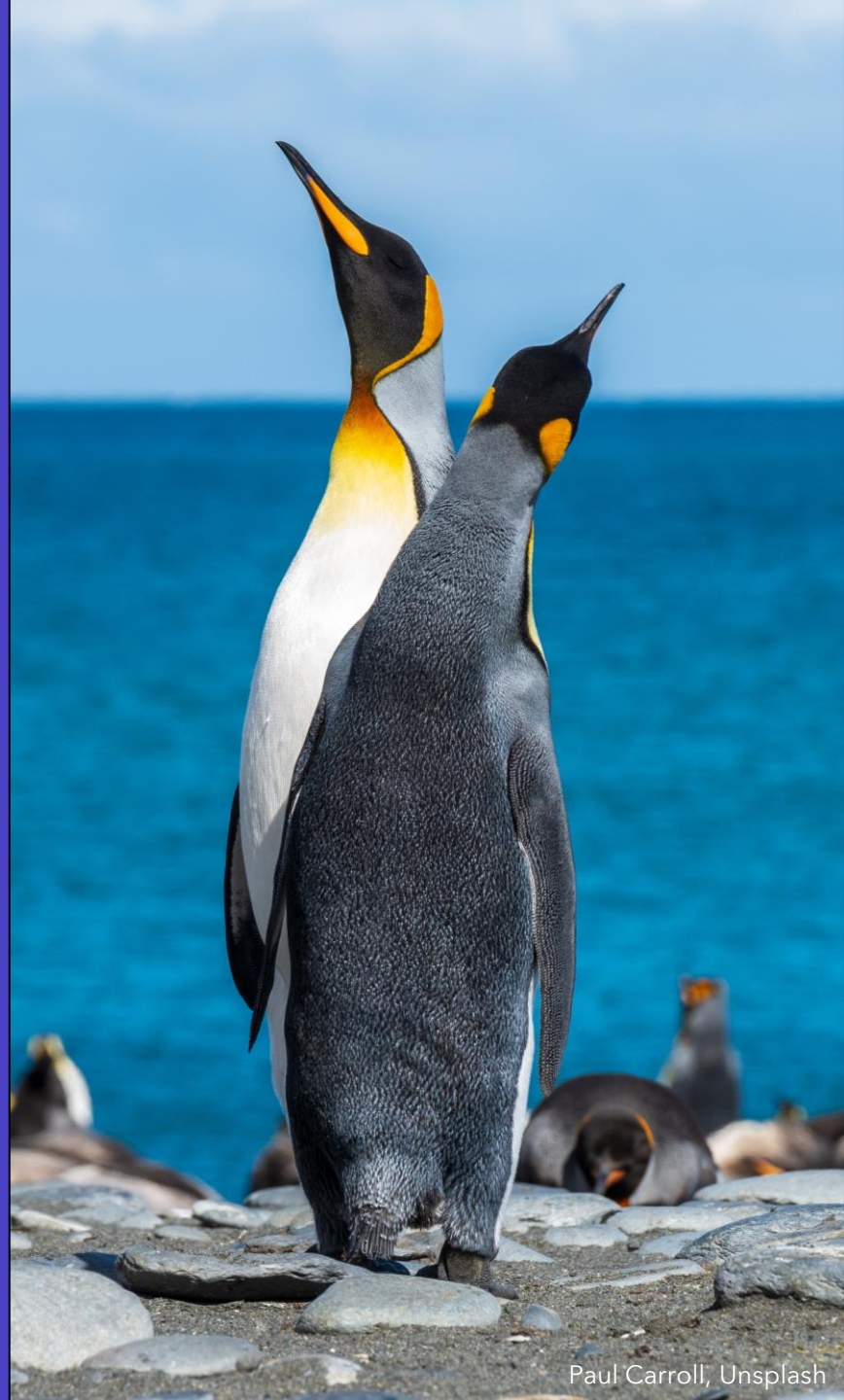
SGSSI MPA Review Science Symposium

13-14 June 2023
Aurora Conference Centre
Cambridge, UK

Hosted by the Government of South Georgia & the South Sandwich Islands


Paul Carroll, Unsplash

The South Sandwich Islands

NASA

- **The South Sandwich Islands – an understudied Southern Ocean archipelago.** *Martin Collins (BAS)*
- **Spatial and temporal variability and connectivity of the marine environment of the SSI.** *Sally Thorpe (BAS)*
- **Plankton and nekton community structure around the South Sandwich Islands and the influence of environmental variables.** *Cecelia Liszka (BAS)*
- **HOT: Hadal Zones of our Overseas Territories - the South Sandwich Trench.** *Heather Stewart (BGS)*
- **Summary of the DY99 Research Cruise to the South Sandwich Islands.** *Oliver Hogg (Cefas)*
- **Expedition Penguin.** *Ruth Peacey (Talesmith TV)*
- **A Seabird Survey of the South Sandwich Islands Post-Eruption.** *Tom Hart (Oxford Brookes University)*

Martin Collins

British Antarctic Survey


ESA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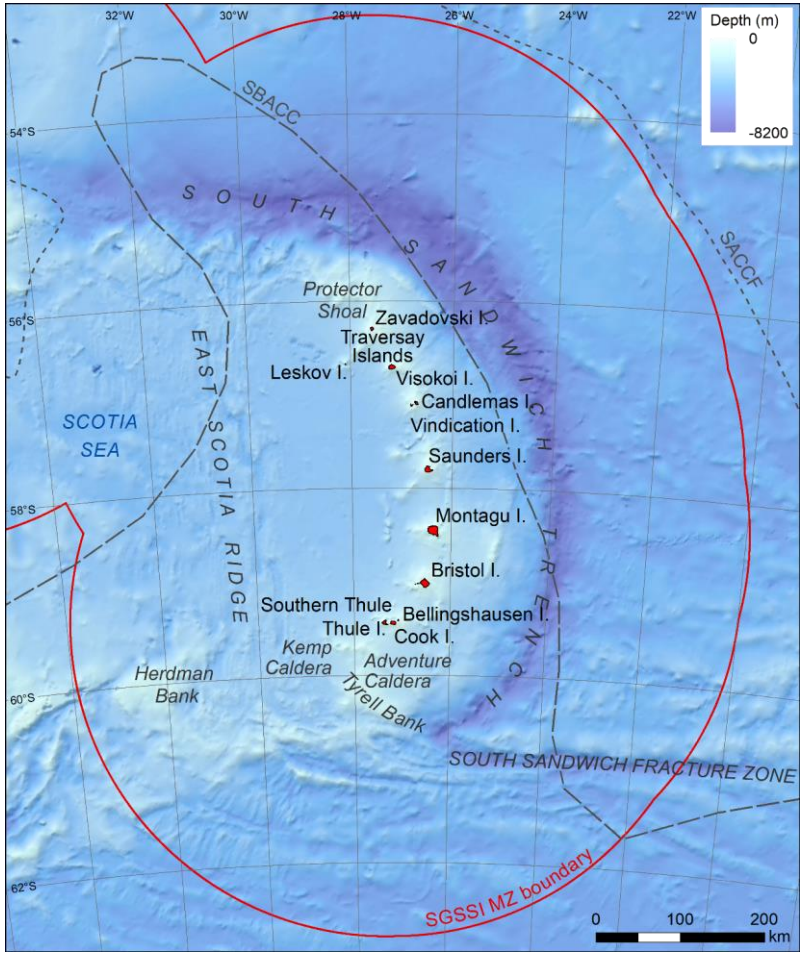
NOC

South Sandwich Islands – an understudied isolated archipelago
Special Issue of Deep-Sea Research II

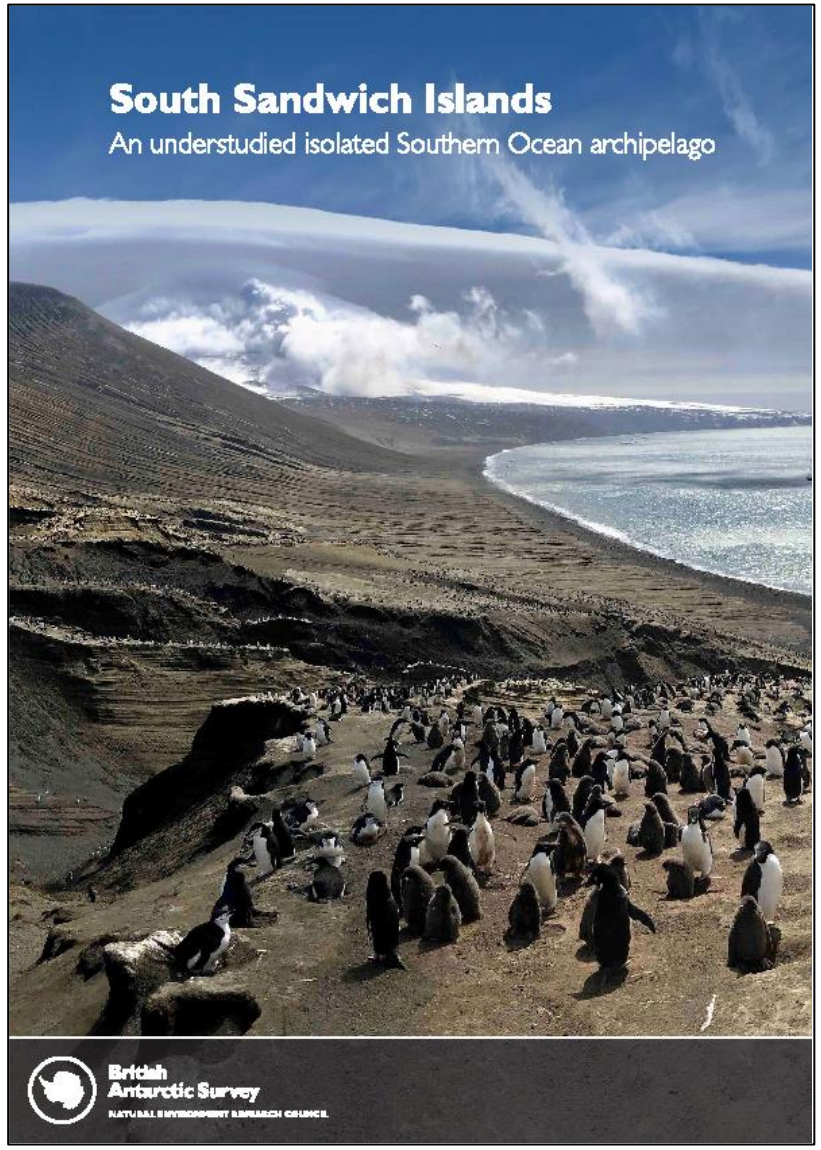
- South Georgia & South Sandwich Islands MPA review in 2018 identified gap in SSI knowledge
- In part, this led to a series of research cruises:
  - *RRS Discovery* cruises 98 & 99 (2019)
  - *Polastern* (2019)
  - *Five Deeps* Expedition (2019)
  - Yacht-based expedition on *Pelagic Australis* (2019/20)
- A series of talks during lockdown led to the idea of a special issue.
- Editors: Collins, Hollyman, Liszka, Trathan (BAS), Oli Hogg (Cefas), Tom Hart (Oxford) & Heather Stewart (BGS).



South Sandwich Islands – an understudied isolated archipelago

Authors	Title
Collins, Hart, Hogg, Hollyman Liszka, Stewart & Trathan	Editorial: South Sandwich Islands - An understudied isolated Southern Ocean archipelago
Thorpe & Murphy, 2022	Spatial and temporal variability and connectivity of the marine environment of the South Sandwich Islands, Southern Ocean
Liszka et al. 2022	Plankton and nekton community structure in the vicinity of the South Sandwich Islands (Southern Ocean) and the influence of environmental factors
Hollyman et al., 2022	Bioregionalization of the South Sandwich Islands through community analysis of bathyal fish and invertebrate assemblages using fishery-derived data
Soeffker et al., 2022	Contrasting life-history traits of two toothfish (*Dissostichus* spp.) species at their range edge around the South Sandwich Islands.
Clucas et al., 2022	Using habitat models for chinstrap penguins, *Pygoscelis antarctica*, to inform marine spatial management around the South Sandwich Islands during the penguin breeding season
Jamieson et al., 2022	Hadal fauna of the South Sandwich Trench, Southern Ocean: Baited camera survey from the Five Deeps Expedition.
Bamford et al., 2022	Humpback whale (*Megaptera novaeangliae*) distribution and movements in the vicinity of South Georgia and the South Sandwich Islands Marine Protected Area
Linse et al., 2022	Megabenthos habitats influenced by nearby hydrothermal activity on the Sandwich Plate, Southern Ocean
Belchier et al., 2022	From sealing to the MPA - A history of exploitation, conservation and management of marine living resources at the South Sandwich Islands
Barlow et al., 2021	Acoustic detections of beaked whales, narrow-band high-frequency pulses and other odontocete cetaceans in the Southern Ocean using an autonomous towed hydrophone recorder

South Sandwich Islands – an understudied isolated archipelago



Sally Thorpe

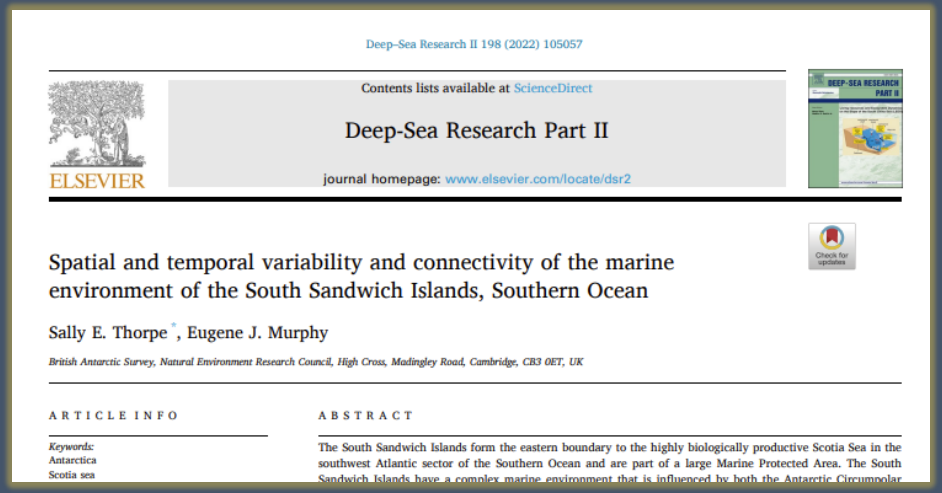
British Antarctic Survey

Spatial and temporal variability and connectivity of the marine environment of the South Sandwich Islands

Sally Thorpe & Eugene Murphy

British Antarctic Survey

seth@bas.ac.uk



Deep-Sea Research II 198 (2022) 105057

Contents lists available at ScienceDirect

Deep-Sea Research Part II

journal homepage: www.elsevier.com/locate/dsr2

Spatial and temporal variability and connectivity of the marine environment of the South Sandwich Islands, Southern Ocean

Sally E. Thorpe *, Eugene J. Murphy

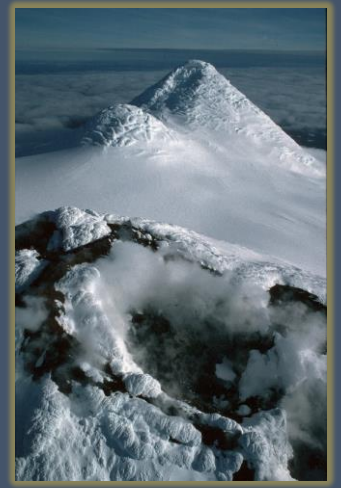
British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, UK

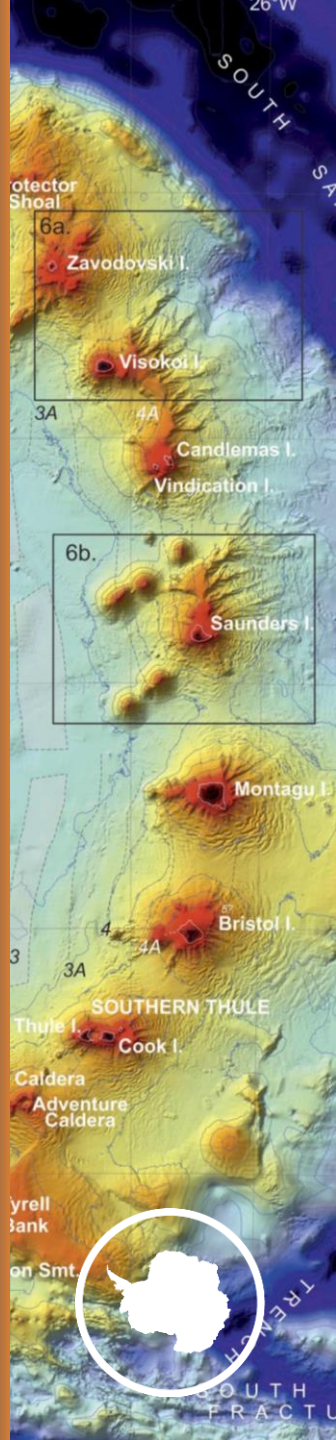
ARTICLE INFO

Keywords:
Antarctica
Scotia sea

ABSTRACT

The South Sandwich Islands form the eastern boundary to the highly biologically productive Scotia Sea in the southwest Atlantic sector of the Southern Ocean and are part of a large Marine Protected Area. The South Sandwich Islands have a complex marine environment that is influenced by both the Antarctic Circumpolar



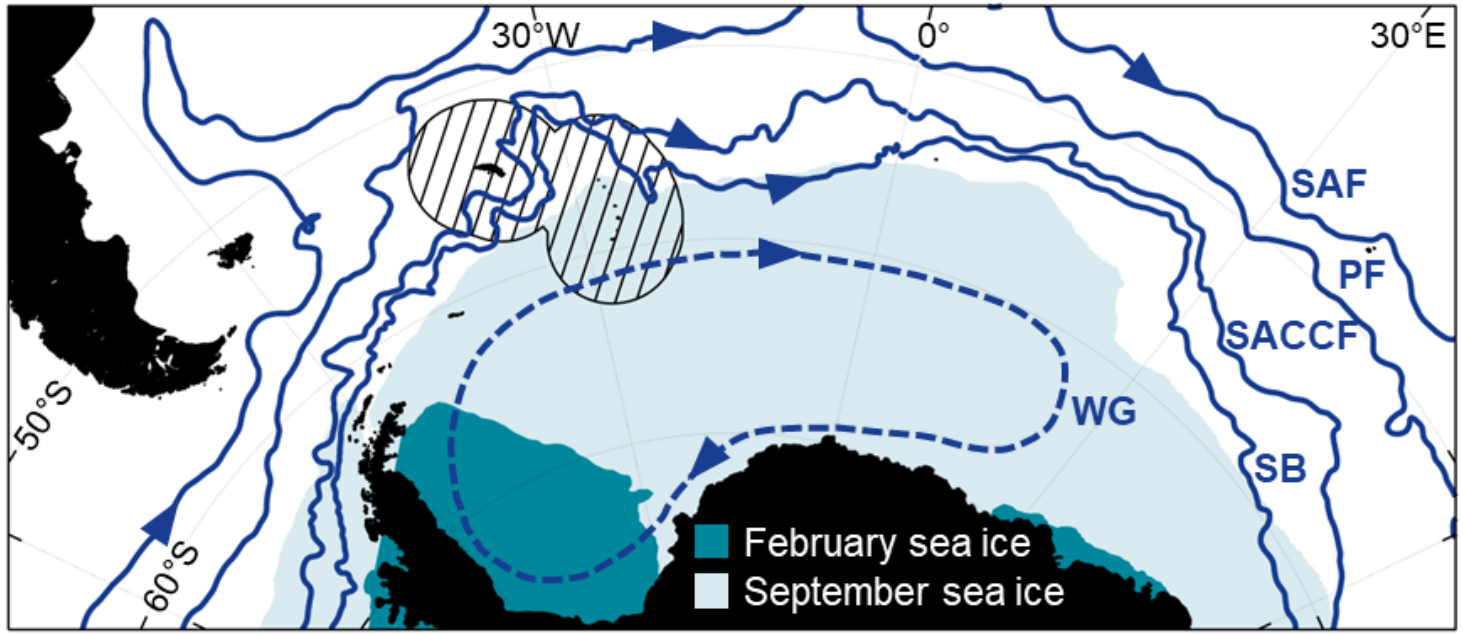


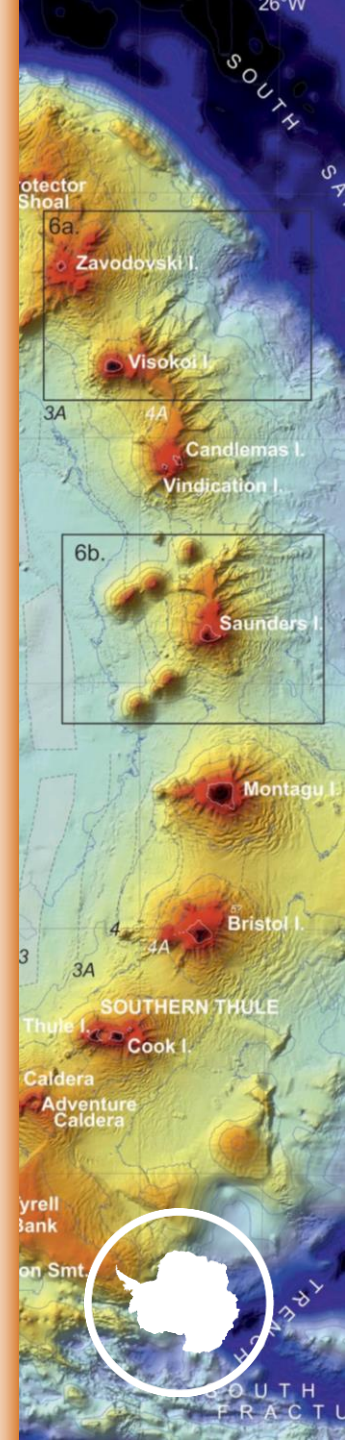
Marine environment

- Temperature
- Sea ice
- Productivity

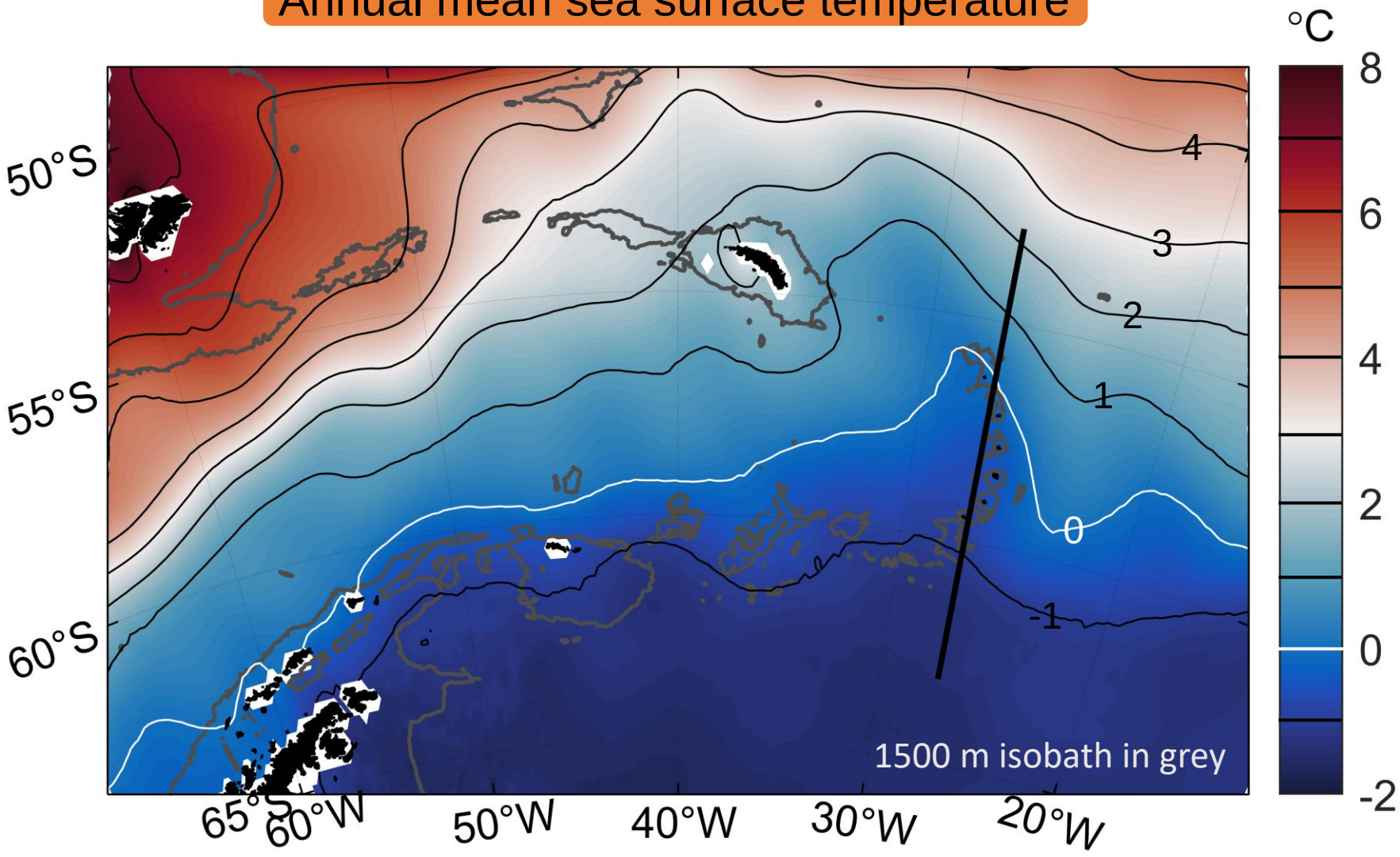
Connectivity

- Within island arc
- Regional





Annual mean sea surface temperature



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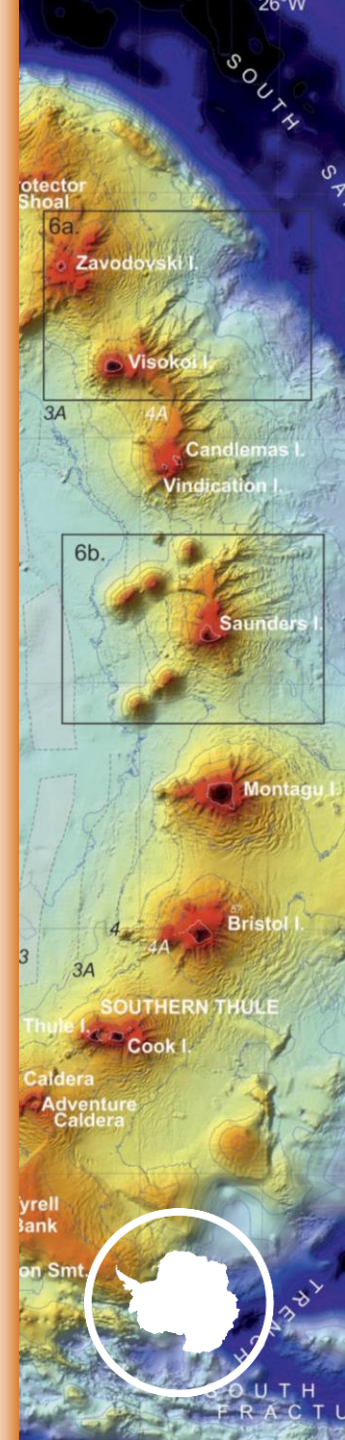
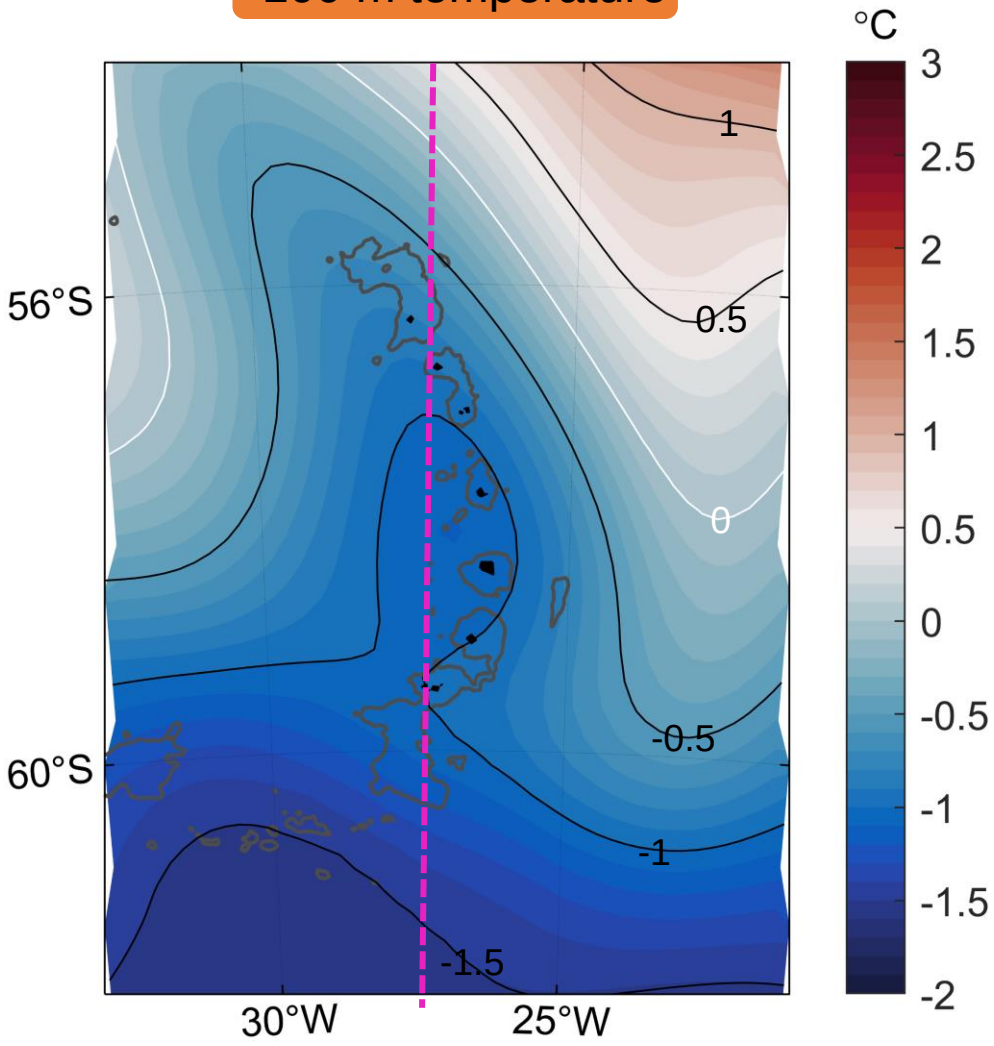
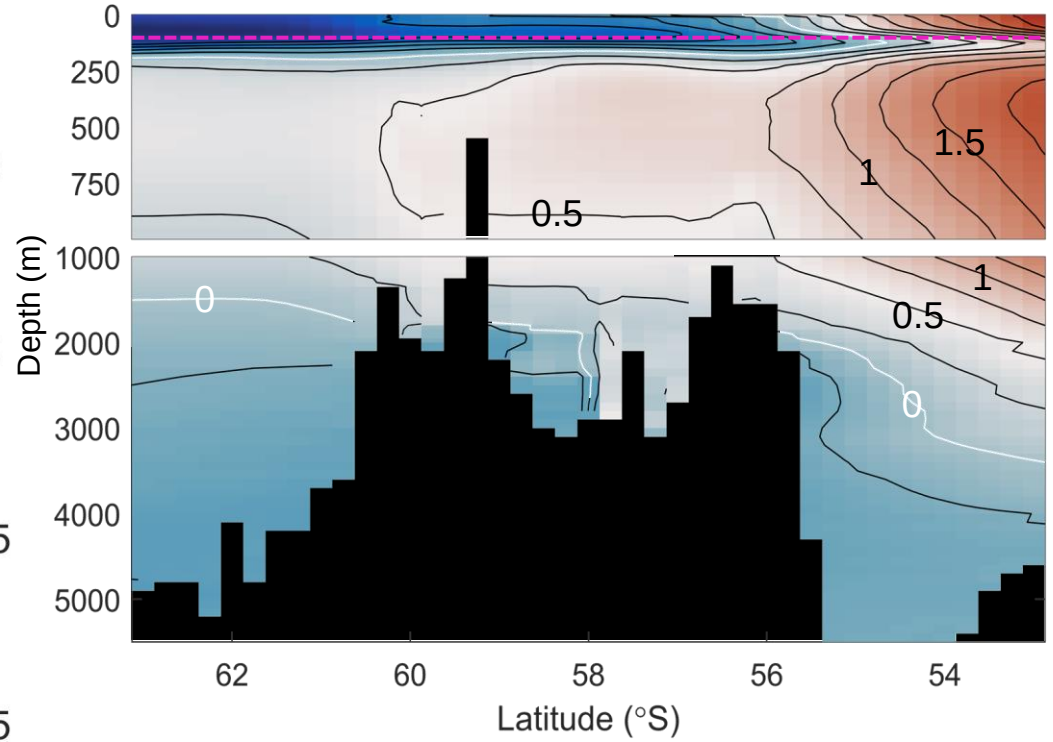
World Ocean Atlas

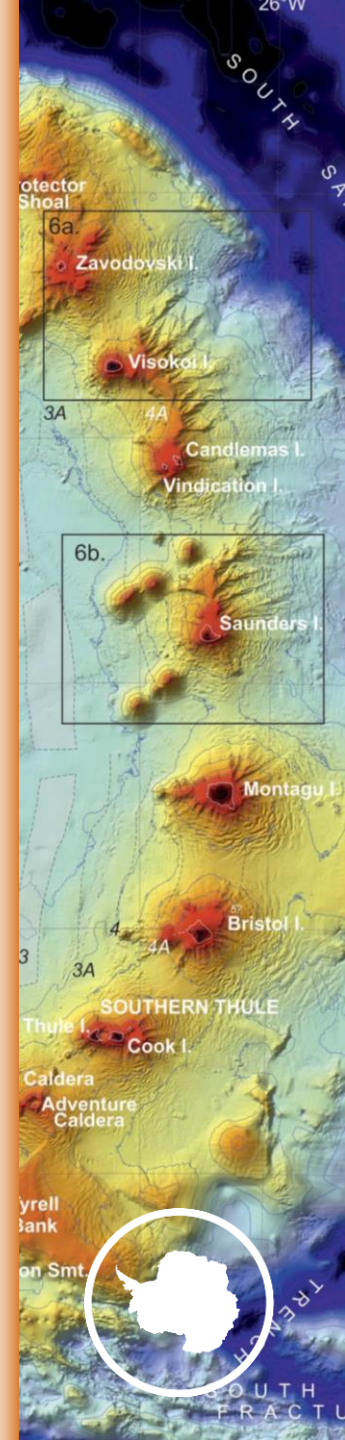


100 m temperature



Vertical temperature section along 27°W





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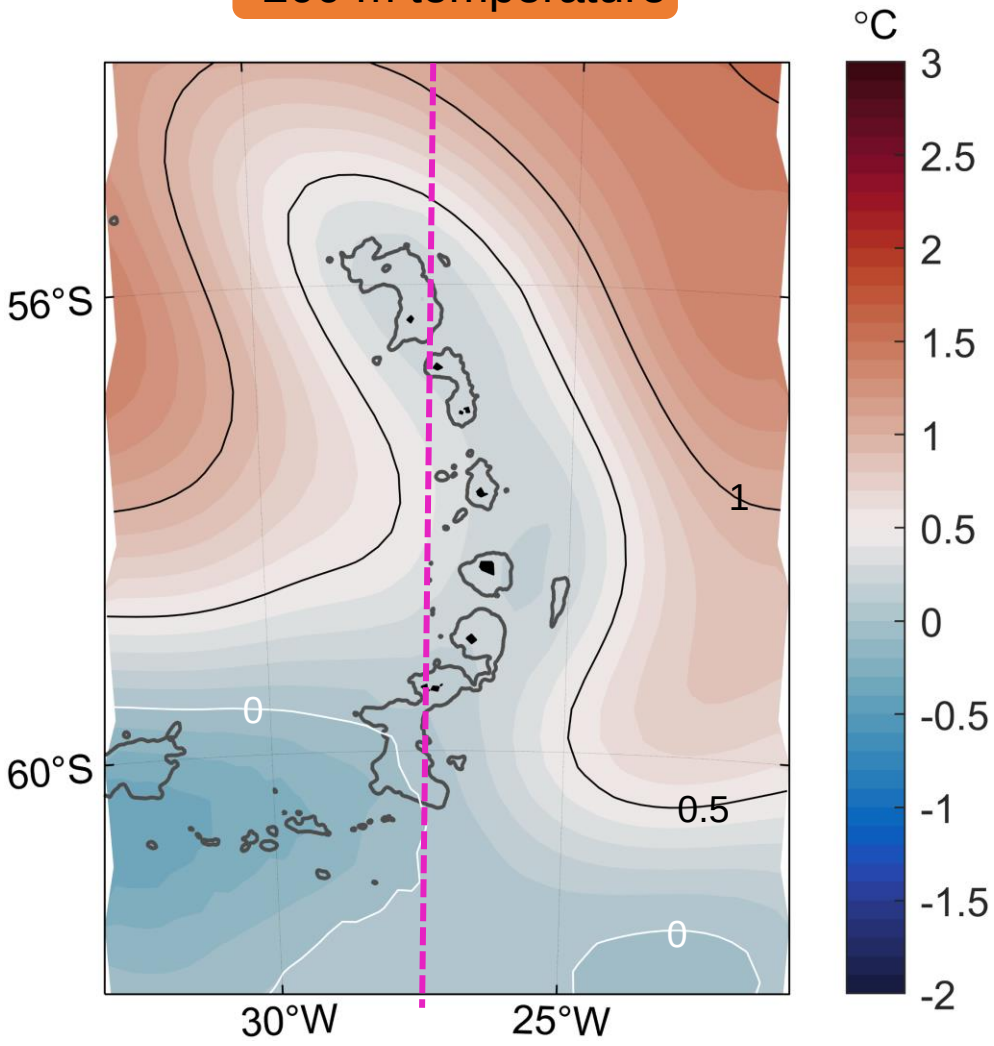
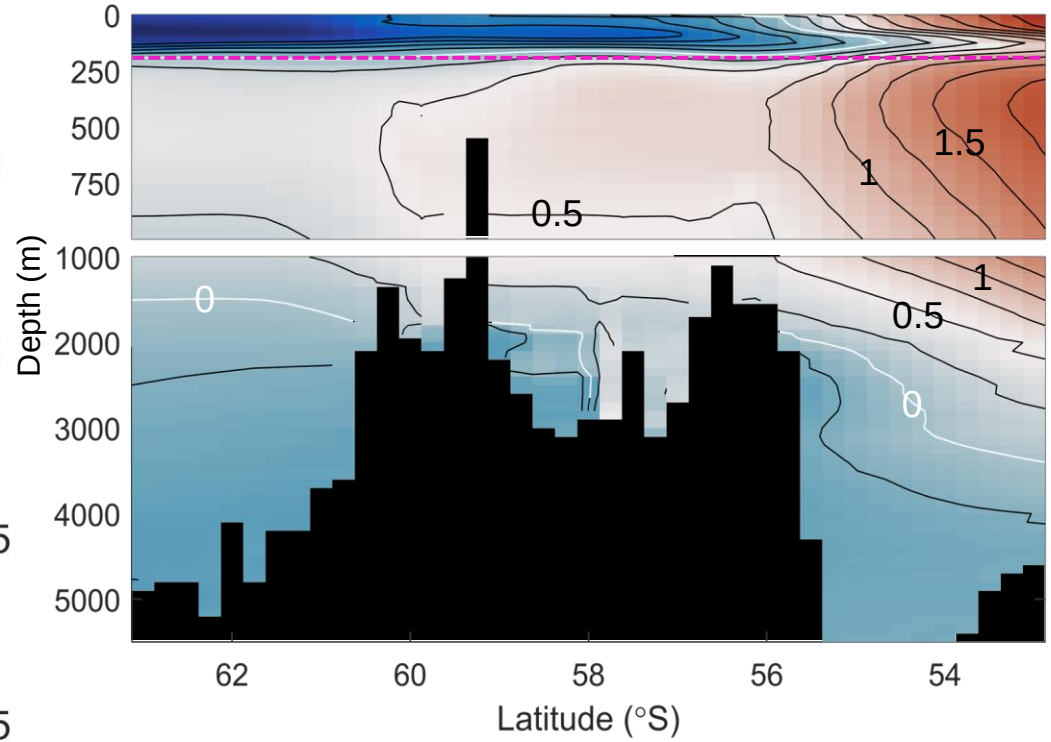
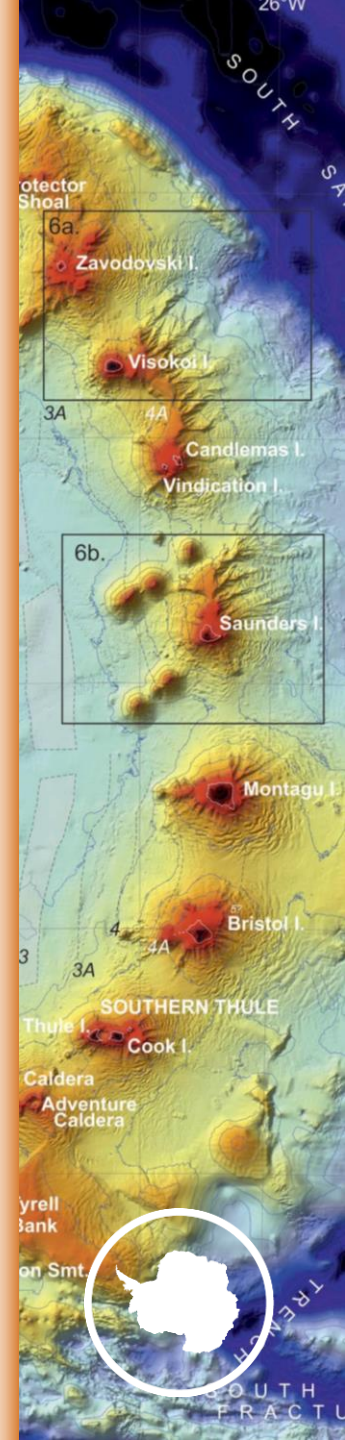
200 m temperature



Vertical temperature section along 27°W





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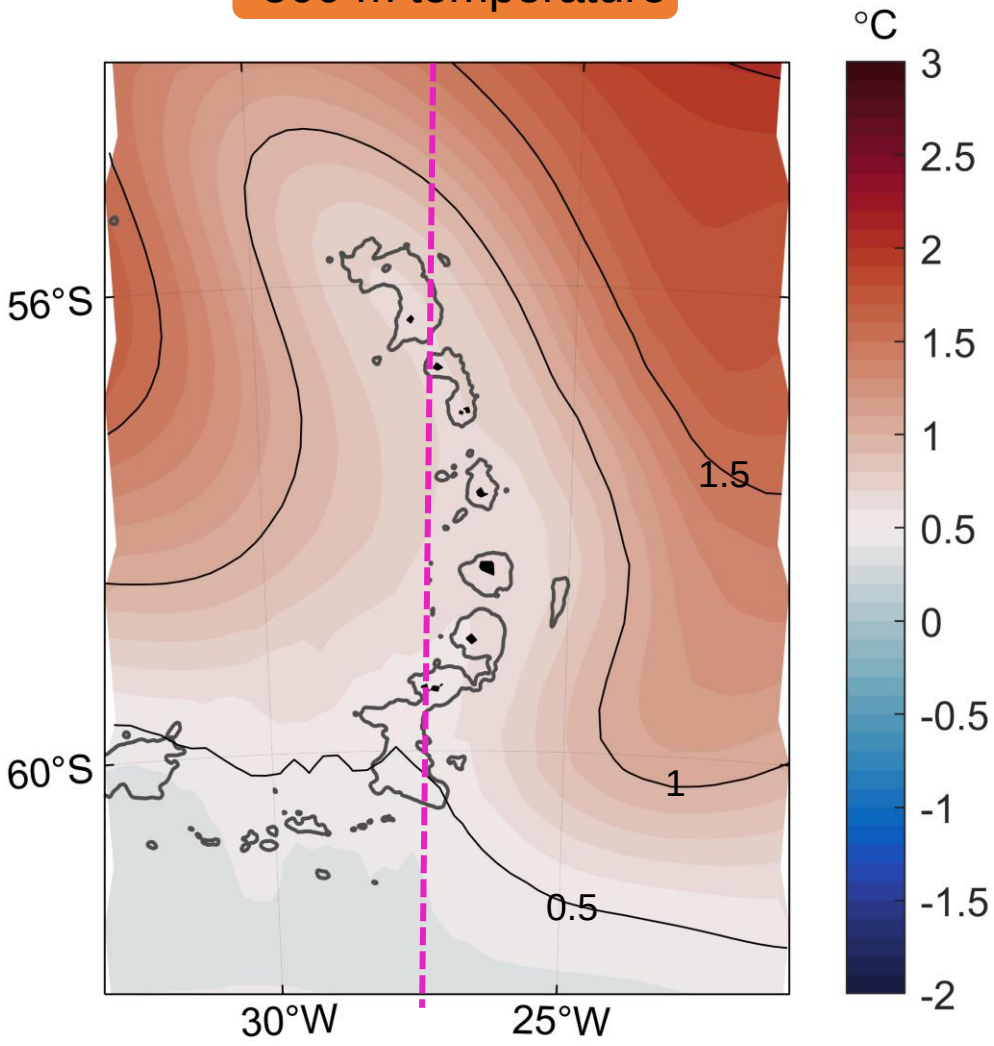
500 m temperature



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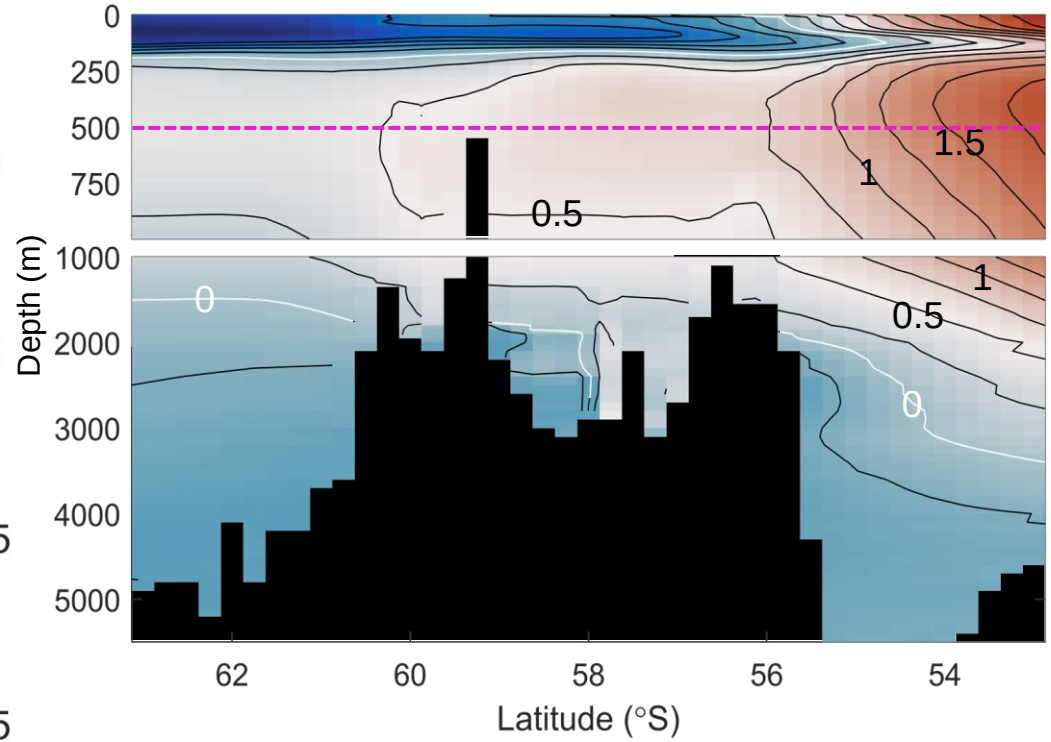

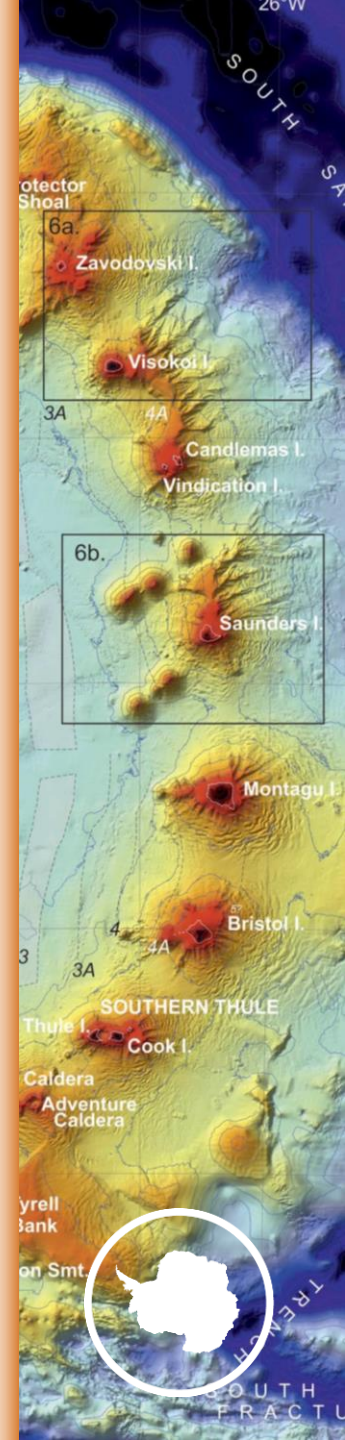

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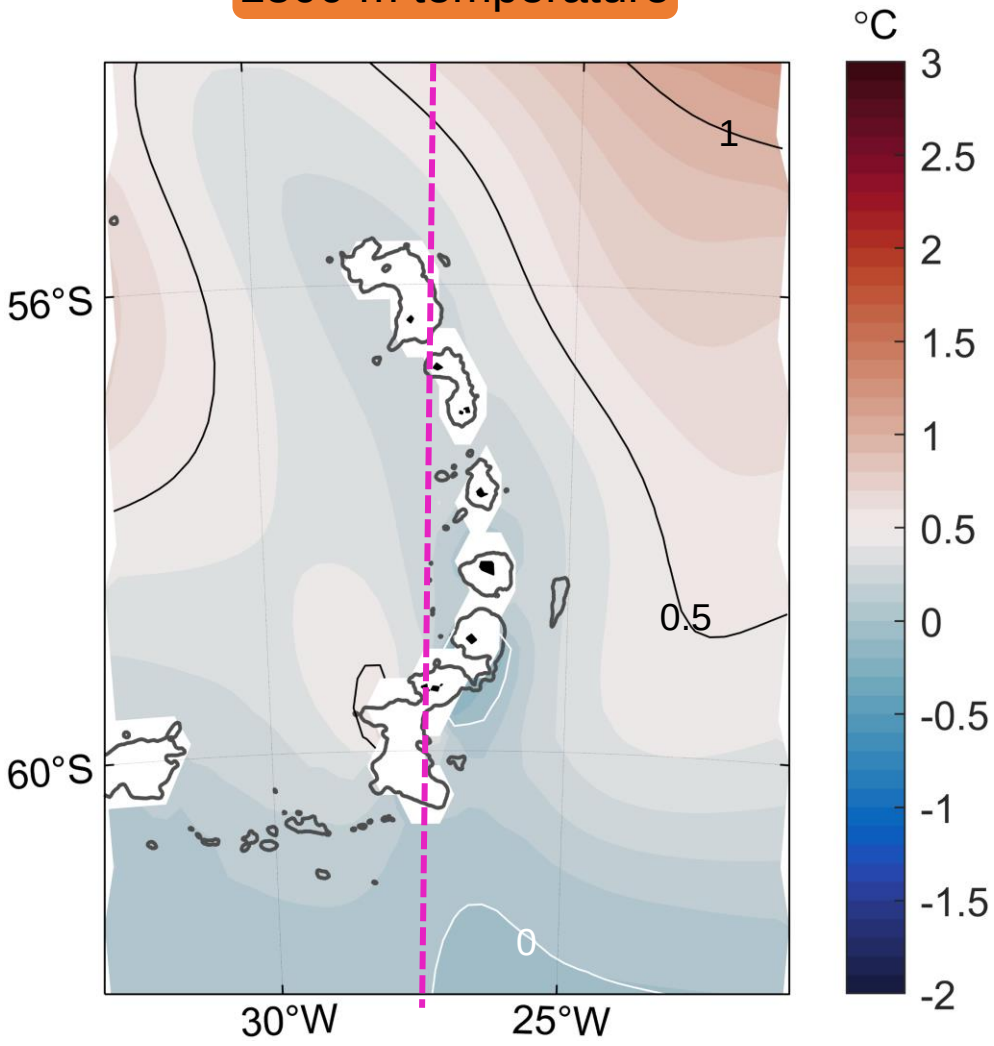
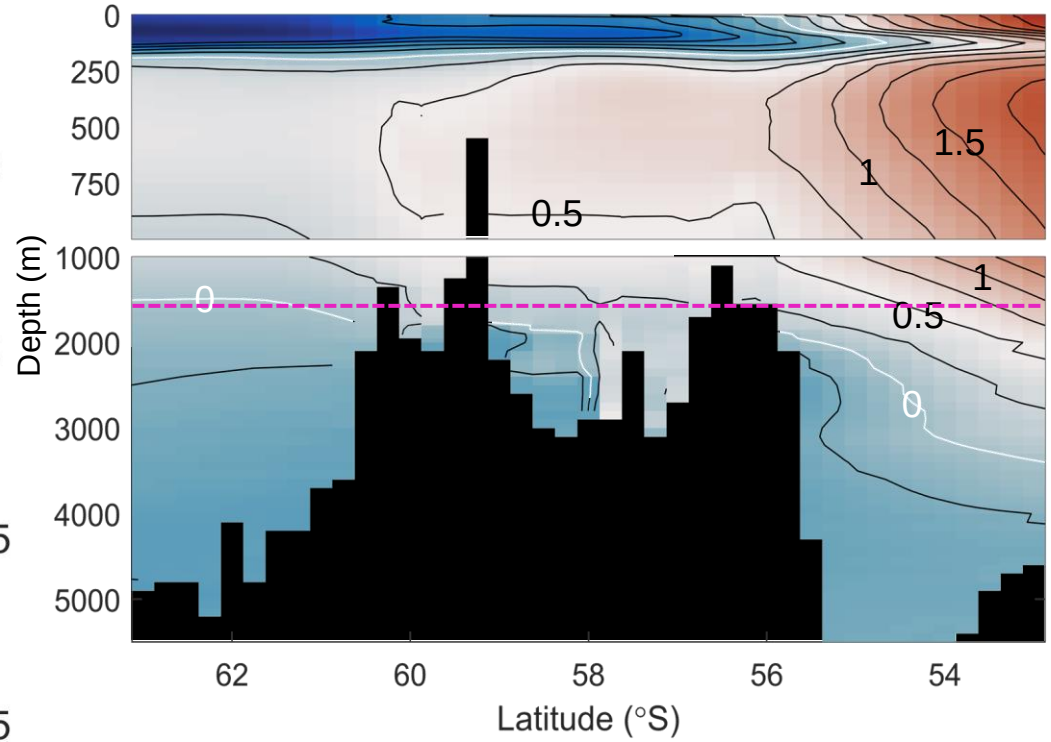
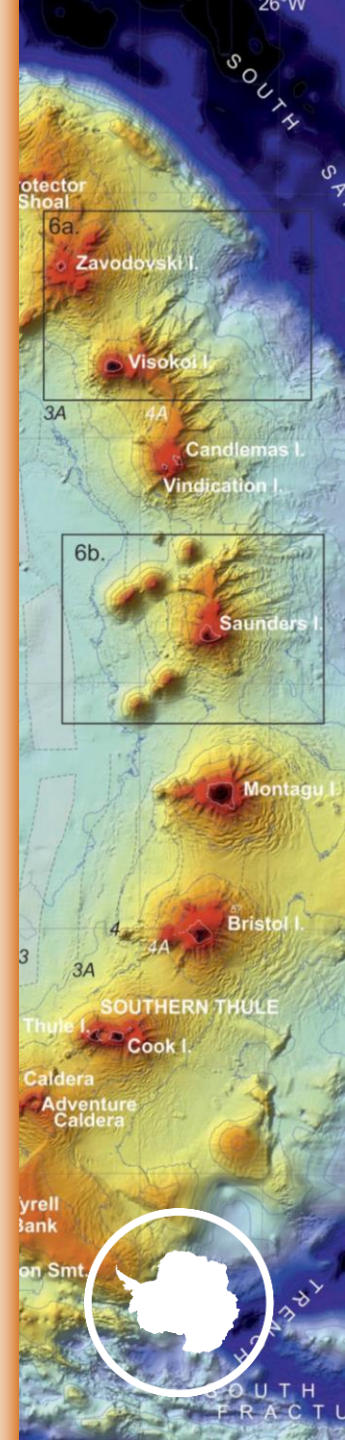
1500 m temperature



Vertical temperature section along 27°W





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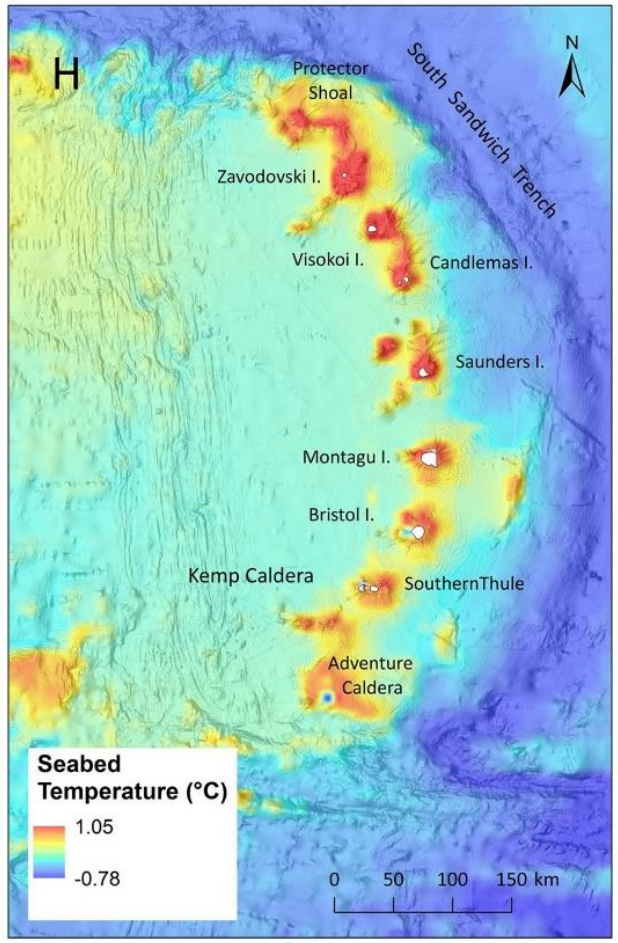
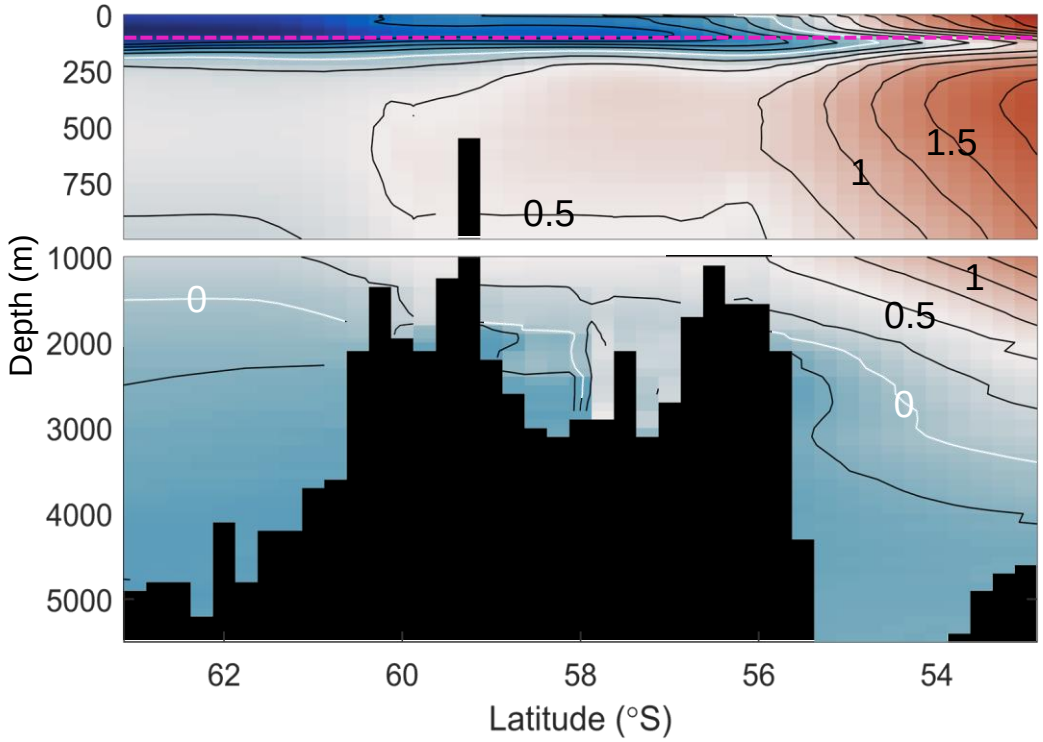
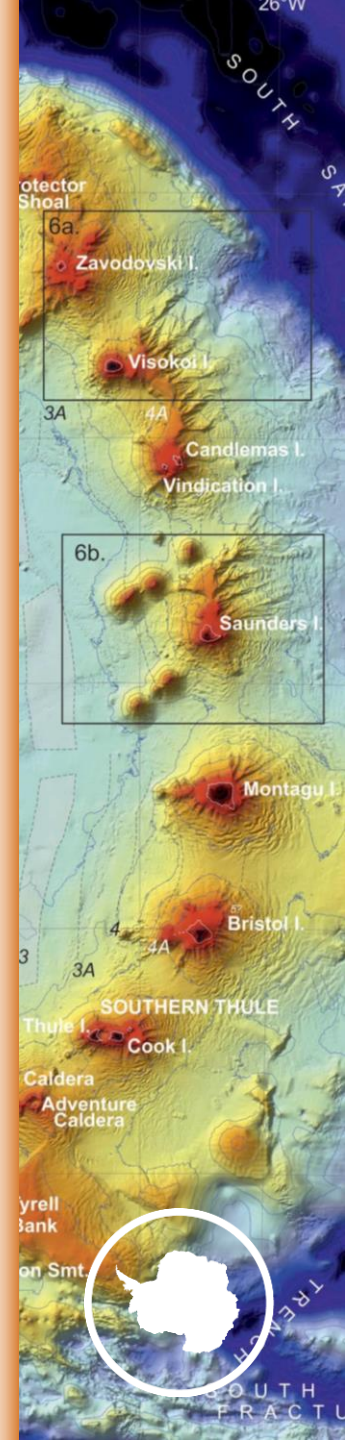
Seafloor temperature



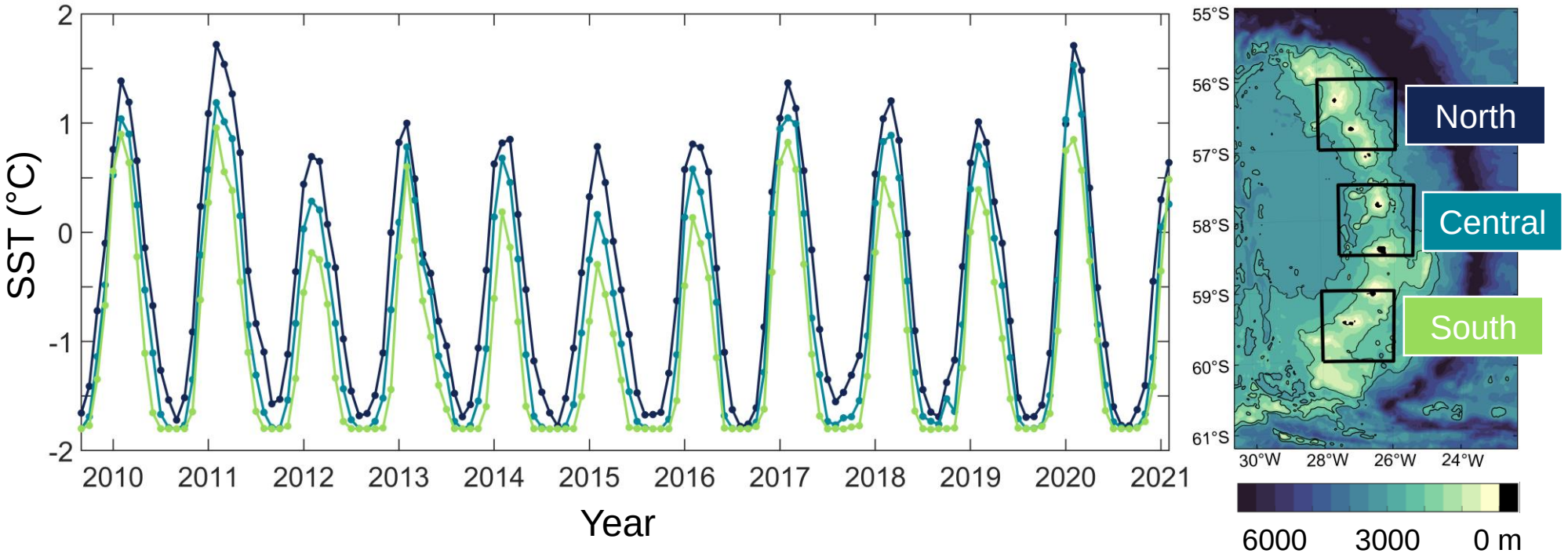
Hogg et al (2021)

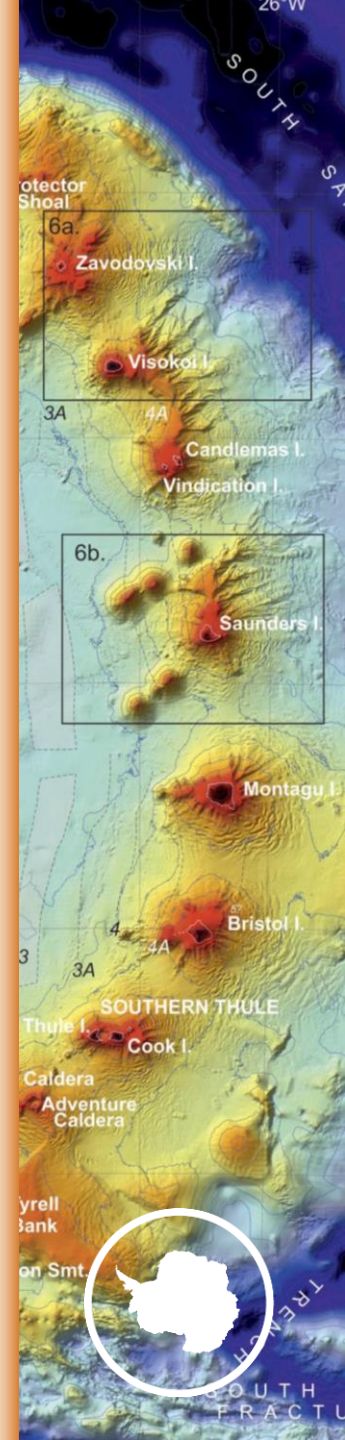
Vertical temperature section along 27°W





Temporal variability in sea surface temperature





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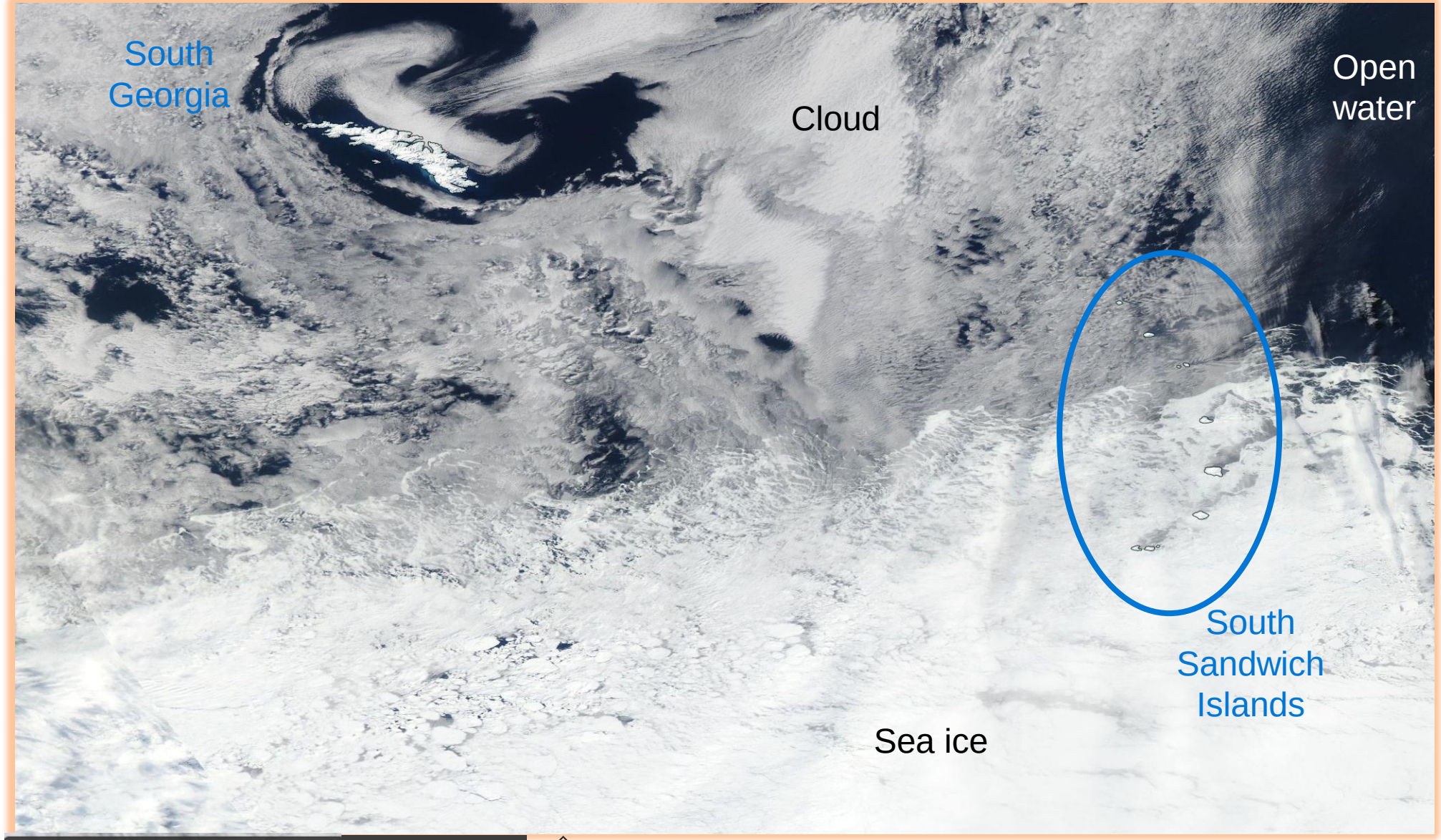
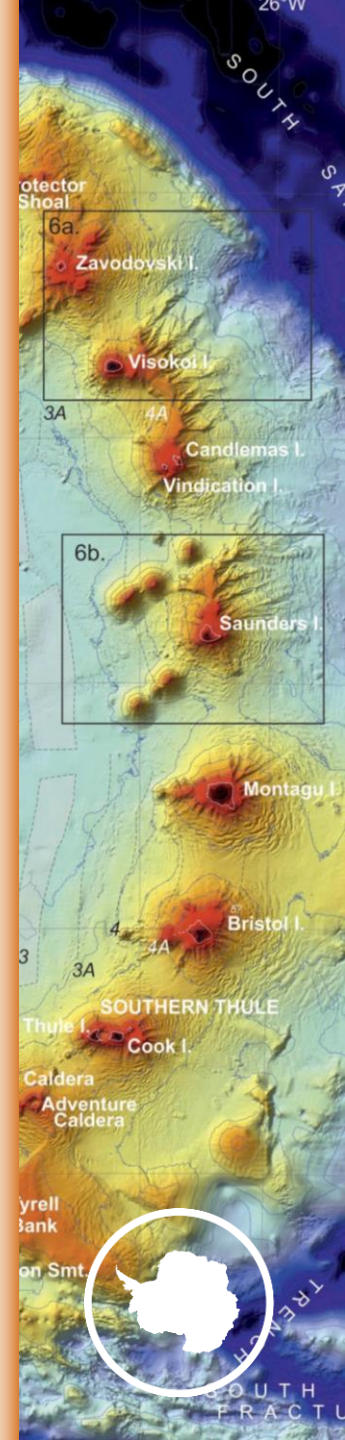
ESA SST CCI and C3S


South Georgia
Cloud
Open water
South Sandwich Islands
Sea ice
NASA WORLDVIEW 2022 SEP 22


26°W
SOUTH
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6a.
Zavodovski I.
Visokoi I.
3A
4A
Candlemas I.
Vindication I.
6b.
Saunders I.
Montagu I.
Bristol I.
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4A
3
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SOUTHERN THULE
Thule I.
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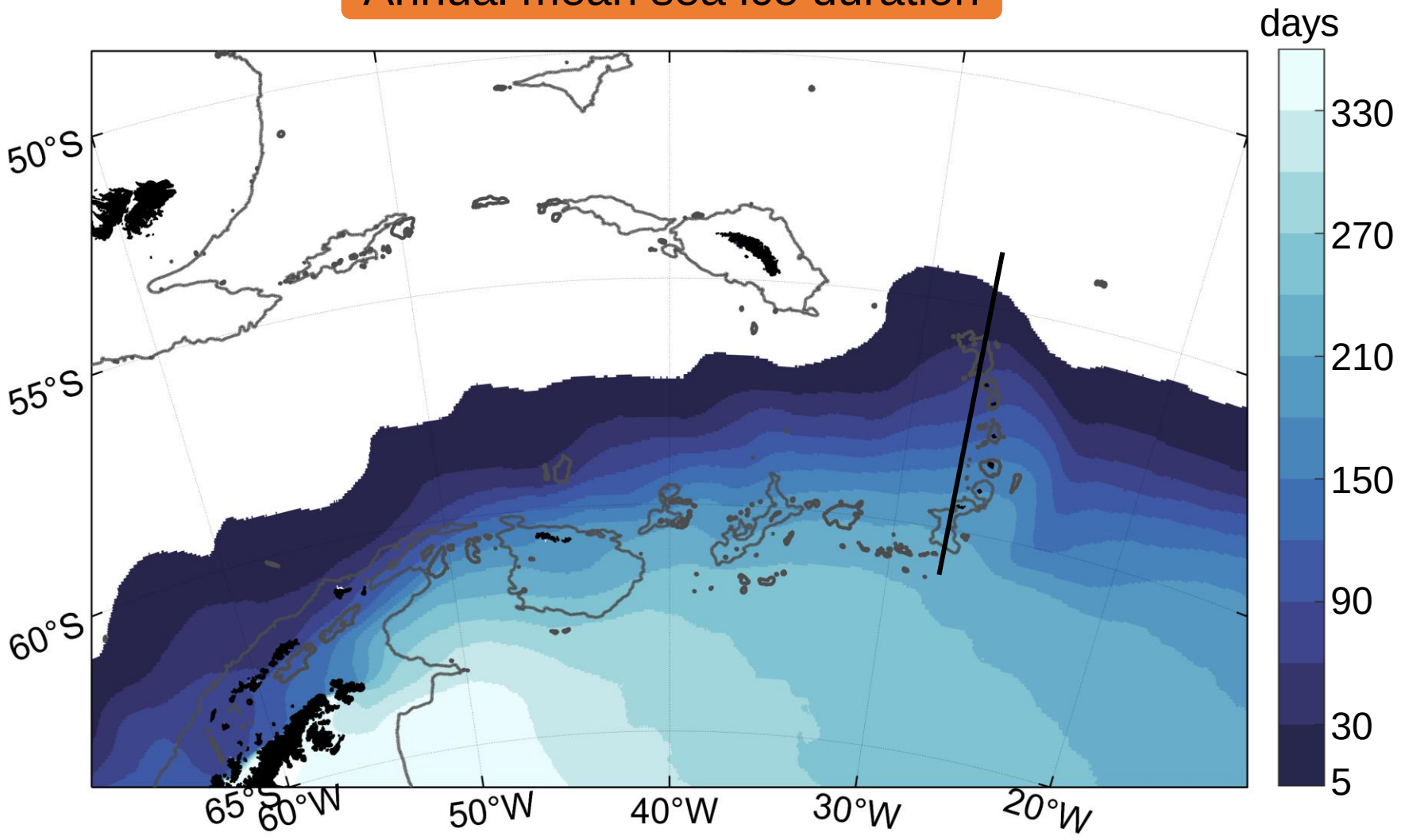
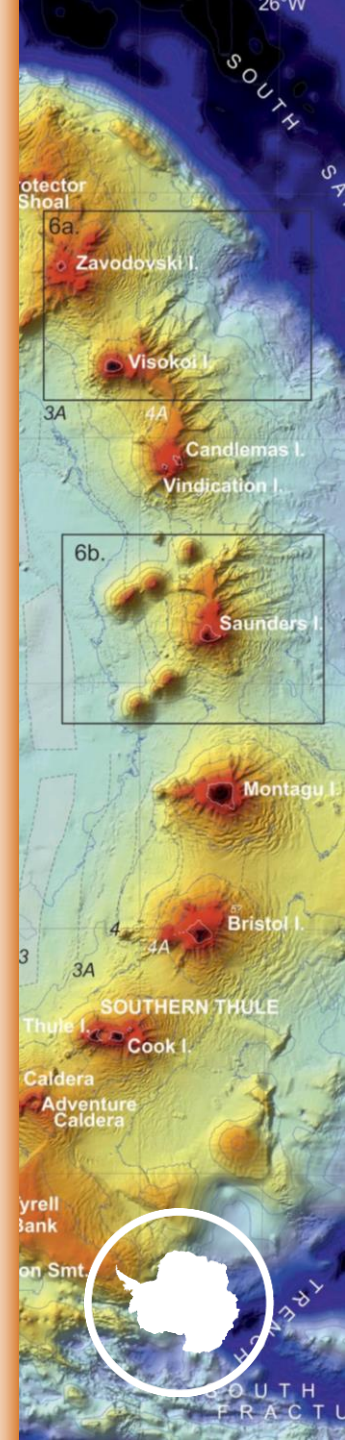
FRACTU

Annual mean sea ice duration





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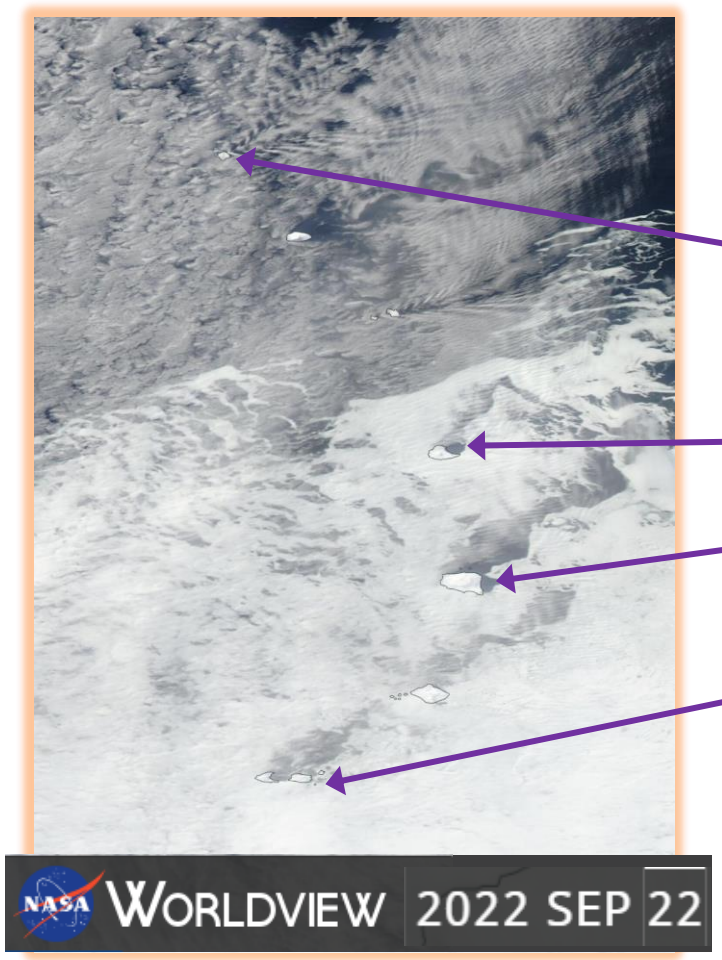
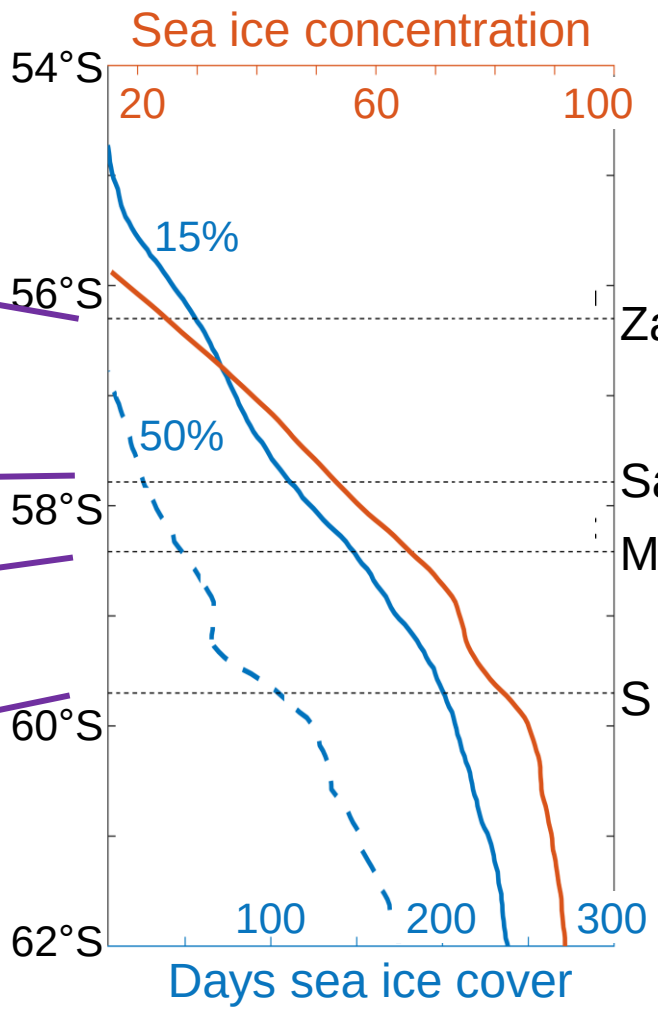
ESA SST CCI and C3S

Annual mean sea ice cover



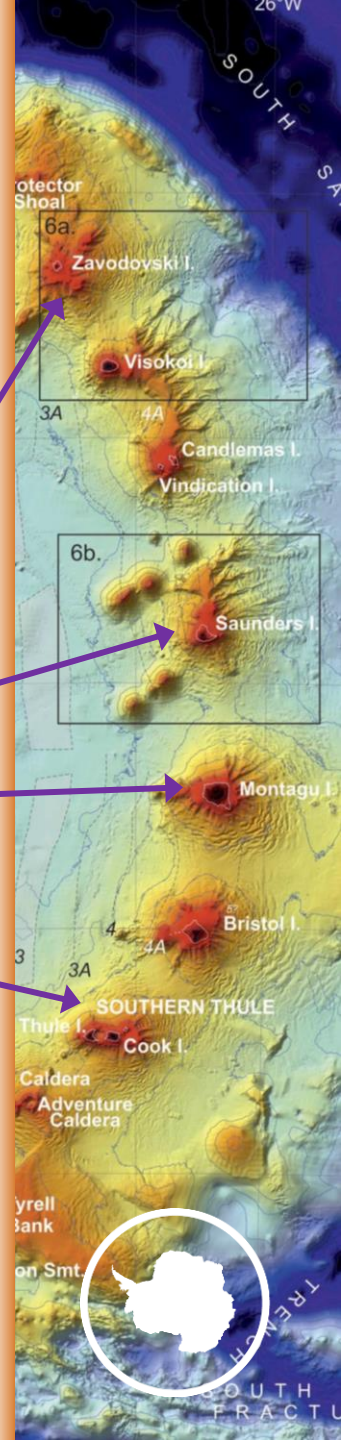


Zavadovski

Saunders

Montagu

S Thule



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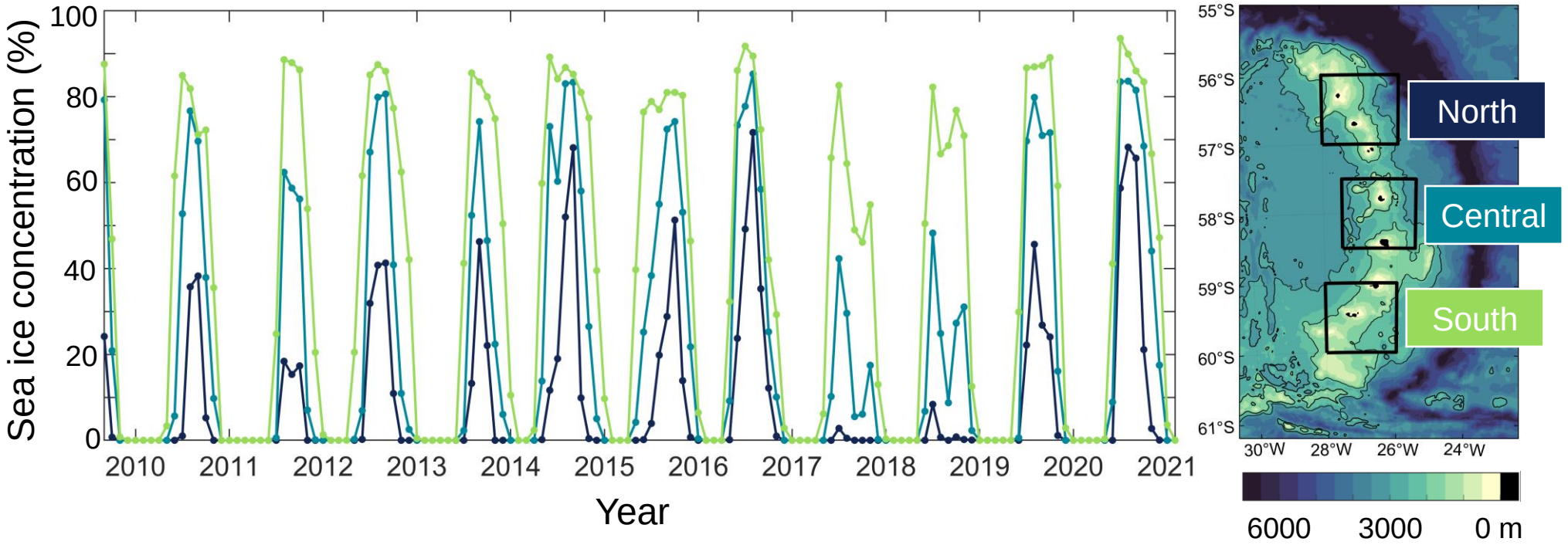
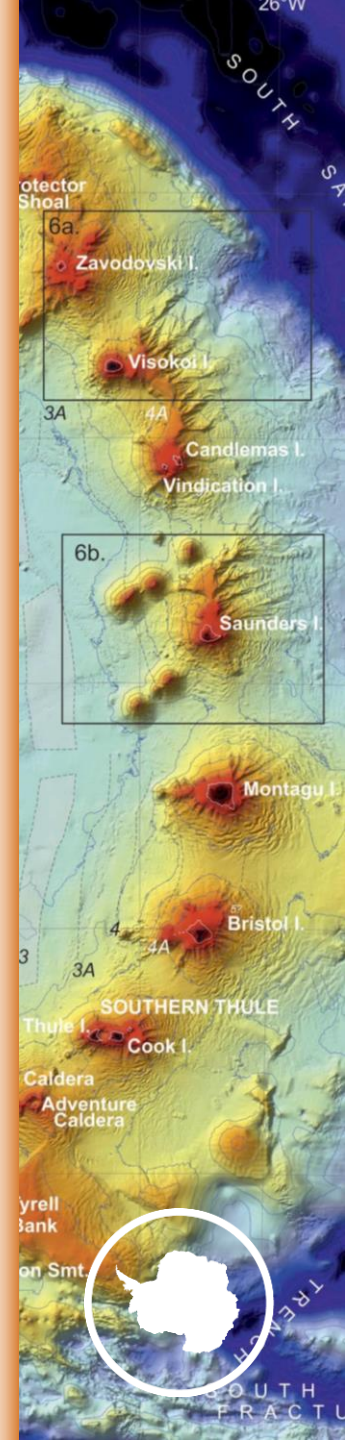
Temporal variability in sea ice cover





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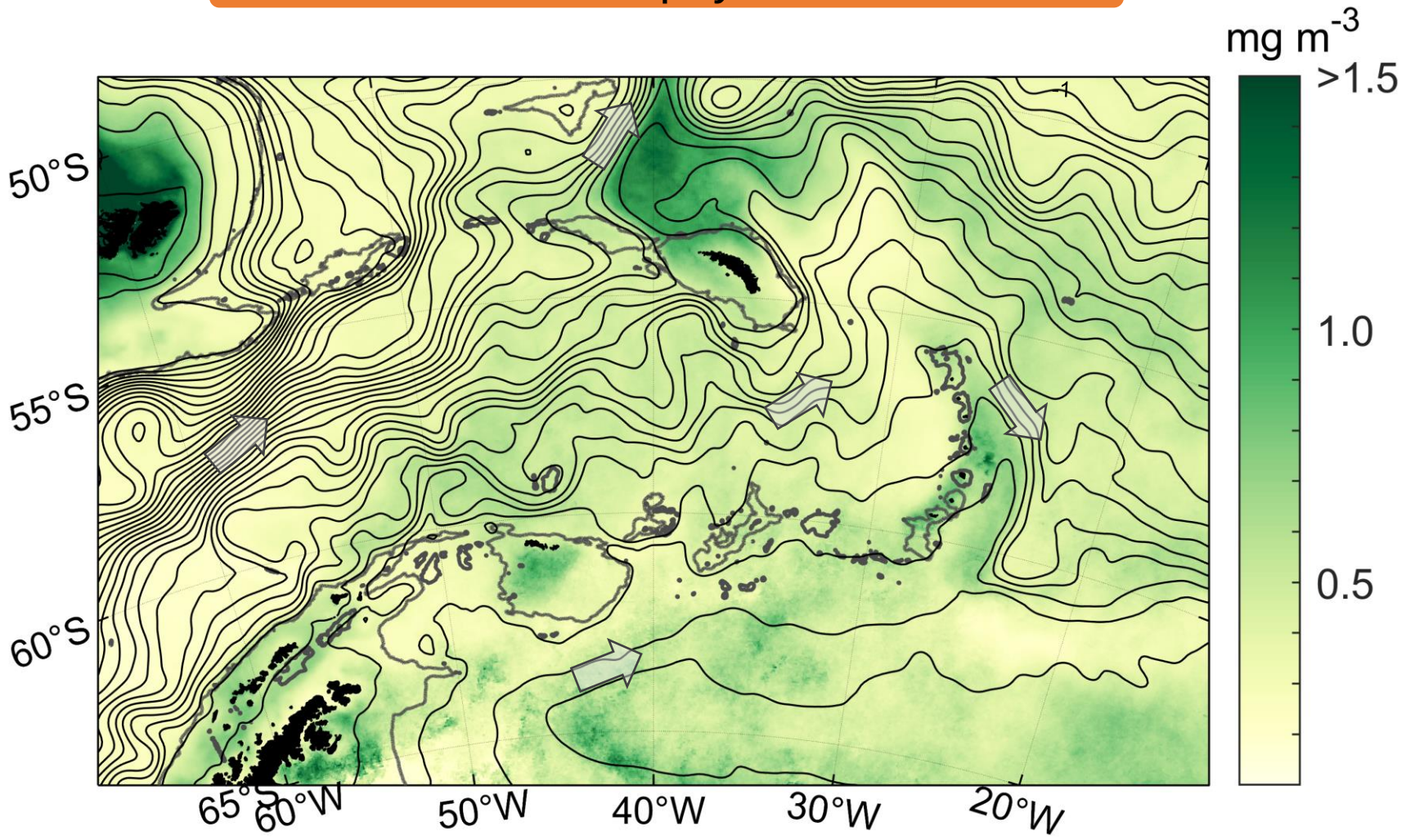
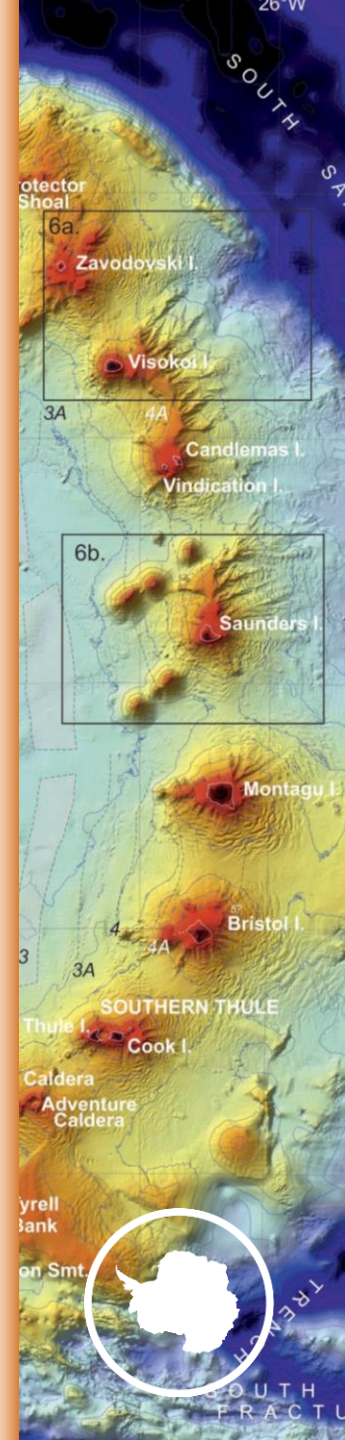
ESA SST CCI and C3S

Annual mean chlorophyll a concentration





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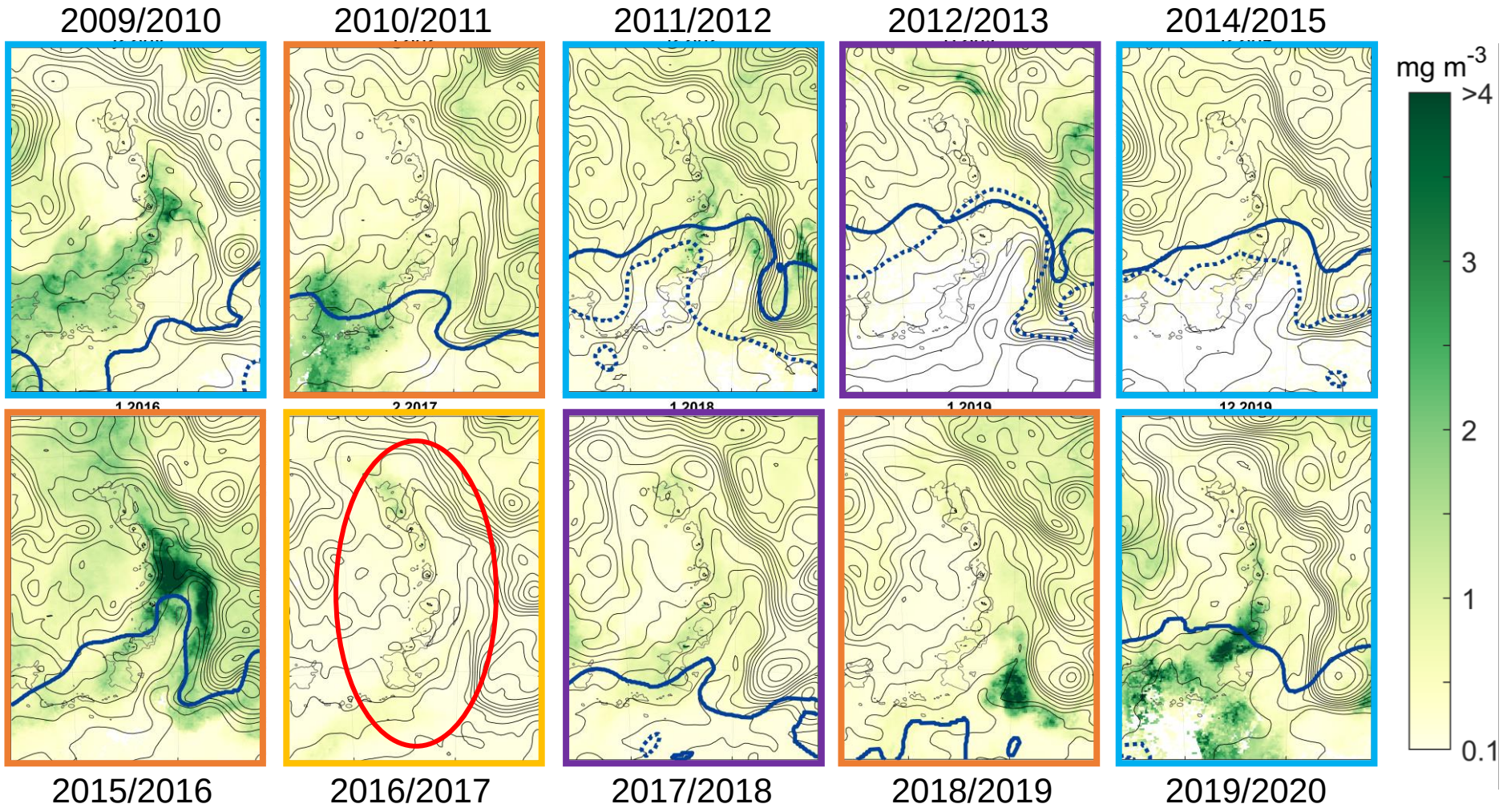
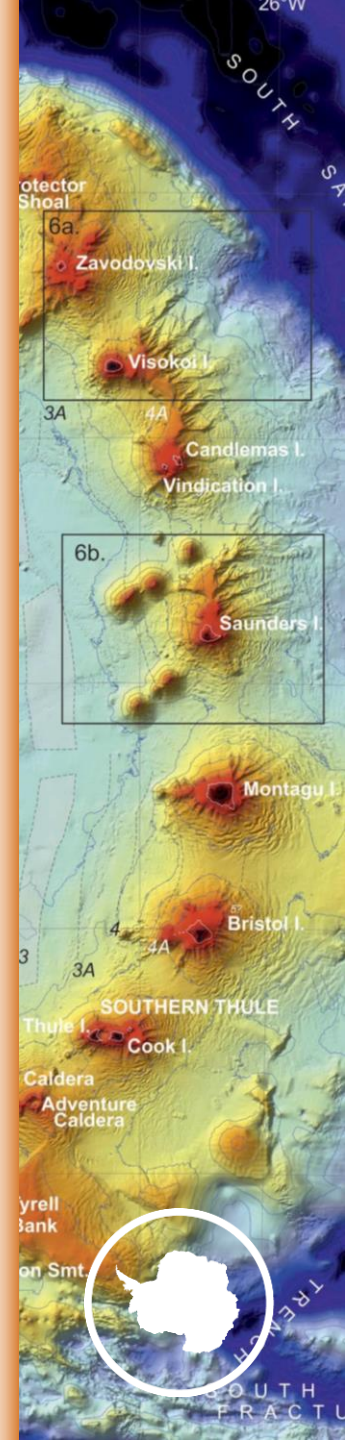
Global Ocean Colour

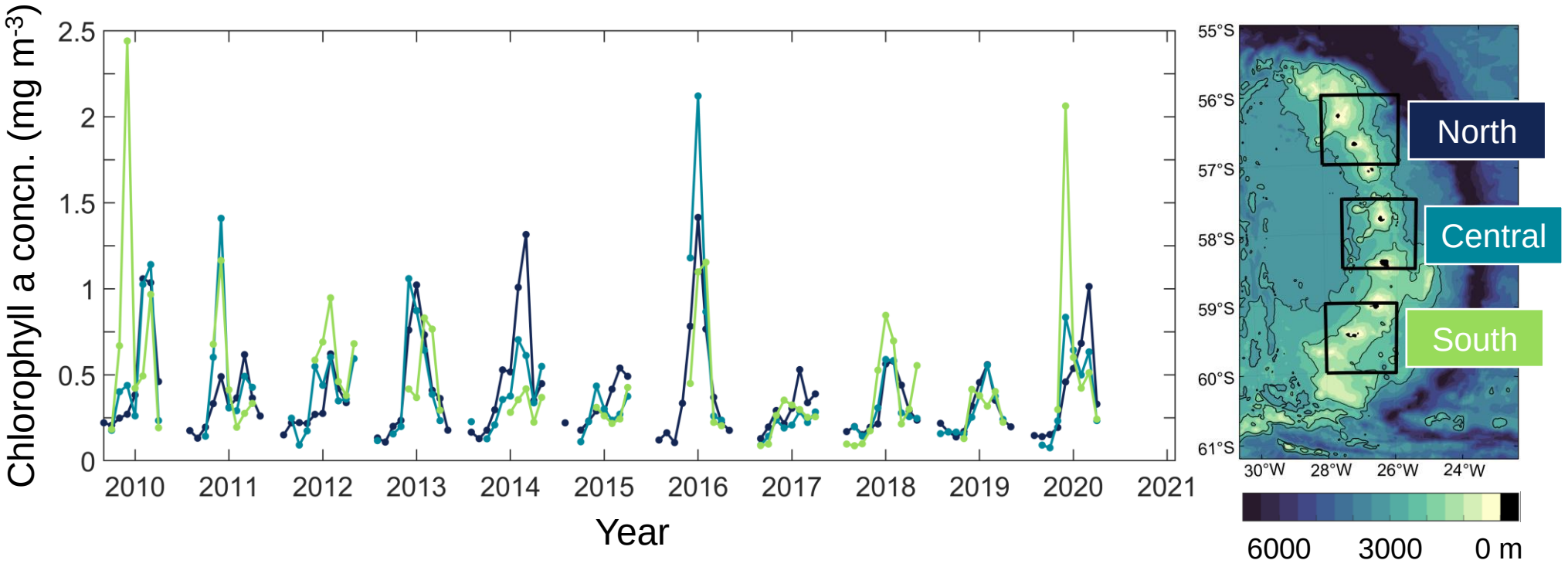
Global Ocean Physics Reanalysis

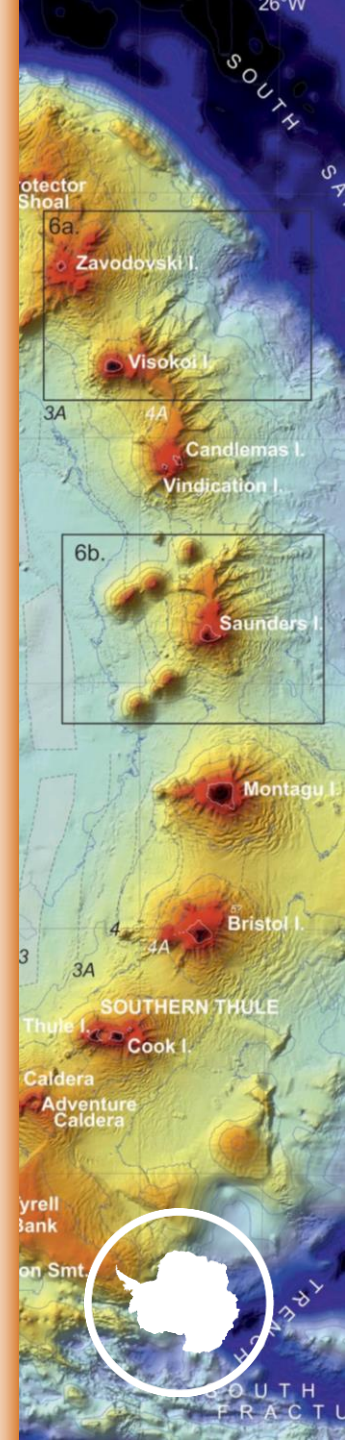
Temporal and spatial variability in phytoplankton blooms





Variability in chlorophyll a concentration





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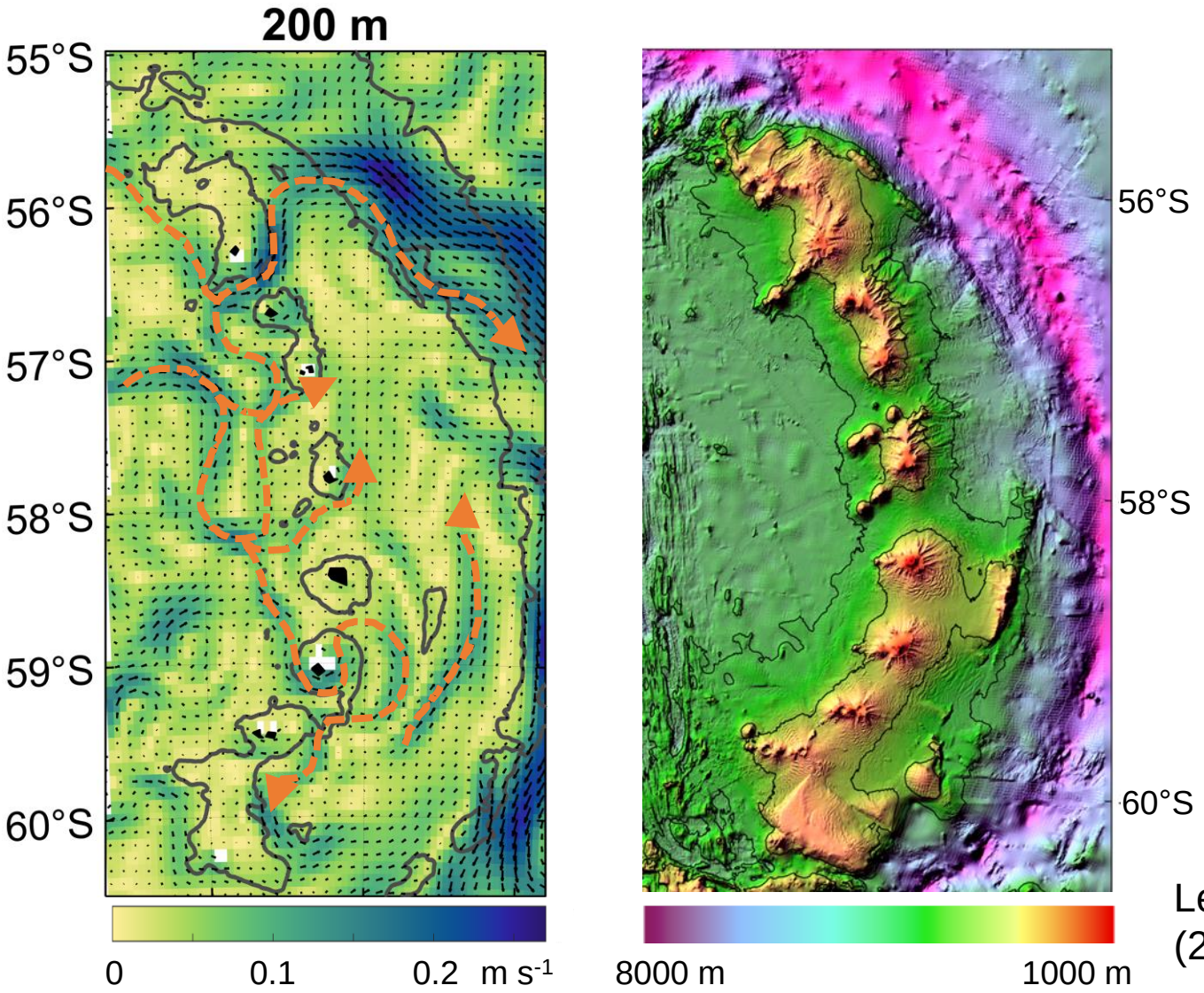
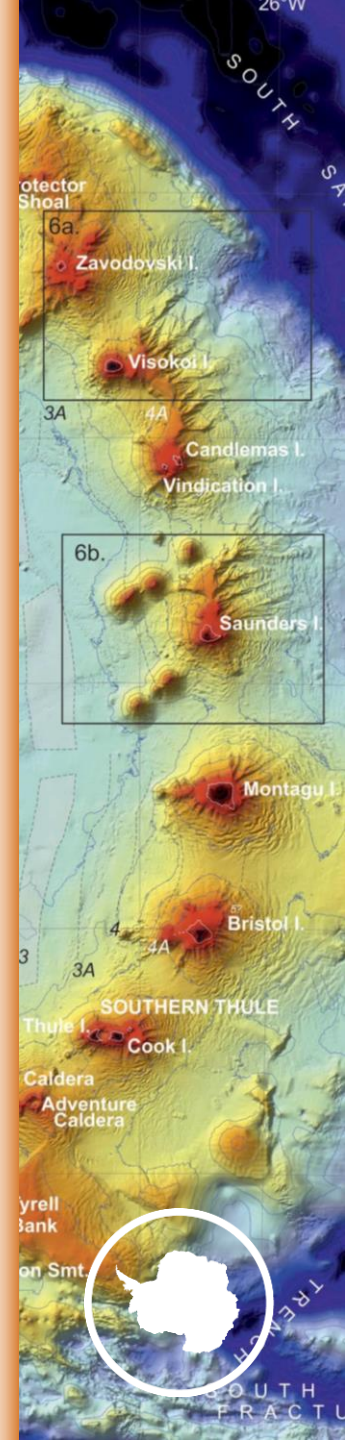
Global Ocean Colour

Annual mean ocean currents



Leat et al (2014)



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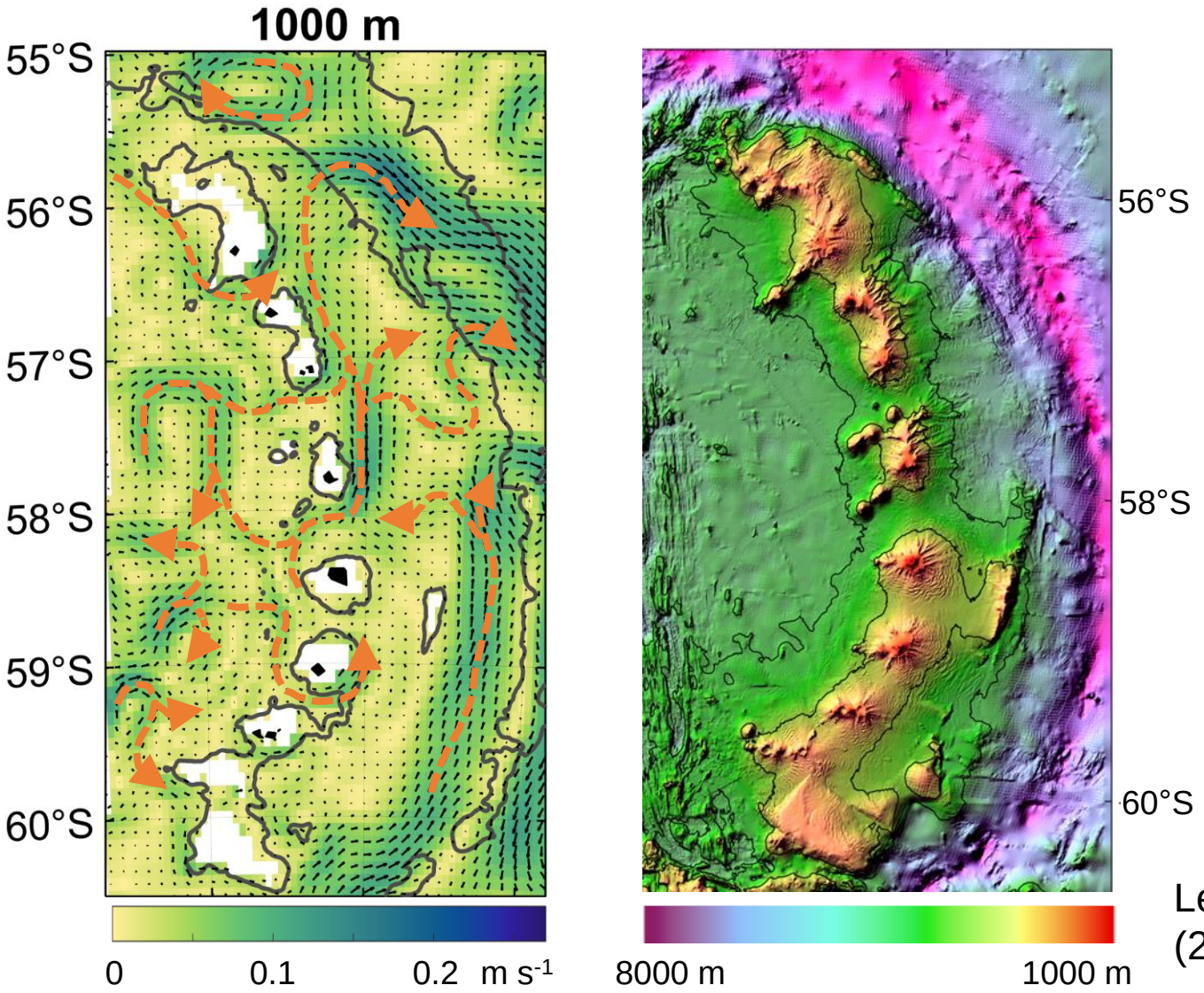
Global Ocean Physics Reanalysis

Annual mean ocean currents



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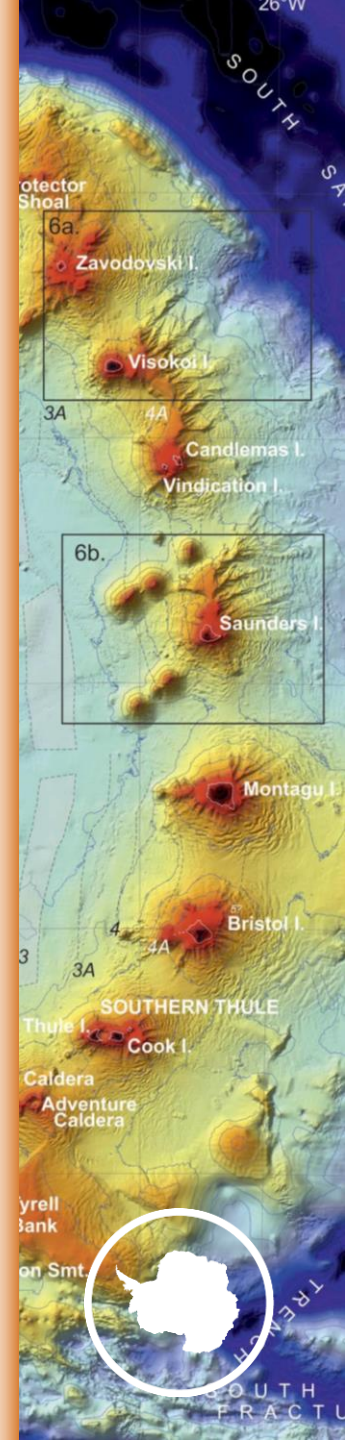

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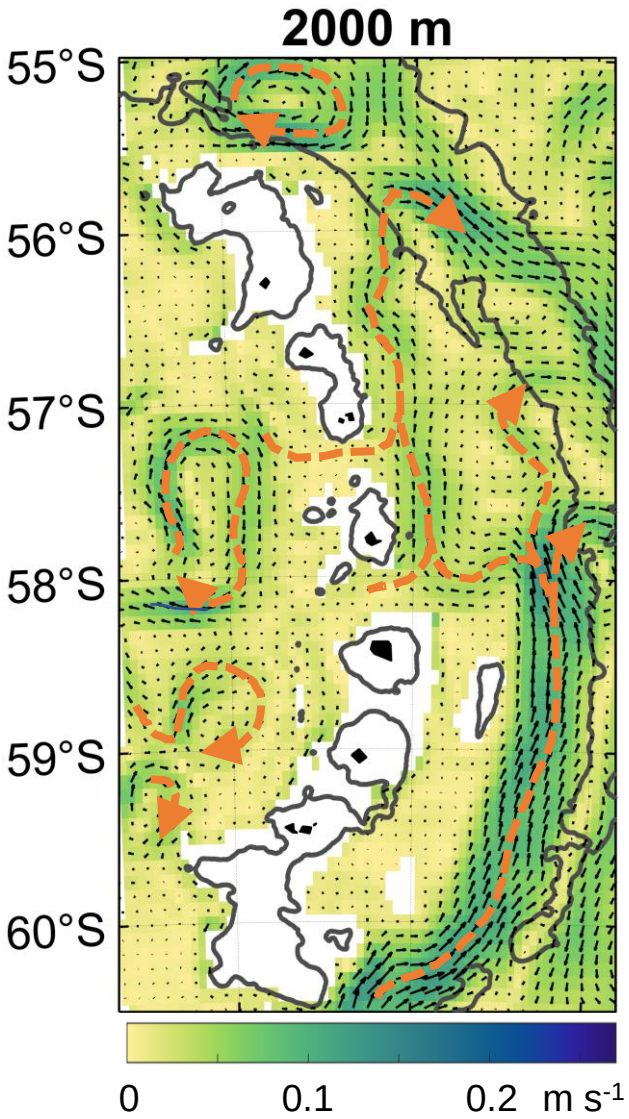
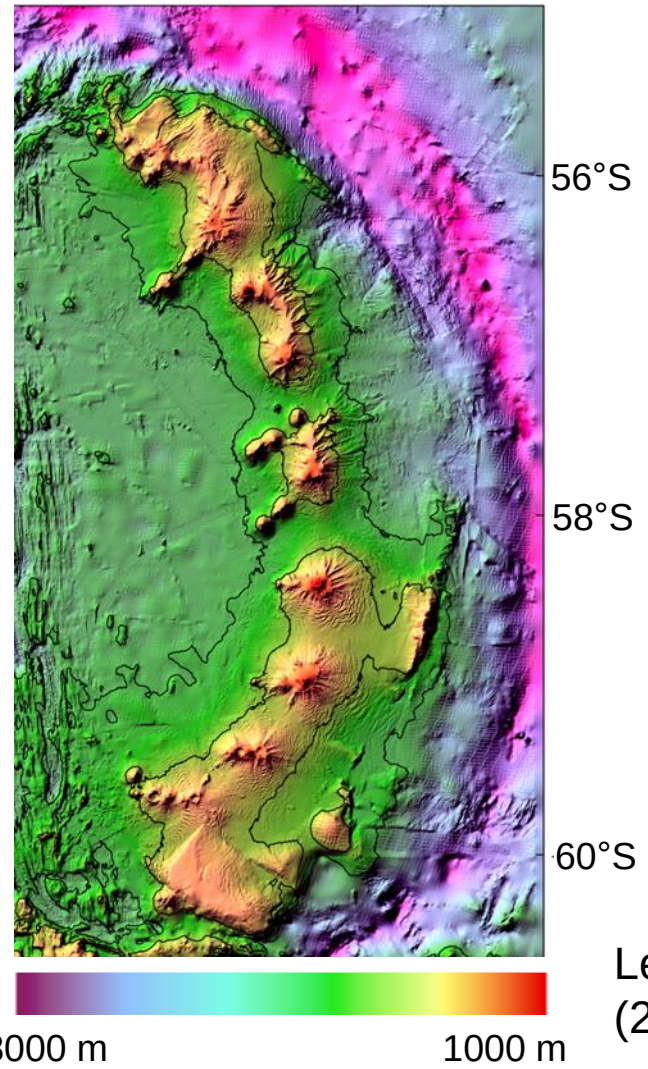
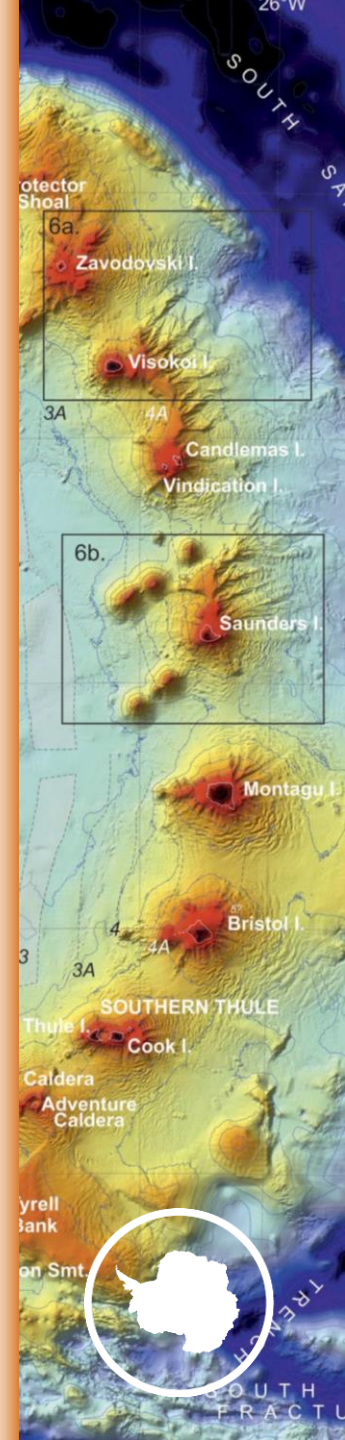




Leat et al (2014)



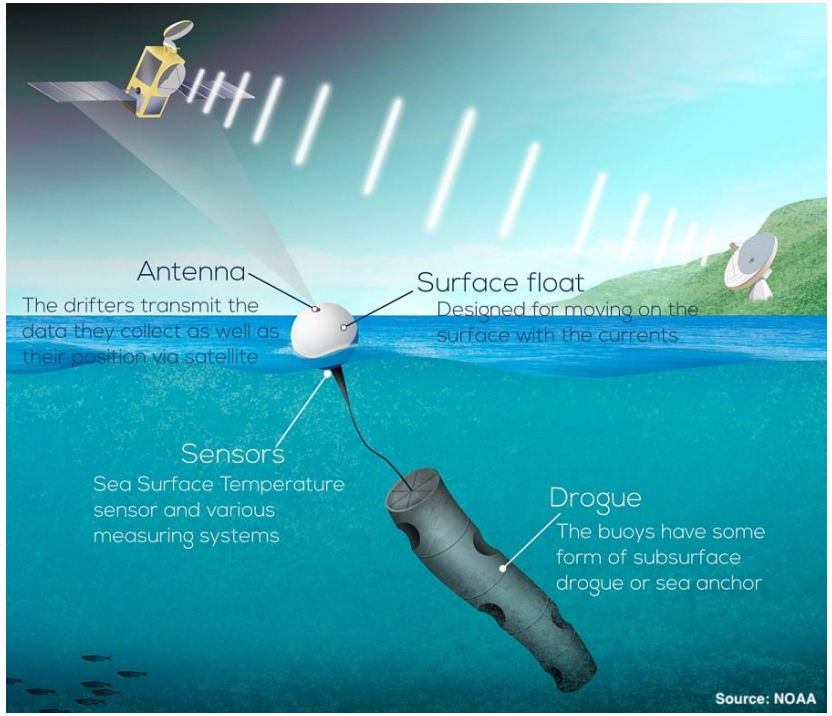
Copernicus Europe's eyes on Earth

Copernicus Marine Service

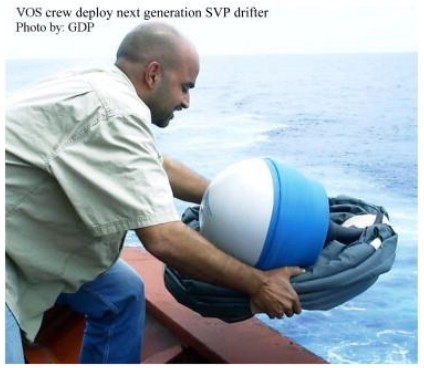
Global Ocean Physics Reanalysis

Oceanic transport

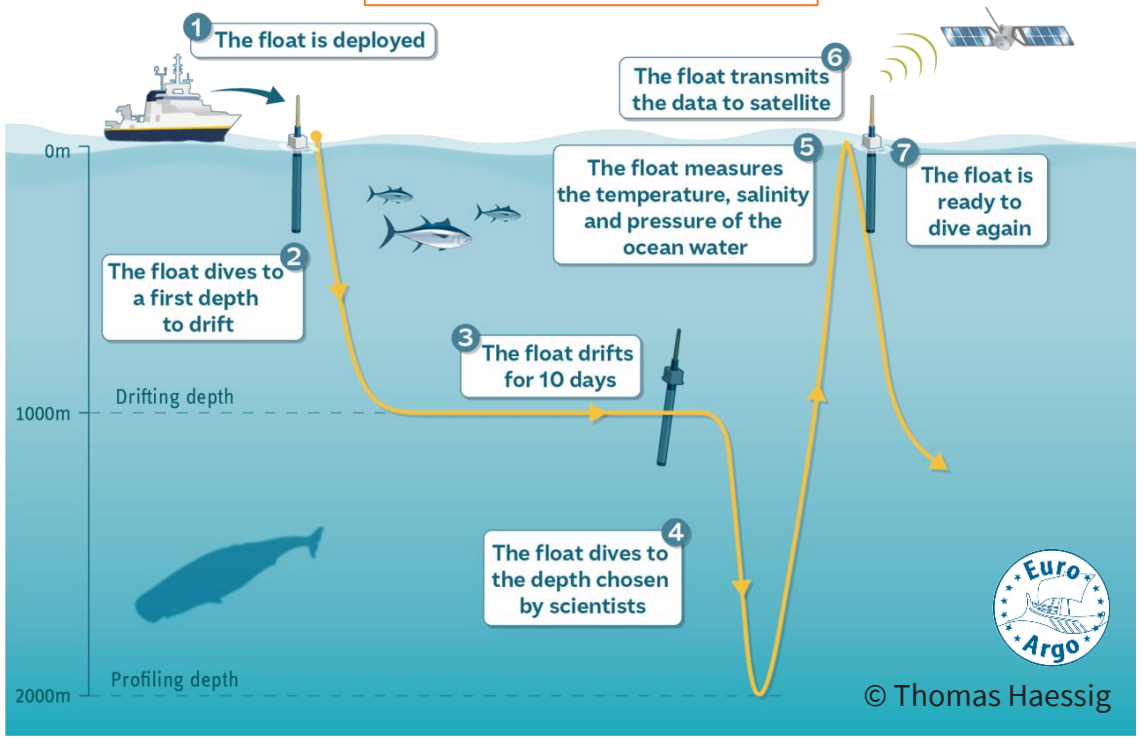
Surface drifter: 15 m

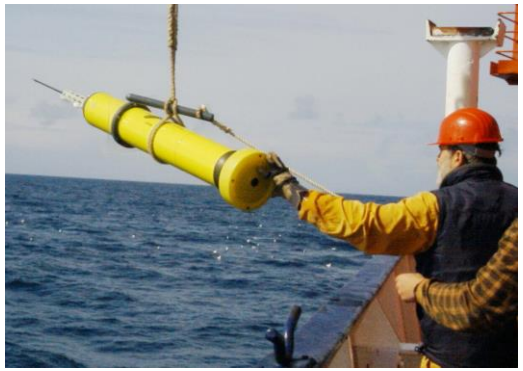


Atlantic Oceanographic & Meteorological Laboratory
U.S. Department of Commerce



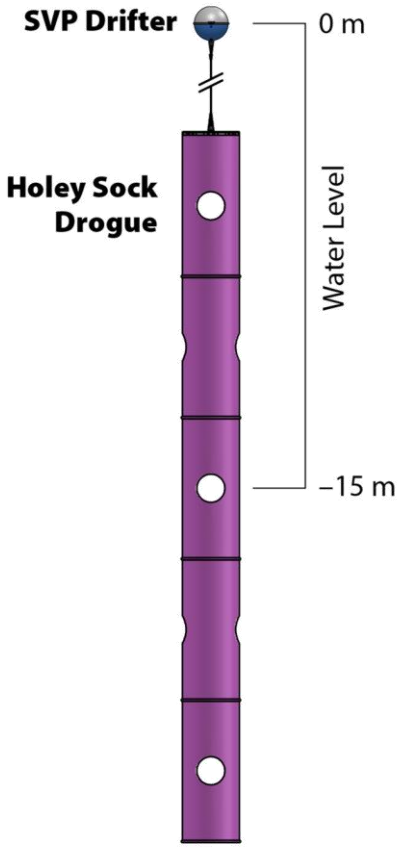
Argo float: 1000 m

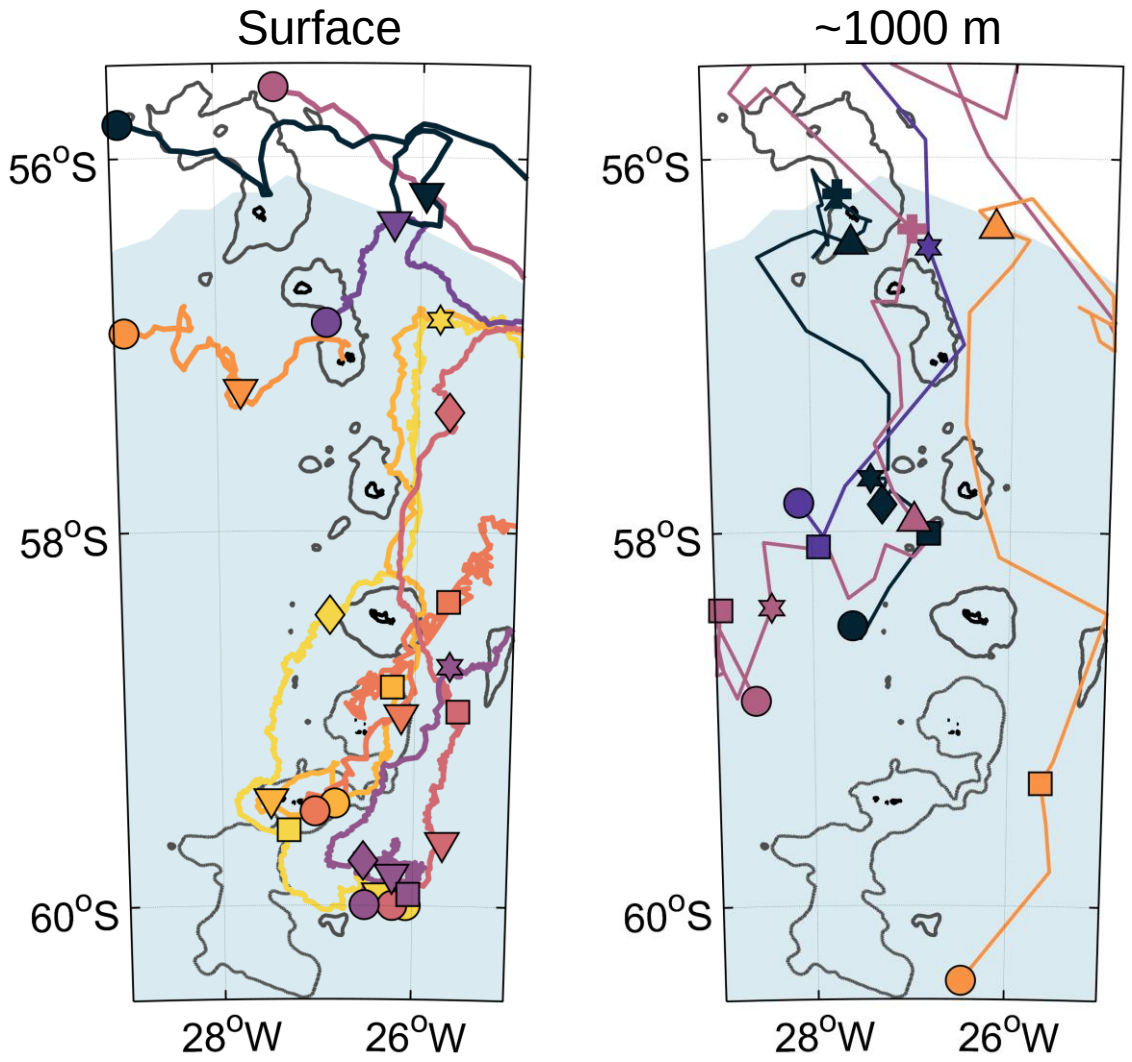


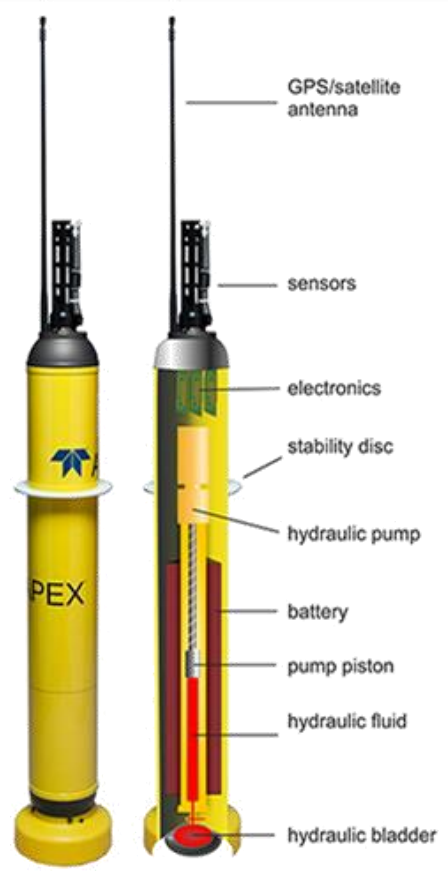


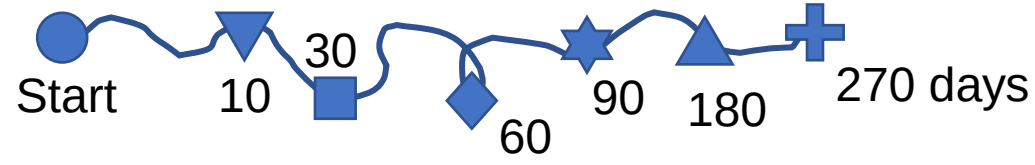
Argo

Oceanic transport

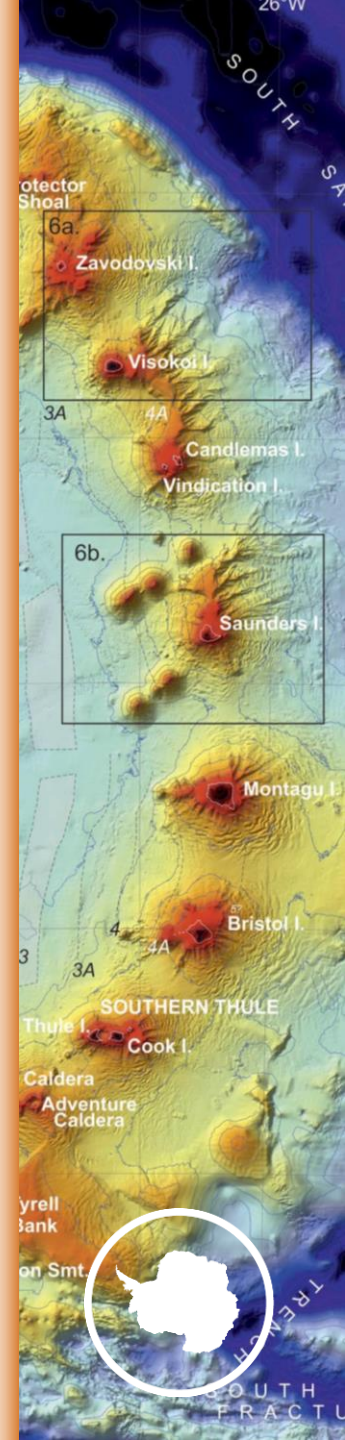








Winter sea ice



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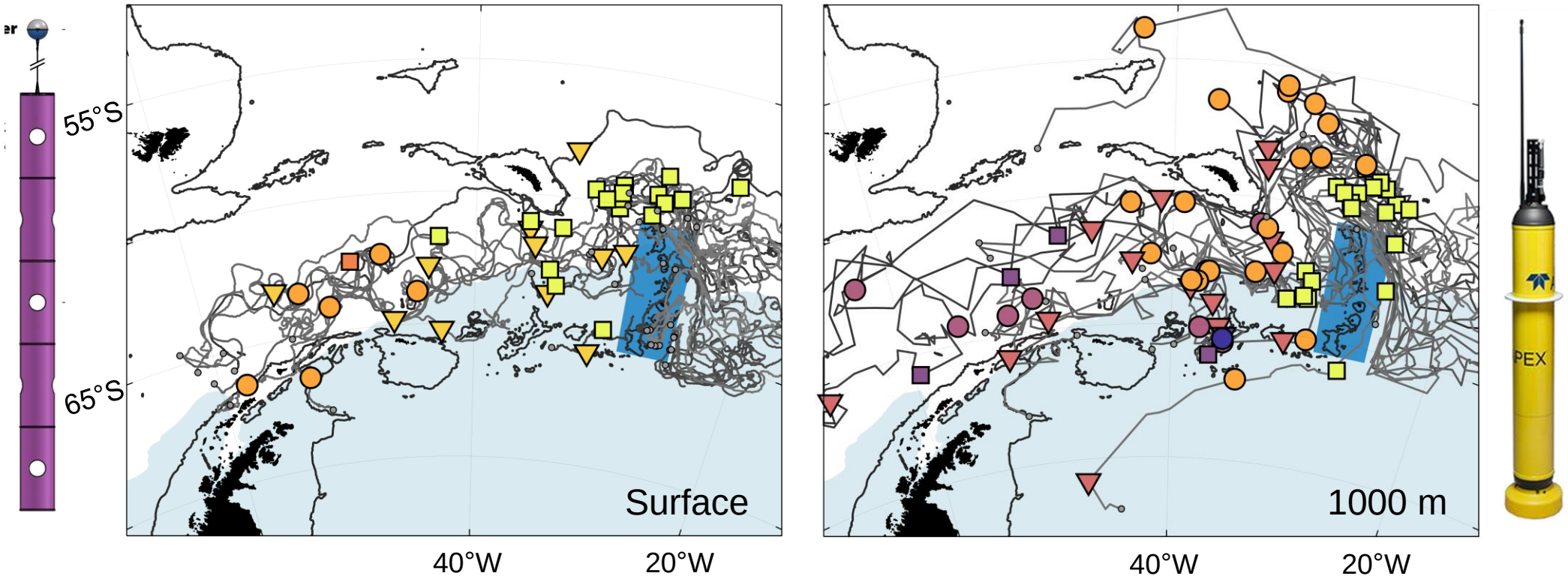
Oceanic transport



Transport time to South Sandwich Islands

1 3 6 9 12 Months

1.5 2 3 4 5 6 Years

Winter sea ice

Atlantic Oceanographic & Meteorological Laboratory
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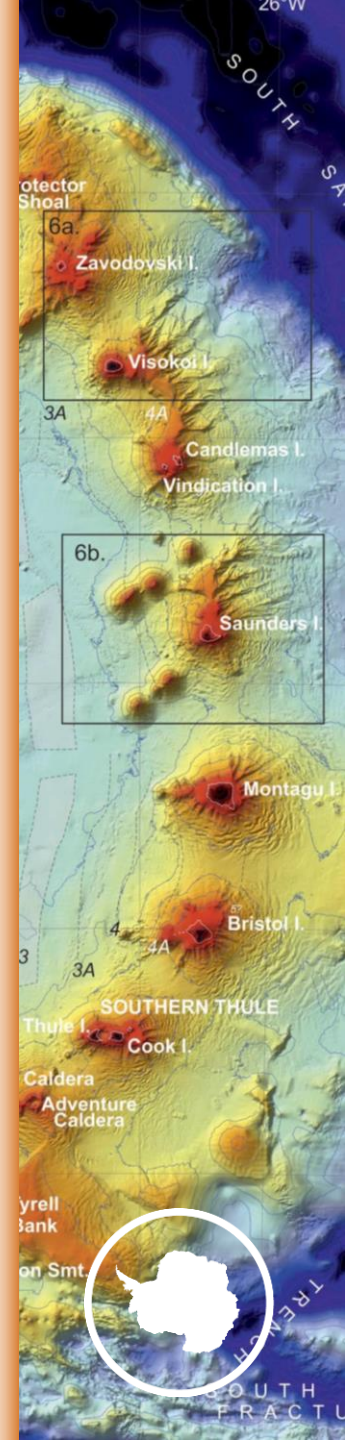
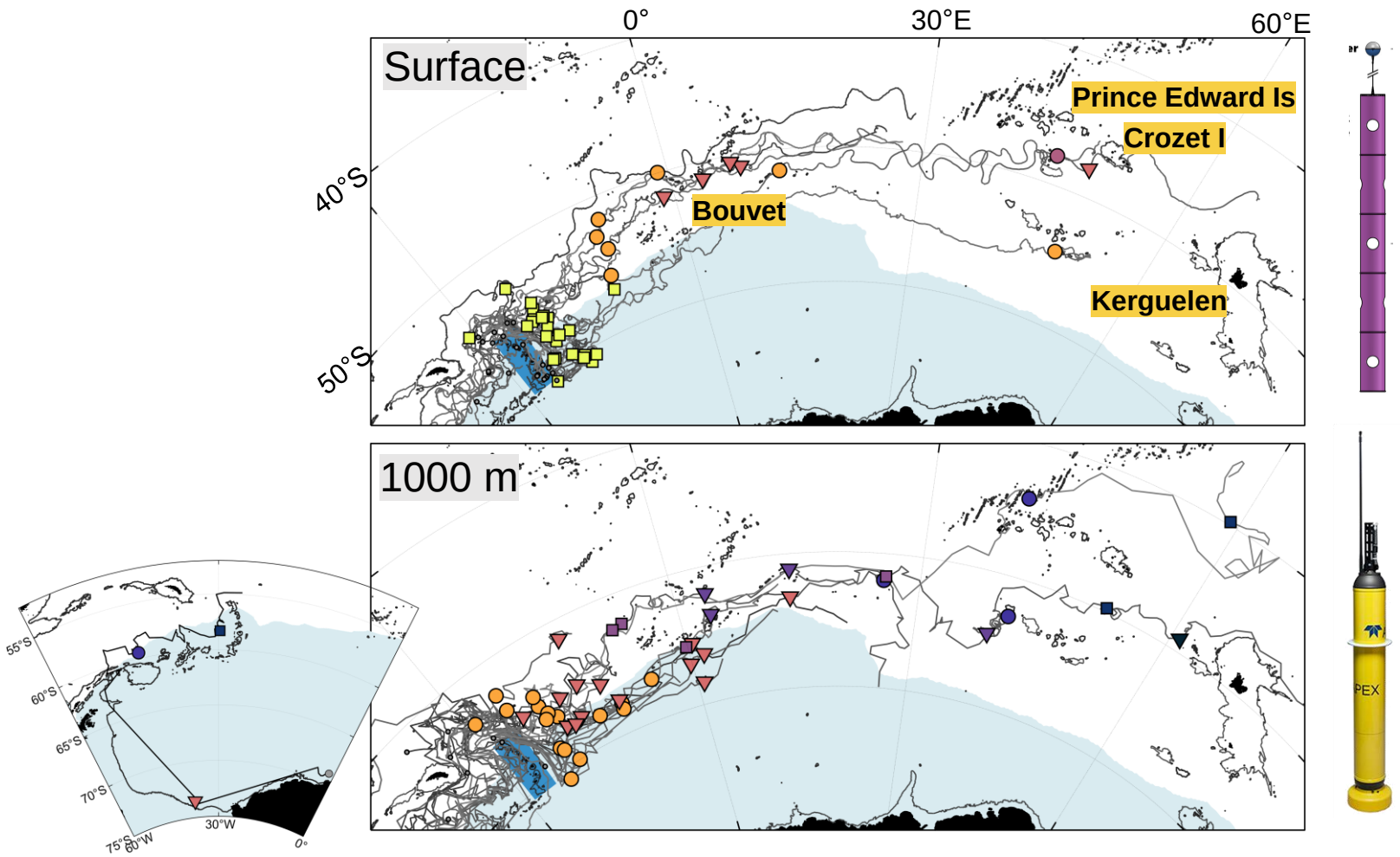


Oceanic transport

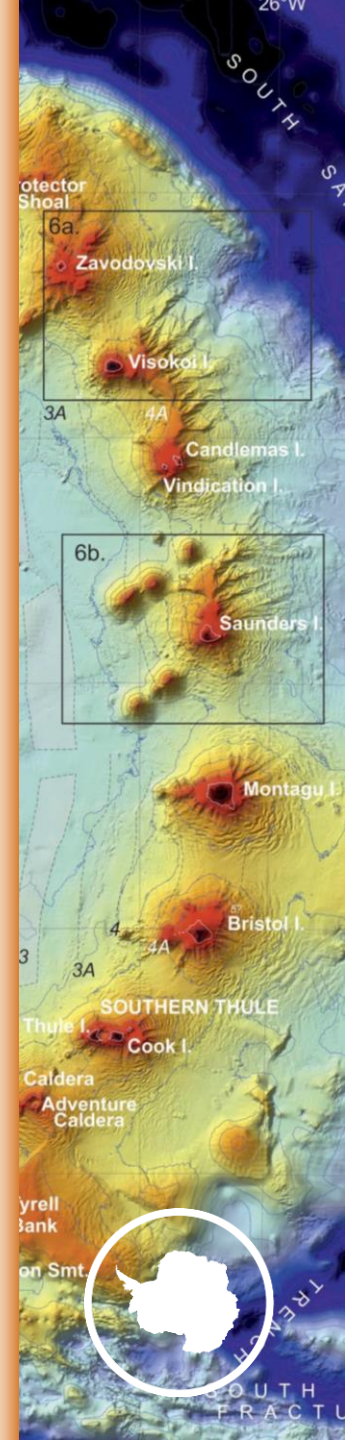


Transport time to South Sandwich Islands

1 3 6 9 12 Months | 1.5 2 3 4 5 6 Years

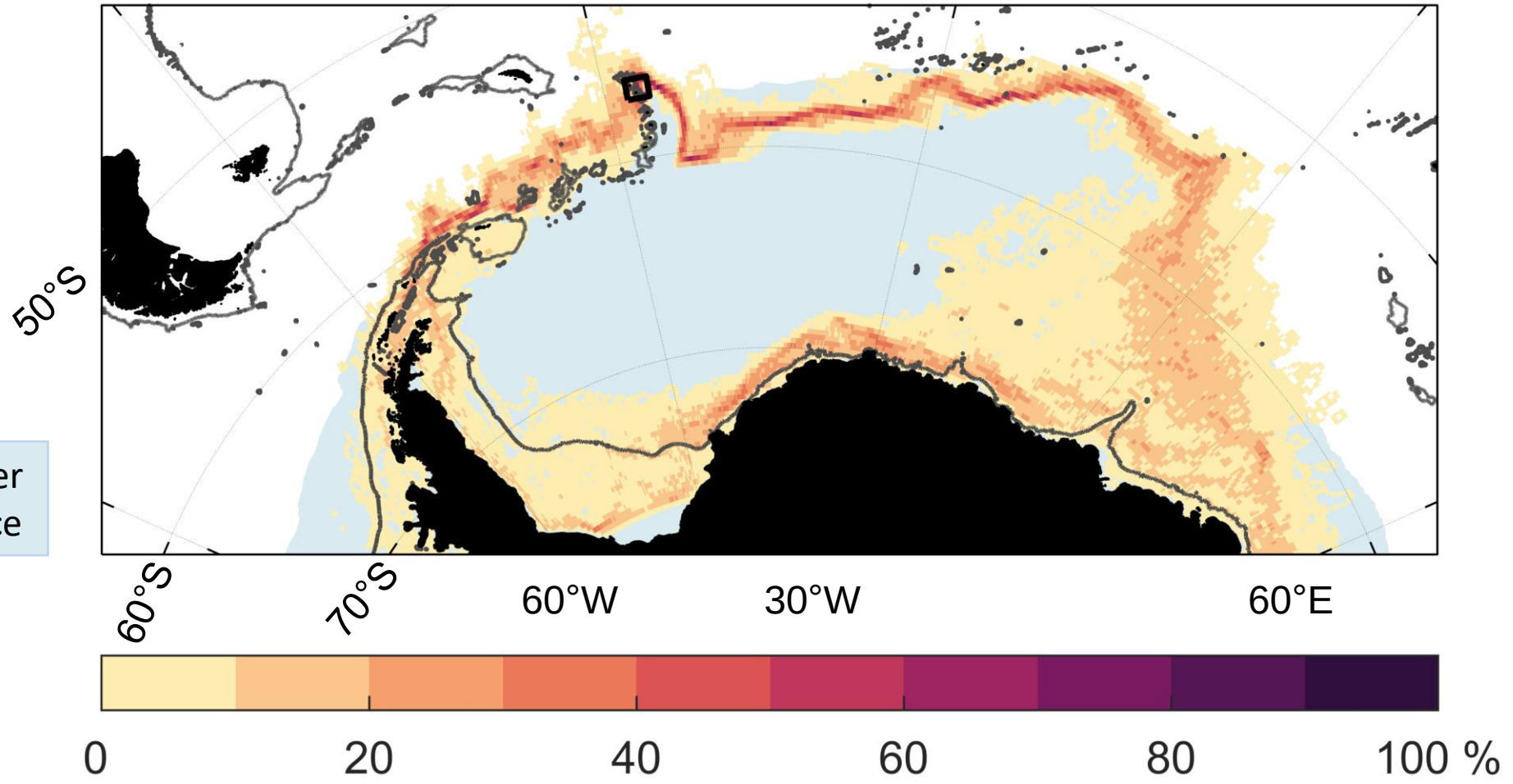
Winter sea ice

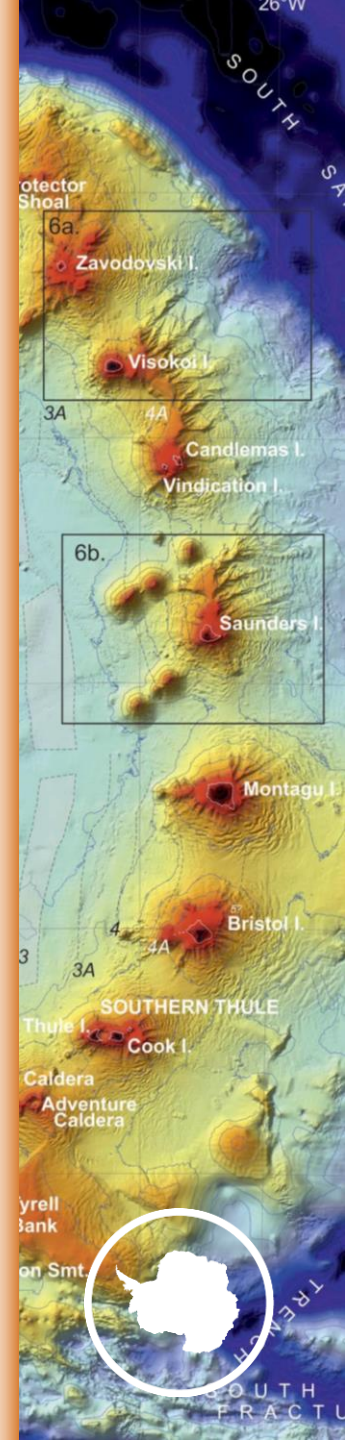
Atlantic Oceanographic & Meteorological Laboratory
U.S. Department of Commerce



Regional connectivity

Winter sea ice





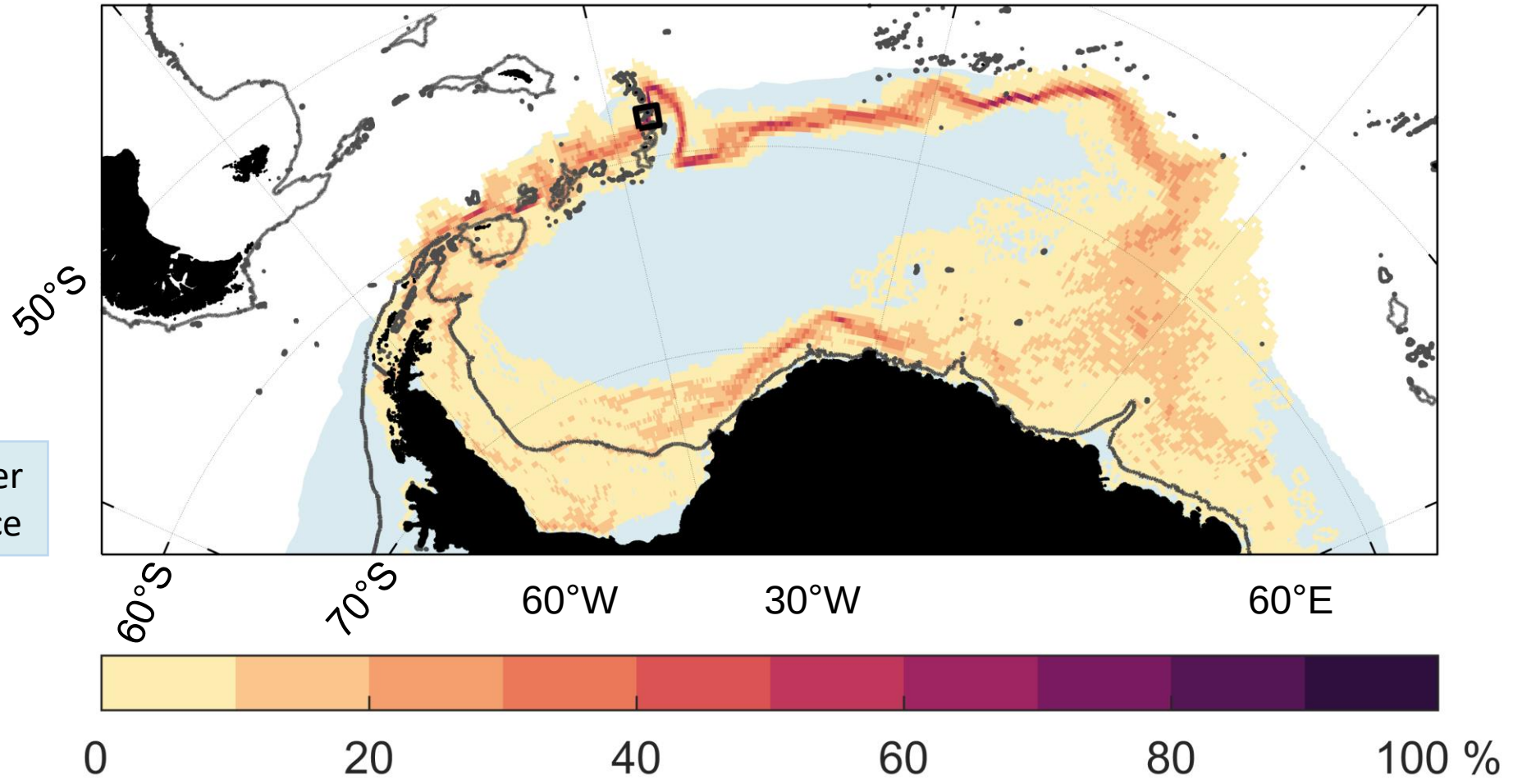
Copernicus Europe's eyes on Earth

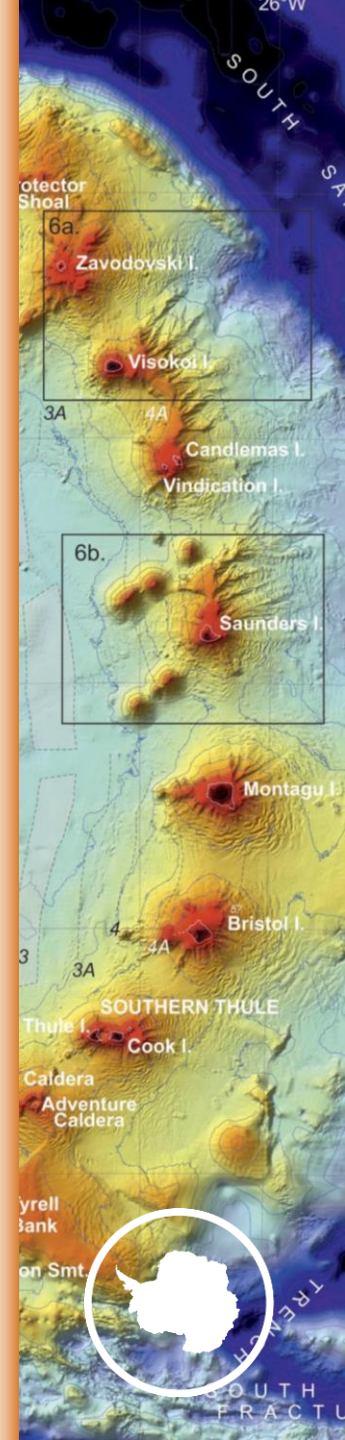
Copernicus Marine Service

Global Ocean Physics Reanalysis

Regional connectivity

Winter sea ice





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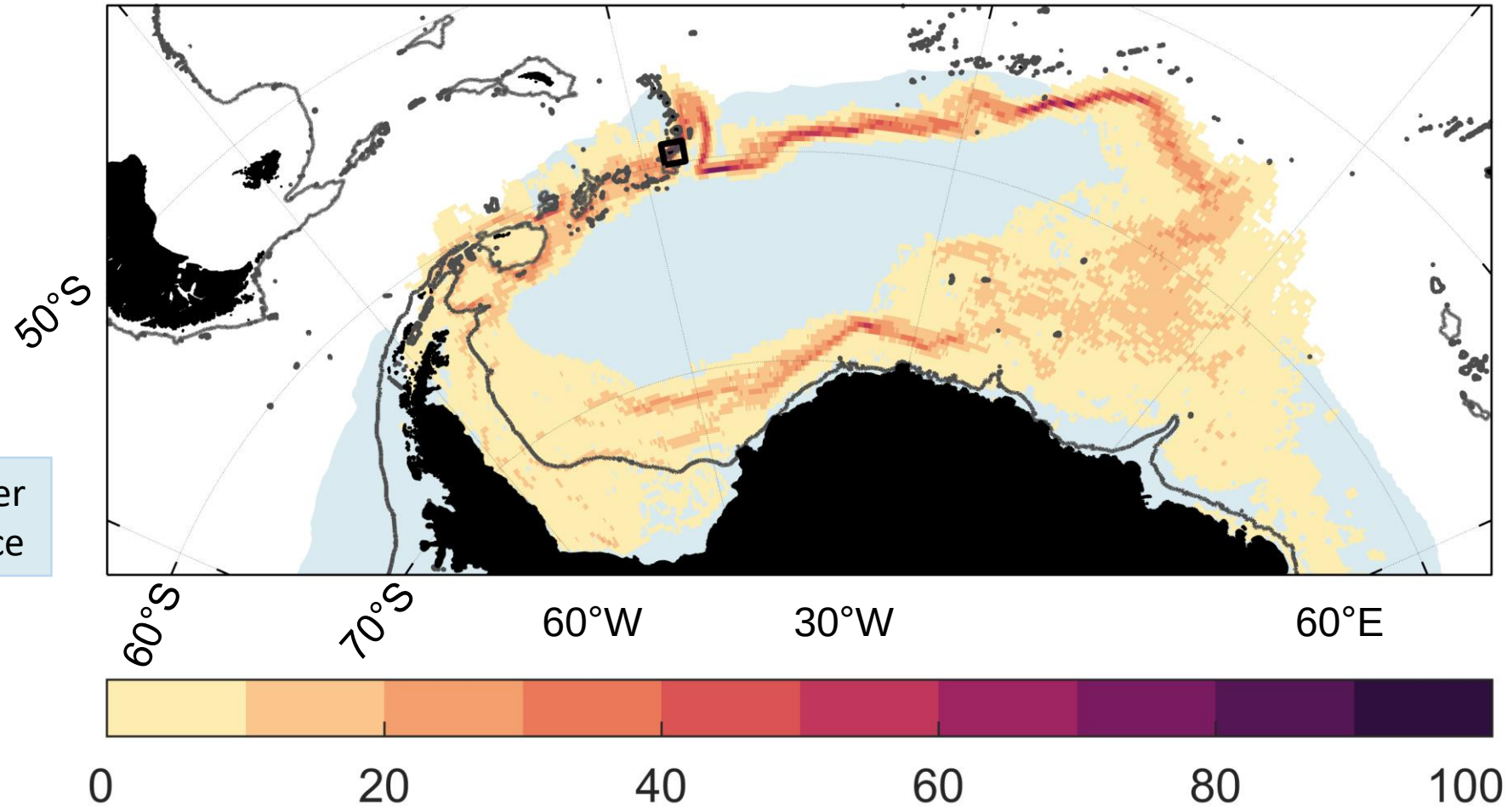
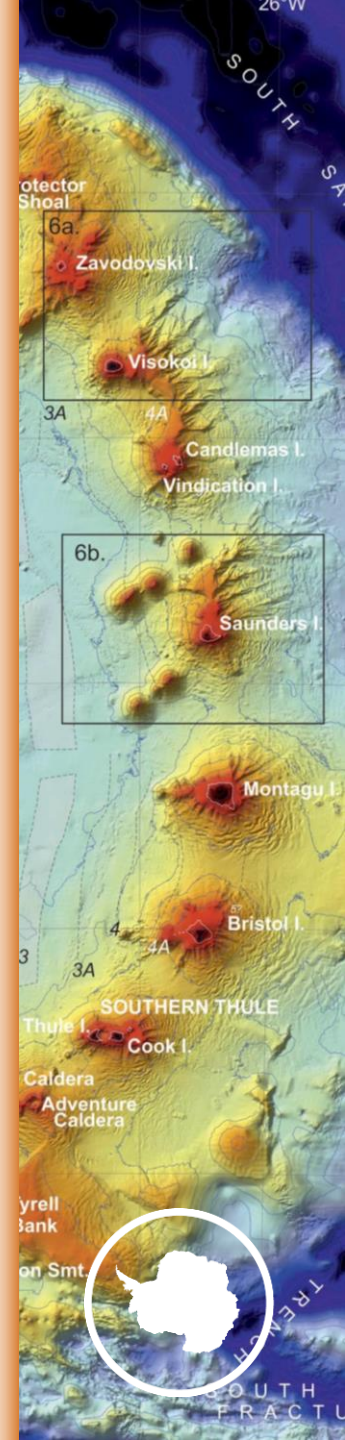


Winter sea ice



Copernicus Europe's eyes on Earth

Copernicus Marine Service

Global Ocean Physics Reanalysis

Summary

Complex marine environment

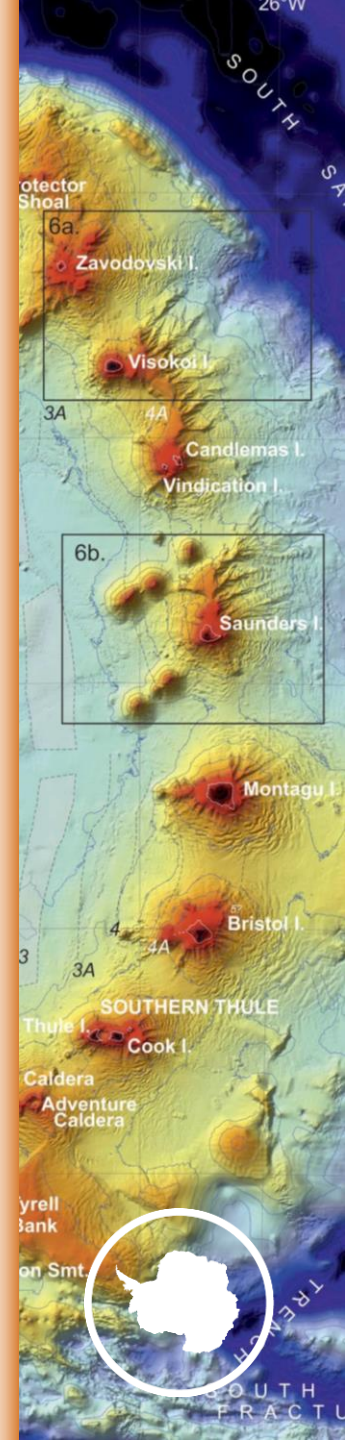
Latitudinal gradients

Highly variable

Well connected

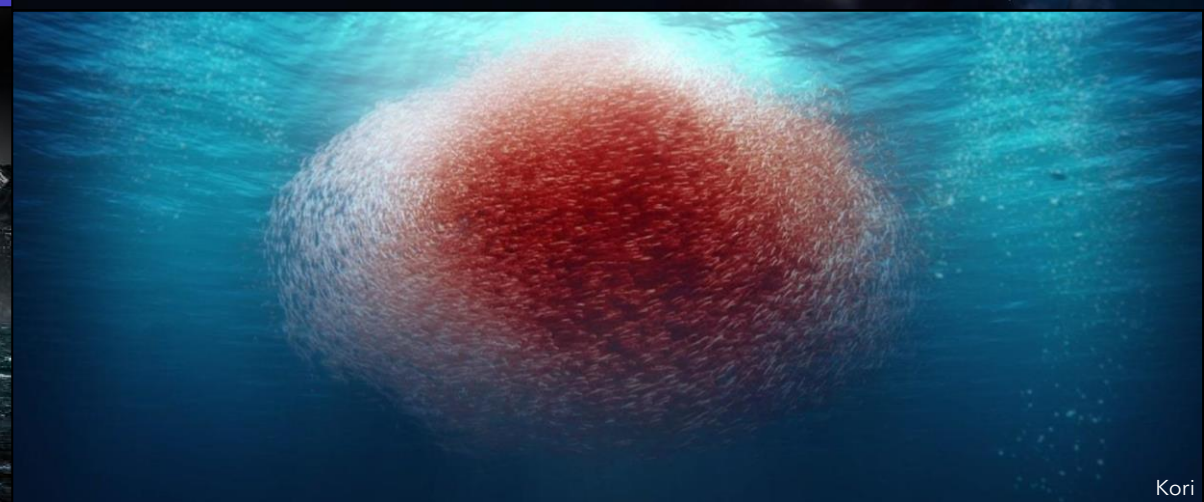
seth@bas.ac.uk

Bristol Island, photo by Alex Tate
Bathymetric map, Leat et al (2014)



Cecilia Liszka

British Antarctic Survey



Plankton and nekton community structure around the South Sandwich Islands and the influence of environmental factors

SGSSI MPA Symposium

13th June 2023

Dr Cecilia Liszka, Dr Sally Thorpe, Marianne Wootton, Dr Sophie Fielding, Prof Eugene Murphy, and Prof Geraint Tarling

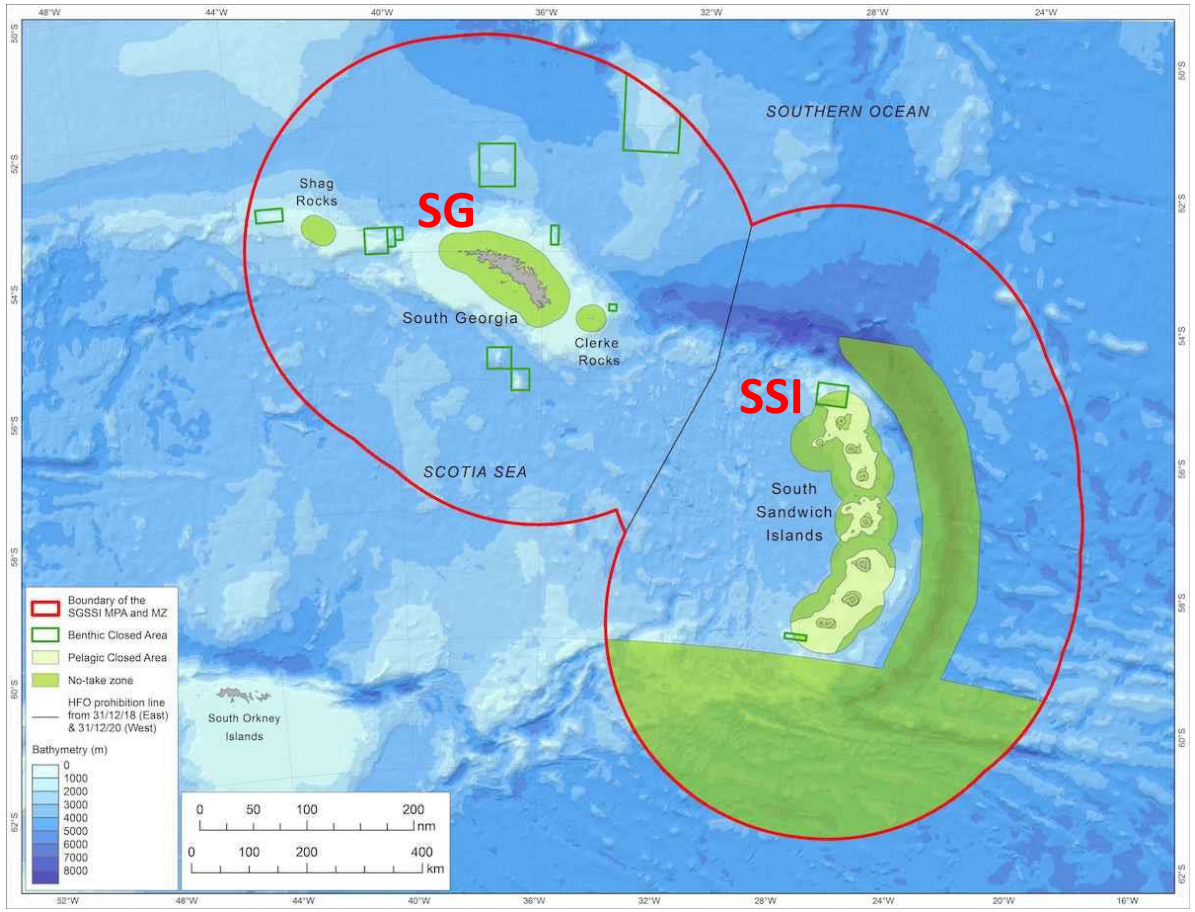
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Marine Biological Association

Government of South Georgia & the South Sandwich Islands

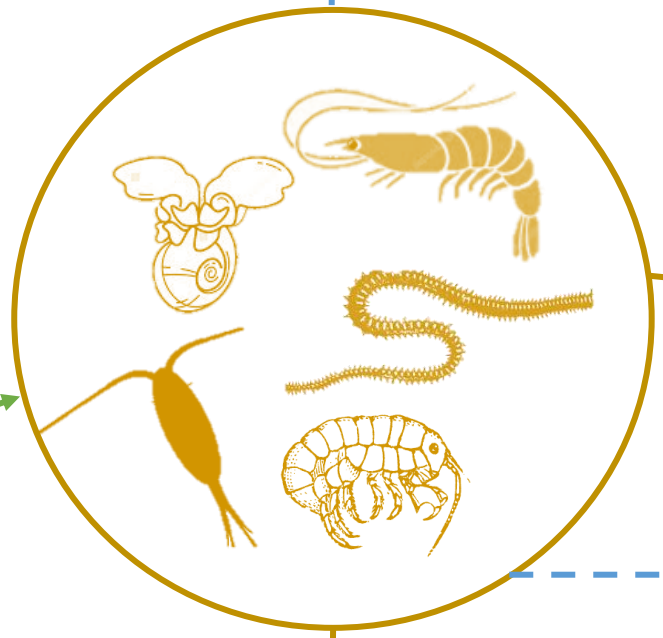
POLAR SCIENCE FOR PLANET EARTH

Physical and management context



https://www.gov.gs/environment/marine-protected-area/

- Eastern Scotia Sea, 500 miles SE of SG
- Aerial exposure of volcanic Scotia Arc
- Part of SGSSI MPA but environmentally distinct
- SSI lacking in data relative to SG
- Pelagic environment very little studied



Carbon & nutrient cycling/export

Deep–Sea Research II 198 (2022) 105073

Contents lists available at ScienceDirect

Deep-Sea Research Part II

journal homepage: www.elsevier.com/locate/dsr2

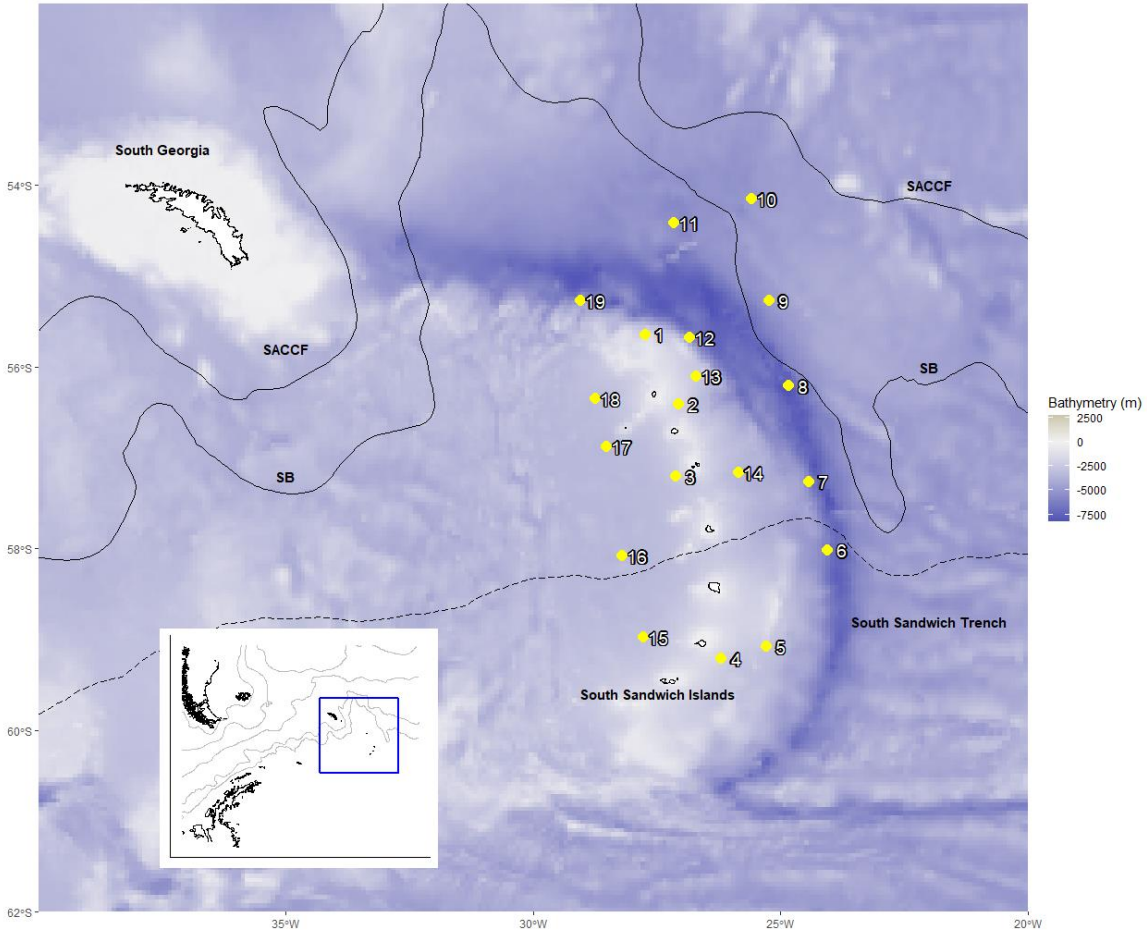
Plankton and nekton community structure in the vicinity of the South Sandwich Islands (Southern Ocean) and the influence of environmental factors

Cecilia M. Liszka [a,*], Sally E. Thorpe [a], Marianne Wootton [b], Sophie Fielding [a], Eugene J. Murphy [a], Geraint A. Tarling [a]

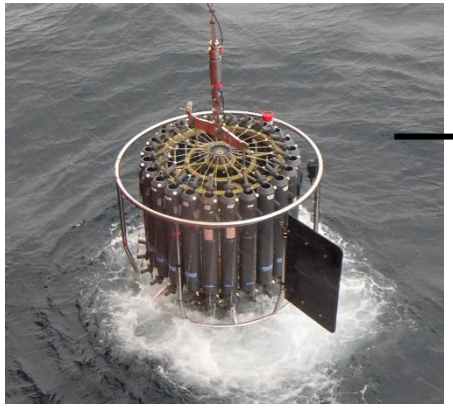
Objective 1: Examine composition & distribution of phyto-, zoo- & nekton communities at the South Sandwich Islands

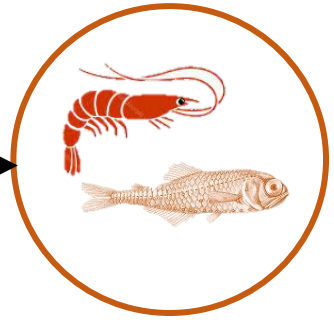
Objective 2: Identify the principal environmental influences on these plankton communities

Sample & data collection



Plankton data



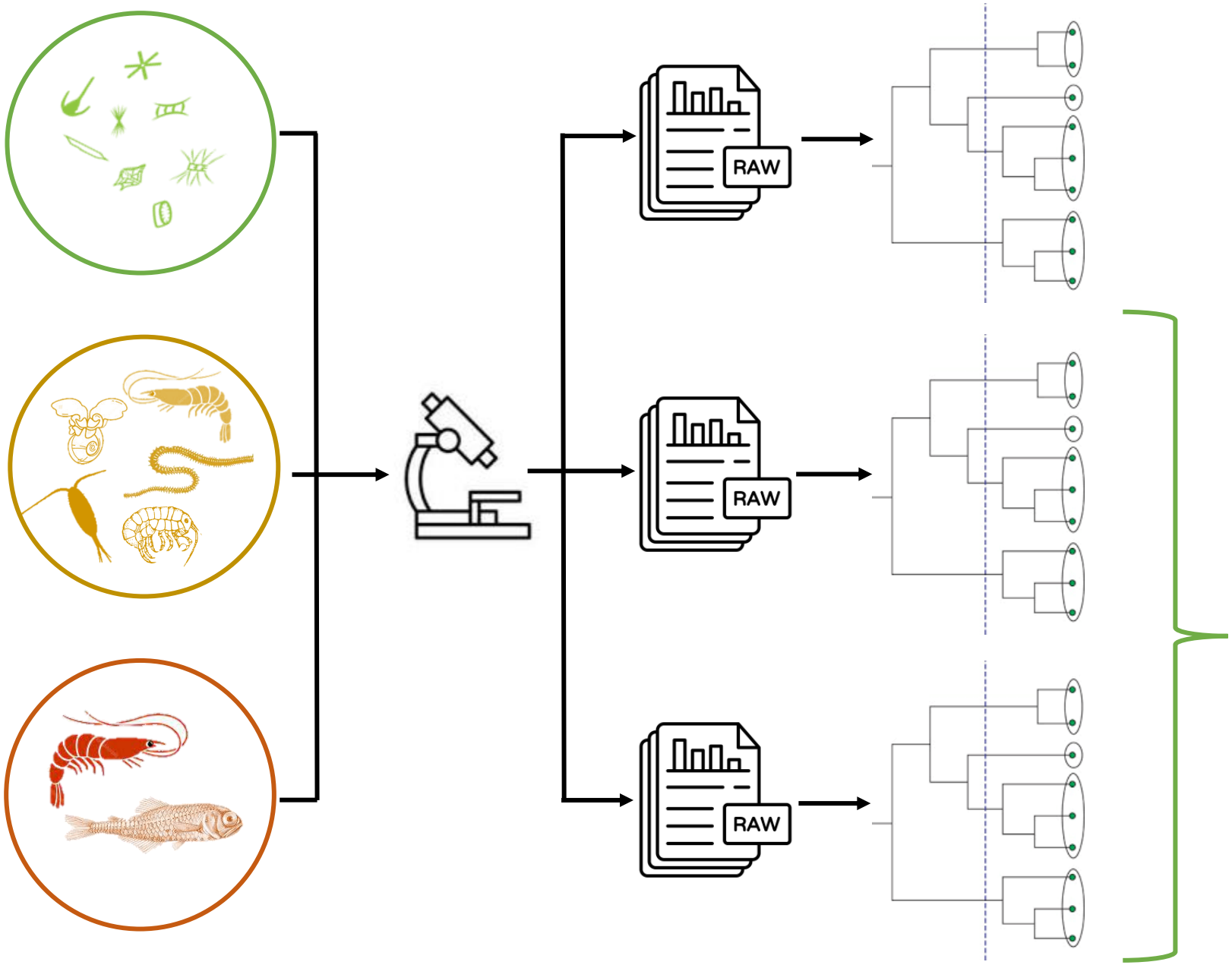


Environmental data

Including…

- Bathymetry
- Chlorophyll-a & phaeophytin
  - integrated, max, mean
- SST/ temp min/ max subsurface temp
- Salinity
- Primary productivity
- Mixed layer depth
- Distance to ice edge

…from satellite, CTD (in situ), and derived…



Environmental data

Normalise to comparable scale

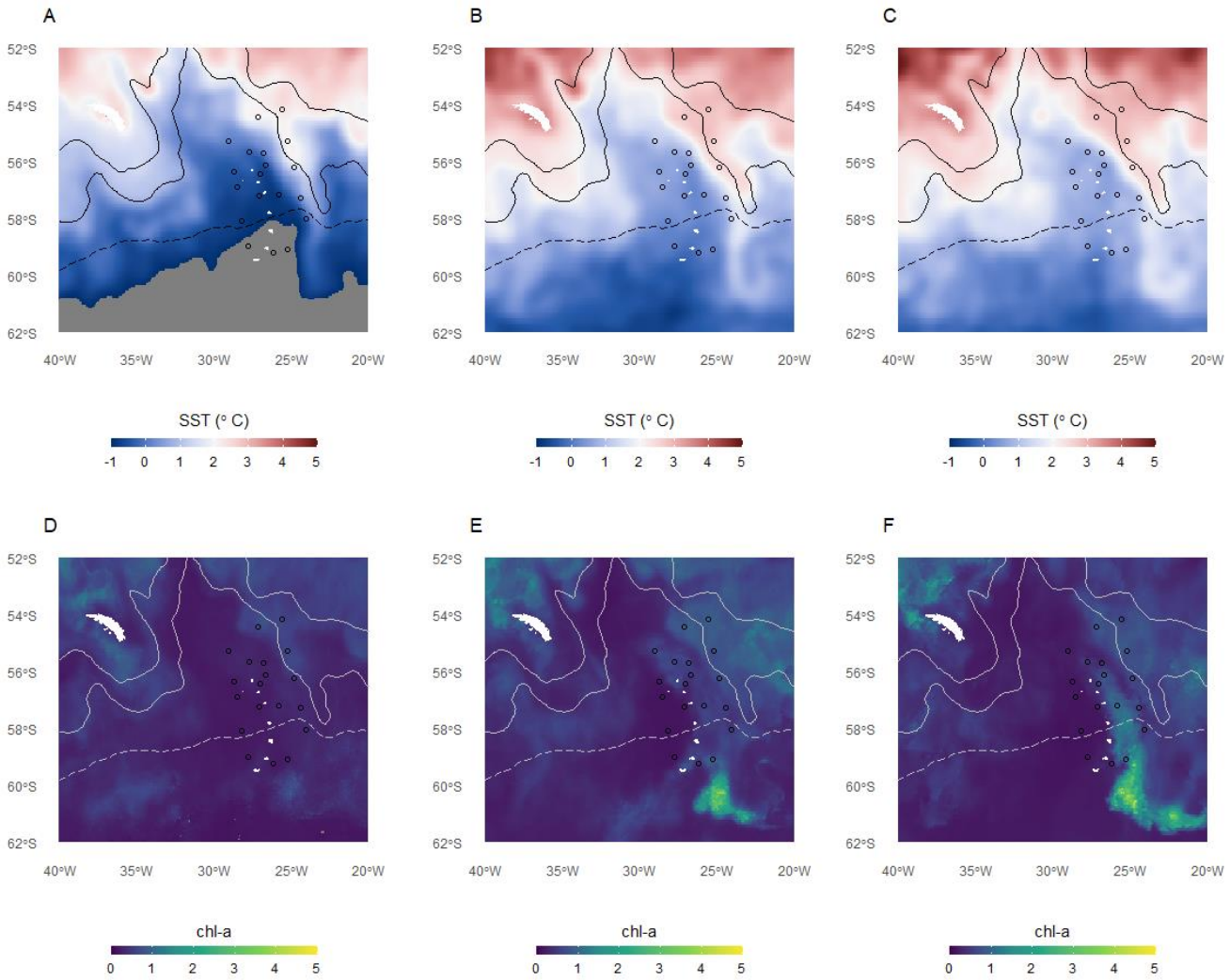
BIOENV = identify subset of variables that correlates maximally with sample matrix dissimilarities

study period

Dec 2018 Jan 2019 Feb 2019

SST

chl-a



2 water masses separated by SB

→ 2 to 5 ˚C (N) vs -1 to 1.5 ˚ C (S)

→ High abundances, small diatoms north of SB (e.g. *Chaetoceros, Fragilariopsis, Pseudo-nitzschia*)

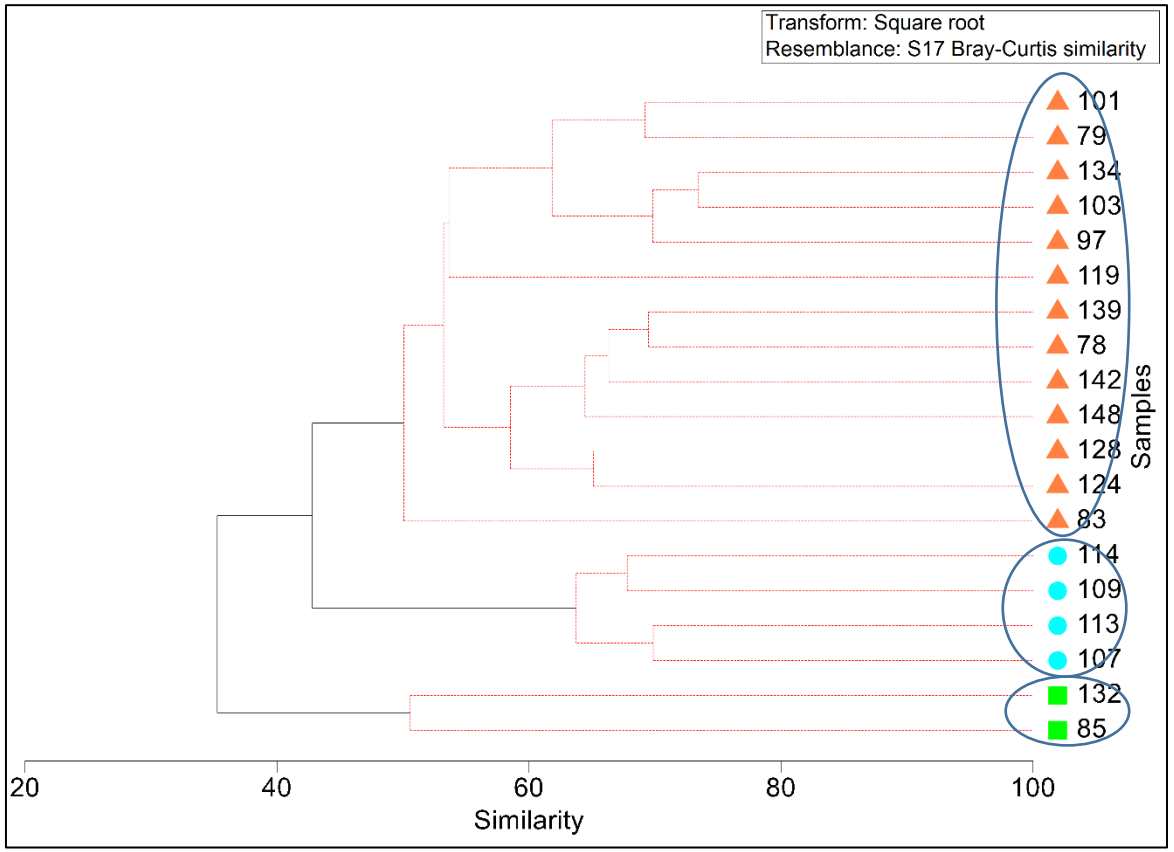
Bloom propagating N from SE

→ High sub-surface chl-max (10.44 µg l^{-1})

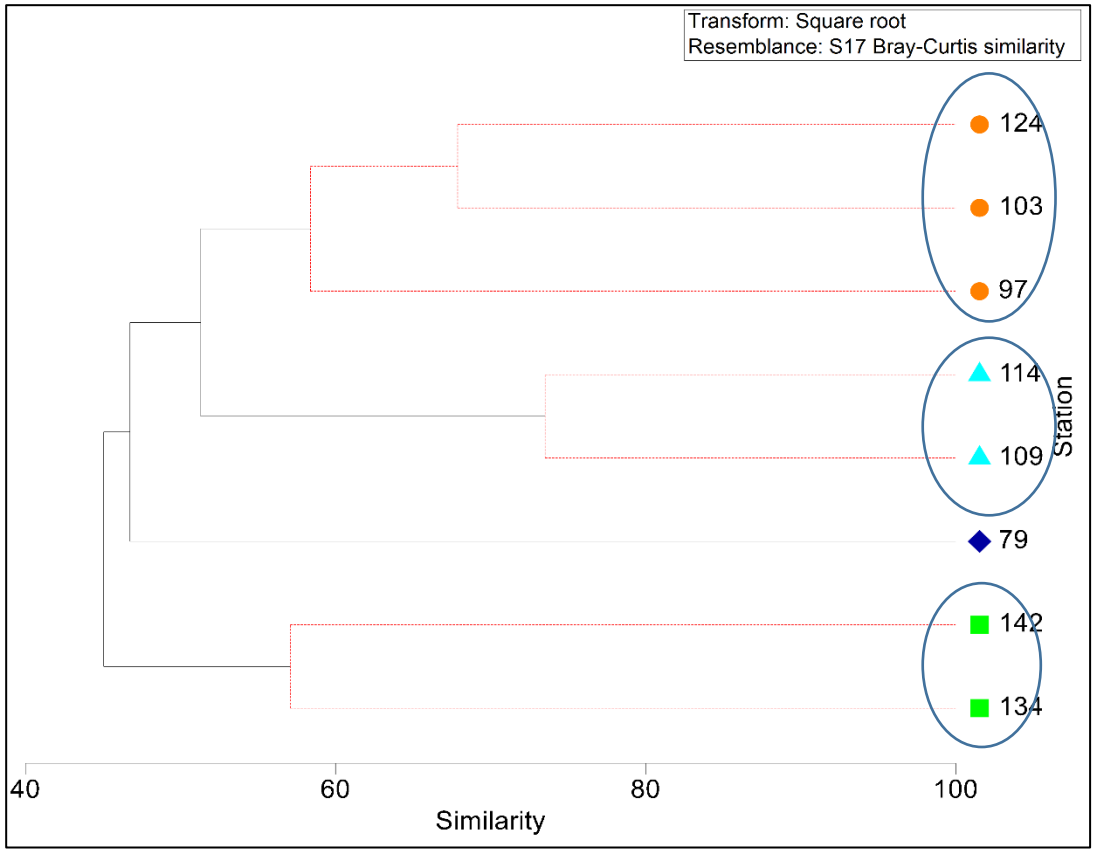
→ High abundances, large diatoms (*Rhizosolenia, Proboscia*) + dinos in bloom

→ Lower abundances, flagellates & *Phaeocystis* spp. to west

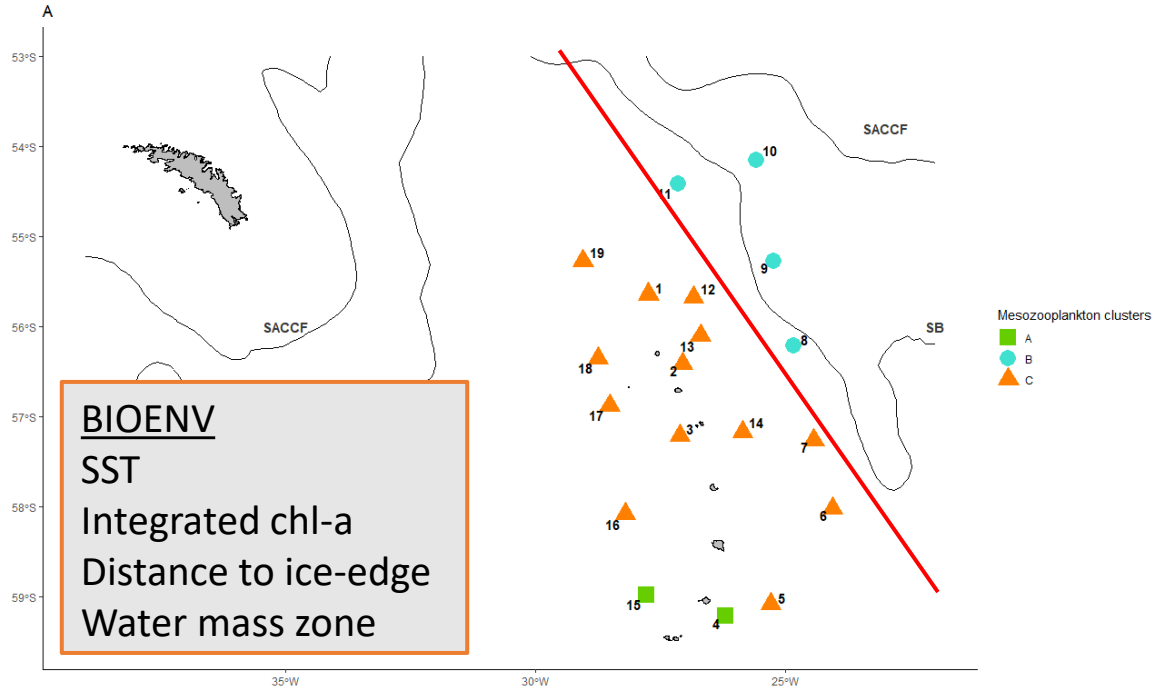
Mesozooplankton



Macrozooplankton

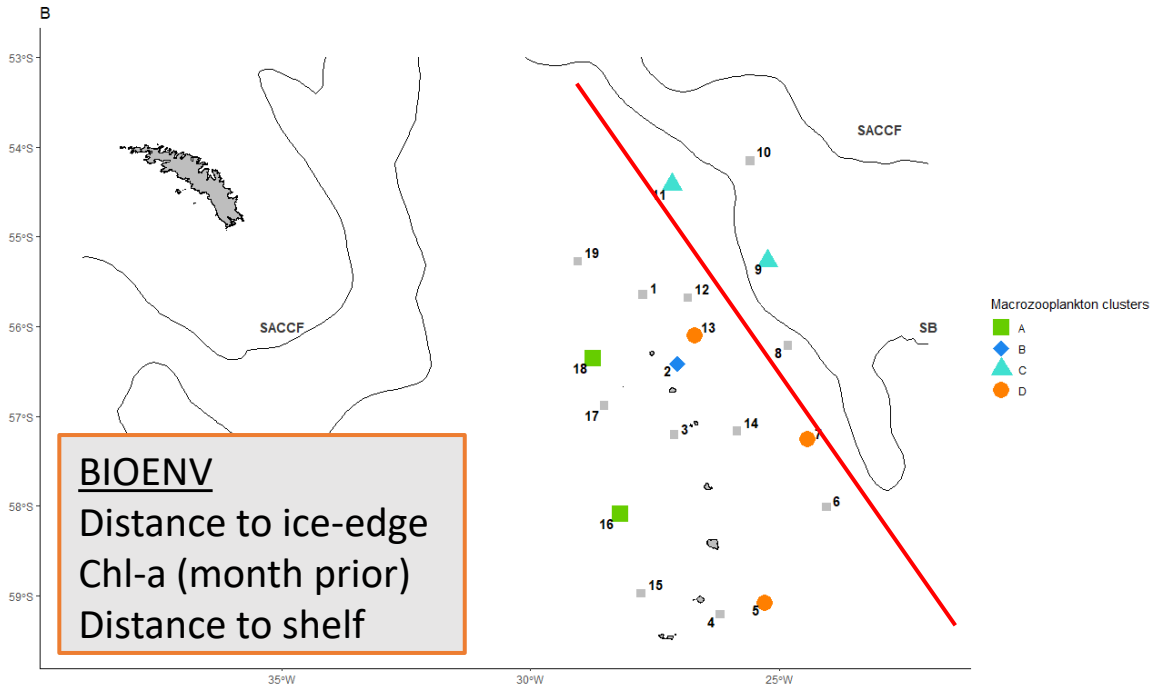


Mesozooplankton



- nSB: high biomass - *R. gigas, C. simillimus, C. propinquus* & larval euphausiids
- sSB: no *C. simillimus;* high *C. acutus* & *Thysanoessa*
- Far south: v. low biomass, mostly gelatinous

Macrozooplankton



- nSB: *T. gaudichaudii, E. triacantha*
- East (bloom): highest *S. thompsonii* & mesopelagic fish
- Periphery: low biomass but highest *E. superba*
- Single station with highest *Thysanoessa*

Summary

- SB = clear boundary separating biomass-high, warmer water community (north), from intermediate biomass, colder water community (south)
- Large calanoid copepods dominate mesozooplankton = north of SB
- Euphausiids (esp. *Thysanoessa* spp.) & myctophids dominate macrozooplankton = south of SB
- Bloom = high diversity & abundance of phytoplankton inc. large diatoms
- Zooplankton community structure potentially sensitive to future changes in SST, chl-a & sea-ice distribution

Any questions?

Thank you to: co-authors Prof. Geraint Tarling, Dr Sophie Fielding, Prof. Eugene Murphy, Dr Sally Thorpe, Marianne Wootton; Captain, crew and scientists on DY908; Martina Brunette (MBA) and Plankton Sorting and Identification Center Morski Instytut Rybacki (Gdynia, Poland).

And funders: UK FCDO Overseas Territories Blue Belt programme, and NERC-BAS ALI-Science Southern Ocean ecosystems project.

To find out more about the SSI, check out the DSRII Special Issue

Marine Biological Association

Government of South Georgia & the South Sandwich Islands

British Antarctic Survey
Natural Environment Research Council

Maritime Institute
Gdynia Maritime University

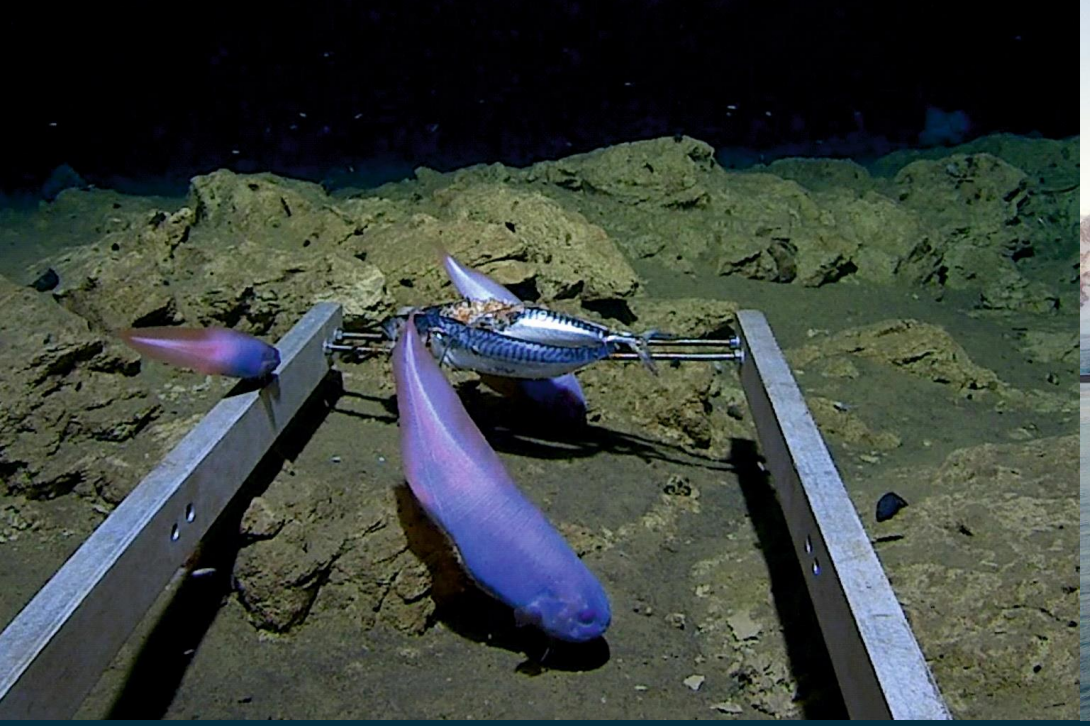
Heather Stewart

British Geological Survey


ESA


Sue G


Five Deeps



HEATHER STEWART, ALAN JAMIESON, JOHANNA WESTON

HOT: Hadal zones of Our Overseas Territories – the South Sandwich Trench

DARWIN PLUS

BGS British Geological Survey

HAST@BGS.AC.UK

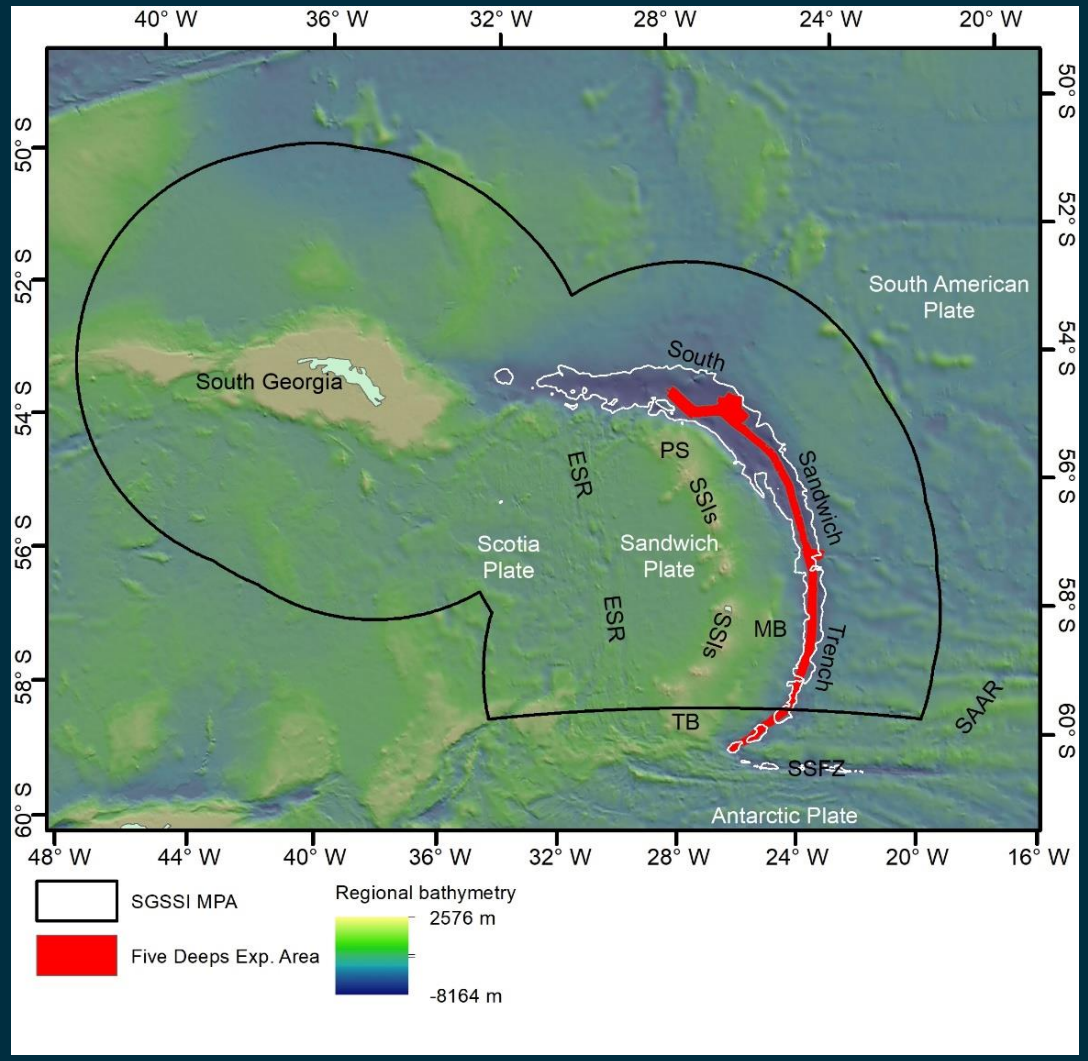
DPLUS093

Rationale

- South Georgia and the South Sandwich Islands Marine Protected Area (MPA) is one of the largest MPAs on Earth covering >1 million km^2.
- Deep water areas were identified as a major knowledge gap (bathymetry, biodiversity and geodiversity).

Luck!

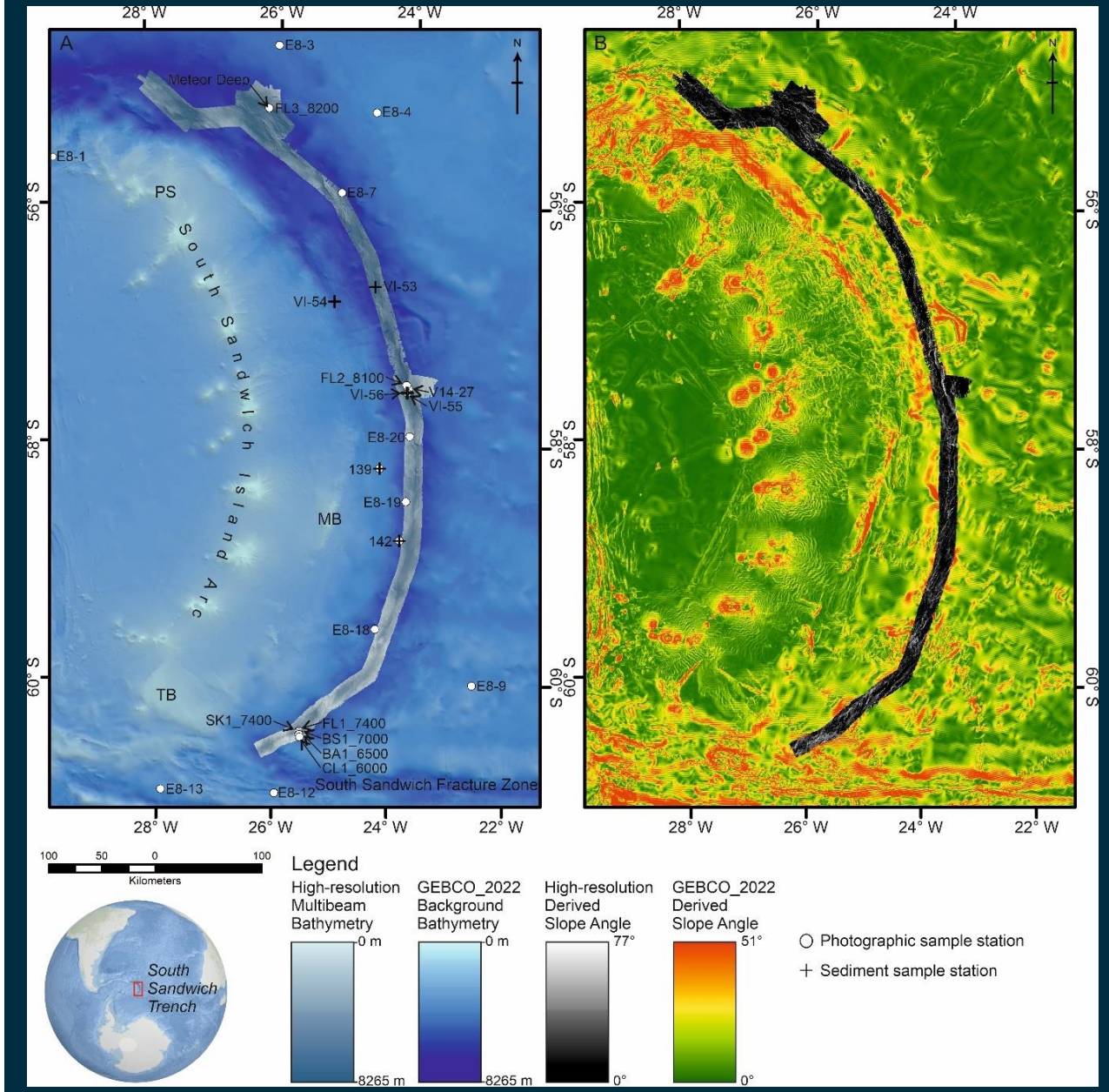
- Five Deeps Expedition to South Sandwich February 2019.

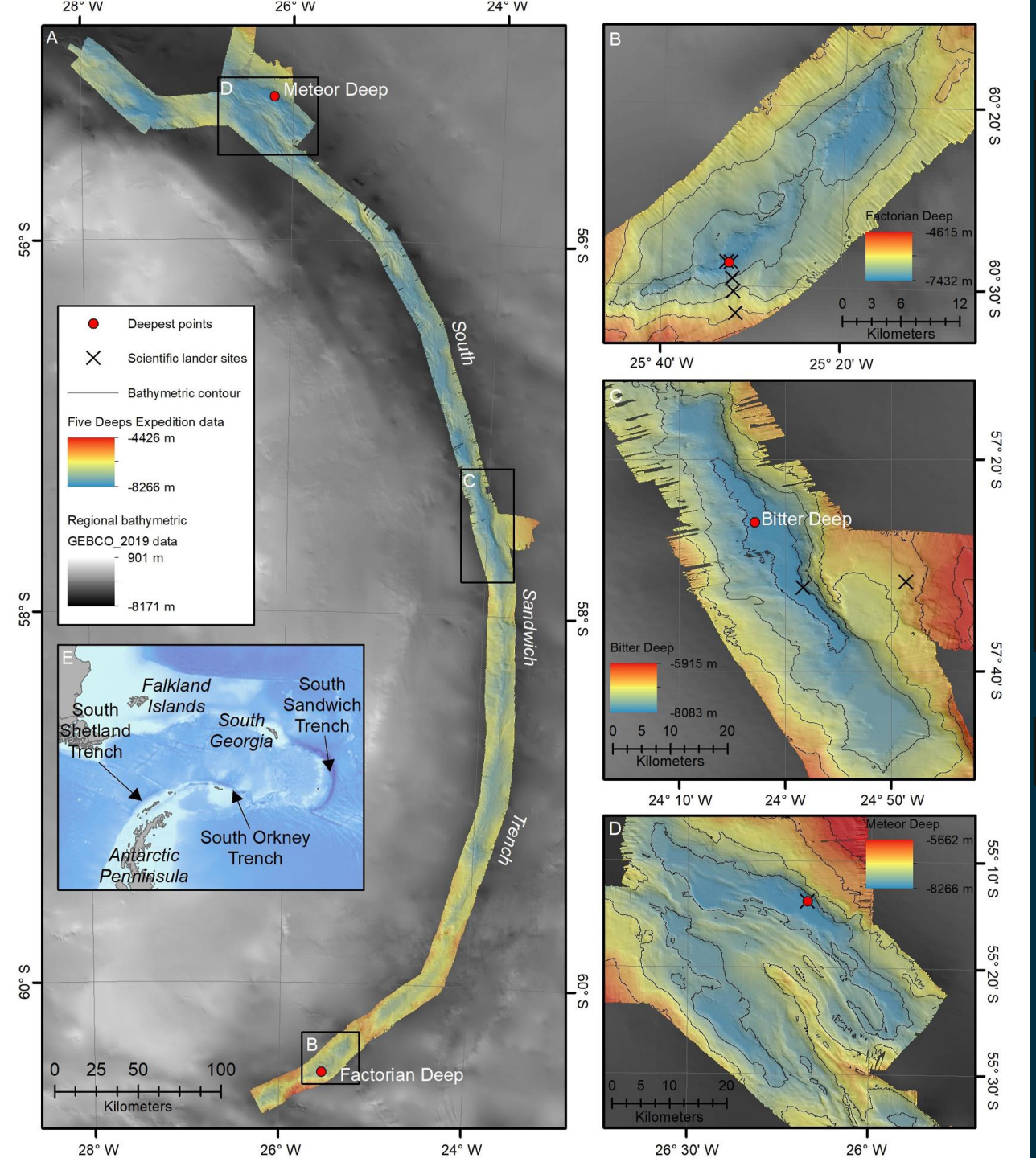


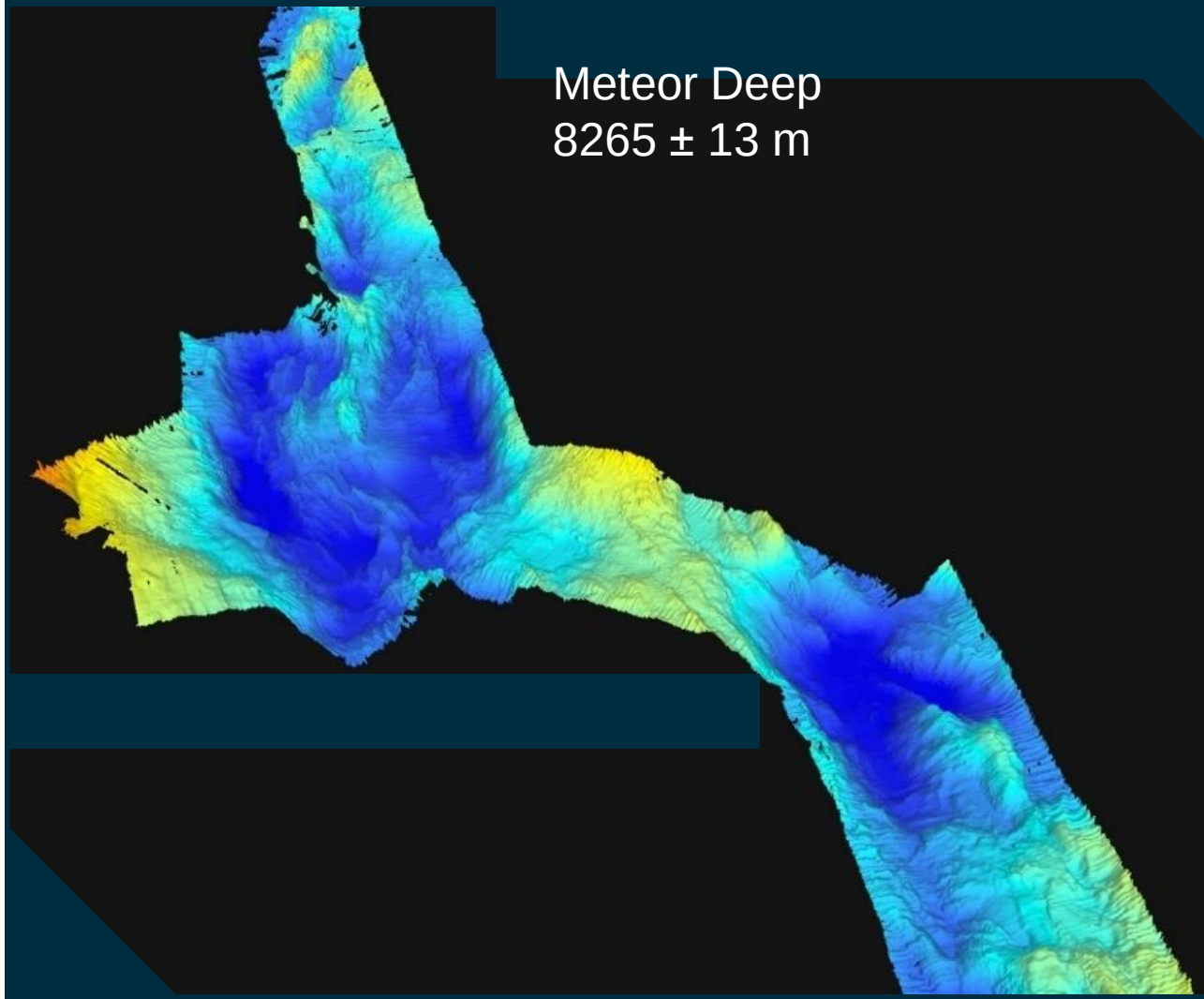
Overview map of the South Georgia and South Sandwich Islands (SGSSI) Marine Protected Area. The white line represents the -6000 m bathymetric contour delineating the South Sandwich Trench study area. Regional bathy from Ryan et al. 2009 doi:10.1029/2008GC002332.

Data gathering

- Even with recent mapping efforts and compilation exercised undertaken by both BAS and IBCSO (International Bathymetric Chart of the Southern Ocean) little accurate information was known.
- Five Deeps acquired 15,052 km^2 of multibeam data acquired of which 15,045 km^2 was new coverage and suite of scientific lander stations.
- Data mining exercise to include information from other expeditions.





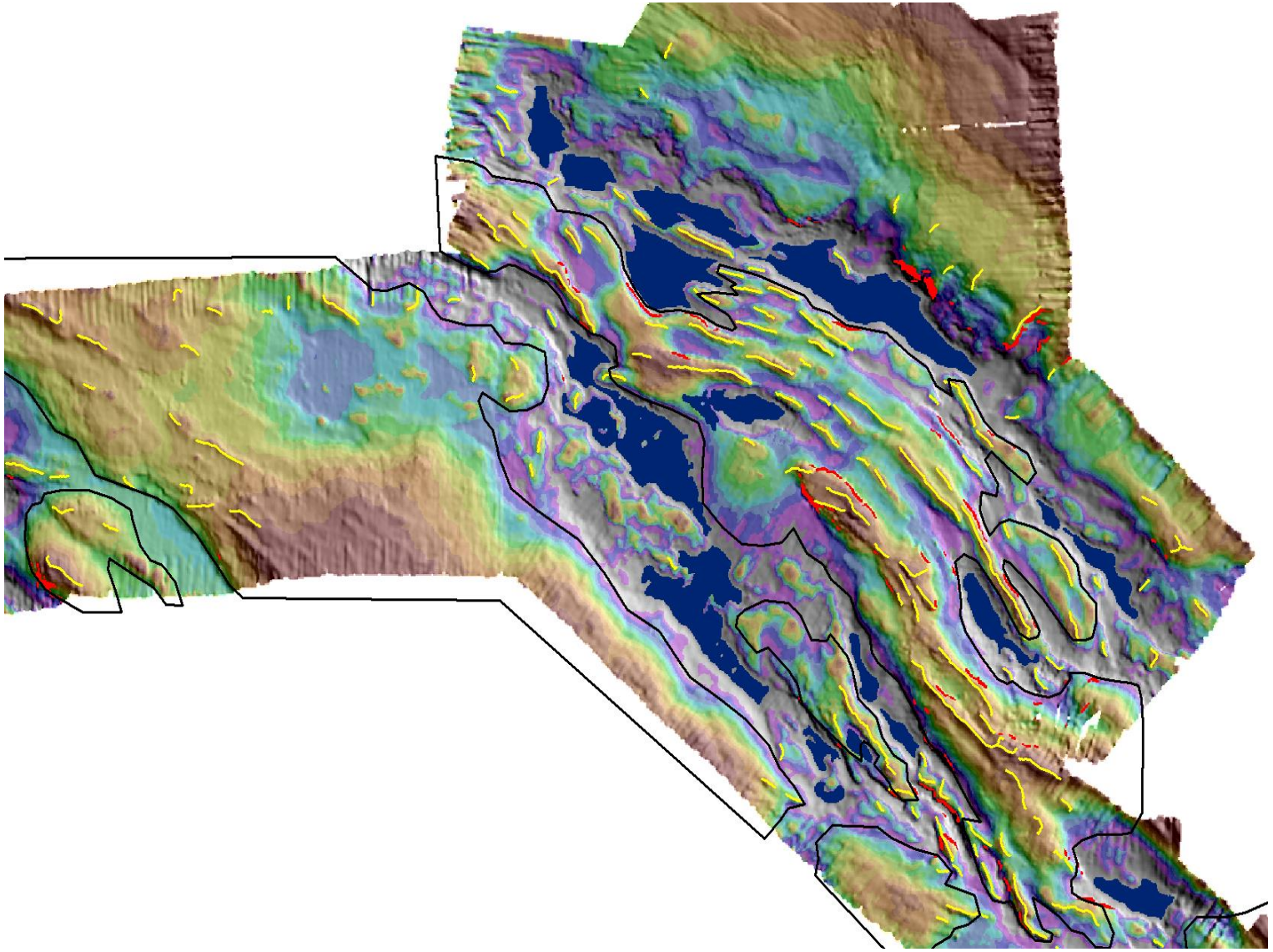


Meteor Deep
8265 ± 13 m

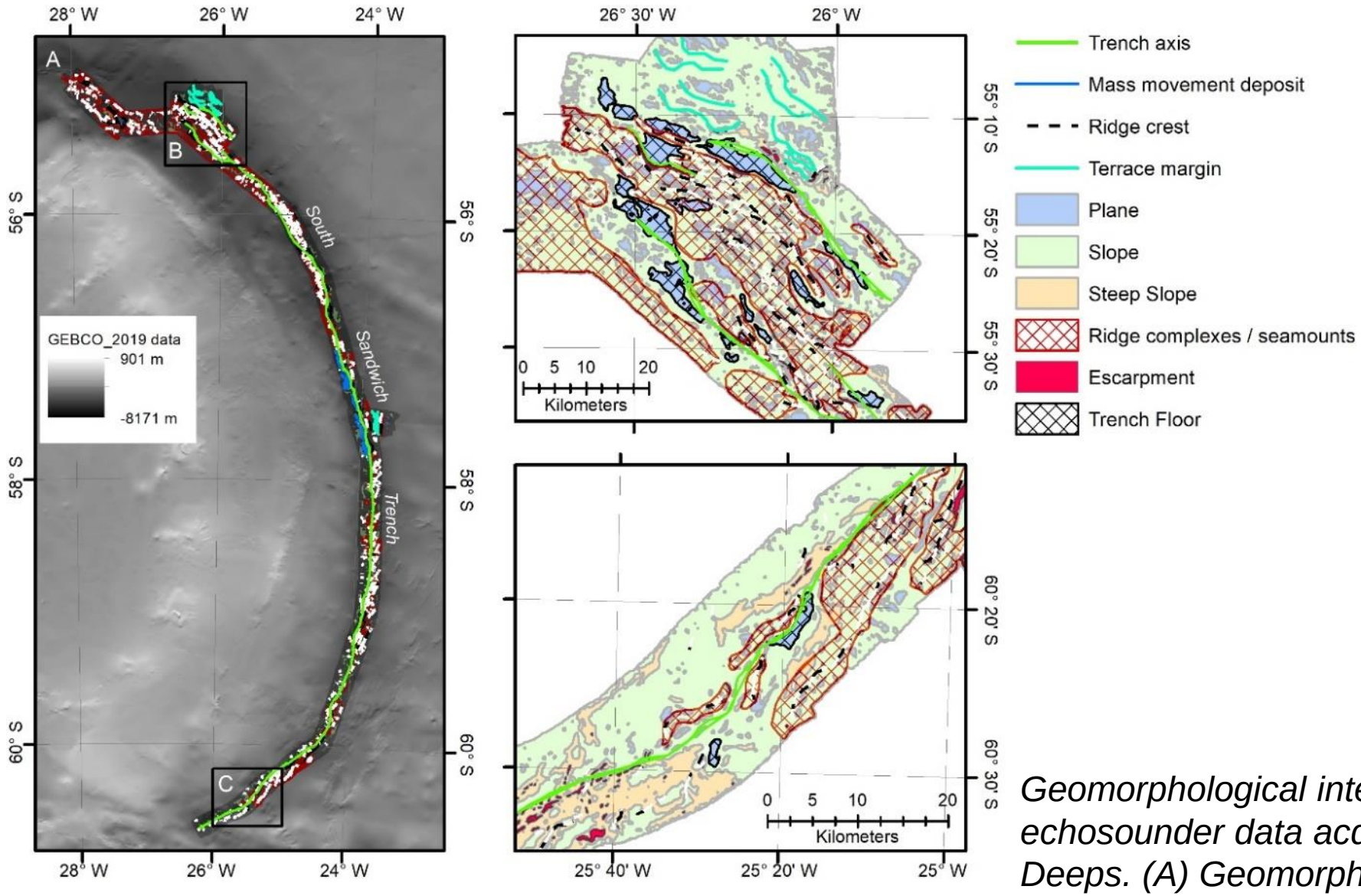
Bongiovanni, Stewart & Jamieson, 2022

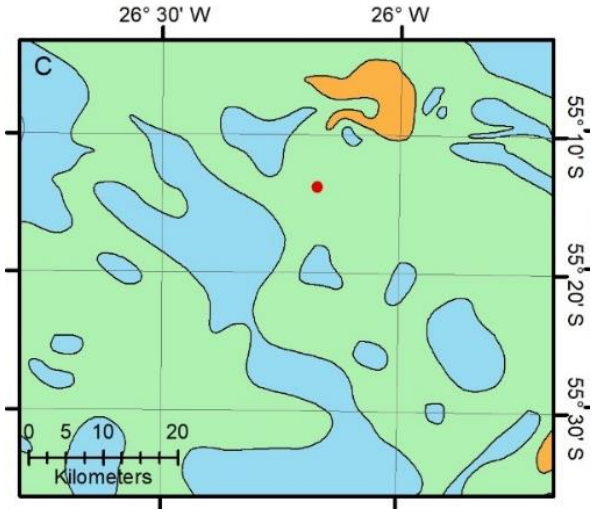
Methodology

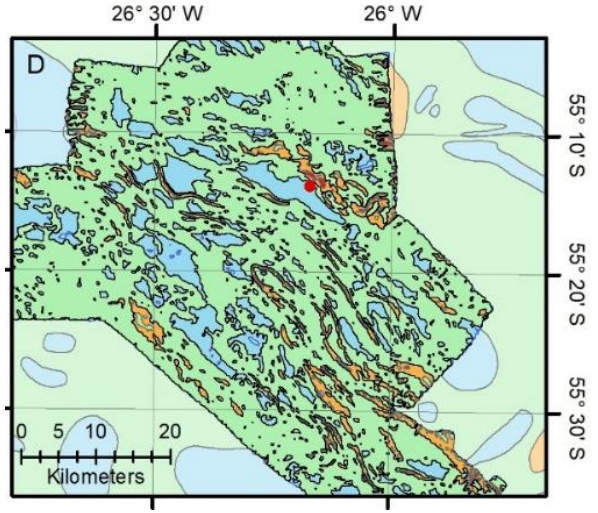
- Geomorphological interpretation in ArcGIS.
- Combination of automated methods run on the bathymetric grid (e.g. TASSE (Lecours, 2015) and BRESS) and expert interpretation.
- Features to map:
  - Trench floor, ridges, escarpments, slopes, seamounts, terraces, submarine landslides (headwalls).



Lecours, V. (2015) Terrain Attribute Selection for Spatial Ecology (TASSE), v.1.0, available at: www.marinegis.com (last access: 01 Feb 2020).

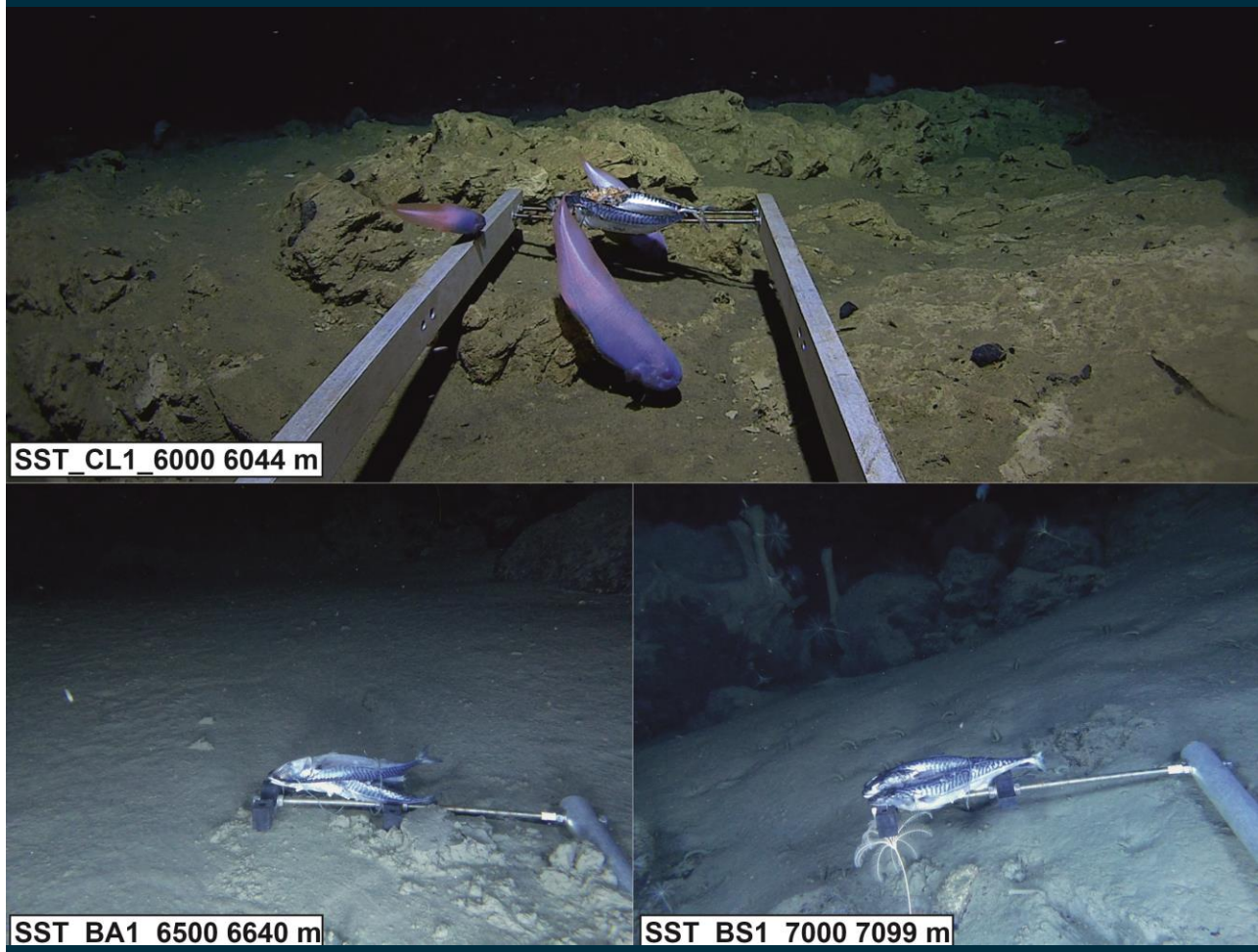






Geomorphological interpretation of multibeam echosounder data acquired as part of the Five Deeps. (A) Geomorphological map of the South Sandwich Trench derived from MBES data. (B) Inset map showing the geomorphology of Meteor Deep. (C) Inset map showing the geomorphology of Factorian Deep.

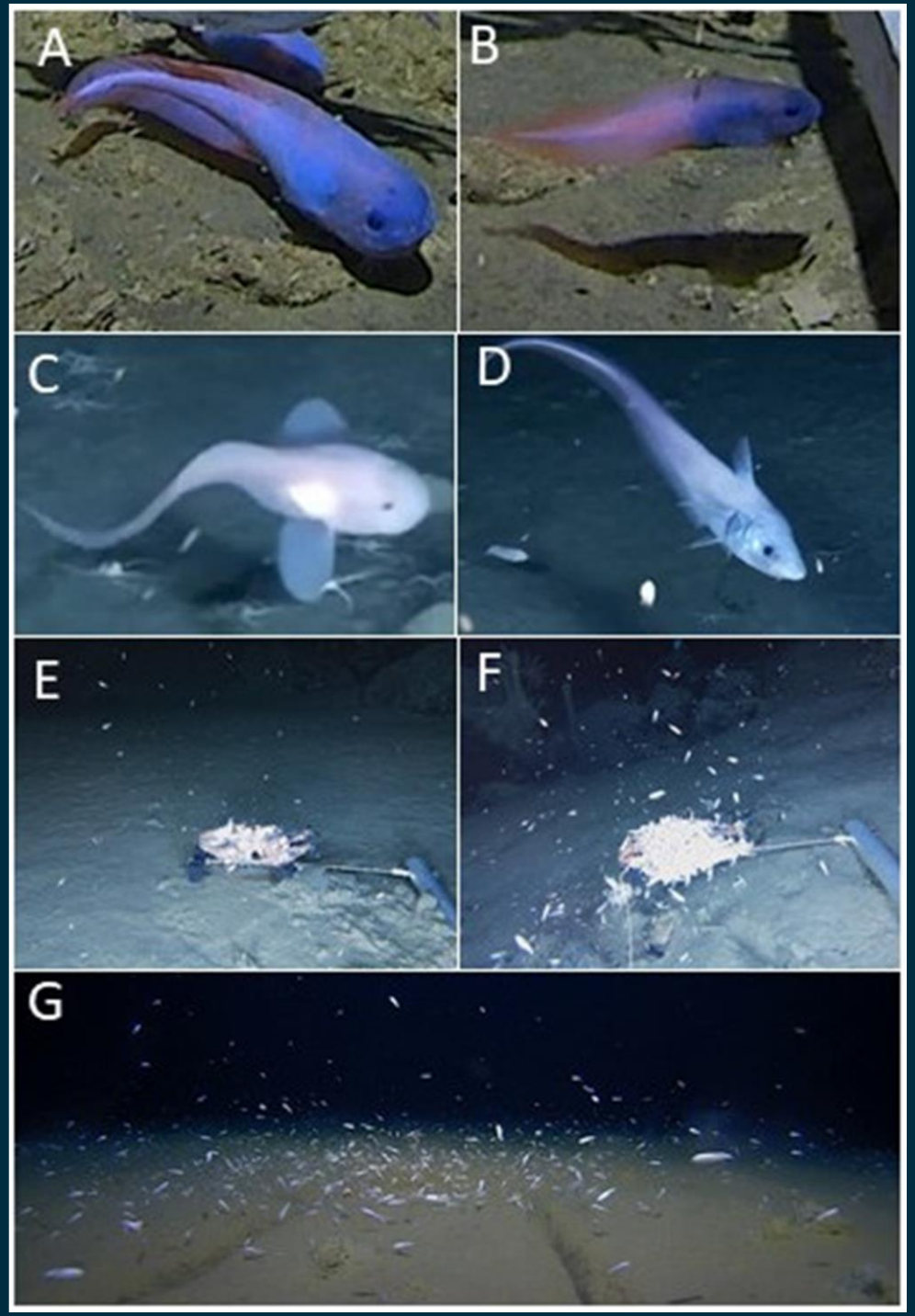
- Very little research has been carried out into the hadal fauna of the South Sandwich Trench since the Russian expeditions of the 1960s and 70s.
- This study describes the first visual assessment of hadal fauna from the SST from a series of seven baited camera and trap deployments (6044-8265 m).
- Notably, three species of hadal fish (Liparidae), with very low population densities were observed at depths 1000 m shallower than expected.



Jamieson et al. 2021

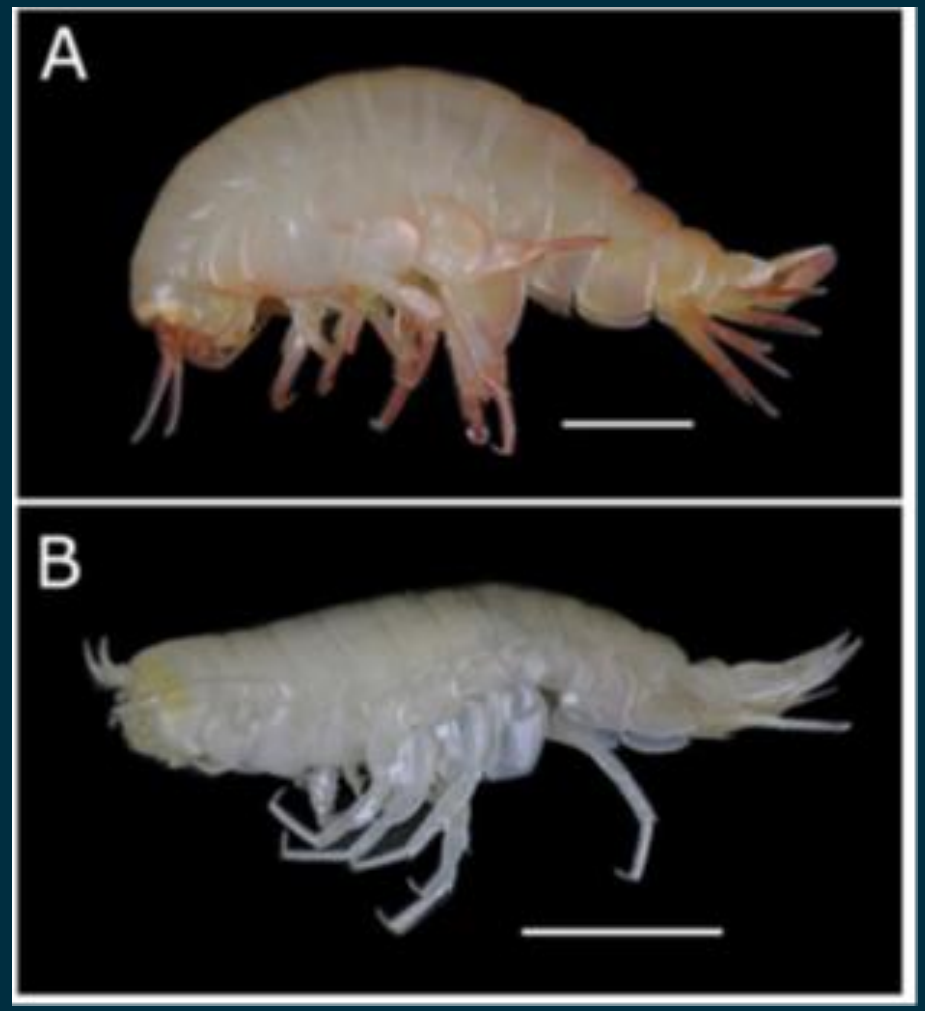
- Three species of hadal snailfish (Liparidae) were seen.
- Unknown species of Macrourid was seen at 6640 m (*Macrourid* sp. *stet*). This deep macrourid was also observed at 5200 m in the South Shetland Trench. These are almost certainly the same species and possibly restricted to the Southern Ocean.
- No fish were observed at the 7099 m site or deeper.

Demersal fauna of the South Sandwich Trench. A - Liparid sp. indet. 2-SAND (6044 m), B - Paraliparis sp. 1-SAND (6044–6640 m), C - Liparid sp. indet. 3-SAND (6640 m), D - Macrourid sp. stet. 1-SAND (6640 m), E - scavenging amphipod aggregation at 6640 m, F – scavenging amphipod aggregation at 7099 m, and G the largest aggregation of scavenging amphipods at 7439 m despite burial of the bait in soft sediment.



Jamieson et al. 2021

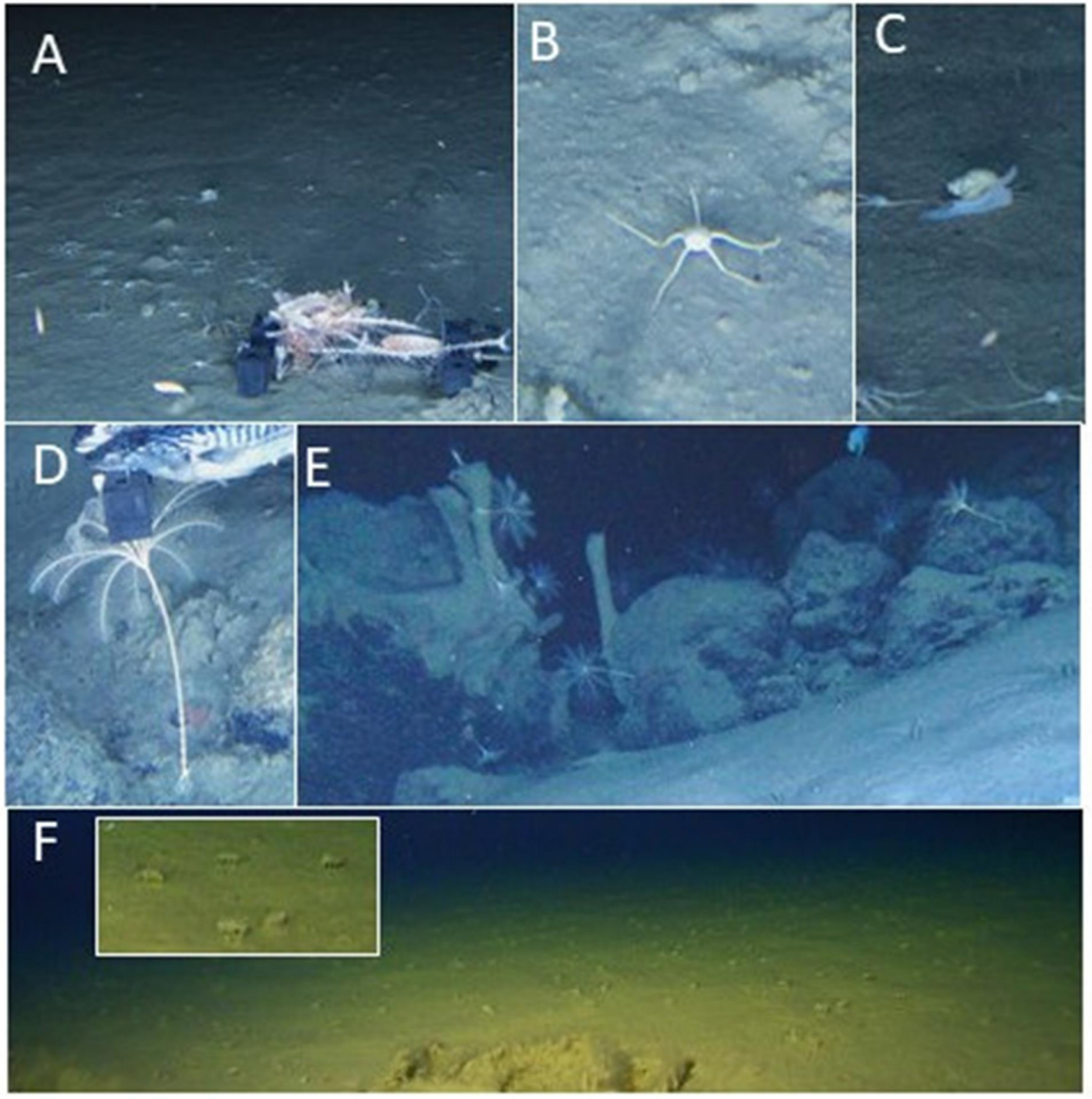
- In comparison to other hadal features, the overall species richness of scavenging amphipods was low although ecologically notable.
- Four species of scavenging amphipods were recovered, extending the known distribution of *Eurythenes andhakarae*, *Hirondellea dubia*, and *Bathycallisoma schellenbergi* to the SST.



Two scavenging amphipod species recovered from the South Sandwich Trench. A - Eurythenes andhakarae (7099 m); and B – Bathycallisoma schellenbergi (8266 m). Scale bar represents 1 cm.

Jamieson et al. 2021

- Large densities of brittle stars (Ophiuroidea) were seen in the shallower hadal depths, while dense aggregations of holothurians (Elpididae) were observed within trench-fill basins.
- In addition, gastropods, sponges, and stalked crinoids were observed.



Epifauna of the SST. A – aggregation of ophiuroids (6640 m), B – Single ophiuroid (6640 m), C – gastropod (6640 m), D – close-up of crinoid (7099 m), E – magnified and enhance image of crinoids and sponges (7099 m), F – high density of elpidid holothurians at 7400m at the point of lander touchdown with magnified inset showing characteristic tubular feet of Elpididae.

Summary

- The SST is the only sub-zero hadal environment on Earth with a recorded bottom temperature of between -0.34°C at 3500 m and 0.01°C at 7442 m depth (average -0.09°C @>6000 m).
- The vertical distribution of fish, and potentially the absence of groups such as the scavenging decapods, are likely due to the extremely low temperatures compared to most other trenches.
- High densities of brittle stars seen on the upper trench slopes, and dense aggregations of holothurians observed along the deep trench axis suggest a significant energy input form the surface.
- Three species of hadal fish (Liparidae), were observed at depths 1000 m shallower than expected, likely due to the piezo-thermal effect decreasing their depth range.
- Hitherto unknown seafloor morphology revealed for the first time.

THANK YOU

Any questions?

PUBLICATIONS

- Stewart et al. In Review. *The Seafloor Geomorphology of the South Sandwich Trench, Southern Ocean.*
- Weston et al. 2023. *Eurythenes sigmiferus and Eurythenes andhakarae (Crustacea: Amphipoda) are sympatric at the abyssal Agulhas Fracture Zone, South Atlantic Ocean*. Deep-Sea Research Part I: Oceanographic Research Papers. https://doi.org/10.1016/j.dsr.2023.104050
- Weston et al. 2022. *Barriers to gene flow in the deepest ocean ecosystem: Evidence from global population genomics of a cosmopolitan amphipod.* Science Advances. DOI: 10.1126/sciadv.abo6672
- Weston and Jamieson. 2022. *The Multi-Ocean Distribution of the Hadal Amphipod, Hirondellea dubia Dahl, 1959 (Crustacea, Amphipoda).* Frontiers in Marine Science. https://doi.org/10.3389/fmars.2022.824640
- Jamieson et al. 2021. *A global assessment of fishes at lower abyssal and upper hadal depths (5000 to 8000 m).* Deep-Sea Research Part I: Oceanographic Research Papers. https://doi.org/10.1016/j.dsr.2021.103642
- Jamieson et al. 2021. *Hadal fauna of the South Sandwich Trench, Southern Ocean: Baited camera survey from the Five Deeps Expedition.* Deep-Sea Research Part II: Topical Studies in Oceanography. https://doi.org/10.1016/j.dsr2.2021.104987
- Bongiovanni et al. 2022. *High-resolution multibeam sonar bathymetry of the deepest place in each ocean.* Geoscience Data Journal. https://doi.org/10.1002/gdj3.122
- Swan et al. 2021. *Worldwide distribution and depth limits of decapod crustaceans (Penaeoidea, Oplophoroidea) across the abyssal-hadal transition zone of eleven subduction trenches and five additional deep-sea features.* Crustacean Biology. https://doi.org/10.1093/jcbiol/ruaa102
- Jamieson and Linley. 2021. *Hydrozoans, scyphozoans, larvaceans and ctenophores observed in situ at hadal depths.* Journal of Plankton Research https://doi.org/10.1093/plankt/fbaa062
- Stewart 2021. *Deeper, darker colder – exploring the South Sandwich Trench.* https://edinburghgeolsoc.org/eg_pdfs/edinburgh-geologist-69.pdf

- *Five Deeps Expedition to map the South Sandwich Trench (spanning the Atlantic and Southern oceans).* Caladan Oceanic LLC (2021) https://doi.org/10.5285/143e304e-b9d5-43bf-b323-f2ab517bc18b

Oliver Hogg

Centre for Environment, Fisheries and Aquaculture Science


ESA


Sue G


Cefas

Benthic biodiversity in the South Sandwich Islands

Results from the RRS Discovery Research Expedition DY99

Oliver T. Hogg, Anna Downie, Rui Vieira and Chris Darby

Blue Belt Programme

UK Government

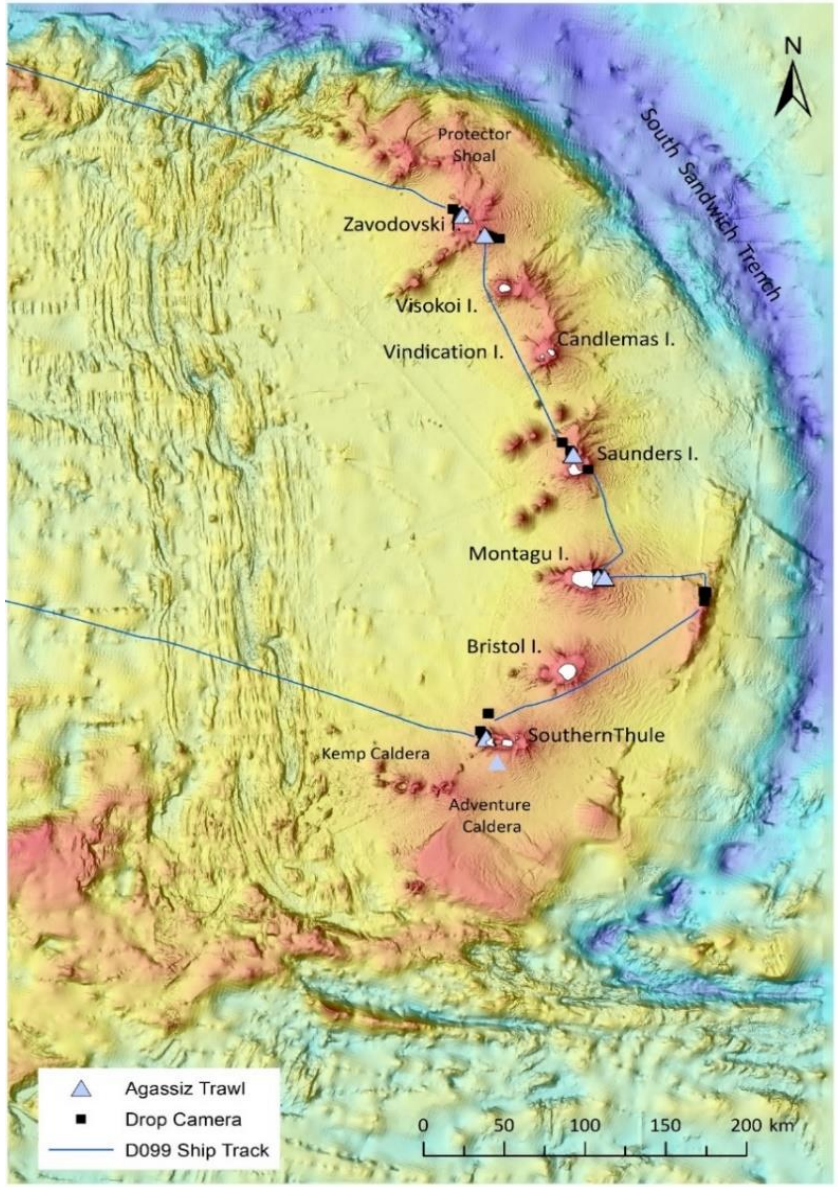
- **SGSSI 2018 MPA review recap** - the MPA was likely to be fulfilling its conservation and management objectives, but the SSI marine environment had been little studied compared to that of South Georgia and identified a range of information gaps where future research would be of benefit (GSGSSI, 2018).

Discovery Expedition 99 Aims

- Collect high-resolution seabed imagery.
- Acquire acoustic data to improve information on seabed bathymetry.
- Specimen collection via Agassiz trawl and benthic dredge.
- Marine mammal observations.

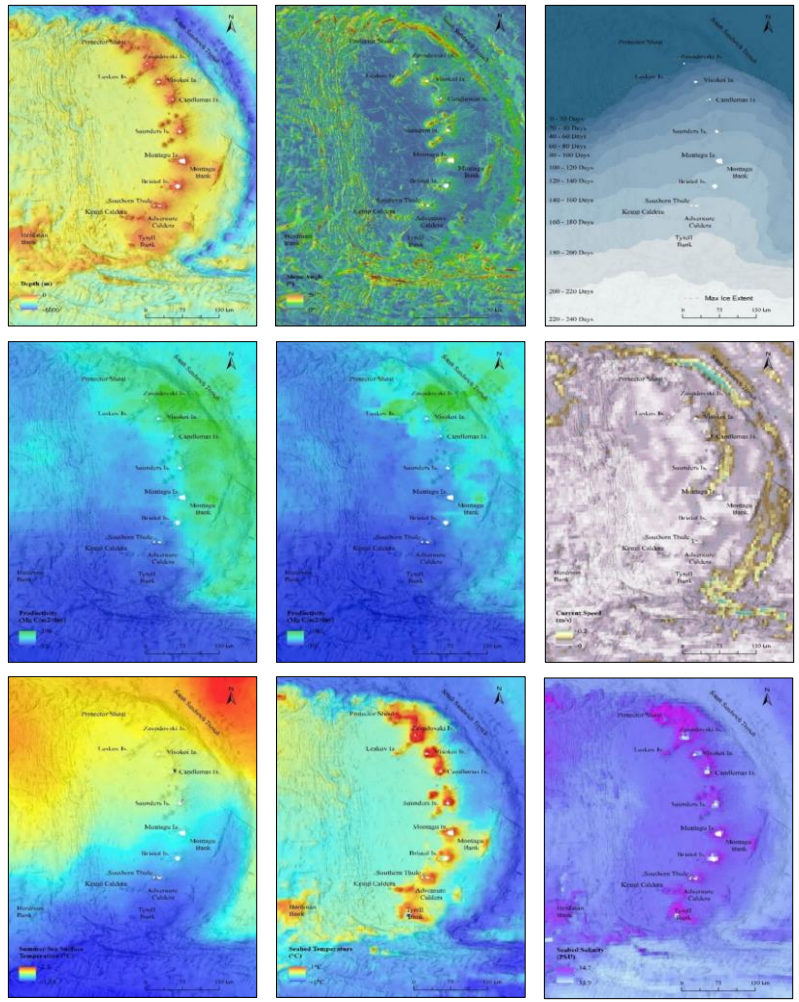
DY99 Survey Stats

- 38 camera transects from 6 survey areas - 4,124 still images and 31 hours of video
- 12 trawl and dredge stations - 3,000 benthic specimens
- High resolution (10m) MBES data

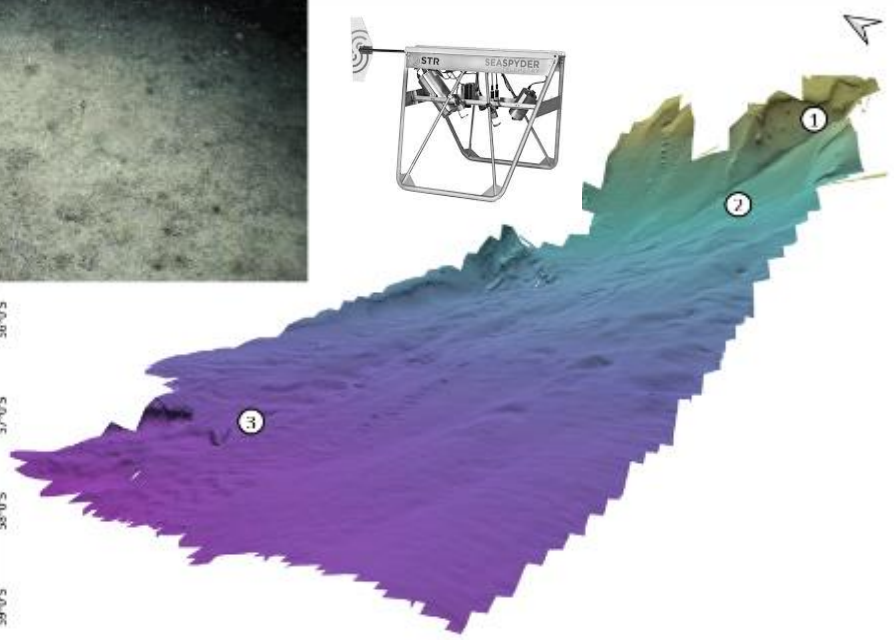


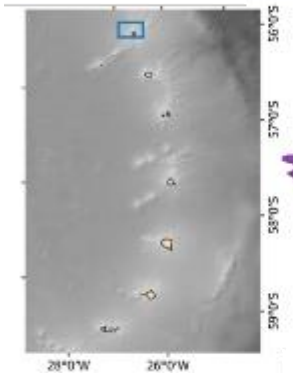
1. Modelling VME indicator taxa

2. Bioregionalisation mapping analysis

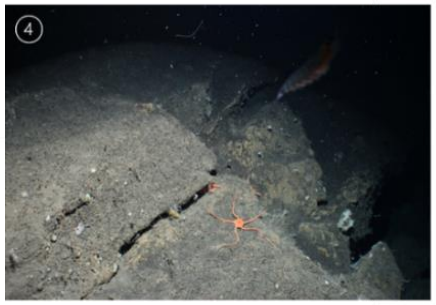


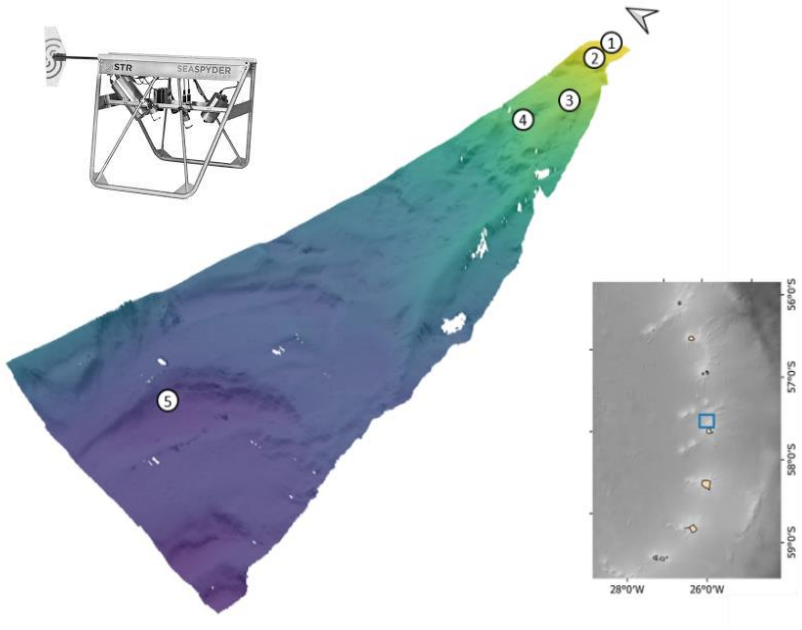
UK Government





Western side of Zavodovski Island



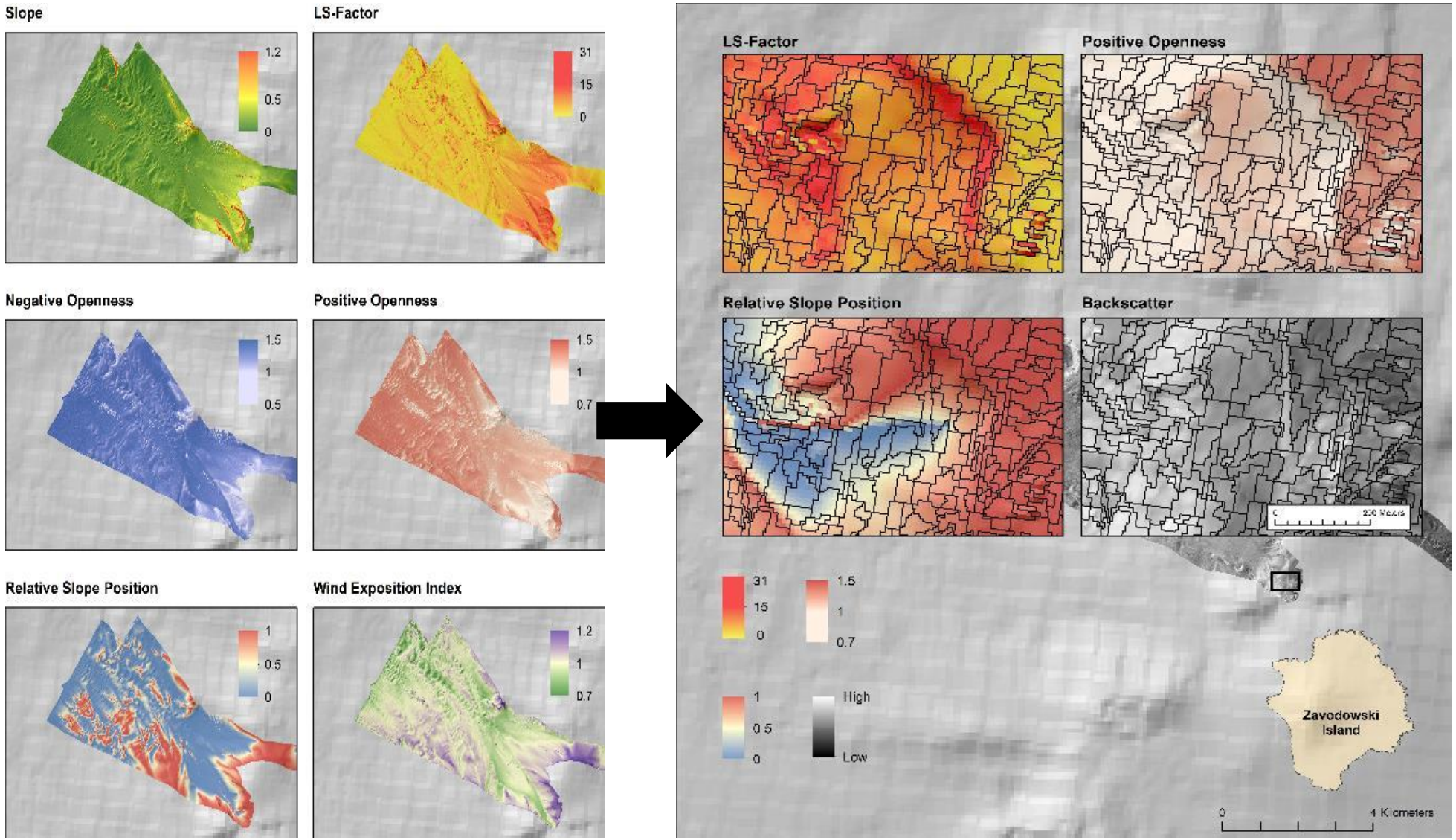


Northern side of Saunders Island

UK Government

Modelling VME Indicator taxa

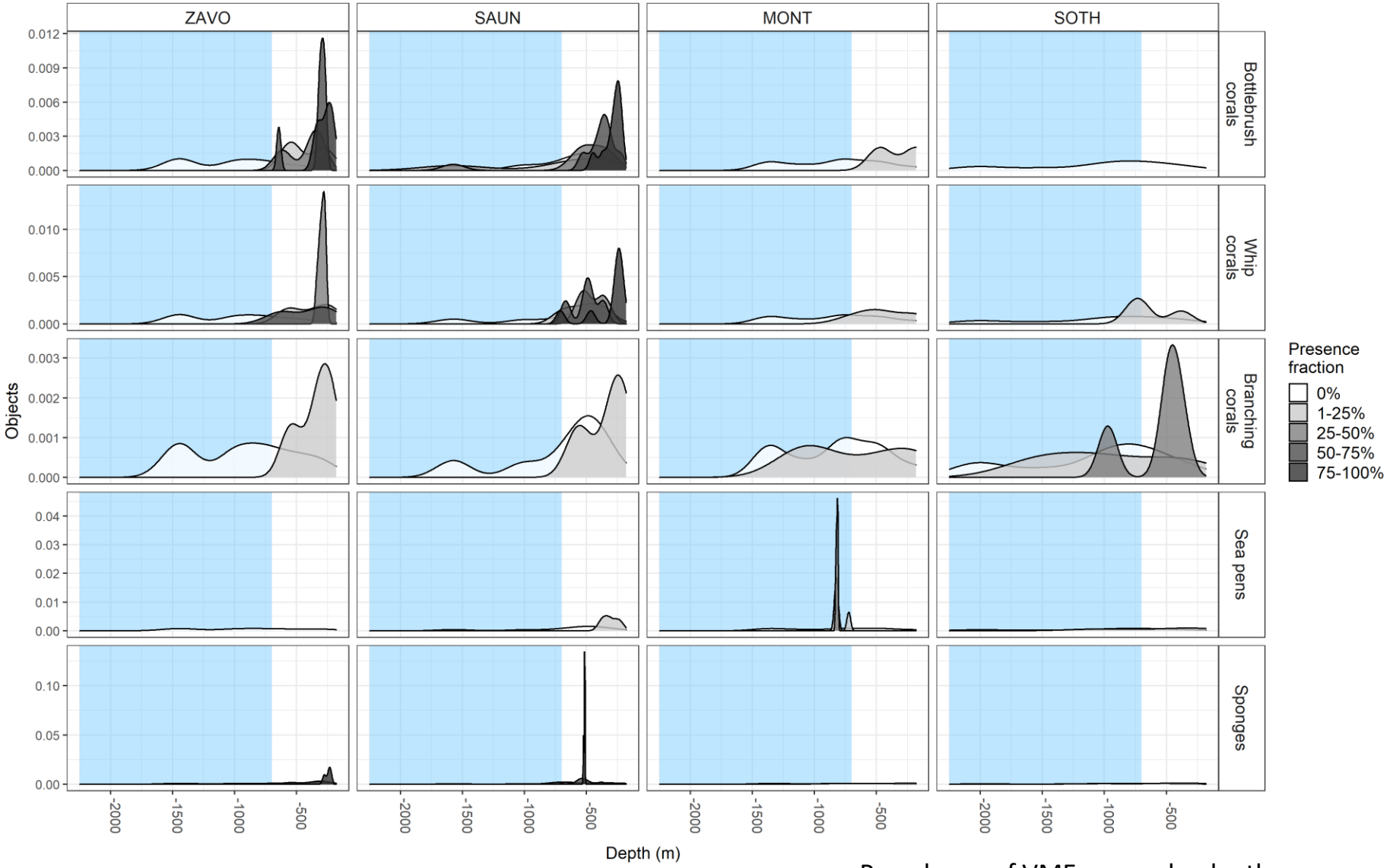
- What are VME?
- VME indicator taxa most commonly observed included bottlebrush corals and whip corals.
- Object based image analysis used alongside a classification rules approach to model the spatial distribution of VME.



Close-up example of the results of the OBIA segmentation used to create maps of potential VME distribution.

OBIA Segmentation

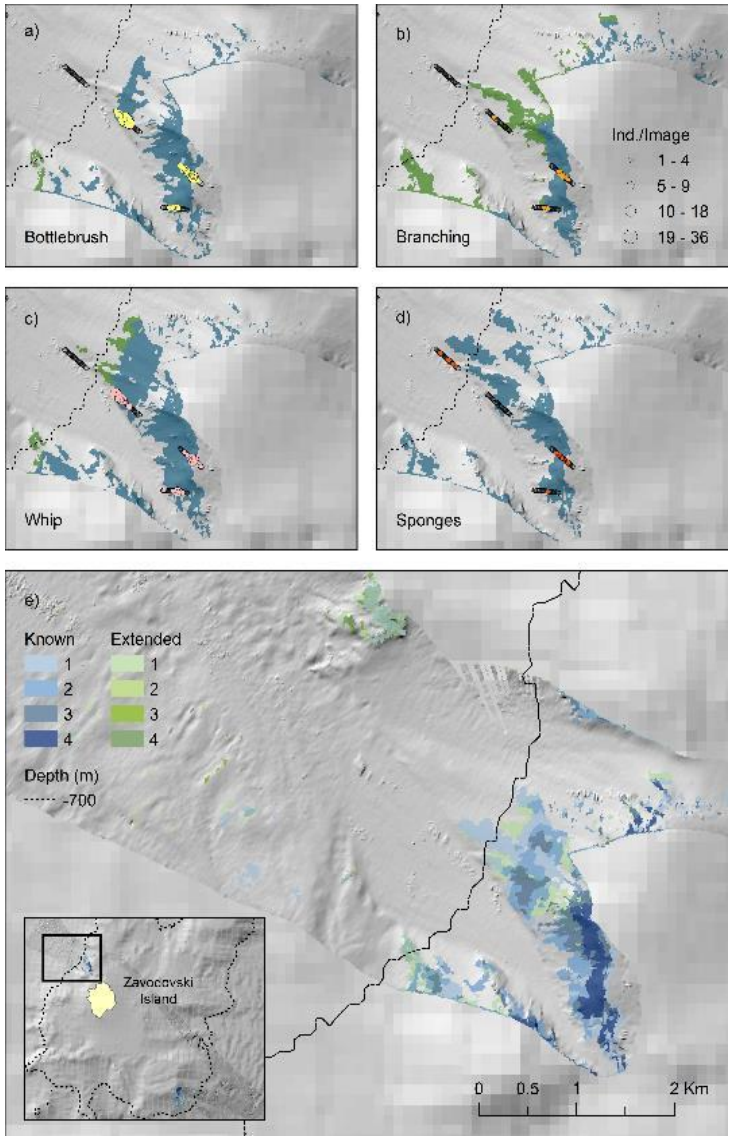
UK Government

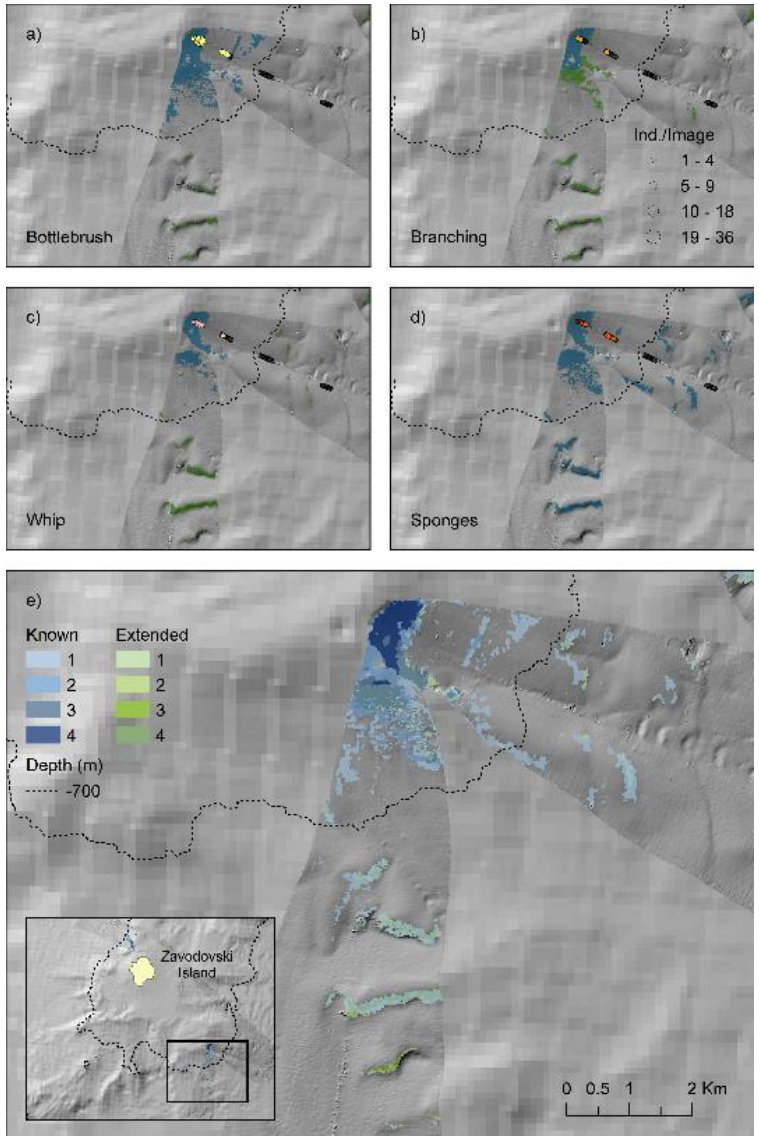


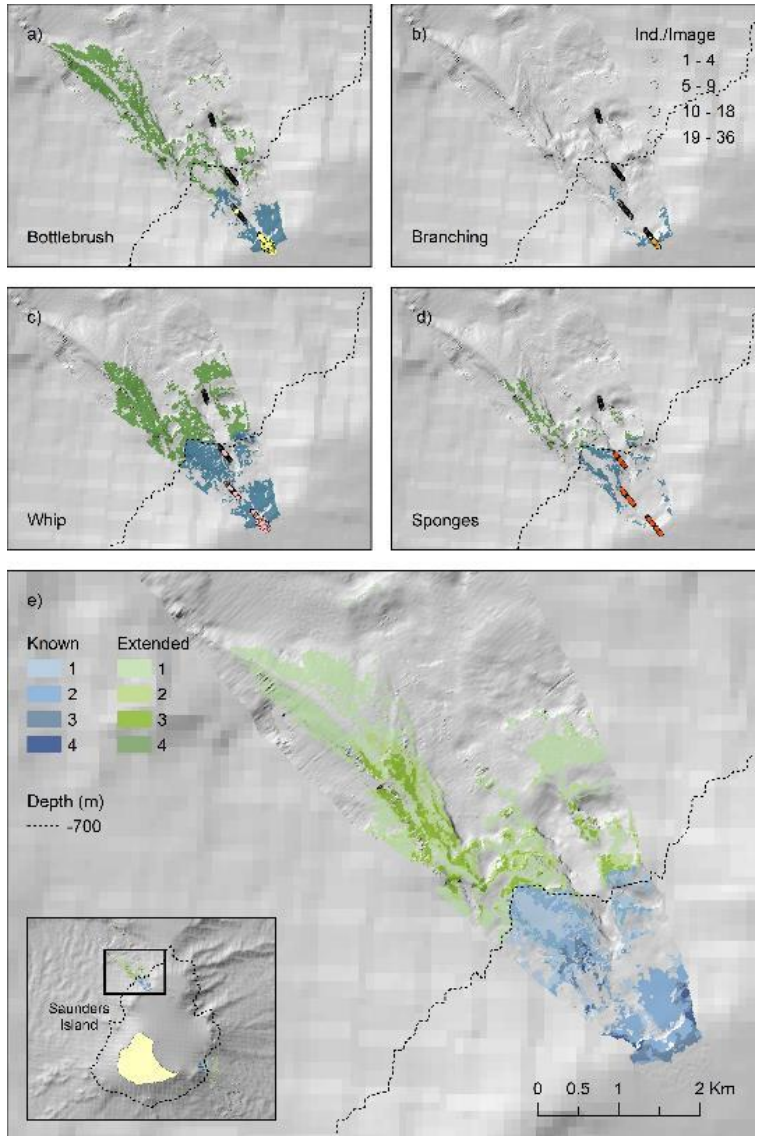
Prevalence of VME groups by depth

VME by Depth

UK Government







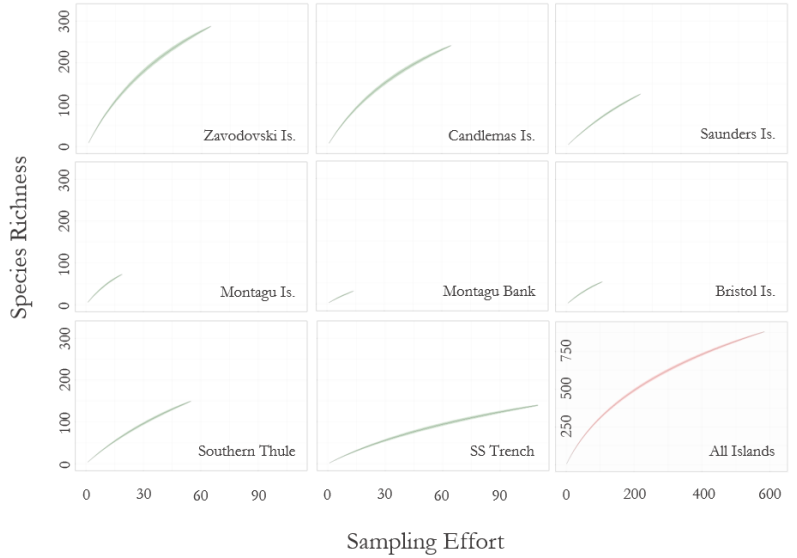
VME Models

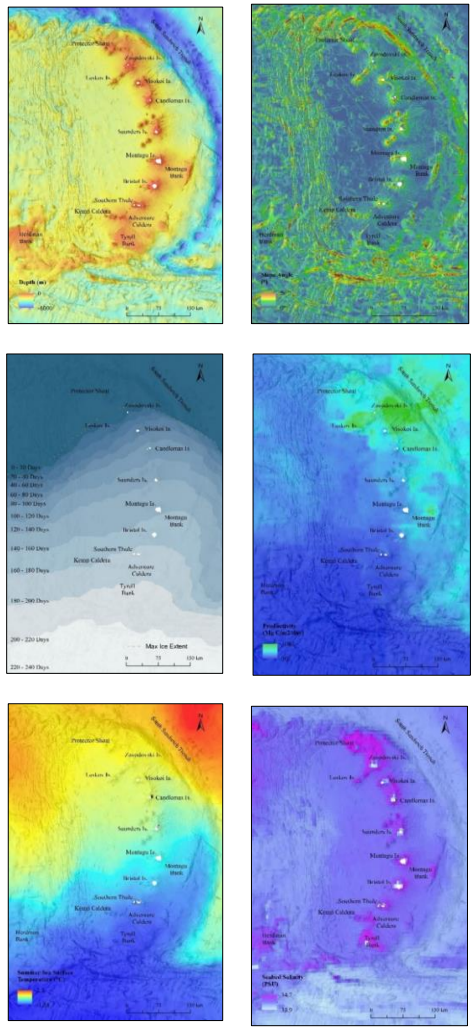
UK Government

Regional Biogeography

- DY99 data combined with data from fisheries bycatch and open access databases.
- The SSI are both diverse and biogeographically distinct.
- This is particularly notable given the islands' small shelf area and young geological age.
- Novel species discovery remains high.

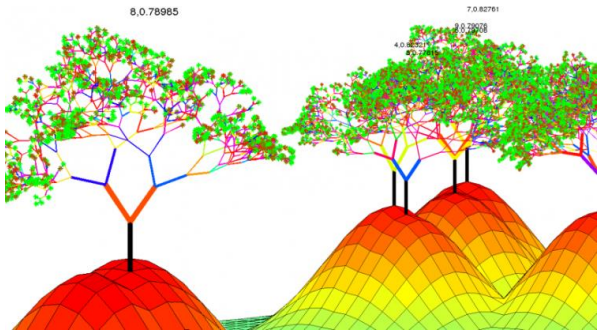
	South Sandwich Is.	South Georgia	South Orkney Is.
Total Species	**883**	**1631**	**855**
Island Only	**58.2%** (514)	**69.3%** (1130)	**49.4%** (422)
All Scotia Species	**16.2%** (143)	**8.8%** (143)	**16.7%** (143)
SSI – SG Shared	**16.7%** (147)	**9.0%** (147)	-
SSI – SOI Shared	**8.9%** (79)	-	**9.2%** (79)
SG – SOI Shared	-	**12.9%** (211)	**24.7%** (211)



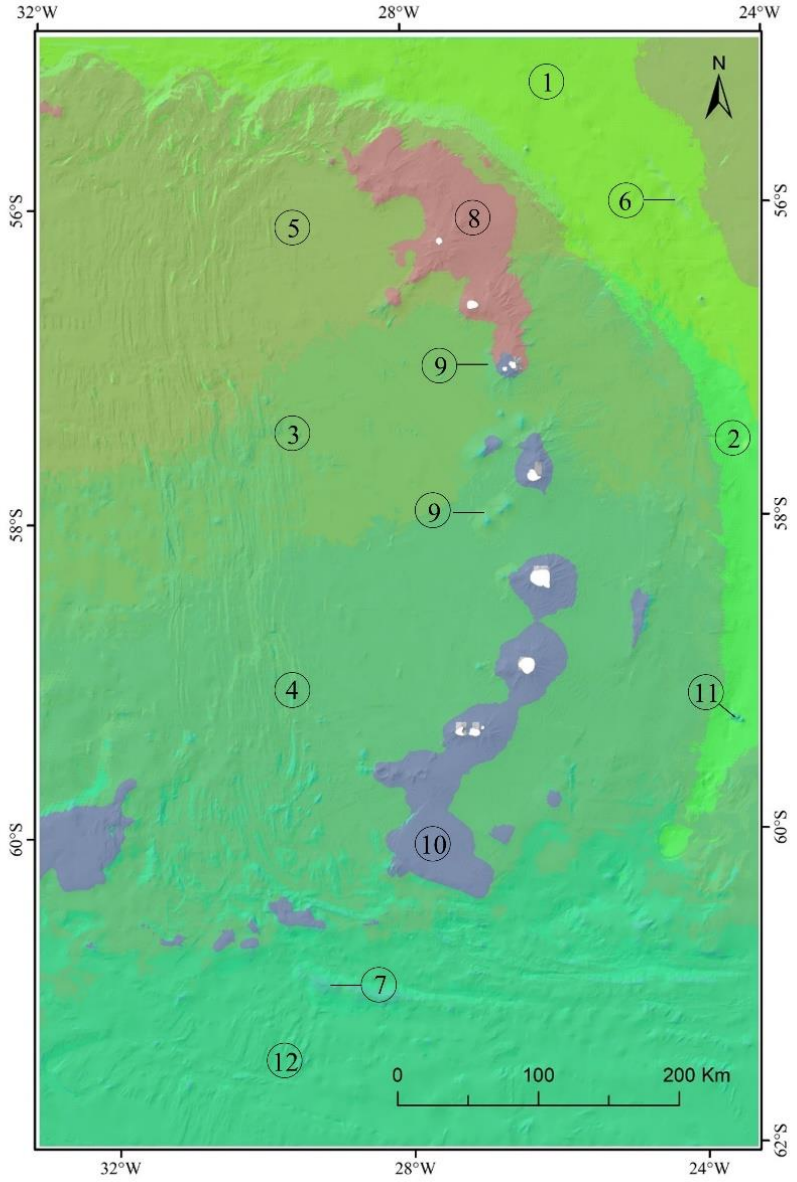


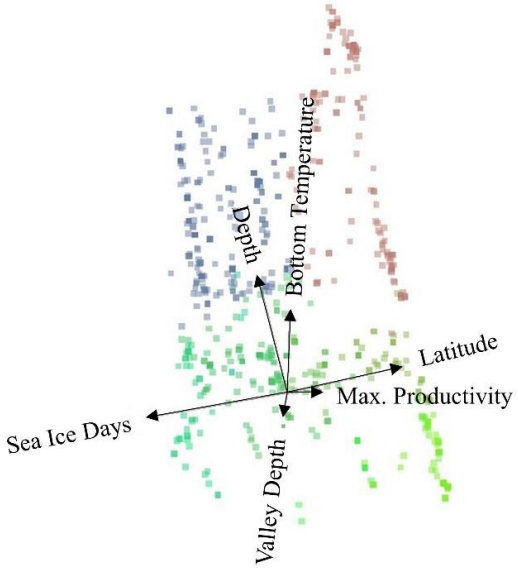
Gradient Forest – change in communities over environmental gradients

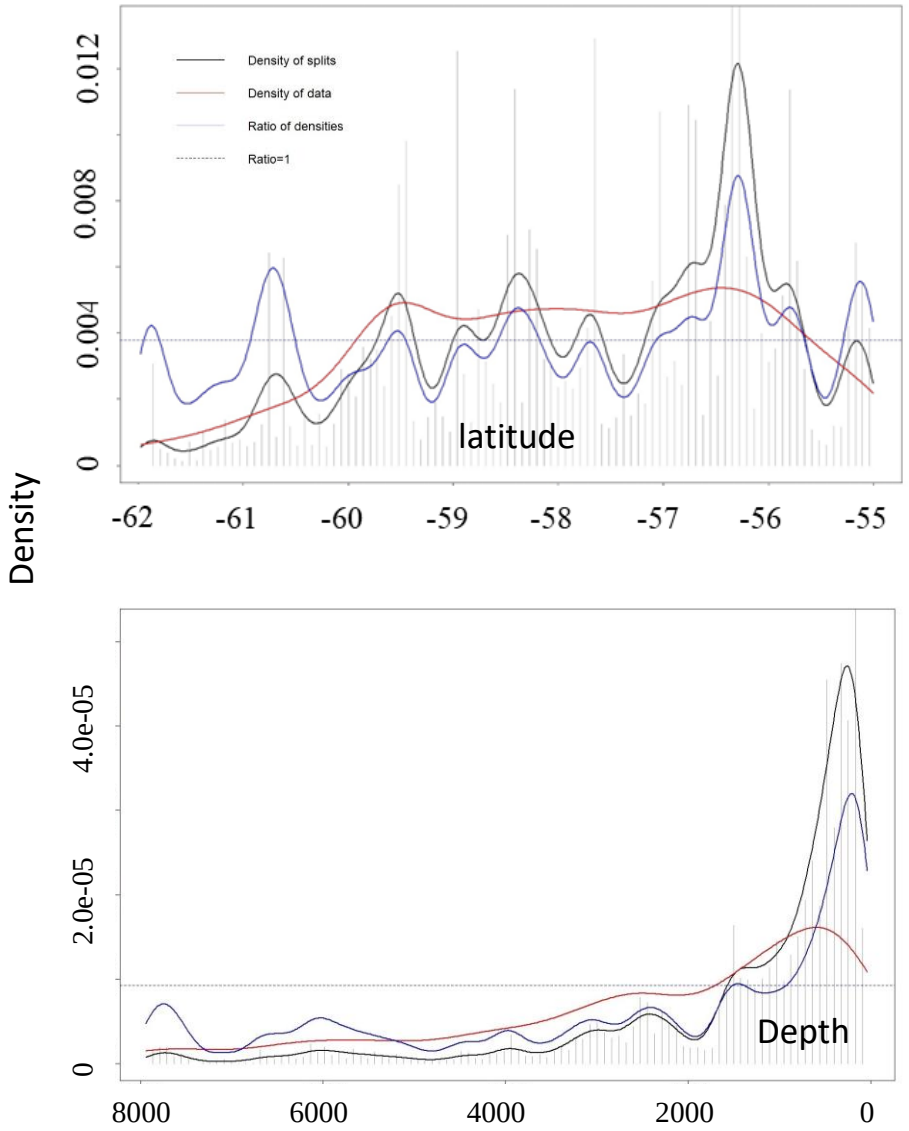
- Gradient forest is a multivariate approach to partitioning the environment to biologically distinct units.
- Uses random forests to extract information about functional group turnover along environmental gradients.
- Maps distinct discontinuities in environmental and faunal character.



Ellis, Nick, Stephen J. Smith, and C. Roland Pitcher. 2012. Gradient forests: calculating importance gradients on physical predictors. Ecology 93:156–168





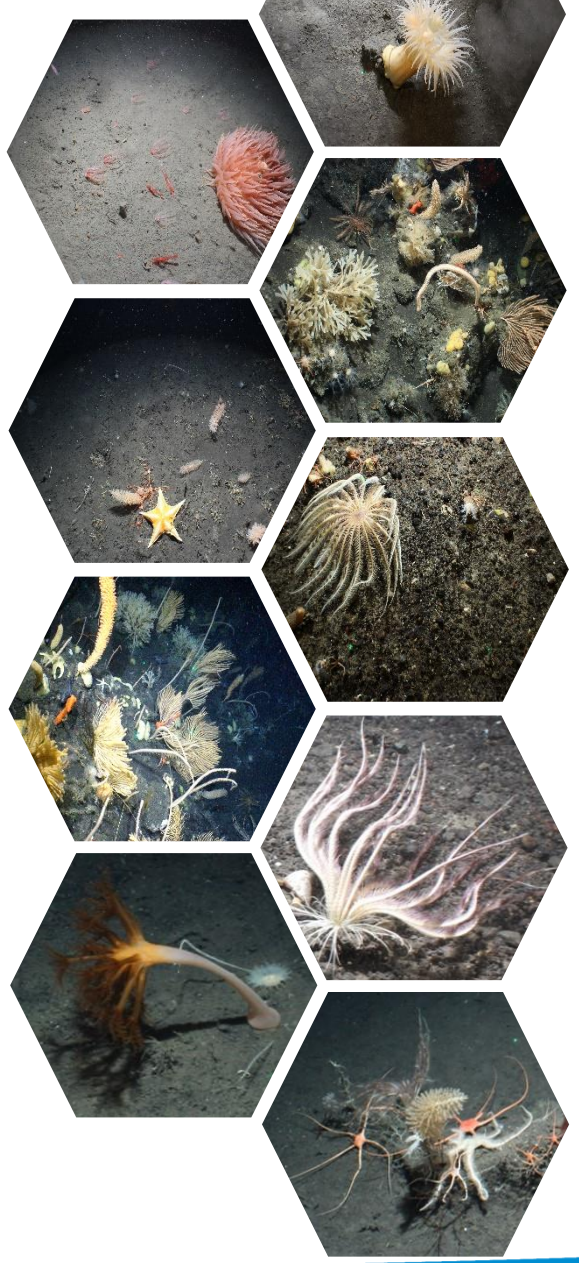


Gradient Forest Bioregionalisation

UK Government

Conclusions

- Drop-camera observations recorded a marked change in abundance, faunal composition and VME indicator taxa with depth and substrate type.
- VME indicator taxa are largely confined to waters shallower than 700m.
- The South Sandwich Islands are both diverse in benthic fauna and biogeographically distinct from neighbouring islands in the Scotia Arc.
- Compositional changes in benthic fauna were observed from north to south across the archipelago. This was manifest in distinct north and south bioregions
- The current regional extent of the spatial protection within the MPA for benthic species is considered appropriate.



frontiers in Marine Science

ORIGINAL RESEARCH
published: 23 August 2021
doi: 10.3389/fmars.2021.650241

Macrobenthic Assessment of the South Sandwich Islands Reveals a Biogeographically Distinct Polar Archipelago

Oliver T. Hogg, Anna-Leena Downie, Rui P. Vieira and Chris Darby*

Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, United Kingdom

The sub-Antarctic South Sandwich Islands forms part of one of the largest marine protected areas (MPAs) in the world. Whilst the neighbouring island of South Georgia is known to be a biodiversity hotspot, very little was known about the benthic biodiversity or biogeography of the South Sandwich Islands. Here we present findings from the first biophysical assessment of this polar archipelago. Using open-access datasets, alongside results from a recent UK Government-funder Blue Belt expedition to the region, we assess how the island's biodiversity is structured spatially and taxonomically and how this is driven by environmental factors. The South Sandwich Islands are shown to be both biologically rich, and biogeographically distinct from their neighbouring provinces. A gradient forest approach was used to map the archipelago's benthic habitats which, based on the functional composition of benthic fauna and environmental characterisation of the benthic environment, demonstrated a distinct biogeographical north-south divide. This faunal and environmental discontinuity between the South Sandwich Islands and the rest of the MPA and between the different islands of the archipelago itself, highlights the importance of the zoned protection across the South Georgia and South Sandwich Islands Marine Protected Area.

Keywords: benthic ecology, marine conservation, marine spatial planning, Southern Ocean, bioregionalisation, habitat mapping, functional trait analysis

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Marine Conservation and Sustainability, a section of the journal Frontiers in Marine Science

Received: *06 January 2021*
Accepted: *29 July 2021*
Published: *23 August 2021*

Citation:
Hogg OT, Downie A-L, Vieira RP and Darby C (2021) Macrobenthic Assessment of the South Sandwich Islands Reveals a Biogeographically Distinct Polar Archipelago. Front. Mar. Sci. 8:650241. doi: 10.3389/fmars.2021.650241

INTRODUCTION

The South Sandwich Islands (SSI) archipelago forms part of the Scotia Arc, a predominantly submarine ridge that extends from the Terra del Fuego region of South America to the Antarctic Peninsula (**Figure 1**). The archipelago consists of seven main volcanic islands stretching in a 390 km long island arc on a broadly north–south axis. The water surrounding the islands form part of the South Georgia and South Sandwich Islands Marine Protected Area (SGSSI MPA), covering over 1 million km^2 and representing one of the largest MPAs in the world (Collins et al., 2012; Trathan et al., 2014).

Both the SSI and neighbouring South Georgia are internationally important sites for higher predators, hosting some of the largest populations of seabirds and marine mammals on Earth (Convey et al., 1999; Murphy et al., 2007; Clarke et al., 2012; Trathan et al., 2014; Rogers et al., 2015). Furthermore, South Georgia is recognised to be of global importance due to its abundant, diverse and unique benthic fauna (Barnes et al., 2011; Hogg et al., 2011). This diversity is thought to

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ORIGINAL RESEARCH
published: 22 June 2021
doi: 10.3389/fmars.2021.662285

Distribution of Vulnerable Marine Ecosystems at the South Sandwich Islands: Results From the Blue Belt Discovery Expedition 99 Deep-Water Camera Surveys

Anna-Leena Downie, Rui P. Vieira, Oliver T. Hogg and Chris Darby*

Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom

The South Sandwich Islands (SSI) are a chain of volcanic islands located to the east of the Scotia Sea, approximately 700 km south-east of South Georgia. To date, knowledge of the SSI benthic environment remains limited. In this context, the Blue Belt Programme conducted a scientific survey in the SSI Marine Protected Area (MPA) during February/March 2019 to examine the biodiversity and distribution of benthic communities and their potential vulnerability to licensed longline research fisheries. Here we report results from analysis of multibeam echosounder (MBES) data and drop camera imagery data collected in selected locations around the SSI. A total of eight vulnerable marine ecosystem (VME) indicator morphotaxa were mapped along the slopes of the SSI, showing a substantial variation in taxon composition and frequency of occurrence, both along bathymetric and latitudinal gradients. Our results suggest that VME indicator taxa are mostly restricted to waters shallower than 700 m. As such, based on our present understanding of the region's benthic environment the MPA, as currently established, offers effective protection for the majority of the VME indicator taxa.

Keywords: benthic ecology, marine conservation, vulnerable marine ecosystems (VME), marine spatial planning, Southern Ocean

OPEN ACCESS

Edited by:
David Andrew Feary, MRAG Ltd, United Kingdom

Reviewed by:
David A. Bowden, National Institute of Water & Atmospheric Research, New Zealand
Chris Yesson, Zoological Society of London, United Kingdom

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Specialty section:
This article was submitted to Marine Conservation and Sustainability, a section of the journal Frontiers in Marine Science

Received: *31 January 2021*
Accepted: *10 May 2021*
Published: *22 June 2021*

Citation:
Downie A-L, Vieira RP, Hogg OT and Darby C (2021) Distribution of Vulnerable Marine Ecosystems at the South Sandwich Islands: Results From the Blue Belt Discovery Expedition 99 Deep-Water Camera Surveys. Front. Mar. Sci. 8:662285. doi: 10.3389/fmars.2021.662285

INTRODUCTION

The UK's Overseas Territories (UKOTs) are home to over 90% of the United Kingdom's biodiversity and are of fundamental importance to regional and international marine conservation (FCO, 2012). Located in the South Atlantic sector of the Southern Ocean, the overseas territory of South Georgia and the South Sandwich Islands (SGSSI) is recognised as a globally important wildlife haven. The islands are an internationally significant site for higher predators, hosting some of the largest populations of seabirds and marine mammals on Earth (Ratcliffe and Trathan, 2011; Trathan et al., 2014; Rogers et al., 2015). Furthermore, regional studies centred around South Georgia demonstrate a diverse and distinct benthic fauna with a high proportion of species recorded as endemic to the region (Barnes et al., 2011; Hogg et al., 2011; De Broyer et al., 2014).

In 2012, the Government of South Georgia & the South Sandwich Islands (GSGSSI) declared a sustainable use Marine Protected Area (MPA) across its maritime zone, covering an area of 1.24 million km^2 (GSGSSI, 2018). The MPA saw additional enhancements in 2013 and 2018

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BRIEF RESEARCH REPORT
published: 28 July 2021
doi: 10.3389/fmars.2021.660152

Cetaceans Sightings During Research Cruises in Three Remote Atlantic British Overseas Territories

Stephanie M. Martin[1], Marta Soeffker[2,3], Andy Schofield[4], Rhys Hobbs[5], Trevor Glass[1] and Simon A. Morley[6]*

[1] Tristan da Cunha Government, Edinburgh of the Seven Seas, Tristan da Cunha, [2] Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom, [3] School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, [4] Royal Society for the Protection of Birds, Sandy, United Kingdom, [5] Marine Section, Environment, Natural Resources and Planning Directorate, St Helena Government, Jamestown, Saint Helena, [6] British Antarctic Survey, Natural Environment Research Council, Cambridge, United Kingdom

Marine mammal sightings were recorded during research cruises to three remote, mid-ocean British Overseas Territories in the South Atlantic and Southern Ocean. In March to April 2018 and 2019, the Exclusive Economic Zones (EEZs) of tropical St Helena and temperate Tristan da Cunha were surveyed. The sub-polar waters of South Georgia and the South Sandwich Islands (SGSSI) were surveyed in February to March 2019. At St Helena in 2018, five species were recorded during 11 sightings, and in 2019, four species, with one additional unidentified species, during seven sightings. Most of these sightings were of dolphin species, which are known to be resident around the Island and seamounts. In Tristan da Cunha in 2018, a total of five identified and one unidentified species were recorded during six sightings, half of which were associated with the Islands or seamounts. In 2019, due to rough weather, no sightings were recorded in the Tristan da Cunha waters. Around SGSSI, 162 sightings of 236 cetaceans were made in 2019, mostly of baleen whales, with seven species identified with certainty. Sightings around the southern South Sandwich Islands included beaked whales and large dolphins, whereas baleen whales dominated in the northern South Sandwich Islands. These results provide new data for rarely surveyed regions, helping to build a spatial picture of important areas for marine mammals, which will help inform marine spatial protection strategies.

Keywords: St Helena, Tristan da Cunha, South Georgia and South Sandwich Island, Marine protected area, whales and dolphins

OPEN ACCESS

Edited by:
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Reviewed by:
Danielle Kreb, Conservation Foundation for Rare Aquatic Species of Indonesia, Indonesia
Wolfram Geissler, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Germany

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Specialty section:
This article was submitted to Marine Conservation and Sustainability, a section of the journal Frontiers in Marine Science

Received: *28 January 2021*
Accepted: *25 June 2021*
Published: *28 July 2021*

Citation:
Martin SM, Soeffker M, Schofield A, Hobbs R, Glass T and Morley SA (2021) Cetaceans Sightings During Research Cruises in Three Remote Atlantic British Overseas Territories. Front. Mar. Sci. 8:660152. doi: 10.3389/fmars.2021.660152

INTRODUCTION

The remote British Overseas Territories in the South Atlantic (St Helena and Tristan da Cunha) and in the Southern Ocean (South Georgia and the South Sandwich Islands - SGSSI) span the global migration routes of cetaceans, from tropical breeding to polar feeding grounds (**Figure 1**). The exclusive economic zones (EEZs) of these territories also provide habitat for resident cetacean populations. However, due to their remoteness the lack of, or limited data, makes it difficult to assess cetacean populations within these territories and how they have changed since or recovered

Some Further Reading

UK Government

Ruth Peacey

Talesmith TV


ESA


Sue G


Wolfgang Kaehler


EXPEDITION PENGUIN
COMING SOON
Produced & Directed by Ruth Peacey
Cinematography
Hamza Yassin
Tom Hart

Tom Hart

Oxford Brookes University

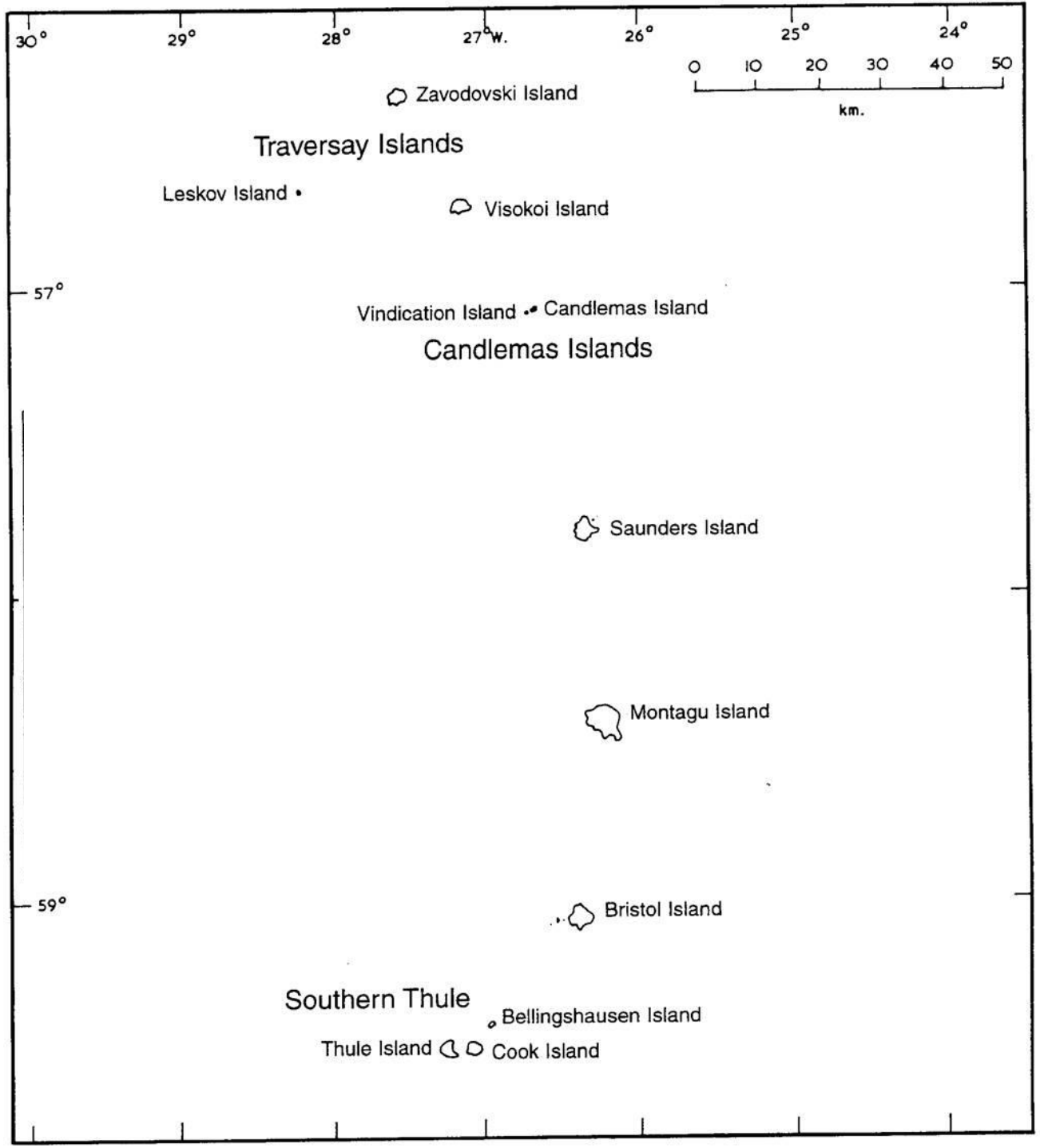

ESA


Sue G


Tom Hart

Counting the South Sandwich Islands

Dr Tom Hart


30°
29°
28°
27°W.
26°
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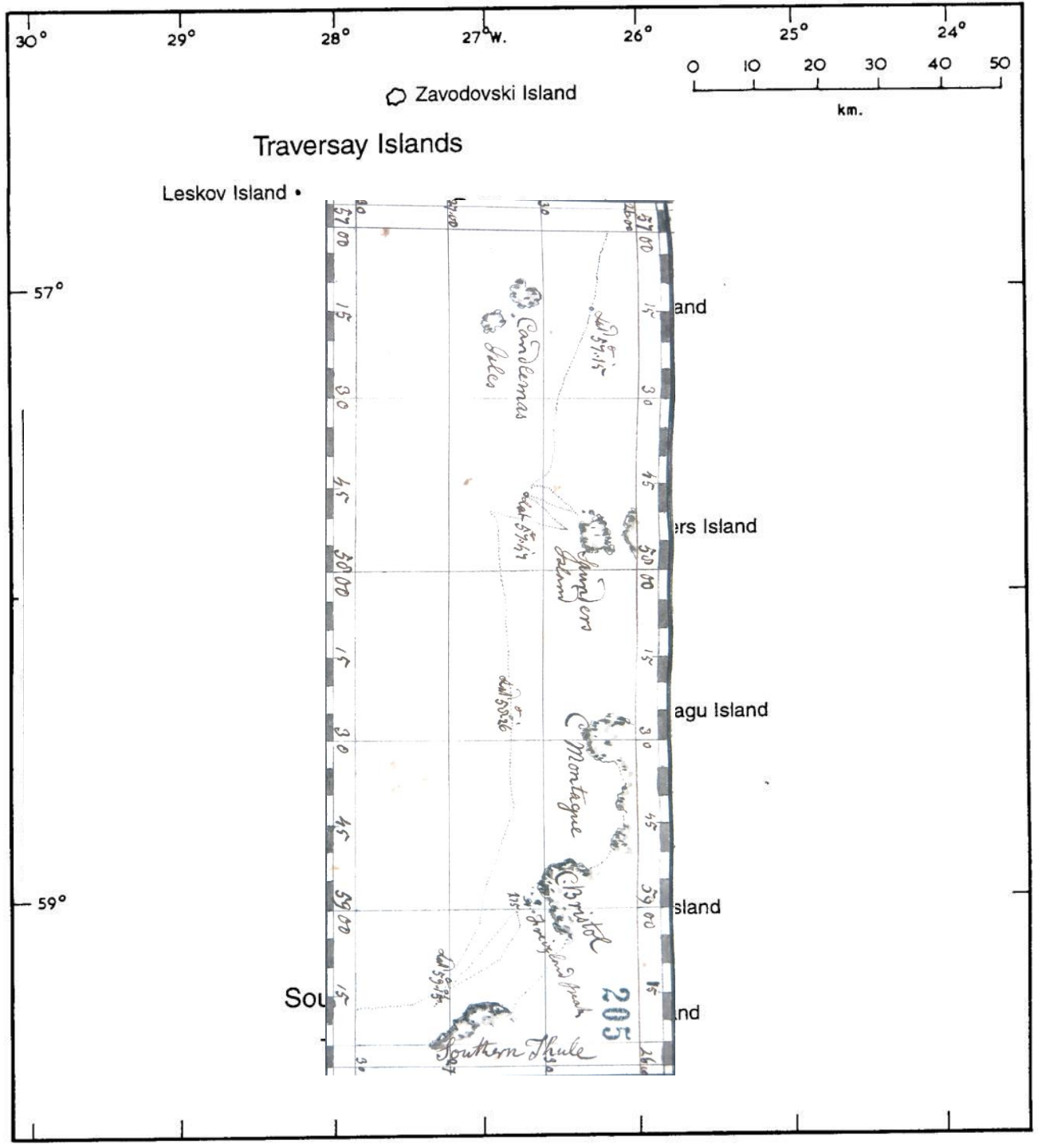
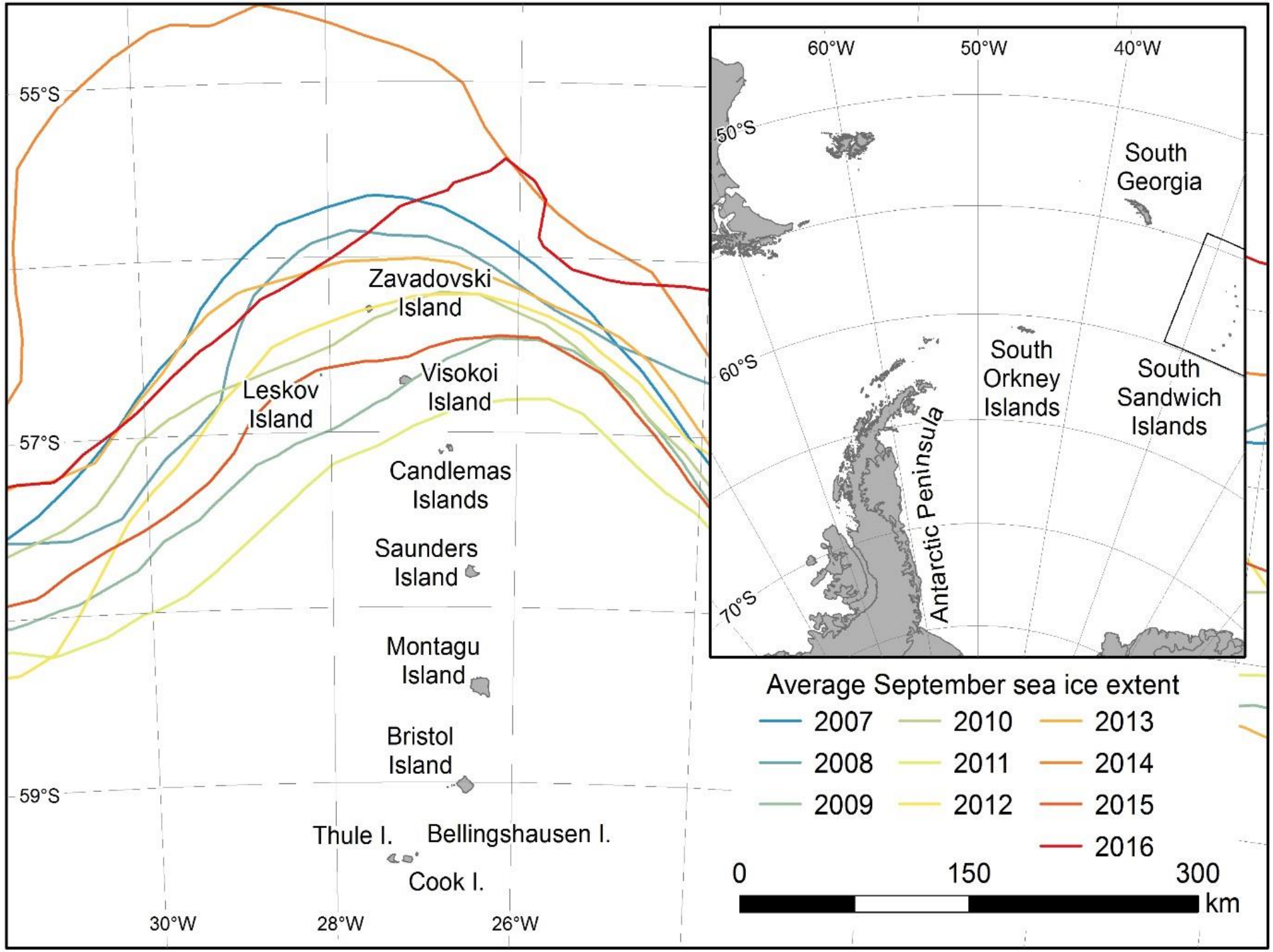
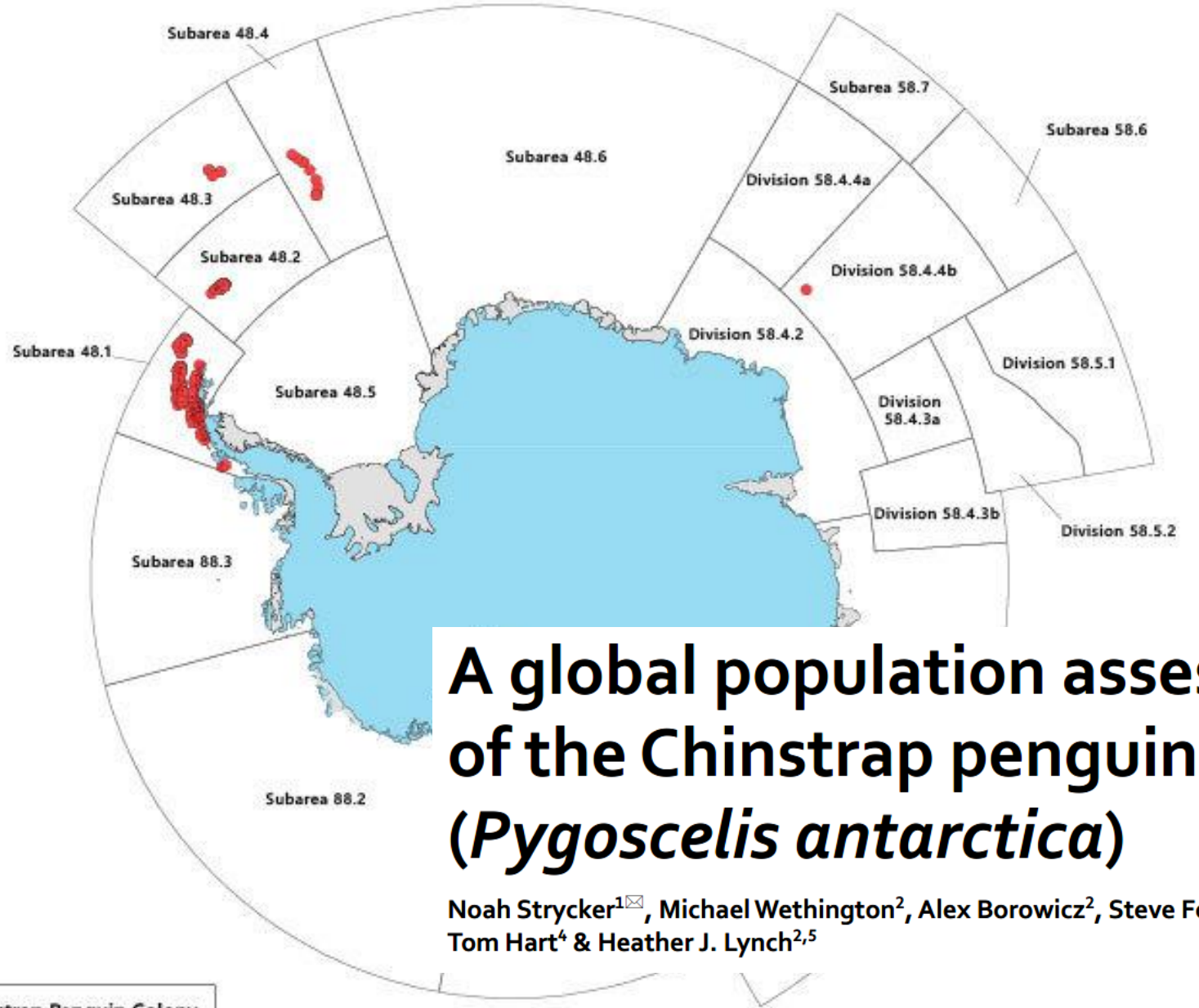
24°
0 10 20 30 40 50
km.
Zavodovski Island
Traversay Islands
Leskov Island
Visokoi Island
57°
Vindication Island
Candlemas Island
Candlemas Islands
Saunders Island
Montagu Island
59°
Bristol Island
Southern Thule
Bellingshausen Island
Thule Island
Cook Island


30°
29°
28°
27°W.
26°
25°
24°
0 10 20 30 40 50
km.
Zavodovski Island
Traversay Islands
Leskov Island
57°
59°
Candlemas
Saunders
Montague
Bristol
Southern Thule
205

Discovery and science

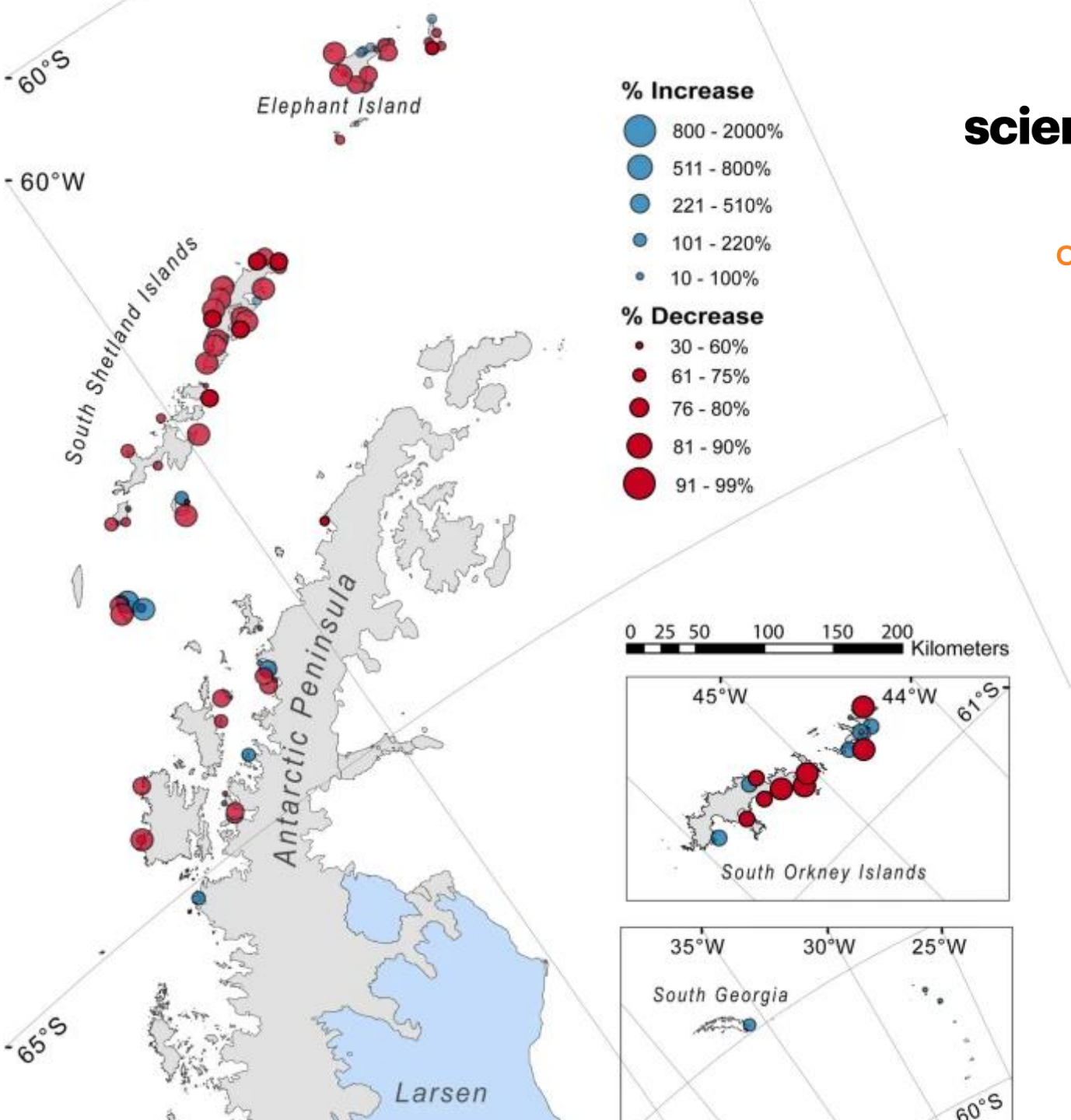
- First discovered by Captain James Cook, 1775, HMS Resolution
- Possible sealers 1816-18
- Northern three islands (Traversay) discovered by Bellingshausen in 1819
- Few sealers, late 1890s
- Larson, Undine 1908
- 1930 Discovery II
- 1964 – Holdgate and Baker HMS Protector
- 1976 – 1982 Corveta Uruguay
- 1999 – HMS Endurance/RS James Clark Ross/Damien 2 (Convey et al 1999).
- 2011 – Golden Fleece/Oceanites (Lynch et al 2016)
- 2016 onwards – camera on Saunders Island
- 2019-2023 – drone penguin counts from Pelagic Australis, Vinson of Antarctica


55°S
57°S
59°S
30°W
28°W
26°W
Zavadovski Island
Leskov Island
Visokoi Island
Candlemas Islands
Saunders Island
Montagu Island
Bristol Island
Thule I.
Bellingshausen I.
Cook I.
60°W
50°W
40°W
50°S
60°S
70°S
South Georgia
South Orkney Islands
South Sandwich Islands
Antarctic Peninsula
Average September sea ice extent
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
0
150
300
km



A global population assessment of the Chinstrap penguin (*Pygoscelis antarctica*)

Noah Strycker[1]✉, Michael Wethington[2], Alex Borowicz[2], Steve Forrest[2], Chandi Witharana[3], Tom Hart[4] & Heather J. Lynch[2,5]

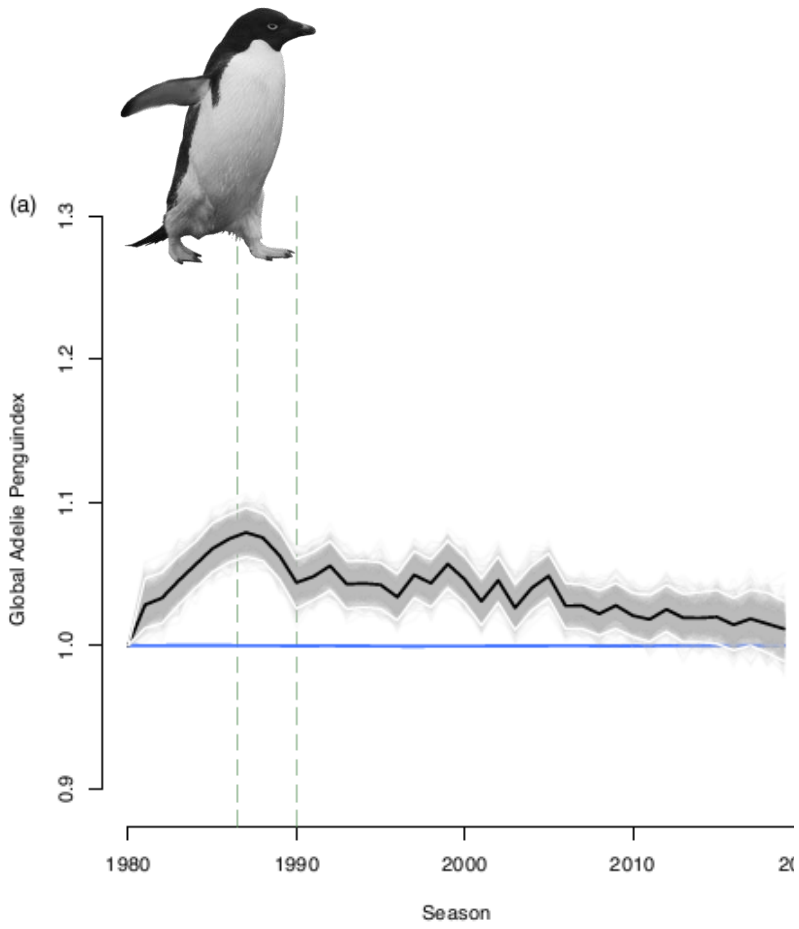


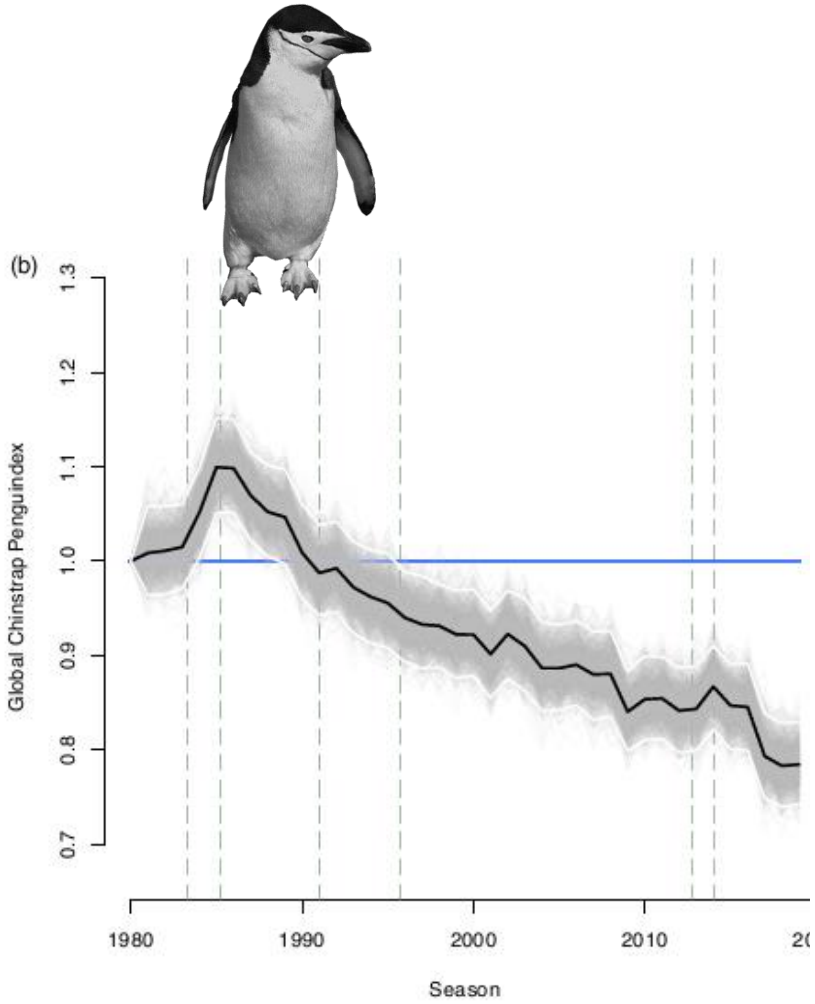
scientific reports

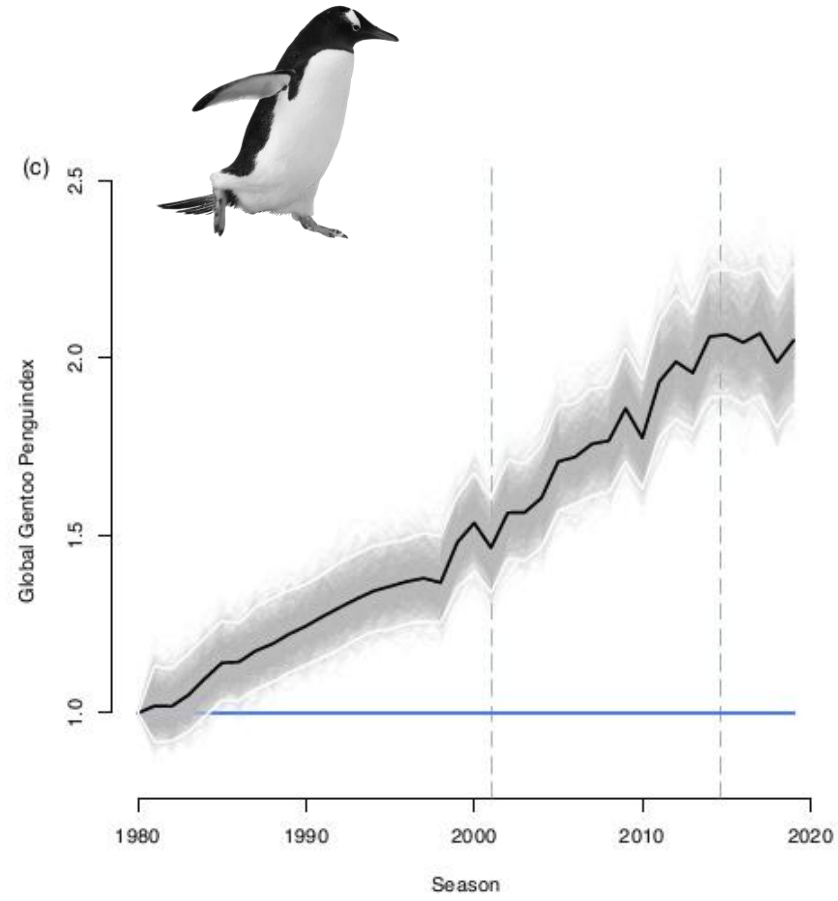
OPEN

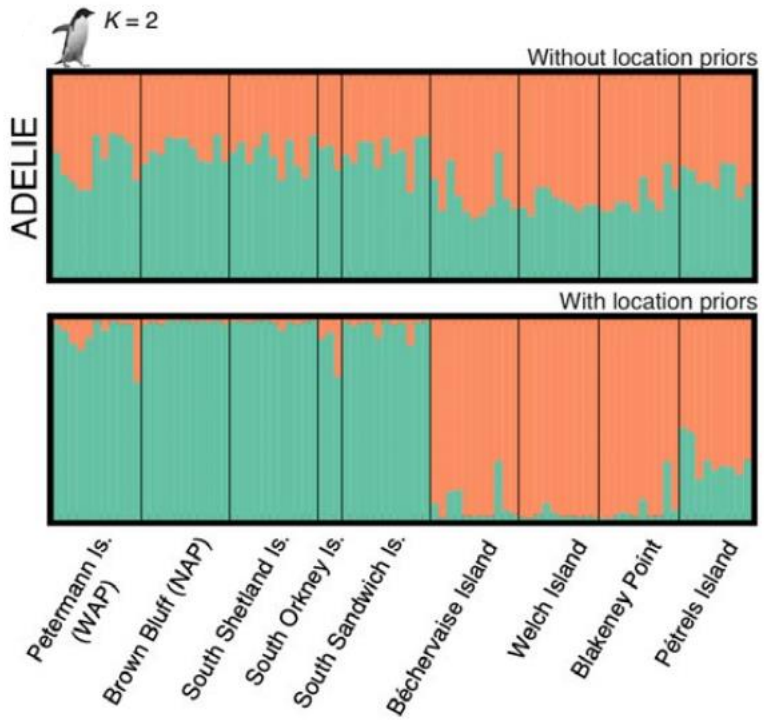
A global population assessment of the Chinstrap penguin (*Pygoscelis antarctica*)

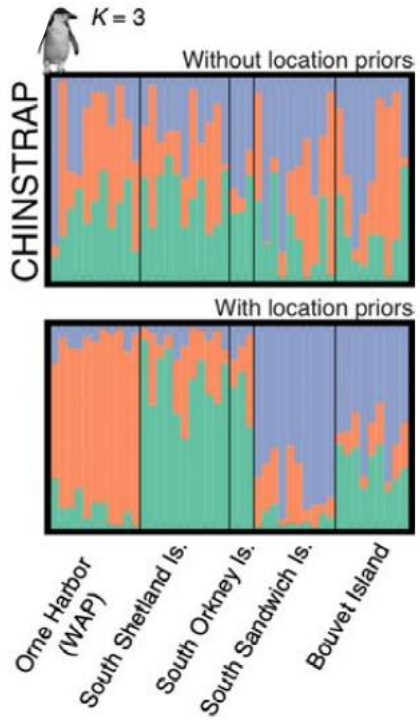
Noah Strycker[1✉], Michael Wethington[2], Alex Borowicz[2], Steve Forrest[2], Chandi Witharana[3], Tom Hart[4] & Heather J. Lynch[2,5]

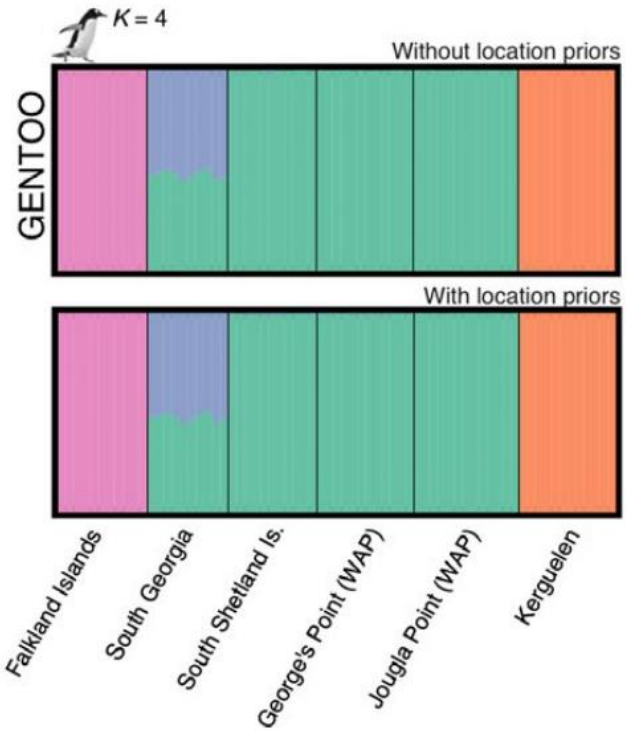

(a)
Global Adelie Penguindex
0.9
1.0
1.1
1.2
1.3
1980
1990
2000
2010
Season


(b)
Global Chinstrap Penguindex
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1980
1990
2000
2010
Season

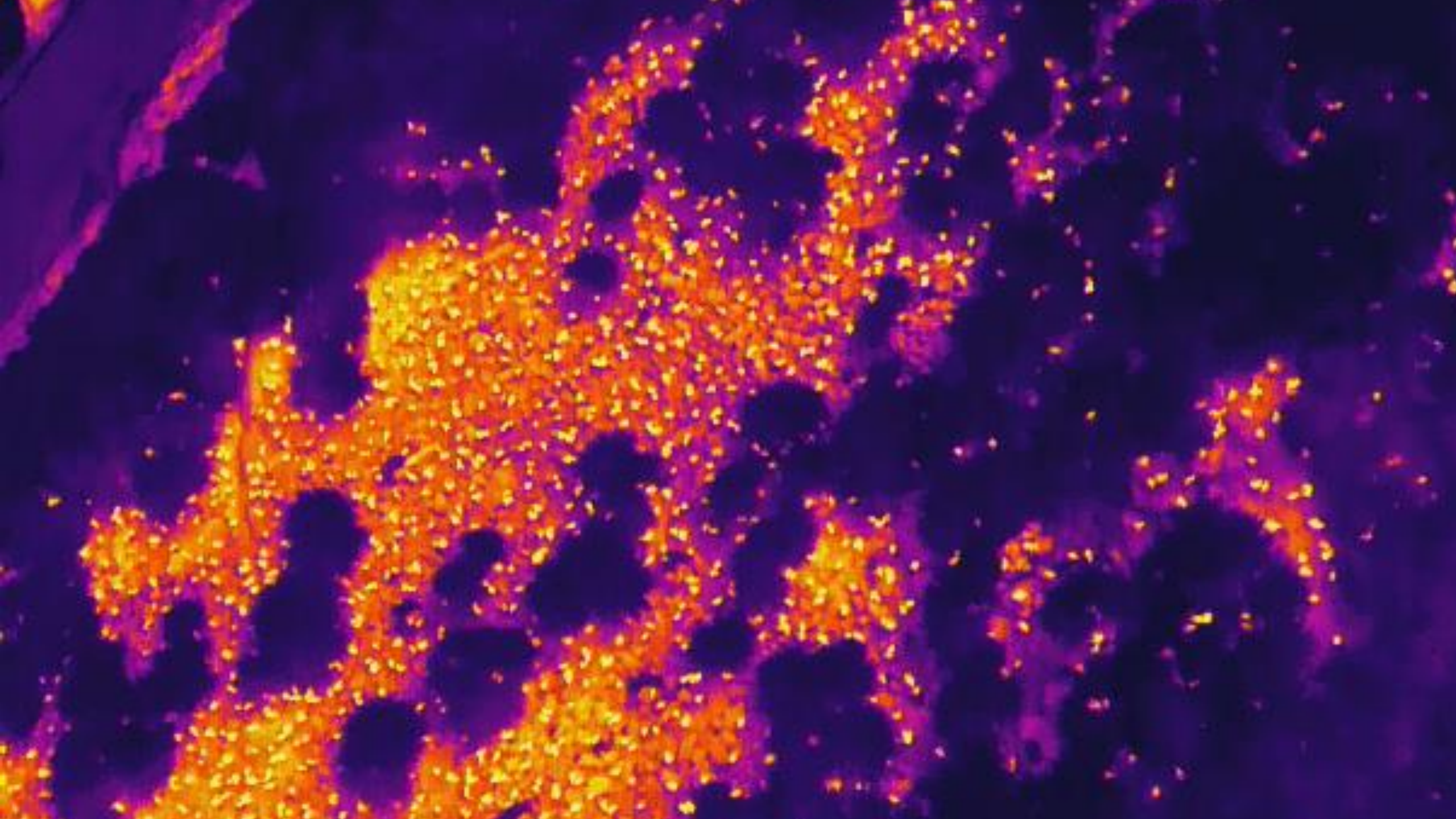

(c)
Global Gentoo Penguindex
1.0
1.5
2.0
2.5
1980
1990
2000
2010
2020
Season

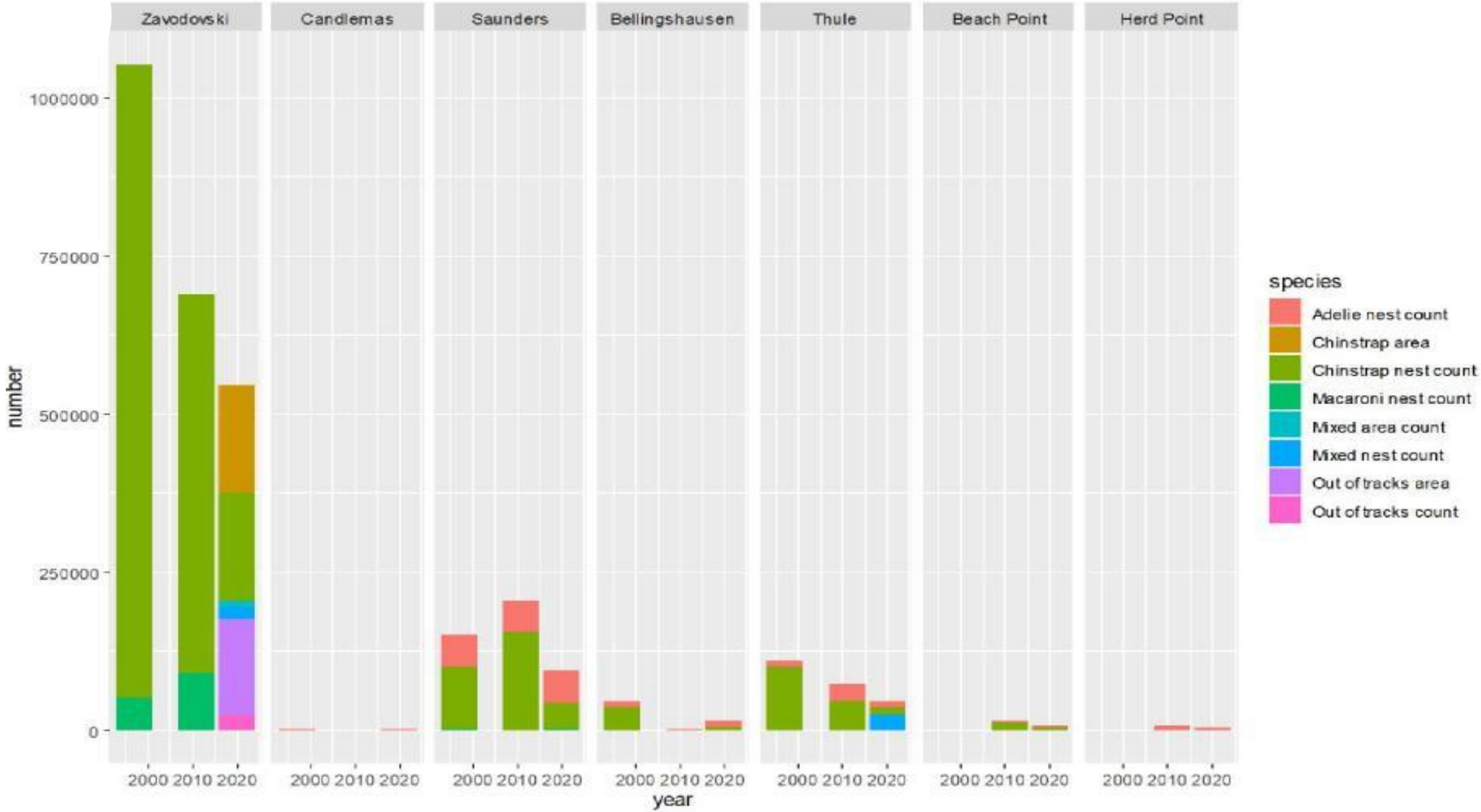

K = 2
ADELIE
Without location priors
With location priors
Petermann Is. (WAP)
Brown Bluff (NAP)
South Shetland Is.
South Orkney Is.
South Sandwich Is.
Béchervaise Island
Welch Island
Blakeney Point
Pétrels Island


K = 3
CHINSTRAP
Without location priors
With location priors
Orne Harbor (WAP)
South Shetland Is.
South Orkney Is.
South Sandwich Is.
Bouvet Island

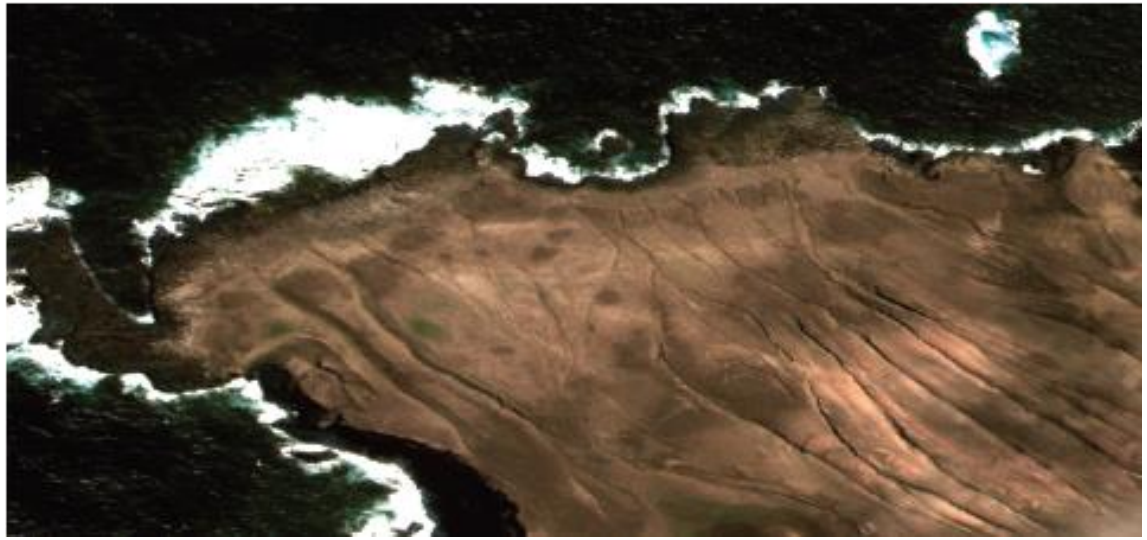

K = 4
GENTOO
Without location priors
With location priors
Falkland Islands
South Georgia
South Shetland Is.
George's Point (WAP)
Jougla Point (WAP)
Kerguelen


MAVIC 3 ENTERPRISE



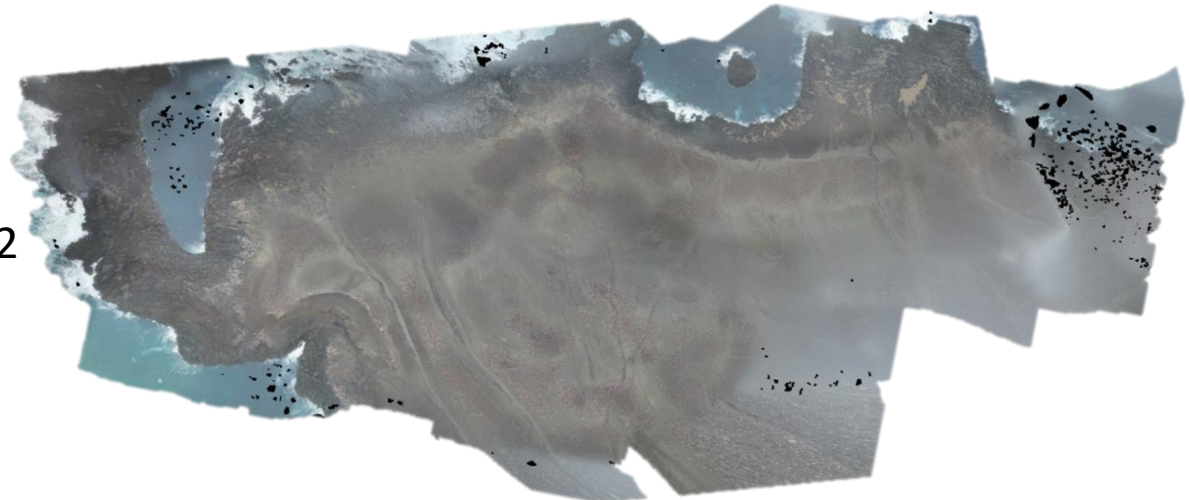

Zavodovski
Candlemas
Saunders
Bellingshausen
Thule
Beach Point
Herd Point
1000000
750000
500000
250000
0
number
2000 2010 2020
year
species
Adelie nest count
Chinstrap area
Chinstrap nest count
Macaroni nest count
Mixed area count
Mixed nest count
Out of tracks area
Out of tracks count

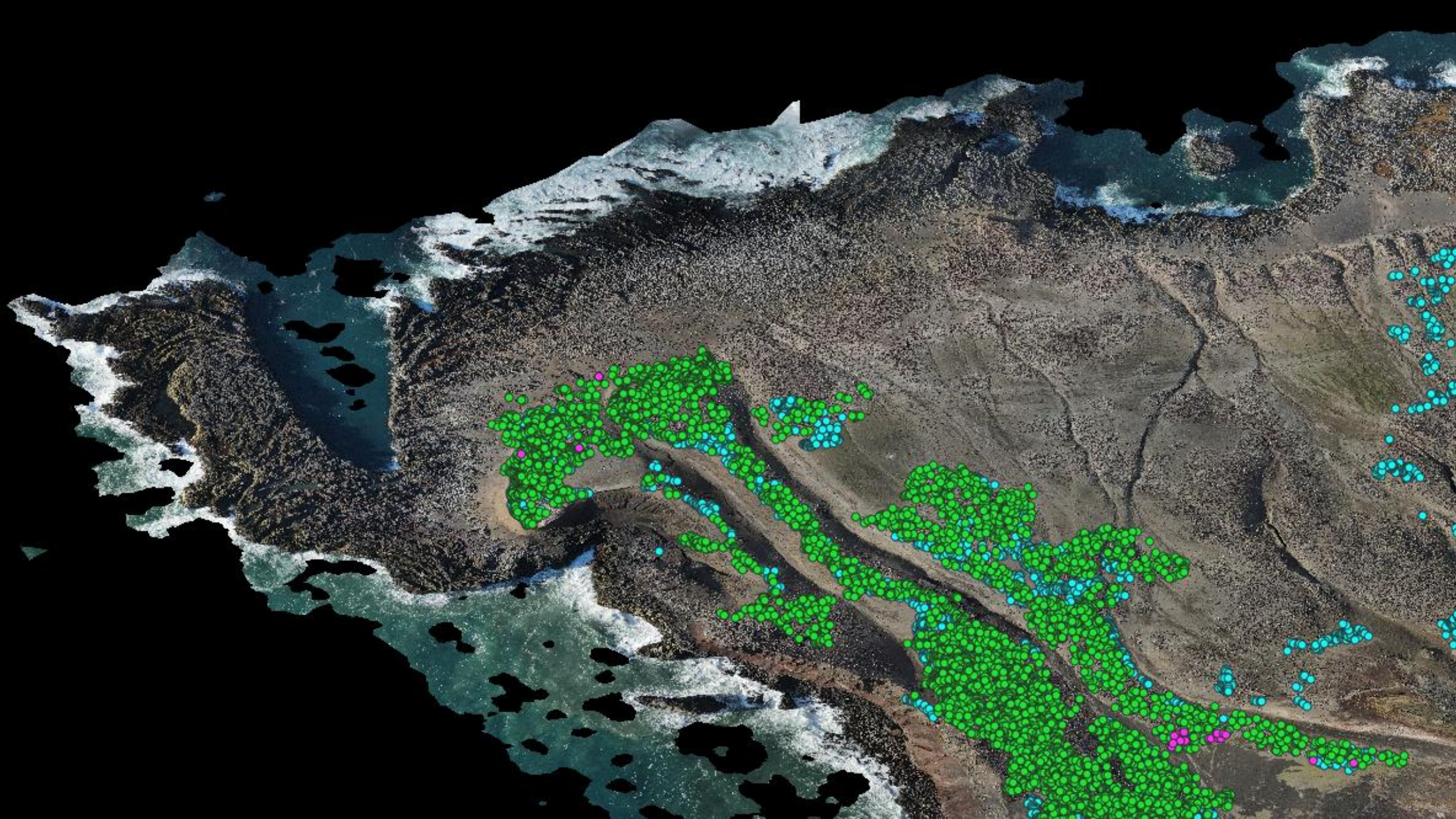
2012



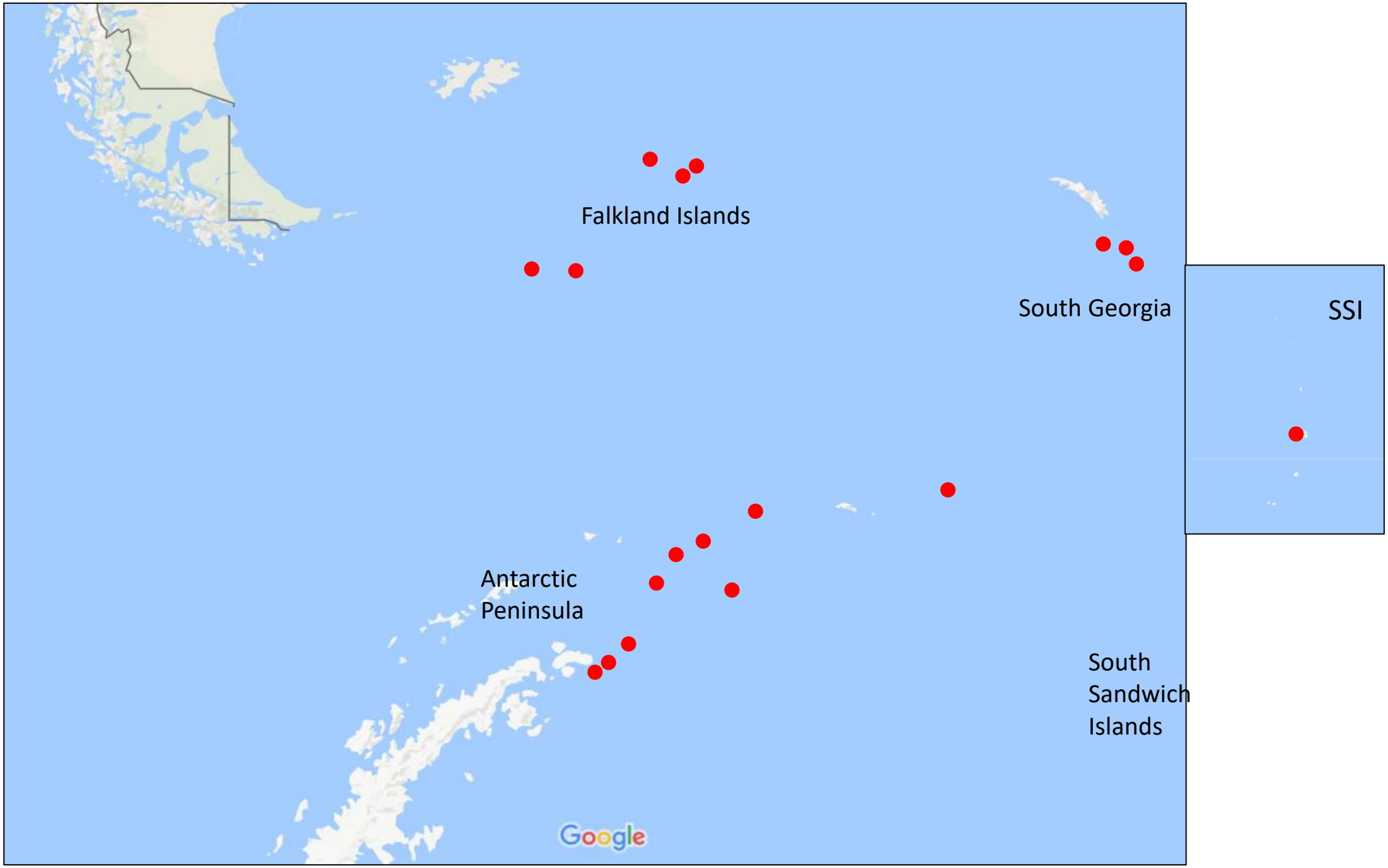
2016

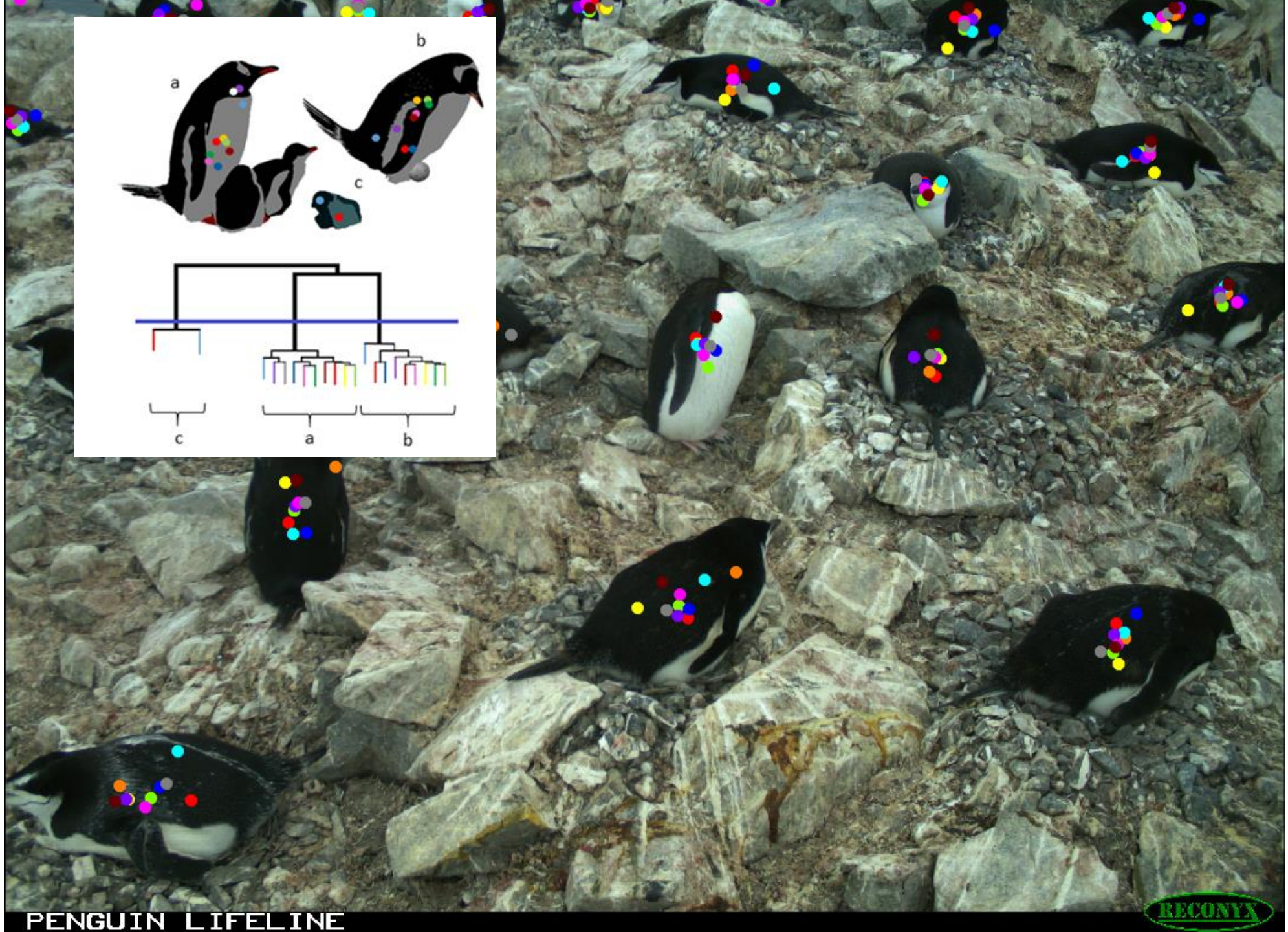
2022

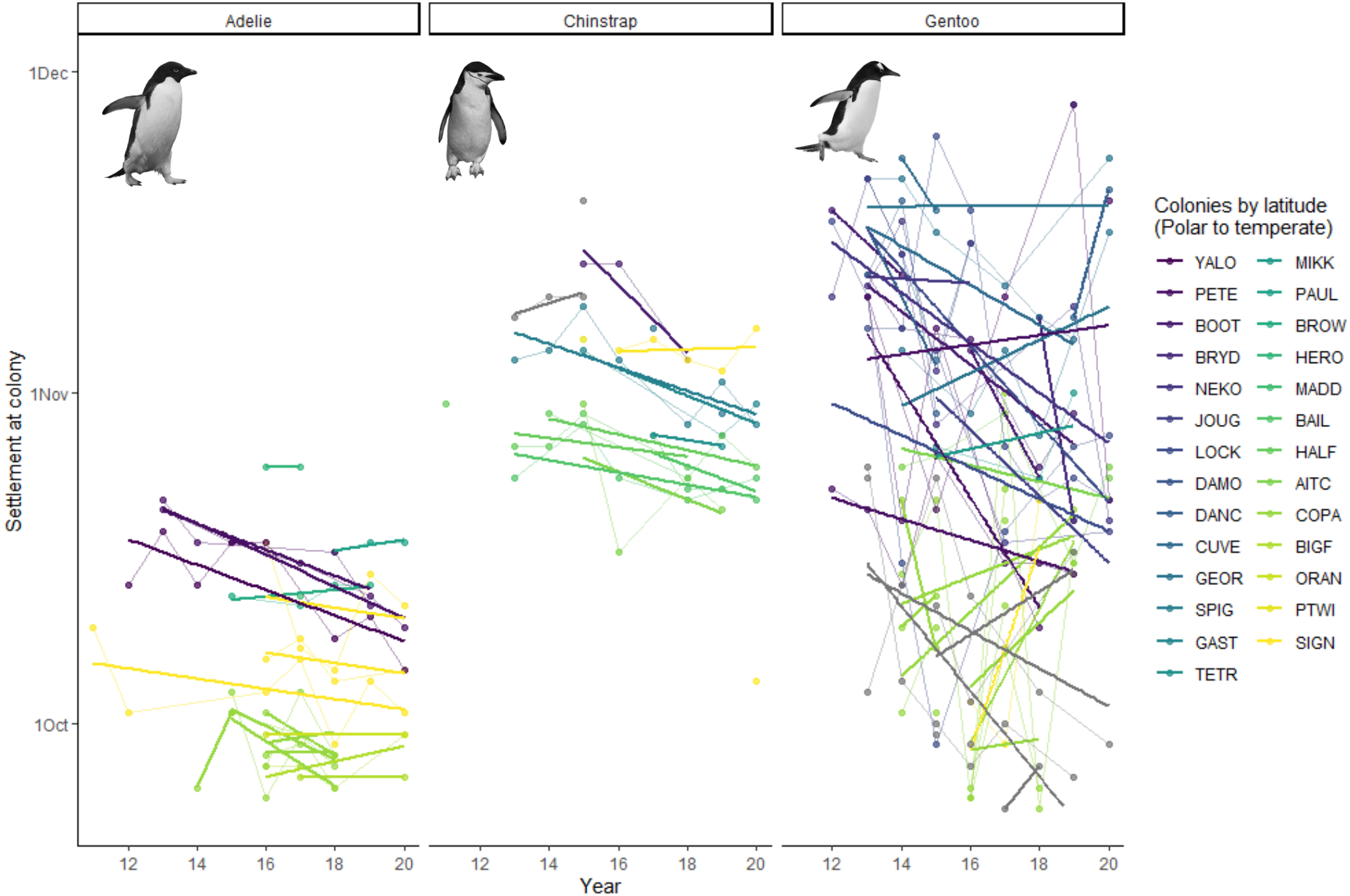


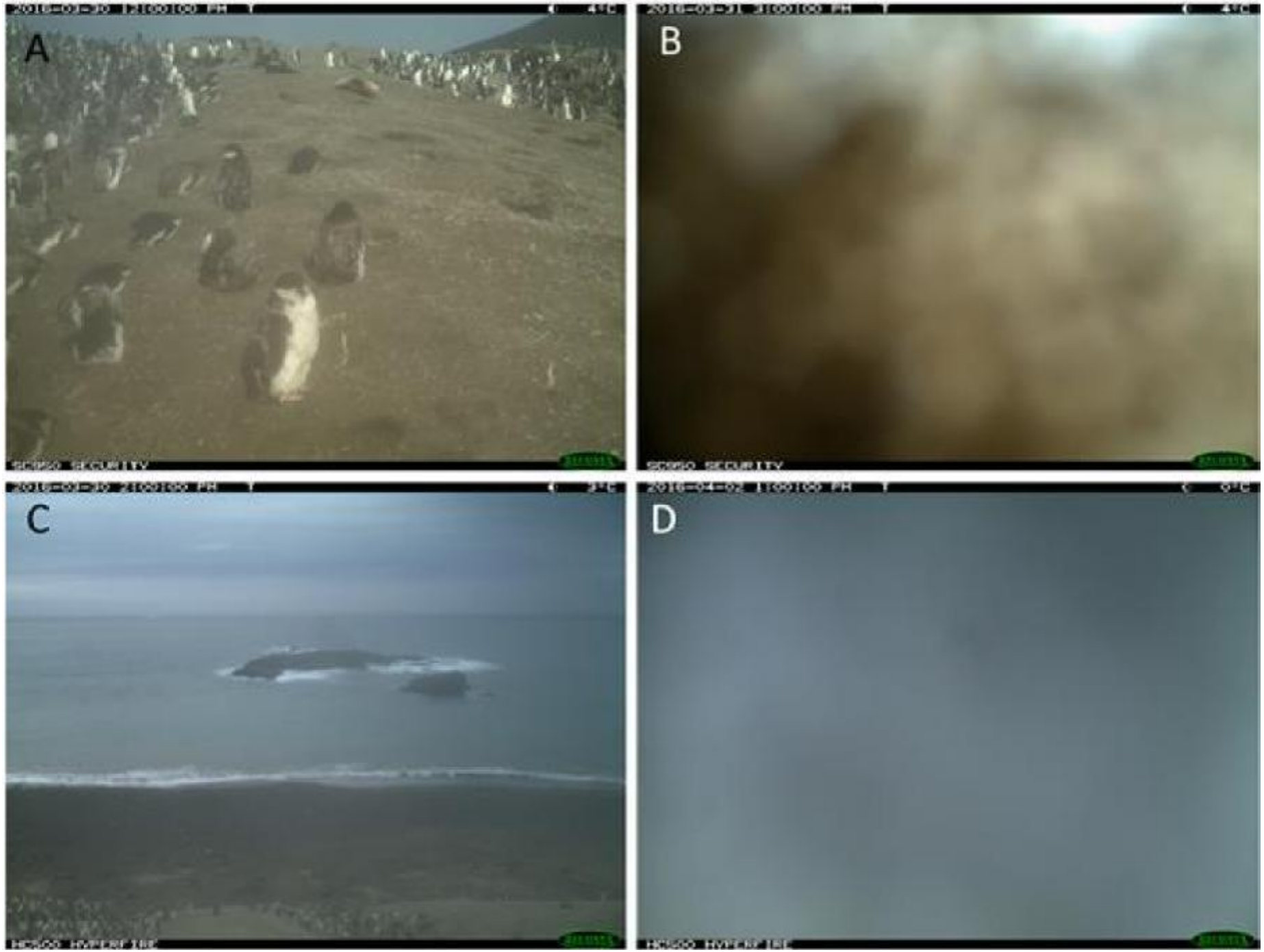


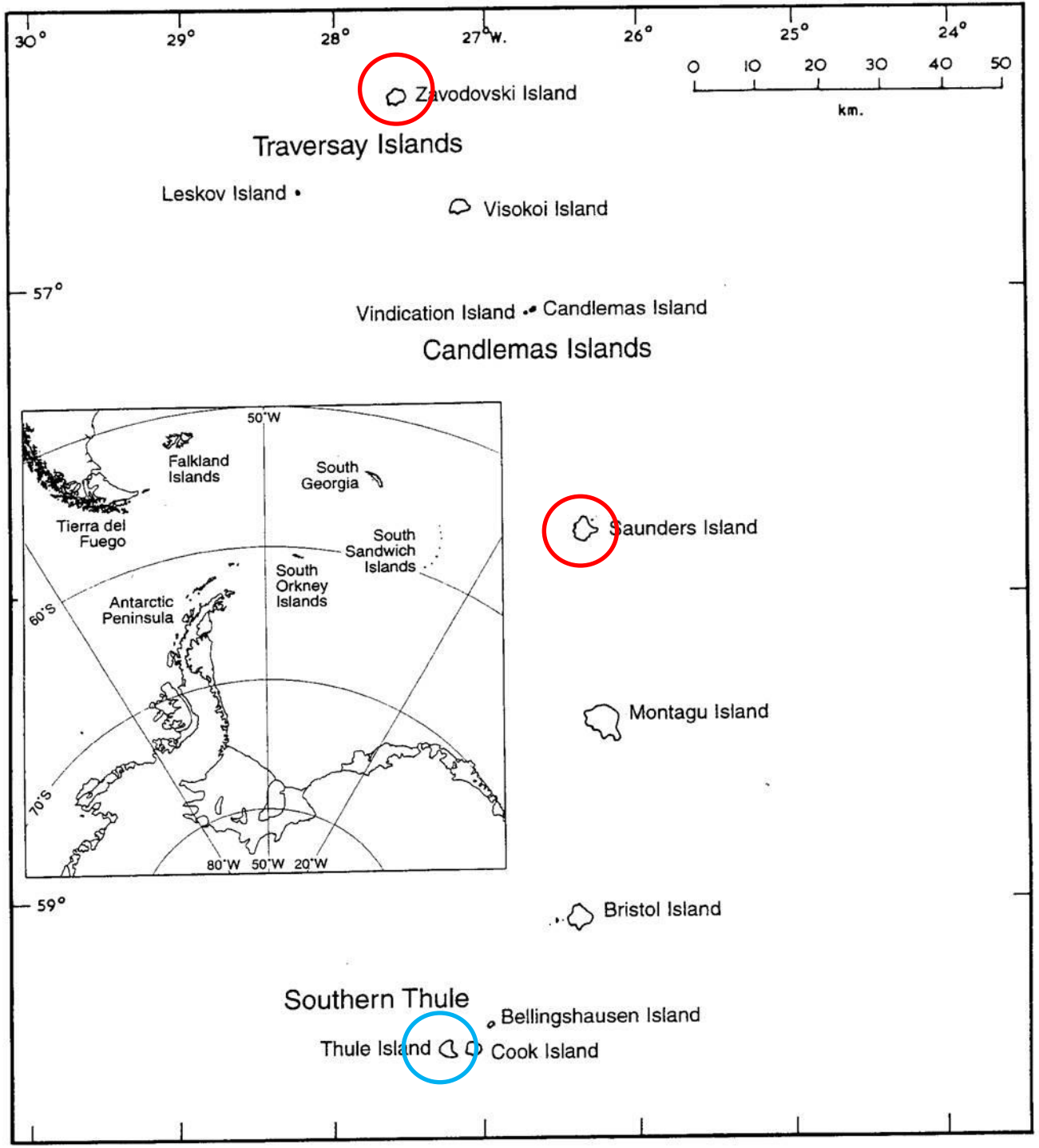

2013-11-12 11:00:00 AM T
1°C
HC500 HYPERFIRE
RECONYX


Falkland Islands
South Georgia
SSI
Antarctic
Peninsula
South
Sandwich
Islands
Google


a
b
c
c
a
b
PENGUIN LIFELINE
RECONYX


Adelie
Chinstrap
Gentoo
1Dec
1Nov
1Oct
Settlement at colony
12
14
16
18
20
Year
Colonies by latitude
(Polar to temperate)
YALO
PETE
BOOT
BRYD
NEKO
JOUG
LOCK
DAMO
DANC
CUVE
GEOR
SPIG
GAST
TETR
MIKK
PAUL
BROW
HERO
MADD
BAIL
HALF
AITC
COPA
BIGF
ORAN
PTWI
SIGN

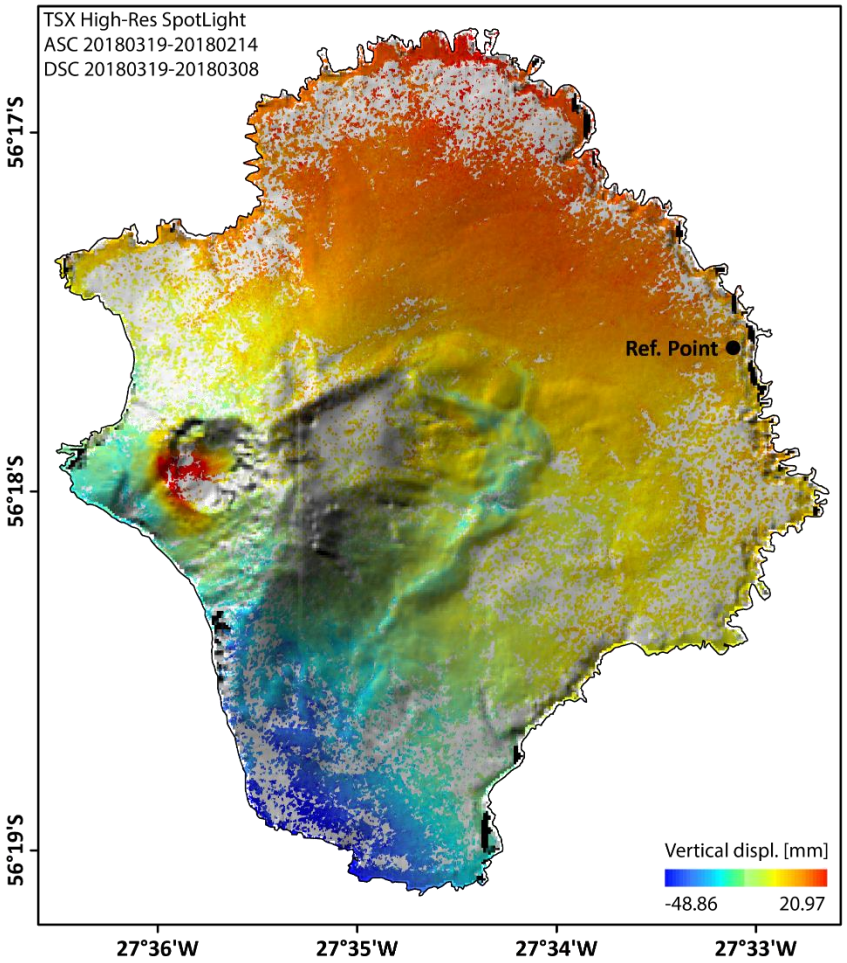

A
B
C
D



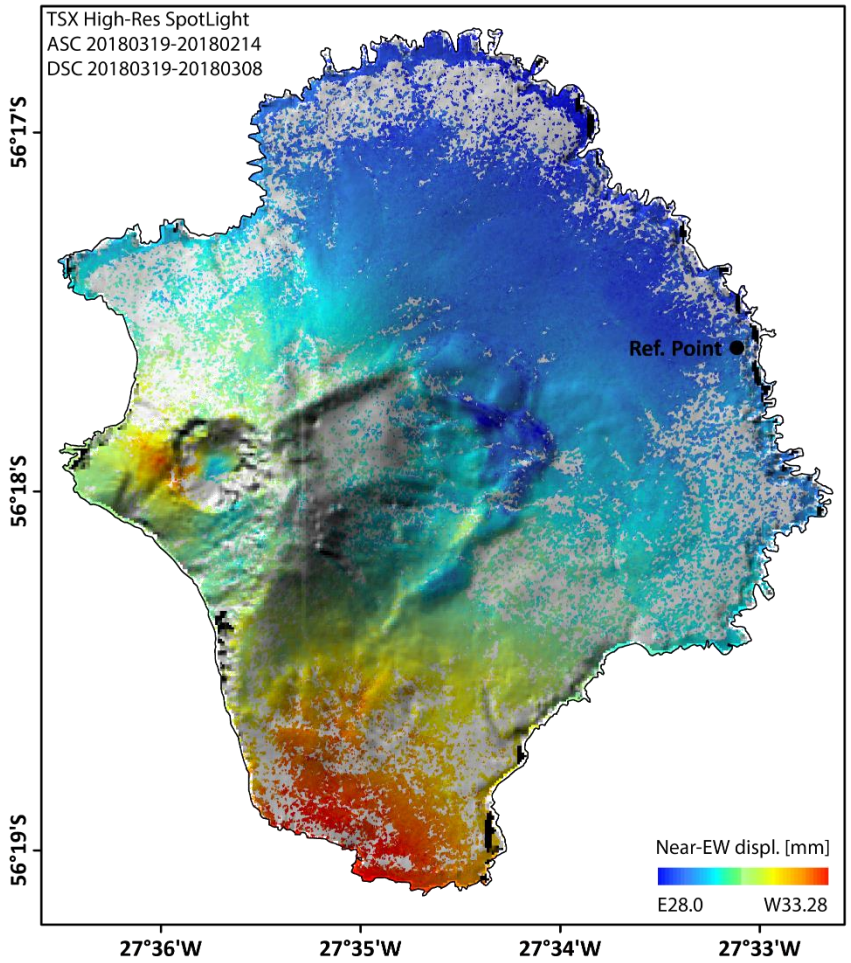
Deployed

To be deployed

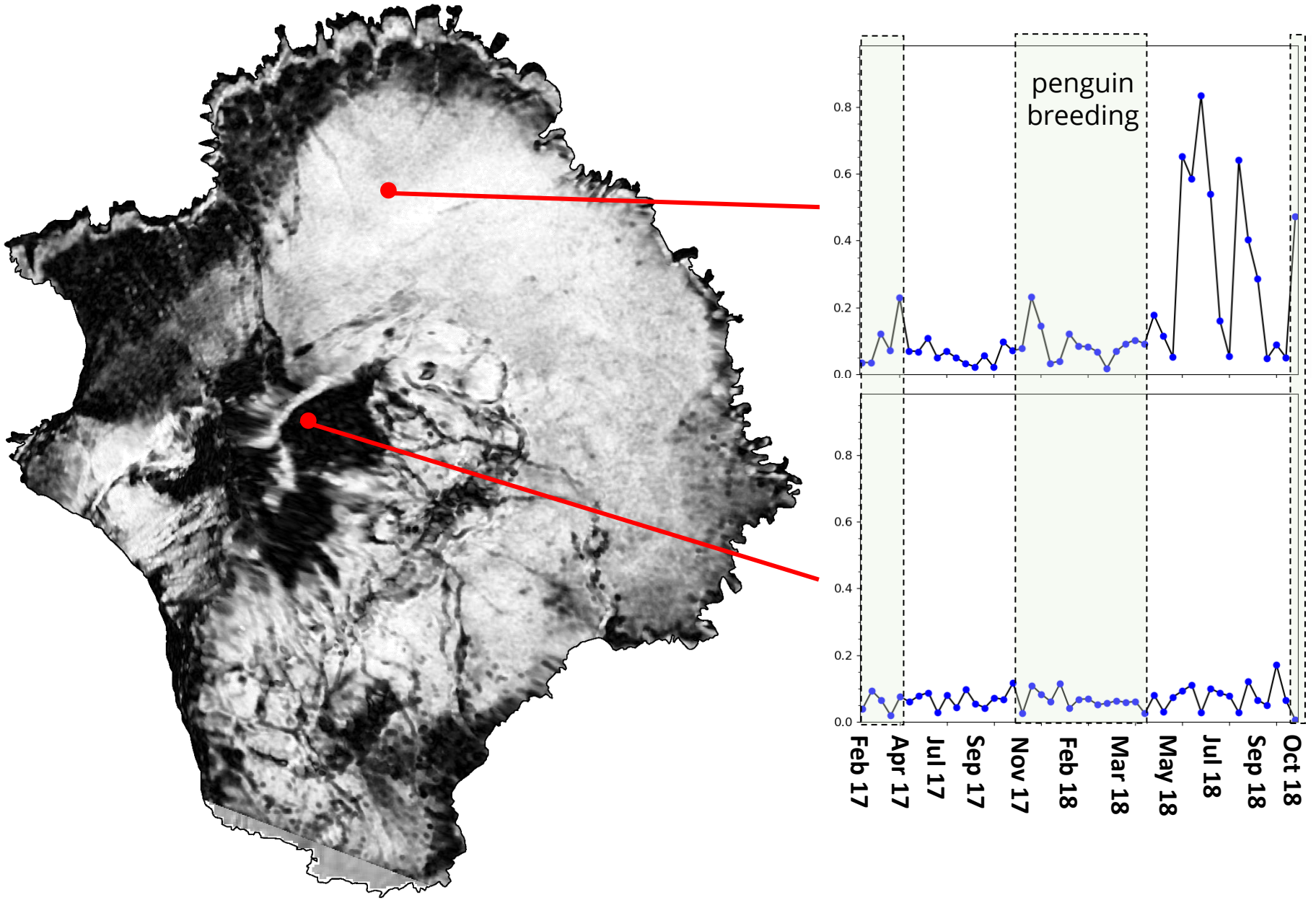
Zavodovski Island, South Sandwich Islands

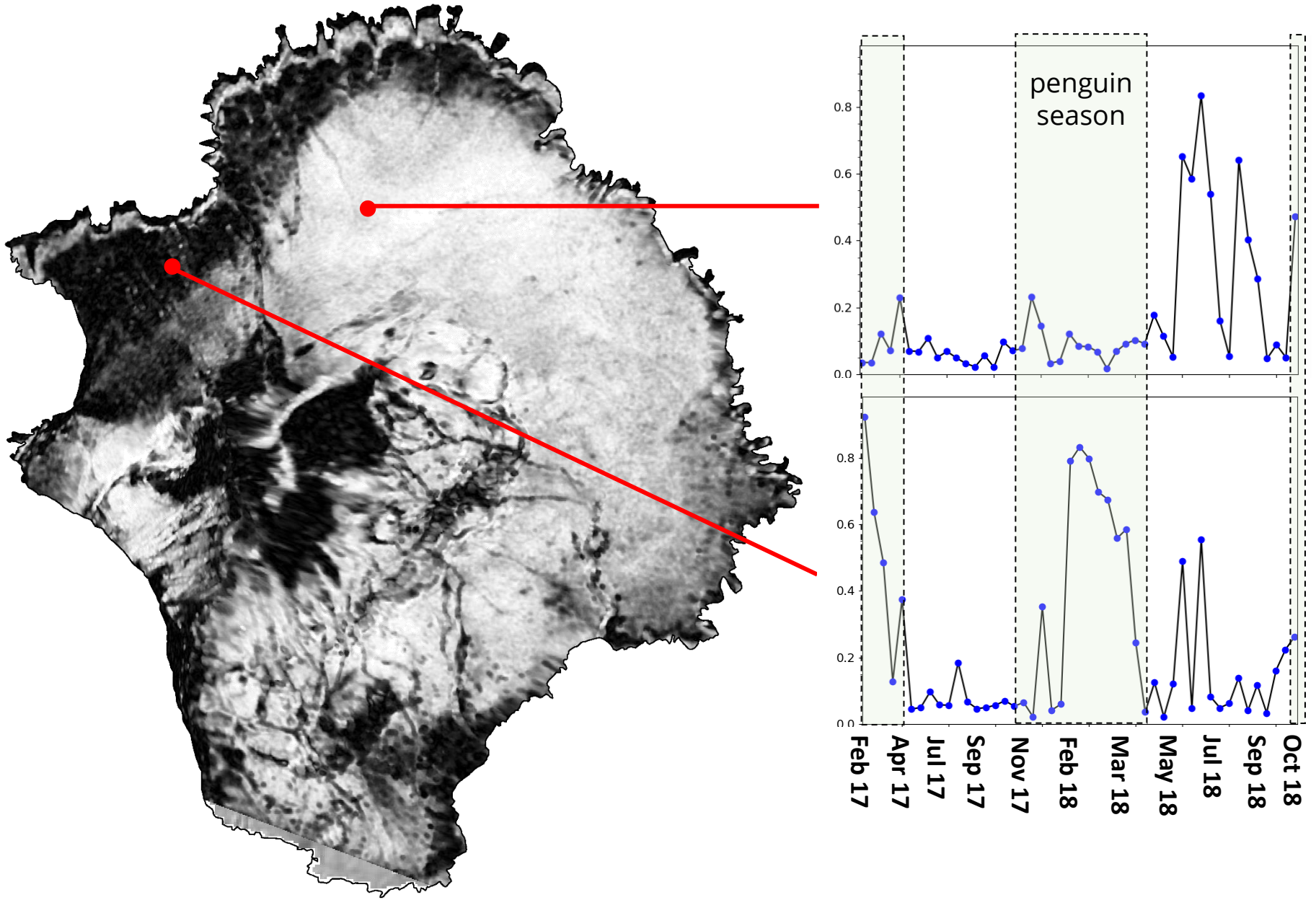


Zavodovski Island, South Sandwich Islands



F-E Region	South Sandwich Islands Region
Time	2018-03-10 14:27:57.8 UTC
Magnitude	5.5 (Mw)
Epicenter	27.77°W 56.30°S
Depth	27 km
Status	C - confirmed


penguin
breeding
0.0
0.2
0.4
0.6
0.8
Feb 17
Apr 17
Jul 17
Sep 17
Nov 17
Feb 18
Mar 18
May 18
Jul 18
Sep 18
Oct 18


penguin
season
0.0
0.2
0.4
0.6
0.8
Feb 17
Apr 17
Jul 17
Sep 17
Nov 17
Feb 18
Mar 18
May 18
Jul 18
Sep 18
Oct 18

Take home

- SSI still appear to be relatively stable.
- The 2016 volcanic activity appears to have had little impact on populations.
- The islands' population are still likely vulnerable to climate change given trends elsewhere, BUT not the same fishing pressure that has been associated with declines in Chinstrap and Adelies elsewhere.


PENGUIN WATCH
OXFORD BROOKES UNIVERSITY
UNIVERSITY OF OXFORD
ZOONIVERSE
Stony Brook University
LSU
LOUISIANA STATE UNIVERSITY
Quark Expeditions
CHEESEMANS' ECOLOGY SAFARIS
John Ellerman Foundation
save our seas foundation
oceanites
THE UNIVERSITY OF WESTERN AUSTRALIA
THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH
CONICET
CADIC
WCS
Federation University
ZSL
LET'S WORK FOR WILDLIFE
DARWIN INITIATIVE
tawaki project
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
FALKLANDS CONSERVATION
WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930
CO-EXIST PROJECTS
#HELPSAVEOURSEAS
WWF
HELLY HANSEN
POSEIDON EXPEDITIONS
Golden Fleece Expedition Cruises
Australian Government
Department of Sustainability, Environment, Water, Population and Communities

Government of South Georgia & the South Sandwich Islands

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