Skomer Marine Conservation Zone Project Status Report 2023

NRW Evidence Report 752

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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 2023. 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 2023:

Fe gofnododd gwaith monitro'r fôr-wyntyll binc, *Eunicella verrucosa,* golledion pellach yn 2023. Mae asesiad o gyflwr môr-wyntyllion unigol yn dangos bod wyau'r morgi brych *Scyliorhinus stellaris* wedi'u cofnodi ar 59% o fôr-wyntyllion a bod necrosis lefel 4 (epiffytau yn tyfu ar rannau helaeth o'r fôr-wyntyll) wedi cynyddu o 2.4% o fôr-wyntyllion yn 2002 i 11% yn 2023.

Cwblhawyd yr arolwg o enedigaethau'r morlo llwyd ar yr ynys a'r tir mawr rhwng mis Awst a Rhagfyr a chofnodwyd 425 o forloi bach. Mae cofnodion y niferoedd o forloi bach a anwyd ym Mharth Cadwraeth Morol Sgomer ar eu huchaf erioed dros y 3 blynedd diwethaf, gyda chyfartaledd o 439 o forloi bach wedi'u geni rhwng 2021 a 2023. Ers 2009 bu cynnydd cyson yn nifer y morloi bach a anwyd ar yr ynys a'r tir mawr.

Cynhaliwyd arolwg o'r gwely *Zostera marina* yn North Haven. Mae canlyniadau 2023 yn dangos gostyngiad o 2.3% yn yr arwynebedd o gymharu â'r arolwg diwethaf yn 2018. Bu cynnydd bach o ran dwysedd yr egin ar draws y gwely (mae nifer yr egin fesul m^2 wedi cynyddu o 42.4 egin / m^2 yn 2018 i 47.4 egin / m^2 yn 2023). Mae dwysedd yr egin yn dal i gynyddu ers y cyfraddau isel yn 2014, gyda 2023 yn dangos y cofnodion uchaf hyd yma o ran dwysedd cyfartalog yr egin.

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 2023. 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 UK Marine Strategy (UKMS). 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 2023 and a summary of the results to date. Section 5 provides a summary of the oceanographic and meteorological surveillance projects.

Notable records in 2023:

Pink sea fan, *Eunicella verrucosa*, monitoring recorded further losses in 2023. Condition assessment for individual sea fans show that bull huss *Scyliorhinus stellaris* eggs were recorded on 59% 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 11% in 2023.

The Grey seal pupping survey was completed at both island and mainland sites from August to December and 425 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 2021-23 at 439 pups. Since 2009 there has been a steady increase in pup production at both the island and mainland sites.

The *Zostera marina* bed in North Haven was surveyed. The 2023 results show a 2.3% decrease in area of extent compared to the last survey in 2018. There has been a slight increase in shoot density across the bed (number of shoots per m^2 has increased from 42.4 shoots / m^2 in 2018 to 47.4 shoots / m^2 in 2023). The shoot density continues to increase from the low counts in 2014, with 2023 showing the highest average shoot density recorded to date.

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 three 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 Environmental Change Network (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

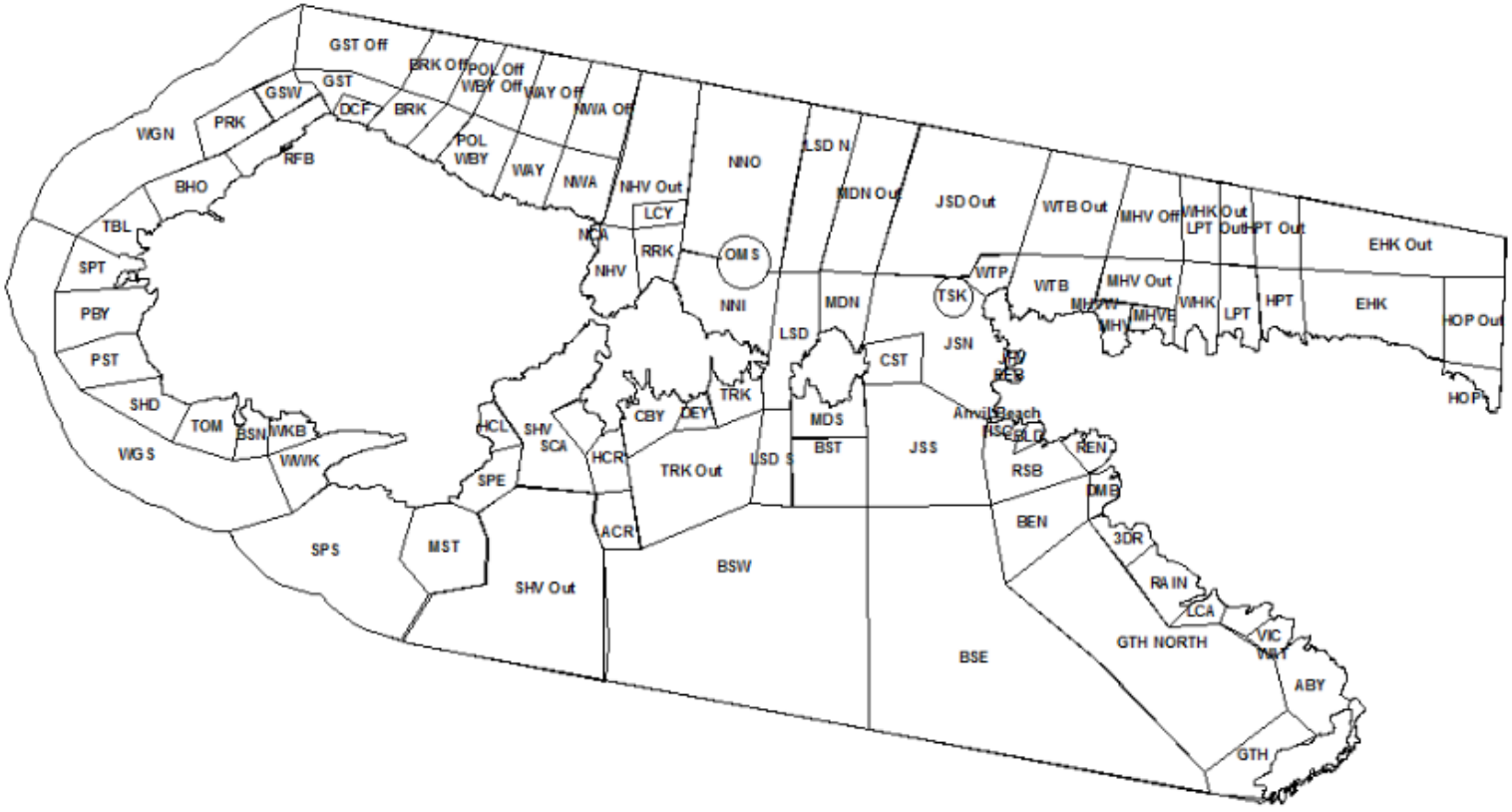
Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Sub-Littoral Algal communities	Algae species and community survey	1983, 1986,1994, 1999, 2007	No current planned survey	Hiscock 1983 & 1986, Scott 1994, Brodie & Bunker 1999/2000, Maggs & Bunker 2007.	Yes, Skomer 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, 2023	Every 4 years, next planned 2027	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, 2023	Every 4 years Next survey planned 2027	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. Massey et al 2024	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, 2022	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 1992-2023, 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,	Yes, Skomer MCZ office.

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
				Bullimore 2010	
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” , Coastwatch 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. Biological Project Summaries

4.1. Littoral Communities

4.1.1. Project Rationale

Littoral rock communities are a management feature of the Skomer MCZ. It includes intertidal boulders and suptralittoral lichens which are habitats of principal importance under Section 7 of the Environment (Wales) Act 2016. 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 and boulder shores over the continuum of exposure and aspect ranges.

4.1 3. Sites

Table 4.1.1 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 below. Sites were divided into 4 zones, based on shore height Above Chart Datum (ACD)

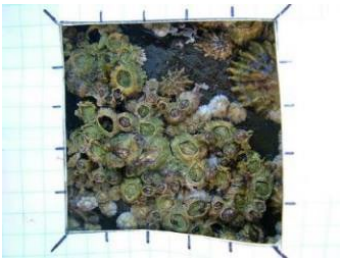
Lower shore – 1.8m ACD
Middle shore – 4.2m ACD
Upper shore – 6.0m ACD
Splash zone ~ 9.0m ACD (selected sites only)

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 conspicuous 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 4.1.1). 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 4.1.1 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 are a mix of bedrock and boulders and 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.

A different combination of survey methods is used as appropriate for each littoral site depending on the shore type (bedrock or boulders) along with aspect and exposure, these are summarised in Table 4.1.2.

Table 4.1.2 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 & 2023 : All Skomer sites completed along with all MarClim sites.

The survey methods for each site completed in years 2003 to 2022 are shown in 4.1.3.

Table 4.1.3 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
2023	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 4.1.2.

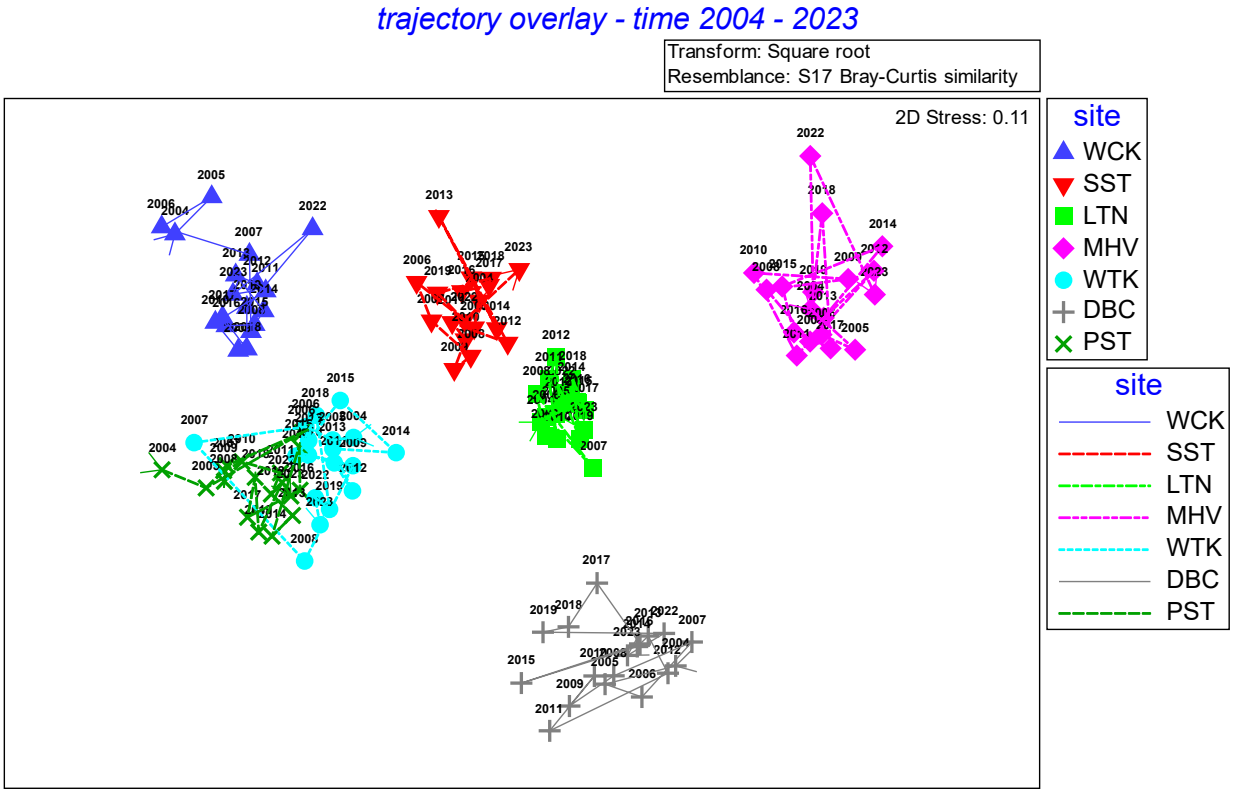
General summary:

- The sites neatly separate out and stay separate over the twenty year period. This suggests community composition at each site is distinct from the other sites (except WTK and PST which have similar communities) .
- Between the years there isn't a lot of variation within each site. The communities are stable over the time period.
- No one year consistently sticks out as an outlier, again, suggesting the communities are stable over the time period.

An "ANOSIM" test for differences between years showed no significant difference between any of the years. Sample statistic (R): -0.077 Significance level of sample statistic: 100%. This confirms that there is no significant change in the intertidal communities over time.

The communities on the shores have not shown any major changes during the monitoring period 2003 to 2023. The shores were not surveyed in 2020 or 2021.

Figure 4.1.2 PRIMER Multi-dimensional scaling (MDS) plot of all littoral community data 2004 – 2023 (Averaged to site and year with a trajectory line with time).

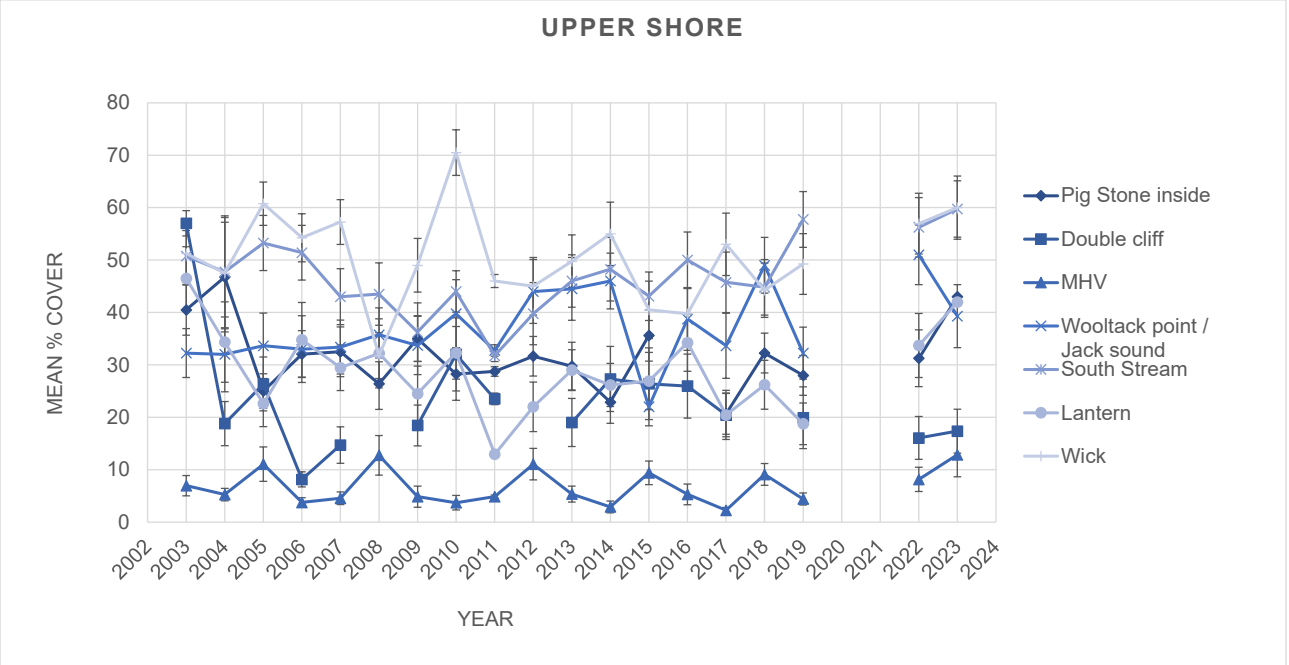


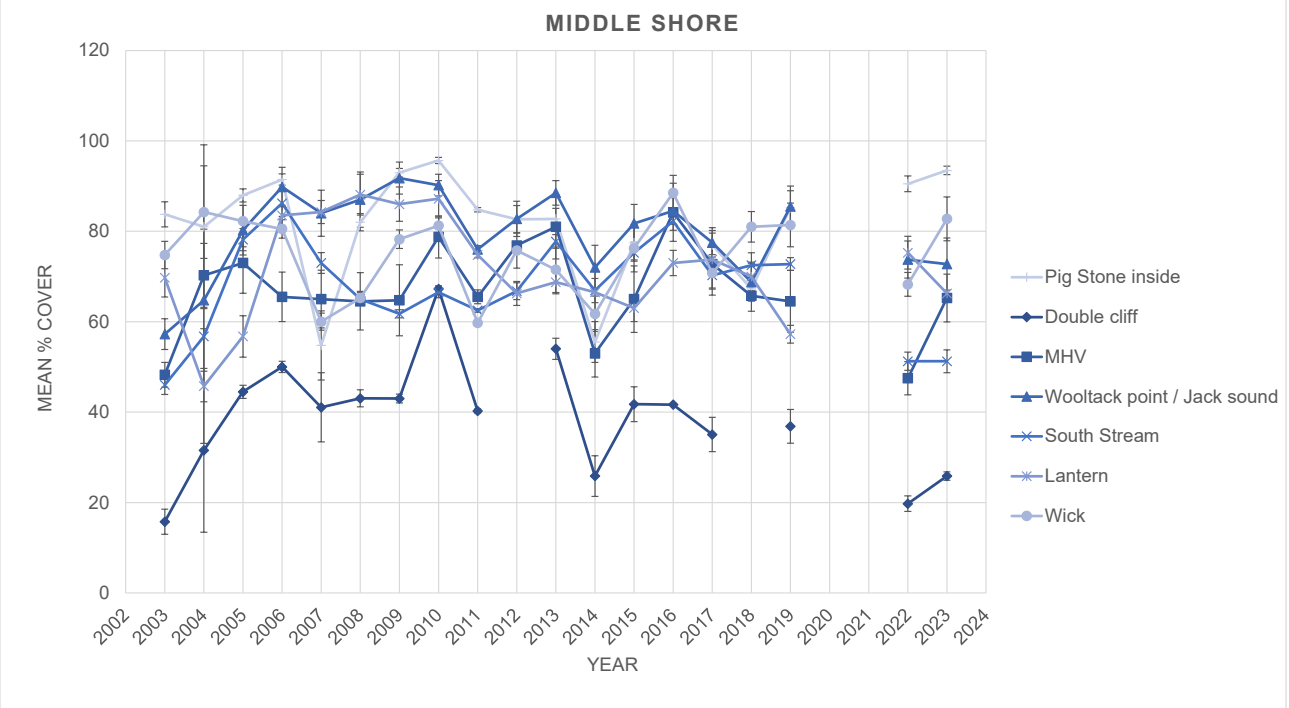
Detailed analysis of some specific groups of species are given below.

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 2023 the barnacle coverage showed little change (Figure 4.1.3).

Figure 4.1.3 Changes in upper, middle and lower shore barnacle coverage 2003 – 2023, with standard error bars.





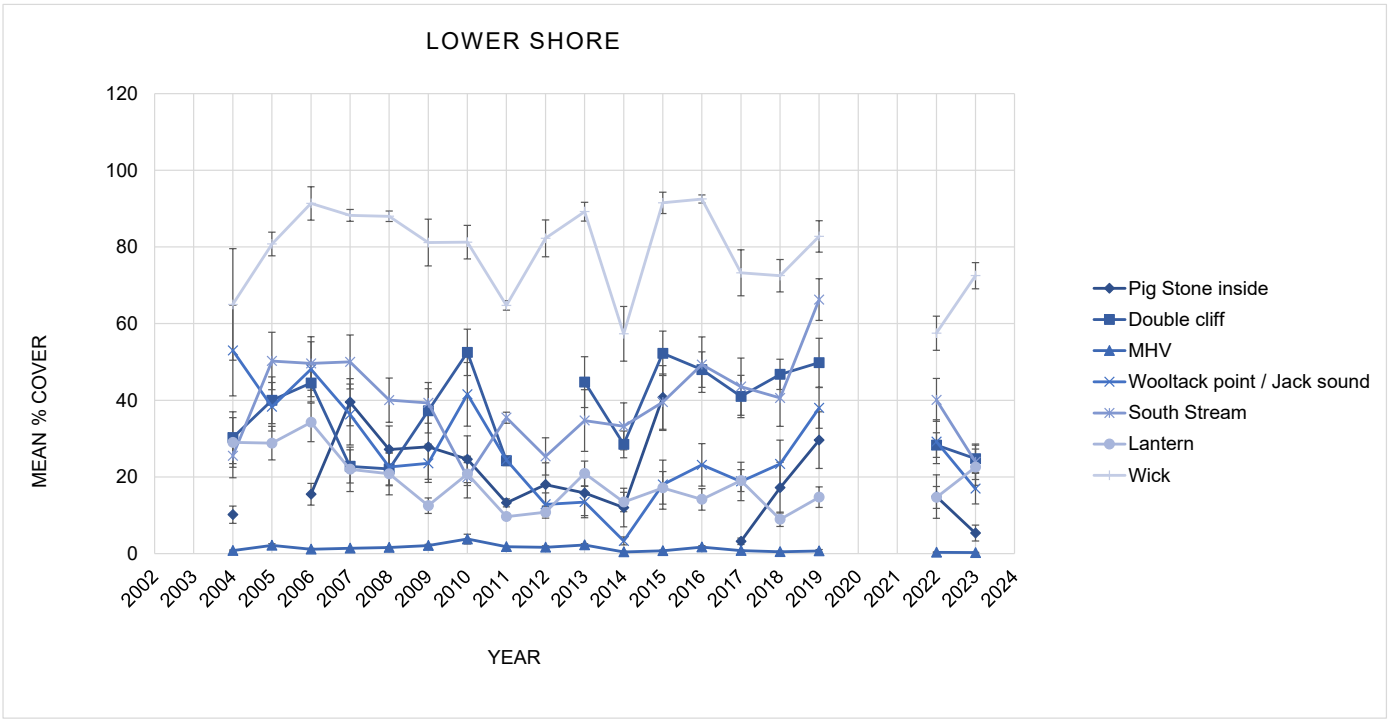
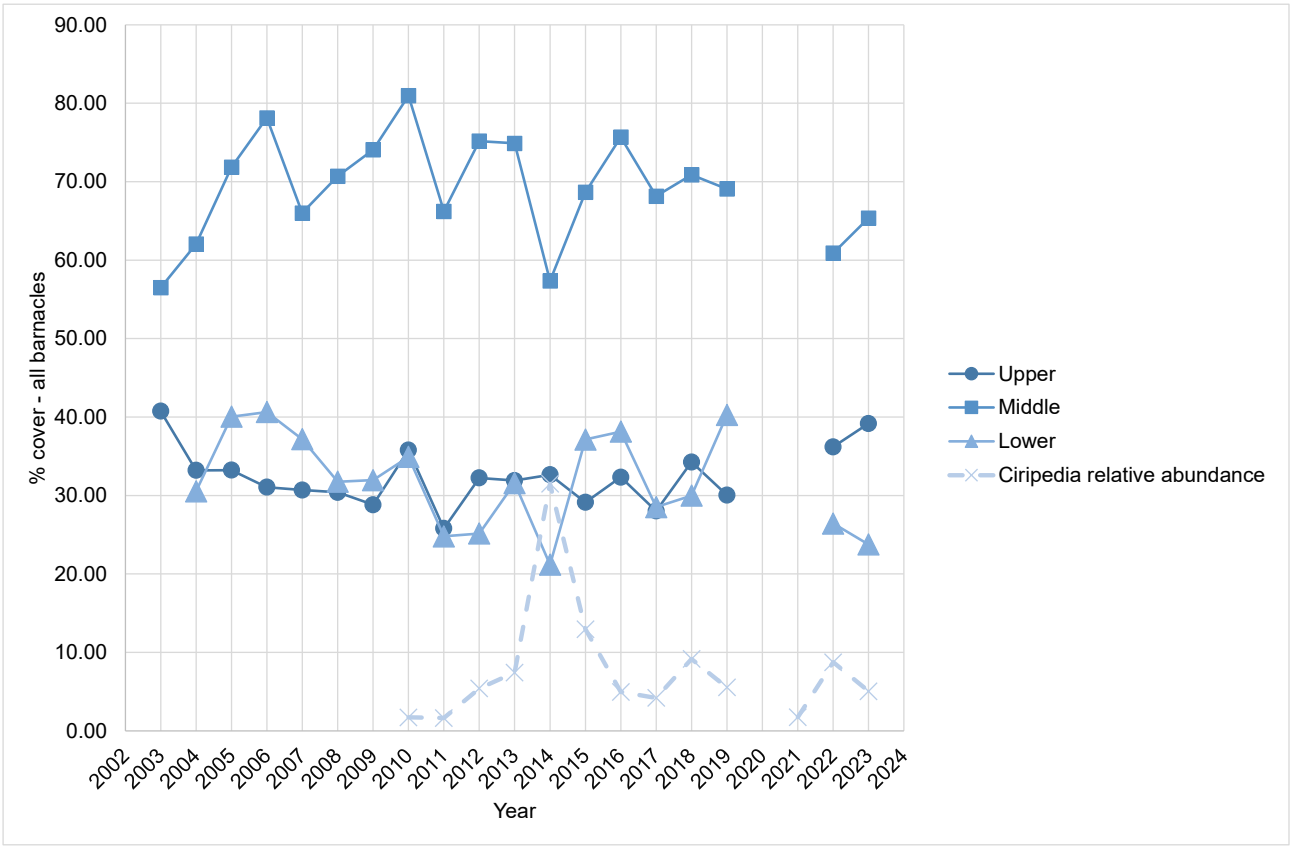


Figure 1.1.4 Changes in barnacle coverage – averaged across all sites for each shore zone. Includes relative % abundance of barnacle larvae (*Cirripedia*) in the zoo plankton.



Barnacle coverage (all species) has remained relatively stable with 60-80% coverage in the middle shore and 25-40% coverage in the upper and lower shores. It does not correlate with the amount of *Cirripedia* larvae seen in the zoo plankton samples (see *Figure 4.12.4*. in Plankton section).

Barnacle Species Ratios

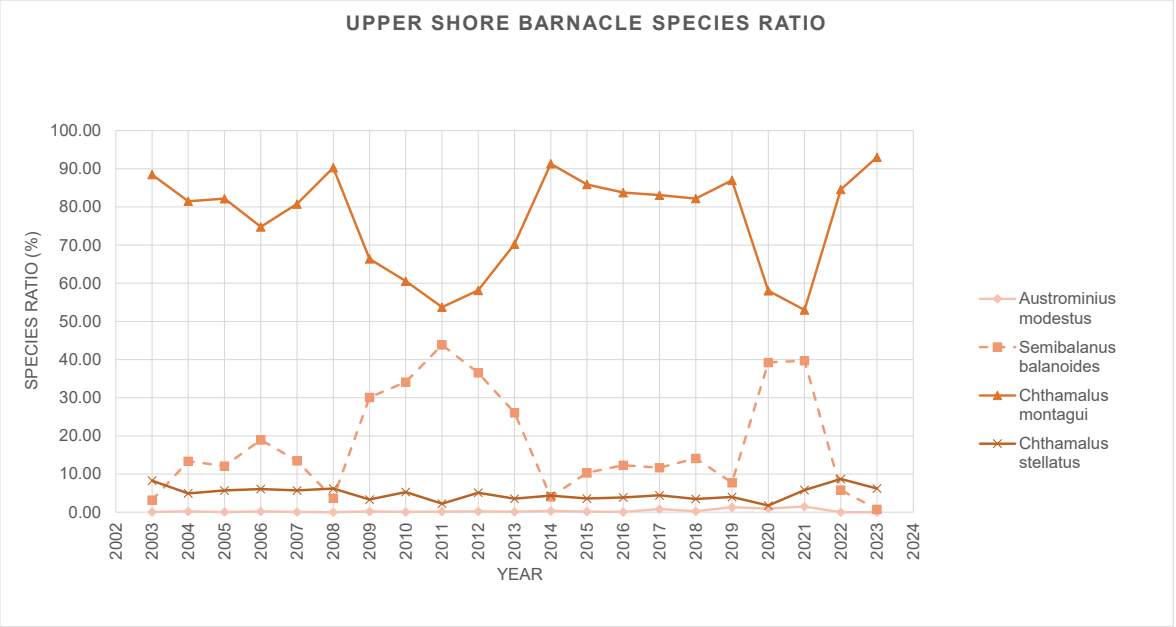
The barnacle species counts have been completed from the photographs of the 5 cm x 5 cm quadrats at the 3 MarClim Sites: Martins Haven, North Haven and South Haven (photographs taken at the other sites are stored for analysis when time allows).

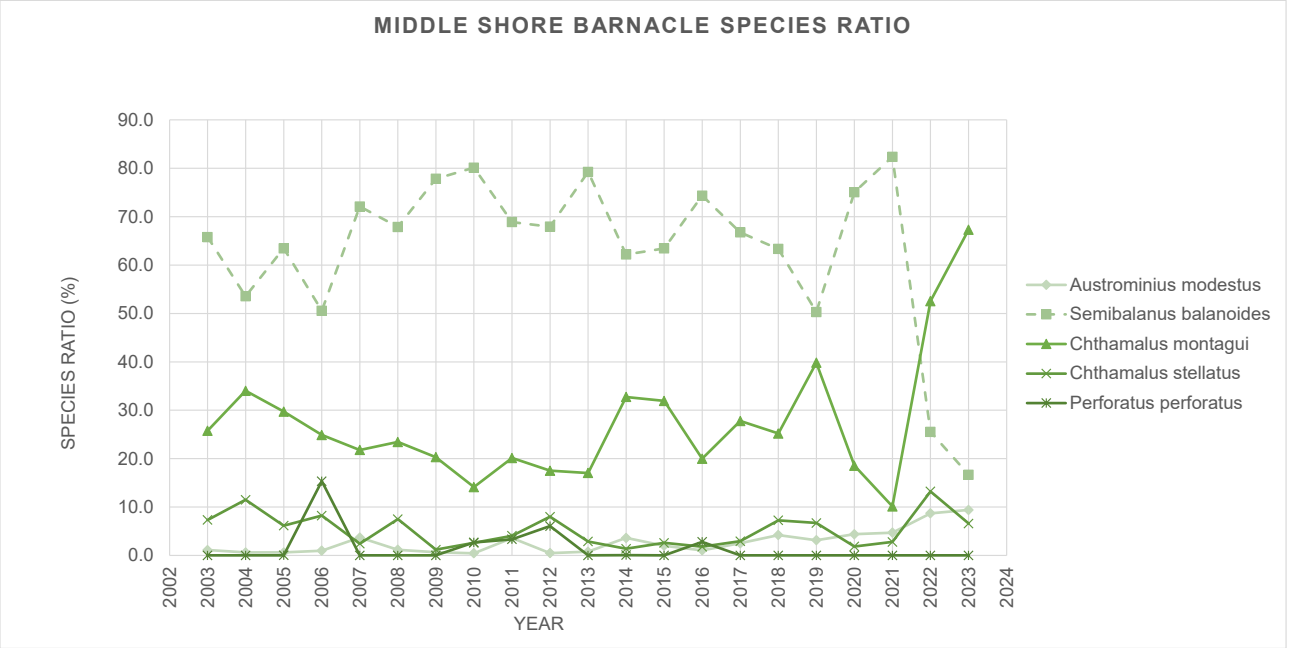
The 3 shore zones show how the different species tend to be dominant in different zones, with *Chthamalus spp* dominating the upper shore and *Semibalanus balanoides* being more abundant in the middle & lower shores (Figure 4.1.5). In 2022 and 2023 *S. balanoides* abundance ratio has declined by 60% in the middle shore and 80% in the lower shore. The overall coverage of barnacles has not changed much in that time (see Figure 4.1.4 above) and the space has been claimed by *Chthamalus spp*.

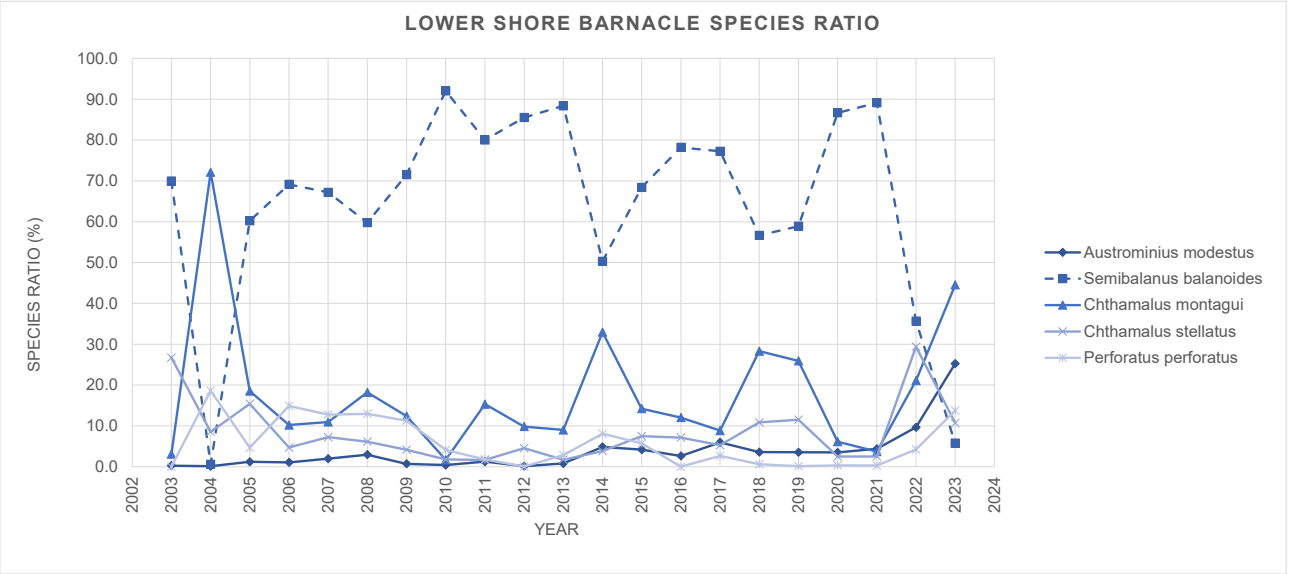
The *Chthamalus* spp have a preference for warmer waters with a more southerly distribution in the UK. *S. balanoides* has a more northerly distribution. This may be due to spring sea temperatures affecting spat survival.

The minimum sea temperatures in 2022 and 2023 were the highest on record since 2007 (8.8ºC compared to an average of 7.8 ºC) this may have affected the survival of the early settlement of *S. balanoides* spat. The summer maximum temperatures in 2022 & 2023 were some of the highest on record (17.1 ºC & 17.5 ºC) this may have improved the survival of the *Chthamalus* spat. The plankton data does not suggest a shift in the seasonal timing of barnacle larvae with the majority of planktonic larvae seen in March – May (see Figure 4.12.4.).

Figure 2.1.5 Changes in upper, middle and lower shore barnacle species ratios 2003 – 2023.



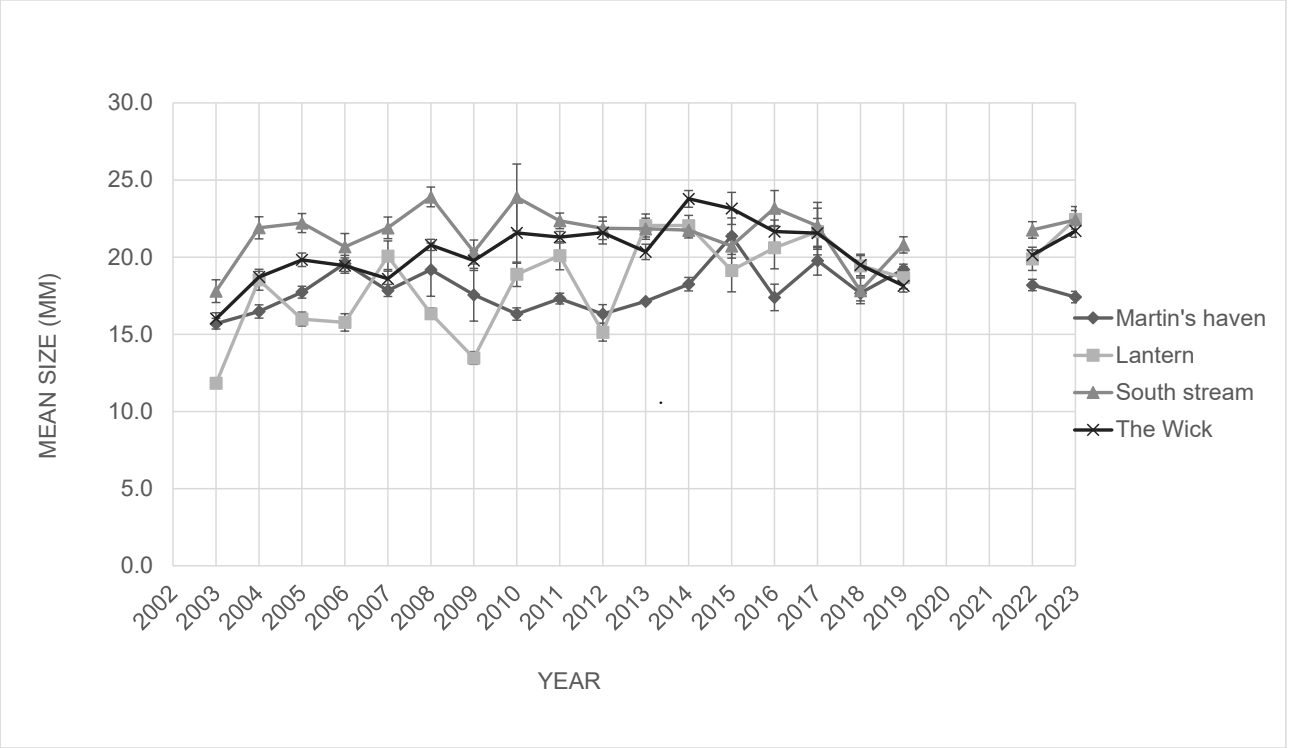




Limpet Size and Counts

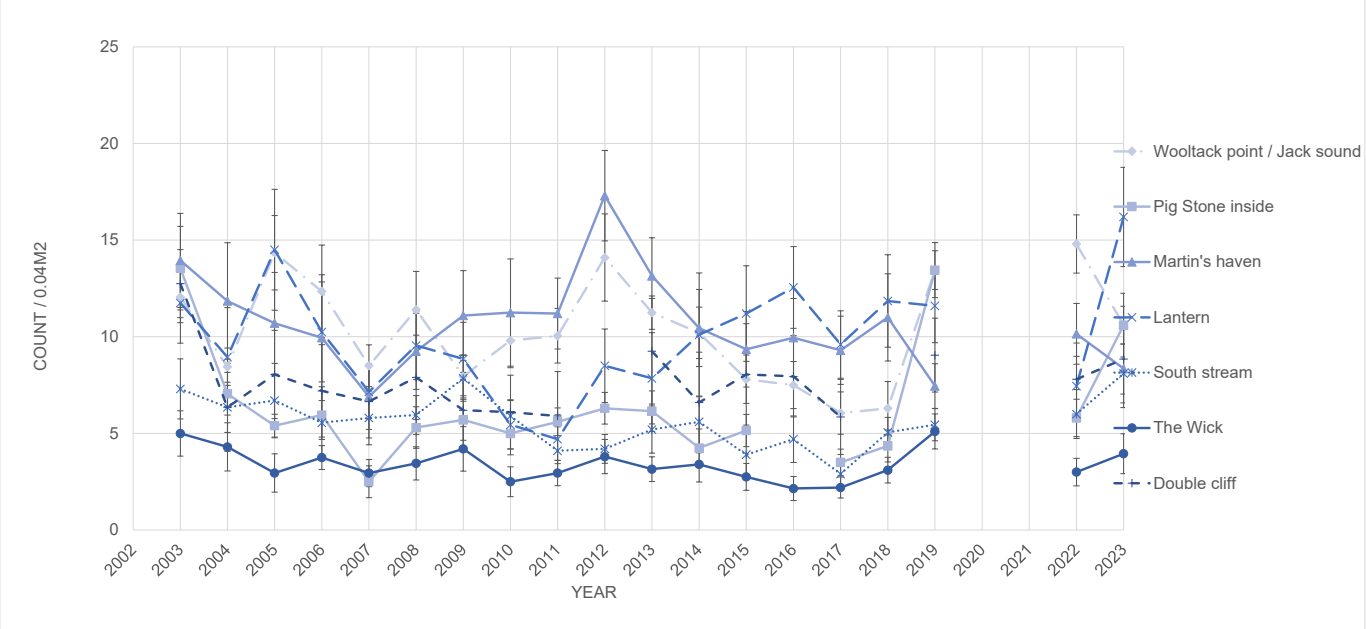
The mean limpet size (mm) recorded shows a stable trend at most sites, the Lantern showing the greatest fluctuations. In 2023 the mean limpet size ranged between 17 mm to 23 mm across all four sites. No recording was completed in 2020 and 2021 (Figure 4.1.5).

Figure 4.1.6 Mean limpet size 2003 – 2023 (per 0.04 m^2) with standard error bars.



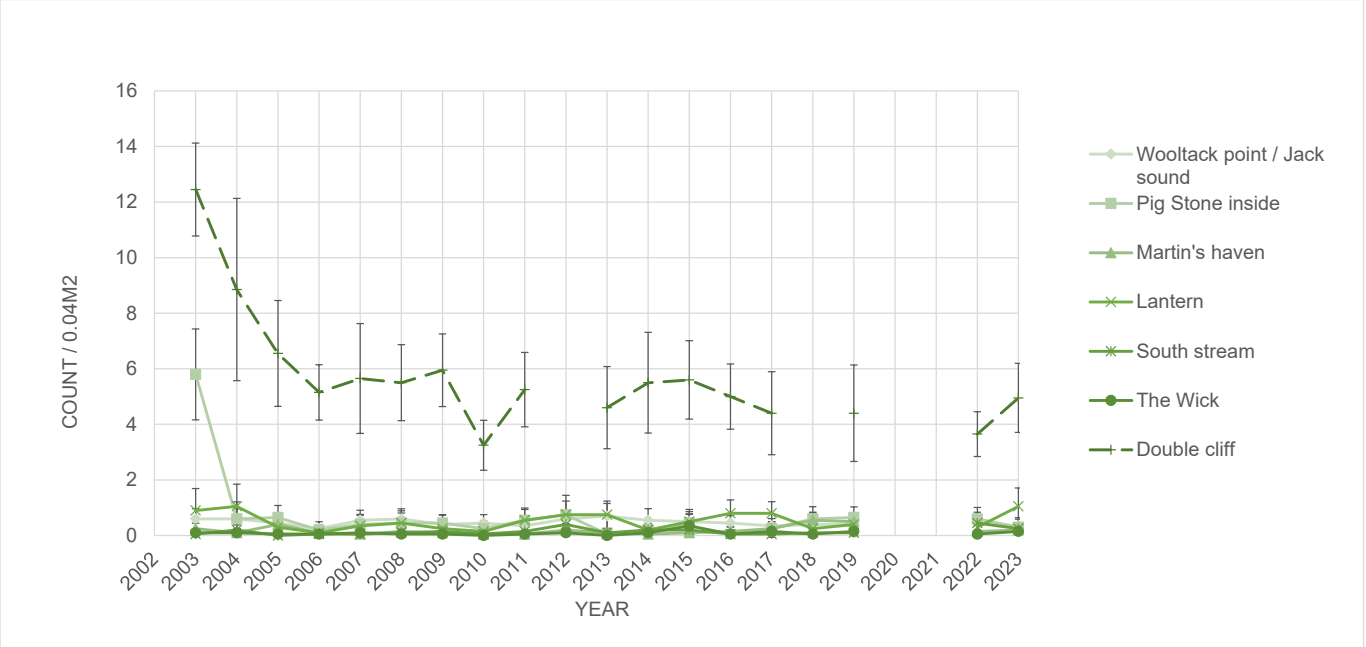
In the middle shore the highest numbers of limpets are found on the north facing shores, but these figures tend to be the most erratic (Figure 4.1.6).

Figure 4.1.7 Changes in middle shore limpet counts 2003 – 2023 (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 sites (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 4.1.7).

Figure 4.1.8 Changes in upper shore limpet counts 2003 - 2023 (per 0.04 m^2) with standard error bars.



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 for reporting (Mieszkowska, N & Sugden, H (2022)

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 selected 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 – 2023 using Species Thermal Midpoint (STM) values from Burrows (2016) (Figure 4.1.8).

The CTI scores for the 3 shores surveyed within Skomer MCZ show no significant change averaging a CTI of 11 -12^{o}C which would match the ambient sea surface temperatures for the same period (Figure 4.1.9).

Figure 4.1.9 Community Thermal Index (CTI) Pembrokeshire MarClim shores 2002 – 2023, with standard error bars.

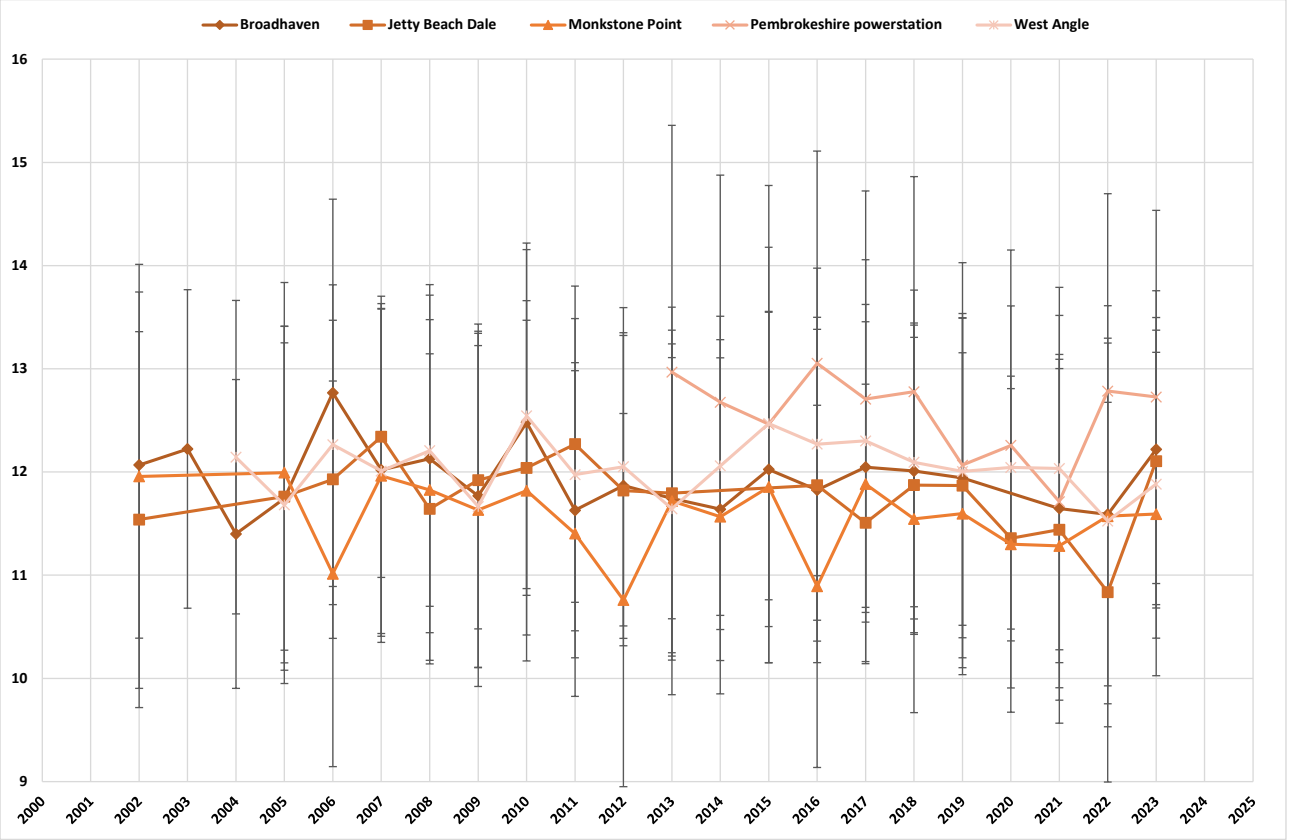
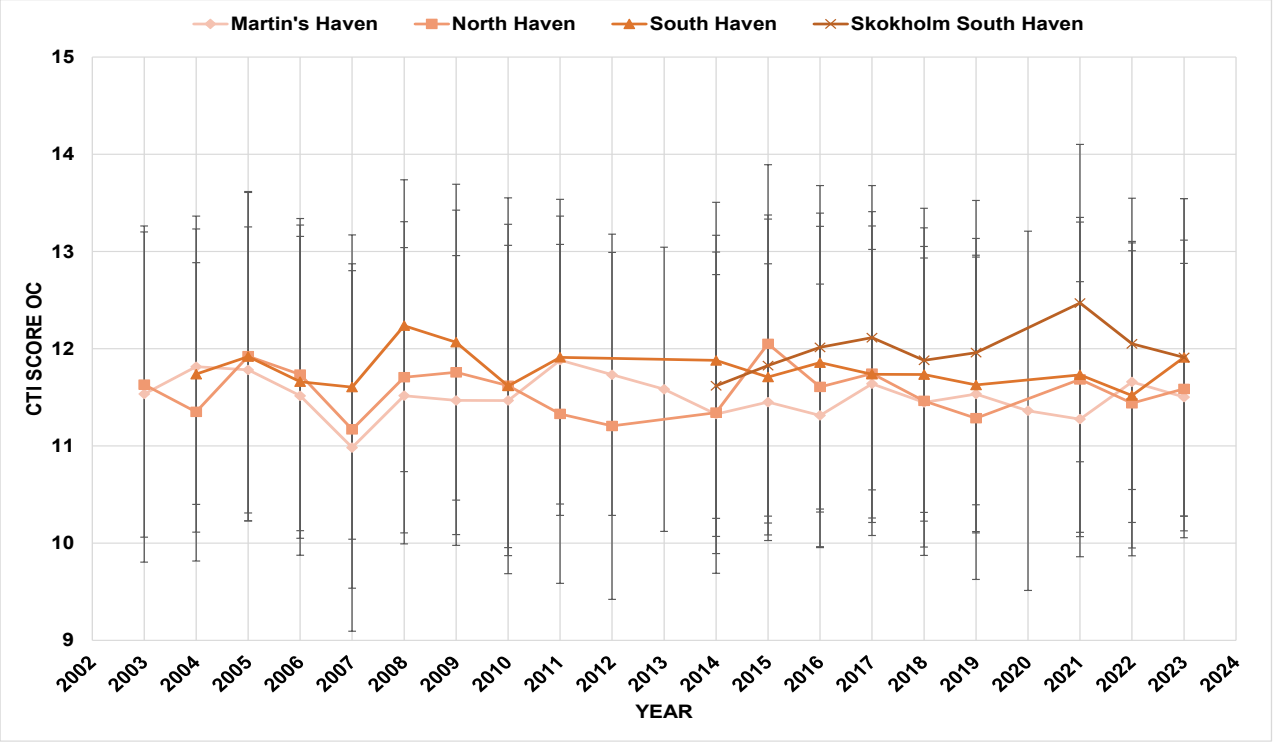


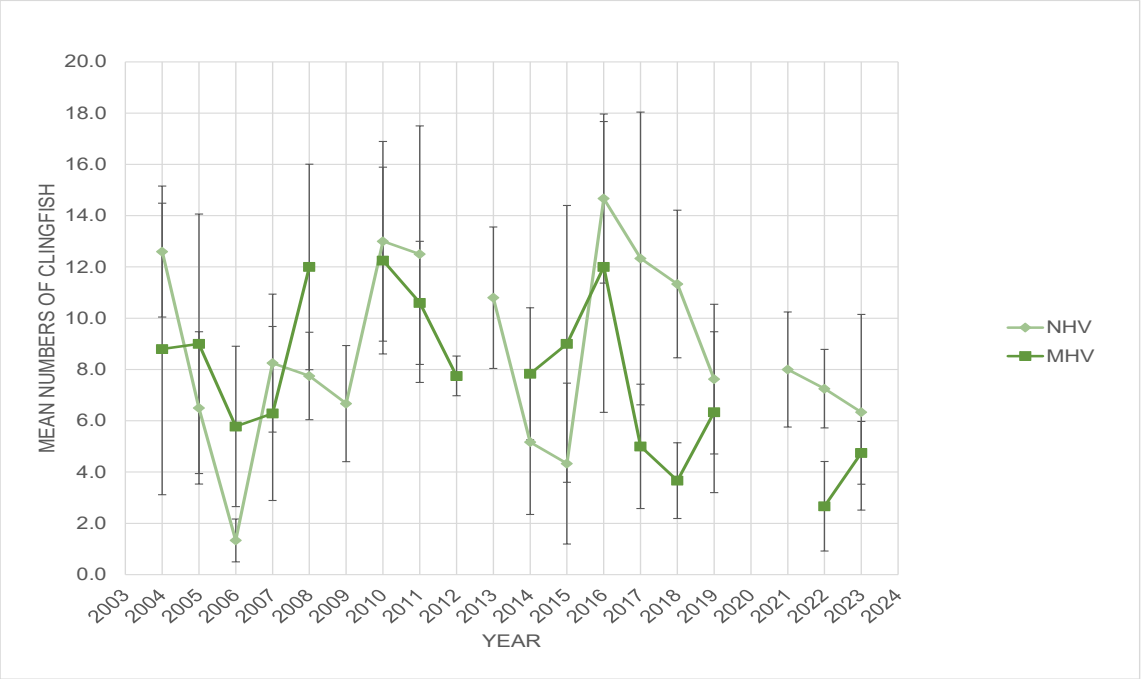
Figure 4.1.10 Community Thermal Index (CTI) Pembrokeshire MarClim shores. Skomer MCZ: Martins Haven - MHV, North Haven - NHV, South Haven - SHV 2002 – 2023 and Skokholm Island - SKH 2014 – 2023, with standard error bars.



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 4.1., but there are always clingfish present and eggs are always seen at the time of the survey in various stages of development.

Figure 4.1.1 Average numbers of clingfish 2003 – 2023 at North Haven (NHV) and Martins Haven (MHV), with standard error bars.



4.1.7. Current Status

- The littoral rock and boulder community features for Skomer MCZ is in favourable conservation status. The shores appear to be stable and, in a condition, typical of the area without any significant changes to the communities.
- So far there is no evidence of any prolonged shift in the community due to climate.
- 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 UK Marine Strategy Part 1. 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 in favourable condition and 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).

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.

4.2.5. Project history

Transects: 1993 to 2022 photo quadrats taken at Thorn Rock (Table 1.2.1).

Table 1.2.1 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 Camera
2023	80	All completed – very low levels of surface sediment

Species surveys:

Table 4.2.2 presents the years sponge species surveys were completed at Thorn Rock, High Court Reef and Wick.

Table 4.2.2 Sponge species surveys summary.

Year	Thorn Rock	High Court Reef	Wick
2003	Yes	No	No
2007	Yes	No	No
2011	Yes	No	Yes
2015	Yes	Yes	Yes
2019	Yes	Yes	Yes
2023	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, no photos were taken in 2023. The digital photographs are merged together to form a mosaic of the full 1 m2 quadrats. These data have been stored and supplied to Dr.James Bell, Wellington University, New Zealand for ongoing research and analysis.

Survey frequency varied between 1-3 survey events in a year (from 2006 to 2016) 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 in 2017 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

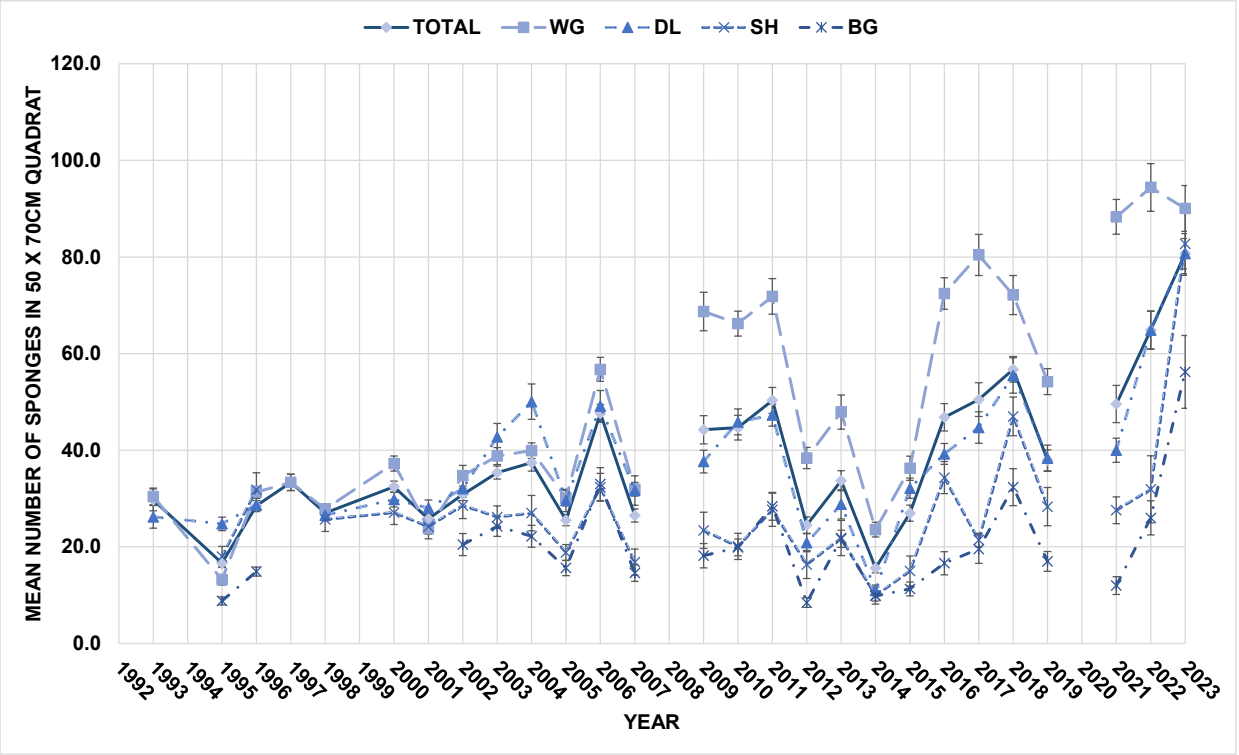
Transects:

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 Section 4.2.8 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 and over time.

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 4.2.1).

In 2023 the new digital camera was used again. The image quality was good, and it was noted that there was very little fine sediment on the rock on the day the photographs were taken.

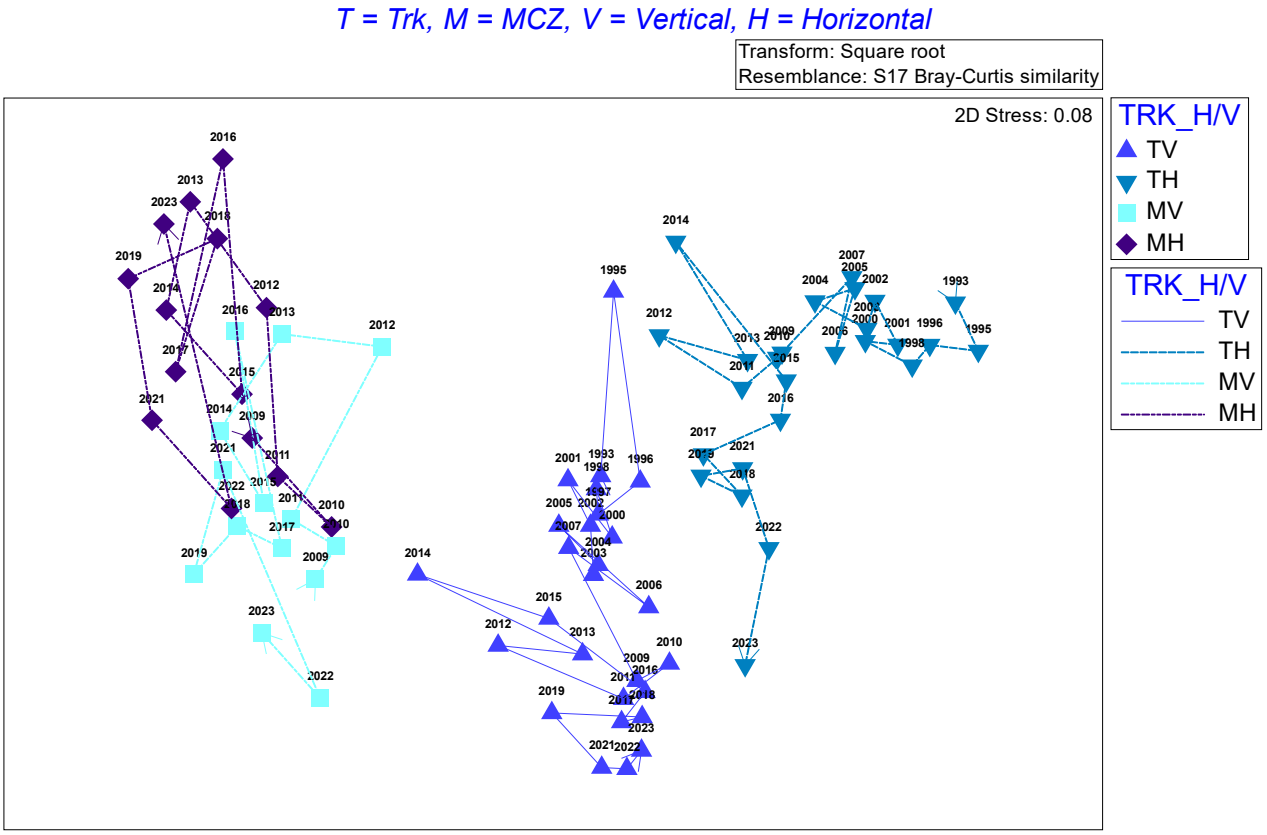
Figure 4.2.1 Mean number of sponges counted in each quadrat at 4 sites –Thorn Rock 1993-2021, with standard error bars. (Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL).



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 4.2.2).

The inclination of each site is noted (Vertical rock face or flat-horizontal aspect). The inclination of the rock seems to make a big difference to the types of sponge morphologies recorded. The sites at Thorn rock (TRK) are notably different to those elsewhere in the MCZ with much higher abundances of sponges from a wider range of morphologies.

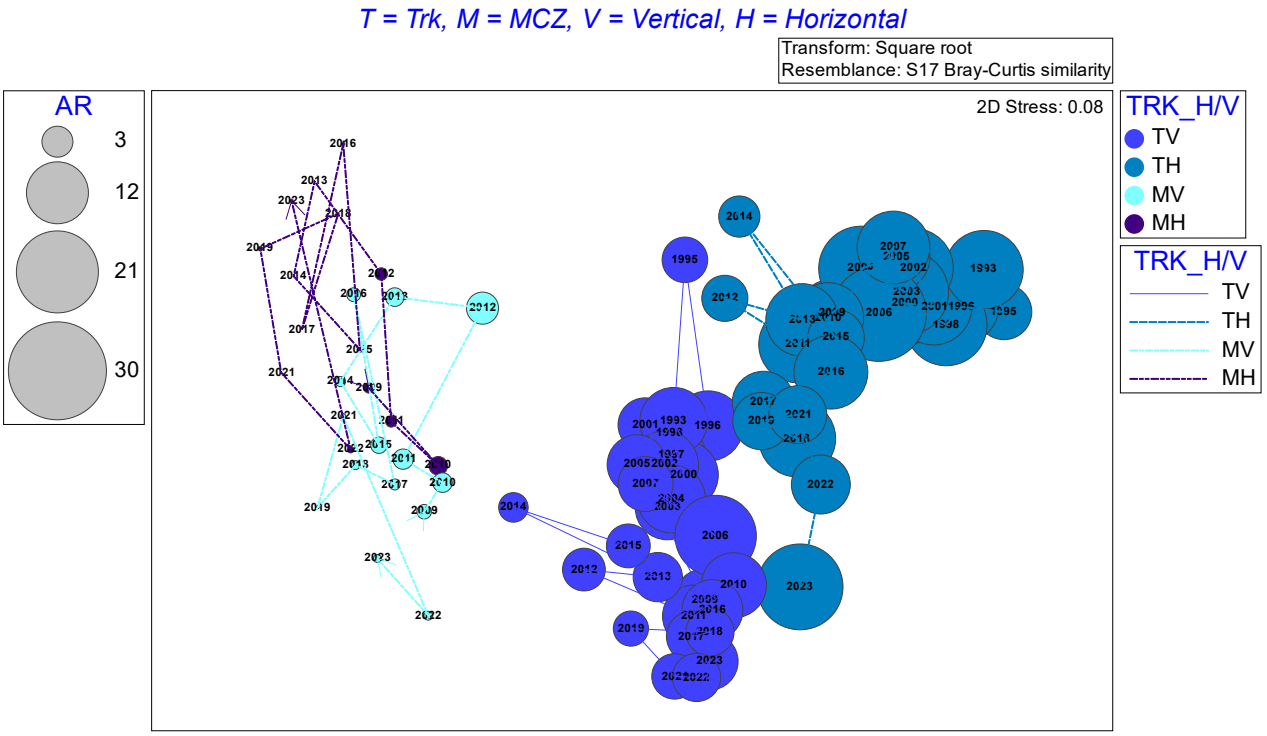
Figure 3 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data averaged by site and year 1995 – 2023 with the sites collated to those at Thorn Rock (T), those around the rest of the MCZ (M) and Vertical & Horizontal (V / H) inclinations. Trajectory overlay with year.



The data used in this plot has been averaged from 4 sites at Thorn rock (3 -Horizontal, 1 Vertical) and 7-10 sites from elsewhere around the MCZ with a mixture of vertical and horizontal aspects.

The plot shows a clear separation between the Thorn rock sites (T - Triangles) and the rest of the MCZ (M - squares). One of the main differences between the sponge communities at Thorn rock and the rest of the MCZ is the abundance of erect sponge species (see Figure 4.2.3)

Figure 4.2.3 PRIMER MDS plot of sponge assemblages at Skomer MCZ 1995-2023. Plot overlaid with bubbles representing the relative abundance of arborescent (AR erect) sponges.



The sponge community at Thorn rock has much higher numbers of Arborescent (AR erect) sponges. The diversity of sponge morphologies is also higher at Thorn rock with globular, papillate and tubular sponge morphologies also being more abundant at Thorn rock.

The encrusting and massive sponge morphologies show different trends in the data when compared to the arborescent sponges.

Encrusting sponges prefer the vertical incline rock surfaces. The horizontally inclined rock sites at Thorn rock have shown a trend of increasing numbers of encrusting (EN) sponges in the last 5 years (circled on plot). 2023 had the highest abundance of encrusting sponges since 1993, (Figure 4.2.). Records from photographs are very dependent on image quality and surface sediment. It could be that these increases in encrusting sponges are an artifact of silt obscuring the sponges in earlier years. We do not have a good way of measuring silt levels other than a qualitative assessment by eye. Possible solutions to this would be to use counts of cup corals as a proxy for sediment levels but this assumes cup coral numbers do not vary from year to year.

The passive sediment collector at Thorn Rock records how much sediment is in the water column from April to September. This data suggests a declining trend in suspended sediment (Fig 4.2.5.) experienced at the site year to year but does not provide specific levels of sediment on the day the sponge photographs are taken. It is possible that less sediment settling on site is allowing us to see sponges that were always there or that the community is shifting due to changes in silt levels.

Figure 4.2.4 PRIMER MDS plot of sponge assemblages at Skomer MCZ 1995-2023. Plot overlaid with bubbles representing the relative abundance of encrusting (EN) sponges. (Circled area shows increasing numbers on horizontal rocks at Thorn Rock)

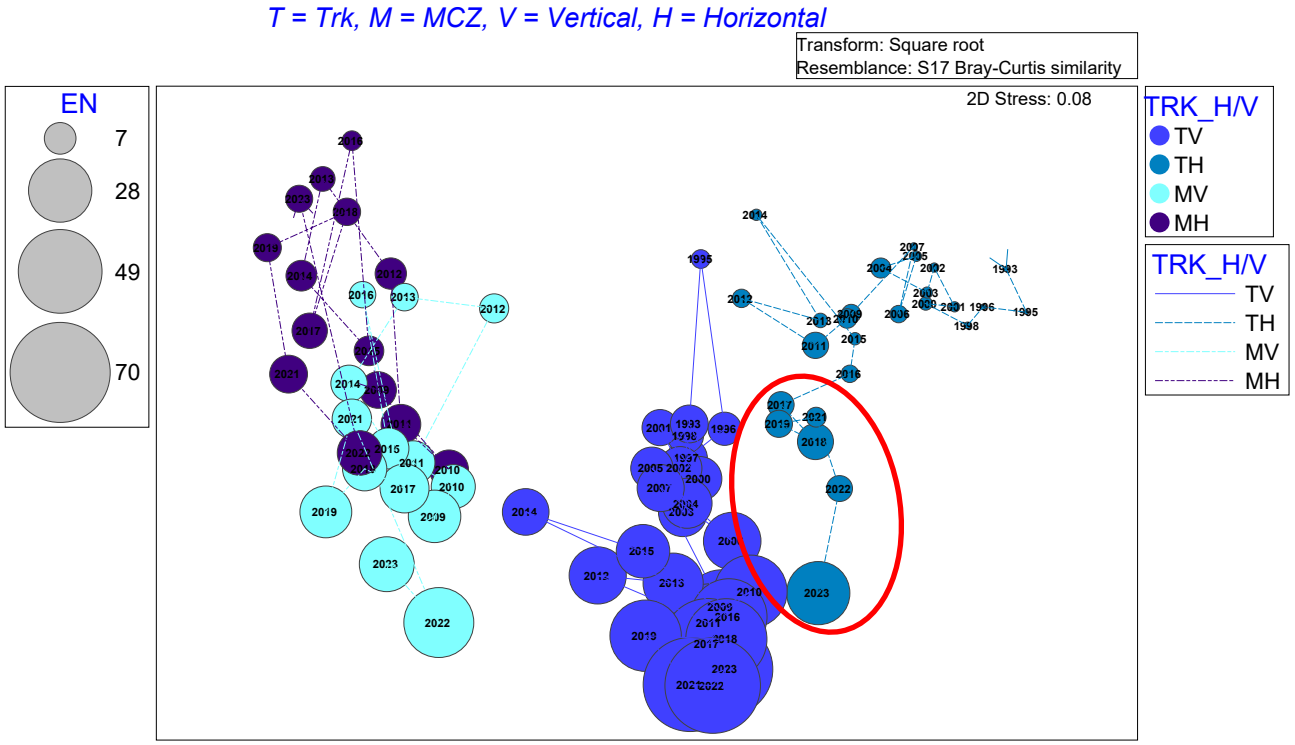
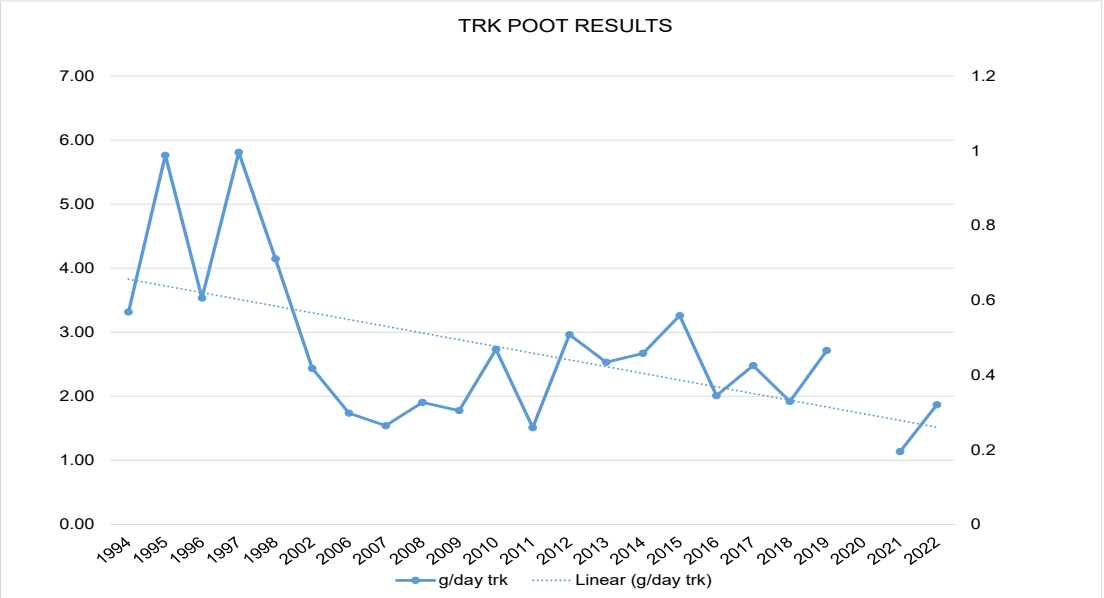
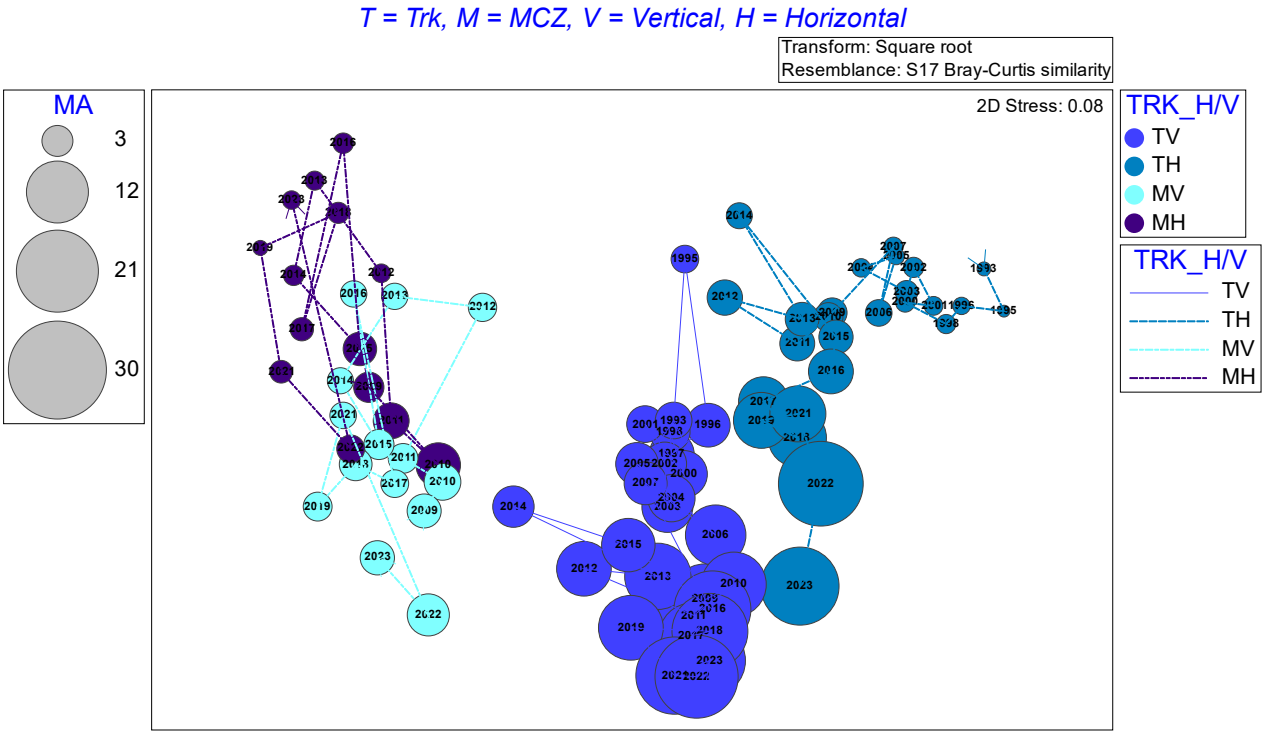


Figure 4.2.5 Average weight (g) of sediment collected per day at Thorn Rock (Apr-Sep) 1994 – 2022



Massive sponges also show a similar trend to that shown by the erect sponges, (Figure 4.2.6). The horizontal sites at Thorn rock have shown an increase in massive sponge abundance over time, especially in the last 5 years. Massive sponges are less likely to be obscured from view by surface sediment unless they are very small.

Figure 4.2.6 PRIMER MDS plot of sponge assemblages at Skomer MCZ 1995-2023. Plot overlaid with bubbles representing the abundance of massive sponges morphologies.



Species surveys:

A full species survey was completed in 2023 at Thorn Rock sites, High Court Reef and the Wick. Photographs were taken in the field and samples collected, where necessary, for spicule preparations and microscopic analysis to confirm identification. Analysis and reporting will be completed in 2024.

4.2.7. Current status

- The sponge community feature for Skomer MCZ conservation status is stable at the MCZ level but there appears to be a shift in the horizontal rock community at Thorn Rock in the last 5 years.
- The species surveys show that Skomer has a high biodiversity of sponge species. 42 of the 130 species recorded at the MCZ (Jones 2020). This will be updated in 2024 with the results of the 2023 species survey.
- The last 5 years suggest an increase in encrusting and massive sponge morphologies at the horizontal sites at Thorn rock. It is unclear what is driving this change.

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 2027.
- Continue support of sponge research carried out by academic bodies.
- Report sponge community feature as stable and in favourable condition.

4.3. *Eunicella Verrucosa* Population

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 4.3.1 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 (Waybench west)	SSFG	1994
Thorn Rock	TRK	2002
Waybench	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’.

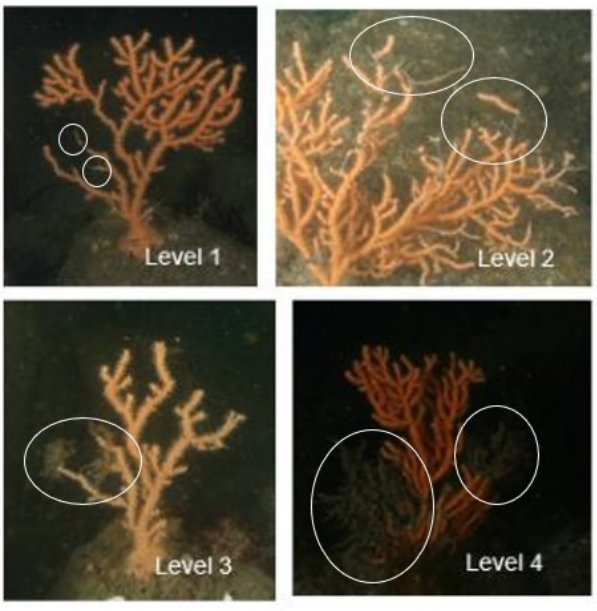
- Photographs are taken using a single camera mounted on a 50 cm x 70 cm frame. Both sides of the sea fan are photographed.
- Each sea fan is visually inspected for damage, fouling by epibiota, entanglement with man-made materials, necrosis (loss of living tissue) and the presence of predatory molluscs *Candiella 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 *Candiella 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 4.3.2 and Figure 4.3.1).

Table 4.3.2 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 4.3.1 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 2023: 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 2023: 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 – 2023. 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 4.3.3. Between 1994 and 2005 areas with sea fan were explored and mapped to establishing monitoring sites, in 2005 there were 10 sites and 111 sea fan surveyed. In subsequent years some sites were expanded through mapping and further sea fans have been added to the programme, in 2014 a peak of 124 natural fans were monitored.

Table 4.3.3 Skomer MCZ sea fan survey results 1994 -2023.

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

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
2002	9	86	86	0	0	1	0	0
2003	9	99	99	0	1	0	0	0
2004	9	101	100	0	0	0	0	0
2005	10	114	111	3	1	1	0	0
2006	10	119	116	3	7	0	0	0
2007	10	121	118	3	1	2	0	0
2008	10	126	122	4	0	0	0	0
2009	10	128	121	7	0	1	0	0
2010	10	126	120	6	0	3	1	0
2011	10	126	122	4	0	0	2	0
2012	10	126	121	5	0	0	0	0
2013	10	129	124	5	0	0	0	0
2014	9	124	120	4	0	0	0	0
2015	10	125	123	2	0	3	2	0
2016	10	118	115	3	1	9	0	0
2017	10	114	112	2	0	3	1	0
2018	10	110	108	2	1	4	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	90	86	4	0	13	0	0
2023	10	90	85	5	0	3	0	1
totals	**n/a**	**n/a**	**n/a**	**n/a**	**12**	**50**	**6**	**n/a**

Losses

A total of 50 losses of natural sea fans and 6 losses of artificially attached sea fans have been recorded throughout the period of this project.

In 2022, 3 fans were found missing, these were re-checked in 2023 and the 3 fans: BHO11, MDS5 and RRK26 were confirmed as losses. In 2023 one further sea fan was missing, MDS2, this will be checked, and its status confirmed in 2024.

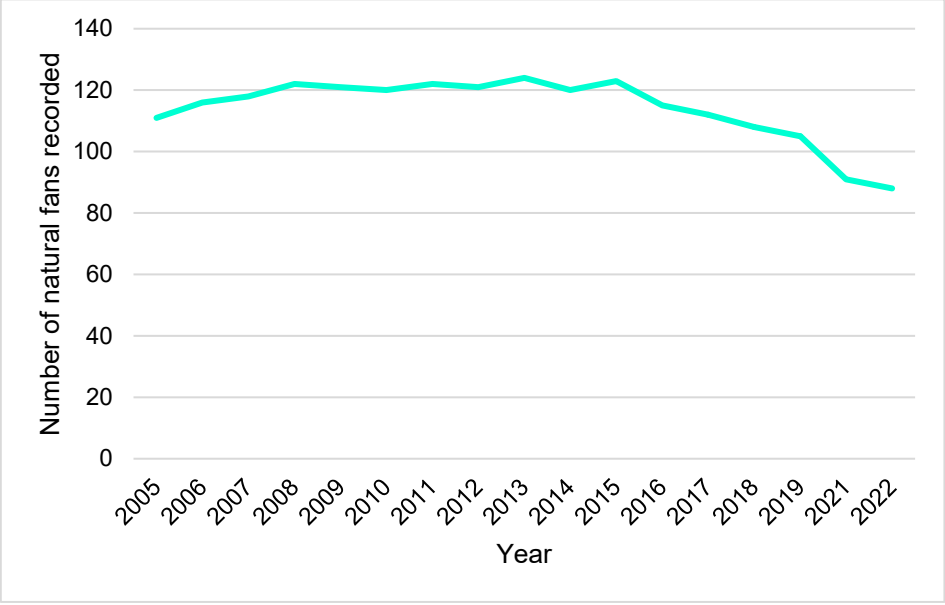
In 2022 two broken off sea fans were found at Waybench site, both damaged and not recognisable as ones previously recorded. They were attached to ringbolts with cable ties and named WAY17 and WAY18, both were still present in 2023. In 2023 one broken sea fan was found at Rye rocks (Figure 4.3.2), recognisable as RRK16, it was attached using cable ties to the Lucy mast.

Figure 4.3.2 Broken off sea fan at Rye Rocks (RRK16)

The rate of 'natural' sea fan losses has increased in the last 8 years. At the 10 sites in the ten-year period from 2005 to 2014, the total number of natural sea fans recorded were between 119-124 fans and during this period 7 losses were recorded. In the eight years from 2015 to 2022 the losses have increased, there have been 40 'natural' fans and 3 'artificially attached fans' confirmed as missing in this period. One further 'natural fan' was absent in 2023, to be confirmed as a loss in the 2024 field season.

The total number of natural sea fans recorded from the 10 sites from 2005 to 2022 is shown in Figure 4.3.3. The increase in numbers between 2005 and 2014 is due further expansion of the sites, a decreasing trend is shown since 2015 due to the large number of losses.

Figure 3.4.3 Total number of natural sea fans recorded from 10 sites 2005 to 2022 (2020 omitted as no survey completed) Note: artificially attached sea fans not included in these data.



Recruitment

Recruitment has been low 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 are variable as described in Table 4.3.4. BHO23 was a confirmed loss in 2010, NWAe15 in

2021 and RRK26 in 2022. The cluster of 5 “new recruits” at BHO showed no growth in 12 years and in 2022 all were confirmed as losses (Table 4.3.4).

Table 4.3.4 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 2023.
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 2023.
NWAe15	2005	Found below NWAe13. 3 branches in 2005 grown to 8 branches in 2018 and then reduced to 2 branches in 2019. Confirmed loss in 2021.
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. All confirmed loss in 2022.
RRK24	2006	Found next to RRK7. 5 branches in 2006 grown to 18 branches in 2023.
RRK26	2016	Found in gully close to RRK12. 2 branches. Confirmed loss in 2022.
MDS7	2018	Found close to MDS 4 and 5. Only 3 branches in 2023.

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

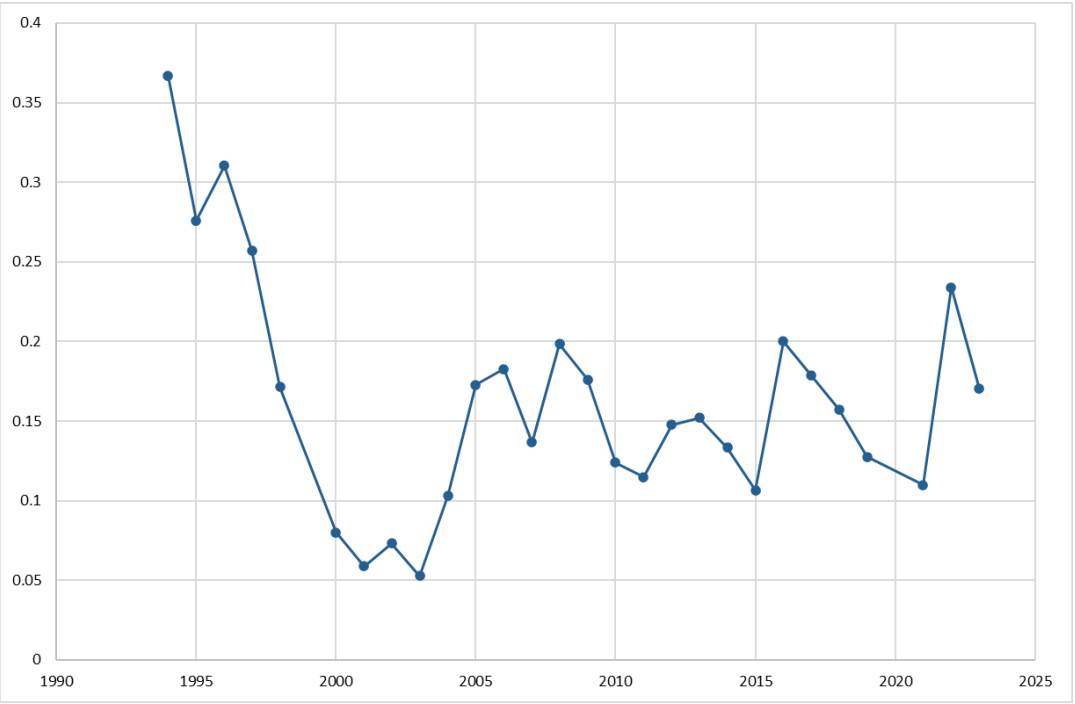
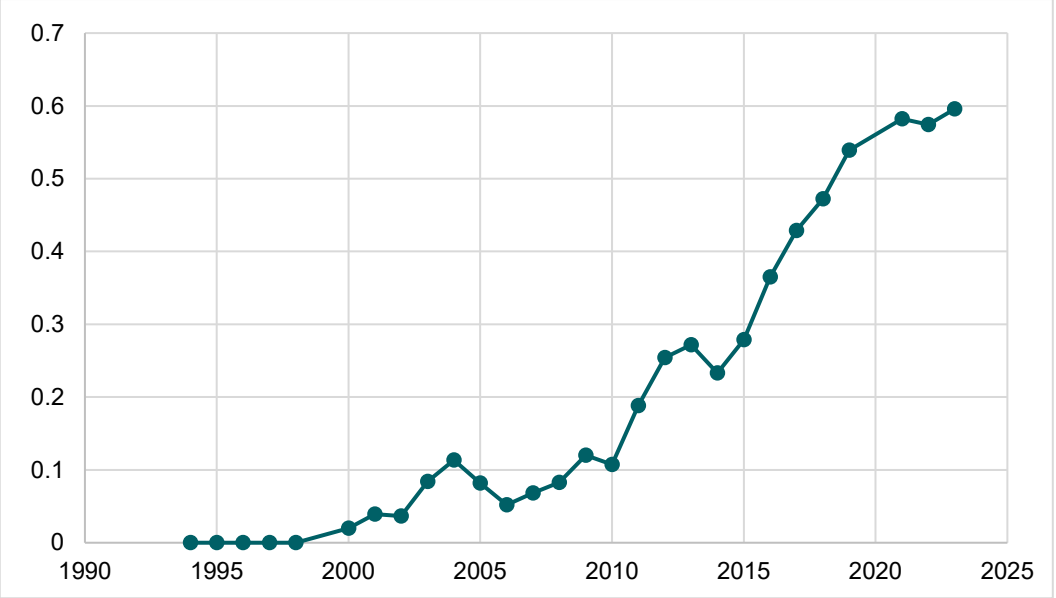


Figure 4.3.5 Proportion of sea fans at Skomer MCZ entangled in *S. stellaris* eggs.



S. canicula eggs were found on 25-35% of recorded sea fans between 1994 to 1997, since then it has fluctuated between 5 and 25% of sea fans from all sites, in 2023 17% of fans were recorded with *S. canicula eggs* (Figure 4.3.4). *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 59% of sea fans recorded with these eggs in 2023 (Figure 4.3.5).

2. Biota entanglement including 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 4.3.6).

Figure 4.3.6 Percentage of sea fans at Skomer MCZ entangled in biota and the average percentage of entanglement per sea fan.

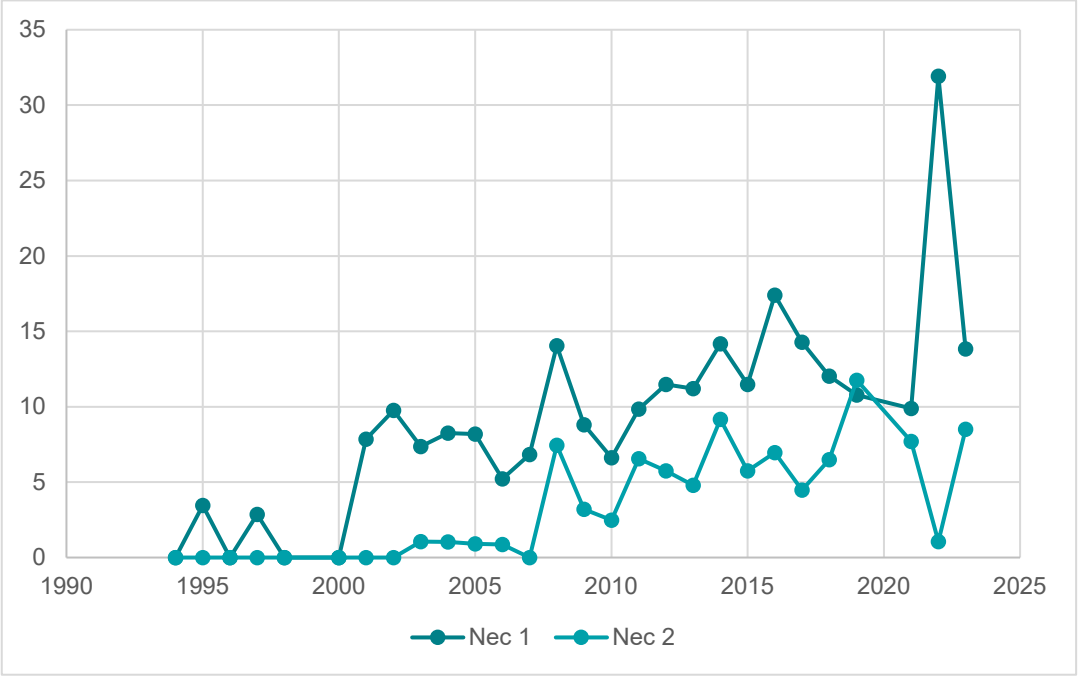
S. canicula eggs and *S. stellaris* eggs make up the bulk of the entangled biota and the pattern of entanglement reflects the percentage of sea fans entangled in eggs as shown in Figures 4.3.4 and 4.3.5. There has been an increase in entanglement since 2011 from 27% to 60% of sea fans in 2023 (Figure 4.3.6, 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 4.3.7).

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 17% in 2023 (Figure 4.3.6, bottom line).

Figure 3.4.7 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 3.4.1, Table 3.3.2), necrosis was recorded on 62% of sea fans in 2023. 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.

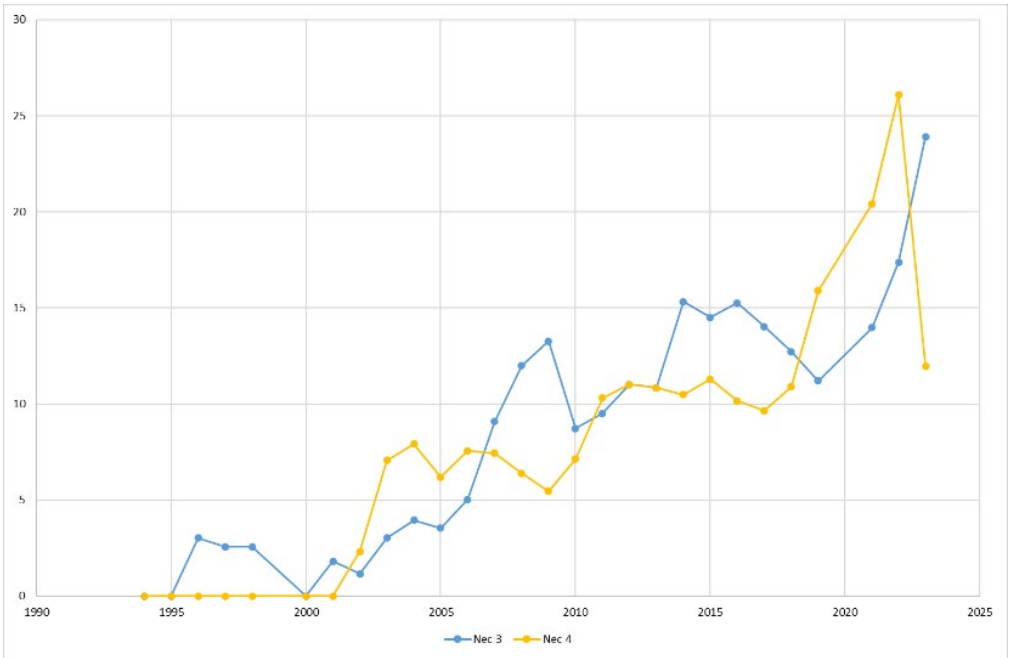
   Figure 3.4.8 Percentage of sea fans at Skomer MCZ with necrosis level 1 and 2.



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 then dropped down to 14% in 2023. 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 2023 was only recorded on 8% of sea fans (Figure 4.3.8).

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 17% of sea fans. 2023 saw the highest recorded percentage of level 3 necrosis at 24%. 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 to 10%. During 2019, 2021 and 2022 increases were recorded with the highest record of 25.5% in 2022, this dropped back to 11% in 2023 (Figure 3.4.9).

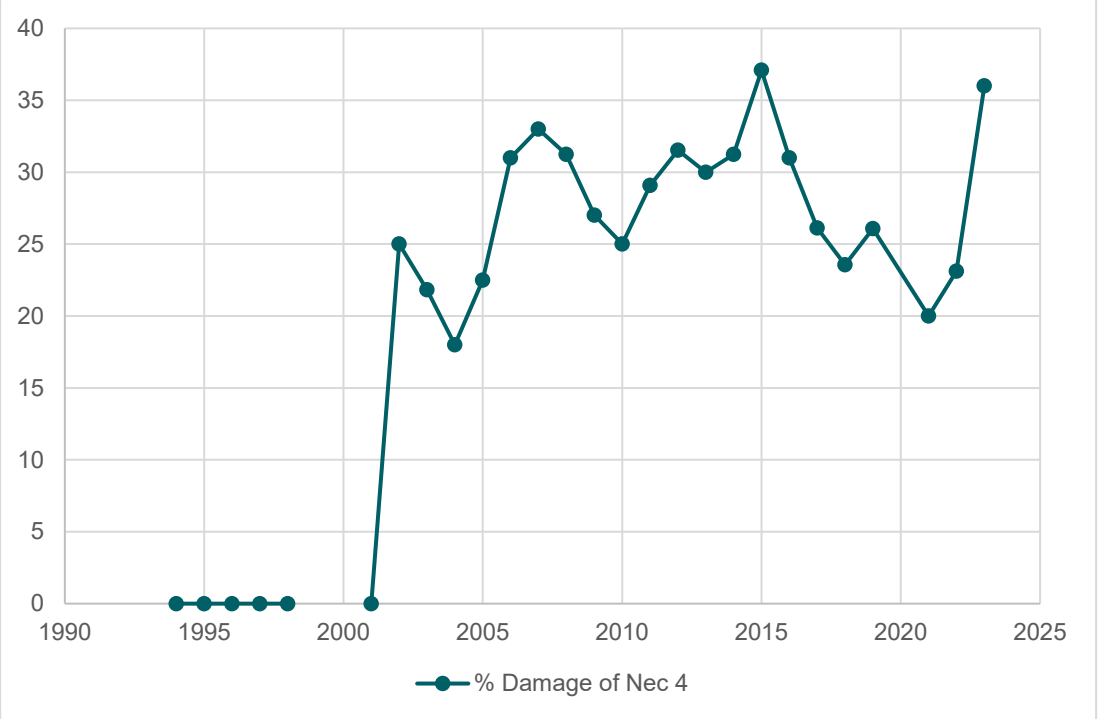
Figure 3.4.9 Percentage of sea fans at Skomer MCZ with necrosis level 3 and 4.



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 3.4.10).

   Figure 4.3.10 Sea fan with 30% level 4 necrosis damage as shown in circled areas.

Figure 4.3.11 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 2023 was recorded as 36% damage per sea fan (Figure 4.3.11).

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. In 2023 one sea fan at Rye Rocks (RRK16) was found dislodged from the rock, it has been artificially attached to the Lucy mast and its fate will be checked in 2024.

5. Nudibranch *C. odhneri* and mollusc *S. patula* presence are recorded. *C. odhneri* has been recorded on 7 occasions between 2004 and 2022 with a maximum of 4 individuals on a single fan, whilst *S. patula* has only been found on 4 occasions. In 2023 very unusually high numbers of *C. odhneri* were found, they were recorded on 28 sea fans with between 2-4 individuals found on each with egg masses. No *S. patula* were recorded in 2023.

Figure 4.3.12 *Candiella odherni* mating on sea fan.

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. Angling line entanglement were recorded on one sea fan at West Hook in 2023 and this was cleaned off.

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*'. In 2023 small clippings were collected and preserved. DNA

was successfully extracted from samples across the range and sent off for sequencing. The whole genome sequencing results are currently being analysed. Growth analysis is currently being carried out on captive and wild populations with the Skomer sea fans also being included. Annual growth rates for the captive sea fans have been on average 1.4 cm (around 15% increase) in the longest branch and an average surface area increase of 1.8 cm^2 (around 32 % increase in surface area) for the first year. Ocean dynamic models are being optimised but outputs indicate interesting larval dispersal patterns around Skomer Island.

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 50 natural sea fans and 6 artificially attached sea fans confirmed as lost from the monitoring sites between 1994 and 2023. There is 1 further possible loss in 2023 to be confirmed. There were no new recruits recorded in 2023.
- Biota entanglement has increased on sea fans from 27% in 2011 to 60% in 2023. *S. canicula* eggs were found on 17% of sea fans and *S. stellaris* eggs were recorded on 59% 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 17% in 2023.
- Necrosis was recorded on 62% of seafans in 2023, of this 23% was at level 3 (epiphytes growing on tips) and 11% 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, since 2002 it has steadily increased with a peak of 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 2023 was recorded as 36%.

4.3.9. Recommendations

- Report pink sea fan status as declining and in unfavourable condition.
- 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 2 *A. glomeratum* 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

There has been a declining trend and disappearance or near disappearance of colonies from 5 sites. Currently only colonies at North Wall East and Junko’s reef remain healthy.

North Wall Stereo: A healthy colony area has been recorded since 1982 within 3 quadrats, since 2006 the size of the colonies has slowly reduced until finally no colonies were found from 2019.

North wall (main): A large number of colonies were recorded spread across a steep vertical wall since 2002, the peak quadrat count of 23 was in 2005, the numbers of colonies reduced over the next 5 years to only 2 quadrats and no colonies have been found since 2013.

Rye Rocks: A small area with colonies that were first recorded in 2005, these have not been found since 2015 (not included in graph as low numbers).

Thorn Rock: A small area with colonies was recorded from 2002 to 2019 within 2 quadrats, no colonies have been seen since 2021.

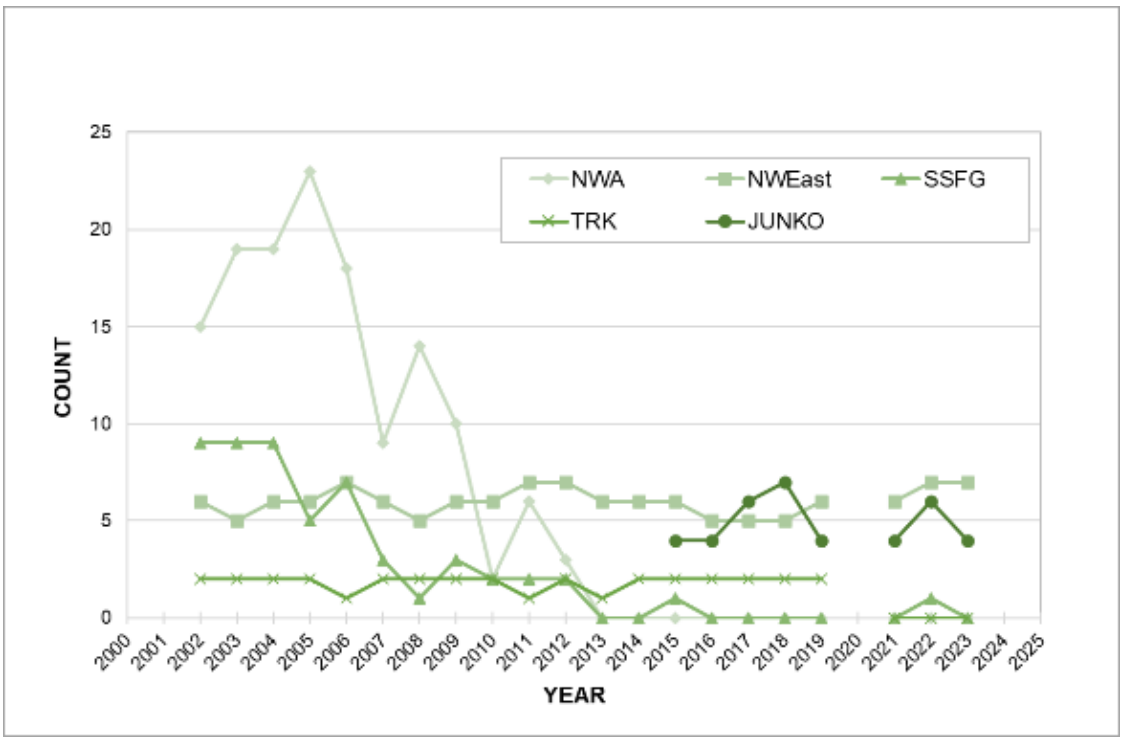
Sandy Sea Fan Gully: A small area of colonies that were first recorded in 2002 on a vertical wall alongside *Parazoanthus axinellae*. It was recorded in 7 quadrats but slowly reduced in area to only 2 from 2008 and none since 2013, a very small colony has been found a few times since then including in 2022 and 2023.

North Wall East: A healthy colony area has been recorded since 2002 with 7 quadrats. This has stayed healthy with 7 quadrats recorded in 2023.

Junko’s Reef: A healthy colony area has been recorded since 2015 with 4 quadrats, this has stayed health with 4 quadrats recorded in 2023.

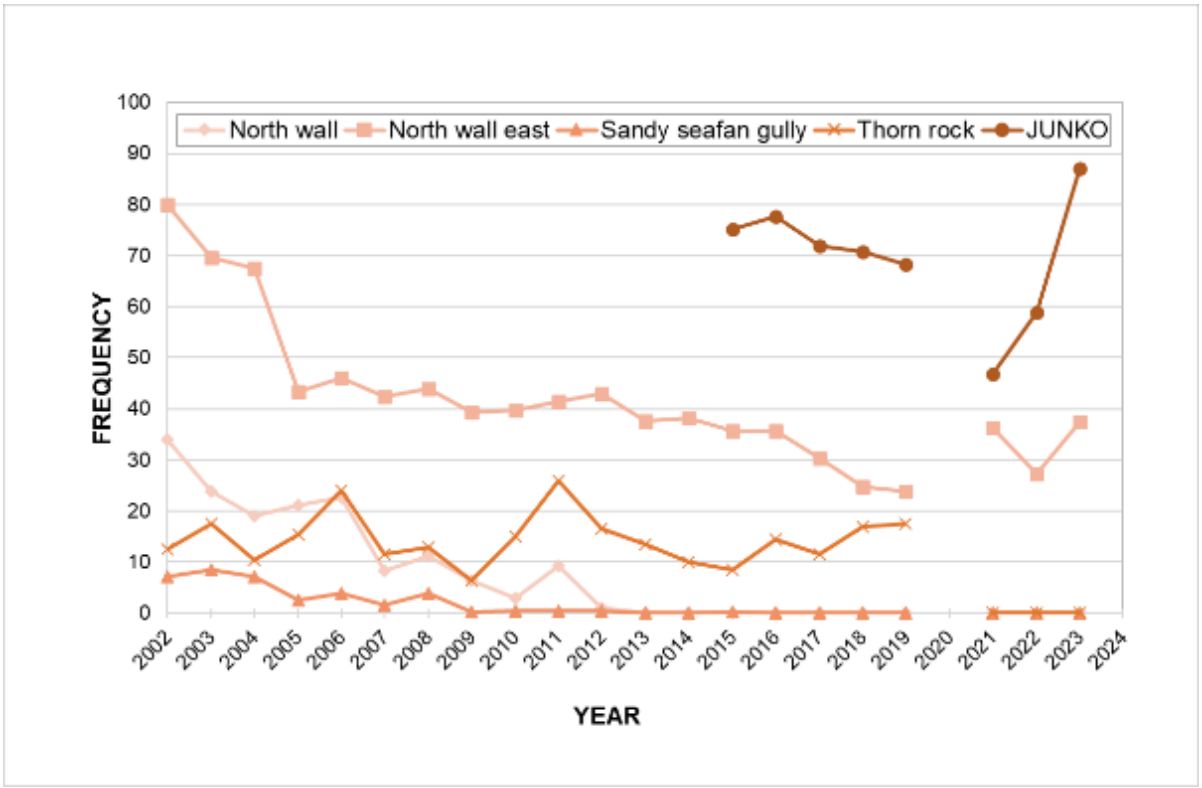
The number of quadrats with *A. glomeratum* recorded at North Wall (main), North Wall East, Sandy Sea Fan Gully, Thorn Rock and Junko’s Reef sites is shown in Figure 4.4.1.

Figure 4 Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2023: NWA = North Wall main, NWEast = North Wall east, SSFG = Sandy Sea fan gully, TRK = Thorn rock and JUNKO = Junko's reef.



The mean frequency counts of *A. glomeratum* colonies at North Wall (main), North Wall East, Sandy Sea Fan Gully, Thorn Rock and Junko's Reef sites are shown in Figure 4.4.2. A declining trend of colony frequency is recorded at all sites except for Junko's Reef.

Figure 4.4.2 Mean frequency of *A. glomeratum* per quadrat Skomer MCZ 2002 – 2023



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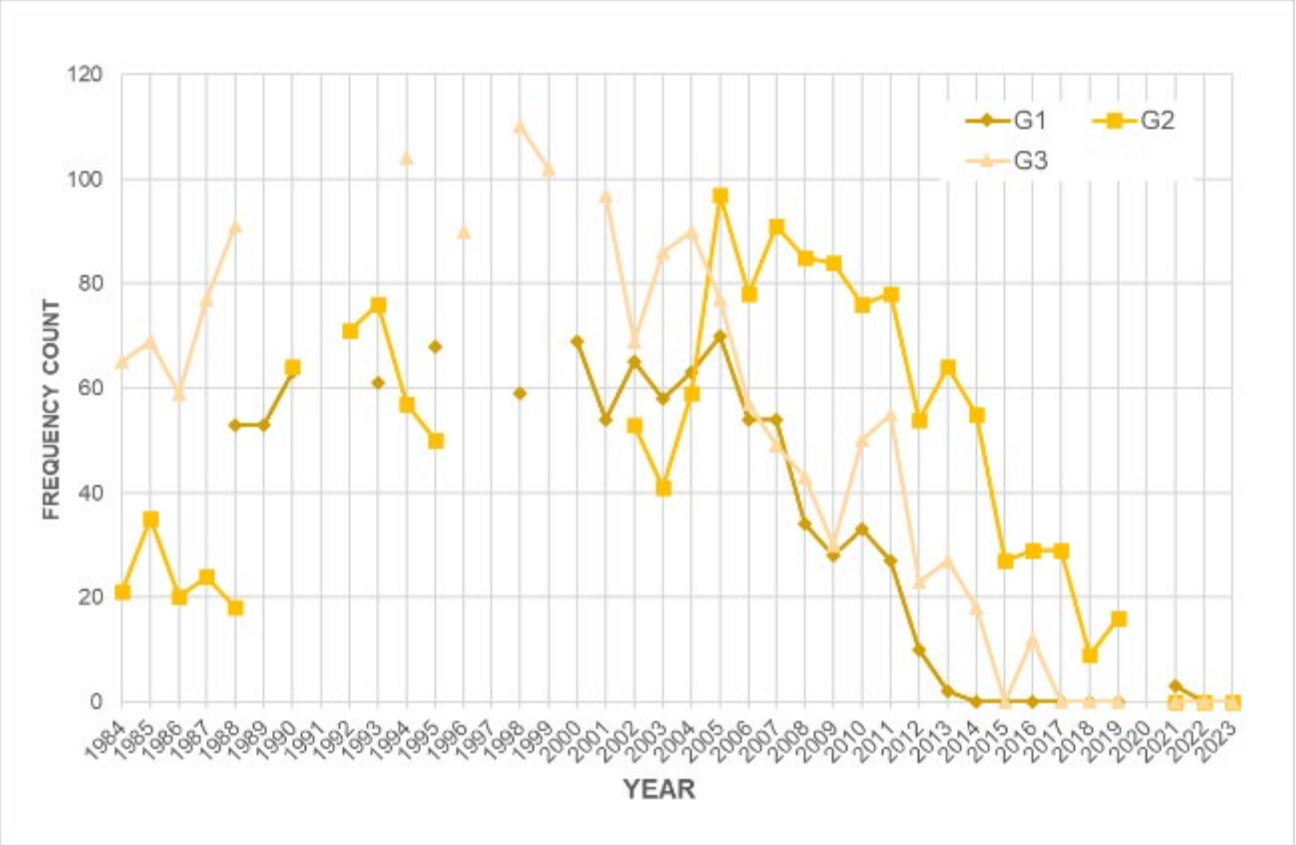
North Wall Stereo colony

The time series for these 3 photo quadrats on the north side of Skomer goes back to 1982. 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 4.4.3).

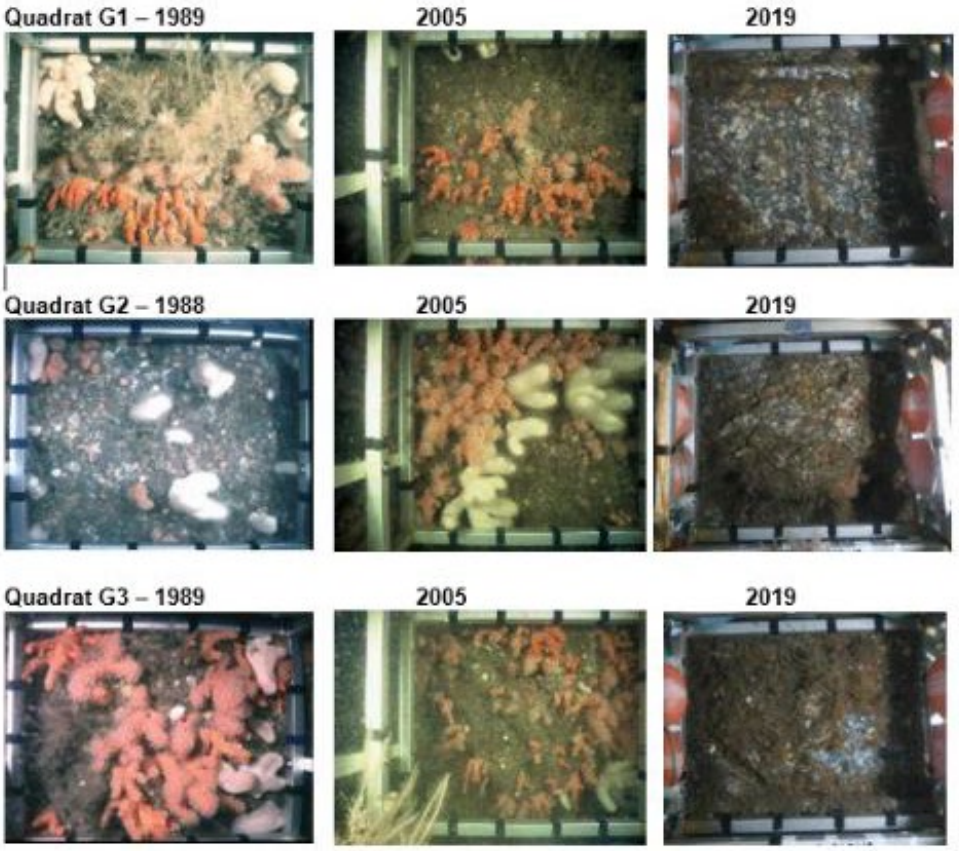
Figure 4.4.3 Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North Wall. (G1 – Quadrat 1, G2 – Quadrat 2, G3 – Quadrat 3)



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 shown in Figure 4.4.4, it is interesting to note that *Alcyonium digitatum* (white deadman's fingers) has also reduced significantly in the three quadrats.

Figure 4.4.4 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 colonies have disappeared from 5 sites. North Wall East and Junko's reef are the only sites left with healthy colonies but frequency of *A. glomeratum* is showing a decline at North Wall East.
- 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.

  Despite the habitats being suitable for *A.glomeratum* no new colonies have been found during monitoring dives at these sites.

4.4.7. Recommendations

- Report *A. glomeratum* feature as declining and in unfavourable condition.
- 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 4.5.1 Yellow trumpet anemone sites names and survey start date.

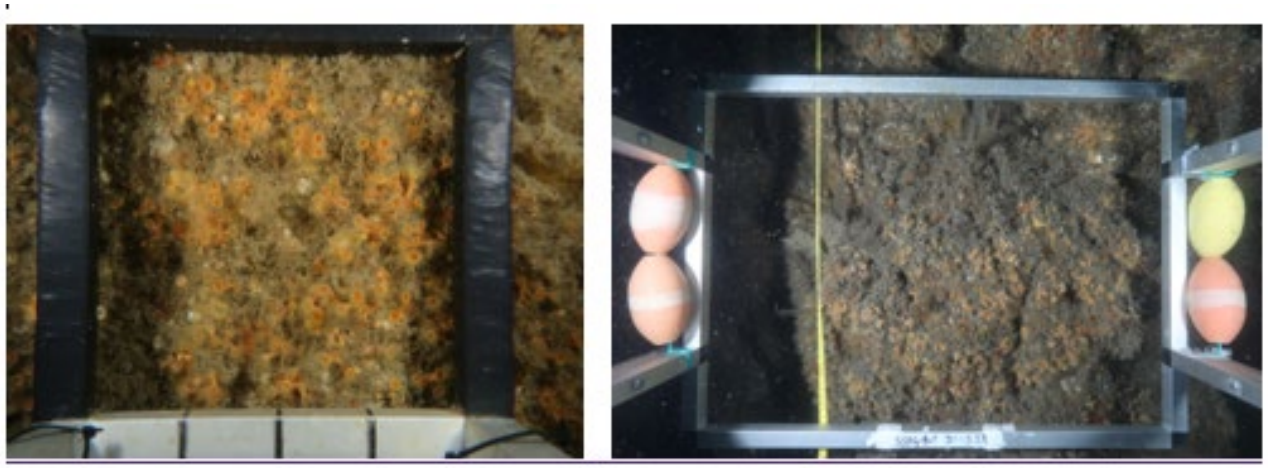
Site	Survey Start Year
Sandy Sea Fan Gully	2002
Sandy Sea Fan Gully Buttress	2015
Thorn Rock (3 colonies)	2002
Way Bench (2 colonies)	2002

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 4.5.1, 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 4.5.1, right). See Burton, Lock & Newman (2002) for details. In 2022 a new digital camera was used for the transect pictures which has an increased pixel resolution.

Figure 4.5.1 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

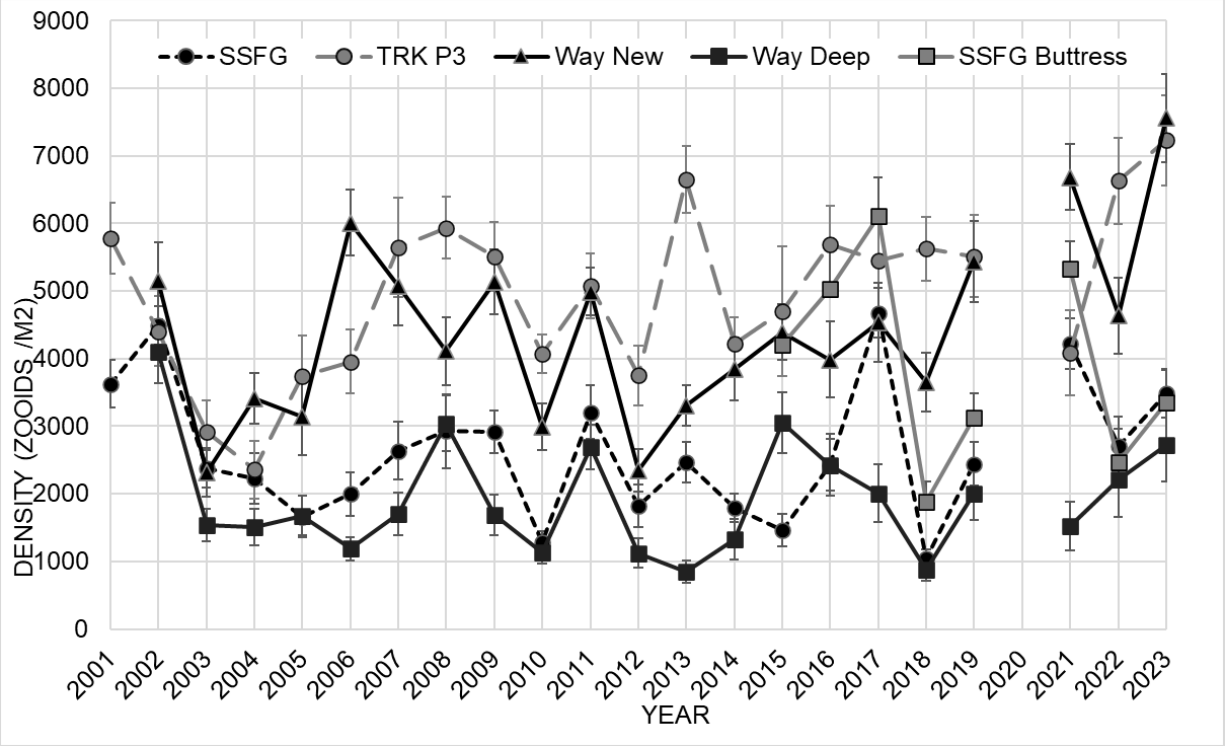
The fieldwork completed in 2023 is shown in Table 4.5.2.

Table 4.5.2 *Parazoanthus axinellae* fieldwork completed at Skomer MCZ in 2023.

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 5.2.2).

Figure 5.5.2 Mean density of *P. axinellae* (number of zooids /m^2) at five Skomer MCZ sites 2001 – 2023 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 in 2023 showed a decrease from 2022 (Figures 5.5.3 and 5.5.4).

Figure 5.5.3 Mean frequency of *Parazoanthus axinellae* 2002 – 2023. Thorn Rock (TRK) transects.

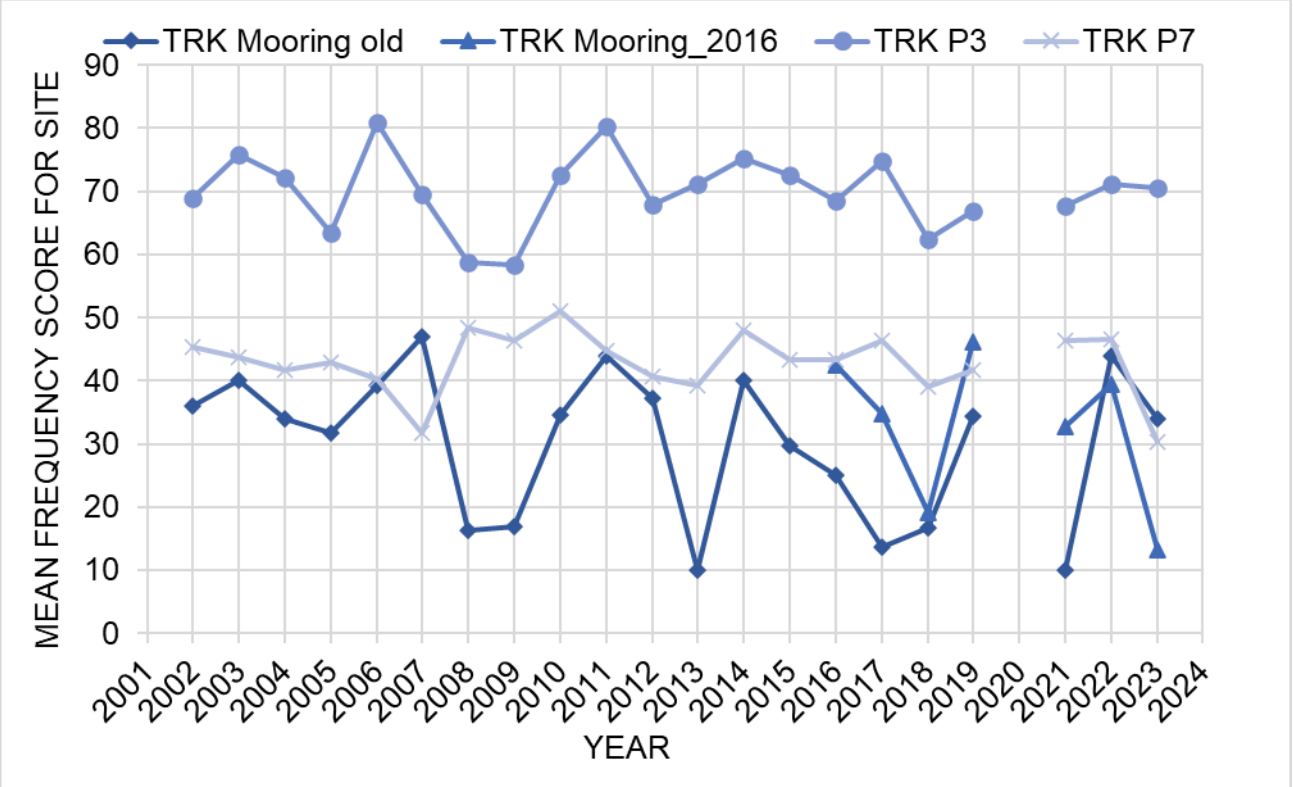
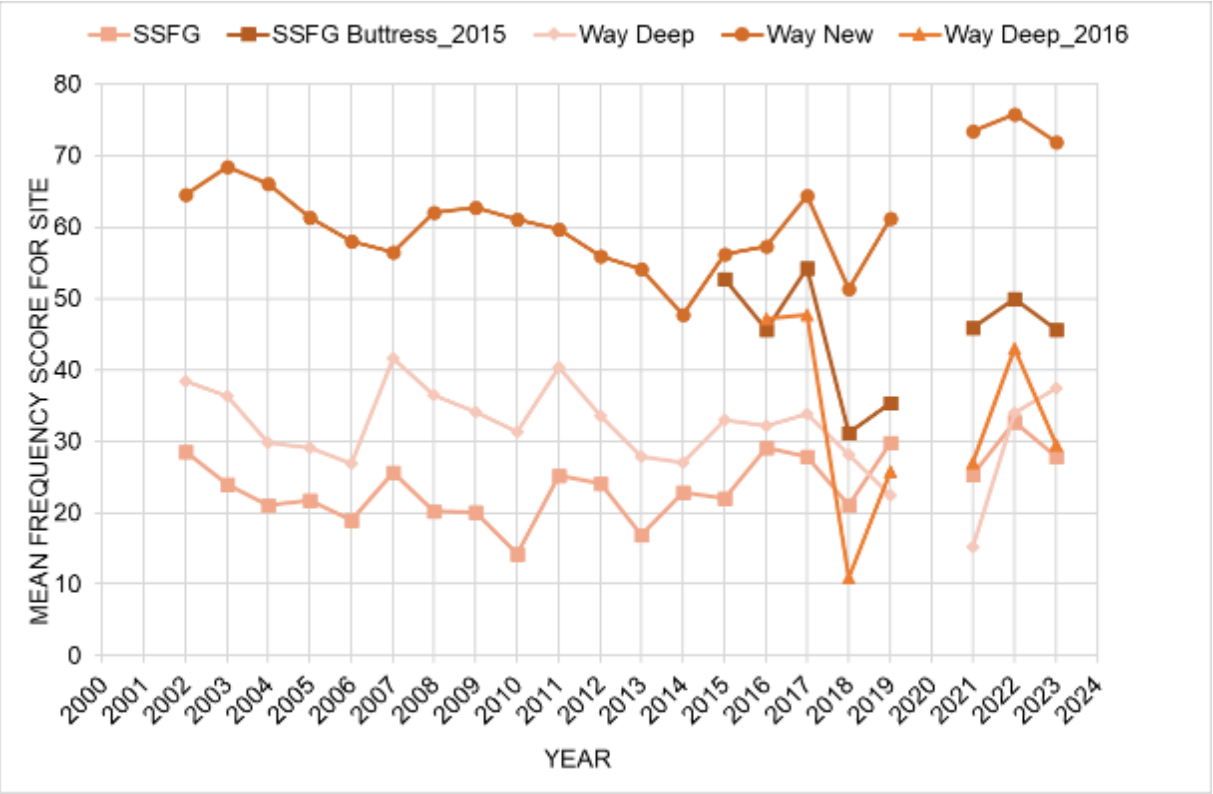


Figure 5.5.4 Mean frequency of *Parazoanthus axinellae* 2002 – 2023. Waybench and Sandy Sea Fan Gully transects.



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* 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. Large colonies are ecologically important, acting as micro-habitats, and colonies are known to harbour a large number of species including juvenile 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 physical 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 4.6.1 *Pentapora foliacea* monitoring sites at Skomer MCZ in 2023.

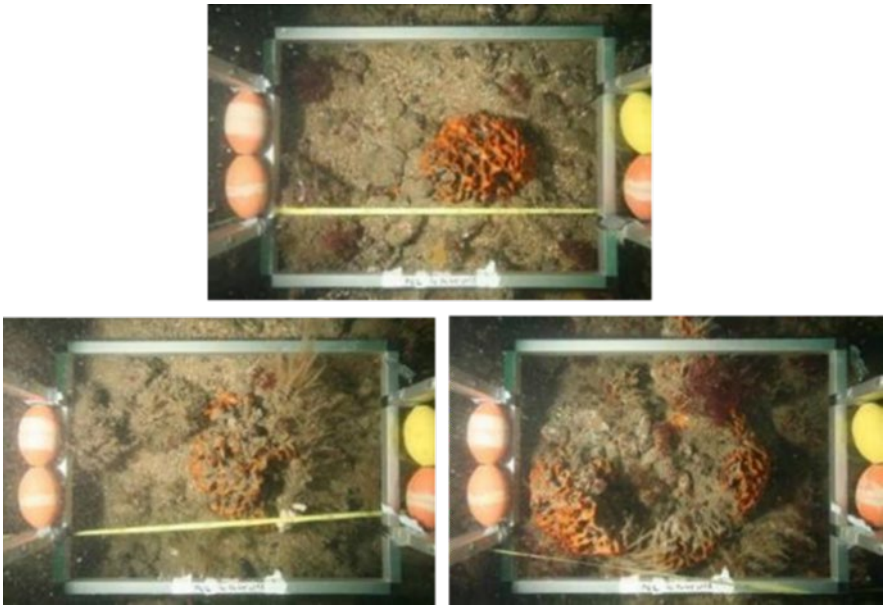
Site	Substrata	dataset
North of the Neck	ground ropes	2002 - onwards
North wall	rock and boulders	1984 – 2002
Way bench	rock and boulders	1993/4 restarted 2002 -onwards
Bernie's Rocks	boulders	1995 onwards
South Middleholm	rock	2003 - onwards
West Hook	rock	2004 - onwards
Pool	boulders	2013 - onwards
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 4.6.1).

Figure 4.6.1 *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 stereophotographs. 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

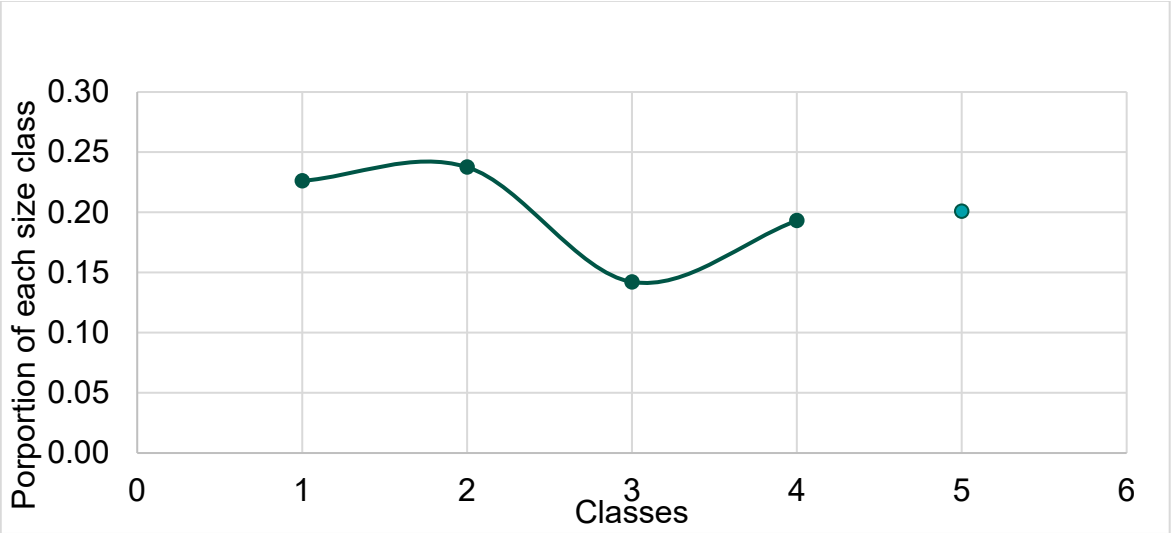
Photo datasets collected each year for each survey sites are shown in Table 4.6.2.

Table 4.6.2 *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**
2023	no	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**no**	**yes**

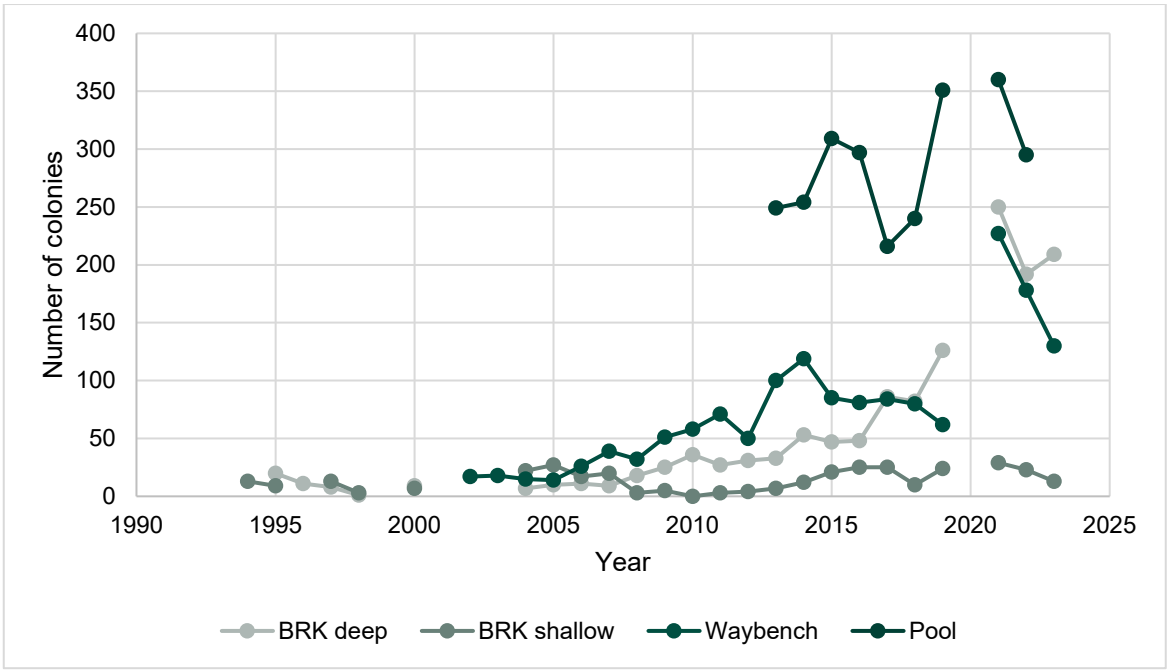
The normalised population curve in Figure 4.6.2 shows the proportions of each size class (1-4) across all Skomer sites and gives an overall pattern of size-class distribution. Class 5 is not connected via the curve as it is not a continuum from class 4 but is related to degradation which can develop 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 4.6.2 *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 4.6.3. In 2023 the Pool site was not surveyed. The total numbers recorded at each of these sites increased between 2019 and 2021, but a slight drop in numbers was observed in 2022.In 2023 the Pool was not surveyed, numbers at Bernies Rock deep and Waybench continue to be higher than pre-2019.

Figure 4.6.3 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 dropped in 2022 to 178 and to 130 colonies in 2023 (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 having 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 2023 numbers of colonies remained high with 209 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 and 309 colonies, in 2019 this increased to 351 colonies and in 2021 to 360 colonies, with all classes represented. In 2022 the numbers of colonies remained healthy with 295 recorded, (Figure 34), no survey was completed in 2023.

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.

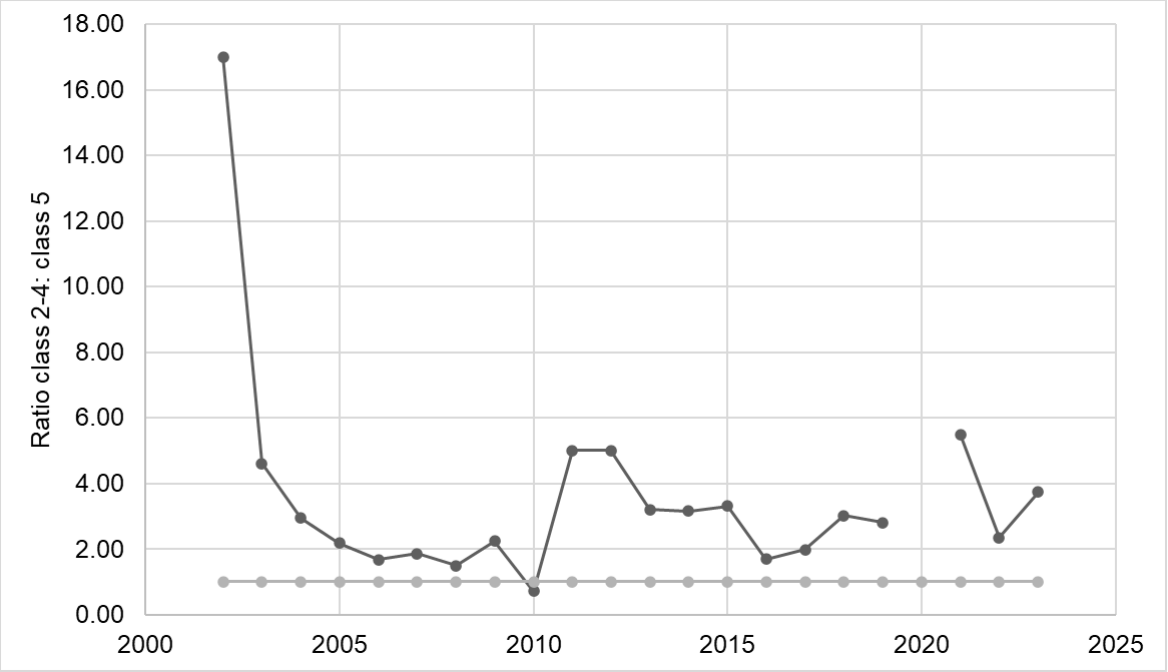
South Middleholm is a small bedrock site on the south side of the island and subjected to the prevailing south-westerly swell. Class 1 to 3 individuals are the most common, with very few developing into class 4, instead developing directly to class 5.

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 2023 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 4.6.4), therefore there are more healthy growing colonies than degraded colonies.

Figure 4.6.4 *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 4.6.5).

Figure 4.6.5 *Pentapora foliacea* – interaction with fishing gear.

Evidence of damage from angling line has also been observed tangled in *P. foliacea* at the new Martins Haven east survey site in each year it has been surveyed (2021-2023), this location is popular with shore angling (Figure 4.6.6).

Figure 4.6.6 *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 – 2023. 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. Pool site was not surveyed in 2023 but numbers of colonies at both Waybench and Bernies Rock still remain 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.
- 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 the conservation status of *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

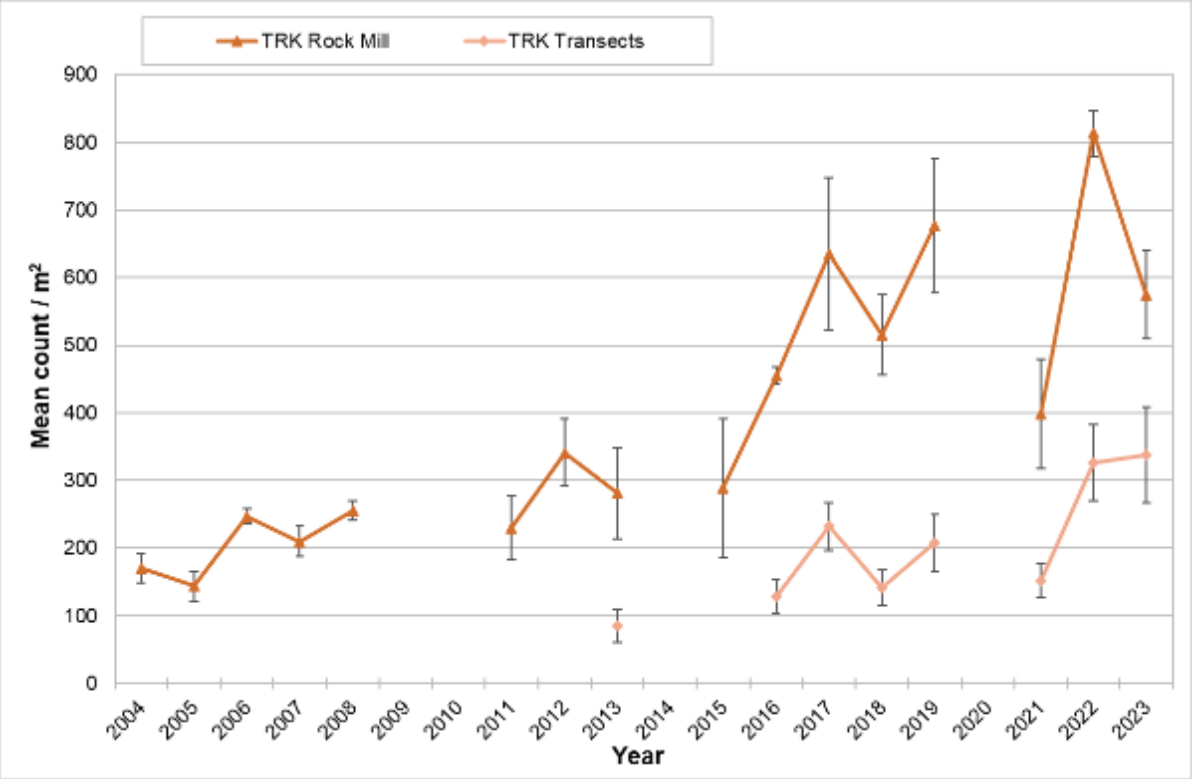
Approximately 70 quadrats have been analysed on an annual basis since 1993 from photographs taken for the sponge community project at Thorn Rock. Photographs are taken using a 50 cm x 70 cm framer using a digital SLR camera and counts are carried out using image analysis techniques described in Burton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

4.7.5. Results

Balanophyllia regia

Thorn Rock Mill and transect data have been standardised to abundance per 1m^2 to enable comparison between the 50 cm x 40 cm and the 50 cm x 70 cm framers (Figure 4.7.1).

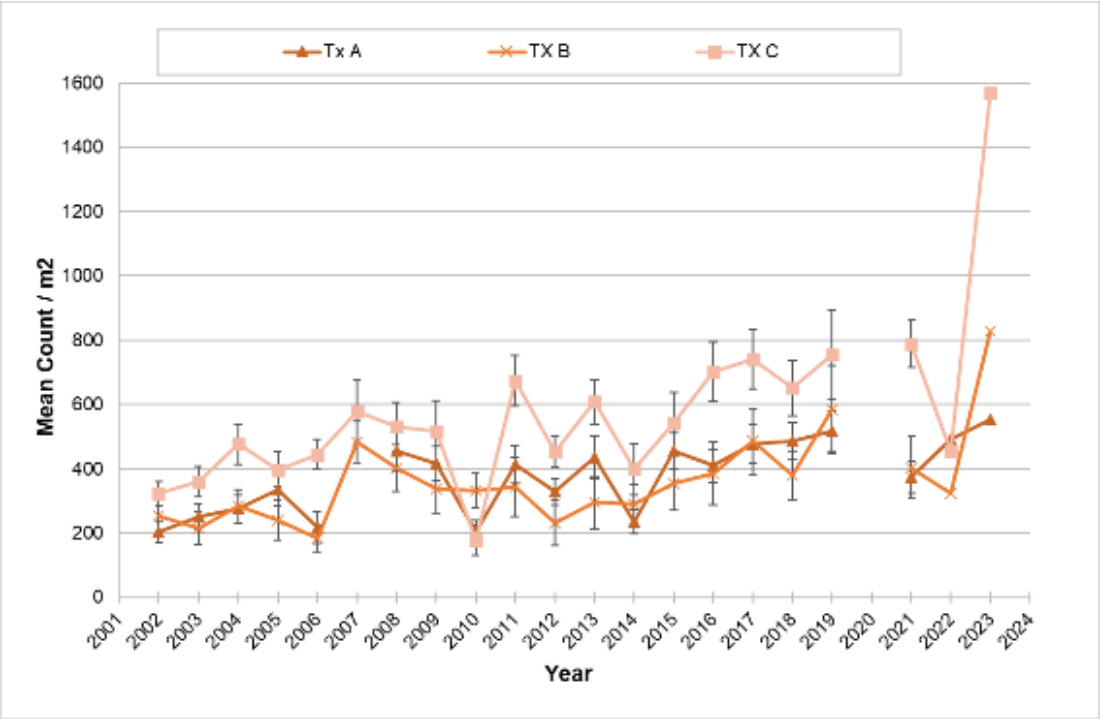
Figure 4.7.1 Mean abundance per metre^2 (and standard error) of *Balanophyllia* regia at Rockmill and Transects at Thorn Rock (counted within 50 cm x 40 cm framers).



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, this dropped slightly in 2023. The average count/m^2 of *B. regia* at the transects is lower than that at Rockmill. Further data are needed to monitor trends.

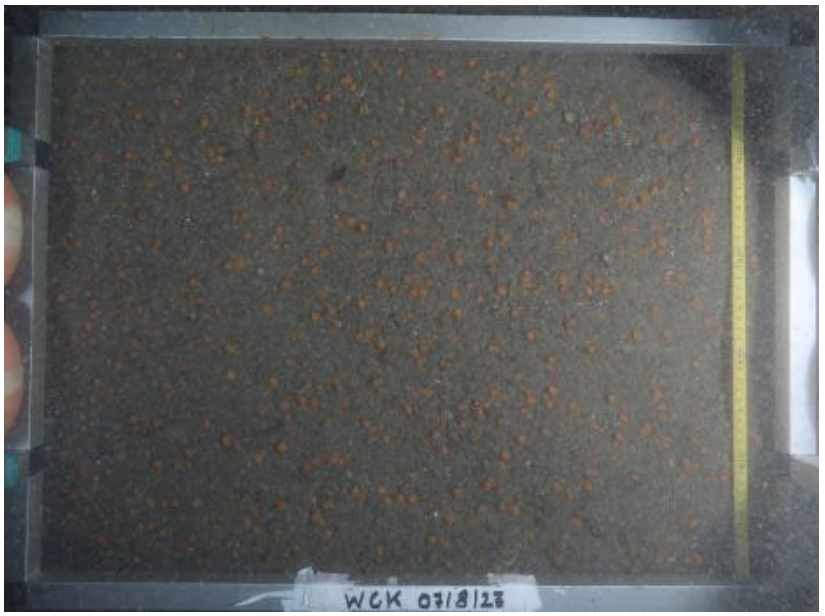
At the Wick, all data have been standardised to abundance per 1m^2 to enable comparison between the 50 cm x 40 cm and the 50 cm x 70 cm framers (Figure 4.7.2).

Figure 4.7.2 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 2023 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 4.7.2). In 2023 a record number of 921 individuals were counted in one 50 cm x 70 cm framer (2631/m^2) (Figure 4.7.3).

Figure 4.7.4 *Balanophyllia regia* (individuals 541) in 1 50 cm x 70 cm framer at the Wick, representing a density of 2631/m^2.



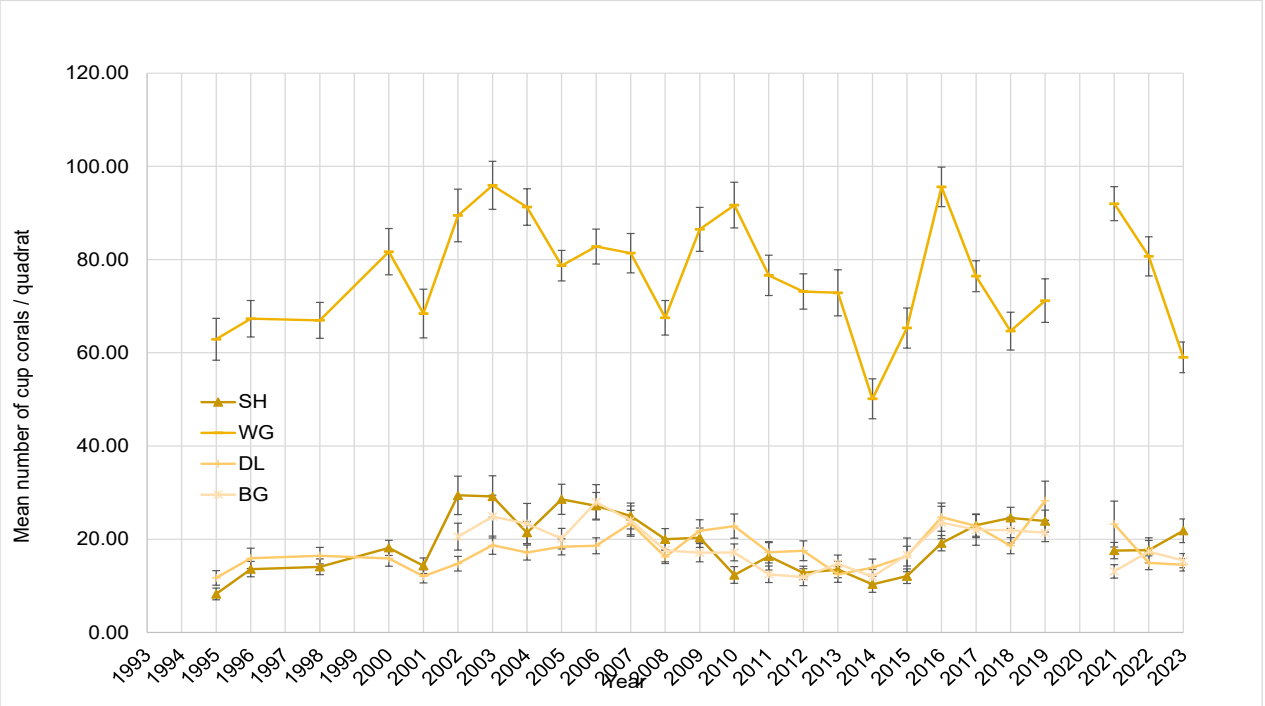
Caryophyllia smithii

The average density of *C. smithii* has fluctuated at each of the Thorn Rock sites (Figure 4.7.5). This may be due to variable levels of surface sediment affecting the actual numbers visible during recording.

The Windy gully (WG) quadrats show significantly higher counts compared to the other sites. This is most likely due to it being the only vertical wall site where less surface sediment accumulates. The other three sites are all on horizontal rock.

The abundance has fluctuated at Windy gully (WG) but 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)) nor what variability in their numbers would be natural.

Figure 4.7.5 Mean Number of *Caryophyllia smithii* /m^2 quadrat at Thorn Rock (4 transects) 1995 – 2023.



4.7.6. Current Status

- Variability in observed numbers of both *B. regia* and *C. smithii* is partly due to varying levels of surface sediment.
- The populations appear stable and in favourable condition.

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 the conservation status of *B. regia* and *C. smithii* feature as stable and in favourable condition.

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. Grey 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).

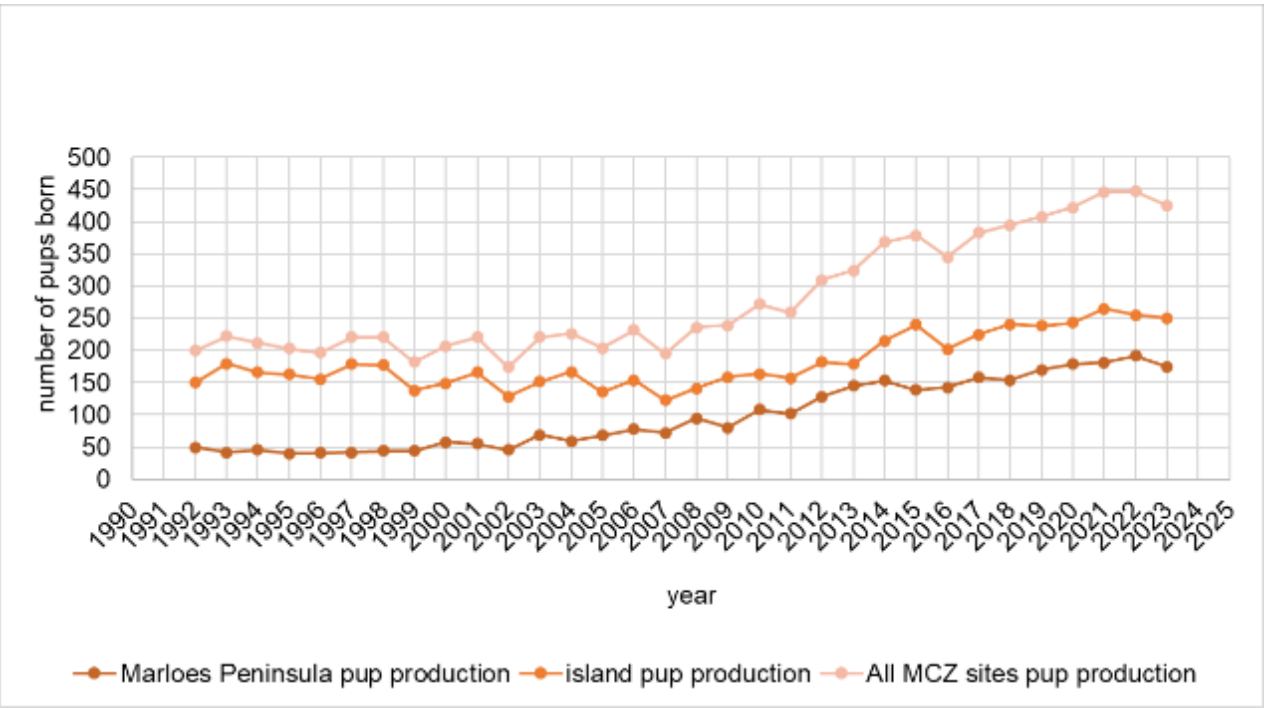
4.8.6. Results

A full report for the 2023 Skomer seal census details the production for the island sites, (Buche 2024). The survey data from the island and mainland sites have been combined to provide data for the whole Skomer MCZ.

Pup production

In 2023, 250 pups were born at Skomer Island sites and 175 pups at mainland sites giving a total of 425 pups born in the MCZ (Figure 4.8.1).

Figure 4.8.1 Skomer MCZ pup production 1992 - 2023.

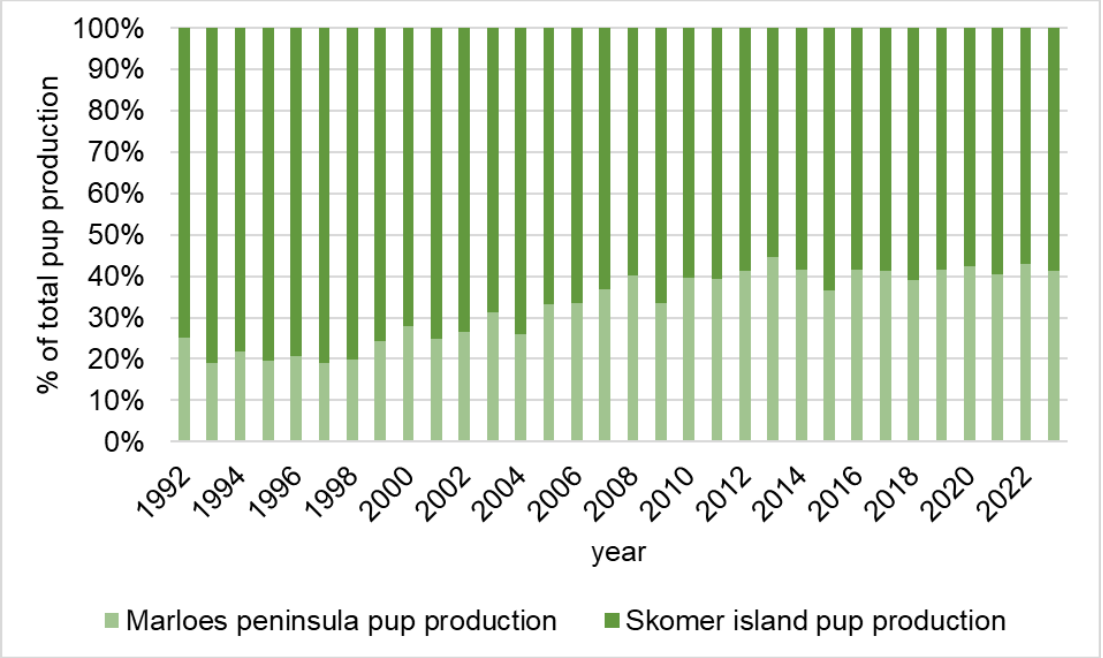


Pup production in the Skomer MCZ for the past 5 years has shown the highest totals recorded for the area, with production averaged for 2019-23 being 429 pups.

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 4.8.1).

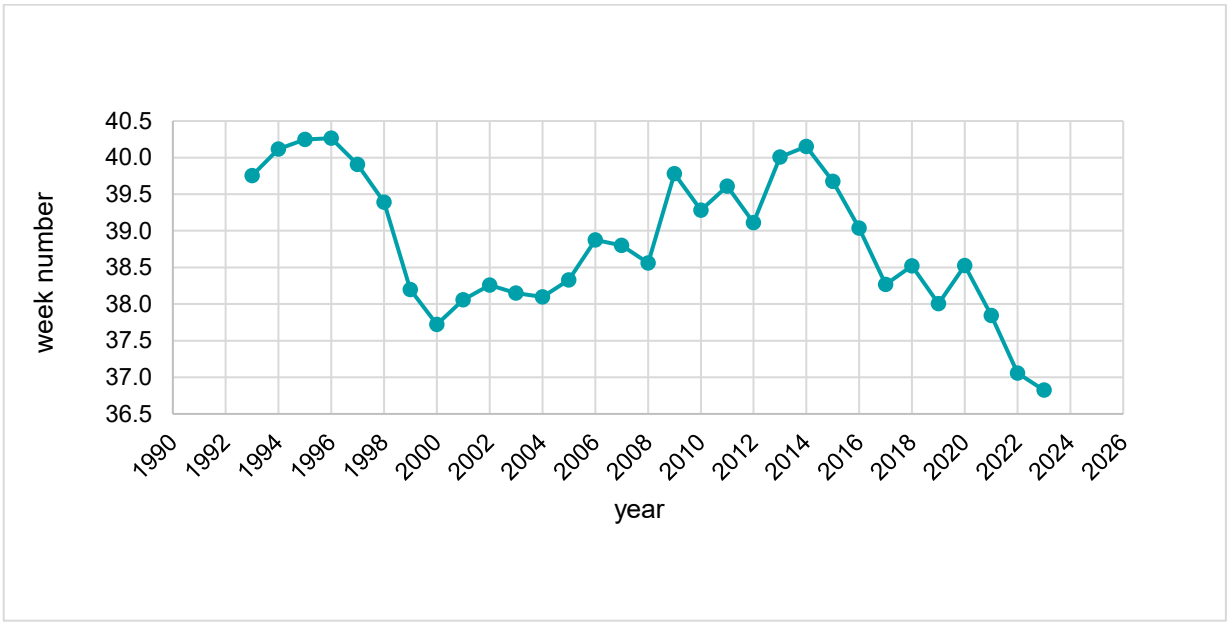
In 2023 Skomer MCZ pup production was 59% at Skomer island sites and 41% at Marloes peninsula sites. Pup production at the Marloes peninsula sites versus the Skomer island sites expressed as a percentage of the total pup production for the Skomer MCZ is shown in Figure 4.8.2. From 1992 to 2002 Marloes 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 41.8% of total production.

Figure 4.8.2 Skomer MCZ pup production – percentage born on Island vs. mainland sites



The highest number of births was 86 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 36 to 40 (3rd September to 7th October). During the 10-year period from 2014 to 2023 the mode week has progressively moved earlier in the season, in 2023 its earliest ever recorded in week 36.8 (14th September). (Figure 4.8.3).

Figure 4.8.3 Mode week of seal pup production at Skomer MCZ 1992 – 2023.



Pup survival

In 2023, pup survival through to moult was recorded as 74.8% for Skomer sites and 89% for Marloes Peninsula sites, with a combined survival for the Skomer MCZ of 80%.

Pup survival assessment is based on the following criteria applied to pups when last seen (Table 4.8.1)

Table 4.8.1 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.

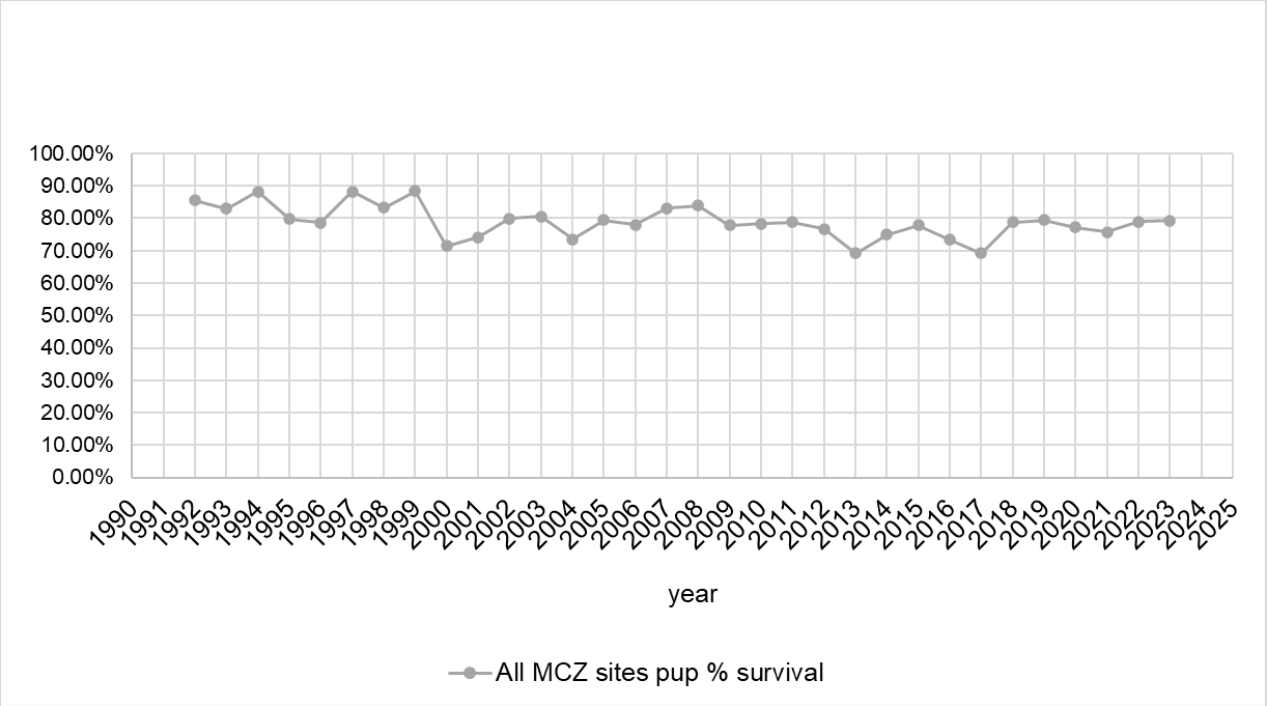
Died. All pups seen alive but subsequently recorded dead. These can be from class 1 to 5 in

Table .

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

In the Skomer MCZ, pup survival from 1992 to 2023 has fluctuated between 69% and 88%, with an average of 79% (Figure 4.8.4).

Figure 4.8.4 Skomer MCZ pup survival 1992 – 2023.



Pollution and Litter

Monofilament line and netting were the most visible pollutants affecting seals in 2023. 29 individual seals on Skomer 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.

No pollution by oil or tar was observed in 2023, however large quantities of beach rubbish including fishing ropes, netting, and bag loads of plastic debris were collected and cleared from South Haven beach in August by Skomer Island Wardens and volunteers and removed by boat by the Skomer MCZ team. A large bundle of netting was also recovered from North Haven (Figure 4.8.5).

Figure 4.8.5 Netting being recovered from North Haven beach

Seal behaviour

In 2023, as in most years, females were observed nursing others' young.

Some eye infections were noted in 2023. 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 2023, fourteen small incidents were recorded, and boats were observed within the voluntary no access zone (Table 4.8.2).

Table 4.8.2. Seal disturbance (records by Skomer Island staff) on Skomer Island in 2023

Level of disturbance: 1 = unaware of human presence); 2 = alert/aware of human presence but stay on beach 3 = Panic and rush into the water, stay nearshore 4= Panic rush into water and swim away from shore.

Date	Location	Type of boat	Level of disturbance	Notes
15/8/23	MWK/CBY	Lobster Potter	1	Laying pots right into mouth of MWK and CBY
16/8/23	NHV	RIB	2	Cruised close to cliffs and beach, made hauled-out seals on RRK look up and one entered the water
20/8/23	NHV	Lobster Potter	1	Went close to seals on RRK
28/8/23	SHV	Zodiac	1	Divers
1/9/23	NHV	Dale Queen	1	One seal hauled-out lifted head
2/9/23	GST	Kayak	2	Disturbed haul-out on GST
8/9/23	NHV	Lobster Potter	2	Boat was too fast, too close and talked too loudly.
8/9/23	NHV	Lobster Potter	1	Disturbed haul-out on RRK
10/9/23	CBY	5 Kayaks	2	Disturbed seals on CBY, went past close to mouth of bay.
10/9/23	PSB	4 Kayaks	2	Kayaks disturbed seals at Pigstone Bay
12/9/23	SHV	Yacht		Pembrokeshire Sailing yacht
15/9/23	NHV	Motorboat	1	Divers inside no access zone, talking and whooping, seals on NHV beach looking at them
15/9/23	NHV/SHV	Microlite	1	
15/10/23	NHV	9 Kayaks	2	Were too noisy, disturbed haul-out on NHV main beach, later pulled kayak onto rocks at landing steps
25/10/23	NHV	Lobster Potter	2	Went up to RR too fast und seals panicked into water

4.8.7. Current Status

- In 2023, pup numbers reached 425, 14 pups less than the management plan target pup production lower limit of 439 pups (average of last 3 years). 425 pups is still however considered a healthy total and is the 3rd highest recorded.
- Pup survival was 80%, 4% more than the management plan target percentage survival lower limit of 76% (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 in order to minimise disturbance to breeding seals.
- Report the conservation status of the Grey seal species feature as stable and in favourable condition.

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* (pictured above) 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 2023. There are no records in years 2003, 2007, 2010, 2011 and in 2020 (Figure 4.9.1). 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 Sailing crew in

2017 or 2018, records were received in 2019 but none for 2020 - 2022. Records have been received for 2023. 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).

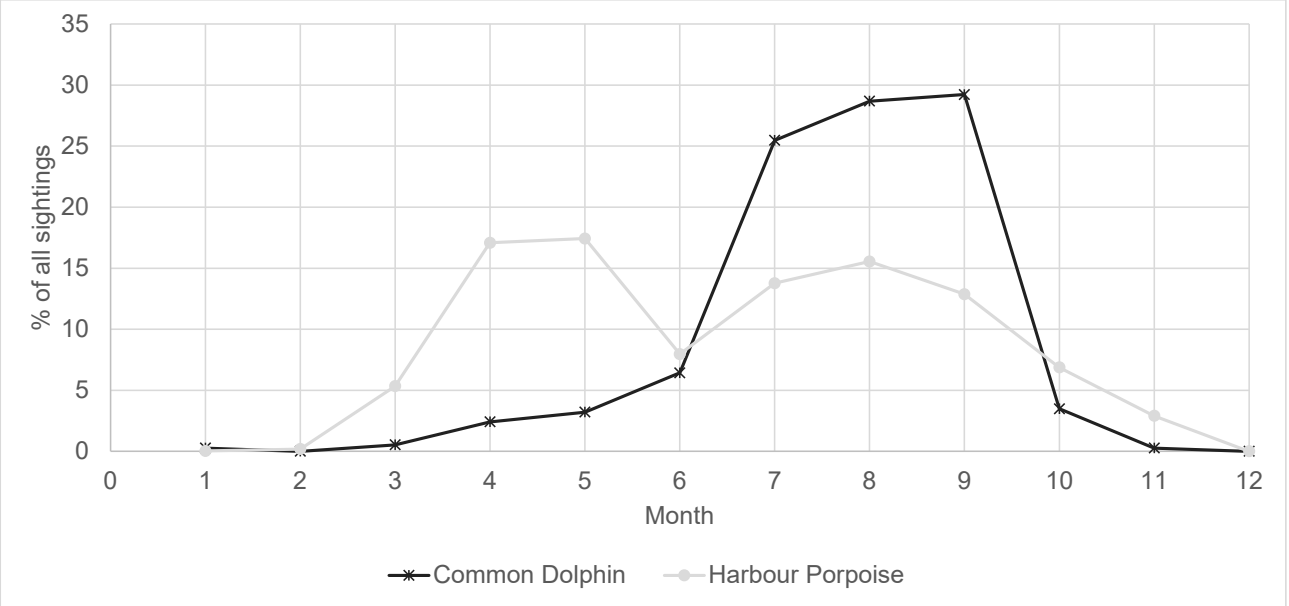
Figure 4.9.1 Harbour porpoise sightings Skomer MCZ 2001 – 2023. No recording occurred in 2010, 2011 and 2020.

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

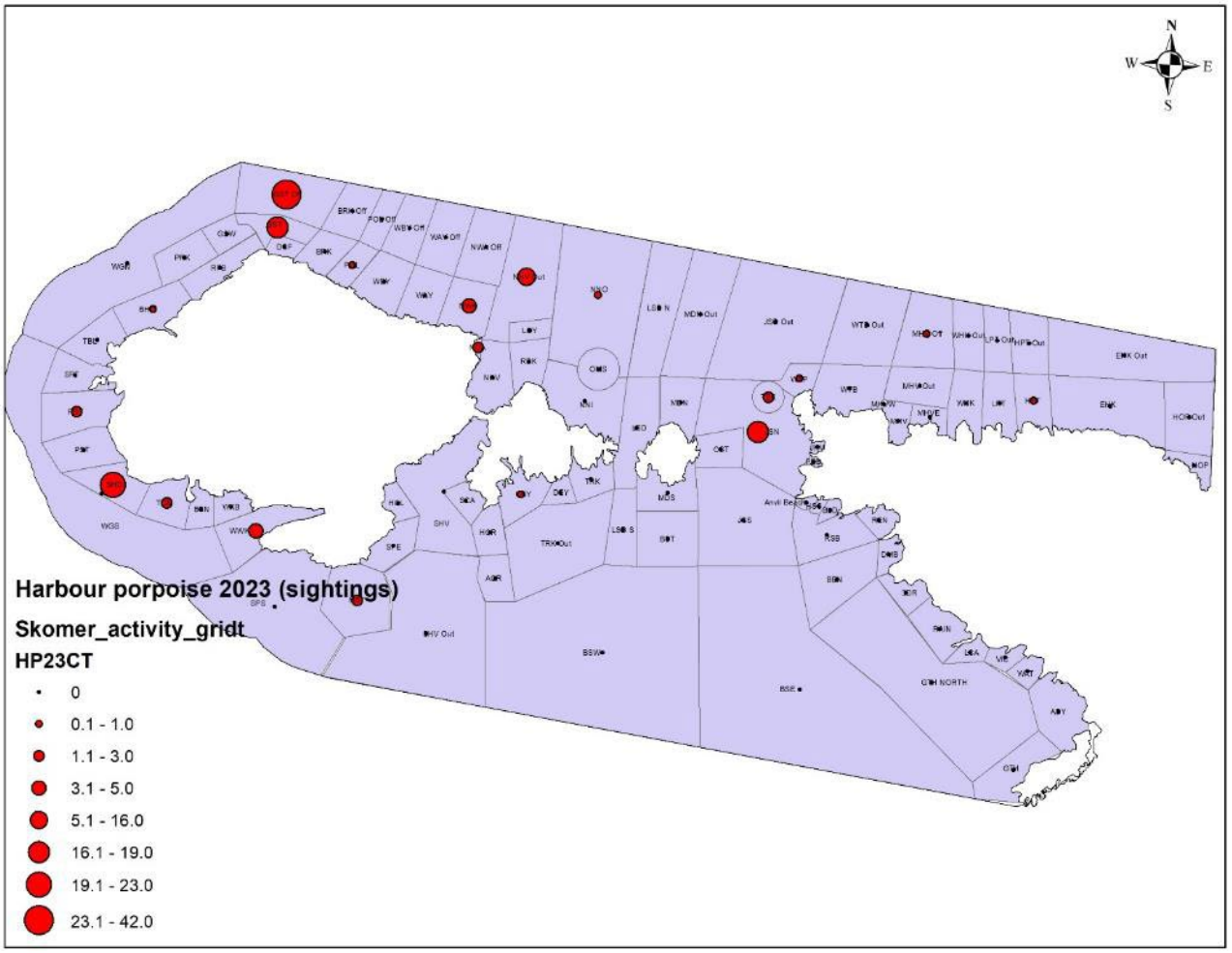
Harbour porpoise are sighted throughout the whole year and are assumed to be resident or regular users within the MCZ. Common Dolphins *Delphinus delphis* are predominantly seen from July to September as shown in Figure 4.9.2.

Figure 5.2 Percentage of sightings per month 2001 to 2022 Harbour porpoise and Common dolphin.



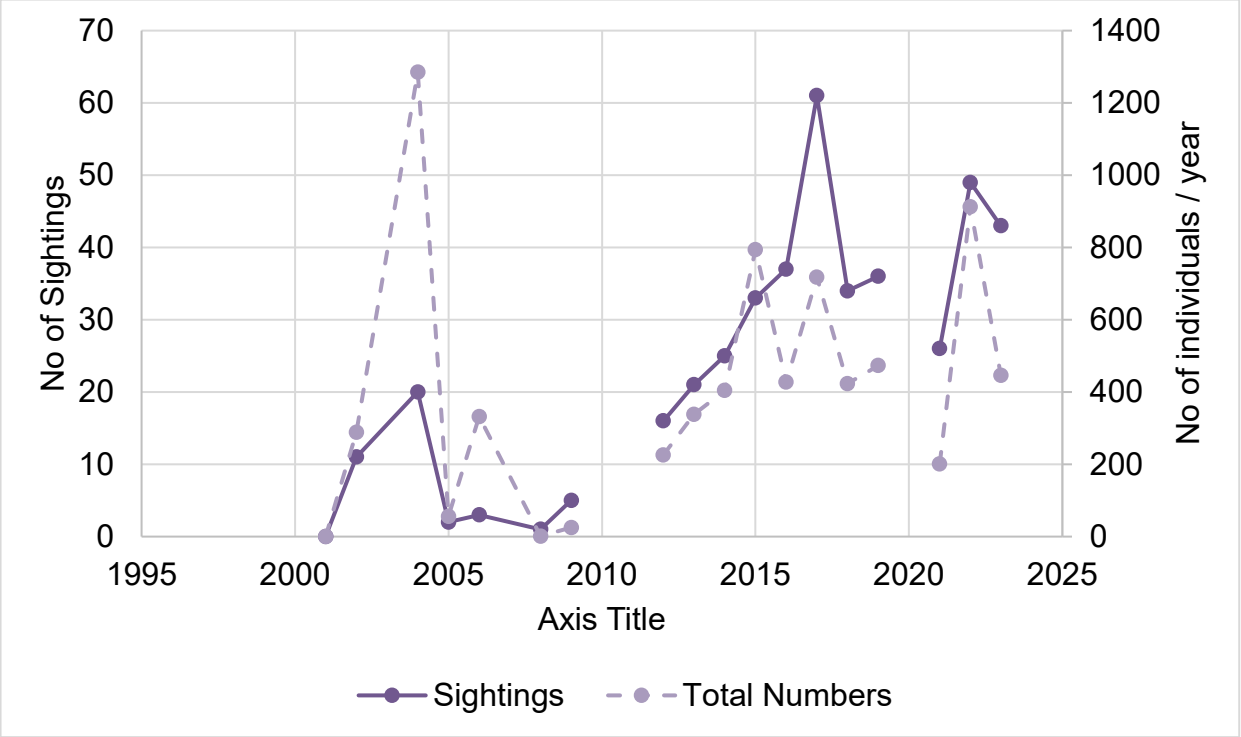
There are hot spots of sightings around the MCZ. The tidal races off the Garland Stone and Skomer Head are popular spots to see Harbour Porpoise (see Figure 4.9.3).

Figure 4.9.3 Harbour porpoise sightings and distribution Skomer MCZ 2023.



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 (Figure 4.9.4). 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 and 2023 the number of sightings and total numbers seen have increased.

Figure 4.9.4 Common dolphin sightings within Skomer MCZ 2001 to 2023.



Bottlenose dolphins *Tursiops truncatus* are not often seen within the MCZ, but in 2019 there were 2 sightings of individuals off the Garland stone and 5 individuals were seen in 2022 and 2 sightings in 2023.

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 2023 there were 5 sightings of Risso's Dolphin.

A single sighting of a Minke Whale was recorded for the first time in the MCZ, it was spotted by Island staff outside of North Haven.

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 start record sightings.
- Support cetacean research, for example deploy acoustic loggers.
- Report the conservation status of the cetacean feature as unknown.

4.10. *Zostera marina*

4.10.1. Project Rationale

Zostera marina is the only flowering plant within the British Isles that grows and produces seed entirely submerged by seawater. *Z. marina* populations are highly productive habitats and they provide an important stabilising function for the mobile marine sediments. The maintenance of *Z. marina* populations directly influences the associated algal & invertebrate communities that it supports, which are an important source of food for birds.

In 1994 the UK government published the UK Biodiversity Action Plan (BAP) for species and habitats identified as threatened; seagrass beds were included as threatened habitats. BAP was superseded by the NERC Act (2008) and further by the Environment (Wales) Act, 2016, where seagrass beds are listed as a Section 7 habitat due to the declines and level of threat to this habitat.

Seagrass beds are recognised as a 'sub-feature' of shallow inlets and bays within Special Areas of Conservation (SACs) under the EU Habitats Directive 1992 (Council Directive 92/43/EEC).

Zostera beds are on the OSPAR list of 'Threatened and/or Declining Species and Habitats' in the most recent assessment (OSPAR, 2022) *Zostera* beds are classified as having poor overall status in Arctic Waters (Region I); North Sea (Region II); Celtic Seas (Region III) and Bay of Biscay & Iberian Coast (Region IV).

4.10.2. Objectives

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

4.10.3. Site

- North Haven

4.10.4. Method

Permanent markers define the corners of a survey plot of 60 x 65 m^2 in North Haven and lead lines marked every 5m are laid for the survey duration. Within the plot area, transects are completed every 5m. Every 5 metres along each transect *Zostera* shoot counts are taken in six 25 x 25 cm^2 quadrats. The transect lines are continued outside the survey plot where *Z. marina* is present. Quadrat counts are completed along these transects at 5 metre intervals out to 60m.

For detailed methodology see Lock *et al* 2006.

4.10.5. Results

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

1982 A detailed method was devised based on a fixed grid area and use of a defined abundance scale. This method formed the basis of the survey completed in 1997.

1997 Permanent plot markers were established, and methods developed for *Z. marina* shoot density and boundary maps (Lock 1998).

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

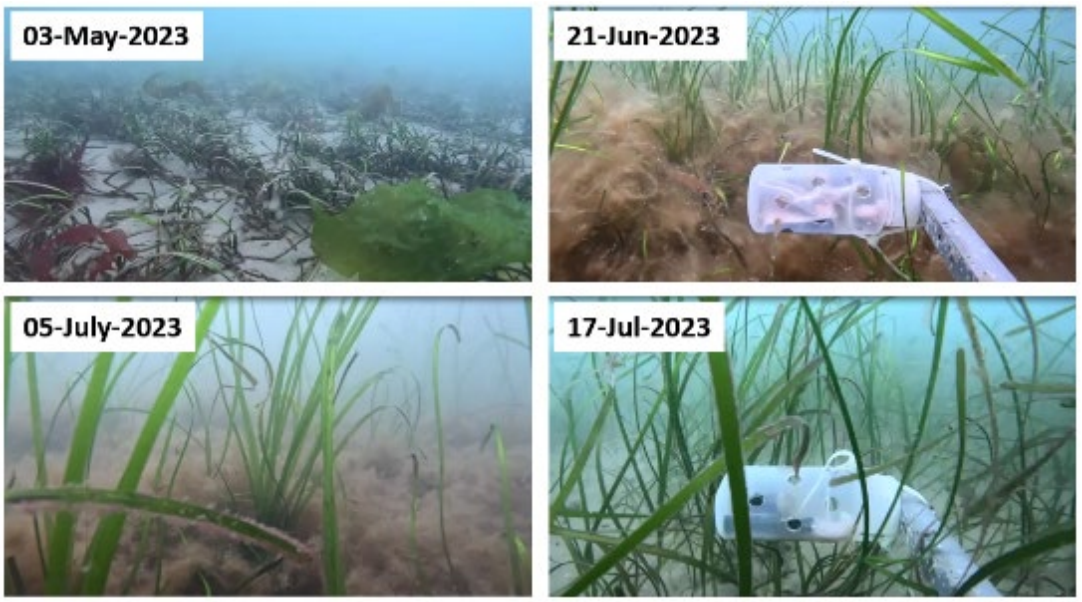
2002 *Z. marina* shoot density and boundary map was completed following the method established in 2002 and maps were compared with those from 1997 (Lock 1003).

2006, 2010, 2014 and 2018. A *Z. marina* shoot density and boundary map was completed following the method established in 2002 with additional transects every 5m out to the east and west.

2013, 2014, 2015, 2018, 2019, 2021 and 2022. An acoustic survey of the extent of the Z. marina bed using a Biosonics DT-X split beam echo sounder.

2023 A repeat survey of *Z. marina* shoot density and boundary using the 2006 methods was completed. A dense blanket of filamentous brown algae covered the bed during the survey period in June and July (Figure 4.10.1), this severely hampered the survey work and some modifications to the method were needed. Density counts were completed in 3 quadrats at each station as opposed to the 6 completed in previous surveys. A remote underwater video survey was completed. See Massey *et al* 2024 for the full report.

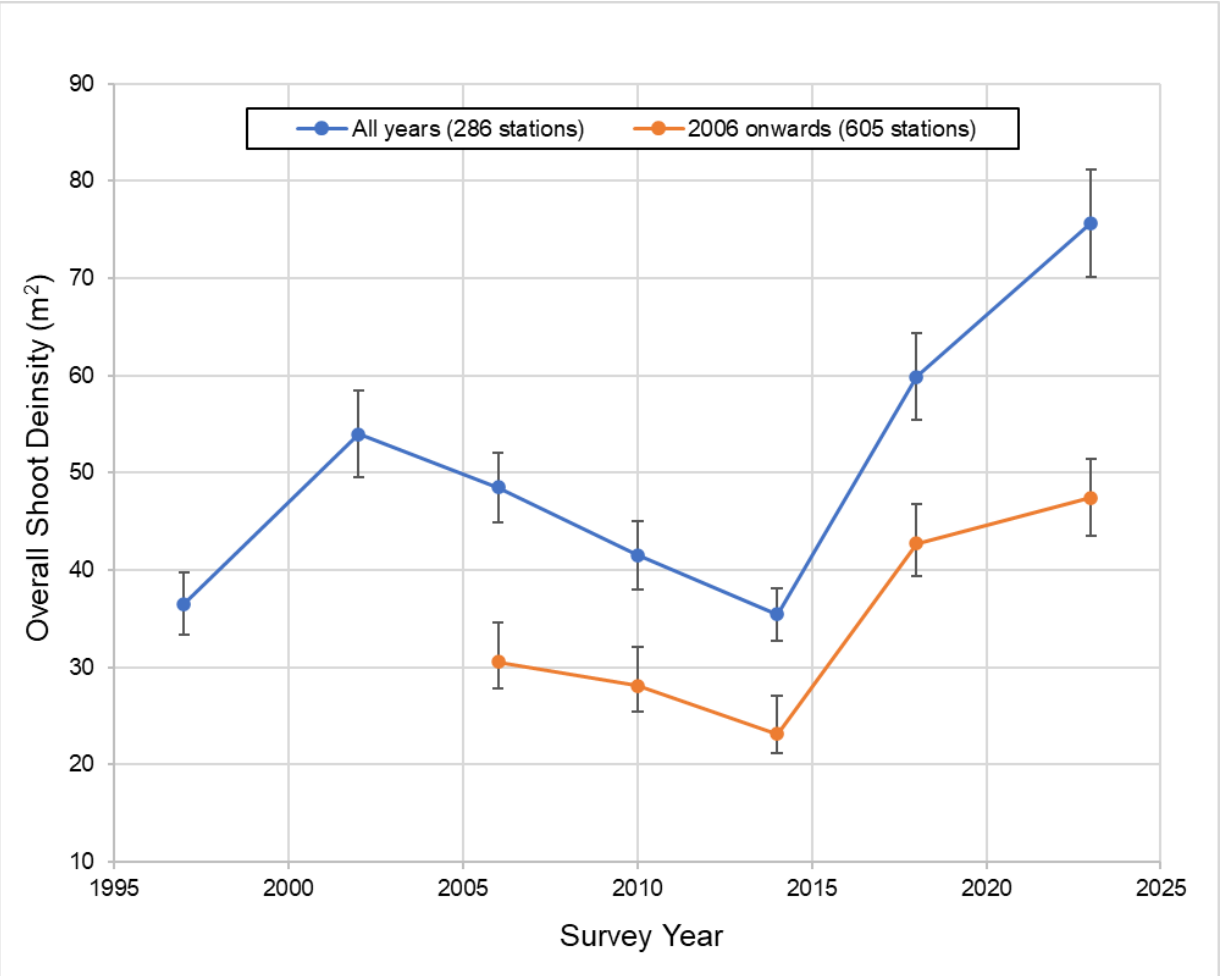
Figure 4.10.1. Appearance of filamentous brown algae over the North Haven *Zostera marina* bed



2023 Density Results

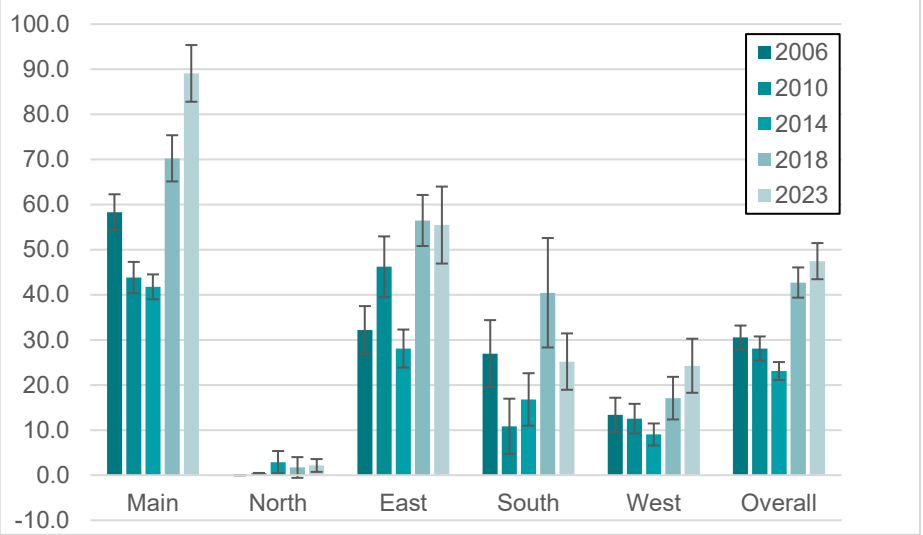
The central bed has been surveyed consistently from 1997 to 2023 but the outer transects (north, south, east and west) were only partly done in 1997 and 2002, and in 2006 the number of sampling stations were increased. By comparing the same sample stations used in 1997 and 2002 across all years, it is possible to make direct comparisons between all the results since 1997 (Figure 4.10.2). Comparing all data sets (1997 to 2023), there was a decline in overall shoot density from 2002 to 2014 but significant increases have been recorded in 2018 and 2023. 2023 has the highest overall shoot density recorded to date.

Figure 4.10.2. Comparison of shoot densities 1997-2023 and 2006-2023 (95% S.E. bars) [using data from survey stations sampled in every survey year].



Compared to 2018, increases in shoot density were recorded in the main, north and west beds. Overall shoot density in 2023 was higher than in the previous four surveys (Figure 4.10.3).

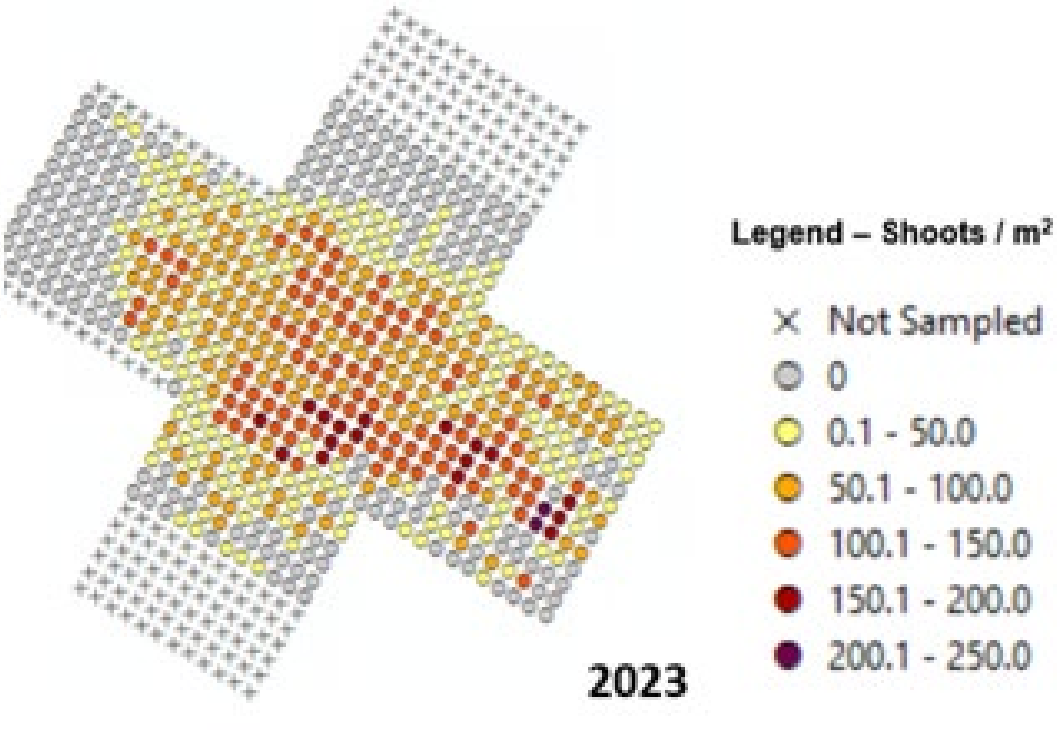
Figure 4.10.3. Comparison of shoot densities 2006-2023 (95% S.E. bars) [using data from survey stations sampled in every survey year].



A one-way ANOVA test between years on (logx+1) transformed data showed a significant difference in shoot density between years P<0.01%. A Tukey test showed shoot density to be significantly higher in 2023 than in 1997 and 2014.

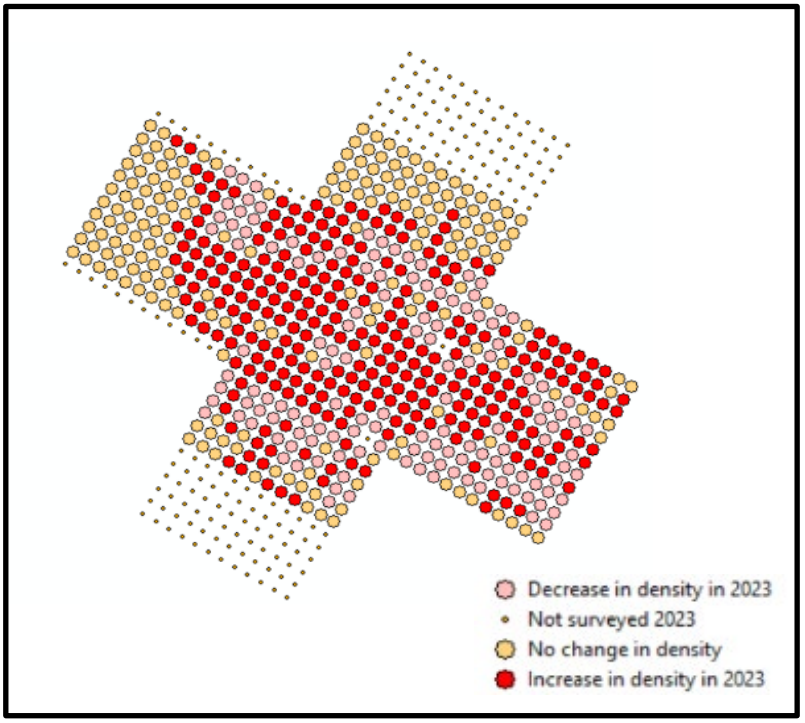
Thematic maps were produced showing the variation in shoot density across the whole seagrass bed (Figure 4.10.4).

Figure 4.10.4 Density map from 2023 survey (shoots / m^2)



Differences in shoot densities between the last 2 surveys (2018 and 2023) have been mapped in ArcGIS by plotting a function of; difference = 2023 density - 2018 density. A negative value means a decrease in density in 2023 compared to 2014 (Figure 4.10.5).

Figure 4.10.5. Differences in shoot density between 2018 and 2023 surveys.



Area of extent results

Since 1997 there have been 3 methods used to estimate the area of extent of the North Haven *Z. marina* bed, the results from these and comparison been the methods are shown in Figure 4.10.6 and Table 4.10.1.

Figure 4.10.6. Graph of seagrass extent in (m^2) 1982 - 2023, estimated by different methods.

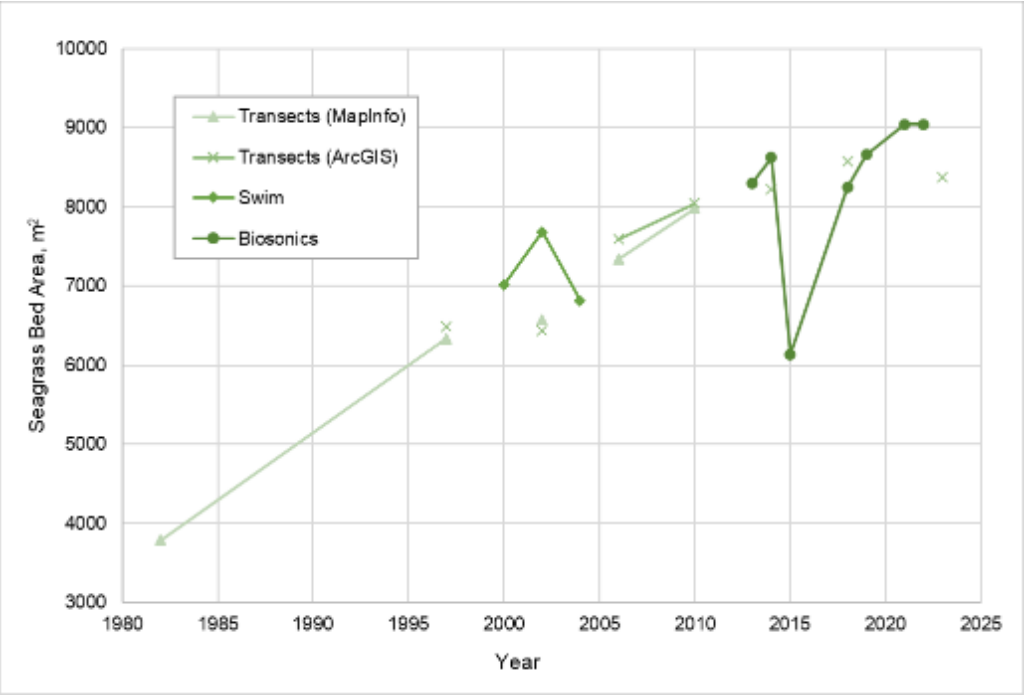


Table 4.10.1. Estimated coverage (area in m^2) of *Z. marina* in North Haven. 1982-2023, all survey methods.

Year	Polygon drawn from survey transects (MapInfo)	Polygon drawn from survey transects (ArcGIS)	Diver boundary swim	Biosonics acoustic survey (60-70 PAI)
1982	3788	n/a	n/a	n/a
1997	6333.4	6484.2	n/a	n/a
2000	n/a	n/a	7007.8	n/a
2002	6569.5	6439.6	7683.20	n/a
2004	n/a	n/a	6817.5	n/a
2006	7336.6	7587.2	n/a	n/a
2010	7980.6	8044.0	n/a	n/a
2013	n/a	n/a	n/a	8290
2014	n/a	8224.6	n/a	8621
2015	n/a	n/a	n/a	6133
2018	n/a	8567.6	n/a	8244
2019	n/a	n/a	n/a	8659
2021	n/a	n/a	n/a	9040
2022	n/a	n/a	n/a	9039
2023	n/a	8367.1	n/a	n/a

The two GIS methods (MapInfo and ArcMap) using two different projections (WGS 84 & British National Grid) give similar results. The area of extent appears to be increasing and in 2023 the area estimate of 8367.1 m^2 was recorded from the diver survey.

Acoustic Survey Results 2013 - 2022

The NRW Fisheries assessment team surveyed the North Haven *Z. marina* bed in 2013, 2014, 2015, 2018, 2019, 2021 and 2022 using the same Biosonics DT-X sonar equipment (see Clabburn *et al.* 2014 for methods). The results are shown in Table 4.10.2 and the 2022 maps for area extent are shown in Figure 4.10.7 and Figure 4.10.8.

Different cut off (contour) values can be used to set the edge of the *Z. marina* bed, the 60% contour appears to match up best with the *in situ* diver area estimate. In 2015 the area estimate was very low (Table 4.10.2), no *in situ* data was available to confirm this.

Table 4.10.2. Estimated area of North Haven seagrass bed (m^2) 2013-2021, as mapped by Biosonics Survey

% Area Inhabited Contour	2013	2014	2015	2018	2019	2021	2022
90	6140.2	6282.1	3833	6086	n/a	n/a	n/a
80	7126.0	7329.4	4910	7004	n/a	n/a	n/a
70	7742.1	8041.8	5572	7589	n/a	n/a	n/a
60	8290.1	8621.1	6133	8244	8659	9040	9039

Figure 4.10.7 Biosonics plot of seagrass bed area extent in 2022 (using 60% Area Inhabited contour values).

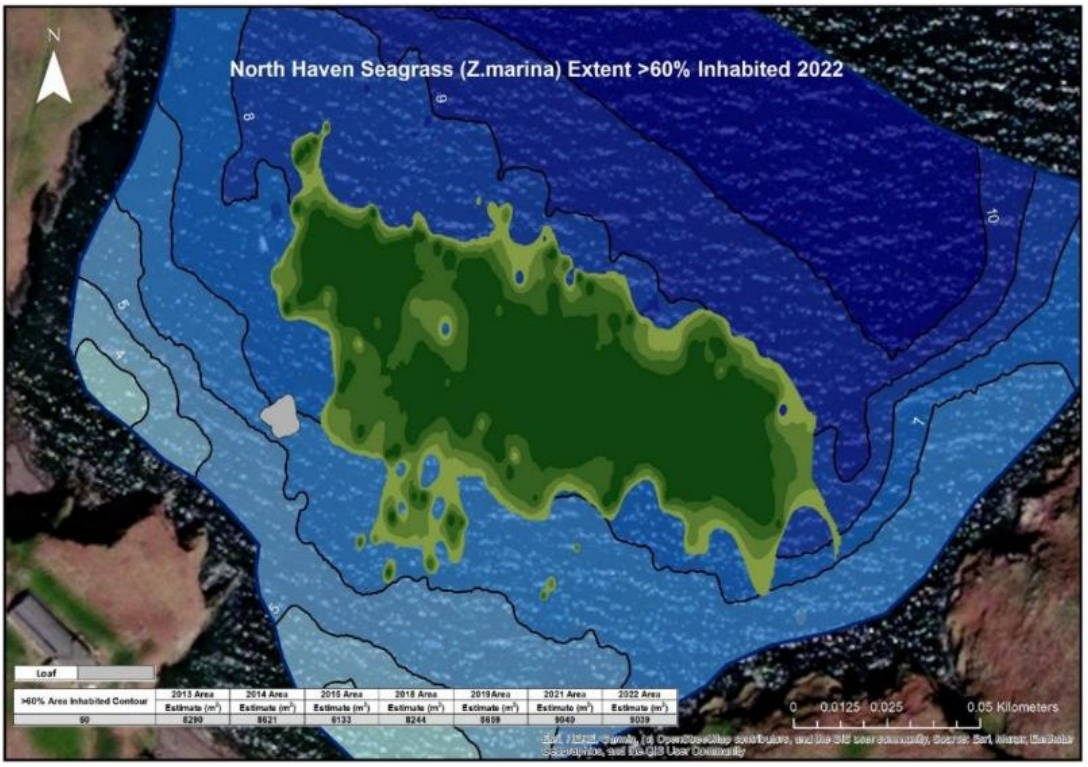
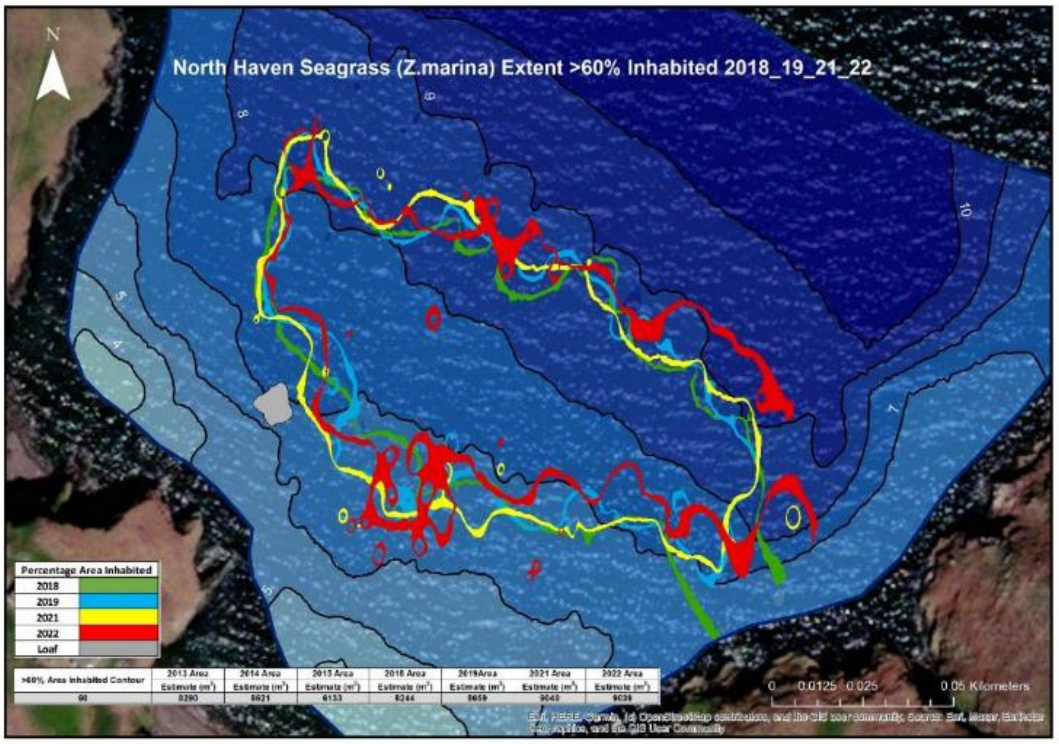


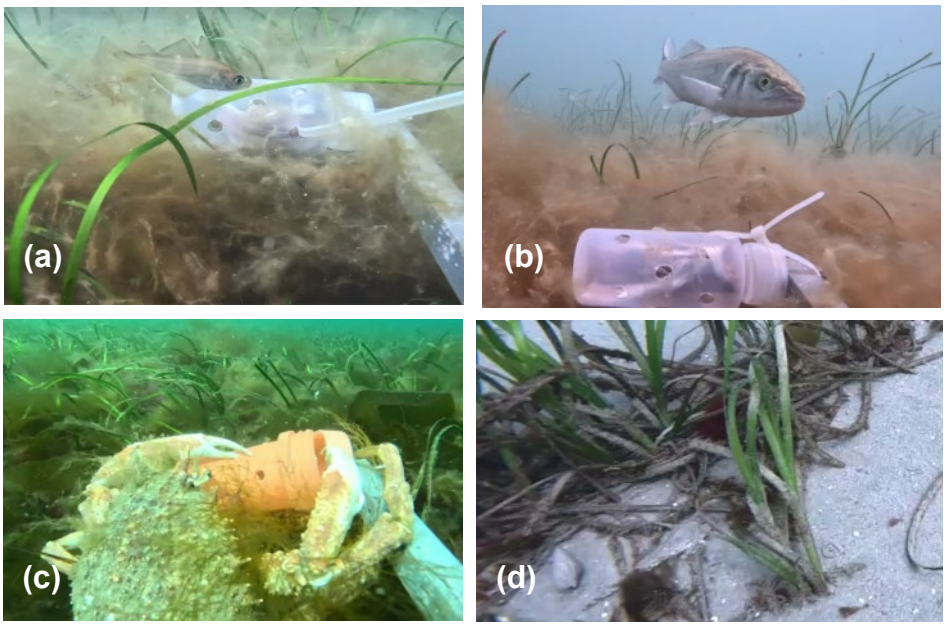
Figure 4.10.8. Biosonics plot of seagrass bed area extent (using 60% Area Inhabited contour values) for years 2018, 2019, 2021 & 2022.



Species survey results

In 2023 a baited remote underwater video system (BRUVS) was deployed on 17 occasions between April 2023 and January 2024 at locations across the North Haven seagrass bed. The analysis of video footage is ongoing, to date footage from 8 of the deployments has been reviewed. A selection of BRUVS video frame stills is shown in Figure 4.10.9.

Figure 4.10.9. A selection of species captured by the BRUVS: (a) bib; (b) sea bass; (c) spider crab (stealing the initial bait tube!) and (d) netted dog whelk



4.10.6. Supported research

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

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

4.10.7. Targets

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

The extent of the *Z. marina* bed:

Upper Specified limit: No limit set

Lower Specified limit: 6484.2 m^2 (from 1997 level)

In 2023 the extent is **8367.1 m^2** and is therefore in favourable condition.

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

Upper Specified limit: No limits set

Lower Specified limit: comparable mean density $^{>}/_{=}$ 35.1 shoots/ m^2 (from 2014 level)

In 2023 the comparable mean density is **75.7shoots /m^2** and is therefore in favourable condition.

4.10.8. Recommendations

- Report the conservation status of the *Zostera marina* feature as in favourable condition.
- Continue the 4 yearly *in situ* volunteer diver survey and maintain the continuity of data.
- Continue with an annual acoustic survey of the seagrass bed for area of extent and check the boundary areas of the bed with a drop-down video to confirm acoustic results.
- Continue with the BRUVS survey of the seagrass bed to provide monitoring of annual algal growth and presence of mobile fauna within the seagrass bed.
- Developing a project to monitor shoot density & length, plant health and surveillance of environmental factors would allow some conclusions to be drawn about changes in shoot density. Ideally this would be an annual survey.
- Start monitoring C: N, ^{15}N and C:P ratios along with measurements of leaf biometrics.
- Link in with other research and monitoring projects for seagrass around Wales and the UK (see Unsworth et al. 2014).

4.11 General Species Recording

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

4.11.1. Project Rationale

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

4.11.2. Crawfish

Crawfish *Palinurus elephas* (Figure) is an Environment Act (Wales) 2016, Section 7 species of principal importance. From 2009 to 2023 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 4.11.1 Crawfish, *Palinurus elephas*.

4.12.3. Sunfish

Sunfish *Mola mola* is the largest bony fish in the world; they are an ocean vagrant that can be found in both tropical and temperate waters. They feed mainly on jellyfish so are found often when there are jellyfish blooms around the coast. Sunfish are often recorded in the Skomer MCZ in low numbers from July to September when seawater temperatures are around 15ºC or warmer. Sunfish records are from both MCZ staff and from Dale Princess crew. Although they can grow up to 1000kg, those recorded are usually relatively small

individuals. In some years several individuals have been spotted whilst in other years there have been no records. In 2023, there was 1 record in July.

4.11.4. Non-native species

In 2023 careful searches for non-native species were completed at each of the shores during the MarClim surveys:

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. It has not been recorded since 2018.

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 2023.

4.11.5. 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.

4.12. Plankton Recording

4.12.1 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.

4.12.2. Objectives

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

4.12.3. Sites

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

4.12.4. Method

Zooplankton

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

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

2023 – 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).

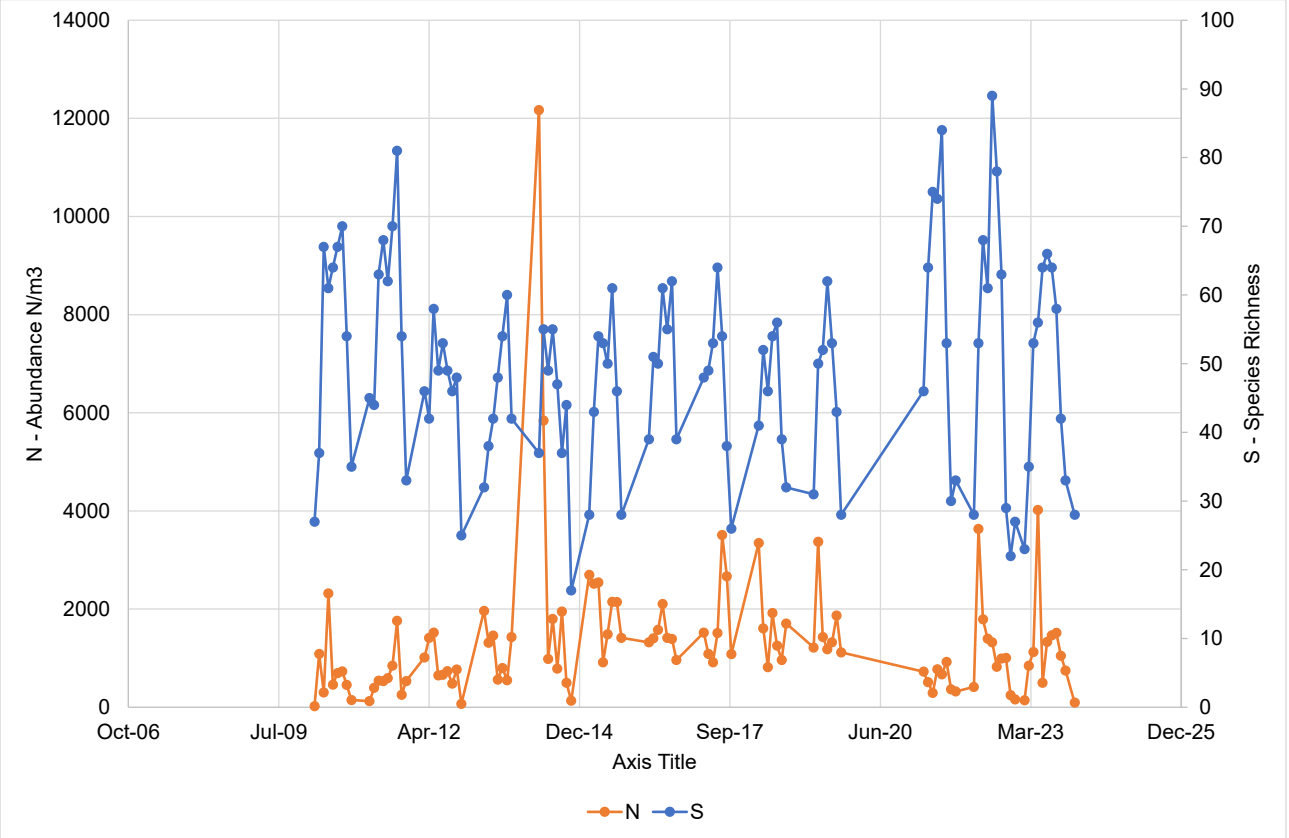
- 2010, 2011 & 2012 - Samples were collected from March to November, these were analysed by the Plymouth Marine Laboratory, (no report: raw data provided).
- 2013–onwards – Zooplankton samples were sent to Dr D. Conway (Plymouth Marine Biological Association) for identification and enumeration, (no report: 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.

4.12.5. Results

Zooplankton

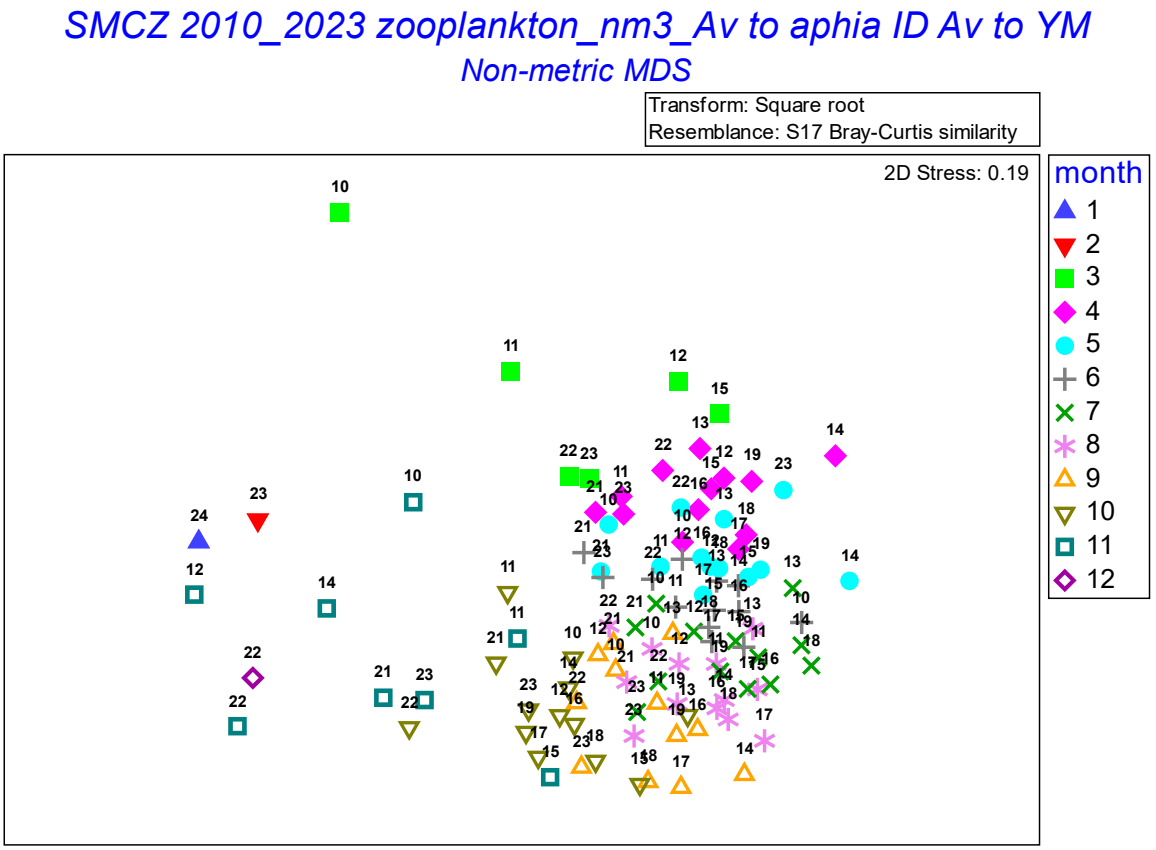
Figure 4.12.1 Average plankton species richness (S) and total number of individuals / abundance (N) 2010- 2023.



The peak in abundance in April 2014 was due to huge numbers of barnacle larvae in the plankton (Figure 4.12.1).

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 4.12.2).

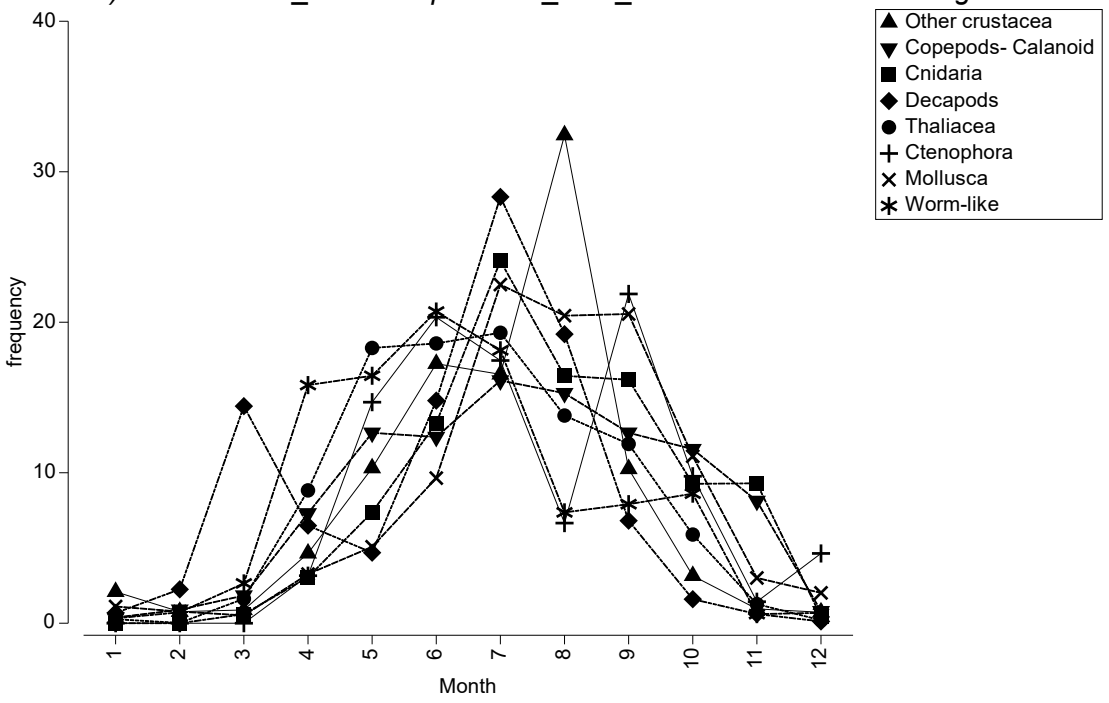
Figure 4.12.2 MDS plot of zooplankton community showing seasonal changes (symbols representing months and labelled with year).



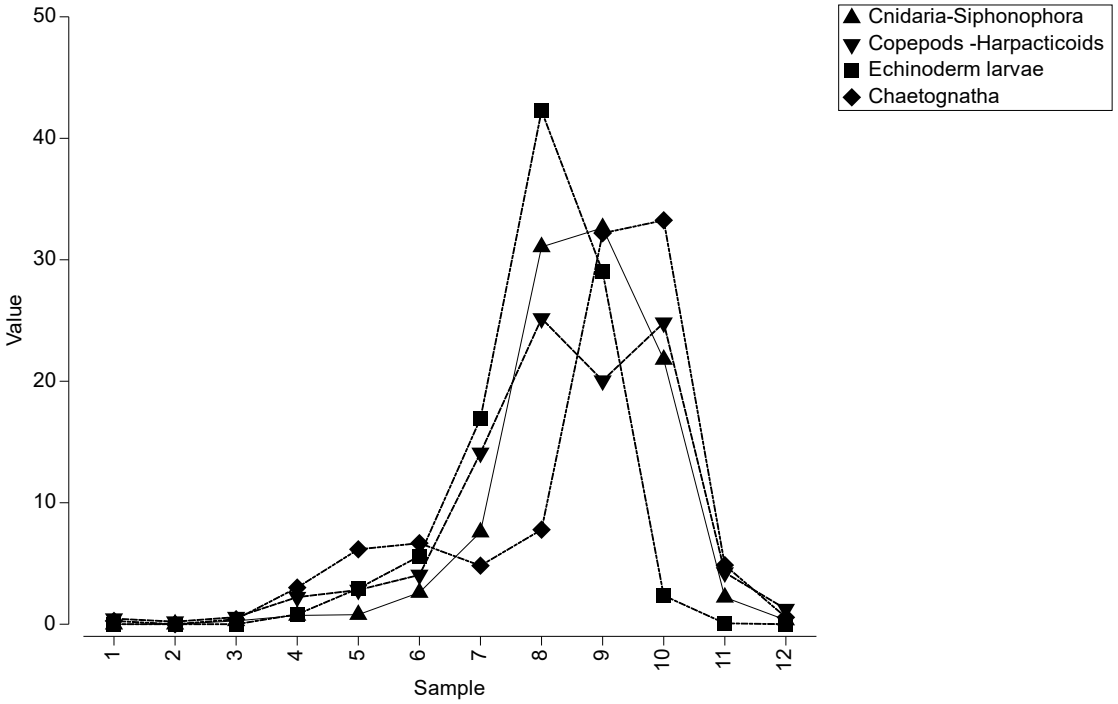
Statistical analysis of the dataset shows a strong seasonal pattern with months grouping together. However, these groups are in lines, which does suggest inter-annual variability. This seasonal pattern is driven by different groups of taxa appearing in the plankton at different times. Figure 4.12.3 shows how selected groups have different seasonal patterns. Cirripedia (e.g. barnacle larvae) are most abundant early in the year while echinoderm larvae are abundant later in the year.

Figure 4.12.3 Seasonal abundance patterns for the major groups of zooplankton taxa averaged from data collected between 2010 - 2023 with 4 obvious patterns; a)– Taxa with a broad seasonal distribution with peak abundance in Jul-Aug, b)- taxa with an Autumn peak, c)- taxa with a spring peak & d)- taxa with twin peaks of abundance.

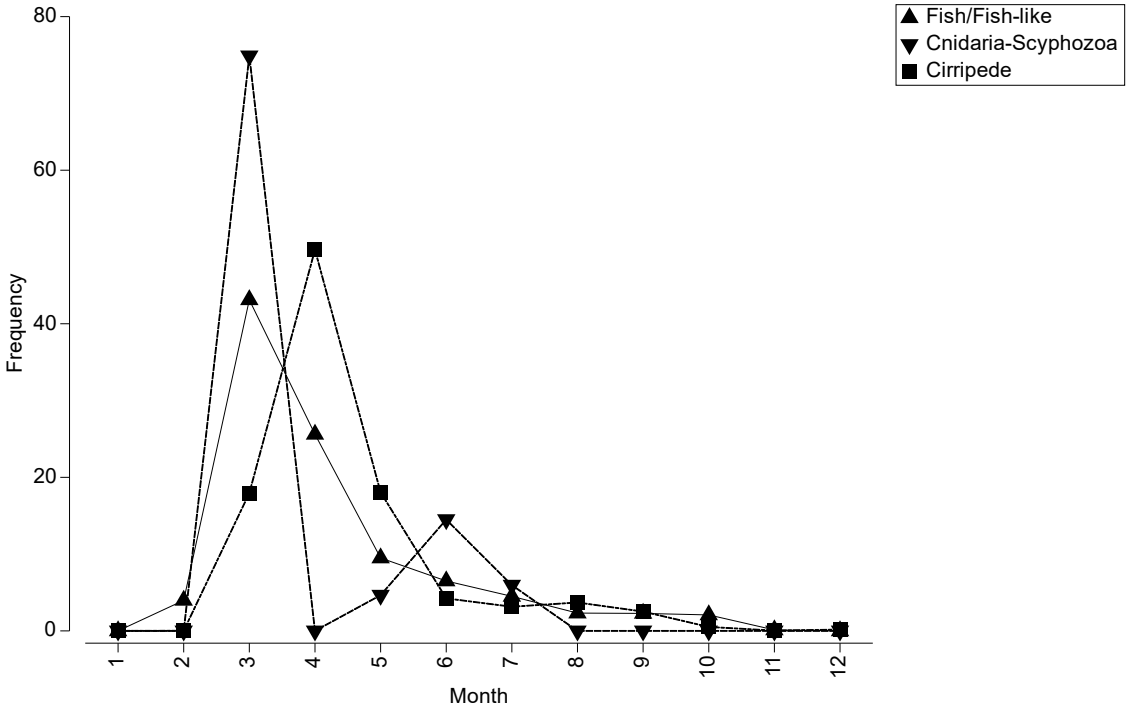
a) -SMCZ 2010_2023 zooplankton_nm3_Av Month seasonal changes.



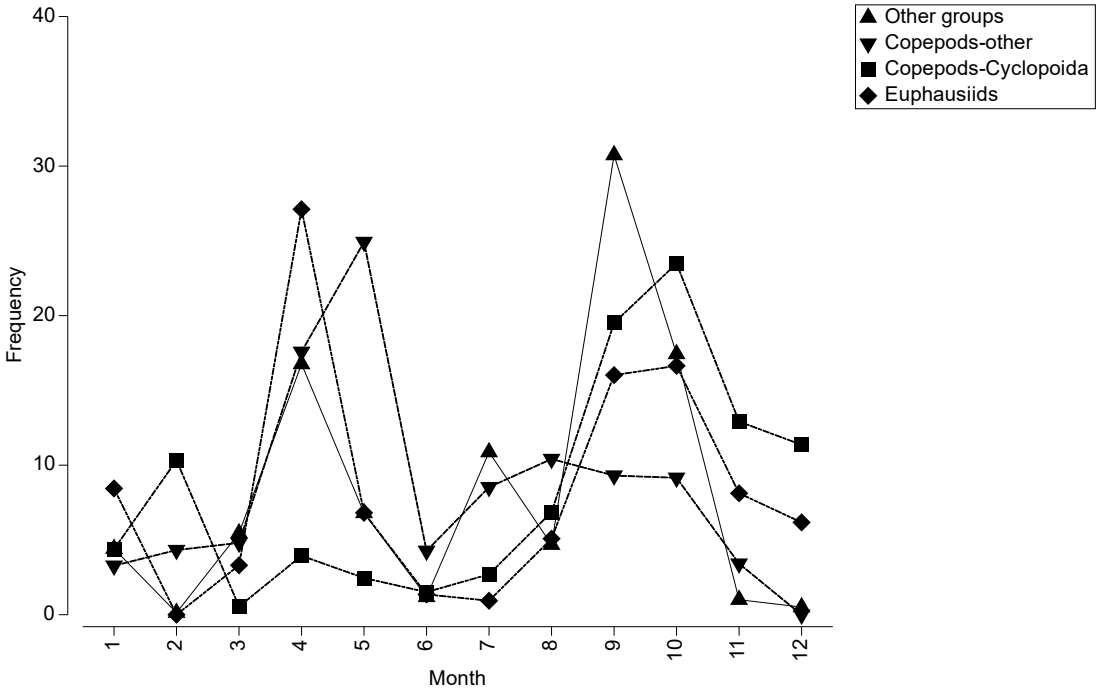
b) - SMCZ 2010_2023 zooplankton_nm3_Av Month seasonal changes.



c) - SMCZ 2010_2023 zooplankton_nm3_Av Month Seasonal changes.



d) - SMCZ 2010_2023 zooplankton_nm3_Av Month Group

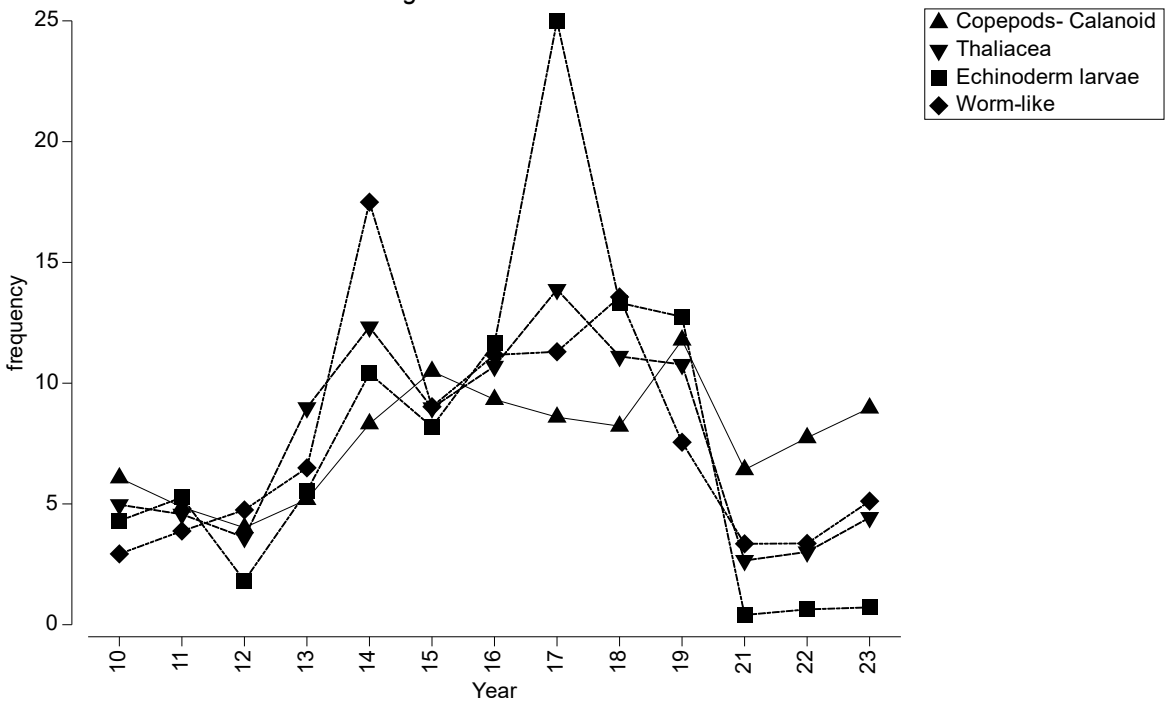


Annual variation in abundances of major groups are plotted in Figure 4.12.4. In general abundances are lower in 2021 for all groups except decapods. 2022 was also a low abundance year but did show some increases. In general 2023 saw an increase in abundance.

Figure 4.12.4 Coherence plots for the major taxonomic groups making up the zooplankton community at Skomer MCZ 2010 – 2023; a & b- taxa with a notably drop in abundance in 2021, c - taxa with consistent abundance over time & d – *Ciripedia* & *Cladoceria*.

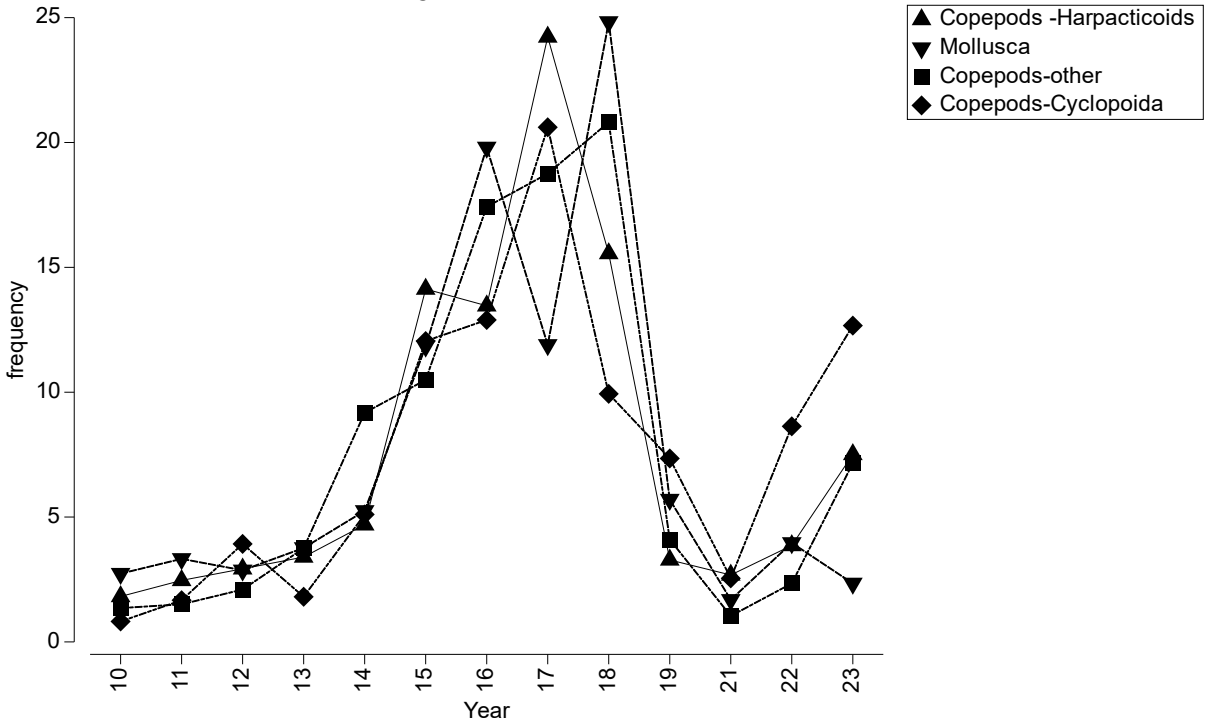
a)- SMCZ 2010_2023 zooplankton_nm3 averaged to year.

Changes in relative abundnace over time.



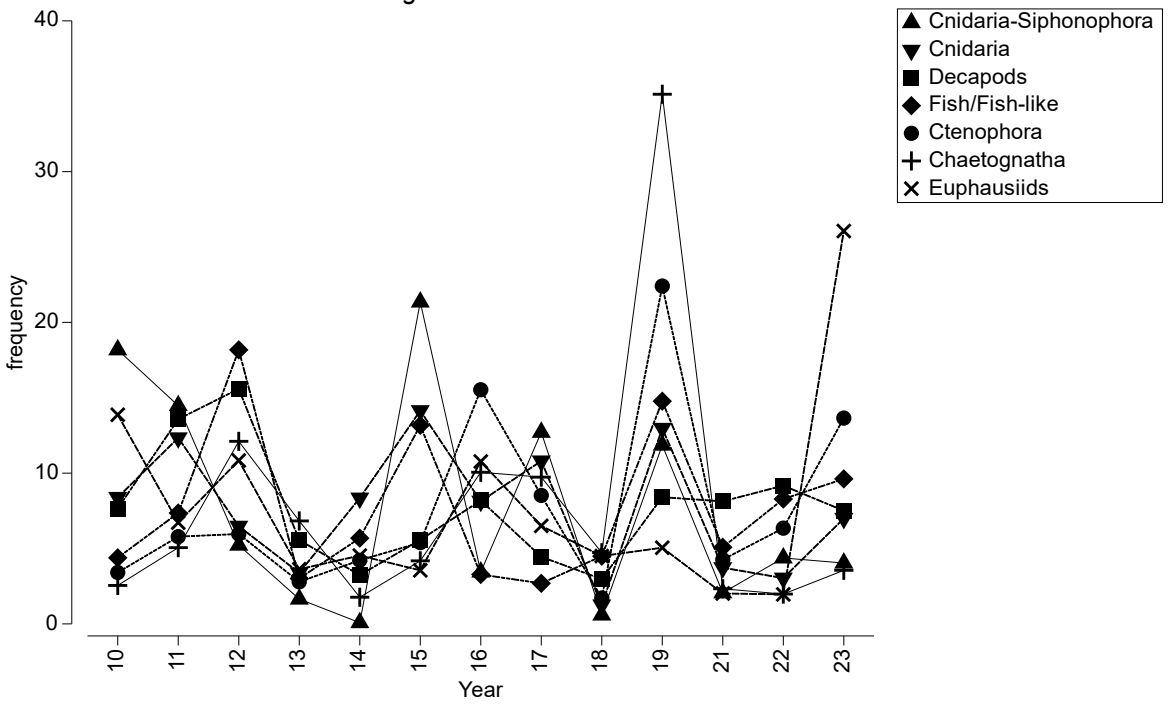
b)- SMCZ 2010_2023 zooplankton_nm3_averaged to year.

Changes in relative abundance over time.



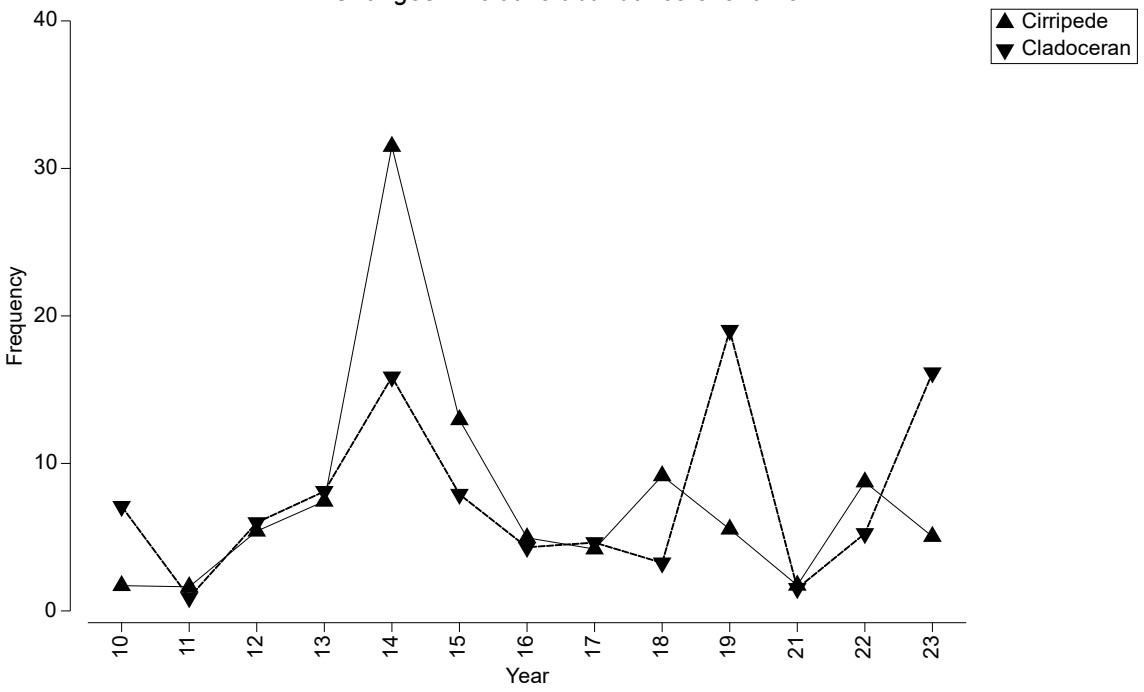
c)- SMCZ 2010_2023 zooplankton_nm3_averaged to year.

Changes in relative abundnace over time.



d)- SMCZ 2010_2023 zooplankton_nm3_averaged to year.

Changes in relative abundance over time.



These plots do highlight how variable the species 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.

4.12.7 Current status

- A 10+ year timeseries of zooplankton has been collected. These data are comparable with other sites in the UK (e.g. 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”.

4.12.8. Recommendations

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

5. 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

- Old Coastguard station, Wooltack Point, Martins Haven.

  Grid Ref: SM 7588 0922 (L 51º 44' 78'N 005 º 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 replaced with a new probe in Nov 2021.

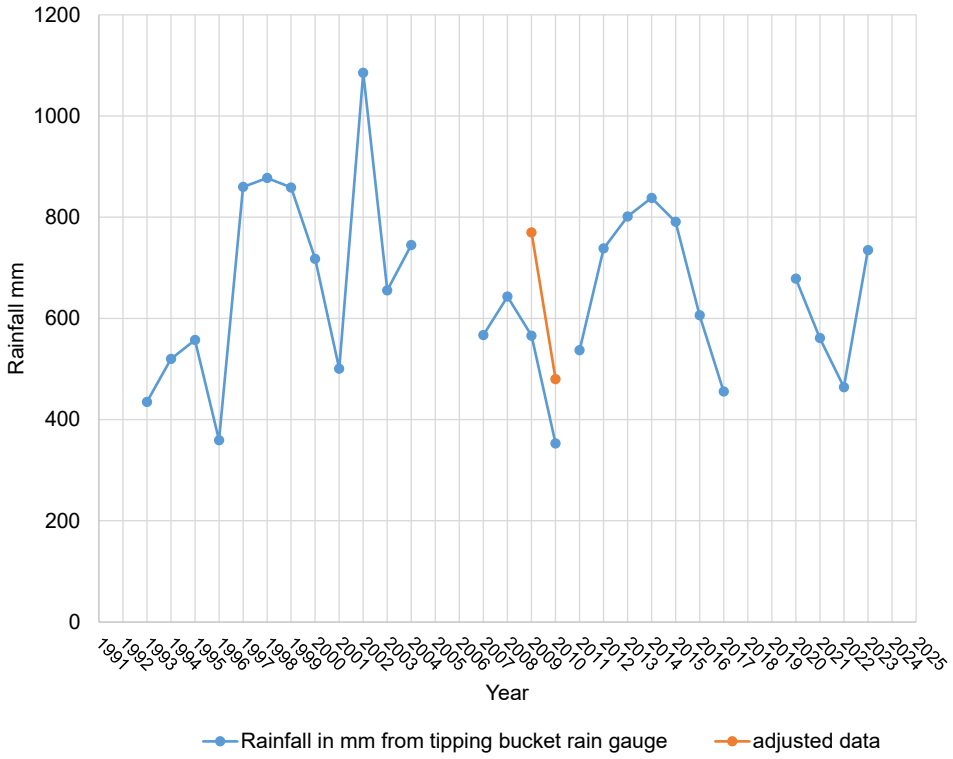
In 2022 the only malfunction on the weather station was seized bearings on the anemometer in February, about 4 days of wind strength records were lost before the bearings were replaced.

In 2023 (06th Apr 2023) a new wind recording system was installed which use sound (Wind Sonic) to measure wind and removes the need for bearings. Both systems are currently running alongside each other so we can compare the readings.

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 (**Error! Reference source not found.**Figure 5.1.1 Skomer MCZ automatic weather station total rainfall (mm) data (incomplete data for 2018 & 2023).



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 5.1.2).

Figure 6 Skomer MCZ automatic weather station, radar plot average wind direction and strength 1993 – 2023.

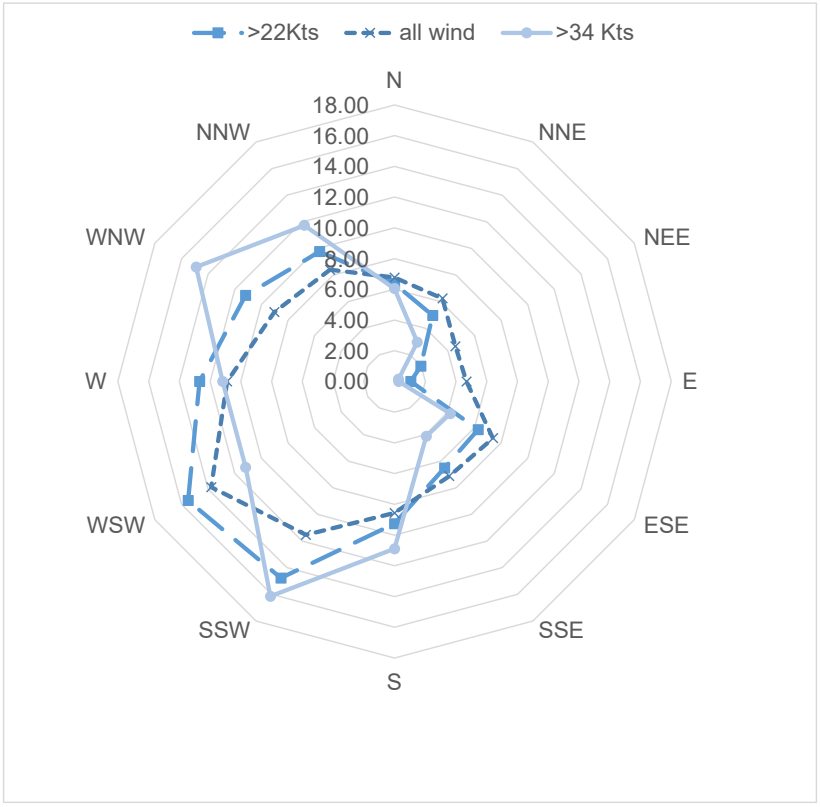
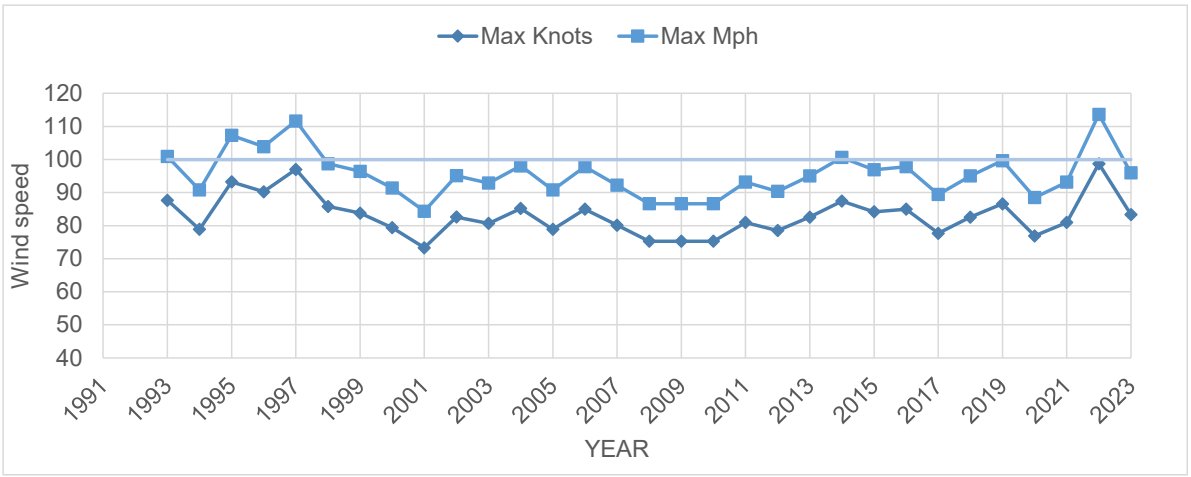


Figure 5.1.3 Skomer MCZ automatic weather station data, maximum wind strength (knots) 1993 – 2023.



The maximum gust recorded for 2008, 2009 and 2010 was exactly the same (86.6 mph) (Figure 5.1.3). 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). 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 (in Dec 1999: 85% was greater than 22 knots) but it is very variable from year to year. Fig 5.1.4 compares 2023 with the overall average wind >22knots for each month of the year. In 2023 February and June had very little wind >22 knots but November and December had more than average stronger winds.

Figure 7 Skomer MCZ automatic weather station data – percentage of wind greater than 22 knots for each month. All years averaged and 2023 data.

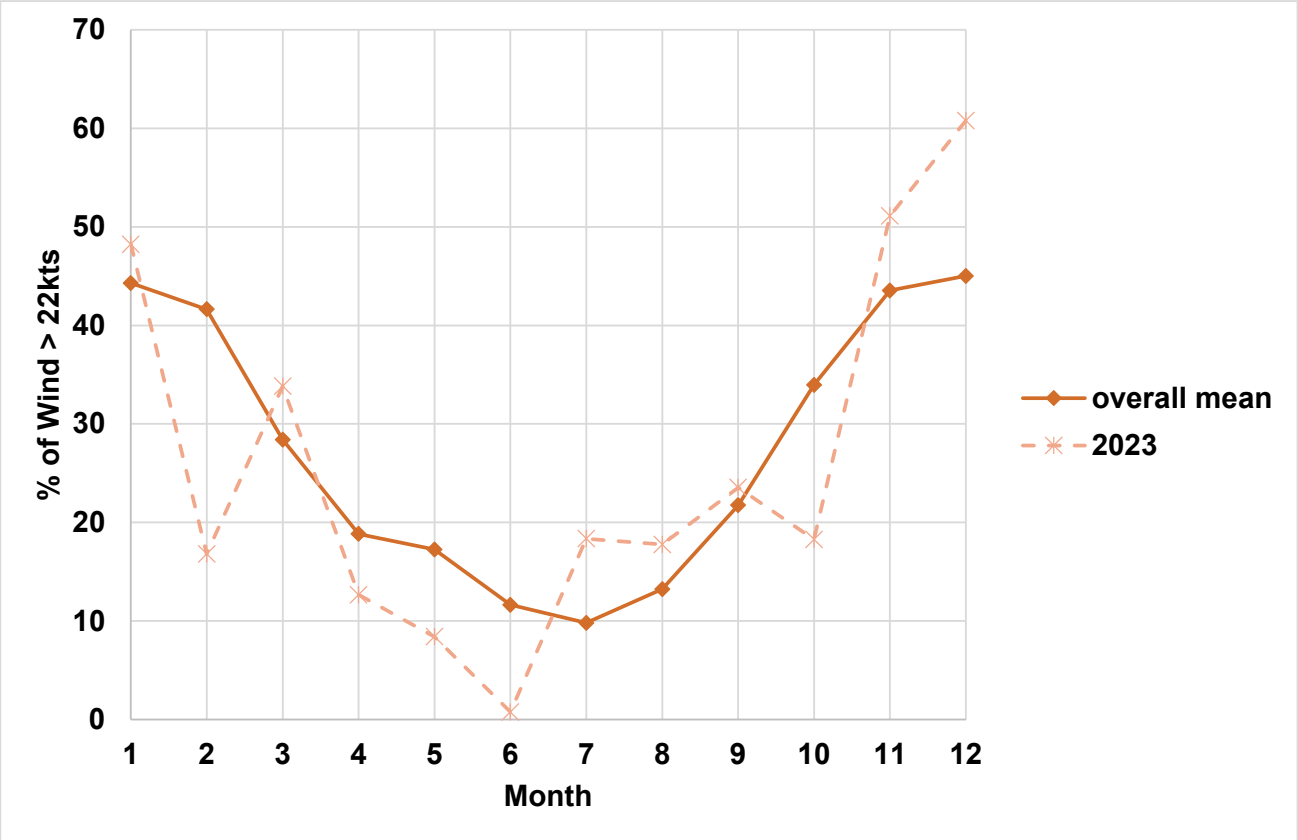
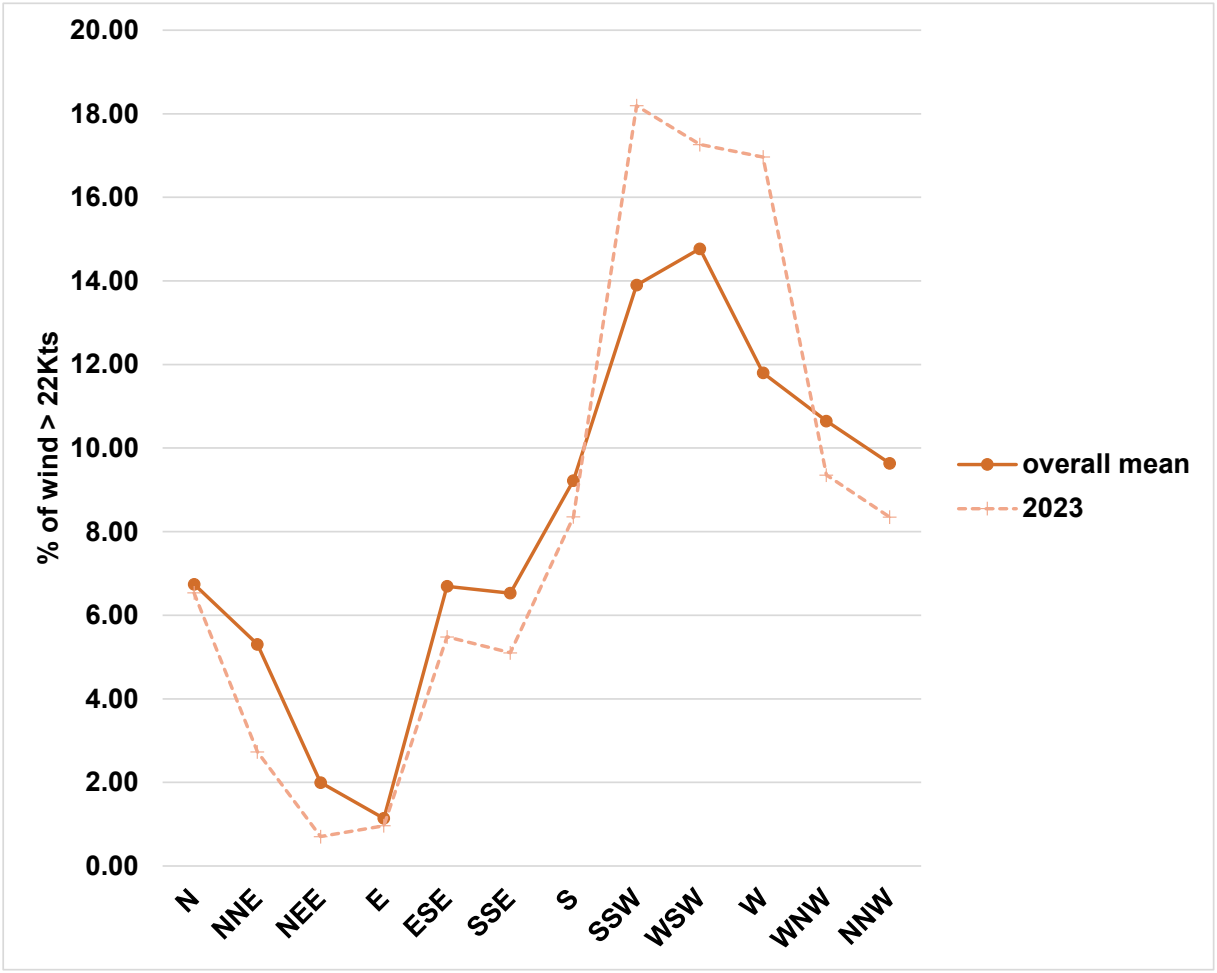


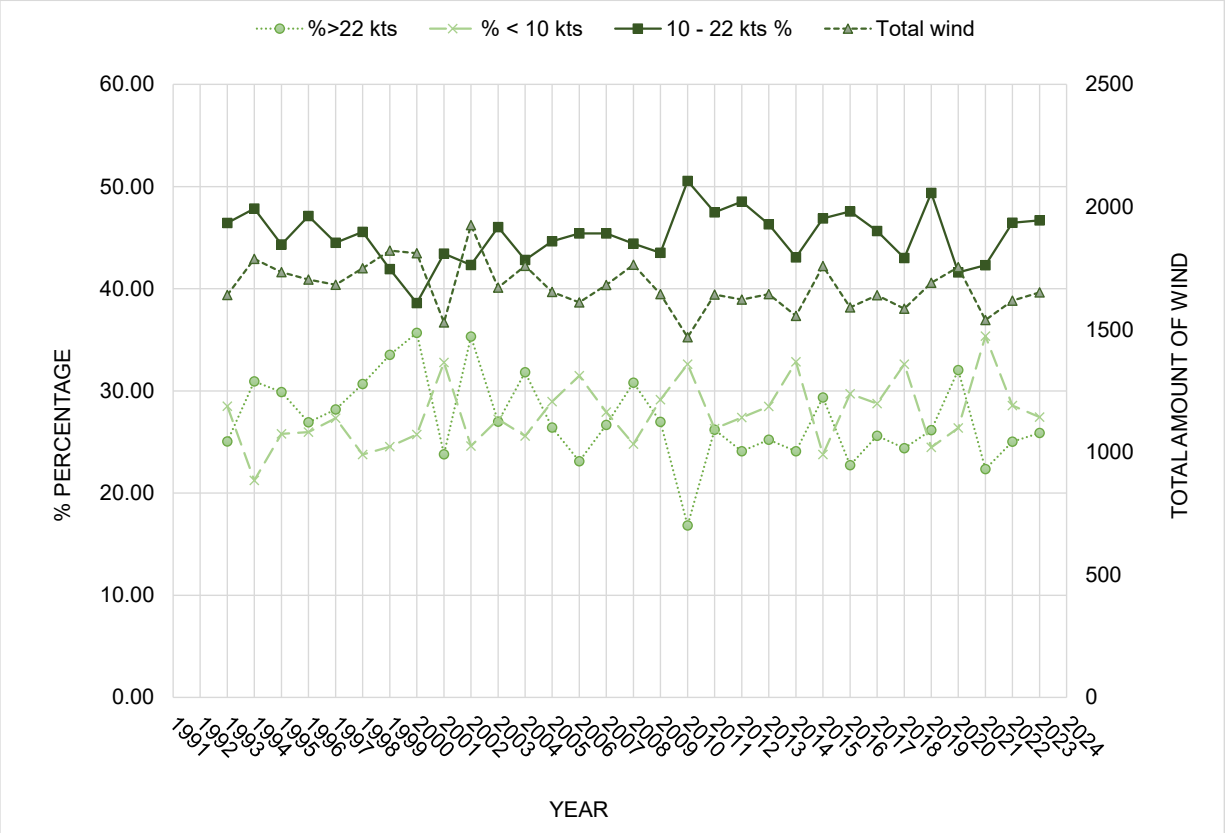
Figure 5.1.5 Skomer MCZ automatic weather station data – percentage of wind over 22 knots from each wind direction.



2023 follows a similar pattern of wind distribution to the overall mean. There was more wind recorded from the S - W than is usually seen (Figure 5.1.5). Most of the stronger winds come from the SSW, WSW & W. 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 5.1.6).

Figure 5.1.6 Skomer MCZ automatic weather station data – “total annual wind” 1993 to 2023.



The 2023 annual meteorological summary from the Skomer MCZ automatic weather station is shown in Table . More detailed data is available.

Monthly average air temperature, relative humidity and solar radiation results are summarised in Figure 8 to Figure 5.1.10.

Table 5.1.1 Skomer MCZ automatic weather station – 2023 annual meteorological summary.

Natural Resources Wales - Skomer Marine Conservation Zone					YEAR	SUMMARY		2023					
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	8.1	8.1	7.7	9.2	11.9	15.5	15.4	15.8	16.6	13.3	10.3	9.9
T107_1 0c	MAX	12.0	11.2	11.2	15.3	16.3	22.8	21.5	20.4	25.9	17.4	14.5	12.6
	MIN	0.5	2.4	0.2	3.0	7.6	9.0	12.6	12.2	11.2	6.0	0.8	0.6
BAROMETRIC PRESSU	MEAN	1006.9	1021.5	999.2	1004.9	1011.6	1006.6	998.4	1002.0	1001.5	994.2	992.8	998.1
	MAX	1033.0	1040.0	1028.0	1023.0	1024.0	1019.0	1014.0	1016.0	1021.0	1021.0	1025.0	1031.0
	MIN	977.0	1003.0	973.0	967.0	989.0	990.0	982.0	969.0	978.0	960.0	944.0	966.0
RELATIVE HUMIDITY	MEAN	83.6	85.1	87.9	85.0	87.3	86.1	87.7	90.2	87.8	88.7	82.9	86.8
	MAX	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	MIN	54.0	50.4	53.7	43.8	55.0	36.7	52.9	67.9	58.3	58.2	57.2	55.0
RAINFALL	TOTAL(mm)	37.4	8.1	78.7	49.3	25.6	29.4	67.7	53.9	60.3	151.5	52.9	120.2
SUNSHINE	MEAN(kw/m2)	0.0	0.1	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0
	sunshine hours	101.0	155.0	204.0	294.0	373.0	383.0	333.0	320.0	239.0	153.0	114.0	53.0
	Sunshine hrs (10min)	97.2	152.5	193.0	288.3	371.3	377.8	328.0	314.5	237.5	150.5	111.7	49.8
NET RADIATION	MEAN	-16.5	1.8	27.8	60.6	112.1	113.5	113.9	85.0	43.0	8.2	-10.5	-14.6
MAX GUST	m/s	38.3	22.9	31.7	42.9	22.5	19.6	25.4	32.92	33.33	26.7	34.2	36.3
	direction	248.7	267.5	261.9	293.0	111.6	256.9	258.2	163.6	174.9	171.6	327.6	211.9
	Knots	74.5	44.5	61.5	83.4	43.7	38.0	49.4	64.0	64.7	51.8	66.4	70.4
	Days > F7 MEAN	1	0	1	1	0	0	0	0	0	0	0	4
	Days > F7 Gust	23	14	21	7	5	1	20	13	15	17	25	27
	days max hr av>F7	12	0	7	2	0	0	2	3	4	3	11	14
Notes													
Campbell scientific service - 09 Feb 2023		No data from 08:30 - 12:30 - data removed											
		Recommended change of wind vane - booked for 06th apr											
		Rain gauge was full of dead flies - needs cleaning on more regular basis											
Campbell scientific installation of wind sonic sensor - 06 Apr 2023													
Old wind vane and anenometer left in situ and recording													

Figure 8 Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2023 with monthly min / max error bars.

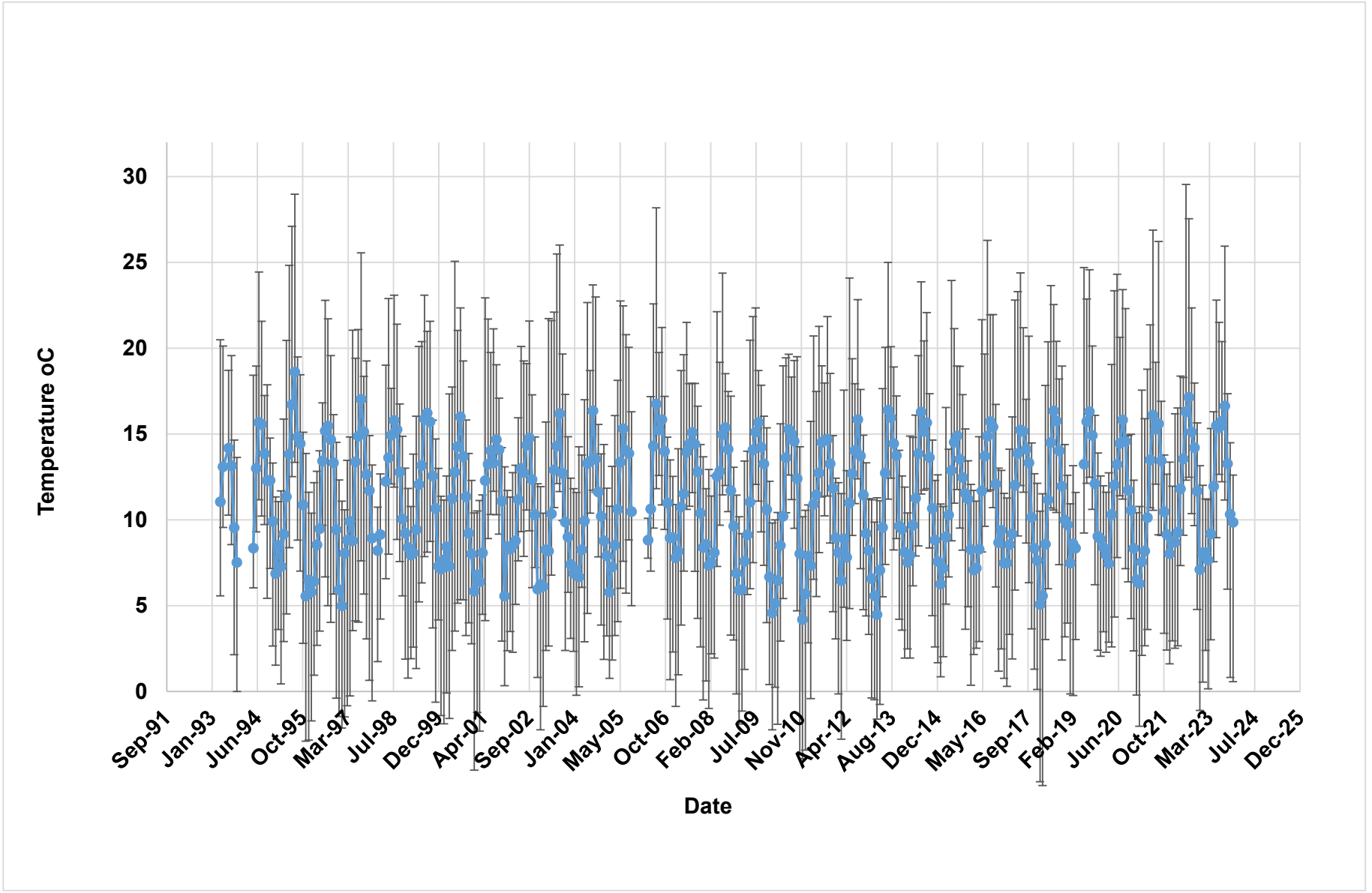


Figure 5.1.8 Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (°C) 2006 – 2023.

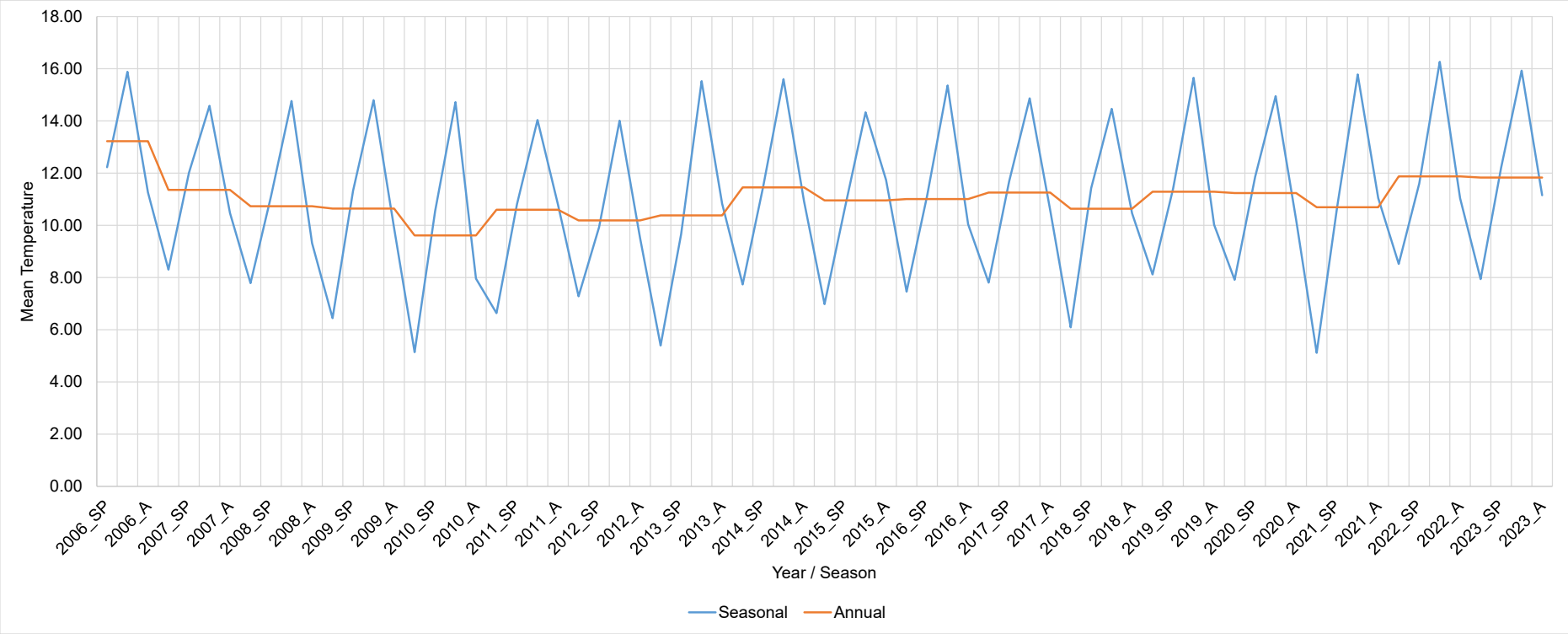
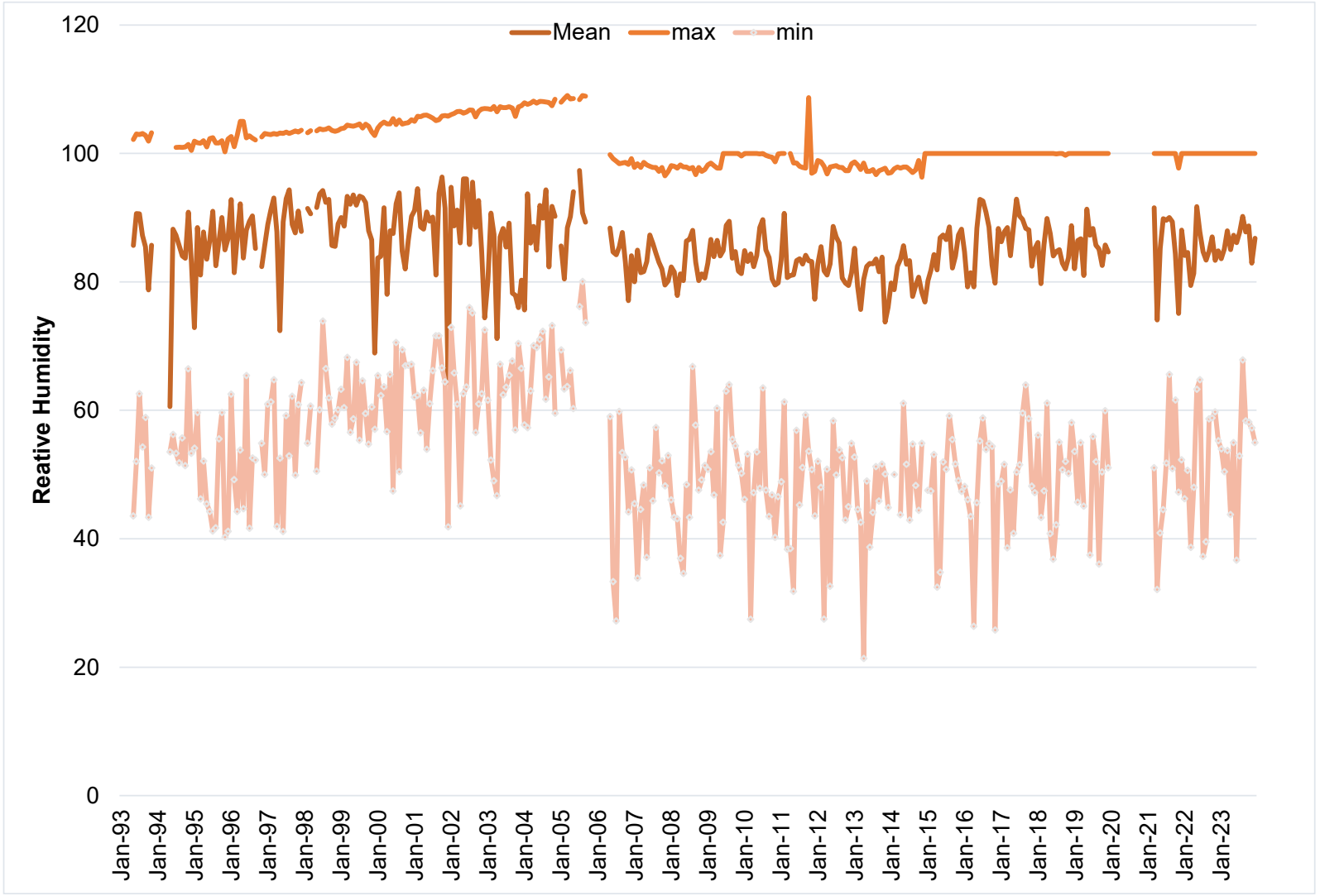
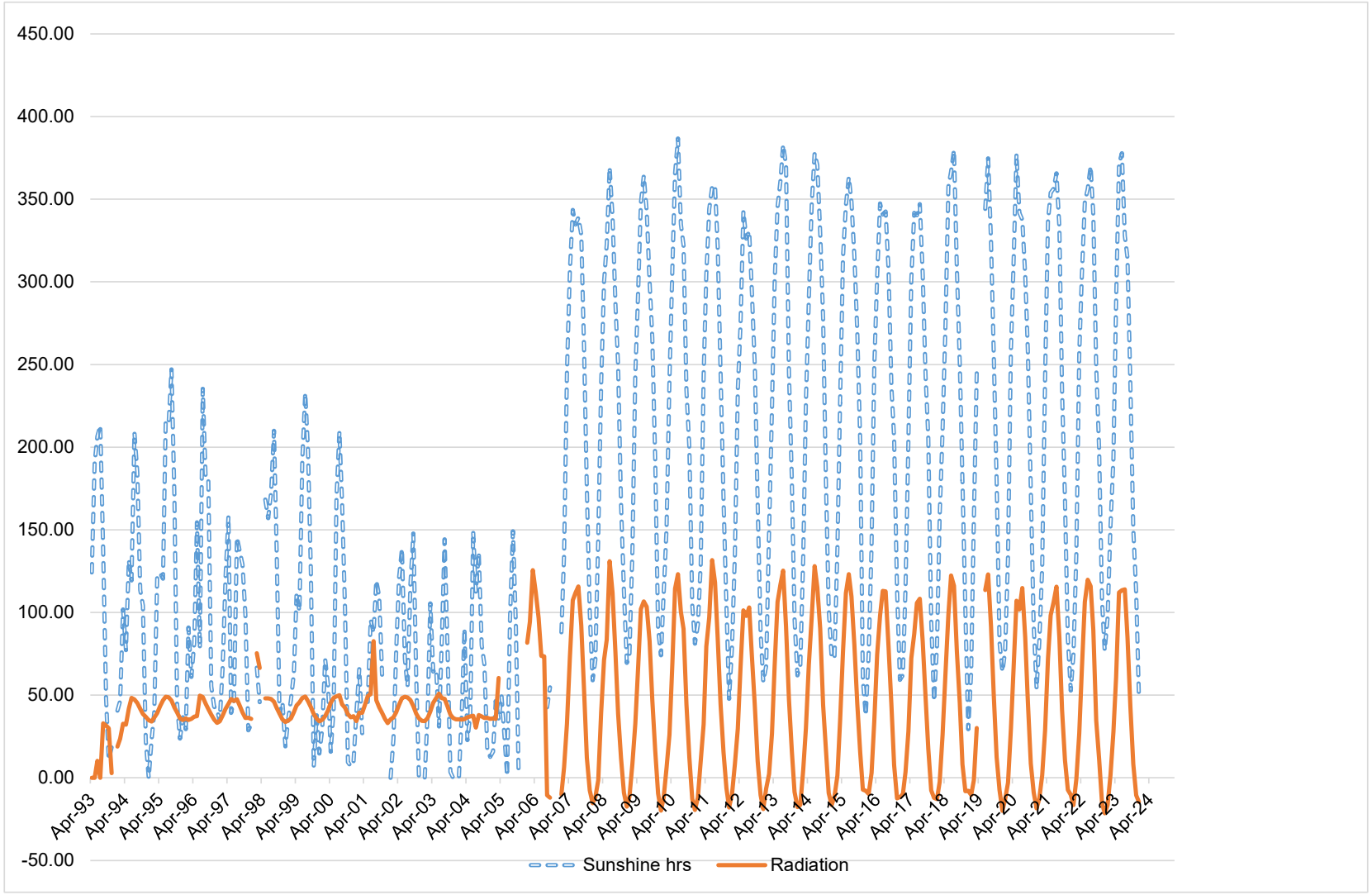


Figure 5.1.9 Skomer MCZ automatic weather station – relative humidity 1993 – 2023.



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 5.1.10 Skomer MCZ automatic weather station – solar radiation (W/m^2) and sunshine hours 1993 – 2023.



There was an obvious change in the data when the weather station equipment was changed in 2006. This is 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 (Table 5.1.1). 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 5.2.1 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
2023	Feb - Nov

Vemco minilog seabed temperature logger deployment:

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

5.2.6. Results

Oceanographic monitoring site

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. 2023 saw another very mild winter 8.7°C and had the highest recorded summer temperature of 17.5 °C (**Error! Not a valid bookmark self-reference.** 5.2.2).

Table 5.2.2 Skomer MCZ maximum and minimum annual seabed temperatures 2000 to 2023 (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. 7
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	16.8
2014	8.14	16.7
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	17.1
2023	8.7	17.5

A summary of the seabed temperature (data from Vemco minilog at 19 m BCD) is shown in Figure 5.2.1. Monthly means have been calculated from seabed temperature but substituted with the CTD probe seabed temperature data where logger data were absent.

Figure 9 Skomer MCZ summary of monthly mean seabed temperature 1992 – 2023.

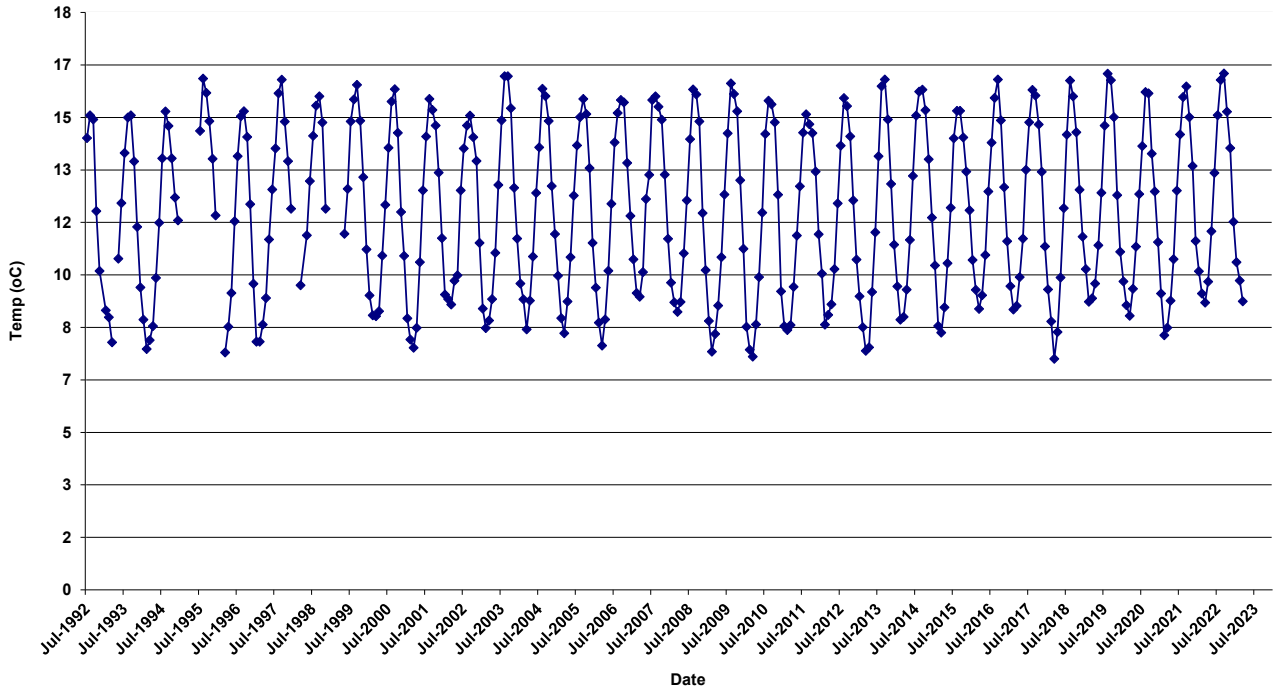
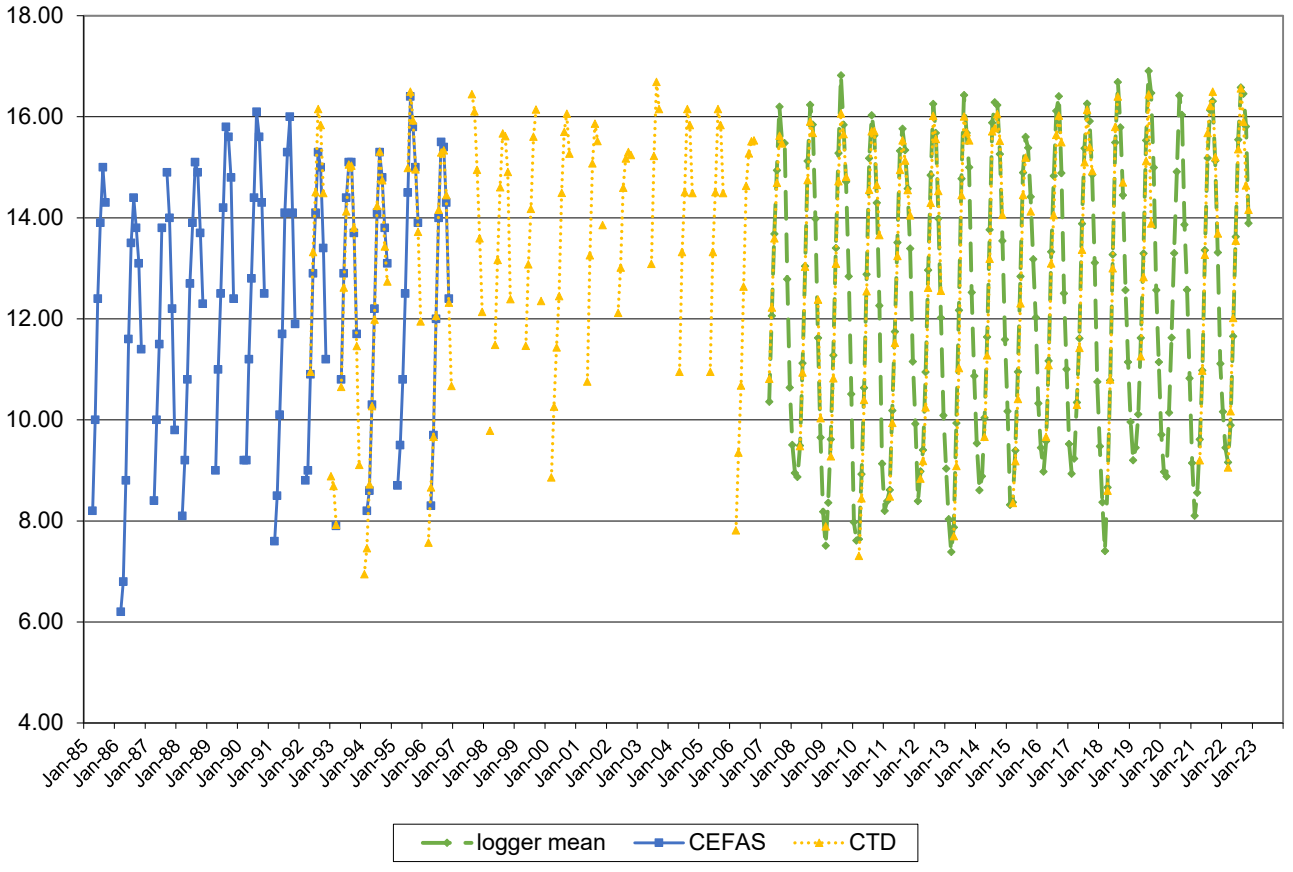


Figure 5.2.2 Skomer MCZ summary of monthly mean sea surface temperature (°C) 1985 – 2023.



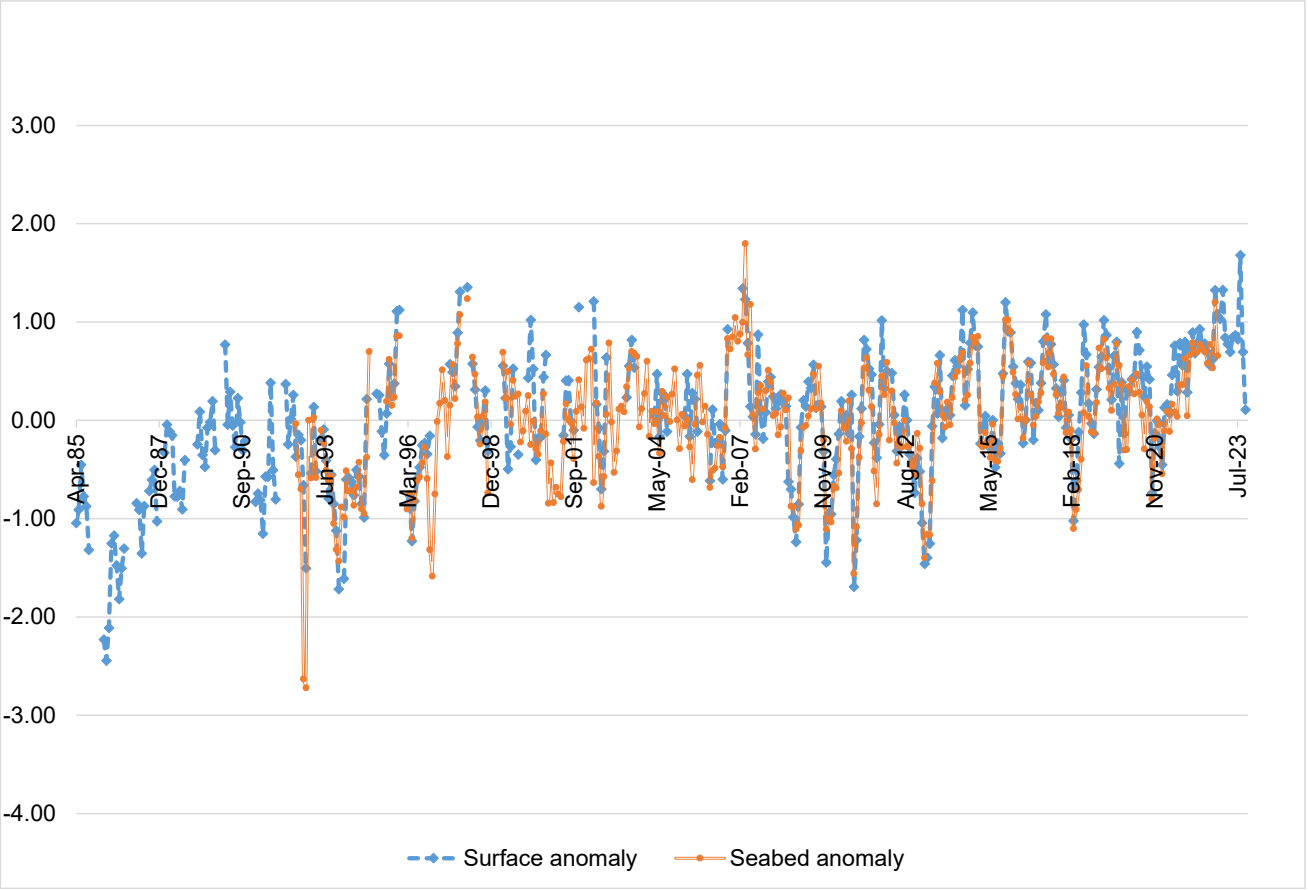
A summary of the sea surface temperature is shown in Figure 5.2.2. This is made up of:

- CEFAS data taken from North Haven, Skomer at high tide and only recorded when the Skomer warden was on site;
- Skomer MCZ drop down CTD probe data from a depth profile at intervals: 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 5.2.3).

Figure 10 Skomer MCZ sea temperatures – monthly anomaly between the specific monthly mean and the grand monthly mean, surface and seabed anomalies (April 1985 – July 2023).

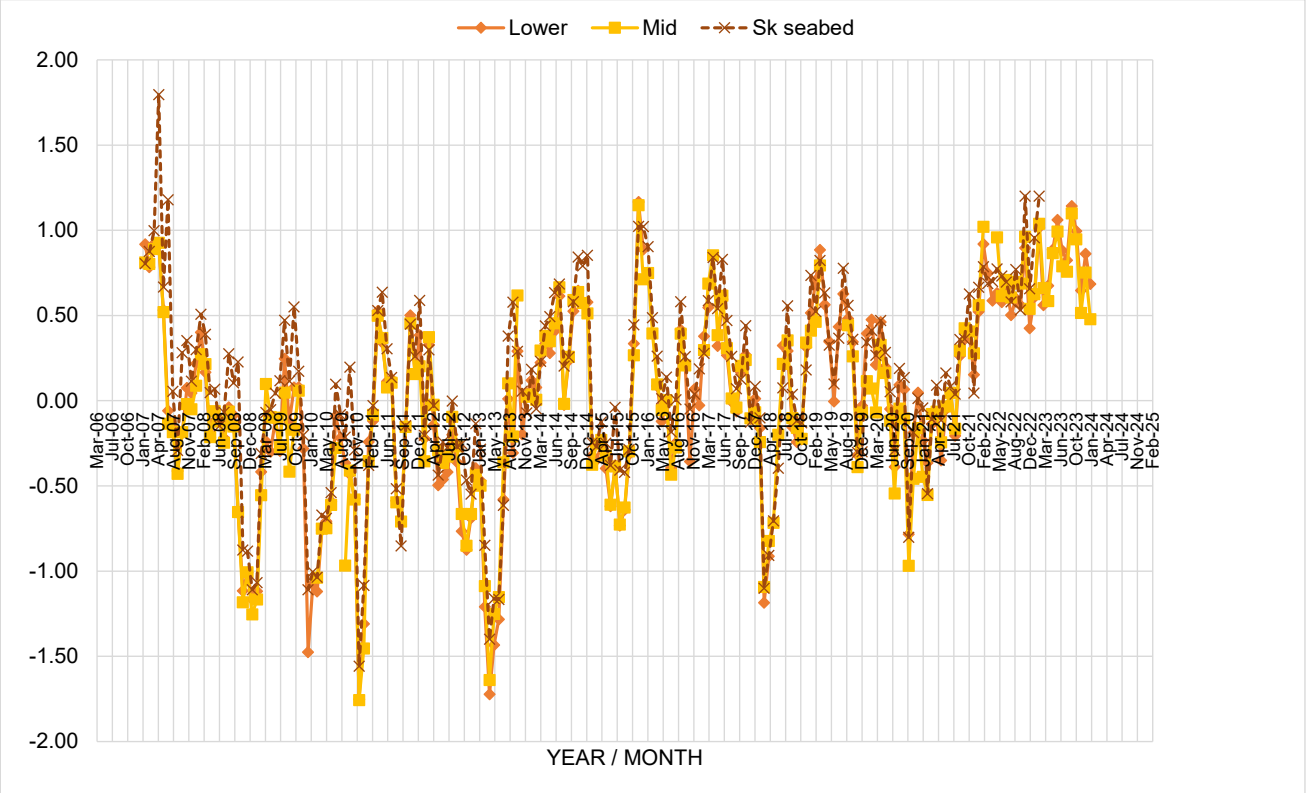


Sea temperatures prior to 1995 were generally colder than average. From 1995 to 2006 there was a warmer period, but from 2006 onwards the data have been very erratic with some very cold winter temperatures but some warm summer temperatures. 2022 and 2023 recorded above average sea temperatures.

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 (**Error! Reference source not found.**). The data from the intertidal loggers follow a very similar trend to the logger recording on the seabed at Skomer.

Figure 5.2.4 Martins Haven intertidal temperature loggers - monthly anomaly between the specific monthly mean and the grand monthly mean, Lower shore, middle shore and seabed anomalies (2007 – 2023).



This data is a subset of the temperature logger data taken when the logger is immersed in water. 2022 and 2023 temperatures have been consistently higher than average.

5.2.7. Current Status

There does not appear to be any long-term trend in sea water temperatures but the last 2 years (2022 & 2023) have been consistently warmer than average (see figs 5.2.3 & 5.2.4.) and the highest ever Skomer sea bed temperature was recorded in 2023 since records began in 1985.

5.2.8. Recommendations

- Continue dataset to form a long-term record of variation in seabed temperature at Skomer MCZ.
- Keep the dataset as complete as possible. An additional logger running at the same time would add redundancy into the methods should the equipment fail or get lost.

5.3. Seawater Turbidity / Suspended Particulates and Seabed Sedimentation

5.3.1. Project Rationale

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

Historically, at Skomer, high deposition levels of fine sediments have been observed to partially or completely bury certain sessile life forms, preventing them from feeding and, in the longer term, killing them.

5.3.2. Objectives

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

5.3.3. Sites

- Oceanographic Monitoring Site (OMS): (51.73913 -5.26976) north side of Skomer (1992)
- Thorn Rock (TRK): (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 (Table 5.3.1). 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 3 Skomer MCZ sediment trap sampling effort from 1994 to 2023 at OMS and Thorn rock (TRK).

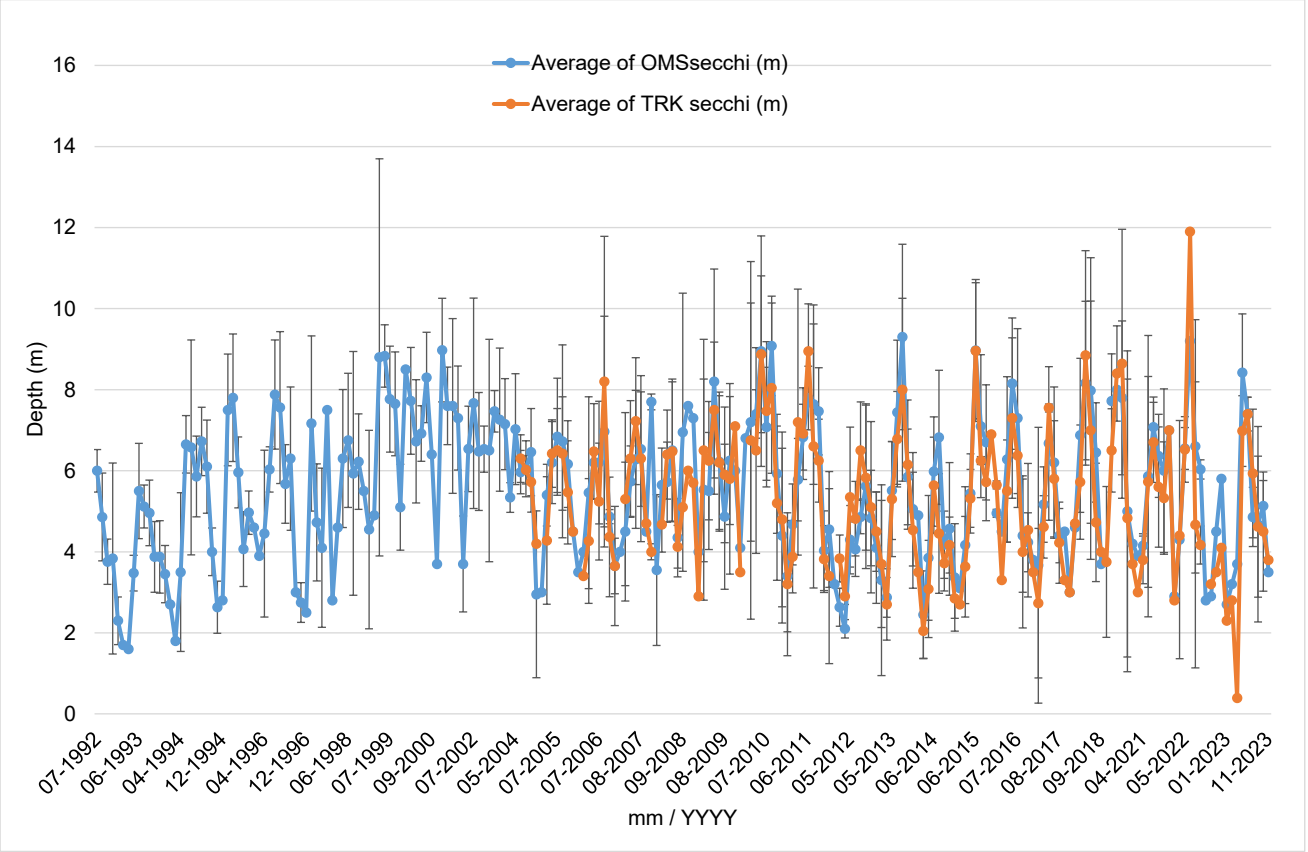
Year	Months with samples	Sites	Notes
1994	Jul – Dec	OMS & TRK	None
1995	Jan – Dec	OMS & TRK	None
1996	Feb – Dec	OMS & TRK	None
1997	Mar – Dec	OMS & TRK	None
1998	Mar – Sep	OMS & TRK	None
1999- 2001	No samples	None	Re-established 02 Nov 2001
2002	Mar – Nov	OMS & TRK	TRK site damaged
2003	May – Sep	OMS 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
2023	Apr - Oct	OMS & TRK	None

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 5.3.2.

Figure 5.3.2 Skomer MCZ summary of monthly mean Secchi disc data (m) 1992 – 2023 with standard error bars.



TRK and OMS follow a very similar trend over time suggesting that the waters on the north and south side of the island are well mixed. This rather dynamic picture can be simplified by calculating the mean Secchi disk value for each year as shown in Figure 5.3.3 a & b.

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 since then there has been a drop in water clarity at both sites continuing in 2023.

Figure 5.3.3 (a) Skomer MCZ summary of annual mean Secchi disc data (m) for OMS site with standard error bars 1992 - 2023.

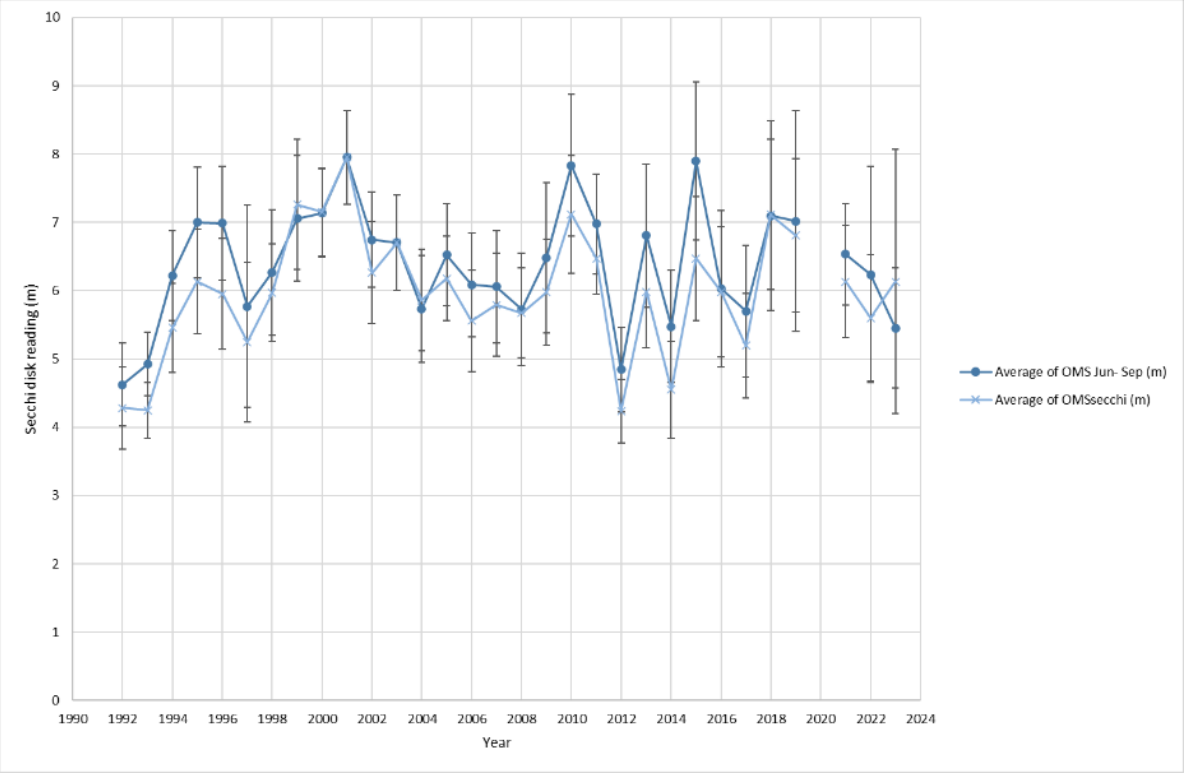
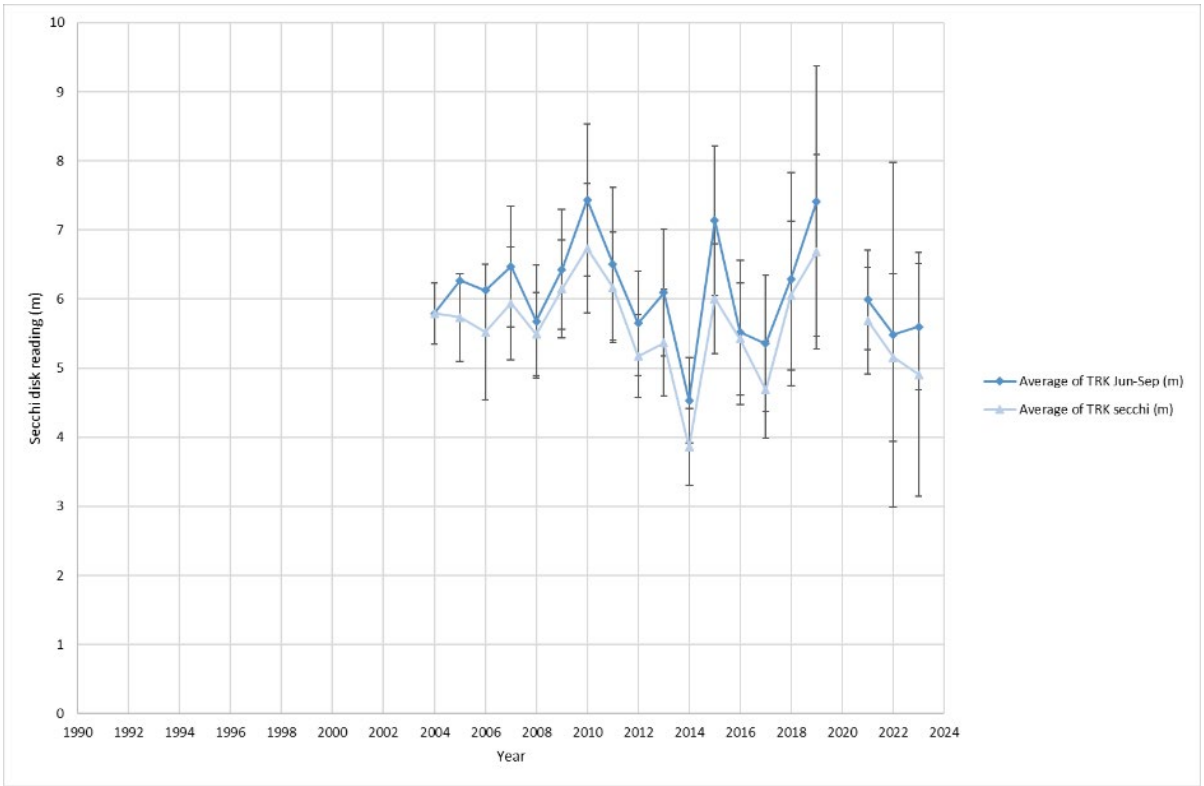


Figure 11 (b) Skomer MCZ summary of annual mean Secchi disc data (m) for TRK site with standard error bars 2004 - 2023.



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. Results for 1994 to 2022 from Thorn Rock are shown in Table 5.3.2 and for OMS in Table 5.3.3. The combined results for the two sites are shown in Figure 5.3.1. The 2023 samples are currently being analysed and this data will be available in 2024.

Table 5.3.2 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 5.3.3 Skomer MCZ sediment trap sample analysis from OMS site (1994 to 1998 % sand data estimated).

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

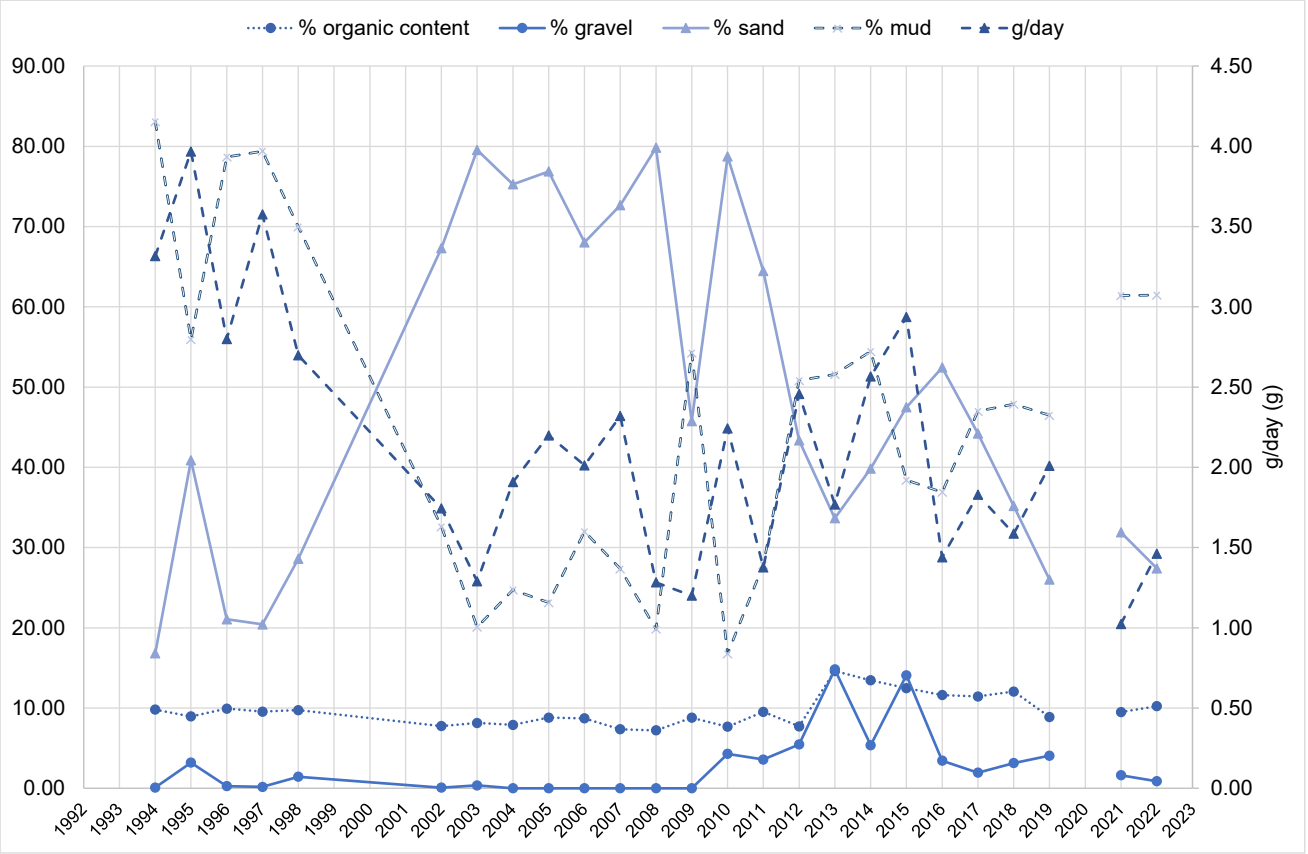
Another change in 2013 was that the organic content analysis included heating the sample to 550^{o}C rather than 450^{o}C resulting in more carbonates being included in the % organic content. This explains the sudden rise in the 2013 values. The ignition temperature used from 2014 onwards at the NRW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

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

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 5.3.5 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). 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 provides 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.
- Access the Water Framework Directive (WFD) chlorophyl data for Skomer water samples 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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