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

Fisheries

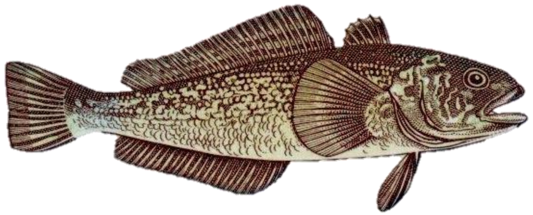
- **The South Georgia groundfish survey: using long term data to assess the population dynamics and ecology of historically exploited fish species.** *Philip Hollyman (BAS)*
- **The use of miniature cameras to monitor the behaviour and benthic impact of longline fishing gear at South Georgia.** *Chris Darby (Cefas)*
- **Spatial, temporal and demographic variability in Patagonian toothfish (*Dissostichus eleginoides*) spawning from twenty-five years of fishery data.** *Connor Bamford (BAS)*
- **The use of electronic monitoring to assess the risks of using net monitoring cables.** *James Moir Clark (MRAG)*
- **Oceanographic Variability in Cumberland Bay: implications for glacier dynamics and transport of mackerel icefish larvae.** *Joanna Zanker (BAS)*
- **The South Georgia Risk Tool – a bespoke and interactive management tool.** *Oliver Hogg (Cefas)*

Phil Hollyman

British Antarctic Survey

The South Georgia groundfish survey: using long term data to assess the population dynamics and ecology of historically exploited fish species

Philip R. Hollyman, Simeon L. Hill, Vladimir V. Laptikhovsky, Mark Belchier, Susan Gregory, Alice Clement, Martin A. Collins



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Cefas

POLAR SCIENCE FOR PLANET EARTH

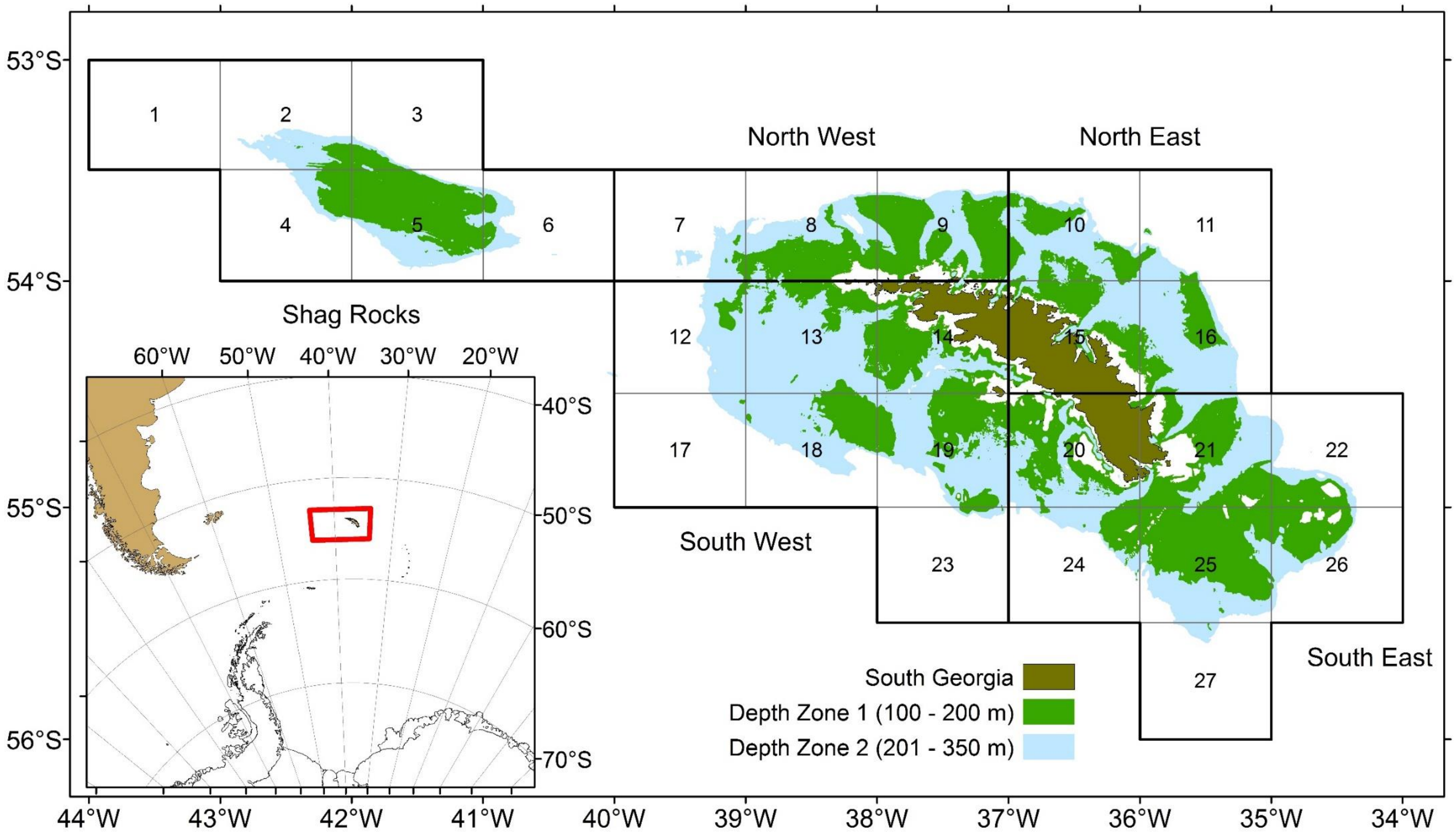
South Georgia groundfish survey

The groundfish survey is a biennial bottom trawl survey which has been conducted since 1987.

It is used to collect key information on mackerel icefish and juvenile toothfish for their respective stock assessments.

Many other fish species are caught during the survey, allowing for detailed, long term analyses of many fish populations around the island

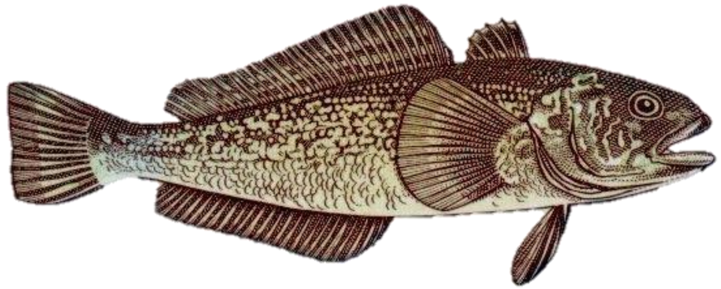
South Georgia groundfish survey



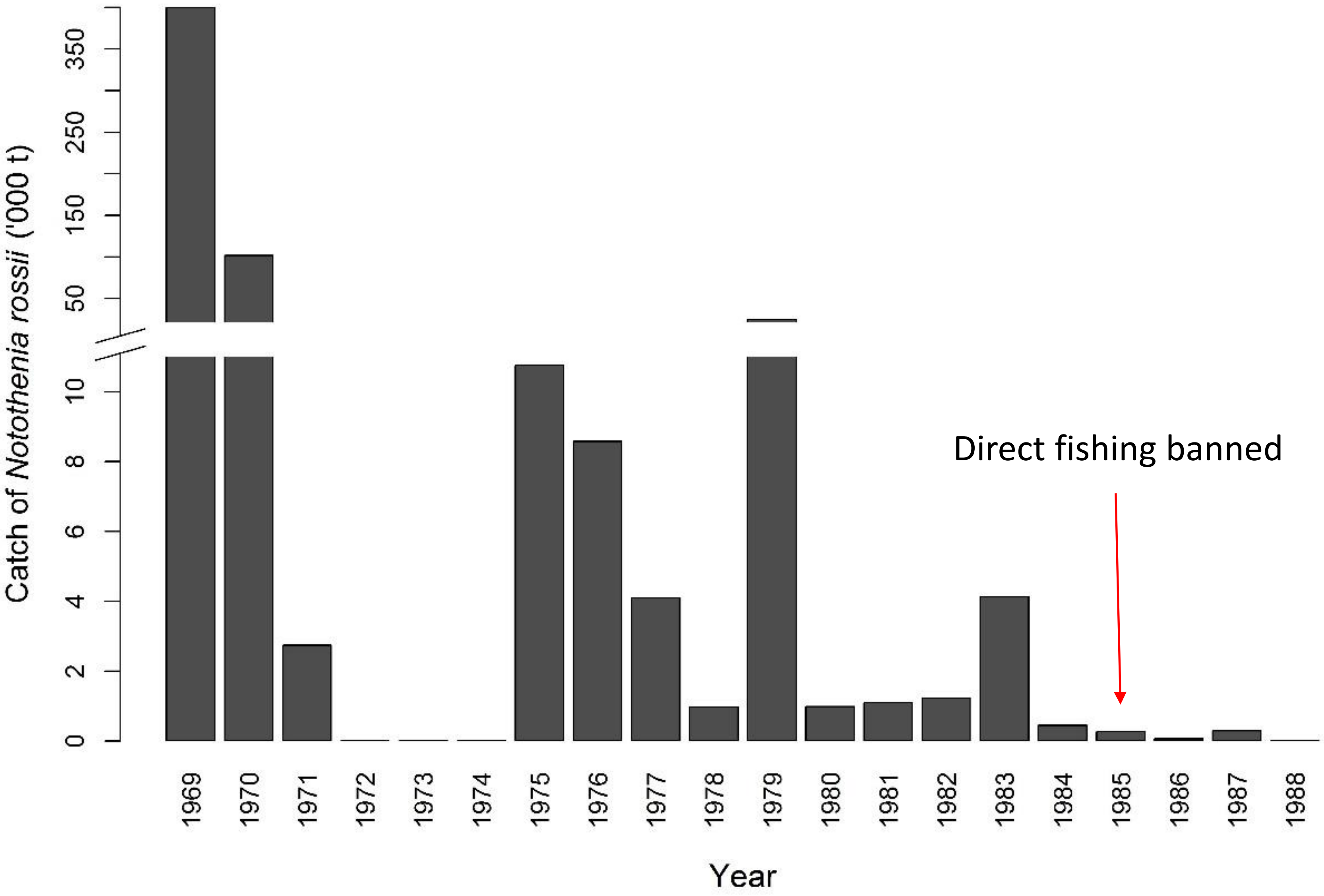
Notothenia rossi (marbled rock cod)

N. rossii is a higher trophic level fish, common to shelf habitats in the southern ocean.

Adults are found between depths of 100 and 400m and they reach a maximum length of ~90 cm.



Historical exploitation at South Georgia



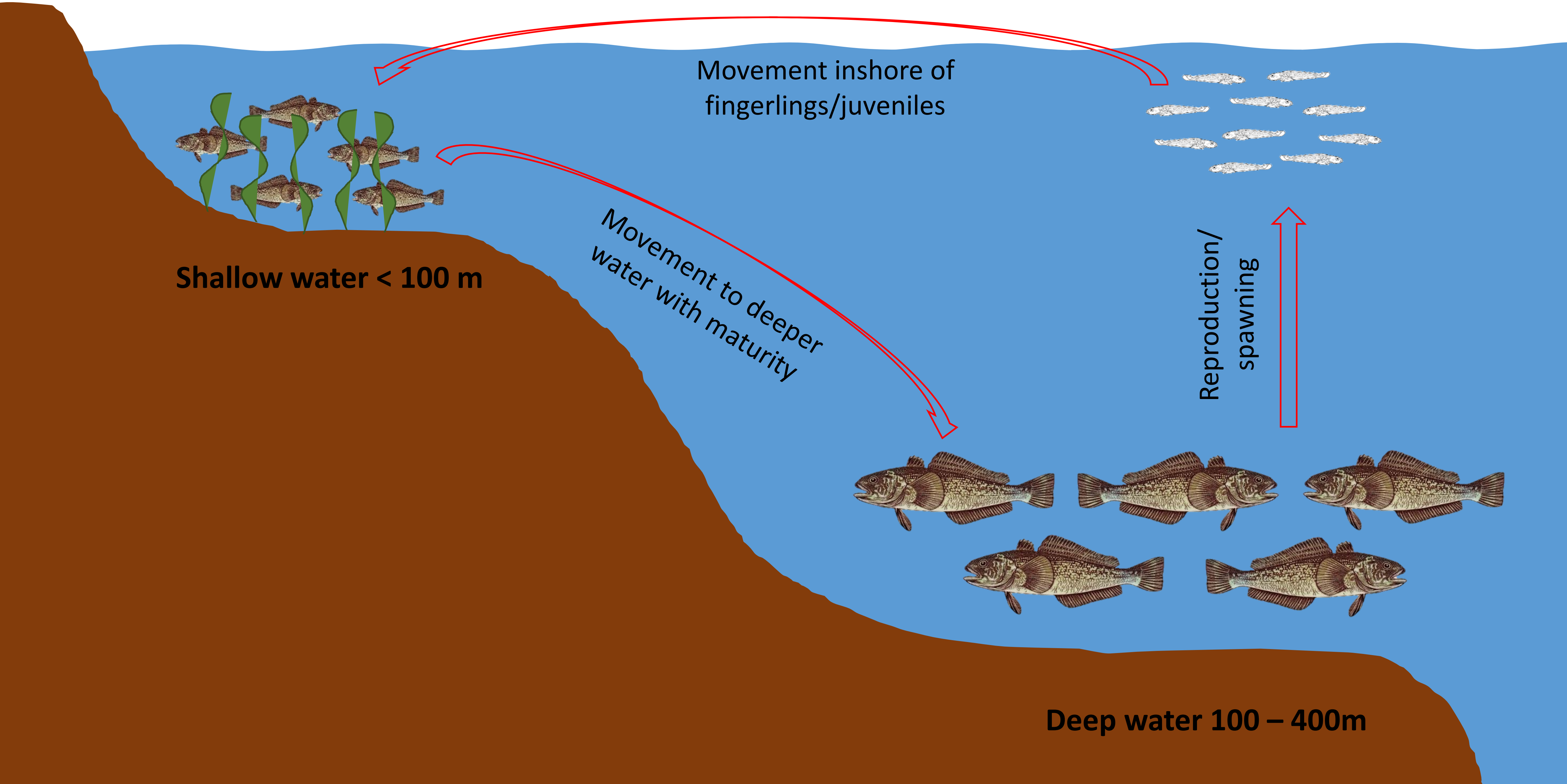
Historical exploitation in subarea 48.3

Early catches from South Georgia were reported as ‘Unspecified demersal Percomorphs’, but are widley accepted to have been mostly *N. rossii* (Everson, 2001)

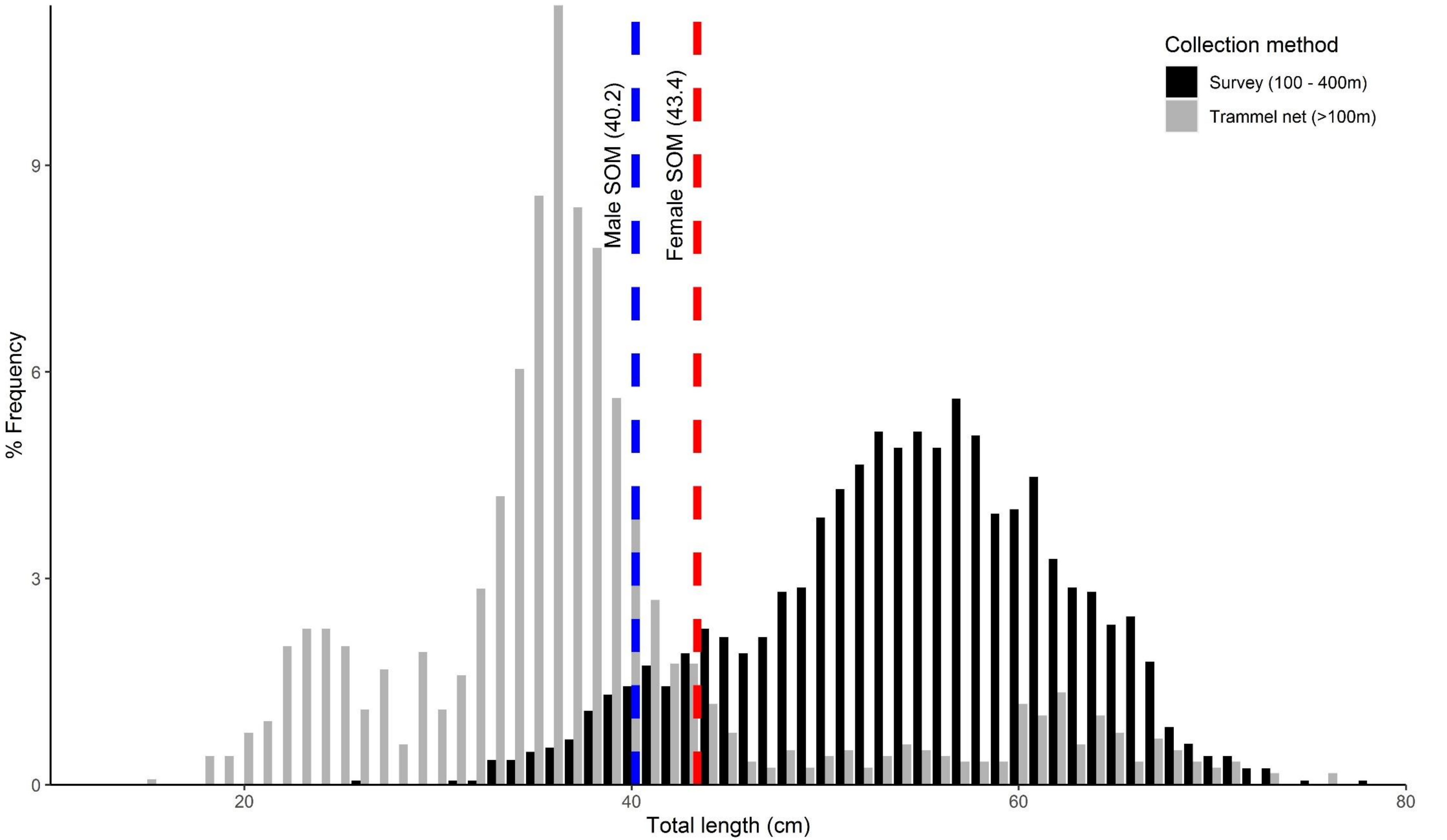
400,000t is roughly equal to the combined annual catch of all species within the Southern Ocean today (CCAMLR area)

Records from the early fishing efforts are limited, it is difficult to gauge the exact location of fishing effort at the time. It is assumed that *N. rossii* has not recovered to it’s pre-exploitation biomass

Life cycle of *Notothenia rossii* – what do we know?



Length frequency between 2001 and 2007



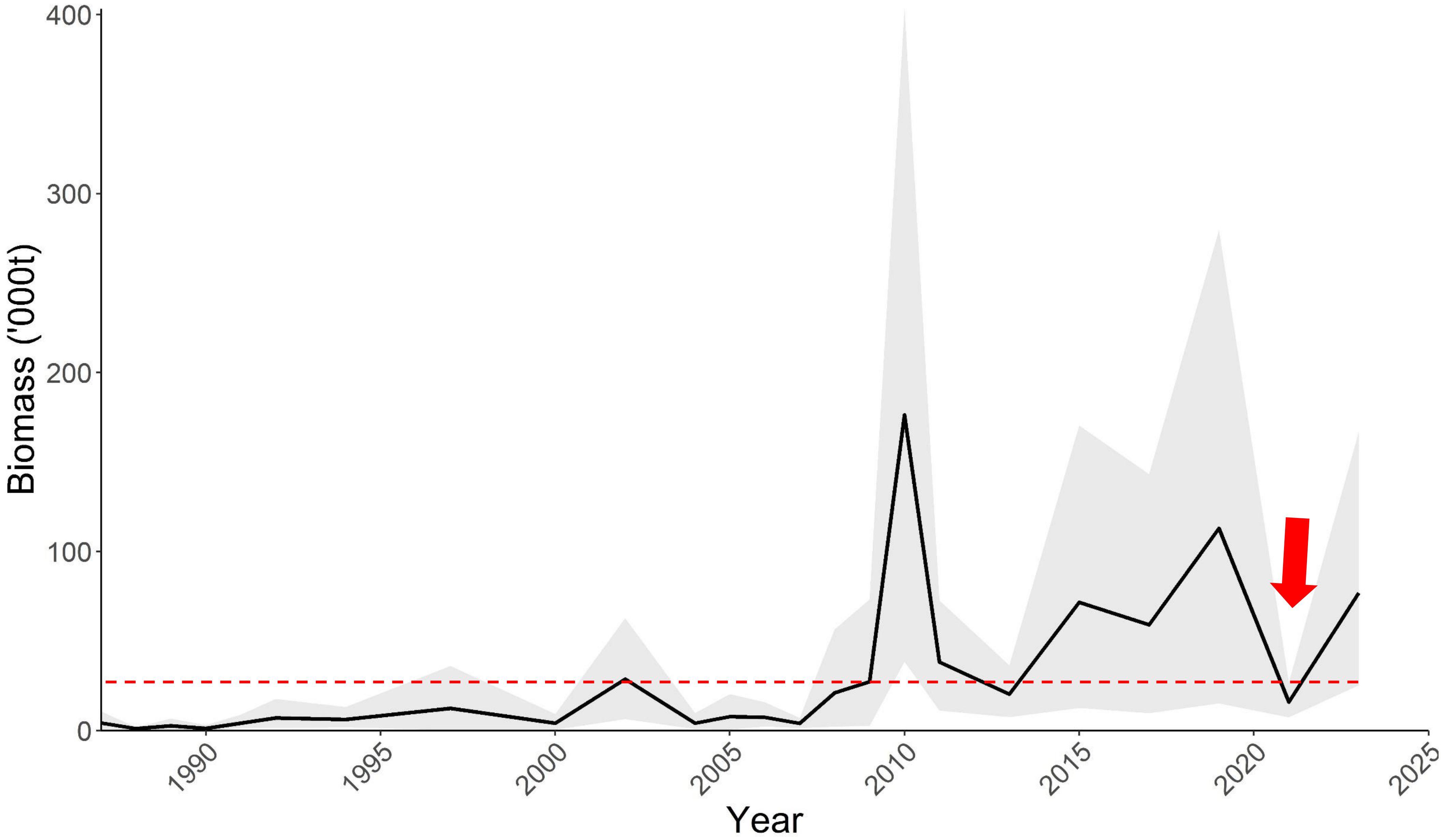
Only larger (>30cm) mature fish are caught in deeper water during the groundfish survey. Mainly smaller, immature fish were caught in shallow water trammel nets. This suggests depthward migration with maturity

N. rossii larvae have only been recorded 5 times in the 20 year larval sampling effort at King Edward Point.

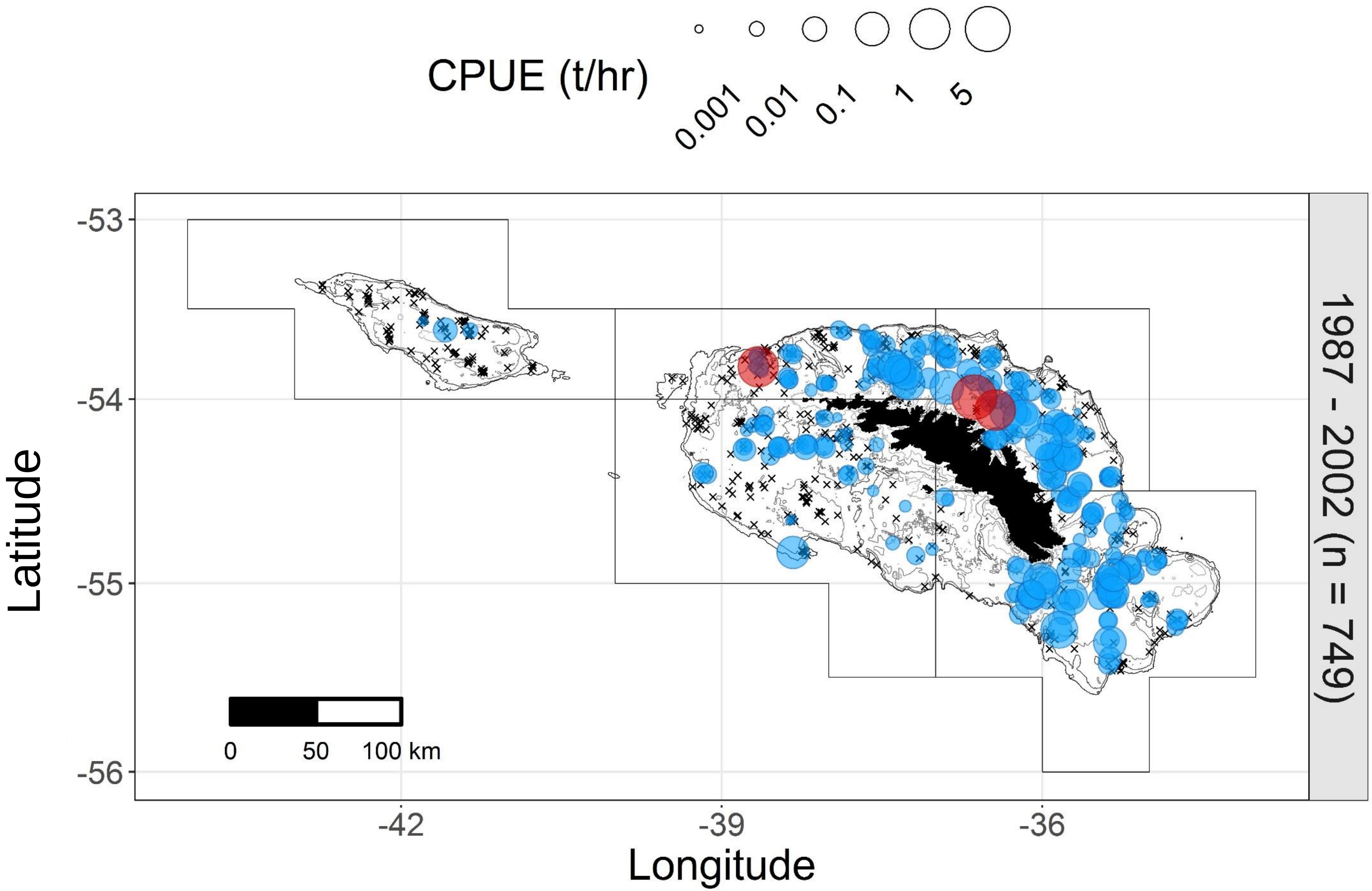
Suspected *N. rossii* larvae have been found on the Western Core Box survey, supporting the idea of offshore spawning

Is *Notothenia rossii* recovering at South Georgia?

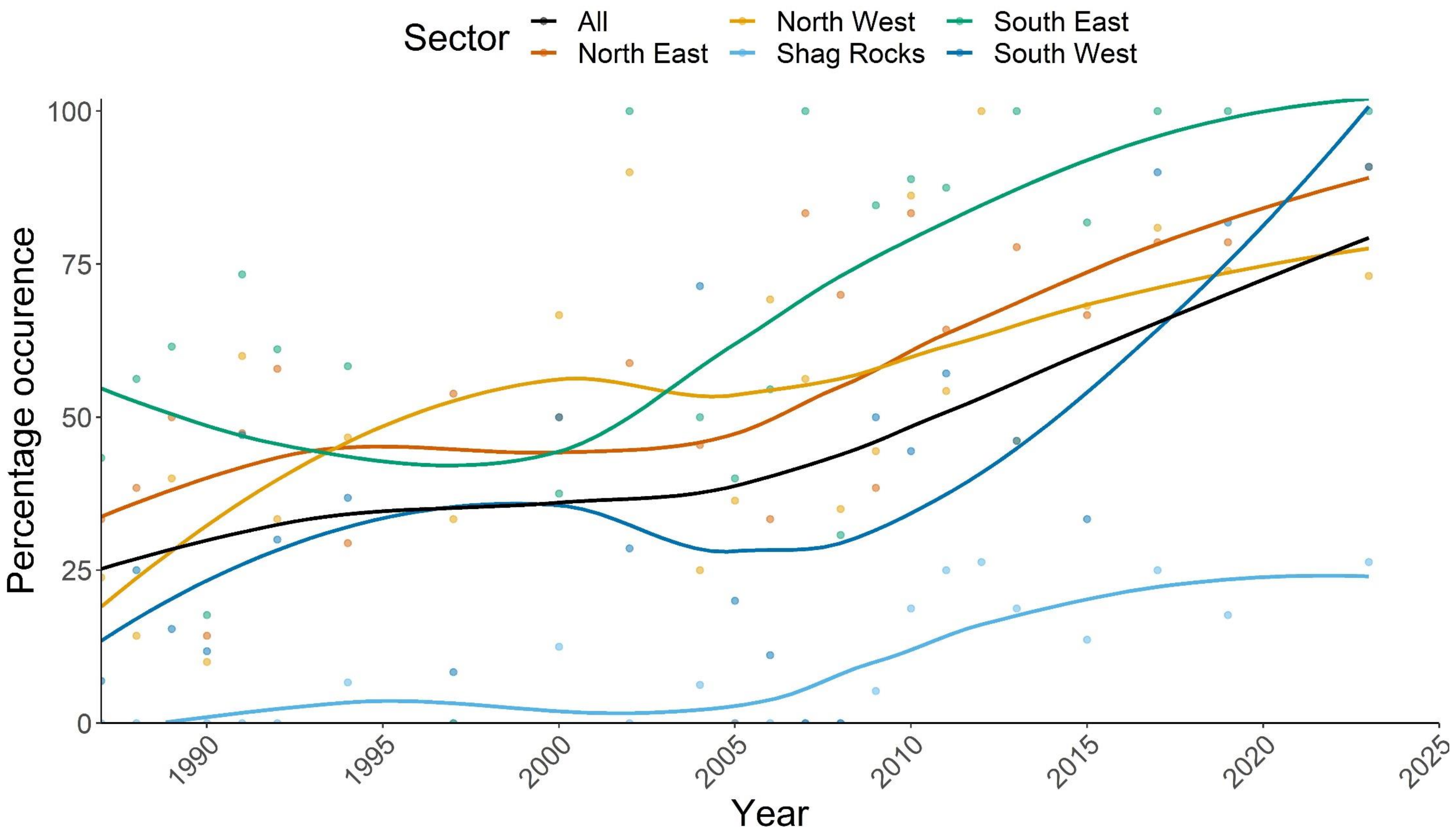
Biomass estimates from the groundfish survey



Change in catch of *N. rossii*



Percentage of survey hauls containing *N. rossii*



Why was there a delay in recovery?

Was the population recovery slowed by the large/recovering populations of fur seals at South Georgia?

- Juvenile *N. rossii* would be prime food for fur seals in shallower water
- Largest catches of *N. rossii* are in the South East where the fur seal populations are thought to be the smallest

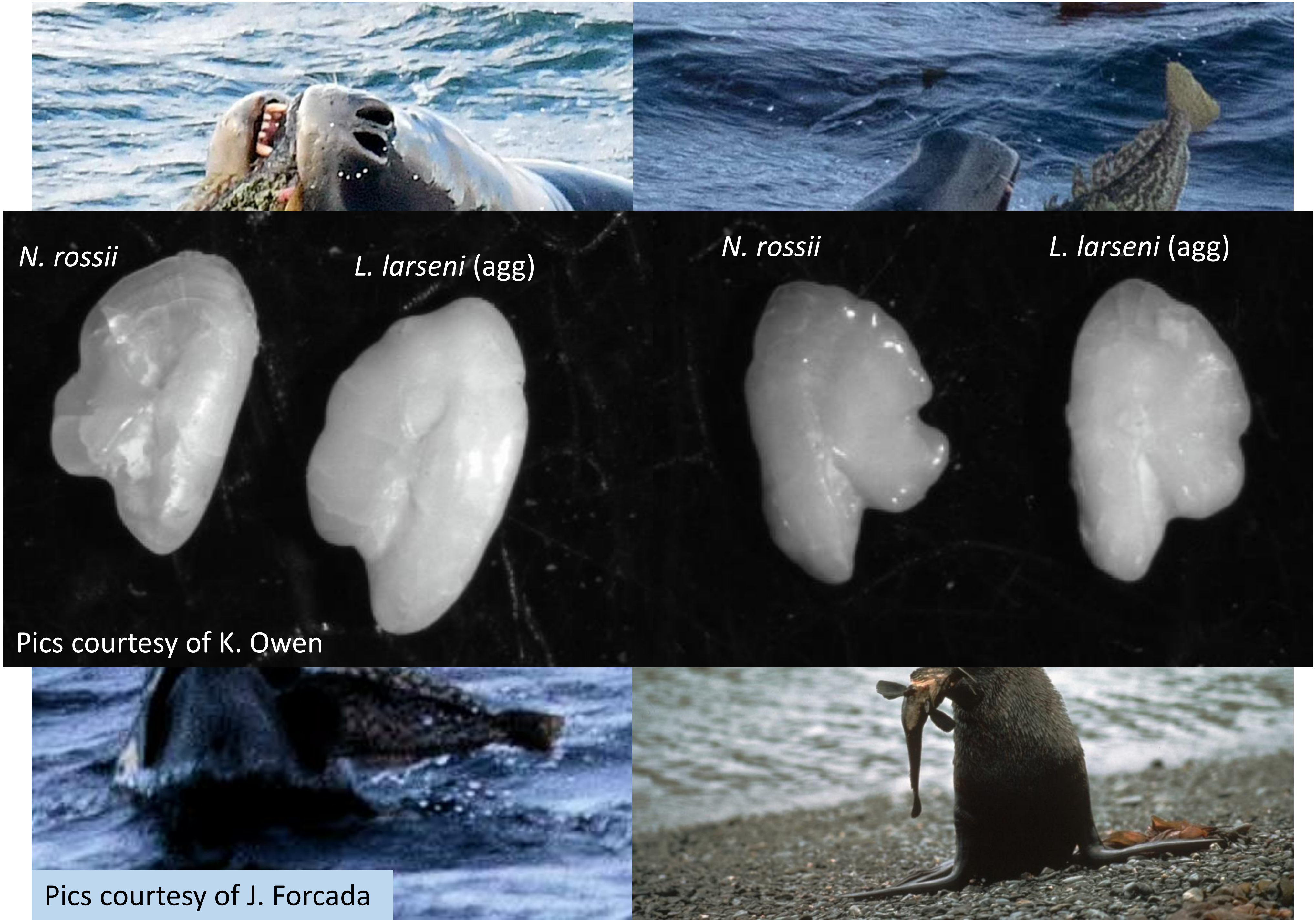
Are they eaten by fur seals?

Not commonly seen in fur seal diet data, even though they are available





Pics courtesy of J. Forcada


N. rossii
L. larseni (agg)
N. rossii
L. larseni (agg)
Pics courtesy of K. Owen
Pics courtesy of J. Forcada

Conclusions

Since 2005, *N. rossii* does appear to be making a recovery at South Georgia – still nowhere near pre-exploitation biomass.

Distribution has also changed with more catches at Shag Rocks

The delay in recovery may have been due to predation on juvenile *N. rossii* by fur seals

Given slow recovery to date it is unlikely that population will fully recover, but was the pre-exploitation biomass representative?

Chris Darby

Centre for Environment, Fisheries and Aquaculture Science

The use of miniature cameras to monitor the behaviour and benthic impact of longline fishing gear at South Georgia

A collaboration between, fishing vessel crew and companies, scientific observers, GSGSSI & Cefas

Blue Belt Programme

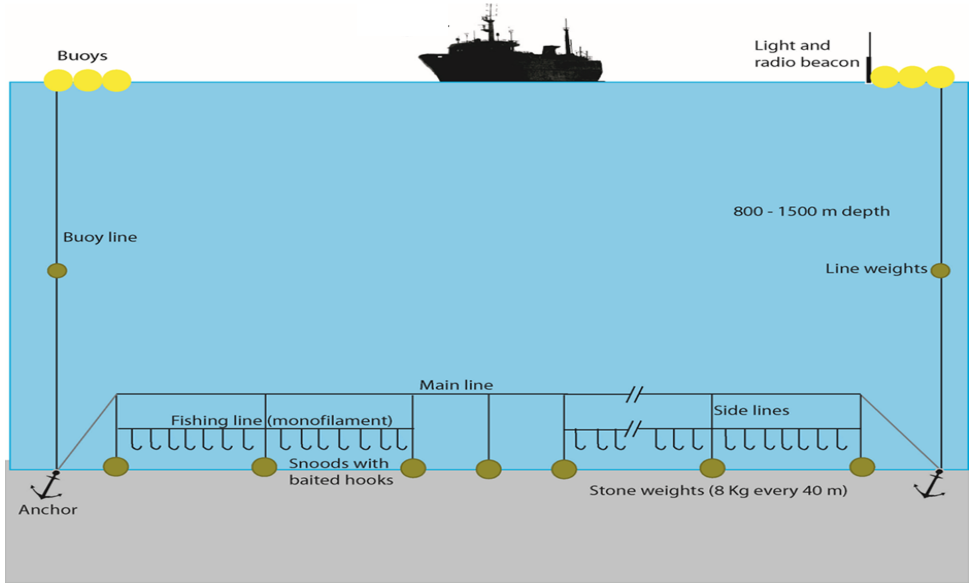
UK Government

Understanding and protecting biodiversity

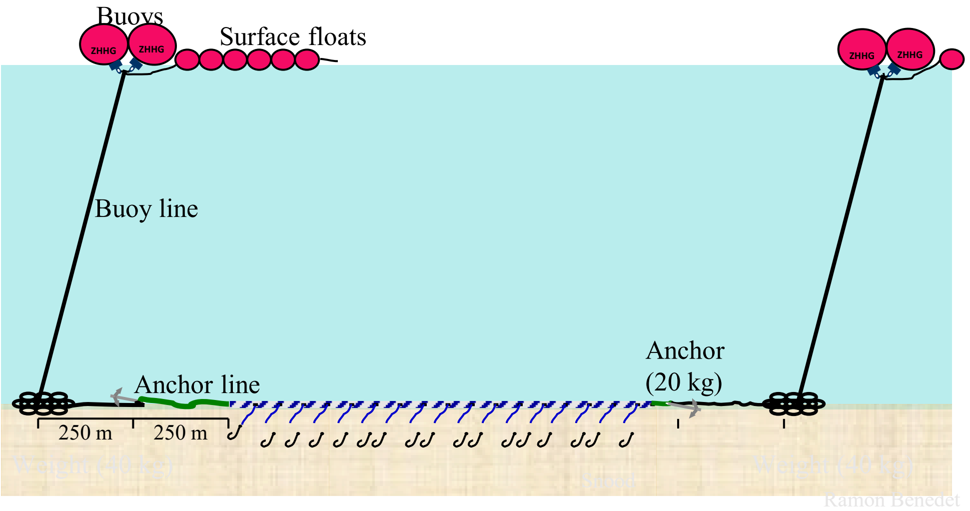
- SGSSI Research and Monitoring plan - Conserve marine biodiversity, habitats and critical ecosystem function. Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent marine ecosystems
- BB programme objectives – Research into the effects of fishing on the SGSSI benthic environment including (i) the novel use of longline-mounted camera systems and their application in marine management (ii) modelling changes in risk to the marine environment due to fisheries displacement.

Benthic fishing gears

Spanish longline



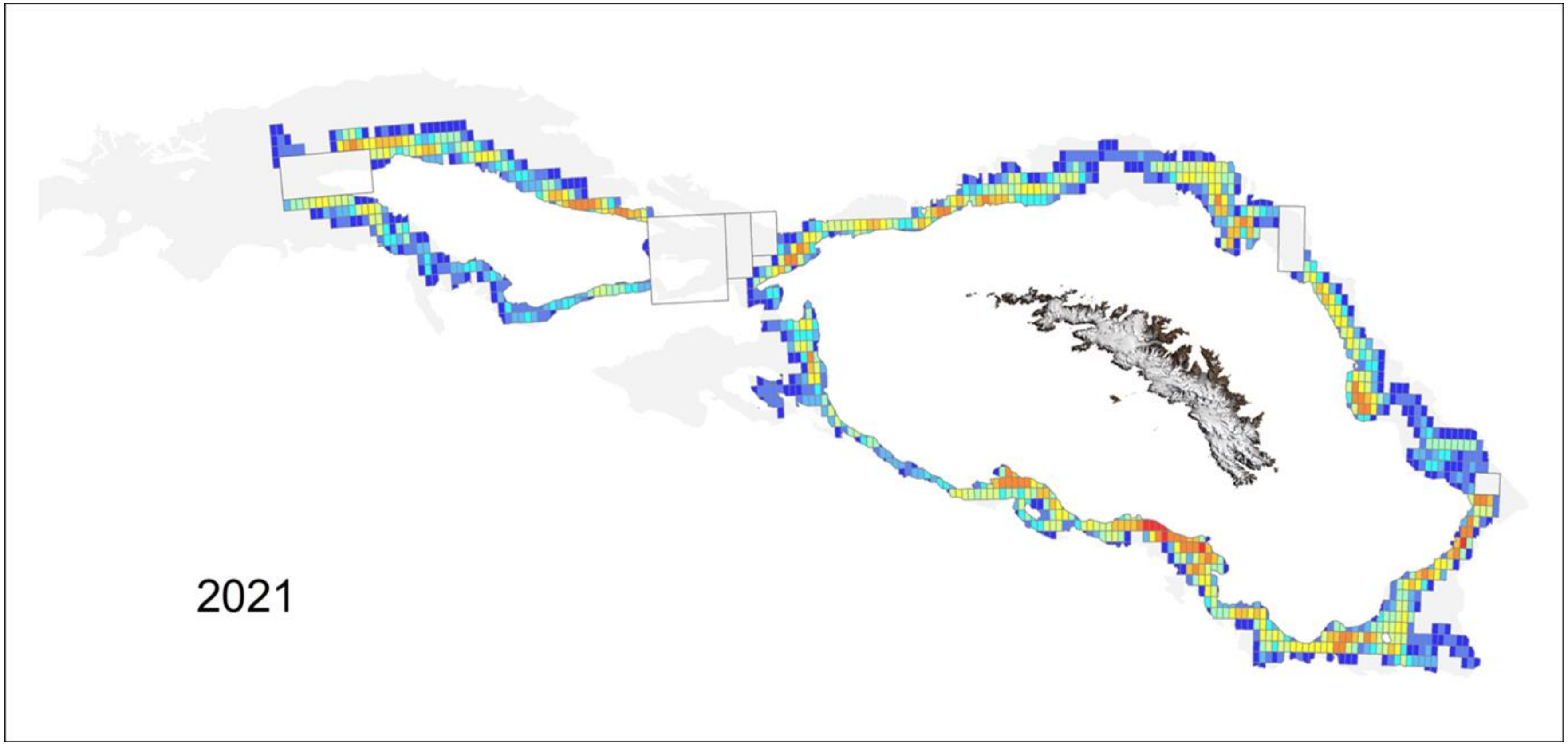
Auto(long)line



Historic fishing patterns

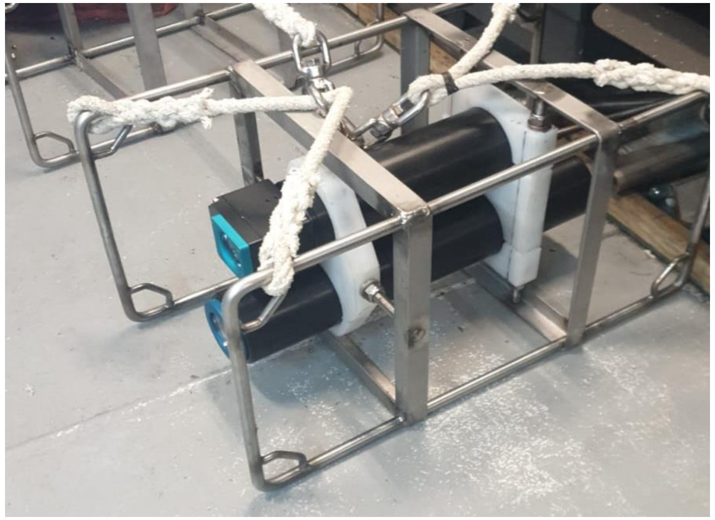
Year	Longline footprint (km2)	% Fishing Zone	% MPA
2012	27.32	0.0707	0.0022
2013	29.33	0.0759	0.0024
2014	28.42	0.0735	0.0023
2015	24.18	0.0625	0.0019
2016	25.03	0.0647	0.0020
2017	23.66	0.0612	0.0019
2018	27.12	0.0701	0.0022
2019	31.23	0.0808	0.0025
2020	28.02	0.0725	0.0023
2021	26.48	0.0685	0.0021

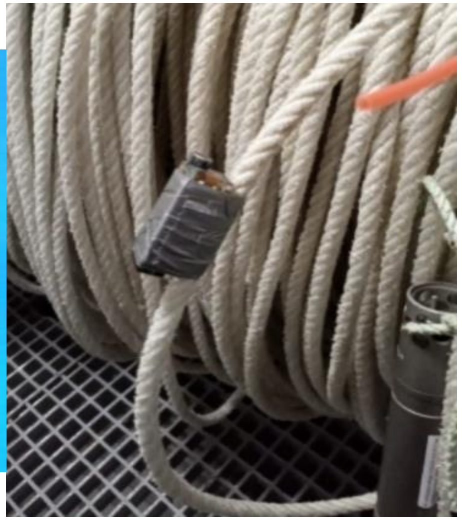
Spatial distribution of longlining



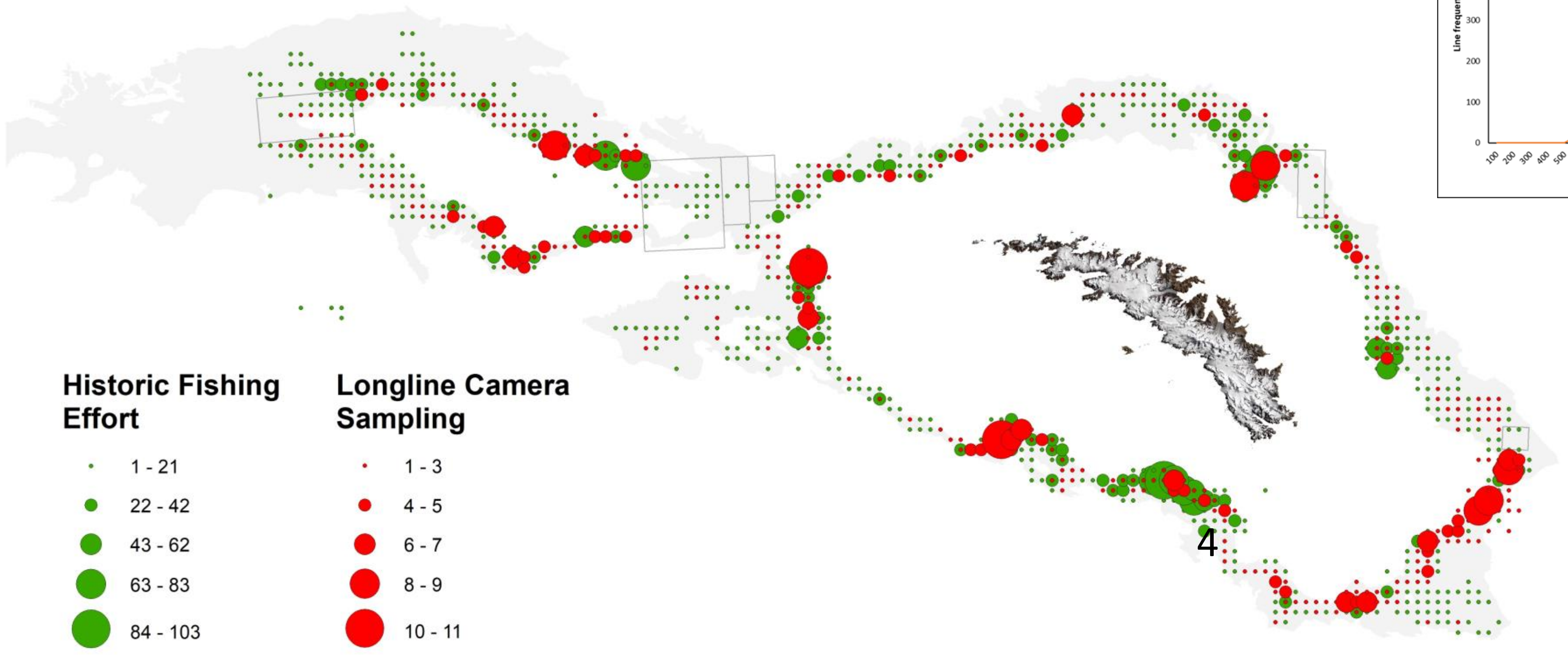
Longline cameras

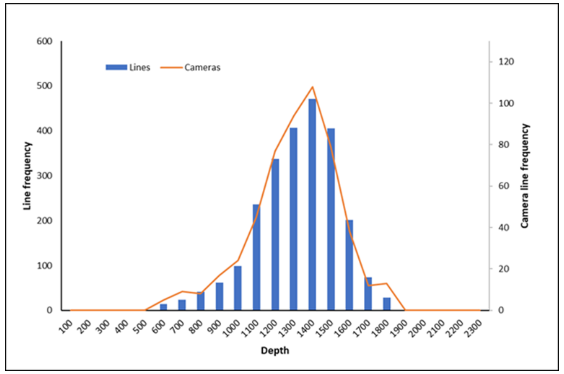
- Three types of cameras: Australian Antarctic Division (AAD), Little Leonardo and GroupB cameras.
- 729 successful deployments of camera systems; ~85% seabed image success rate





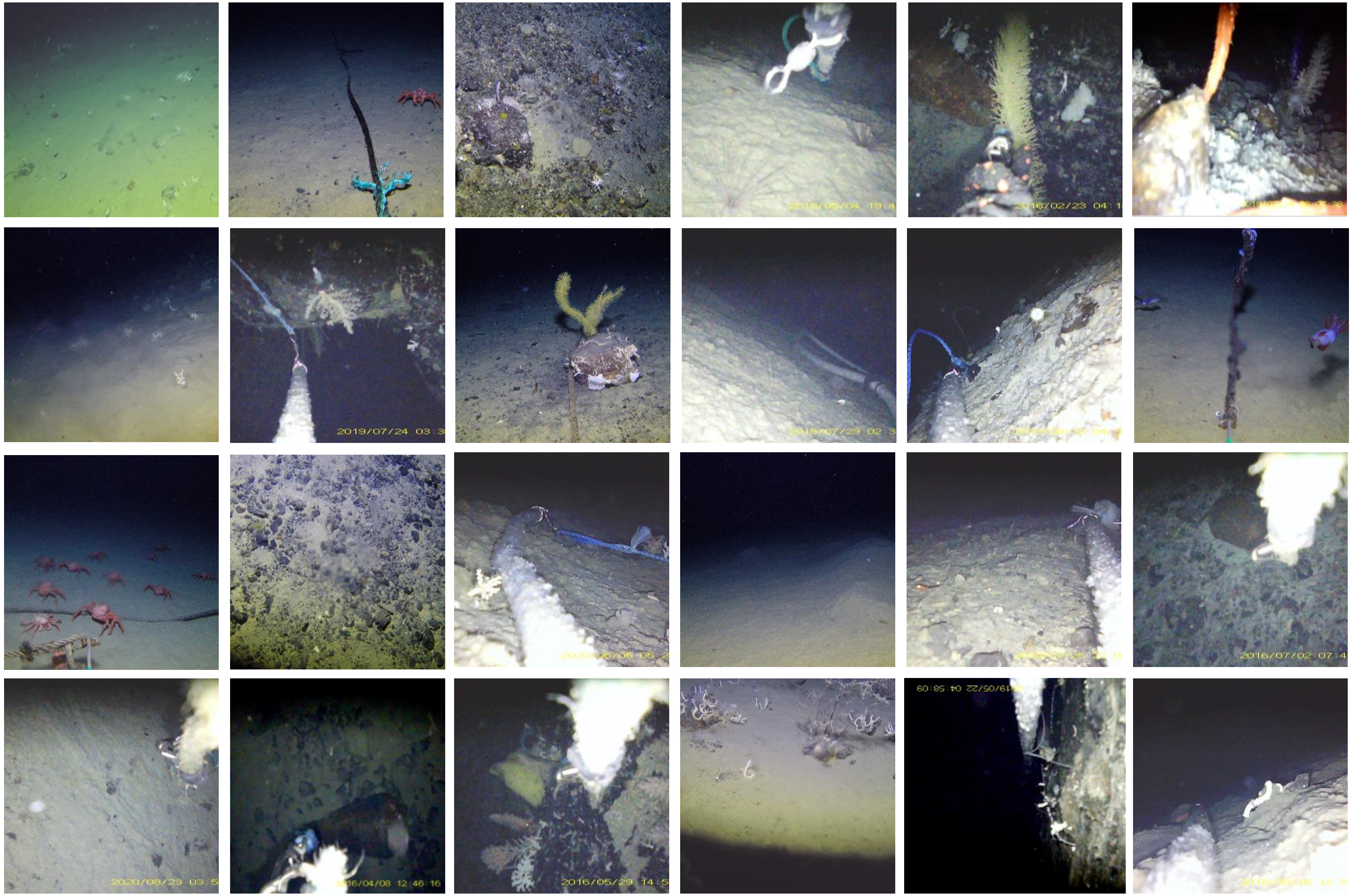
Spatial coverage





- Sediment type
- Benthic organisms
- Line movement
- Other species

Recorded by line #, time, date,

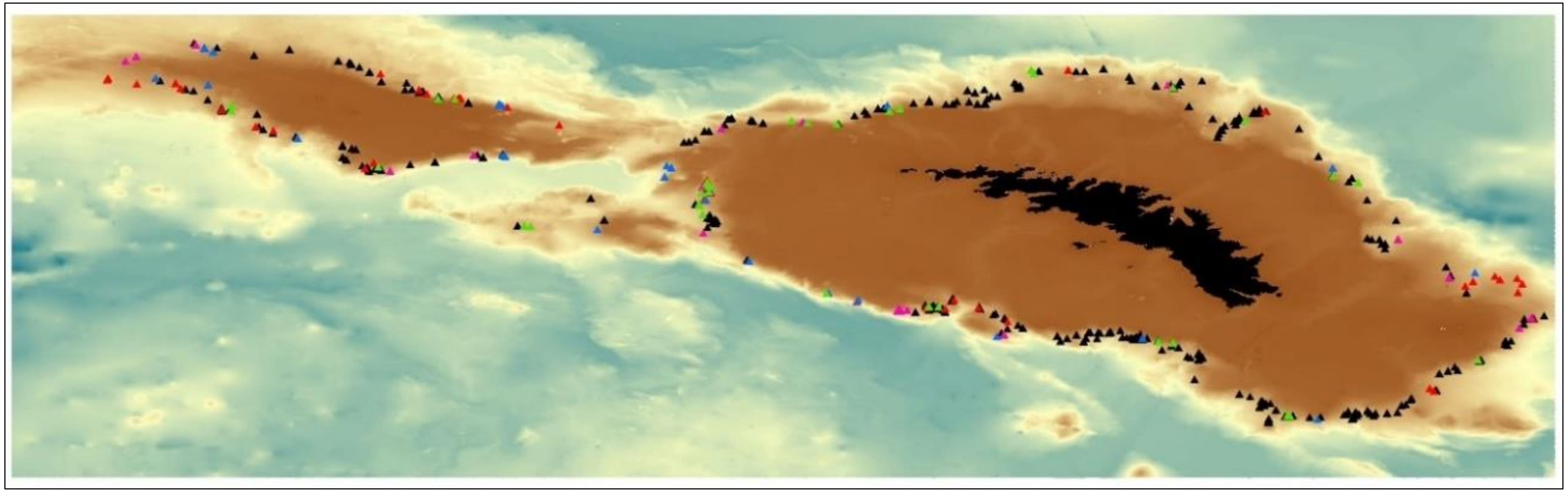


Risk classification

Category	Classification	Frequency in 2018 & 2019
11	Vulnerable benthic species spread across a wide area.	3 lines. 1 within a BCA. 1 research shallow line
1	Wide angle view of dispersed vulnerable species Limited view with frequent abundance.	9 lines. 2 research shallow lines.
0.5	Static line – frequent species in restricted area (e.g. on dropstone) with good view of surroundings with low abundance. Moving line – sparse individuals across a wide area.	13 lines.
0.1	Sparse dropstones or low frequency of species (one or two individuals).	22 lines.
0	Bare areas.	479 lines.

Substrate

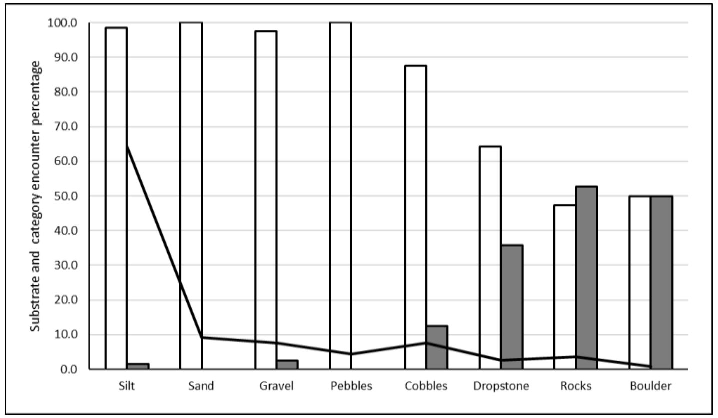
Substrate	Silt	Sand	Gravel	Pebbles	Cobbles	Dropstone	Rocks	Boulder
Proportion	0.64	0.09	0.08	0.04	0.08	0.03	0.04	0.01

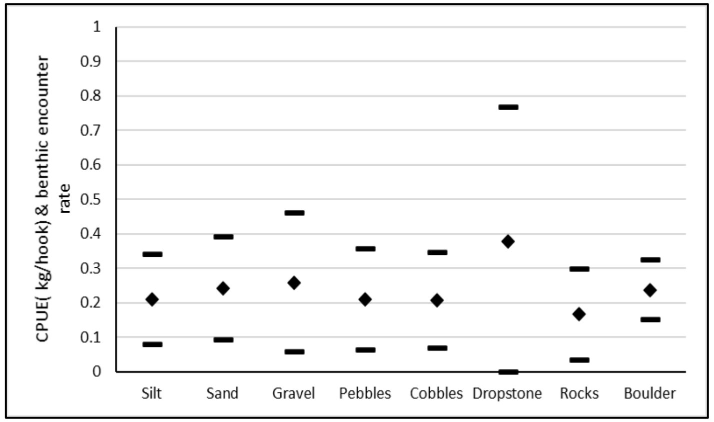


Silt – black, sand – red, gravel – blue, pebbles – pink and cobbles – green

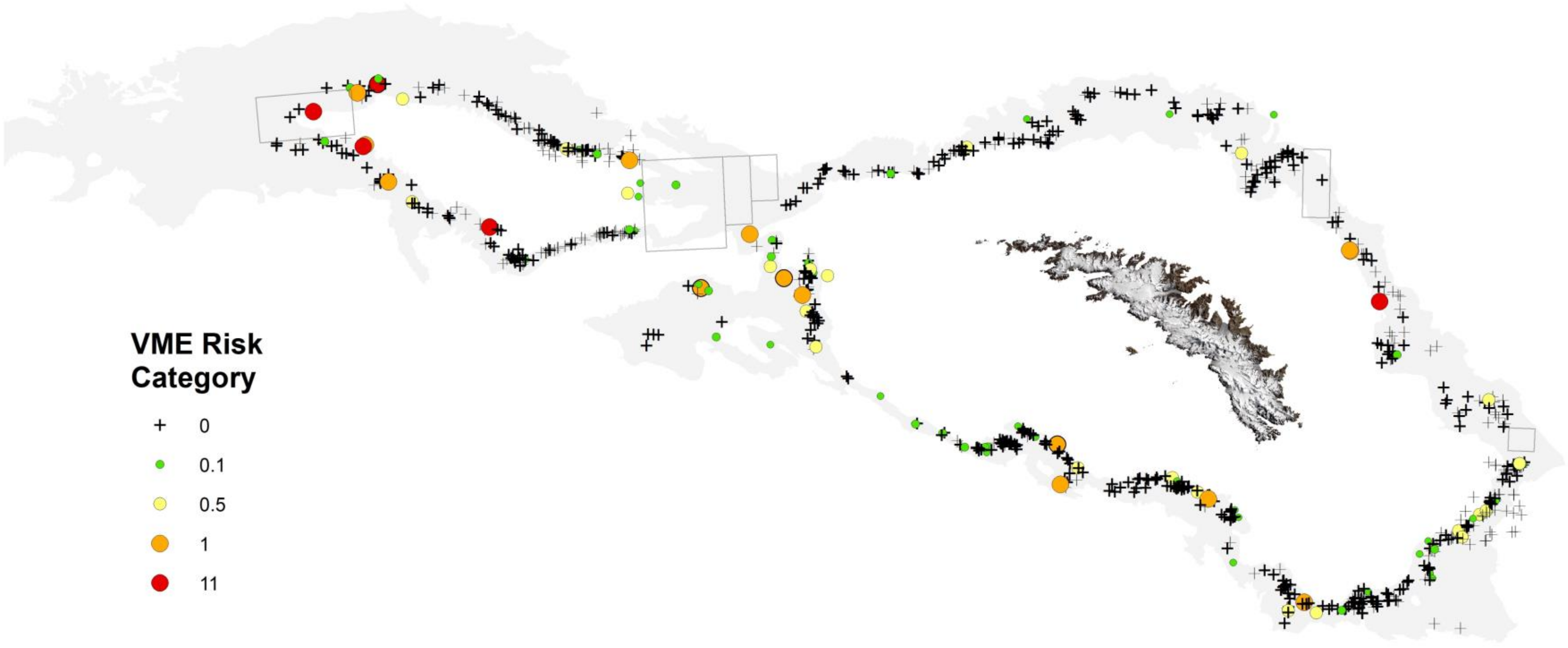
Risk category by substrate type

Category	Silt	Sand	Gravel	Pebbles	Cobbles	Dropstone	Rocks	Boulder
0	97.3	98.0	85.0	91.3	77.5	42.9	36.8	25.0
0.1	1.2	2.0	12.5	8.7	10.0	21.4	10.5	25.0
0.5	0.6	0.0	0.0	0.0	5.0	28.6	15.8	50.0
1	0.6	0.0	2.5	0.0	7.5	0.0	26.3	0.0
11	0.3	0.0	0.0	0.0	0.0	7.1	10.5	0.0





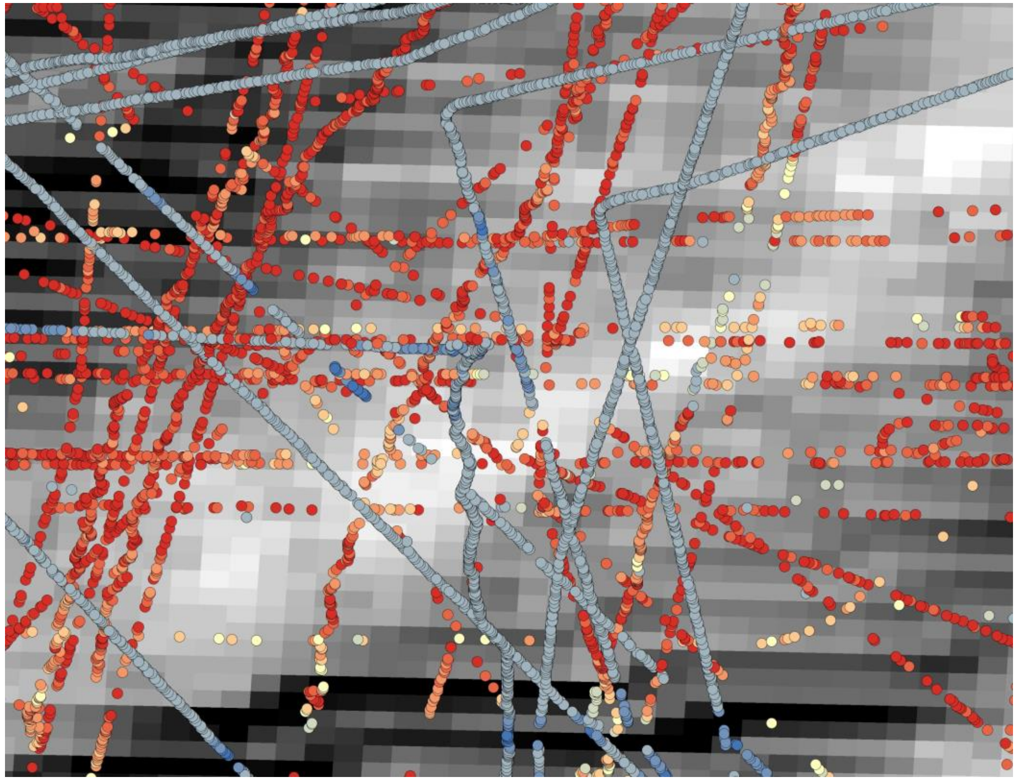
Risk distribution



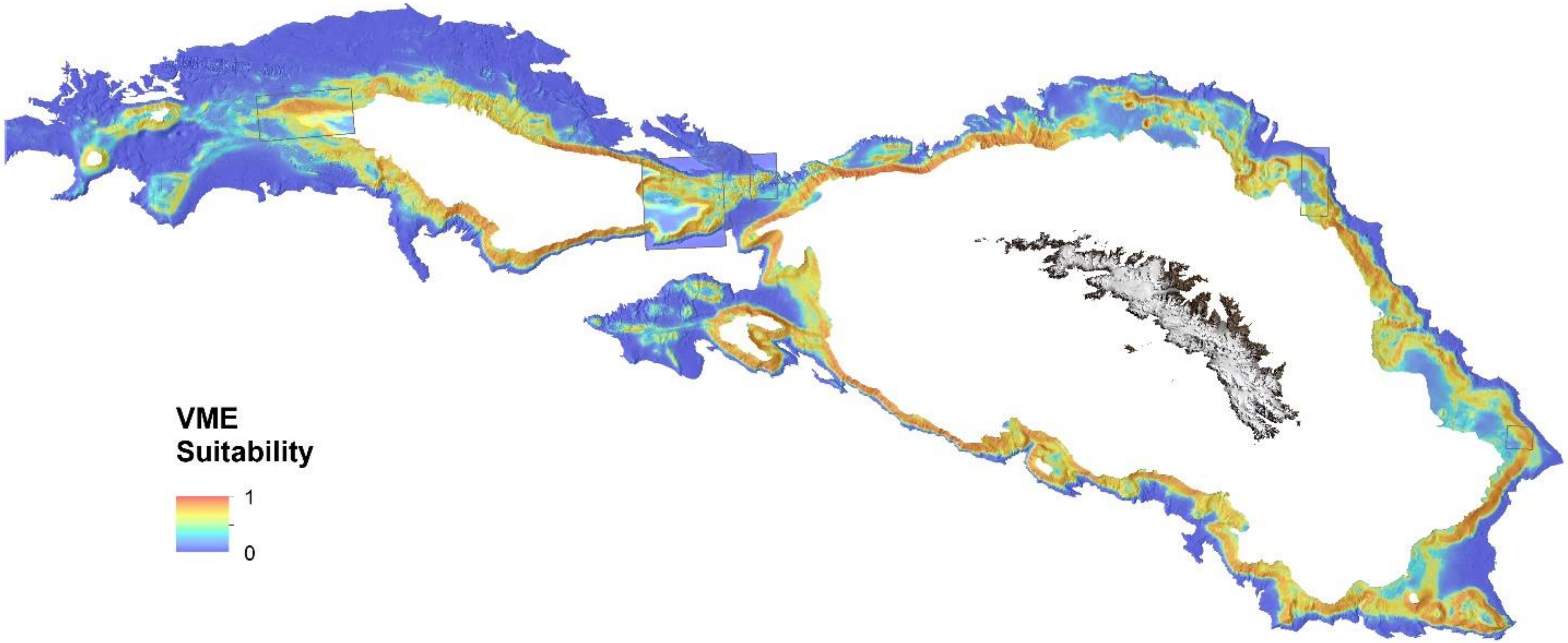
Line movement

Camera Protocols SG23

Olex bottom hardness data from fishing vessels

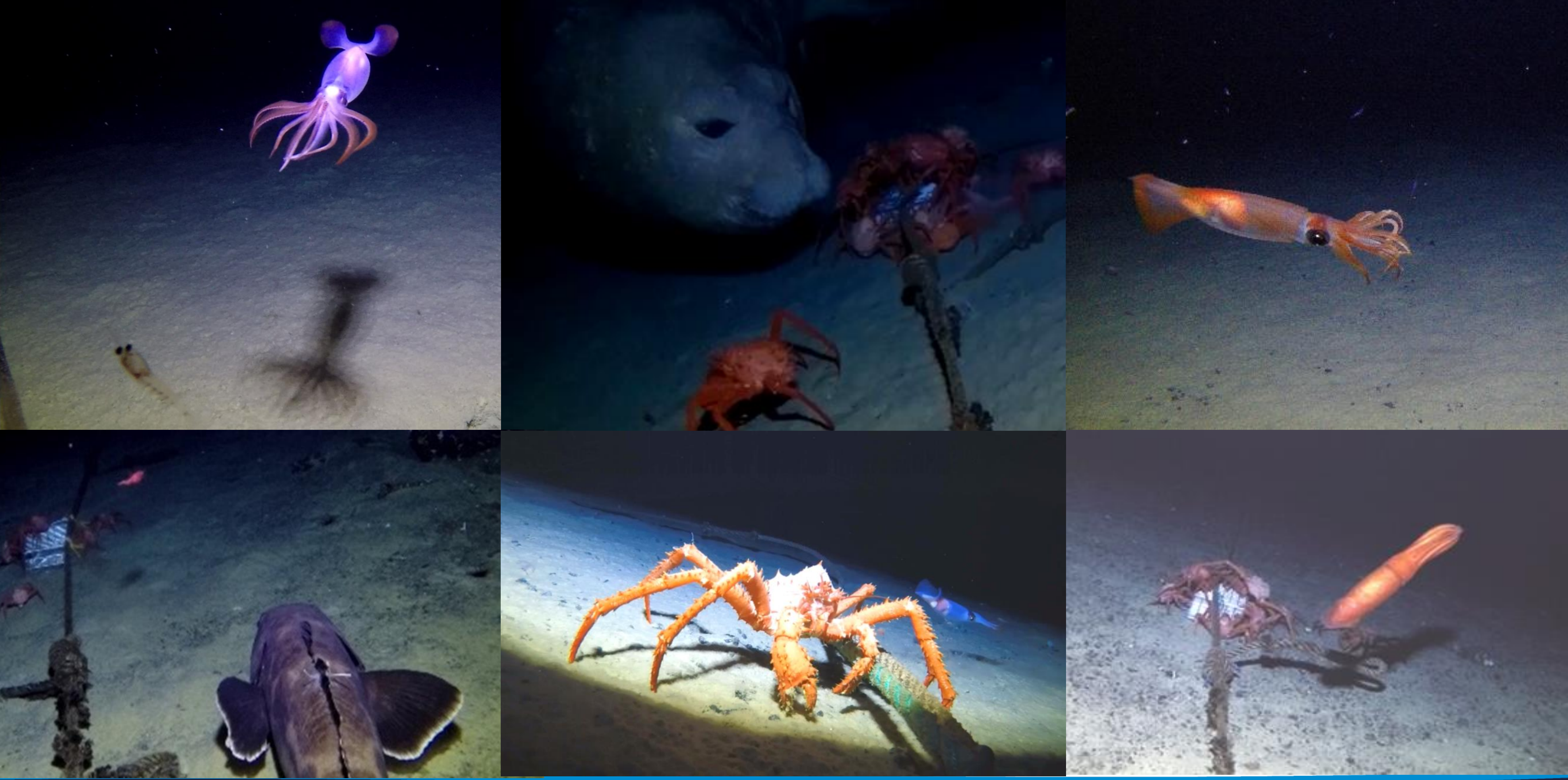


VME Modelling



Understanding and protecting biodiversity

- Small fishing footprint with limited lateral line movement.
- Fishing activity mostly occurrs in regions of low or no VME
- VME indicator taxa common, but VME rare in the fishing areas
- Management protocols established to address identified VME locations.
- Risk tool to evaluate risk of increased VME interactions when introducing management measures.
- Very successful collaboration between GSGSSI, industry and science.
- Only possible with the initial trial investment from Blue Belt
- Links to similar results from the DY99 SSI survey.



Connor Bamford

British Antarctic Survey

– Patagonian toothfish spawning at South Georgia –

What 25 years of fishery data show

Connor Bamford

Phil Hollyman

Martin Collins

Chris Darby

José Abreu

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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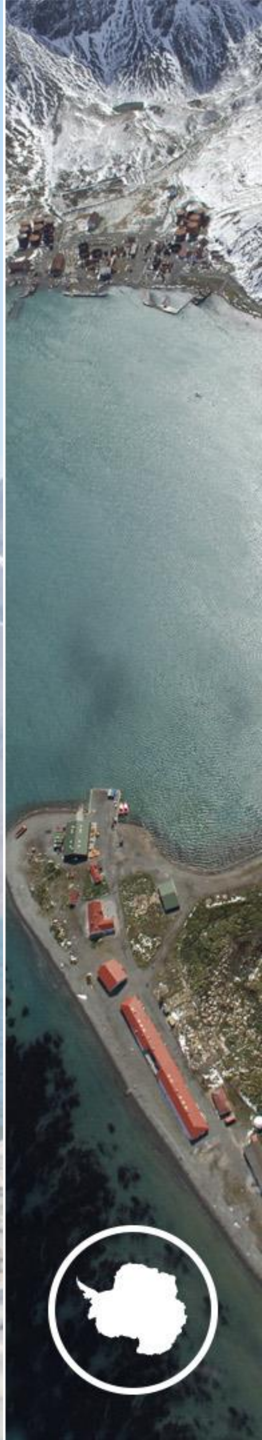
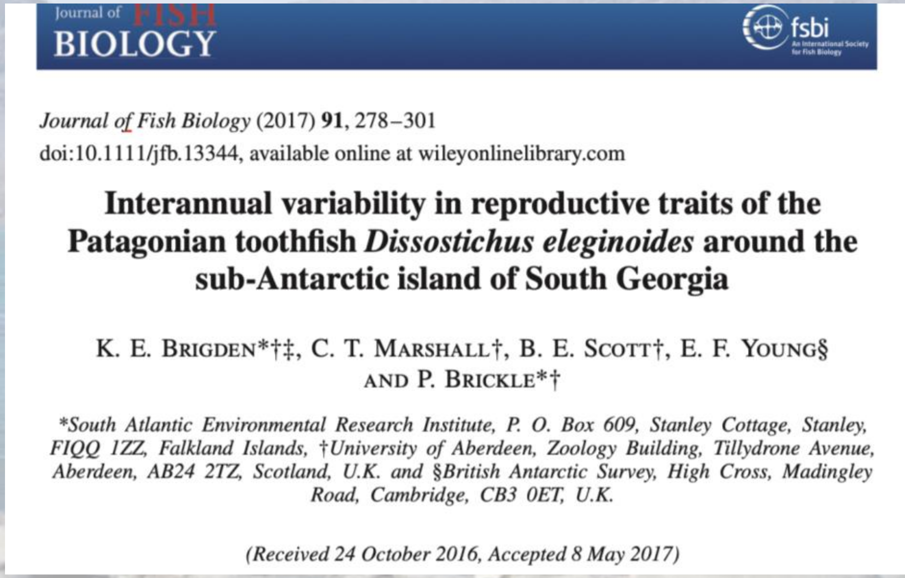


Rationale

- Toothfish spawning at South Georgia is:
  - Not discrete, occurs island-wise - unlike on the Patagonian shelf
  - There has been an apparent shift to later spawning

- Given recent extraneous factors & events, we re-examined these patterns with 7 years of additional data


Journal of FISH BIOLOGY
fsbi An International Society for Fish Biology
Journal of Fish Biology (2017) **91**, 278–301
doi:10.1111/jfb.13344, available online at wileyonlinelibrary.com

Interannual variability in reproductive traits of the Patagonian toothfish *Dissostichus eleginoides* around the sub-Antarctic island of South Georgia

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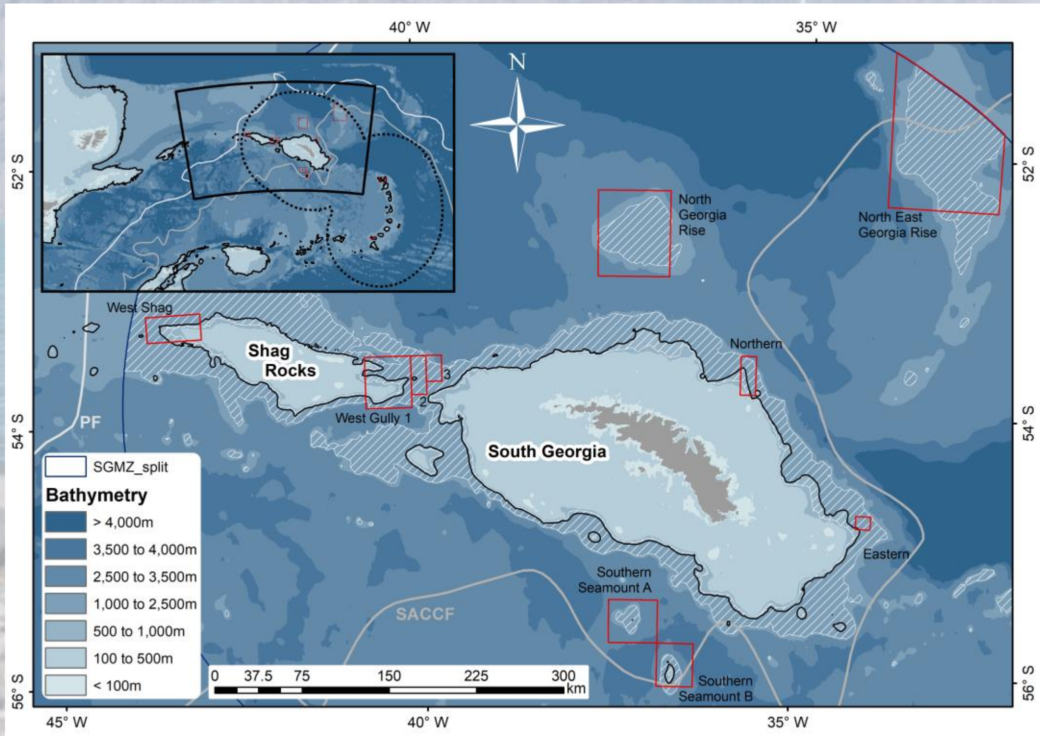
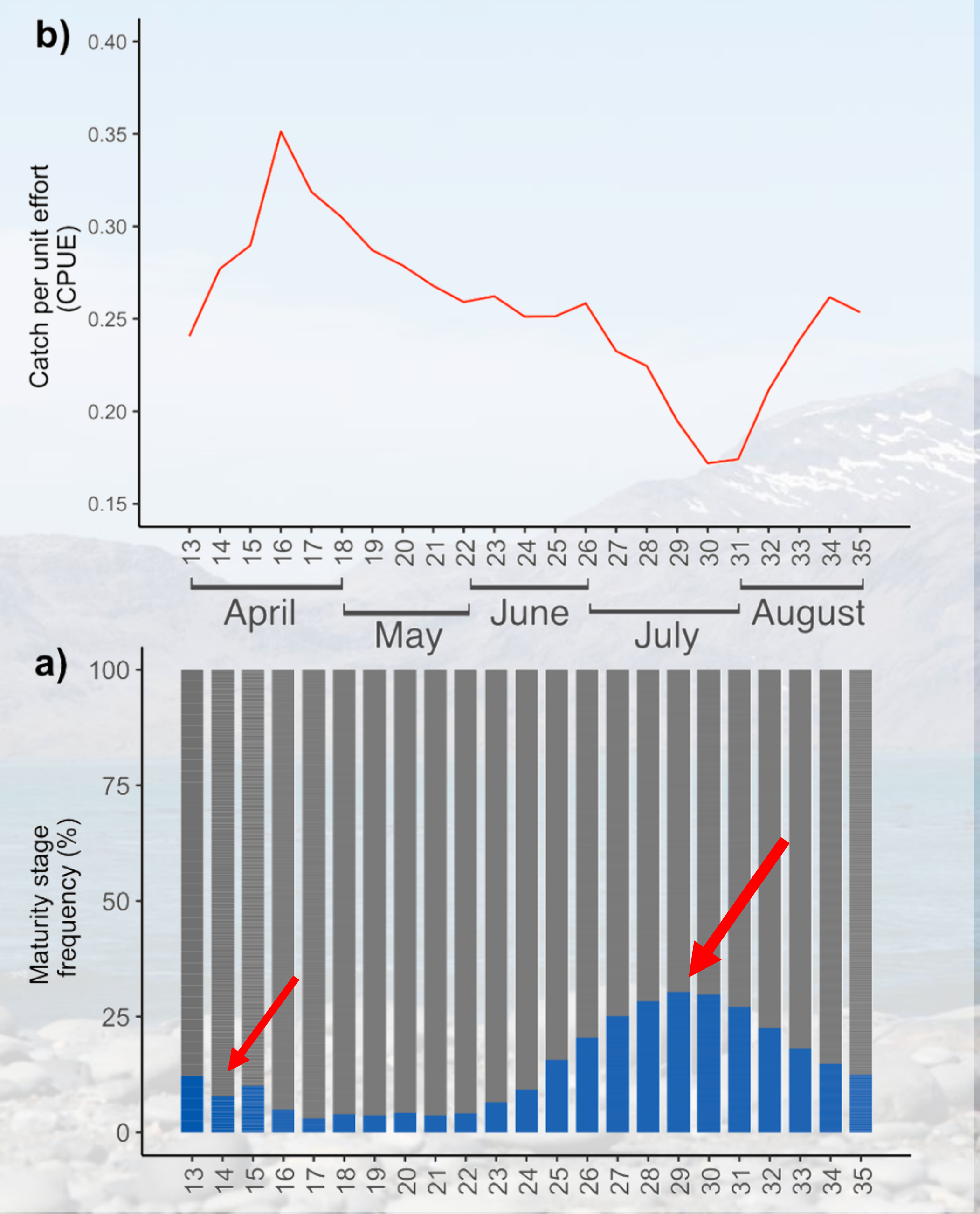
**South Atlantic Environmental Research Institute, P. O. Box 609, Stanley Cottage, Stanley, FIQQ 1ZZ, Falkland Islands, †University of Aberdeen, Zoology Building, Tillydrone Avenue, Aberdeen, AB24 2TZ, Scotland, U.K. and §British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, U.K.*

(Received 24 October 2016, Accepted 8 May 2017)

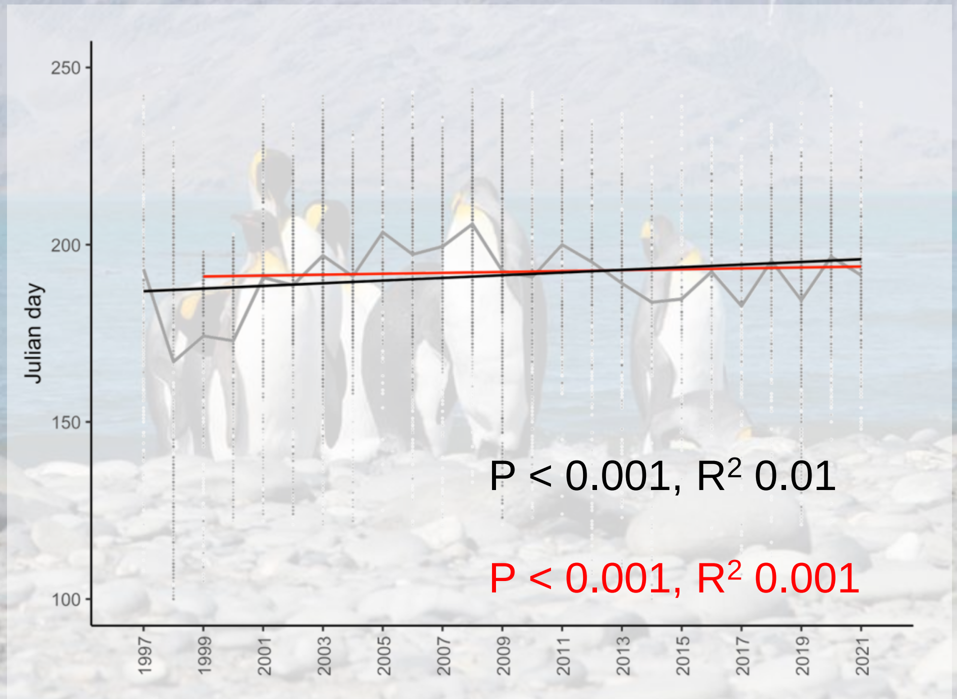


Data of the fishery



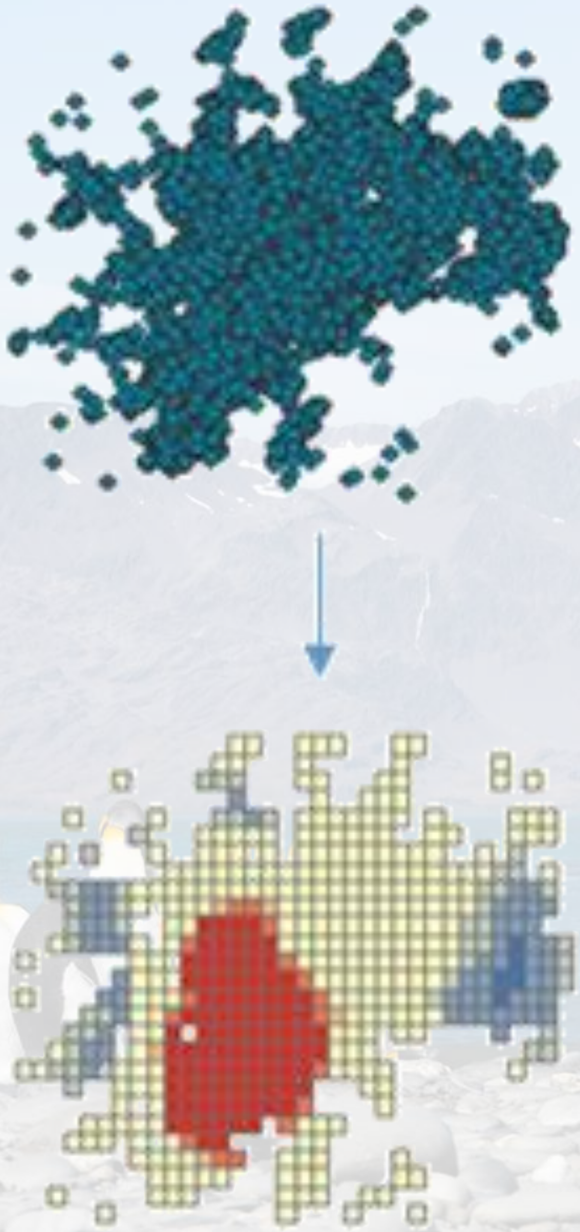
Data show that:

- Catch fluctuates through the season
- Significant drop in CPUE in July
- But spawning catch increases during July
- Hints of a **dual peak** in spawning
- Shift to later spawning has minimal ‘real-world’ impact

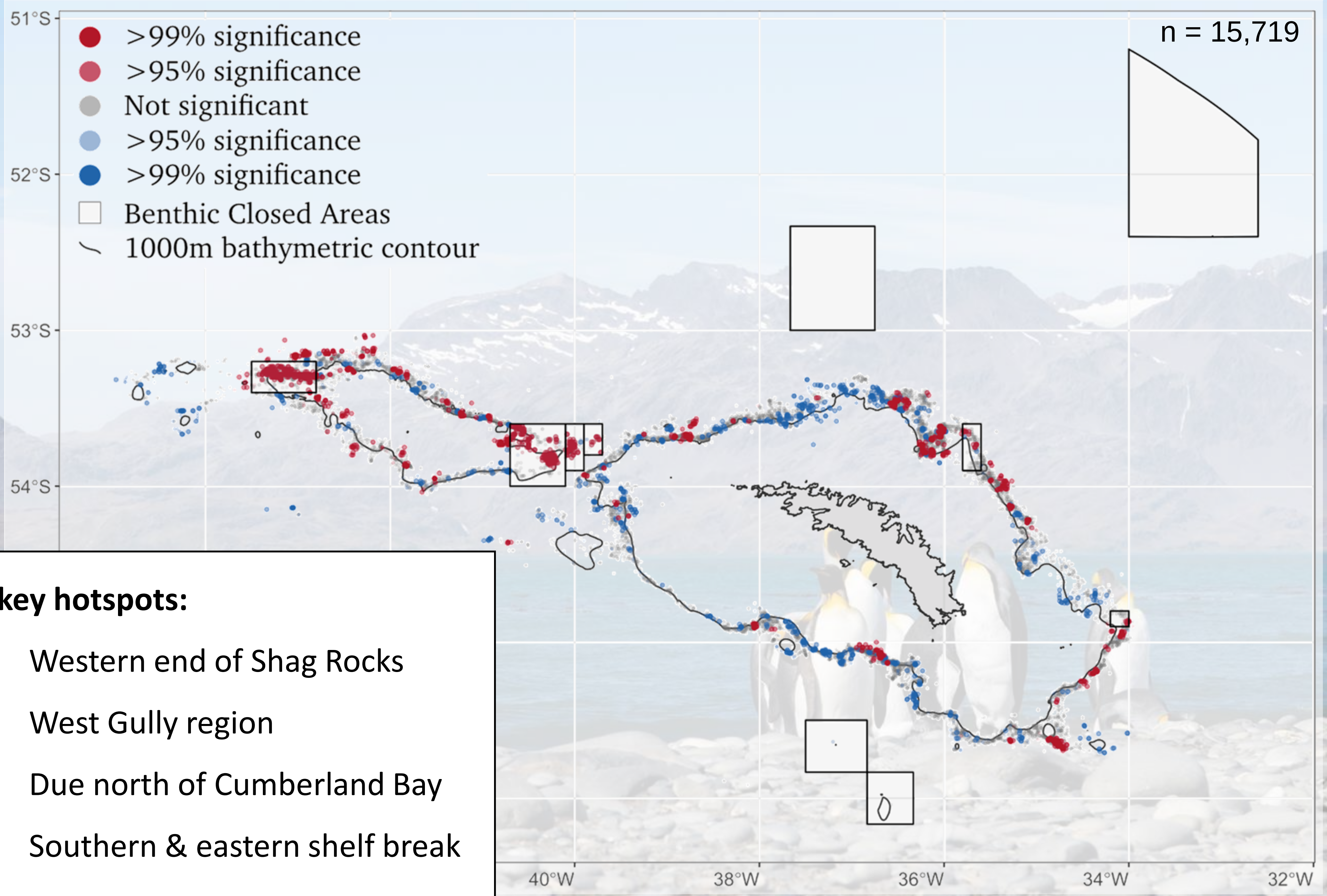


Spatial patterns in toothfish spawning…

- Stage 4 data (spawning fish) only
- *Getis-Ord Gi** hotspot analysis
- Examines spatial clustering in point data
- Z-score output translated to P-values to yield hot and coldspots



Results: spawning hotspots 1997 to 2021



Several key hotspots:

- Western end of Shag Rocks
- West Gully region
- Due north of Cumberland Bay
- Southern & eastern shelf break

Key outcomes

- **More spawning males** are caught than females
- Spawning occurs **island wide**, but **hotspots** are present
- There is evidence of a **dual peak** in spawning at SG
- **Drop in CPUE during spawning** suggests that toothfish have a natural reduced catchability
- There is a high degree of **overlap between spawning hotspots** and the network of **Benthic Closed Areas** around South Georgia

References

- Brigden, K.E., Marshall, C.T., Scott, B.E., Young, E.F., Brickle, P., 2017. Interannual variability in reproductive traits of the Patagonian toothfish *Dissostichus eleginoides* around the sub-Antarctic island of South Georgia. Journal of Fish Biology 91 (1), 278-301. doi: 10.1111/jfb.13344

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James Moir Clark

Marine Resources Assessment Group


ESA


Sue G


Judith Brown

The Use of Electronic Monitoring to Assess the Risks of Net Monitoring Cables

South Georgia MPA Symposium 13th - 14th June 2023

James Moir Clark – j.clark@mrag.co.uk

MRAG

Background

- Net monitoring cables (NMC) allow expanded data flow for improved catch reporting and monitoring of net performance.
- 1991 CCAMLR adopted a Conservation Measure prohibiting the use of net monitoring cables (NMC) from the 94/95 fishing season.
  - Concern over bird mortalities in trawl fisheries off Kerguelen and Soviet squid trawl fishery.
- Solutions considered by CCAMLR at the time included making the wire more visible through larger diameter or fitting high visibility streamers.
- Both options thought too expensive and switching to an acoustic link would be cheaper over time.

Background

- Due to changes in technology / trawling techniques Norway proposed reintroduction of the NMC.
- CCAMLR agreed to a trial for 2020 season:
  - 100% observer coverage, observers to monitor NMC and warp at least twice daily;
  - Use of a electronic monitoring (cameras);
  - Use of mitigation measures.
- Trial was further extended to 2021 and 2022 seasons with increased coverage (~20%) using electronic monitoring and shore based observers.

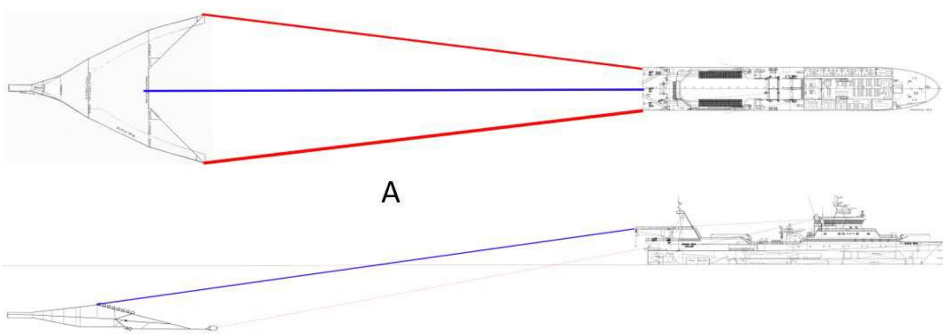
Why use a Net Monitoring Cable

Can help understand gear performance while fishing as well as how it interacts with marine life.

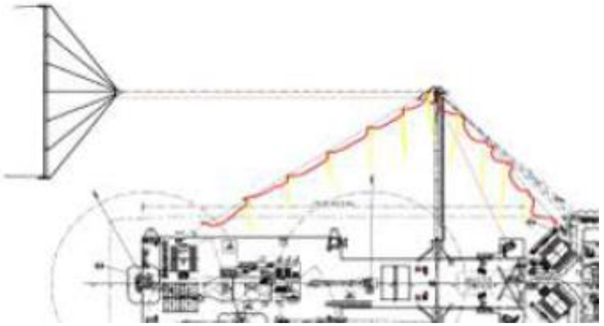
Specifically:

- Monitoring activity of predators in relation to gear and predator exclusion devices
- Monitoring of short-term gear performance
- Monitoring krill behaviour in relation to gear with attached camera systems

Change in NMC configuration.



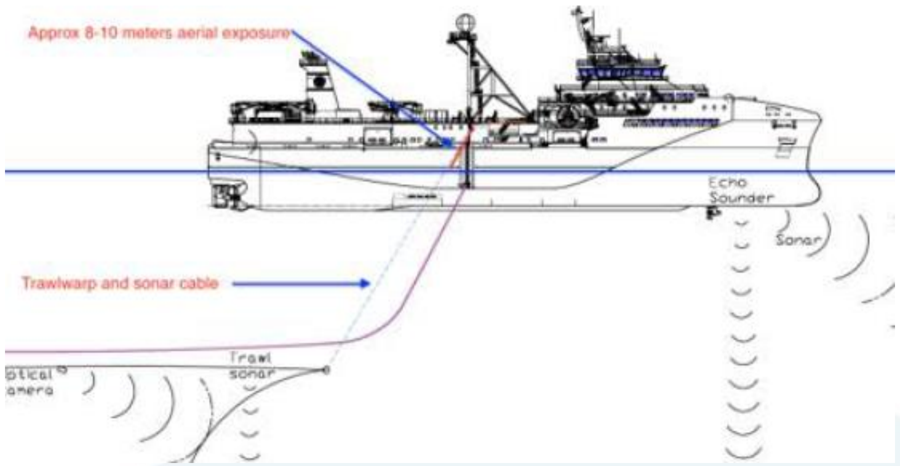
A



B

A) Squid trawler (3rd wire).

B) Kill trawler (parallel to warp, reduced aerial exposure).



Methodology

- Observation rates were raised through increased observations at sea (on deck and electronic monitoring) and on land though video observations, for part of the season.
- Strikes classified by what they hit (cable, warp, mitigation, unknown) and ‘type’ of strike.
  - **Aerial:** The bird contacts the warp in the air and hits the water with little to no control of its flight.
  - **Water:** The warp contacts the bird, driving any part of the body beneath the surface of the water, but not fully submerged.
  - **Sinker:** The warp contacts the bird and the entire body is submerged
  - **Light:** Warp contacts the bird, no contact with water is made.

Results

- Observation rates increased from ~2% for normal CCAMLR monitoring (2 x 15min deck observation periods / day) up to >20% using electronic monitoring (at sea and shore based) and increased deck observations.
- Observation rate at 22.6% between March and June 2022.
- Combination of deck observations (24%) and video Monitoring (76%)

Results 2021

			Cable					Warp					Both			Mitigation			Unknown			
			Aerial	Air	Light	Sinker	Water	Aerial	Air	Light	Sinker	Water	Aerial	Air	Light	Aerial	Air	Light	Aerial	Light	Water	Total
Trial 2	Antarctic Endurance	BIZ																	1		1	2
		DAC	2							1												3
		FUG																				0
		MBX																				0
		PWP	4		10			16		21	1		1					1				54
		TAA						2		3	1	1										7
	Antarctic Sea	BIZ																				0
		DAC	5					5					1									11
		FUG	1																			1
		MBX											1									1
		PWP	2		1			9											1			13
		TAA	1					1		1												3
	Saga Sea	BIZ																				0
		DAC	16	16		1	5	7	7	1	2	1			2				1			59
		FUG					1															1
		MBX																				0
		PWP	80		24	9	1	14		14	2				2	1			1	1		149
		TAA	1		2	1		1														5
		Total	112	16	37	11	7	55	7	41	6	2	3	0	4	1	0	1	4	1	1	309

Results 2022

			Cable					Warp					Both			Mitigation			Unknown			
			Aerial	Air	Light	Sinker	Water	Aerial	Air	Light	Sinker	Water	Aerial	Air	Light	Aerial	Air	Light	Aerial	Light	Water	Total
Trial 3	Antarctic Endurance	BIZ																				0
		DAC	1		1																	2
		FUG																				0
		MBX																				0
		PWP																				0
		TAA																				0
	Antarctic Sea	BIZ																				0
		DAC						1		1		1	1							1		5
		FUG																				0
		MBX																				0
		PWP																				0
		TAA																				0
	Saga Sea	BIZ																				
		DAC	43		2	1	14	4								1		1	1	1		68
		FUG						1														1
		MBX																				0
		PWP																1				1
		TAA																				0
		Total	44	0	3	1	14	6	0	1	0	1	1	0	0	1	0	2	1	2	0	77

Conclusion

- Trials gone over three seasons with increased observer coverage to collect baseline data.
- Difficulties with monitoring at night and in poor weather conditions.
- Maintaining observation rate of >20% not feasible (required three observers over 5 weeks monitoring ~4 hours of footage a day).
- Mitigation measures were shown to be effective resulting in reduced coverage (5%) for vessels that have undertaken trial.
- AI is being developed.

Implementation details

- Used footage from trials to track birds and cables (if they are thick enough in image), although problems with some footage due to the position of the of the cameras and the granularity of the footage.

- In this case machine learning (not deep learning) was used to detect or track the birds and ship lines.
    - Helps understand the scene from a computer vision perspective.
  - At the time, unaware of any deep learning methods that will track these cables well. Deep learning object tracking requires more annotated data, e.g. for of out-of-plane movement (birds shrink and sometimes disappear into the background).

- Strike detection requires multiple factors including bird acceleration

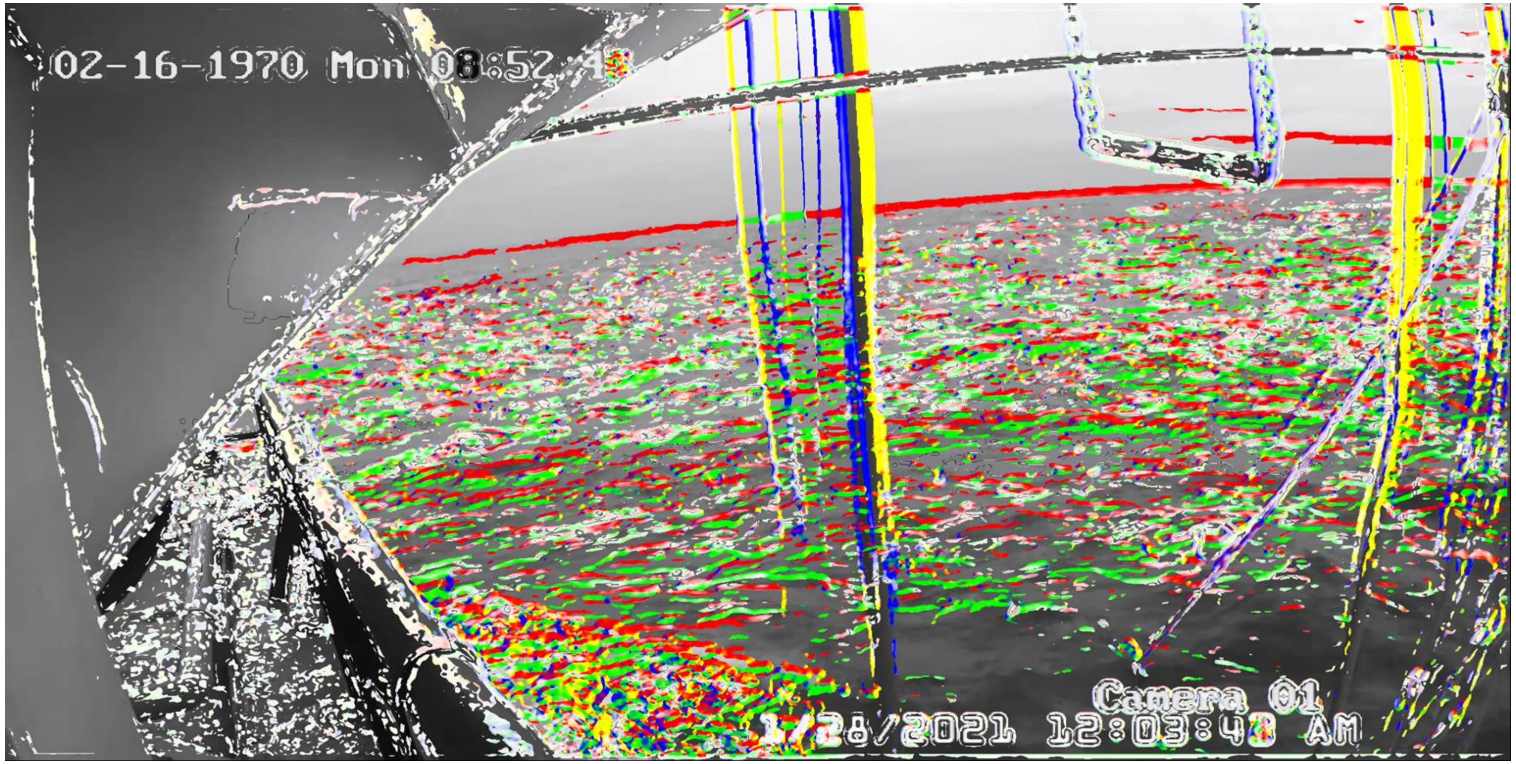
Scene details

Scene is noisy

- Wave breaks and birds can be visually similar
- Birds at a distance can be too small for detection
- Foreground cables can occlude birds

Smaller cables can be difficult to detect and track

Target ship cables move ~1-3 pixels



Movement in the image over 1 second. Warm colours show larger movement. Cool colours (and white) show smaller movement.


Object velocity over time
Magnitude
Frame number
Mon 08:52:39
Strike
Play
Camera 01


Object velocity over time
Magnitude
Frame number
Mon 08:52:42
Strike
Play
Camera 01


Object velocity over time
Magnitude
Frame number
Mon 08:52:43
Strike
Camera 01


Object velocity over time
Magnitude
Frame number
Mon 08:52:43
Strike
Camera 01

MRAG


Object velocity over time
Magnitude
Frame number
Mon 08:55:30
No strike
Camera 01


Object velocity over time
Magnitude
Frame number
Mon 08:55:31
No strike
Camera 01

Object velocity over time
Magnitude
Frame number
Mon 08:55:31
No strike
Camera 01


Object velocity over time
Magnitude
Frame number
Mon 08:55:31
No strike
Camera 01

References

WG-IMAF-2022/10, WG-IMAF 2022/11

Joanna Zanker

British Antarctic Survey

Oceanographic variability in Cumberland Bay, South Georgia:
implications for glacier retreat and fisheries management

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

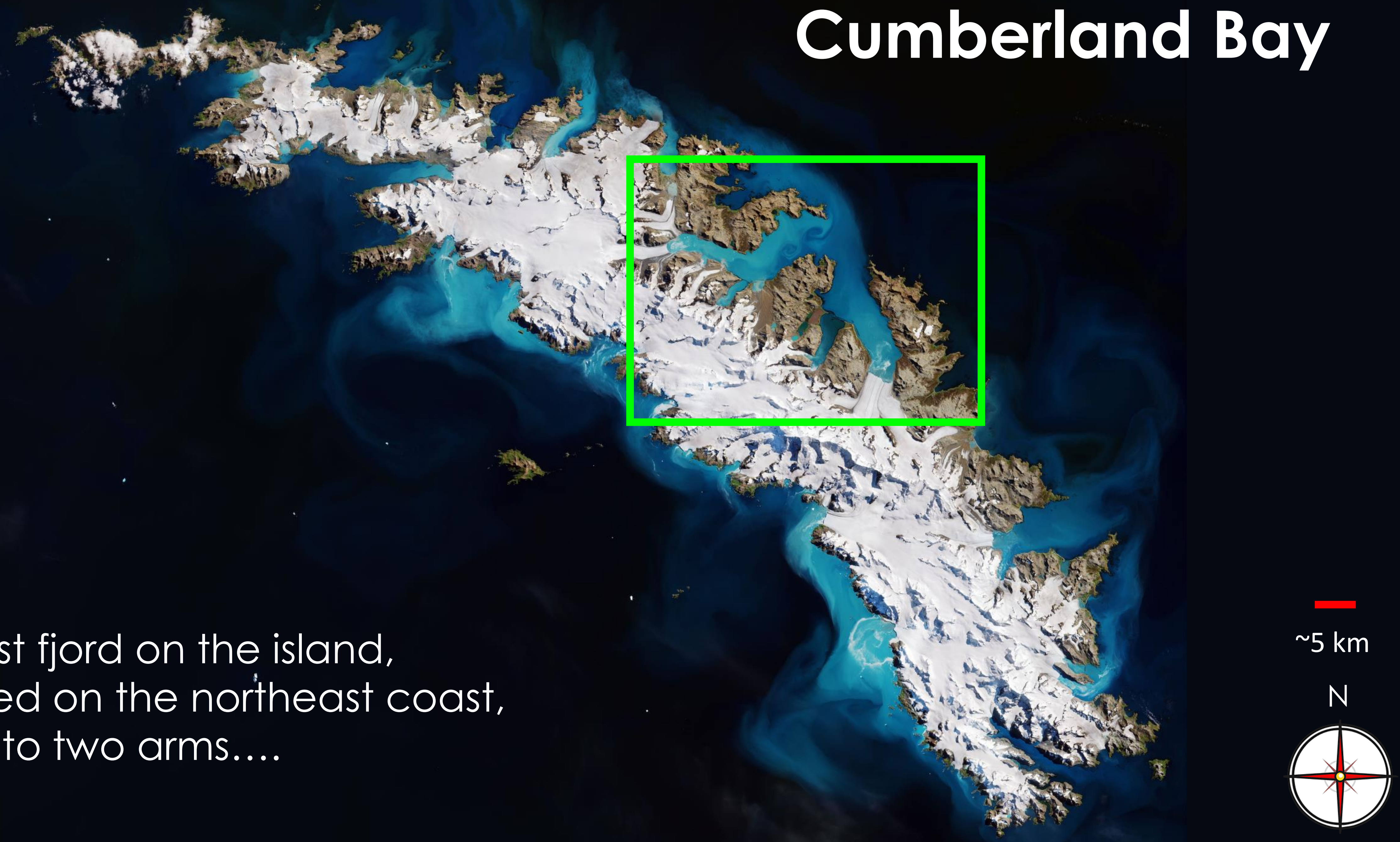
Joanna Zanker
INSPIRE DTP

UNIVERSITY OF Southampton

ENVIRONMENTAL RESEARCH INSTITUTE SOUTH ATLANTIC

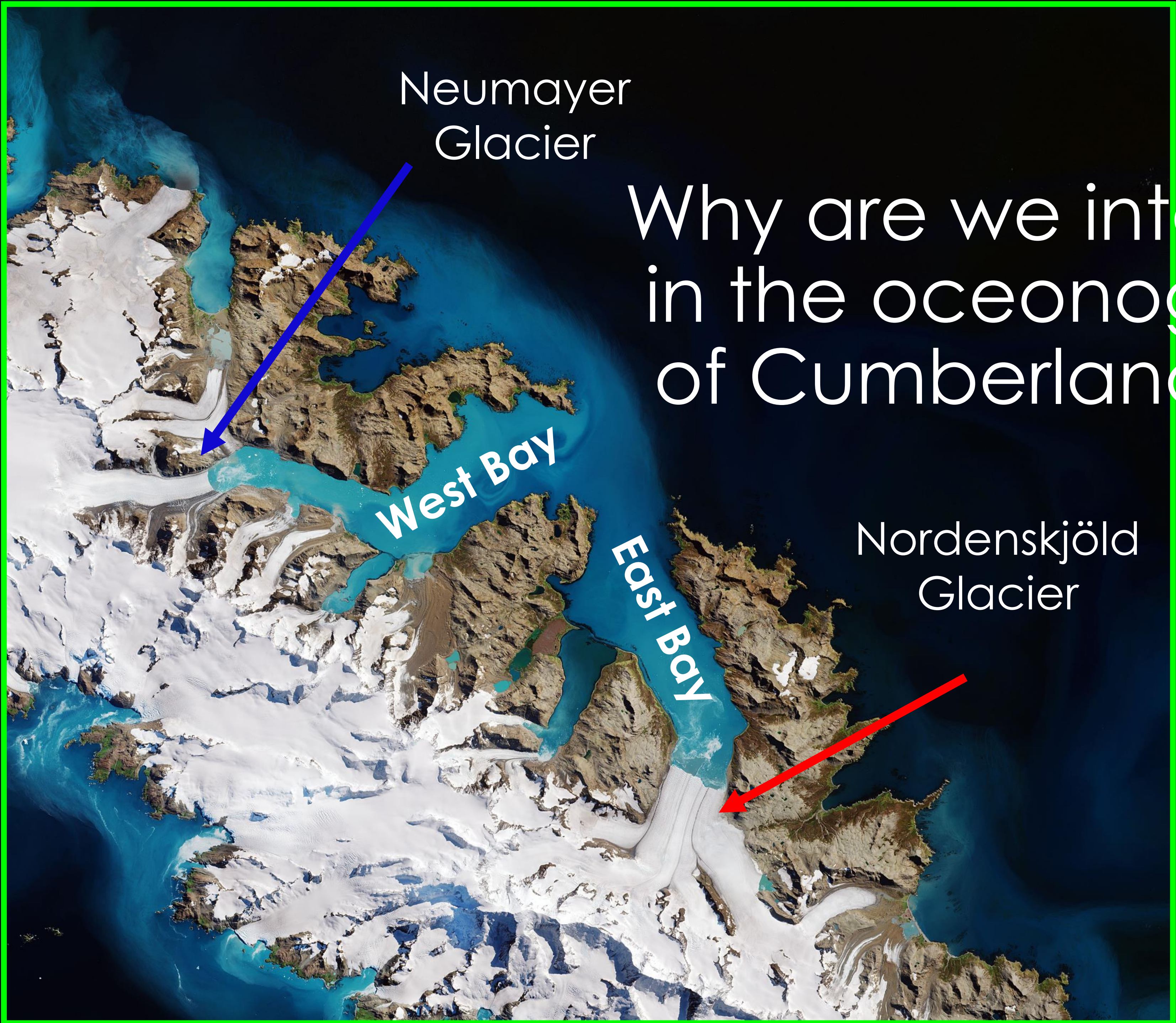
Supervisors: Emma Young (BAS), Ivan Haigh (UoS), Paul Brickle (SAERI), Paul Holland (BAS)

Cumberland Bay



Largest fjord on the island, situated on the northeast coast, split into two arms….

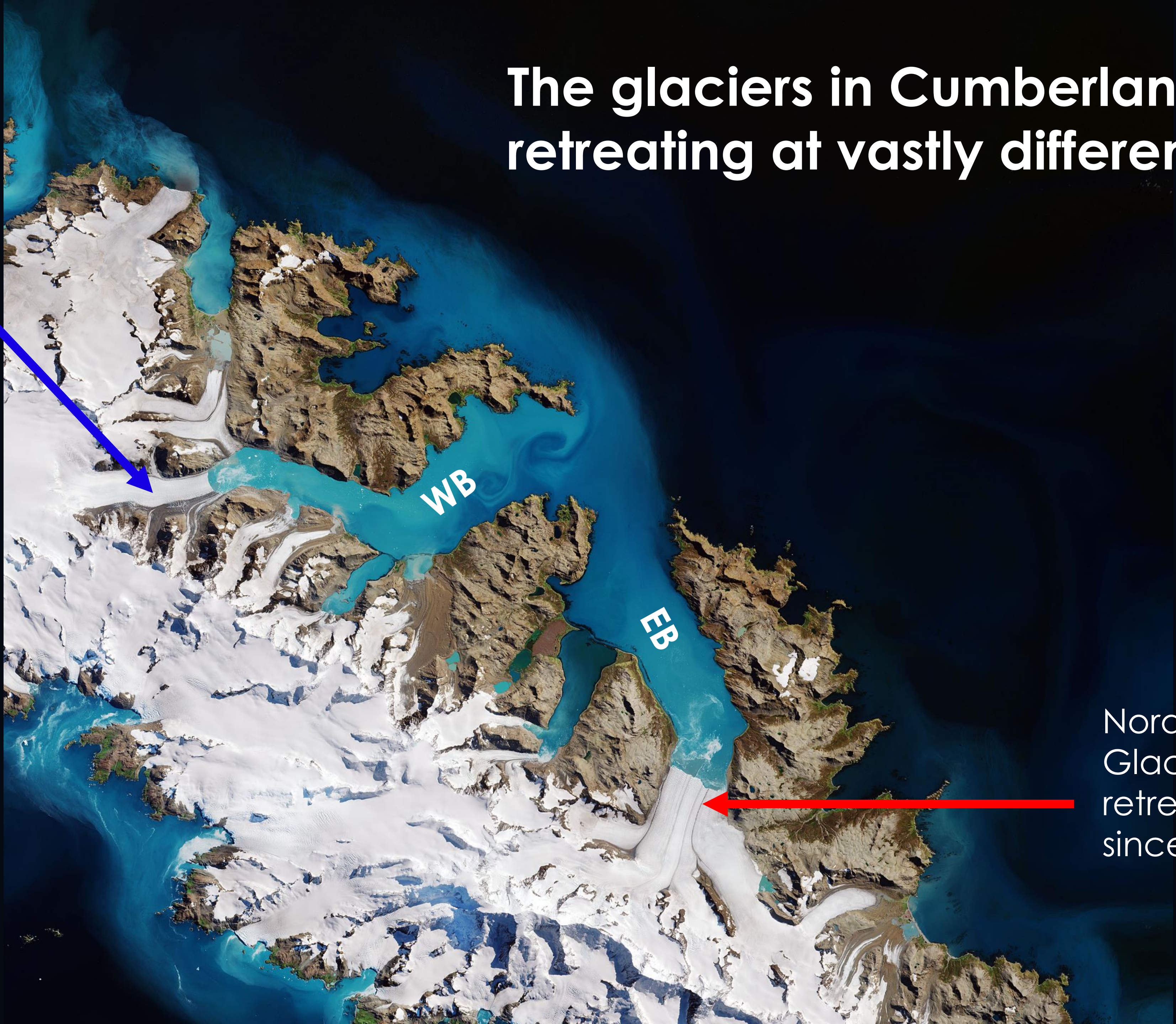
.... each with a large marine terminating glacier.



Why are we interested in the oceanography of Cumberland Bay?

The glaciers in Cumberland Bay are retreating at vastly different rates.

Neumayer Glacier has retreated >10 km since 1957



Nordenskjöld Glacier has retreated <2 km since 1957


BBC
Frozen Planet II


BBC
Frozen Planet II

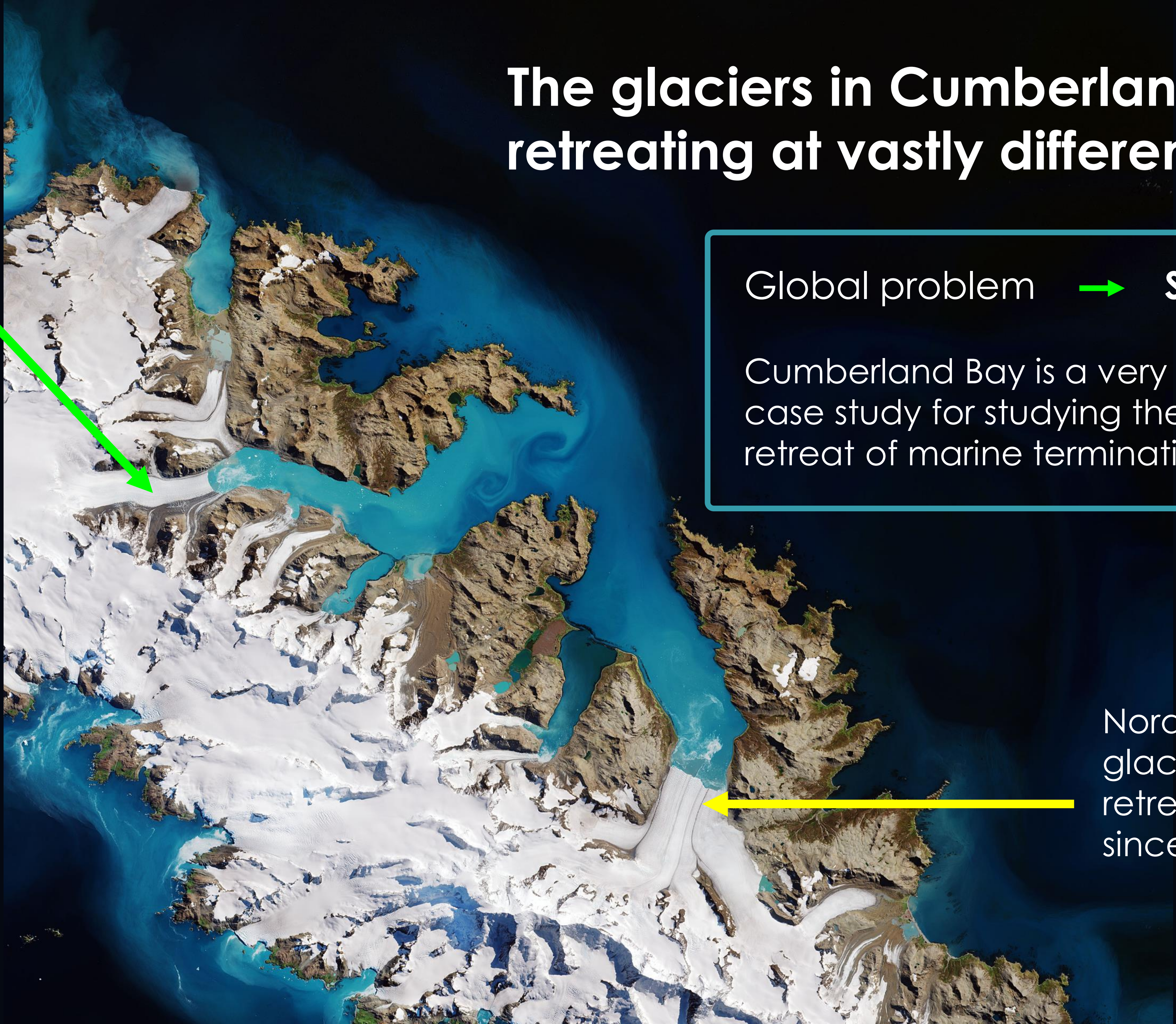

BBC
Neumayer Glacier on South Georgia
Frozen Planet II


BBC
has lost nearly six miles
of ice in just 20 years.
Frozen Planet II


Frozen Planet II


BBC
Frozen Planet II

The glaciers in Cumberland Bay are retreating at vastly different rates.

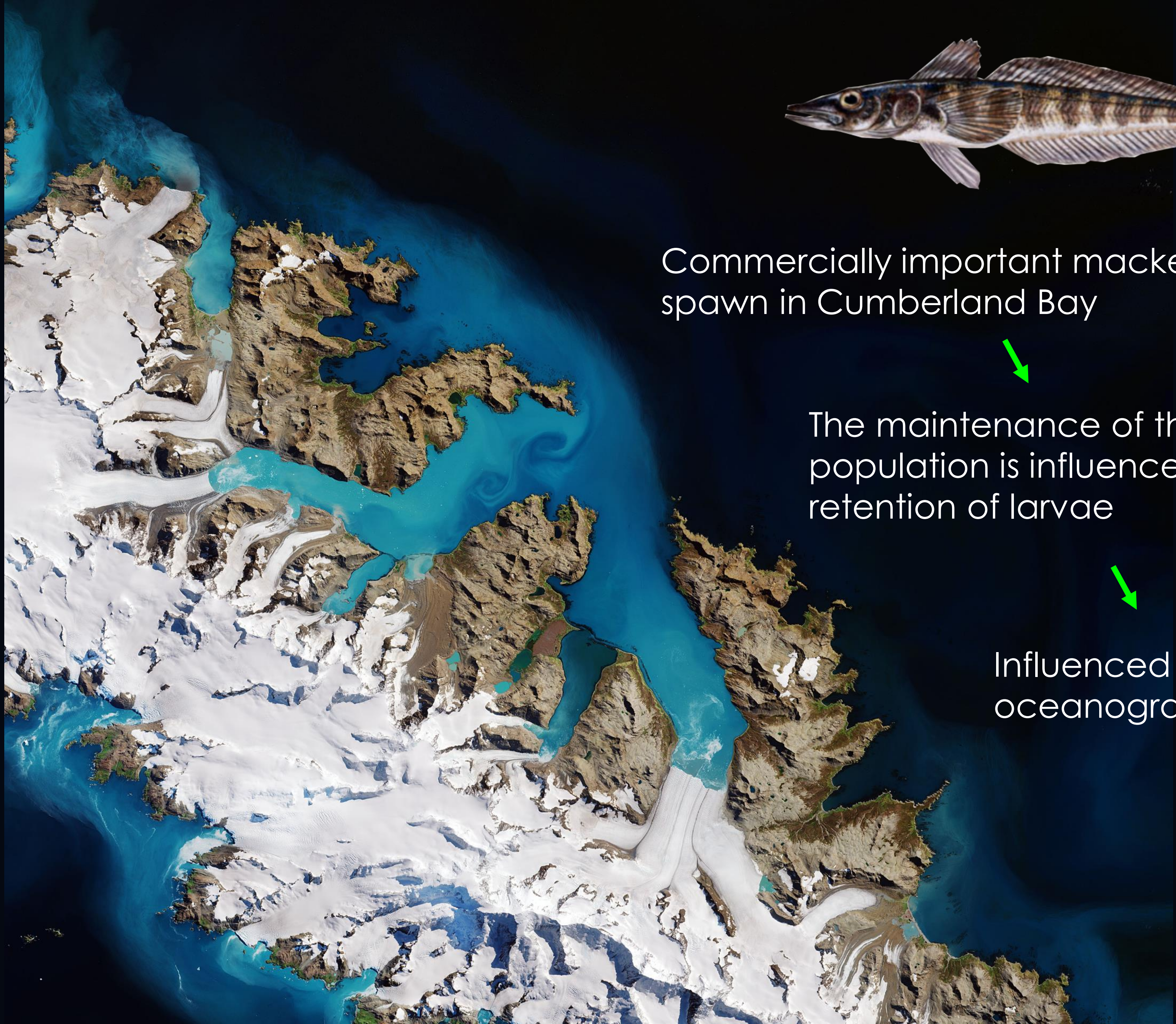


Neumayer glacier has retreated >10 km since 1957

Global problem → **Sea-level rise**

Cumberland Bay is a very interesting case study for studying the drivers of retreat of marine terminating glaciers.

Nordenskjöld glacier has retreated <2 km since 1957



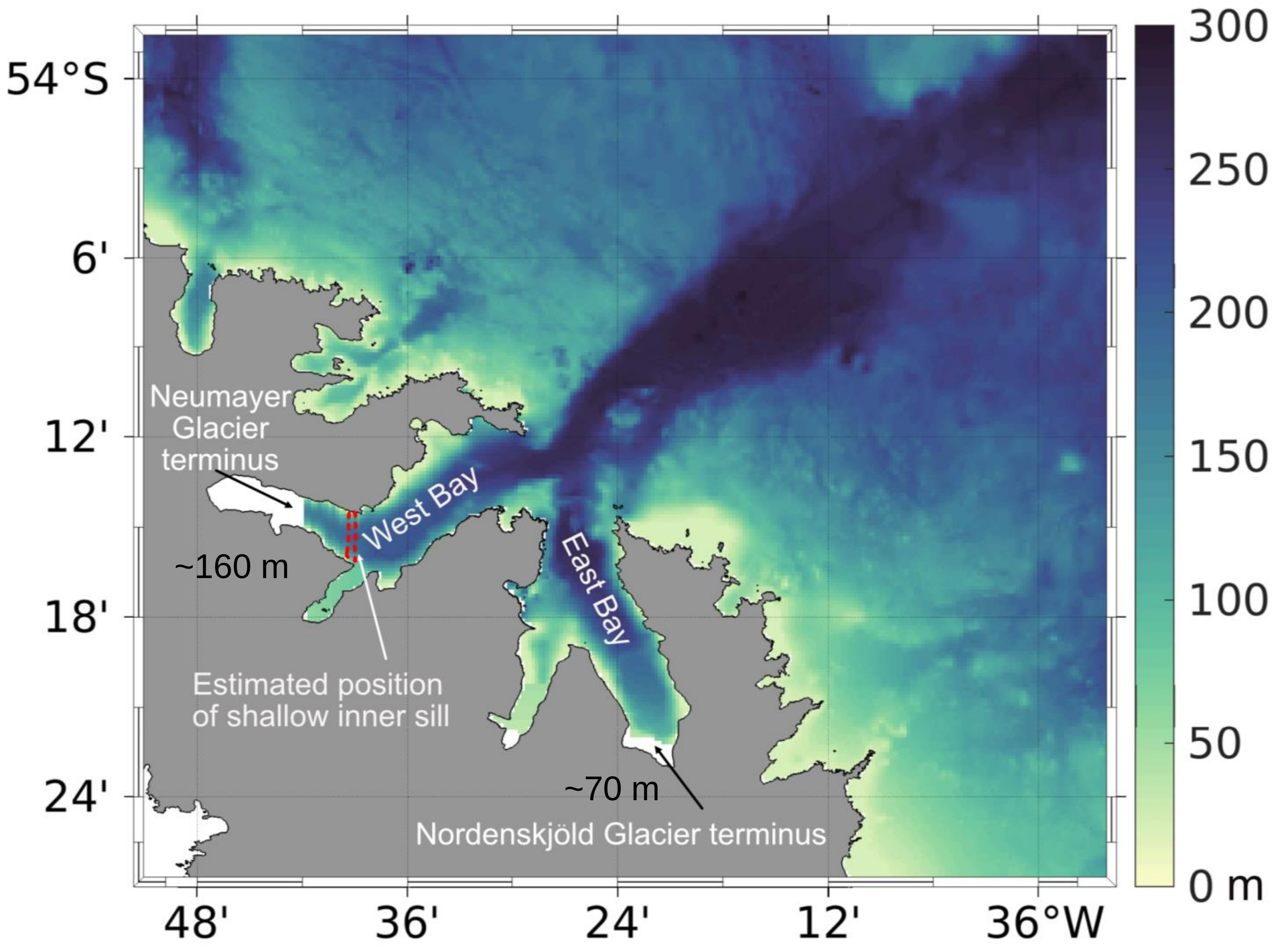
Commercially important mackerel icefish spawn in Cumberland Bay

The maintenance of the adult population is influenced by successful retention of larvae

Influenced by oceanographic variability

HOW: High resolution modelling

200 m resolution bathymetry (Hogg et al. 2016)



Bathymetry

- 200 m horizontal resolution
- 1 - 30 m in vertical
- Postulated inner sill

Atmospheric forcing

- ERA5 reanalysis dataset

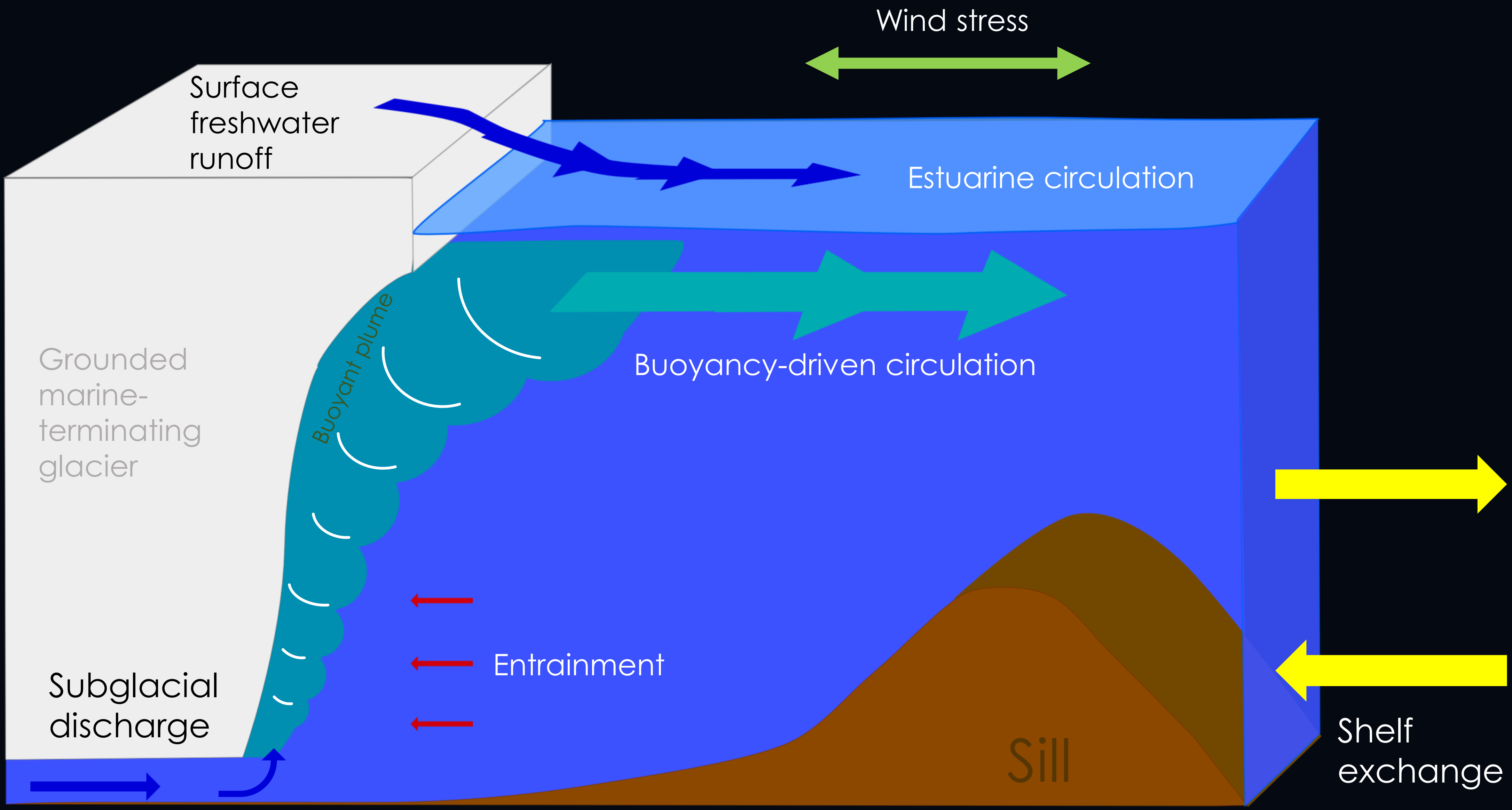
Open boundary forcing

- 3 km regional model (Young et al. 2016)

Glacial meltwater runoff

- Novel parameterisation

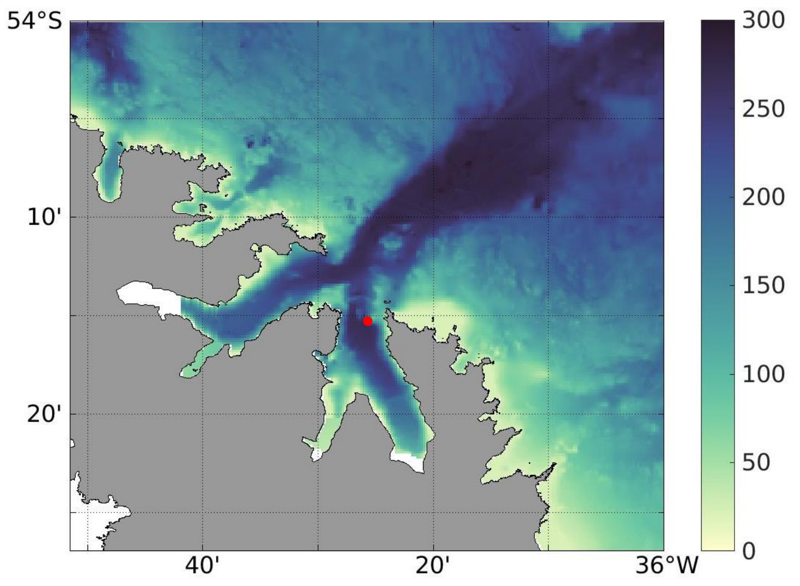
Fjord circulation

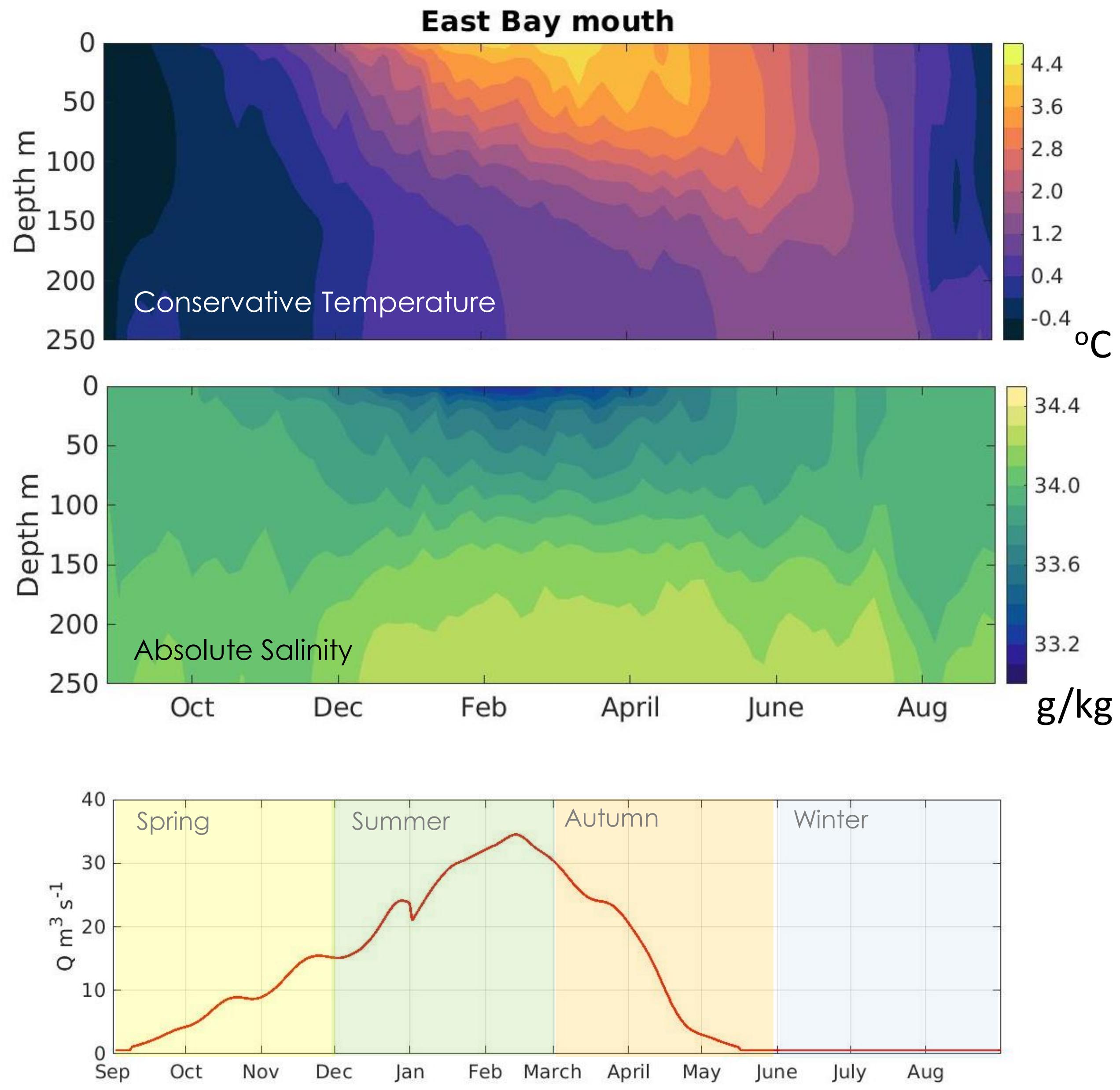


What does the oceanographic variability look like in Cumberland Bay?

Seasonal cycle

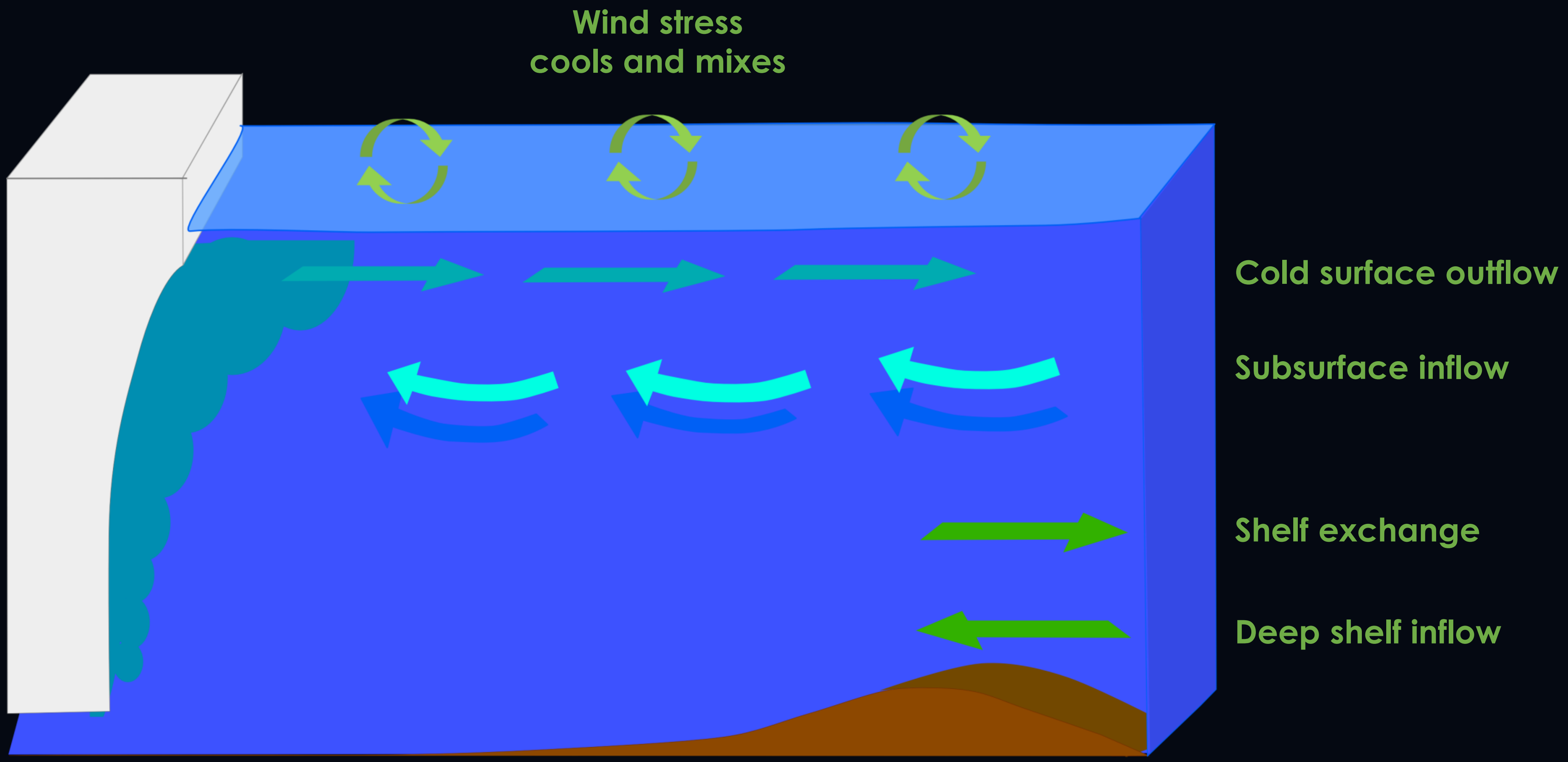
- Cold, high salinity well-mixed water column in spring
- Surface waters warm and freshen into summer and autumn, stratification strengthens
- Stratification weakens in winter



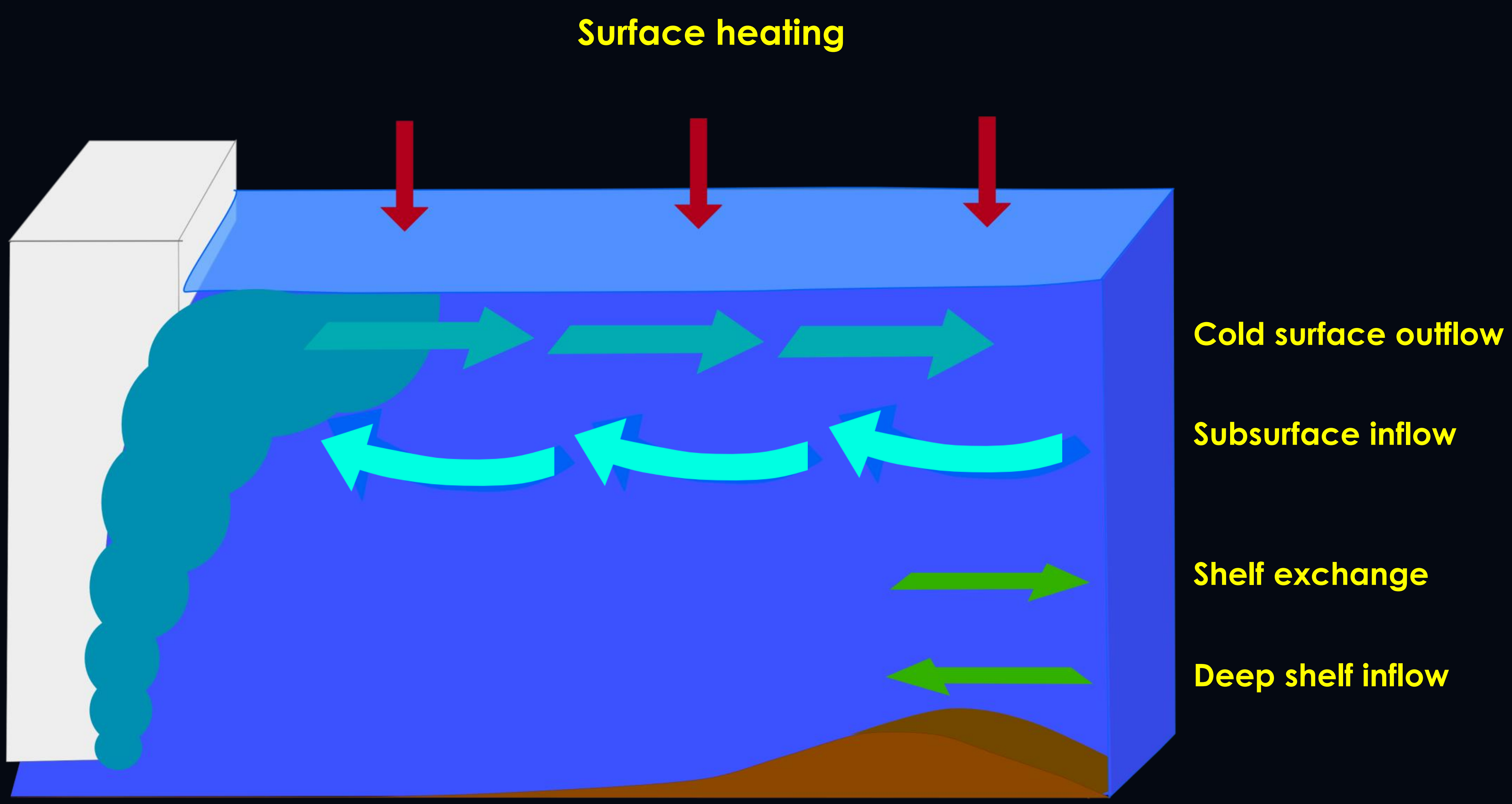


What is driving the variability?

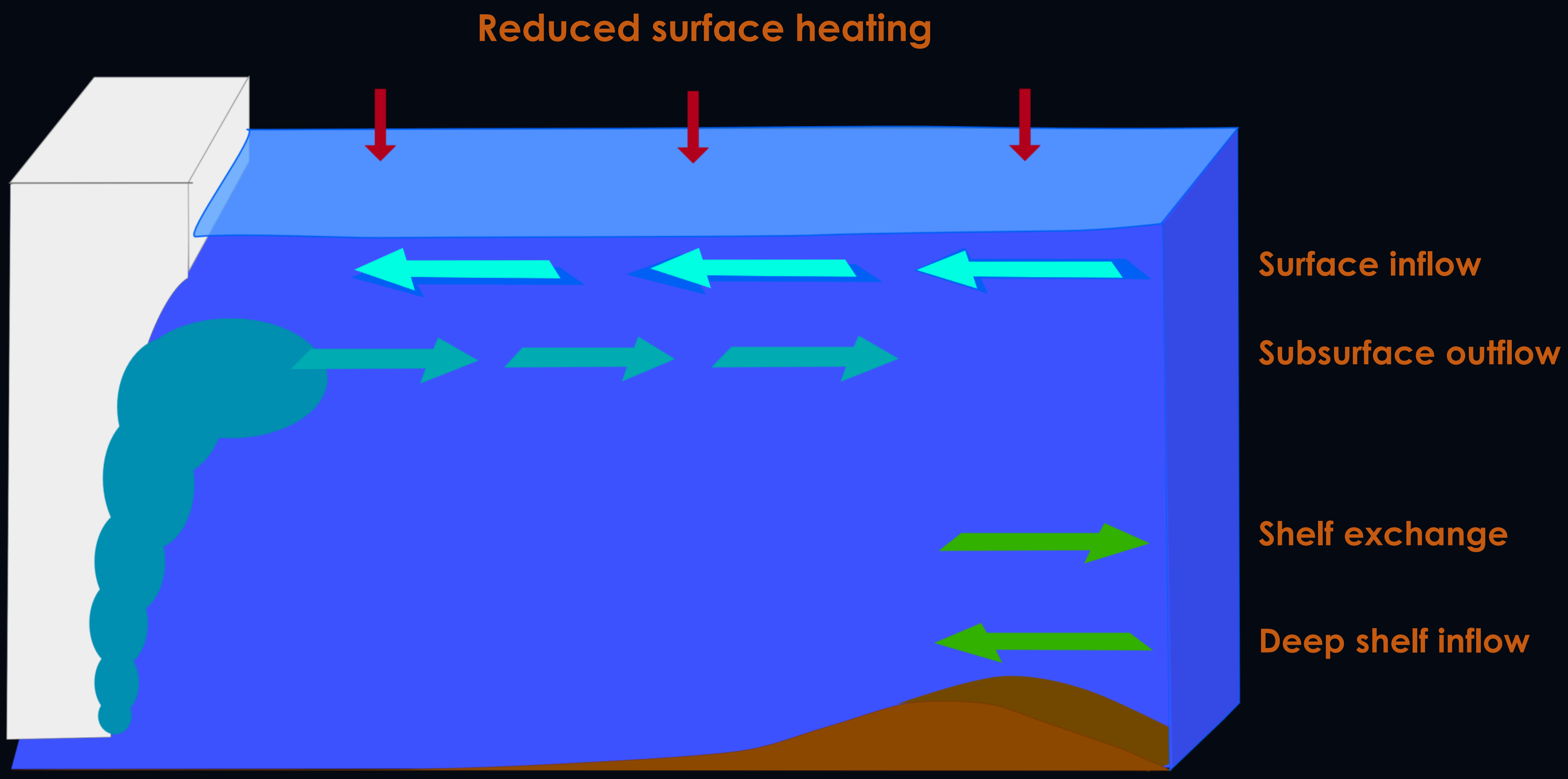
Spring


Wind stress
cools and mixes
Cold surface outflow
Subsurface inflow
Shelf exchange
Deep shelf inflow

Summer


Surface heating
Cold surface outflow
Subsurface inflow
Shelf exchange
Deep shelf inflow

Autumn

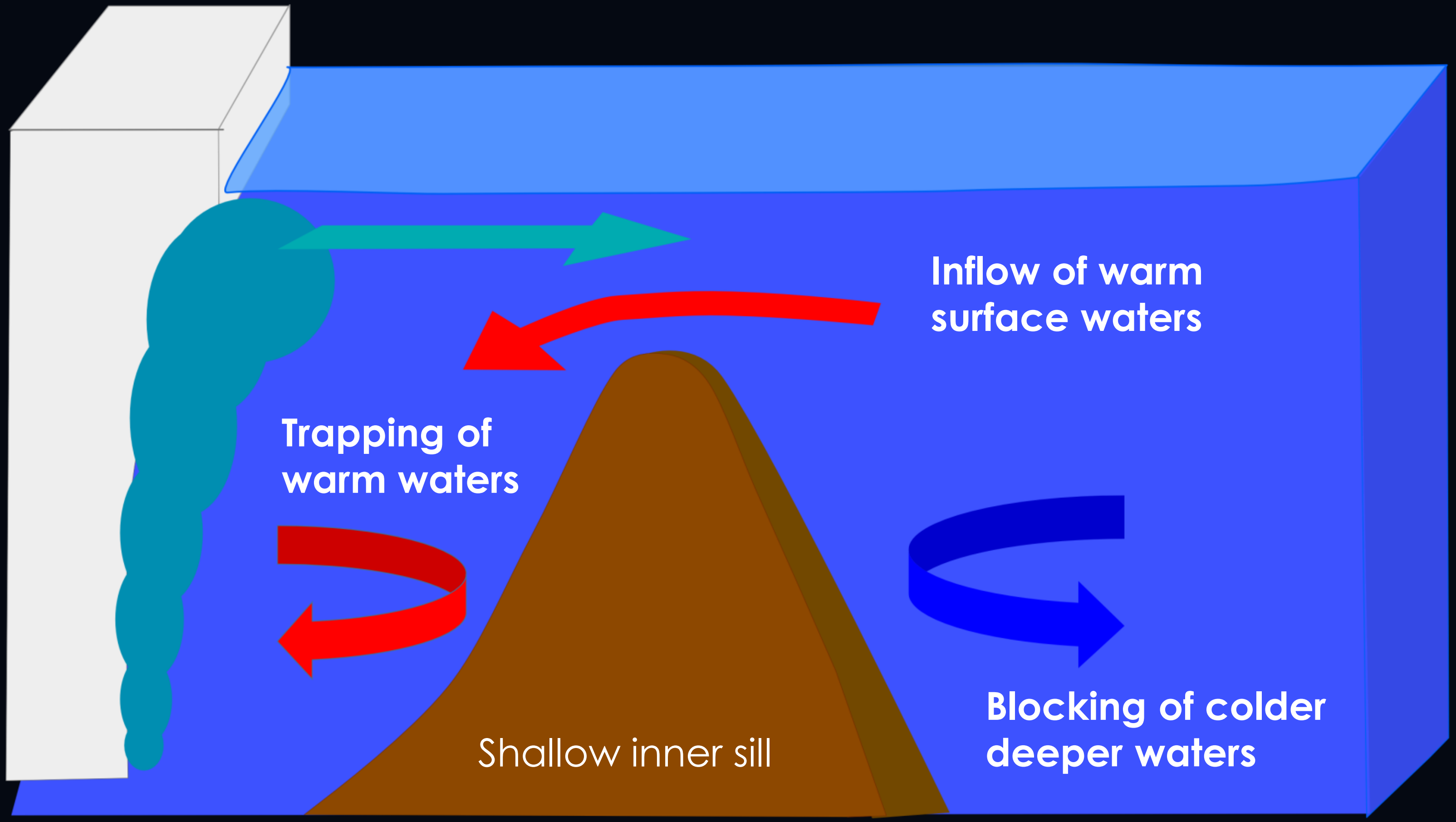

Reduced surface heating
Surface inflow
Subsurface outflow
Shelf exchange
Deep shelf inflow

Winter

Different regimes in West Bay and East Bay

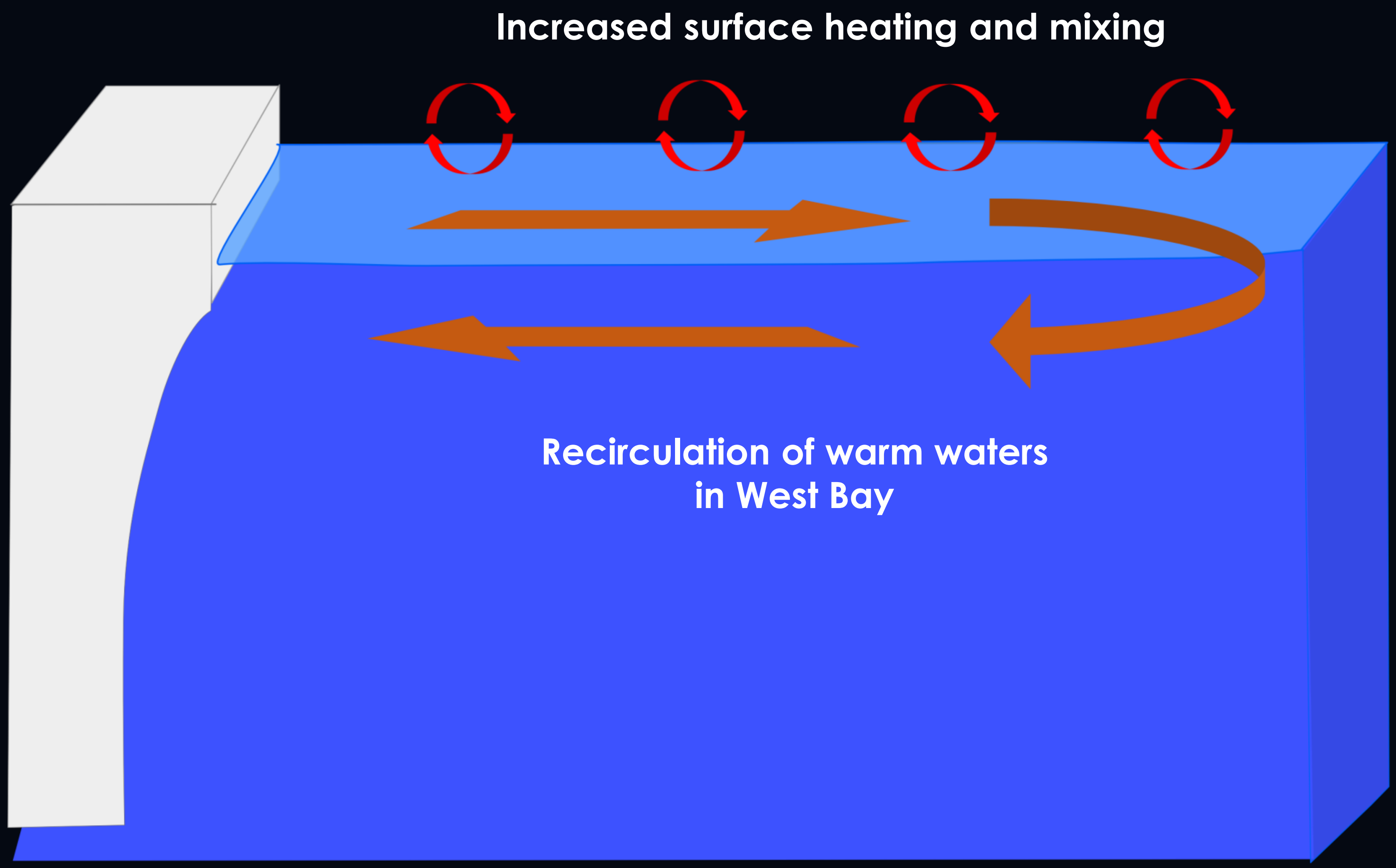
What is driving the differential glacier retreat?

Shallow inner sill in West Bay



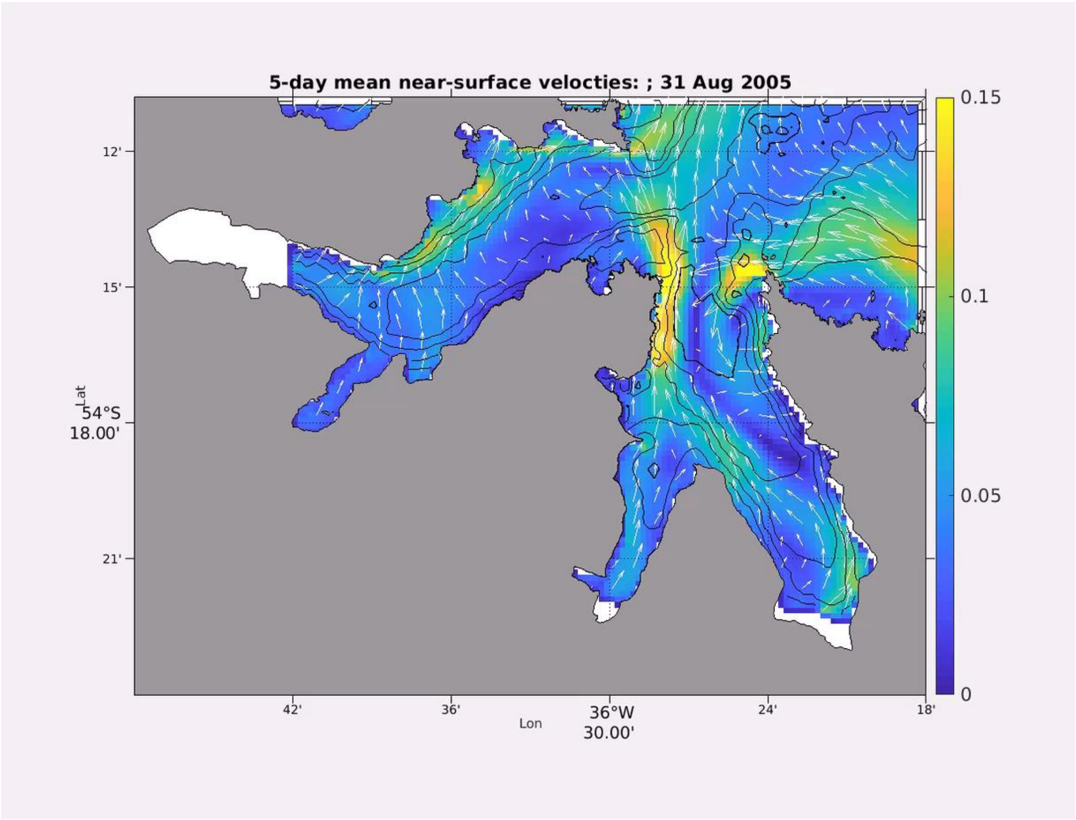
Föhn winds

(Warm dry, downslope winds – increased air temperature and wind speed)



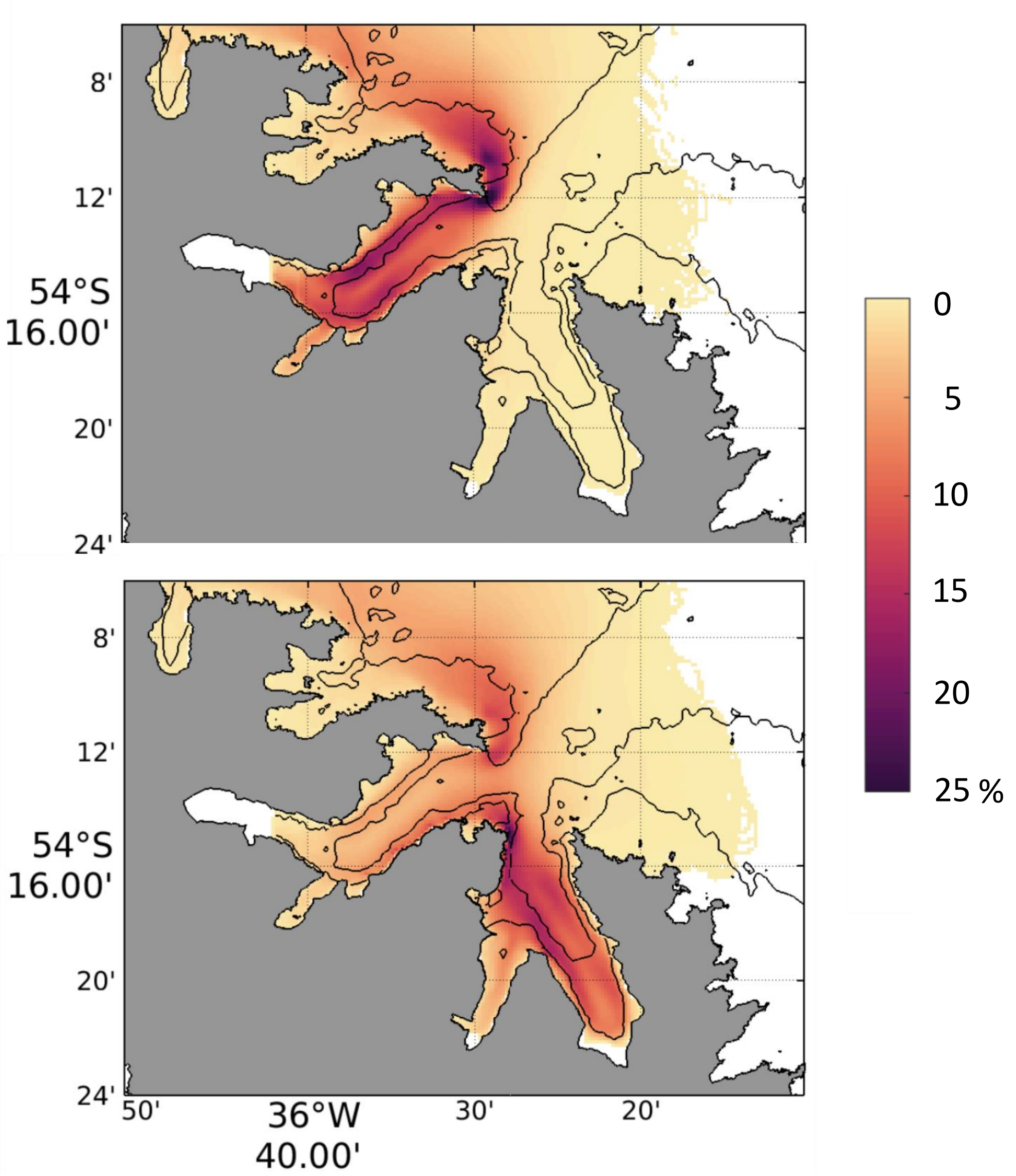
How does oceanographic variability influence the retention of mackerel icefish larvae?

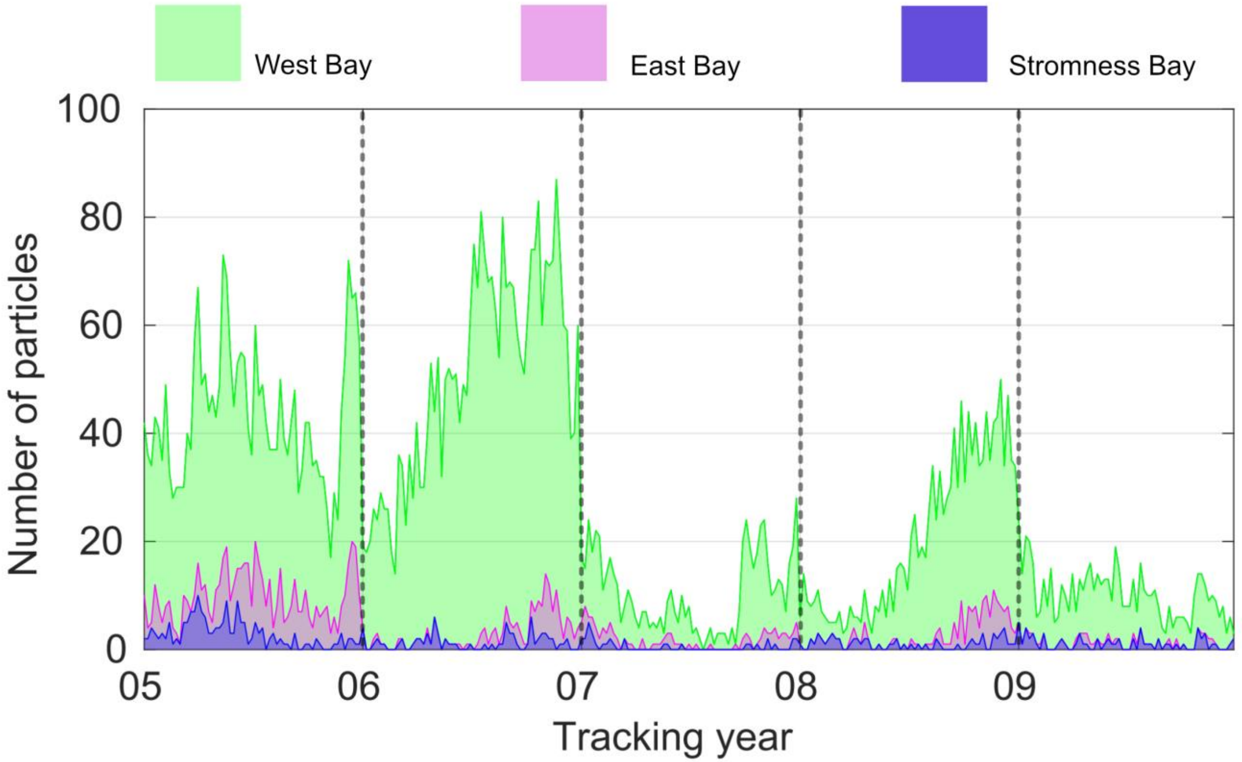
Individual Based Model tracks mackerel icefish larvae using the model flow fields for 90 days



Main hatching period of August to October targeted for analysis

Preferred pathways





Total number of particles retained for each release period after 90 days tracking

Key findings

- Interannual variability in retention
- Most of the particles retained after 90 days started and ended in West Bay
- Retention is sensitive to winds and meltwater runoff (which are changing)
- Timing of spawning, hatching and development matters
- Diel Vertical Migration (DVM) reduces retention

Summary

joazan@bas.ac.uk

- A **new high-resolution model** of fjord water circulation for Cumberland Bay highlights different circulation regimes between West Bay and East Bay.

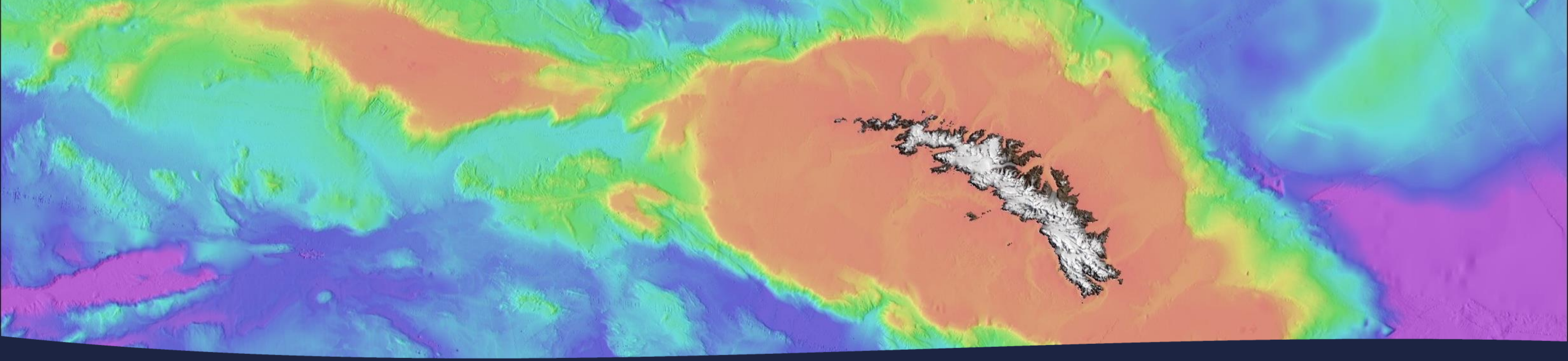
- Persuasive evidence that **differential glacier retreat** is driven by the presence of an **inner sill** and/or **föhn winds.**

- Oceanographic variability influences successful retention of mackerel icefish larvae and factors linked to **climate change (winds, glacial meltwater)** are likely to influence **retention of larvae** significantly.

New tool providing oceanographic context to ecosystem studies

Oliver Hogg

Centre for Environment, Fisheries and Aquaculture Science



Modelling Risk in South Georgia's Marine Protected Area

Oliver T. Hogg, Matthew Kerr, Lenka Fronkova, Roi Martinez, William Procter, Lisa Readdy and Chris Darby

Blue Belt Programme

UK Government

Understanding and protecting biodiversity

- **SGSSI Research and Monitoring plan**

  – Conserve marine biodiversity, habitats and critical ecosystem function | Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent marine ecosystems

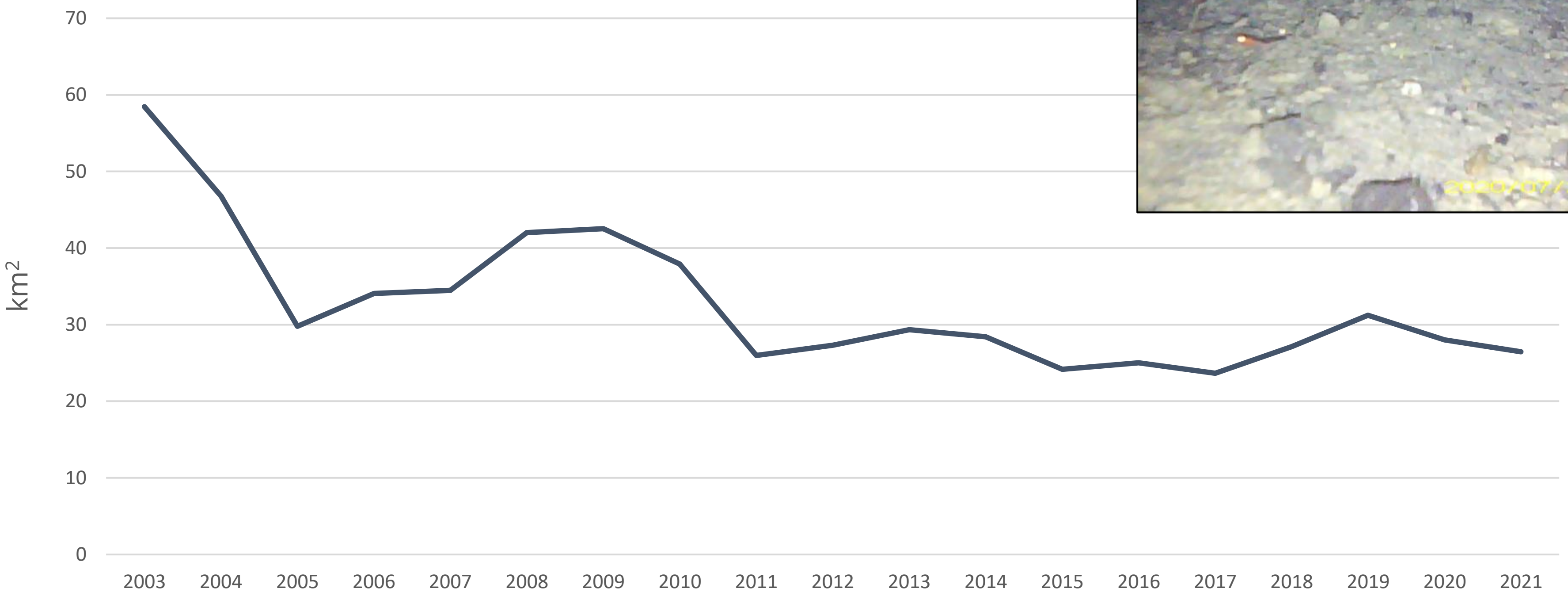
- **MPA Review**– Following a decade of protection one of the key questions is whether the MPA is configured in the optimal way to balance marine protection and a sustainable fishery?

Rich seabed assemblages South Georgia & the South Sandwich Islands

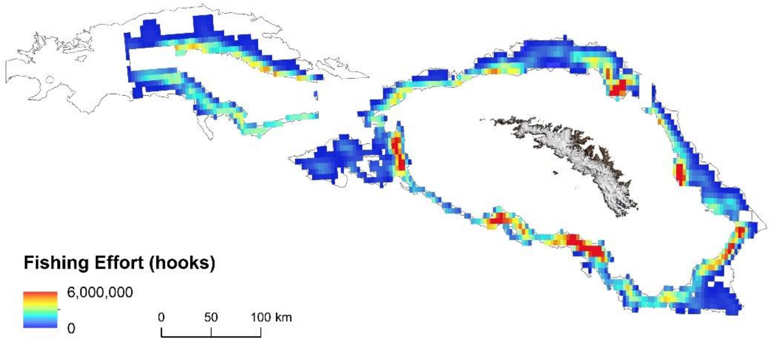
Blue Belt Programme

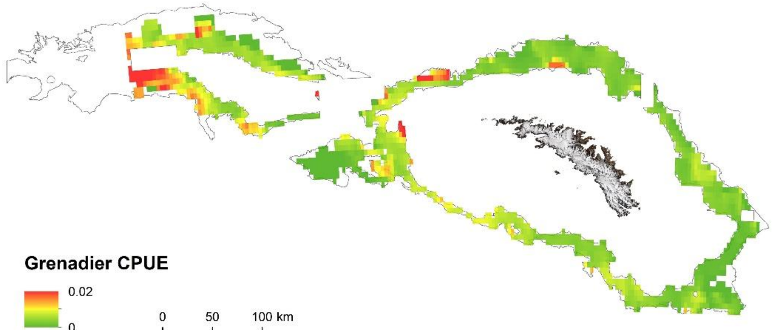
- **The Question –** What is the impact of fishery on marine ecosystems and what are the effect of changing the configuration of the MPA?
- **BB programme work** – Ongoing research into the effects of fishing on the SGSSI benthic environment including (i) the novel use of longline-mounted camera systems and their application in marine management (ii) modelling changes in risk to the marine environment due to fisheries displacement.

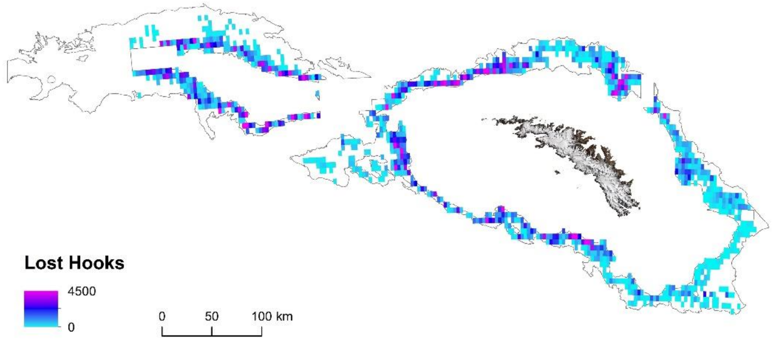
Longline footprint

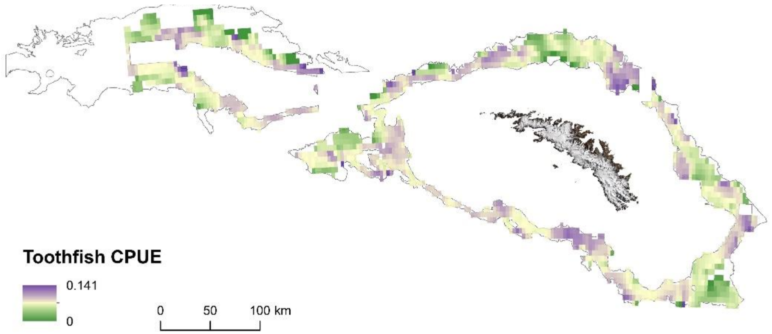


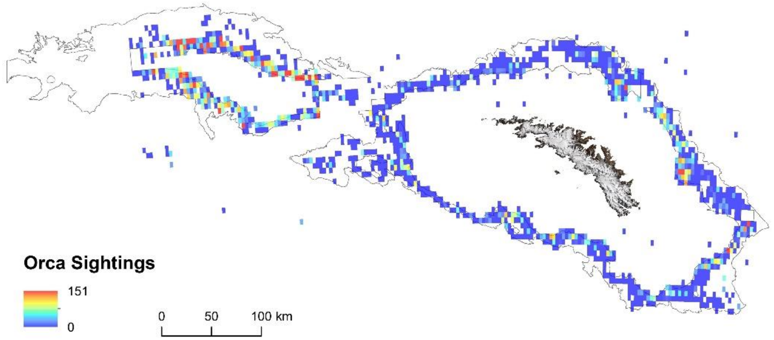
Historic fishing patterns

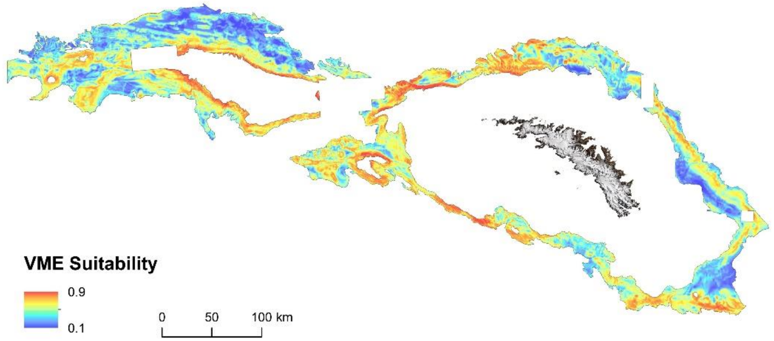

Fishing Effort (hooks)
6,000,000
0
0 50 100 km

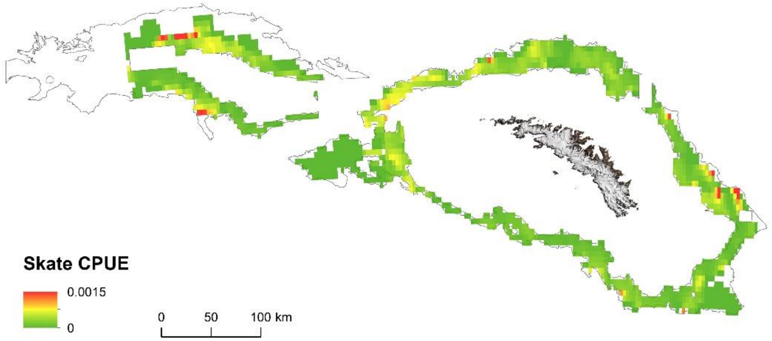

Grenadier CPUE
0.02
0 50 100 km

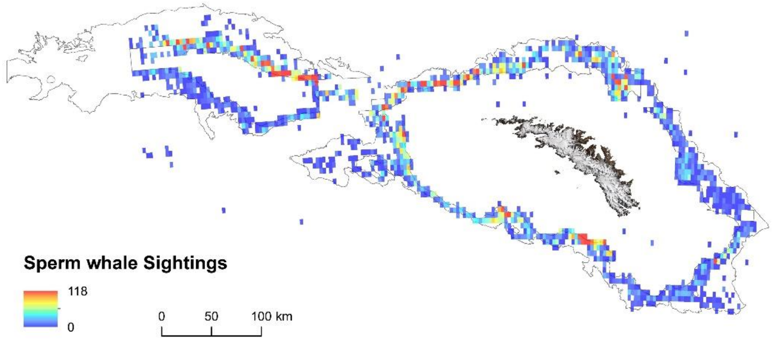

Lost Hooks
4500
0
0 50 100 km

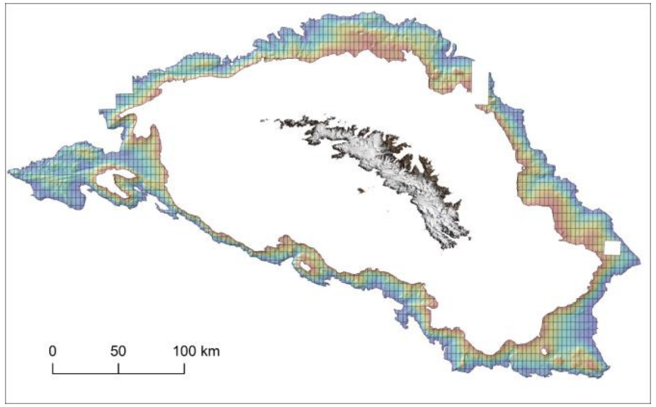

Toothfish CPUE
0.141
0
0 50 100 km


Orca Sightings
151
0
0 50 100 km

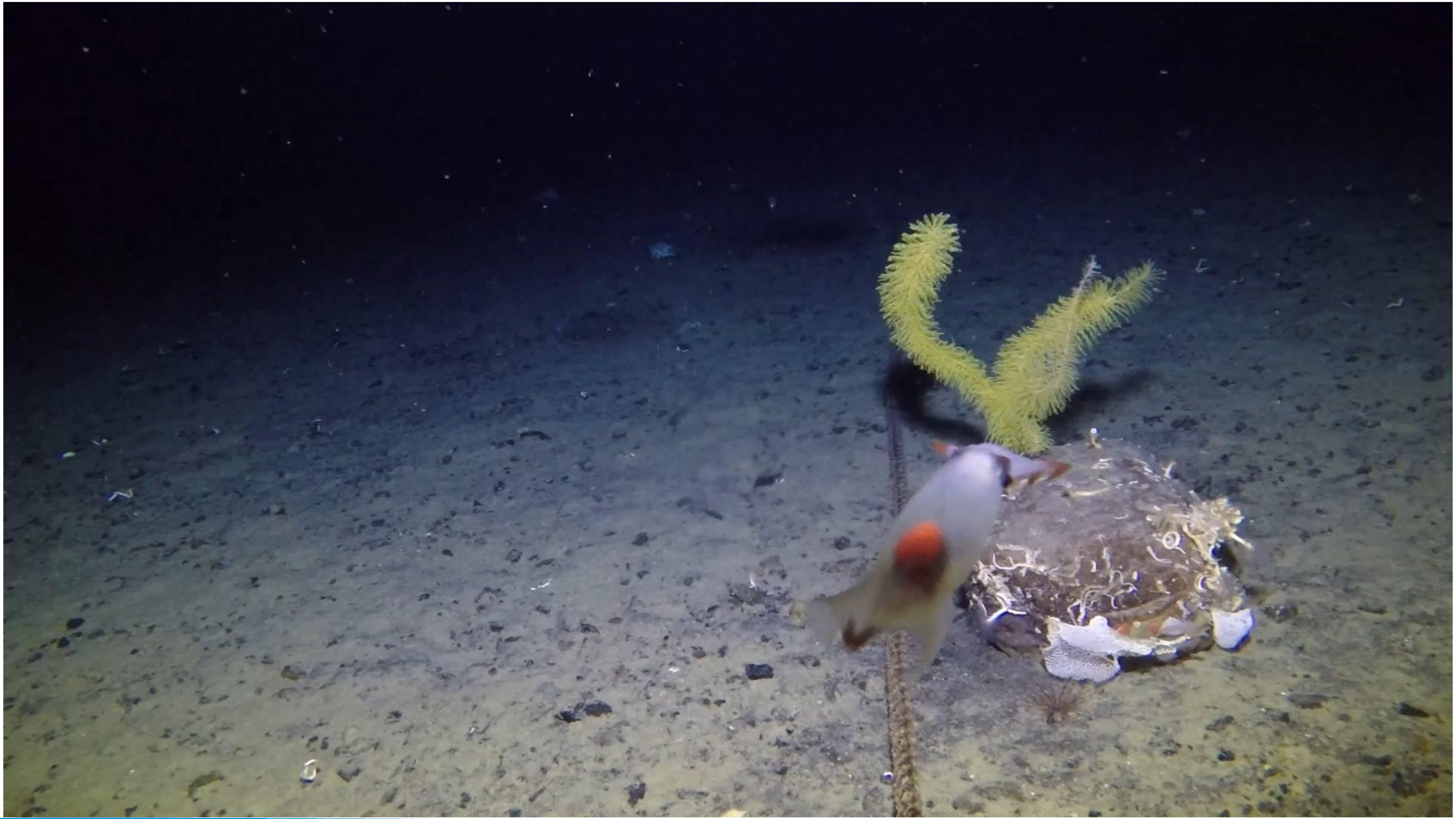

VME Suitability
0.9
0.1
0 50 100 km


Skate CPUE
0.0015
0
0 50 100 km


Sperm whale Sightings
118
0
0 50 100 km


0 50 100 km

Risk Layers

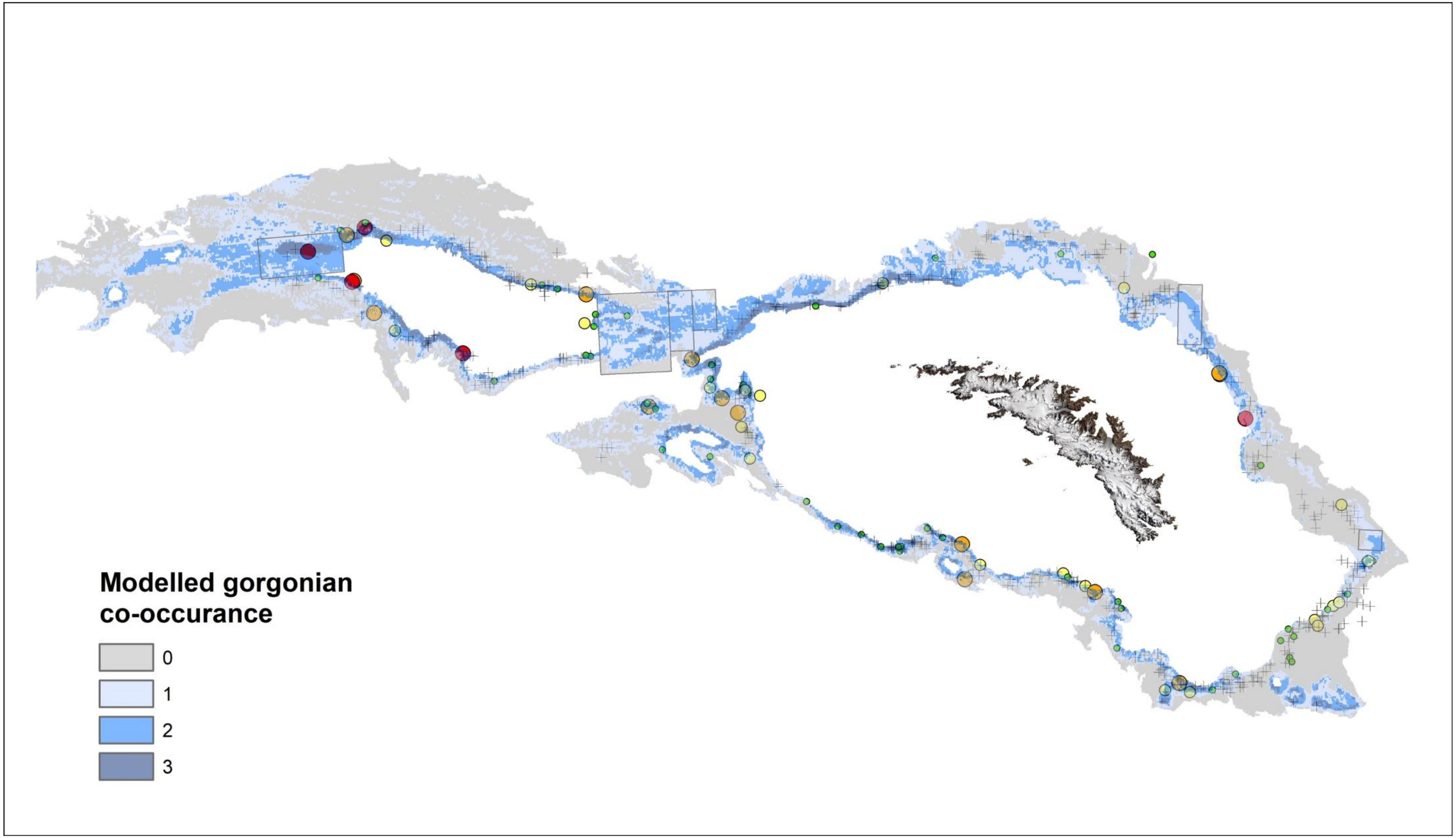


Deep-water cameras

UK Government

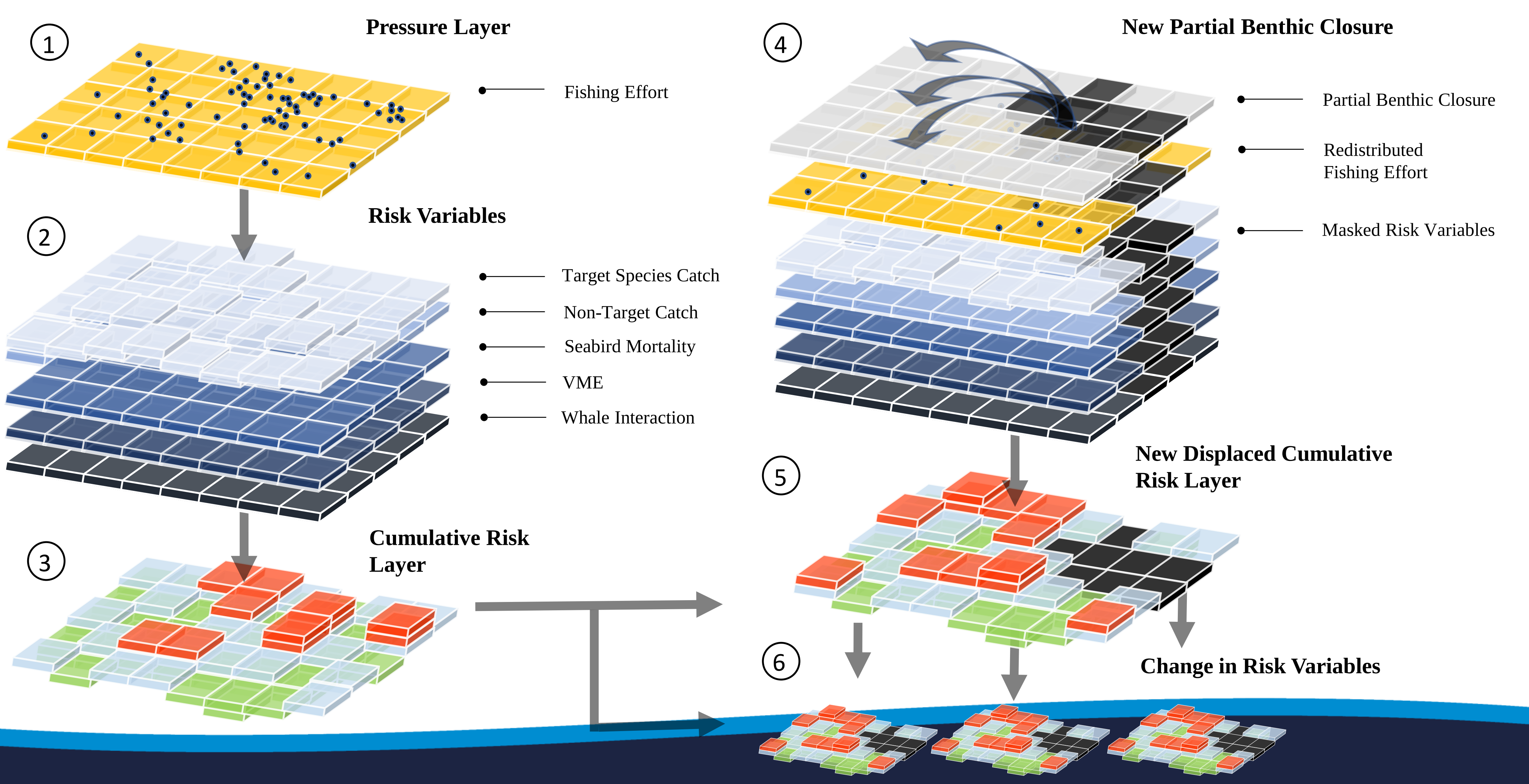
VME Layer

UK Government

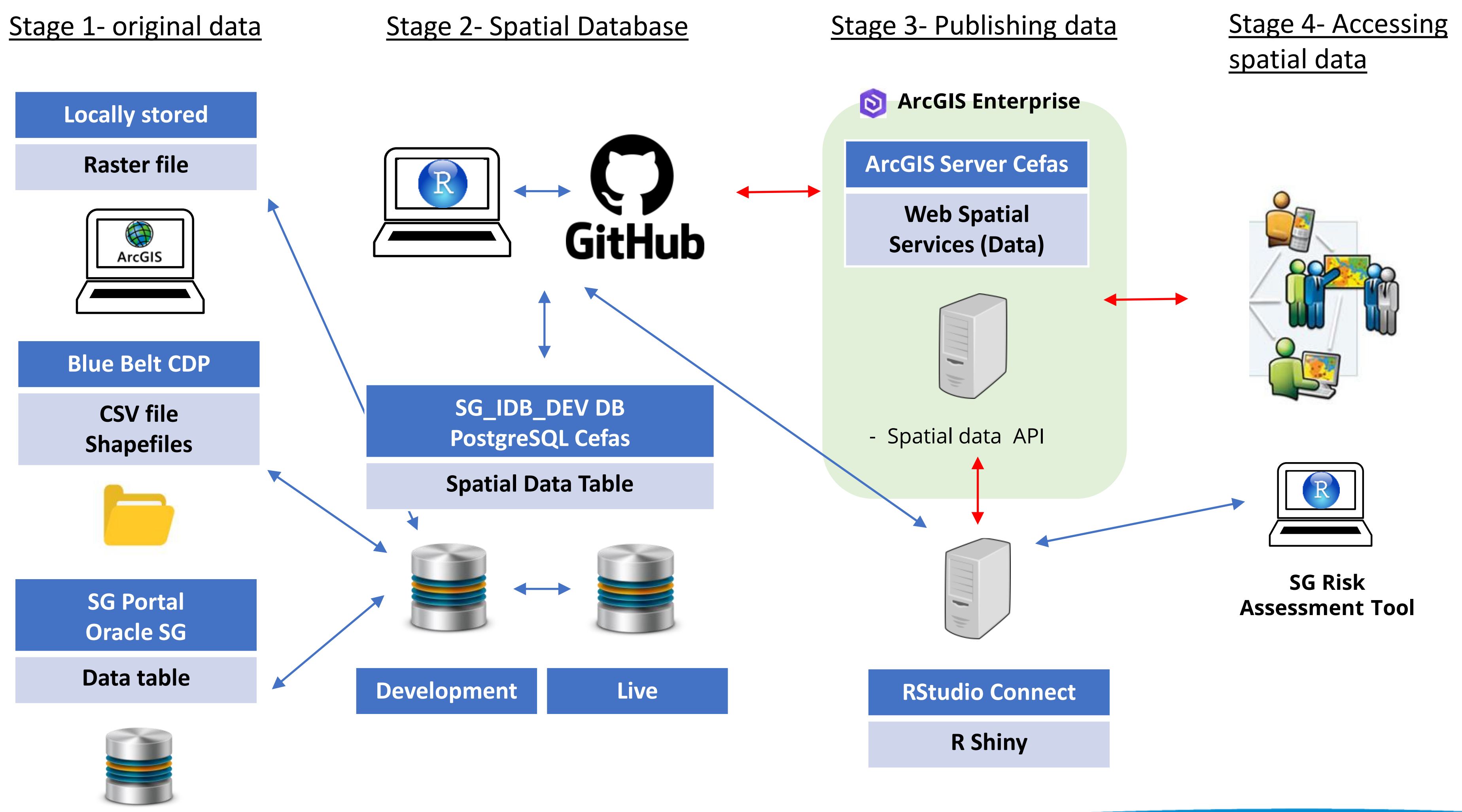


VME Modelling work

UK Government

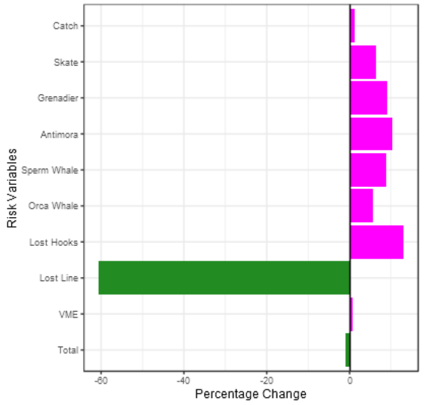


Displacement Model



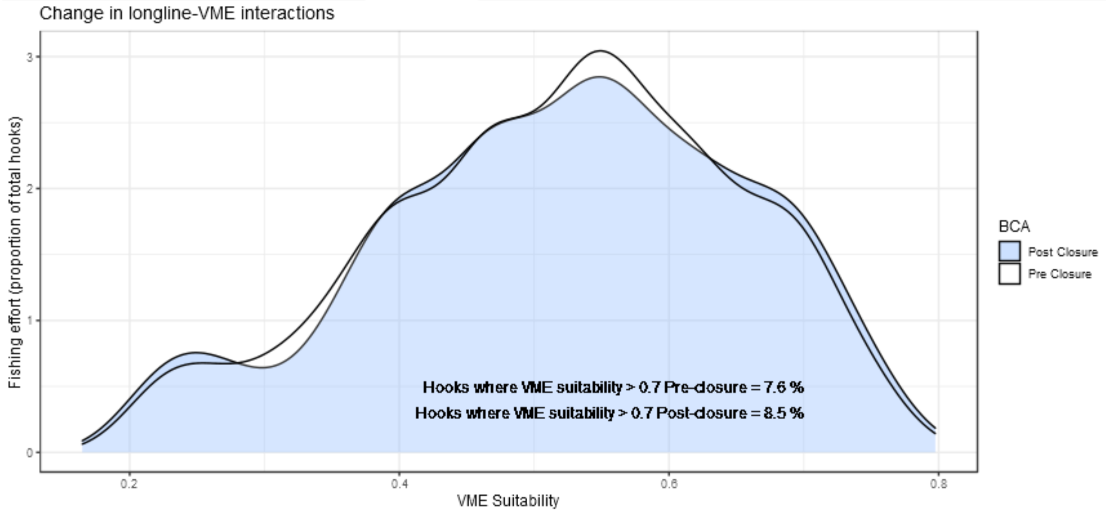
Data Workflow

Inputs | Risk Maps | Risk Summary | VME plot

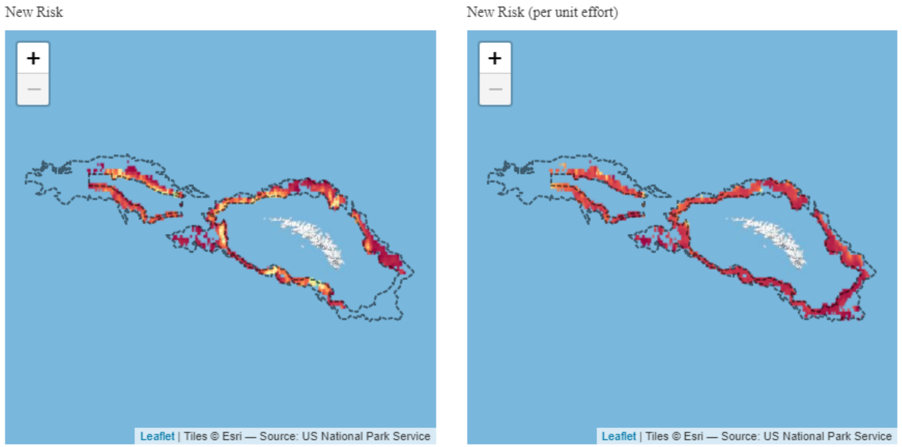


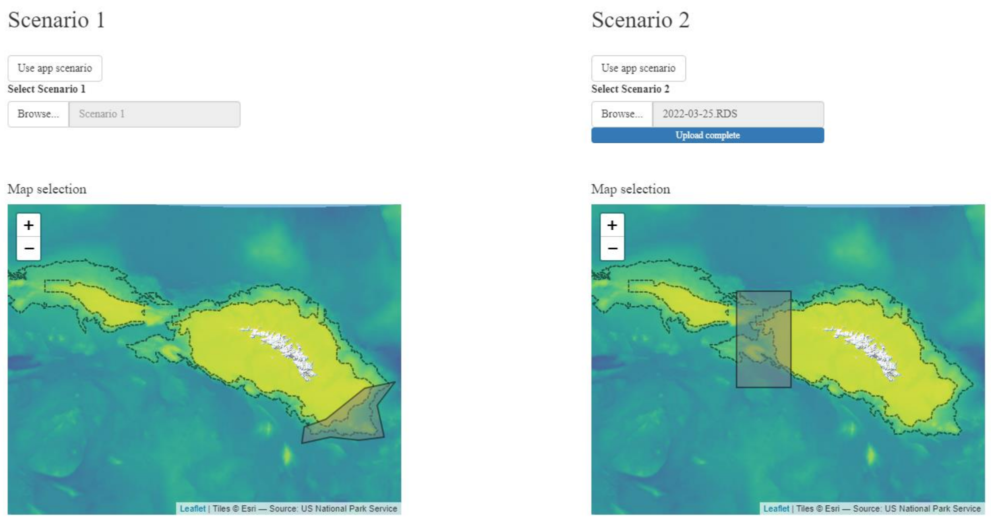
	Pre Closure	Post Closure	Percentage Change
Toothfish Catch (kg)	56975971.48	57601701.88	1.1
Skate Catch (kg)	39763.31	42414.17	6.67
Grenadier Catch (kg)	1229533.96	1349837.82	9.78
Antimora Catch (kg)	542696.27	604326.9	11.36
Sperm Whale Count	12400	13632	9.94
Orca Count	9763	10575	8.32
Lost Hooks	401844	454884	13.2
Lost Hooks Attached to Lines	182235	139522	-23.44
VME (% hooks with >70% likelihood)	7.6	8.5	11.84

Inputs | Risk Maps | Risk Summary | VME plot



Inputs | Risk Maps | Risk Summary | VME plot

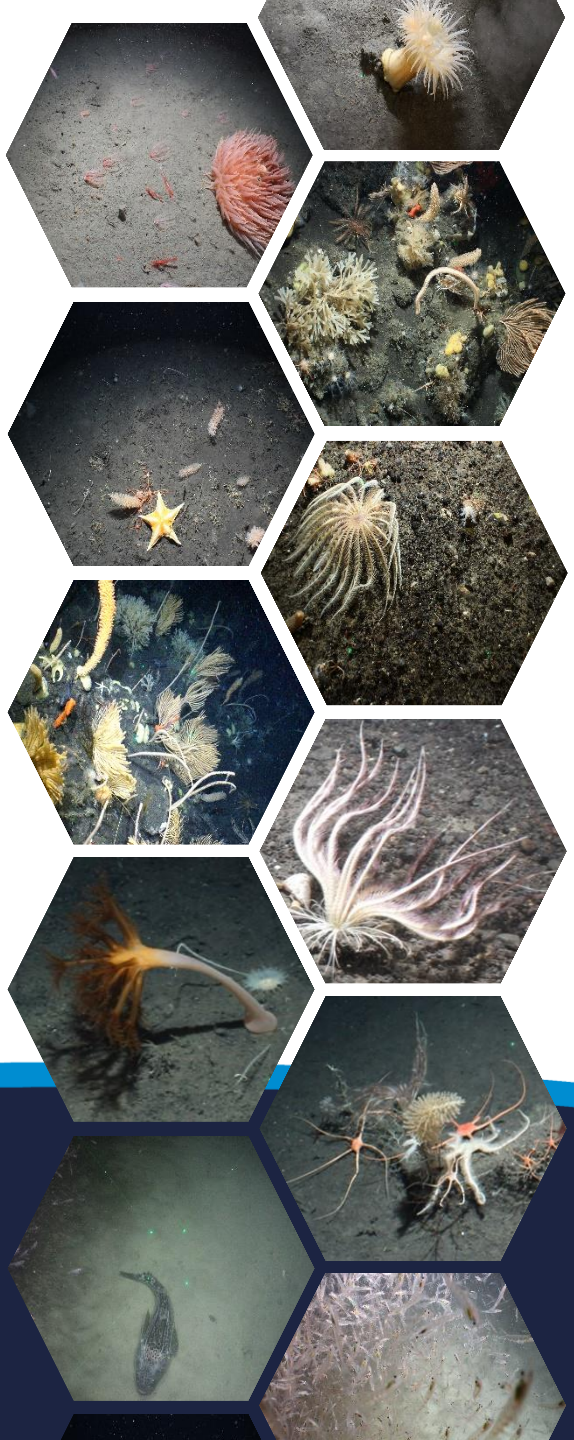




Risk Tool Analytics

Next Steps

- Develop based on feedback from GSGSSI
- Additional functionality
  Weighted risk layers | New data layers |Bespoke graphical outputs |Analyse effect of opening up previously closed areas | Scenario comparisons
- More complex displacement calculations
- Automatically updated data layers as additional seasons data
- Data visualisation - Arc Enterprise development
- Improved input data – e.g., industry data, mini-camera data



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Paul Carroll, Unsplash