What is known about the Falklands marine ecosystem now and under climate change?

Jesse van der Grient
Quantitative marine ecology, SAERI
jvandergrient@saeri.ac.fk

DPLUS148: Climate change resilience in the Falklands fisheries and marine environment

Funding:
DEFRA Darwin funding
FIG environmental studies budget
John Cheek Fund – Fortuna
Shackleton Fund

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- What do we know about the dynamics in the marine environment?
  - Data synthesis
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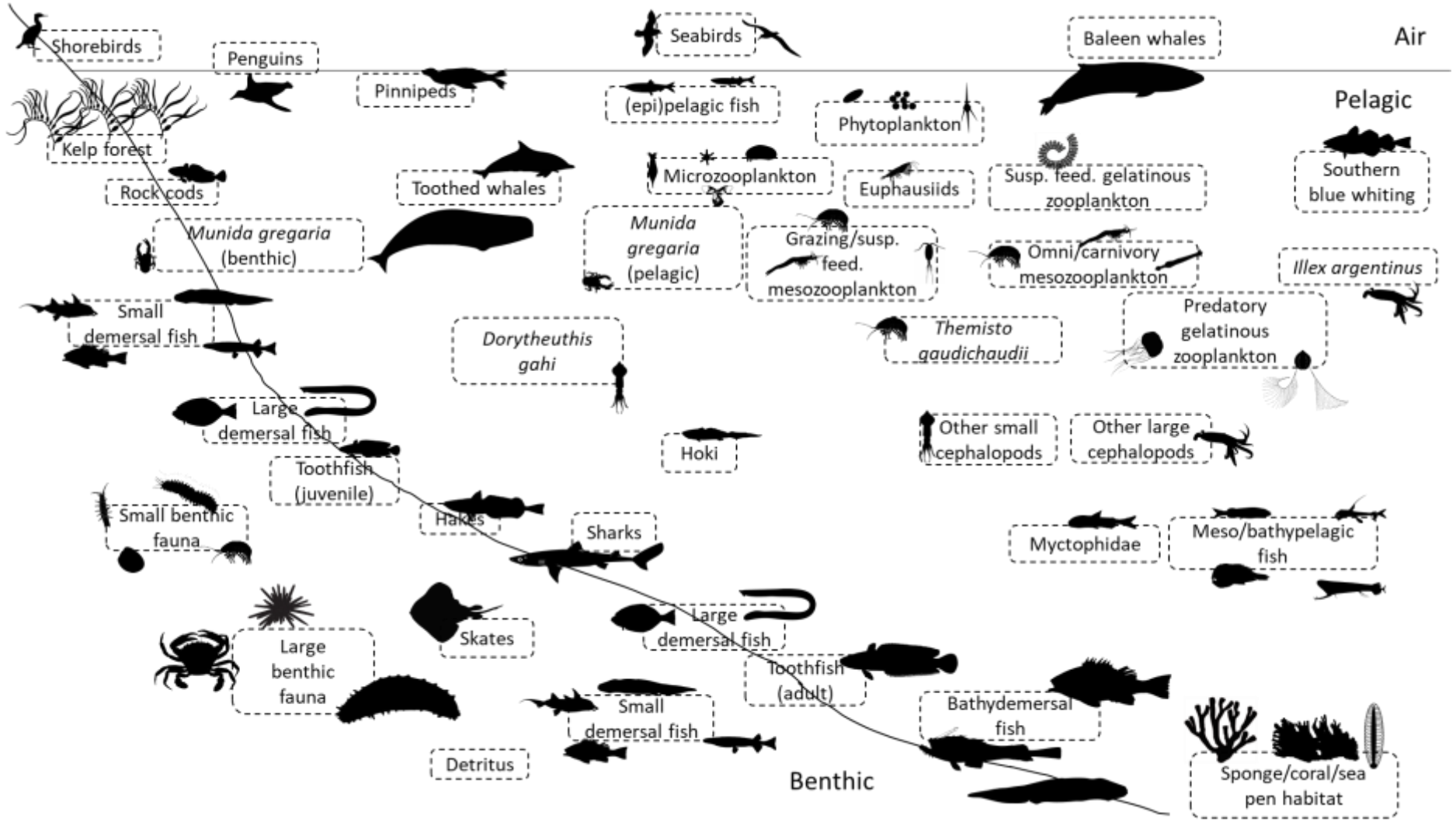

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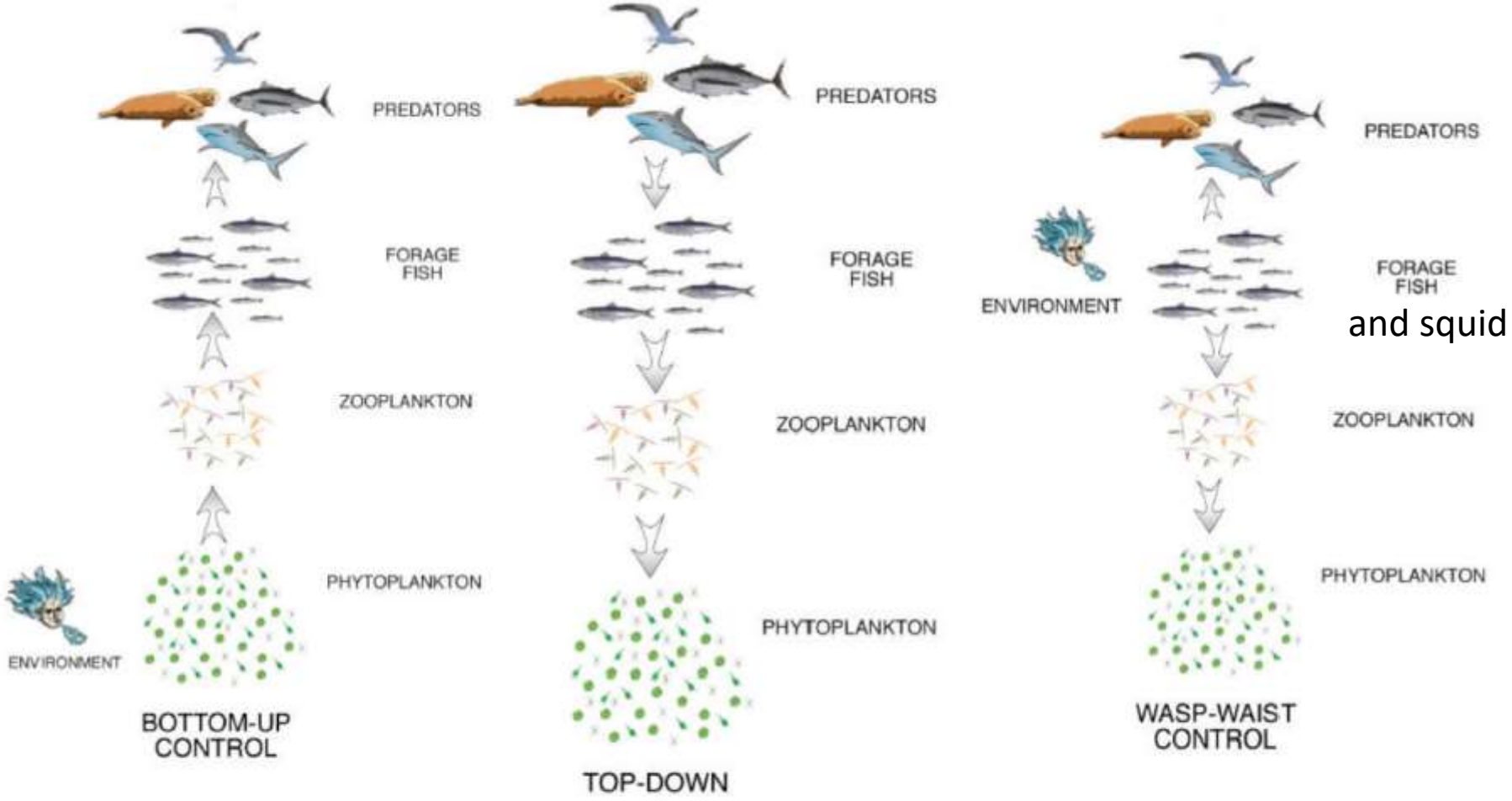

The functioning of marine ecosystems
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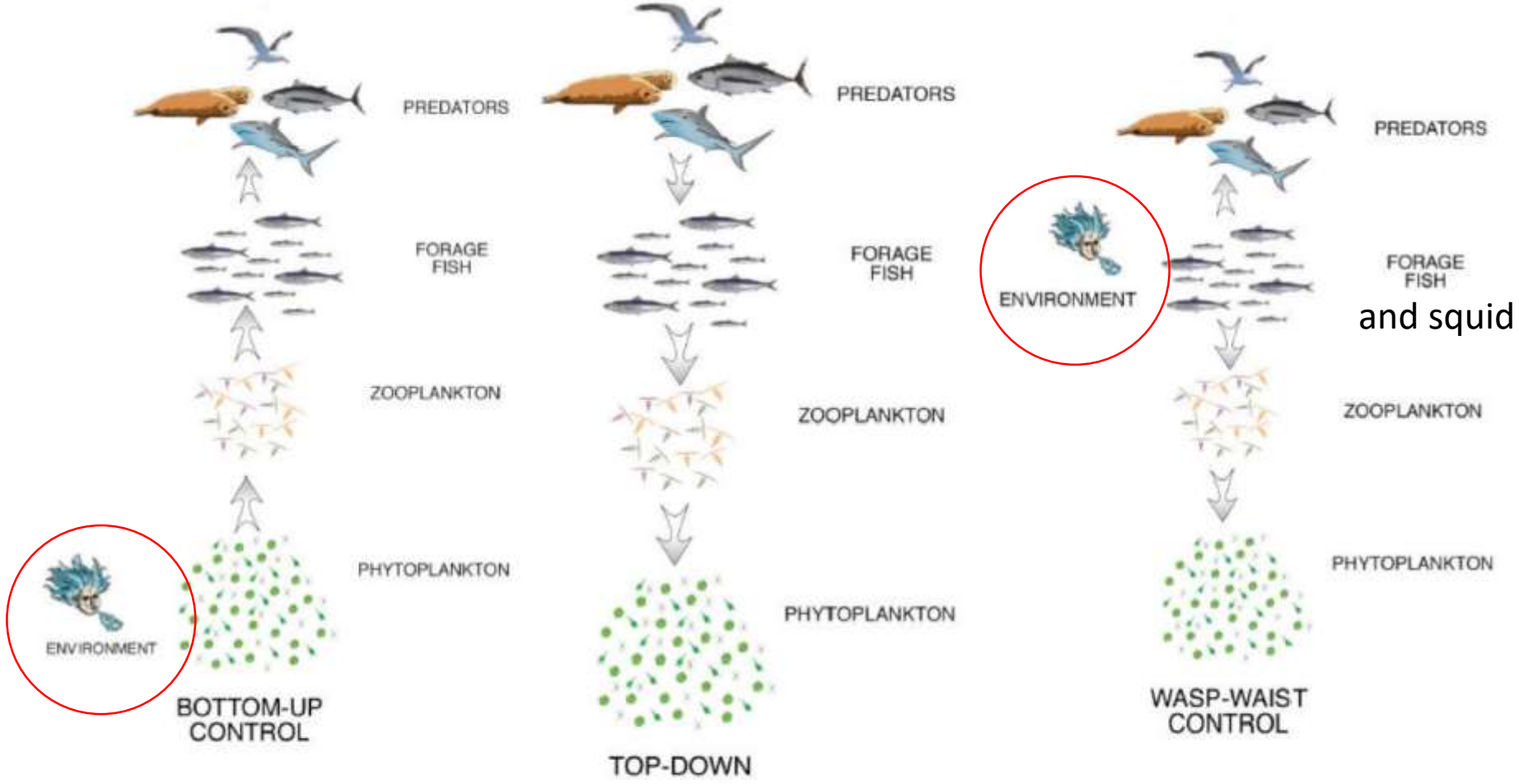

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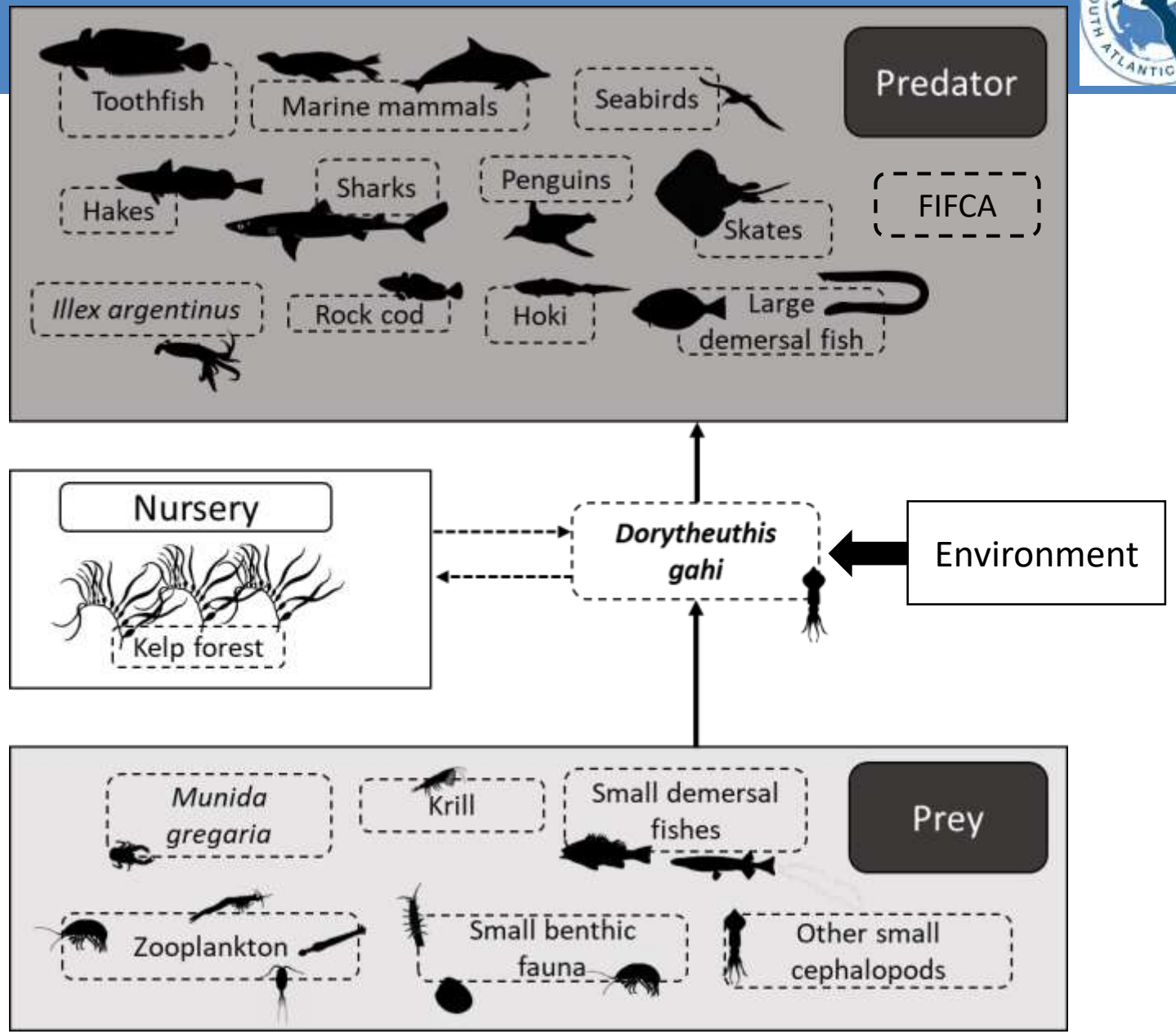
- Rich and diverse
- Wasp-waist interactions

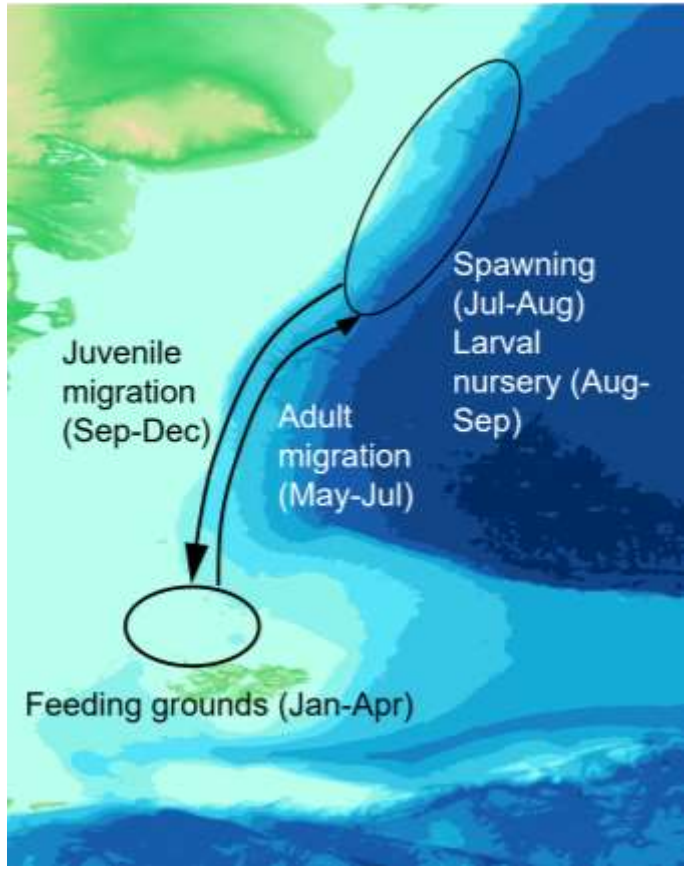


What do we know about the dynamics in the marine environment?

- Rich and diverse
- Wasp-waist interactions
- Migratory species and stocks
  - Larval connectivity with mainland S America

Doryteuthis migration

Illex migration



What do we know about the dynamics in the marine environment?

The Falkland Islands marine ecosystem: A review of the seasonal dynamics and trophic interactions across the food web

Synthesis is published – if you want a copy, email: jvandergrient@saeri.ac.fk

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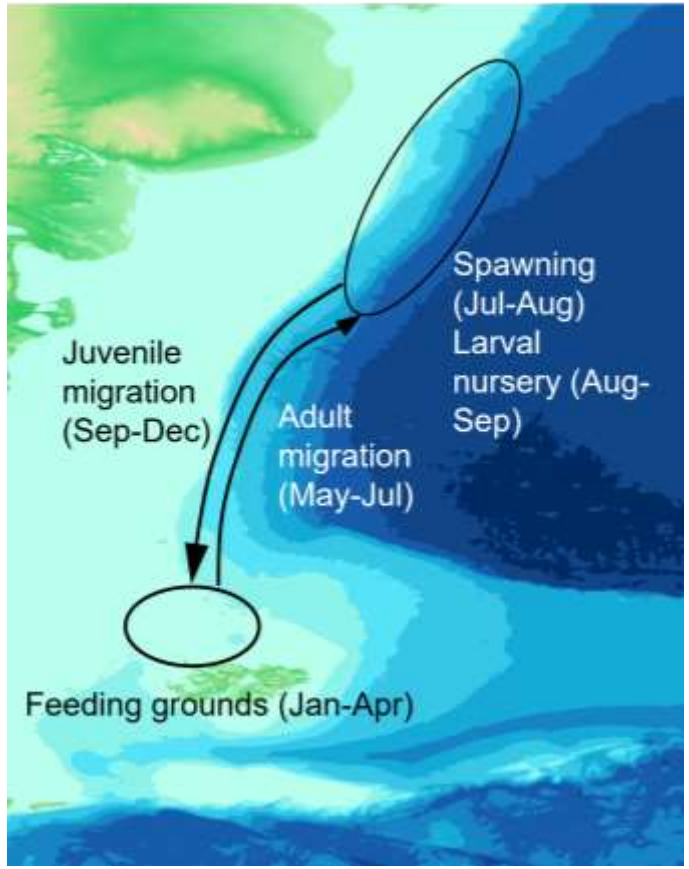


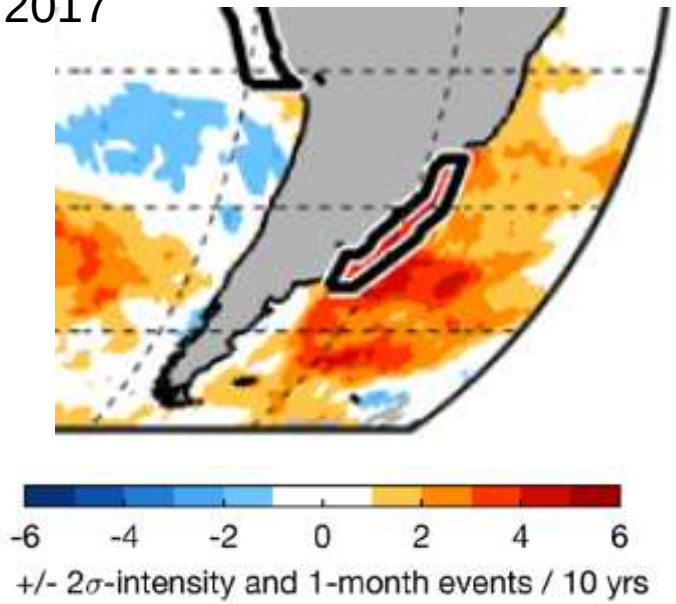
What do we know about the dynamics in the marine environment?

Environmental factor	Trend
Air temperature	Increased
Inshore water temperature	?
Marine heatwaves	Increased intensity and frequency?
Falkland Current temperature	Stable or decline – depending on models
pH	? Off the coast of Brazil pH dropped between -0.1 ± 0.06 and -0.2 ± 0.1 (depending on water mass) since the Industrial Revolution
Confluence location	-0.11° ± 0.076° decade^{-1}
Falkland Current strength and direction?	?
Wind, upwelling, primary production, …	? An increase in more southerly winds and an increase in the temperature gradient between the Falkland Current and adjacent shelf waters could result in increased turbulent mixing. This can result in increased chlorophyll production via the increased availability of nutrients. Chlorophyll production has increased 1 mg m^{-3} decade^{-1} on average on the shelf and slope.

What do we know about marine heatwaves?

Observed frequency changes

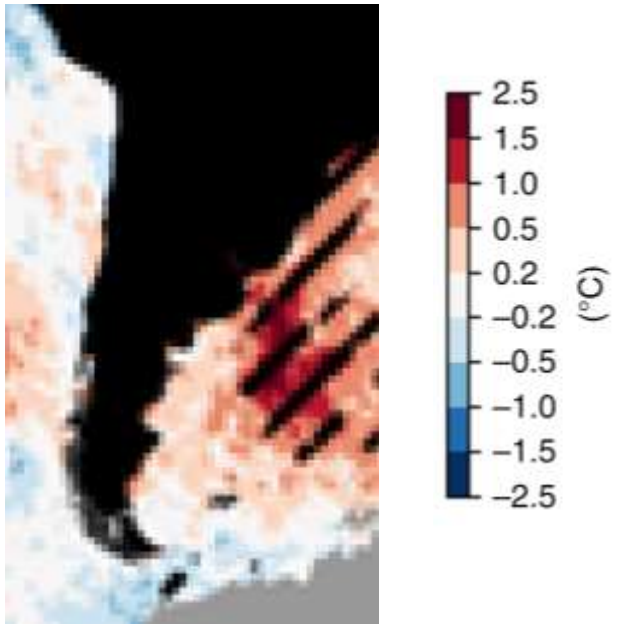
Difference between 1958–1987 and 1988–2017



Xu et al. 2022

Marine heatwave intensity

Difference between 1982-1998 and 2000-2016



Oliver et al. 2018

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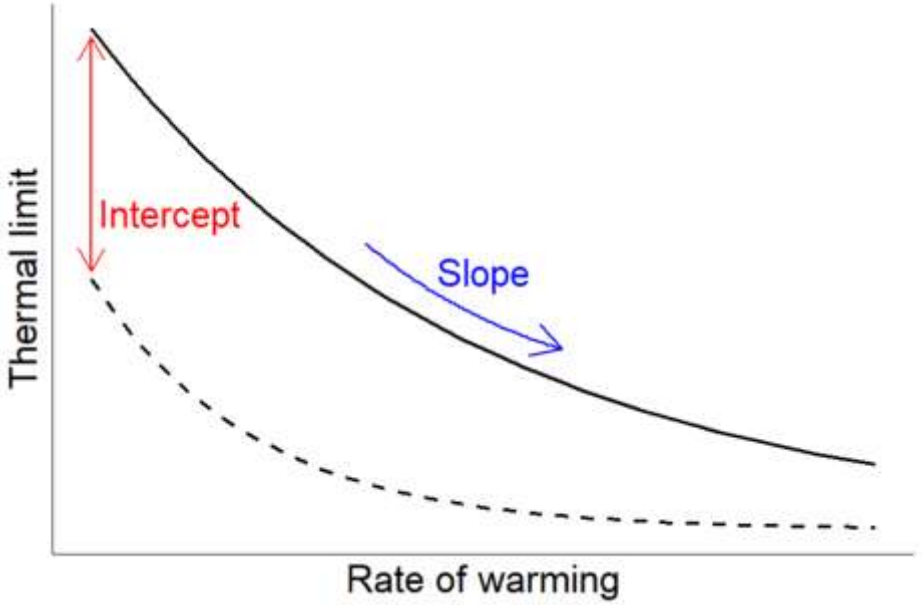
What are the potential impacts of temperature changes inshore?

Intercept = tolerance to heatwaves

Slope = plasticity for long-term warming



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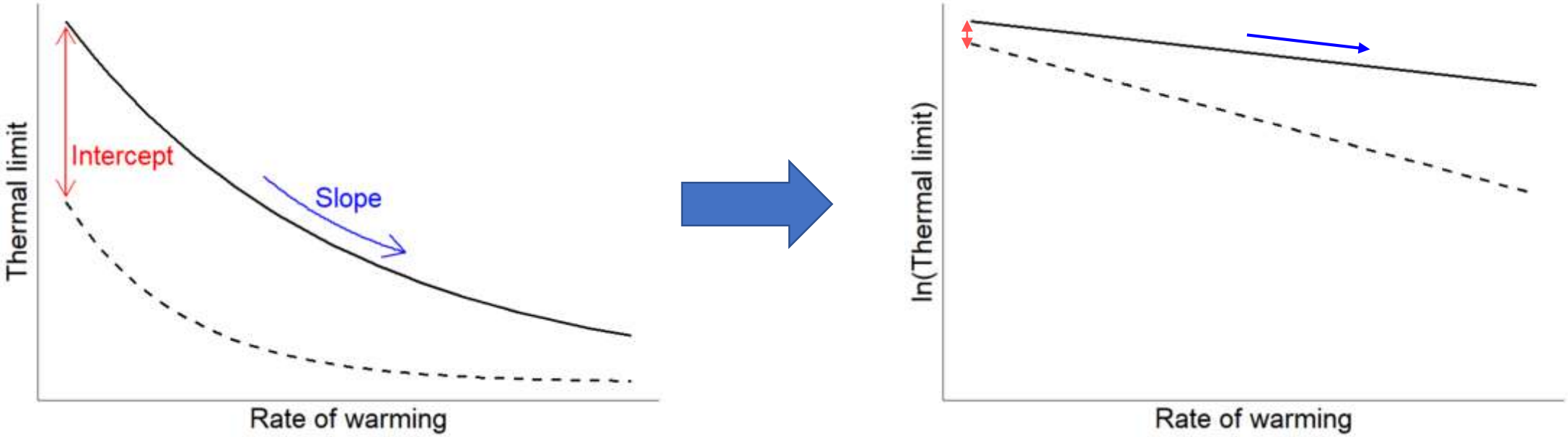

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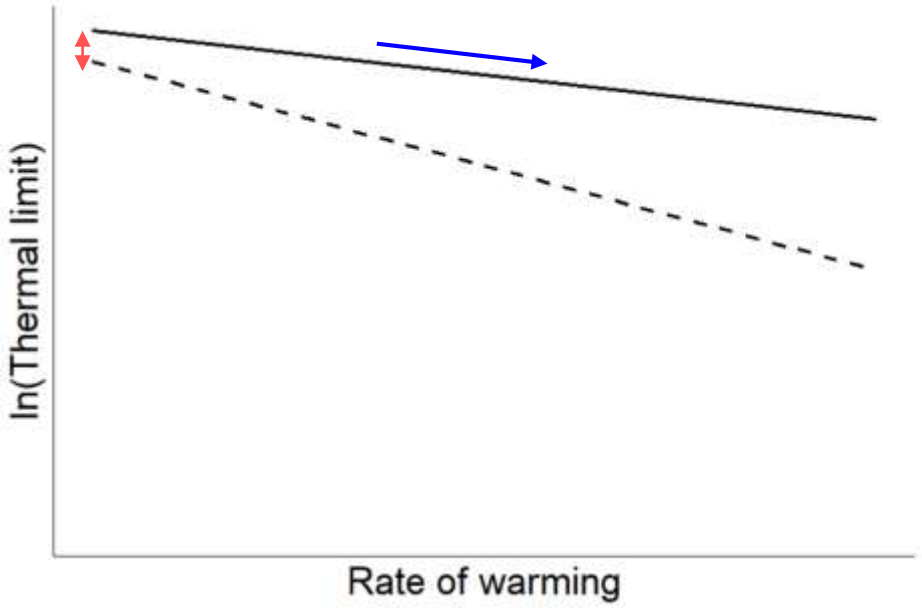
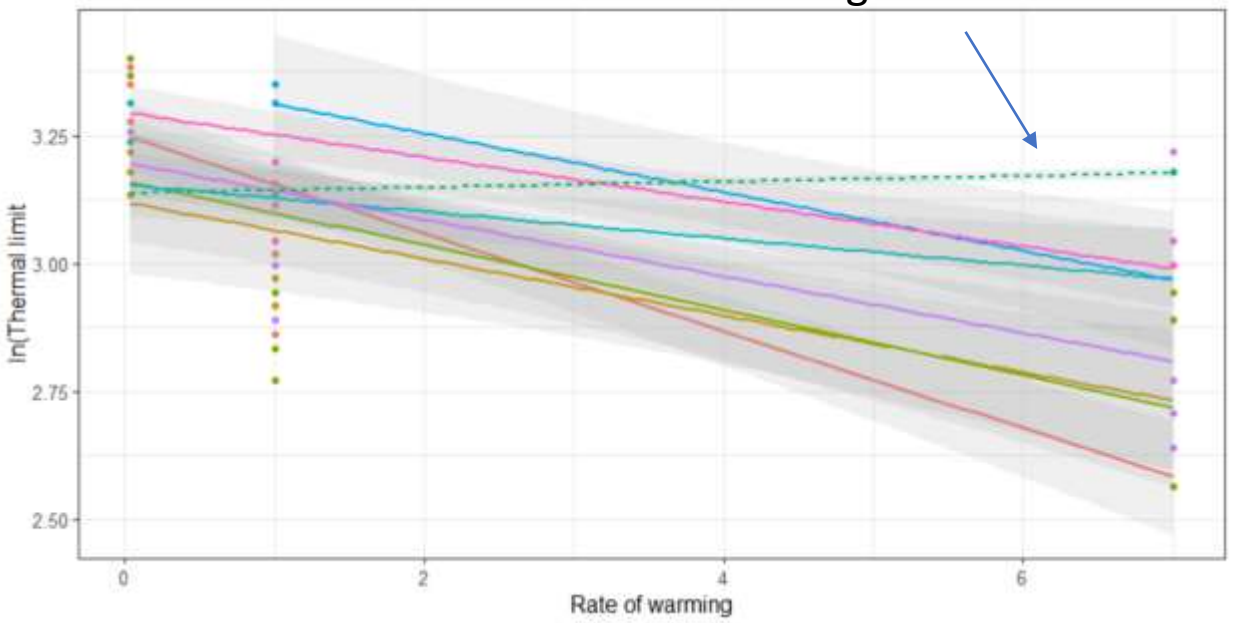


Large lobster krill



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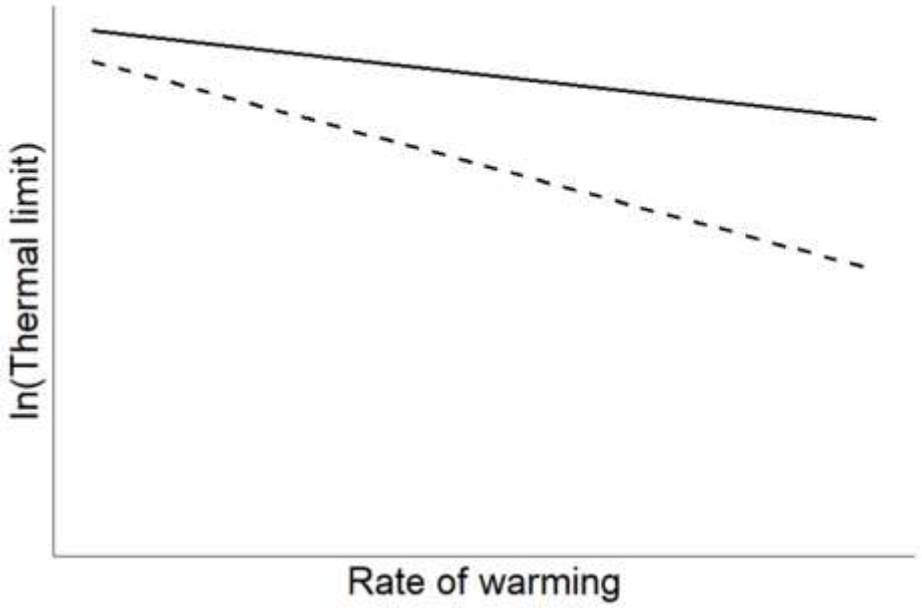
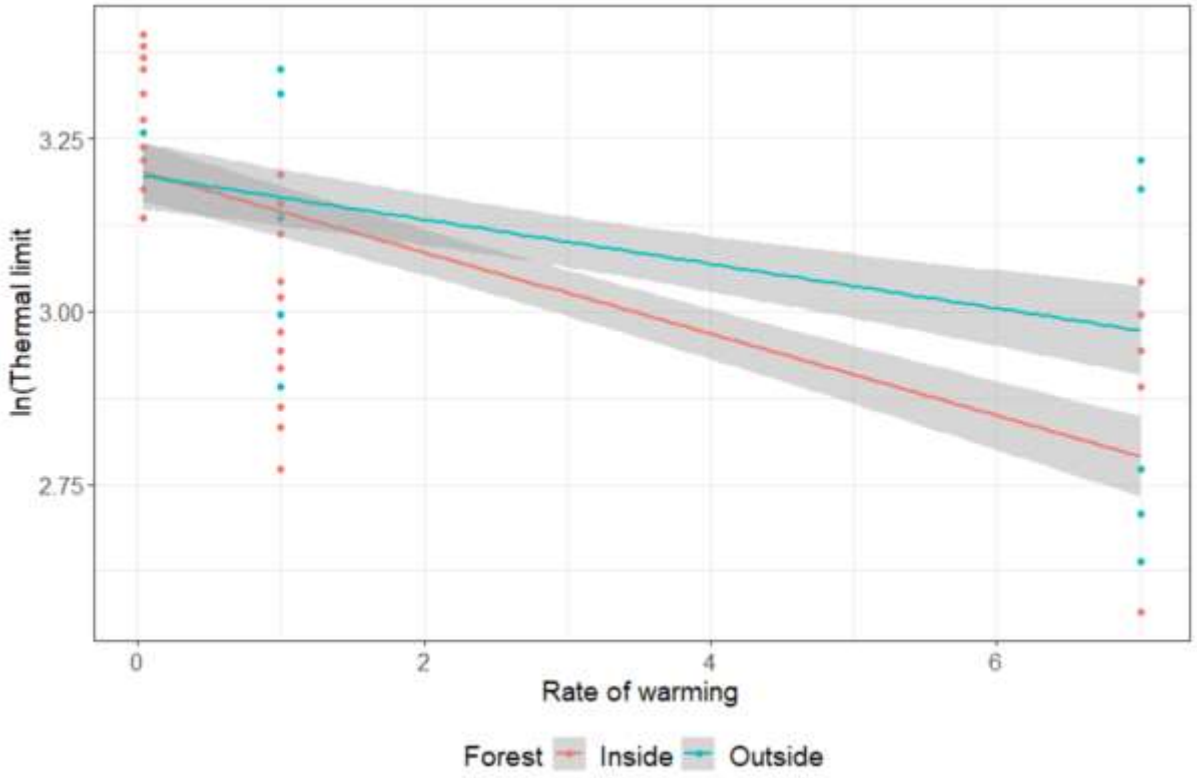


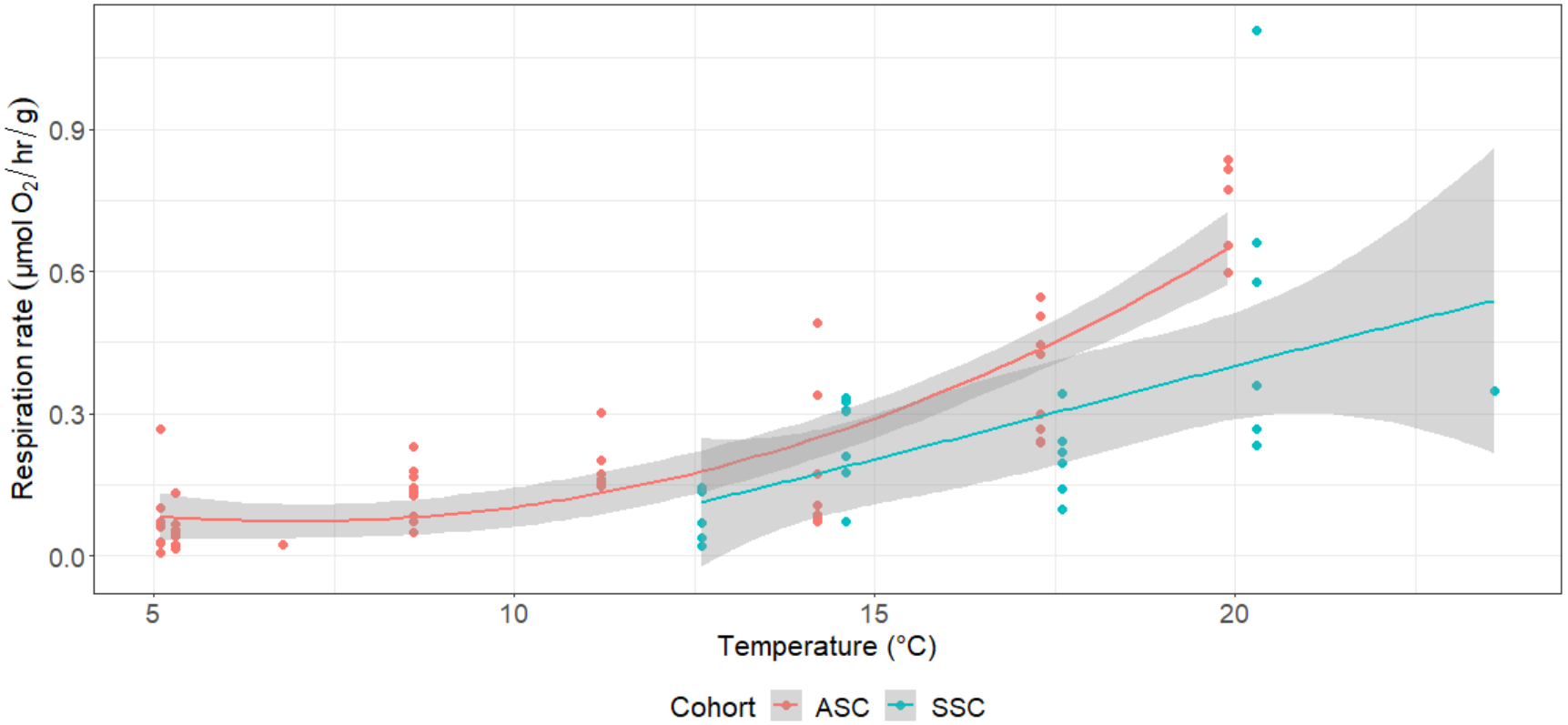


What are the potential impacts of temperature changes inshore?

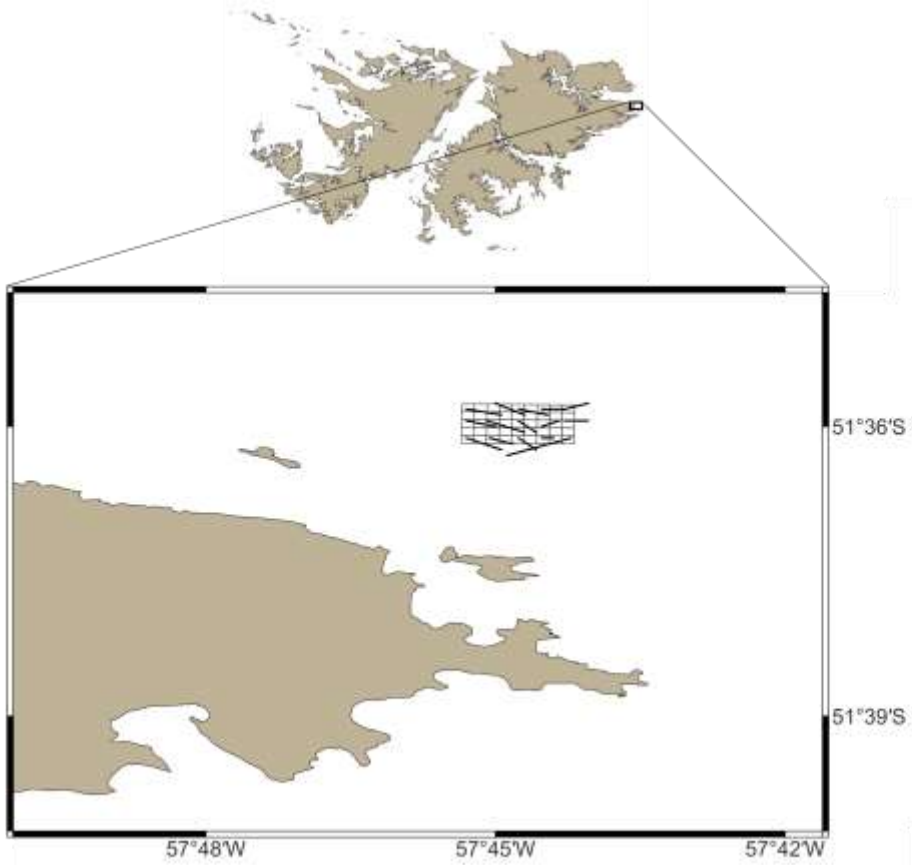
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ASC	migration	feeding grounds			spawning		egg development		hatching		maturation	migration
SSC	hatching	maturation		migration			feeding grounds			spawning		hatching

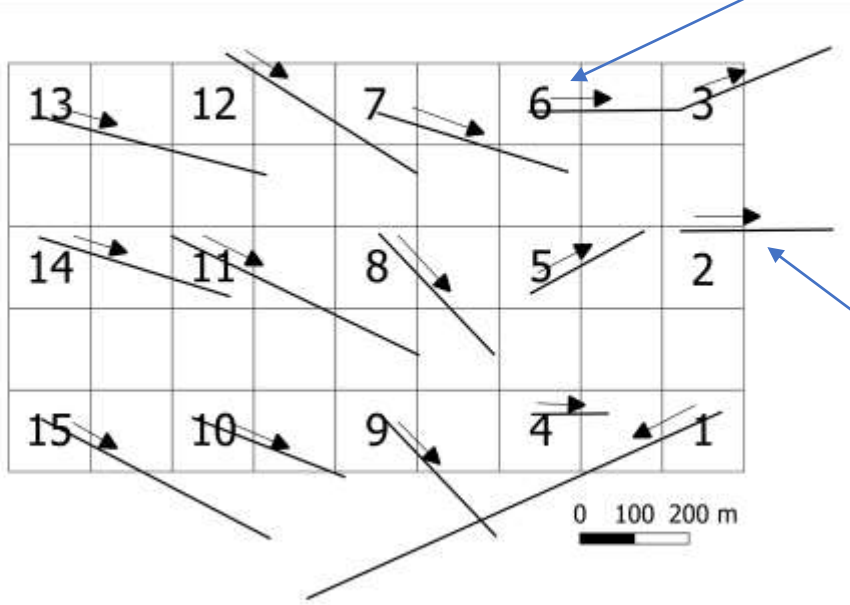
4-6 months difference in spawning
2-3 months difference in hatching

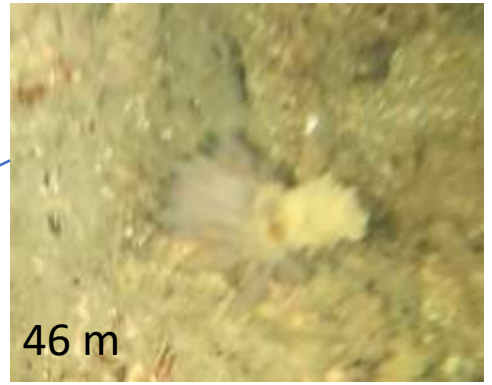
What are the potential impacts of temperature changes inshore?



Squid spawning plasticity: use of deeper water







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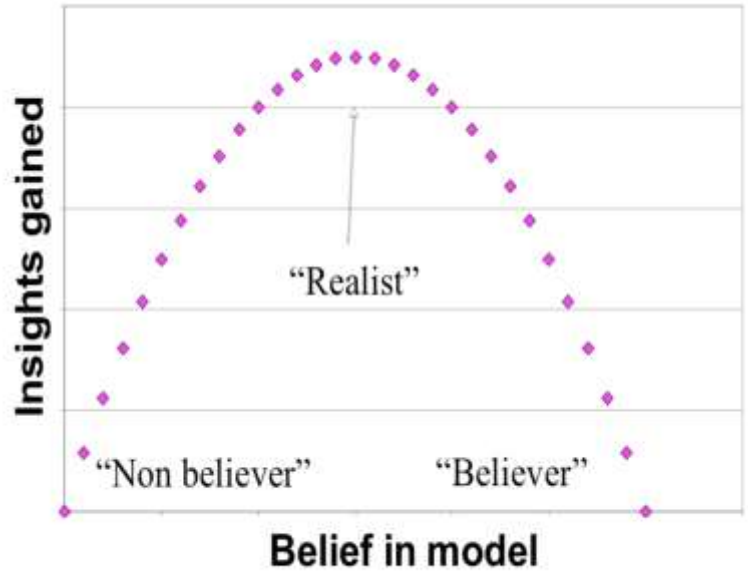
- Synthesizing food-web information and environmental change in a fishery system
  - Ecosystem modelling
    - What is the ecosystem like?
  - Decision-support tool
    - What are outcomes of different policy options?
    - What are the trade-offs that can arise from ecological processes and management interventions?
    - Develop strategic and tactical resource management advice

Aydin's Modelling Yield Curve



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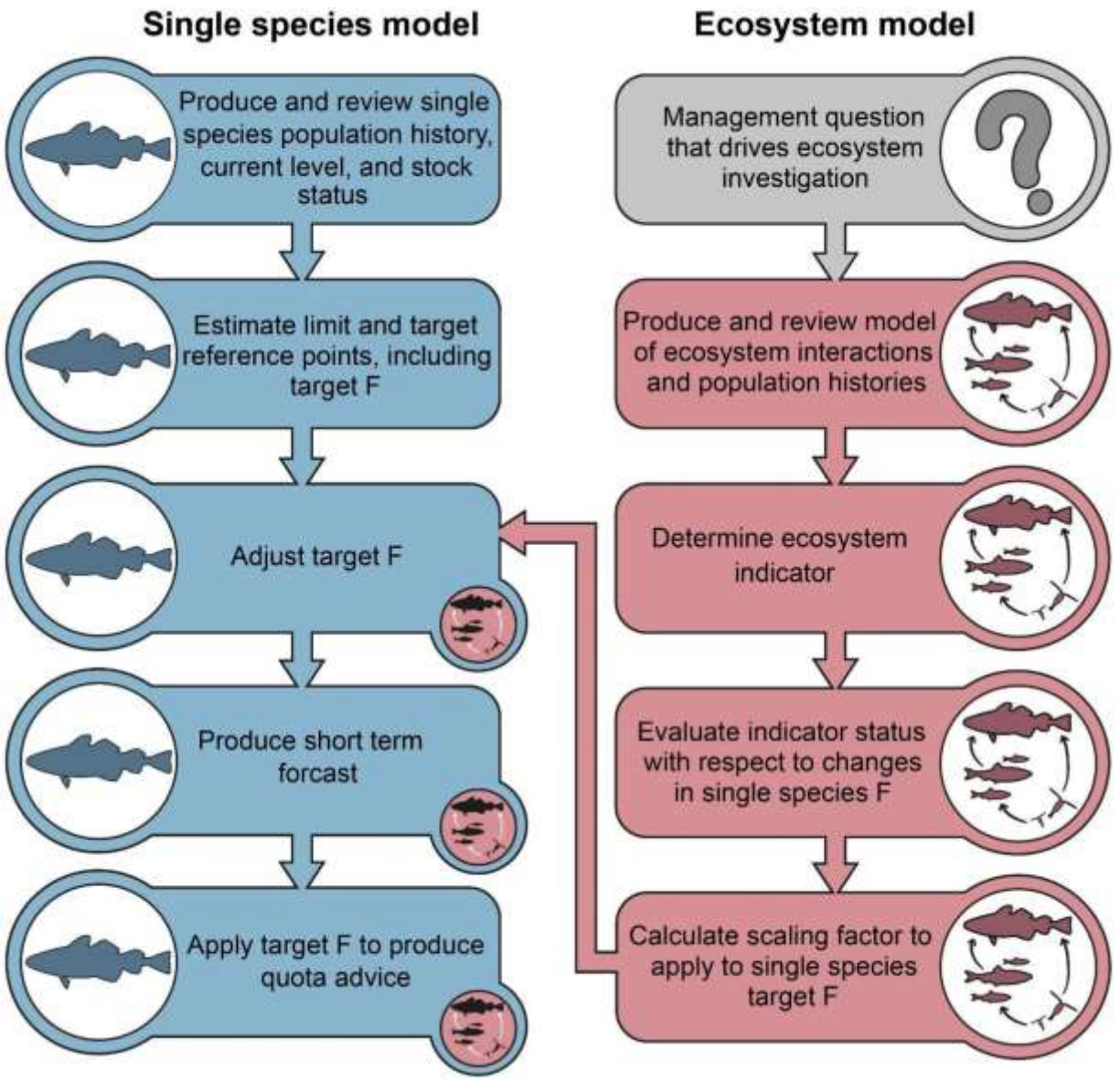

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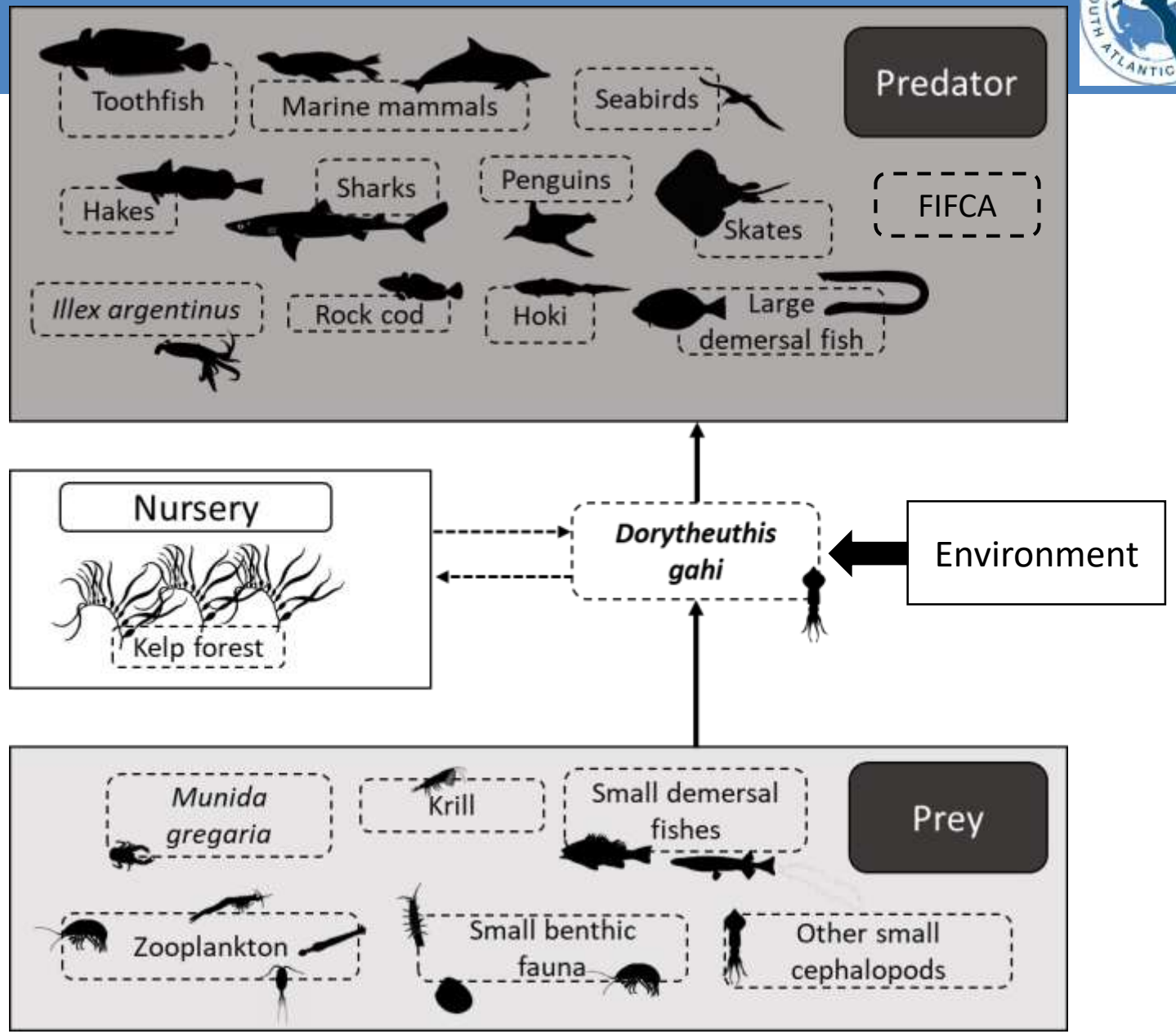

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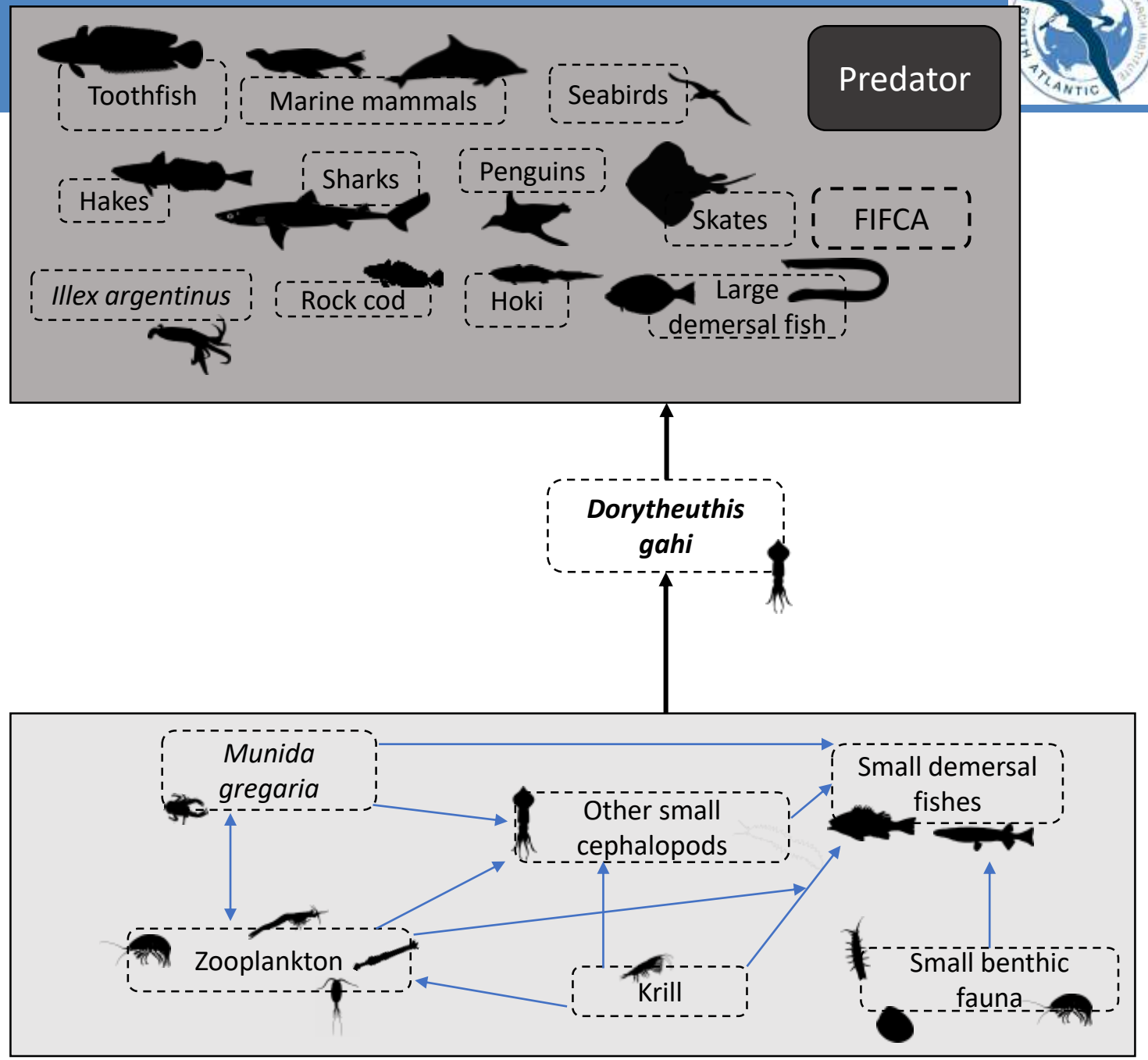

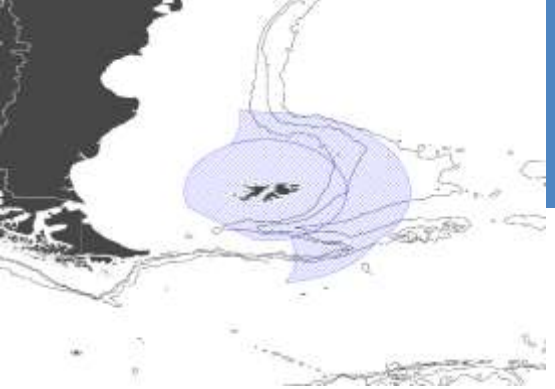

Prey-predator interactions, biomass estimates and energy flow

- Represents biomass
- Represents interaction with width indicating relative flow

Trophic level

5
4
3
2
1

Fisheries
Finfish
Illex
Toothfish
Skates
Loligo

Large other cephalopods
Southern hake
Common hake
Large demersal fishes
Hoki
Pinnipeds
Seabirds
Sharks
Gentoo penguins
Toothed whales
Argentine squid
Patagonian toothfish
Small other cephalopods
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Deep pelagic fishes
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Patagonian squid SSC
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Myctophidae
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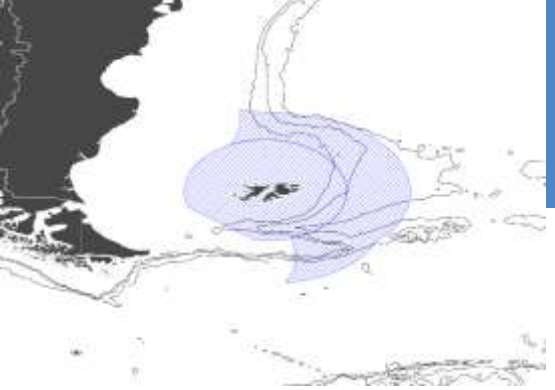

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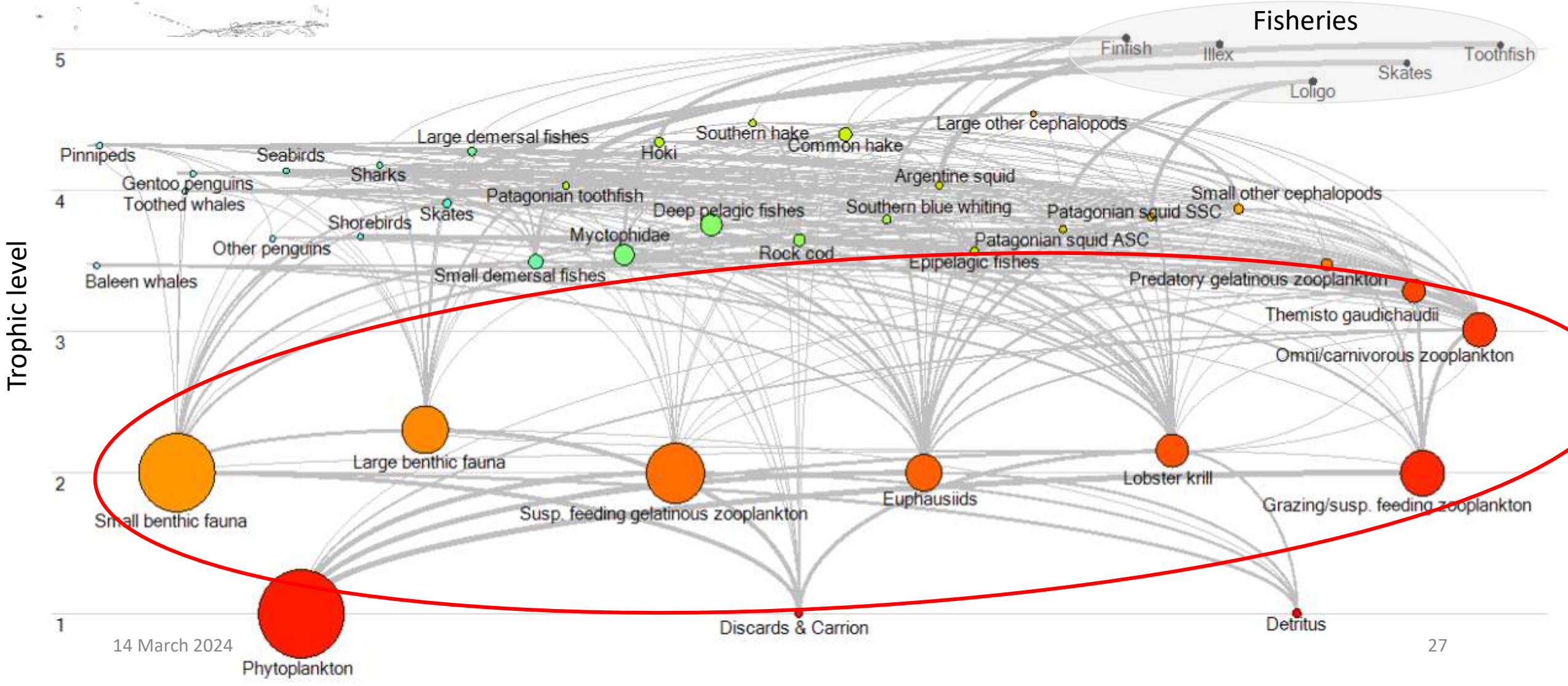

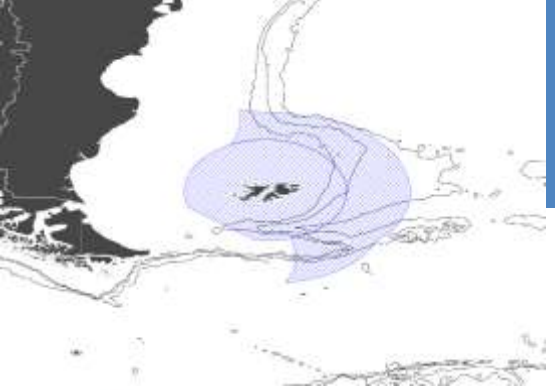

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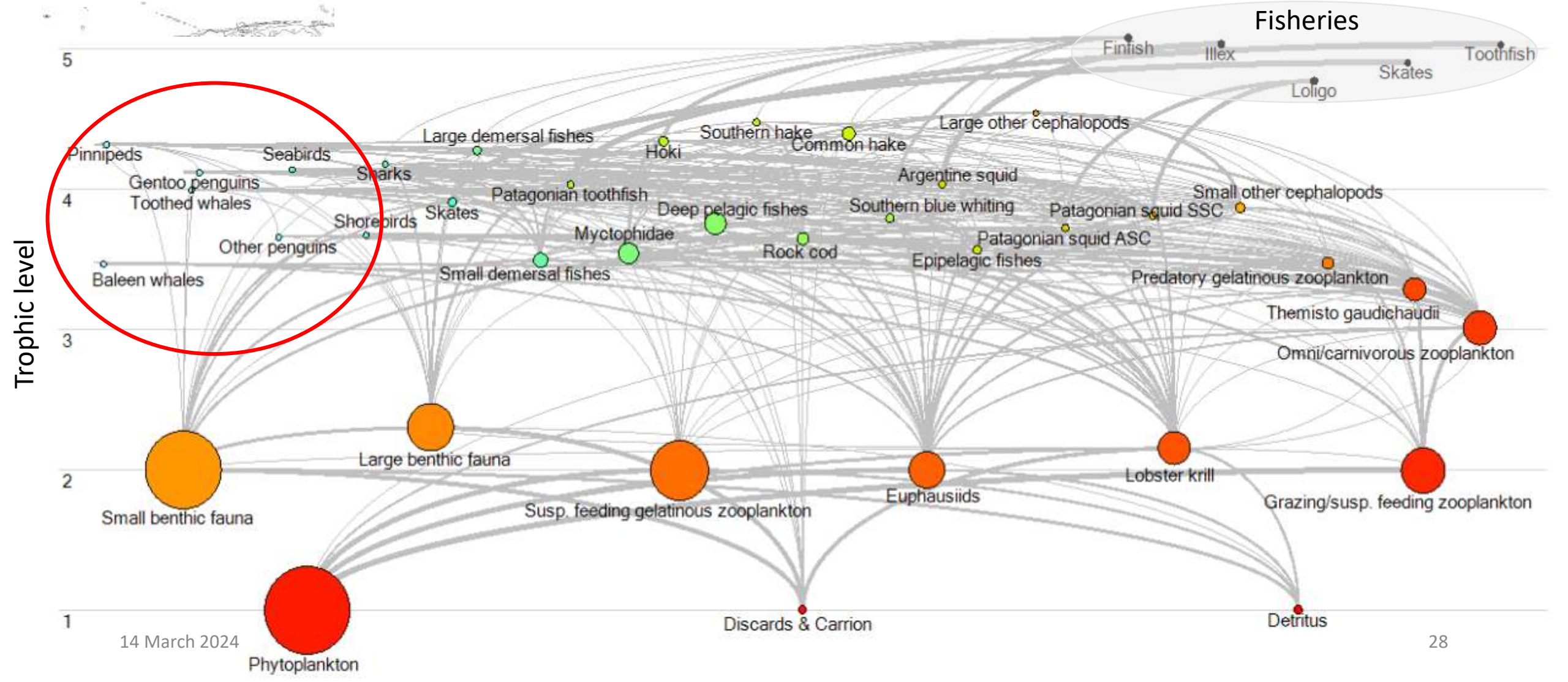

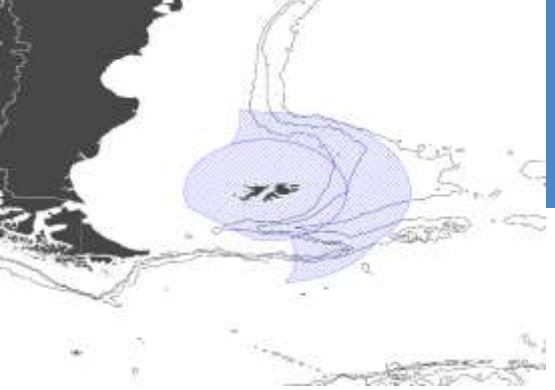

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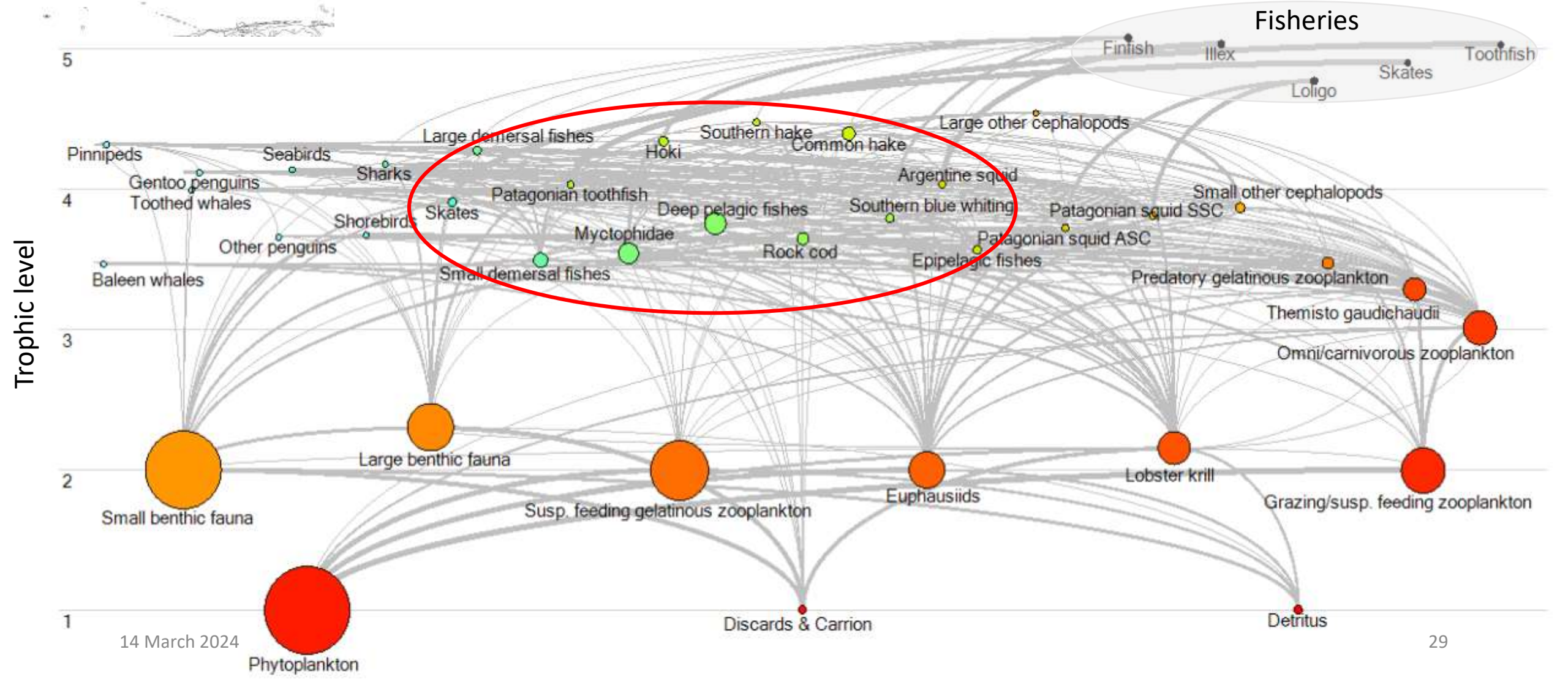

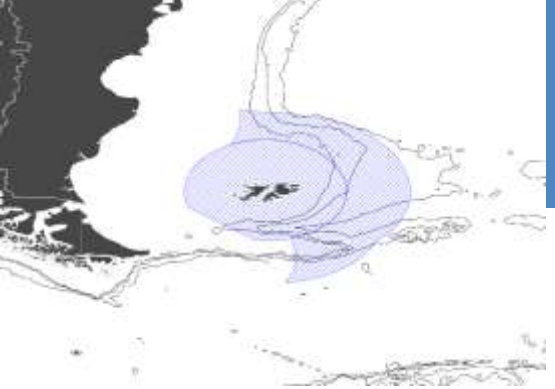

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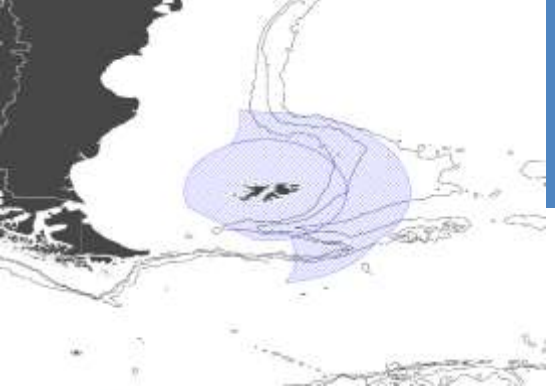

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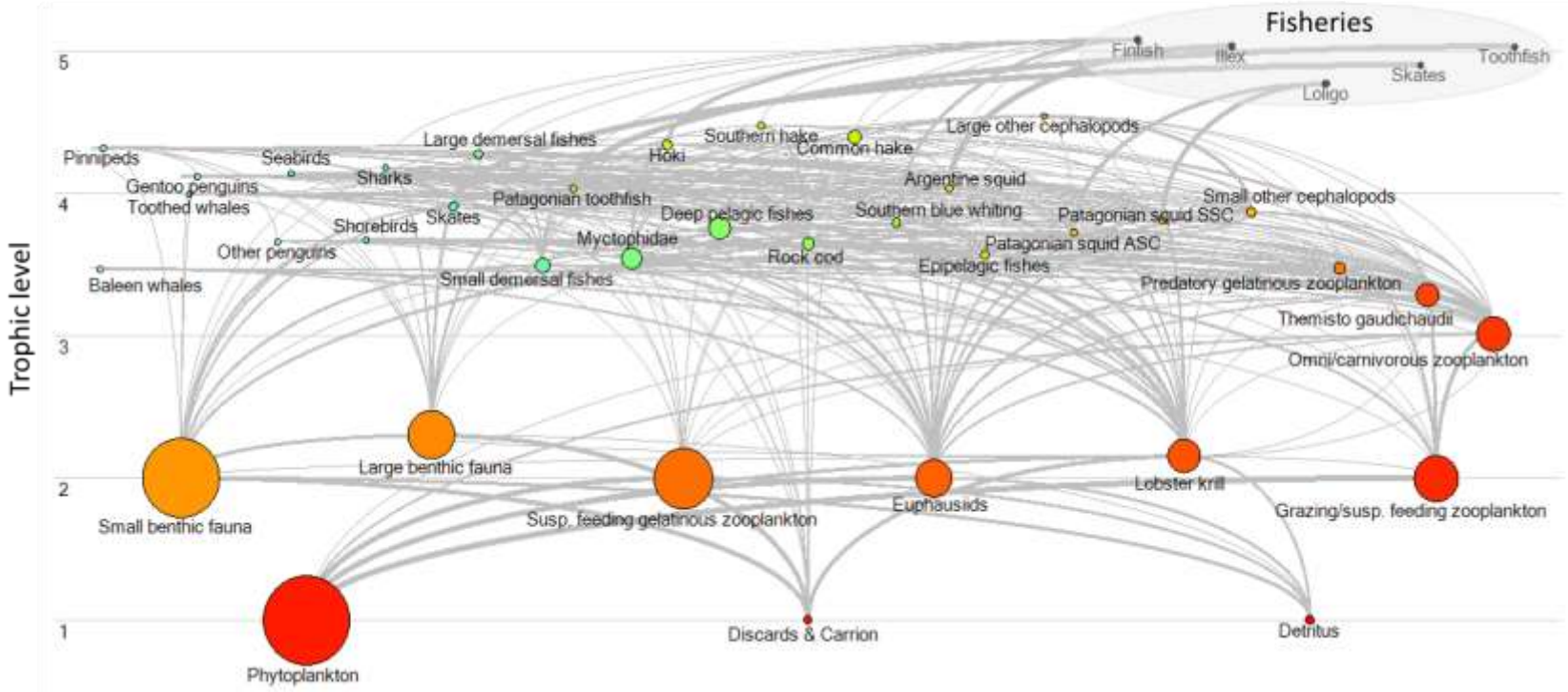
What was expected and what was surprising in the ecosystem structure?

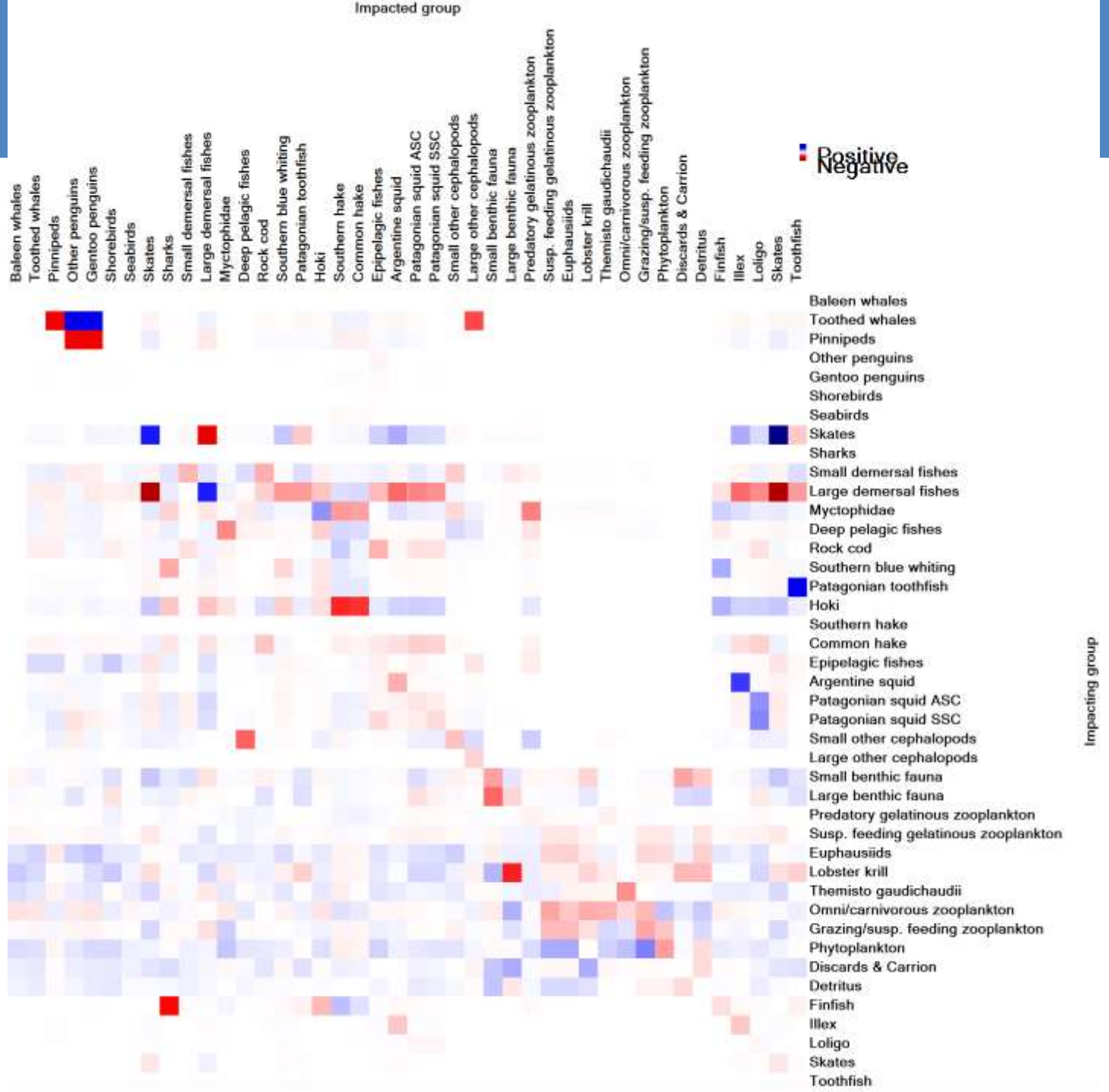
High biomass (surprises)

- Gelatinous zooplankton
- Deep pelagic fishes
- Myctophids

High ecotrophic efficiency:

- Patagonian squid (both cohorts)
- Rock cod
- Skates (surprise)

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Negative
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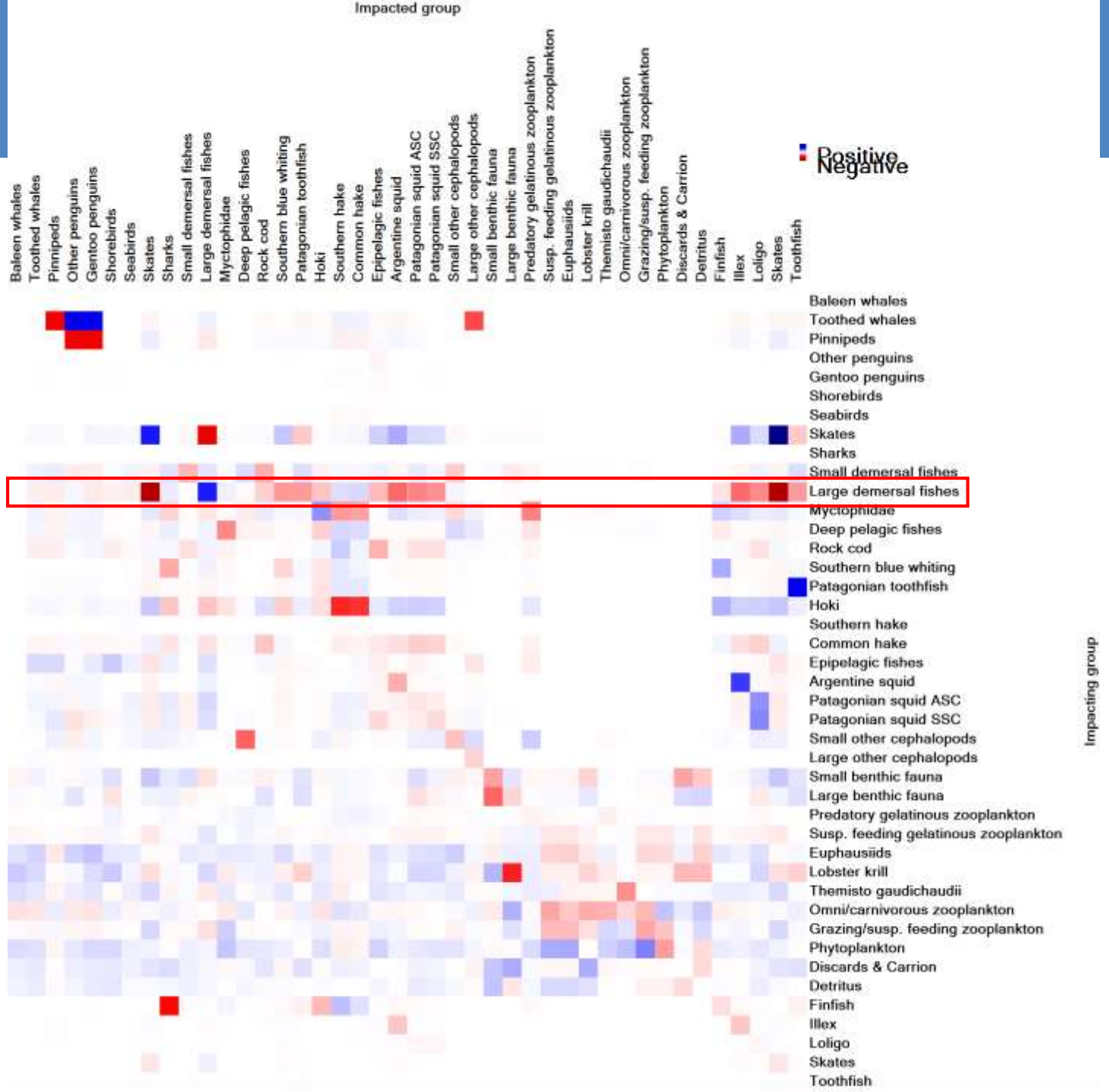
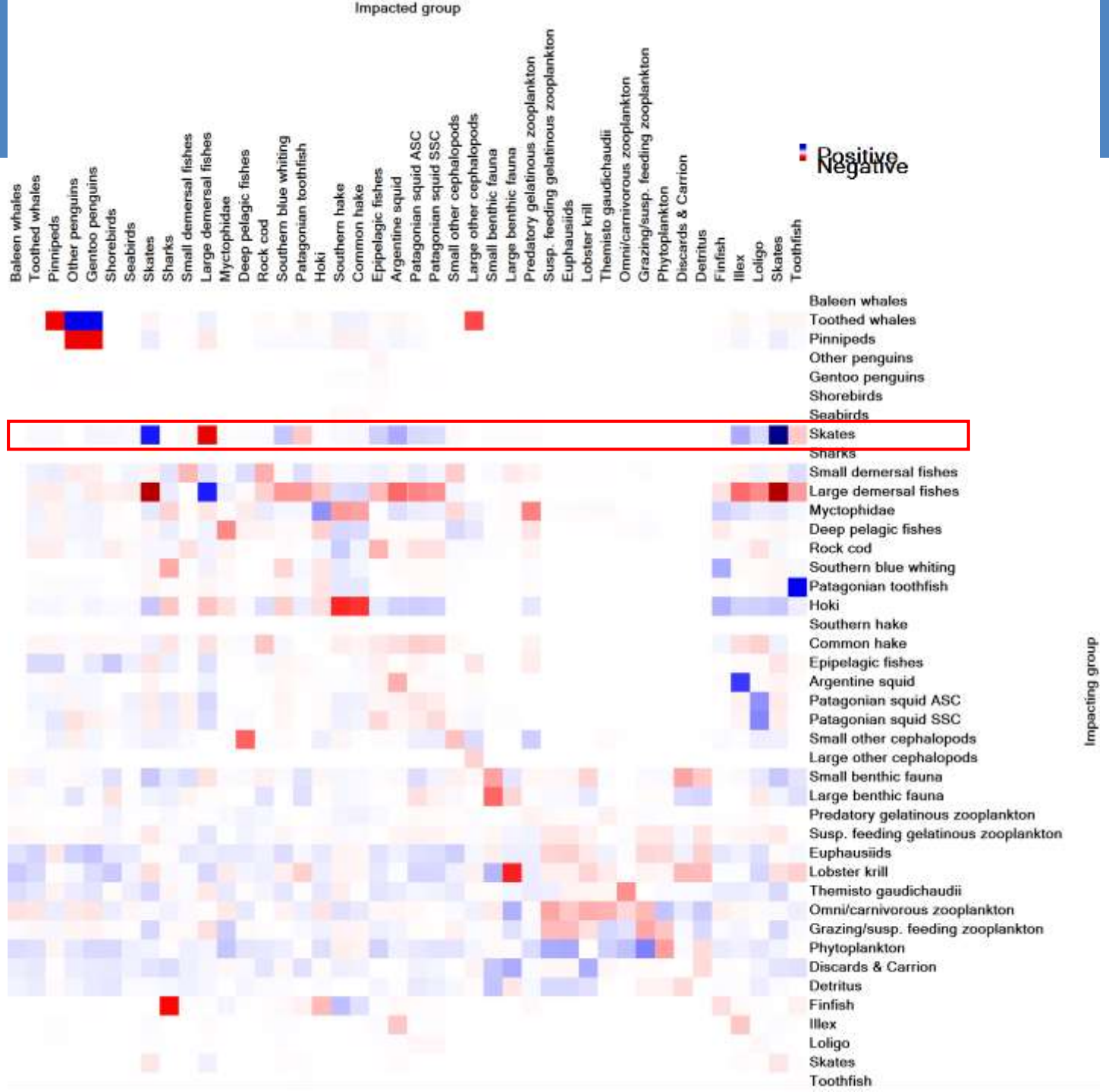
Large demersal fishes have potentially reducing association with various other groups (directly or indirectly)



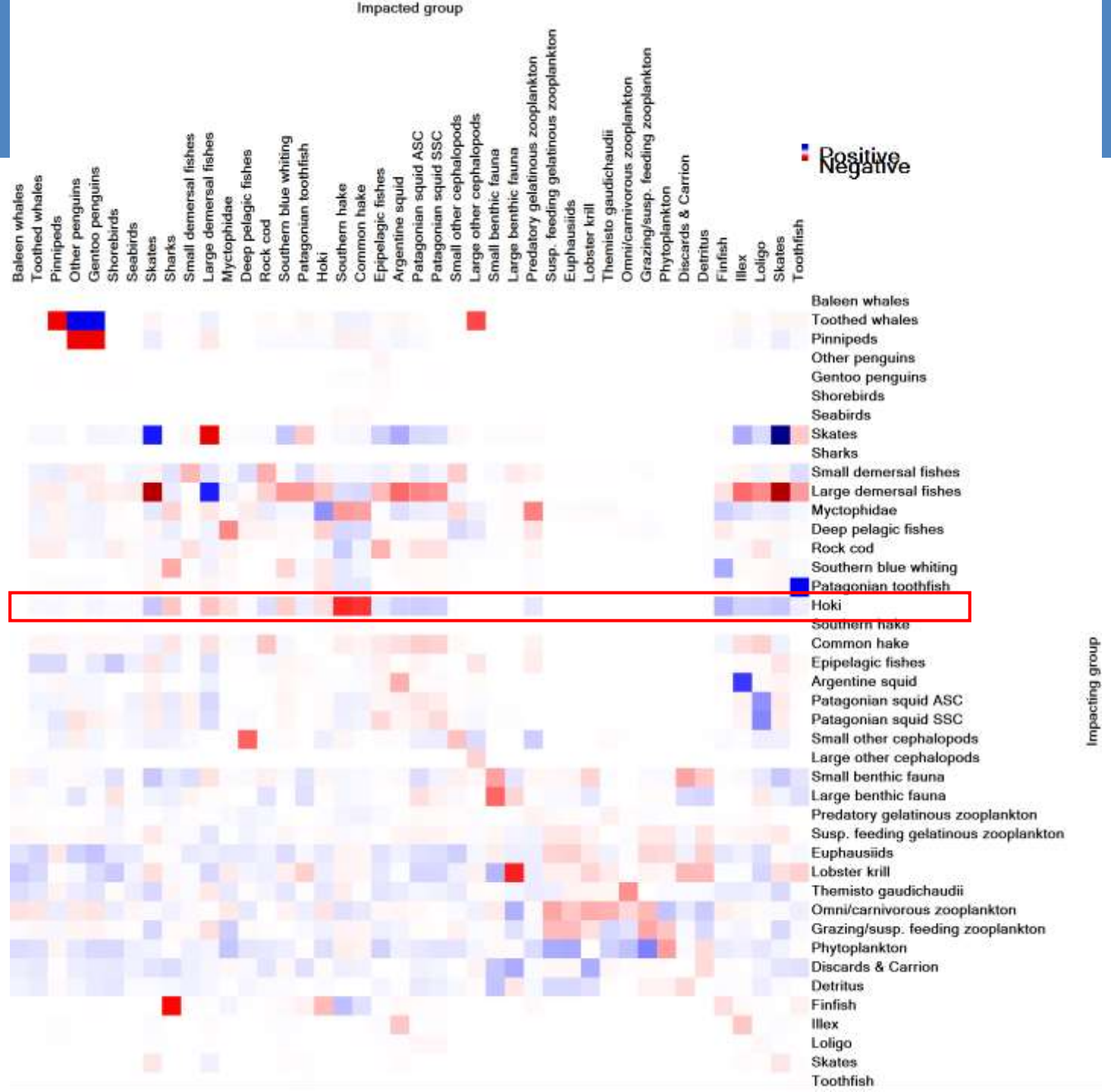
Skates potentially have reducing association with large demersal fishes

Do changes in skates biomass correlate to other changes observed?

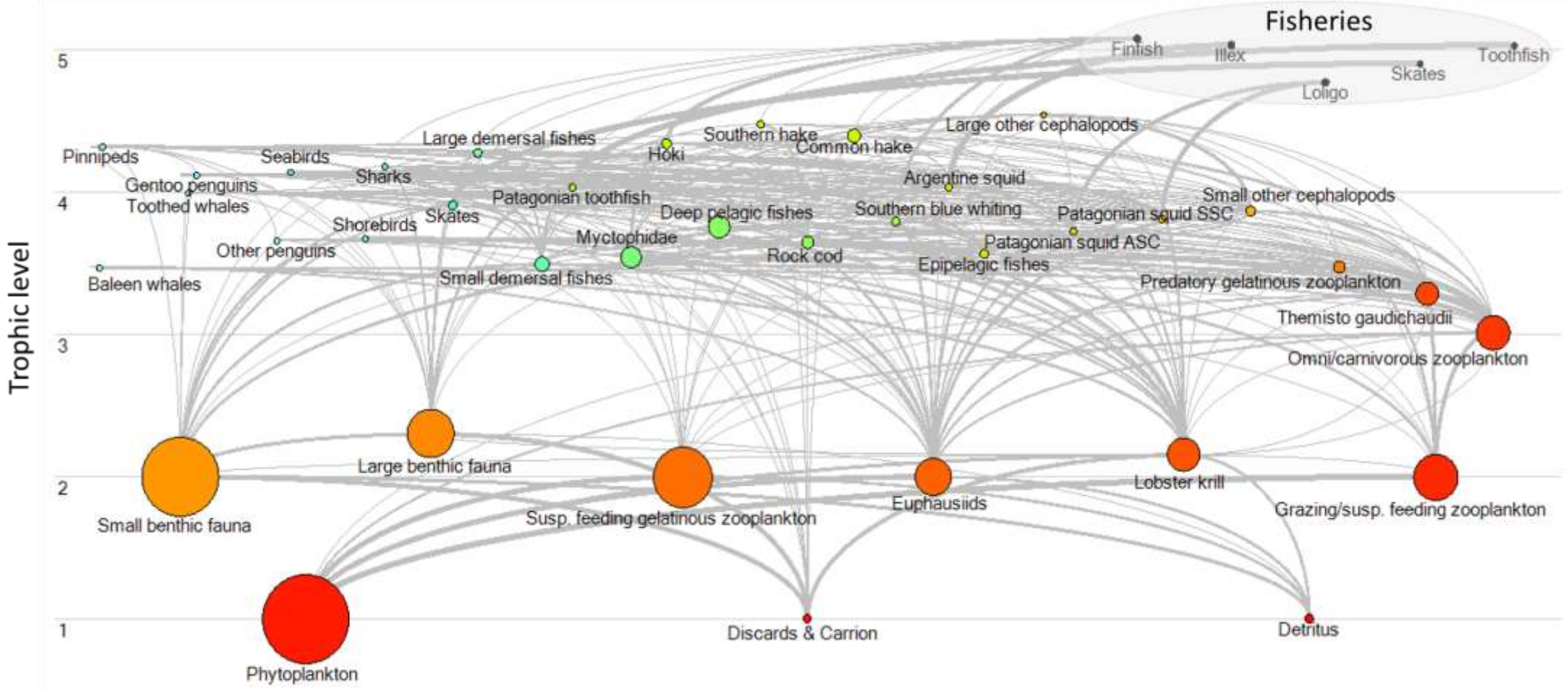


Hoki has a reducing association with hakes

Do current changes in hake biomass correlate with other food-web change?

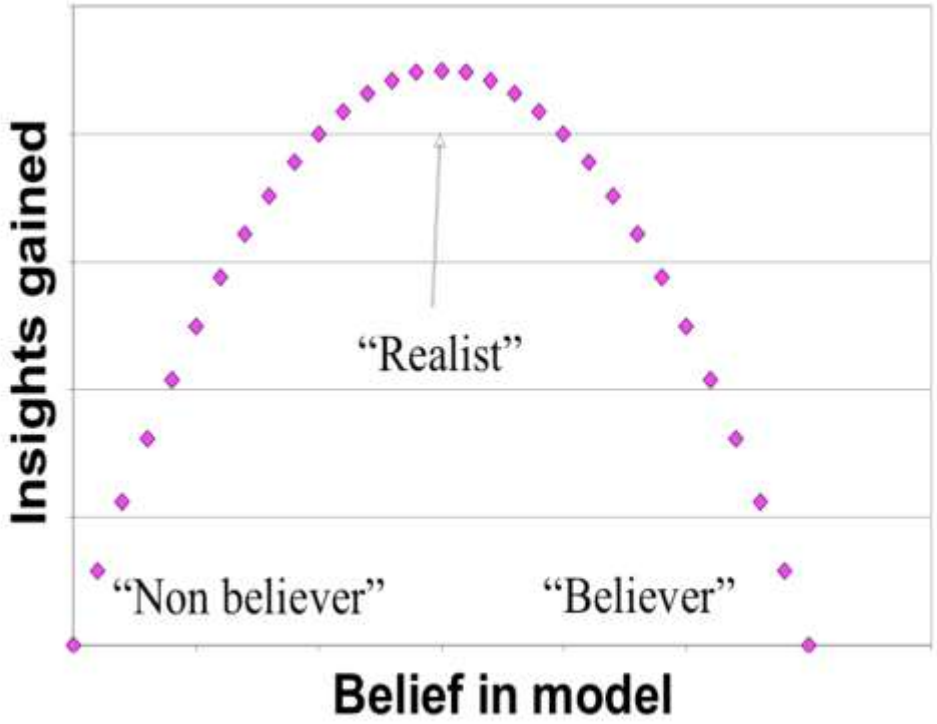


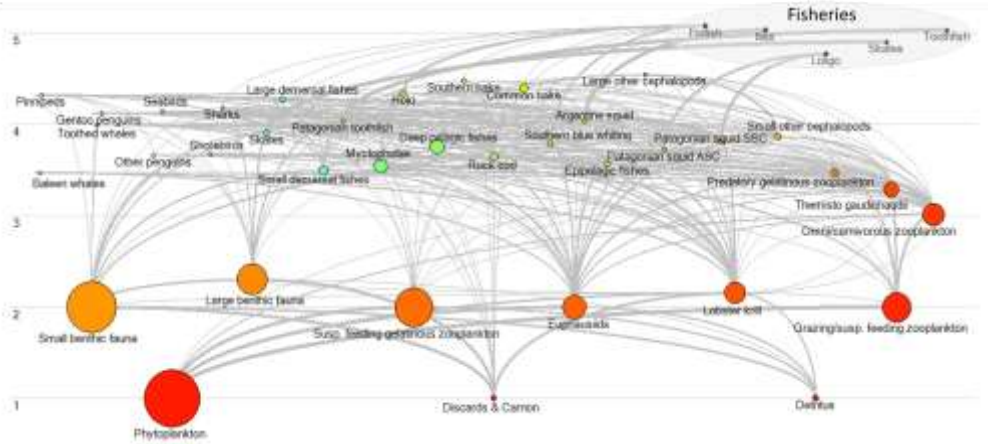
How well can the model replicate trends from 2001-2021?



How well can the model replicate trends from 2001-2021?

Aydin's Modelling Yield Curve



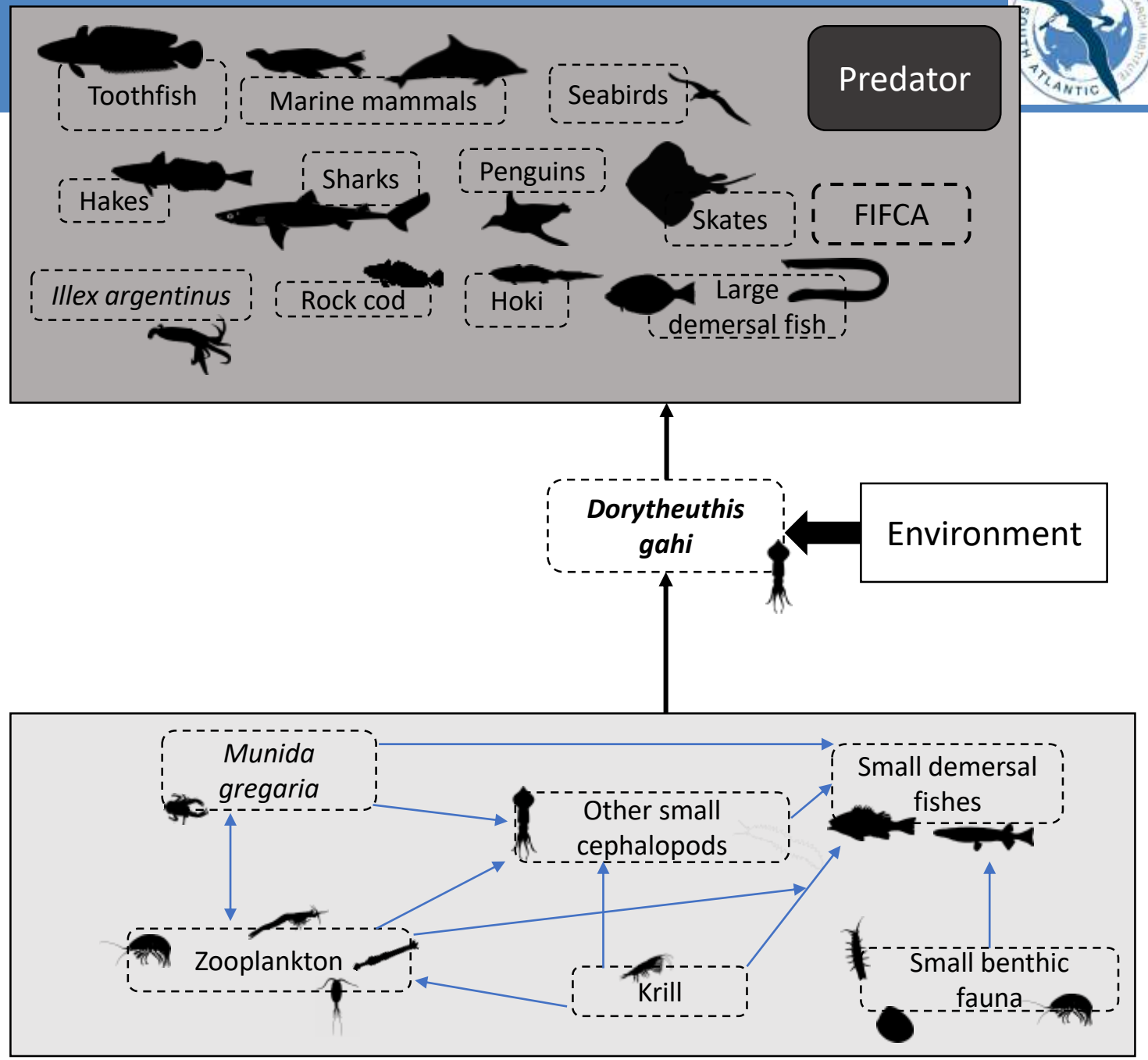


How well can the model replicate trends from 2001-2021?

Towards an operational model

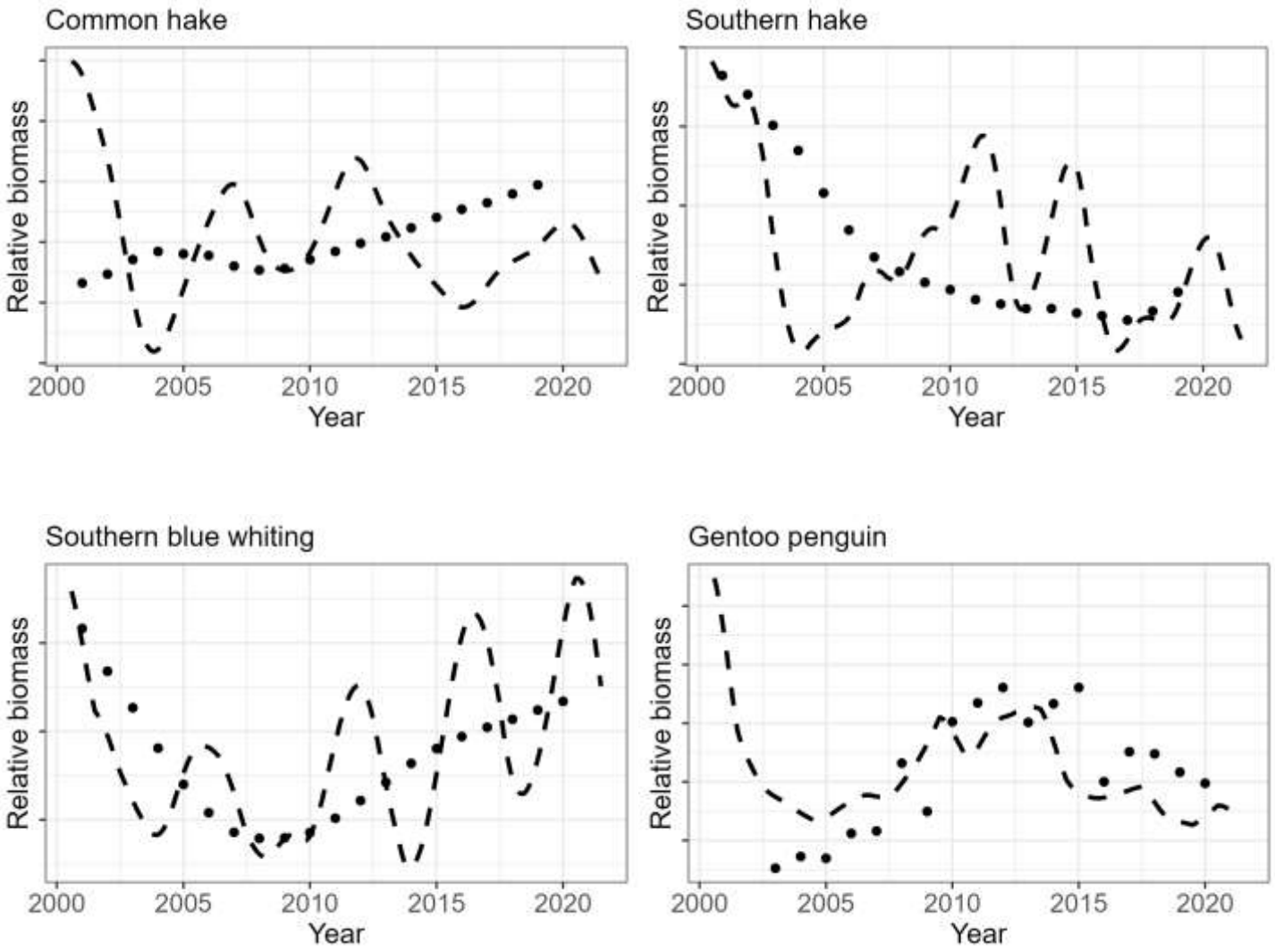
Environment

Primary productivity
Historical catches
Temperature (bottom and sea surface)
Windspeed
Mixed layer depth
Surface current speeds



– – Model result

● Fisheries reconstructed biomass or survey data



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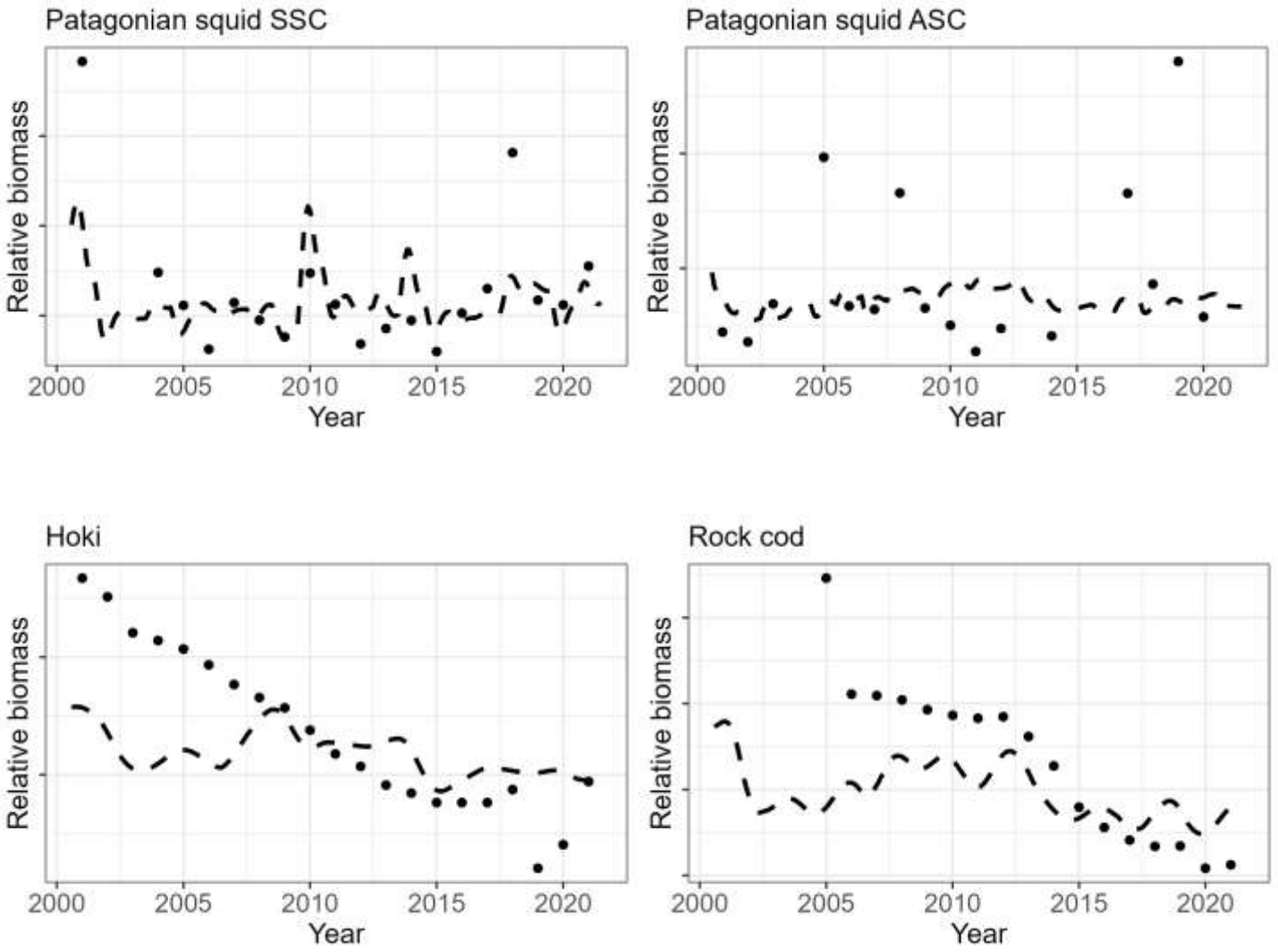
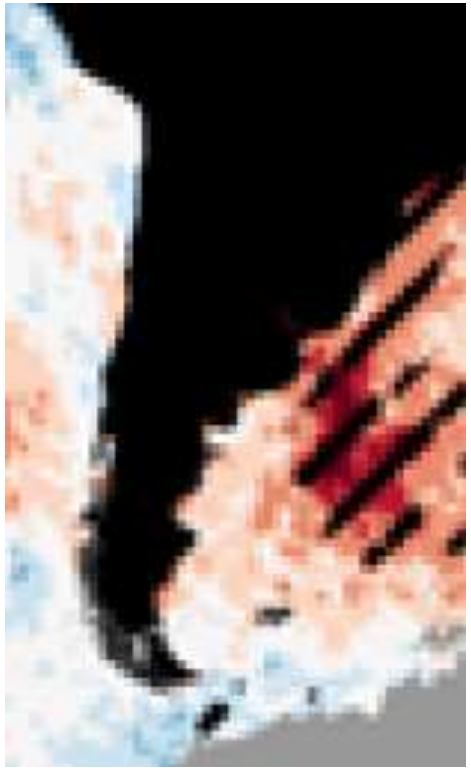
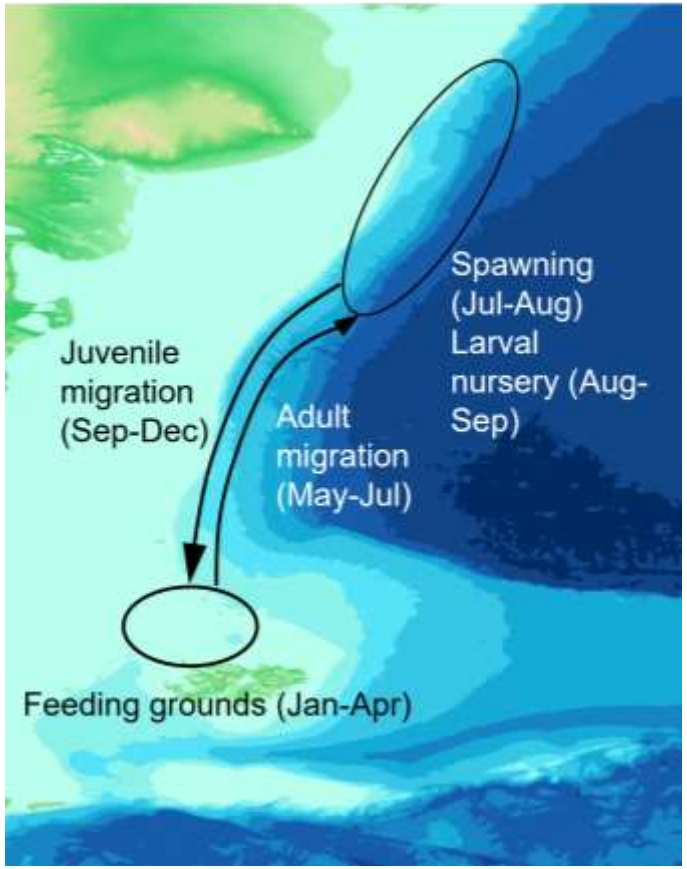


What do we know about the dynamics in the marine environment?

- How might spatial variation around the Falkland Islands and further afield affect the dynamics around the Islands?
- How may environmental factors currently not included in the model affect the food web? E.g.,
  - Transient zone position
  - Falkland Current dynamics
  - Marine heatwaves?
  - Potential poleward migration?



Illex migration



DPLUS148: Climate change resilience in the Falklands fisheries and marine environment

Conclusions

- Reasonably stable system – for now/based on what we incorporated
- Spatial effects, especially those from other regions, could cause unexpected effects
  - Investigate other environmental factors beside temperature
- There is a need to collaborate further for knowledge exchange