Cyfoeth Naturiol Cymru
Natural Resources Wales

Skomer Marine Conservation Zone Project Status Report 2022

NRW Evidence Report 656

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Dyma’r unfed ar hugain adroddiad statws prosiect a gynhyrchwyd gan **Parth Cadwraeth Morol Sgomer**. Mae’n grynodeb o gynnydd a statws cyfredol prosiectau monitro ym Mharth Cadwraeth Morol Sgomer yn ystod 2022. Mae’r prosiectau hyn nid yn unig yn darparu’r dystiolaeth sydd ei hangen i adrodd ar gyflwr Parth Cadwraeth Morol Sgomer ei hun, ond maent hefyd yn gwneud cyfraniad pwysig at y dystiolaeth a ddefnyddiwyd wrth asesu cyflwr a statws cadwraeth Ardal Cadwraeth Arbennig Forol Sir Benfro, y mae’r Parth Cadwraeth Morol ynddi. Mae data hirdymor Parth Cadwraeth Morol Sgomer, defnydd biolegol yn ogystal â defnydd dynol, hefyd wedi cael ei ddefnyddio i sefydlu ac adrodd ar ddangosyddion biolegol ar gyfer gofynion y DU o dan Gyfarwyddeb Fframwaith y Strategaeth Forol. Manylir ar achosion penodol lle defnyddiwyd data Parthau Cadwraeth Morol Sgomer i gefnogi mentrau heblaw'r rhai sy'n uniongyrchol gysylltiedig â'r Parth Cadwraeth Morol mewn crynodebau prosiectau unigol.

Mae’r tablau statws prosiect yn Adran 2 yn rhoi crynodeb o’r holl brosiectau monitro sydd wedi’u sefydlu yn y Parth Cadwraeth Morol. Mae Adran 4 yn manylu ar brosiectau biolegol y gweithiwyd arnynt yn ystod 2022 a chrynodeb o’r canlyniadau hyd yma. Mae Adran 5 yn rhoi crynodeb o'r prosiectau gwyliadwriaeth cefnforegol a meteorolegol.

Cofnodion nodedig yn 2022:

Môr-wyntyll binc, *Eunicella verrucosa*, nododd monitro golled bellach yn 2022. Mae asesiad cyflwr ar gyfer môr-wyntyllau unigol yn dangos bod wyau’r morgi brych *Scyliorhinus stellaris* wedi’u cofnodi ar 57% o fôr-wyntyllau a bod madredd lefel 4 (epiffytau yn tyfu ar ardal helaeth o'r môr-wyntyll) wedi cynyddu o 2.4% o wyntyllau yn 2002 i 23% yn 2021.

Cwblhawyd yr arolwg o loi bach morloi llwyd ar safleoedd ynys a thir mawr rhwng Awst a Rhagfyr a chofnodwyd 447 o loi bach. Mae cynhyrchiant lloi bach ym Mharth Cadwraeth Morol Sgomer dros y tair blynedd diwethaf wedi dangos y cyfansymiau uchaf a gofnodwyd erioed gyda chynhyrchiad cyfartalog ar gyfer 2020-22 yn 438 o loi bach. Ers 2009 bu cynnydd cyson mewn cynhyrchiant lloi bach ar safleoedd yr ynys a’r tir mawr.

Ar ôl dwy flynedd o oedi, roedd modd cynnal arolwg deifio o Gregyn bylchog gan wirfoddolwyr. Cwblhawyd 39 trawslun mewn 7 safle yn gorchuddio 2280 m^2 a mesurwyd 1414 o gregyn bylchog, nodwyd eu hoed a'u dychwelyd i'r dwfr. Mae canlyniadau 2022 wedi dangos cynnydd arall yn nwysedd y cregyn bylchog ar draws y Parth Cadwraeth Morol cyfan. Mae tystiolaeth gref o recriwtio iach yn y chwe blynedd diwethaf ac mae'n ymddangos bod y recriwtiaid ifanc hyn yn sbarduno'r cynnydd yn niferoedd cregyn bylchog yn y rhan fwyaf o safleoedd.

Cwblhawyd yr arolwg o amrywiaeth Noethdagellogion, a chofnodwyd 55 o rywogaethau sy'n cynrychioli 68% o'r rhywogaethau o noethdagellogion sydd wedi'u cofnodi ar ddeifiau ym Mharth Cadwraeth Morol Sgomer Cofnodwyd cyfanswm o 83 rhywogaeth rhwng 1975 a 2022 o arolygon deifio ac arolygon o isfilod gwaddod. Mae'r amrywiaeth ym Mharth Cadwraeth Morol Sgomer yn uchel iawn gyda 70% o rywogaethau'r DU yn cael eu cynrychioli mewn ardal o 13.2 cilometr sgwâr.

Executive summary

This is the twenty first 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 2022. 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 2022 and a summary of the results to date. Section 5 provides a summary of the oceanographic and meteorological surveillance projects.

Notable records in 2022:

Pink sea fan, *Eunicella verrucosa*, monitoring recorded further losses in 2022. Condition assessment for individual sea fans show that bull huss *Scyliorhinus stellaris* eggs were recorded on 57% 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 23% in 2021.

The Grey seal pupping survey was completed at both island and mainland sites from August to December and 447 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 2020-22 at 438 pups. Since 2009 there has been a steady increase in pup production at both the island and mainland sites.

After a two year delay, the Scallop volunteer diving survey was able to take place. 39 transects were completed at 7 sites covering 2280 m^2 and 1414 scallops were measured, aged and returned to the water. The 2022 results have shown another increase in density of scallops across the whole MCZ. There is strong evidence of healthy recruitment in the last 6 years and these young recruits appear to be driving the increase in scallop numbers at most sites.

The Nudibranch diversity survey was completed, 55 species were recorded representing 68% of the nudibranch species that have been recorded on dives in the Skomer MCZ. A total of 83 species have been recorded between 1975 and 2022 from both diving and sediment infauna surveys. The diversity in the Skomer MCZ is very high with 70% of UK species represented in an area of 13.2 square kilometres.

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 there are 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 are able to respond quickly to potentially damaging events and intervene. Sometimes this is by our mere presence acting as a deterrent, and sometimes by educating those who might cause harm unknowingly.

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

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 O2, 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

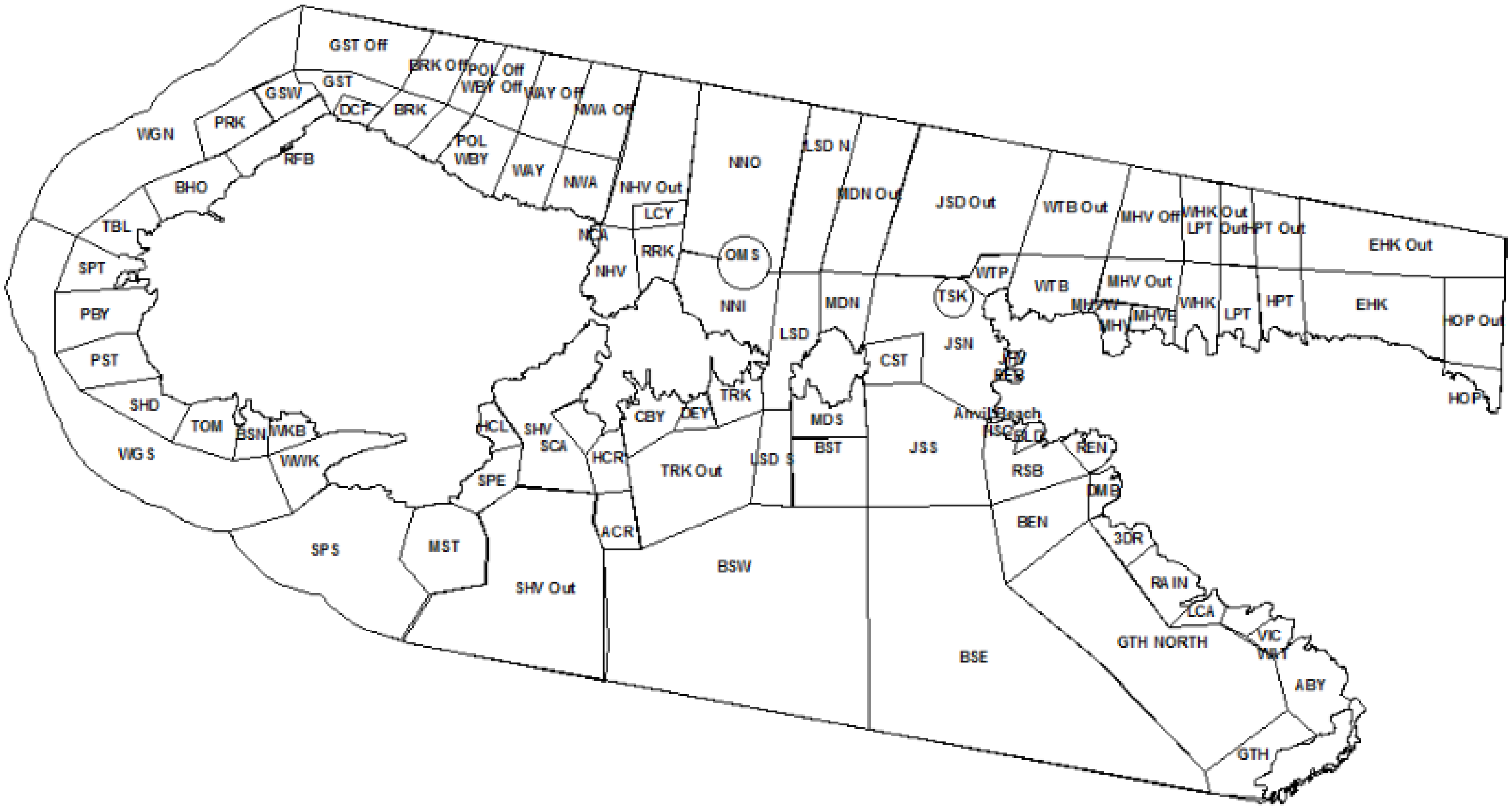
Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Sub-Littoral Algal communities	Algae species and community survey	1983, 1986,1994, 1999, 2007	No current planned survey	Hiscock 1983 & 1986, Scott 1994, Brodie & Bunker 1999/2000, Maggs & Bunker 2007.	Yes, Skomer 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 2023	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 1992-2022, Skomer MCZ annual reports.	Yes, Skomer MCZ office.
Nudibranch species	Species recording.	1975, 1991 2002, 2006, 2010, 2014, 2018 & 2022	Every 4 years Next survey planned 2026	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 Next survey planned 2024	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.

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
King scallop ***Pecten maximus***	UCS survey in 1979 and 1980 Survey completed, 3 sites- 2000 and 7 sites 2004, 2008, 2012, 2016, 2022	2000, 2004, 2008, 2012, 2016, 2022	Every 4 years. Next survey planned 2026	Bullimore 1985, Jones 1979 & 1980, Lock 2002, Luddington *et al*. 2004, Lock *et al*. 2009 & 2013, Burton *et al*. 2016. Massey *et al* 2022.	Yes, Skomer MCZ office.
Echinoderm species	Abundance of *Echinus esculentus* in Skomer MCZ using volunteer survey methods. Data for Marthasterias glacialis, *Crossaster papposus* & *Luidia ciliata*.	2003,2007 & 2011, 2015, 2019.	Every 4 years. Next survey planned 2025	Luddington *et al*. 2004, Lock *et al*. 2008, 2011, 2016 & 2019.	Yes, Skomer MCZ office.
Commercial Crustacean	Parlour pot and diving study (Plymouth student project), parlour pot study and shell disease survey.	2003, 2011	Aug / Sep 2003, Jul – Oct 2011	Fothergill 2004, no	Yes-SMCZ office
Commercial Crustacean	Crawfish recording	2011 onwards	Annual	No	Yes-SMCZ office, NBN database.
Cetaceans	Observations of all Cetacean species.	2001 onwards	Records from Skomer Island, “Dale Sailing” and SMCZ team	No	Yes-SMCZ office
Invasive and non-native species	Recording of non-native species during littoral and sublittoral surveys	ongoing	Annual	No	Yes, Skomer MCZ office, NBN database.

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

Site code	Site Name
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 cm x 50 cm) 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)

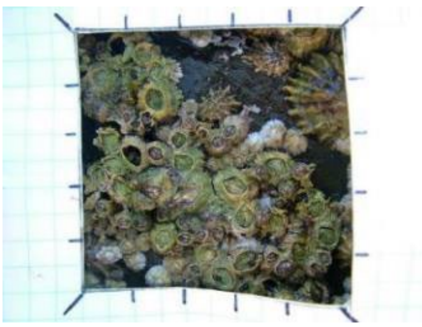
Lower shore – 1.8m ACD
Middle shore – 4.2m ACD
Upper shore – 6.0m ACD
Splash zone ~ 9.0m ACD (selected sites only)

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:

- 1m^2 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 cm x 50 cm quadrat, placed within each 1m^2 quadrat.
- Limpets are counted in 5 randomly selected grid cells, providing 20 samples at each shore height.
- % cover of barnacle species is estimated in 5 randomly selected grid cells and barnacles are photographed within the same 5 grid cells using a 5 cm x 5 cm 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 cm x 5 cm 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 cm x 50 cm 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 cm x 5 cm quadrats to complete barnacle species counts.
- Limpet species counts in 50 cm x 50 cm 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, with the exception of the lichen community at Hopgang, which showed signs of necrosis.

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

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

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

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

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

2020: Only MarClim field work was completed due to Covid restrictions.

2021: Only MarClim field work was completed.

2022: All Skomer sites completed along with all MarClim sites.

The survey methods for each site completed in years 2003 to 2022 are shown in Table 3.

Table 3 Summary of survey sites completed 2003 – 2022. (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	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2005	MarClim	MarClim	Yes	Yes	Yes	Yes	No LS	Yes	Yes	Yes
2006	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2007	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2008	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2009	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2010	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2011	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2012	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2013	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2014	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2015	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2016	MarClim	MarClim	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
2017	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2018	MarClim	MarClim	Yes	Yes	Yes	No US / MS	Yes	Yes	Yes	Yes
2019	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2020	MarClim	MarClim	No	No	No	No	No	No	MarClim	No
2021	MarClim	MarClim	No	No	No	No	No	No	MarClim	No
2022	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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.

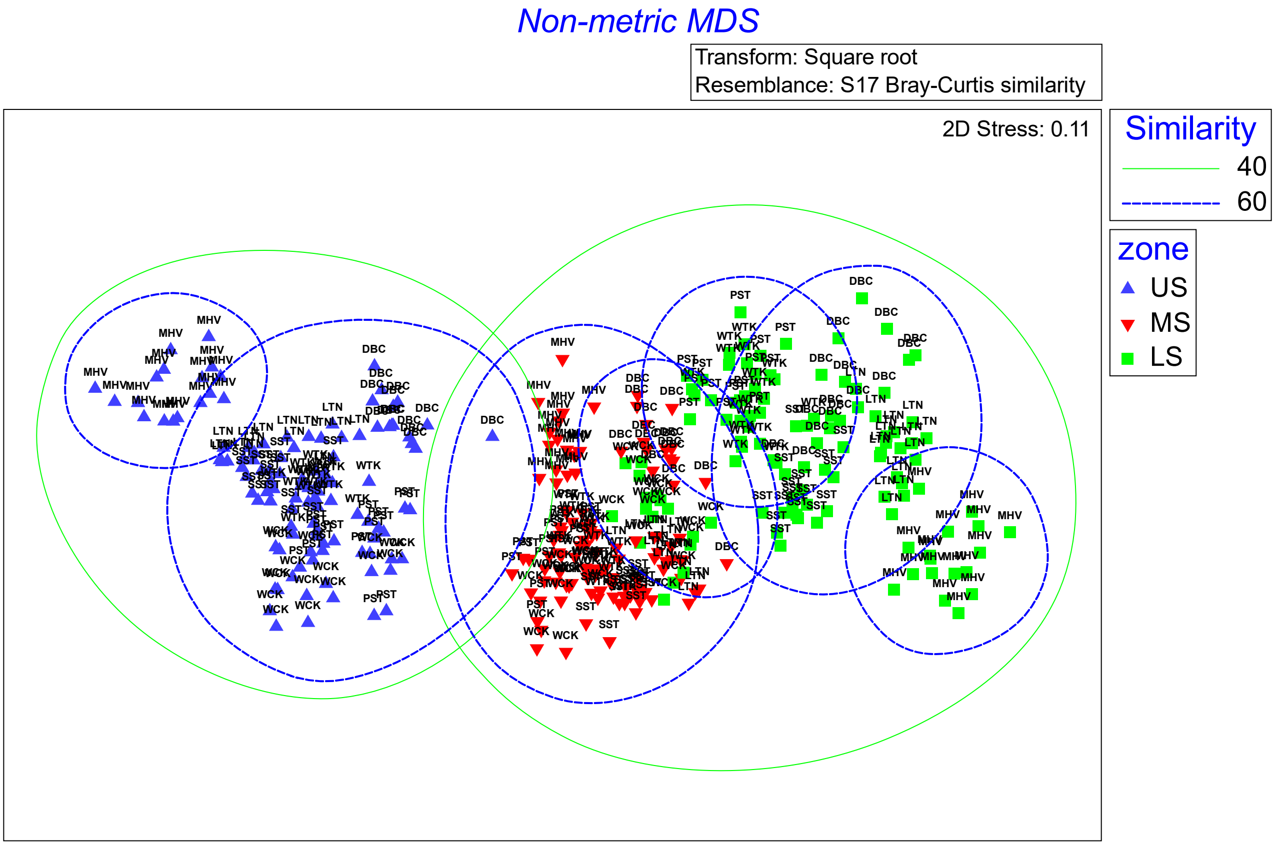
2012 did not show any major variations from the overall trends seen since 2004.

An "ANOSIM" test for differences between years showed no significant difference between any of the years. Sample statistic (R): -0.028 Significance level of sample statistic: 95%

The communities on the shores have not shown any major changes during the monitoring period 2003 to 2022. 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 2004 – 2022 (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 2022 the barnacle coverage showed little change (Figure 3).

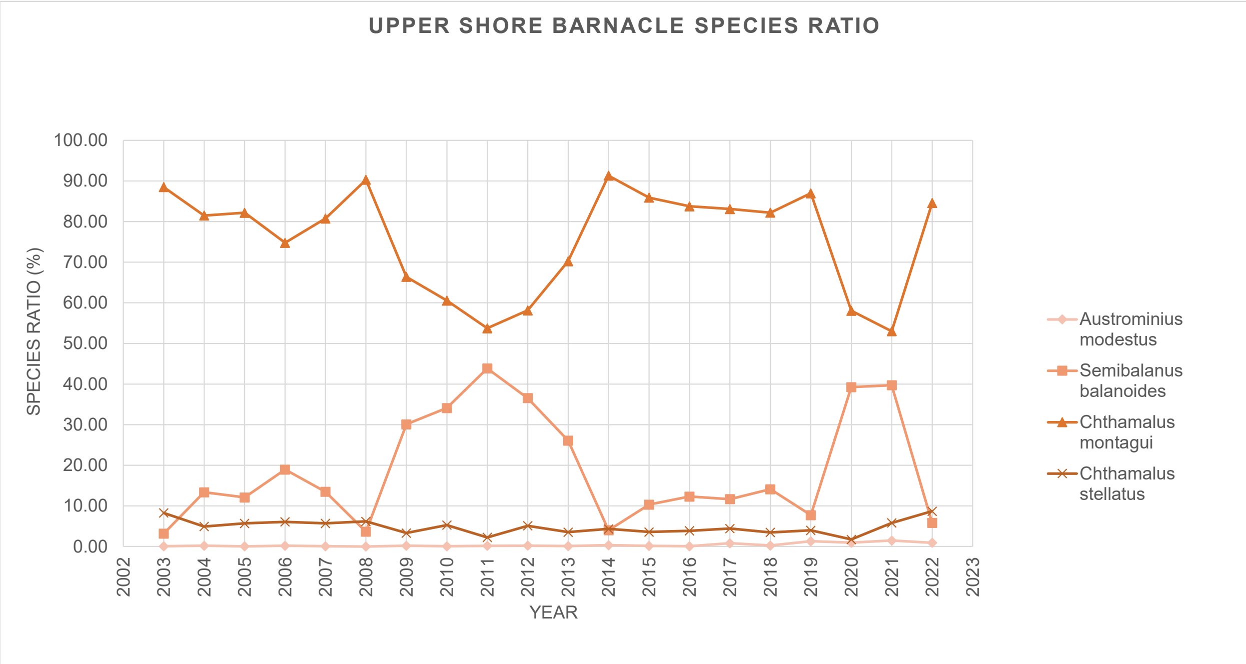
Figure 3 Changes in upper, middle and lower shore barnacle coverage 2003 – 2022, with standard error bars.

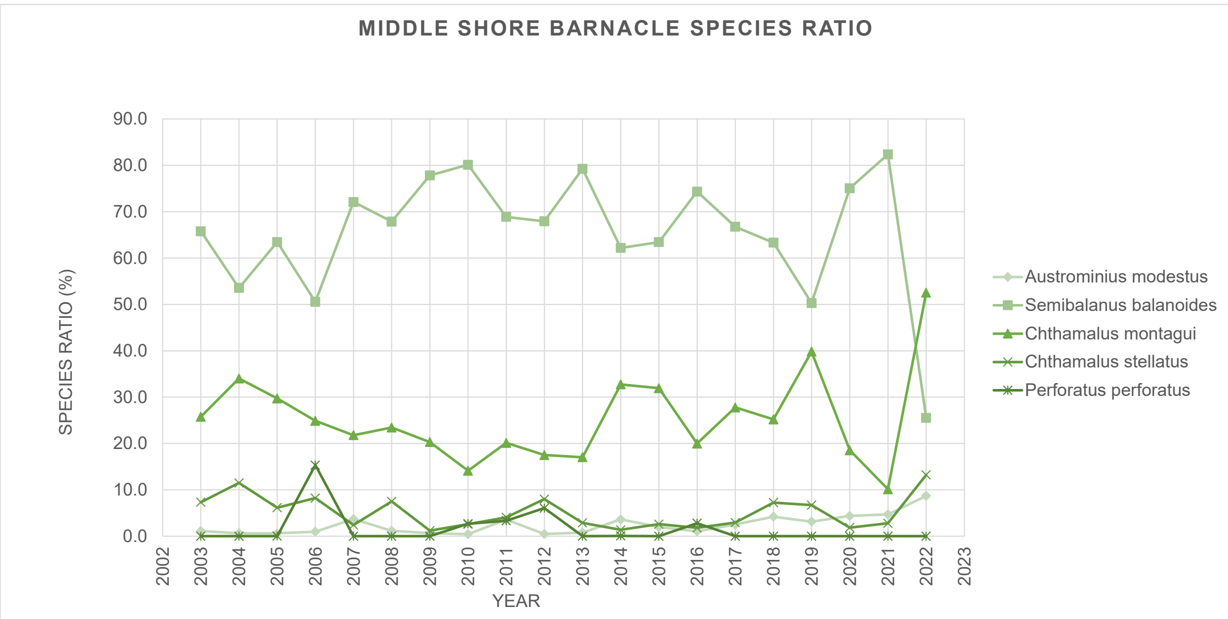
Barnacle Species Ratios

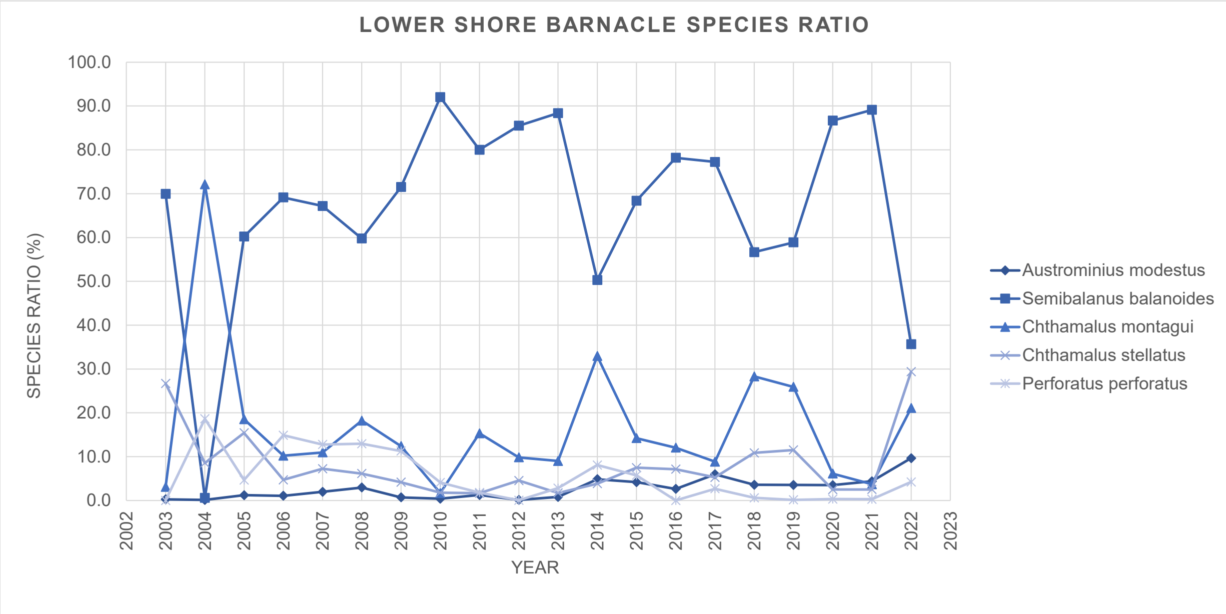
The barnacle species counts have been completed from the photographs of the 5 cm x 5 cm quadrats at the 3 MarClim Sites: Martins Haven, North Haven and South Haven (photographs taken at the other sites are stored for analysis when time allows).

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*. In 2022 there was another large shift in the species ratios with *S. balanoides* decreasing in all shore zones and *Chthamalus spp.* increasing (Figure 4).

Figure 4 Changes in upper, middle and lower shore barnacle species ratios 2003 – 2022.







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 – 2022 (per 0.04 m^2) with standard error bars.

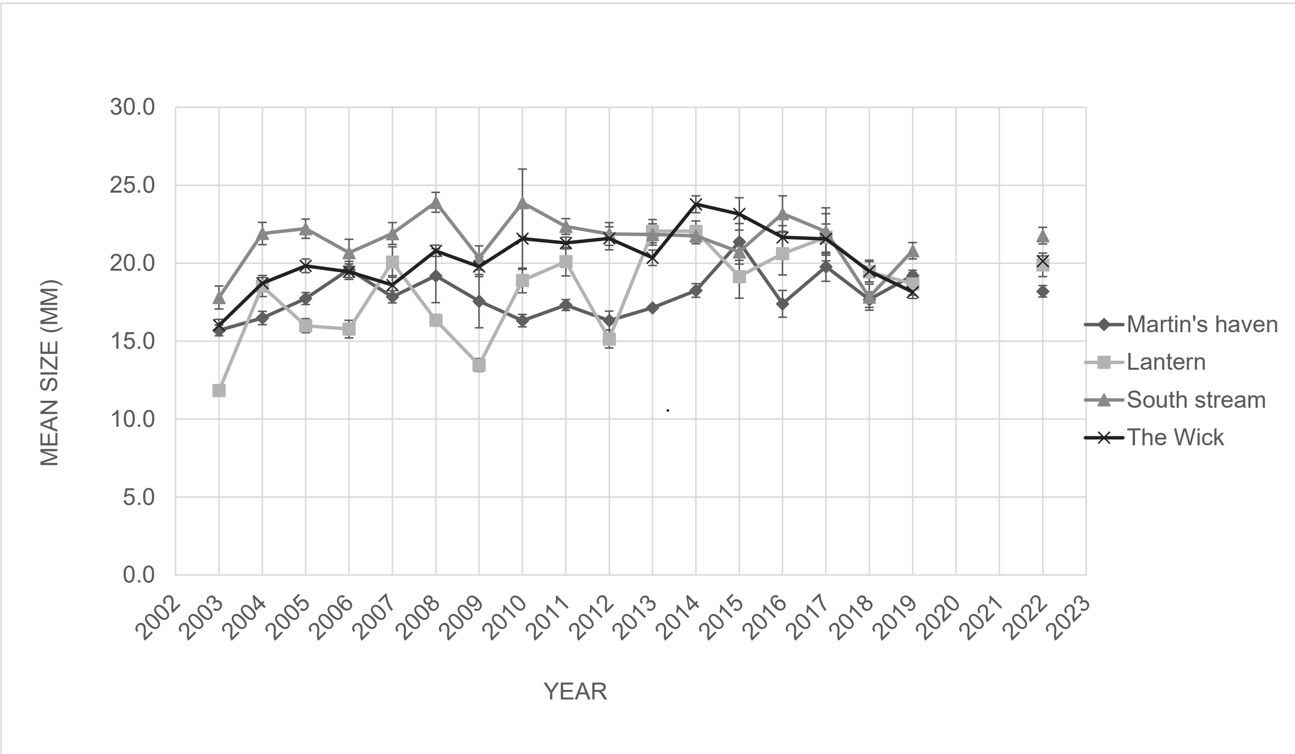
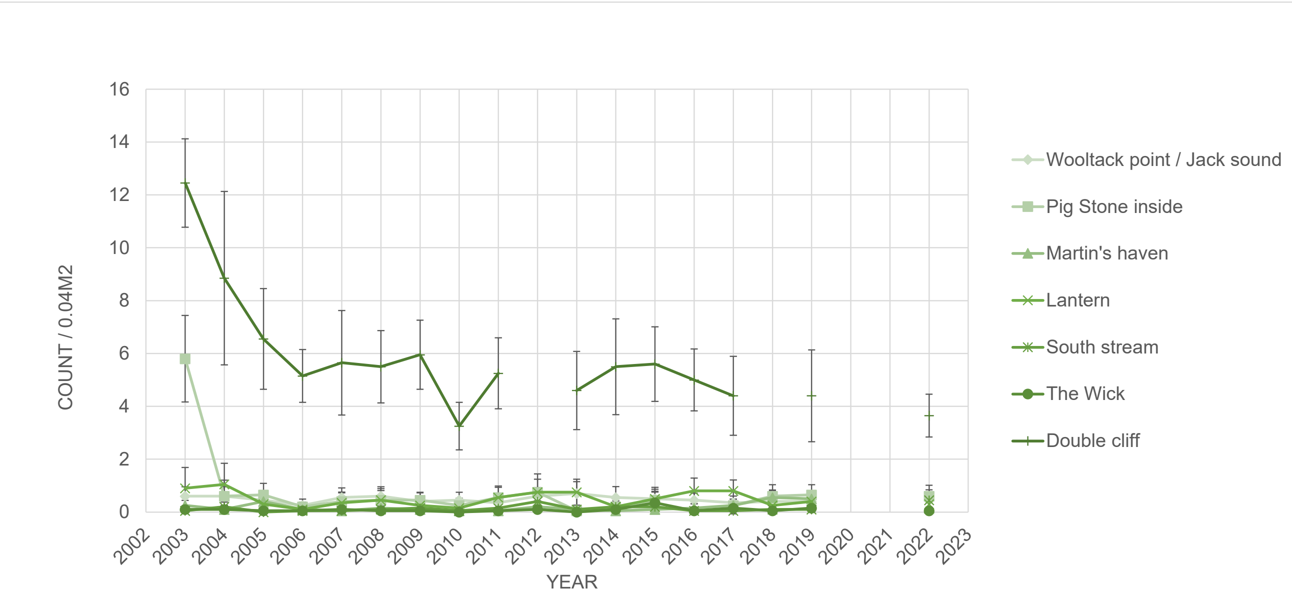


Figure 6 Changes in middle shore limpet counts 2003 – 2022 (per 0.04 m^2) with standard error bars.

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 - 2022 (per 0.04 m^2) 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 0.04 m^2. Double cliff upper shore was not surveyed in 2012, 2018, 2020 and 2021. 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 – 2022 using Species Thermal Midpoint (STM) values from Burrows (2016) (Figure 8).

The CTI scores for the 3 shores surveyed within Skomer MCZ show no significant change averaging a CTI of 11 -12°C which would match the ambient sea surface temperatures for the same period (Figure 9).

Figure 8 Community Thermal Index (CTI) Pembrokeshire MarClim shores 2002 – 2022, with standard error bars.

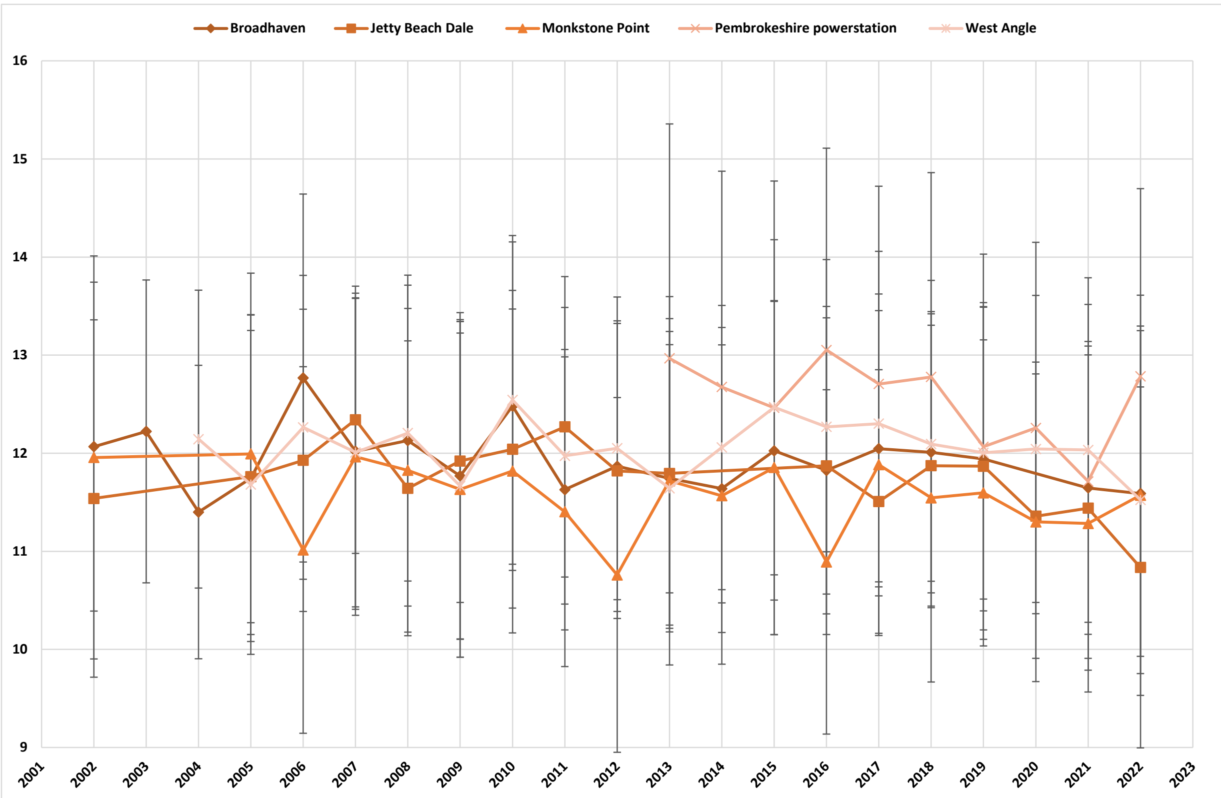
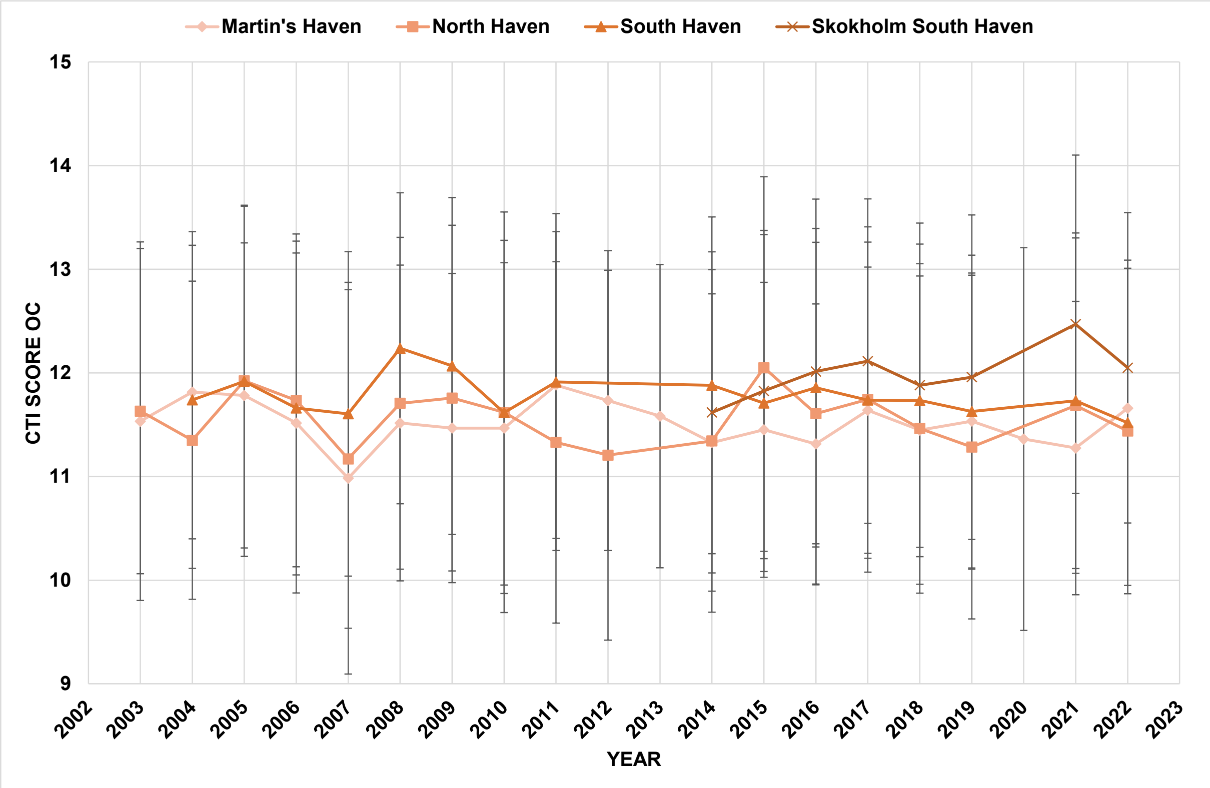


Figure 9 Community Thermal Index (CTI) Pembrokeshire MarClim shores. Skomer MCZ: Martins Haven - MHV, North Haven - NHV, South Haven - SHV 2002 – 2022 and Skokholm Island - SKH 2014 – 2022, with standard error bars.



Clingfish records (Lepadogaster lepadogaster)

Timed searches (3 min) have been completed at North Haven (NHV) and Martins Haven (MHV) from 2004 onwards. 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.

Figure 10 Average numbers of clingfish 2003 – 2022 at North Haven (NHV) and Martins Haven (MHV), with standard error bars.

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.

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 are demonstrably suitable for CTI calculation and this could provide added value to NRW by helping meet our statutory reporting responsibilities.
- Report littoral communities feature as stable.

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

4.2.4. Methods

Transects: Annually, photos are taken along four fixed transects at Thorn Rock. 1994 to 2008 photographs were taken from fixed positions along the transect using paired cameras set up on a 50 cm x 70 cm frame, in 2009, the cameras were replaced with a digital SLR taking high resolution images.

Sponge assemblages are classified into morphology types (Bell & Barnes 2001). This has proved to be a quick and simple method to analyse annual photographic datasets, as long as the four-yearly species “inventory” (see below) is used to check that there has been no undetected “drift” in species composition of the assemblage.

Species survey: Every 4 years species photographs are taken in the field and samples collected, where necessary, for spicule preparations and microscopic analysis to confirm identification.

In 2003, all sponge species were identified in sixteen 50 cm x 70 cm 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 (Table 5).

Seasonal survey from fixed quadrats: In 2005, fifteen 1 m^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 20 cm). 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 together to form a mosaic of the full 1 m^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 2022 photo quadrats taken at Thorn Rock (Table 4).

Table 4 Data gathered from Thorn Rock sponge transects 1993 to 2002. 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	All completed. - Digital SLR replaced 35mm slide film
2010	81	All completed
2011	82	All completed
2012	81	All completed- lots of surface sediment
2013	82	All completed
2014	83	All completed - poor visibility
2015	81	All completed
2016	83	All completed
2017	81	All completed
2018	80	All completed
2019	75	All completed
2020	0	No fieldwork
2021	78	All completed
2022	80	All completed. - New Digital SLR

Species surveys:

Table 5 presents the years sponge species surveys were completed at Thorn Rock, High Court Reef and Wick.

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

Samples have been supplied to the Natural History Museum (London) and National Museum Wales, to be stored as part of the national sponge collection.

Seasonal survey from fixed quadrats:

The quadrat survey has been completed annually from 2006 to 2019, no photos were taken in 2020 but resumed in 2021 and was repeated in 2022. Survey frequency varied between 1-3 survey events in a year depending on weather and resources to allow seasonal variability to be identified. Seasonal variability was successfully identified in the publication Berman *et al.* (2013), so it was decided to reduce the survey to once annually in September to concentrate on annual variability and reduce the amount of fieldwork required.

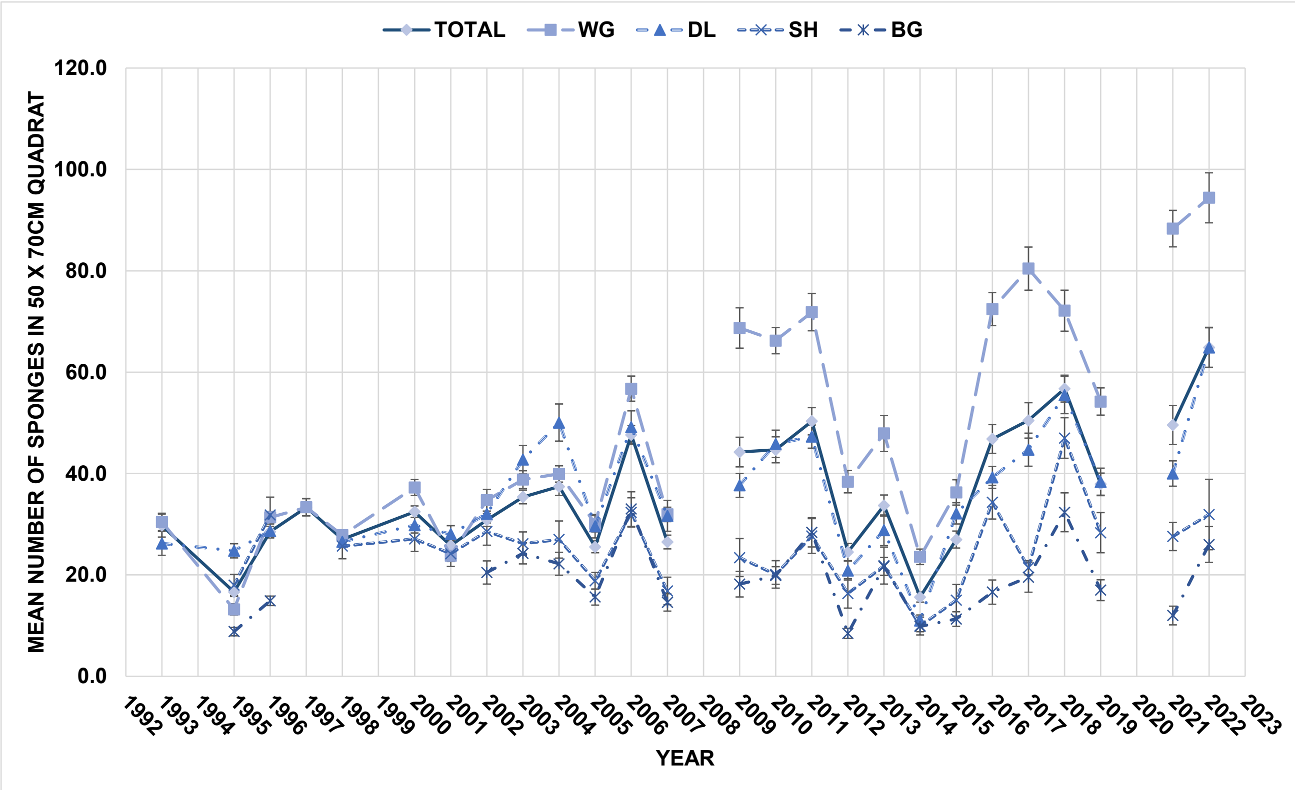
4.2.6. Results

Transects:

Sponge Morphology Analysis. This method has been used for all the quadrats taken at Thorn Rock, except the "seasonal survey" 1 m^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.

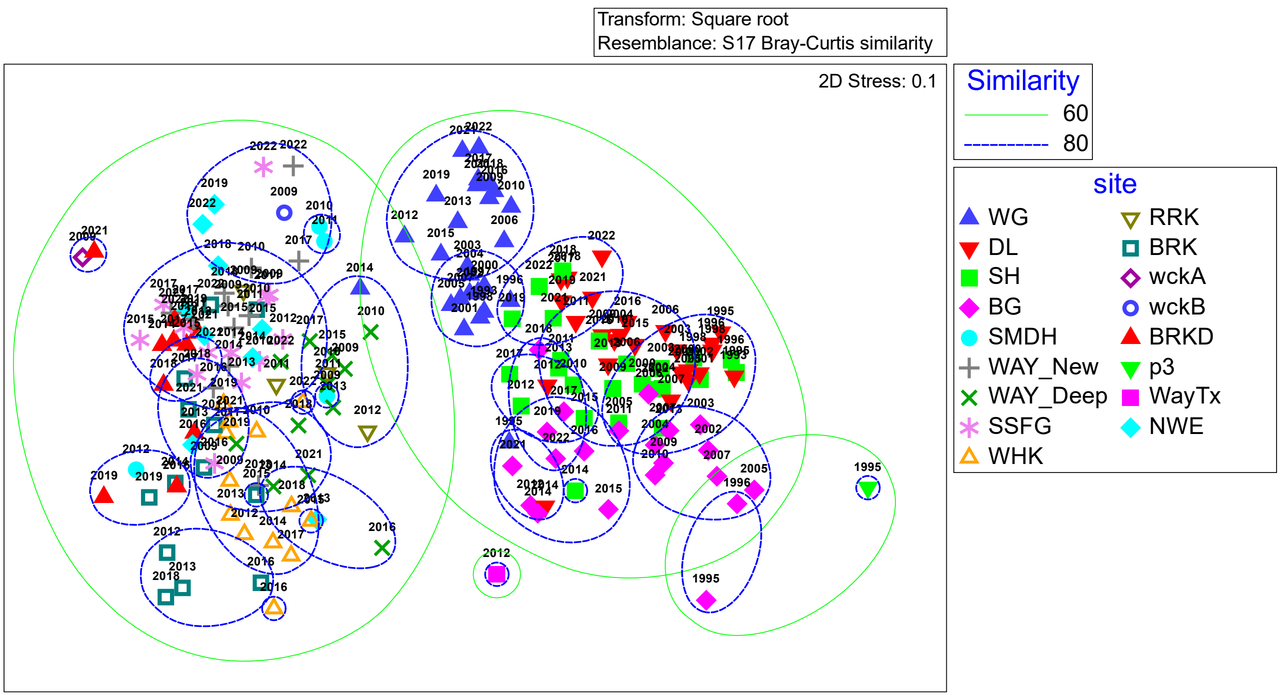
Improvement in image quality and resolution has meant that more sponge entities have been recorded from 2009 onwards compared to previous years. However, in 2012 and 2014 there was a noticeable drop in the numbers of sponges across all transects. In 2019 all sites decreased in abundance, despite good image quality and this lower number was again recorded in 2021. In 2022 a new digital camera with increased pixel resolution was used (sensor size: 6720 X 4480 pixels =1.54 increase in resolution compared to old camera) and the number of sponges seen increased in 2022. It was noted that small entities could be confidently identified in the new images. This may account for some of the increases seen in 2022. (Figure 11).

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).



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 – 2022.

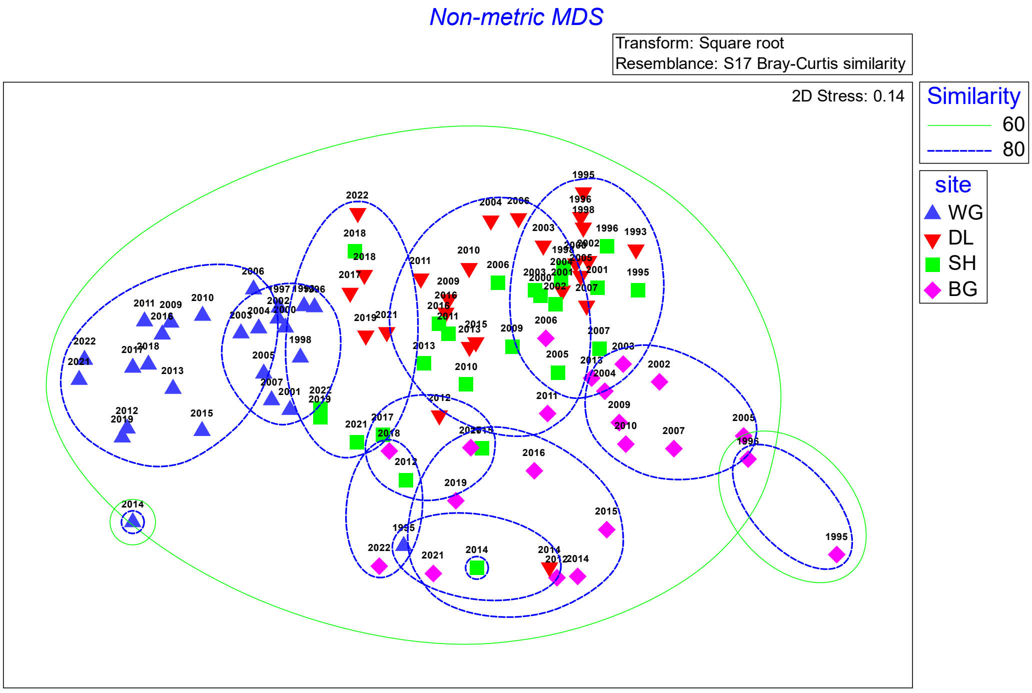


Site codes: WG,DL,SH and BG are all sites at Thorn Rock. All the other sites are located along the north side of Skomer island and the north Marloes peninsula.

In Figure 12 the Thorn Rock transects: Windy Gully (WG), 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: 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.
- 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.
- Report sponge community feature as stable.

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 chosen as it is near to the edge of its range and may act as an indicator of climatic change.

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.

E. verrucosa 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. Lusitanian species have become important indicators of climate change in the UK. It is reasonable to assume that species that are near the limit of their distribution will exhibit greater sensitivity to changes in the physical environment.

Damage can be caused through changes in water temperature, poor water quality and possibly from extensive entanglement in biota. Pink sea fans have 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 the 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 cm x 70 cm frame. Both sides of the sea fan are photographed.

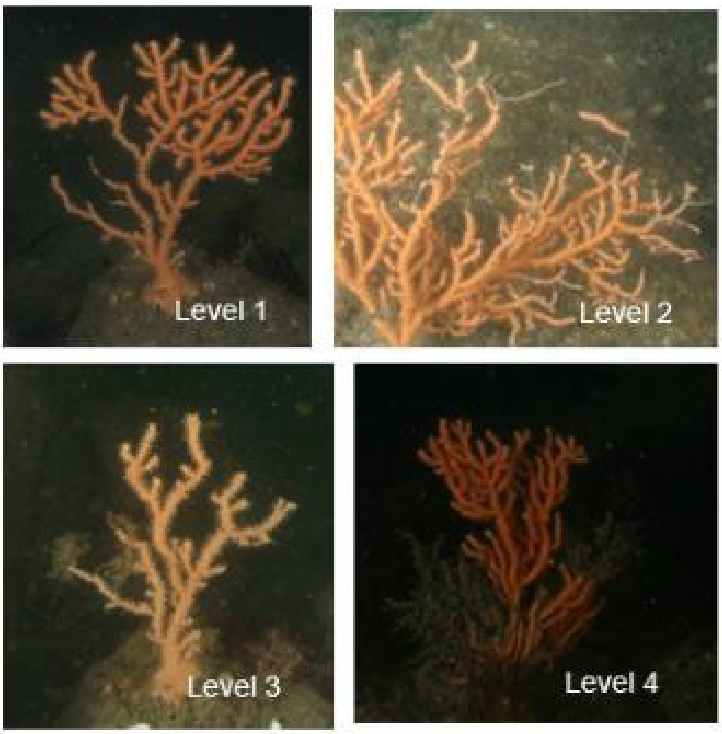
- Each sea fan is visually inspected for damage, fouling by epibiota, entanglement with man-made materials, necrosis (loss of living tissue) and the presence of predatory molluscs *Duvaucelia odhneri* and *Simnia patula*.
- Where practicable, and if enough polyps remain alive on the colony for it to 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 nudibranch *Duvaucelia odhneri* and mollusc *Simnia patula*.
- Missing sea fans are recorded, these are searched for the following year to confirm that they are losses.

Photo analysis allows 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. Necrosis is assessed on a level 1 to 4 rating (Table 7 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	Epiphytes 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 2022: 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 2022: To help understand potential causes of sea fan losses at Skomer MCZ, human activity data have 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. These data are available in the Skomer MCZ Annual reports 2018 – 2022. 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. The new method was applied to the full data set of sea fan photos.

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 -2022.

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	no data	no data	no data
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

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
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	91	89	2	0	0	0	0
2022	10	91	87	4	0	12		3
totals	**n/a**	**n/a**	**n/a**	**n/a**	**12**	**48**	**6**	**n/a**

Losses

A total of 48 losses of natural sea fans and 6 losses of artificially attached sea fans have been recorded throughout the period of this project.

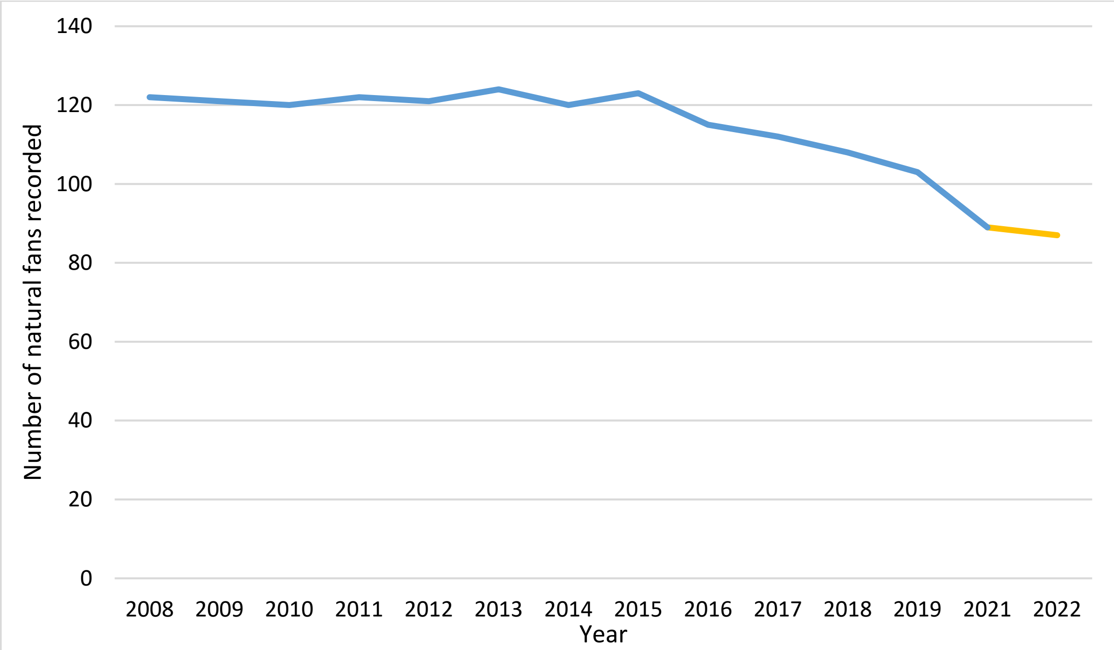
In 2021,16 fans were not found including the last 2 of the original 5 BHO baby fans. These were re-checked in 2022 and 12 fans: NWAe15, BHO10, BHO20, BHO24, BHO30, RRK8, BRK5, BRK6, SMD1, WAY15, WAY16 and 1 of the original 5 BHO baby fans were confirmed as losses. RRK15, BRK4, NWAe3 and 1 of the original 5 BHO baby fans were refound.

In 2022, 3 more fans were found missing, BHO11, MDS5 and RRK26, these will be checked, and their status confirmed in 2023.

Two broken off sea fans were found at Waybench site, these have been attached to ringbolts with cable ties and named WAY17 and WAY18. The two fans were both damaged and not recognisable as ones previously recorded.

The rate of 'natural' sea fan losses has increased in the last 8 years. In the seven year period from 2007 to 2014, the total number of natural sea fans recorded were between 120-124 fans. During this period 6 losses were recorded. Since 2015 the losses have increased, during the seven year period from 2015 to 2022 there have been 38 'natural' fans and 3 'artificially attached fans' confirmed as missing. A further 3 'natural fans' were absent in 2022, to be confirmed as losses in the 2023 field season (Figure 15).

Figure 15 Total number of natural sea fans recorded 2005 to 2021 and number of sea fans in 2022 (to be confirmed in 2023). Note: artificially attached sea fans not included in these data.



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, NWAe15 in 2021 and the cluster of 5 "new recruits" at BHO showed no growth in 12 years and in 2022 only one remained (Table 9).

Table 9 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 2022.
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 2022.
NWAe15	2005	Found below NWAe13. 3 branches in 2005 grown to 8 branches in 2018 and then reduced to 2 branches in 2019 no further growth seen in 2022.
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 between 2006 and 2019. Only 1 found in 2022.
RRK24	2006	Found next to RRK7. 5 branches in 2006 grown to 18 branches in 2022.
RRK26	2016	Found in gully close to RRK12. 2 branches. Not seen in 2022.
MDS7	2018	Found close to MDS 4 and 5. 6 branches.

Sea fan condition

All sea fan photos have been assessed for sea fan condition as follows:

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

Figure 16 Proportion of sea fans at Skomer MCZ entangled in *S. canicula* eggs.

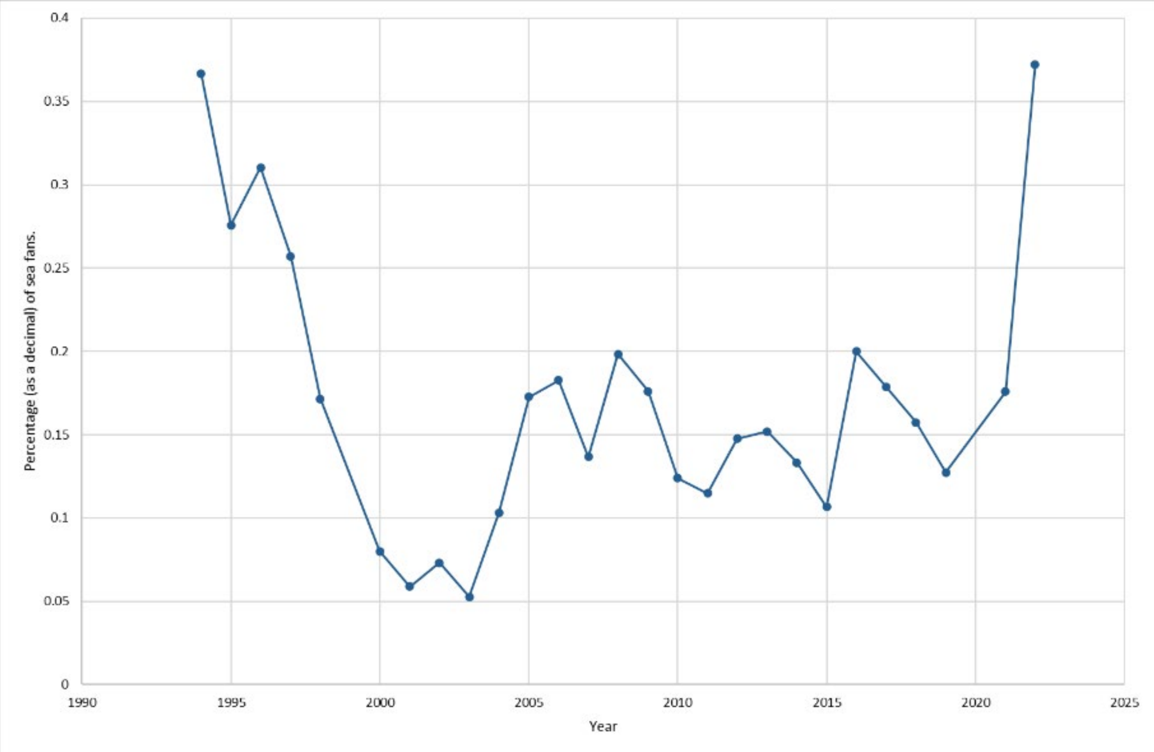
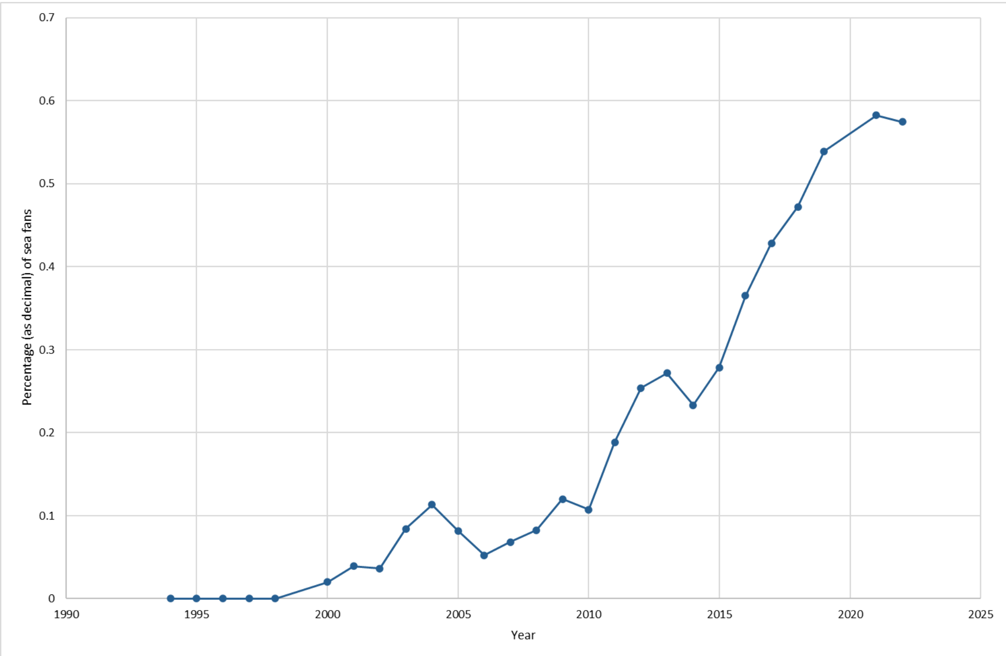


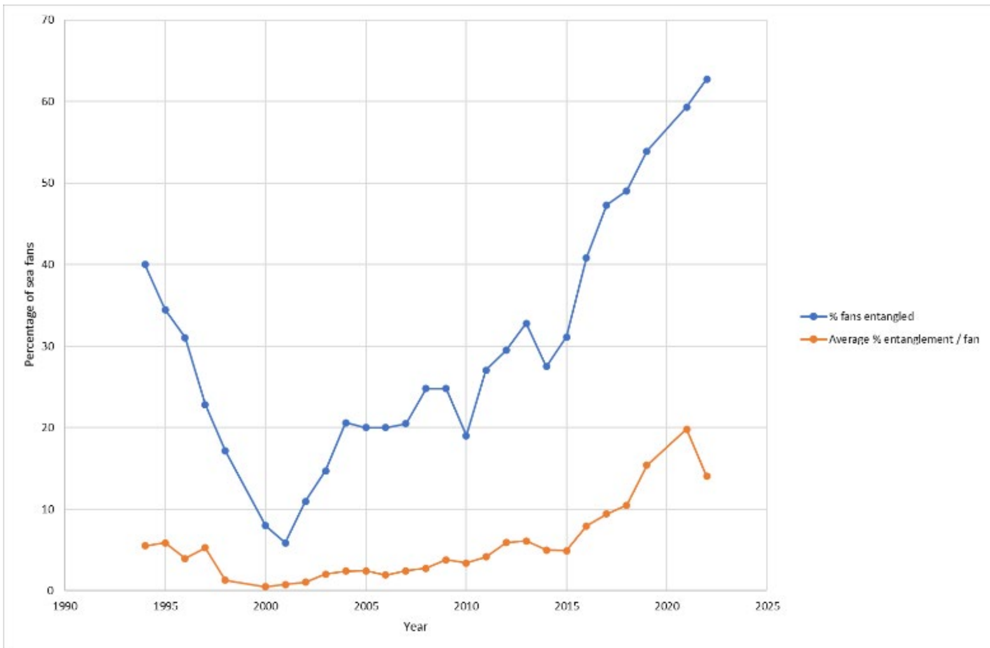
Figure 17 Proportion of sea fans at Skomer MCZ entangled in *S. stellaris* eggs.



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, an increase to 35% of fans was recorded in 2022 (Figure 16). *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 57% of sea fans recorded with these eggs in 2022 (Figure 17).

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, they can cause damage to the sea fan tissues (Figure 18).

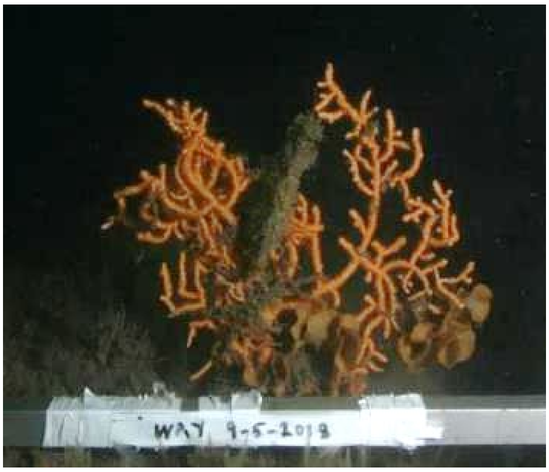
Figure 18 Percentage of sea fans at Skomer MCZ entangled in biota and the average percentage of entanglement per sea fan.



S. canicula eggs and *S. stellaris* eggs make up the bulk of the entangled biota and the pattern of entanglement is a reflection of the percentage of sea fans entangled in eggs as shown in Figures 16 and 17. There has been an increase in entanglement since 2011 from 27% to 62% of sea fans in 2022 (Figure 18, 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 19).

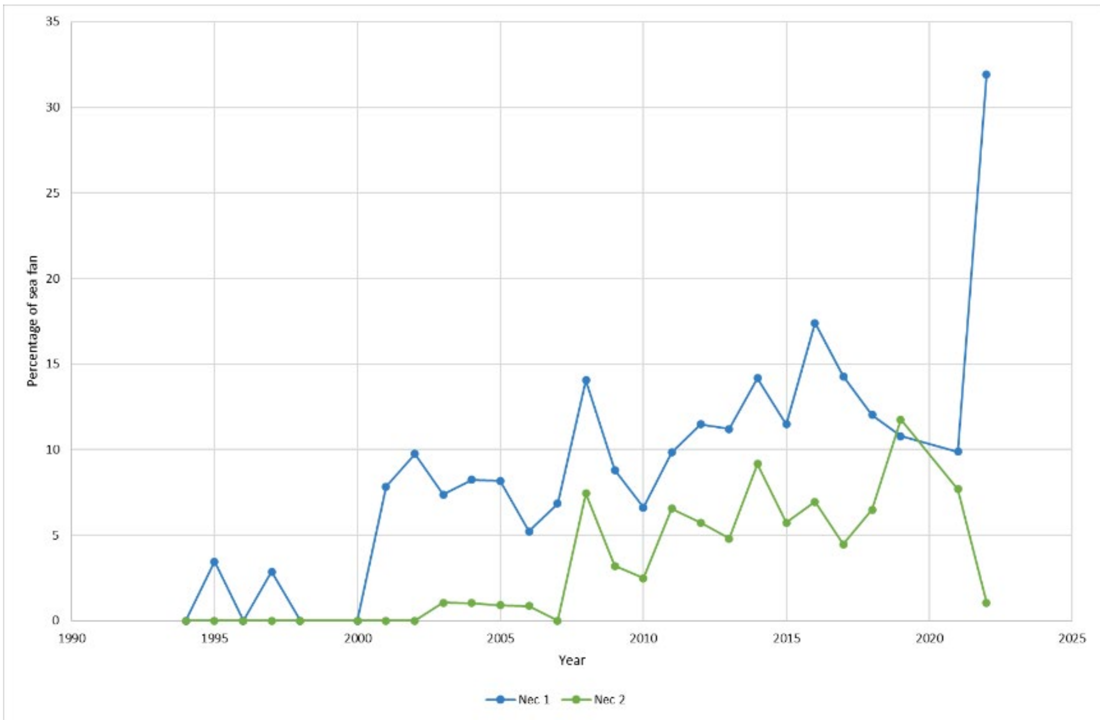
Between 1994 to 2015, those sea fans with entanglement averaged between 0.5 to 6% cover and in 2016 this increased to 8%. Since 2016 this increased each year reaching 20% in 2021 but dropping slightly to 14% in 2022 (Figure 18, bottom line).

Figure 19 Sea fan with *S. stellaris* egg covered in bryozoan turf and *Pentapora foliacea*, an epiphytic species growing on the sea fan (necrosis level 4).



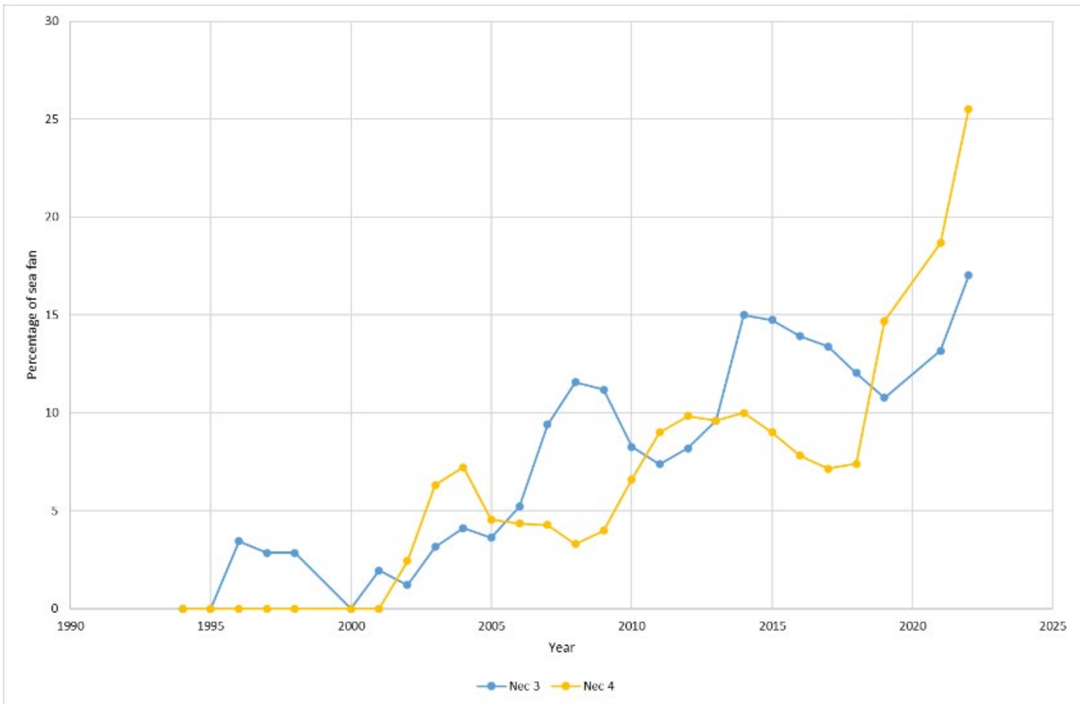
3. Necrosis is assessed for each sea fan and recorded on a scale from level 1 to 4 (Figure 14, Table 7), necrosis was recorded on 74% of sea fans in 2022. Both levels 3 and 4 have opportunistic epiphytes growing on the sea fan, which can include bryozoan, hydroids and small red algae. On occasion, bryozoan sea fingers *Alcyonidium diaphanum*, deadman's fingers *Alcyonium digitatum* and ross coral *Pentapora foliacea* have been recorded growing on sea fans.

Figure 20 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, this increased to 31% of sea fans in 2022. 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 2022 was only recorded on 1% of sea fans (Figure 20).

Figure 21 Percentage of sea fans at Skomer MCZ with necrosis level 3 and 4.

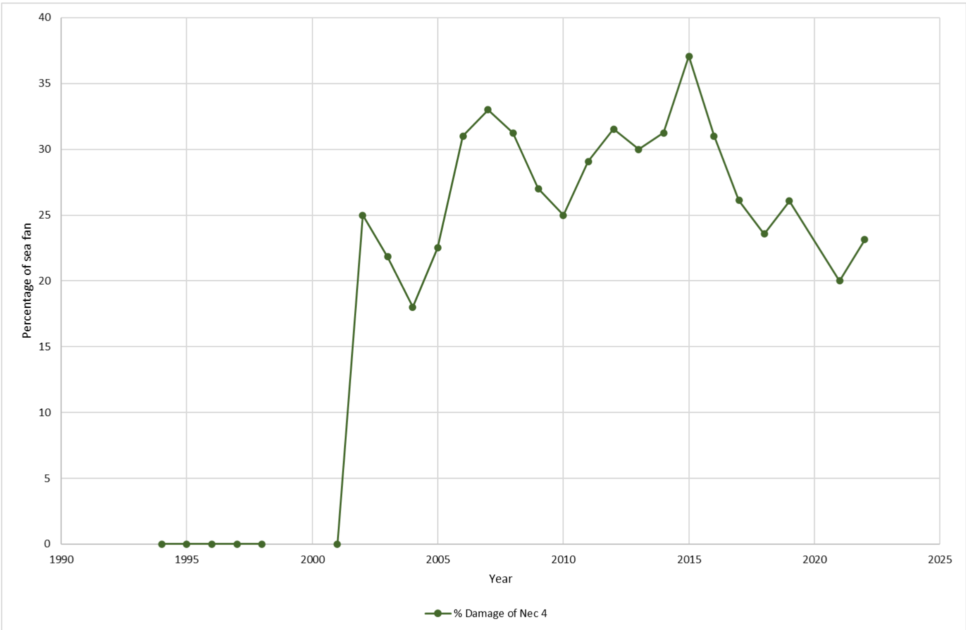


Necrosis level 3 (epiphytes growing on tips) was found on 0 to 5% of sea fans between 1994 and 2006 and since 2007 increased, varying between 7.3 and 15.3% of sea fans. 2022 saw the highest recorded percentage of level 3 necrosis at 17%. Necrosis level 4 (extensive areas of bare necrosis or epiphytes 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 18.6% of sea fans respectively. This increased again in 2022 to 25.5% of sea fans (Figure 21).

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 22).

Figure 22 Sea fan with 30% level 4 necrosis damage.

Figure 23 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 2022 was recorded as 23% damage per sea fan (Figure 23).

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 are recorded. Very low numbers of these species have been found over the years, none were recorded in 2022.

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 2022.

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).
- 2022 ongoing Exeter University: A programme of research has begun, 'Factors limiting marine connectivity at a species range edge – the case of the pink sea fan, *Eunicella verrucosa*'. Small clippings from some Skomer sea fans and photo data will be used to support this research.

4.3.8. Current status

- The 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 48 natural sea fans and 6 artificially attached sea fans confirmed as lost from the monitoring sites between 1994 and 2022. There are 3 further possible losses in 2022 to be confirmed. There were no new recruits recorded in 2022.
- Biota entanglement has increased on sea fans from 27% in 2011 to 62% in 2022. *S. canicula* eggs were found on 35% of sea fans and *S. stellaris* eggs were recorded on 57% of sea fans. Opportunistic species grow on the egg cases and on the tendrils, tightly entangled in the sea fan branches. For sea fans recorded with entanglement, the average percentage of sea fan area was 14% in 2022.
- Necrosis was recorded on 74% of seafans in 2022, of this 17% was at level 3 (epiphytes growing on tips) and 25% 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%. In 2021 it had increased to 20% and to 25% in 2022.

- 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 2022 was recorded as 23%.

4.3.9. Recommendations

- Report pink sea fan status as unfavourable, declining.
- 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;

4.4. *Alcyonium glomeratum* Population

4.4.1. Project Rationale

Alcyonium glomeratum (red sea fingers) is a Lusitanian species, common in the Mediterranean (Garrabou 1999), reaching its northern limit on the west coast of the UK near southern Scotland. Lusitanian species have become important indicators of climate change in the UK. It is reasonable to assume that species that are near the limit of their distribution will exhibit greater sensitivity to changes in the physical environment.

The population of *A. glomeratum* is a component of the Lusitanian anthozoan management feature of the Skomer MCZ, it is chosen as it may act as an indicator of climatic change. *A. glomeratum* is a component of the fragile sponge and anthozoan community habitat of priority importance under Section 7 of the Environment Act (Wales) 2016.

4.4.2. Objectives

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

4.4.3. Sites

Table 10 Red sea fingers site names and survey start date.

Site	Survey Start Year
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 cm x 40 cm) are photographed using stereo or high definition digital SLR photography.

All other sites: photographs (mono) are taken using a 50 cm x 70 cm framer using high definition digital SLR photography.

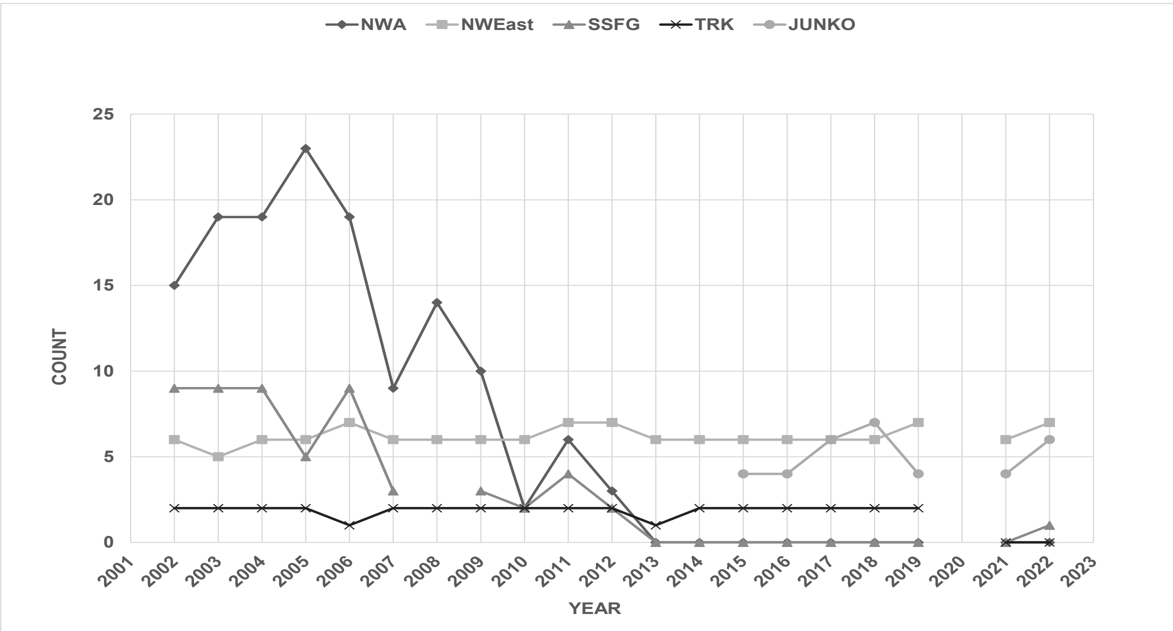
The colonies are gently “wafted” before photographing to make them retract in an attempt to control the variability in colony size. The images are analysed by overlaying a 5 cm x 5 cm grid and recording presence/absence of *A. glomeratum* within each grid square.

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

4.4.5. Results

Quadrat results for the following sites are shown in Figure 24 to Figure 27.

Figure 24 Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2022. : NWA = North Wall main, NWEast = North Wall east, SSFG = Sandy Sea fan gully, TRK = Thorn rock and JUNKO = Junko’s reef.



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. In 2022 one quadrat at SSFG did have small colonies present.

Alcyonium glomeratum mean frequency count

The declining trend or disappearance of *A. glomeratum* has continued at all sites (Figure 25).

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 4 cm squares) then presence counted for each square (Figure 26).

Figure 25 Mean frequency of *A. glomeratum* per quadrat Skomer MCZ 2002 – 2022.

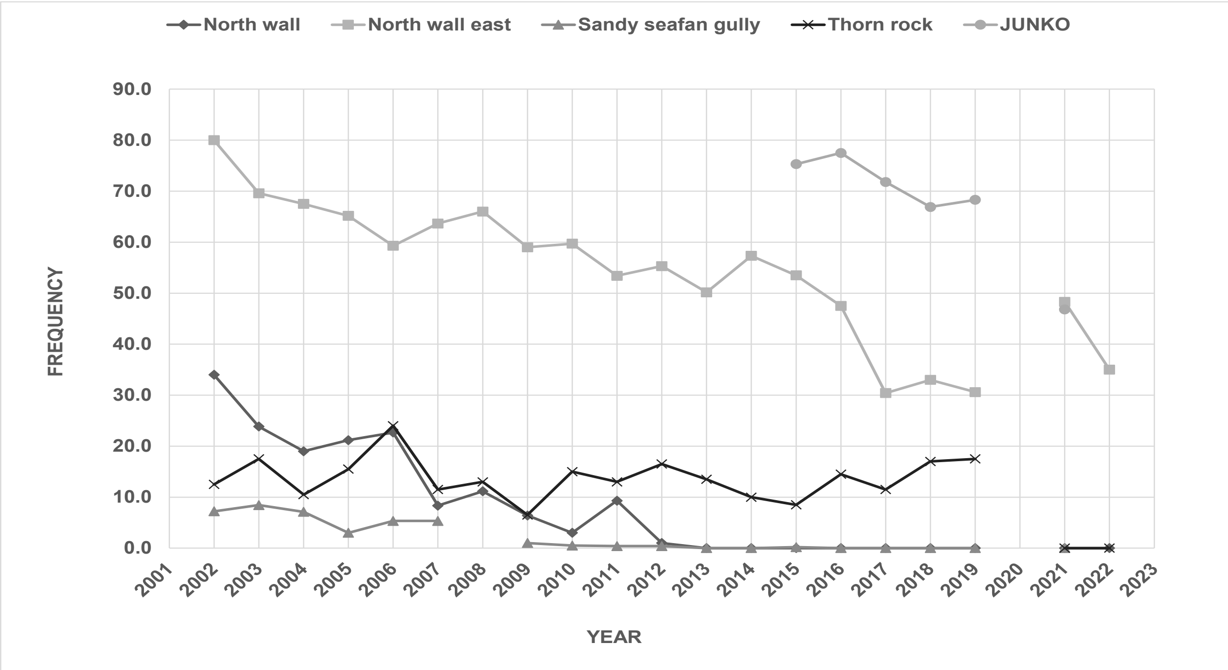
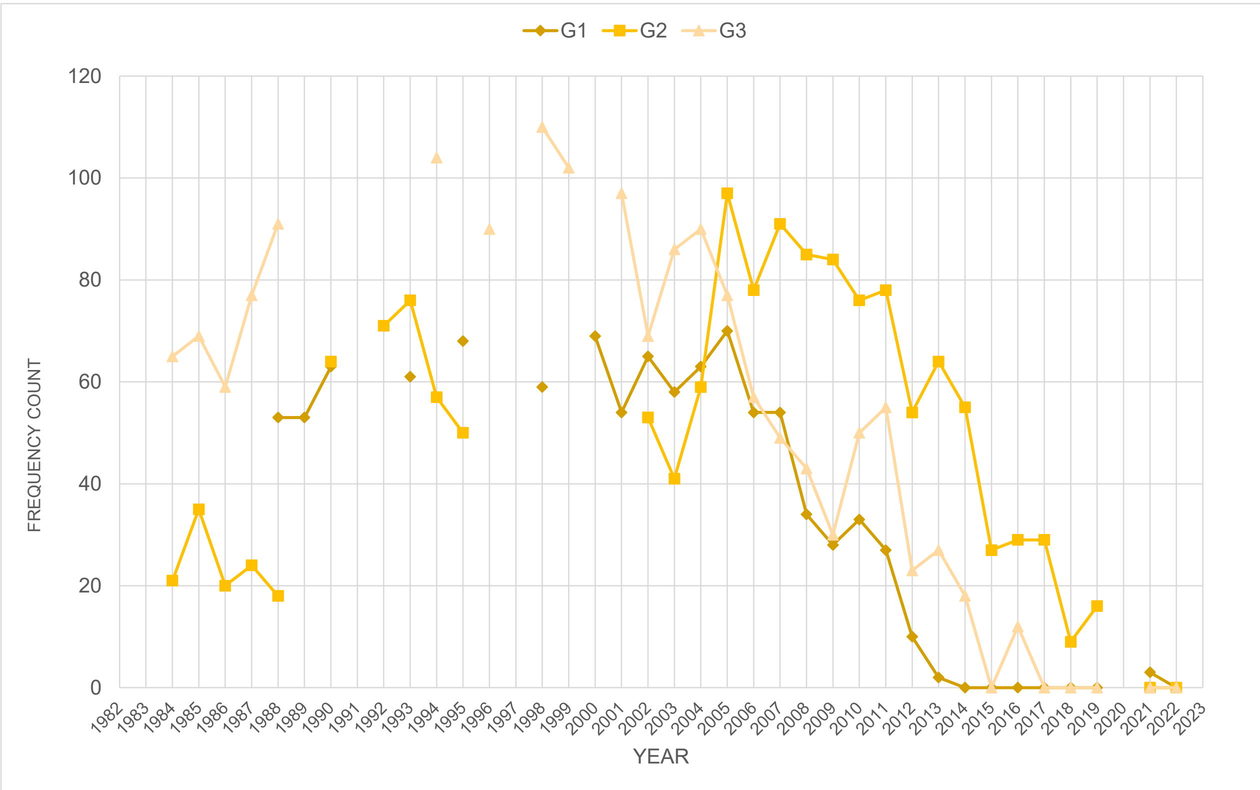


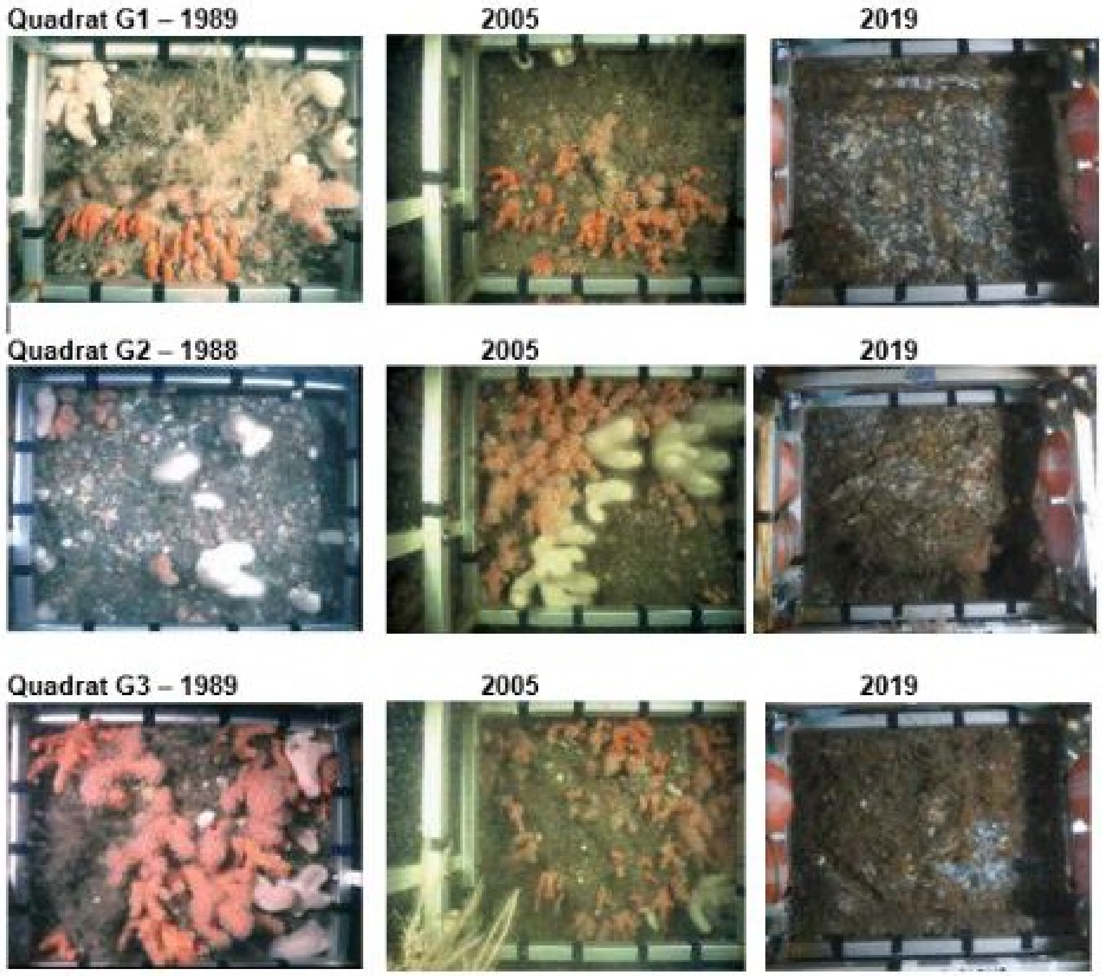
Figure 26 Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North Wall.



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 disappeared at this site.

Looking at the "then and now" photographs (Figure 27) it is interesting to note that *Alcyonium digitatum* (white deadman's fingers) has also reduced significantly in the three quadrats.

Figure 27 Photographic examples of declining populations of *A. glomeratum* at Skomer MCZ between 1989 and 2019.



4.4.6. Current Status

- The Lusitanian anthozoan assemblages feature for Skomer MCZ is in unfavourable conservation status due to a negative trend in *A. glomeratum* population. The abundance at the monitoring sites is declining: North Wall East and Junko's reef due 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

- Report *A. glomeratum* feature as unfavourable, declining.
- 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 Pembrokeshire Marine SAC.

4.5. *Parazoanthus axinellae* Population

4.5.1. Project Rationale

The yellow trumpet anemone, *Parazoanthus axinellae* (O. Schmidt 1862) is a colonial anthozoan found on inclined rocky substrata from depths of 5 m to 50 m.

P. axinellae forms dense aggregations of polyps that have an important role in the benthic community. Like many colonial organisms *P. axinellae* grows by repeated replication of structural units conferring the ability to asexually reproduce (fragmentation and fission) and inferring a high regenerative capability (Jackson 1977; Hughes & Cancino 1985). *P. axinellae* is thought to be able to reproduce sexually as well as asexually (Manuel 1988) but sexual reproduction is difficult to observe and identify in the field (Garrabou 1999).

P. axinellae is a Lusitanian species, common in the Mediterranean, reaching its northern limit on the west coast of the UK near southern Scotland (Garrabou 1999). Lusitanian species have become important indicators of climate change in the UK. It is reasonable to assume that species that are near the limit of their distribution will exhibit greater sensitivity to changes in the physical environment.

The population of *P. axinellae* is a component of the Lusitanian anthozoan management feature of the Skomer MCZ, it is chosen as it is near to the edge of its range and may act as an indicator of climatic change. *P. axinellae* is a component of the fragile sponge and anthozoan community habitat of priority importance under Section 7 of the Environment Act (Wales) 2016.

4.5.2. Objectives

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

4.5.3. Sites

Table 11 Yellow trumpet anemone sites names and survey start date.

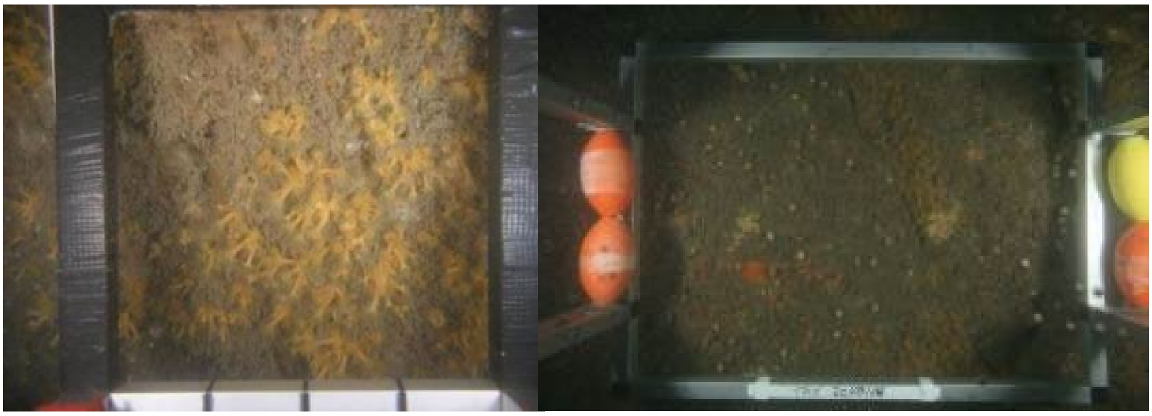
Site	Survey Start Year
Sandy Sea Fan Gully	2002
Sandy Sea Fan Gully Buttress	2015
Thorn Rock (3 colonies)	2002
Way Bench (2 colonies)	2002

4.5.4. Methods

Density Estimates: Close-up photographs are taken using a digital camera. The digital camera is mounted on a 20 x 20 cm framer. *P. axinellae* polyps are counted in each 20 x 20 cm quadrat (Figure 28, left).

Coverage of the Colony: A series of transects are placed through the colonies. Photographs are taken using a 50 cm x 70 cm 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 cm x 5 cm grid and recording presence/absence of *P. axinellae* within the grid squares (Figure 28, right). See Burton, Lock & Newman (2002) for details. In 2020 a new digital camera was used for the transect pictures which has an increased pixel resolution.

Figure 28 Left: density method using a 20 cm x 20 cm framer; and right: colony coverage method using a 50 cm x 70 cm framer.



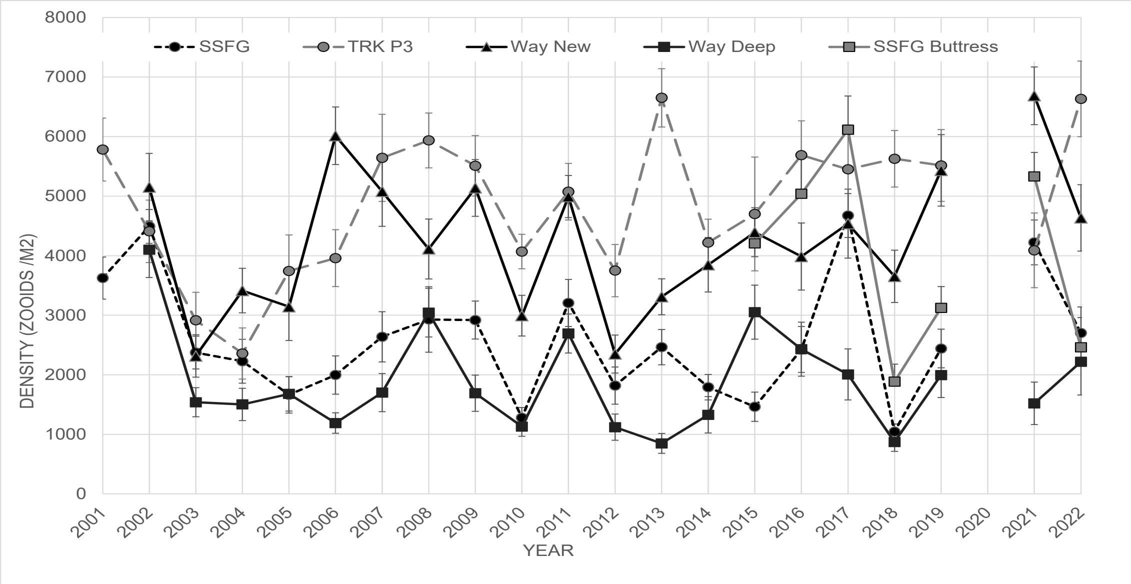
4.5.5. Results

Table 12 *Parazoanthus axinellae* fieldwork completed at Skomer MCZ in 2022.

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

The mean density of *P. axinellae* (number of polyps /m^2) at all sites has shown fluctuations from year to year, but overall there is no obvious trend (Figure 29).

Figure 29 Mean density of *P. axinellae* (number of zooids /m^2) at five Skomer MCZ sites 2001 – 2022 with standard error bars.



The frequency of *P. axinellae* at all sites has shown fluctuations year to year, but overall show a stable population. All sites showed an increase in 2022 (Figures 30 and 31).

Figure 30 Mean frequency of *Parazoanthus axinellae* 2002 – 2022. Thorn Rock (TRK) transects.

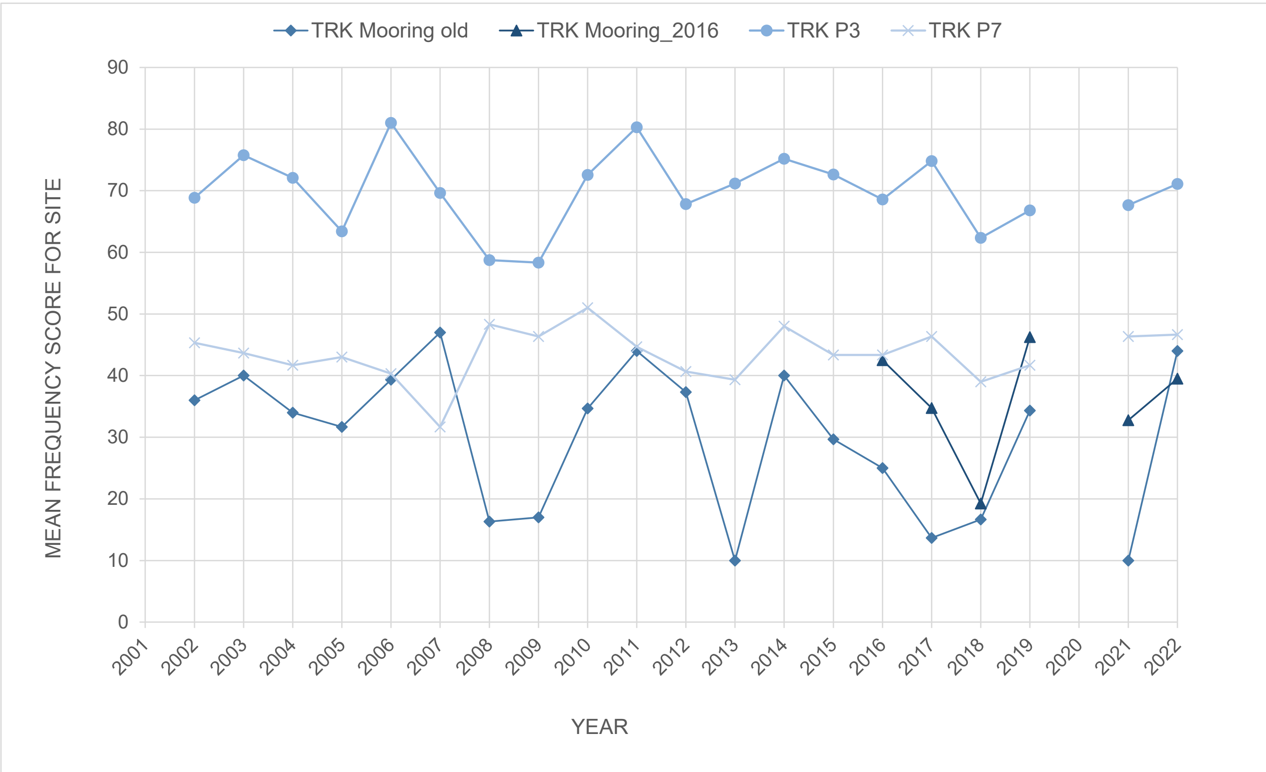
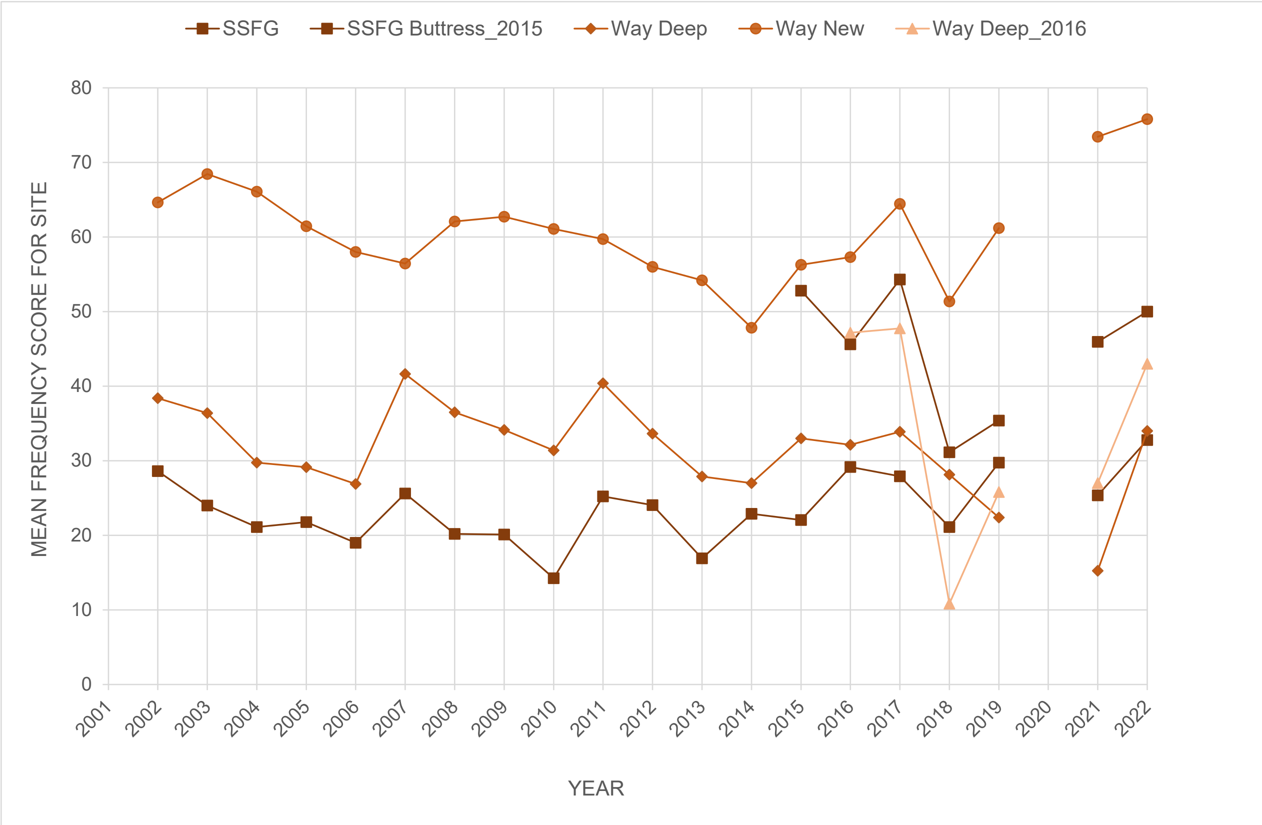


Figure 31 Mean frequency of *Parazoanthus axinellae* 2002 – 2022. Waybench and Sandy sea fan gully transects.



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 *P. axinellae* feature as stable.

4.6. *Pentapora foliacea* (ross coral) Population

4.6.1. Project Rationale

Pentapora foliacea forms fragile (brittle) colonies ranging in size from single 'flakes' to those over 1 metre wide and is considered regionally important at Skomer MCZ. Larger colonies are ecologically important, acting as micro-habitats, and colonies are known to harbour a large number of species including larval forms of commercially important species.

Colonies are vulnerable if subjected to changes in environmental conditions, elevated levels of chemical pollutants, suspended sediments and seabed sedimentation, and physical damage by natural events and/or anthropogenic activities. As such, they are regarded as useful indicators of disturbance. The level of potential damage and recovery is dependent on the health, growth, recruitment and robustness of the current population. They were selected as a management feature of the Skomer MCZ and are 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 13 *Pentapora foliacea* monitoring sites at Skomer MCZ in 2022.

Site	Substrata	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 along marked transects at each site following detailed site proforma. Photographs are taken using a 50 cm x 70 cm framer. In 2008 a digital SLR camera replaced the film camera providing high quality images allowing improved photo analysis.

Photo analysis is completed using morphological classification. Class 1 (single flakes) to class 4 (20 cm 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 32).

Figure 32 *Pentapora foliacea* - examples of Class 4 (top) and Class 5b (bottom) colonies.

4.6.5. Project History

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 800 cm^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 al.* 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 the 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.

4.6.6. Results

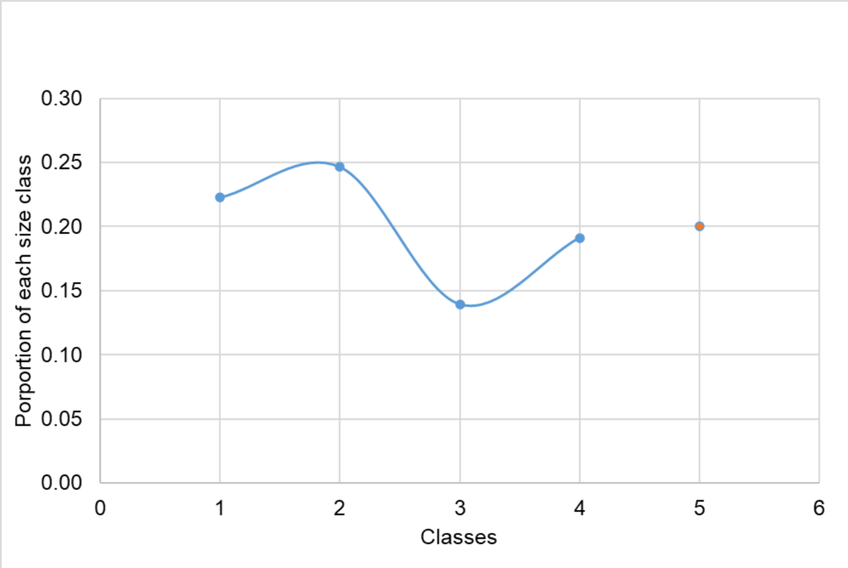
Photo datasets collected each year for each survey sites are shown in Table 14.

Table 14 *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
2022	no	yes	yes	yes	yes	yes	yes	yes	yes

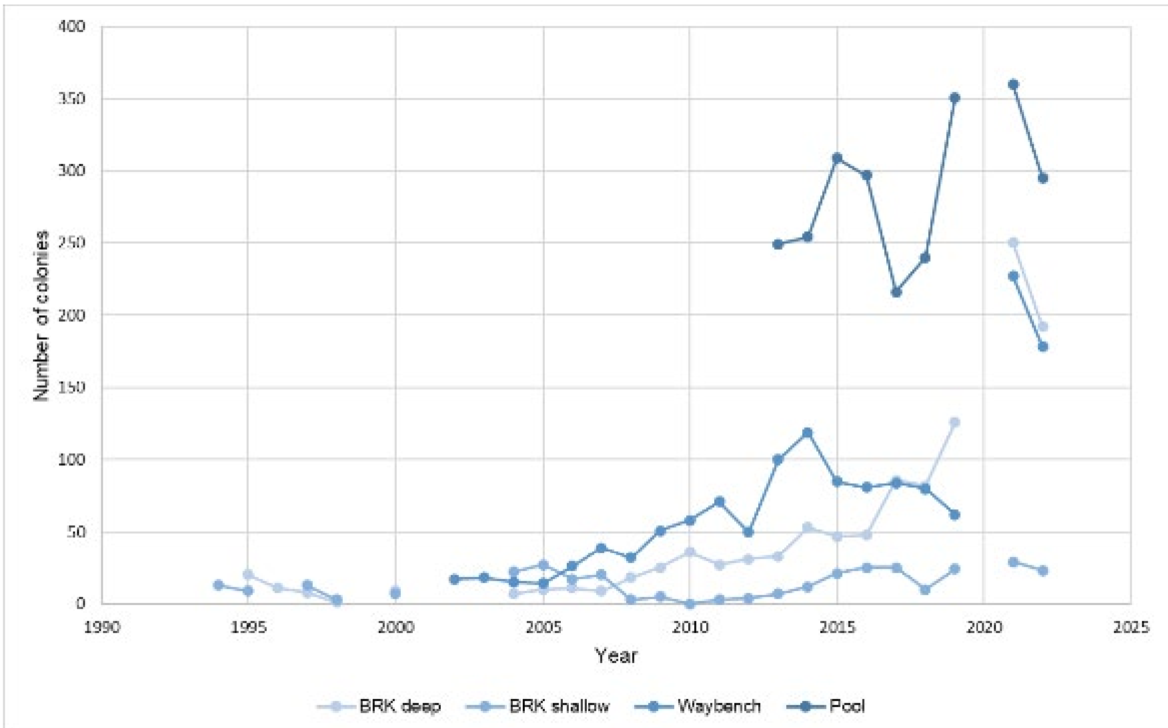
The normalised population curve in Figure 33 shows the proportions of each size class (1-4) across all Skomer sites and gives an overall pattern of size-class distribution. Class 5 is not connected via the curve as it is not a continuum from class 4 but is related to degradation which can develop directly 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 33 *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 34. The total numbers recorded at each of these sites increased between 2019 and 2021, but a slight drop in numbers was observed in 2022.

Figure 34 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 and this remained high with 178 colonies recorded in 2022 (Figure 34).

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 2022, 23 colonies were recorded at the shallow site, similar to previous years (Figure 34). 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. In 2022 numbers of colonies remained high with 192 recorded (Figure 34).

The Pool monitoring was started in 2013, located on the north side of Skomer. The site is a boulder slope from 10 m down to 22 m 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, in 2022 the numbers of colonies remained healthy with 295 recorded (Figure 34).

North Neck, South Middleholm, West Hook and Martins Haven East represent small area sites.

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.

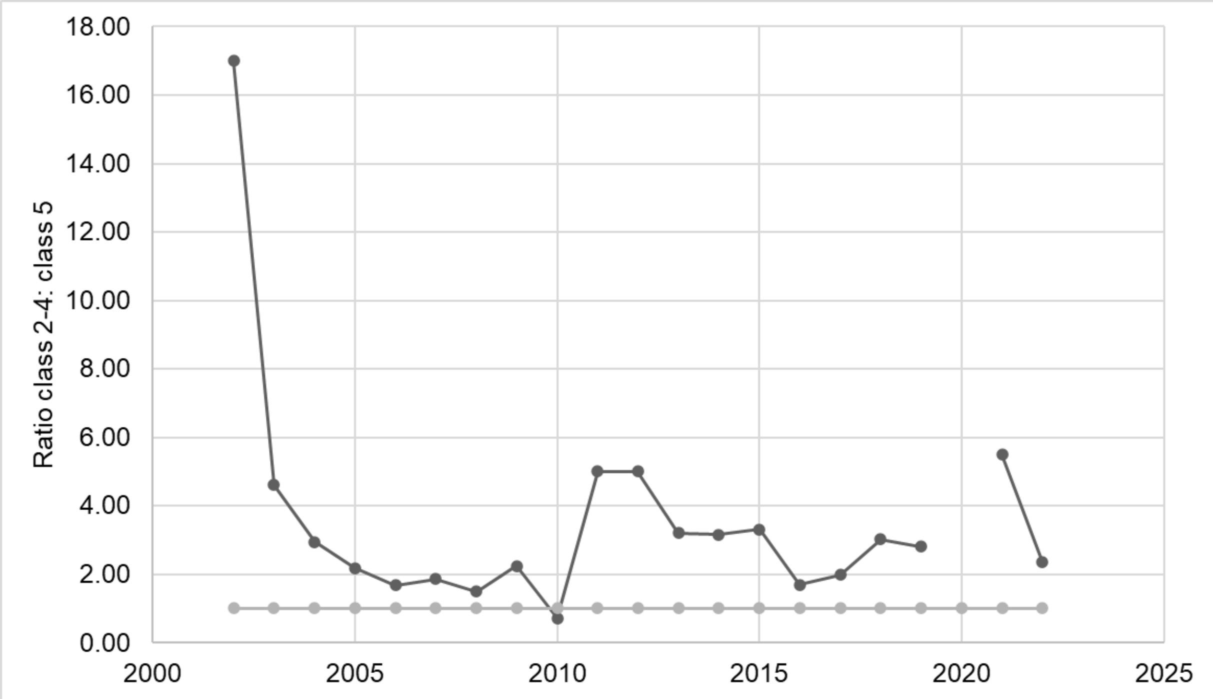
South Middleholm is a small bedrock site on the south side of the island and subjected to the prevailing south-westerly swell. Class 1 to 3 individuals are the most common, with very few developing into class 4, instead developing directly to class 5.

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 2022 is shown in Figure 35. 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 35), therefore there are more healthy growing colonies than degraded colonies.

Figure 35 *Pentapora foliacea* - ratio of class 2-4 colonies to class 5 colonies - all Skomer sites.



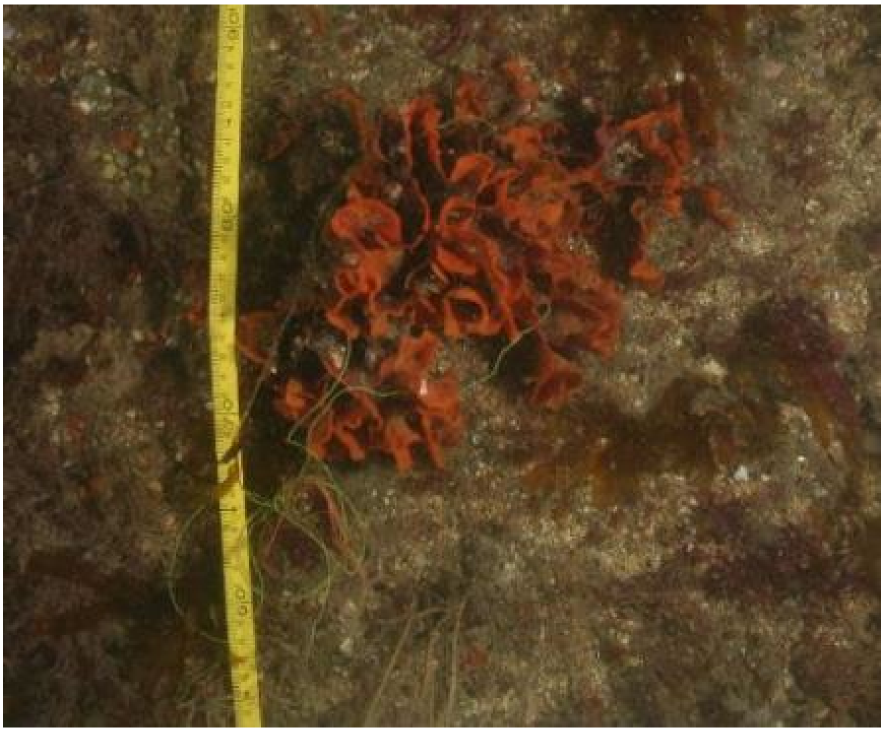
The current dataset forms an important baseline for Skomer sites. However, it needs to be remembered that all sites are currently subject to anthropogenic activities including pot fishing, angling and recreational diving, which all have the potential to harm *P. foliacea* colonies.

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 seabeds (Figure 36).

Figure 36 *Pentapora foliacea* – interaction with fishing gear.

Evidence of damage from angling line was also observed in 2021 and 2022 tangled in *P. foliacea* at the new Martins Haven east survey site, this location is popular with shore angling (Figure 37).

Figure 37 *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 – 2022. [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

- At the largest survey sites: Waybench, Pool and Bernies Rock an increase in total numbers of colonies (all classes) were recorded in 2021, this dropped in 2022 but still remained high compared to previous years.
- 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.
- 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 *P. foliacea* feature 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 — *B. regia* 1984 to current and *C. smithii* 1993 to current
- The Wick — *B. regia* 2002 to current

4.7.4. Methods

Balanophyllia regia

1. Thorn Rock*:* The 'Rockmill' with 5 quadrats and a single boulder quadrat was established in 1984 and since 2004 has been photographed with the digital SLR fixed to a 50 cm x 40 cm framer. In 2013, 2 new transects were set up with a combined 16 quadrats.
2. The Wick: Three transects with 51 quadrats were established at the Wick in 2002. A 50 cm x 40 cm framer was used up until 2008 when it was replaced with a larger 50 cm x 70 cm framer using a digital SLR camera.
3. Counts are carried out using image analysis techniques described in Burton *et al.* (2002).

Caryophyllia smithii

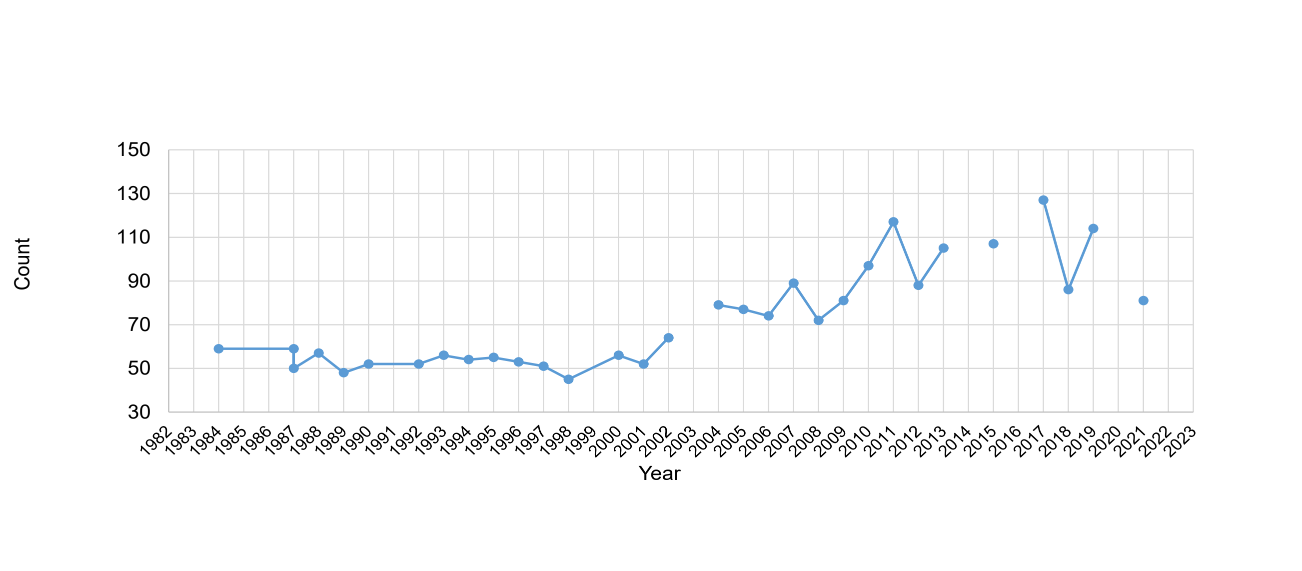
Approximately 70 quadrats have been analysed on an annual basis since 1993 from photographs taken for the sponge community project at Thorn Rock. Photographs are taken using a 50 cm x 70 cm framer using a digital SLR camera and counts are carried out using image analysis techniques described in Burton *et al.* (2002).

4.7.5. Results

Balanophyllia regia

At Thorn Rock individual *Balanophyllia regia* have been traced for 30 years in a single fixed-position 40 cm x 50 cm quadrat. Numbers have shown a general increase between 1998 and 2021 (Figure 38), which suggests recruitment could have occurred. Variability in abundance counts can occur due to changes in surface sediment which obscures small individuals.

Figure 38 Thorn Rock *Balanophyllia regia* counts (within a single 40 cm x 50cm quadrat).



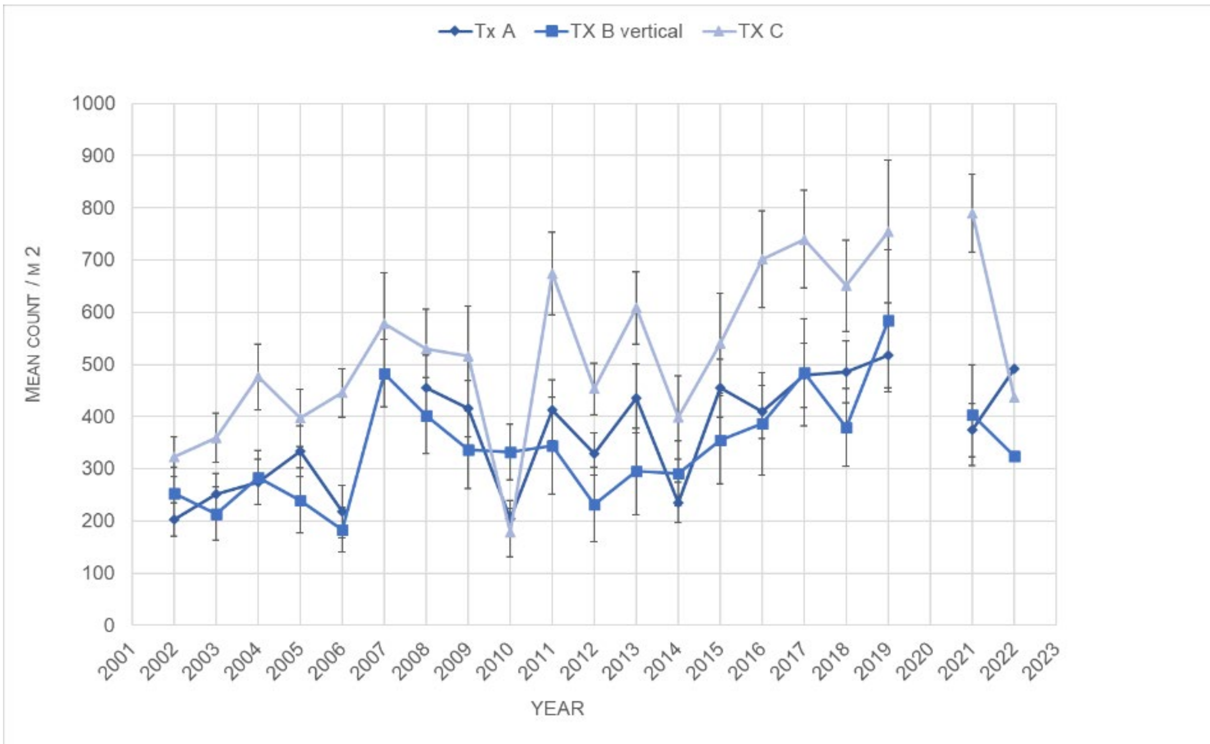
Thorn Rock Mill and transect data have been standardised abundance per 1m^2 to enable comparison between the 50 cm x 40 cm and the 50 cm x 70 cm framers (Figure 39).

Figure 39 Mean abundance per metre^2 (and standard error) of *Balanophyllia* regia at Rockmill and Transects at Thorn Rock (counted within 50 cm x 40 cm framers).

The average count/m^2 of *B. regia* has fluctuated at the Rockmill, variability is most likely due to a combination of dense covering of algae obscuring the corals and thick coverings of silt at the site from time to time. Years with data missing are due to poor photographic conditions. An increase in numbers has been recorded over the last ten years with highest counts to date in 2022 when high photo quality was obtained with clear images of the corals. The average count/m^2 of *B. regia* at the transects is lower than that at Rockmill, further data are needed to monitor trends.

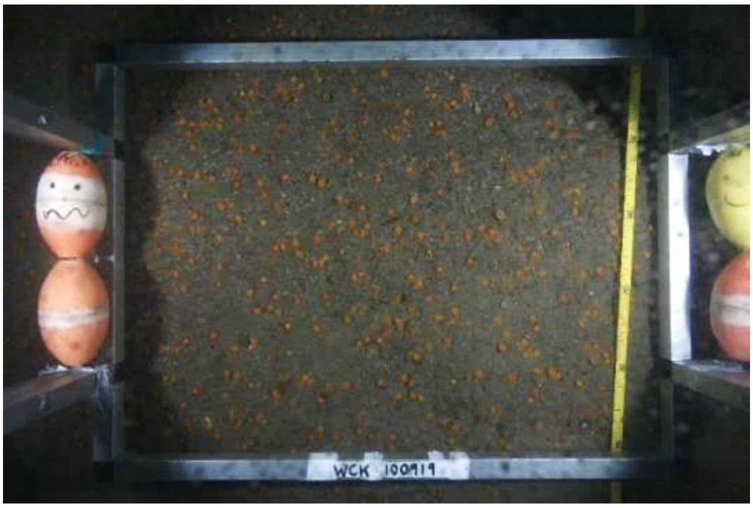
At the Wick, all data have been standardised abundance per 1m^2 to enable comparison between the 50 cm x 40 cm and the 50 cm x 70 cm framers.

Figure 40 Mean abundance per metre^2 (and standard error) of *Balanophyllia* regia at Transects A, B and C at the Wick, counted within 50 cm x 40 cm framers (pre-2008) and 50 cm x 70 cm framers (since 2008).



The average count/m^2 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 cm x 70 cm framer (1546/m^2) (Figure 41).

Figure 41 *Balanophyllia regia* (individuals 541) in 1 50 cm x 70 cm framer at the Wick, representing a density of 1546/m^2.



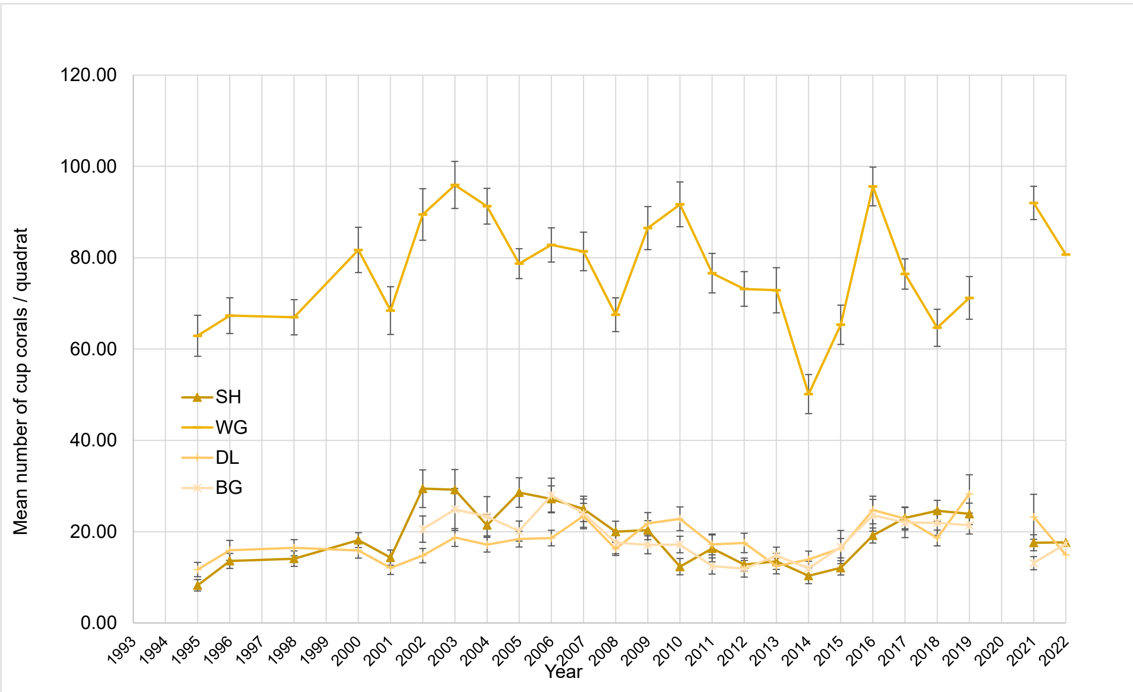
Caryophyllia smithii

The average density of *C. smithii* has fluctuated at each of the Thorn Rock sites (Figure 42). 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 41). 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 has 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)) nor what variability in their numbers would be natural.

Figure 42 Mean Number of *Caryophyllia smithii* /m^2 quadrat at Thorn Rock (4 transects) 1995 – 2022.



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 *B. regia* and *C. smithii* feature 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 1996b). 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 1996b.) 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 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 mapped 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).

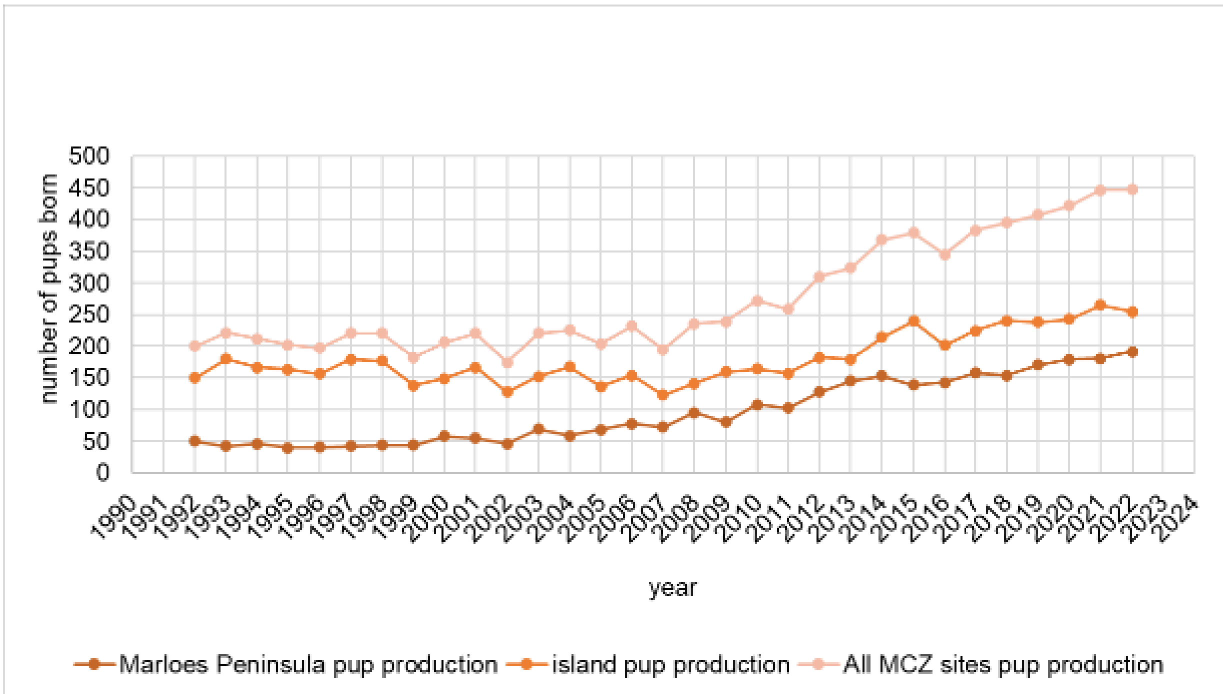
4.8.6. Results

A full report for the 2022 Skomer seal census details the production for the island sites, (Buche 2023). The survey data from the island and mainland sites have been combined to provide data for the whole Skomer MCZ.

Pup production

In 2022, 255 pups were born at Skomer Island sites and 192 pups at mainland sites giving a total of 447 pups born in the MCZ (Figure 43).

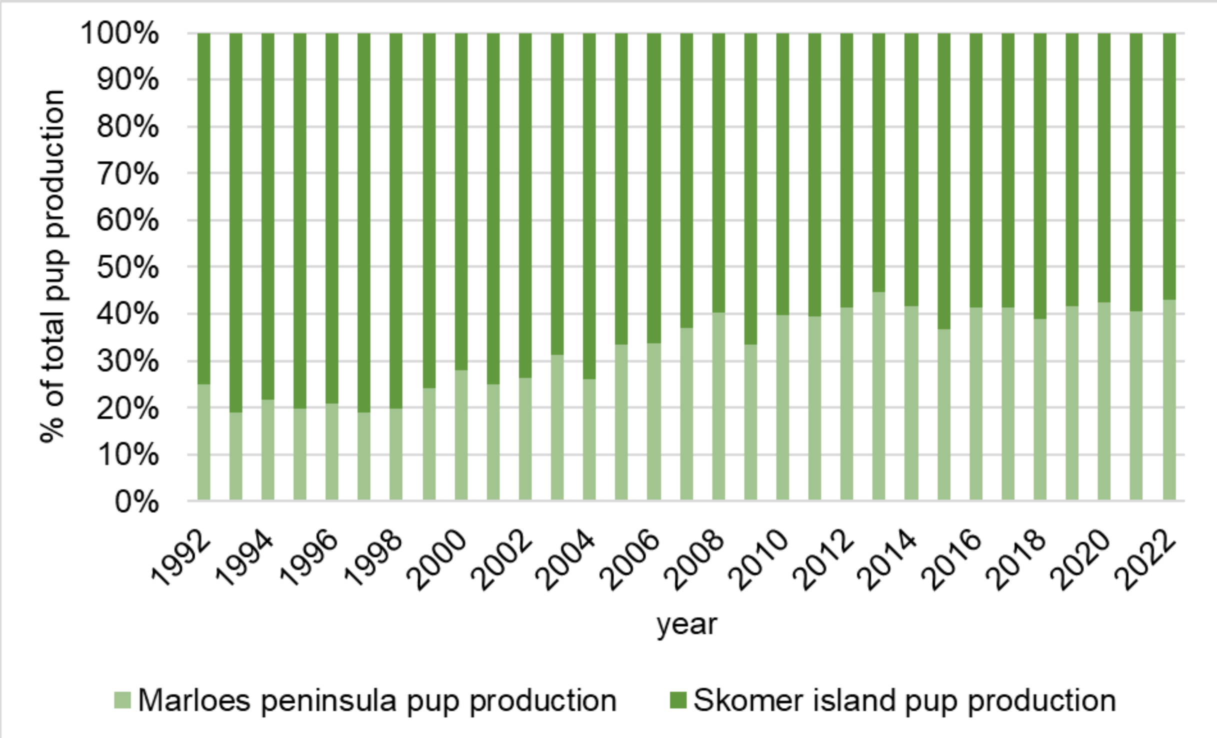
Figure 43 Skomer MCZ pup production 1992 - 2022.



Pup production in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area, with production averaged for 2018-22 being 423 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 43).

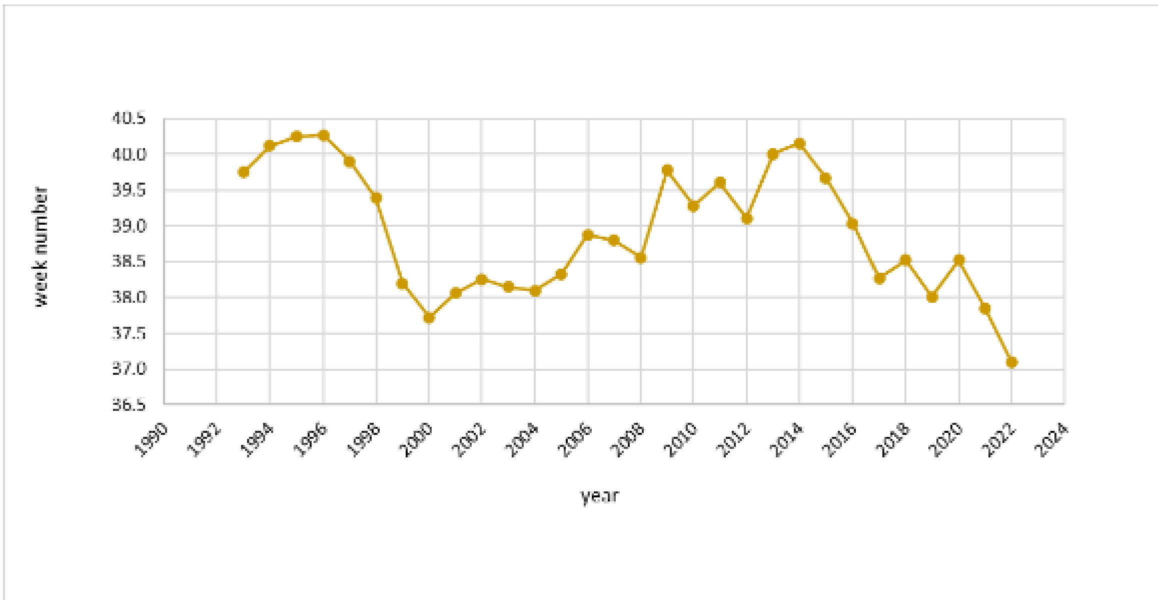
In 2022 Skomer MCZ pup production was 57% at Skomer island sites and 43% at Marloes peninsula sites. Pup production at the Marloes peninsula sites versus the Skomer island sites expressed as a percentage of the total pup production for the Skomer MCZ is shown in Figure 44. From 1992 to 2002 Marloes peninsula 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 41.5% of total production.

Figure 44 Skomer MCZ pup production – percentage born on Island vs. mainland sites.



The highest number of births was 91 pups in week 37 (10th to 16th September). The trend over the last 24 years shows that the mode week of production has fluctuated between weeks 37 to 40 (10th September to 7th October) (Figure 45).

Figure 45 Mode week of seal pup production at Skomer MCZ 1992 – 2022.



Pup survival

In 2022, pup survival through to moult was recorded as 73% for Skomer sites and 88% for Marloes Peninsula sites, with a combined survival for the Skomer MCZ of 79%.

Pup survival assessment is based on the following criteria applied to pups when last seen (Table 15)

Table 15 Seal pup survival assessment method

Class	Size	Assessment
1	Very small	Assumed not to survive
2	Small but healthy	In good condition, reasonable chance of survival
3	Good size	Most should survive
4	Very good size	All should survive
5	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:

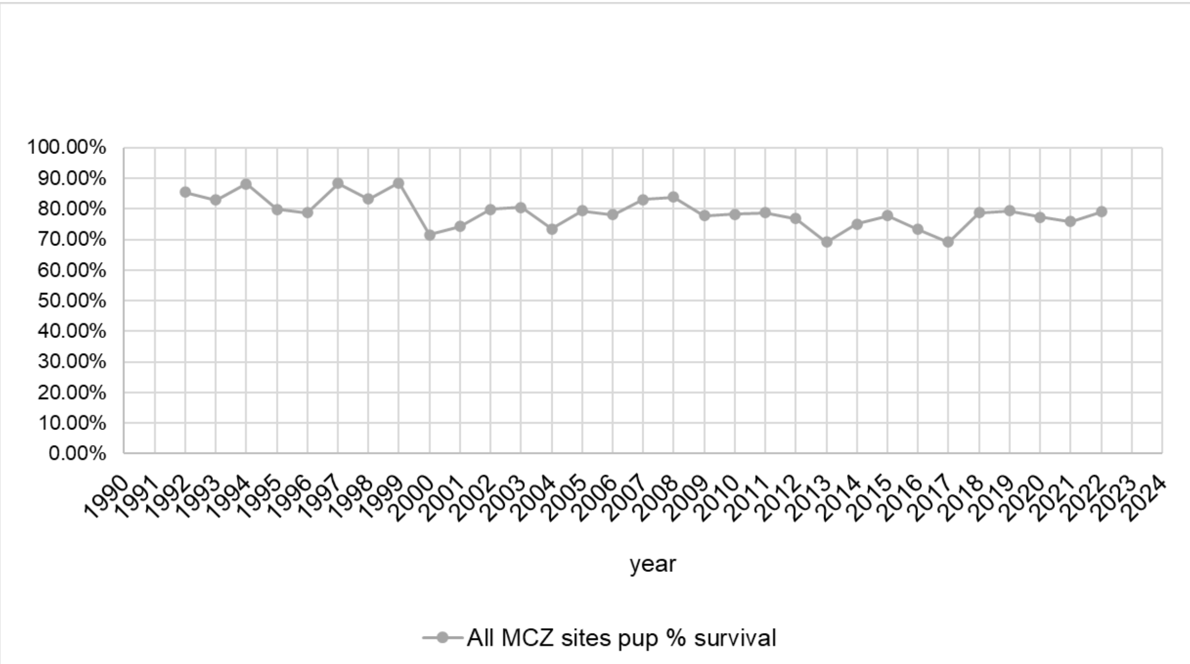
Stillborn. These include both stillborn and those that died immediately after birth and were not seen alive.

Died. All pups seen alive but subsequently recorded dead. These can be from class 1 to 5 in Table 15.

Assumed mortality. These include pups assessed not to have survived following the survival assessment.

In the Skomer MCZ, pup survival from 1992 to 2022 has fluctuated between 69% and 88%, with an average of 79% (Figure 46).

Figure 46 Skomer MCZ pup survival 1992 – 2021.



Pollution and Litter

Monofilament line and netting were the most visible pollutants affecting seals in 2022. 41 individual seals on Skomer (two males, 34 females and five 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. This is similar to 2021 when 40 individual seals were recorded with netting.

No pollution by oil or tar was observed in 2022, however large quantities of beach rubbish including fishing ropes, netting, polystyrene, sheet aluminium and bag loads of plastic debris were on both South Haven beach, Driftwood Bay and the Wick sites. In August beach cleans were conducted by NRW's Skomer MCZ team and The Wildlife Trust's Skomer Island Wardens and volunteers.

Figure 47 Beach clean on South Haven beach (L) and The Wick (R)

Seal behaviour

In 2022, as in most years, females were observed nursing others' young.

Some eye infections were noted in 2022. It seems to mostly affect pups on Matthew's Wick, it is possible that this is due to the site only gets flooded during spring tides and rotting seaweed, seal excrement, dead pups, etc. accumulate on the beach, possibly spreading diseases.

Seal disturbance

In 2022, one significant disturbance, which involved a large number of seals, a dinghy was launched from a yacht anchoring in South Haven and two people made their way around South Castle. The dinghy was seen going with speed into Amy's Reach with seals splashing out of the way, then the boat entered Matthew's Wick, blocking the narrow exit and panicking the seals which were hauled-out on the beach. The seal fieldworker finally managed to get the boater's attention after which they returned to their yacht.

Six smaller incidents were recorded and boats were regularly observed within the voluntary no access zone (Table 16).

Table 16 Seal disturbance (records by Skomer Island staff) on Skomer Island in 2022.

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
16/08/22	12:00	SHV	yacht	2	went with dinghy up to the SBS where newly born pup was calling, cow went into water
16/08/22	13:18	SHV	yacht	1	anchor noise made cow look up
24/08/22	13:00	NHV	RIB	2	dropping off/collecting divers close to RRK, seals entering the water
28/08/22	13:00	NHV	motorboat	1	seals on RRK lift heads due to PA system
12/09/22	14:20	NHV	fishing boat	2	went past RRK, seals entering water
18/09/22	17:30	MWK	dinghy	2	went into AMR and MWK, seals entering water
20/10/22	08:58	NHV	helicopter	1-2	flew 4 times past NHV between 8:58 and 10:13h, some seals rushing towards water but not entering

4.8.7. Current Status

- In 2022, pup numbers reached 447, 9 more pups than the management plan target pup production lower limit of 438 pups (average of last 3 years).
- Pup survival was 79%, 4% more than 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 Sailing crews maintaining records 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 48). 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 - 2022. 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 and volunteers (Wildlife Trust of South & West Wales).

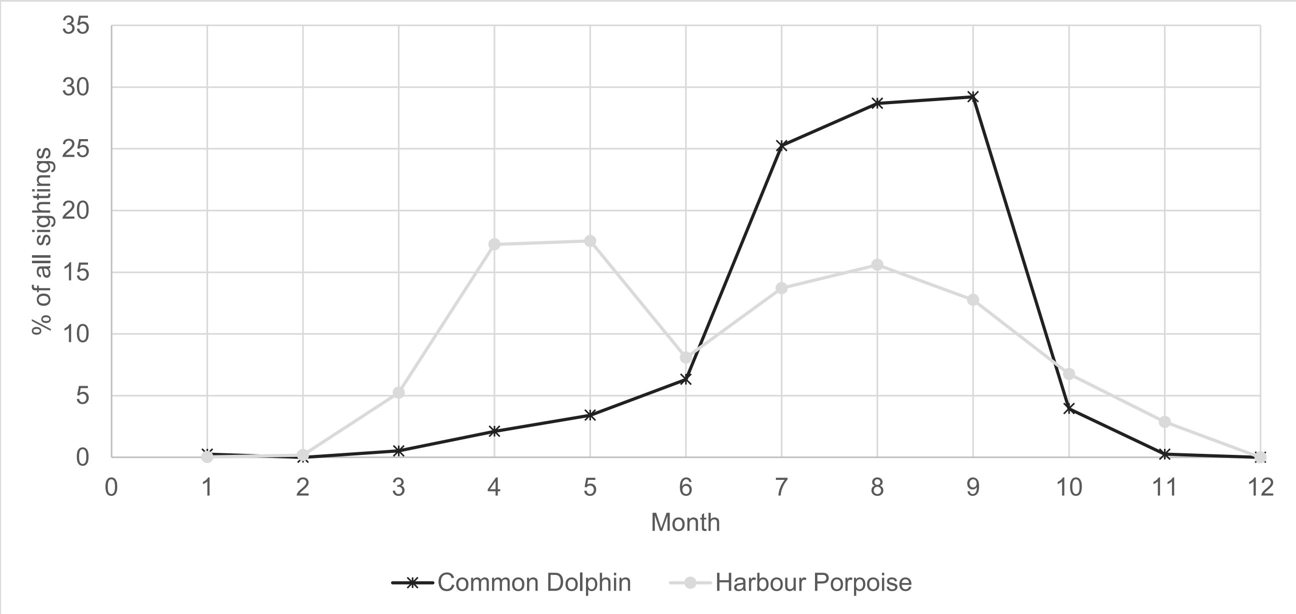
Figure 48 Harbour porpoise sightings Skomer MCZ 2001 – 2022. No recording occurred in 2010, 2011 and 2020.

A “Sighting” refers to a single event when one 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 and in 2021 the amount of recording effort was reduced especially from Skomer NNR due to lower numbers of researchers and volunteers. In 2022 Skomer NNR was functioning at full capacity.

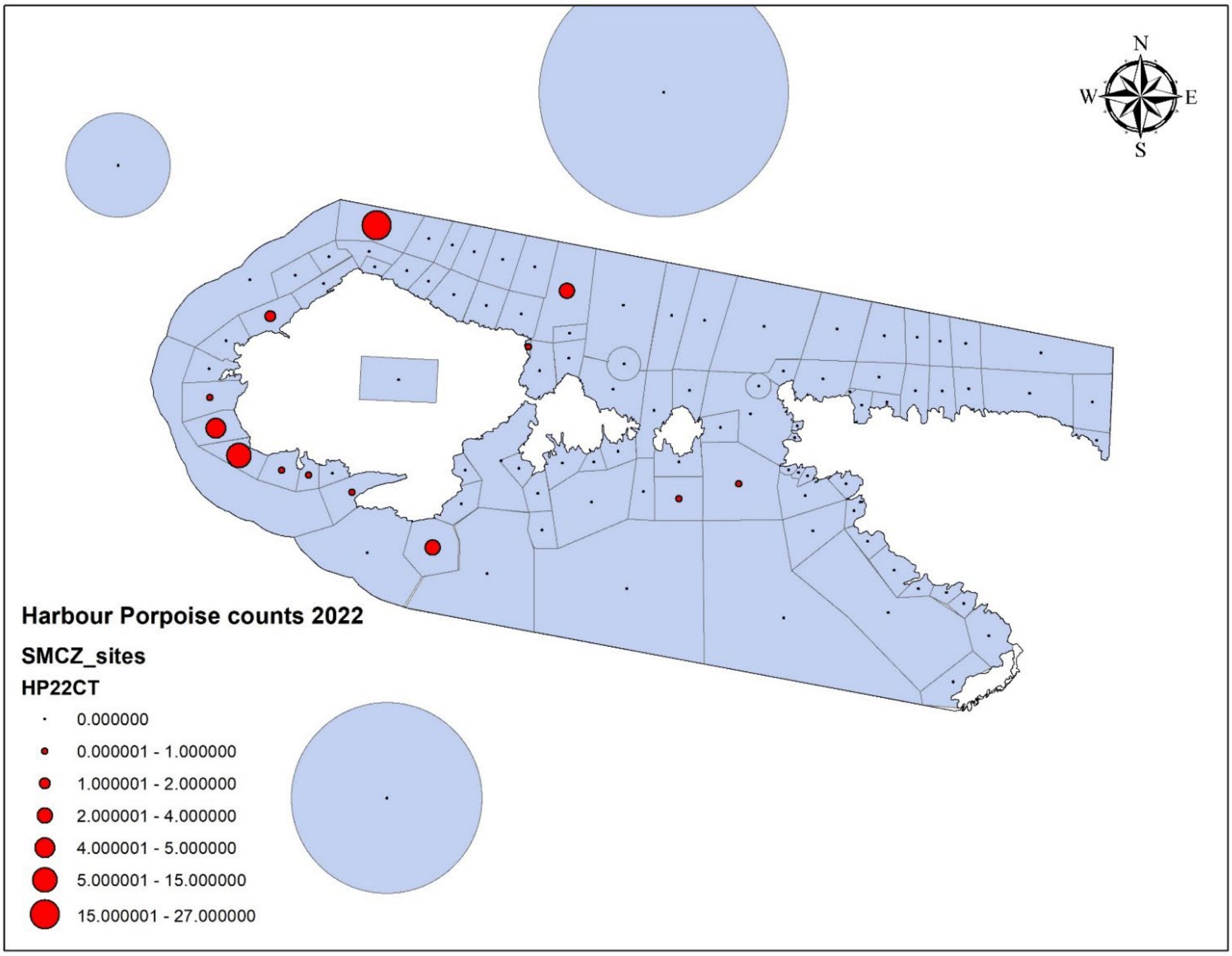
Harbour porpoise are sighted throughout the whole year and are assumed to be resident or regular users within the MCZ. Common Dolphins *Delphinus delphis* are predominantly seen from July to September as shown in Figure 49.

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



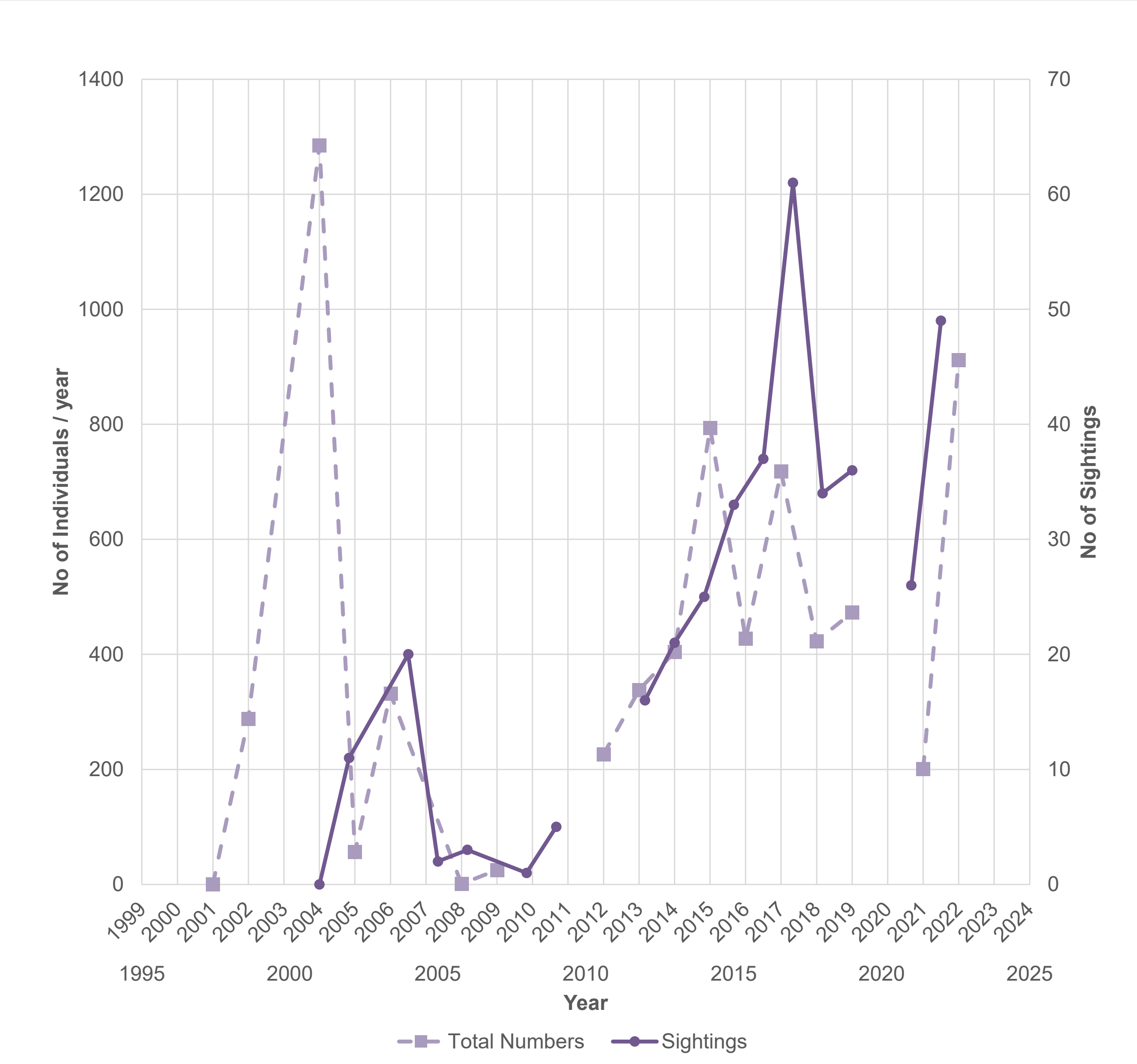
There are hot spots of sightings around the MCZ. The tidal races off the Garland Stone and Skomer Head are popular spots to see Harbour Porpoise (see Figure 50).

Figure 50 Harbour porpoise sightings and distribution Skomer MCZ 2022.



These data are not effort-corrected but are useful in showing areas that harbour porpoise frequent. All vagrant and mobile species records are now recorded using this site code format. Common dolphin 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. 2021 had very few sightings but in 2022 there were 49 sightings totalling 912 individuals.

Figure 51 Common dolphin sightings within Skomer MCZ 2001 to 2022.



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 and 5 bottlenose dolphins were seen in 2022.

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 Risso's from High Court Reef. No Risso's were seen in 2022.

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.

Insufficient data are available to report on the cetacean feature in the Skomer MCZ so its status is judged to be ‘unknown’.

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 Skomer Island NNR staff and Dale Sailing crews to record sightings.
- Encourage and support volunteers based at the Deer Park coastguard hut to record sightings.
- Support cetacean research, for example deploy acoustic loggers.
- Report cetacean feature as unknown.

4.10. Nudibranch Species Diversity

4.10.1. Project Rationale

Nudibranchs are molluscs of the Subclass Opisthobranchia in which the adult stage has completely lost both the shell and operculum. All known nudibranchs are carnivorous, and most are specialised predators feeding on specific prey organisms (Picton & Morrow *1*994). Most are seasonal and reliant on their prey for food, shelter and a place to lay their eggs. Being near the top of the food chain they can act as an indicator of the health of the communities they rely on. The Skomer MCZ nudibranch population has for many years been identified as being rich and diverse including nationally rare and scarce species (Bunker, Picton & Morrow 1993).

Nudibranchs are a feature of the Skomer Marine Conservation Zone (MCZ) for which species diversity and the presence of rare or scarce species are attributes used to assess conservation status.

The Skomer MCZ is within the Pembrokeshire Marine Special Area of Conservation (SAC) and data collected here is used to help assess the condition of features of the SAC. The main relevant features are 'Reef' and 'Large Shallow Inlet and Bay'. The nudibranch data are applicable to some of the attributes of Favourable Conservation Status, particularly those relating to typical species.

4.10.2. Objectives

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

4.10.2. Sites

All of the Skomer MCZ.

4.10.3. Methods

Full survey: Surveys are carried out in early summer. Sites from around the whole Reserve are chosen to provide a range of habitat types. The sub-littoral habitat found at each site is described briefly and associated nudibranch species recorded as a list for each site. In addition, an overall list of species is compiled for the Skomer MCZ and species recorded photographically.

Annual check list: Species from the checklist are recorded along with other notable observations during other monitoring dives throughout the season, sites are not targeted specifically for nudibranch records.

Nudibranch annual check list:

Acanthodoris pilosa
Facelina auriculata
Facelina annulicornis
Doris pseudoargus
Edmundsella pedata
Crimora papillata
Antiopella cristata
Diaphorodoris luteocincta
Limacia clavigera
Doto fragilis
Doto pinnatifida
Polycera faeroensis
Polycera quadrilineata
Amphorina farrani
Duvaucelia lineata
Duvaucelia odhneri

4.10.4 Project History

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

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

2003 and 2004 all 16 species from the checklist were recorded in both years. A notable record was *Duvaucelia odhneri* on the pink sea fan, *Eunicella verrucosa*. *D. odhneri* is a nationally scarce species (Moore 2002).

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

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

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

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

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

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

In 2018 – full survey completed and 55 species recorded. During the survey *Amphorina linensis* was recorded for the first time in the reserve at several sites, and *Doto hydrallmaniae* was also recorded for the first time at South Middleholm. Other notable records included *Duvaucelia odhneri and Okenia elegans.* During other MCZ monitoring projects *Palio nothus* was recorded at the 'The Loaf', North Haven by Kerry Lewis.

4.10.5 Results

A total of 55 nudibranch species were recorded at 16 survey sites in the Skomer MCZ during the 2022 survey. 27 dives targeting nudibranch recording were completed at 16 sites by the Skomer MCZ team and volunteers between 13th and 24th June 2022. Additional sites were also explored during other Skomer MCZ monitoring dives.

A review was completed of all records for surveys between 1975 and 2022 including sediment infauna surveys. A combined total of 83 nudibranch species have been recorded in the Skomer MCZ as shown in Table 17 to Table 19.

Table 17 Nudibranch species and entities recorded in the Skomer MCZ during MCZ diving surveys

Species	2002	2006	2010	2014	2018	2022	No. of years recorded
Acanthodoris pilosa	Yes	No	Yes	Yes	Yes	Yes	5
Aegires punctilucens	Yes	No	Yes	Yes	Yes	Yes	5
Aeolidia papillosa	No	Yes	No	No	No	No	1
Amphorina andra	No	No	No	No	No	Yes	1
Amphorina farrani	Yes	Yes	Yes	Yes	Yes	Yes	6
Amphorina linensis	No	No	No	No	Yes	Yes	2
Amphorina pallida	No	Yes	Yes	Yes	Yes	No	4
Ancula gibbosa	No	No	Yes	Yes	No	Yes	3

Species	2002	2006	2010	2014	2018	2022	No. of years recorded
Antiopella cristata	Yes	Yes	Yes	Yes	Yes	Yes	6
Atalodoris pusilla	No	Yes	No	No	Yes	No	2
Atalodoris oblonga	No	No	Yes	Yes	Yes	Yes	4
Cadlina laevis	No	Yes	Yes	Yes	No	No	3
Capellinia fustifera	No	No	No	Yes	Yes	Yes	3
Crimora papillata	Yes	Yes	Yes	Yes	Yes	Yes	6
Cuthonella concinna	No	No	No	Yes	No	Yes	2
Catriona aurantia	No	Yes	Yes	Yes	Yes	No	5
Dendronotus frondosus	No	Yes	Yes	Yes	Yes	No	5
Diaphoreolis viridis	No	No	Yes	No	Yes	No	2
Diaphorodoris luteocincta	Yes	Yes	Yes	Yes	Yes	Yes	6
Diaphorodoris alba	Yes	No	Yes	No	Yes	Yes	4
Doris pseudoargus	Yes	Yes	Yes	Yes	Yes	Yes	6
Doris sticta	No	Yes	No	Yes	No	Yes	3
Doto coronata agg.	Yes	Yes	No	Yes	Yes	Yes	5
Doto cuspidata	Yes	Yes	Yes	Yes	Yes	Yes	6
Doto dunnei	No	No	Yes	Yes	Yes	Yes	4
Doto eireana	No	Yes	Yes	Yes	Yes	Yes	5
Doto floridicola	No	No	No	Yes	Yes	Yes	3
Doto fragilis	Yes	Yes	Yes	Yes	Yes	Yes	6
Doto koenneckeri	Yes	No	Yes	No	No	Yes	3
Doto hydrallmaniae	No	No	No	No	Yes	Yes	2
Doto hystrix	No	No	Yes	No	Yes	No	2
Doto lemchei	Yes	No	Yes	Yes	Yes	Yes	5
Doto maculata	No	No	Yes	Yes	Yes	No	3
Doto millbayana	Yes	Yes	Yes	Yes	Yes	Yes	6
Doto pinnatifida	Yes	Yes	Yes	Yes	Yes	Yes	6
Doto tuberculata	Yes	No	Yes	Yes	Yes	Yes	5
Duvaucelia lineata	Yes	Yes	Yes	Yes	Yes	Yes	6
Duvaucelia odhneri	No	No	Yes	No	Yes	Yes	3
Duvaucelia plebeia	No	No	No	No	No	Yes	1
Edmundsella pedata	Yes	Yes	Yes	Yes	Yes	Yes	6
Eubranchus exiguus	Yes	No	Yes	Yes	Yes	Yes	5
Eubranchus tricolor	Yes	Yes	Yes	Yes	Yes	Yes	5
Eubranchus vittatus	No	No	Yes	No	Yes	No	2
Facelina annulicornis	Yes	Yes	Yes	Yes	Yes	Yes	6
Facelina auriculata	Yes	Yes	Yes	Yes	Yes	Yes	6
Facelina bostoniensis	No	No	Yes	Yes	No	Yes	3
Favorinus branchialis	Yes	Yes	Yes	Yes	Yes	Yes	6
Favorinus blianus	No	No	Yes	No	Yes	No	2
Fjordia browni	No	Yes	Yes	No	Yes	Yes	4
Fjordia lineata	No	Yes	Yes	Yes	Yes	No	4
Fjordia chriskaugei	No	No	Yes	No	No	No	1
Geitodoris planata	No	No	Yes	Yes	Yes	Yes	4
Goniodoris nodosa	No	Yes	Yes	Yes	Yes	Yes	5

Species	2002	2006	2010	2014	2018	2022	No. of years recorded
Jorunna tomentosa	No	No	Yes	Yes	Yes	No	3
Limacia clavigera	Yes	Yes	Yes	Yes	Yes	Yes	6
Lomanotus genei	No	No	Yes	No	No	No	1
Microchlamylla gracilis	Yes	No	Yes	Yes	Yes	Yes	5
Okenia aspersa	No	No	Yes	No	No	No	1
Okenia elegans	No	No	Yes	Yes	Yes	No	3
Onchidoris bilamellata	No	No	No	No	No	Yes	1
Palio nothus	No	No	No	No	Yes	No	1
Polycera capitata/norvegica	No	No	Yes	Yes	No	Yes	3
Polycera faeroensis	Yes	Yes	Yes	Yes	Yes	Yes	6
Polycera kernowensis	No	Yes	Yes	Yes	Yes	Yes	5
Polycera quadrilineata	Yes	Yes	Yes	Yes	Yes	Yes	6
Rostanga rubra	No	Yes	Yes	Yes	Yes	Yes	5
Rubramoena amoena	No	Yes	Yes	Yes	Yes	Yes	5
Rubramoena rubescens	Yes	No	No	Yes	Yes	Yes	4
Tergipes tergipes	Yes	No	Yes	Yes	Yes	No	4
Thecacera pennigera	No	Yes	Yes	Yes	Yes	Yes	5
Trapania lineata	No	No	Yes	No	No	Yes	2
Trinchesia caerulea	No	No	No	No	No	Yes	1
Trinchesia cuanensis	No	No	No	No	Yes	Yes	2
Tritonia hombergii	Yes	No	Yes	Yes	Yes	Yes	5
Zelentia pustulata	No	Yes	Yes	No	Yes	No	3
Total no. species for each year	**30**	**35**	**59**	**52**	**59**	**55**	

Table 18 Other diving records of nudibranchs in Skomer MCZ

Species	Years recorded	Site name
Cuthona foliata	1975 (recorded by Saunders)	Not known
Goniodoris castanea	1972, 1988	JSD, RRK
Polycera elegans	1972, 1975	NWA, WTK
Lomanotus marmoratus	1991, 2013	MHV, HPT
Trapania tartanella	2009	RRK

Table 19 Additional nudibranch records from sediment infaunal surveys (Rostron 1993, 1996; Barfield 1998, 2003, 2007).

Species	Years recorded	Site number or name
Embletonia pulchra	1998	7, WTP
Onchidoris muricata	1993	12, 19
Onchidoris sparsa	1998 2003 2007	6, 7 5, 7, 12 6

Nudibranch species recorded include several classed as nationally scarce or with limited national distribution in the British Isles, a selection of these are described below and shown in Figure 52 to Figure 55.

1. *Duvaucelia odhneri* (Figure 52). A nationally scarce species (Moore 2002) found in the south west of Britain. Feeds on the pink sea fan *Eunicella verrucosa*. Present in small numbers within Skomer MCZ and monitored on the pink sea fan surveys that are conducted yearly.

Figure 52 *Duvaucelia odhneri* and distribution map of *Duvaucelia odhneri* (NBNAtlas, accessed 6/9/22 https://nbn.org.uk), photo Phil Newman.

2. *Thecacera pennigera* (Figure 53). This is a species that is confined to the south and west coasts of Britain. It is regularly recorded from Skomer MCZ, and has been found during all surveys since 2006.

Figure 53 *Thecacera pennigera* and distribution map (NBN Atlas, accessed 6/9/22 https://nbn.org.uk), photo Ross Bullimore.

3. *Zelentia pustulata* (Figure 54). This is a northern species in Britain with few records but regularly found around Skomer and Skokholm Islands (Figure 55). Recorded in the Skomer MCZ during the 2006, 2010 and 2018 surveys, but not found in 2022.

Figure 54 *Zelentia pustulata*, photo Jen Jones.

Figure 55 UK Distribution map of *Zelentia pustulata* and distribution in the Skomer MCZ and around Skokholm Island (NBN Atlas, accessed 6/9/22 https://nbn.org.uk).

A total of 83 nudibranch species have been recorded in the Skomer MCZ between 1975 and 2022 from both diving and sediment infauna surveys. 75 species have been found on those surveys carried out between 2002 and 2022, of which 14 species were unrecorded in the MCZ before 2002. Nudibranch species recorded include several classed as nationally scarce or with limited national distribution in the British Isles.

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

55 species were recorded on dives during 2022, representing 68% of the nudibranch species that have been recorded on dives in the Skomer MCZ. This is similar to 2018 and 2010 (59), and 2014 (52 species). The lower number of species in 2014 was most likely due to the survey sites being covered in a thick layer of silt which buries many of the sessile filter feeding animals. In contrast there were low levels of silt on the reefs and good diving visibility in both 2010 and 2018 surveys and again in 2022. However, in spite of the good conditions it was noted by all surveyors that there was a significant reduction in the overall number of nudibranchs present in 2022, even though a relatively high number of species were found. There does not appear to be any obvious reason for this, as all surveys have taken place around the same time of year, and food sources were in good supply.

4.10.6 Current Status

- In 2022, 55 species were recorded, representing 68% of the nudibranch species that have been recorded on dives in the Skomer MCZ.
- The diversity of nudibranch species in the Skomer MCZ is very high with 70% of UK species represented in an area of 13.2 square kilometres.
- As specialised predators nudibranch species are a good indicator of the overall ecosystem health.
- The nudibranch population feature for the Skomer MCZ is considered to be in favourable condition and can be used to report on the relevant features of Pembrokeshire Marine SAC relating to species richness and diversity.

4.10.7. Recommendations

- Annually complete the 16 species checklist and photograph unusual species for identification during other Skomer MCZ dive survey work.
- Complete a nudibranch species survey in the Skomer MCZ every 4 years including a nudibranch "Bioblitz" at Martins Haven with volunteer divers, next survey due 2026.
- Enter the 4 yearly survey data and species list into the Marine Recorder database for inclusion in the NBN Atlas dataset.
- Report the nudibranch population feature to be in favourable condition.

4.11. Scallop (*Pecten maximus*) population

4.11.1. Project Status

Ongoing. Volunteer survey every 4 years (next survey 2026).

4.11.2. Project Rationale

Scallop populations are a management feature of the Skomer MCZ as well as being a component of the sediment faunal community feature. The decision to select scallops as a management feature in its own right stems largely from the history of the area: Scallops were collected commercially and recreationally in the area of the MCZ until 1990.

In 1990, the South Wales Sea Fisheries Committee (SWSFC) introduced a byelaw prohibiting scallop collecting by any means and since 2010 the bylaws are the responsibility of Welsh Government. Welsh Assembly Government Inshore Fisheries Legislation byelaws numbers 27 and 28 (Appendix 1) prohibit the use of dredges or beam trawls as well as the removal of *P. maximus* and *Chlamys opercularis* (now *Aequipecten opercularis)* from the Skomer MCZ by any means. Seabed protection outside the MCZ was further enhanced by the introduction of the Scallop Fishing (Wales) Order 2010, which has prohibited dredging for King scallop within 1 nautical mile of the Welsh coast.

Monitoring of the scallop population not only provides valuable evidence on the recovery from exploitation of an important component of the sediment community, but also to assess the effectiveness of the fishery byelaw. Long-term population data for an unexploited commercial species is also valuable for fishery managers.

4.11.3. Objectives

- To estimate the density of *P. maximus* within suitable habitats in the Skomer MCZ.
- To determine *P. maximus* population dynamics: age distribution and size distribution and growth rates.

4.11.4. Sites

The 2000 survey established three sites, a further four sites were added in 2004. The seven sites were resurveyed in 2008, 2012, 2016 and 2022. Because scallop data are deemed to be of a sensitive nature, site locations are kept anonymous for reporting purposes.

4.11.5. Methods

In 2000 a method was developed suitable for volunteer diving teams at fixed sites which could be repeated in subsequent surveys. Full methods are detailed in Lock & Newman (2002).

- Sites are marked using GPS positions with temporary sinkers, buoyed to the surface.

- The sinkers are used by divers as the start point to lay transect tapes 30m or 50m following compass bearing directions: N, NE, E, SE, S, SW, W and NW where topographic features allow.
- Each pair is equipped with a surface marker buoy (SMB), a compass, net bags, a torch and a 50m tape measure.
- Survey transects are completed by divers working in buddy pairs. The scallops are collected with one diver positioned on either side of the tape. Scallops are collected by divers from a four-metre band, two metres either side of the transect tapes (the width can be reduced to a two metre band if densities are very high or if the visibility is low).
- On completion of every dive, the direction, length and width of each transect is recorded to enable survey area to be calculated for each transect.
- The scallops are brought to the surface and kept alive in containers of clean seawater, their growth rings measured, shells marked with notches for identification and then returned to the site.
- This is repeated for up to 8 transects over suitable habitat at each site.
- All scallop shells are also checked for the presence of the invasive non-native slipper limpet, *Crepidula fornicata*. These are counted, removed from the scallop shell and destroyed (results are detailed in Section 4.12.5).

4.11.6. Project History

A summary of the scallop surveys carried out is shown in Table 20

In 1979 / 80 a small survey was completed (Jones & Hodgson 1979; Jones 1980). No density estimates. Age class data suggest strong recruitment in 1973-75 and then a decline for 1976-1980.

Bullimore (1985a) summarised the available data for 1979 – 1982. Scallop survey was completed at North Marloes Peninsula sites and North of the Neck, densities of 0.01m^{-2} $^{(}$1/100 m^{2}) were estimated for all sites.

In 2000, survey was completed using a small team of 8 volunteer divers and 3 fixed sites were established. The results suggest an increase in density to 0.05 m^{-2} (5/100 m^{2}) compared to 1985 with a maximum site density of 0.01m^{-2} (1/100 m^{2}). The age class data suggested strong recruitment in 1992 – 94, 2 years after the SWSFC byelaw was introduced and the first full year of staff presence at Skomer MNR.

2002 - A collaborative SWSFC/ Skomer MCZ scallop poster, explaining the byelaw, was produced. This was distributed to local dive clubs and dive shops and has been posted at local slipways.

In 2004, survey was completed with a large team of 50 volunteer divers. Sites established in 2000 were re-surveyed and a further 4 sites established. The total area surveyed was 11,120 m^{2} and 1293 individuals were measured.

In 2008, survey was completed at the 7 sites previously established with a team of 40 volunteer divers. The total area surveyed was 9780 m^{2} and 1661 scallops were measured.

The 2012 survey repeated the 7 sites with a team of 32 volunteer divers. Visibility was poor during the survey, therefore it was decided to reduce the search area to a 1 m band either side of 30 m length transects at most sites. The total area surveyed was 3240 m^{2} and 913 scallops were measured. A new control site was also set up in 2012 just outside of the Skomer MCZ northern boundary in St Brides Bay.

The 2016 survey was completed at the 7 sites and the St Brides Bay site also repeated. Visibility was good and the volunteer team completed 60 transects covering 8620 m^2 and collecting 2534 scallops.

The 2022 survey was completed at the 7 sites and the St Brides Bay site also repeated. Visibility was poor at the start of the survey, therefore it was decided to reduce the search area to a 1 m band either side of 30 m length transects at most sites. 23 volunteer divers took part, 39 transects covering 2280 m^2.

Table 20 Summary of survey results for the whole MCZ 1984 – 2022.

Year	Total *P. maximus*	Survey Area (m^2)	MCZ Transects completed	Notes
1984	36	Timed searches	10	Not a comparable method
2000	155	3400	17	3 sites surveyed
2004	1292	11120	63	7 sites surveyed including the 3 sites from 2000
2008	1661	9780	61	7 sites surveyed
2012	913	3480	49	7 sites surveyed but with poor visibility so transect area was reduced
2016	2534	8620	60	7 sites surveyed Good visibility
2022	1414	2280	39	7 sites surveyed but with poor visibility so transect area reduced

4.11.7. Results

Average density of scallops in Skomer MCZ

The average density of scallops in the Skomer MCZ as a whole can be calculated in different ways:

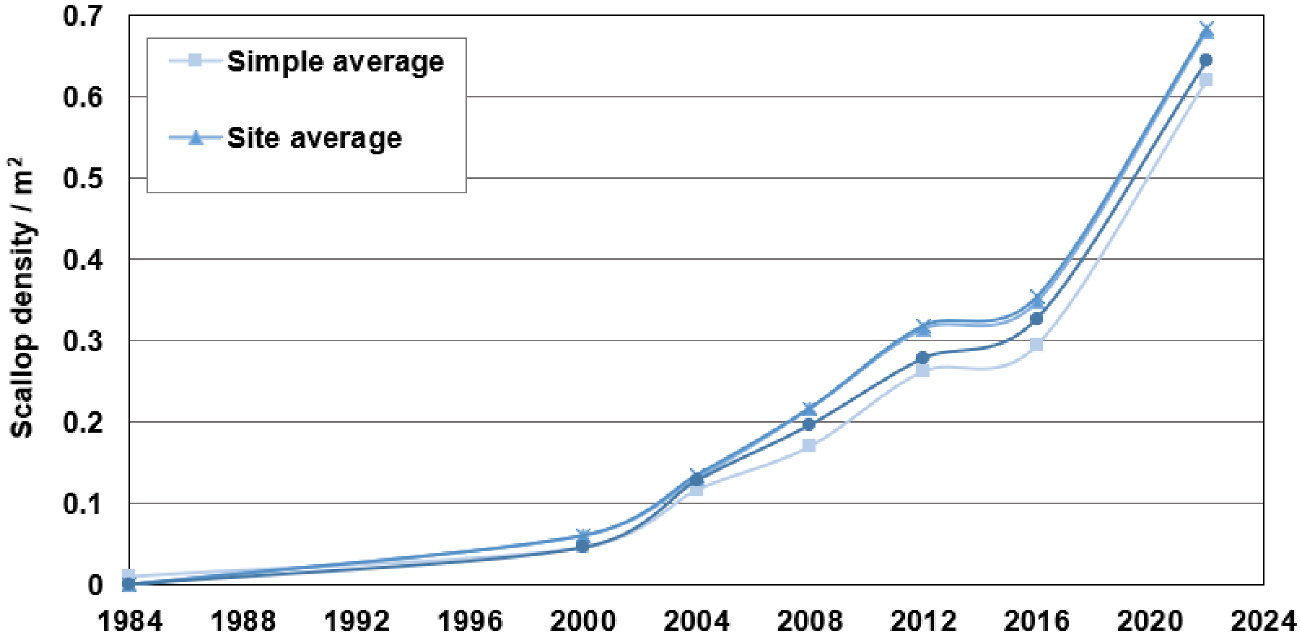
1. *Simple mean*: Total number of scallops / total area surveyed.
2. *Simple site density mean:* total number of scallops at each site / total area surveyed at each site. Then average these to get an annual average.
3. *Site transect density mean*: calculate a density for each transect at each site then average these densities. Then average the 7 site densities to get an annual average.
4. *Transect average*: calculate densities for all of the transects completed that year and then average these.

These have been calculated and results shown in the following Table 21and Figure 56.

Table 21 Densities of *P. maximus* / m^2 for the surveyed area within MCZ 1984 – 2022

Year	Simple Average Density	Simple Site Density Average	Transect Site Density Average	All Transect Average
1984	0.01	*Not applicable*	*Not applicable*	*Not applicable*
2000	0.05	0.06	0.06	0.05
2004	0.12	0.13	0.13	0.13
2008	0.17	0.22	0.22	0.20
2012	0.26	0.31	0.32	0.28
2016	0.29	0.35	0.35	0.33
2022	0.62	0.68	0.68	0.64

Figure 56 Average density of *P. maximus* /m^2 for the MCZ survey area 1984 – 2022.



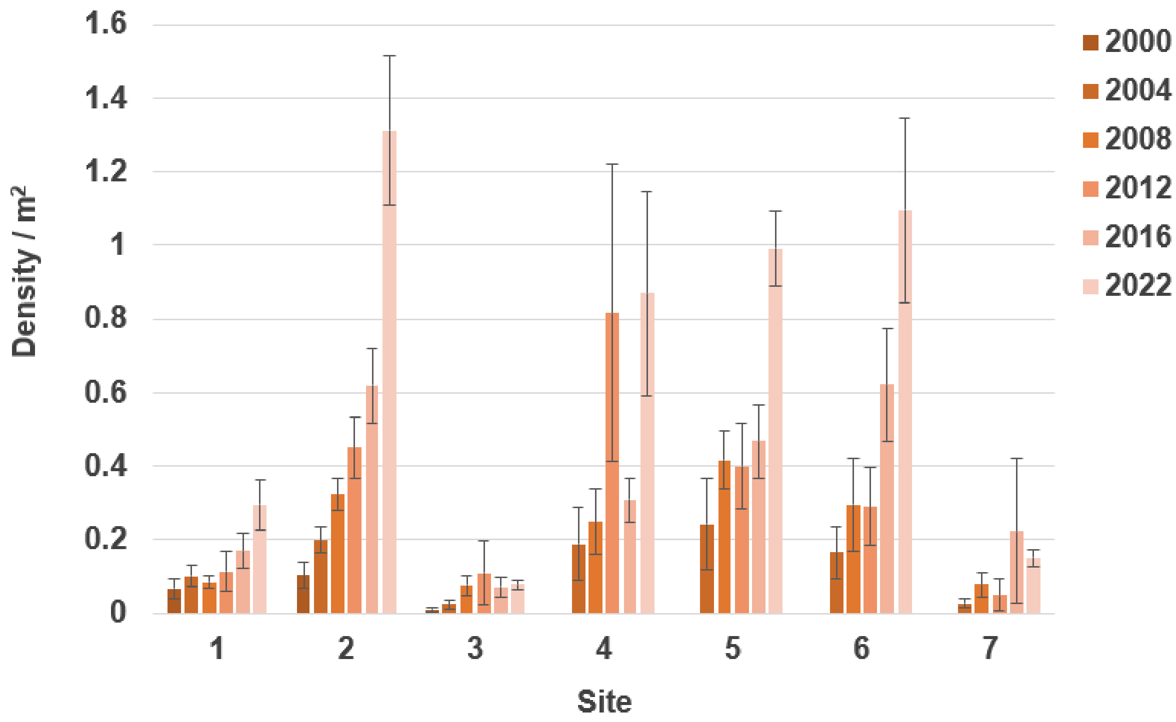
The trend is the same whichever method is chosen to calculate the annual average density (Figure 56). An increase in density was seen between 2000 and 2012 then appeared to level off in 2016, but then a dramatic increase in density is shown in 2022.

The simple average is always the lowest estimate of density and suggests similar densities between 2012 (0.26/m^2) and 2016 ((0.29/m^2). The density estimated in 2016 is about 6 times greater than in 2000 (0.05/m^2) and in 2022 (0.62/m^2) is just over double the density found in 2016 and 12.4 times greater than in 2000.

Density results are very variable between sites and years, suggesting a highly clumped dispersion of scallops across the MCZ. Density does not change uniformly across all of the sites surveyed in the MCZ. This suggests that certain sites have a habitat more suited to the settlement and growth of *P. maximus* than others. Skomer scallop sites have a range of sediment profiles as well as varying degrees of exposure to wave action and tidal currents.

The lowest density in 2022 was found at site 3 (0.08/m^2) with the highest density found at site 2 (1.31/m^2). With the exception of site 7 (where density has decreased by 32% since 2016) densities at all other sites have increased since the previous survey in 2016. Five sites show a dramatic (>70%) increase compared to 2016.

Figure 57 Individual site density changes (*P. maximus* / m^2) 2000 – 2022 with 95% confidence intervals.



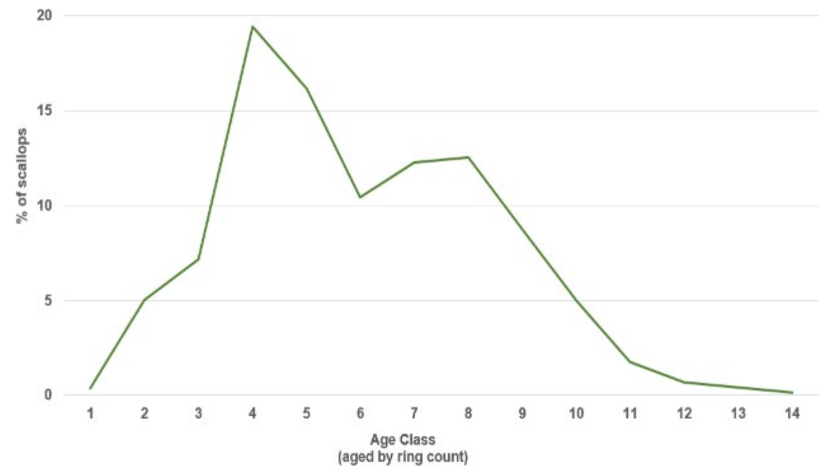
The annual density results show an increasing trend in scallop density, however this trend is not uniform across all the sites. There is a lot of variability in how each site responds over time.

At St Brides bay sites the seabed substrate is dominantly sand waves compared to the rich mixed sediment sites found at the sites within the Skomer MCZ. In 2012 the average density was 0.15 *P. maximus* /m^2. In 2016 this dropped to 0.06 and in 2022 surveyed density was 0.02 *P. maximus* /m^2 . There is not enough of a time series to interpret trends at the St Brides sites but densities are consistently lower than those found within the MCZ boundary.

Growth rate and age structure.

All scallops were measured and age estimates made from annual growth rings, see Figure 58.

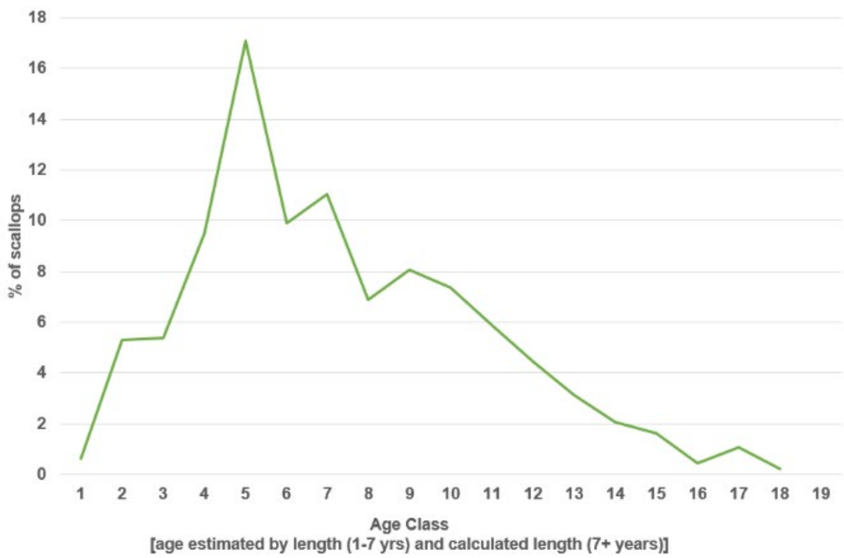
Figure 58 Age structure of *P. maximus* in 2022, sampled across all MCZ sites. Aged using growth ring count method.



The 4-year-old size class is strongly represented, suggesting good recruitment in 2018. The peak of 4-year-old scallops seen in 2016 is not seen as a peak of 10-year-old scallops on this graph. However a peak of 7 and 8-year-olds is seen. Using ring-count method the oldest recorded scallop was aged at 14 years. Older *P. maximus* are difficult to age by counting the age rings, because beyond a certain age the rings on the shell are very close together and hard to differentiate. For this reason this method is probably only accurate in estimating age up to the 7 or 8-year-old age class.

To improve the accuracy for older scallops an average annual growth rate was derived from that year's actual measured growth rates for all scallops of the age range seven and over. This growth rate was used to calculate theoretical overall length of scallops at age seven and over for the specific year.

Figure 59 Age structure of *P. maximus* in 2022 across all MCZ sites. Scallops aged using estimated age from mean length (age 1-7 yrs) and calculated mean length (age 7+yrs).



The results shown in Figure 59show ages extending out to 18-year-old scallops. The largest peak is at 5-years-old and a small peaks are now seen in the 7, 9 and 10-year old age classes. The peak of 10-year-olds correlates with the peak of 4-year-old scallops seen in 2016.

The modal age class within MCZ sites for each survey year is shown in Table 22.

Table 22 Modal age class of *P. maximus* within MCZ sites.

Year	2000	2004	2008	2012	2016	2022
Modal age class, years (aged by calculated length after 7yrs)	6	8	5	3	4	5

In 2000, there were only 155 *P. maximus* to measure so these data may not be comparable to estimates from the following years. Since 2004 there has been a shift of the modal size class towards younger *P. maximus* (3-5 years). Without supporting information about recruitment and survival rates it is difficult to interpret these results but it would be useful to compare these results to other populations around the UK.

Analysis of the age structure data within each site and between years did not show any strong trends. Age structure is very variable between sites and sites are not consistent between years. It does suggest that the proportion of scallops under 4 years old is increasing over time.

Growth rates

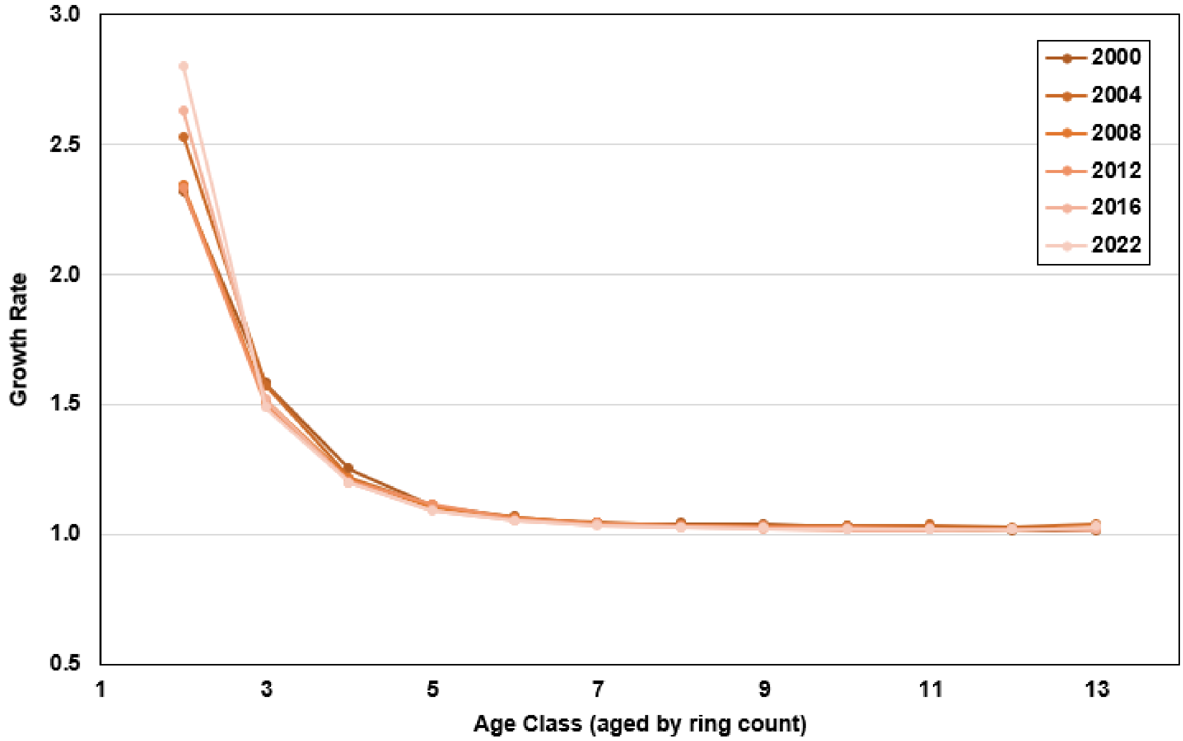
The rate of change in size can be calculated between each age class to show how growth varies as *P. maximus* ages. Growth rates have been calculated using the formula: '*size at t +1 / Size at t = proportional change in size' (where t = year by ring count)*. Growth rates for 2000-2022 and associated 95% confidence limits are shown in Table 23and Figure 60.

Table 23 Growth rates between age classes (2000 – 2022)

Year	Age 1 to 2	Age 2 to 3	Age 3 to 4	Age 4 to 5	Age 5 to 6	Age 6 to 7	Age 7 to 8	Age 8 to 9	Age 9 to 10	Age 10 to 11	Age 11 to 12	Age 12 to 13
2000	2.320	1.581	1.250	1.108	1.066	1.043	1.040	1.037	1.029	1.023	1.013	1.014
2004	2.530	1.570	1.217	1.112	1.059	1.044	1.035	1.032	1.032	1.034	1.025	1.038
2008	2.340	1.515	1.212	1.105	1.062	1.042	1.033	1.027	1.023	1.022	1.017	1.031
2012	2.328	1.494	1.203	1.114	1.056	1.040	1.031	1.027	1.026	1.022	1.019	1.018
2016	2.627	1.516	1.196	1.093	1.052	1.034	1.025	1.020	1.016	1.016	1.021	1.015
2022	2.799	1.486	1.196	1.088	1.052	1.032	1.026	1.021	1.021	1.018	1.017	1.029

All survey years show a similar trend of growth rate, with the rapid growth rates seen in scallops aged 2 and 3, slowing down in 4 and 5-year-olds and almost stopping by age 6.

Figure 60 Changes at Skomer MCZ in scallop growth rates with age (2000 – 2022).



4.11.8. Current Status

- The 2022 results have shown another increase in density of scallops across the whole MCZ.
- There is strong evidence of healthy recruitment in the last 6 years and these young recruits appear to be driving the increase in scallop numbers at most sites.
- Growth rates are very similar across the years.
- The *P. maximus* population feature for the Skomer MCZ is considered to be in favourable condition

4.11.9. Recommendations

- Compare these results with other protected and fished areas in the UK.
- Offer the dataset to a university to produce a peer reviewed paper.
- Increase sampling effort outside the MCZ in St Brides Bay to allow comparison with the MCZ results.
- Report king scallop *P. maximus* feature to be in favourable condition.

4.12 General Species Recording

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

4.12.1. Project Rationale

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

4.12.2. Crawfish

Crawfish *Palinurus elephas* (Figure 61) is an Environment Act (Wales) 2016, Section 7 species of principal importance. From 2009 to 2022 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 61 Crawfish, *Palinurus elephas* photo Kate Lock.

4.12.3. Ocean quahog

The Ocean quahog *Arctica islandica* (Figure 62) is an Environment Act (Wales) 2016, Section 7 species of principal importance and on the OSPAR list of threatened and/or declining species. The ocean quahog is a bivalve mollusc that lives buried in sandy seabeds. They are very slow growing and extremely long-lived - with individual clams living for hundreds of years. In 2022, it was recorded by Skomer MCZ staff during the scallop *Pecten maximus* survey and these data are entered into Marine Recorder for access onto the National Biodiversity Network.

Figure 62 Ocean quahog *Arctica islandica* photo Kate Lock.

4.12.4. Sunfish

Sunfish *Mola mola* is the largest bony fish in the world; they are an ocean vagrant that can be found in both tropical and temperate waters. They feed mainly on jellyfish so are found often when there are jellyfish blooms around the coast. Sunfish are often recorded in the Skomer MCZ in low numbers from July to September when seawater temperatures are around 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 2022, there was 1 record in July.

4.12.5. 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 2022 careful searches were completed at each of the shores during the MarClim surveys but it was not found.

Wire weed *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 12 years. On each occasion it has just been 1-2 individuals. It was not recorded in 2022.

American slipper limpet *Crepidula fornicata* (Figure 63) is an INNS species and was first recorded from Welsh coastal waters in 1952 when single individuals were found in the low intertidal in the Milford Haven Waterway (MHW), south west Wales. Its establishment and local spread happened rapidly. However, there was no indication of a northwards range extension until 2008 when two individuals were found in the Skomer MCZ during the scallop survey. In the 2012 survey a total of ten *C. fornicata* were found, all attached to king scallops *P. maximus* or queen scallops *Aequipecten opercularis*. Individuals were solitary or occurred in stacks of two, and at least three of the bottom-most individuals were carrying eggs, i.e. had reached sexual maturity and reproduced successfully. The sampling effort involved in the 2012 survey is considered high with 1074 scallops inspected and densities of *C. fornicata* were very low.

In 2016 the scallop survey found a total of 68 *C. fornicata* attached to scallop shells either as individuals or in stacks. Once again the sampling effort involved in the survey was high with 2534 scallops inspected and the density of *C. fornicata* low, 2.3% of scallops inspected, however the numbers were an increase from previous records.

The 2022 scallop survey found a further increase with a total of 185 *C. fornicata* either as individuals or stacks found attached to 5% of scallops inspected (75 scallop shells from 1456 inspected).

The records have been entered into i-record for access onto the National Biodiversity Network.

Figure 63 American slipper limpet *Crepidula fornicata* attached to a king scallop *Pecten maximus.*

4.11.9. Recommendations

- Continue recording phyla that are under-recorded in particular species of principal importance as defined under Section 7 of the Environment Act (Wales) 2016 and ‘Alien’ invasive (INNS) and non-native species (NNS).
- Continue recording of unusual, rare, scarce or vagrant species.
- Records are entered into the JNCC-administered Marine Recorder database for access via the National Biodiversity Network on-line gateway.

4.13. Plankton Recording

4.13.1 Project Rationale

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

4.13.2. Objectives

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

4.13.3. Sites

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

4.13.4. 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 200μm mesh net hauled vertically from 40 m.

PML method adopted: A 200 micron mesh net is hauled vertically from 35 – 40 m depth at approximately 0.2 m 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 1 m below the surface. This was then used to filter three 250 ml 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 30 cm diameter opening was used. The samples were collected by a vertical haul from 20 m with the net attached to a CTD probe (Conductivity, Temperature and 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.

In 2021, standard L4 method was used to collect Zooplankton samples (200µm net, vertical haul from 40 m). 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 125 ml surface water sample preserved in Lugol’s solution.

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

2022 – continuation of the 2021 methodology.

Analysis History

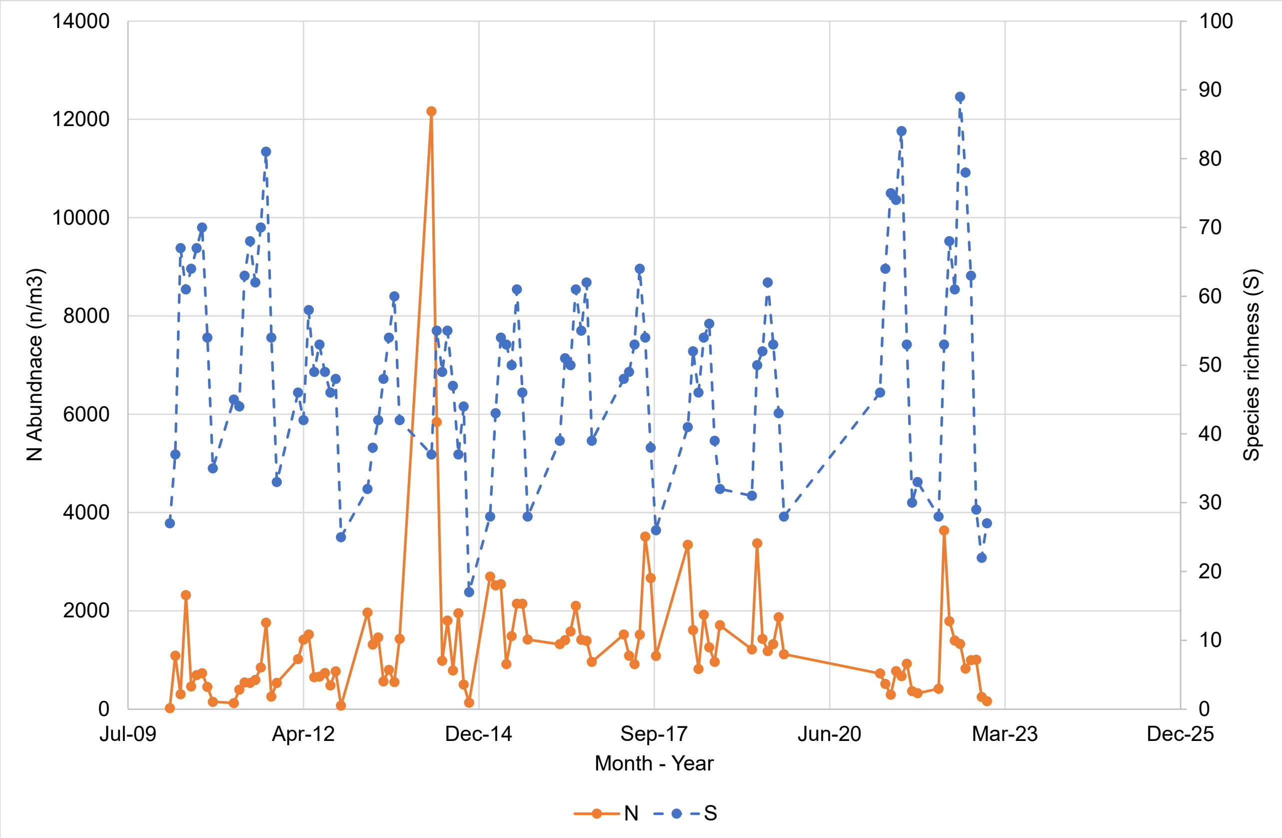
2009: 12 plankton samples were sent to the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) for identification and enumeration by Dr D. Conway. The sample dates were from the 10th May 2009 to the 9th Nov 2009. All zooplankton individuals were identified to species level where possible and counted. 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 and 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 onwards - 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.

4.13.5. Results

Zooplankton

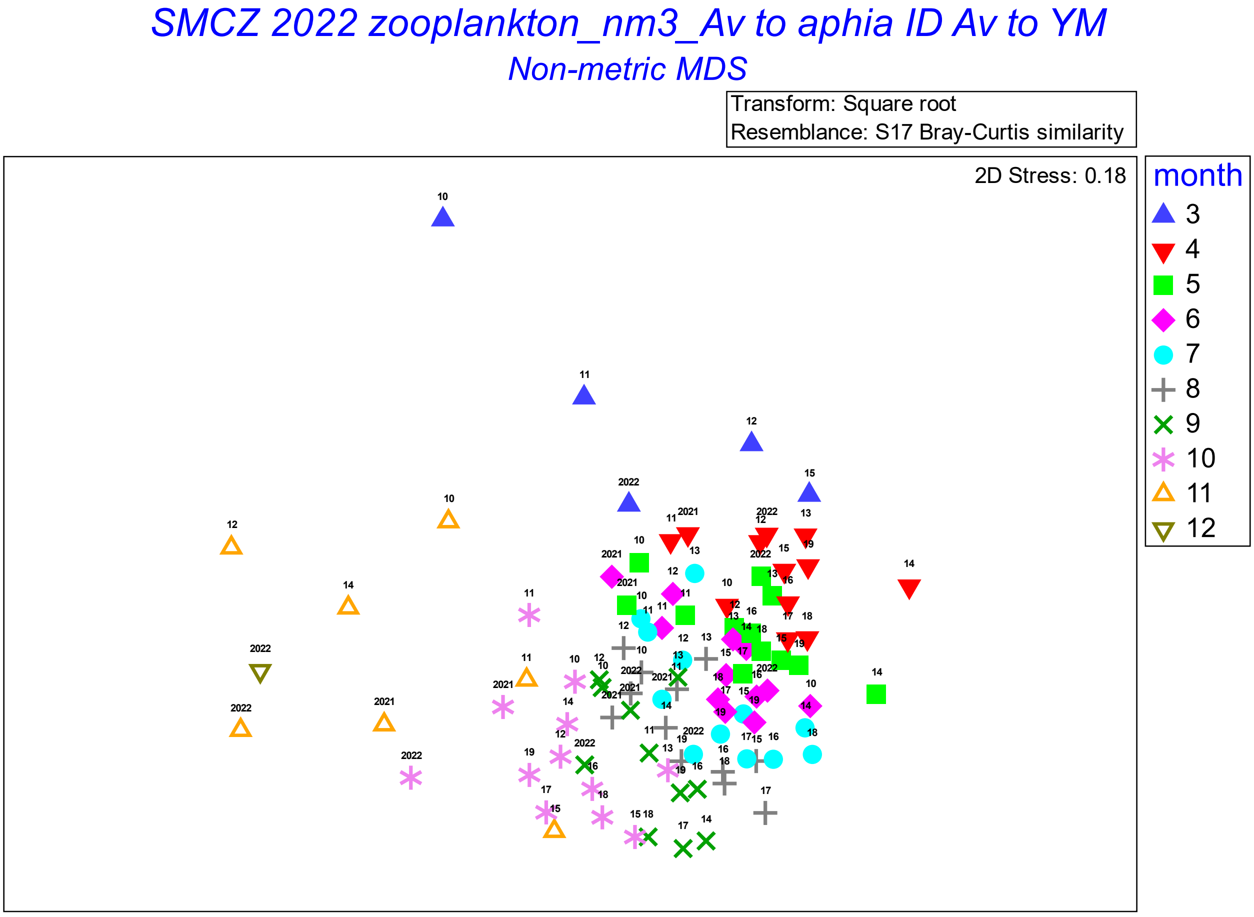
Figure 64 Average plankton species richness (S) and total number of individuals / abundance (N) 2010- 2022.



The peak in abundance in April 2014 was due to huge numbers of barnacle larvae in the plankton (Figure 64).

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 analyses: Individual species can be selected, differences between years can be analysed or the whole dataset can be combined to look for seasonal trends (Figure 65).

Figure 65 MDS plot of zooplankton community showing seasonal changes (symbols representing months and labelled with year).



Statistical analysis 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 66 shows how selected groups have different seasonal patterns. Cirripede (e.g. barnacle larvae) are most abundant early in the year while echinoderm larvae are abundant later in the year.

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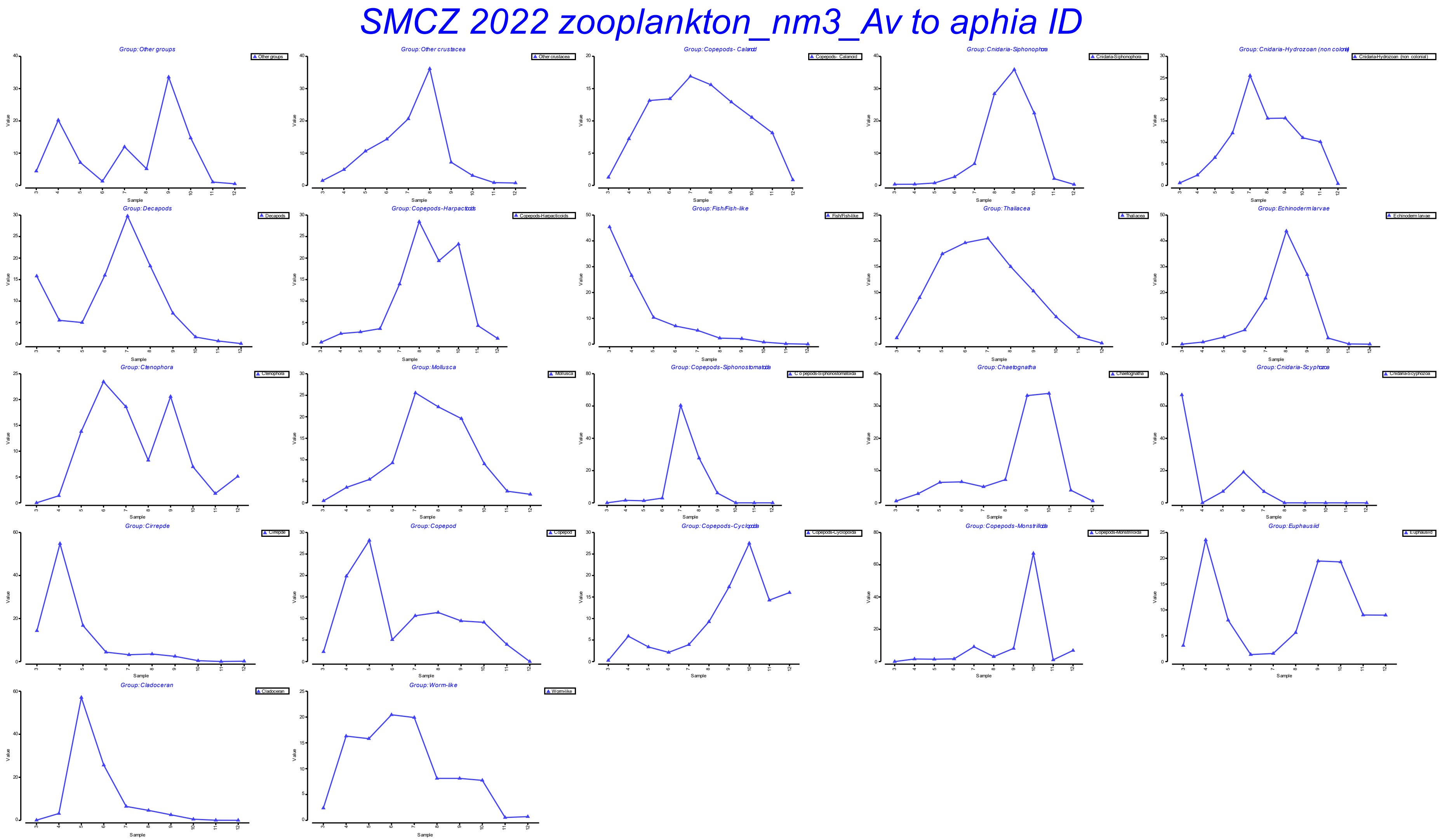
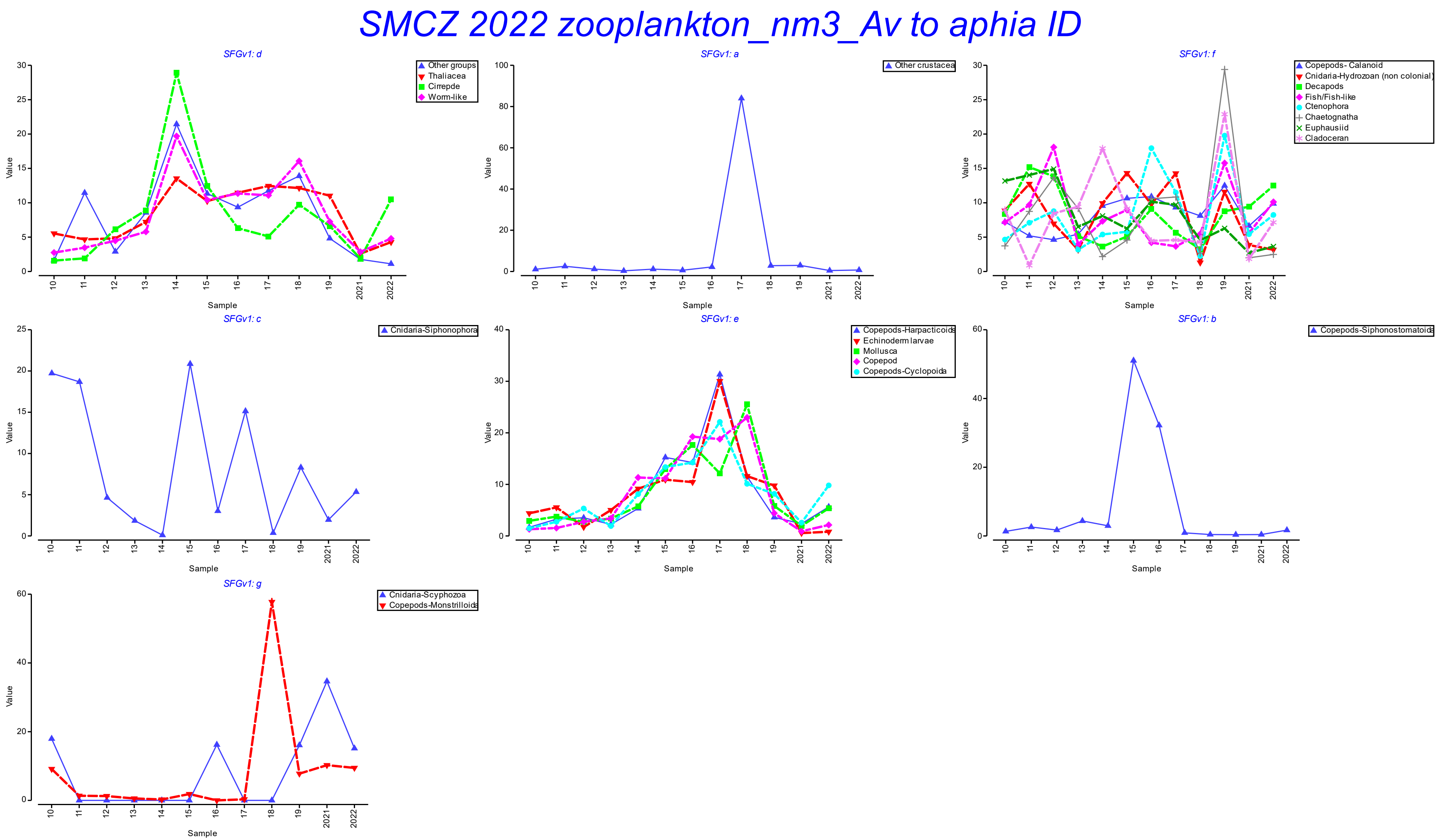
Figure 66 Seasonal abundance patterns for the major groups of zooplankton taxa sampled from March to December averaged from data collected between 2010 - 2022.



Annual variation in abundances of major groups are plotted in Figure 67. In general abundances are lower in 2021 for all groups except decapods. 2022 was also a low abundance year but did show some increases compared to 2021.

Figure 67 Coherence plots for the major taxonomic groups making up the zooplankton community at Skomer MCZ 2010 - 2022.



The big spike in "Other Crustacea" in 2017 is down to an influx of marine mites (*Acari* spp). These plots do highlight how variable the abundances are between years and between species.

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.

4.13.7 Current status

- A 10+ year timeseries of zooplankton has been collected. These data are comparable with other sites in the UK (Plymouth L4).
- Skomer MCZ Zooplankton data have now been archived with DASHH (marine species and habitats data archive) and submitted to the Pelagic Lifeforms Tool dataset.
- Phytoplankton data are 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.
- With the current data available it is not possible to report on the zooplankton and phytoplankton status in Skomer MCZ, so the condition of this feature is judged to be "unknown".

4.13.8. Recommendations

- Continue to collect zooplankton & phytoplankton samples on at least a monthly basis with as much coverage across the whole year as possible.
- Report zooplankton and phytoplankton feature as unknown.

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.

In 2022 the only malfunction on the weather station was seized bearings on the anemometer in February, about 4 days of wind strength records were lost before the bearings were replaced.

5.1.7. Results

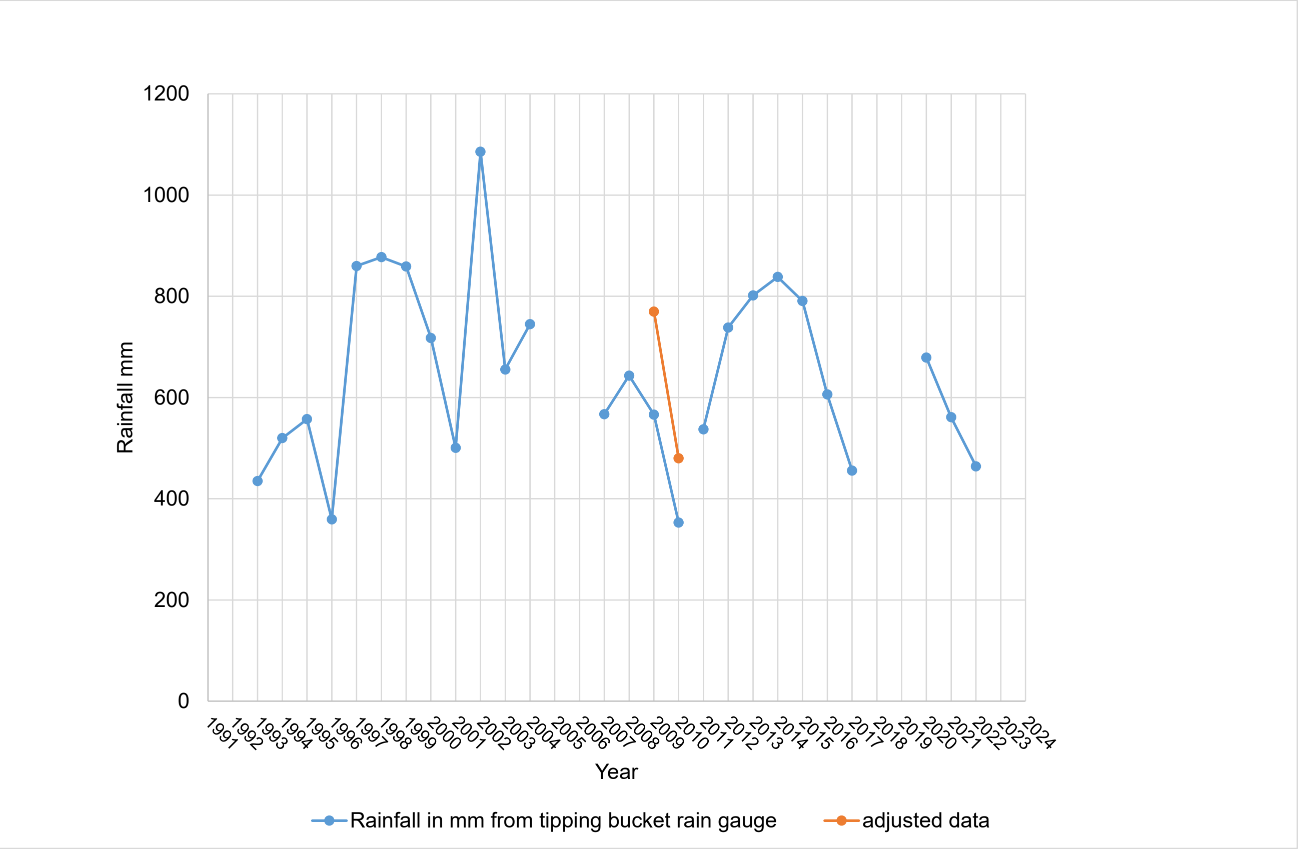
Rainfall

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

Figure 68).

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.

Figure 68 Skomer MCZ automatic weather station total rainfall (mm) data (incomplete data for 2018 & 2022).



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.

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 69).

Figure 69 Skomer MCZ automatic weather station, radar plot average wind direction and strength 1993 – 2022.

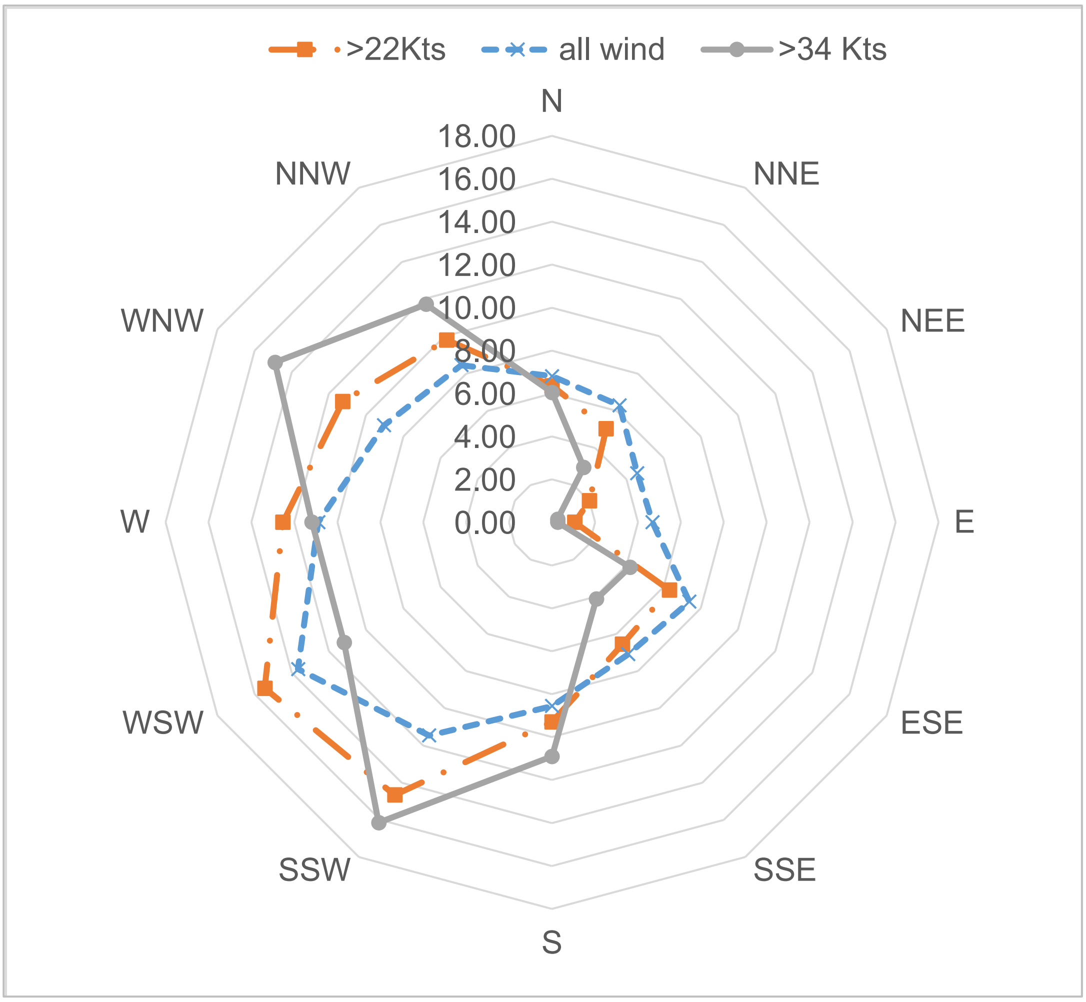
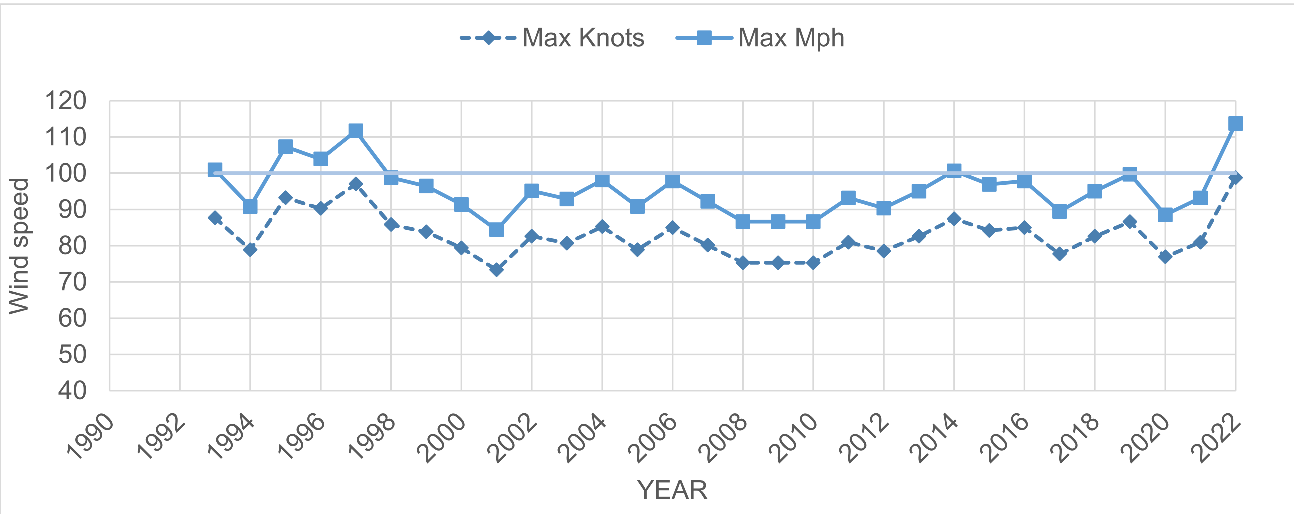


Figure 70 Skomer MCZ automatic weather station data - maximum wind strength (knots) 1993 – 2022.



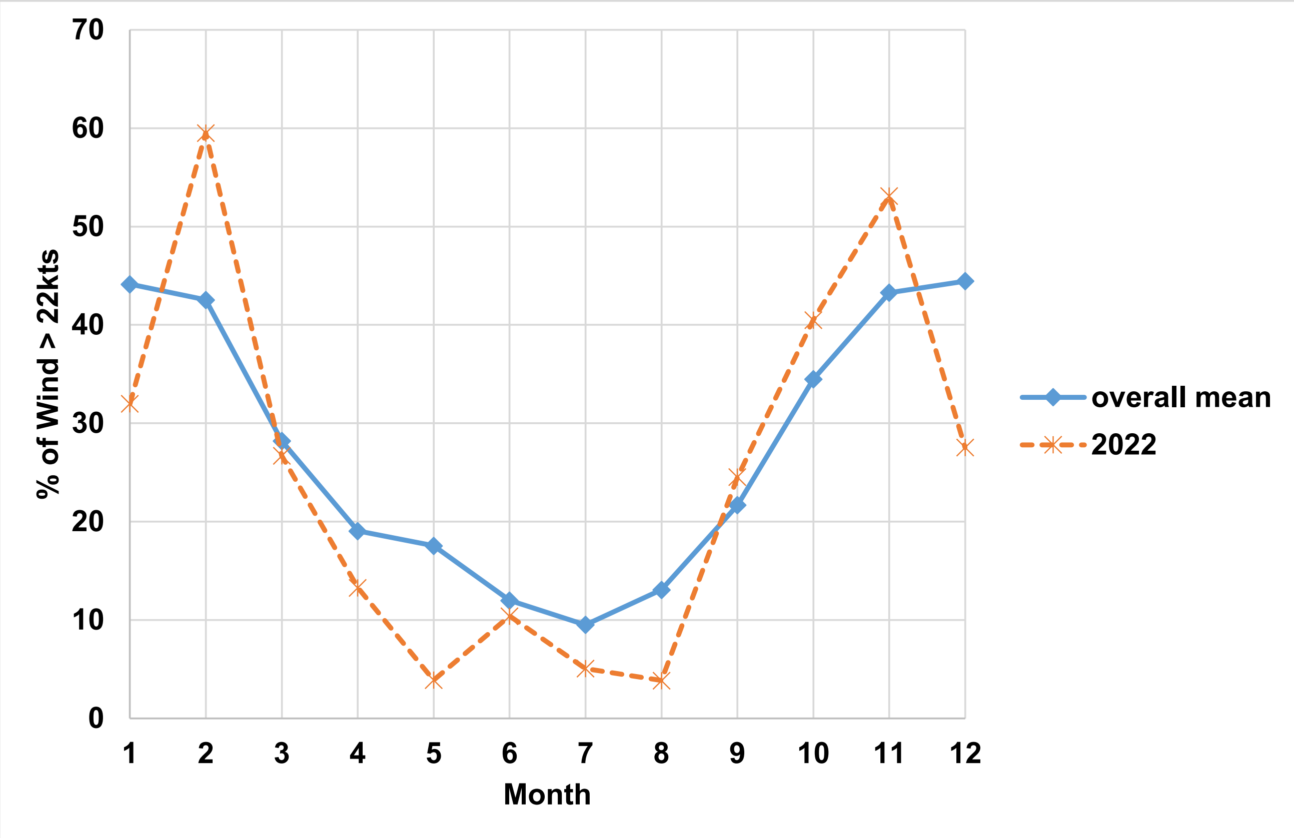
The maximum gust recorded for 2008, 2009 and 2010 was exactly the same (86.6 mph) (Figure 70). This led to the suspicion that the anemometer bearings were faulty. After the bearings were replaced in 2011 higher gusts were recorded. 2021 saw a maximum gust of 93.2 mph in December, while other high records 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 70). 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% > 22 knots) but it is very variable from year to year.

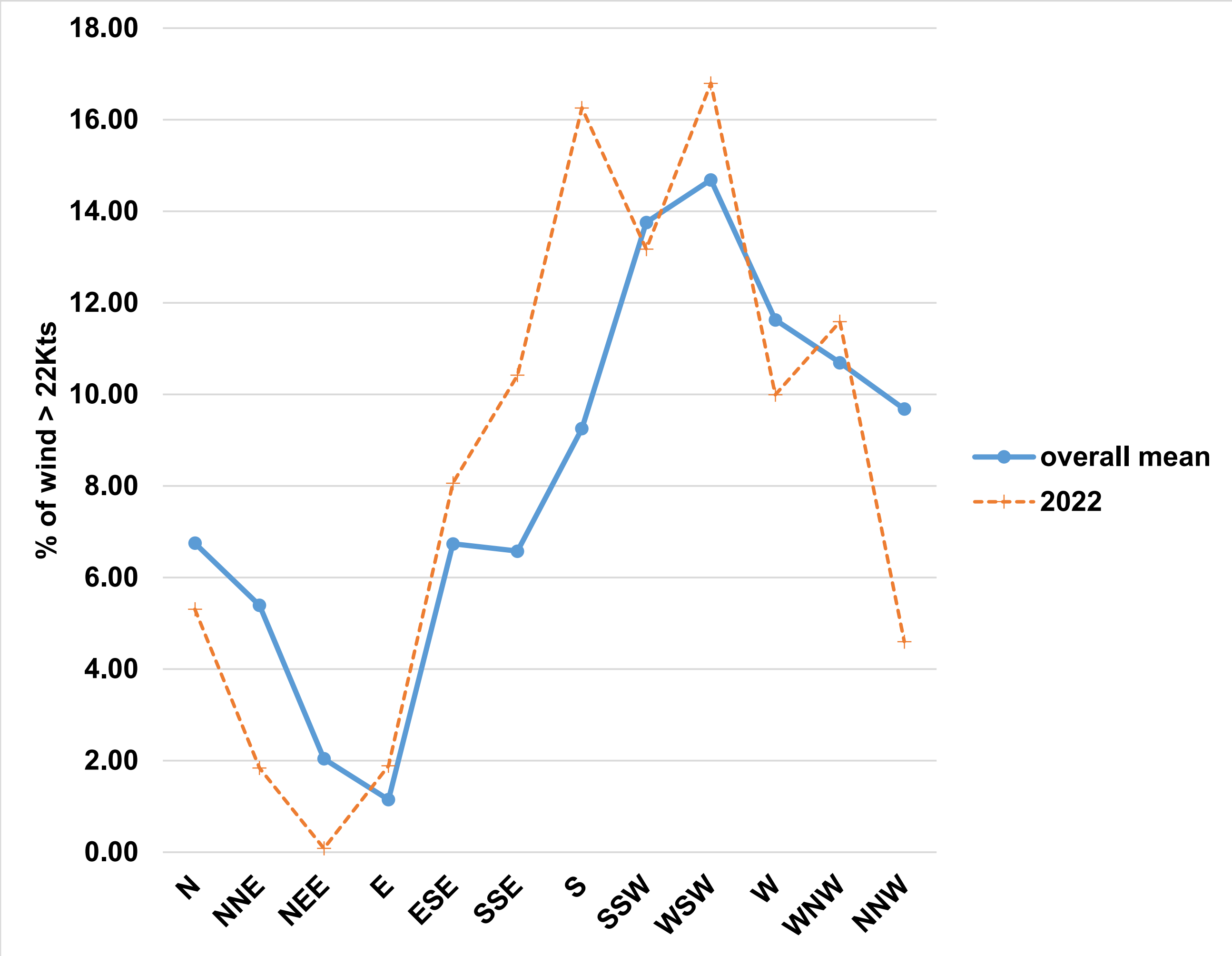
Another ecologically important measure of exposure is total annual wind, which is a measure of the energy that littoral and sublittoral habitats are subjected to. The total amount of wind is calculated from the percentage of wind recorded in each year at each Beaufort force multiplied by the mid wind 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 71 Skomer MCZ automatic weather station data – percentage of wind greater than 22 knots for each month. All years averaged and 2022 data.



The winter months of February and November were especially windy in 2022.

Figure 72 Skomer MCZ automatic weather station data – percentage of wind over 22 knots from each wind direction.



2022 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 72). Most of the stronger winds come from the SW, WSW & WNW. The east tends to have the lowest percentage of strong winds.

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 73).

The 2022 annual meteorological summary from the Skomer MCZ automatic weather station is shown in Table 24. Monthly average air temperature, relative humidity and solar radiation results are summarised in Figure 74 to Figure 77.

Figure 73 Skomer MCZ automatic weather station data – “total annual wind” 1993 to 2022.

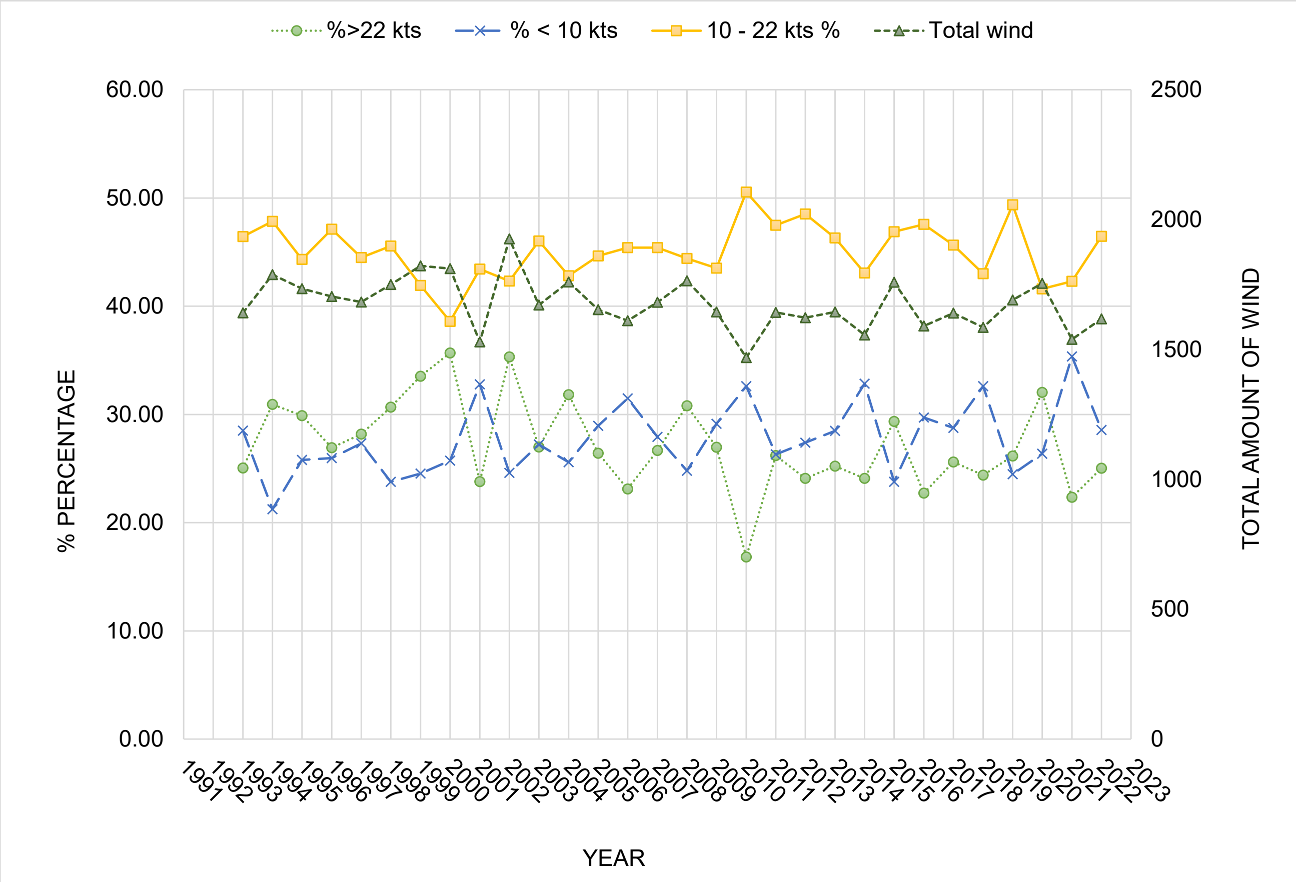


Table 24 Skomer MCZ automatic weather station – 2022 annual meteorological summary.

Natural Resources Wales - Skomer Marine Conservation Zone					**YEAR**	**SUMMARY**		**2022**					
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	8.019937	8.74046	8.6894	9.27181	11.79566	13.552	16.294	17.139	15.115	14.208	11.667	7.104423
T107_1 0c	MAX	13.36	11.96	16.18	16.52	18.37	18.3	29.54	27.54	22.35	17.97	15.64	13.15
	MIN	1.605	2.95	2.519	2.661	7.339	9.1	12.31	12.48	10.36	9.66	4.781	-1.103
BAROMETRIC PRESSURE	MEAN	1018.707	1007.77	1013.05	1009.23	1011.172	1008.4	1014.7	1011.5	1006.5	1004.2	997.31	1002.667
	MAX	1035	1026	1034	1026	1022	1021	1028	1025	1020	1021	1021	1022
	MIN	989	969	985	979	996	990	999	995	989	984	973	977
RELATIVE HUMIDITY	MEAN	84.11581	84.5631	79.4146	81.3264	91.73246	87.816	84.677	83.4	84.797	87.001	83.336	84.84659
	MAX	100	100	100	100	100	100	100	100	100	100	100	100
	MIN	46.24	50.65	38.67	48.03	63.26	64.75	37.26	39.53	58.67	58.83	59.76	55.27
RAINFALL	TOTAL(mm)	14.824	73.3	23.12	35.762	40.796	24.888	13.056	8.976	38.492	64.872	73.036	53.04
SUNSHINE	MEAN(kw/m2)	0.033893	0.06949	0.14064	0.2013	0.243184	0.2756	0.2633	0.2261	0.1379	0.0925	0.0428	0.031682
	sunshine hours	73	142	260	311	353	364	377	340	257	204	112	80
	Sunshine hrs (10min)	74.5	135	256.5	305	348.3333	356.17	369.83	340.33	248.33	198.67	106.5	77.16667
NET RADIATION	MEAN	-16.4679	-0.75807	26.9216	66.6263	106.4446	119.78	115.93	89.359	34.551	11.341	-15.28	-21.5093
MAX GUST	m/s	28.75	50.83	27.92	32.08	20.42	26.67	21.25	20.001	30.83	29.17	35.42	33.33
	direction	225.5	217.5	173	237.2	242.4	204	223.4	357.6	144.8	228.9	214.7	199.1
	Knots	55.84975	98.7424	54.2374	62.3186	39.66789	51.809	41.28	38.854	59.89	56.666	68.807	64.74686
	Days > F7 MEAN	0	0	0	0	0	0	0	0	0	0	0	0
	Days > F7 Gust	15	25	16	8	9	9	7	3	13	22	28	14
	days max hr av>F7	7	9	4	3	0	1	0	0	4	8	14	7
Notes													
Feb 18th 2022 @ 11:00 max wind recorded was 50.83 m/s this then siezed the bearing in the anenometer and no more reading were collected until- 22 Feb													
Replacement Anemometer installed 10:20 22 Feb 2022				Missing about 4 days of wind speed data									
21-10-2022 10:00 - clock was altered - 17hrs backwards. Noticed on the 25th Oct 2022 and re set.													
Hourly and 10 min times have been recorrected BUT daily files needed the values RE-calculating using excel functions.													

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

Figure 74 Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2022 with monthly min / max error bars.

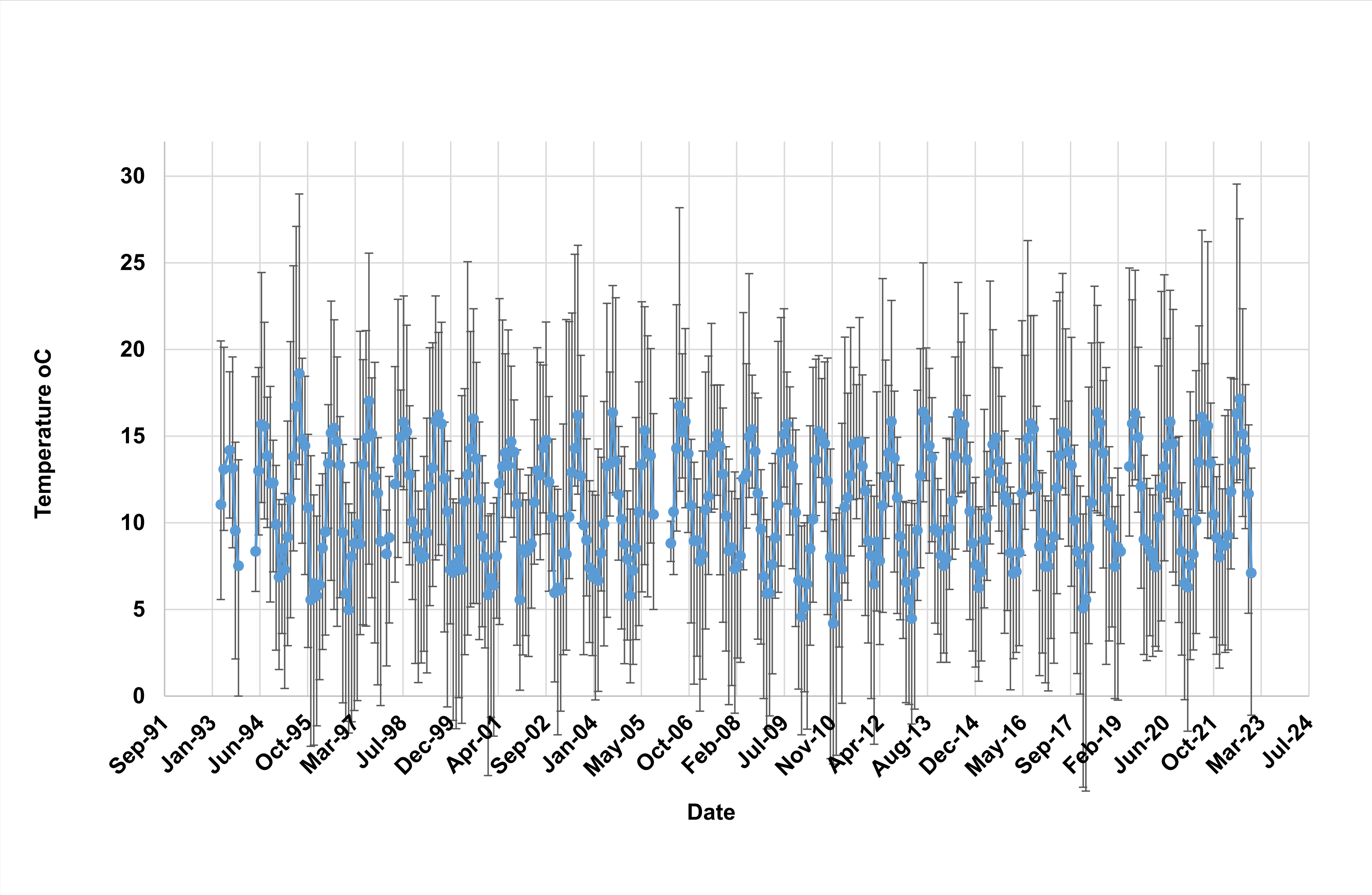


Figure 75 Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (°C) 2006 – 2022.

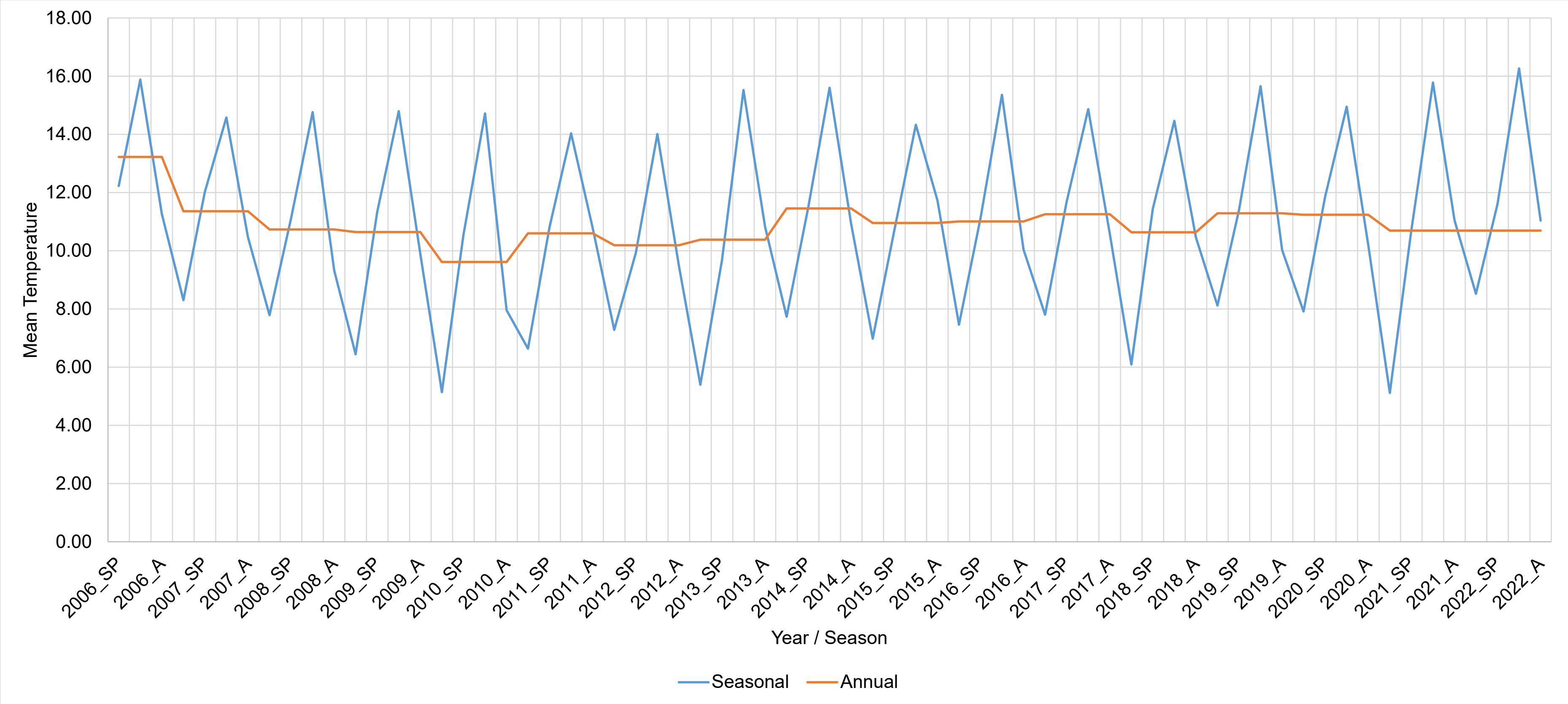
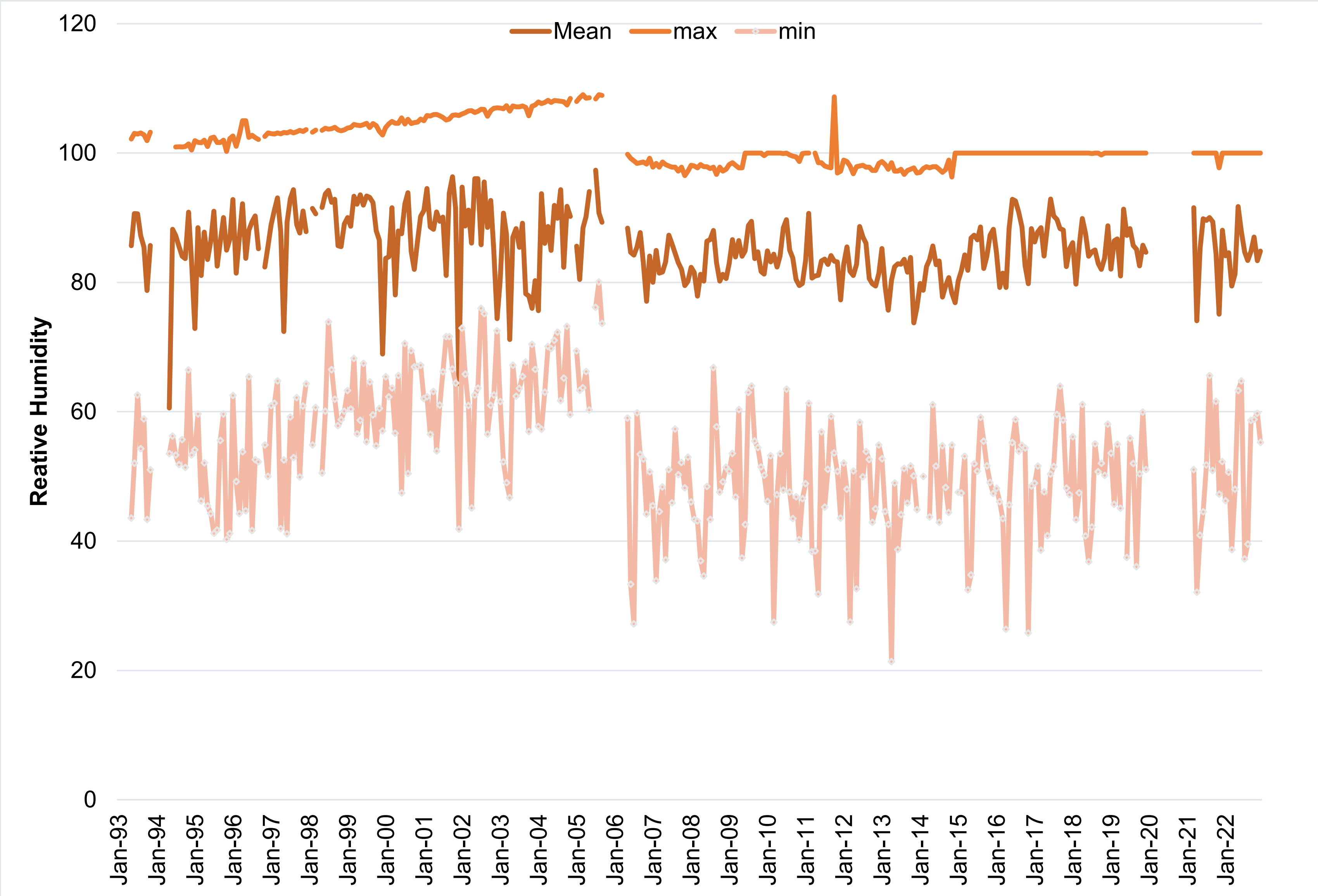
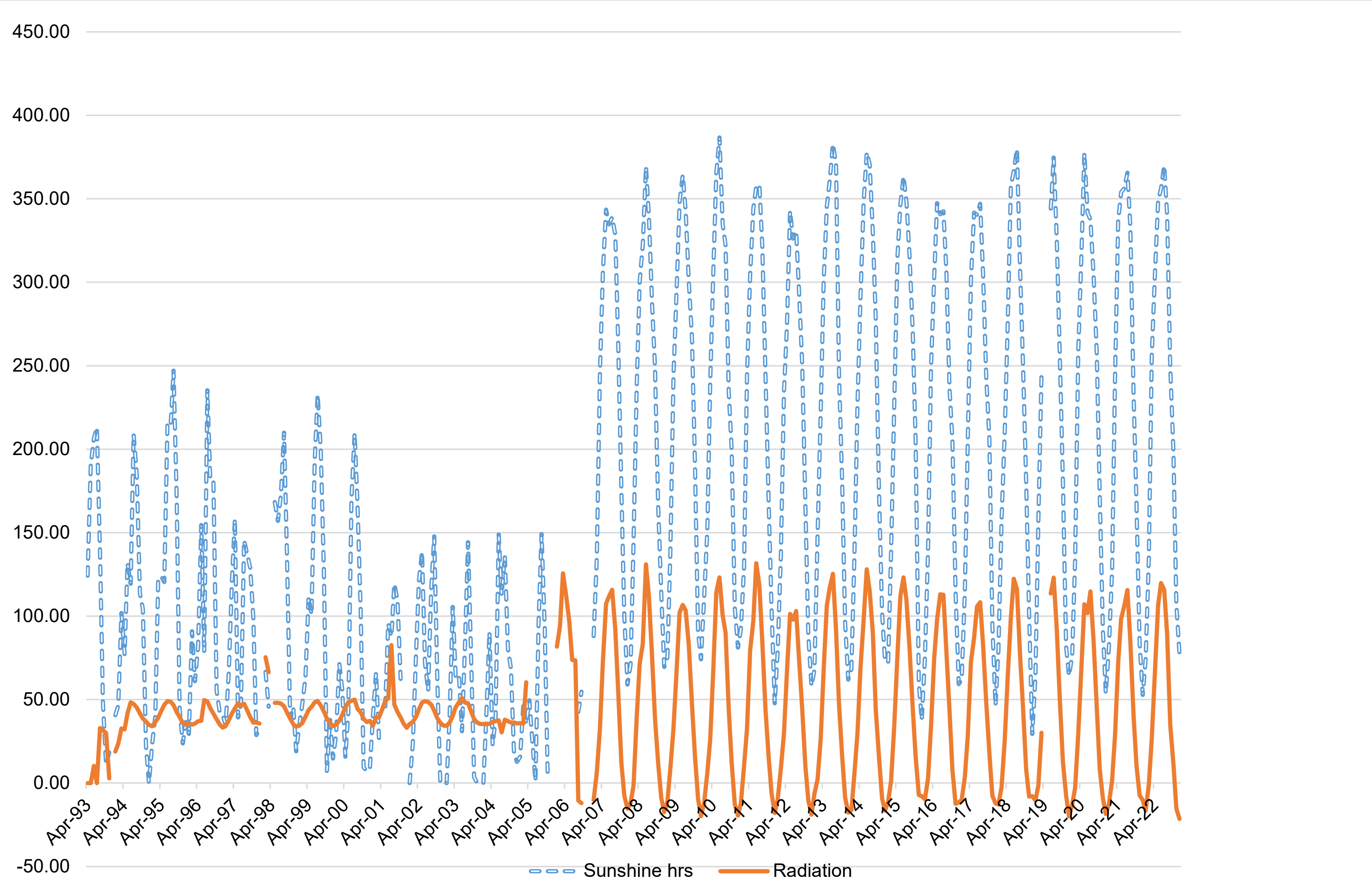


Figure 76 Skomer MCZ automatic weather station – relative humidity 1993 – 2022.



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 77 Skomer MCZ automatic weather station – solar radiation (W/m^2) and sunshine hours 1993 – 2022.



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 25 Valeport series 600 MKII CTD probe water profile records.

Year	Months samples were taken
1992	Jul – Nov
1993	Jan – Dec
1994	Feb – Dec
1995	Jul – Dec
1996	Mar – Dec
1997	Aug – Dec
1998	Mar – Nov
1999	May – Nov
2000	Mar- Oct
2001	May – Nov
2002	May – Oct
2003	Jun – Sept
2004	May – Oct
2005	May – Oct
2006	Mar – Oct
2007	Apr – Oct

Year	Months samples were taken
2008	Apr – Dec
2009	Feb – Oct
2010	Mar – Nov
2011	Mar – Nov
2012	Mar – Nov
2013	Apr - Oct
2014	Apr - Nov
2015	Mar - Oct
2016	Apr - Oct
2017	Apr - Oct
2018	Apr - Oct
2019	Apr – Oct
2020	No records
2021	May - Oct
2022	Mar - Dec

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 26 Skomer MCZ maximum and minimum annual seabed temperatures 2000 to 2021 (June) at 19 m 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	16.4
2022	8.8	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. 2012 was much warmer in comparison with a very mild 8.8°C in the winter (Table 26).

A summary of the seabed temperature (data from Vemco minilog at 19 m BCD) is shown in Figure 78. Monthly means have been calculated from seabed temperature but substituted with the CTD probe seabed temperature data where logger data were absent.

Figure 78 Skomer MCZ summary of monthly mean seabed temperature 1992 – 2022.

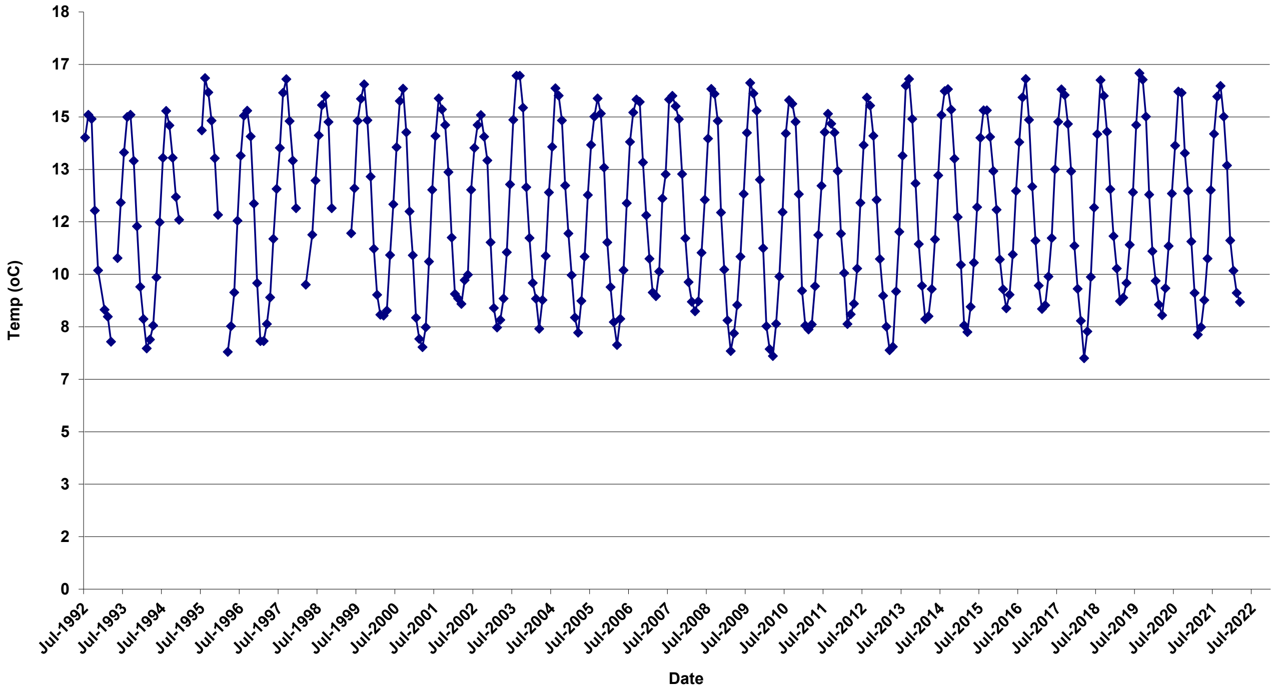
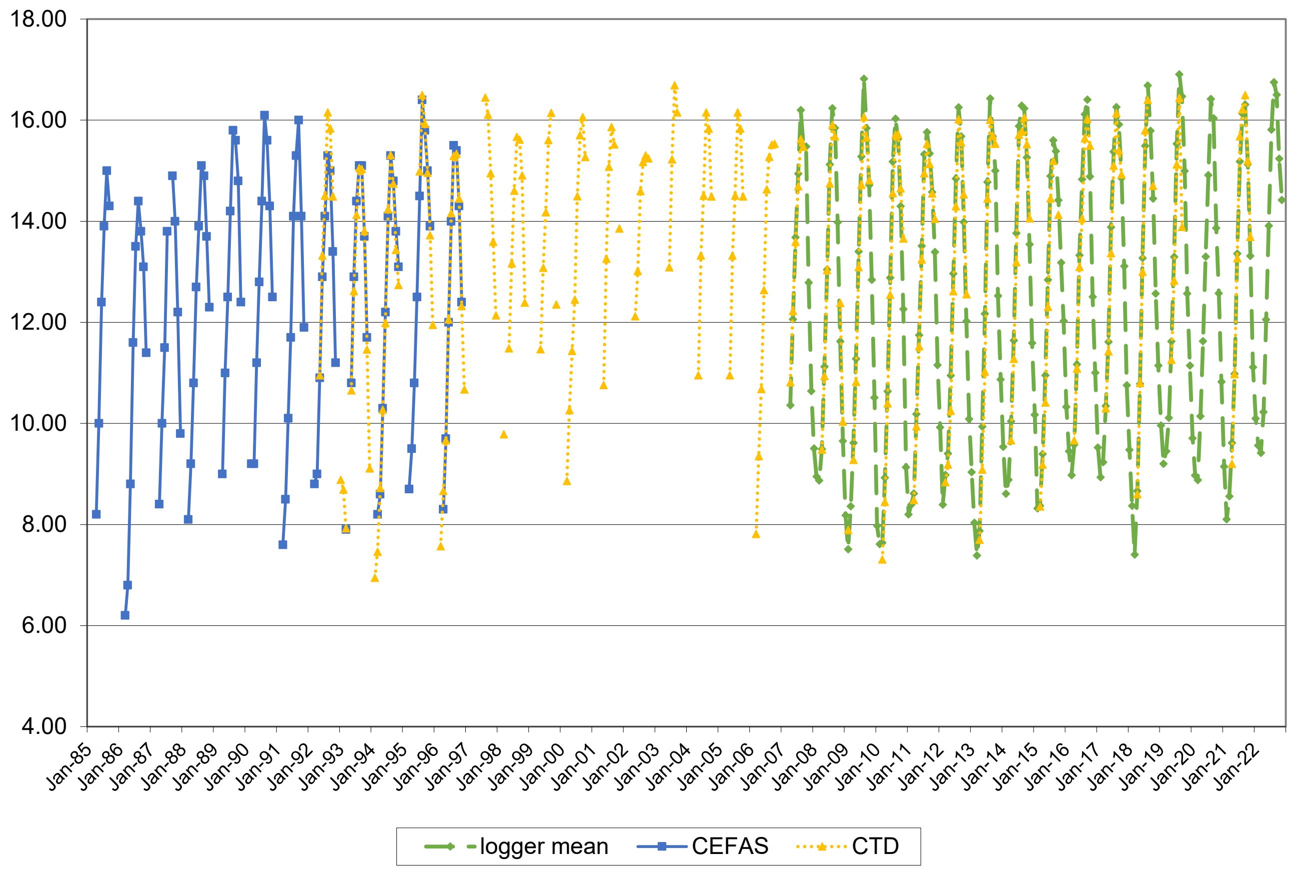


Figure 79 Skomer MCZ summary of monthly mean sea surface temperature (°C) 1985 – 2022.



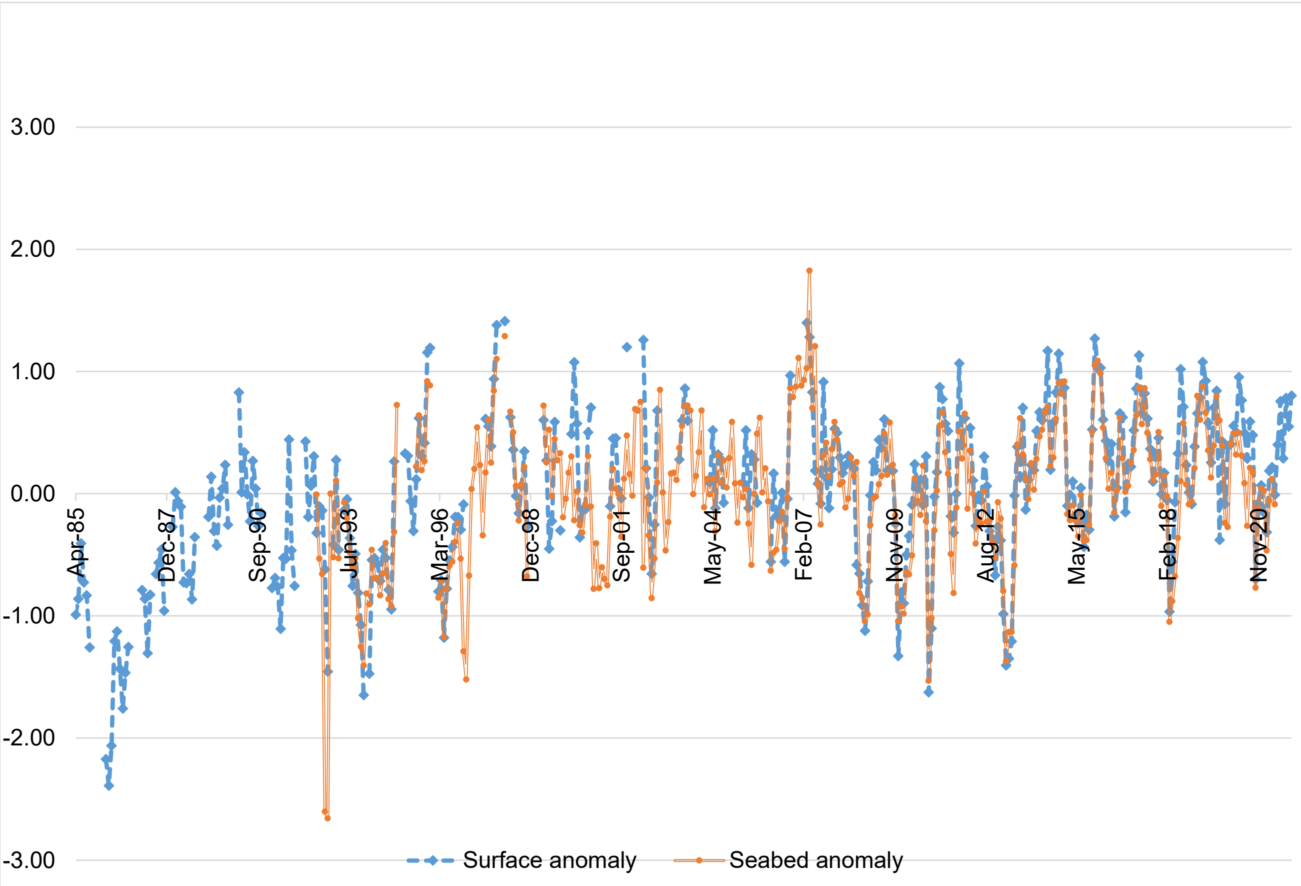
A summary of the sea surface temperature is shown in Figure 79. This is made up of:

- 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: 1 m, 5 m, 10 m, 15 m below sea level and 2 m above seabed. Only 1 m and 5 m 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 80).

Figure 80 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. In 2022 the seabed logger was downloaded in April but since then it has not been retrieved.

Shore monitoring sites

The loggers provide a record of the temperature regime experienced by sessile organisms in the intertidal 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 81). The data from the intertidal loggers follow a very similar trend to the logger recording on the seabed at Skomer.

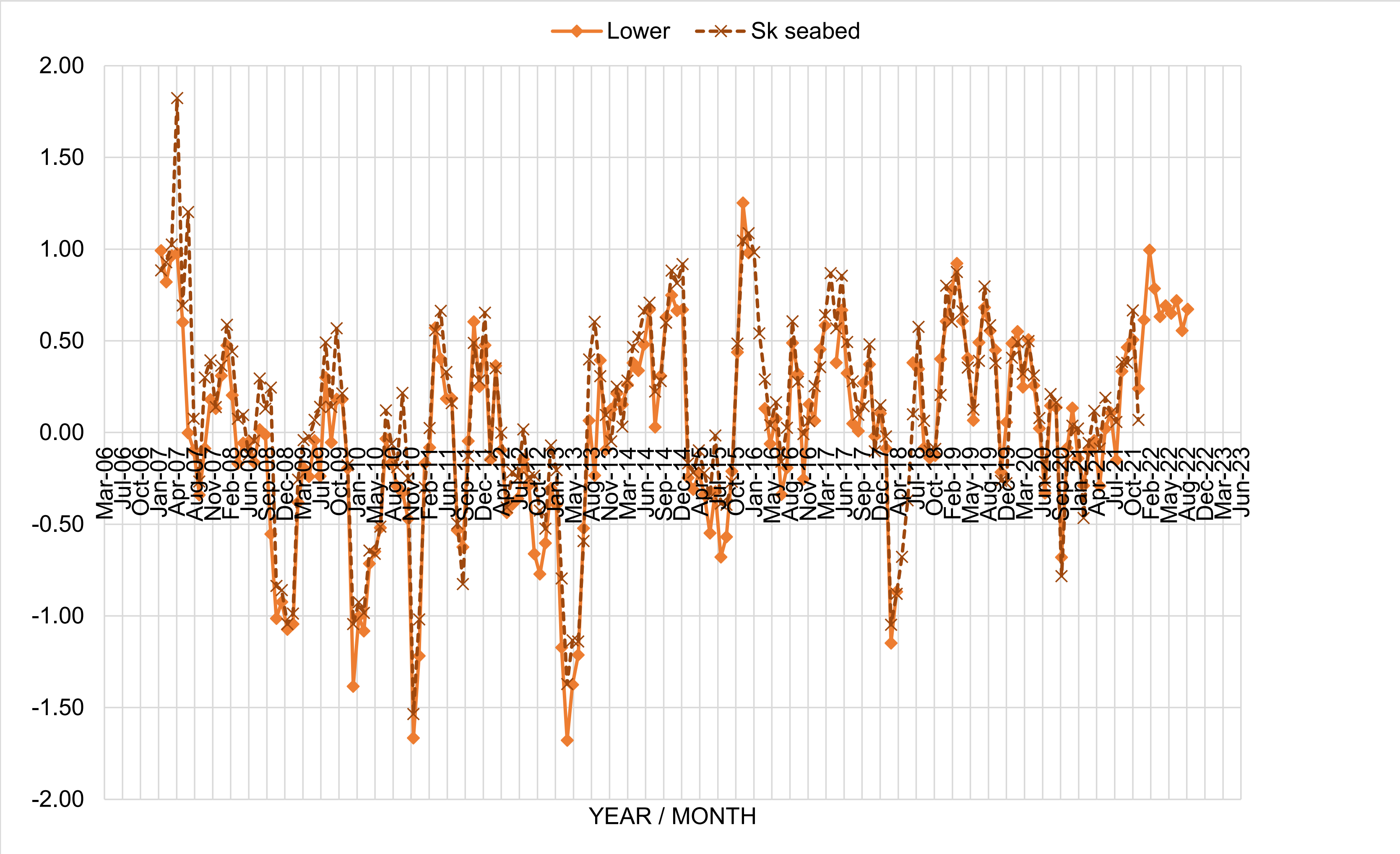
5.2.7. Current Status

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.

Figure 81 Martins Haven shore (lower shore) temperature loggers - anomaly 2007 – 2022 with Skomer seabed logger anomaly shown for comparison.



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 30 cm 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.
- 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 0.6 m below the surface. This was discontinued in 2013.

Table 27 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	None
2022	Apr - Sep	OMS & TRK	Collectors still on seabed

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 82.

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 83.

Figure 82 Skomer MCZ summary of monthly mean Secchi disc data (m) 1992 – 2022 with standard error bars.

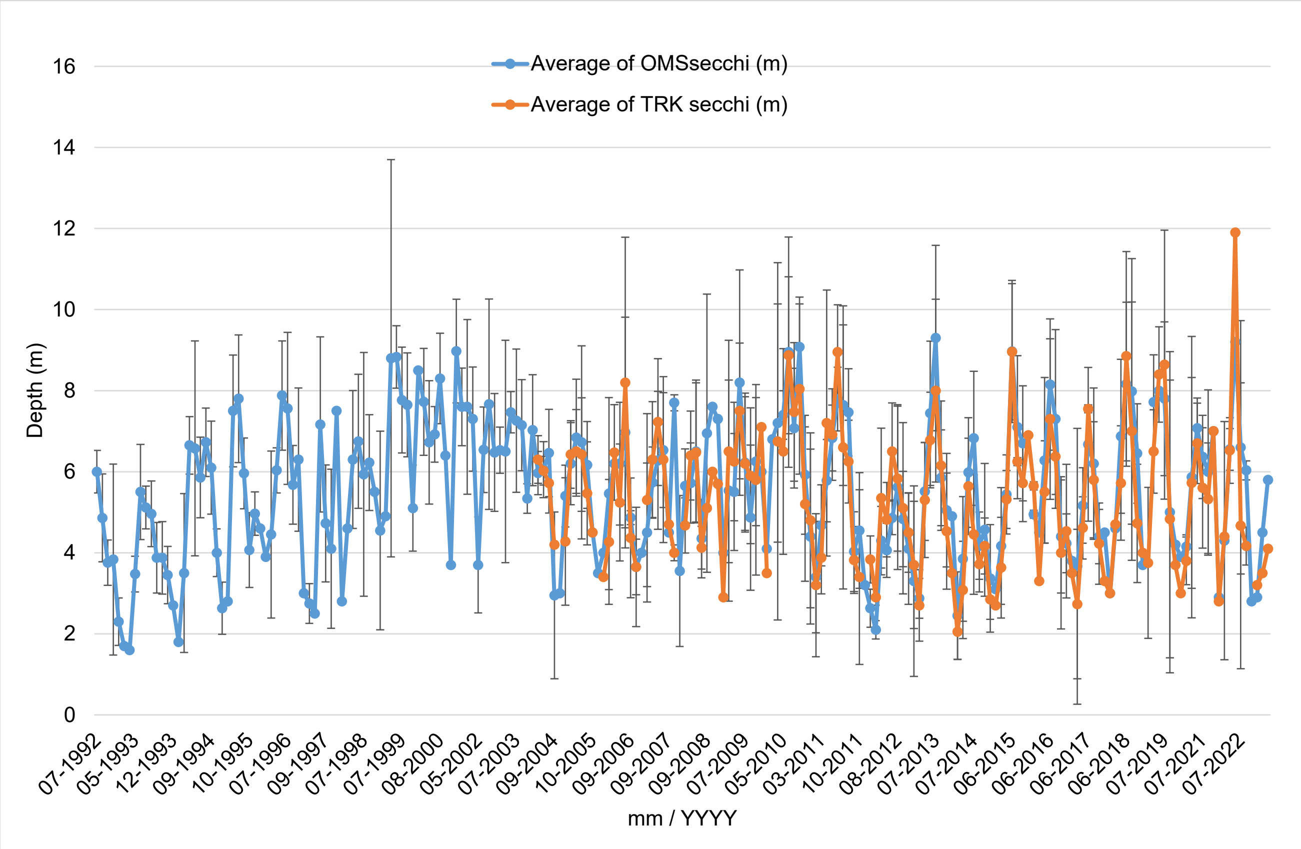
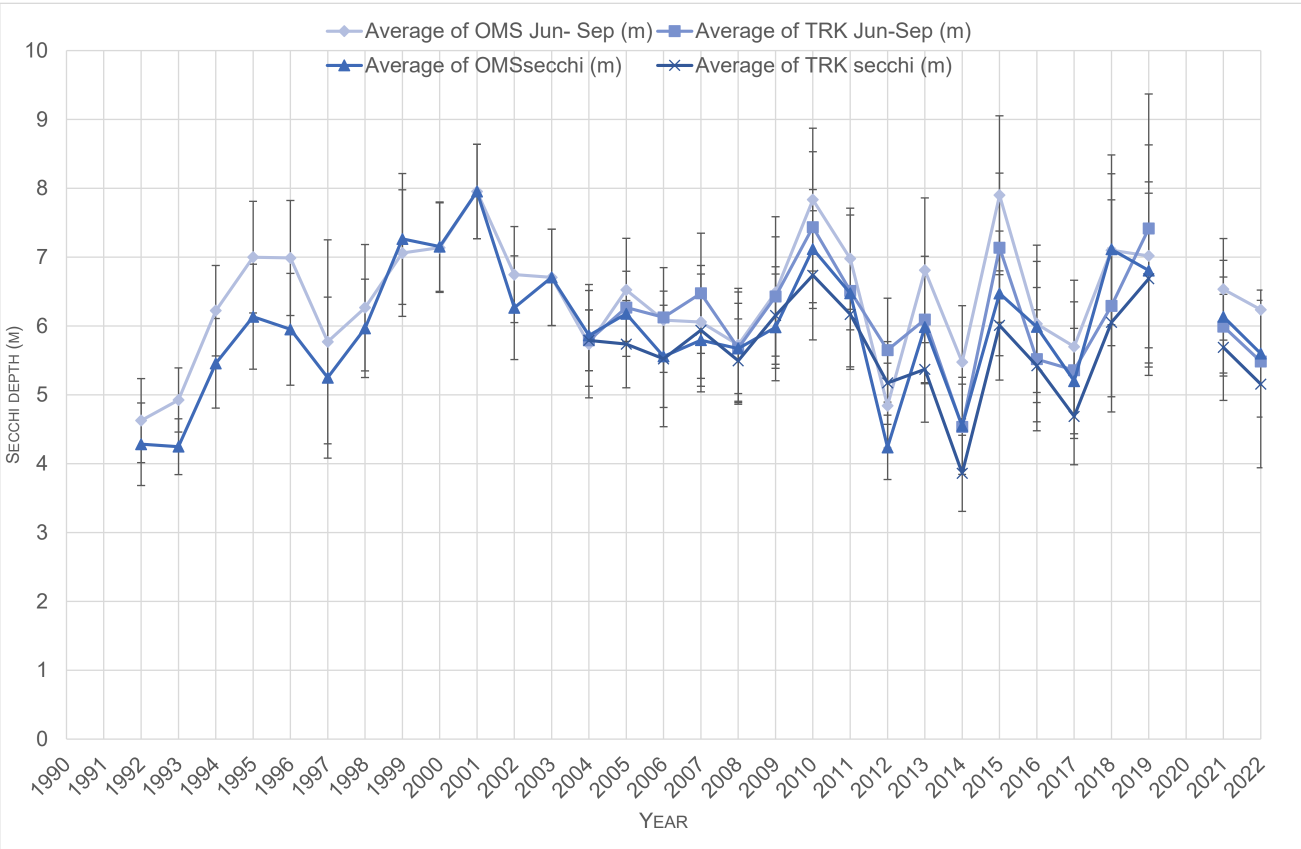


Figure 83 Skomer MCZ summary of annual mean Secchi disc data (m) with standard error bars.



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. Water clarity then improved in 2018 and 2019 but has dropped again in the last 2 years.

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 28, Figure 84).

Table 28 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
2022	1.87	10.10	0.08	29.61	68.16

Table 29 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

OMS	g/day oms	% organic content	% gravel	% sand	% mud
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
2022	1.05	10.40	1.67	25.19	54.76

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 (no data recorded for sand in 1995 – 1998).

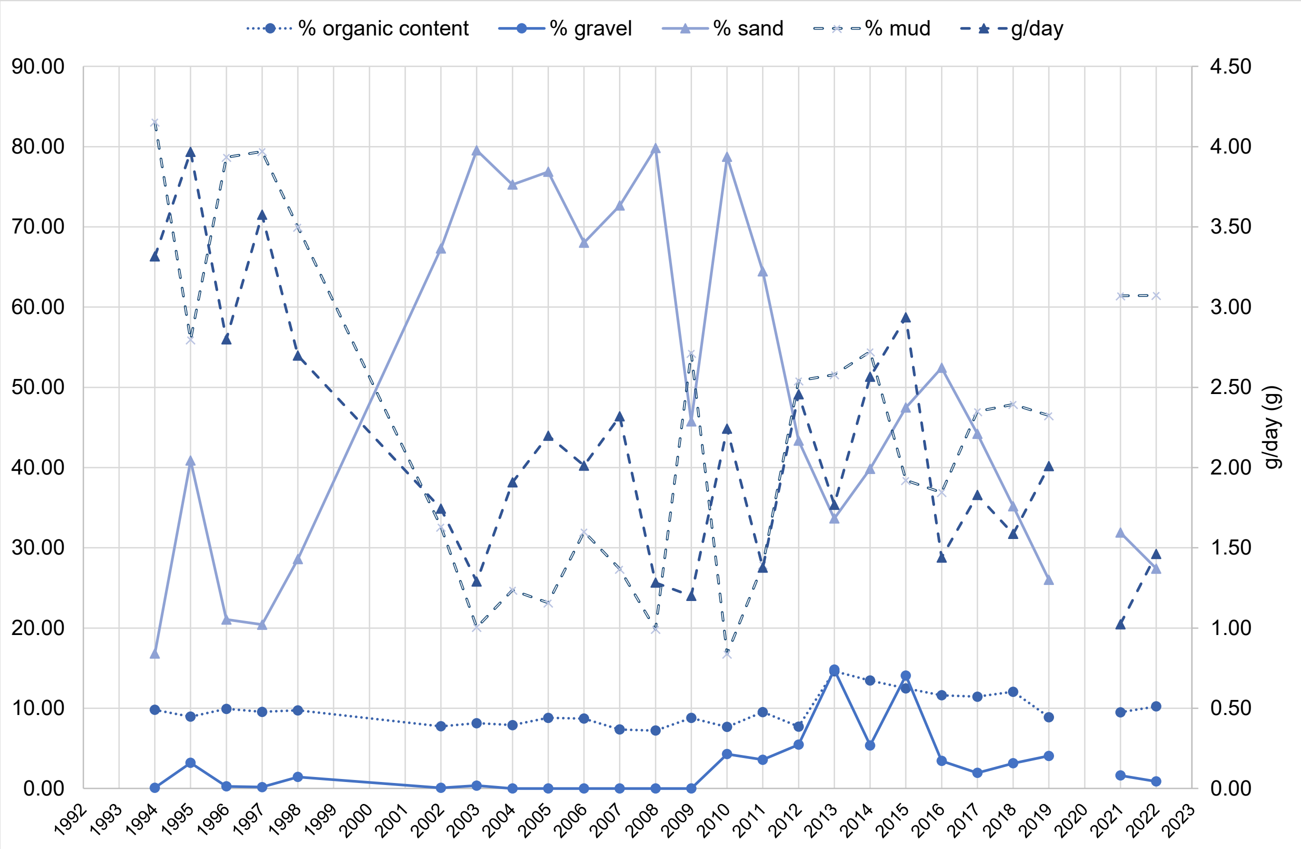
Another change in 2013 was that the organic content analysis included heating the sample to 550°C rather than 450°C resulting in more carbonates being included in the % organic content. This explains the sudden rise in the 2013 values. The ignition temperature used from 2014 onwards at the NRW laboratories is 480°C.

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

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

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

Figure 84 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 84). The settlement rate of sediment was higher in the 1990's (3-4g/day) this dropped in the 2000's to fluctuate between 1.2 – 3g/day. 2021 saw the lowest settlement rate (1 g/day).

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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