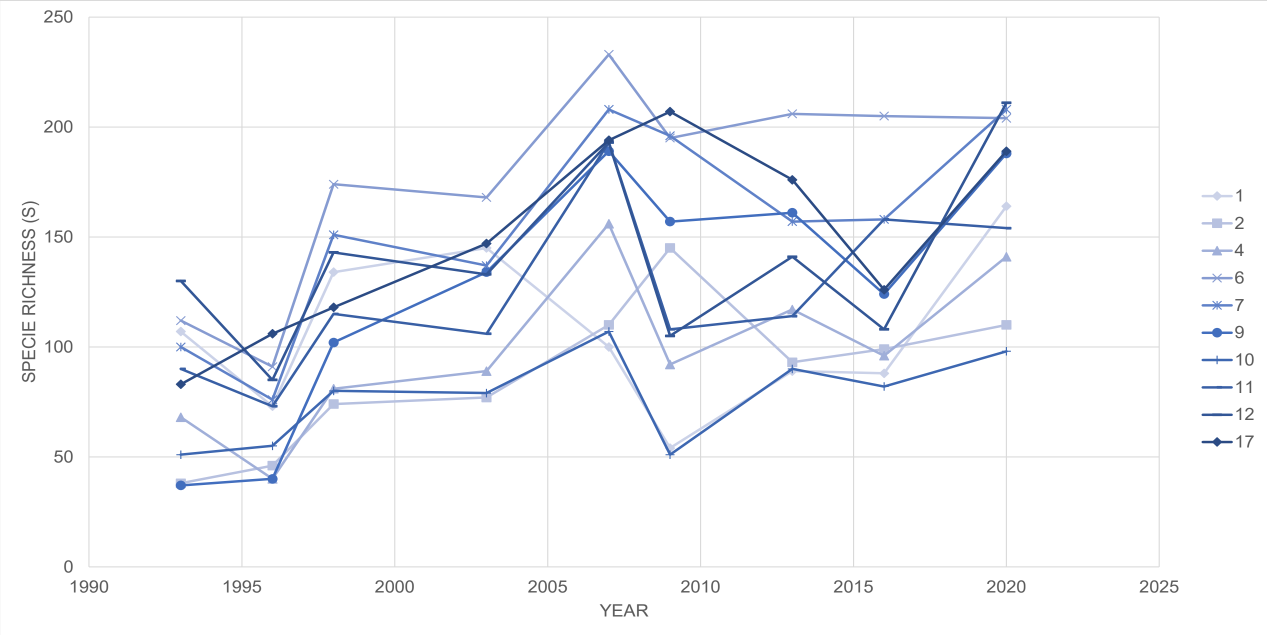
Species Richness -Using the biodiversity truncation.

Table 13 Average species richness, average abundance or number of individuals and average species diversity indices at Skomer MCZ.

Index name	Richness (S)	Abundance (N)	Margalef Richness (d)	Eveness (J)	Shannon (H(loge)	Simpson(1-Lambda)
1993	310	580.1	48.6	0.73	4.20	0.96
1996	246	175.7	47.4	0.81	4.44	0.98
1998	368	704.6	56.0	0.77	4.54	0.98
2003	382	773.4	57.3	0.74	4.39	0.97
2007	506	1304.2	70.4	0.77	4.79	0.99
2009	517	915.6	75.7	0.78	4.85	0.99
2013	491	784.4	73.5	0.77	4.79	0.99
2016	427	708.0	64.9	0.76	4.58	0.98
2020	532	1046.5	76.4	0.78	4.88	0.99

The 2020 survey had the highest number of species (S) and a high abundance of individuals (N). Since 2007, there have consistently been 400+ species recorded in each survey (Table 13).

Figure 55 Species richness 1993 – 2020 for each sampling station at Skomer MCZ.



The 10 stations generally follow the same pattern over the years except for station 1, which was moved by 300m in 2007, due to a change in the local sediment dynamics (the site was now rock, no grabs possible). This may be responsible for station 1 deviating from the general pattern of change (Figure 55).

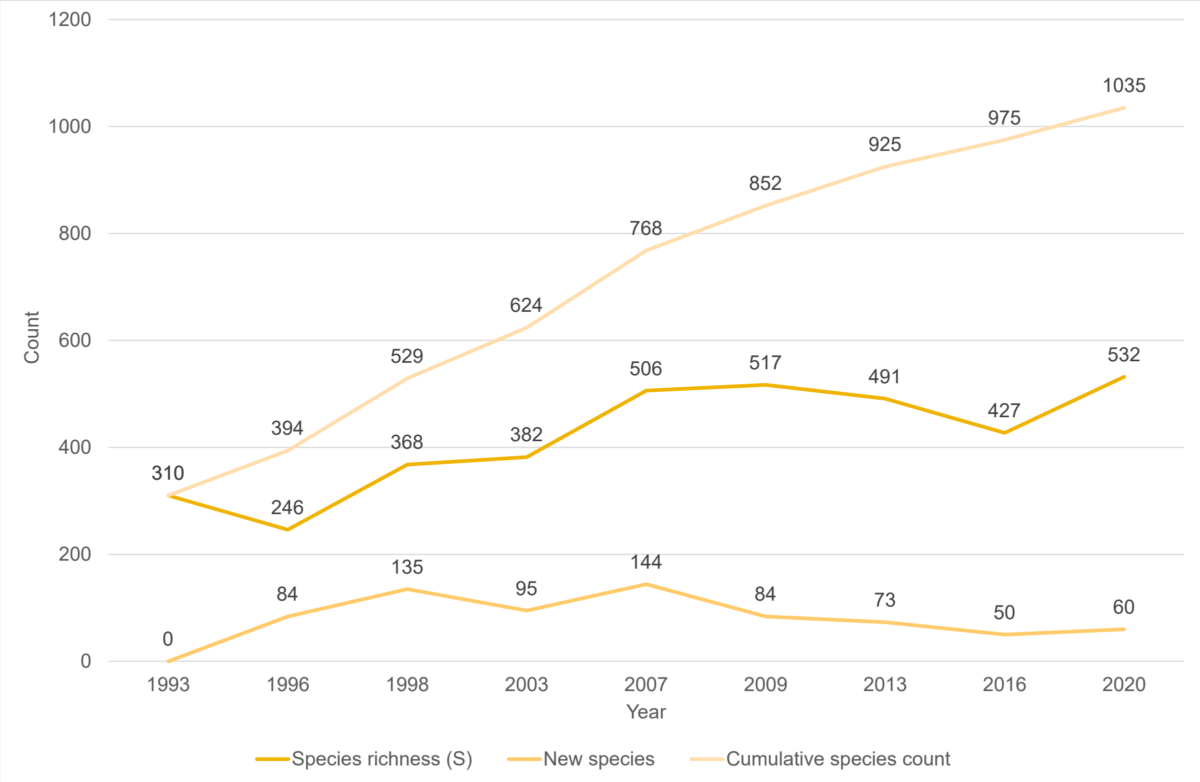
The 2020 results show a general increase in species compared to the previous survey.

Species have been very variable over the survey period with 100+ new species recorded in some new surveys (Table 14). In 2020, 60 new species were recorded which have not been identified in any of the previous surveys. The cumulative count of species is still increasing (Figure 57) which suggests that the infauna community in the sediment around Skomer are both diverse and dynamic. It also suggests that the sampling effort of 24 grabs / year is not sufficient to capture the full diversity within the site.

Table 14 Average species richness (S), compared to cumulative total and new species observed in each survey.

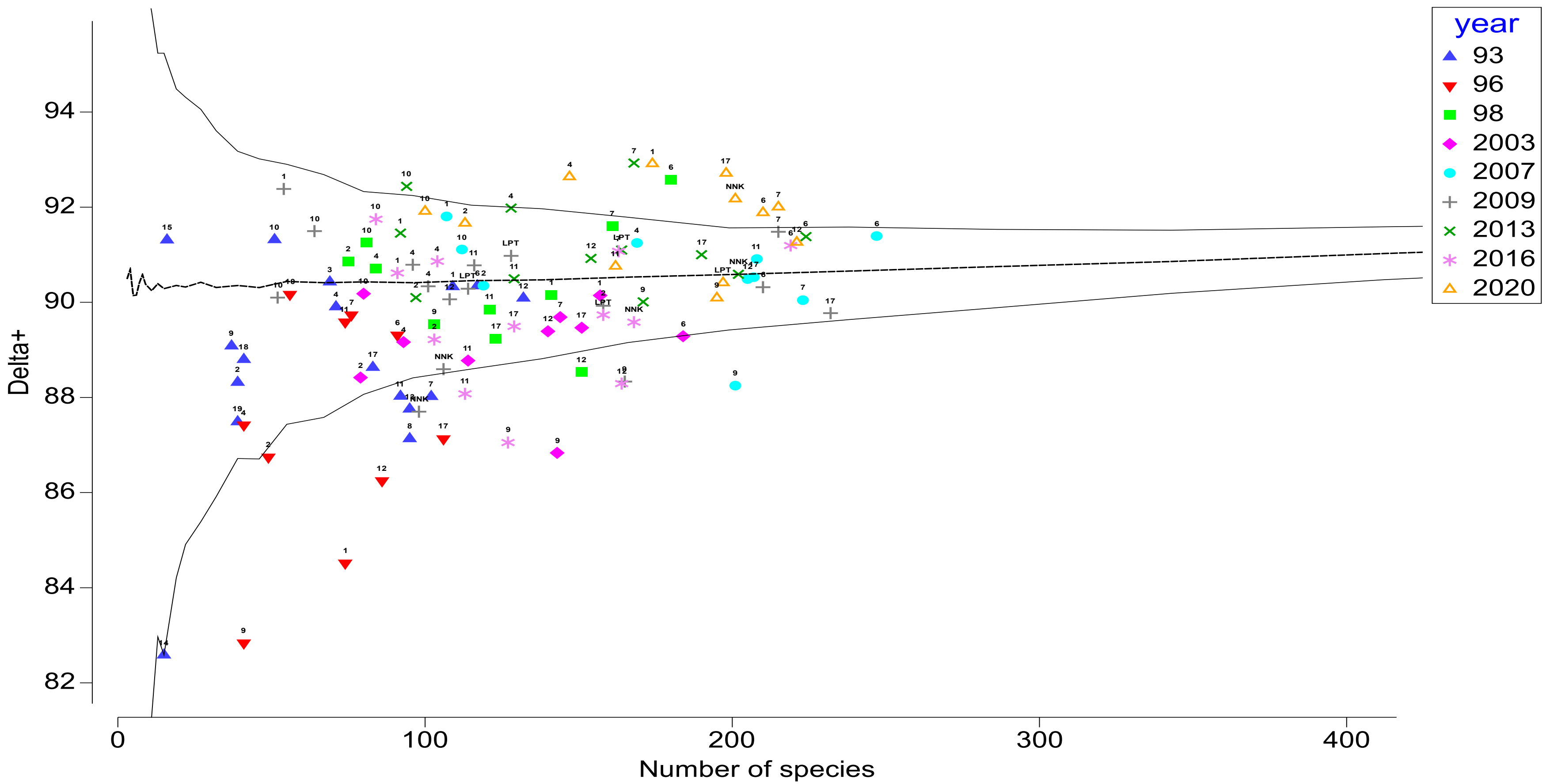
Year	**1993**	**1996**	**1998**	**2003**	**2007**	**2009**	**2013**	**2016**	**2020**
Species richness (S)	310	246	368	382	506	517	491	427	532
New species	0	84	135	95	144	84	73	50	60
Cumulative species count	310	394	529	624	768	852	925	975	1035

Figure 56 Species richness (S), cumulative species count & new species observed 1993-2020.



Another way of looking at diversity is to use the taxonomic diversity measures available in the statistical package Primer 7. This uses an underlying taxonomic tree to assess how closely related the Taxa are to each other as well as how many different species there are. Sites are given a higher diversity score if they include species from a range of higher taxonomic group (Figure 57).

Figure 57 Funnel plot of taxonomic distinctness tests 1993 – 2020 (Delta+ from Primer 7).



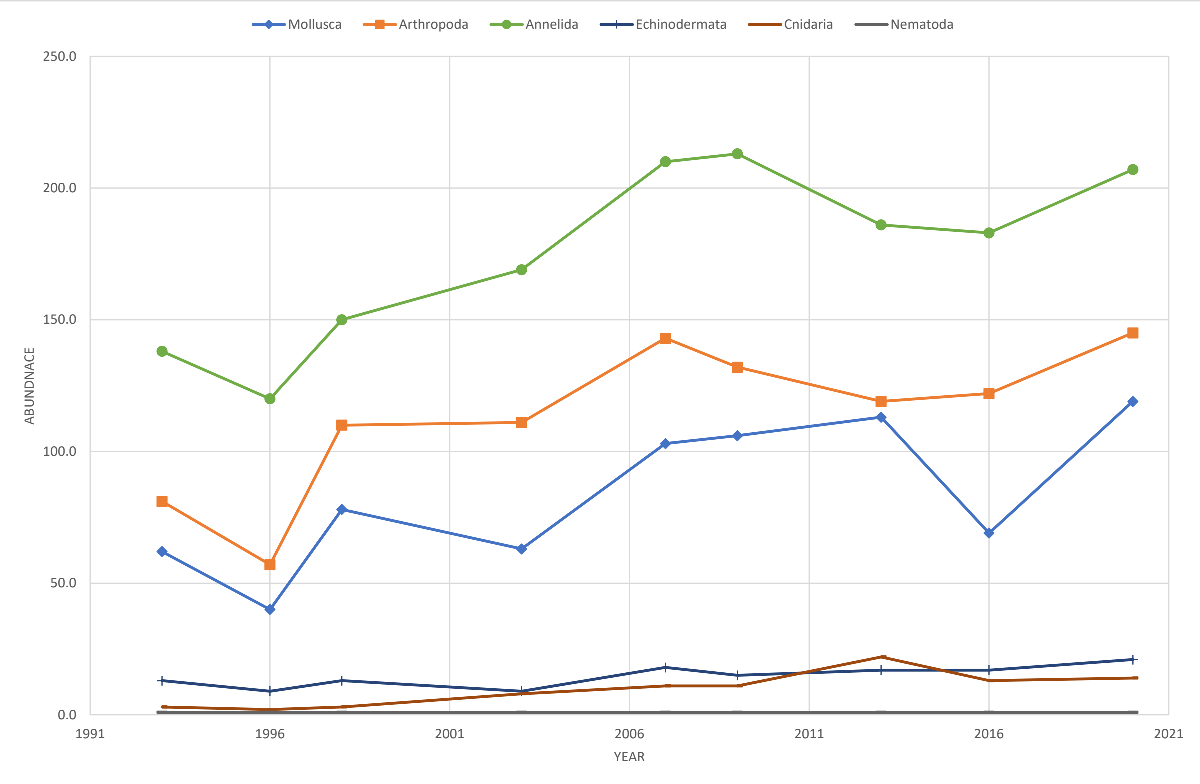
The samples from 1993 & 1996 drop below the expected values (i.e., below the lower funnel line). This suggests that species are coming from a narrower mix of taxonomic groups compared to the rest of the data set. All of 2020 samples are within or above the 95% boundary of the expected levels, suggesting a good mix of taxonomic diversity.

A simple way of looking at this very diverse set of species is to look at the representation of the major phyla (top level of the taxonomic tree) (Table 15). The graph below plots the number of species in each phylum from the different years (Figure 58).

Table 15 Number of taxa found from each phylum 1993 – 2020.

Taxa Group	1993	1996	1998	2003	2007	2009	2013	2016	2020
Mollusca	62.0	40.0	78.0	63.0	103.0	106.0	113.0	69.0	119.0
Arthropoda	81.0	57.0	110.0	111.0	143.0	132.0	119.0	122.0	145.0
Hemichordata	1.0	0.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0
Nemertea	1.0	1.0	2.0	2.0	1.0	3.0	3.0	1.0	1.0
Sipuncula	3.0	5.0	3.0	4.0	3.0	6.0	6.0	5.0	4.0
Annelida	138.0	120.0	150.0	169.0	210.0	213.0	186.0	183.0	207.0
Echinodermata	13.0	9.0	13.0	9.0	18.0	15.0	17.0	17.0	21.0
Cnidaria	3.0	2.0	3.0	8.0	11.0	11.0	22.0	13.0	14.0
Nematoda	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Chordata	4.0	7.0	4.0	9.0	9.0	16.0	13.0	8.0	12.0
Entoprocta	0.0	0.0	0.0	0.0	1.0	3.0	1.0	2.0	1.0
Chaetognatha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Porifera	0.0	1.0	1.0	2.0	2.0	7.0	7.0	2.0	2.0
Platyhelminthes	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0
Rhodophyta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Phoronida	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 58 Graph of number of taxa of different phyla 1993 -2020.



Annelida (worms), Arthropoda (crabs, gammarids etc.) and Mollusca are always the 3 major phyla represented in the species lists. It is taxa from these phyla that drive the changes in diversity.

Temporal changes analysis (using PRIMER v7)

The data was truncated, and juveniles were removed resulting in a matrix of 792 taxa from 193 grab samples (1993-2020). This data was averaged to site and year, square root transformed to reduce the effect of very abundant species and then analysed with a Bray Curtis similarity index. A Bray Curtis similarity coefficient was used to construct resemblance matrices for the multivariate analysis.

To reduce the size of the taxa list down to a manageable number for species plots and cluster dendrograms the BEST BV-STEP routine was used to select a subset of species which would match (RELATE) to the overall full species list matrix at 0.95 correlation.

The routine was repeated with each set of taxa being removed from the overall set until the BEST routine failed to reach a Spearman's rank correlation of 0.95 match. This process resulted in a final analysis list of 108 taxa from the square root transformed data. A Multi-dimensional scaling plot (MDS) is a visual way to look at how similar sites are in terms of species composition (Figure 60).

Figure 59 PRIMER Multi-dimensional scaling (MDS) plot showing the grouping of samples from 1993 – 2020 Skomer MCZ infauna data.

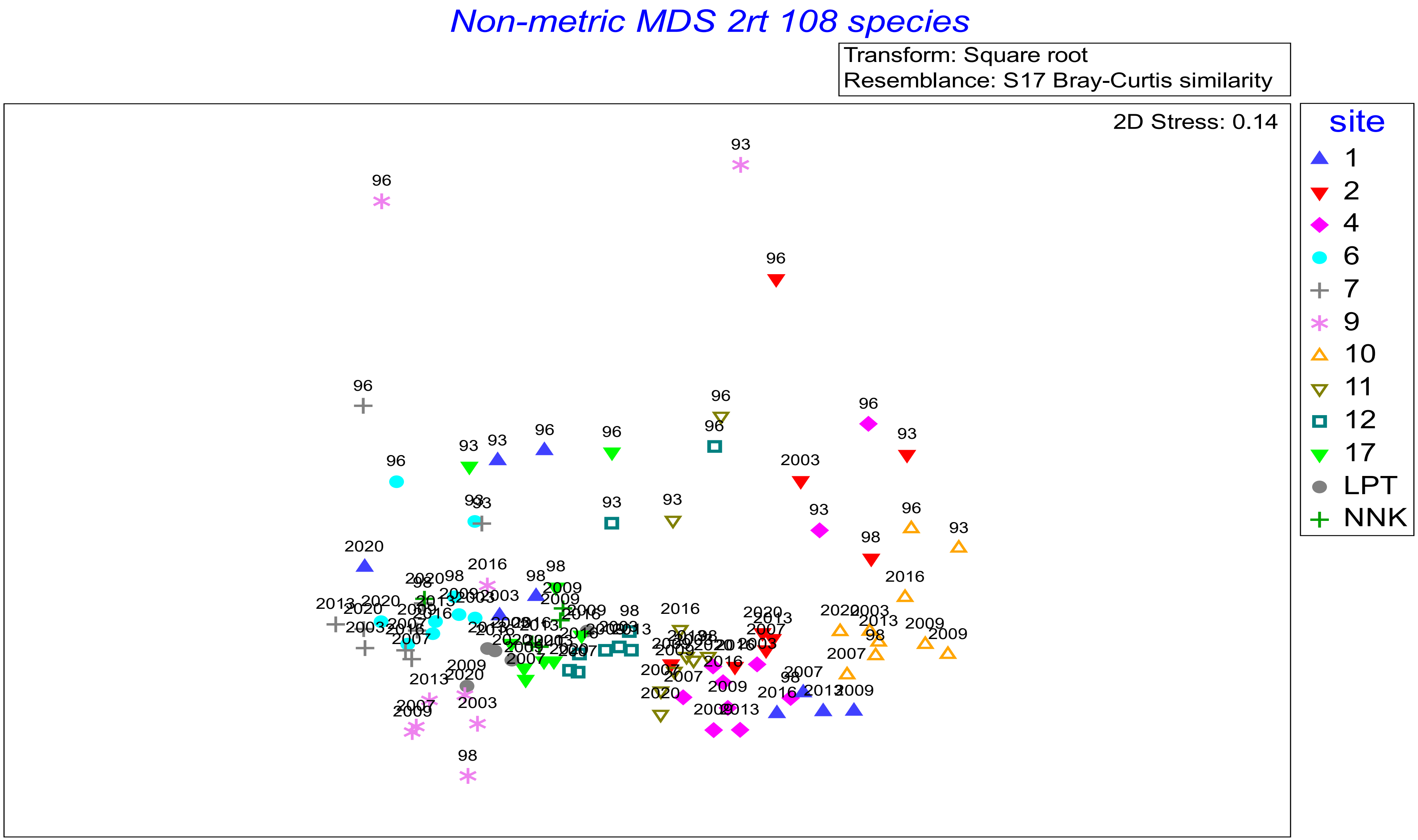
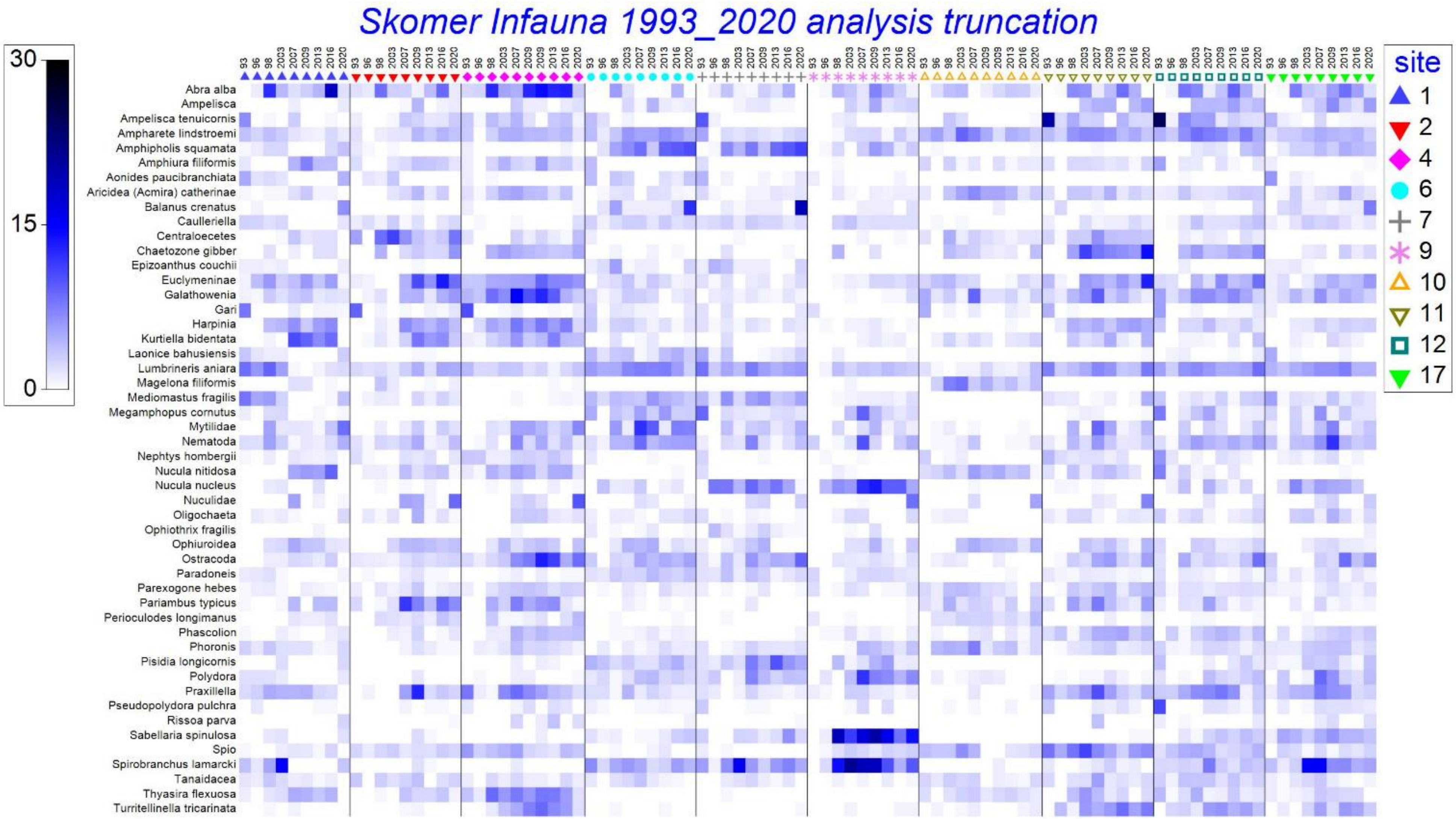


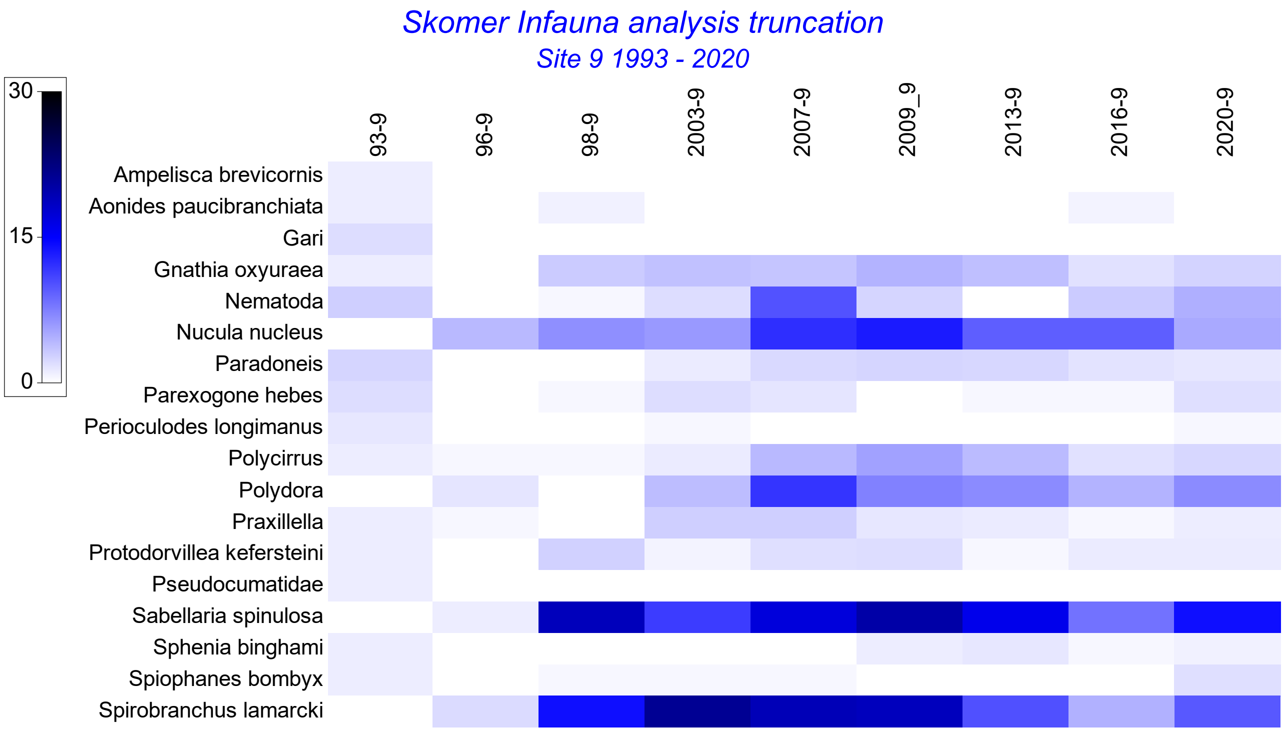
Figure 60 Shade plot of Analysis truncation data (2rt transformed, top 50 species) ordered by site.



The MDS Primer plot (figure 59) shows that both 1993 and 1996 differ from all other year sets. The community appears to have been very stable for the last ten to fifteen years. The different sites form very similar patterns year on year, suggesting that the communities are stable. The shade plot (Figure 60) gives simple visual representation of where and when species occur, the color scale represents abundance.

Station 9 is very variable between years (see MDS plot - figure 59). This was investigated further and was found to be due to species associated with rocks and pebbles, *Sabellaria spinulosa* and *Spirobranchus Lamarcki* (Figure 61). Some of the variability will be down to whether the grab included pebbles/cobbles that had these species attached.

Figure 61 Shade plot of main species driving the inter-annual differences at station 9 1993- 2020.



4.11.7 Current Status

The last five surveys have shown the infauna community to be healthy and species rich. There was a suggestion of a decline in species richness in 2009 & 2013, but this has increased again in 2016 and compared to other areas of the UK the sediment communities around Skomer MCZ are very diverse.

4.11.8 Recommendations

- Re-survey in 2024.

Publish results and put the results into context with similar surveys from the surrounding area.

4.12. Plankton Recording

4.12.1 Project Rationale

Whilst plankton is not identified as a management feature for Skomer MCZ, it's 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 species have planktonic larval stages. The abundance and species composition of plankton is influenced by available nutrients, water movement, temperature and light.

4.12.2. Objectives

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

4.12.3. Sites

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

4.12.4. Method

Zooplankton:

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

2010 onwards: A review of the results and objectives called for a change in methods. It was proposed that the sampling from Skomer matched that from other plankton time series projects to make the results comparable. The Plymouth Marine Laboratory (PML) has a plankton sample time series (L4), which would act as a good comparison site. The methods used at L4 are replicated at Skomer and analysis completed by PML. This uses a 200um mesh net hauled vertically from 40m.

PML method adopted: A 200-micron mesh net is hauled vertically from 35- 40m depth at approximately 0.2m per second from a set sampling location. The sample is collected in the 'cod-end' bottle and this is preserved in 4% formalin. This process is repeated to give two samples per sampling event. Samples are collected on a weekly basis between May to September and then on a monthly basis for other months.

Phytoplankton and chlorophyll:

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

2013 onwards – discontinued due to lack of funding for analysis.

2019 - Phytoplankton sampling was restarted in June. A 20-micron mesh net with a 30cm diameter opening was used. The samples were collected by a vertical haul from 20m with the net attached to a CTD probe (Conductivity,Temperatrure & Salinity). Samples were then stored in 2% formalin.

For the zooplankton ID and enumeration, the procedure was as follows: Formaldehyde was rinsed from the sample using a 20-micron filter and the sample transferred to tap water. The sample was then divided into eighths with a Folsom splitter. One of the eighths was then made up to 100 ml to dilute it further, agitated vigorously and then a 0.5 ml subsample was taken with a graduated pipette to get a 1600th subsample. This was then put on a Sedgewick Rafter graduated slide and the cells counted in a series of traverses under the high power of a compound microscope with a mechanical stage.

No Samples taken in 2020

2021 Standard L4 method was used to collect Zooplankton samples (200um net, vertical haul from 40m). The phytoplankton method was changed to match the Water Framework Directive (WFD) phytoplankton method. This also included collecting water samples for turbidity, salinity, dissolve inorganic nutrients, chlorophyll (1l filtered), temperature and dissolved oxygen. The phytoplankton sample is a 125ml surface water sample preserved in lugol's solution.

An increased effort was made to collect at least 1 zooplankton and phytoplankton samples very month with higher sampling rates (2+) for the months of April – September.

4.12.4.1 Analysis History

2009 : 12 plankton 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 where 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 were analysed by the Plymouth Marine Laboratory, (no report: raw data provided).

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

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

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

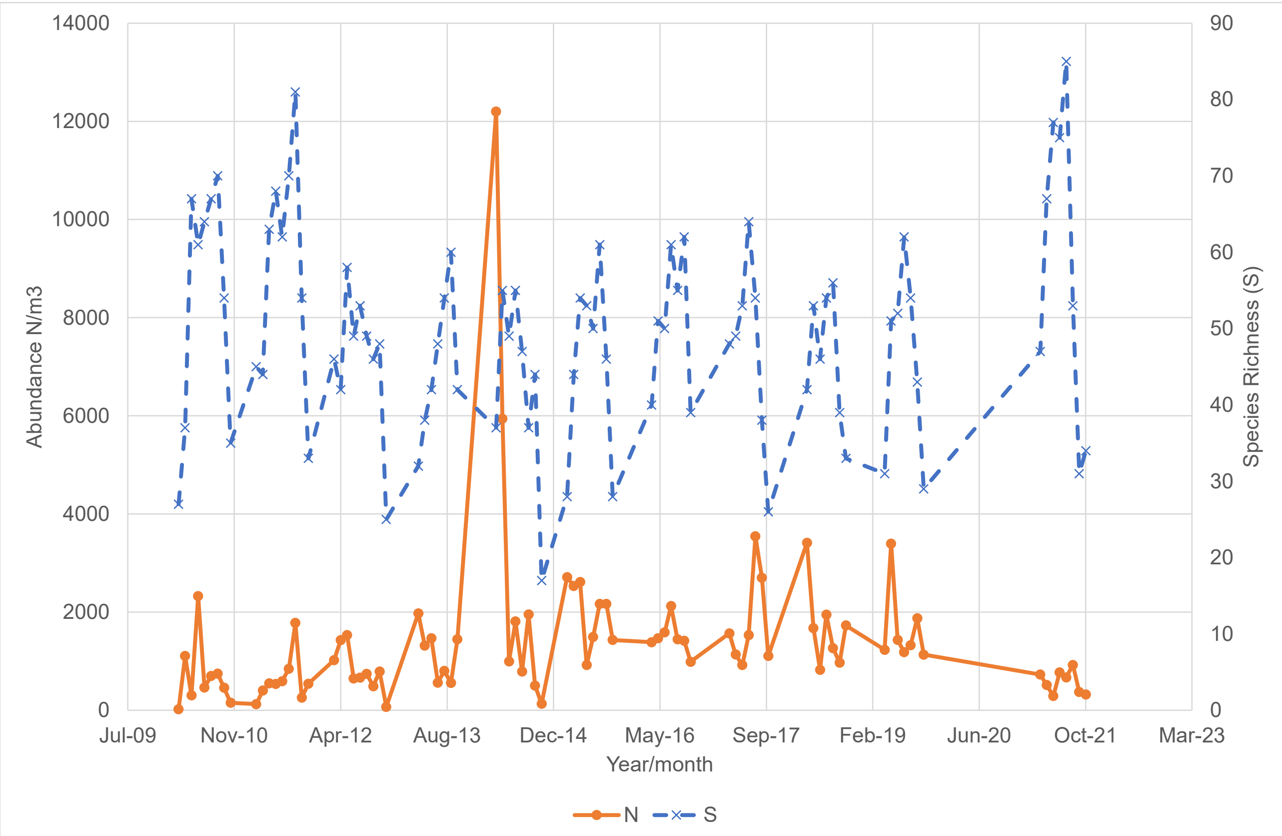
- In 2020 No field work was completed.

- In 2021 Zooplankton sampling was completed alongside the collection of phytoplankton samples collected using the Water Framework Directive methodology. This also included the collection of nutrient and chlorophyll samples. Zooplankton Identification conducted by Marine Biological association. Phytoplankton identification conducted by CEFAS. Zooplankton data entered into DASHH Pelagic Lifeforms Tool.

4.12.5. Results

Zooplankton:

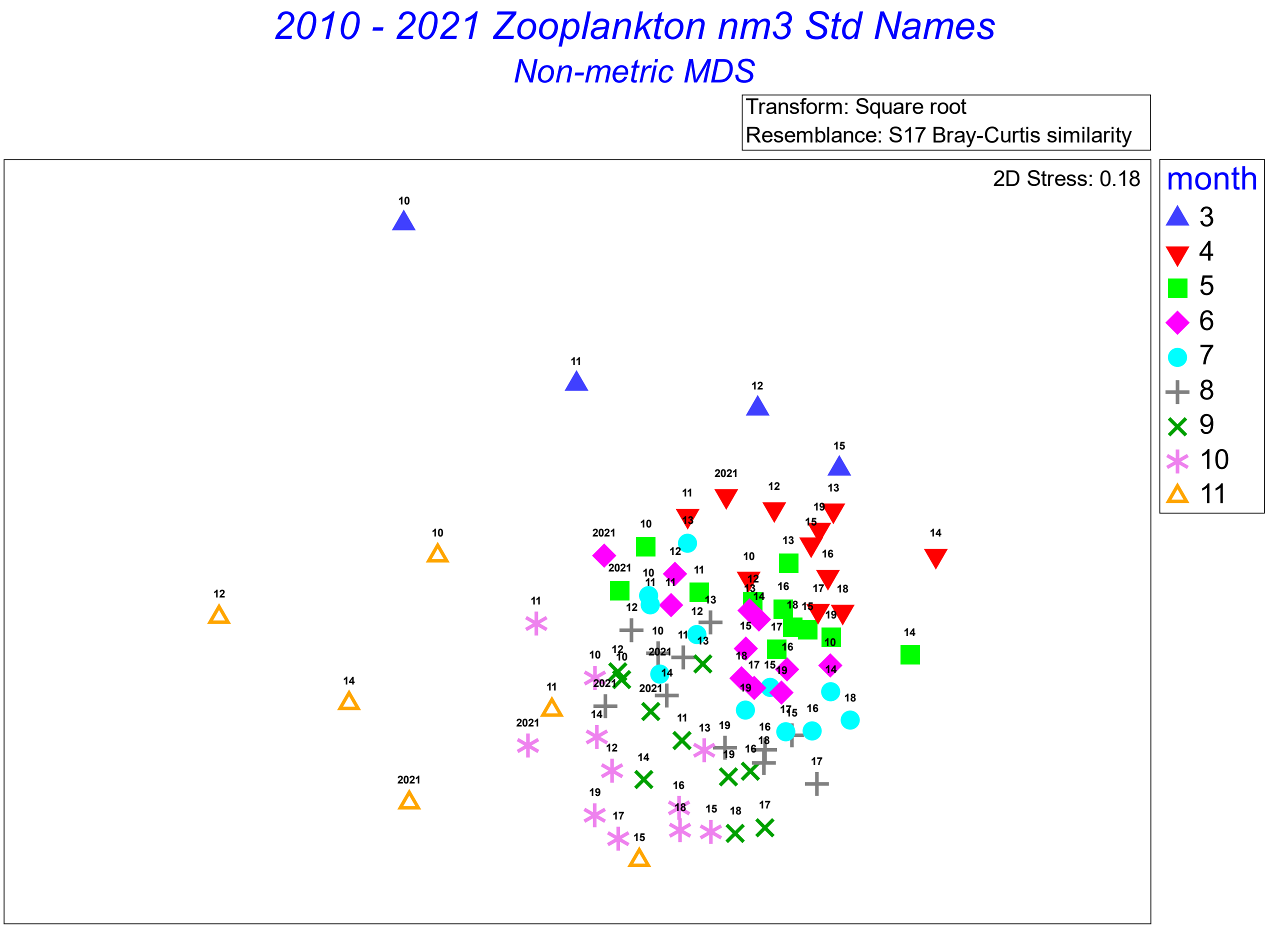
Figure 62 Average plankton species richness (S) and total number of individuals / abundance (N) 2009- 2021.



The peak in abundance in April 2014 was due to huge numbers of barnacle larvae in the plankton (Figure 62).

All zooplankton data are held on file at the Skomer MCZ office in spreadsheet format and as Primer files. This allows for a wide range of data analysis: Individual species can be selected, differences between years can be analysed or the whole dataset can be combined to look for seasonal trends (Figure 64).

Figure 63 MDS plot of zooplankton community showing seasonal changes (symbols representing months and labelled with year).



Statistical analysis of the differences of the dataset shows a strong seasonal pattern with months grouping together. However, these groups are in lines, which does suggest inter-annual variability. This seasonal pattern is driven by different groups of taxa appearing in the plankton at different times. Figure 64 shows how selected groups have different seasonal patterns. Cirrepde (e.g., Barnacle larvae) are most abundant early in the year while Echinoderm larvae are abundant later in the year.

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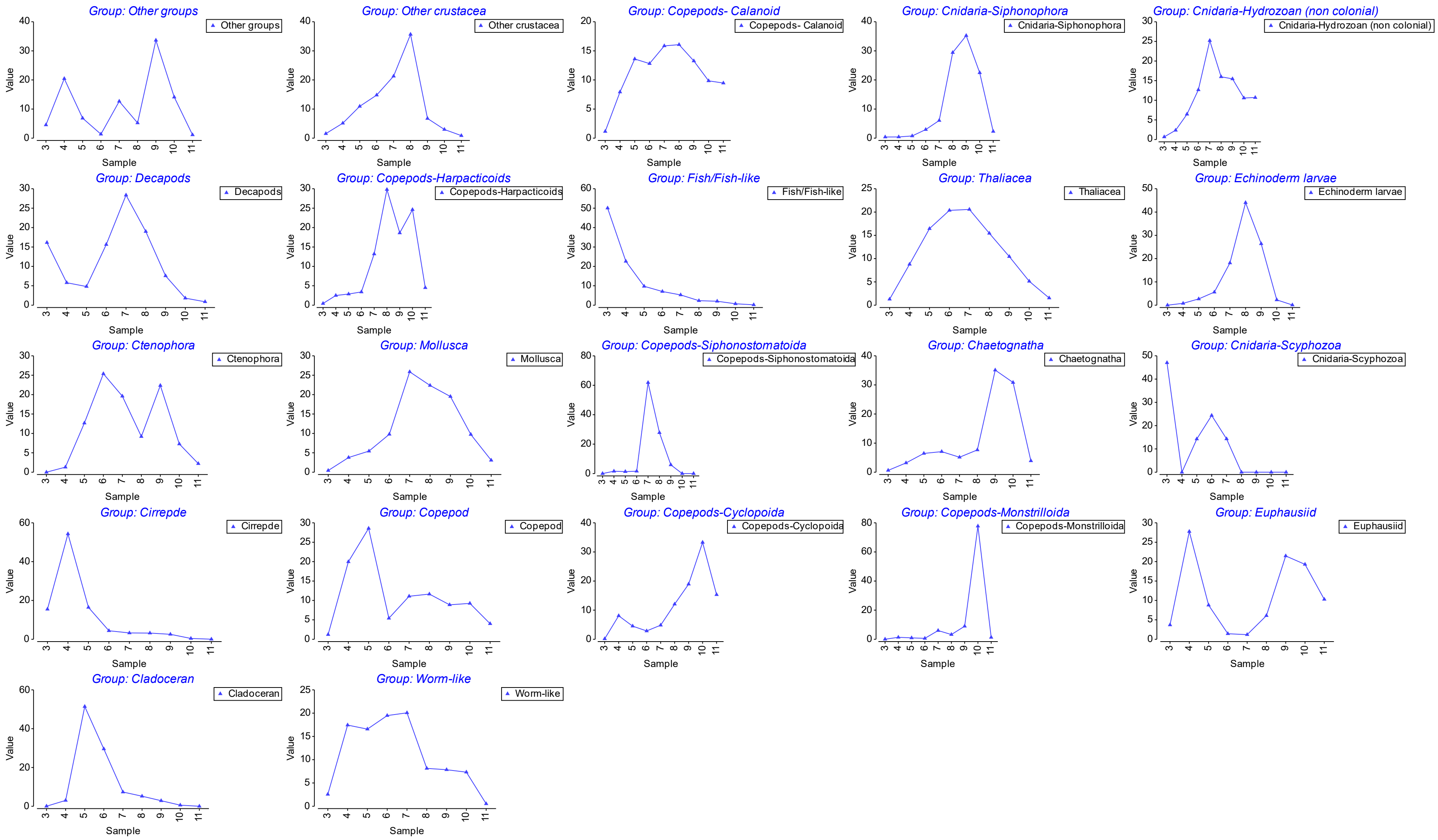
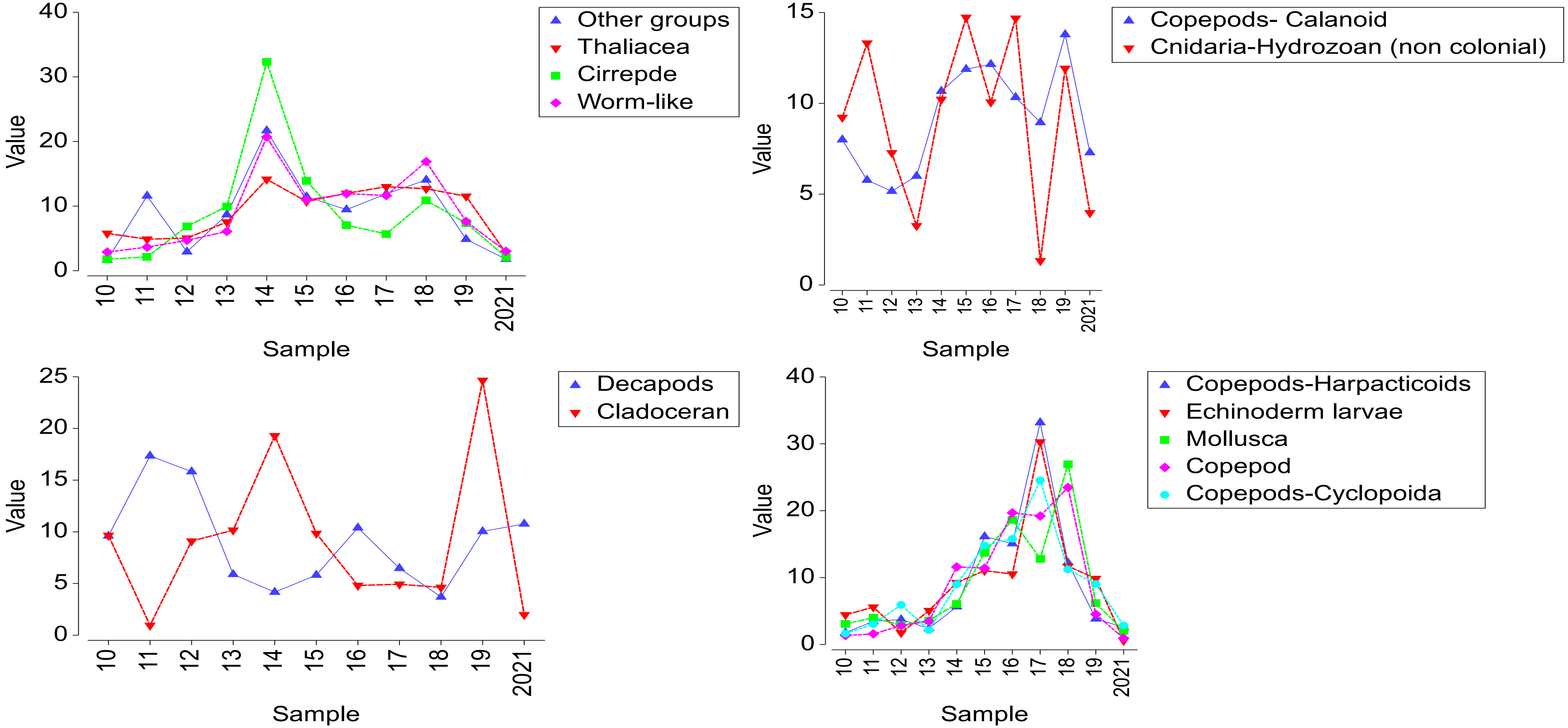
Figure 64 Seasonal abundance patterns for the major groups of zooplankton taxa sampled from March to November averaged from data collected between 2010 - 2021.



Annual variation in abundances of major groups is plotted in Figure 65. In general abundances are lower in 2021 for all groups except decapods.

Figure 65 Coherence plots for the major taxonomic groups making up the zooplankton community at Skomer MCZ 2010 - 2021.



Phytoplankton.

There has not been a consistent approach to collecting phytoplankton samples at Skomer MCZ. In 2021 the WFD methodologies were adopted as these will provide comparable results to samples taken all across the UK.

4.12.7 Current status

- A 10+ year timeseries of zooplankton has been collected. This data is comparable with other sites in the UK (Plymouth L4).
- Skomer MCZ Zooplankton data has now been archived with DASHH (marine species and habitats data archive) and submitted to the Pelagic Lifeforms Tool dataset.
- Phytoplankton data is now being collected in such a way that samples from Skomer MCZ can be compared with other WFD sampling stations across the UK. The data will also be compatible with the Pelagic Lifeforms tool in the future.

4.12.8. Recommendations

- Continue to collect Zooplankton & Phytoplankton samples on at least a monthly basis with as much coverage across the whole year as possible.

5. Skomer MCZ Meteorological and Oceanographic Project Summaries

5.1. Meteorological Data

5.1.2. Project Rationale

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

5.1.3. Objectives

To provide continuous meteorological data for the Skomer MCZ.

5.1.4. Sites

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

5.1.5. Methods

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

April 2006 – current. Installation of a Campbell Scientific Environmental Change Network (ECN) compatible weather station with a CR1000 measurement and control system. 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 enables the data to be automatically updated into an external website.

5.1.6. Project history relevant to data

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

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

In January 2012, the rain water chemistry sample was reduced to a 250ml sub-sample.

In January 2014, the anemometer failed and there were no data from 2nd -13th Jan 2014. A new anemometer was installed on the 13th January 2014.

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

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

In 2020 the relative humidity probe was unreliable, but it was not possible to service the station and therefore the data have not been used. The temperature data collected by the same probe were also discarded.

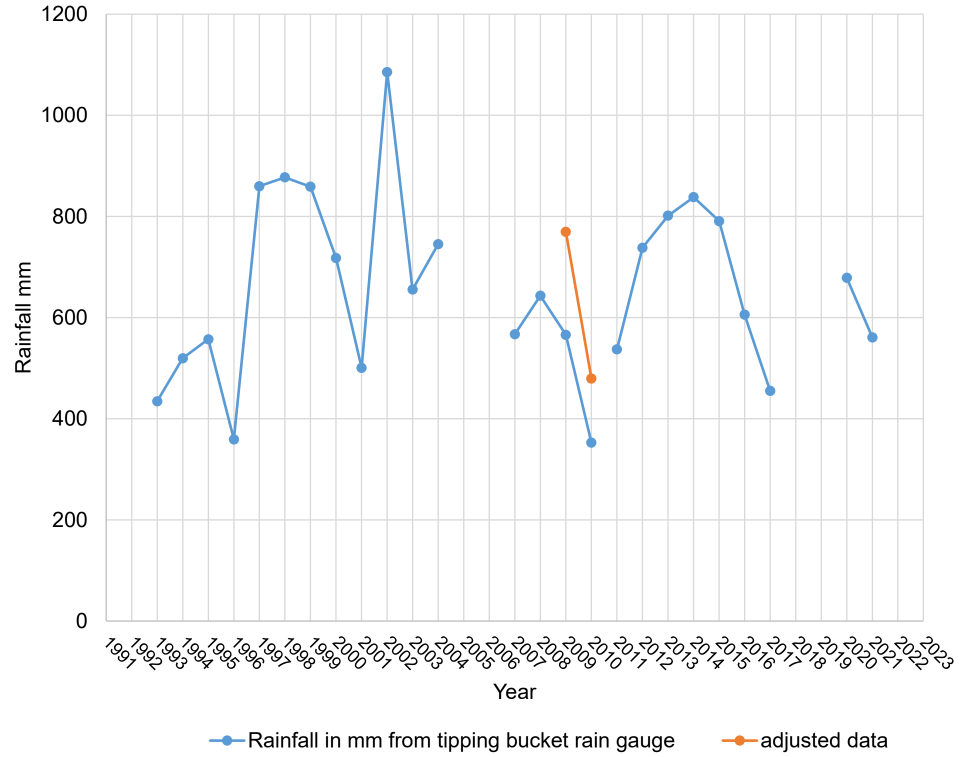
In 2021 the weather station was serviced (03 March 2021) and the relative humidity probe was changed. Humidity data were unreliable in January & February. The new relative humidity probe failed again in Oct 2021 and was replace with a new probe in Nov 2021.

5.1.7. Results

Rainfall

The rain gauge was not calibrated properly in 2009 and 2010 so a correction has been added to the records (Figure 66).

Figure 66 Skomer MCZ automatic weather station total rainfall (mm) data (incomplete data for 2018 & 2021).

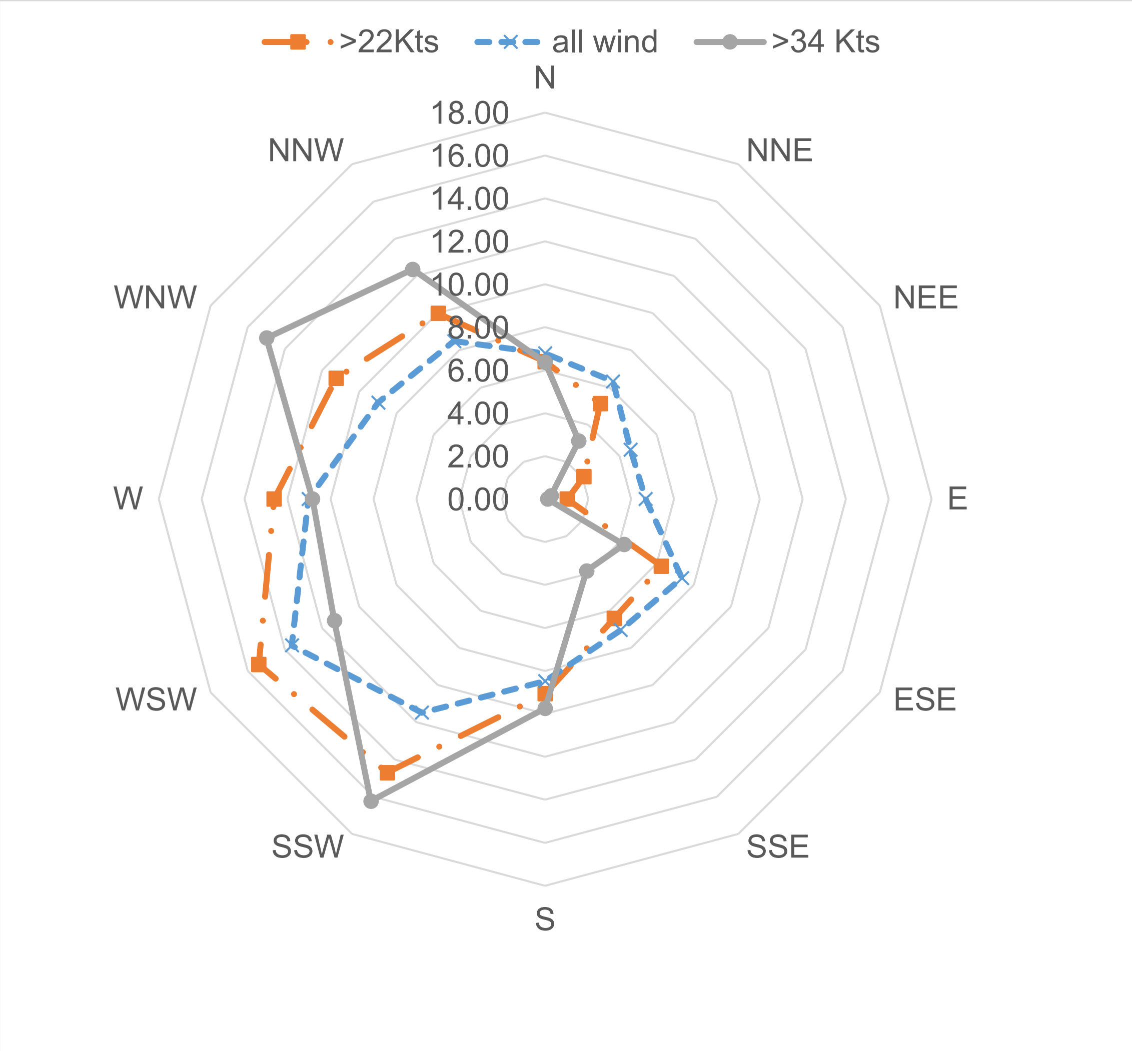


There was some extreme weather in February 2014 with 100mph winds recorded on the 12th. The rain gauge recorded 199mm of rain for that day, but it is likely that this was a false reading, so this has been removed from the data. The winds will have vibrated the rain gauge causing it to “tip” when there was no water in the bucket. To prevent this happening in future the gauge was fixed more securely. However, during routine servicing in 2018 it was discovered that the rain gauge had stopped working during mid- March 2018. A new rain gauge was fitted on the 11th April 2018. Unfortunately, this rain gauge was not robust enough to survive the exposure and was blown off the roof on the 14th October 2018. A more robust rain gauge was fitted on the 21st December 2018. The 2018 and 2019 rainfall data are incomplete and unreliable. Further problems with excessive rain readings being recorded during periods of high winds were seen in 2020. The rain gauge is now strapped to the roof of the coastguard hut, but it is still necessary to check the rain data after strong winds.

Wind speed and direction

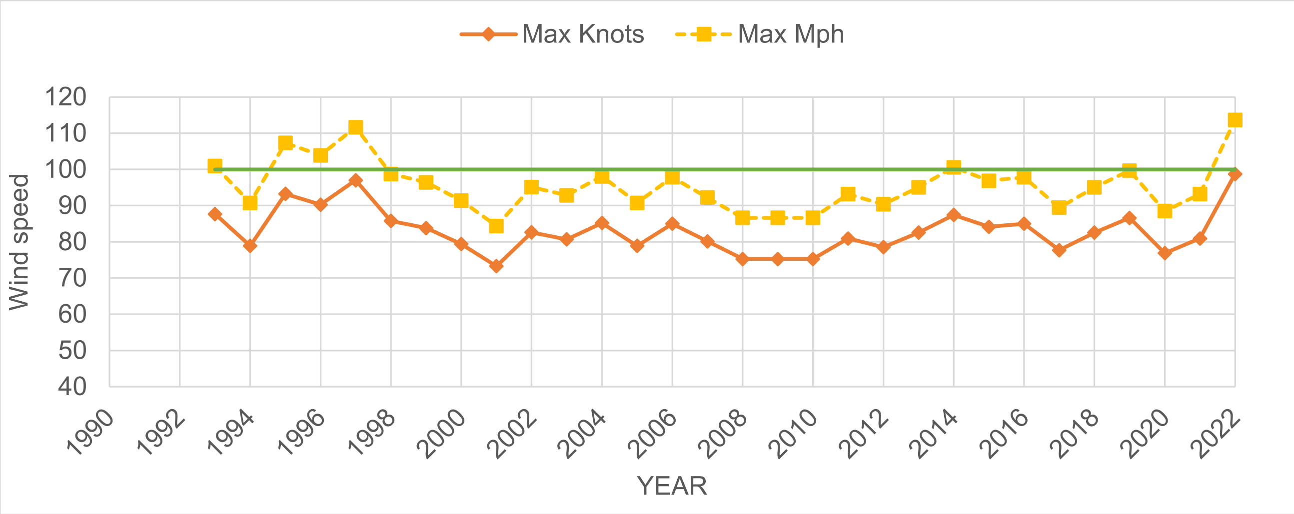
Extreme wind speeds can affect littoral and sublittoral habitats and communities by subjecting them to damaging levels of exposure. Changes in wind direction can also affect normally sheltered habitats.

Figure 67 Skomer MCZ automatic weather station, radar plot average wind direction and strength 1993 – 2021.



A radar plot of frequency of wind direction shows that the prevailing winds come from the WSW and this has not changed over the period data have been gathered. The stronger winds (>34 knots) are more bimodal in distribution with peaks from the SSW and the WNW (Figure 67).

Figure 68 Skomer MCZ automatic weather station data - maximum wind strength (knots) 1993 – 2022.



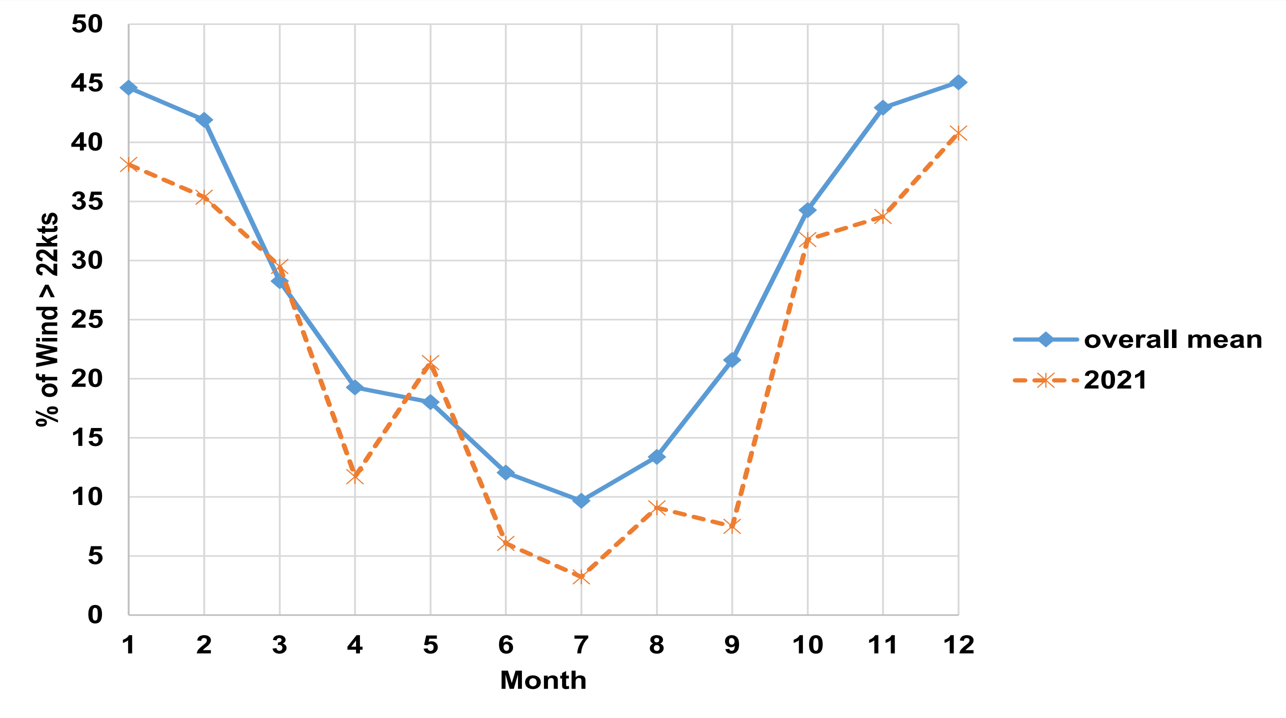
The maximum gust recorded for 2008, 2009 and 2010 was exactly the same (86.6 mph) (Figure 68). This led to the suspicion that the anemometer bearings were faulty. After the bearings were replaced in 2011 higher gusts were recorded. 2021 saw a maximum gust of 93.2 mph in December, while other high records were in November with a gust of 91.3 mph, and May saw some unusually high wind strengths of 79.2 mph.

In 2022 (18th Feb 2022) Storm Eunice brought some very windy weather and a record reading of 113 mph was recording at 11:00am (Figure 68). The bearings in the anemometer then seized so no more readings were taken during the storm. Previous to this the highest recorded gust at Wooltack point was 111 mph on 05th Jan 1997.

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.

Another ecologically important measure of exposure is total annual wind, which is a measure of the energy that littoral and sublittoral habitats are subjected 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 (Figure 71).

Figure 69 Skomer MCZ automatic weather station data – percentage of wind greater than 22 knots for each month. All years averaged and 2021 data.

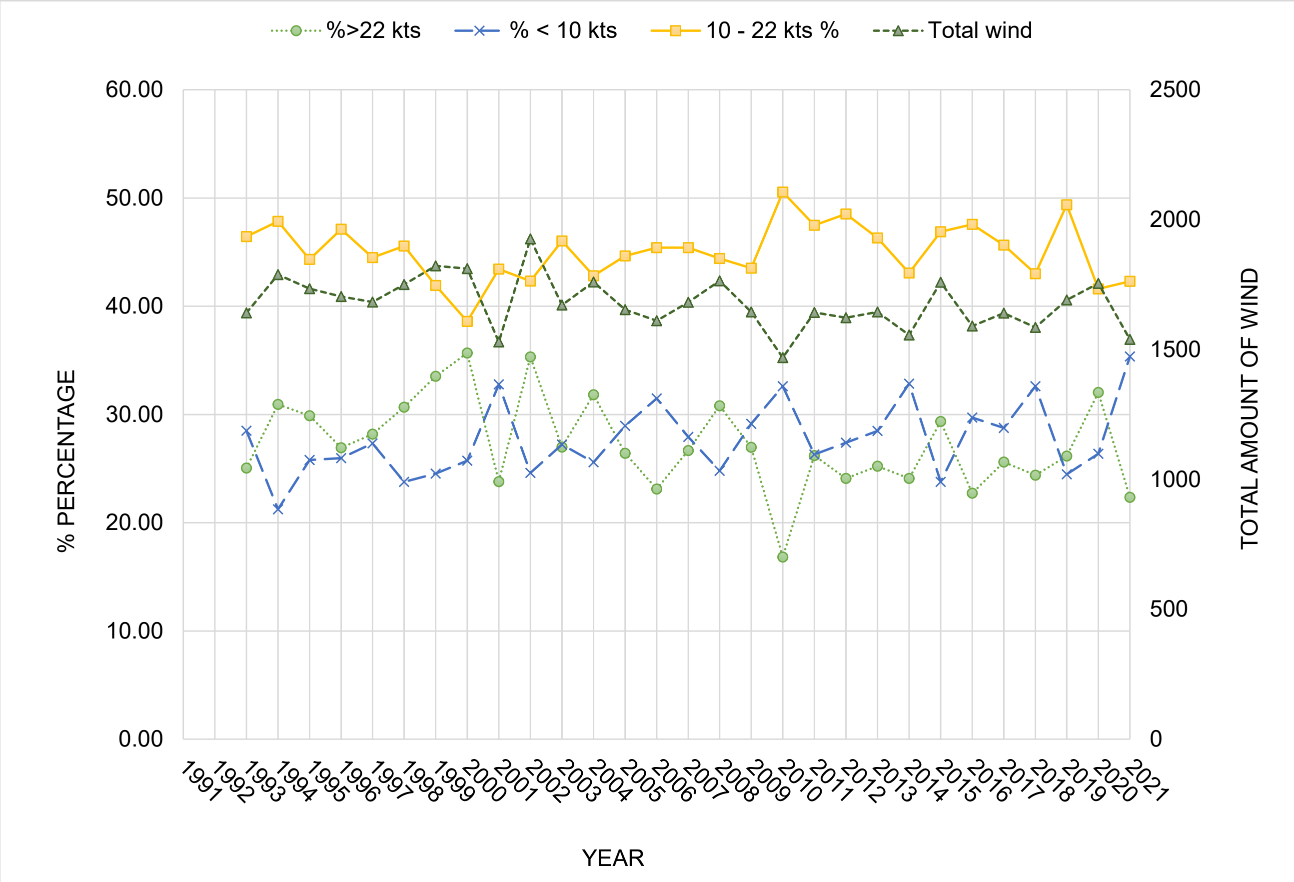


2021 had a slightly different pattern of wind distribution to the overall mean. There was more wind recorded from the S and WNW than is usually seen. (Figure 71). Most of the stronger winds come from the SW, WSW & WNW. The east tends to have the lowest percentage of strong winds.

Figure 70 Skomer MCZ automatic weather station data – percentage of wind over 22 knots from each wind direction.

2002 was the windiest year with 35% of all the wind greater than 22 knots. 2010 was the calmest year with only 17% of the wind stronger than 22 knots and 33% of the wind less than 10 knots (Figure 72).

Figure 71 Skomer MCZ automatic weather station data – “total annual wind” 1993 to 2021.



The 2021 annual meteorological summary from the Skomer MCZ automatic weather station is shown in Table 16. Monthly average air temperature, relative humidity and solar radiation results are summarised in figures 72 to 75.

Table 16 Skomer MCZ automatic weather station – 2021 annual meteorological summary.

Natural Resources Wales - Skomer Marine Conservation Zone					**YEAR**	**SUMMARY 2021**							
Weather station - Coatguard lookout hut, Wooltack point													
Grid ref: SM75880922													
Geographical position: 51.44.78N 005.14.78W			Height of anonometer above ordinance datum -					61.15m					
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AIR TEMP	MEAN	6.506409	6.2795	7.55146	8.17725	10.12019	13.491	16.097	15.281	15.592	13.44	10.461	9.13563
T107_1 0c	MAX	10.41	10.77	17.55	15.89	18.78	21.36	26.88	19.18	26.22	16.9	13.77	12.66
	MIN	-0.21	-2.032	2.1	2.656	3.611	10.7	10.55	12.07	9.12	9.09	3.383	2.408
BAROMETRIC PRESSURE	MEAN	1004.231	1003.92	1014.6	1016.46	1002.441	1012.2	1008.1	1010.4	1010.7	1005.9	1012.1	1004.12
	MAX	1023	1036	1030	1028	1022	1022	1023	1026	1026	1027	1028	1034
	MIN	969	980	976	1000	983	1000	988	985	995	973	982	967
RELATIVE HUMIDITY	MEAN	97.08824	107.763	91.5367	74.0699	85.22324	89.851	89.596	90.028	89.368	84.361	75.095	88.05832
	MAX	163.5	148.8	100	100	100	100	100	100	100	100	97.7	100
	MIN	0.341	51.2	51.05	32.1	40.92	44.54	51.79	65.61	50.91	61.6	47.24	52.28
RAINFALL	TOTAL(mm)	57.5	31.1	28.424	2.856	79.434	10.336	52.894	19.312	79.696	98.462	26.93	74.118
SUNSHINE	MEAN(kw/m2)	0.03649	0.06656	0.11516	0.24408	0.247222	0.2535	0.2549	0.1982	0.129	0.0762	0.0384	0.024848
	sunshine hours	82	131	237	341	360	364	367	334	238	173	87	57
	Sunshine hrs (10min)	81.66667	127.333	242.5	336.833	353.8333	356.33	365.67	333	234.67	168.33	84	52.83333
NET RADIATION	MEAN	-12.6743	1.42236	28.5736	72.1611	98.32899	106.1	115.67	84.784	41.079	10.851	-7.314	-10.2998
MAX GUST	M/s	33.75	29.17	39.58	25	35.42	18.33	26.25	25.42	25	37.08	40.83	41.67
	direction	246.7	168.3	252.8	333.3	191.5	14.5	314.5	240	251.3	225.3	348.3	210.3
	MPH	75.49673	65.2515	88.5381	55.9235	79.23241	41.003	58.72	56.863	55.924	82.946	91.334	93.21329
	Days > F7 MEAN	0	4	2	0	1	0	0	0	0	1	2	4
	Days > F7 Gust	23	18	14	8	13	2	4	7	7	18	20	19
	days max hr av>F7	6	9	8	2	5	0	1	0	1	10	2	0
Notes													
Service - 03 March 2021 - new RH & temp probe													
Feb Humidity data not reliable													
RH probe not working - 08/Oct - 26 Nov. New probe installed 26/11/2021													

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

Figure 72 Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2021 with monthly min / max error bars.

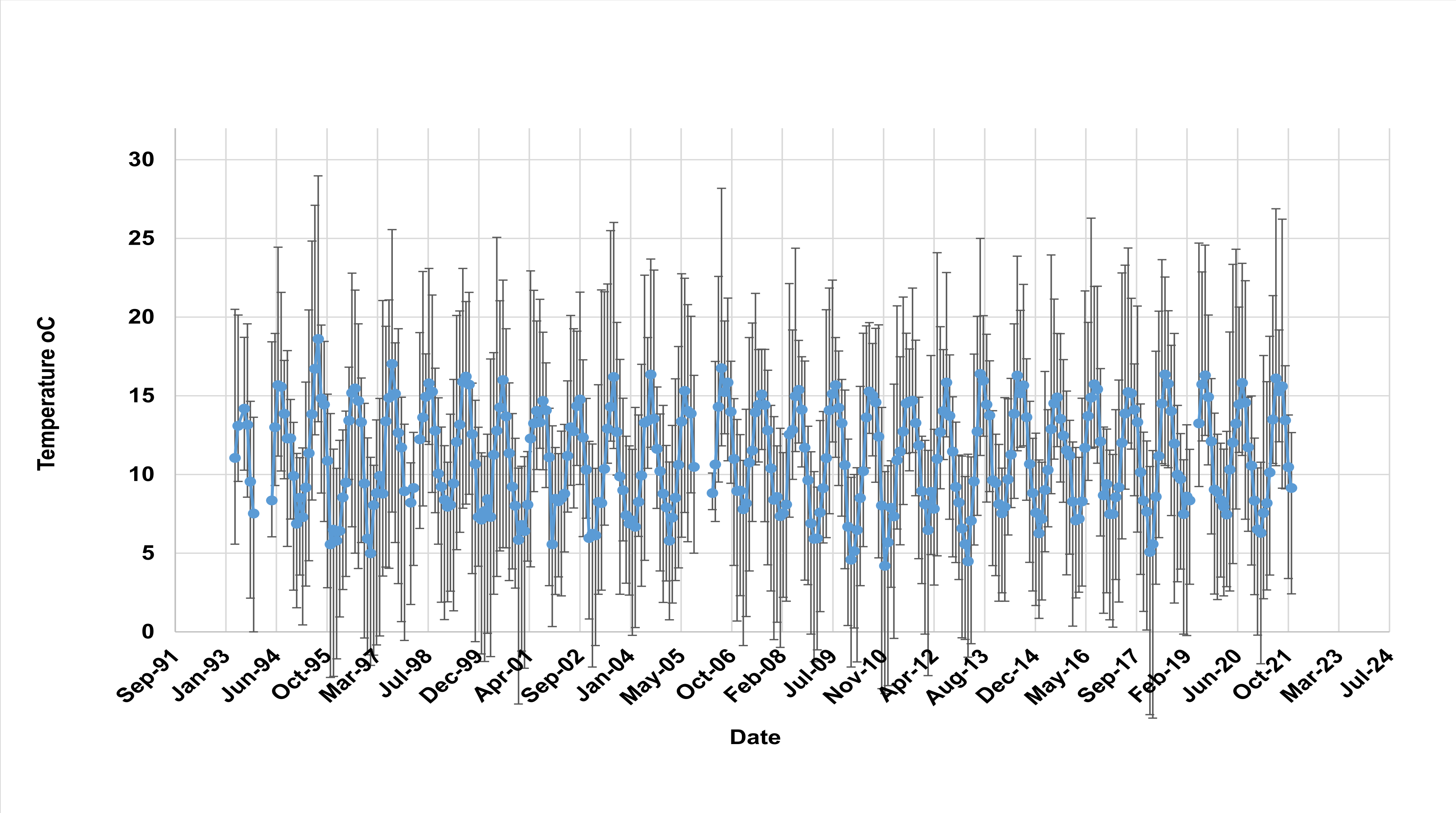


Figure 73 Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (ºC) 2006 – 2021.

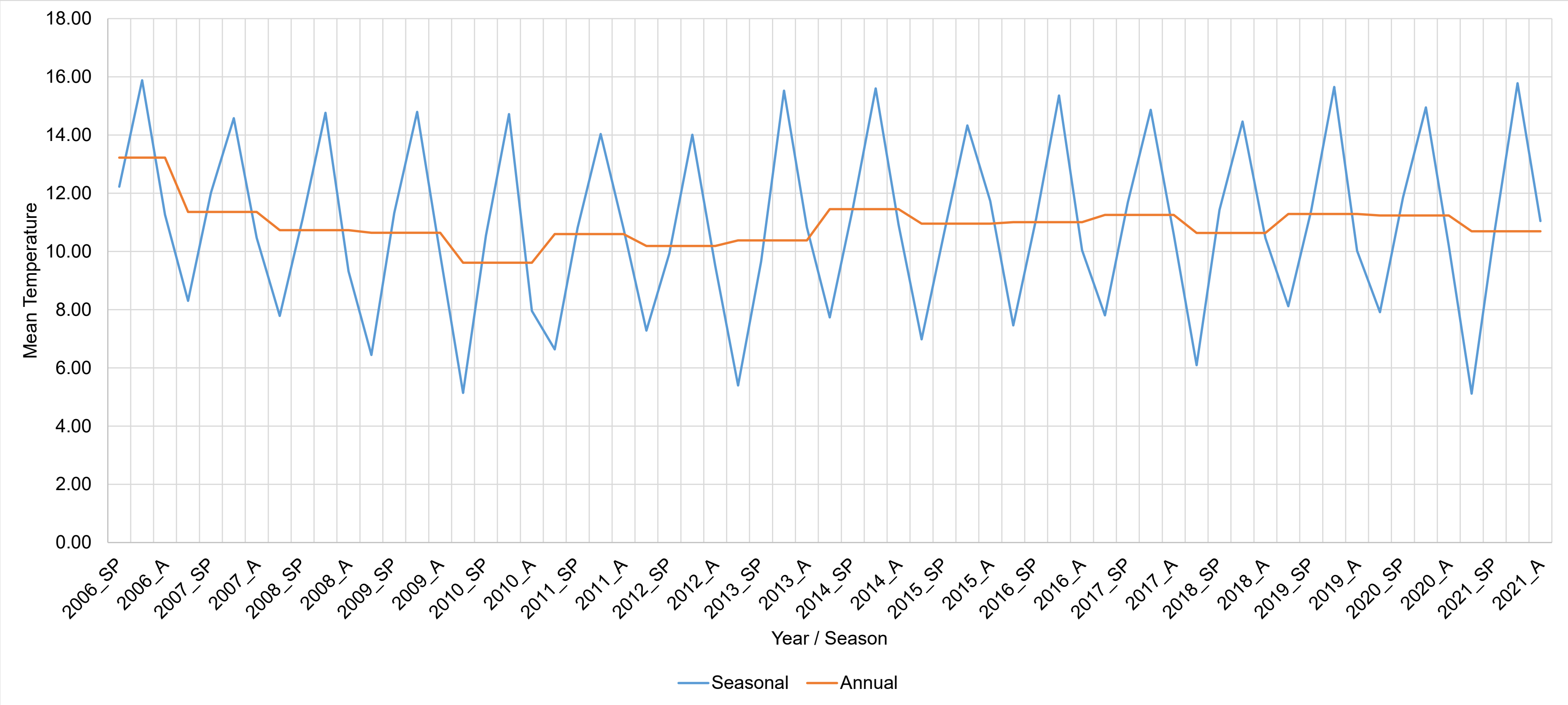
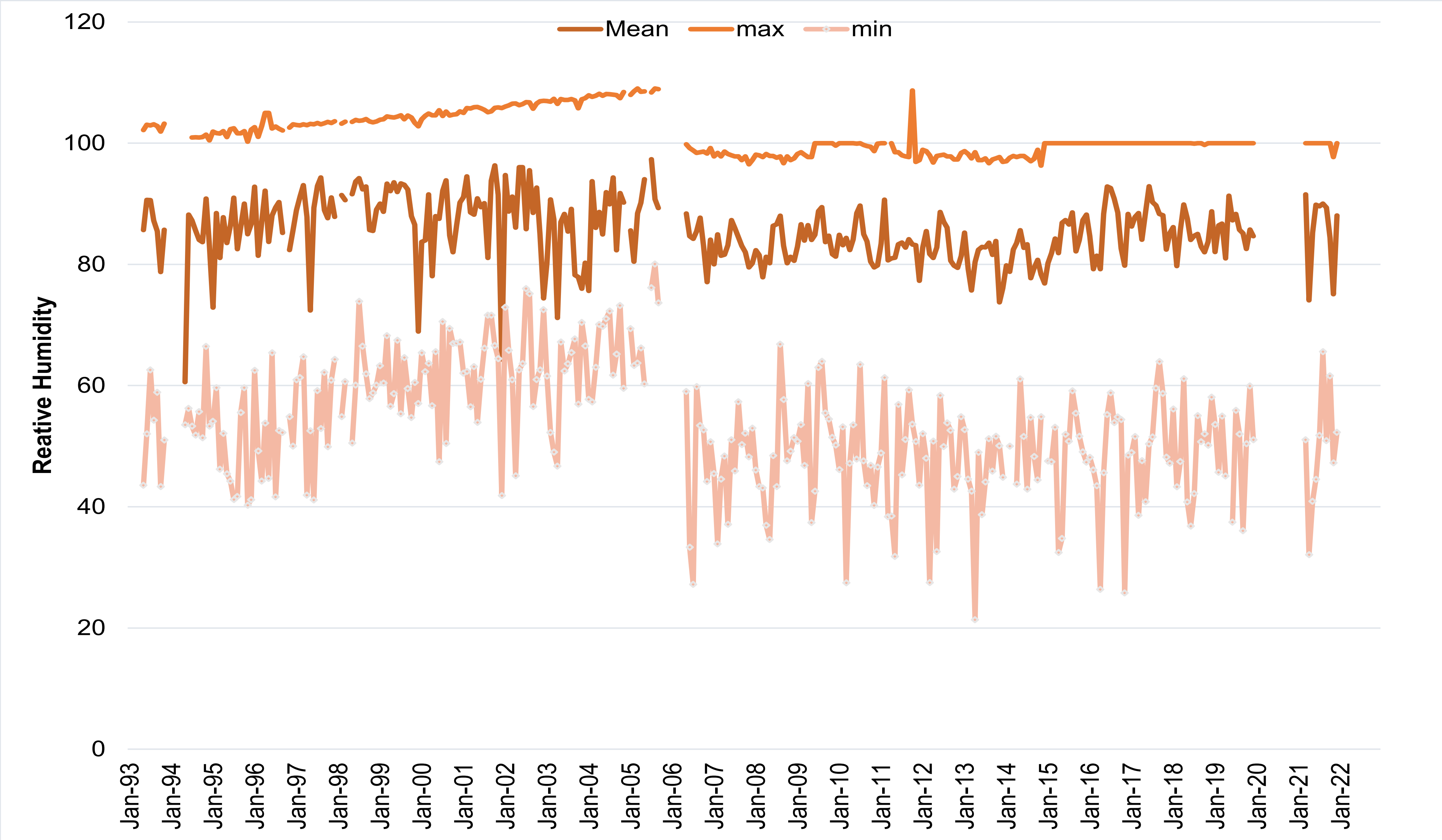
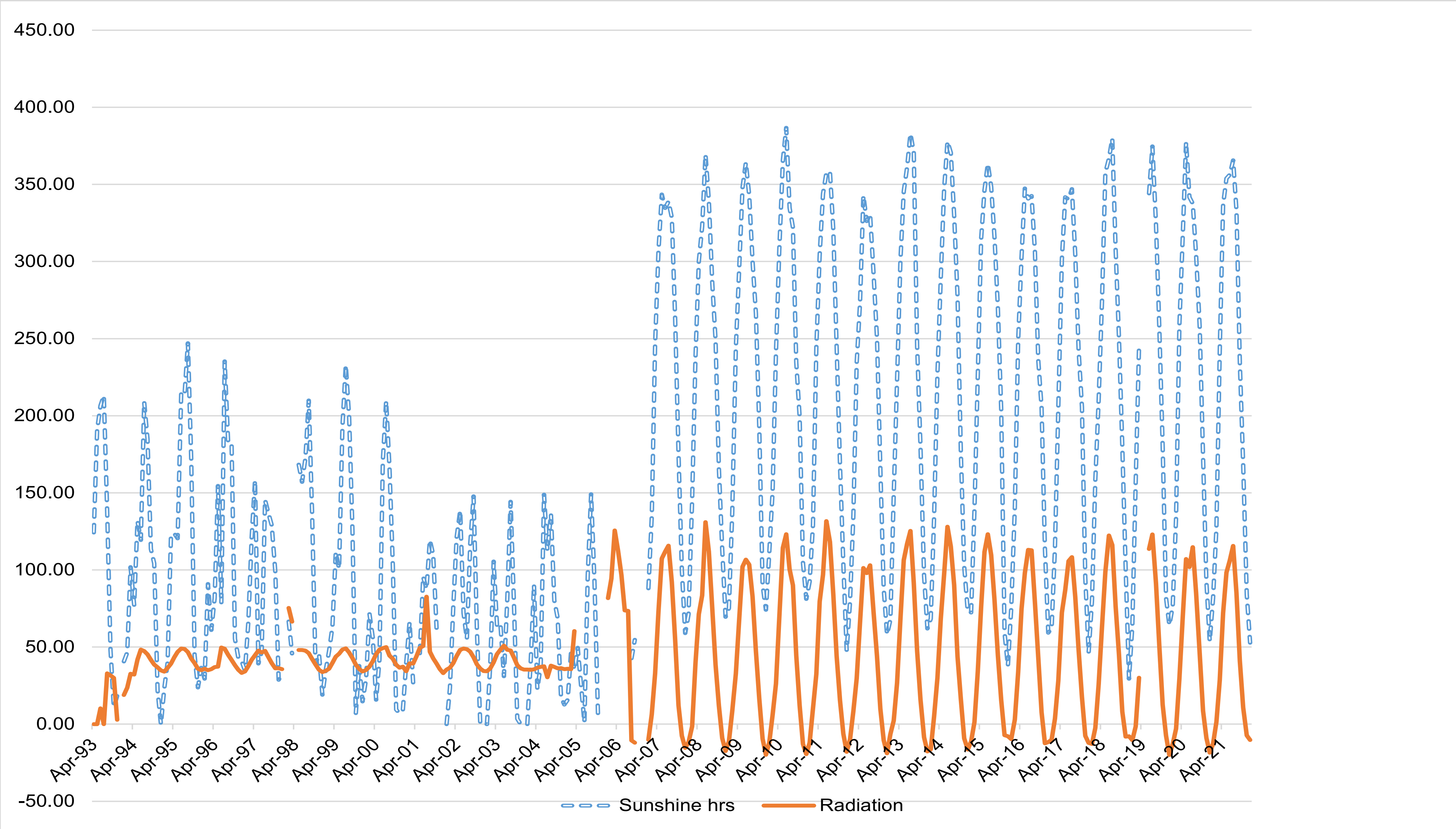


Figure 74 Skomer MCZ automatic weather station – relative humidity 1993 – 2021.



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 75 Skomer MCZ automatic weather station – solar radiation (W/m2) and sunshine hours 1993 – 2021.



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.

5.1.8. Current Status

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

5.1.9. Recommendations

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

5.2. Seawater Temperature Recording

5.2.1. Project Rationale

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

5.2.2. Objectives

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

5.2.3. Sites

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

7.2.4. Methods

Ocean monitoring site (OMS)

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

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

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

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

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

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

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

Shore Sites

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

5.2.5. Project history

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

Table 17 Valeport series 600 MKII CTD probe water profile records:

Year	Months samples were taken	Year	Months samples were taken
1992	Jul – Nov	2007	Apr – Oct
1993	Jan – Dec	2008	Apr – Dec
1994	Feb – Dec	2009	Feb – Oct
1995	Jul – Dec	2010	Mar – Nov
1996	Mar – Dec	2011	Mar – Nov
1997	Aug – Dec	2012	Mar – Nov
1998	Mar – Nov	2013	Apr - Oct
1999	May – Nov	2014	Apr - Nov
2000	Mar- Oct	2015	Mar - Oct
2001	May – Nov	2016	Apr - Oct
2002	May – Oct	2017	Apr - Oct
2003	Jun – Sept	2018	Apr - Oct
2004	May – Oct	2019	Apr – Oct
2005	May – Oct	2020	No records
2006	Mar – Oct	2021	May - Oct

Vemco minilog seabed temperature logger deployment:

- Aug 1993 – Nov 1994
- Dec 1996 – Sept 1997
- Jul 1999 – Apr 2001
- Jun 2001 – 8th May 2002
- 30th May 2002 – ongoing (now using Onset Temp Pro V2 logger)

5.2.6. Results

Oceanographic monitoring site:

Table 18 Skomer MCZ maximum and minimum annual seabed temperatures 2000 to 2021 (June) at 19m below chart datum.

Year	Minimum temperature °C	Maximum temperature °C
2000	8.4	16.27
2001	7.27	16.3
2002	8.7	15.6
2003	7.6	17.1
2004	7.7	16. 76
2005	7.36	16.4
2006	7.5	16.3
2007	8.8	16.3
2008	8.4	16.3
2009	7	16.8
2010	6.9	16.8
2011	7.6	15.9
2012	8.0	16.6
2013	6.98	16.82
2014	8.14	16.72
2015	7.8	15.98
2016	8.5	16.8
2017	8.3	16.4
2018	6.6	16.6
2019	8.7	17.2
2020	8.4	16.3
2021	7.3	Logger not retrieved

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°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°C) with March temperatures

1°C below the average. 2019 was much warmer in comparison with a very mild 8.7 °C in the winter and the warmest summer record since 2003 - 17.2 °C (Table 18).

A summary of the seabed temperature (data from Vemco minilog at 19m BCD) is shown in Figure 76. Monthly means have been calculated from seabed temperature but substituted with the CTD probe seabed temperature data where logger data were absent.

Figure 76 Skomer MCZ summary of monthly mean seabed temperature (19m BCD) 1992 – 2021.

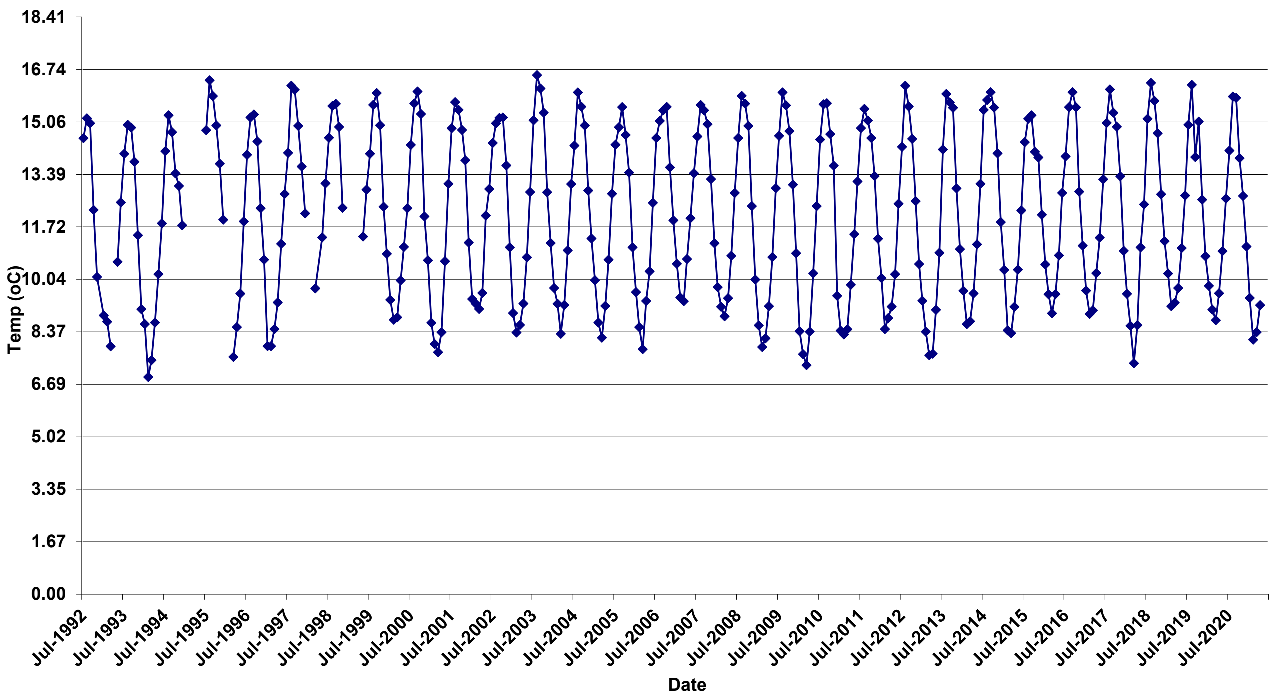
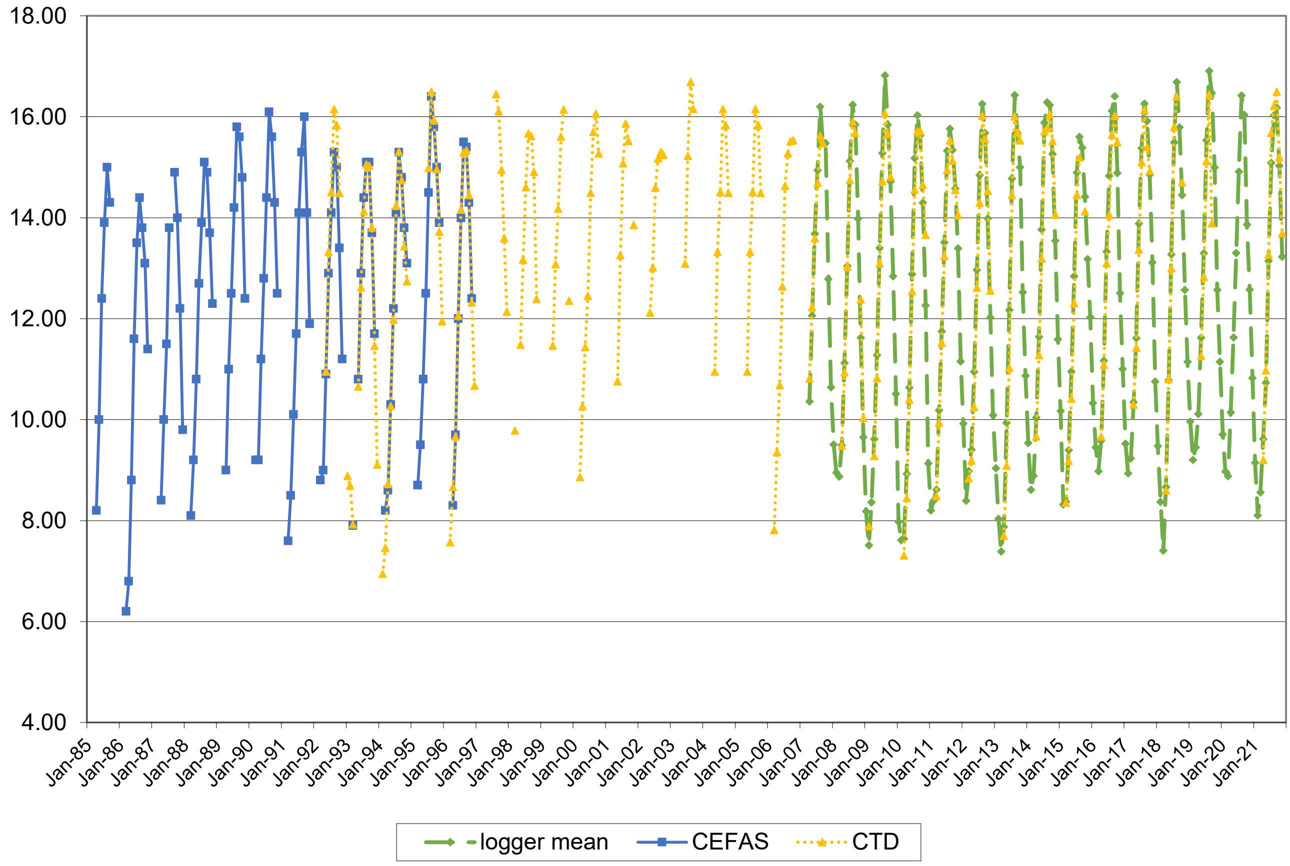


Figure 77 Skomer MCZ summary of monthly mean sea surface temperature 1985 – 2021.



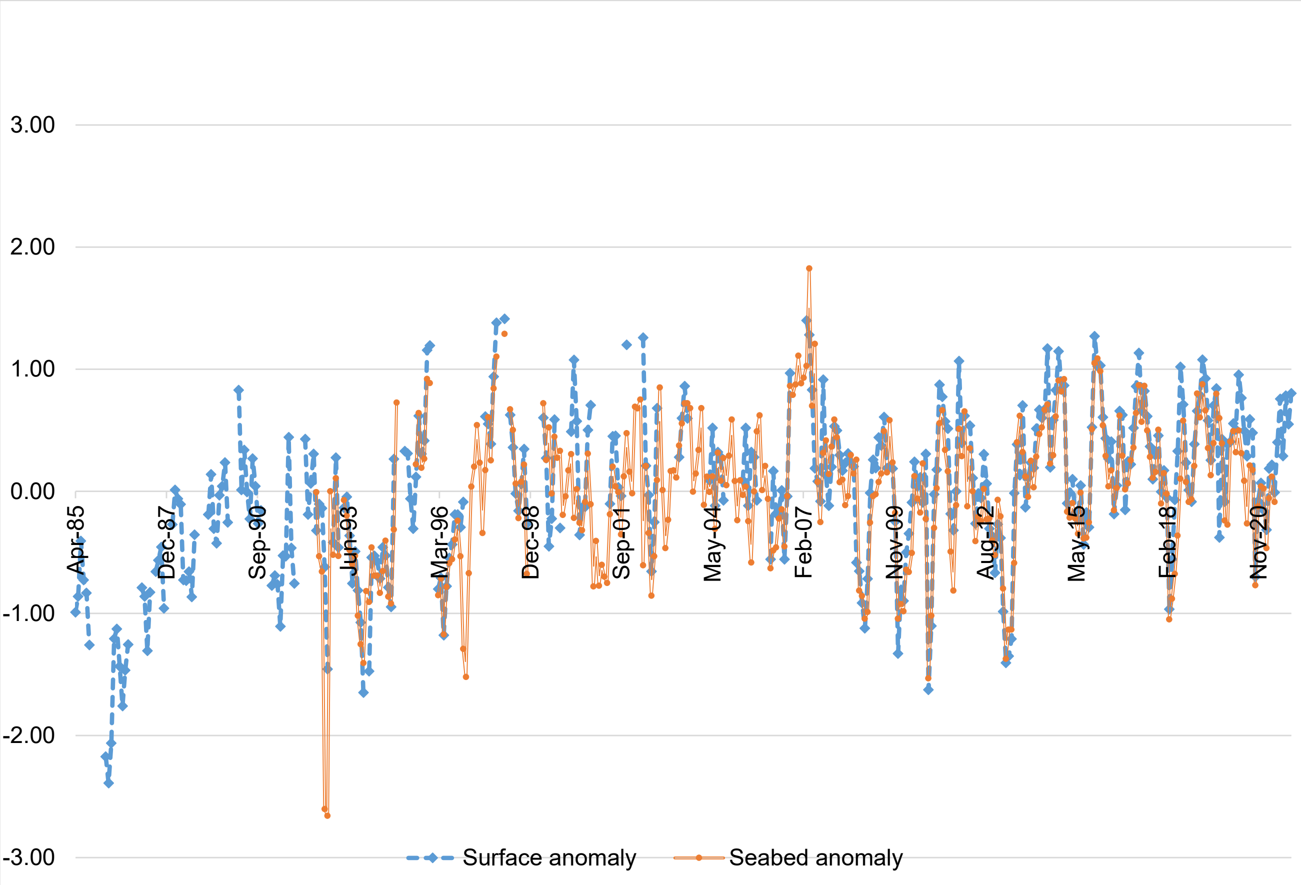
A summary of the sea surface temperature is shown in Figure 77. This is made up of:

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

Comparing the overall monthly mean with the monthly mean for each year.

By taking the mean for a specific month across the whole dataset (grand monthly mean) and comparing this with the same month's mean for a specific year (specific monthly mean) the "monthly anomaly" can be calculated. Repeating this calculation for each month of each year in the dataset gives an indication of how cold or warm that particular month was compared to the whole dataset (Figure 78).

Figure 78 Skomer MCZ sea temperatures – monthly anomaly between the specific monthly mean and the grand monthly mean, surface and seabed temperatures (1985 – 2021).

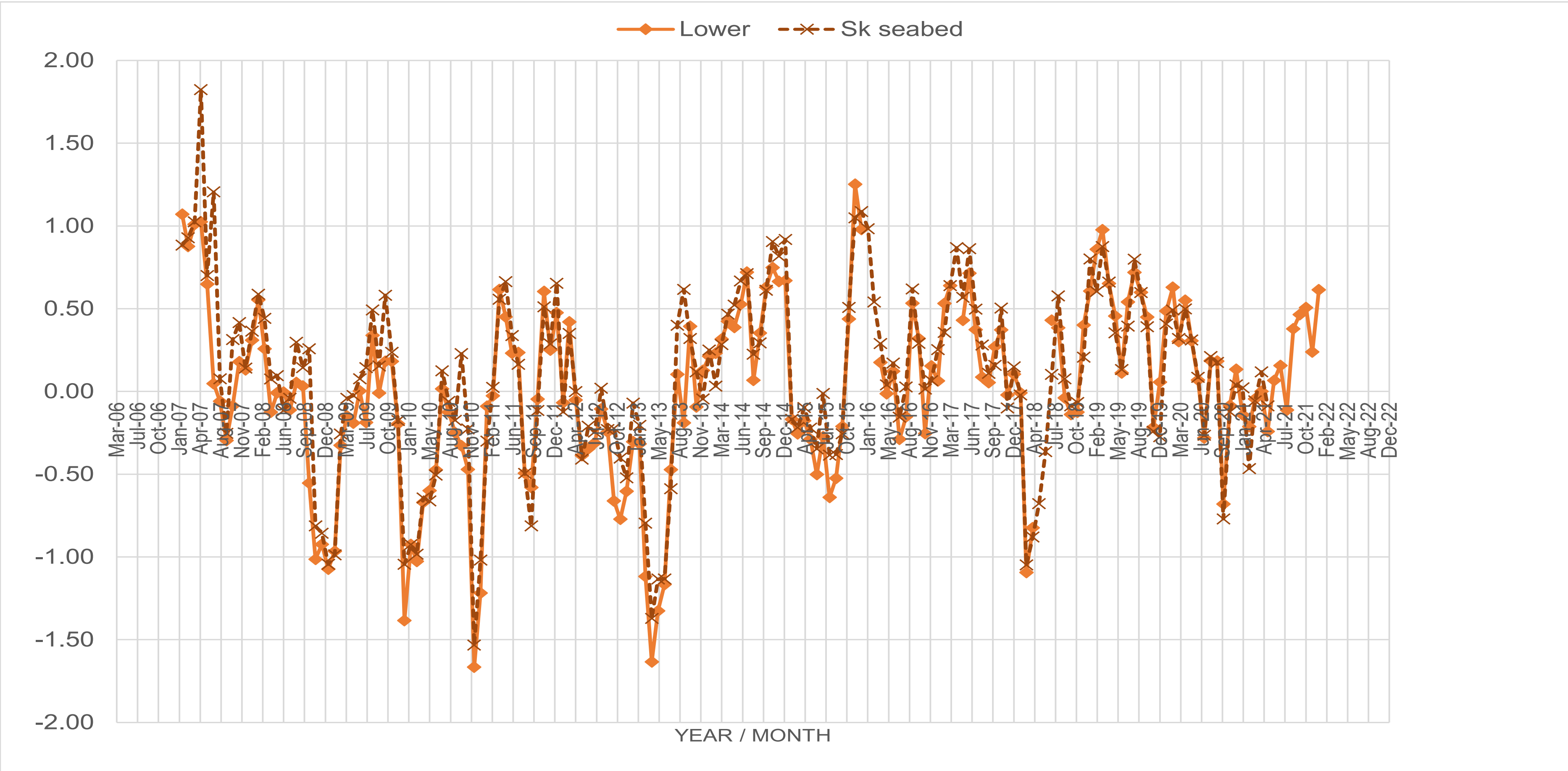


Sea temperatures prior to 1995 were generally colder than average. From 1995 to 2006 there was a warmer period, but from 2006 onwards the data have been very erratic with some very cold winter temperatures but some warm summer temperatures. In 2021 the loggers were retrieved. The seabed logger was downloaded with all of 2019 – 2021 data intact but the Sea Surface Temperature logger (SST) had been lost in a storm, so there is no data available for that period. Although the dedicated SST logger was lost the intertidal loggers did survive the storms and they can be used to estimate SST over the period of missing data.

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 (Figure 79). The data from the intertidal loggers follow a very similar trend to the logger recording on the seabed at Skomer.

Figure 79 Martins Haven shore (lower shore) temperature loggers - anomaly 2007 – 2021 with Skomer seabed logger anomaly shown for comparison.



5.2.7. Current Status

There does not appear to be any long-term trend in sea water temperatures.

5.2.8. Recommendations

- Continue dataset to form a long-term record of variation in seabed temperature at Skomer MCZ.

- Keep the dataset as complete as possible. An additional logger running at the same time would add redundancy into the methods should the equipment fail or get lost.

5.3. Seawater Turbidity / Suspended Particulates and Seabed Sedimentation

5.3.1. Project Rationale

Coastal waters are naturally turbid, but this turbidity can change due to anthropogenic activities such as dredge spoil dumping or freshwater run-off from poor land management. Turbidity can also increase due to high phytoplankton levels. Increases in turbidity have the potential to adversely affect many of the species of the Skomer MCZ which depend upon filter feeding strategies that can become “clogged” with metabolically useless material or others that depend on photosynthesis and are affected by lack of light penetration through seawater.

Historically, at Skomer, 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.

5.3.2. Objectives

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

5.3.3. Sites

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

5.3.4. Methods and Project History

- Secchi disk measurements*:* the depth to which a white 30cm diameter “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 (Figure 81).

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

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

Table 19 Skomer MCZ sediment trap sampling effort from 1994 to 2019 at OMS and Thorn rock (TRK).

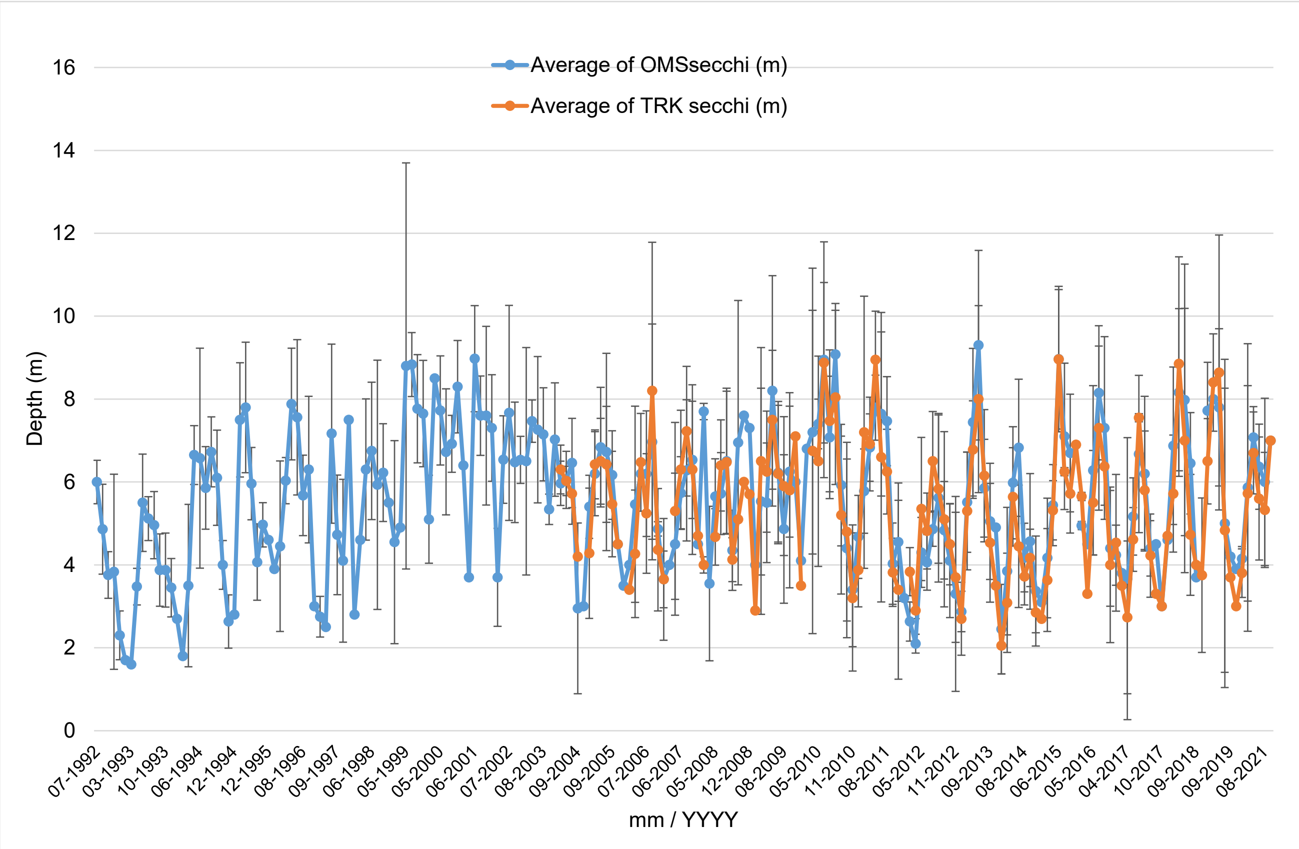
Year	Months with samples	Sites	Notes
1994	Jul – Dec	OMS & TRK	None
1995	Jan – Dec	OMS & TRK	None
1996	Feb – Dec	OMS & TRK	None
1997	Mar – Dec	OMS & TRK	None
1998	Mar – Sep	OMS & TRK	None
1999- 2001	No samples	None	Re-established 02 Nov 2001
2002	Mar – Nov	OMS & TRK	TRK site damaged
2003	May – Sep	OMS only	None
2004	May – Sep	OMS only	None
2005	Jun- Oct	OMS only	Collector damaged
2006	Jun - Oct	OMS & TRK	Repaired and TRK re-established
2007	May - Sep	OMS & TRK	None
2008	May - Sep	OMS & TRK	None
2009	Apr - Sep	OMS & TRK	Shell fragments in samples.
2010	Apr - Sep	OMS & TRK	None
2011	Apr - Nov	OMS & TRK	None
2012	Apr - Sep	OMS & TRK	None
2013	Apr - Oct	OMS & TRK	New Lab used
2014	Apr - Oct	OMS & TRK	None
2015	Apr - Oct	OMS & TRK	None
2016	Apr - Oct	OMS & TRK	None
2017	Apr - Oct	OMS & TRK	None
2018	Apr - Oct	OMS & TRK	None
2019	Apr - Oct	OMS & TRK	None
2020	No Samples	None	None
2021	May - Oct	OMS & TRK	Awaiting analysis

5.3.5. Results

Turbidity

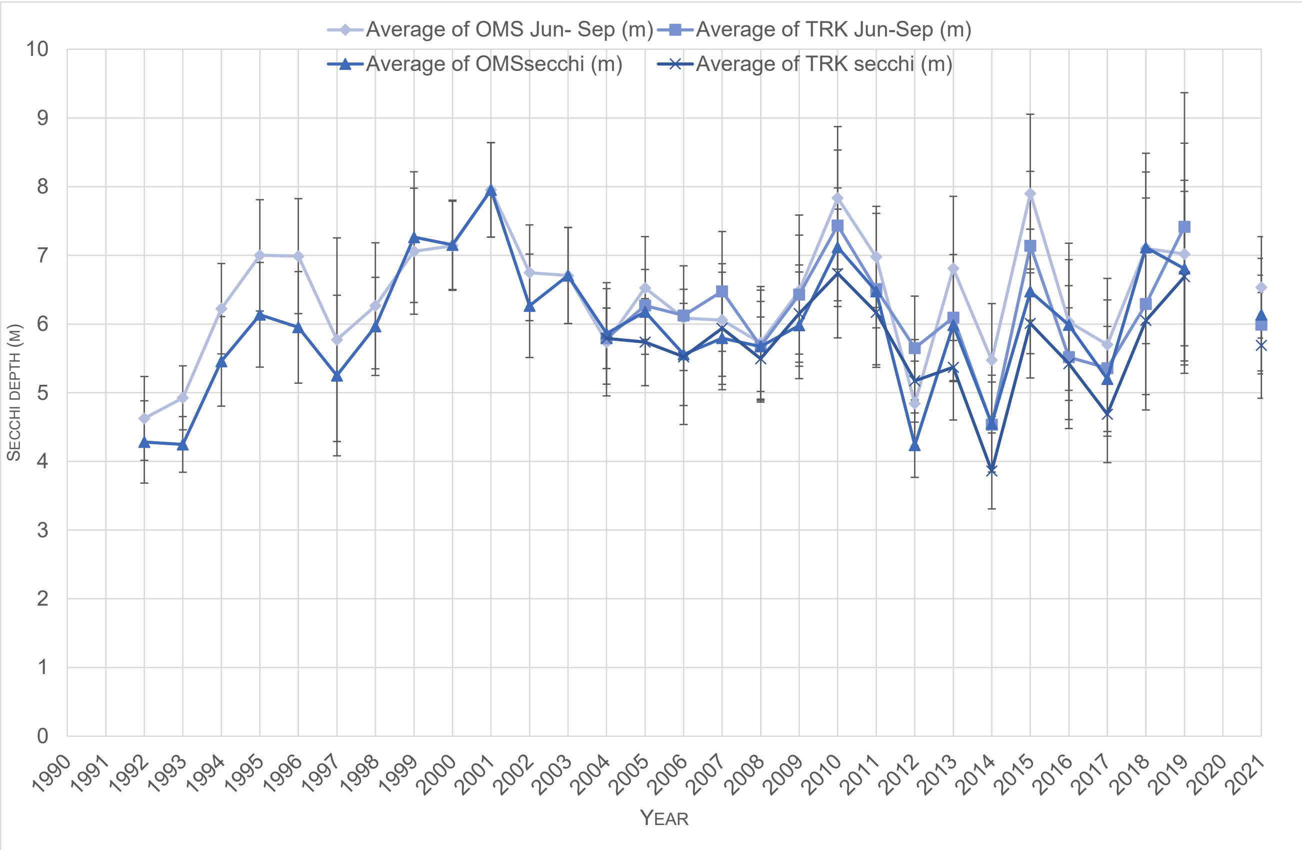
Secchi disc: Measurements have been taken with reasonable consistency for the months of May to October since 1992. The mean monthly Secchi disc readings for OMS and Thorn Rock (TRK) are shown in Figure 80.

Figure 80 Skomer MCZ summary of monthly mean Secchi disc data (m) 1992 – 2021 with 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 81.

Figure 81 Skomer MCZ summary of annual mean Secchi disc data (m) with standard error bars.



The Secchi disc readings for Thorn Rock in 2014 were 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 had returned towards average levels but in 2017 there was a drop in water clarity at both OMS and TRK.

Seabed sedimentation

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

Table 20 Skomer MCZ sediment trap sample analysis from Thorn Rock (TRK) site (1994 to 1998 % sand data estimated).

TRK	g/day	% organic content	% gravel	% sand	% mud
1994	3.32	9.80	0.10	16.83	83.07
1995	5.76	8.59	0.41	55.76	43.83
1996	3.53	9.90	0.21	22.56	77.23
1997	5.81	9.43	No Data	No Data	No Data
1998	4.15	10.25	0.23	23.89	75.89
2002	2.44	7.61	0.00	61.63	38.36
2006	1.74	8.65	0.00	60.35	39.65
2007	1.54	7.73	0.00	69.81	30.19
2008	1.91	7.13	0.00	78.39	21.23
2009	1.78	8.66	0.00	44.06	55.94
2010	2.73	7.70	3.66	79.47	16.67
2011	1.51	9.31	2.73	68.80	24.61
2012	2.96	7.55	1.43	41.12	57.08
2013	2.53	15.34	3.14	35.04	61.86
2014	2.67	13.33	0.18	31.04	68.77
2015	3.26	11.18	2.23	51.32	46.47
2016	2.01	10.85	1.07	51.33	45.21
2017	2.48	11.12	0.47	39.20	56.07
2018	1.92	10.80	0.93	33.25	62.67
2019	2.71	9.14	1.66	32.06	52.99
2020	No Data	No Data	No Data	No Data	No Data
2021	1.14	9.15	0.86	31.47	65.43

Table 21 Skomer MCZ sediment trap sample analysis from OMS site (1994 to 1998 % sand data estimated).

OMS	g/day oms	% organic content	% gravel	% sand	% mud
1995	2.17	9.33	7.37	18.56	74.07
1996	2.16	9.95	0.40	17.08	82.52
1997	1.69	9.64	0.18	20.43	79.40
1998	1.25	9.24	5.08	42.73	52.19
2002	1.05	7.91	0.17	73.51	26.32
2003	1.29	8.14	0.37	79.54	20.09
2004	1.91	7.90	0.00	75.27	24.72
2005	2.20	8.80	0.00	76.86	23.14
2006	2.33	8.79	0.00	76.80	23.21
2007	2.94	7.05	0.00	74.93	25.07
2008	0.56	7.34	0.00	81.48	18.23
2009	0.68	8.90	0.00	47.27	52.73
2010	1.75	7.66	4.93	77.99	16.88
2011	1.26	9.73	4.36	60.54	30.81
2012	2.00	7.87	9.12	45.39	45.14
2013	1.01	13.79	26.48	32.25	41.30
2014	2.46	13.57	10.55	48.65	40.11
2015	2.61	13.80	25.94	43.63	30.34
2016	0.79	12.38	5.54	53.42	29.51
2017	1.36	11.72	2.99	47.80	40.50
2018	1.31	13.30	5.00	36.77	35.55
2019	1.39	8.48	6.16	20.70	40.79
2020	No Data	No Data	No Data	No Data	No Data
2021	0.91	9.84	2.38	32.31	57.40

The samples from 2002 to 2012 were analysed by British Geological Society (BGS). In 2013 the sediment samples were sent to the NRW Llanelli laboratories for analysis, using a different set of analysis tools / machines to BGS. Text in red in Tables 20 and 21 indicates values were estimated (no data recorded for sand in 1995 – 1998).

Another change in 2013 was that the organic content analysis included heating the sample to 550^{o}C rather than 450^{o}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^{o}C.

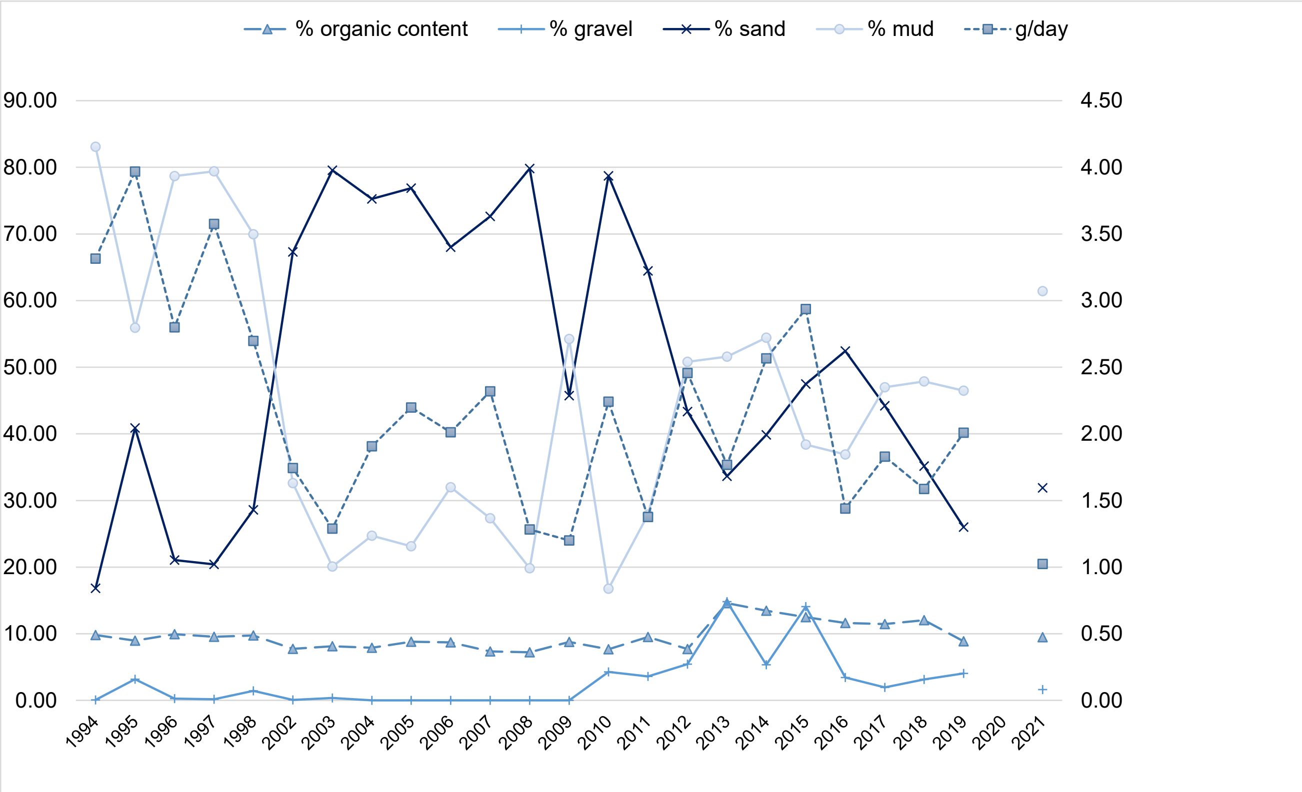
The NRW laboratories carry out a slightly different suite of metals analysis, but it is more comprehensive: cobalt and antimony are not done but manganese, mercury, lithium, aluminium, barium, tin, and iron are all now added to the metal analysis.

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.

In 2020 no samples were collected, and 2021 metal samples are awaiting analysis.

Figure 82 Skomer MCZ sediment trap total sediment sampled, PSA and organic content analysis – OMS and Thorn Rock sites combined.



General trends: 1994 to1998 samples were characterised by higher mud content to sand content. 2002 to 2008 samples had higher sand content to mud content and a reduced overall sedimentation rate overall, whereas from 2009 the trend has reverted to higher mud content and higher levels of gravel (Figure 82).

5.3.6. Current Status

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

- 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 a 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 had a beneficial effect. Dredge spoil disposal techniques and locations have not changed again, but sediment deposition and turbidity have occasionally reverted to levels not seen since the early 1990s.

5.3.7. Recommendations

- Continue the Secchi disk readings as often as possible to continue the long-term dataset.
- Continue passive sediment trap collection for particle size analysis and metals analysis.
- Restart the water samples for chlorophyll not only to help monitor primary productivity in the plankton (see Section 4.13), but also to enable turbidity due to phytoplankton to be factored into the interpretation of overall turbidity data.

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