Skomer Marine Conservation Zone Project Status Report 2024

NRW Evidence Report 845

Author Names: M. Burton, K. Lock, A. Massey & J. Jones

About Natural Resources Wales

Natural Resources Wales' purpose is to pursue sustainable management of natural resources. This means looking after air, land, water, wildlife, plants and soil to improve Wales' well-being, and provide a better future for everyone.

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence-based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well-resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

This Evidence Report series serves as a record of work carried out or commissioned by Natural Resources Wales. It also helps us to share and promote use of our evidence by others and develop future collaborations. However, the views and recommendations presented in this report are not necessarily those of NRW and should, therefore, not be attributed to NRW.

Report series:	Marine Evidence Report
Report number:	845
Publication date:	March 2025
Title:	**Skomer Marine Conservation Zone, Project Status Report 2024**
Author(s):	Burton, M., Lock, K., Massey, A., Jones, J.,
Quality assurance:	Tier 2
Peer Reviewer:	Mike Camplin
Approved By:	Lucie Haines
Restrictions:	None

Distribution List (core)

NRW Library, Bangor	2
National Library of Wales	1
British Library	1
Welsh Government Library	1
Scottish Natural Heritage Library	1
Natural England Library (Electronic Only)	1

Distribution List (others)

Via NRW website

Recommended citation for this volume:

Burton M, Lock, K, Massey, A & Jones, J. (2025) Skomer Marine Conservation Zone, Project Status Report 2023. NRW Evidence Report 845

Contents

Crynodeb gweithredol

Dyma'r ail adroddiad statws prosiect ar hugain a gynhyrchwyd gan Barth Cadwraeth Morol Sgomer (MCZ). Mae'n grynodeb o gynnydd a statws cyfredol prosiectau monitro ym Mharth Cadwraeth Morol Sgomer yn ystod 2024. 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 i'r dystiolaeth a ddefnyddiwyd wrth asesu cyflwr a statws cadwraeth Ardal Cadwraeth Arbennig Forol Sir Benfro (PMSAC), 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 Strategaeth Forol y DU (UKMS). Manylir ar achosion penodol lle defnyddiwyd data Parth 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 2024 a chrynodeb o'r canlyniadau hyd yma. Mae Adran 5 yn rhoi crynodeb o'r prosiectau gwyliadwriaeth cefnforegol a meteorolegol.

Cofnodion nodedig yn 2024:

Cofnododd gwaith monitro'r fôr-wyntyll binc, *Eunicella verrucosa,* golledion pellach yn 2024. Dengys asesiad o gyflwr môr-wyntyllion unigol fod wyau'r morgi brych *Scyliorhinus stellaris* wedi'u cofnodi ar 56% 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 a 2024.

Roedd gan gynefinoedd môr-wiail arolygon â ffocws yn 2024. Cafodd dulliau o gofnodi rhywogaethau, dwysedd a dosbarthiad môr-wiail eu profi. Llwyddodd arolwg plymio gwirfoddol ar y penwythnos i gofnodi poblogaethau pysgod, echinodermau a chramenogion mewn parc môr-wiail a pharthau coedwig môr-wiail.

Cwblhawyd gwaith adnabod samplau rhywogaethau sbwng o arolwg 2023. Cofnodwyd hyd at 78 rhywogaeth, ac mae 11 ohonynt heb eu disgrifio neu angen ymchwil pellach. Mae'r arolygon rhywogaethau'n dangos bod gan Barth Cadwraeth Forol Sgomer fioamrywiaeth uchel o rywogaethau sbwng gyda chyfanswm o 132 rhywogaeth sbwng wedi'u cofnodi dros holl flynyddoedd yr arolwg.

Mae tymereddau cynnes y môr yn ystod y gaeaf wedi'u cofnodi am y 3 blynedd diwethaf gyda'r lefel uchaf erioed o 9.1°C yn 2024. Mae cymarebau rhywogaethau cregyn llong ar y traethau canol ac isaf wedi dangos symudiad o'r rhywogaeth dŵr oer *Semibalanus balanoides* yn dominyddu i'r rhywogaeth dŵr cynnes Cthalamus spp a geir fel arfer ymhellach i'r De.

Executive summary

This is the twenty-second 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 2024. 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 (PMSAC), within which the MCZ is situated. Skomer MCZ long-term data, both 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 2024 and a summary of the results to date. Section 5 provides a summary of the oceanographic and meteorological surveillance projects.

Notable records in 2024:

Pink sea fan, *Eunicella verrucosa*, monitoring recorded possible further losses in 2024. Condition assessment for individual sea fans show that bull huss *Scyliorhinus stellaris* eggs were recorded on 56% 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 and 2024.

Kelp habitats had focused surveys in 2024. Methods to record kelp species, density and distribution were tested. A volunteer dive survey weekend recorded fish, echinoderm and crustacean populations in kelp park and kelp forest zones.

Sponge species sample identification was completed from the 2023 survey. A total of 78 species were recorded, of which 11 are undescribed or require further research. The species surveys show that Skomer MCZ has a high biodiversity of sponge species with a total of 132 sponge species recorded over all survey years.

Warm winter sea temperatures have been recorded for the last 3 years with a record high of 9.1^{o}C in 2024. Barnacles species ratios on middle and lower shores have shown a shift from the cold water *Semibalanus balanoides* dominating to the *Cthalamus spp* usually found further South.

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 established 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 take place 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

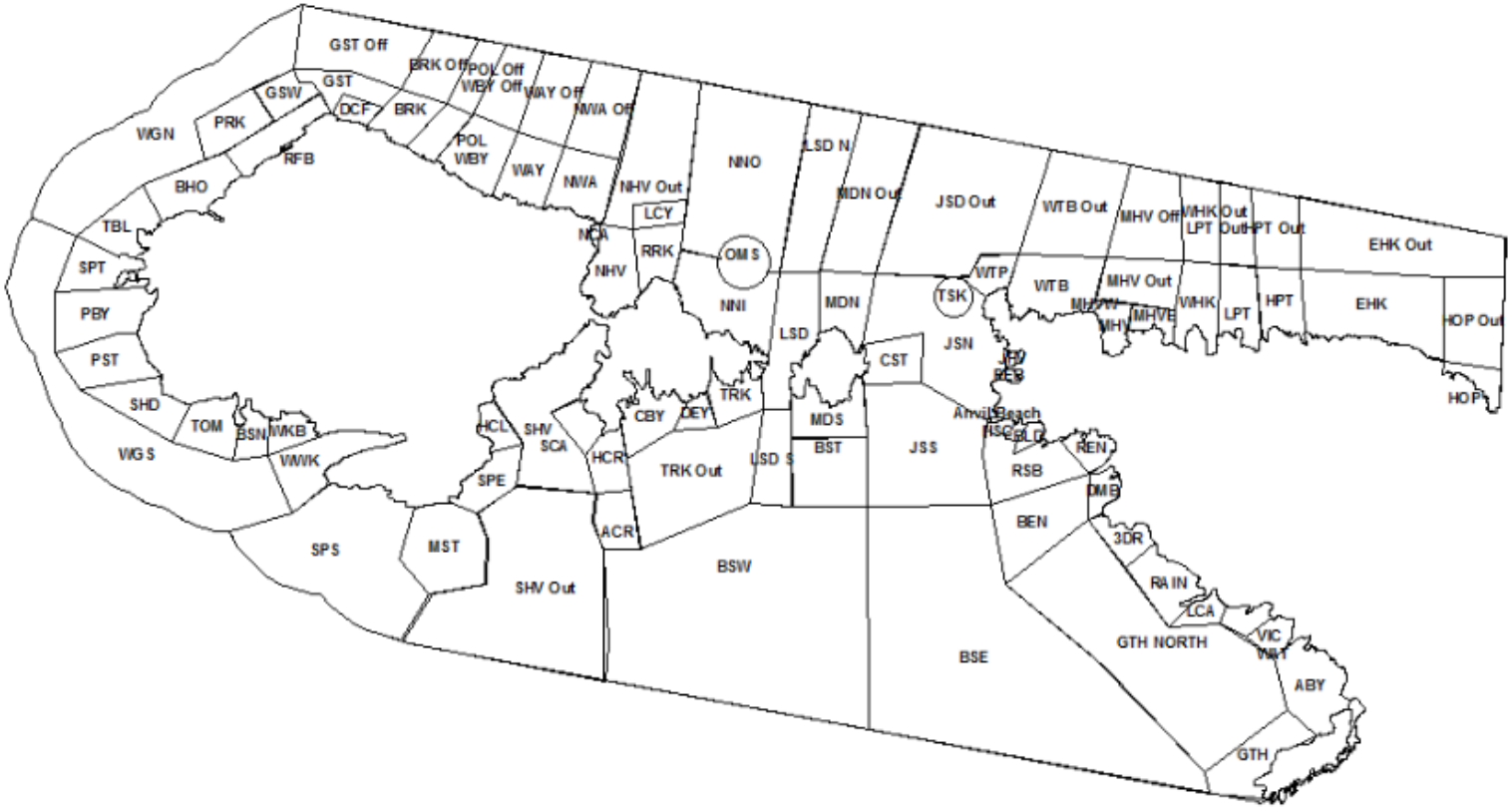
Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
Sub-Littoral Algal communities	Algae species and community survey.	1983, 1986,1994, 1999, 2007	No current planned survey	Hiscock 1983 & 1986, Scott 1994, Brodie & Bunker 1999/2000, Maggs & Bunker 2007.	Yes, Skomer MCZ office. Algae herbarium stored at National Museum Wales.
Sub-Littoral Algal communities	Kelp forest and algae community survey	Method testing 2024	Every 4 years	No	Yes, Skomer MCZ office.
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, 2024.	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, 2024	Every 4 years, next survey planned 2028	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.

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
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.
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.

Dataset	Brief description	Year sets	Sampling frequency	Report	Data summary and availability
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 2025	Lock 1998, Lock *et al*. 2006, Tompsett 2006 .	Yes, Skomer MCZ office.
Territorial fish	Drop-down video surveys	2009, 2010	Student projects	Sweet 2009, Bullimore 2010	Yes, Skomer MCZ office.
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 the table in Section 3.2 for a list of site names)



3.2 Site codes with corresponding site names

Site code	Site Name
ACR	Anchor Reef
ABY	Albion Beach
BEN	The Bench
BHO	Bull Hole
BLD	Boulder Beach
BRK / BRK Off	Bernie's Rocks / Offshore
BSE	Broad Sound East
BSN	The Basin
BST	Black Stones
BSW	Broad Sound West
CBY	Castle Bay
CST	Crab Stones
DCF	Double Cliff
DEY	"Dead Eye" wreck
DMB	Dead Man's Bay
EHK / EHK Out	East Hook / Outer
GST / GST Off	Garland Stone / Offshore
GSW	Garland Stone West
GTH / GTH North	Gateholm / North
HCL	High Cliff
HCR	High Court Reef
HOP / HOP Out	Hopgang / Outer
HPT / HPT Out	High Point / Outer
HSC	Horseshoe Cave
JNK	Junko's Reef
JHV	Jeffrey's Haven
JSD Out/ JSN / JSS	Jack Sound / North / South
LCA	Little Castle Beach
LCY	"Lucy" wreck
LPT / LPT Out	Low Point / Outer
LSD / LSDN / LSDS	Little Sound /North/South
MDN / MDS / MDN Out	Middleholm North / South / North Outer
MHV / MHVE / MHVW / MHV Out / MHV Off	Martins Haven / East / West / Outer / Offshore
Site code	Site Name
MST	Mew Stone
NCA	North Castle
NHV / Out	North Haven / Outer
NNI / NNO	North Neck Inner / Outer
NWA / NWA Off	North Wall / Offshore
OMS	Oceanographic Monitoring Site
PBY	Pig Stone Bay
PEB	Pebbly Beach
POL / POL Off	The Pool / Offshore
PST	Pig Stone
RAIN	Rainy Rock
REN	Renney Slip
RFB	Rockfall Bench
RRK	Rye Rocks
RSB	Renney Slip Bay

Site code	Site Name
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. This management feature includes intertidal boulders and supralittoral 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 provides 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 (50cm x 50cm) were established in 1992. The quadrats extend from spring low water into the splash zone at regular height intervals. Photographs are taken annually of each quadrat as permanent records.

In 1992 and 1996 a species abundance survey was completed using the semi-quantitative SACFOR abundance scale (Crump 1993 & 1996).

Littoral Community Monitoring (2003 – Ongoing)

In 2003, new methods were developed, these are detailed in Crump & Burton (2004) and summarised 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 quadrat 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:

- 1 m^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 50cm x 50cm quadrat, placed within each 1 m^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 5cm x 5cm 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 5cm x 5cm quadrat

At Middle Shore Zones:

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

At Splash Zones:

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

MarClim Methodology (2003 - Ongoing):

The MarClim project offers an opportunity to compare Skomer MCZ shores to the rest of the UK and contribute to the assessment of the effects of climate change. Martins Haven,

North Haven, and South Haven 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 5cm x 5cm quadrats to complete barnacle species counts.
- Limpet species counts in 50cm x 50cm quadrats.
- Timed searches of *Phorcus lineatus* and *Steromphala umbilicalis* with 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 re-surveyed 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). 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.

2024: All Marclim sites were completed but only 3 Skomer sites due to adverse weather conditions.

The survey methods for each site completed in years 2003 to 2024 are shown in Table 4.1.3.

Table 4.1.3 Summary of survey sites completed 2003 – 2024. (Lower shore: LS, Middle shore: MS, Upper shore: US. Yes = all planned completed).

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	LS only	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 only	No
2021	MarClim	MarClim	No	No	No	No	No	No	MarClim only	No
2022	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2023	MarClim	MarClim	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2024	MarClim	MarClim	No	Yes	No	No	No	Yes	Yes	No

4.1.6. Results

Littoral Community Monitoring was only possible at 3 of the 7 sites due to bad weather over the spring tides in August. Data analysis is therefore limited and not been completed for the following parameters: whole community analysis, mean percentage of barnacles,

limpet size and counts. Data analysis for the 2004 to 2023 results are detailed in the 2023 report (Burton *et al* 2023).

Barnacle Species Ratios

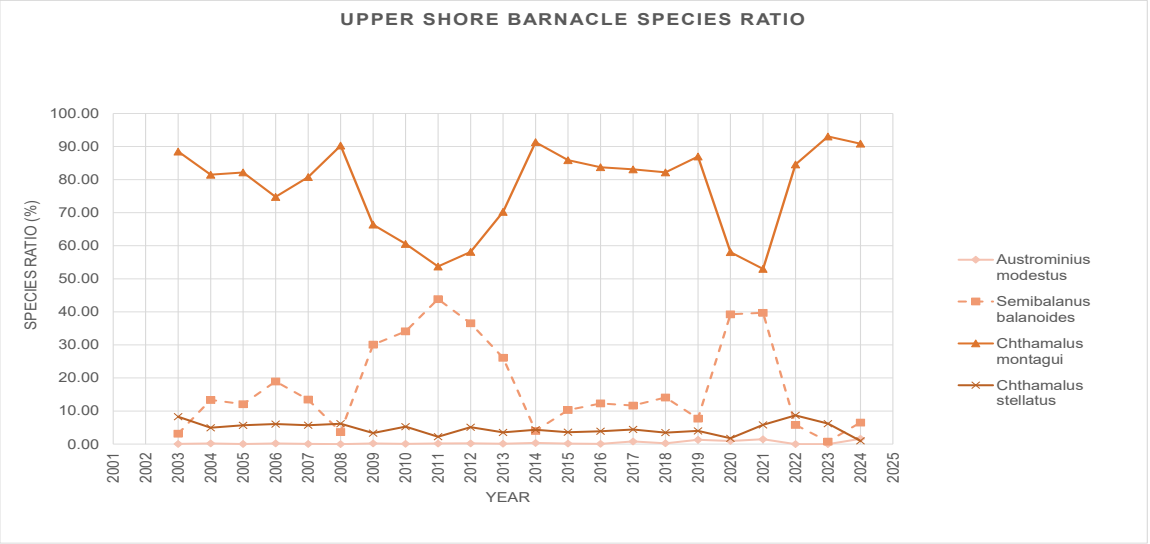
The barnacle species counts have been completed from the photographs of the 5cm x 5cm quadrats at the 3 MarClim Sites: Martins Haven, North Haven and South Haven (photographs taken at the other sites are stored for analysis when time allows).

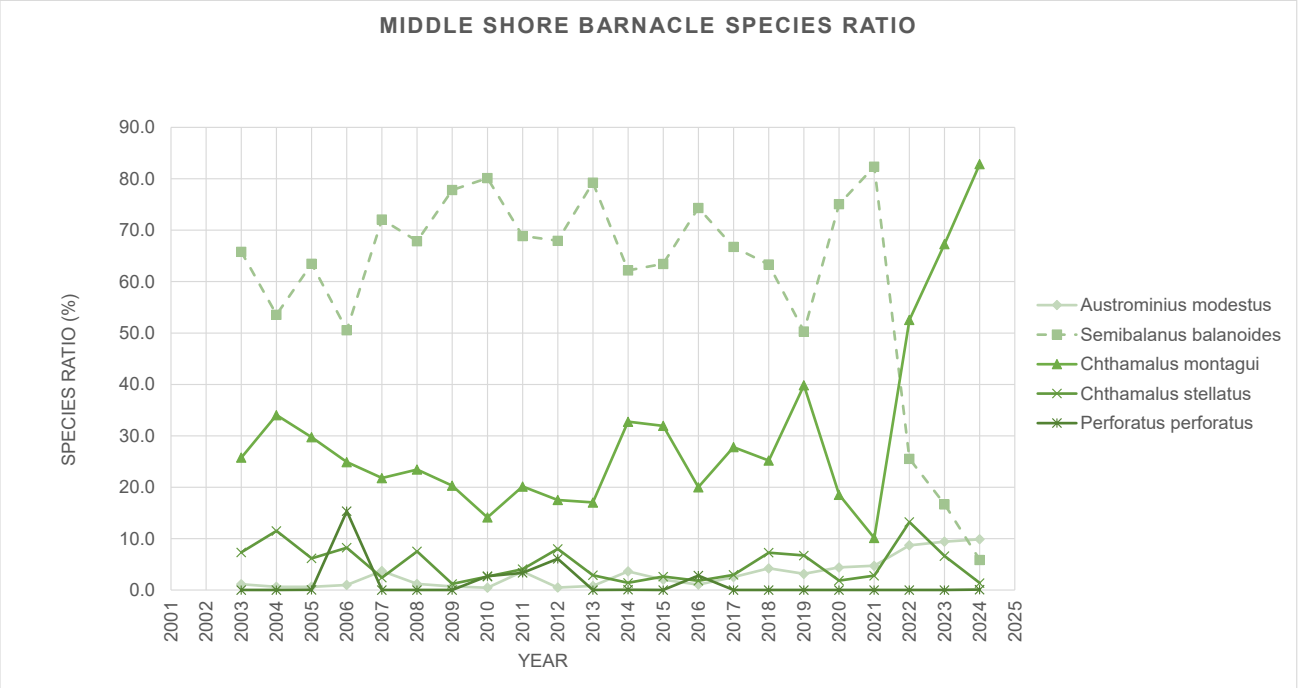
The 3 shore zones show how the different species tend to be dominant in different zones, with *Chthamalus spp* dominating the upper shore and *Semibalanus balanoides* being more abundant in the middle & lower shores (Figure 4.1.5). The *Chthamalus spp* have a preference for warmer waters with a more southerly distribution in the UK. *S. balanoides* has a more northerly distribution.

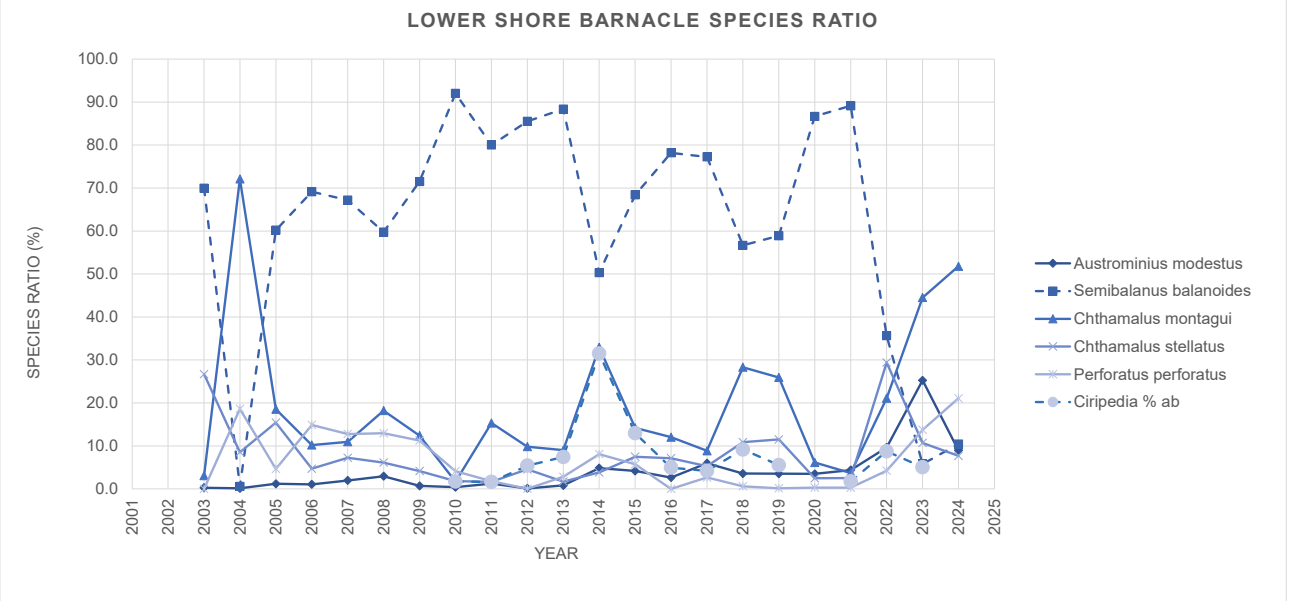
In 2022 *S. balanoides* abundance ratio declined by 60% in the middle shore and 80% in the lower shore and has continued to decline in 2023 and 2024. The overall coverage of barnacles has not changed with the space being claimed by *Chthamalus spp*. This may be due to spring sea temperatures affecting spat survival. The minimum sea temperatures are recorded in March and in 2022, 2023 and 2024 were the highest on record since 2007, with 9.1ºC recorded in 2024 compared to an average of 7.9 ºC for years 2000 to 2024. This may have affected the survival of the early settlement of *S. balanoides* spat. The summer maximum temperatures in 2022 and 2023 were some of the highest on record at 17.1ºC and 17.5ºC (2024 data not yet available) which may have improved the survival rate of *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 to May (see Figure 4.12.4).

Figure 4.1.4 Changes in upper, middle and lower shore barnacle species ratios 2003 – 2024.







MarClim survey

MarClim data have been entered into spreadsheets and supplied to the MarClim team for reporting (Mieszkowska, N & Sugden, H (2022). Marclim will publish a 2024 season report to NRW later in 2025.

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 that istypical 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 change. The barnacle species have shown a shift in species ratios over the last 3

years. *Semibalanus balanoides* has been replaced by *Cathamalus montagui* at all shore heights. This may be due to a series of very mild winters.

- Invasive species have been found but so far none are present in large numbers.

4.1.8. Recommendations

- Continue with the littoral monitoring programme.
- Continue MarClim survey methodology.
- 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 MCZ. 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 assemblages.
- 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. From 1994 to 2008, photographs were taken from fixed positions along the transect using paired cameras set up on a 50cm x 70cm 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 50cm x 70cm quadrats positioned close to the four fixed transects at Thorn Rock. From the 2007 survey onwards no quadrats were used, and surveys were completed in the general vicinity of the Thorn Rock transects, with all specimens identified to the highest possible taxonomic resolution. In 2011, the survey was extended to include The Wick, with High Court Reef being added in 2015.

Seasonal survey from fixed quadrats: In 2005, fifteen 1m^2 quadrats were marked out at three of the four fixed transects locations at Thorn Rock. The quadrats each consist of 25 cells (20cm x 20cm). The quadrats are positioned and then "wafted" to clear the surface silt, before being photographed with a digital camera fixed to a small camera framer.

4.2.5. Project history

Transects: 1993 to 2022 photo quadrats taken at Thorn Rock (4.2.1).

Table 4.2.1 Data gathered from Thorn Rock sponge transects photo quadrats 1993 to 2002. Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL.

Year	Number photo quadrats	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
2024	82	All completed

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 completed in 2021 and 2022, no photos were taken in 2023 but were taken in 2024. The digital photographs are merged together to form a mosaic of the full $1m^2$ quadrats.

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.

New morphology classification method tested in 2023 & 2024.

An internationally recognised system for classifying sponges from different habitats around the world was produced in 2021. Designed specifically to be used on photographs.

Schönberg C,H,L , 2021. Ecological Indicators vol 129. No taxonomy needed: Sponge functional morphologies inform about environmental conditions. Article 107806

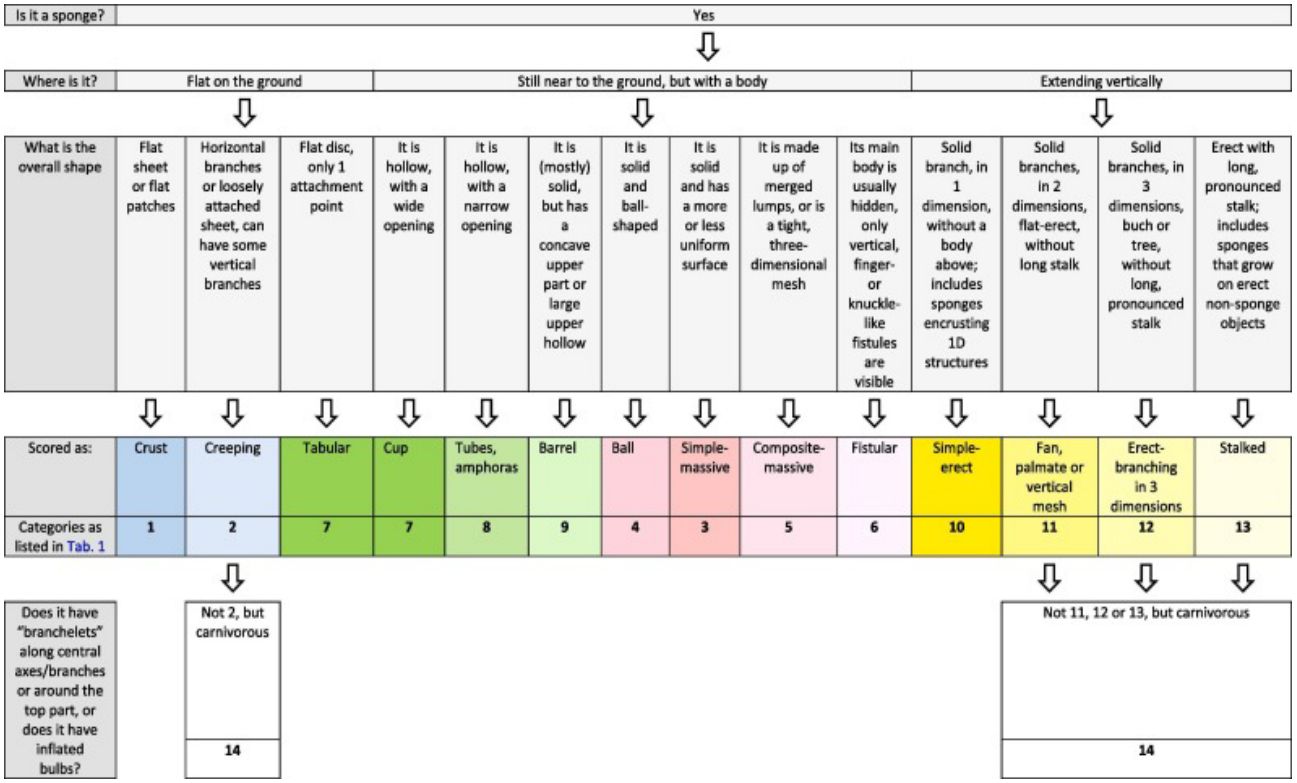
This new system is based on the Bell & Barnes 2001 method but has been expanded. In 2023 the whole MCZ data set was analysed using the Schonberg (2021) method. In 2024 this method was used again and tested for consistency between different observers. The method does take longer to complete, but would potentially allow the MCZ data to be shared with other projects and compared to results from other MPAs around the world.

It is a straightforward process to back transform the results from the new method into the Bell & Barnes 2001 categories, so all analysis for 2023 and 2024 data has been done on back transformed results to align with the Bell & Barnes method.

Figure 4.2.1 The tabulated structure and hierarchy of the classification system based on sponge functional morphologies. There are four basic forms: functioning as encrusting, massive, cup-like and erect (in frames). These are subdivided into some further morpho-functions for finer scoring as indicated by numbering.

1.-2. CRUST-LIKE in function CAAB 10 000901		
1. Encrusting *sensu lato* *CAAB 10 000922	1.1. True crusts, crusts *sensu stricto* CAAB 10 000902	1.1.1. Thin crusts *CAAB 10 000923 1.1.2. Thick crusts *CAAB 10 000924
	1.2. Endolithic-bioeroding CAAB 10 000921 (= "alpha" and "beta" bioeroders)	
2. Creeping, repent CAAB 10 000917		
3.-6. MASSIVE in function CAAB 10 000903		
3. Simple-massive CAAB 10 000904		
4. Globular-massive, balls CAAB 10 000905		
5. Composite-massive, meshes and dense clusters * CAAB 10 000925		
6. Fistular, cryptic-massive, endopsammic CAAB 10 000908 (incl. "delta" bioeroders)		
7.-9. CUP-LIKE in function CAAB 10 000909		
7. Cups CAAB 10 000910	7.1. Tabular "cups" CAAB 10 000920	
	7.2. Incomplete "cups", curled fans CAAB 10 000918	
	7.3. Complete, apically wide cups, vases CAAB 10 000919	
8. Tube-like forms, "narrow cups" *CAAB 10 000926	8.1. Chimneys, proper tubes CAAB 10 000911	
	8.2. Amphoras, sack-like sponges, bladders *CAAB 10 000927	
9. Barrels, "massive cups" CAAB 10 000907 (incl. some "gamma" bioeroders)		
10.-14. ERECT in function CAAB 10 000912		
10. One-dimensionally erect, simple erect CAAB 10 000916		
11. Two-dimensionally erect *CAAB 10 000928	11.1 Erect-laminar, flabellate CAAB 10 000913	
	11.2 Erect-palmate CAAB 10 000914	
	11.3 Erect-reticulate *CAAB 10 000929	
12. Three-dimensionally erect, branching CAAB 10 000915		
13. Stalked CAAB 10 000906		
14. Carnivorous *CAAB 10 000930		

Figure 4.2.2 Decision flow chart or layman key for scoring the 14 sponge functional morphologies that can be used as a proxy for environmental conditions. The scoring context needs to be strictly functional.



4.2.6. Results

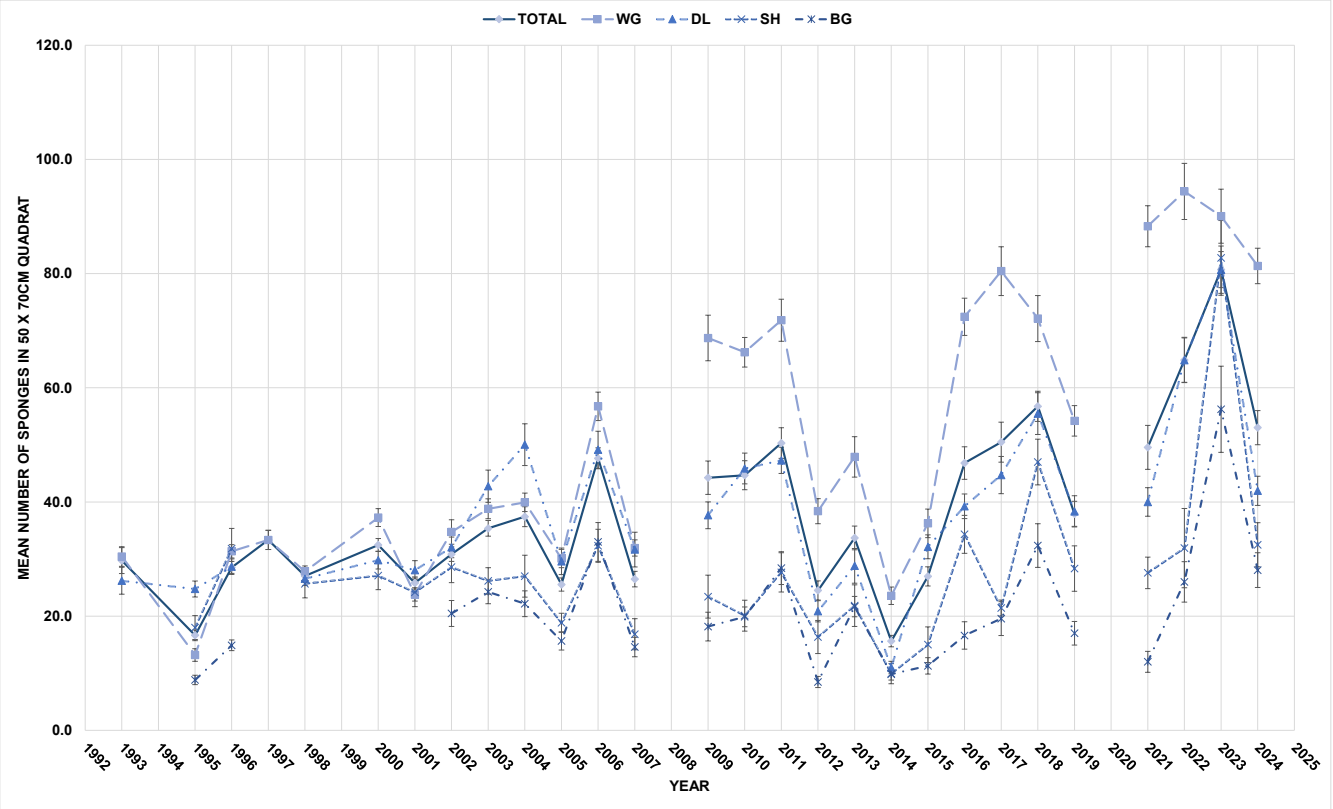
Transects:

The sponge morphology analysis method has been used for all the quadrats taken at Thorn Rock and additionally for a selection of comparable quadrat photos taken at other sites around the MCZ during other projects. The data is then 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 previous 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 4.2.3).

In 2023 & 2024 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.

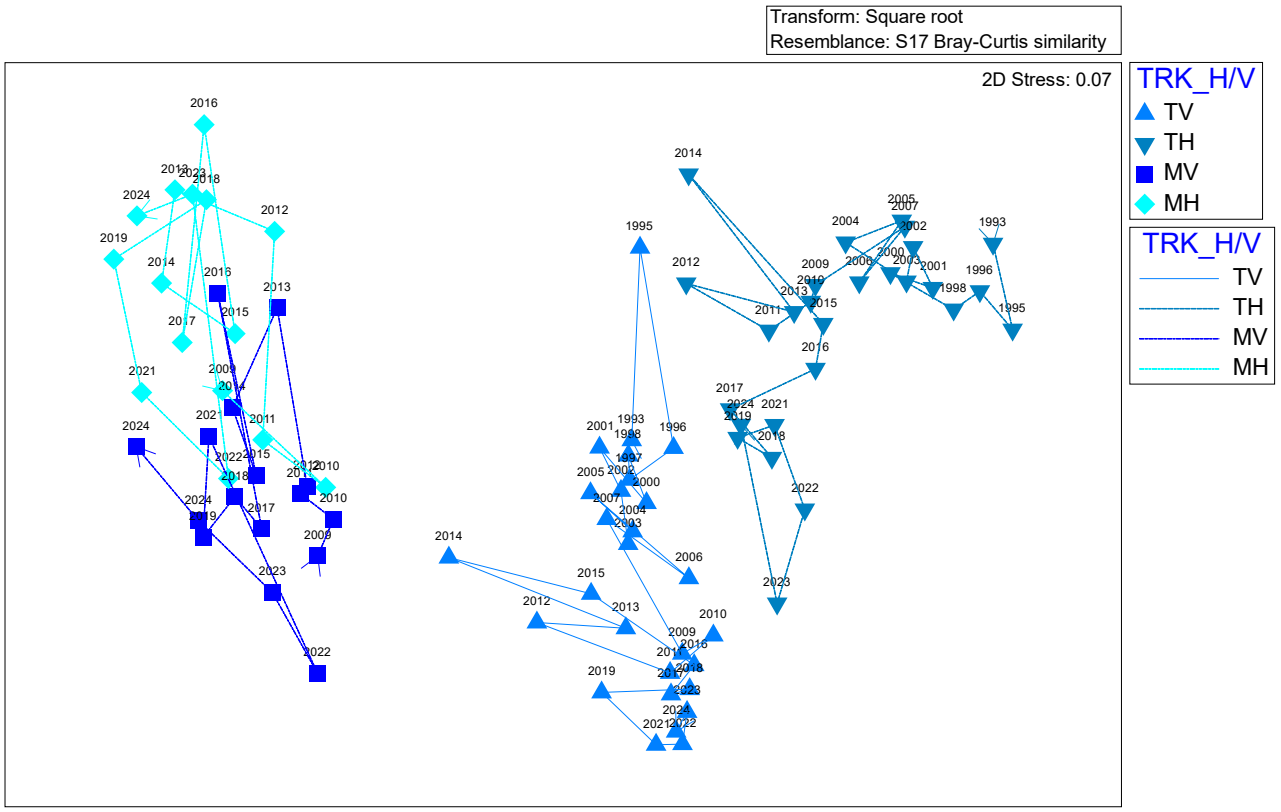
Figure 4.2.3 Mean number of sponges counted in each quadrat at 4 sites –Thorn Rock 1993-2024, with standard error bars. (Transects: Windy Gully =WG, Spongy Hillocks =SH, Broad Gully =BG, Dogleg = DL).



The morphology method for characterising sponge assemblages has also been applied to suitable monitoring photographs taken from a range of other 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 4.2.4).

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 4.2.4 PRIMER Multi-dimensional scaling (MDS) plot of sponge morphology data averaged by site and year 1995 – 2024 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 overlain with year.

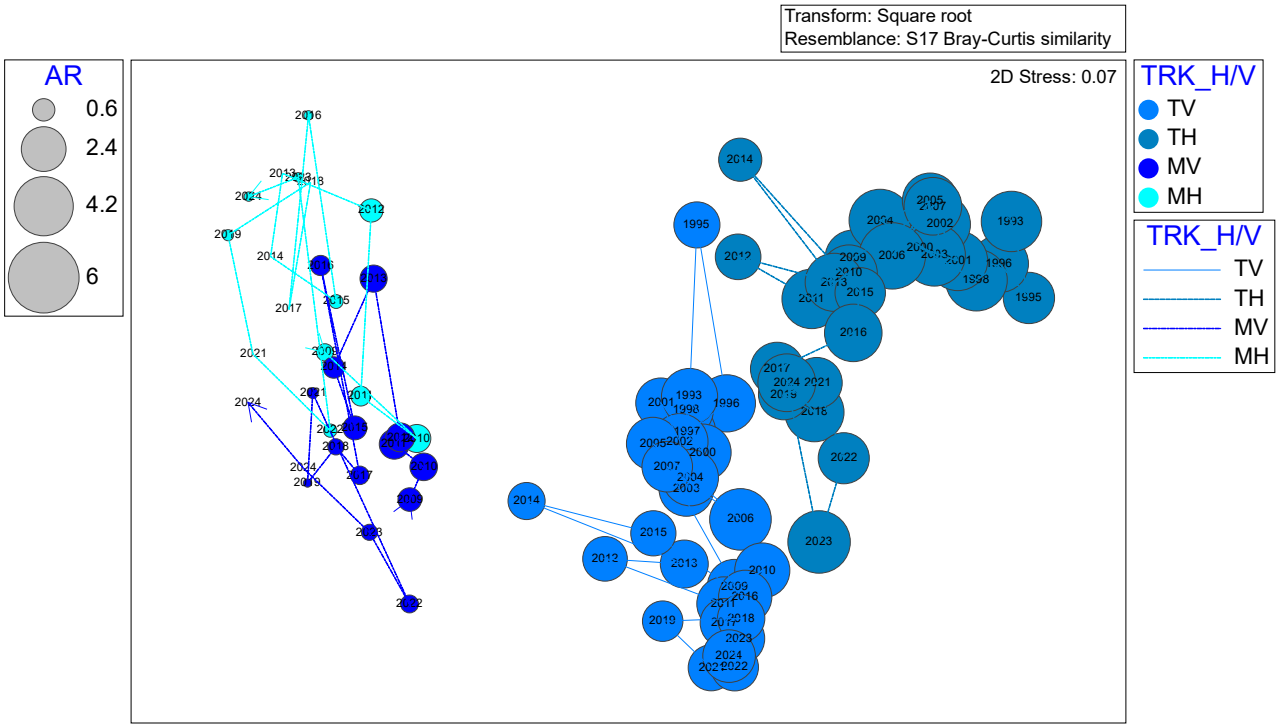


The data used in this plot has been averaged from 4 sites at Thorn Rock (3 -Horizontal, 1 Vertical) and 7-10 sites from elsewhere around the MCZ with a mixture of vertical and horizontal aspects.

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 4.2.5)

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.

Figure 4.2.5 PRIMER MDS plot of sponge assemblages at Skomer MCZ 1995-2024. Plot overlaid with bubbles representing the relative abundance of arborescent (AR erect) sponges.



Species surveys:

In 2023 six sites were surveyed on the south side of Skomer Island as part of the continuing full sponge species monitoring programme, completed every 4 years. Four of the sites are located at Thorn Rock, one at The Wick and one at High Court Reef. A full report for the 2023 Skomer sponge species survey has been completed (Jones *et al* 2024).

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

The survey resulted in 78 species/entities being recorded and identified using a combination of *in situ* recording and collection of samples for analysis. Of these, 11 are undescribed or require further research.

The most commonly occurring species found at all 6 sites were the massive sponges *Cliona celata* and *Pachymatisma johnstonia*, the cushion sponges *Amphilectus fucorum, Dysidea fragilis* and *Hemimycale columella*, the erect sponge *Stelligera montagui* and the encrusting sponges *Plocamionida ambigua* and *Pseudosuberites sulphureus.* Other frequently occurring species included the erect branching sponges *Axinella damicornis*, *Axinella dissimilis*, *Raspailia hispida*, *Raspailia ramosa* and *Stelligera stuposa.*

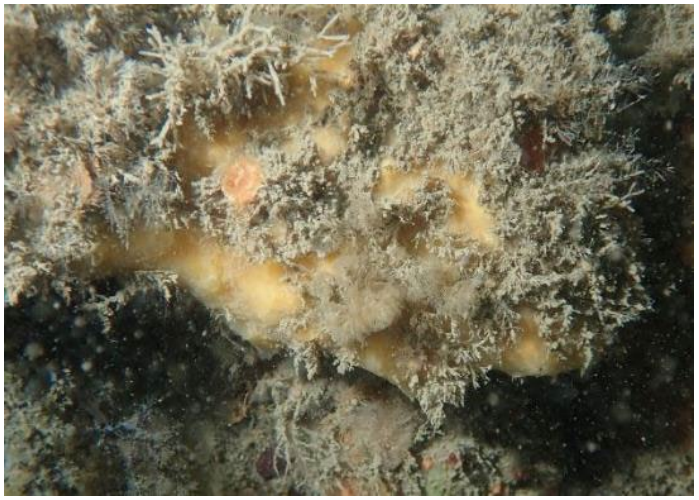
Windy Gully (Thorn Rock) was the richest individual site in terms of species, with a total of 46 species being recorded followed by Hight Court Reef, 44 species and the Wick, 40 species. Dog Leg (Thorn Rock) was the least diverse, with 30 species.

During each survey additional species are being discovered, with potentially one more being found during this survey subject to further research. The encrusting sponge *Ophlitaspongia kildensis* was found in the MCZ for the first time during the 2023 survey at two sites, High Court Reef and Windy Gully (Figure 4.2.6). It has been recorded in Scotland and Northern Ireland but there have been no previous records from Wales or England.

Figure 4.2.6. *Ophlitaspongia kildensis*

A specimen of *Trachytedania cf. ferrolensis* was collected and identified from Windy Gully There are currently no *Trachytedania* species listed from the United Kingdom, hence the name *Trachytedania* cf. *ferrolensis* is being used (originally described from Galicia in NW Spain), pending further research and examination of the type species for comparison.

Figure 4.2.7 *Trachytedania cf. ferrolensis*



A total of 132 sponge species (42 of which have been named to genus level only) have now been recorded from the Skomer MCZ, including records from previous surveys conducted before 2003, when the first of the four-yearly full species surveys took place. Four species present in the Skomer MCZ are on the nationally rare and scarce marine benthic species list for Great Britain (Sanderson 1996) and several have only recently been described or have limited distribution in the British Isles.

4.2.7. Current status

- The species surveys show that Skomer has a high biodiversity of sponge species. A total of 132 species/entities have been recorded at the MCZ of which 42 are undescribed and need further investigation. In 2023, 78 species/entities were recorded (Jones 2024).
- The sponge community feature for Skomer MCZ is stable and in favourable condition.

4.2.8. Recommendations

- Continue application of morphology method for analysis of photos and continue to test the Schönberg 2021 classification method.
- 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.
- Support academic sponge research projects, in particular new species research and identification work on Skomer MCZ samples.
- Continue to provide preserved species samples to National Museum Wales for record verification and future research.
- Maintain Skomer MCZ sponge species records on Marine Recorder database and NBN Atlas.

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 or marine litter (e.g. fishing line). 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’.

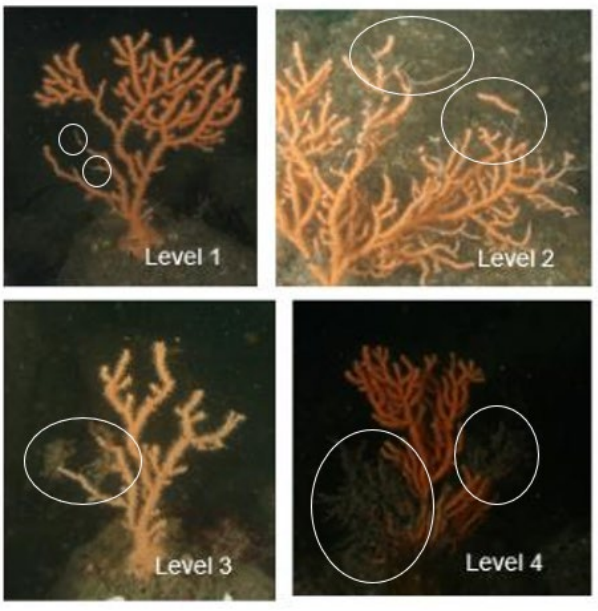
- Photographs are taken using a single camera mounted on a 50cm x 70cm frame. Both sides of the sea fan are photographed.
- Each sea fan is visually inspected for damage, fouling by epibiota, entanglement with man-made materials, necrosis (loss of living tissue) and the presence of predatory molluscs *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 2024: 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 (as described in Section 4.3.4 above) 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. In 2024, 9 of the 10 sites were surveyed as South Middleholm was not dived, and a total 89 natural fans and 6 attached fans monitored.

Table 4.3.3 Skomer MCZ sea fan survey results 1994 -2024.

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

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
1999	0	no data	no data	no data	no data	no data	no data	no data
2000	5	54	54	0	0	0	0	0
2001	5	55	55	0	0	1	0	0
2002	9	86	86	0	0	1	0	0
2003	9	99	99	0	1	0	0	0
2004	9	101	100	0	0	0	0	0
2005	10	114	111	3	1	1	0	0
2006	10	119	116	3	7	0	0	0
2007	10	121	118	3	1	2	0	0
2008	10	126	122	4	0	0	0	0
2009	10	128	121	7	0	1	0	0
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	107	105	2	0	5	0	0
2020	no data	no data	no data	no data	no data	no data	no data	no data
2021	10	93	91	2	0	0	0	0
2022	10	92	88	4	0	13	0	0
2023	10	92	87	5	0	3	0	0
2024	9	89	83	6	0	0	0	3
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 2023, 1 fan was missing, MDS2 (at South Middleholm). South Middleholm was not dived in 2024 so this fan will need to be re-checked in 2025. In 2024 there were two further sea fans missing at Rye Rocks (RRK 1 and RRK15), these will be checked, and their status confirmed in 2025.

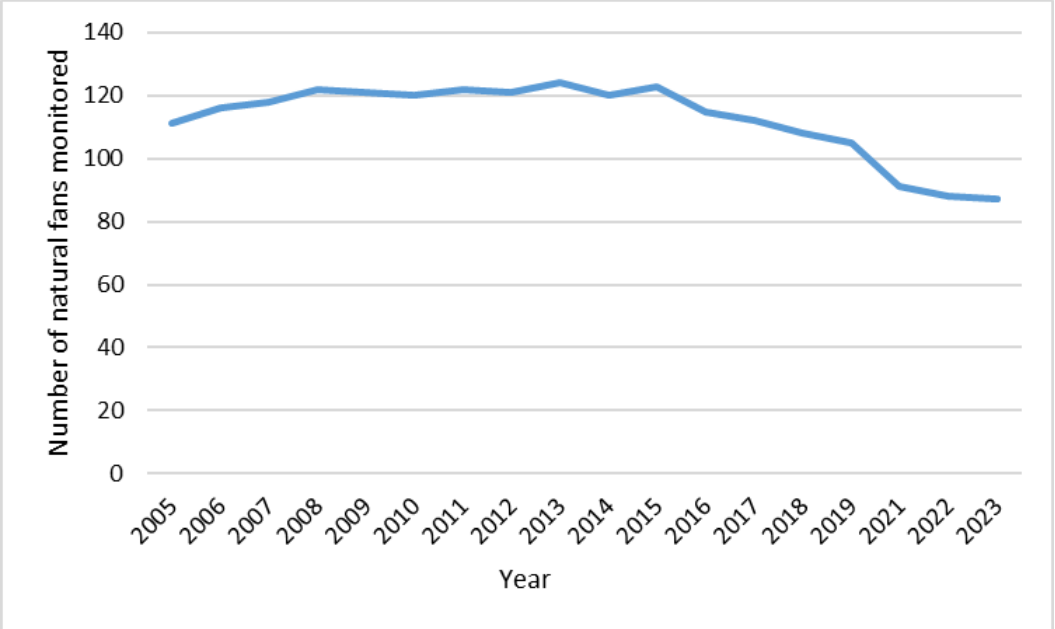
In 2023, one broken sea fan was found at Rye Rocks recognisable as RRK16, it was attached using cable ties to the Lucy mast. It was still present in 2024 and moved to a better location, now attached to a piton. In 2024 a further sea fan at Rye Rocks was found broken off, recognisable as RRK25 (Figure 4.3.2), it was left lying alongside a cluster of other sea fans with the intention of returning to securing it to a ringbolt. The return visit was not possible so we hope to re-find it in 2025.

Figure 4.3.2 Broken off sea fan at Rye Rocks (RRK25)

The rate of 'natural' sea fan losses increased from 2015. At the 10 sites in the ten-year period from 2005 to 2014, the total number of natural sea fans recorded was between 119-124 fans and during this period 7 losses were recorded. In the nine years from 2015 to 2023 the losses have increased, there have been 40 'natural' fans and 3 'artificially attached fans' confirmed as missing in this period. Three further 'natural fan' was absent in 2024, to be confirmed as losses in the 2025 field season.

The total number of natural sea fans recorded from the 10 sites from 2005 to 2023 is shown in Figure 4.3.3. The increase in numbers between 2005 and 2014 is due to further expansion of the sites, a decreasing trend is shown since 2015 due to the large number of losses.

Figure 4.3.3 Total number of natural sea fans recorded from 10 sites 2005 to 2023 (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.

   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 2024 10% 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 56% of sea fans recorded with these eggs in 2024 (Figure 4.3.5).

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

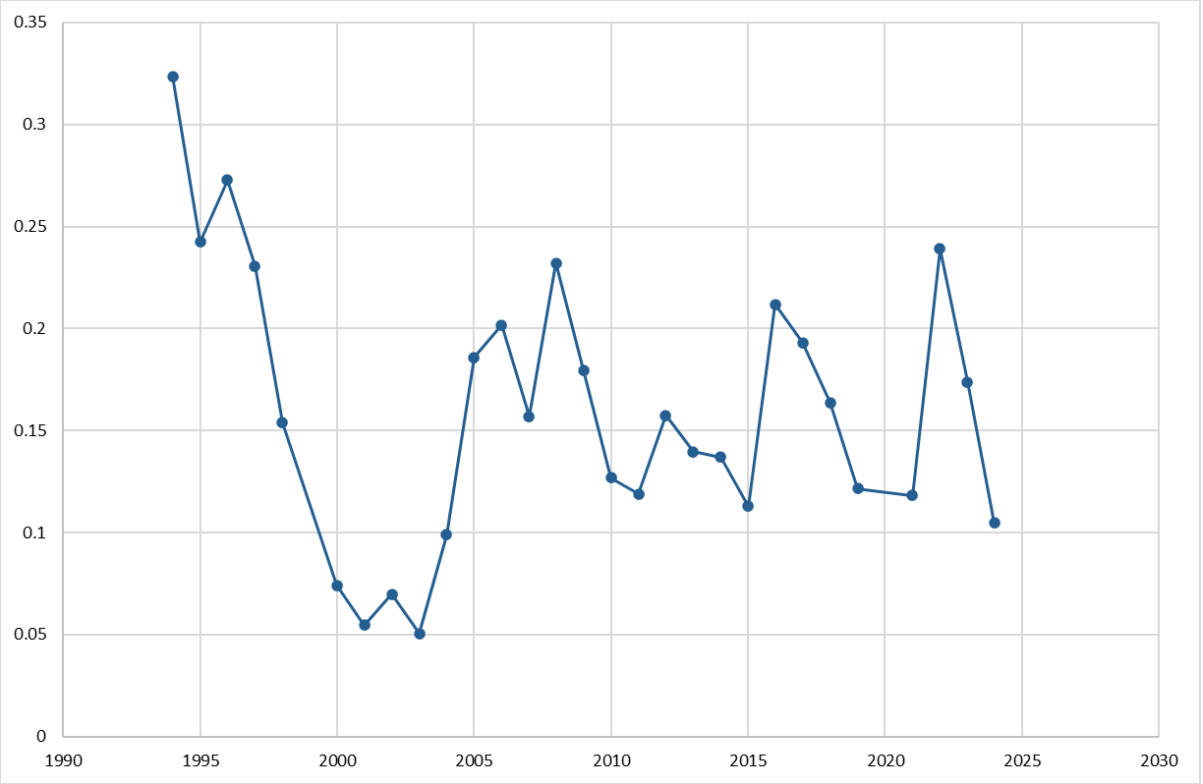
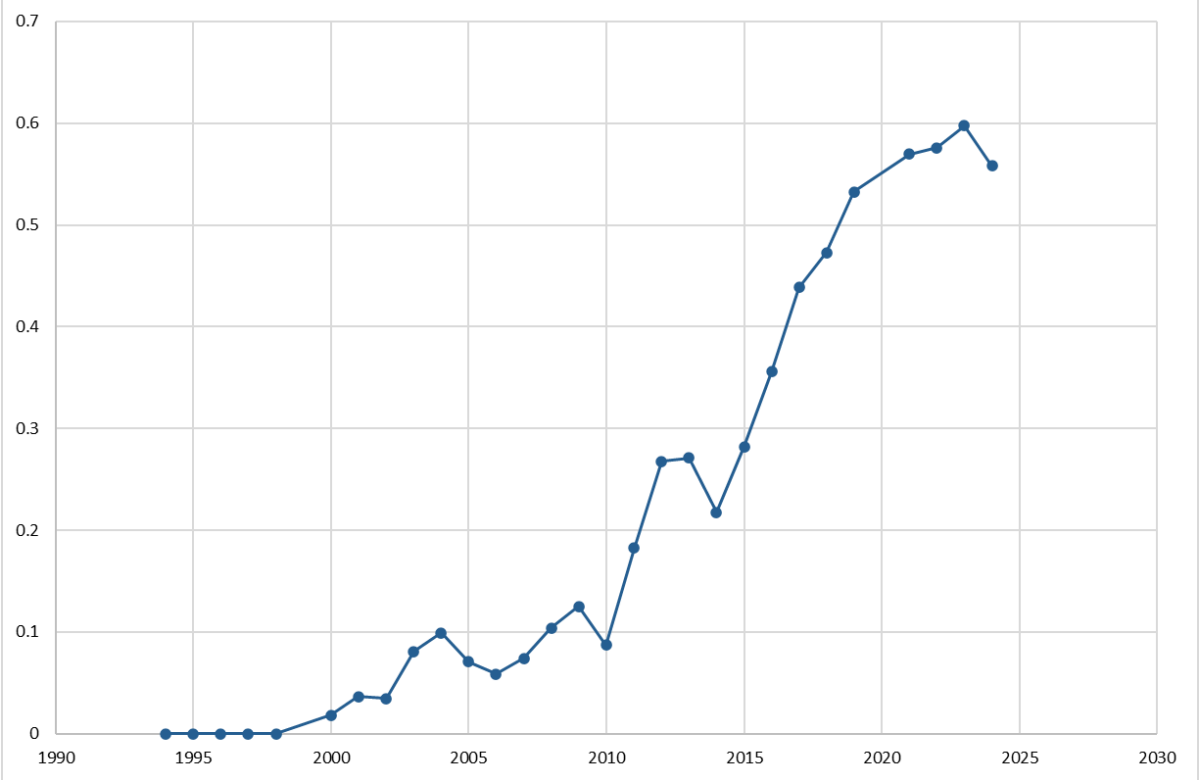
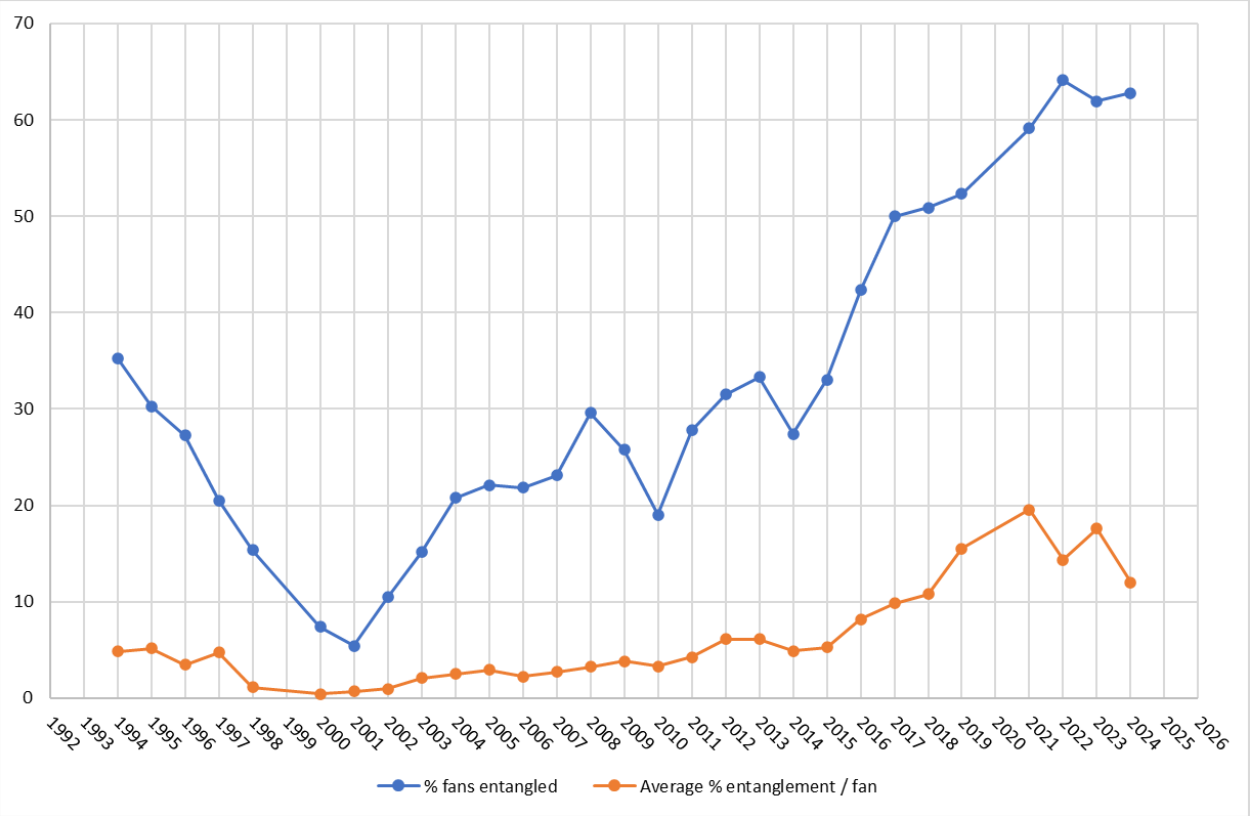


Figure 4.3.5 Proportion of sea fans at Skomer MCZ entangled in *S. stellaris* eggs.



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, 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.



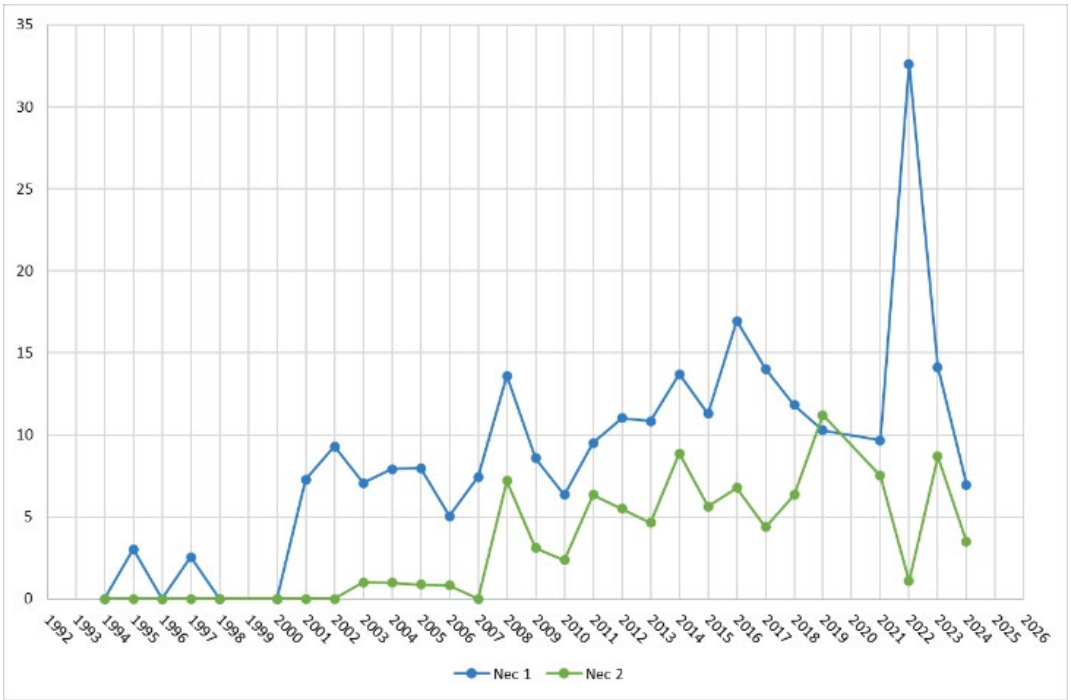
S. canicula eggs and *S. stellaris* eggs make up the bulk of the entangled biota and the pattern of entanglement reflects the percentage of sea fans entangled in eggs as shown in Figures 4.3.4 and 4.3.5. There has been an increase in entanglement since 2011 from 27% to 62% of sea fans in 2024 (Figure 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 to 12% in 2024 (Figure 4.3.6, bottom line).

Figure 4.3.7 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 4.3.1, Table 4.3.2). Necrosis was recorded on 62% of sea fans in 2024. 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 4.3.8 Percentage of sea fans at Skomer MCZ with necrosis level 1 and 2.

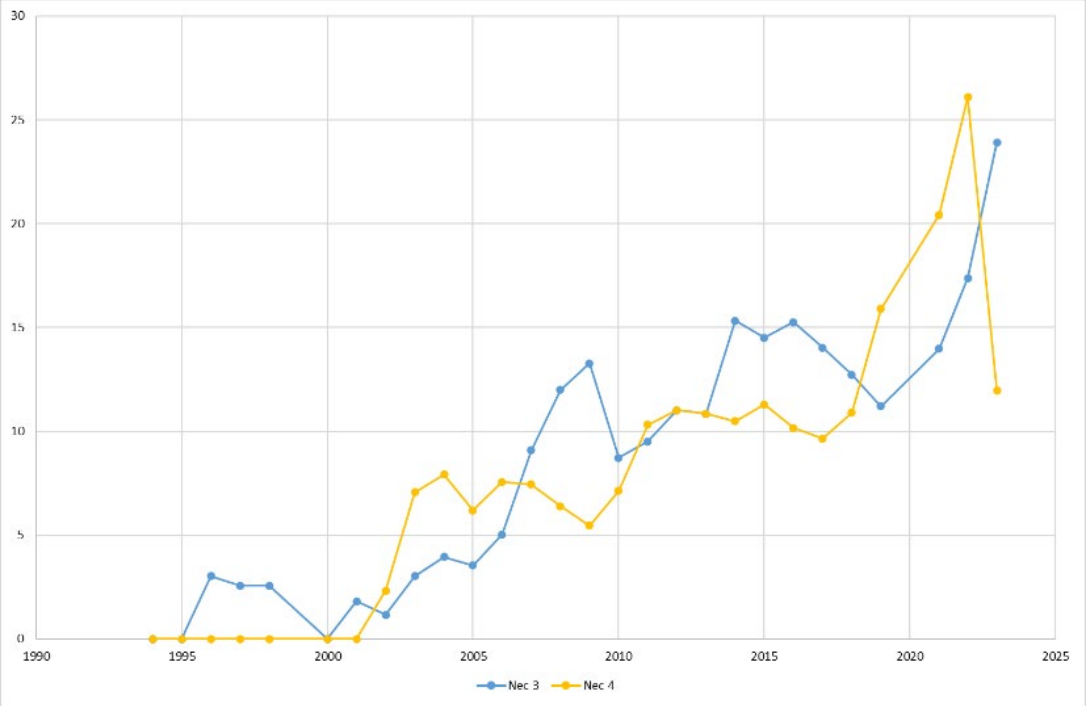


Necrosis level 1 (less than 5 tips necrosed) was recorded on 0 to 17.4% of sea fans since 1994, this increased to 31% of sea fans in 2022 then dropped down to 7% in 2024. Necrosis level 2 (more than 5 tips necrosed, but no epiphytes) was not recorded until 2002, after which it was found on 1% or less of sea fans until 2006. Since 2007 necrosis

level 2 has increased, fluctuating between 2.5 and 11.7%, and in 2024 was only recorded on 3.4% of sea fans (Figure 4.3.8).

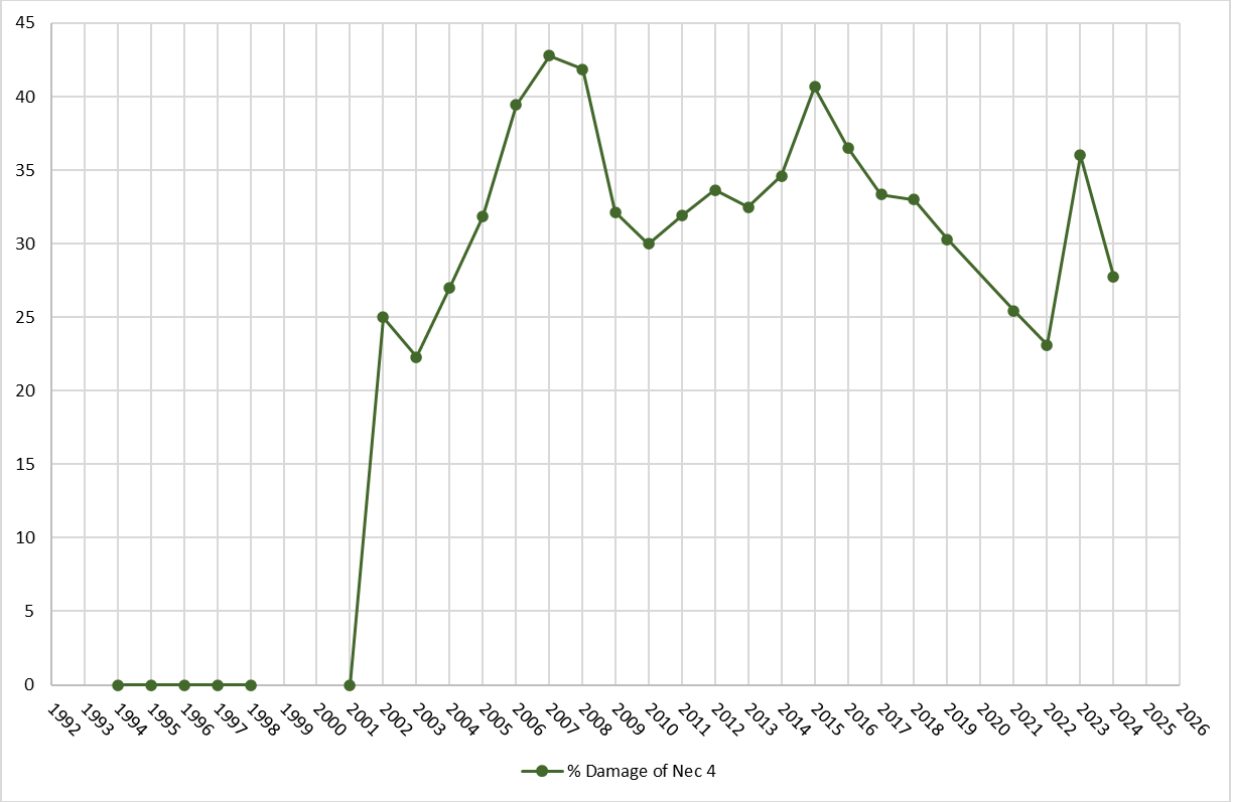
Necrosis level 3 (epiphytes growing on tips) was found on 0 to 5% of sea fans between 1994 and 2006 and since 2007 increased, varying between 7.3 and 17% of sea fans. 2024 saw the highest recorded percentage of level 3 necrosis at 34%. Necrosis level 4 (extensive areas of bare necrosis or epiphytes growing 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 2024 (Figure 3.4.9).

Figure 4.3.9 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 4.3.10).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 2024 was recorded as 27% 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 2024 one sea fan at Rye Rocks (RRK25) was found dislodged from the rock, it was left lying next to a cluster of other sea fans and its fate will be checked in 2025.

5. Nudibranch *Candiella odhneri* (Figure 4.3.13) and mollusc *Simnia 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, unusually high numbers of *C. odhneri* were found, they were recorded on 42% sea fans with between 2-4 individuals found on each with egg masses. In 2024 *C. odhneri* continued to be found in high numbers and were recorded on 60% of sea fans (Figure 4.3.12) 2-4 individuals with egg masses were found on most but as high as 10 individuals were found on one sea fan. No *S. patula* were recorded in 2024.

Figure 4.3.12 Percentage of sea fan with *Candiella odherni* and *Simnia patula*.

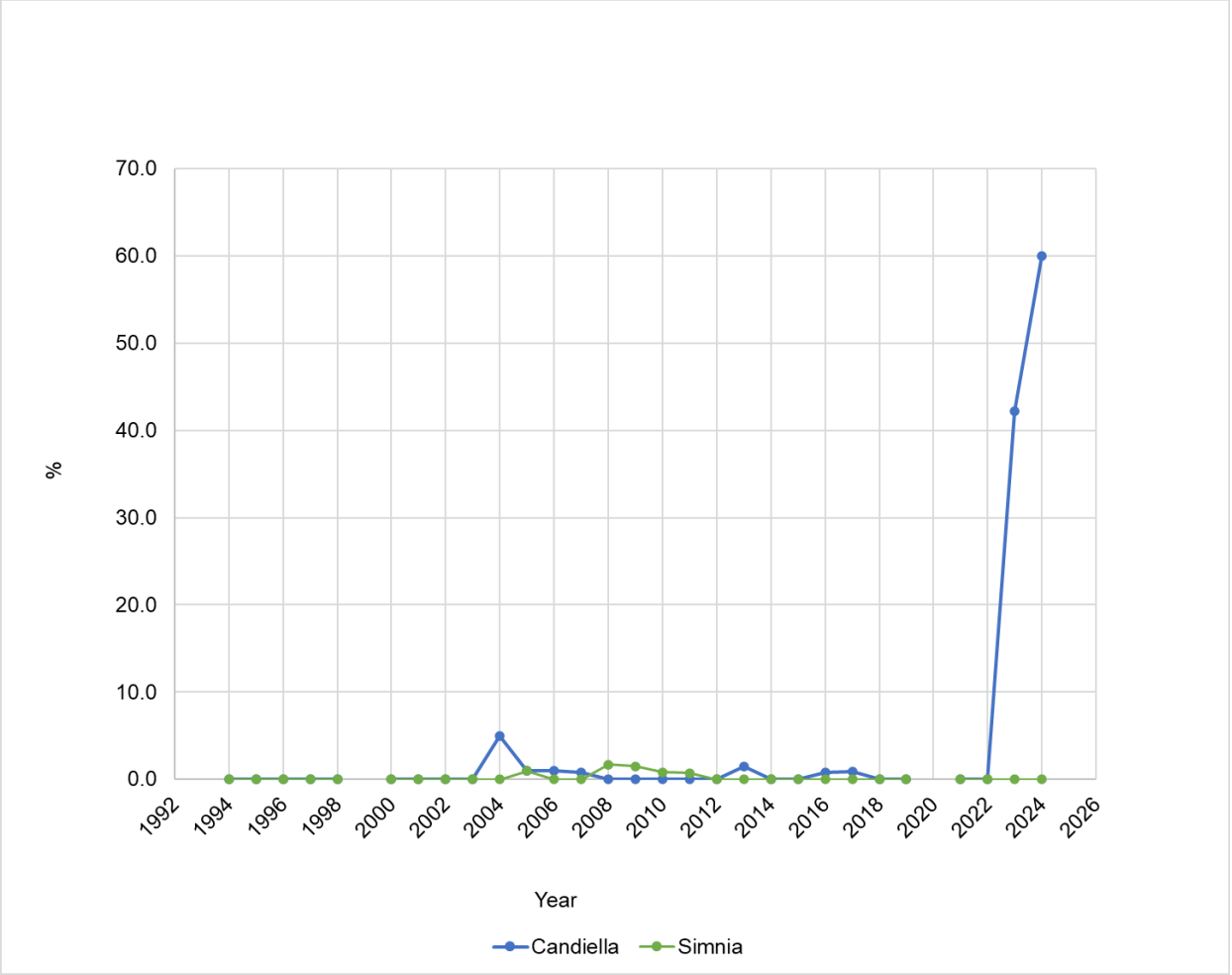


Figure 4.3.13 *Candiella odherni* and egg masses on sea fan.

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 was recorded one sea fan in 2024 at Sandy sea fan gully (Figure 4.3.14) and this was cleaned off (Figure 4.3.15).

Figure 4.3.14 Fishing line entanglement on sea fan.

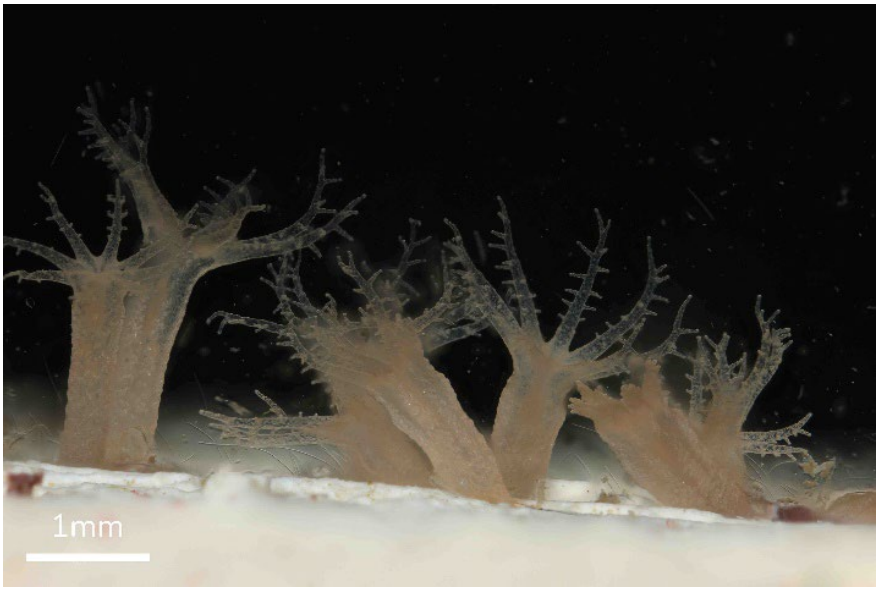
Figure 4.3.15 Fishing line removed from sea fan.

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 and 2024, small clippings were collected to complete DNA analysis. The first subset has already shown higher-resolution connectivity between populations than before. The second submission is currently undergoing sequencing and will help to answer more detailed questions about connectivity and the health of populations. Ocean models have been developed to mimic the dispersal of larvae within the ocean to understand current connectivity patterns and gain insight into how these might change in the future. Research is also being carried out in partnership with the aquarium team at the Horniman Museum and Gardens in south London, sea fan collected off the coast of Devon have been photographed spawning for the first time in a UK institution (see Figure 4.3.16). The larvae have settled and are growing into juvenile sea fan with their progress being constantly monitored (see Figure 4.3.17). Experiments were carried out to obtain crucial information for their conservation, such as the settlement success and the effect of warmer temperatures. All this will be used to evaluate the current MPA network and suggest improvements that will maintain connectivity under future conditions and safeguard our sea fan populations in the UK and beyond.

Figure 4.3.16 Pink sea fan spawning (photo credit: Kaila Wheatley)

Figure 4.3.17 Pink sea fan juveniles (photo credit: Horniman Museum and Gardens)



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 2022. There are 3 further possible losses in 2023 and 2024 be confirmed in 2025. There were no new recruits recorded in 2024.
- Biota entanglement has increased on sea fans from 27% in 2011 to 62% in 2024. *S. canicula* eggs were found on 10% of sea fans and *S. stellaris* eggs were recorded on 56% 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 covered was 12% in 2024.

- Necrosis was recorded on 62% of sea fans in 2024, of this 34% 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 2024 was recorded as 27%.

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 1 *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 (50cm x 40cm) are photographed using stereo or high definition digital SLR photography.

All other sites: photographs (mono) are taken using a 50cm x 70cm 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 5cm x 5cm grid and recording presence/absence of *A. glomeratum* within each grid square.

Photographs are analysed for presence of *A. glomeratum* and a frequency count is completed for each quadrat using a 5cm x 5cm grid (140 squares) for the 50cm x 70cm 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 had been recorded since 1982 within 3 quadrats, since 2006 the size of the colonies 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 2021within 2 quadrats, no colonies have been seen since 2021.

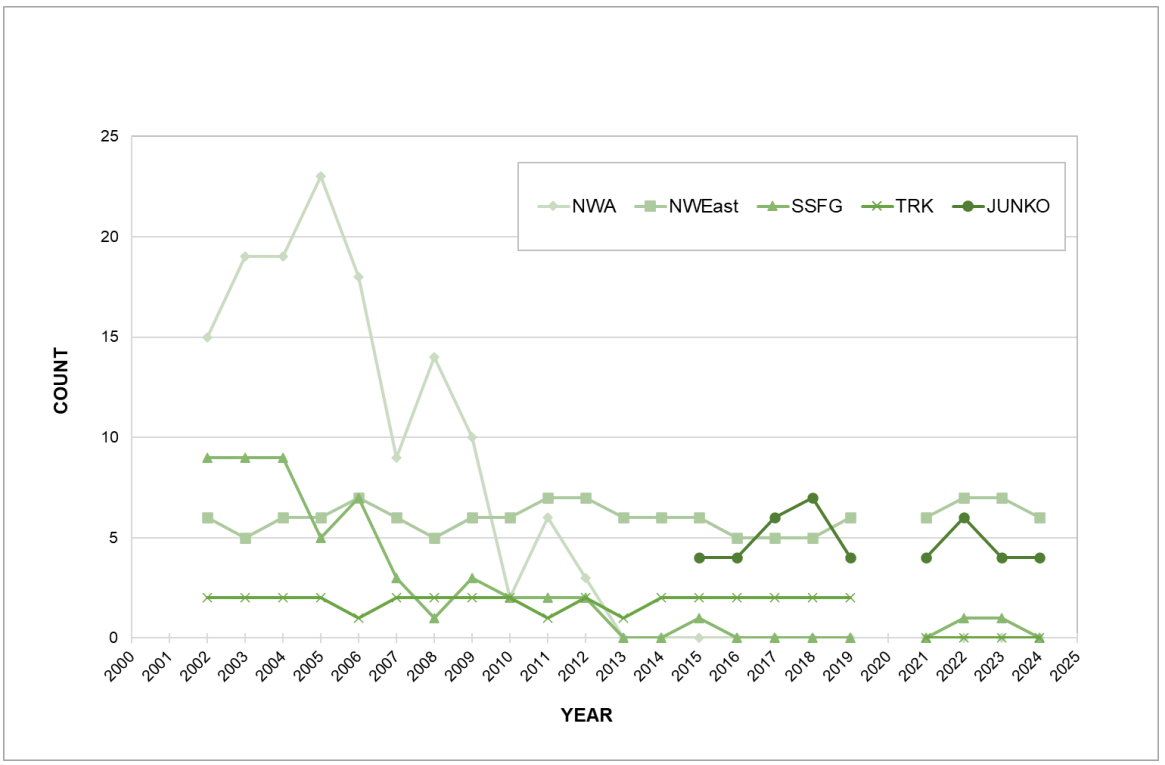
Sandy Sea Fan Gully: A small area of colonies that were first recorded in 2002 on a vertical wall alongside *Parazoanthus axinellae*. It was recorded in 7 quadrats but slowly reduced in area to only 2 from 2008 and none since 2013, a very small colony has been found a few times since then including in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

North Wall East: A healthy colony area has been recorded since 2002 with 7 quadrats. This has stayed healthy with 6 quadrats recorded in 2024.

Junko’s Reef: A healthy colony area has been recorded since 2015 with 4 quadrats, this has stayed health with 4 quadrats recorded in 2024.

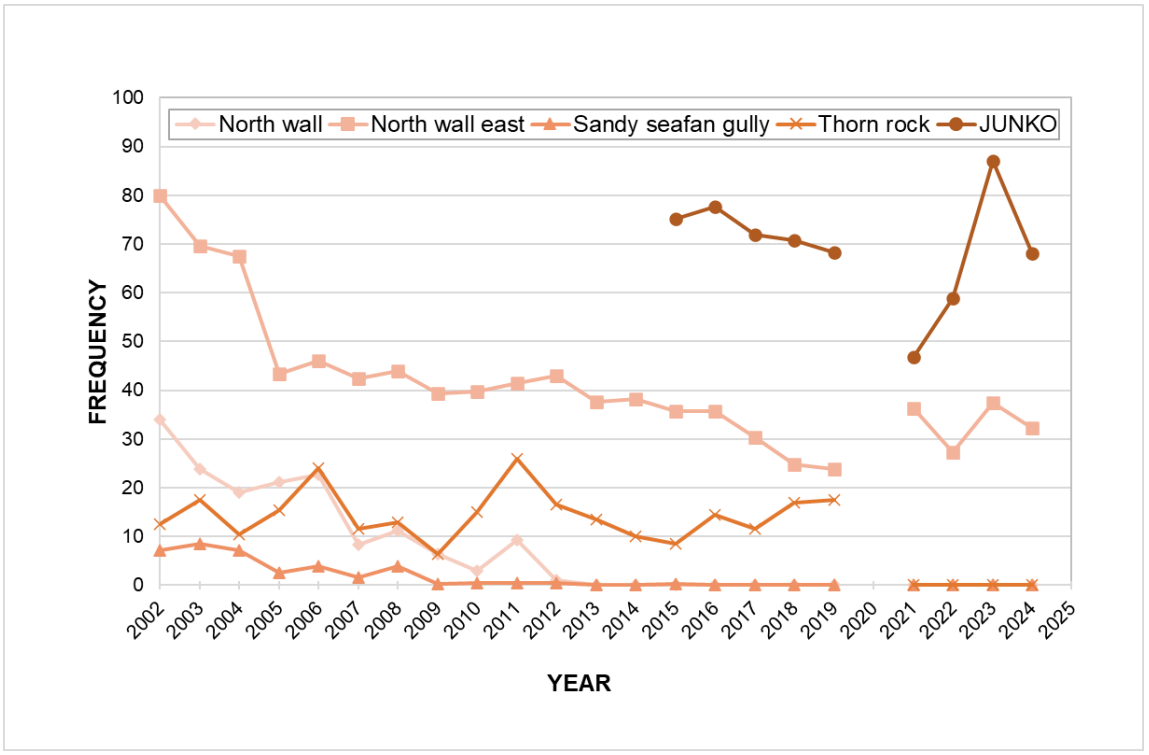
The number of quadrats with *A. glomeratum* recorded at North Wall (main), North Wall East, Sandy Sea Fan Gully, Thorn Rock and Junko’s Reef sites from 2002 to 2024 is shown in Figure 4.4.1.

Figure 1.4.1 Number of quadrats with *A. glomeratum* present at Skomer MCZ sites 2002 – 2024: 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 from 2002 to 2024 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 – 2024

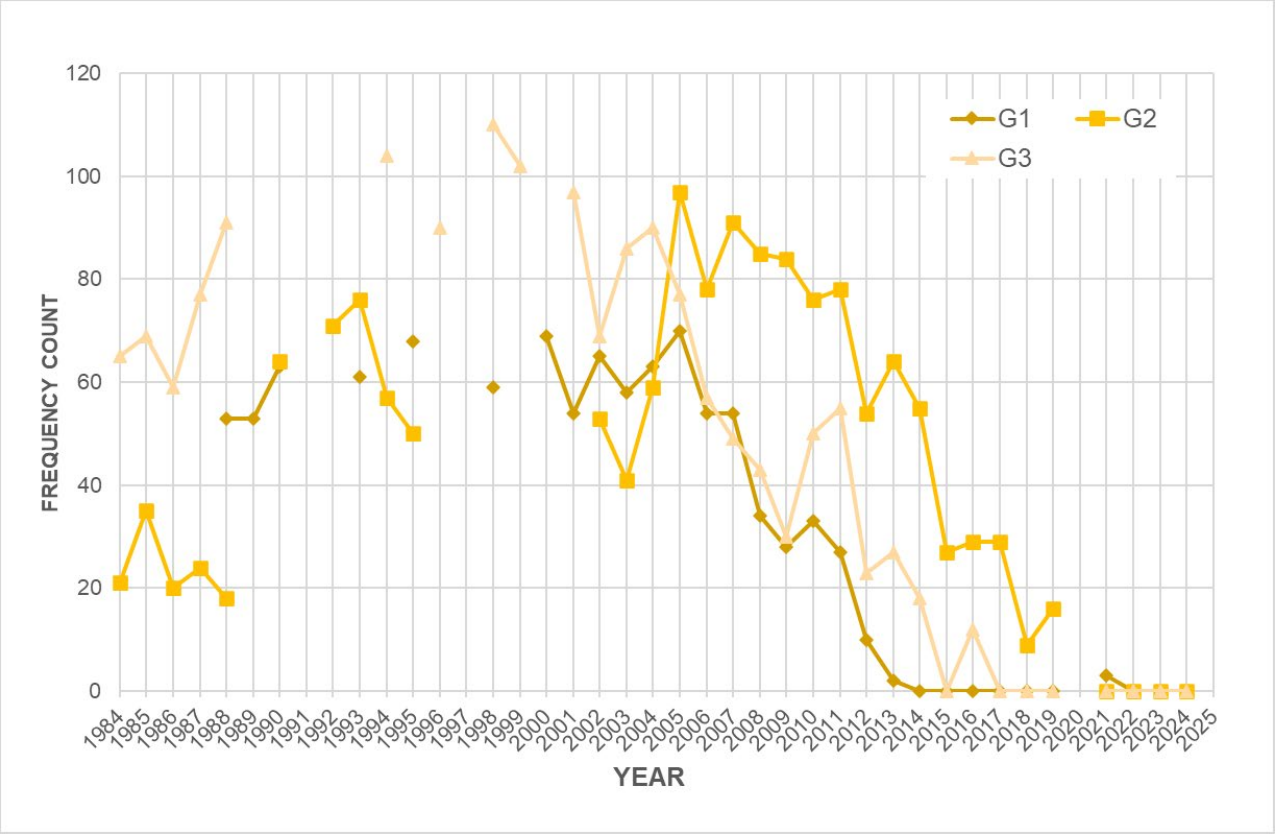


.

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 4cm squares) then presence counted for each square (Figure 4.4.3).

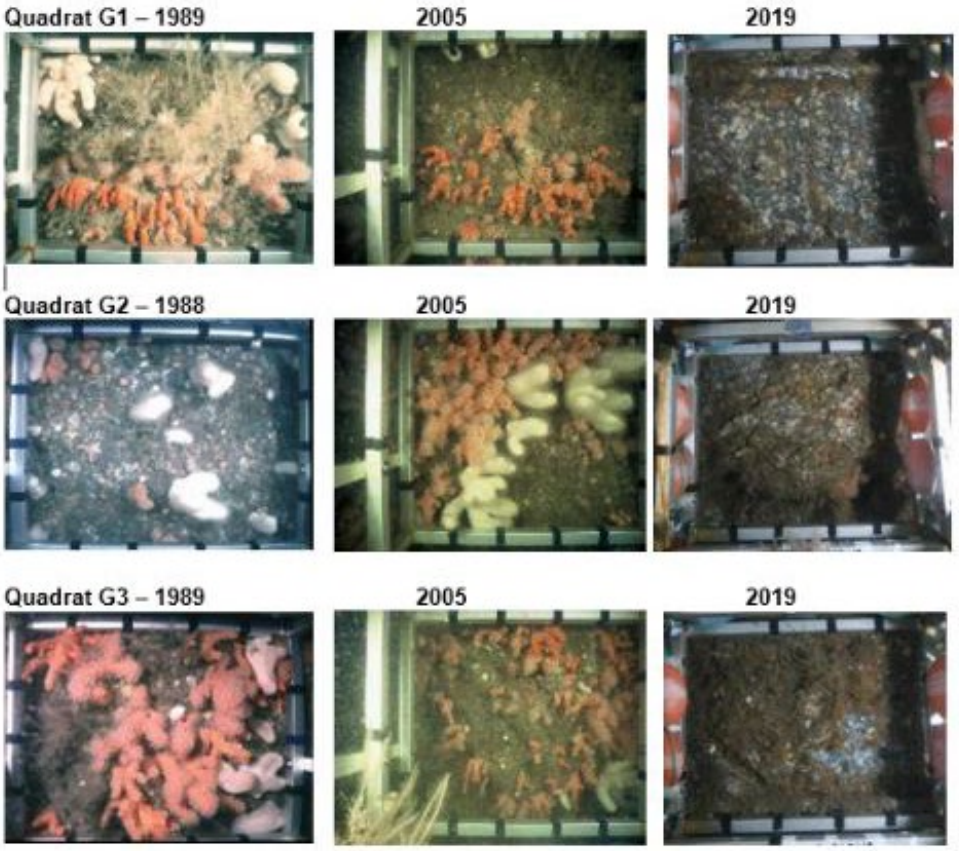
Figure 4.4.3 Frequency count (120 squares) of presence of *A. glomeratum* in 3 quadrats at the North Wall 1984 to 2024. (G1 – Quadrat 1, G2 – Quadrat 2, G3 – Quadrat 3)



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

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.

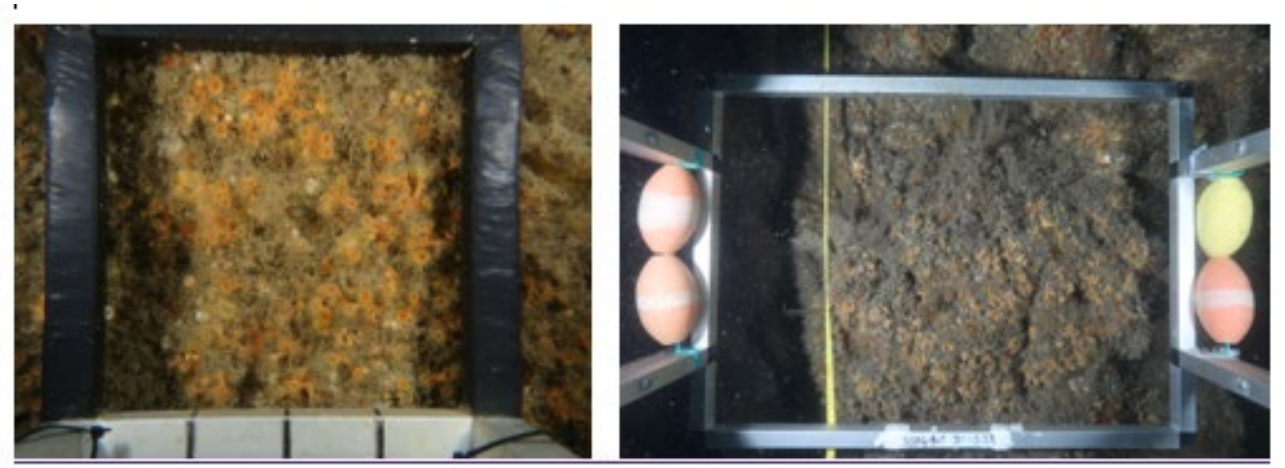
Site	Survey Start Year
Sandy Sea Fan Gully	2002
Sandy Sea Fan Gully Buttress	2015
Thorn Rock (3 colonies)	2002
Way Bench (2 colonies)	2002

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 50cm x 70cm framer. In 2008 a digital SLR camera replaced the film camera providing high quality images allowing improved photo analysis. The images are analysed by overlaying a 5cm x 5cm grid and recording presence/absence of *P. axinellae* within the grid squares to provide frequency counts (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

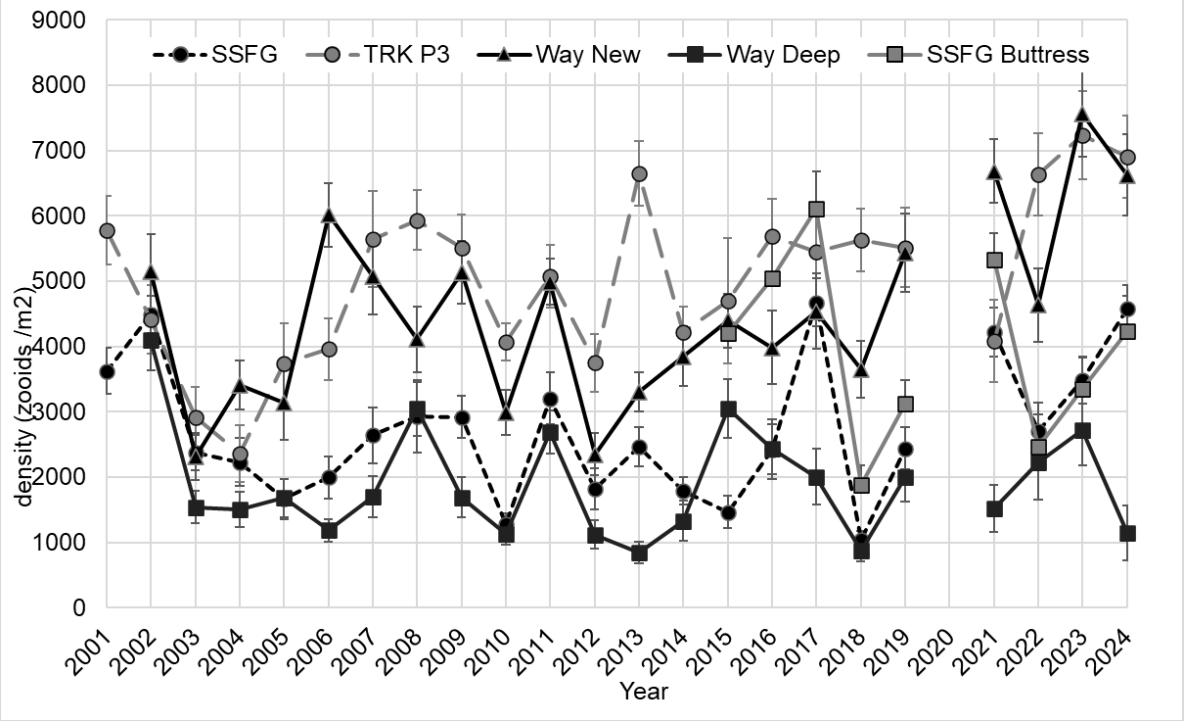
The fieldwork completed in 2024 is shown in Table 4.5.2.

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 4.5.2).

Figure 4.5.2 Mean density of *P. axinellae* (number of polyps /m^2) at five Skomer MCZ sites 2001 – 2024 with standard error bars.



The frequency of *P. axinellae* at all sites has shown fluctuations year to year, but overall show a stable population. The mean frequency of *P.axinellae* at Thorn Rock and Sandy Seafan Gully transects showed an increase from 2023 to 2024 (Figures 4.5.3 and 4.5.4).

Figure 4.5.3 Mean frequency of *Parazoanthus axinellae* 2002 – 2023. Thorn Rock (TRK) transects.

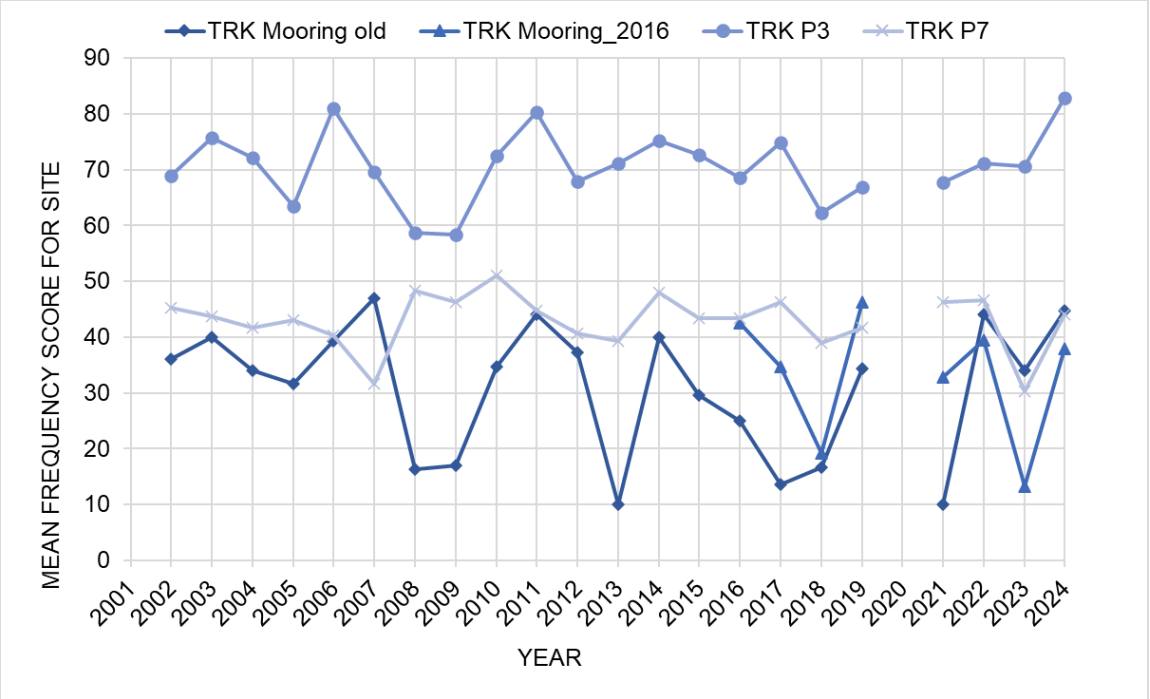
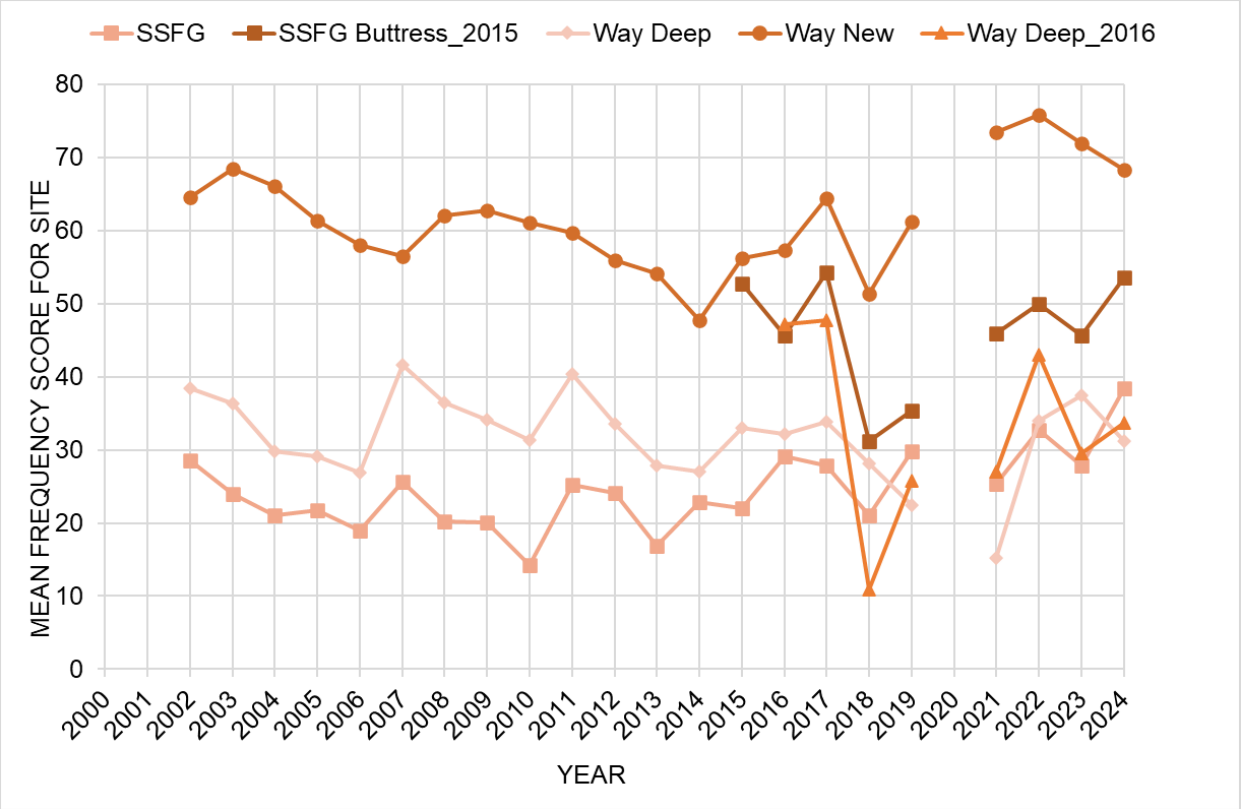


Figure 4.5.4 Mean frequency of *Parazoanthus axinellae* 2002 – 2024. Waybench and Sandy Sea Fan Gully transects.



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 2024.

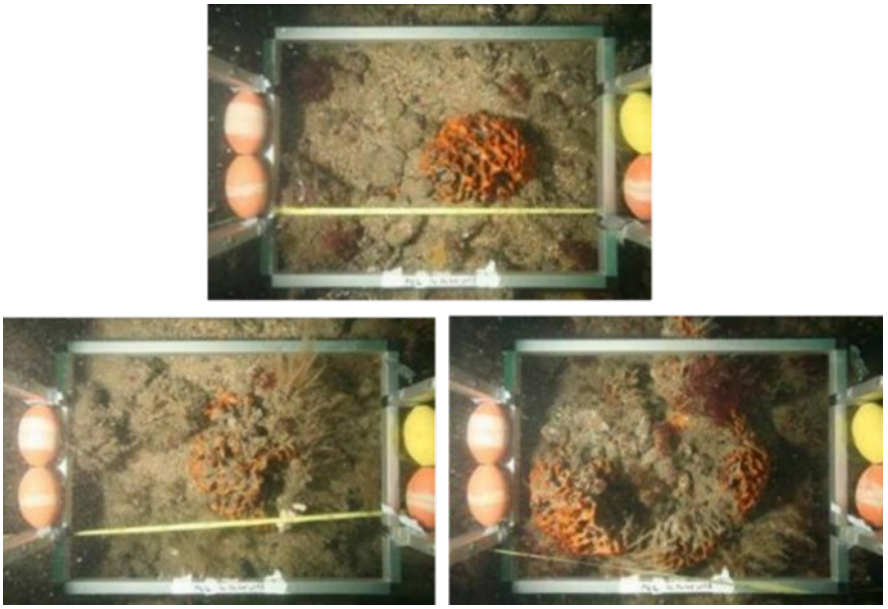
Site	Substrata	dataset
North of the Neck	ground ropes	2002 - onwards
North wall	rock and boulders	1984 – 2002
Way bench	rock and boulders	1993/4 restarted 2002 -onwards
Bernie's Rocks	boulders	1995 onwards
South Middleholm	rock	2003 - onwards
West Hook	rock	2004 - onwards
Pool	boulders	2013 - onwards
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 50cm x 70cm 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

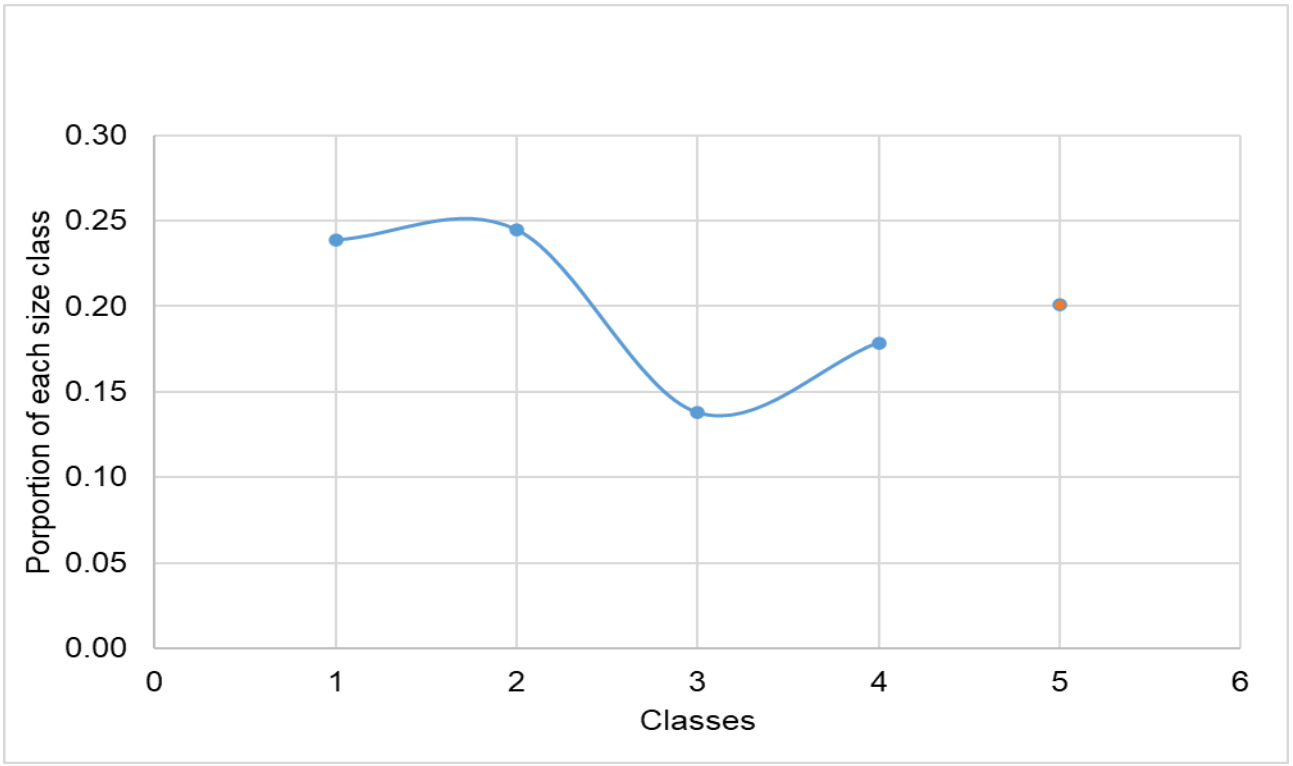
Photo datasets collected each year for each survey sites are shown in Table 4.6.2.

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
2024	no	yes	yes	yes	no	yes	yes	yes	yes

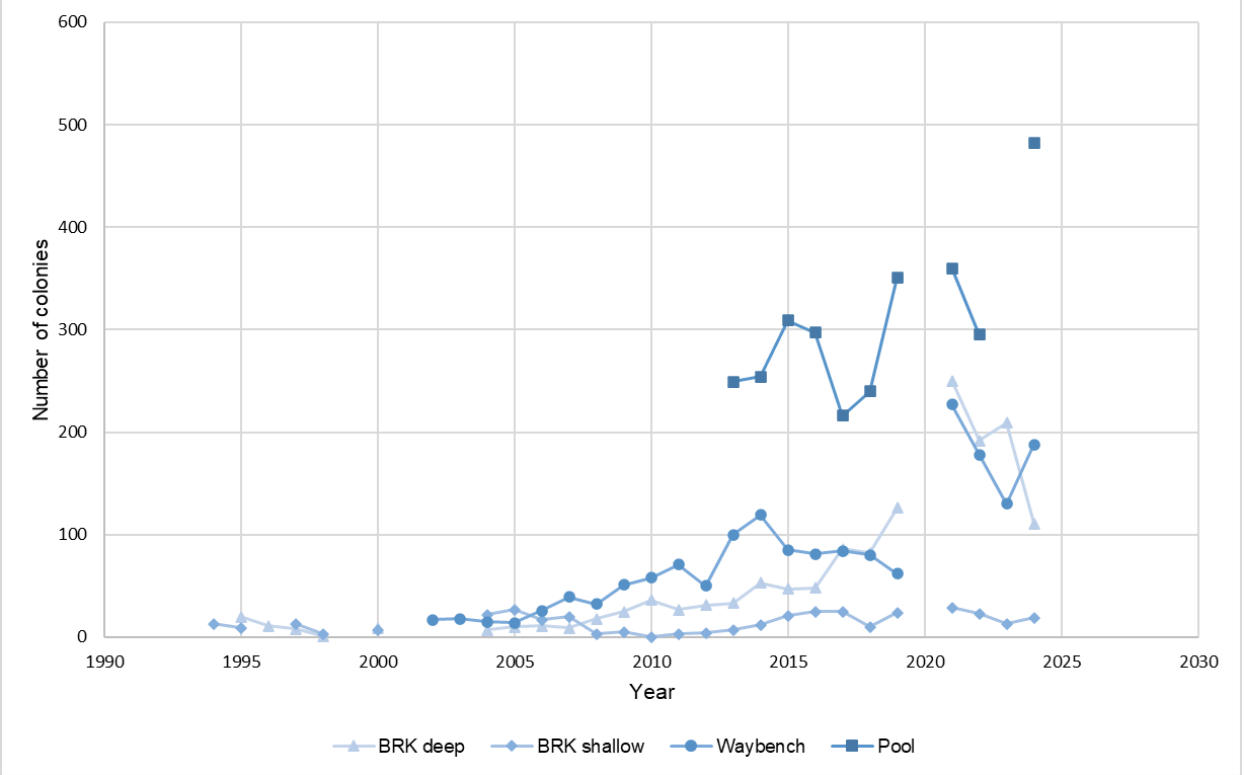
The normalised population curve in Figure 4.6.2 shows the proportions of each size class (1-4) across all Skomer sites and gives an overall pattern of size-class distribution. Class 5 is not connected via the curve as it is not a continuum from class 4 but is related to degradation which can develop 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, Bernies Rock and Martins Haven east are the largest sites surveyed, the total number of colonies (all classes) recorded in each survey year is shown in Figure 4.6.3. 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 2024 and increase in numbers were recorded at the Pool and a drop in numbers at Bernies rock deep site. Waybench numbers continued 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, Bernies Rock shallow and deep sites



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 occasionally 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. Numbers dropped in 2022 to 178 and to 130 colonies in 2023 but increased up to 188 in 2024 (Figure 4.6.3) of which 40% were class 5.

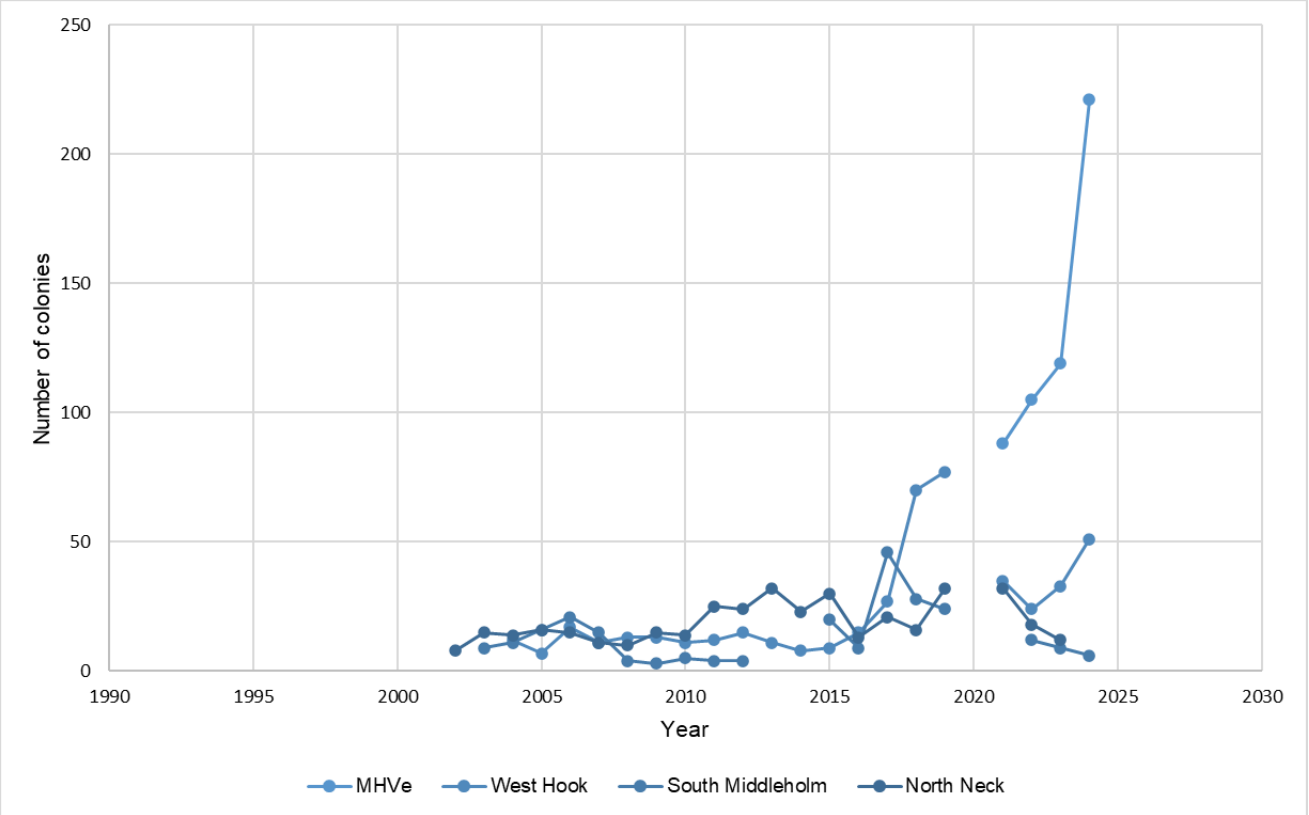
Bernie's Rock is located on the north side of the island. There is a shallow site and a deep site, both consisting of boulder substrate. The number of colonies has varied at both sites year by year, with some years having no colonies present. All classes of colonies are found with many developing into a class 4, before progressing to a class 5. In 2024, 19 colonies were recorded at the shallow site, similar to previous years (Figure 4.6.3). 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 but this dropped to 111 colonies in 2024 (Figure 4.6.3).

The Pool monitoring was started in 2013, located on the north side of Skomer. The site is a boulder slope from 10m down to 22m below chart datum. A large area is surveyed, and large numbers of colonies are found with an even spread of classes present. Between 2013 and 2018, total numbers fluctuated between 216 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 4.6.3), there

was no survey in 2023 but it was completed in 2024 with a record high of 482 colonies recorded of these 56% were the small 1 and 2 size classes showing good recruitment. It will be interesting to see if these small colonies grow to larger sizes.

North Neck, South Middleholm, West Hook represent sites with small survey sites.

Figure 4.6.4 Total number of *Pentapora foliacea* colonies (all classes) recorded each year surveyed at Martins Haven east (MHVe), South Middleholm, West Hook and North Neck sites.



Martins Haven East is a small bedrock site located on the North Marloes Peninsula established as a survey site in 2021. Many of the colonies seem to grow flat across the rocks rather than in a dome, therefore there are high numbers of 1and 2 size classes as only a few form the larger 3 and 4 size classes Angling line is regularly found wrapped around several colonies, a consequence of being located below a popular angling shore site. In 2021 88 colonies were recorded this increased to 105 in 2022, 119 in 2023 and 221 in 2024 (Figure 4.6.4).

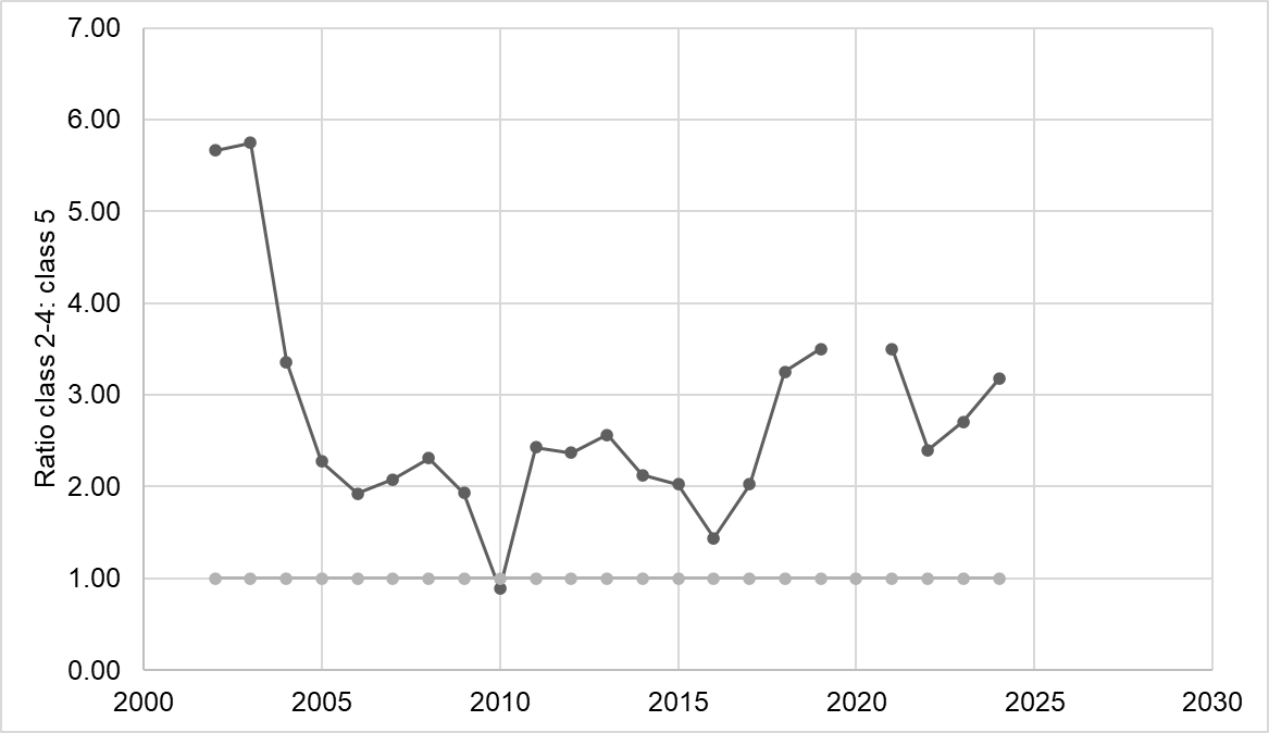
North Neck is unusual as colonies are growing on ground ropes laid upon a mixed sediment seabed. Movement of the ropes due to wave and current action restricts growth of most of the colonies to class 1 and 2. Some individuals grow to class 3 but there are no class 4 individuals. Generally low numbers are recorded (Figure 4.6.4). North of the Neck was not surveyed in 2024.

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. The numbers have ranged between 3 to 46 colonies, only 6 colonies were recorded in 2024 (Figure 4.6.4) all were size classes 1 and 2.

West Hook is a small bedrock site located on the North Marloes Peninsula, most colonies reach class 4 before developing into class 5. It was first established and surveyed in 2004. In 2024 51 colonies were recorded (Figure 4.6.4).

The ratio between class 2-4 and class 5 colonies at all sites between 2002 and 2024 is shown in Figure 4.6.5. 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 4.6.5), therefore there are more healthy growing colonies than degraded colonies.

Figure 4.6.5 *Pentapora foliacea* - ratio of class 2-4 colonies to class 5 colonies - all Skomer sites.



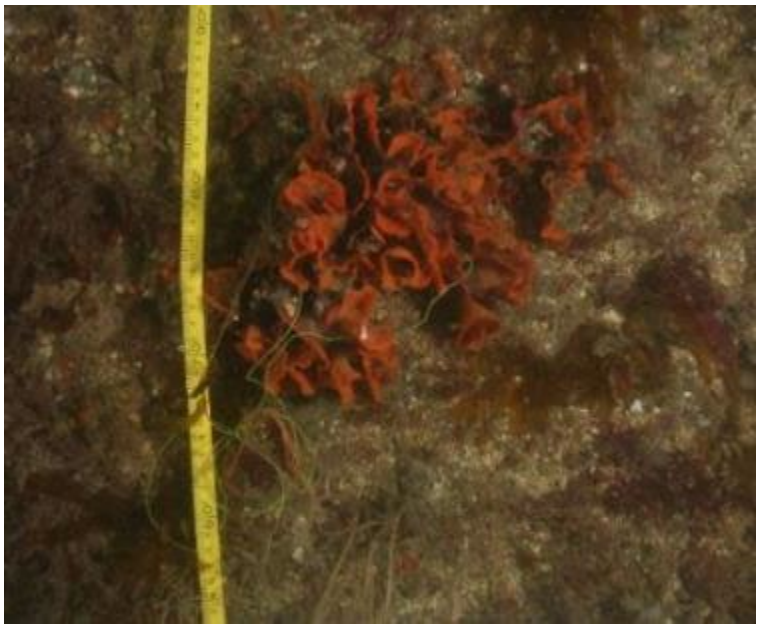
The current dataset forms an important baseline for Skomer sites. However, it needs to be remembered that all sites are currently subject to anthropogenic activities including pot fishing, angling and recreational diving, which all have the potential to harm *P. foliacea* colonies.

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 4.6.6).

Figure 4.6.6 *Pentapora foliacea* – interaction with fishing gear.

Evidence of damage from angling line has also been observed. Line has been found tangled in *P. foliacea* at the new Martins Haven east survey site in each year it has been surveyed (2021-2024) as shown in Figure 4.6.7. This location is popular for shore angling.

Figure 4.6.7 *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. In 2024 numbers of colonies at Waybench and Bernies Rock still remain high compared to previous years and at Pool a record high was recorded. Martins Haven east site first surveyed in 2021 has seen an increase in numbers of colonies each year.
- In most years of recording there has been a higher number of intact and growing colonies (Classes 2-4) compared to “degraded” (Class 5) 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 'Rock Mill' 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 50cm x 40cm 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 50cm x 40cm framer was used up until 2008 when it was replaced with a larger 50cm x 70cm framer using a digital SLR camera.
3. Counts are carried out using image analysis techniques described in Burton *et al.* (2002).

Caryophyllia smithii

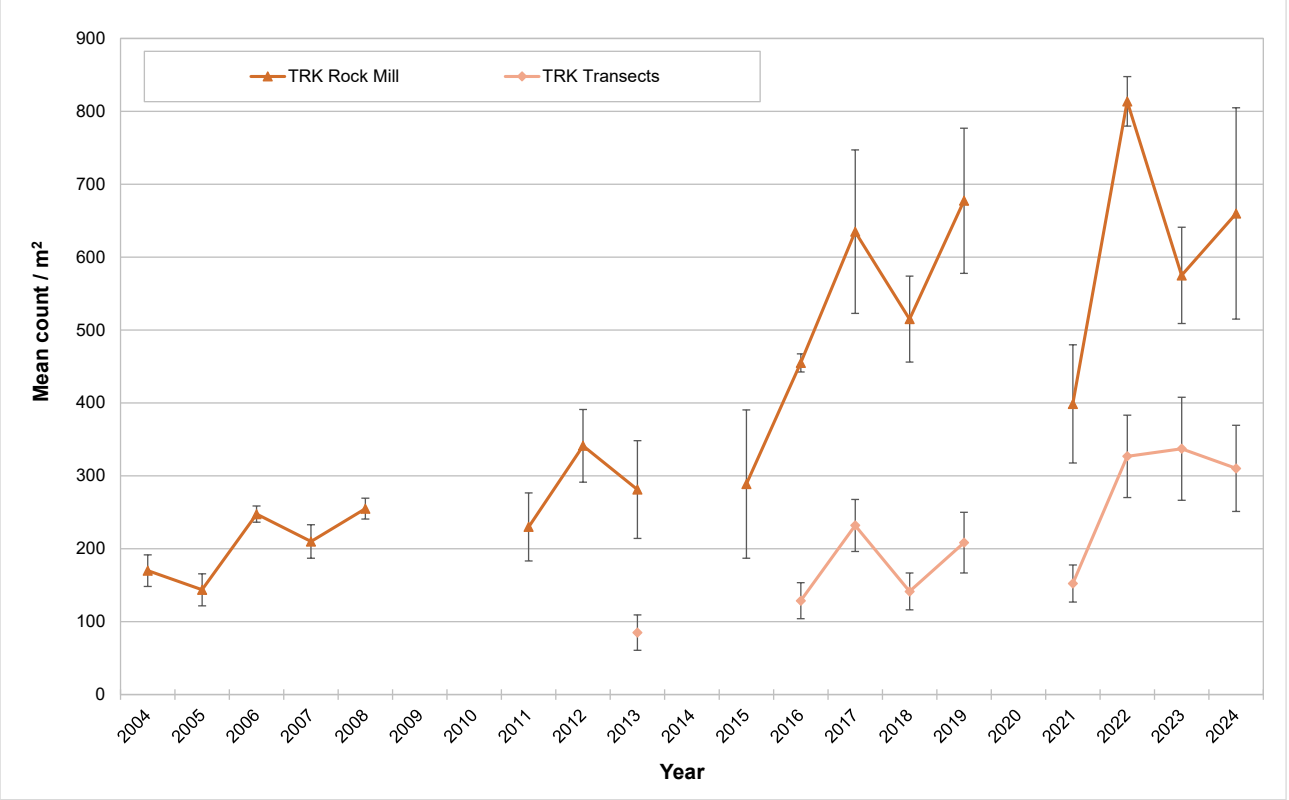
Approximately 70 quadrats have been analysed on an annual basis since 1993 from photographs taken for the sponge community project at Thorn Rock. Photographs are taken using a 50cm x 70cm framer using a digital SLR camera and counts are carried out using image analysis techniques described in Burton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

4.7.5. Results

Balanophyllia regia

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

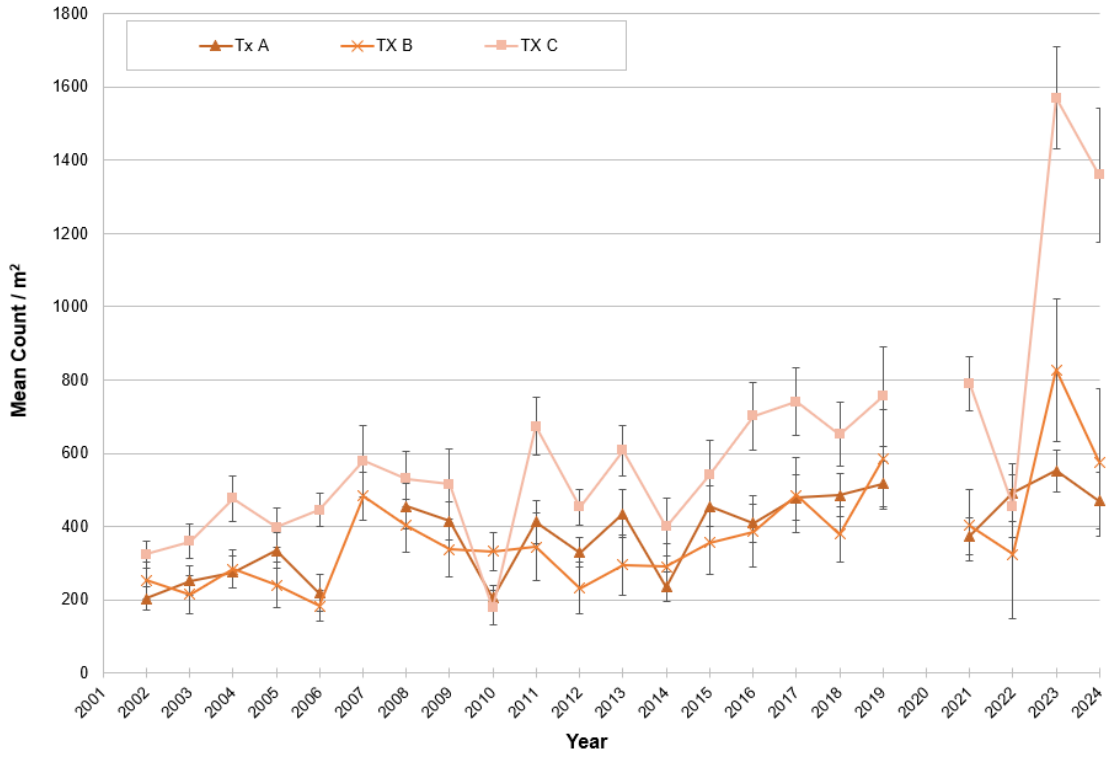
Figure 4.7.1 Mean abundance per m^2 (and standard error) of *Balanophyllia* regia at Rock Mill and Thorn Rock Transects (counted within 50cm x 40cm framers).



The average count/m^2 of *B. regia* has fluctuated at the Rock Mill, 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 Rock Mill. Further data are needed to monitor trends.

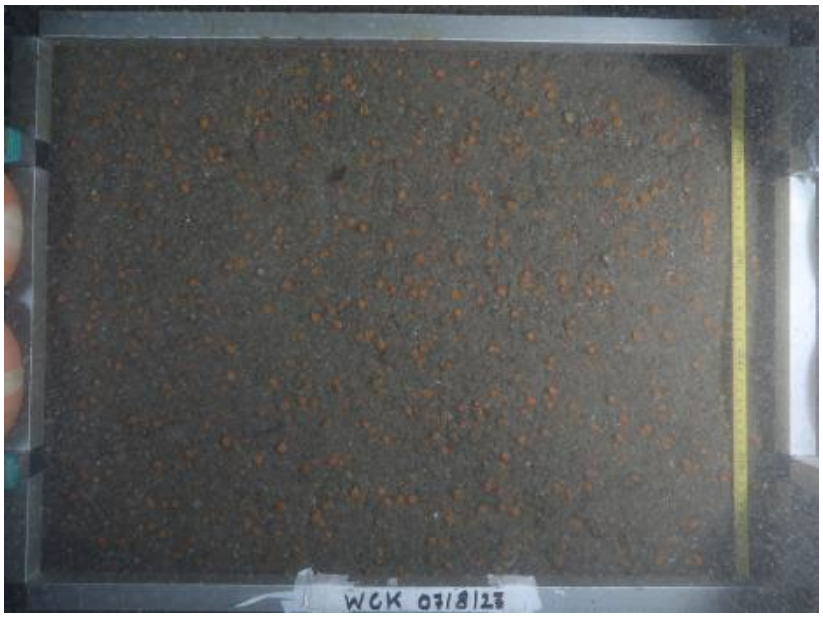
At the Wick, all data have been standardised to abundance per 1m^2 to enable comparison between the 50cm x 40cm and the 50cm x 70cm framers (Figure 4.7.2).

Figure 4.7.2 Mean abundance per m^2 (and standard error) of *Balanophyllia regia* at Transects A, B and C at The Wick, counted within 50cm x 40cm framers (pre-2008) and 50cm x 70cm 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 50cm x 70cm framer (2631/m^2) (Figure 4.7.3). Transect C continued to have high density counts in 2024.

Figure 4.7.3 *Balanophyllia regia* (individuals 921) in a 50cm x 70cm framer at the Wick, representing a density of 2631/m^2.



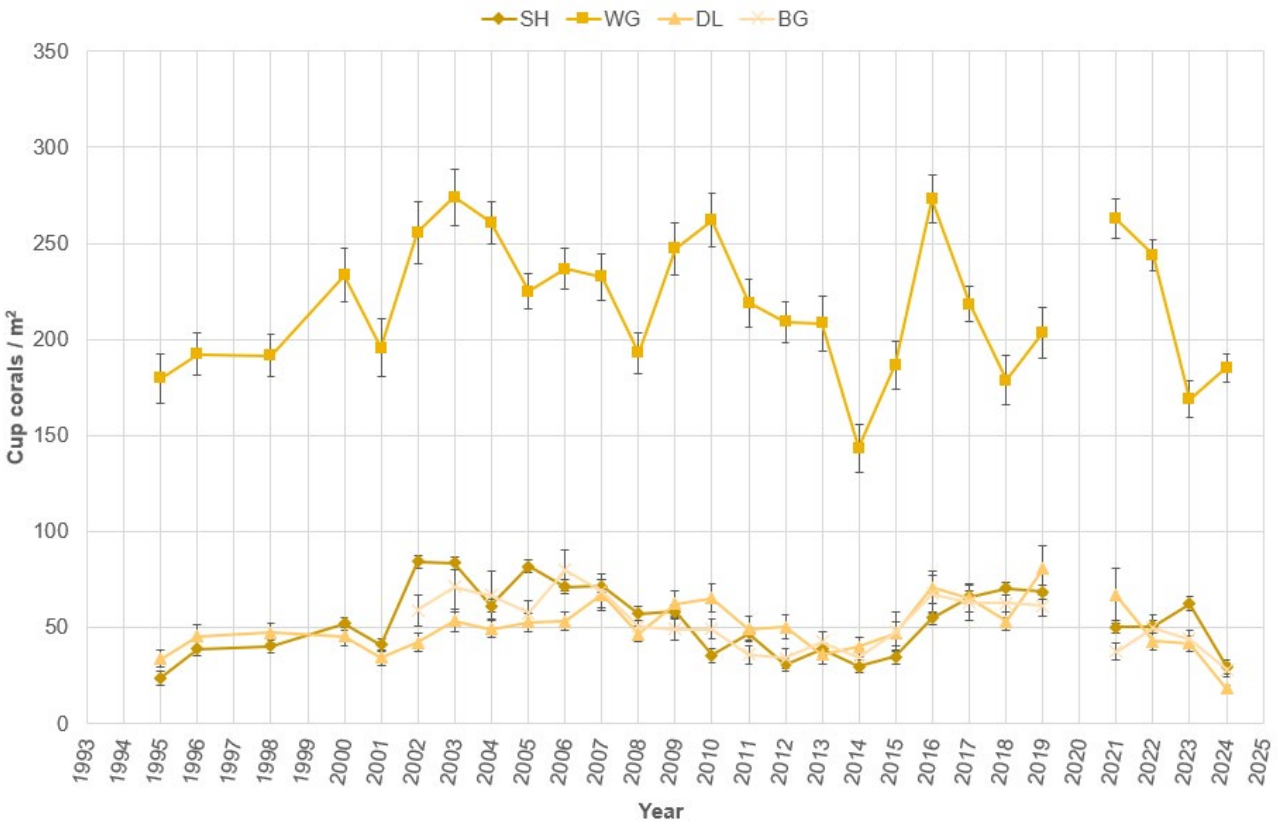
Caryophyllia smithii

The average density of *C. smithii* has fluctuated at each of the Thorn Rock sites (Figure 4.7.4). 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 4.7.4 Mean Number of *Caryophyllia smithii* /m^2 quadrat at Thorn Rock (4 transects) 1995 – 2024.



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 Habitats Regulations (2017) and are 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 island, 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).

2024 Elin Down, a student at Swansea University completed analysis on seal pup survival assessments for Marloes Peninsula data (Down – in preparation).

4.8.6. Results

In 2024 the Skomer island seal survey work was not contracted due to cuts in NRW funding. South and West Wales Wildlife Trust Skomer Island staff reviewed the survey methods to test a scaled down methodology using cliff top views only (beach and cave access stopped). It was established that cliff top recording could be completed at: North Haven, South Haven, Driftwood Bay, Matthews Wick, Castle Bay, South Stream Cave, High Cliff Boulders, The Wick. These sites represent 84% of pup production on Skomer in 2023.

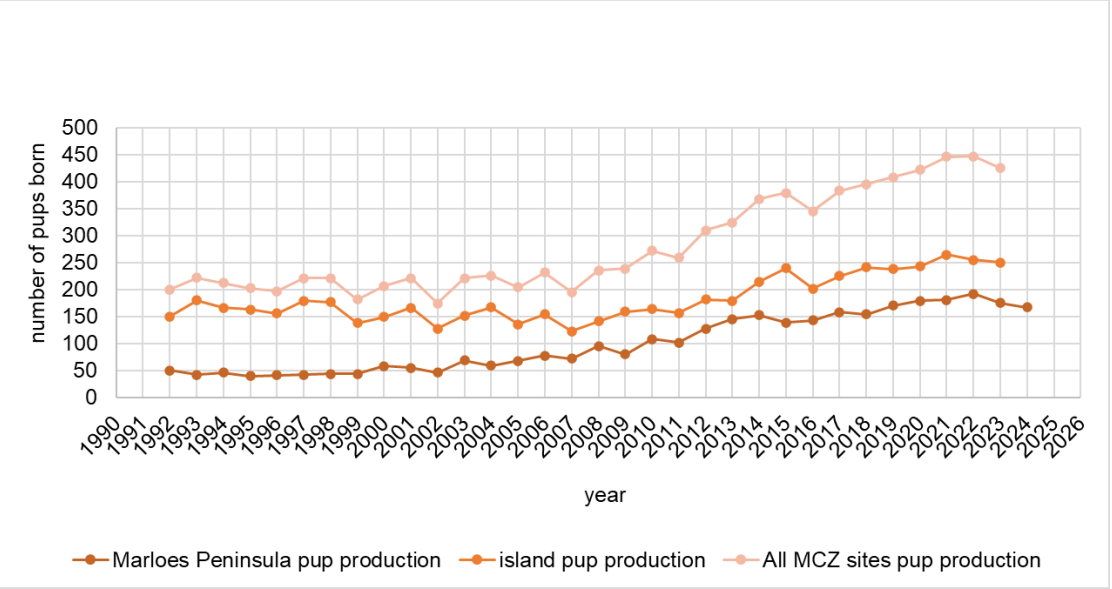
Skomer Island staff with assistance by a Swansea University placement student completed pup production counts every three days during the busy season and weekly as pup numbers reduced from 6th August to 26th October. At each visit two categories of pup counts were made: pups born in last three days and total number of pups, the records have been stored on a spreadsheet. Due to the method changes it was not possible assess survival rates.

The Marloes Peninsula survey was completed at all sites by Skomer MCZ staff.

Pup production

In 2024 167 pups were recorded at Marloes Peninsula sites, this is a slight drop from that recorded in the last 5 years but remains within expected natural fluctuations. Since 2009 there has been a steady increase in pup production at both the island and Marloes Peninsula sites (Figure 4.8.1). In 2024 results from Skomer island sites are unavailable so a total for the Skomer MCZ is not possible.

Figure 4.8.1 Skomer MCZ pup production 1992 - 2024.

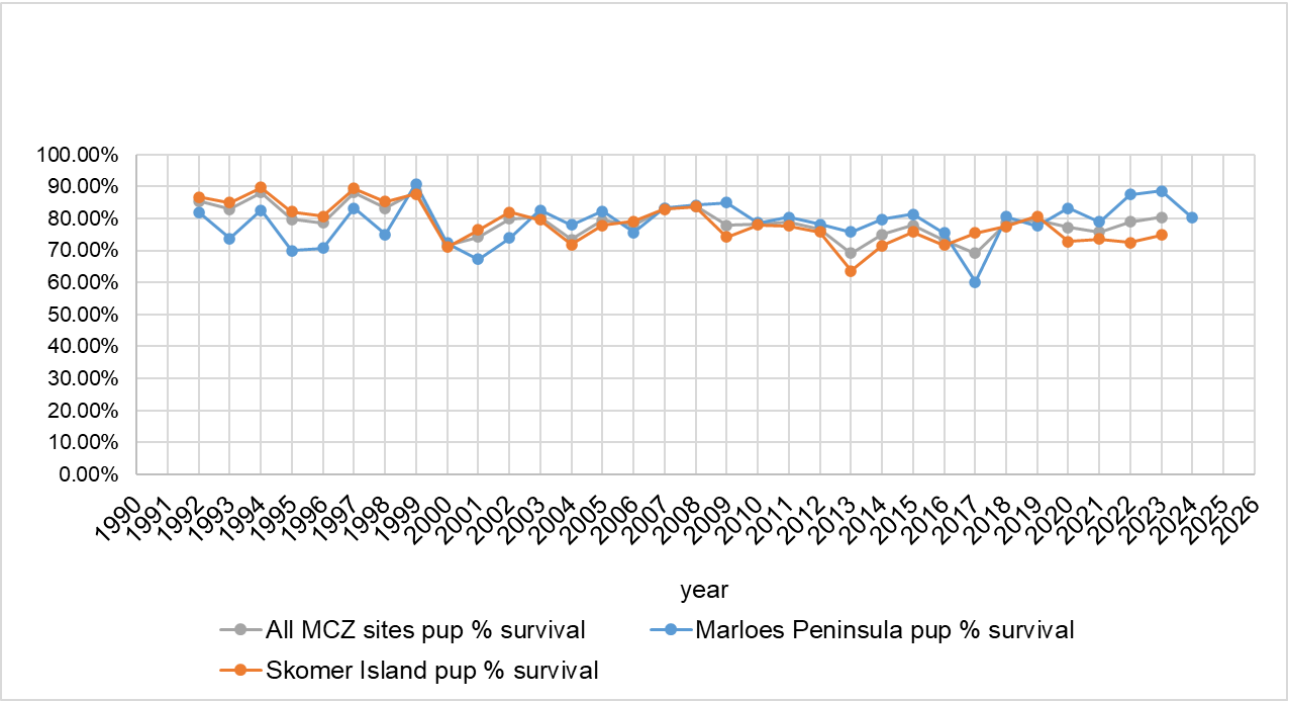


Pup survival

In 2023, pup survival through to moult was recorded as 80% for Marloes Peninsula sites. In 2024 results from Skomer island sites are unavailable so a total for the Skomer MCZ is not possible.

In the Skomer MCZ, pup survival from 1992 to 2024 has fluctuated between 69% and 88%, with an average of 79% (Figure 4.8.2).

Figure 4.8.2 Skomer MCZ pup survival 1992 – 2023.



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. Pups seen alive but subsequently recorded dead.

Assumed mortality. These include pups assessed not to have survived following the survival assessment in Table 4.8.1.

Table 4.8.1 Seal pup survival assessment method

Class	Condition score	Size	Assessment	Pup survival outcome
I	1	Very small	Success not likely	assume not survived
II	2	Small but healthy	In good condition, reasonable chance of success	Subjective assume not survived or survived depending on circumstance.
III/IV/V	3	Good size	Most should be successful	Assumed or known to survive
III/IV/V	4	Very good size	All should be successful	known to survive
III/IV/V	5	Super moulter	All should be successful	known to survive

Pollution and Litter

Monofilament line and netting were the most visible pollutants affecting seals. Figures are not available for 2024 but 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 2024, however large quantities of beach rubbish including fishing ropes, netting, and bag loads of plastic debris are collected and cleared when possible from seal pupping beaches Skomer Island Wardens, the Skomer MCZ team and volunteers.

Seal disturbance

In 2024, fourteen small incidents were recorded, and boats were observed within the voluntary seal exclusion zones.

4.8.7 Supported research

In 2024 Elin Down, Swansea University completed an undergraduate project titled "What is the reliability of survival estimates as a tool for understanding grey seal pup mortality on the Marloes Peninsula?"

This study investigates the survival of grey seal pups on the Marloes Peninsula, Pembrokeshire, over a 30-year period (1993-2023). The main focus of the study was to

conclude the reliability of survival estimates as a measure for understanding grey seal pup survival. Data collected from 13 main pupping sites were analysed to assess annual survival rates and variability across sites. Survival rates were tested under three different assumptions: (AS1) only pups reaching age class 5 were assumed to survive, (AS2) pups reaching age class 4+ were assumed survived, and (AS3) pups reaching age class 3+ were assumed to survive. Results show overall high annual survival rates during the survey period, ranging from 0.8-1. Site-specific variability was observed, with stable survival rates at sites such as Pebbly Beach and Jeffry's Haven. Greater fluctuations in survival was observed at sites such as Boulder Beach, Victoria Bay and Watery Bay. Statistical analysis revealed a significant difference in survival across the three assumptions, suggesting that current survey methods may overestimate pup survival. The findings highlight possible improved future survey methods, including the use of aerial surveys and advanced statistical techniques, to more accurately assess grey seal pup survival and monitor the health of the Marloes Peninsula population.

4.8.8. Current Status

- In 2024 an assessment of the current status on pup production and survival for the Skomer MCZ is not possible as the survey was not completed for Skomer island sites.
- 167 pups were recorded at Marloes Peninsula sites, this is a slight drop from that recorded in the last 5 years but remains within expected natural fluctuations. Pup survival was 80%.
- Grey seals at Skomer MCZ are considered to be in favourable condition based on survey results over the last 10 years.

4.8.9. 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 Habitats Regulations (2017) 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.

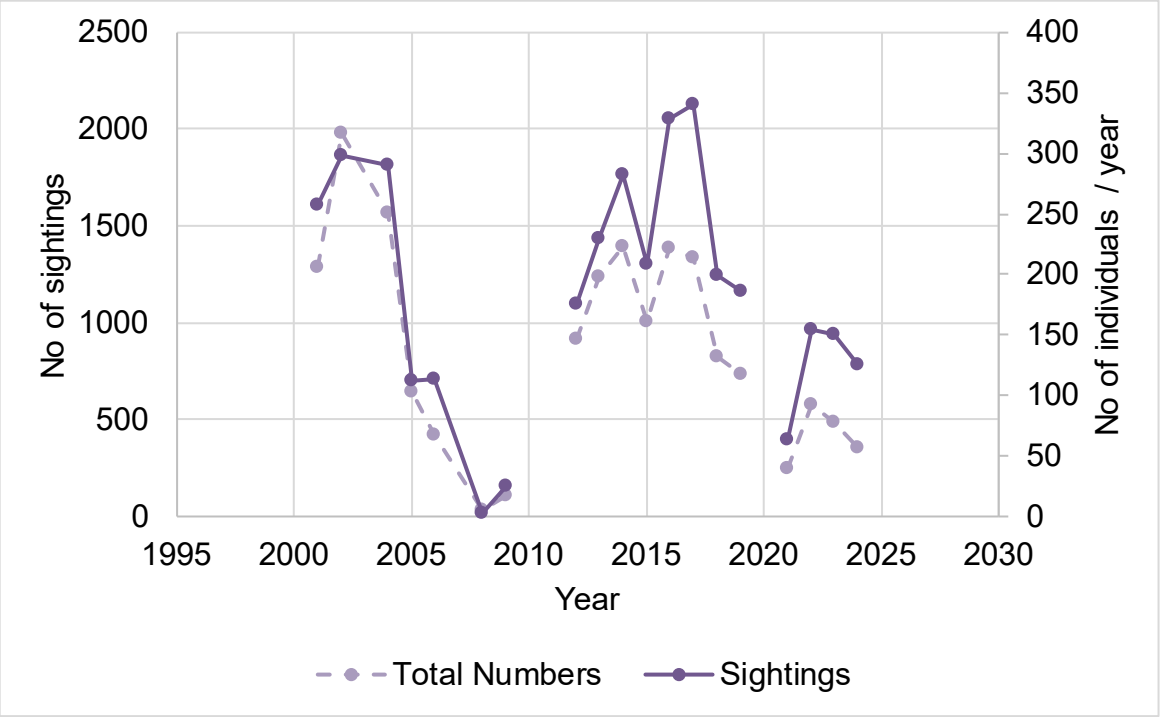
4.9.4. Results

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 2024. 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 – 2024. No recording occurred in 2010, 2011 and 2020.

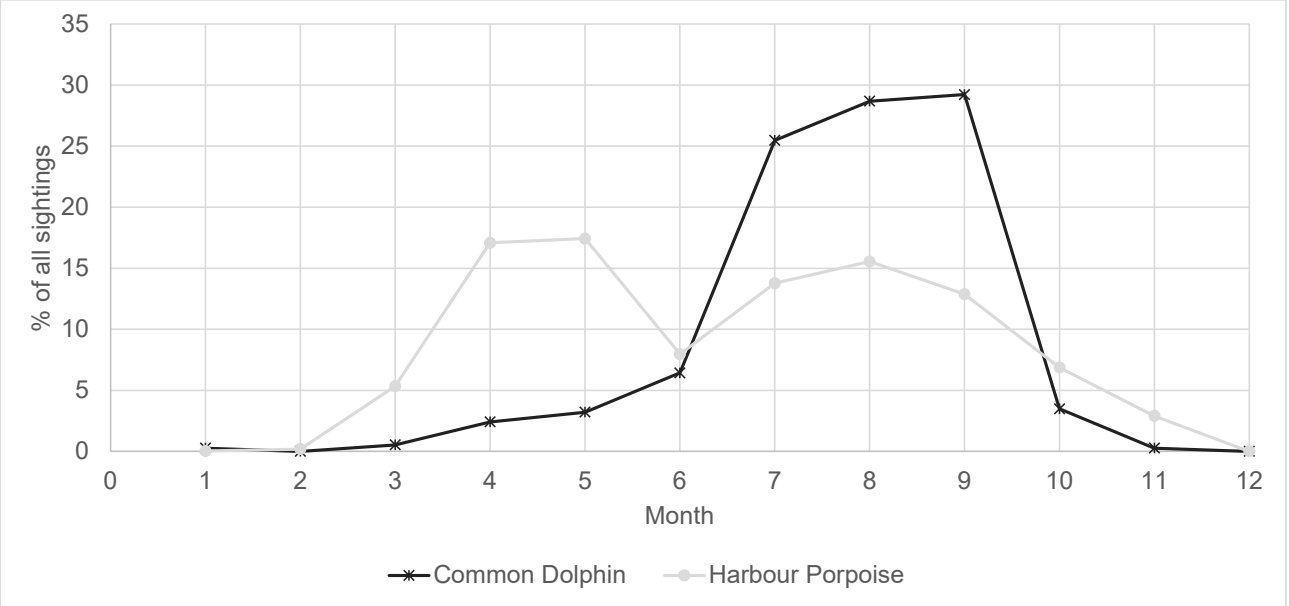


A “sighting” refers to a single event when one or more cetacean is recorded from a specific location. “Total numbers” is the sum of all the counts of a specific cetacean species for the whole year.

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.

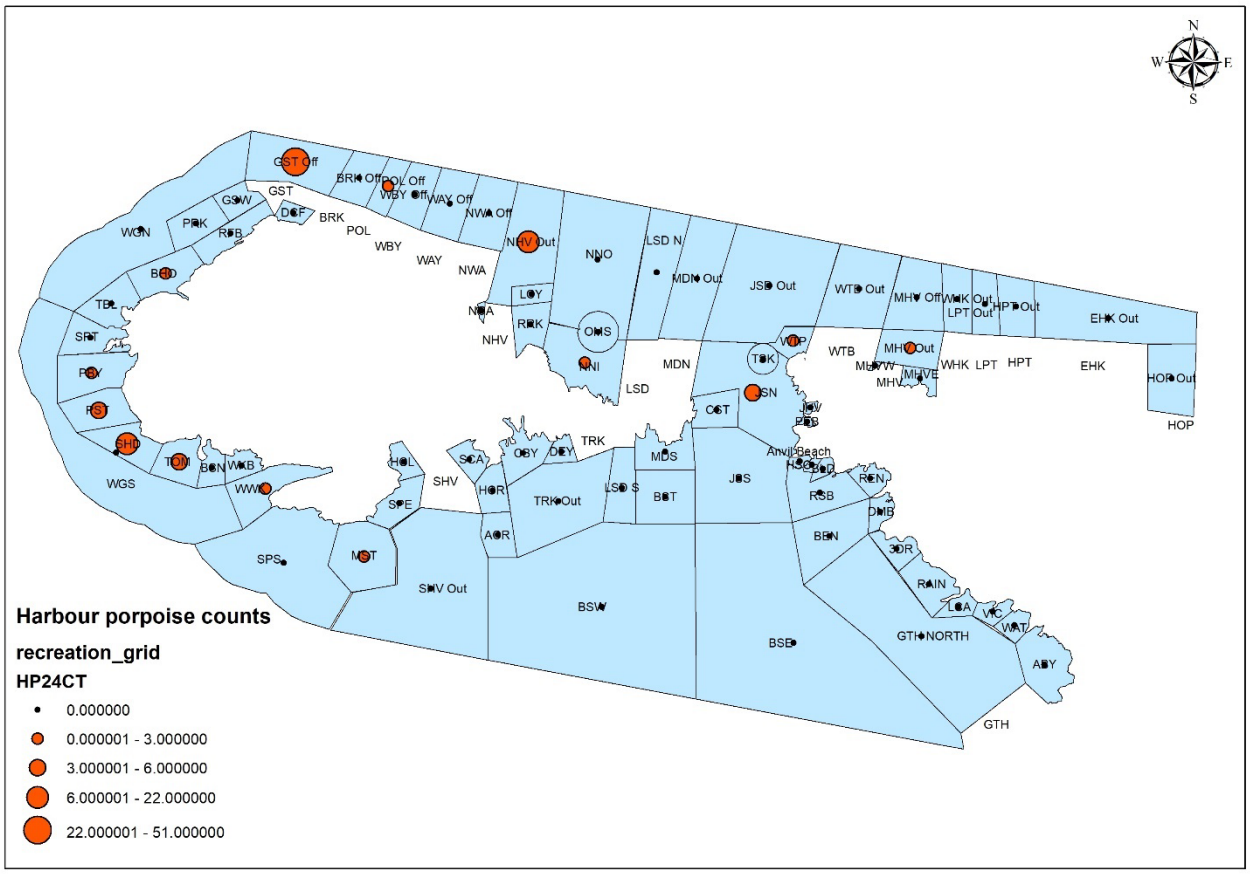
Harbour porpoise are sighted throughout the whole year and are assumed to be resident or regular users within the MCZ. Common Dolphins are predominantly seen from July to September as shown in Figure 4.9.2.

Figure 2.2 Percentage of sightings per month 2001 to 2024 Harbour porpoise and Common dolphin.



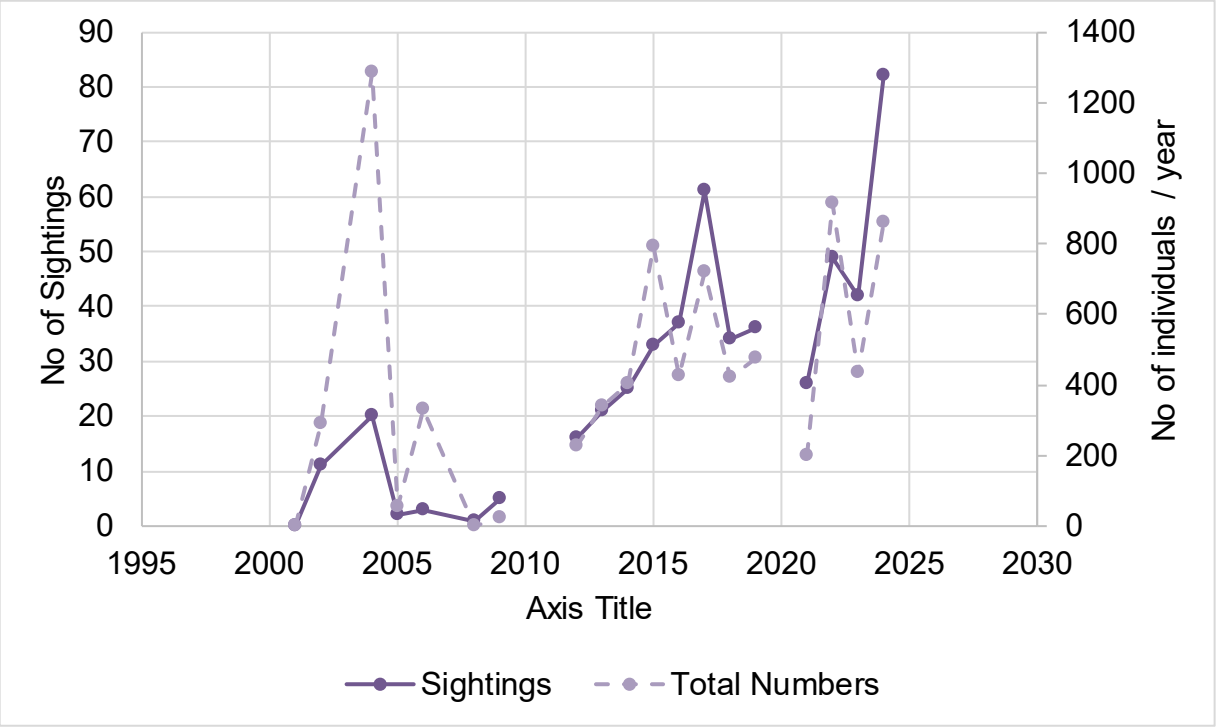
There are hot spots of sightings around the MCZ. The tidal races off the Garland Stone and Skomer Head are popular spots to see Harbour Porpoise (see Figure 4.9.3).

Figure 4.9.3 Harbour porpoise sightings and distribution Skomer MCZ 2024.



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 from 2022 onwards the number of sightings and total numbers seen have increased.

Figure 4.9.4 Common dolphin sightings within Skomer MCZ 2001 to 2024.



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 individuals were sighted off the Garland Stone in 2024.

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. There were no sightings within the MCZ of Risso's Dolphin in 2024.

A single sighting of a Minke Whale was recorded off Skomer Head in 2024.

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. This 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. Algal Communities

4.10.1. Project Rationale

Skomer MCZ's algal communities have been identified as being rich and diverse with 241 species of red, green and brown algae recorded. This represents 34% of the British marine flora and 21% of North Atlantic marine flora including: two nationally scarce species; five near their limit of distribution; four species with specialised habitat preferences and five deep water algal species. Skomer MCZ has been identified as a Criteria B European IPA (important plant area) for marine algae. The area has a wide range of habitats, including excellent examples of algal communities on bedrock, boulders and cobbles. It has a very high diversity of algae with over 240 species recorded. Rare or threatened species include: *Atractophora hypnoides, Sphacelaria mirabilis, Hydrolithon cruciatum* and *Hinksia ovata*.

Indicators of Good Environmental Status (GES) for the sublittoral rock communities in UK waters based on the condition and composition of kelp habitats for the Marine Strategy Framework Directive have been developed by the JNCC (Burrows et al 2014). The development of kelp habitat indicators is based on the MSFD descriptor '*Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions'.*

Kelp habitats dominate the infralittoral zone on bedrock and boulder reefs found along most of the Skomer MCZ coast. Kelp species recorded at Skomer MCZ *include Laminaria digitata*, *Laminaria hyperborea*, *Alaria esculenta*, *Saccorhiza polyshides* and *Saccharina latissimia*. The relative abundance of kelp species is influenced by a range of abiotic (eg. temperature, latitude, wave exposure, light levels, disturbance) and biotic (eg. competition, grazing) factors.

Kelp habitats are important for other species, kelps alter light, nutrients, sediments, physical scour and water flow conditions for proximal organisms while providing structural habitat for a wide range of flora and fauna. In the UK alone, over 1800 species have been recorded from kelp dominated habitats. Kelp habitats also provide habitat for large invertebrates such as echinoderms, of which common urchin *Echinus esculentus* have significant ecological importance and crustaceans some of which have socio-economic importance eg. European lobster *Homarus Gammarus.* Kelp habitats are particularly effective nurseries for juvenile fish, providing shelter from predation and key feeding grounds for many fish species such as Ballan wrasse *Labrus bergylta* and Goldsinny wrasse *Ctenolabrus repestris,* which prey on kelp associated invertebrates. In turn, elevated fish densities in kelp habitats attract large piscivores such as large fish, seals and otters. Species richness on sublittoral rocky reefs around the UK generally increases with increasing relative abundances of all the major canopy forming kelp species (Burrows et al, 2014).

4.10.2. Objectives

- To maintain the current algae species richness and diversity along with the presence of the scarce species and the species nearing their distribution limit.

- To monitor kelp species abundance and distribution as an indication of good environmental status of the sublittoral rock communities.
- To monitor kelp habitat associated fish, echinoderm and crustacean communities.

4.10.3. Sites

- Skomer Head
- Mewstone
- North Wall
- Wick
- Martins Haven Point
- Junko's Rock

(Pre-2007 pebble sites: Martins Haven, Wick Basin, Garland Stone)

4.10.4. Project history

In 1983, detailed surveys of macro-algal populations at a number of sites were conducted (Hiscock, S 1983). In 1984, monitoring of sub-littoral seaweeds at two sites on the north coast of Skomer was established for a 2-year project (Hiscock, S 1986).

In 1998, Brodie and Watson were contracted to provide advice on development of conservation objectives for algal species and community monitoring. In 1999 a survey was carried out at seven sites based on their recommendations and a Skomer MCZ algae herbarium was produced (Brodie & Bunker 2000).

In 2006 Bunker & Luddington completed a review of algal monitoring methods used at Welsh sites including Skomer MCZ. The study investigated whether species lists derived from previous studies are able to show change and are suitable for monitoring purposes. Presence/absence data for algal species at Skomer and other Welsh sites showed variation with depth zone, season and sampling method.

In 2007, Maggs, Johnson and Bunker were contracted to develop methods of quantitative algae species monitoring building on the previous studies and recommendations. A survey was completed where species lists were derived from timed searches at selected depths and kelp density counts were completed at selected sites.

In 2024, proposed dive survey methods in Burrows et al 2014 were reviewed and methods were developed for testing by both the Skomer MCZ dive team and volunteer dive teams.

4.10.5. Methods

In 2024 methods were being tested to monitor kelp species abundance and distribution and to monitor kelp-associated fish, echinoderm and crustacean communities. The use of

Remote Underwater Video System (RUVS) was also explored to capture visual records of algae communities condition.

Kelp Habitat

At each site the maximum depth at which kelp is found is recorded along with the kelp species present.

A 10m weighted rope marked every metre with fluorescent cable ties is laid along a depth contour in 2 depth zones:

- lower infralittoral where kelp forest > 20% cover (approx. 8m bcd)
- upper circalittoral where kelp park < 5 % cover (approx. 11m bcd)

Recording is completed in $1m^2$ 'quadrats' using a 1m pole positioned with its centre perpendicular to the rope and moved between the rope markers (this method allows working around the kelp plants and based on method tested in the 2007 survey, Burton 2008). Recording includes:

1. Number of adult kelp plants (=/> 50cm height), total for each species.
2. Number of juvenile kelp plants (< 50cm height), total for each species.
3. Numbers of crustacean, echinoderm and fish, total for each species.
4. Percentage cover of foliose algae and of encrusting algae.
5. List of dominant red and brown algae species.

Associated Kelp communities – fish, echinoderms and crustaceans

The method has been designed for use with volunteer divers and follows the methods used for territorial fish population survey (Lock 2006) and for the echinoderm populations survey (Lock 2007). It is completed in the 2 depth zones as for the kelp habitat, completing the kelp park zone first then the kelp forest zone. At each site the maximum depth kelp is found is recorded and the kelp species present. The transects are then completed as follows:

1. Dive pair secure weight attached to a 30m tape and start laying the tape on depth contour. The first 5m are used to obtain control in orientation and buoyancy, fish counts start from the 5m mark onwards in a 2m corridor, 1m either side of the tape. Within the 2m corridor record the number of each fish species. Diver pair maintain a swimming speed of 3m per minute.

2. On completion rewind the tape slowly and record numbers of each crustacean and echinoderm species found. For each common urchin *Echinus esculentus*, use callipers to record widest diameter.

Algae communities condition – visual records

A Remote Underwater Video System (RUVS) is used to record the condition of the kelp and algae habitat and the presence of mobile species and to obtain a visual condition

assessment of the algae community at a selection of sites. The RUVS system comprises a GoPro11 in an underwater housing mounted in a modified lobster pot frame; a length of rope and a marker buoy (Figure 4.10.1).

Figure 4.10.1. Skomer MCZ's Remote Underwater Video System (RUVS).

4.10.6. Results

Methods were tested in 2024 by a combination of the MCZ dive team, a team of volunteer divers and drop-down video. Sea conditions with swell and wave surge made the completion of the survey at many of the planned sites not possible. Most sites are located on the open coast and some at exposed locations, meaning flat calm seas are essential to complete the survey. It is planned to complete the survey at further sites in 2025.

Method testing results are as follows:

Kelp Habitat

The Skomer MCZ team completed the method at several sites. To complete the transects in both the kelp park and kelp forest zone took an average of 60 minutes. The weighted rope was divided into 2 x 5m lengths so a pair of divers could work along one length each (Figure 4.10.2). Ties were added to the ends and middle of the rope to allow it to be secured to kelp holdfasts and stay fixed against the steep sloping rock preventing it from sliding down. The 5m ropes were set up end to end along a depth contour. The divers worked simultaneously along a 5m rope section each to completed 5 x 1m^2 quadrat areas. The use of the 1m pole positioned with the centre perpendicular to the rope and then moving between the fluorescent cable tie markers on the rope worked well. The pole was moved along the rope and could be repositioned around kelp plants. This allowed flexibility in working in dense kelp areas which would not have been possible with a large four-sided quadrat.

A good level of algae identification skill is needed to allow recording of the conspicuous red and brown algae species present. This was eased by creating a list of species with 2 letter codes taped to the back of the recording slate that could be used by the recorder. To allow the large amount of data to be collected a well organised recording sheet taped to the slate was essential. This also allowed the surveyor to check that everything needed was recorded.

Figure 4.10.2 Diver recording kelp habitat data

Associated Kelp communities – fish, echinoderms and crustaceans

A volunteer dive team over one weekend were tasked with completing transects in the kelp park and kelp forest zones to record fish, echinoderm (common urchin were also measured) and crustacean species (Figure 4.10.3). In addition, they also recorded the kelp species found and the maximum depth of kelp found at the site.

The method was a merge of the methods developed for territorial fish recording and urchin and starfish recording (fully described in Lock 2006 & 2007). Both these surveys had been completed by volunteer teams and are based on using a 30 or 50m tape being secured and laid out along a depth contour. The volunteers found combining the recording of the 2 surveys straightforward and it was not difficult to add recording number of crustacean species to the method.

Figure 4.10.3 Volunteer diver with writing slate measuring common urchin along transect line.

The volunteers found the method manageable. They found that dividing the tasks between the buddy pair was important; one took responsibility of completing the species counts whilst the other took charge of the tape and measuring urchins. It was also essential to have pre-prepared writing slates to help ensure that all recording was completed.

A level of species identification skill was also found to be essential, so some pre-training is required. Fish identification is aided by the provision on fish ID sheets and a pre-dive briefing.

Sea conditions were the trickiest challenge. Even with only 1m height swell, it was difficult to complete the transects as this causes water movement back and forth in the shallow waters where kelp is found. For divers to hold position and follow a depth contour minimal water movement is essential.

Algae communities condition – visual records

A Remote Underwater Video System (RUVS) was deployed at 3 sites for 1-2 hours at a time. The aim was to record the presence of mobile species and to obtain a visual condition assessment of the algae habitat.

The method proved challenging due to the steep, uneven rocky seabed in the inshore areas where algae communities are found. The modified lobster pot housing the camera was lowered slowly to try and keep it upright on landing on the seabed, but the video records showed that the system was usually positioned at different angles and snagged in the kelp plants. The video records did successfully provide a visual record of algae habitats (Figure 4.10.4) but only rarely recorded the presence of mobile species.

Figure 4.10.4 A selection of algae community images captured by the RUVS

The modified lobster pot housing the camera proved effective in protecting the camera from getting snagged on the uneven seabed or by kelp plants.

The RUVS was a good method in gaining a visual condition of the algae communities at a selection of sites that can be stored as a permanent record but less effective in recording presence of mobile species. An additional benefit of the method is that deployments can be combined with routine monitoring activities thus requiring minimal additional time and effort.

4.10.7. Current status

Insufficient data available to make and assessment.

4.10.8. Recommendations

- To continue recording algae species
- To establish baseline data of kelp habitats at selected sites and repeat every 4 years.
- To use volunteer dive teams to record fish, echinoderm and crustacean communities in kelp habitats and repeat every 4 years.
- To use RUVS to provide visual records of algae communities at a selection of sites annually.

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 NBN Atlas - UK’s largest collection of biodiversity information.

4.11.2. Crawfish

Crawfish *Palinurus elephas* (Figure 4.11.1) is an Environment (Wales) Act 2016, Section 7 species of principal importance. From 2009 to 2024 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 Crawfish survey | iRecord 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*) are the largest bony fish in the world (Figure 4.11.2); 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 the crew of the Dale Princess and Dale Queen. 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 2024, there were 2 records in August.

Figure 4.11.2 Sunfish, *Mola mola.*

4.11.4. Non-native species

In 2024 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 MarClim 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 in the UK in England in 1994, in the Solent and has since spread around the UK. It has not been recorded in the Skomer MCZ since 2018.

Wire weed *Sargassum muticum* (Figure 4.11.3) was first found at Martins Haven attached to a cobble in 2008 and it has been recorded again on 7 annual surveys over the last 13 years including in 2024. On each occasion it has just been 1-2 individuals. In 2024 it was also found during the volunteer diving kelp communities survey on the east side of South Haven in 2.2m depth below chart datum. It was a large patch with plants up to 2m length.

Figure 4.11.3 Wire weed *Sargassum muticum*

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 (Wales) Act 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.

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 40m.

PML method adopted: A 200 micron mesh net is hauled vertically from 35 – 40m depth at approximately 0.2 mper 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 30cm diameter opening was used. The samples were collected by a vertical haul from 20m 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 100ml to dilute it further, agitated vigorously and then a 0.5ml 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 were 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 Environment Regulations 2017 (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, 2023 and 2024– 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).

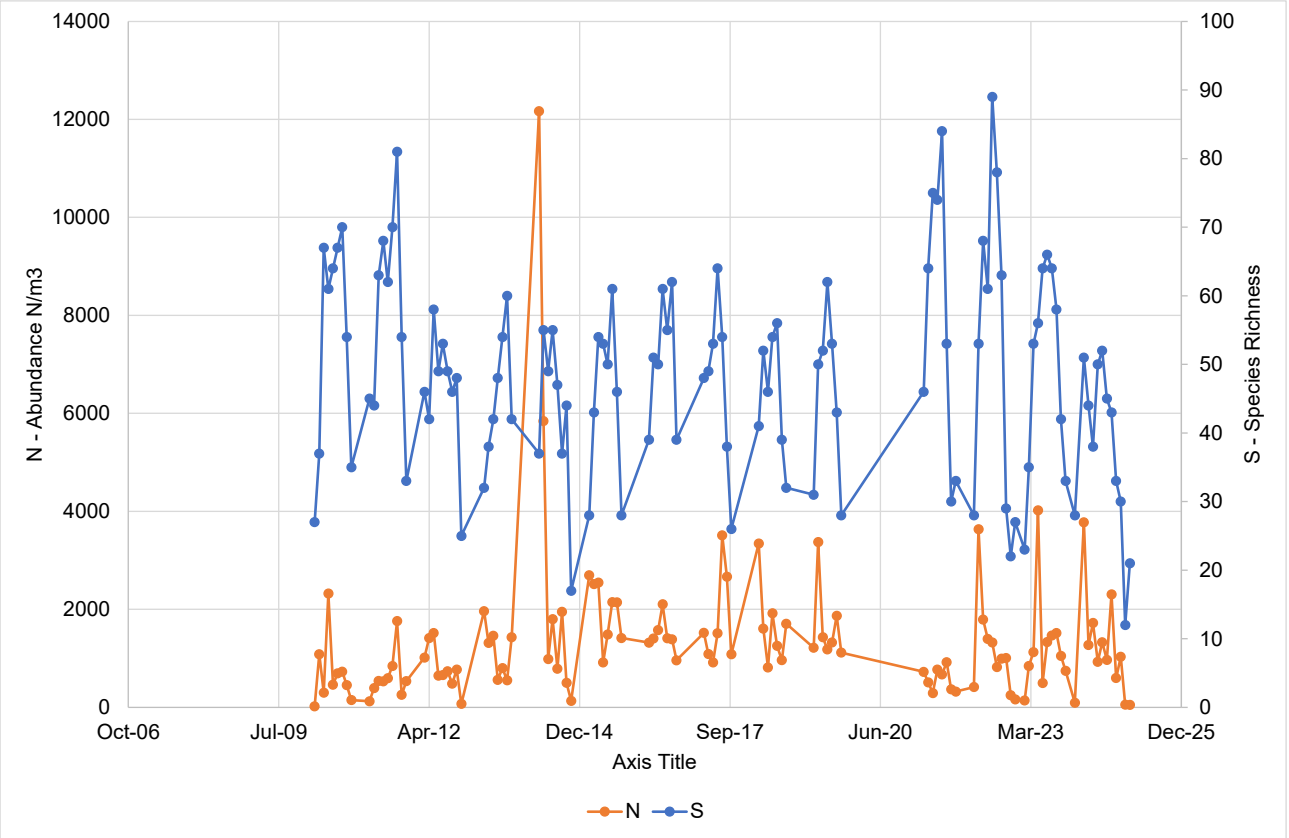
- 2010, 2011 & 2012 - Samples were collected from March to November, these were analysed by the Plymouth Marine Laboratory, (no report: raw data provided).
- 2013 onwards – Zooplankton samples were sent to Dr D. Conway (Plymouth Marine Biological Association) for identification and enumeration, (no report;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

- From 2021 onwards, zooplankton sampling was completed alongside the collection of phytoplankton samples collected using the WFD 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 was entered into DASHH Pelagic Lifeforms Tool.

4.12.5. Results

Zooplankton

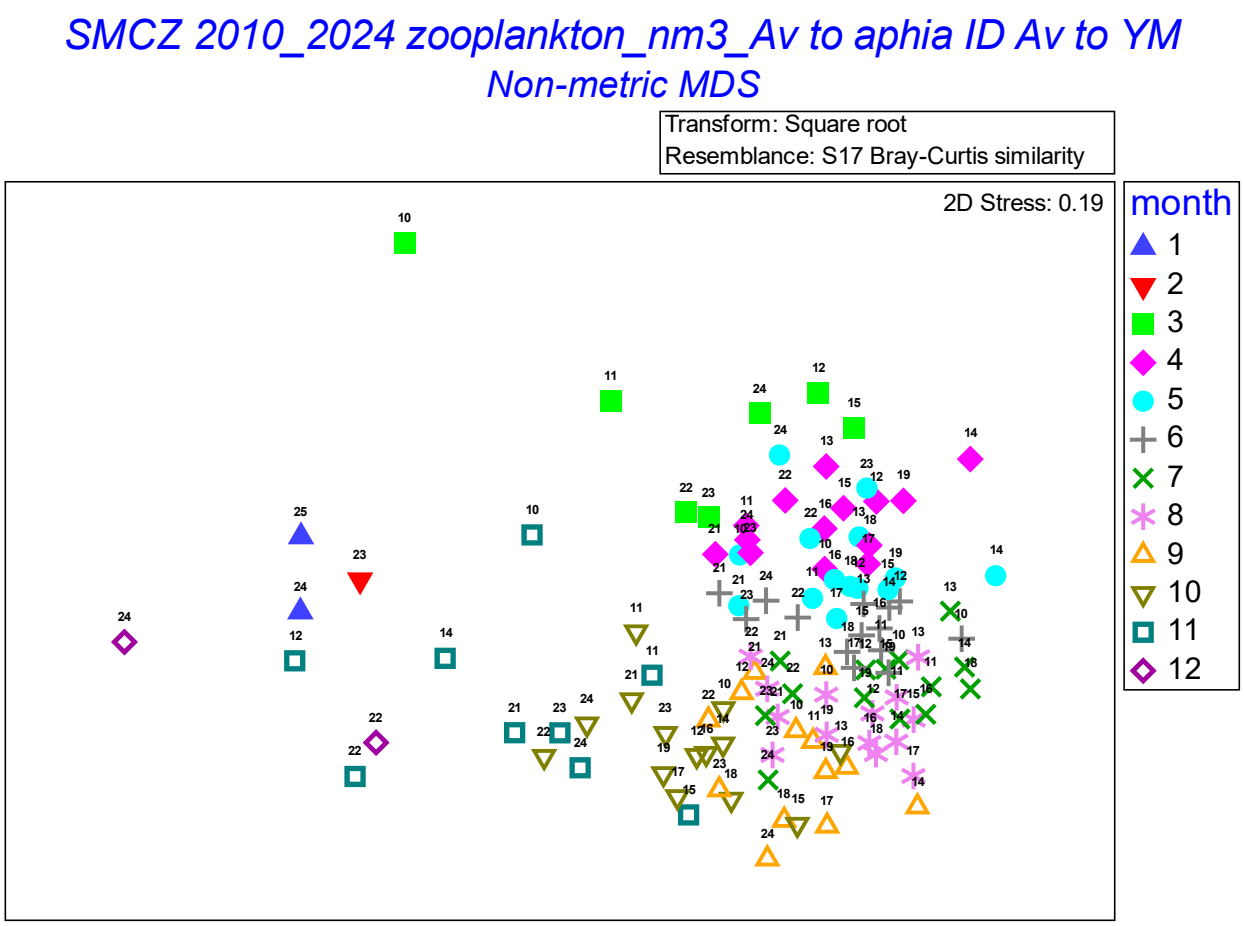
Figure 4.12.1 Average plankton species richness (S) and total number of individuals / abundance (N) 2010- 2024.



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

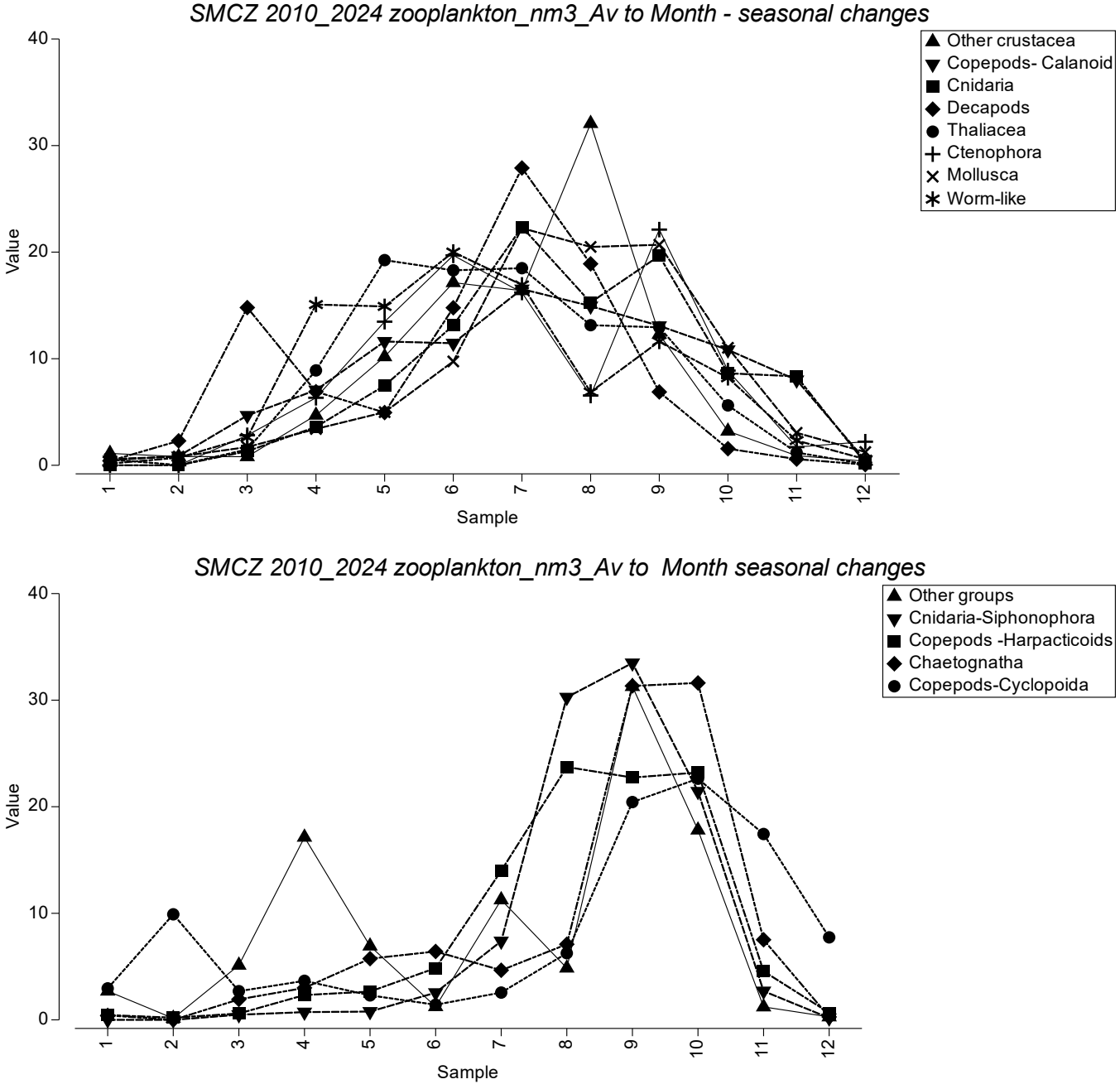
All zooplankton data are held on file at the Skomer MCZ office in spreadsheet format and as Primer files. This allows for a wide range of data analyses; Individual species can be selected, differences between years can be analysed or the whole dataset can be combined to look for seasonal trends (Figure 4.12.2).

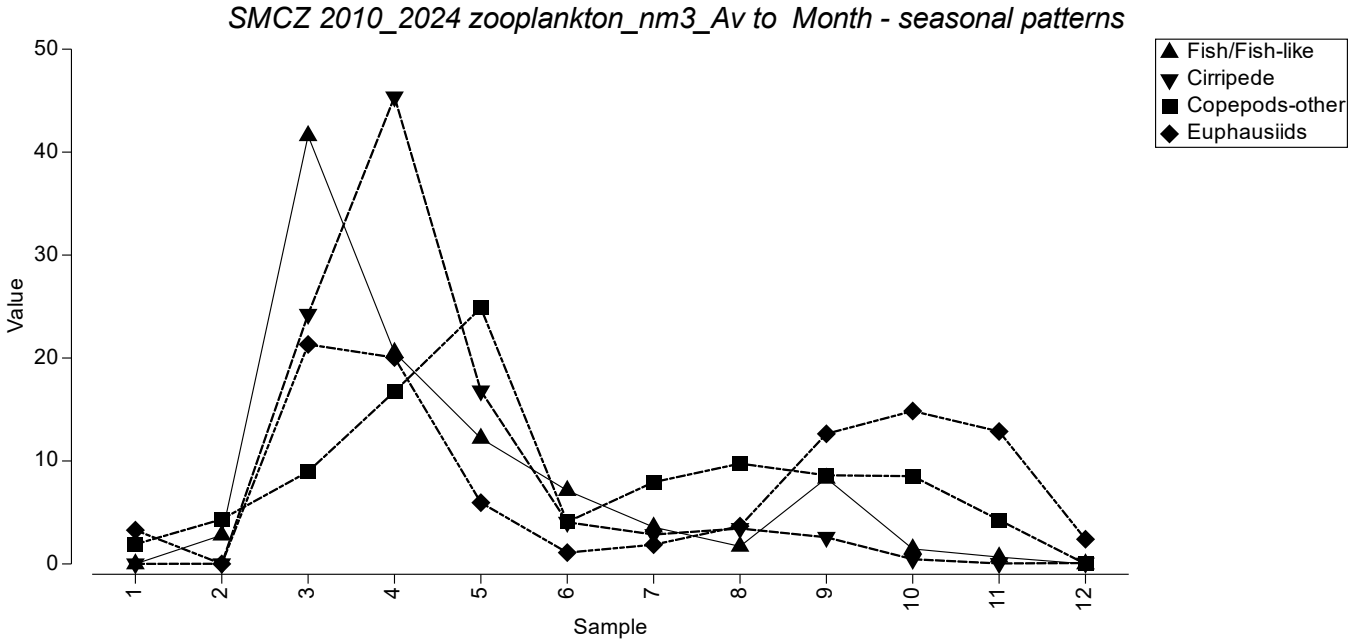
Figure 4.12.2 MDS plot of zooplankton community showing seasonal changes (symbols representing months and labelled with year).



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.

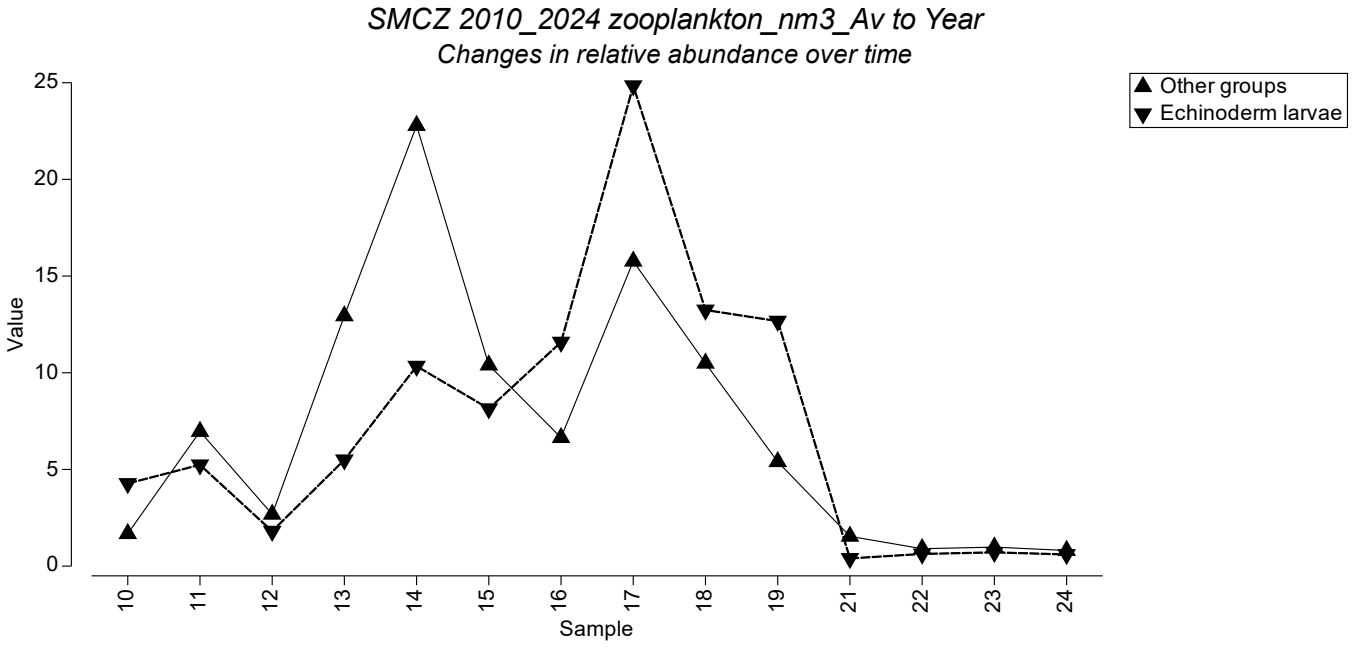
Figure 4.12.3 Seasonal abundance patterns for the major groups of zooplankton taxa averaged from data collected between 2010 - 2023 with 4 obvious patterns; a)– Taxa with a broad seasonal distribution with peak abundance in Jul-Aug, b)- taxa with an Autumn peak, c)- taxa with a spring peak.



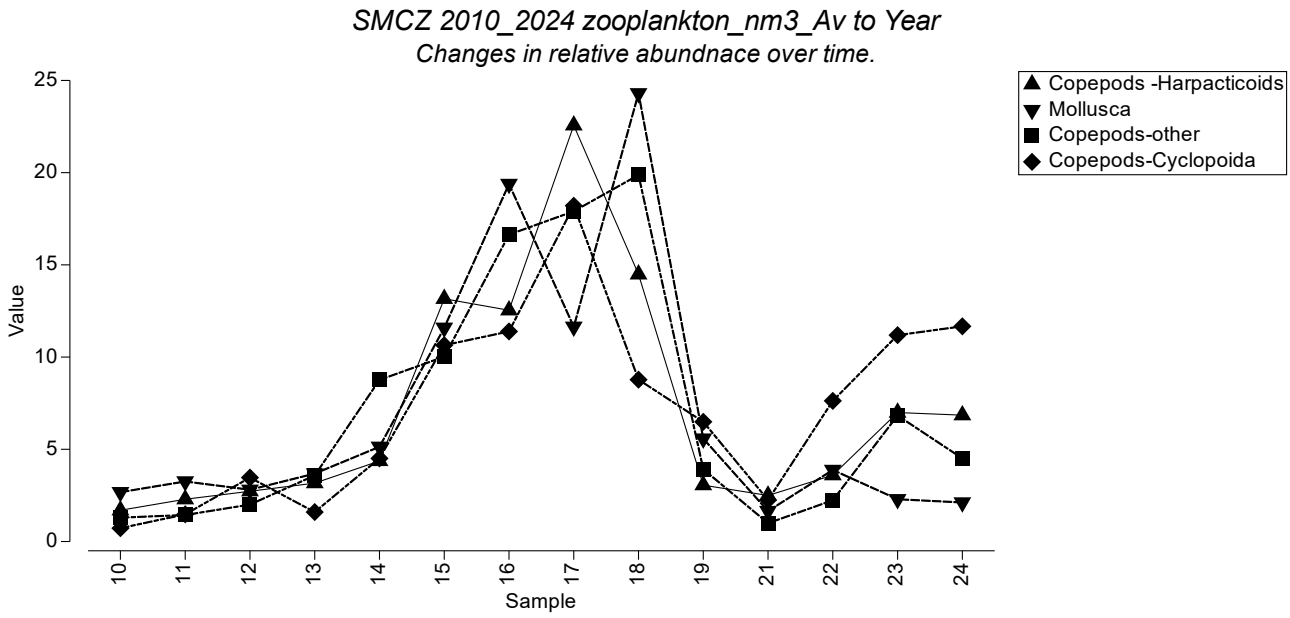


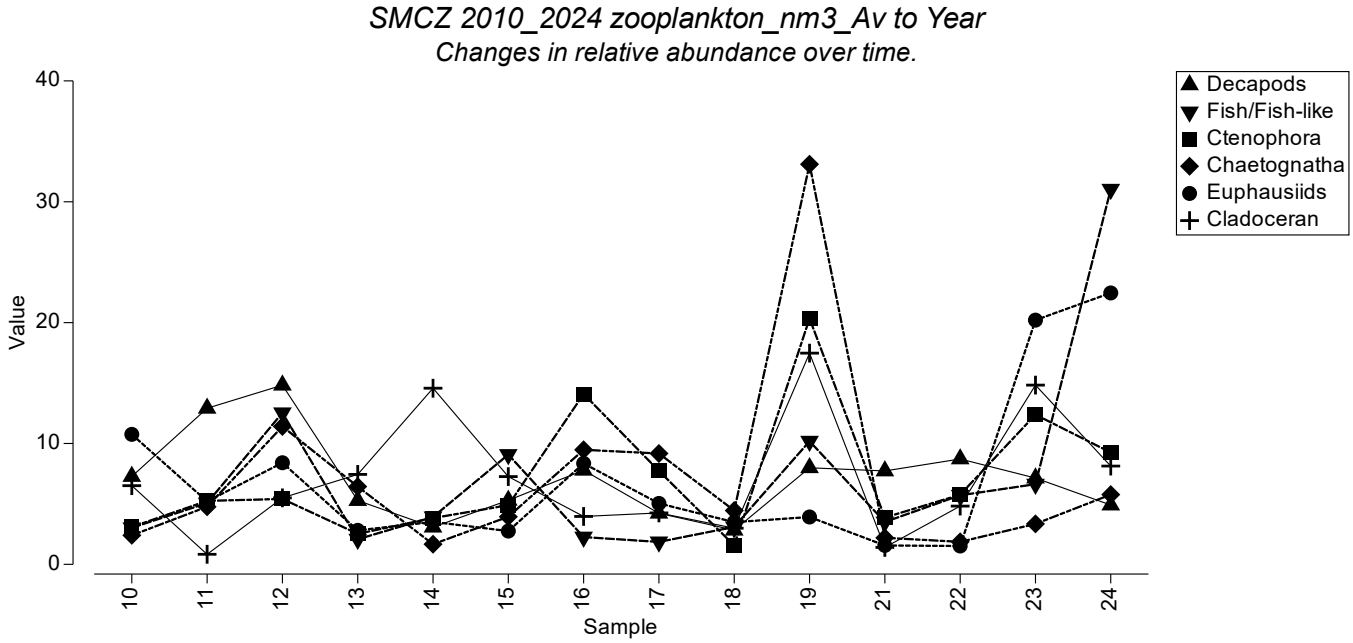
Annual variation in abundances of major groups are plotted in Figure 4.12.4. The plots do highlight how variable the species abundances are between years and between species.

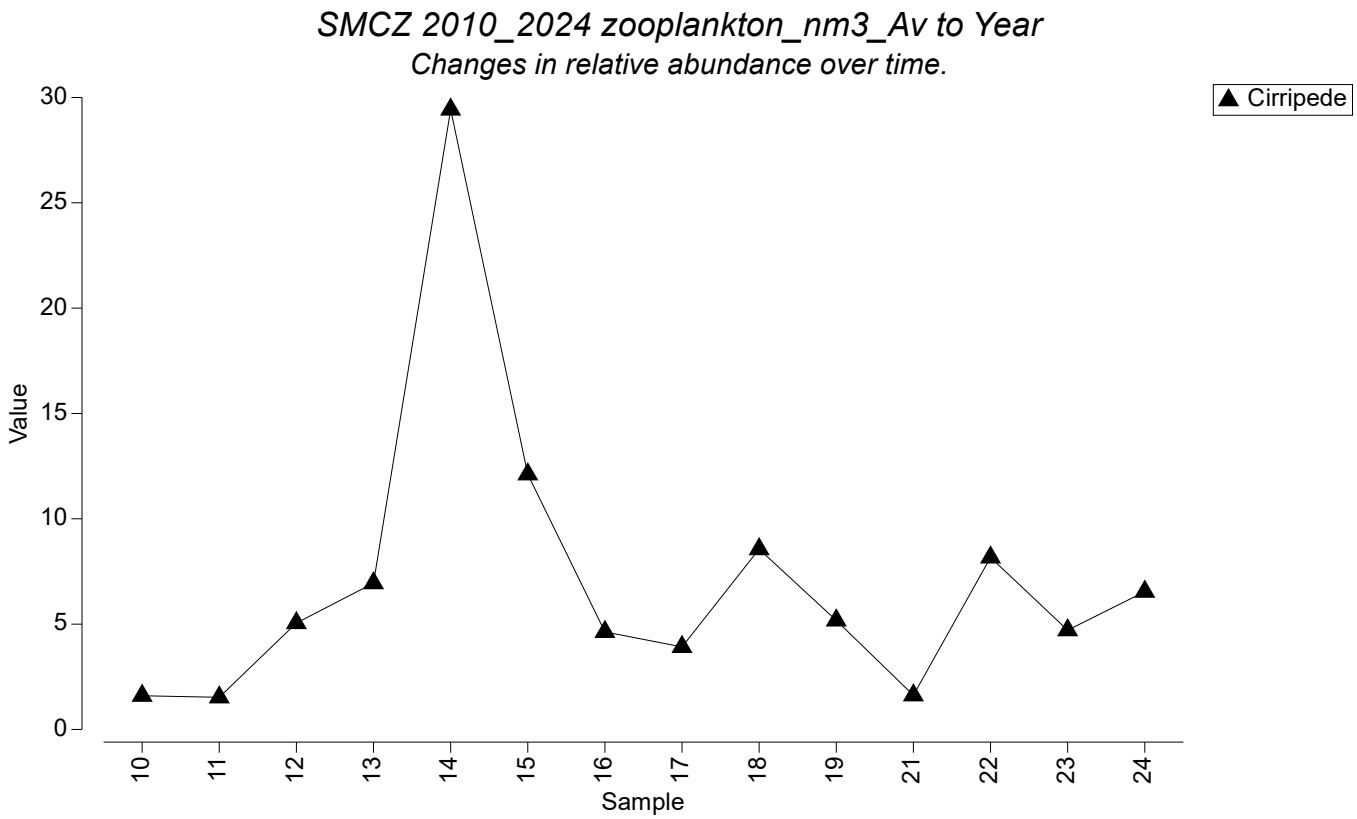
Figure 4.12.4 Coherence plots for the major taxonomic groups making up the zooplankton community at Skomer MCZ 2010 – 2024; a & b- taxa with a notably drop in abundance in 2021, c - taxa with consistent abundance over time & d – Ciripedia.



Echinoderm larvae have been almost absent from the samples since 2021.


SMCZ 2010_2024 zooplankton_nm3_Av to Year
Changes in relative abundnace over time.
Copepods -Harpacticoids
Mollusca
Copepods-other
Copepods-Cyclopoida
Value
Sample


SMCZ 2010_2024 zooplankton_nm3_Av to Year
Changes in relative abundance over time.
Decapods
Fish/Fish-like
Ctenophora
Chaetognatha
Euphausiids
Cladoceran
Value
Sample



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 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 zone. 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 (51° 44' 78" N; 005 ° 14' 78" W).

5.1.5. Methods

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

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

The CR1000 is capable of storing the data internally, but as with the Fairmount weather station the data are automatically downloaded to a computer in the Skomer MCZ office using "Loggernet" software. The data are saved in three files: daily, hourly and 10 minute intervals.

In January 2009 a rain collector and ammonia detector were added to the equipment suite. Monthly collections were made for precipitation chemistry and atmospheric ammonia concentration records. A GMS communicator has been added to the CR1000 allowing

mobile telephone access to the data. This enables the data to be automatically updated into an external website.

5.1.6. Project history relevant to data

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

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

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

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

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

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

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

In 2021 the weather station was serviced (3rd 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 (6th 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.

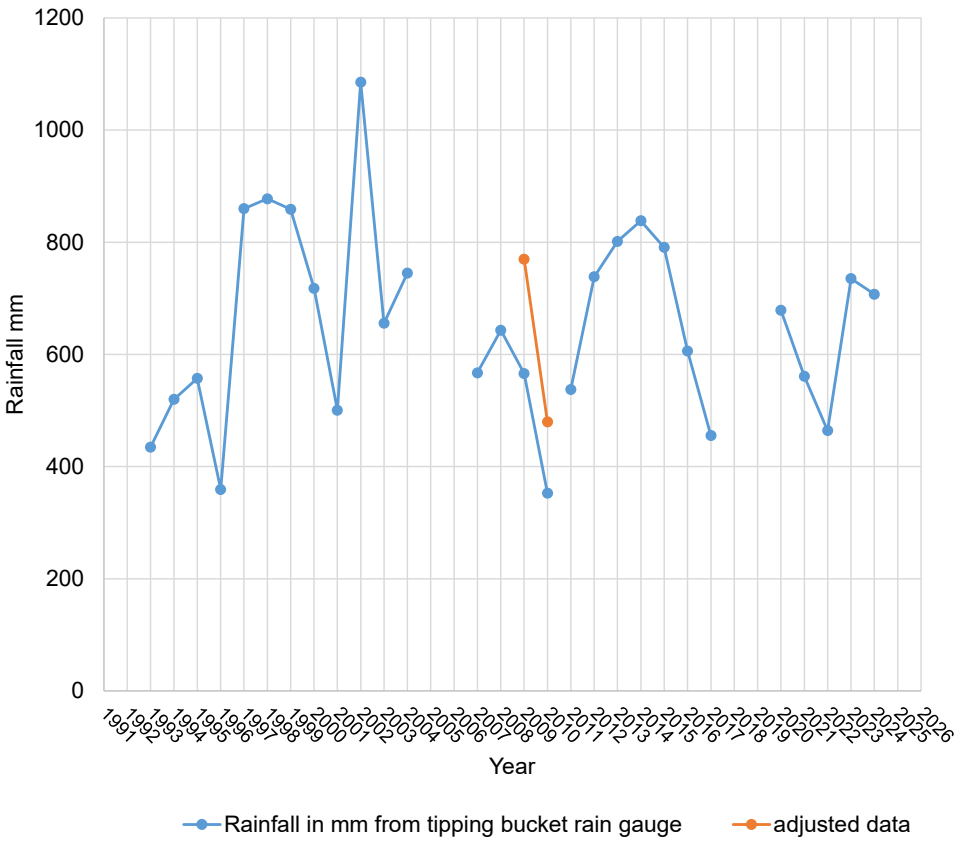
In 2024 WiFi transmitter domes were installed close to the existing anemometer and wind vane making wind data from the old wind system unreliable from 4th Oct 2024 onwards. The wind sonic sensor was moved onto a 3m pole well above the transmitters on 20th Nov 2024. 7th Dec 2024 saw 100mph gusts which damaged the cover of the Air temp & RH sensor. The cover was replaced – no damage or loss of data from the sensors. On 7th December high winds damaged the solar shade on the air temperature probe.

5.1.7. Results

Rainfall

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

Figure 5.1.1 Skomer MCZ automatic weather station total rainfall (mm) data (incomplete data for 2018 & 2019).



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 5.1.2 Skomer MCZ automatic weather station, radar plot average wind direction and strength 1993 – 2024

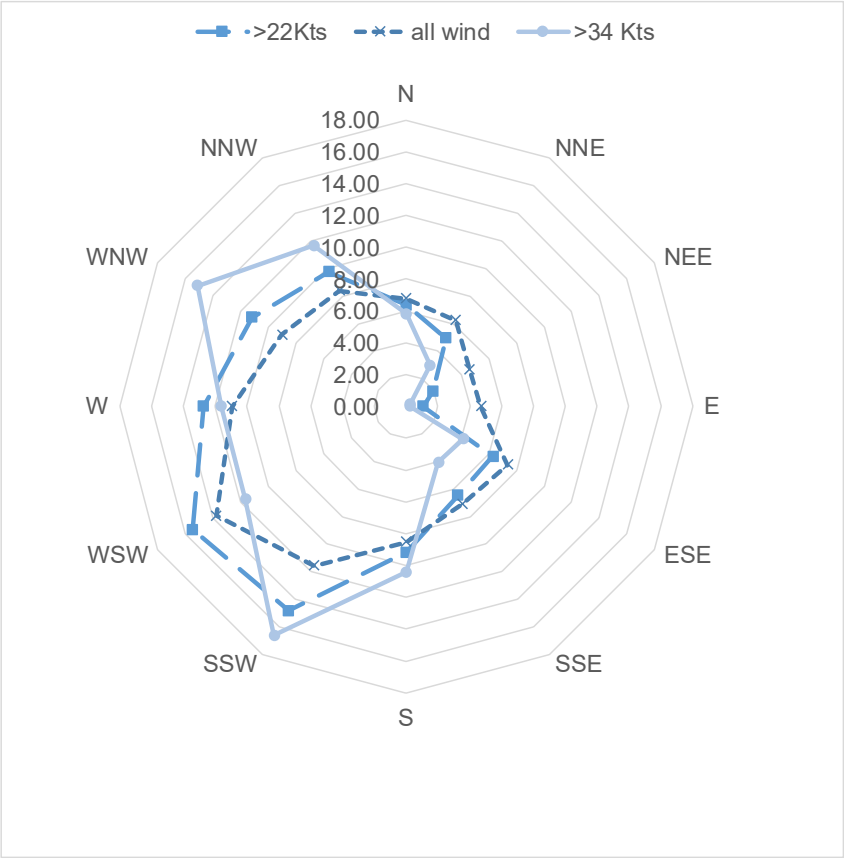
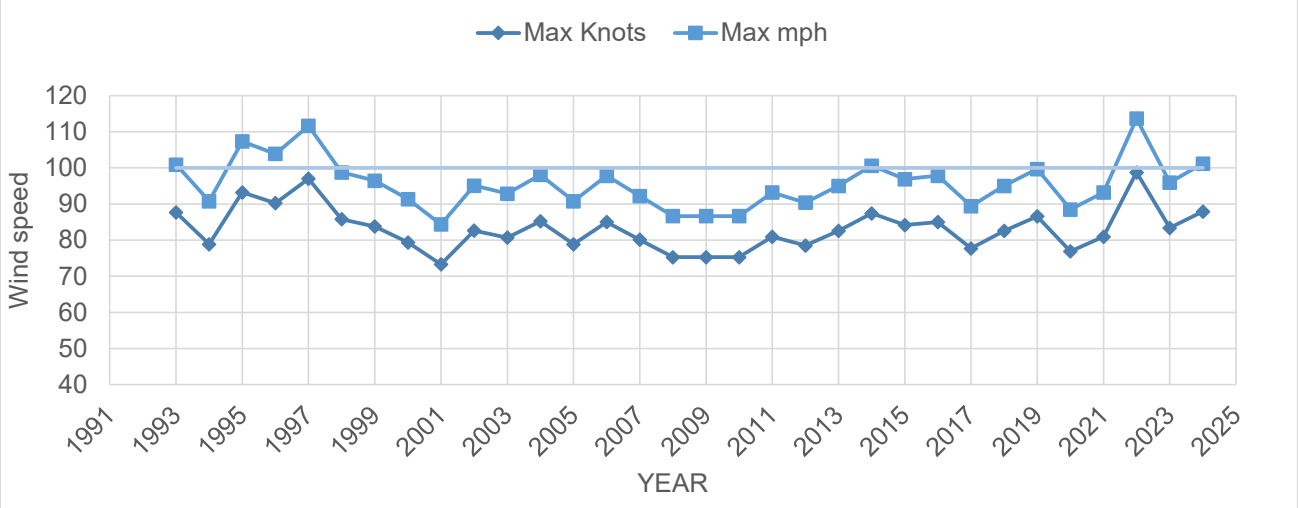


Figure 5.1.3 Skomer MCZ automatic weather station data, maximum wind strength (knots) 1993 – 2024.

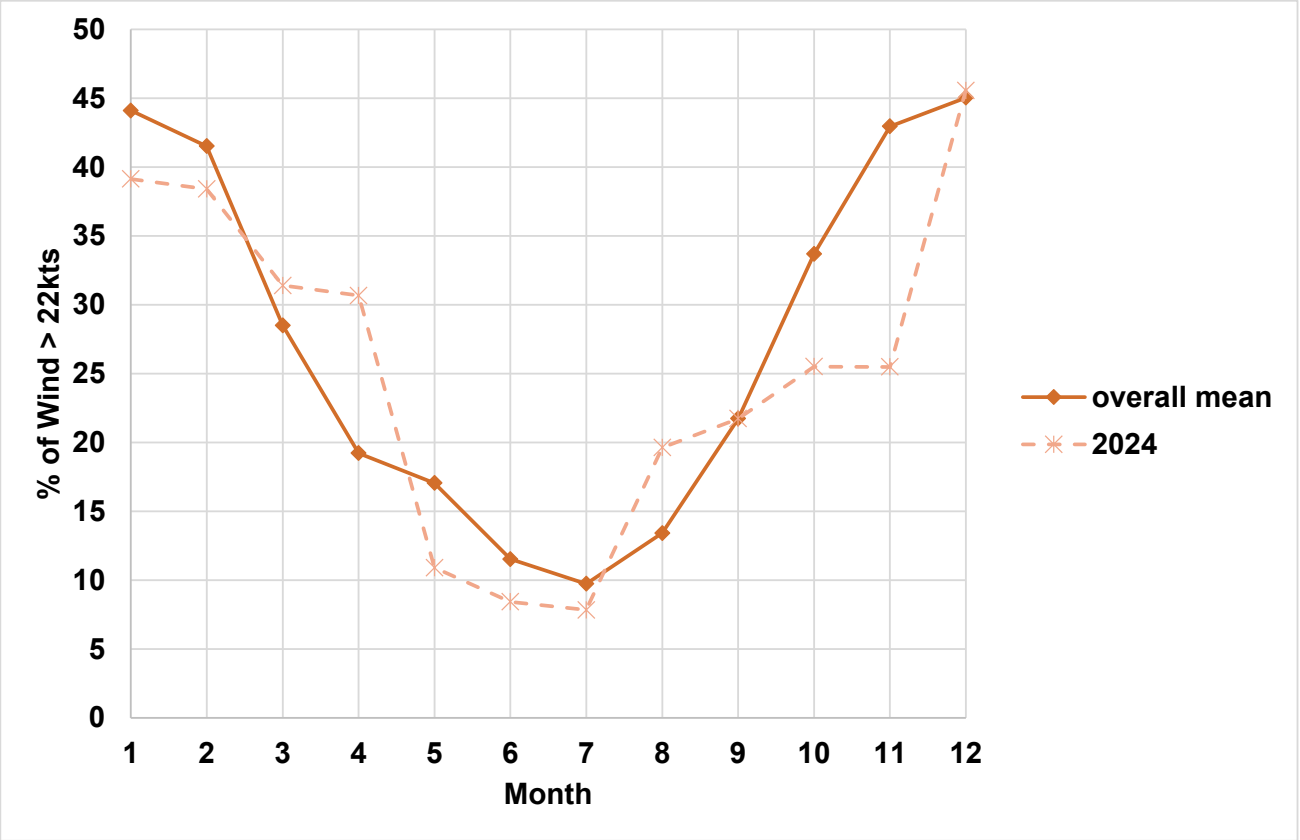


The maximum gust recorded for 2008, 2009 and 2010 was exactly the same (86.6 mph) (Figure 5.1.3). This led to the suspicion that the anemometer bearings were faulty. After the bearings were replaced in 2011 higher gusts were recorded. 2024 saw a maximum gust of 101 mph in December.

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 5.1.3). 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 5th Jan 1997.

The winter months tend to have the highest percentage of strong winds but it is very variable from year to year. Fig 5.1.4 compares 2024 with the overall average wind >22knots for each month of the year (1992-2024). In 2024 wind >22knots was below the overall average for most months with only April and August having more than average stronger winds.

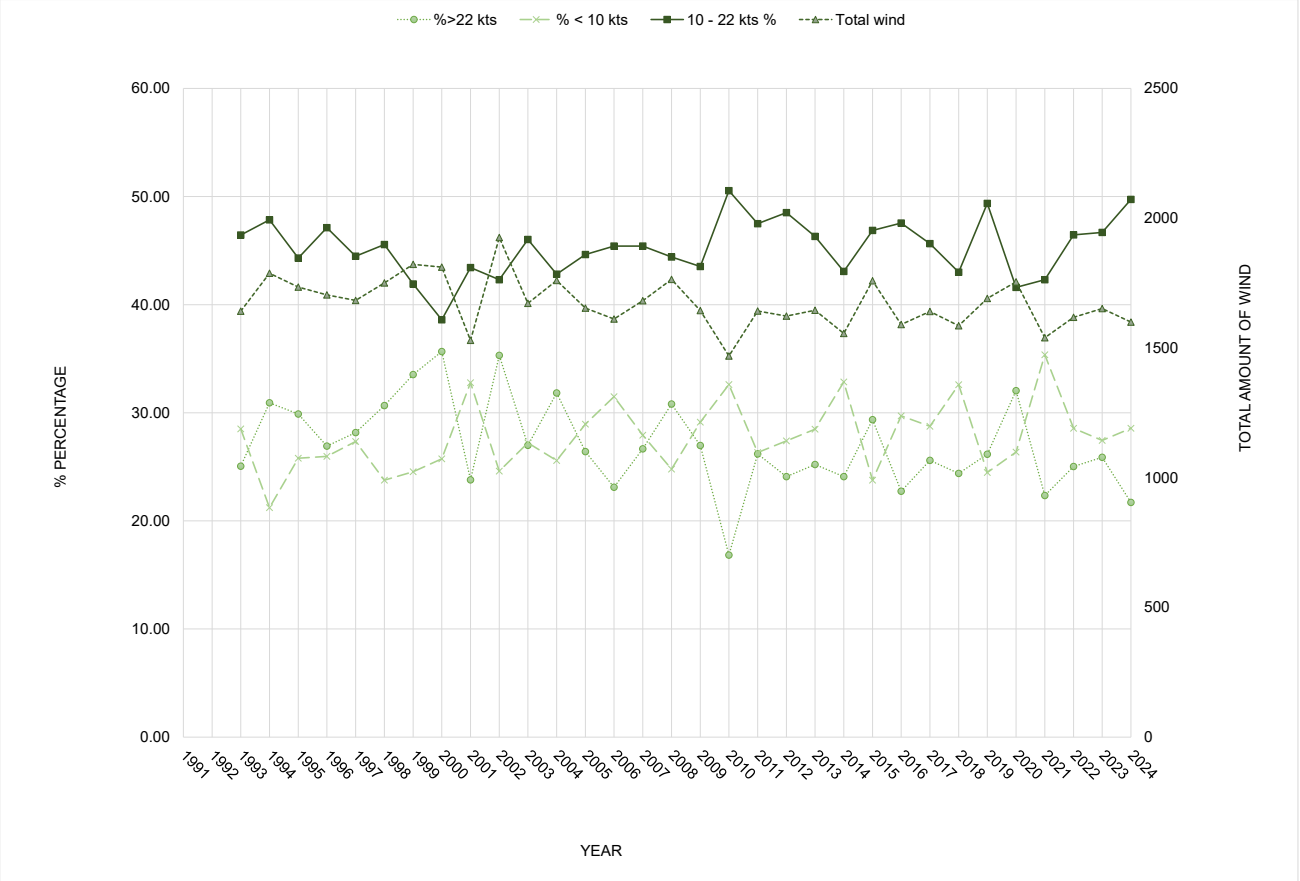
Figure 5.1.4 Skomer MCZ automatic weather station data – percentage of wind greater than 22 knots for each month. All years averaged and 2024 data.



2024 follows a similar pattern of wind distribution to the overall mean (1991-2024). Most of the stronger winds come from the SSW, WSW & W (Figure 5.1.5). The east tends to have the lowest percentage of strong winds

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

Figure 5.1.6 Skomer MCZ automatic weather station data – “total annual wind” 1993 to 2024.



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).

The 2024 annual meteorological summary from the Skomer MCZ automatic weather station is shown in Table 5.1.1. More detailed data is available. In October 2024 Wifi domes were installed on the Coastguard hut roof, these are large structures mounted close to the wind sensors and would disturb the air flow. As a result the wind sensor was moved two metres above the domes into clean air. It possible that the wind vane and anemometer were affected by the domes so wind readings from 4th October to 20th November may be suspect.

Monthly average air temperature, relative humidity and solar radiation results are summarised in 5.1.7 to Figure 5.1.10.

Table 5.1.1 Skomer MCZ automatic weather station – 2024 annual meteorological summary.

Measurement	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean air temp (°C)	7.2	8.9	8.4	9.6	12.3	13.1	14.5	16.0	14.3	13.0	10.7	9.1
Max. air temp (°C)	12.	11.4	12.4	14.0	20.1	18.7	18.9	23.3	20.7	15.9	15.0	13.4
Min. air temp (°C)	-0.4	4.2	2.3	5.0	7.9	8.9	8.9	12.9	9.2	6.8	1.4	3.6
Mean barometric pressure (mb)	100	996.5	991.4	1000.5	1001.7	1004.7	1002.9	1001.9	1003.4	1000.8	1006.6	1010.4
Max. barometric pressure (mb)	103	1029.0	1019.0	1024.0	1022.0	1023.0	1019.0	1017.0	1025.0	1023.0	1033.0	1030.0
Min. barometric pressure (mb)	959	954.0	953.0	977.0	981.0	981.0	985.0	980.0	966.0	974.0	969.0	978.0
Mean relative humidity (%)	82.	92.0	89.5	88.6	88.4	86.5	89.4	86.1	83.5	84.3	84.5	84.8
Max. relative humidity (%)	100	100.0	100.0	100.0	100.0	99.8	100.0	99.0	97.5	99.6	97.4	100.0
Min. relative humidity (%)	53.	65.0	56.9	60.5	57.6	61.3	69.3	59.9	59.1	52.4	46.7	56.7
Total rainfall (mm)	60.	107.6	90.8	66.9	50.1	17.2	54.2	39.4	66.3	67.3	41.8	45.3
Mean sunshine (kw / m^2)	0.0	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.0	0.0
Sunshine hours	86.	114.0	234.0	285.0	354.0	380.0	351.0	304.0	221.0	196.0	69.0	48.0
Sunshine hours (10min)	80.	110.0	222.7	280.2	348.8	371.0	346.2	301.8	215.5	188.0	67.8	48.2
Mean net radiation ($Wm^{-2)}$	-	5.8	29.3	65.8	89.9	128.0	95.3	83.4	33.7	10.0	-5.3	-12.6
Max. wind gust (m/s)	35.	28.0	29.0	34.6	26.3	25.7	21.4	32.88	33.63	31.4	32.2	45.3
Max wind gust (Knots)	69.	54.5	56.2	67.3	51.1	49.9	41.5	63.9	65.3	61.0	62.6	87.9
Direction of max wind gusts	216	262.1	128.7	310.5	133.1	177.8	314.2	252.2	125.6	244.0	254.3	288.9
Days > Force 7 Mean	2	0	0	1	0	0	0	0	0	1	1	5
Days > Force 7 Gust	23	23	24	19	8	7	6	15	10	20	14	21
Days max hr av>Force 7	9	4	4	9	1	1	0	3	4	2	5	13

Figure 5.1.7 Skomer MCZ automatic weather station – monthly average air temperatures 1993 - 2024 with monthly min / max error bars.

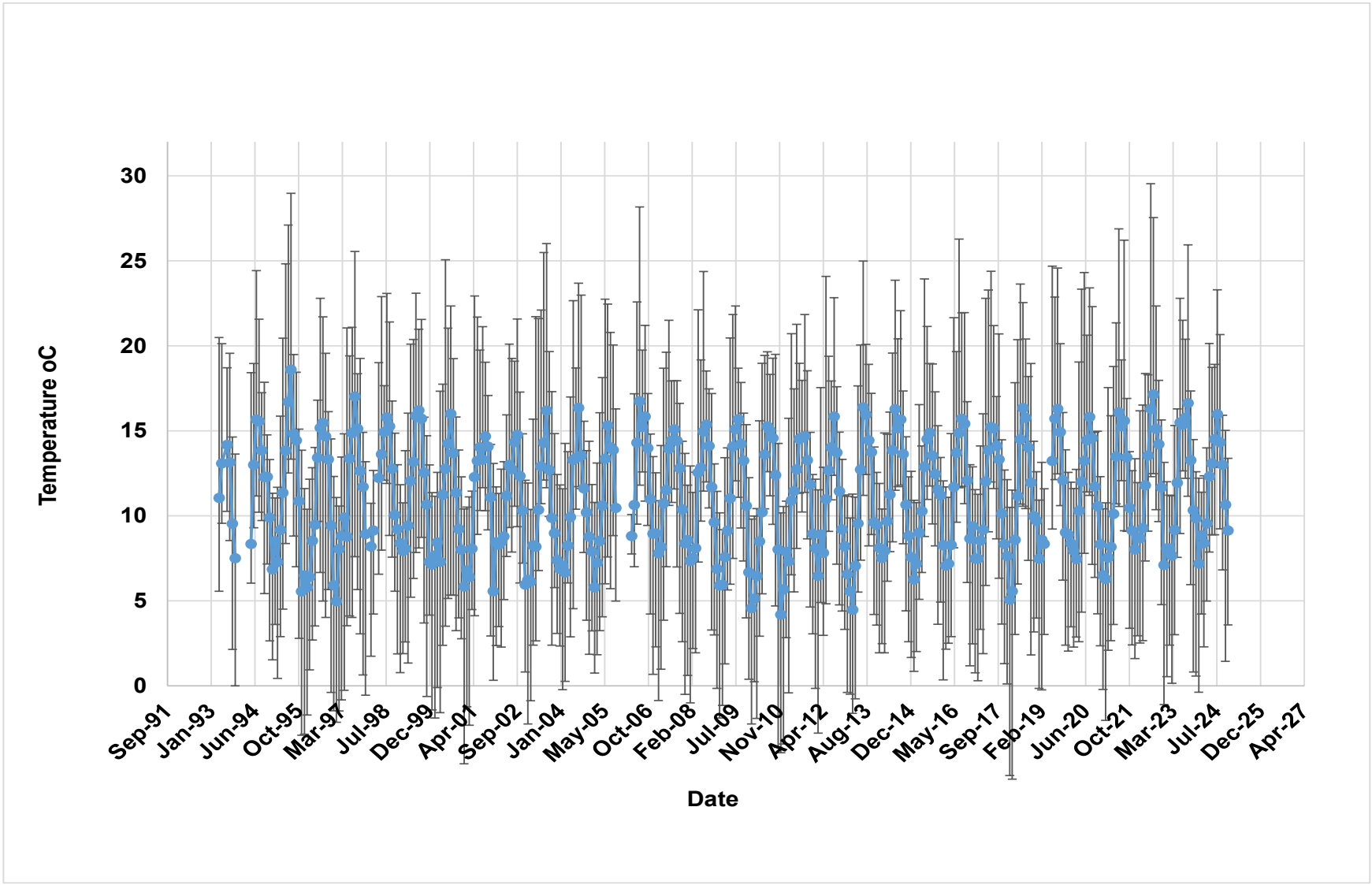


Figure 5.1.8 Skomer MCZ automatic weather station – annual and seasonal mean air temperatures (°C) 2006 – 2024.

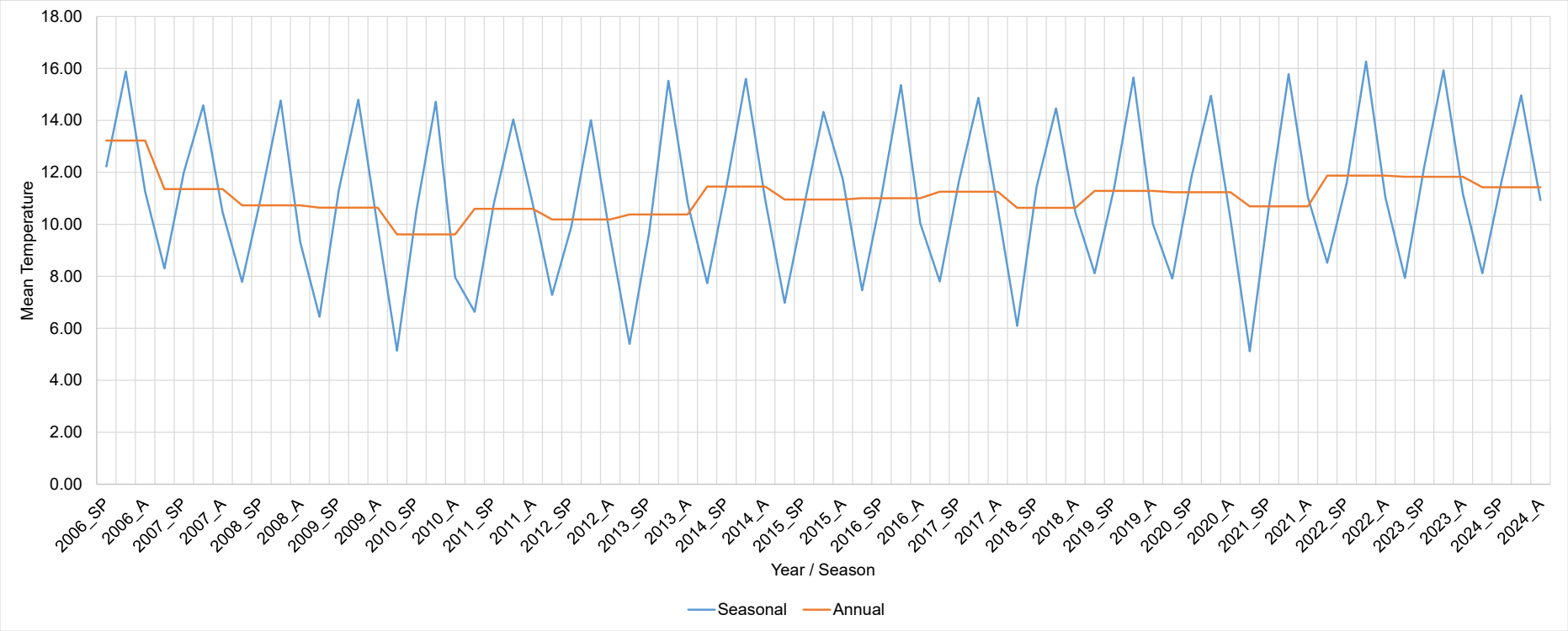
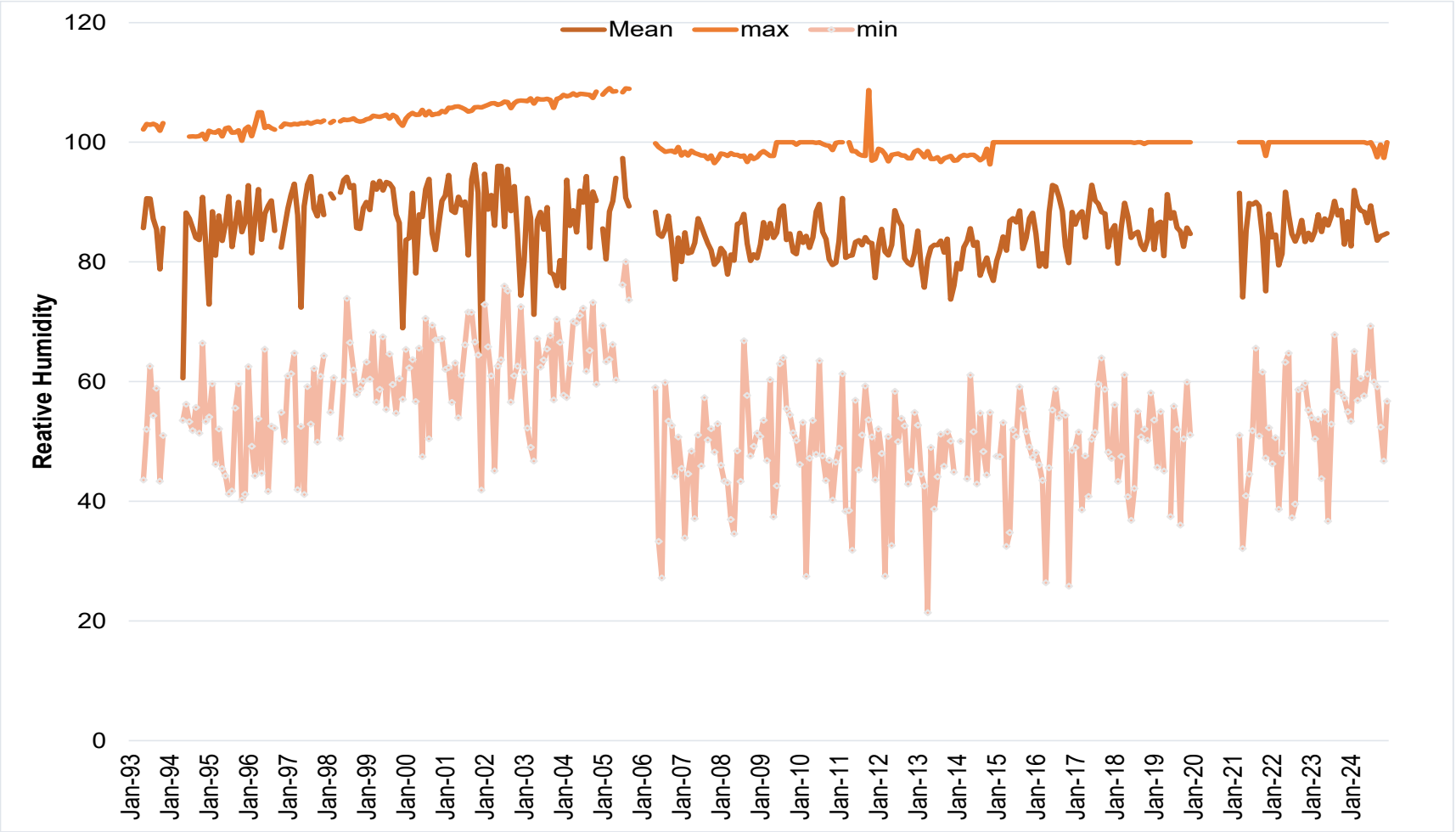
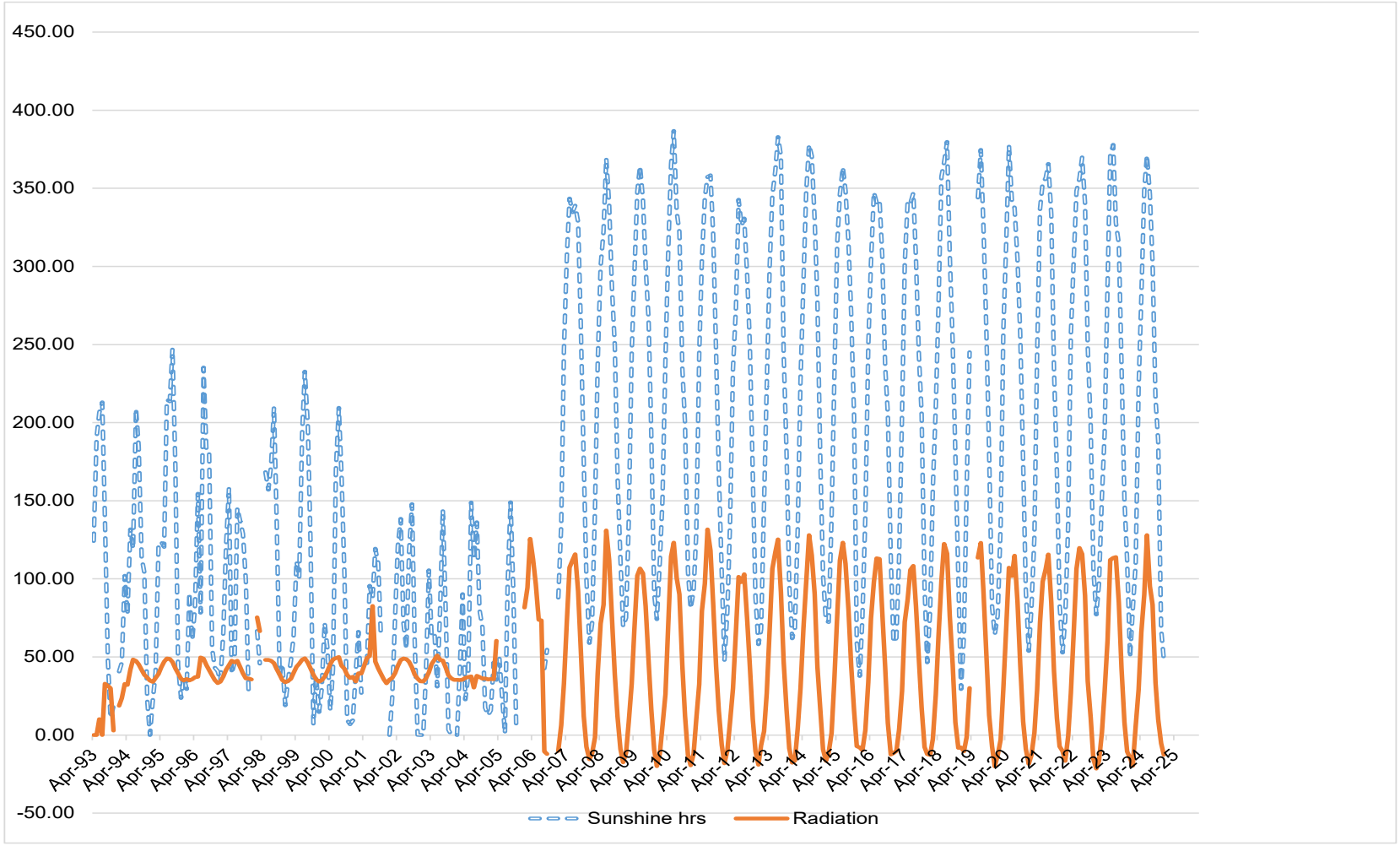


Figure 5.1.9 Skomer MCZ automatic weather station – relative humidity 1993 – 2024.



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 – 2024.



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
2024	Jan – Dec

Vemco minilog seabed temperature logger deployment:

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

5.2.6. Results

Oceanographic monitoring site

Seawater minimum temperatures are recorded in March, the minimum average for 2000 to 2024 is 7.9 ºC, ranging from the lowest of 6.6ºC in 2016 to the highest of 9.1ºC in March 2024 (1.2ºC above the average). The Maximum average seawater temperature for 2000 to 2023 is 16.5 ºC ranging from the lowest 15.6 ºC in 2002 and the highest of 17.5 ºC in 2023. 2022, 2023 and 2024 are showing above average minimum and maximum seawater temperatures as shown in Table 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 ºC	Maximum temperature ºC
2000	8.4	16.27
2001	7.27	16.3
2002	8.7	15.6
2003	7.6	17.1
2004	7.7	16. 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
2024	9.1	No data

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 3 Skomer MCZ summary of monthly mean seabed temperature 1992 – 2024.

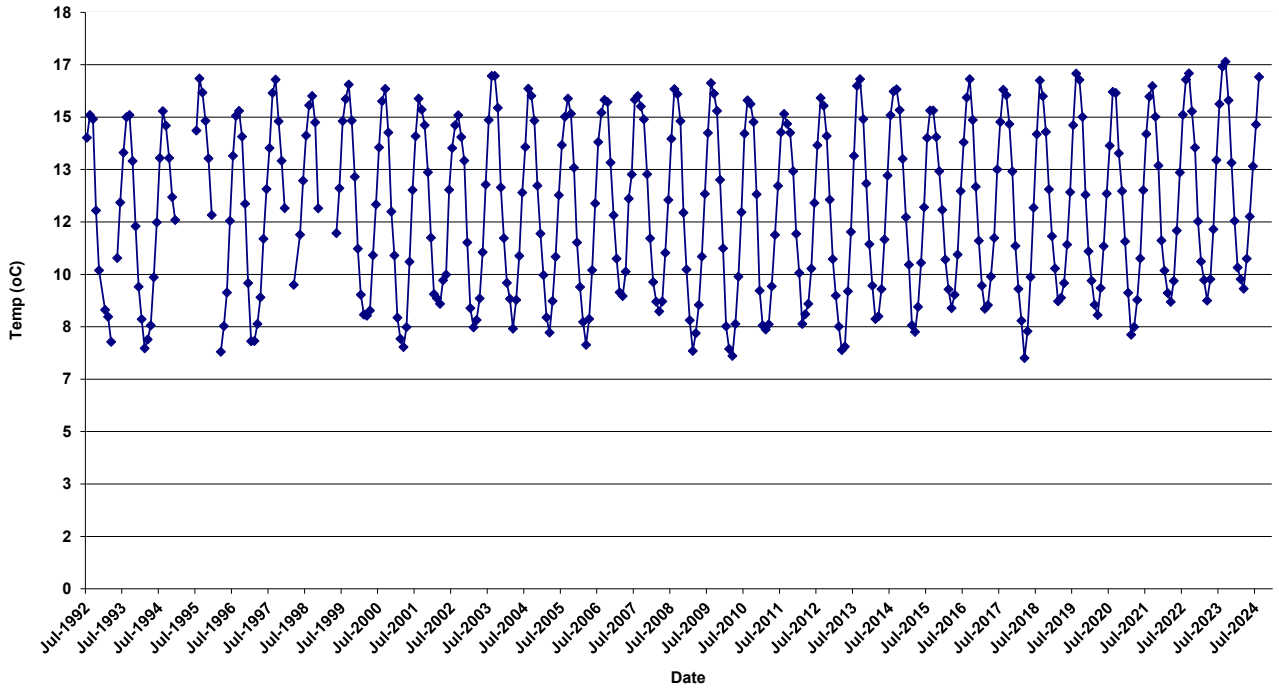
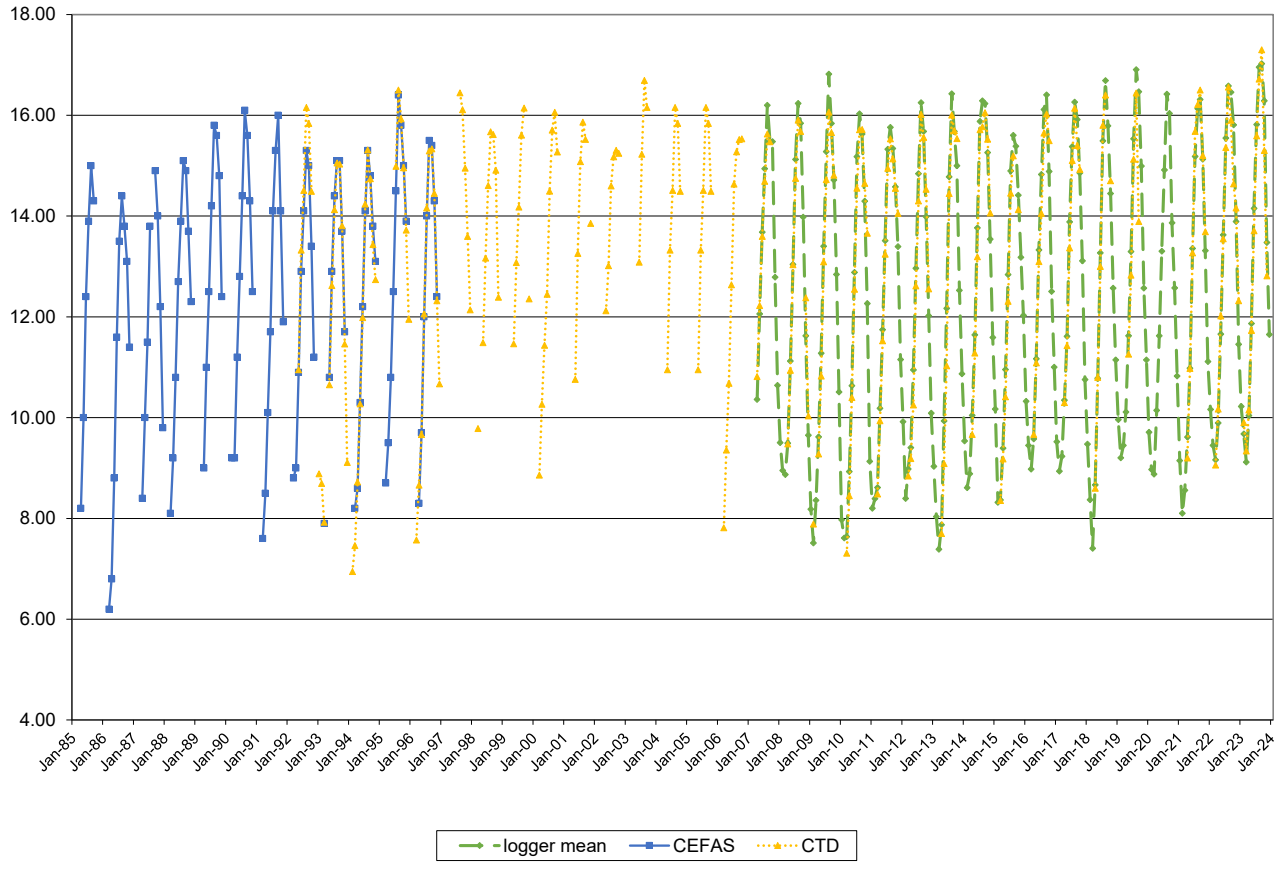


Figure 5.2.2 Skomer MCZ summary of monthly mean sea surface temperature (°C) 1985 – 2023.



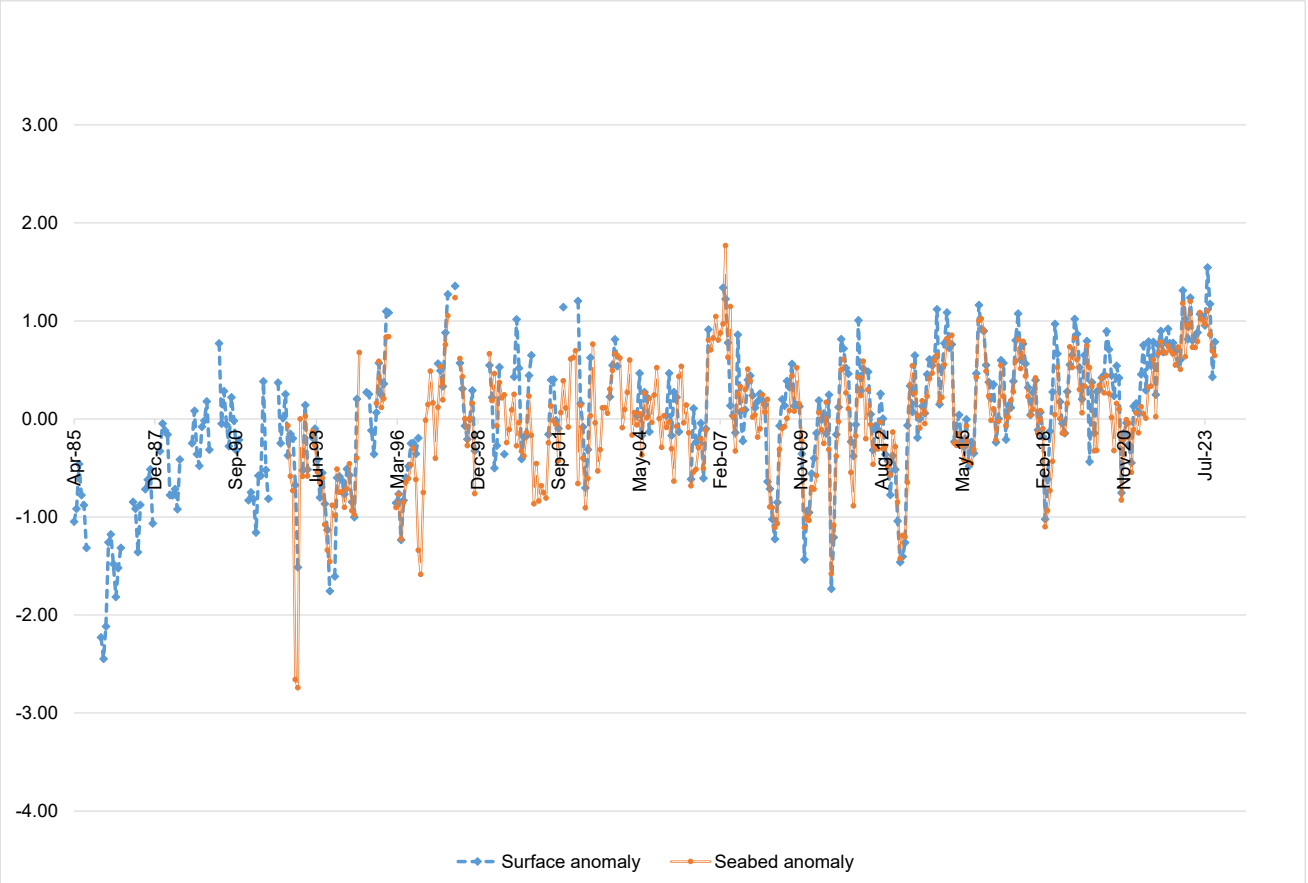
A summary of the sea surface temperature is shown in Figure 5.2.2. This is made up of:

- 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: 1m, 5m, 10m, 15m below sea level and 2m above seabed. Only 1m and 5m are used as sea surface temperature records;
- Mixture of data from shore loggers (when covered by the tide) and YSI 6600 sonde at the OMS site (**Logger mean**).

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

By taking the mean for a specific month across the whole dataset (grand monthly mean) and comparing this with the same month's mean for a specific year (specific monthly mean) the "monthly anomaly" can be calculated. Repeating this calculation for each month of each year in the dataset gives an indication of how cold or warm that particular month was compared to the whole dataset (Figure 5.2.3).

Figure 4 Skomer MCZ sea temperatures – monthly anomaly between the specific monthly mean and the grand monthly mean, surface and seabed anomalies (April 1985 – Dec 2023).

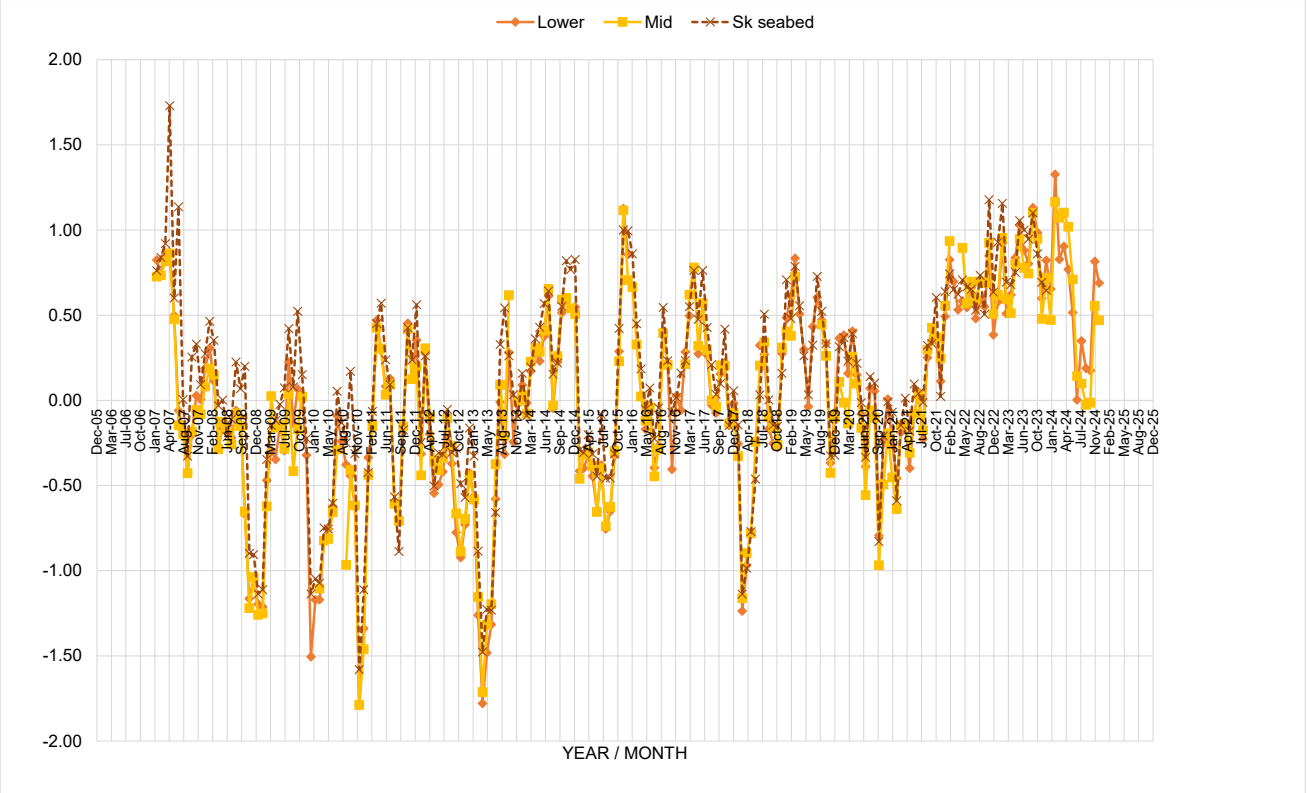


Sea temperatures prior to 1995 were generally colder than average. From 1995 to 2006 there was a warmer period, but from 2006 onwards the data have been very erratic with some very cold winter temperatures but some warm summer temperatures. 2022 and 2023 recorded above average sea temperatures.

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. 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 but in 2024 the summer months were quite average while the winter temperatures were still warmer than usual.

5.2.7. Current Status

There does not appear to be any long-term trend in sea water temperatures but the last 3 years (2022 to August 2024) 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. We have not collected all of the 2024 temperature logger data yet but early analysis of the 2024 data suggests 2024 did not have a warm summer but winter temperatures continue to be higher than average.

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 30cm diameter Secchi disc can be seen through the water column has been recorded during the field season since 1992 at OMS and, since 2004, at Thorn Rock.
- Suspended sediment sampler (pump driven): fixed to the frame on the seabed at OMS site between 1994 and 1997, but with limited success.
- Passive sediment traps: these have been deployed at each site since 1994 (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 2 Skomer MCZ sediment trap sampling effort from 1994 to 2023 at OMS and Thorn Rock (TRK).

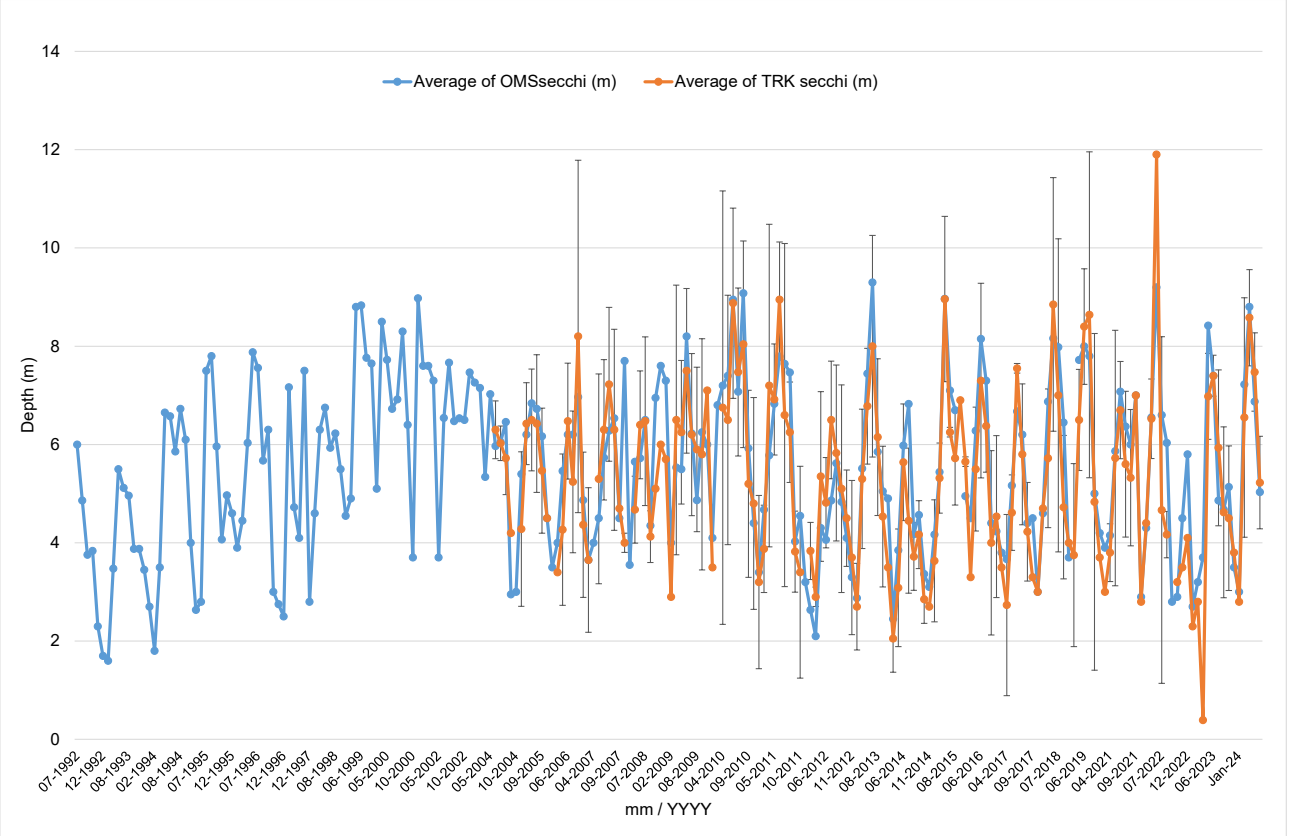
Year	Months with samples	Sites	Notes
1994	Jul – Dec	OMS & TRK	None
1995	Jan – Dec	OMS & TRK	None
1996	Feb – Dec	OMS & TRK	None
1997	Mar – Dec	OMS & TRK	None
1998	Mar – Sep	OMS & TRK	None
1999- 2001	No samples	None	Re-established 02 Nov 2001
2002	Mar – Nov	OMS & TRK	TRK site damaged
2003	May – Sep	OMS 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
2024	Jan - Aug	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. 2024 saw an improvement in water clarity.

Figure 5.3.3 (a) Skomer MCZ summary of annual mean Secchi disc data (m) for OMS site with standard error bars 1992 - 2024.

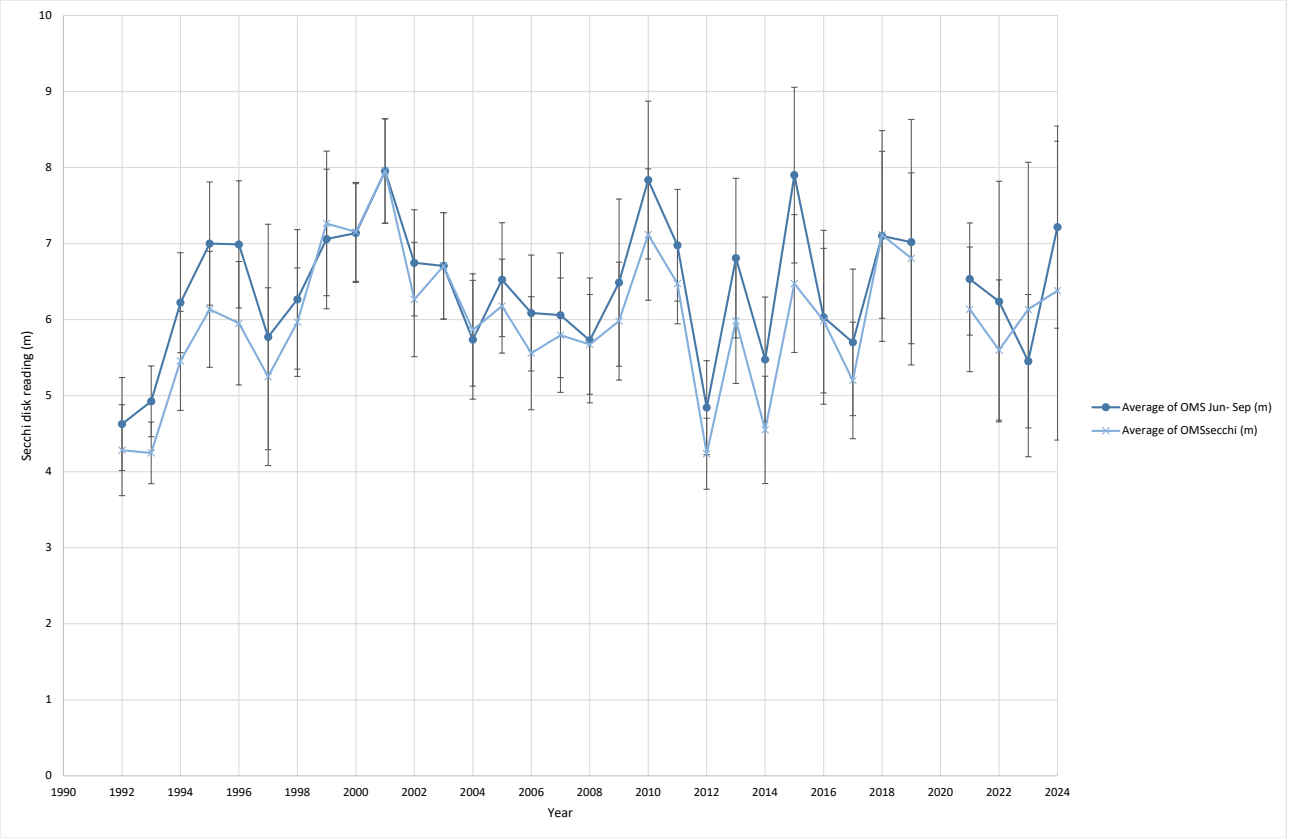
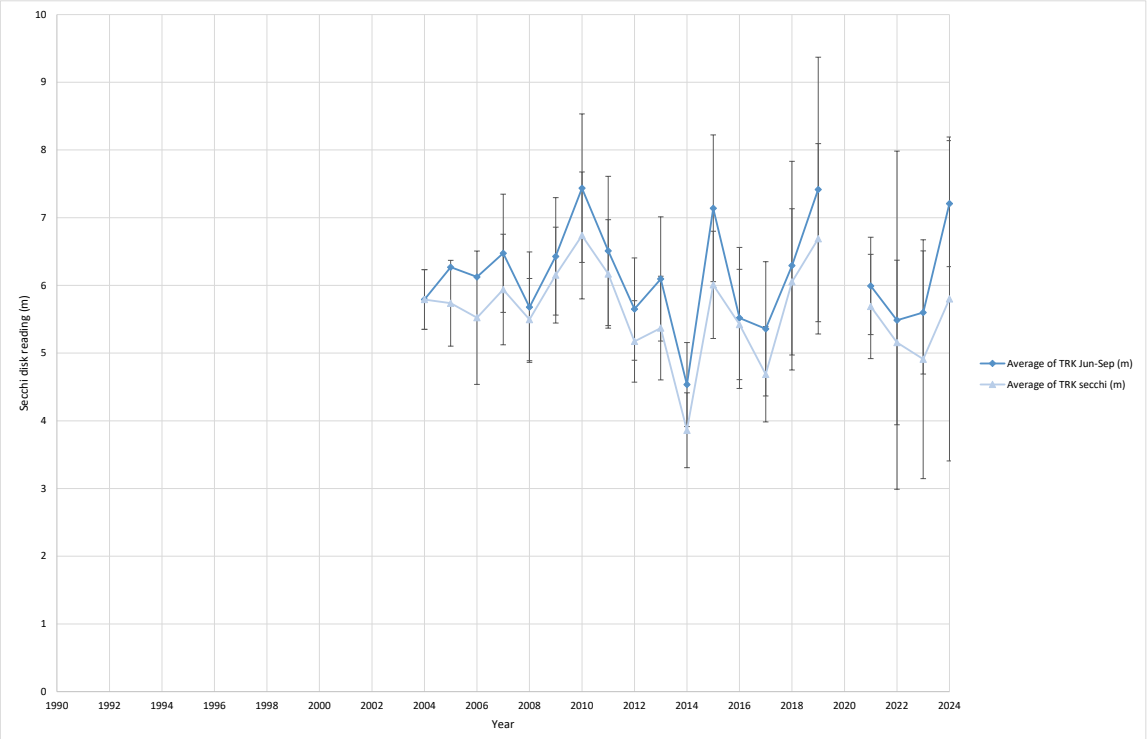


Figure 5 (b) Skomer MCZ summary of annual mean Secchi disc data (m) for TRK site with standard error bars 2004 - 2024.



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 2024 samples are currently being analysed and this data will be available in autumn 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
2023	3.58	11.5	6.50	40.38	51.59

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
2023	1.25	14.73	26.43	40.42	32.57

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).

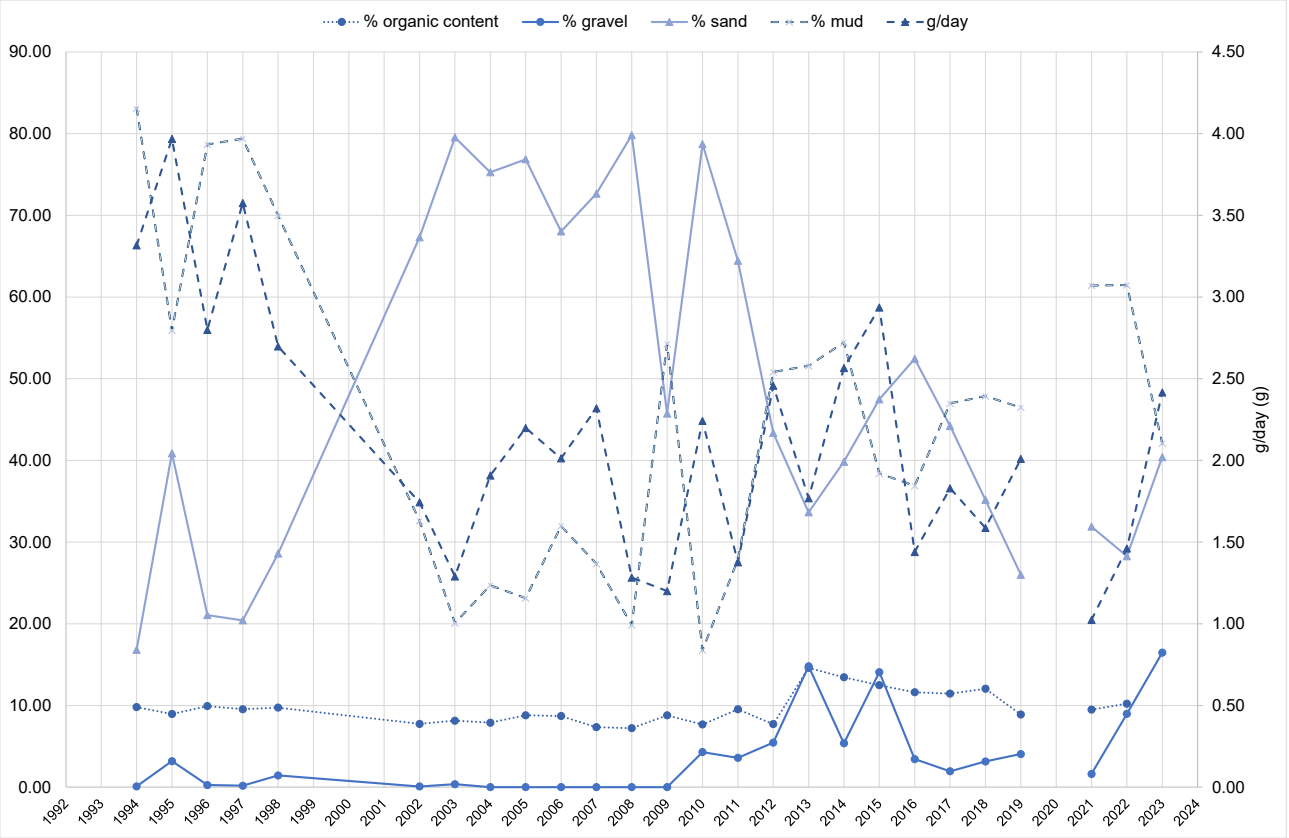
Another change in 2013 was that the organic content analysis included heating the sample to 550^{o}C rather than 450^{o}C resulting in more carbonates being included in the % organic content. This explains the sudden rise in the 2013 values. The ignition temperature used from 2014 onwards at the NRW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

Skomer MCZ Bibliography

Adams, E. J. (1979) A littoral survey of the flora and fauna of the North and South Havens, Skomer Island. Undergraduate dissertation, Swansea.

Alexander, M. (2005). The CMS Management Planning Guide. CMS Consortium, Talgarth, Wales, UK. (www.esdm.co.uk/cms).

Alexander, M. (2015) Skomer MCZ and Skomer Island seal management plan.

Ayling, A. L. (1983). Growth and regeneration rates in thinly encrusting Demospongiae from temperate waters. Biological Bulletin 165: 343-352.

Baines, M. E. (1992) The West Wales grey seal census. Interim report on the 1991 survey. Dyfed Wildlife Trust.

Baines, M. E. (1993) The West Wales grey seal census. Interim report on the 1992 season. Dyfed Wildlife Trust.

Baines, M. E., Earl, S.J. & Strong, P.G. (1994) The West Wales grey seal census. Interim report on the 1993 season. Dyfed Wildlife Trust.

Baines, M.E., Earl S.J., Pierpoint, C.J.L & Poole, J. (1995) The West Wales grey seal census. CCW Contract Science Report no. 131.

Barfield, P. (CORDAH) (1998) Skomer MNR: A repeat survey of the sublittoral macrobenthos. CCW 009/1998

Barfield, P. Sea Nature studies (2004) Skomer MNR: A repeat survey of the sublittoral macrobenthos 2003. CCW West Area Report 28

Barfield, P. Sea Nature studies (2008) Skomer MNR: A repeat survey of the sublittoral macrobenthos 2007. CCW Regional report CCW/WW/08/

Barfield, P. (EMU) (2010) Skomer MNR: A repeat survey of the sublittoral macrobenthos 2009. A Report for CCW.

Bell, J.J & Barnes, D.K.A. (2001) Sponge morphological diversity: a qualitative predictor of species diversity? Aquatic Conserv: Mar. Freshw. Ecosyst. 11: 109-121 (2001).

Bell J.J & Barnes D.K.A. (2002) Modelling sponge species diversity using a morphological predictor: a tropical test of a temperate model. J.Nat. Conserv. 10: 41-50 (2002).

Bell J.J, Burton M., Bullimore B., Newman P. & Lock K. (2006) Morphological monitoring of sub-tidal sponge assemblages. Marine Ecological Progress Series. Vol 311: 79 – 91

Berman J., Burton M., Gibbs R., Lock K., Newman P., Jones J. and Bell J. (2013) Testing the suitability of a morphological monitoring approach for identifying temporal variability in a temperate sponge assemblage. Journal of Nature Conservation. Vol 21, 2013 No.3.

Bettridge, M. (2003) Visitor disturbance on the Atlantic Grey Seal *Halichoerus grypus* during the pupping season, Pebbly beach, Skomer Marine Nature Reserve. HND 2nd year project, Pembrokeshire College.

Bishop, G.M. (1982) A survey of the edible sea urchin *Echinus esculentus* in the Skomer Marine Nature Reserve. Underwater Conservation Society. 10pp.

Boyle, D.P. (2001) Grey seal breeding census: Skomer Island 2001. CCW Report no. 507.

Boyle, D.P. (2009) Grey seal breeding census: Skomer Island 2008. CCW Regional Report CCW/WW/09/1.

Boyle, D.P. (2010) Grey Seal Breeding Census: Skomer Island, 2010. Wildlife Trust of South and West Wales CCW Regional Report CCW/WW/10/07.

Boyle, D.P. (2011) Grey Seal Breeding Census: Skomer Island, 2011. Wildlife Trust of South and West Wales CCW Regional Report CCW/WW/11/01.

Boyle, D.P. (2012) Grey Seal Breeding Census: Skomer Island, 2012. Wildlife Trust of South and West Wales CCW Regional Report CCW/WW/13/01.

Brodie, J. & Watson, D. (1999) Skomer MNR community and species monitoring: algal communities. Advice on conservation objectives. CCW report no. 334.

Brodie, J & Bunker, F. (2000) Skomer MNR community and species monitoring: algal communities. CCW report 387.

Brown, A. (2001) Habitat Monitoring for Conservation Management and Reporting. 3: Technical Guide. Life – Nature project No LIFE95 NAT/UK/000821.

Buche, B & Stubbings E. (2013) Grey Seal Breeding Census: Skomer Island, 2013. Wildlife Trust of South and West Wales. NRW report.

Buche, B & Stubbings E. (2014) Grey Seal Breeding Census: Skomer Island, 2014. Wildlife Trust of South and West Wales. NRW Evidence Report No.65.

Buche, B & Stubbings E. (2015) Grey Seal Breeding Census: Skomer Island, 2015 Wildlife Trust of South and West Wales. NRW Evidence Report No.147.

Buche, B & Stubbings E. (2016) Grey Seal Breeding Census: Skomer Island, 2016 Wildlife Trust of South and West Wales. NRW Evidence Report No.194.

Büche, B & Stubbings E. (2017) Grey Seal Breeding Census: Skomer Island, 2017 Wildlife Trust of South and West Wales. NRW Evidence Report No.252.

Büche, B & Stubbings, E (2019) Grey Seal Breeding Census, Skomer Island 2018. NRW Evidence Report number 325 The Wildlife Trust of South and West Wales.

Büche, B. (2021) Grey Seal Breeding Census, Skomer Island 2021. NRW Evidence Report number 588 The Wildlife Trust of South and West Wales.

Büche, B & Blockley, F. (2022) Grey Seal Breeding Census, Skomer Island 2022. NRW Evidence Report number 653 The Wildlife Trust of South and West Wales.

Büche, B & Bond, S. (2023) Grey Seal Breeding Census, Skomer Island 2023. NRW Evidence Report number 750 The Wildlife Trust of South and West Wales.

Bull J.C., Börger L., Banga R., Franconi N., Lock K.M., Morris C.W., Newman P.B., Stringell T.B. (2017a). Temporal trends and phenology in grey seal (*Halichoerus grypus*) pup counts at Marloes Peninsula, Wales. NRW Evidence Report No: 155, 23pp, Natural Resources Wales, Bangor.

Bull J.C., Börger L., Franconi N., Banga R., Lock K.M., Morris C.W., Newman P.B., Stringell T.B. (2017b). Temporal trends and phenology in grey seal (*Halichoerus grypus*) pup counts at Skomer, Wales. NRW Evidence Report No: 217, 23pp, Natural Resources Wales, Bangor.

Bullimore, B. (1983) Skomer Marine Reserve subtidal monitoring project, 1982-83.

Bullimore, B. (1983, 1986) Photographic monitoring of subtidal epibenthic communities on Skomer Marine Reserve, 1984-85. SMRSMP Report No 5

Bullimore, B. (1983, 1986, 1987) Photographic monitoring of subtidal epibenthic communities on Skomer Marine Reserve, 1986. SMRSMP Report No 6

Bullimore, B. (1985) Diving survey of scallop stocks around SW Wales.

Bullimore, B., Newman, P., Kaiser, M., Gilbert, S. & Lock. K. (1999) A study of catches in a fleet of 'ghost fishing' pots. Fishery bulletin 99 (2).

Bullimore, R. & Foggo, A. 2010. Assessing the effects of recreational fishing upon fish assemblages in a temperate Marine Nature Reserve with remote underwater video Marine Biology and Ecology Research Centre, University of Plymouth.

Bunker, F.StP.D., Iball, K. & Crump, R. (1983) Skomer Marine Reserve, littoral survey, July to September 1982.

Bunker, F.StP.D. (1983) Studies on the macrofauna and sediments of a bed of *Zostera marina* (L) in North Haven, Skomer.

Bunker, F. & Hiscock, S. (1987) Sublittoral habitats, communities and species around Skomer Marine Reserve- a review. FSC/(OFC)/1/87

Bunker, F. & Hiscock, S. (1984) Surveys of sublittoral habitats and communities around Skomer Marine Reserve, 1983.FSC/(OFC)/1/84

Bunker, F.StP.D., & Hiscock, S. (1985) Surveys of sublittoral habitats & communities around Skomer Marine Reserve in 1984. FSC / (OFC)/ 2/85

Bunker, F.StP.D. (1986) A survey of the broad sea fan *Eunicella verrucosa* around Skomer Island Marine Reserve in 1985 FSC report No FSC/(ofc)/ 1/86

Bunker, F., and Mercer, T. (1988) A survey of the ross coral *Pentapora foliacea* around Skomer Marine Reserve in 1986 (together with data concerning previously unsurveyed or poorly documented areas).FSC report fsc/(ofc)/1/88.

Bunker, F., Picton, B. & Morrow, C. (1992) New information on species and habitats in SMNR and other sites off the Pembrokeshire coast.

Bunker, F & Jones J. (2008) Sponge monitoring Studies at Thorn Rock, Skomer Marine Nature Reserve in autumn 2007. CCW regional report CCW/WW/08/7

Burrows M.T., Smale. D., O'Connor N., Van Rein H. & Moore P. (2014) Marine Strategy Framework Directives Indicators for UK Kelp Habitats Part 1. Developing proposals for potential indicators. JNCC Report No.525.

Burrows M.T. (2016). Analysis of long-term trends in the SOTEAG rocky shore monitoring programme: responses to climate change 1976-2014. A report to SOTEAG by SAMS.

Burrows, M.T., Twigg, G., Mieszkowska, N. & Harvey, R. Marine Biodiversity and Climate Change (MarClim): Scotland 2014/15. Scottish Natural Heritage Commissioned Report No. 939

Burton, M. (2002) Summary of commercial potting activities in the Skomer MNR 1989 - 2002. CCW West Area Report No 19

Burton, M., Lock, K. & Newman, P.(2002) Skomer Marine Nature Reserve Monitoring Method Development. Yellow Trumpet Anemone *Parazoanthus axinellae*. CCW West Area Report 14.

Burton, M., Lock, K., Luddington, L. & Newman, P. (2004) Skomer Marine Nature Reserve Project Status Report 2003/4. CCW West Area Report 29.

Burton, M., Lock, K., Ludington L. & Newman, P. (2005) Skomer Marine Nature Reserve Project Status Report 2004/5. CCW Regional Report CCW/WW/04/5

Burton, M., Lock, K., Gibbs, R & Newman, P. (2007) Skomer Marine Nature Reserve Project Status Report 2006/07. CCW Regional Report CCW/WW/08/3.

Burton, M., Lock, K. & Newman, P (2010). Skomer Marine Nature Reserve. Distribution and Abundance of Zostera *marina* in North Haven 2010. CCW Regional Report CCW/WW/10/10

Burton, M., Lock, K., Gibbs, R & Newman, P. (2011) Skomer Marine Nature Reserve Project Status Report. CCW Regional Report CCW/WW/10/8.

Burton, M., Lock, K., Jones, J & Newman, P. (2014) Skomer Marine Nature Reserve Project Status Report 2013/14. NRW Evidence Report.

Burton, M., Clabburn, P., Griffiths, J., Lock, K., Newman, P. (2015). Skomer Marine Conservation Zone. Distribution & Abundance of *Zostera marina* in North Haven 2014. NRW Evidence Report No.69.

Burton M., Lock, K., Newman, P & Jones, J. (2016) Skomer Marine Conservation Zone Project Status Report 2015/16. NRW Evidence Report No. 148.

Burton M., Lock, K., Newman, P & Jones, J. (2016) Skomer Marine Conservation Zone Distribution and abundance of *Echinus esculentus* and selected starfish species 2015. NRW Evidence Report No. 158.

Burton, M., Lock, K., Newman, P. & Jones, J. (2016) Skomer MCZ Scallop Report 2016. NRW Evidence Report No: 196.

Burton, M., Lock, K., Newman, P. & Jones, J. (2018) Skomer MCZ Project Status Report 2017. NRW Evidence Report 251.

Burton, M., Lock, K., Griffiths, J., Newman, P., & Jones, J. (2019) Skomer Marine Conservation Zone Distribution & Abundance of *Zostera marina* in North Haven 2018. NRW Evidence Report No 322.

Burton,M., K. Lock. P. Newman, J. Jones (2019) Skomer Marine Conservation Zone Project Status Report 2018. NRW Evidence Report 324.

Burton, M., K. Lock., P. Newman, J. Jones (2023) Skomer Marine Conservation Zone Project Status Report 2022. NRW Evidence Report 656.

Butler, P.G., Wanamaker, A.D., Scourse, J.D.; Richardson, C.A.; Reynolds, D.J. (2013). Variability of marine climate on the North Icelandic Shelf in a 1357-year proxy archive based on growth increments in the bivalve *Arctica islandica.* Palaeogeography, Palaeoclimatology, Palaeoecology. **373**: 141–151.

Chauvaud, L., Patry, Y., Jolivet, A., Cam, E., Le Goff, C., *et al*. (2012) Variation in Size and Growth of the Great Scallop *Pecten maximus* along a Latitudinal

Clabburn, P., Davies, R., & Griffiths, J. (2014) Assessment of seagrass (*Zostera marina*) beds using hydroacoustics, a feasibility study, Natural Resources Wales internal report.

Clarke, K.R. & Warwick, R.M. (2001) Changes in marine communities: and approach to statistical analysis and interpretation, 2nd Edition. PRIMER-E: Plymouth.

Coutts, E (2006) Bull dominance behaviour patterns for the Grey seal, Halichoerus grypus, at South Haven, Skomer Island 2005. BSc dissertation, Pembrokeshire College.

Crump, R. (1993) Skomer Marine Nature Reserve littoral monitoring project (permanent quadrats) CCW report FC 73 01 27

Crump, R. (1996) Skomer Marine Nature Reserve littoral monitoring project (permanent quadrats) Post Sea Empress oil spill. FC 73-02-48F

Crump, R.G. & Burton, M (2004) Skomer MNR littoral monitoring: development of methods. CCW West Area Report 27.

Devictor, V., van Swaay, C., Brereton, T., Brotons, L. S., Chamberlain, D., Heliölä, J., Herrando, S., Julliard, R., Kuussaari, M., Lindström, Å., Reif, J., Roy, D. B., Schweiger, O., Settele, J., Stefanescu, C., Van Strien, A., Van Turnhout, C., Vermouzek, Z., WallisDeVries, M., Wynhoff, I., Jiguet, F. (2012) Differences in the climatic debts of birds and butterflies at a continental scale. *Nature Climate Change*, **2**, 121.

Duffield, S. E. (2003) Grey seal breeding census: Skomer Island 2002. Wildlife trust of South and West Wales CCW report no 555.

Earl, R.C. (1979) A survey of the edible urchin, *Echinus esculentus* in the Skomer Marine Reserve. 9 pp.

Edwards, E. Bunker, F., Maggs, C.A. & Johnson, M.P. (2003) Biodiversity within eelgrass (*Zostera marina*) beds on the Welsh coast: analysis of epiflora and recommendations for conservation.

Eno, C., NacDonald, D., Kinnear, J., Amos, S., Chapman, C., Bunker, F & Munro, C. (2001). Effect of crustacean traps on benthic fauna. ICES Jo7urnal of Marine Science 58:11-20.

Field, R. (2000) Grey seal breeding census: Skomer Island 1999. Wildlife Trust West Wales, CCW report no. 388.

Fothergill, B. (2004) A comparison of the effectiveness of two surveying techniques for obtaining population information of economically important crustaceans within the Skomer Marine Nature Reserve. Undergraduate project. Institute of Marine Studies, University of Plymouth.

Furby, G.L. (2003) *Eunicella verrucosa*: A study of biology, conservation and growth rates. Under graduate project, University of Cardiff. No 000521837.

Gibbs, R. (2007) Summary of work on *Pentapora foliacea* at Skomer Marine Nature Reserve Autumn 2006. CCW Regional Report CCW/WW/07/1.

Gilbert, S. (1998) Skomer MNR monitoring field data analysis. summary report. Sea Empress contract FC 73-02-84.

Garrabou J. (1999) Life history traits of *Alcyonium acaule* and *Parazoanthus axinellae*, with emphasis on growth. Marine Ecological Progress Series, vol 178. pp 193-204.

Gradient. PLoS ONE 7(5): e37717. doi:10.1371/journal.pone.0037717

Hiscock, K. (1980) SWBSS field survey of sublittoral habitats and species in West Pembrokeshire (Grassholm, Skomer and Marloes Peninsula), 1977-79.

Hiscock, K. (1983) Sublittoral surveys in the region of the Skomer Marine Nature Reserve, 1982. FSC/(OPRU)/5/83.

Hiscock, K. (1990) Marine Nature Conservation Review: Methods. Nature Conservancy Council, CSD Report No. 1072. Marine Nature Conservation Review Occasional Report MNCR/OR/05. Peterborough: Nature Conservancy Council.

Hiscock, K. (1998) Biological monitoring of marine S.A.C.'s: a review of methods for detecting change. JNCC Report No 284 Procedural guideline 6-2.

Hiscock, S. (1983) Skomer Marine Reserve Seaweed Survey 1982 FSC report fsc/(ofc)/2/83

Hiscock, S. (1986) Skomer Marine Reserve Subtidal Monitoring Project: Algal results August 1984 to February 1986. SMRSMP report No 4.

Holland, L. (2013) Genetic assessment of connectivity in the temperate octocorals *Eunicella verrucosa* and *Alcyonium digitatum* in the North East Atlantic. PhD thesis, University of Exeter.

Hudson, K. (1996) Changes in rocky shore communities on Skomer Island between 1992 and 1995.

Hughes, R.N. & Cancino, J.N. (1985) An ecological overview of cloning in metazoa. In Jackson JBC., Buss LW, Cook RE (eds) Population biology and evolution of colonial organisms. Yale University Press, New Haven 9 153-186.

Hunnam, P. J. (1976) Description of the sublittoral habitats and associated biota within the Skomer MNR.

Hunnam, P. and Brown, G. (1975) Sublittoral nudibranch mollusca (sea slugs) in Pembrokeshire waters. *Field Studies*,**4**, 131-159.

Isojunno, S (2008). Temporal habitat use of the harbour porpoise around Skomer and Skokholm islands. CCW Species challenge project report.

Jackson J.B.C. (1977) Competition on marine hard substrata; adaptive significance of solitary and colonial strategies. Am. Nat. vol 3, pp 743 – 767.

Jones, H., Hodgson, A. (1979) Survey of scallops of the Skomer MNR 1979. University of Manchester, Underwater Conservation Society.

Jones, H. (1980) Survey of scallops of the Skomer MNR 1980. University of Manchester, Underwater Conservation Society.

Jones, B., Jones, J. & Bunker, F. (1983) Monitoring the distribution and abundance of *Zostera marina* in North Haven Skomer. Skomer MNR report vol 3 FSC report No FC73-01-168.

Jones, J., Bunker, F., Newman, P., Burton, M. & Lock, K. (2012) Sponge diversity of Skomer Marine Nature Reserve. CCW Regional Report CCW/WW/12/3.

Jones, J., Burton, M., Lock, K. & Newman, P. (2016) Skomer Marine Conservation Zone Sponge Diversity Survey 2015. NRW Evidence Report No.159.

Jones, J., Lock, K., Burton, M., Newman, P. (2020) Skomer Marine Conservation Zone Sponge Diversity Report 2019. NRW Evidence Report 460.

Jones, J., Lock, K., Burton, M., Massey, A. (2023) Skomer Marine Conservation Zone Nudibranch Diversity Survey 2022. NRW Evidence Report 654.

Jones, J., Lock, K., Burton, M., Massey, A. (2024) Skomer Marine Conservation Zone Sponge Diversity Survey 2023. NRW Evidence Report 754.

Lindenbaum, C., Sanderson, W.G., Holt, R.H.F., Kay, L., McMath, A.J. & Rostron, D.M. (2002) An assessment of appropriate methods for monitoring a population of colonial anemone at Bardsey island (Ynys Enlli), Wales, UK. CCW Marine Monitoring Report No: 2, 31pp.

Lock, K. (1998a) Development of method to assess nearshore territorial fish populations. A Skomer Marine Nature Reserve Report, CCW science report 276.

Lock, K. (1998b) Distribution and abundance of *Zostera marina* in North Haven Skomer 1997. CCW science report no.277.

Lock, K. & Newman, P. (2001) Skomer MNR Scallop *Pecten maximus* survey 2000. CCW West Area Report No 16.

Lock, K. (2003) Distribution and abundance of *Zostera marina* in North Haven Skomer 2002. CCW West Area Report No. 22.

Lock, K., Burton, M & Newman, P. (2003) Skomer Marine Nature Reserve Project Status Report 2002/3. CCW West Area Report 24.

Lock, K. (2004) Skomer Marine Nature Reserve Seal Disturbance Study 2002 & 2003. CCW Regional Report CCW/WW/04/6.

Lock, K., Burton M., Newman, P. & Luddington, L. (2006a) Skomer Marine Nature Reserve Territorial Fish Population Study. CCW Regional Report CCW/WW/05/8.

Lock, K., Burton, M., Luddington, L. & Newman, P. (2006b) Skomer Marine Nature Reserve Project Status Report 2005/06. CCW Regional Report CCW/WW/05/9.

Lock, K., Burton M., Gibbs R & Newman P (2007) Distribution and abundance of *Zostera marina* in North Haven, Skomer 2006. CCW Regional Report CCW/WW/08/2.

Lock, K., Gibbs, R., Burton, M & Newman, P (2008) Skomer Marine Nature Reserve Distribution & abundance of *Echinus esculentus* and selected starfish species. CCW Regional Report CCW/WW/08/2.

Lock, K., Gibbs R., Burton M & Newman P (2009) Skomer Marine Nature Reserve Scallop, *Pecten maximus* survey 2008. CCW Regional Report CCW/WW/09/4.

Lock, K., Burton, M., Gibbs, R & Newman, P. (2009) Skomer Marine Nature Reserve Project Status Report 2008/09. CCW Regional Report CCW/WW/09/2.

Lock, K., Newman, P., Burton M (2010) Skomer Marine Nature Reserve Nudibranch Diversity Survey 2010. CCW Regional Report. CCW/WW/10/11.

Lock, K., Burton, M., Newman, P & Jones, J (2012) Skomer Marine Nature Reserve Distribution & abundance of *Echinus esculentus* and selected starfish species 2011. CCW Regional Report CCW/WW/11/04.

Lock, K., Burton, M., Newman, P & Jones, J (2013a) Skomer Marine Nature Reserve Scallop. *Pecten maximus* survey 2012. CCW Regional Report CCW/WW/13/2.

Lock, K., Burton, M., Newman, P & Jones, J. (2013b) Skomer Marine Nature Reserve Project Status Report 2012/13. CCW Regional Report CCW/WW/13/3.

Lock, K., Newman P., Burton, M & Jones, J (2015) Skomer Marine Conservation Zone Nudibranch Diversity Survey 2014. NRW Evidence Report No.67.

Lock, K., Burton, M., Newman, P & Jones, J. (2015) Skomer Marine Conservation Zone Project Status Report 2014/15. NRW Evidence Report No. 66.

Lock, K., Burton, M., Newman, P & Jones, J. (2017) Skomer Marine Conservation Zone Project Status Report 2016. NRW Evidence Report No. 197.

Lock K., Newman, P., Burton, M & Jones J, (2017) Skomer MCZ Grey Seal Survey, Marloes Peninsula 1992 – 2016. NRW Evidence Report 195.

Lock, K., Newman, P., Burton, M & Jones, J (2019) Skomer Marine Conservation Zone Nudibranch Diversity Survey 2018. NRW Evidence Report 321.

Lock, K., Burton, M., Newman, P & Jones, J. (2020) Skomer Marine Conservation Zone, Distribution and Abundance of *Echinus esculentus* and selected starfish species 2019. NRW Evidence Report No.400.

Lock, K., Burton, M., & Jones, J. (2022) Skomer Marine Conservation Zone Project Status Report 2021. NRW Evidence Report No. 589.

Lock, K., Burton, M., Massey, A & Jones, J. (2024) Skomer Marine Conservation Zone Project Status Report 2023. NRW Evidence Report 752.

Lofthouse, C. (2017) Assessing and distinguishing differences in Grey seal (Halichoerus grypus) diet during summer and winter from colonies in South Wales. BSc dissertation, Swansea University.

Longdin & Browning Ltd (2002) Habitat and feature distribution in Pembrokeshire Marine SAC: Acoustic habitat survey. CCW science report 514.

Luddington, L. (2002) Skomer MNR Nudibranch diversity survey, CCW West Area Report No 18.

Luddington, L., Lock, K., Newman P. & Burton, M. (2004) Skomer Marine Nature Reserve Distribution & abundance of *Echinus esculentus* and selected starfish species. CCW West Area Report No. 45.

Luddington, L., Newman, P., Lock, K & Burton, M. (2004) Skomer MNR *Pecten maximus*, King scallop survey 2004. CCW Regional Report CCW/WW/04/2.

Luddington, L., & Bunker, F. (in prep) Algal monitoring in Skomer MNR and other sites around Wales 2005.

Manuel, R.L. (1988) British Anthozoa. The Linnean Society. ISBN 90 04085963, 241pp.

Massey, A., Burton, M., Lock, K., & Jones, J., (2023). Skomer MCZ Distribution & Abundance of *Pecten maximus*, 2023. NRW Report No: 655.

Massey, A., Burton, M., Lock, K., & Jones, J., (2024). Skomer MCZ Distribution & Abundance of *Zostera* marina in North Haven, Skomer, 2023. NRW Report No: 753

Matthews, J. H. (2004) Grey seal breeding census: Skomer Island 2003. Wildlife trust of South and West Wales CCW report no 621.

Matthews, J. H. (2005) Grey seal breeding census: Skomer Island 2004. Wildlife trust of South and West Wales CCW report no CCW/WW/04/7.

Matthews, J. H. (2006) Grey seal breeding census: Skomer Island 2005. Wildlife trust of South and West Wales CCW report no CCW/WW/05/7.

Matthews, J. H. & Boyle, D. (2008) Grey seal breeding census: Skomer Island 2007. Wildlife trust of South and West Wales CCW report no CCW/WW/08/1.

McEvoy, A., Burton, M., Somerfield, P & Atkinson, A. (2013) Cost-effective method for establishing an ecological baseline of the zooplankton at Skomer Marine Nature Reserve. Plymouth Marine Laboratory Scientific Poster.

Middleton J (2021) Harbour porpoise (*Phocoena phocoena*) distributions, monitoring practice and avoidance with common dolphin (*D. delphis*) in the Skomer Island Marine Conservation Zone. Undergraduate dissertation Cardiff University.

Mieszkowska, N., Kendal, M., R. Leaper, A., Southward, S. Hawkins & M. Burrows (2002) MARCLIM monitoring network: provisional sampling strategy and standard operating procedure.

Mieszkowska, N. (2017) MarClim Annual Welsh Intertidal Climate Monitoring Survey (2016). Natural Resources Wales Evidence Report No. 205 pp 27 + viii, Natural Resources Wales, Bangor.

Mieszkowska, N. (2019) MarClim Annual Welsh Intertidal Climate Monitoring Survey 2018. Natural Resources Wales Evidence Report No. 345 pp 23 + x, Natural Resources Wales, Bangor.

Mieszkowska, N. & Sugden, H. (2022). MarClim Annual Welsh Intertidal Climate Monitoring Survey 2021. Natural Resources Wales Evidence Report No. 601 pp 24 + xi, Natural Resources Wales, Bangor.

Moore, J. (2001) Monitoring baseline for sediment surface and burrowing macro and mega fauna in Skomer Marine Nature Reserve. A report to the Countryside Council for Wales from Coastal Assessment, Liaison and Monitoring, Cosheston, Pembrokeshire. 39pp

Moore, J. (2005) Repeat monitoring for sediment surface and burrowing macro and mega fauna in Skomer Marine Nature Reserve. A report to the Countryside Council for Wales from Coastal Assessment, Liaison and Monitoring, Cosheston, Pembrokeshire. 46pp

MNCR (unpublished) (1994) MNCR sublittoral survey of South Pembrokeshire, Dyfed, 1994.

Munro, C (1996) Lyme Bay potting impacts study. Report to JNCC and ESFJC.

Munro, L. & Munro, C. (2003a) Reef Research. Determining the reproductive cycle *of Eunicella verrucosa*. Interim report March 2003. RR Report 3/2003 ETR 07

Munro, L. & Munro, C. (2003b) Reef Research. Determining the reproductive cycle *of Eunicella verrucosa*. Interim report Nov 2003. RR Report 10 Nov 2003

Munro, L. & Munro, C. (2004) Reef Research. Genetic variation in populations of *Eunicella verrucosa*. Interim report Jan 2004. RR Report ETR 11 Jan 2004.

Newman, P. (1992) Skomer MNR Seal breeding on the Marloes Peninsula, Sept – Dec1991

Newman, P. & Lock, K. (2000) Skomer Marine Nature Reserve Management Plan. Working document. Countryside Council for Wales.

Newman, P., Lock, K., Burton, M., Jones, J. (2018) Skomer Marine Conservation Zone Annual Report 2017. NRW Evidence Report No. 250.

Newman, P., Lock, K., Burton, M., Jones, J. (2019) Skomer Marine Conservation Zone Annual Report 2018.

Orsman, C. (1990) Grey seal breeding success- Skomer Island 1989. Dyfed Wildlife Trust.

Orsman, C. (1991) Grey seal breeding success- Skomer Island 1990. Dyfed Wildlife Trust.

Pegg, L. (2004) Human disturbance on Atlantic Grey Seal (*Halichoerus grypus*) during the pupping season at Jeffery's Haven, Skomer Marine Nature Reserve, Pembrokeshire. HND project report.

Picton, B.E. & Goodwin, C.E. (2007) Sponge biodiversity of Rathlin Island, Northern Ireland. Journal of the Marine Biological Association of the UK 87 (6): 1441-1458

Pilsworth, M. (2001) Grey seal breeding census: Skomer Island 2000. CCW report no. 445.

Poole, J. (1992) Grey Seal breeding census, Skomer Island 1991. Dyfed Wildlife Trust.

Poole, J. (1993) Grey Seal breeding census, Skomer Island 1992. Dyfed Wildlife Trust.

Poole, J. (1994) Grey Seal breeding census, Skomer Island 1993. Dyfed Wildlife Trust.

Poole, J. (1995) Grey Seal breeding census, Skomer Island 1994. Dyfed Wildlife Trust.

Poole, J. (1996a) Grey seal breeding census: Skomer Island 1995. CCW report.

Poole, J. (1996b) Skomer Island Grey Seal Monitoring Handbook.

Poole, J. (1997) Grey seal breeding census: Skomer Island 1996. CCW report no 191.

Poole, J. (1998) Grey seal breeding census: Skomer Island 1997. CCW report no 252.

Poole, J. (1999) Grey seal breeding census: Skomer Island 1998. CCW report no 316.

Ronowicz, M., Kuklinski, P., Lock, K., Newman, P., Burton, M. & Jones, J. (2014) Temporal and spatial variability of zoobenthos recruitment in a north-east Atlantic marine reserve. Journal of the Marine Biological Association of the United Kingdom *94*(7), 1367-1376.

Rosta da Costa Oliver, T. & McMath, M. (2012) Grey seal (*Halichoerus grypus*) movement and site use connectivity with in the Irish sea: Implications of Management. CCW Poster.

Rostron, D.M. (1983) Systematic descriptive surveys of animal species and habitats at two sites around Skomer Island.

Rostron, D.M. (1988) Skomer Marine Reserve subtidal monitoring project: animal communities on stones March 1987 to January 1988.

Rostron, D.M. (1994) The sediment infauna of the Skomer Marine Nature Reserve. CCW report 55.

Rostron, D.M. (1996) Sediment interface studies in the Skomer Marine Nature Reserve. CCW 133. FC 73-01-109.

Rostron, D.M. (1997) Sea Empress Subtidal Impact Assessment: Skomer Marine Nature Reserve Sediment Infauna.

Salomonsen, H. M., Lambert, G. I., Murray, L.G. & Kaiser, M.J. (2015). The spawning of King scallop, *Pecten maximus*, in Welsh waters – A preliminary study. Fisheries & Conservation report No. 57, Bangor University. pp.21.

Sayer, S (2013) Skomer – Cornwall seal photo identification project 2007 – 2012. Cornwall Seal Group.

Scott, S. (1994) Skomer MNR: recommendations for monitoring of algal populations. CCW report 63.

Stuart-Smith, R., G. Edgar, N., Barrett, S., Kininmonth, and A. Bates. (2015) Identifying and tracking resilience to ocean warming in marine ecological communities using the Community Temperature Index.*in* The 52nd Australian Marine Science Association Annual Conference.

Sharp, J.H., Winson, M.K., Wade, S., Newman, P., Bullimore, B., Lock, K., Burton, M., Gibbs, R. & Porter, J.S. (2008) Differential microbial fouling on the marine bryozoan *Pentapora fascialis.* Journal of Marine Biological Association of the United Kingdom, 2008, 88(4), 705-710.

Somerfield, P.J., Burton, M., Sanderson, W.G. (2014) Analyses of sublittoral macrobenthic community change in a marine nature reserve using similarity profiles (SIMPROF). Journal of Marine Environmental Research (2014) 1e8.

Sweet, N.A. (2007) An Investigation into the Effects of Shore Angling Pressure on Fish Assemblage Structure within Skomer Marine Nature Reserve. Undergraduate dissertation, University of Plymouth.

Tallaksen, K., Torkel, L., Knutsen, T., Asvjorn Vollestad, L., Knutsen, H & Moland, E. (2017) Impact of harvesting cleaner fish for salmonid aquaculture from replicated coastal marine protected areas. Marine Biology Research pages 359 – 369. Published online: 02 Mar 2017.

Trigg, J. (1998) Temporal changes in distribution and abundance of *Zostera marina* and possible effects on benthic community structure. Undergraduate thesis, Newcastle University.

Vevers J (2020) Investigating temporal change in marine vertical wall epibenthic communities: analysis of a long-term photo-quadrat survey. BIOM34 Research Project in Environmental Biology, Swansea University.

Whittey, K. E. (2016) Assessing the fouling on the growth rate of pink sea fan, *Eunicella verrucosa*, in the Skomer Marine Conservation Zone. Undergraduate dissertation, Cardiff University.

Wilkie, N & Zbijewska, S (2020) Grey Seal Breeding Census, Skomer Island 2019. NRW Evidence Report number 399. The Wildlife Trust of South and West Wales.

Wilkie, N & Zbijewska, S (2021) Grey Seal Breeding Census, Skomer Island 2021. NRW Evidence Report number 535. The Wildlife Trust of South and West Wales.

Woods, C. (2003) Pink sea fan survey 2001/2. A report for the Marine Conservation Society.

Woods, C. (2008) Seasearch pink sea fan surveys 2004/6. A report for the Marine Conservation Society.