Comparisons of Southern Ocean Ecosystems

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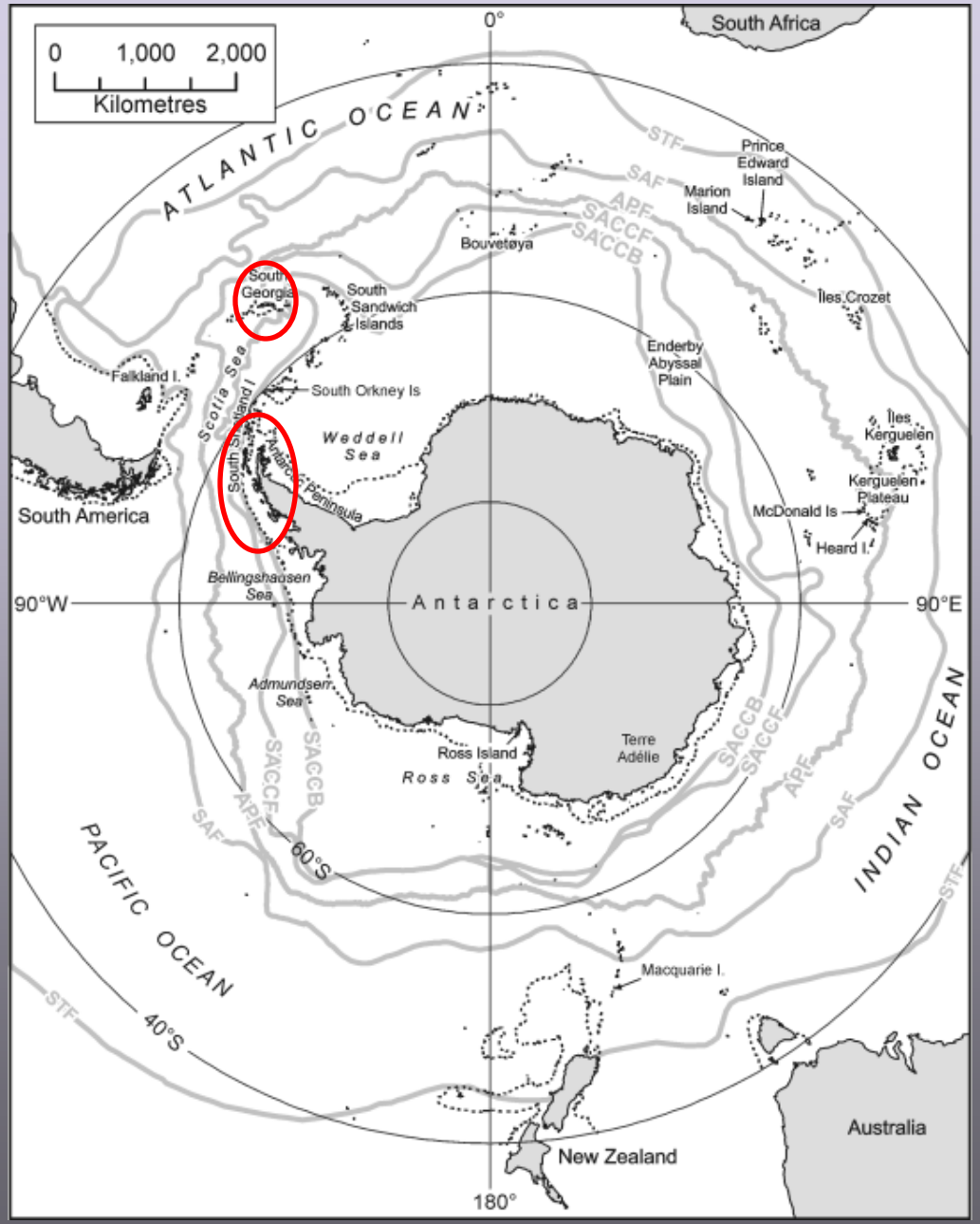
SO GLOBEC and ICED Investigators

Presentation Outline

- Background on Southern Ocean food webs
- Comparative analysis of west Antarctic Peninsula and South Georgia

  connectivity, structure, variability
- Comments on development of Southern Ocean food web models for climate projections (*poster on WAP climate change*)

Southern Ocean Food Webs



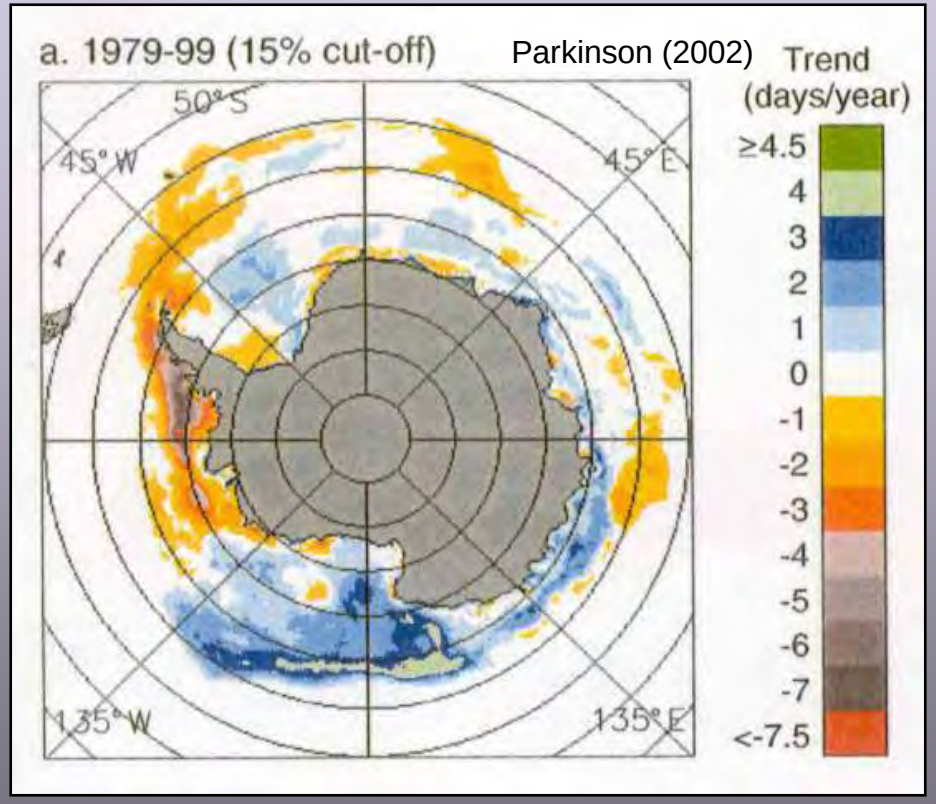
Circumpolar System

Not similar food web throughout

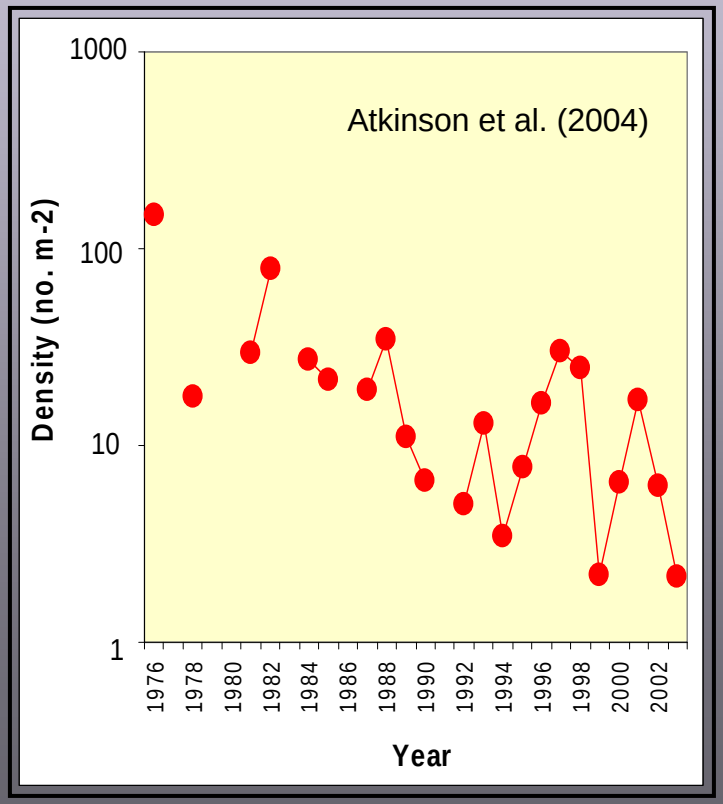
Considerable heterogeneity in forcing and habitat structure

Regional differences in responses

Southern Ocean is Undergoing Major Environmental Changes



30% decline in Antarctic krill in South Atlantic in last 30 years



Upper ocean temperatures have increased by 1ºC in the last 50 years -WAP most rapidly warming region on planet

The Past - Impacts of Harvesting

Harvesting has generated massive perturbations over more than 2 centuries

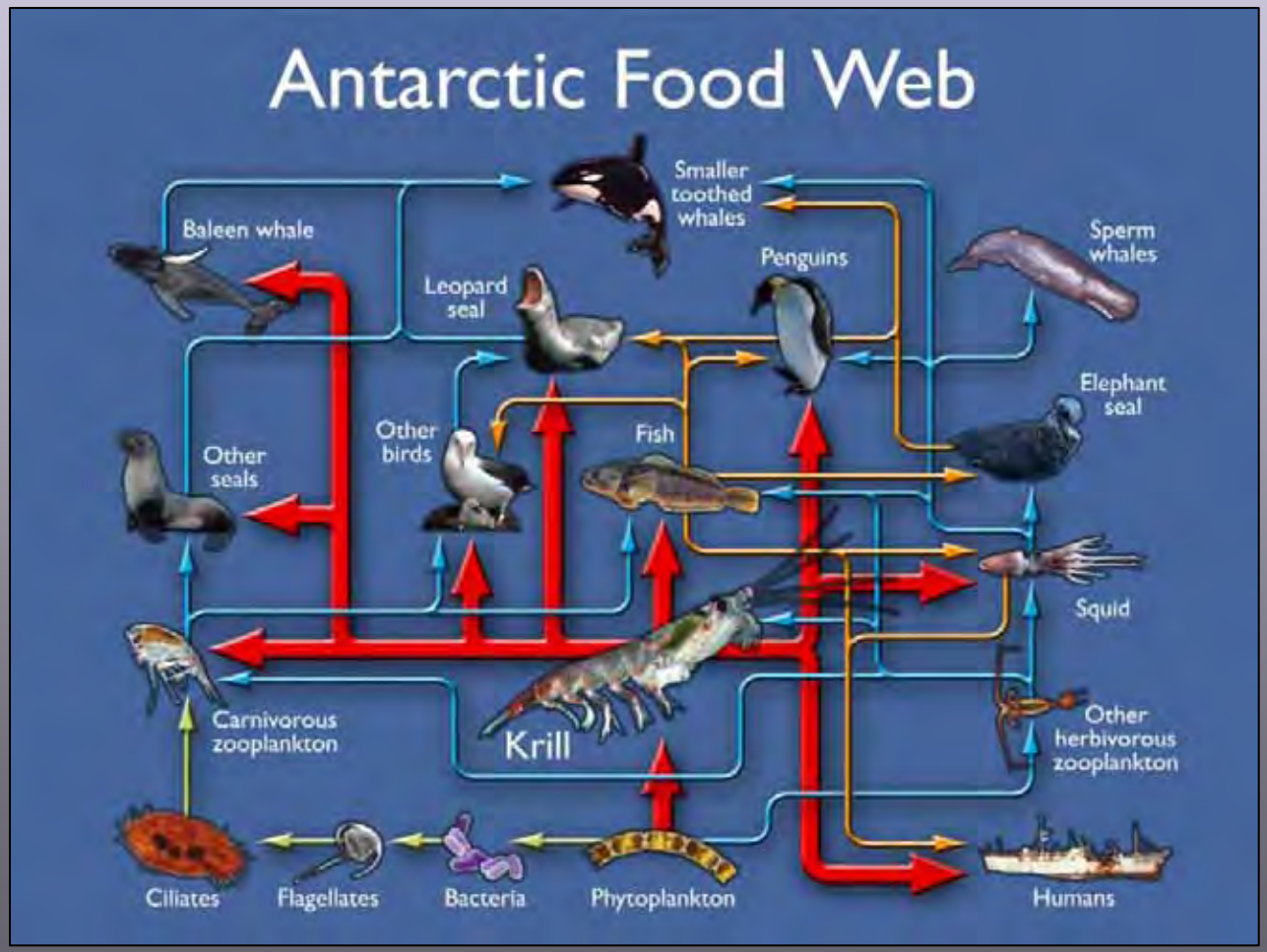
Fur-seals
From 1778 - economic extinction within 35 years

Whales
1906 to 1966 and residual thereafter

Fin-fish, krill
From late 1960s and continuing

Top-down effects => Krill surplus?

What is a Southern Ocean Food Web?

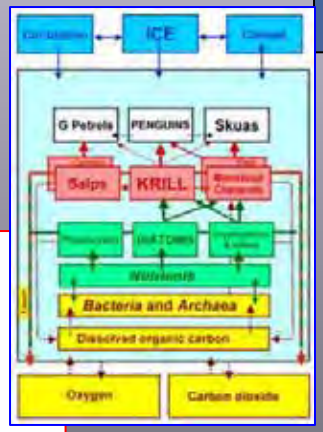


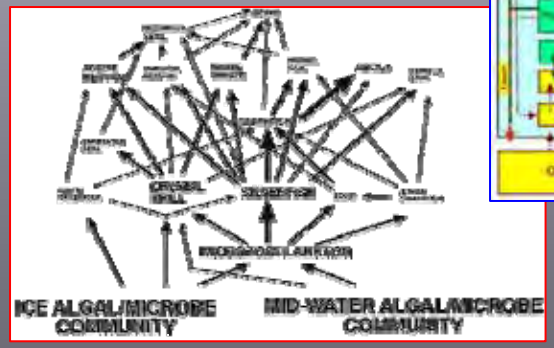
Not Only One - Range of Food Webs

Seasonal length

Sub Antarctic

High Antarctic





Differences due to
Circulation
Sea-ice
Biogeochemistry
Production
Seasonality

Low Production

High Production

WAP and South Georgia

- Support large populations of predators
- Dependent on Antarctic krill
- Differences
    - winter - light, sea ice, length
    - controls - CDW/Southern ACC boundary versus Southern ACC Front
    - advective influences - closed versus open system
    - self sustaining krill population versus non-local inputs of krill
    - high productivity - natural iron fertilization through different mechanisms
- Systems are connected by Antarctic krill

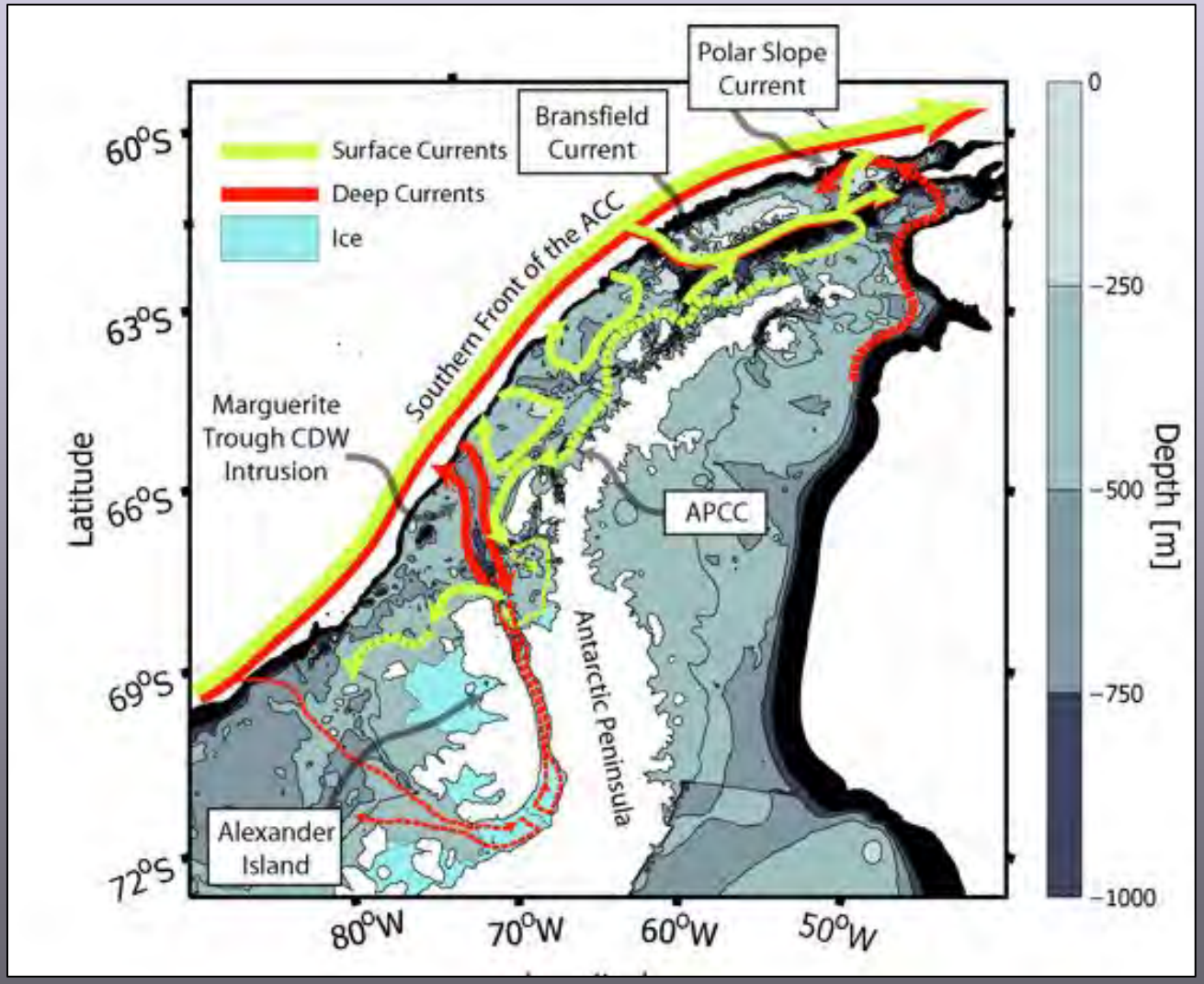
WAP Physical Environment

Depth ~400 m

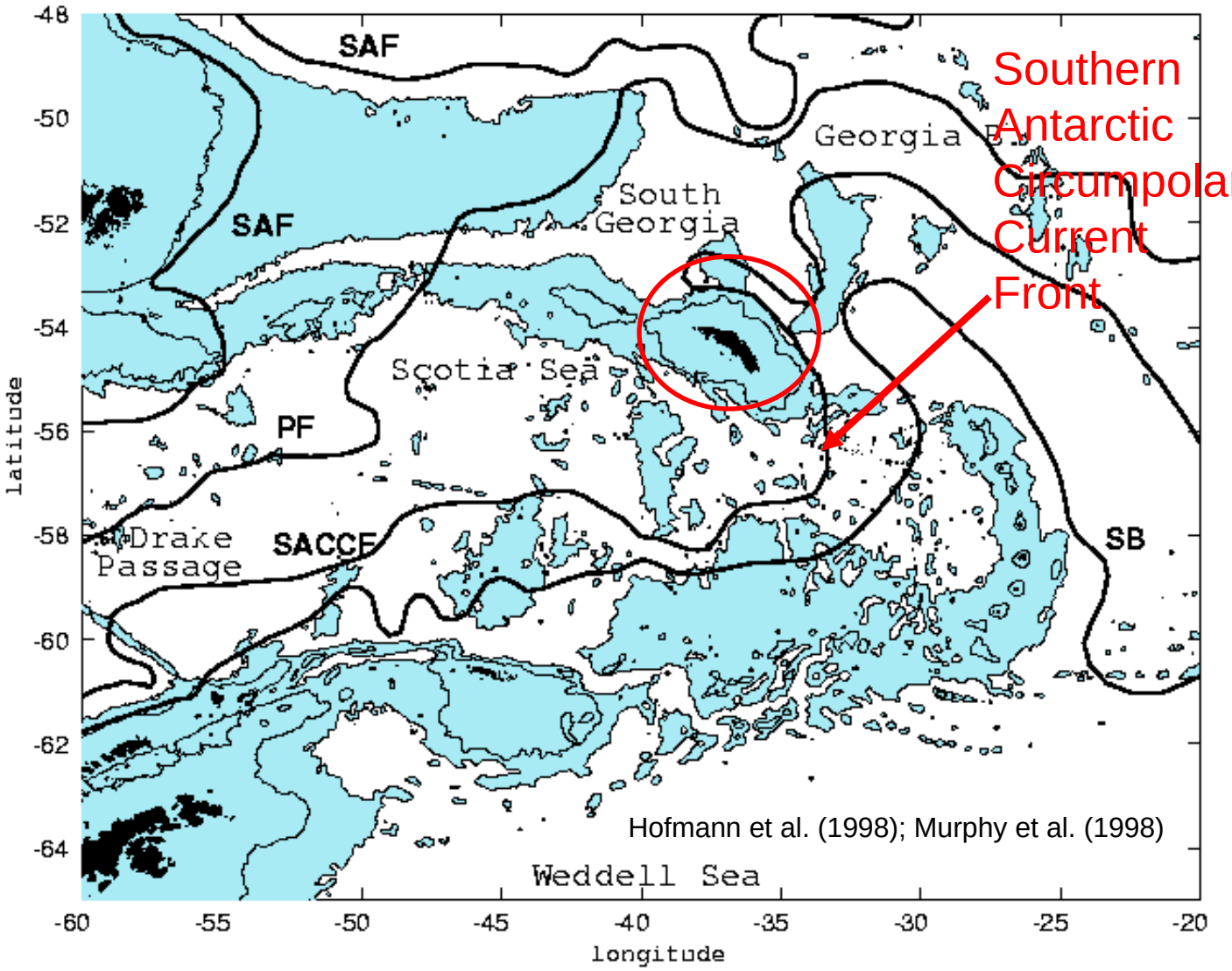
ACC flows along shelf edge

Deep trenches allow connections between shelf and oceanic environments

Direct connection to mesopelagic



South Georgia Physical Environment



Open system

Outside sea ice zone

CDW present but deeper

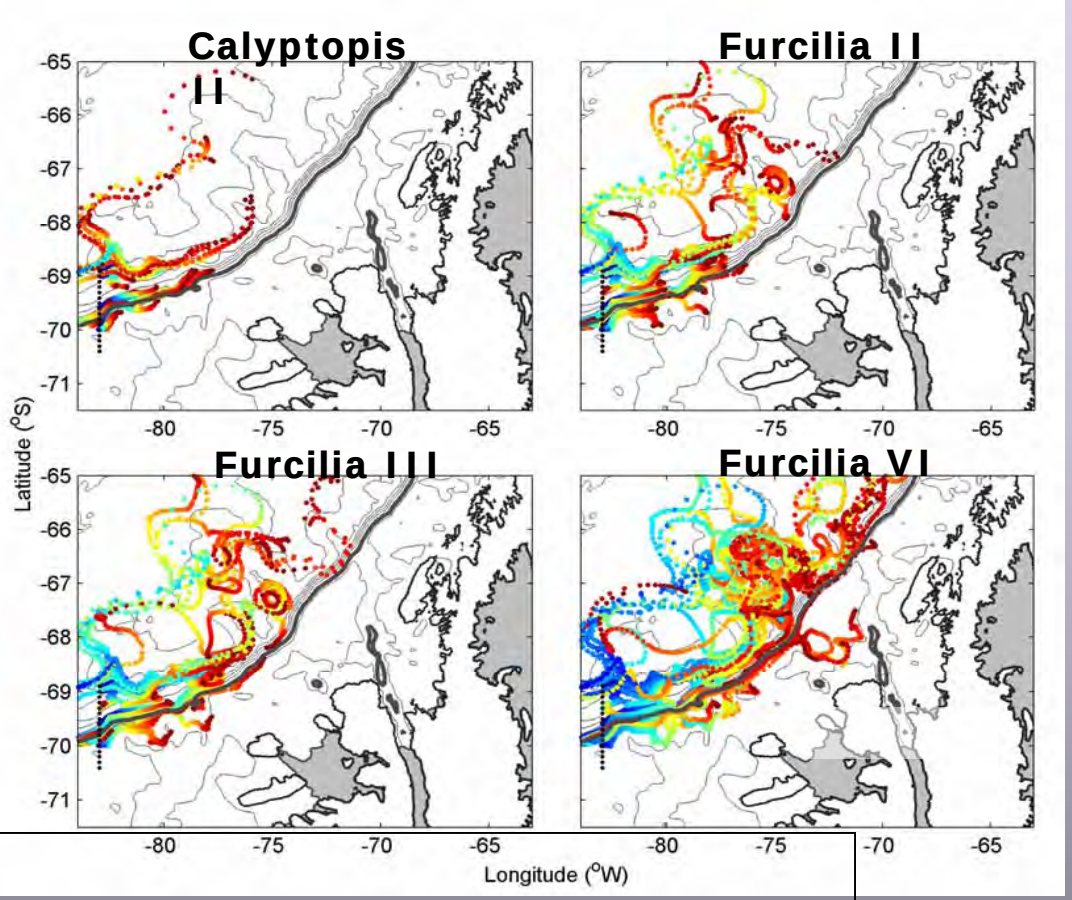
Strong ACC influence

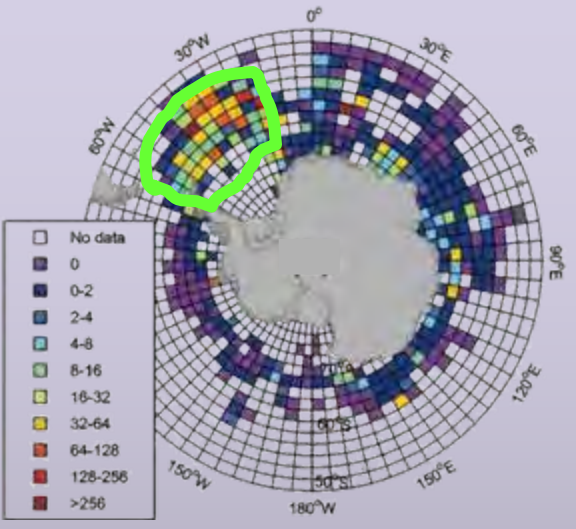
Connectivity - WAP

Lagrangian Simulations

Upstream Remote Inputs

Local Inputs and Retention

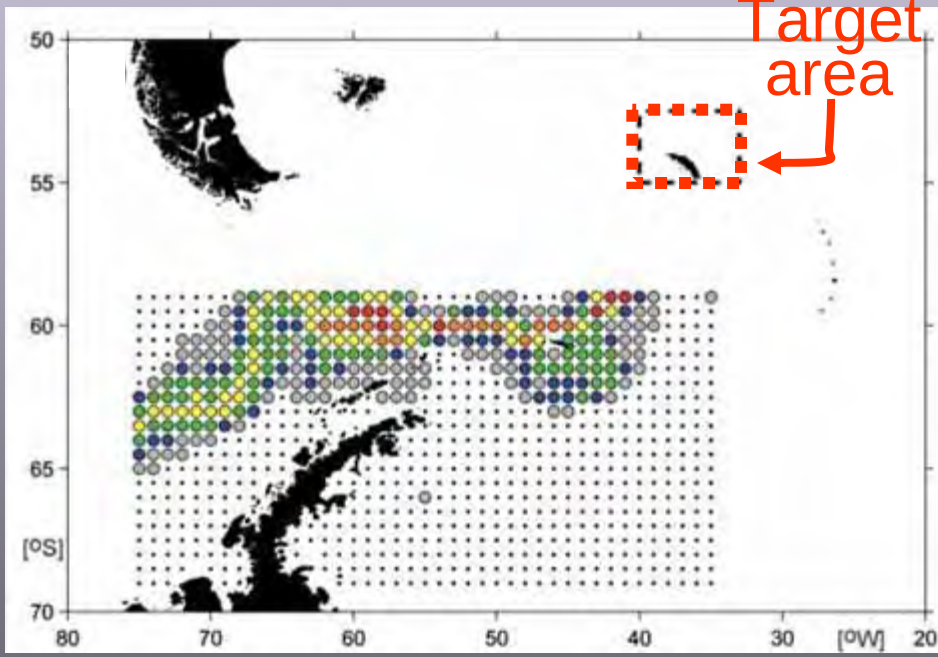


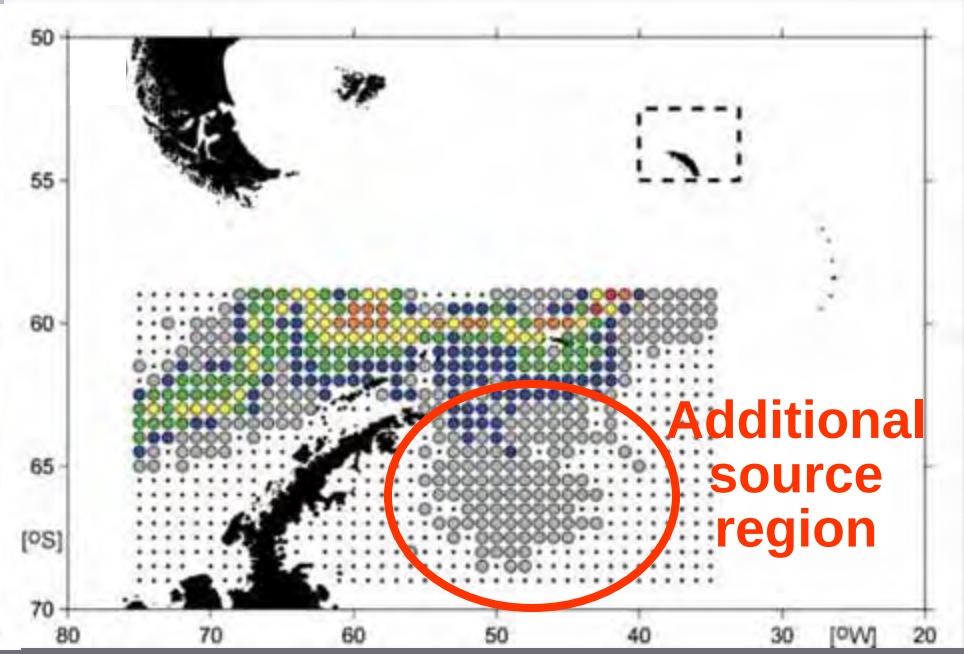


South Georgia - Connectivity

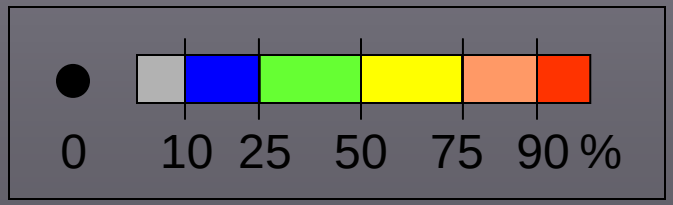
Variability in Source Regions

Lagrangian Simulations



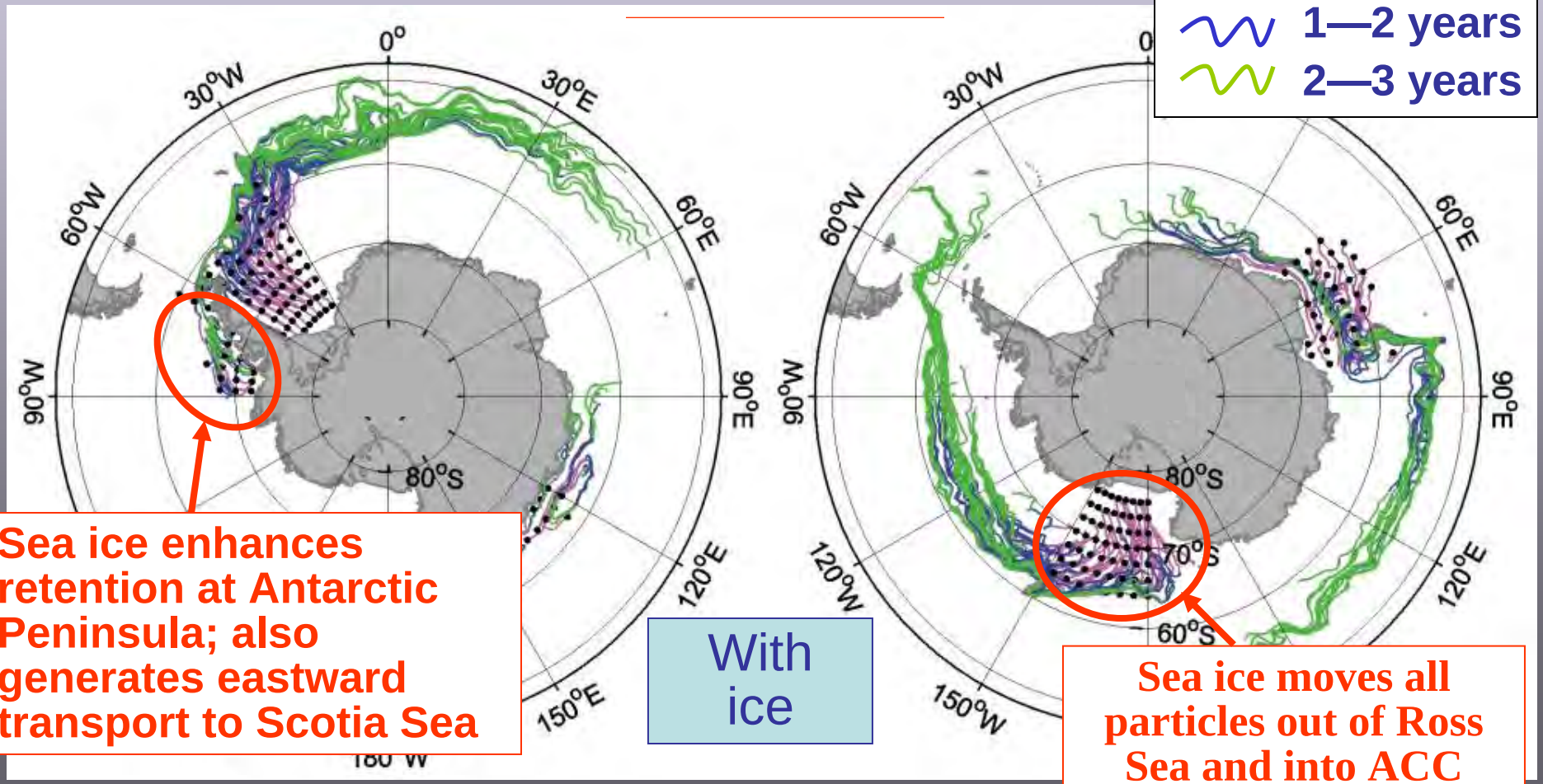


Ocean only advection



Ocean + sea ice advection

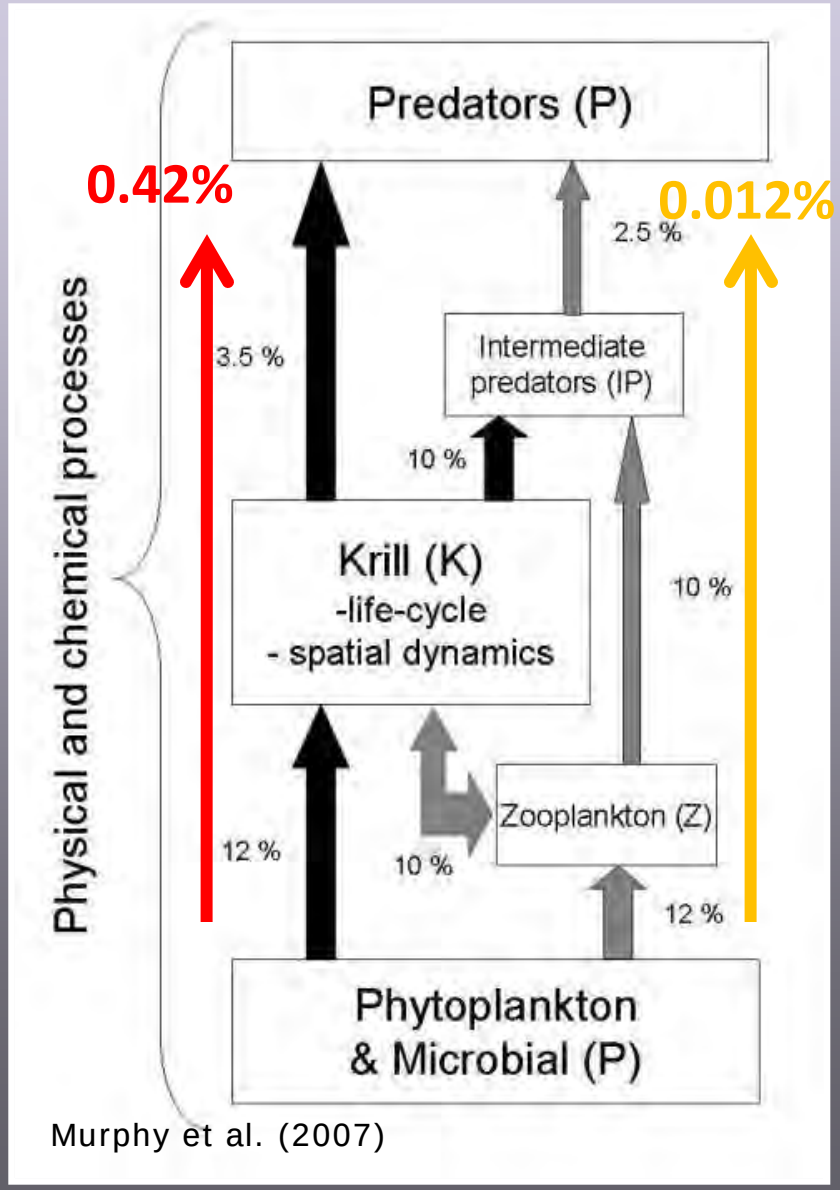
Circumpolar-scale dispersal



Present day MB and South Georgia food webs: Relative efficiency of alternative trophic pathways

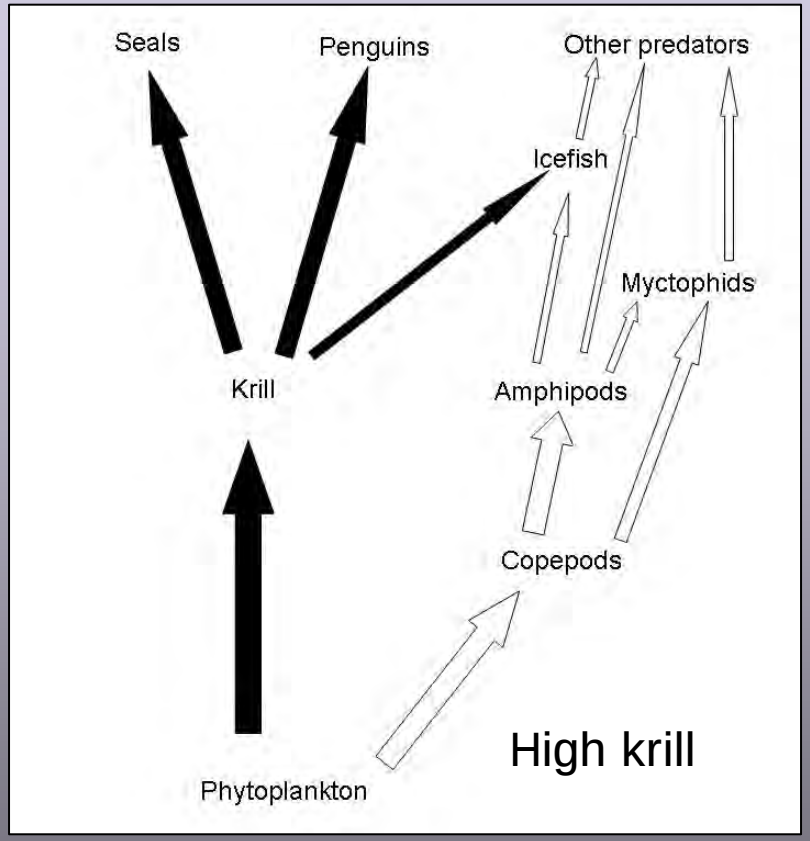
Two principal trophic pathways from primary producers to top predators for WAP and South Georgia

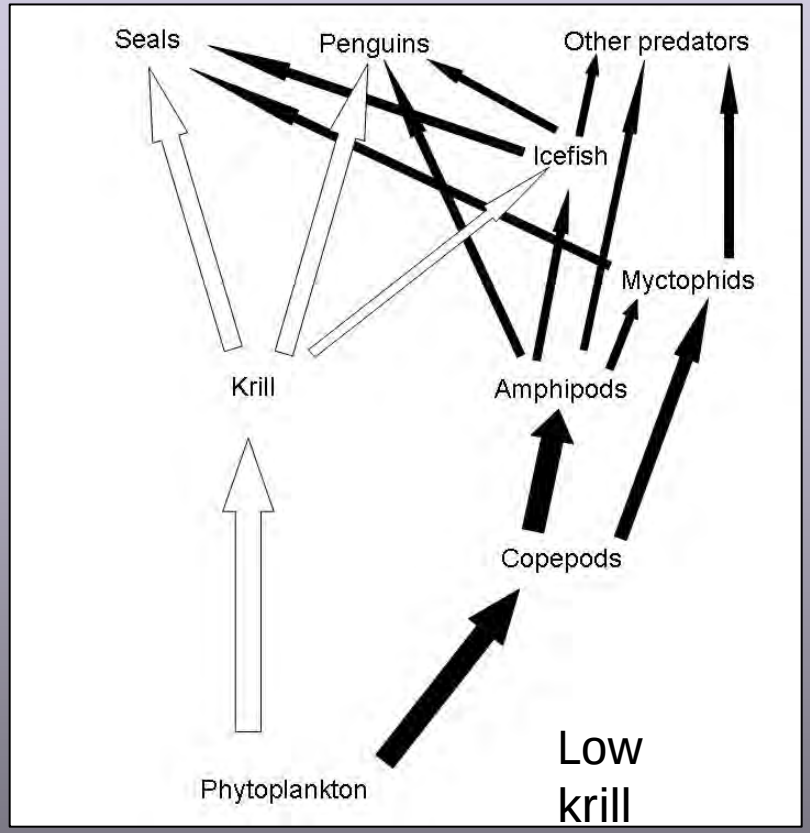
The efficiency of each trophic pathway varies



Murphy et al. (2007)

Alternative Food Web Pathways





Alternative pathways buffer change - reflect/support long-term change?
Need better quantification of alternative pathways
(*poster on food web model*)

cold		warm
high macro- and micronutrients (incl. iron)		low macro- and/or micronutrients (incl. iron)
strong influence of polar waters on lower latitudes		weak influence of polar waters on lower latitudes ?
		reduced stabilisation associated with reduced freshwater and increased winds?
large diatoms		small autrotophs
high seasonal production		low production
krill	copepods	small zooplankton
		salps
high energy flow through krill		complex interactions and energy flows
large predators		small predators
high abundance of largest predators		low abundance of largest predators
potentially high fishing intensity and yield		potentially low fishing intensity and yield

ecosystem transitions

Loss of ice habitat Ğ restricted to areas further south

Disruption of ice dependent life cycles

Impacts on seasonality. Disruption of phenology and generation mis-matches in interaction timings

Enhanced poleward distribution of warmer water species

Effect of Climate Change

Sea ice - habitat
high ---> low

Change type of primary producers
large ---> small

Reduction in krill
krill---> zoop ---> salps

Change in top predators
large ---> small

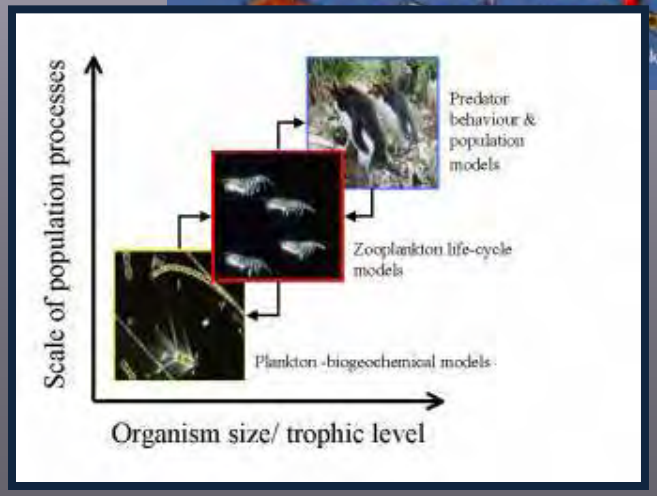
Change in fishing effort
high ---> small

Developing analyses of Southern Ocean food webs

How to deal with:

- Complexity ?
- Variability ?
- Uncertainty ?

Importance of scale

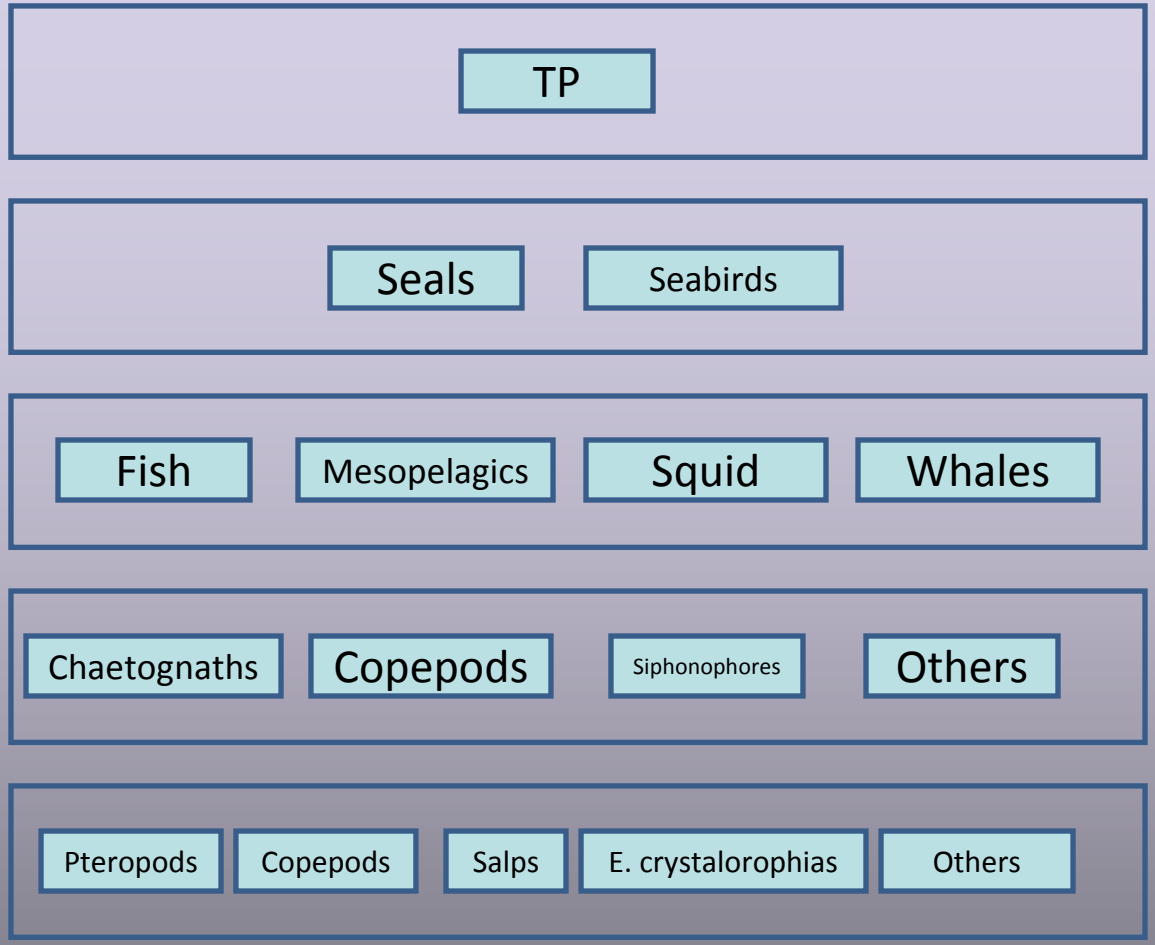


Developing generic models

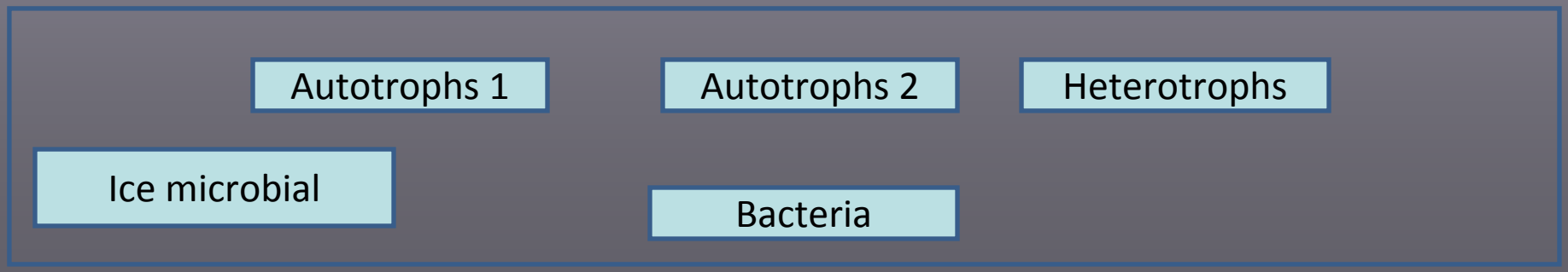
Based on functional groups/key species/size

Krill

Apply same model structure in all areas



Pathways of energy flow change in different regions/times

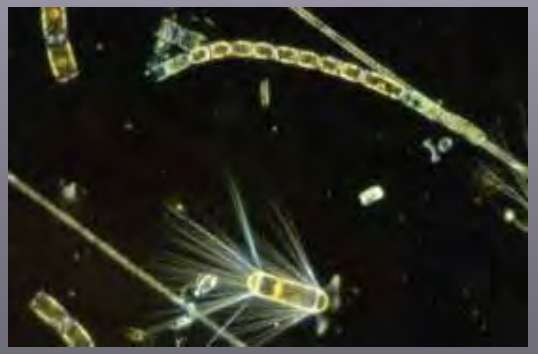


Southern Ocean Food Webs - Concluding Comments

- **Southern Ocean ecosystems changing**
  - Climate, fisheries and biogeochemistry
  - Food webs crucial in determining responses
  - Requires end-to-end understanding

    => projection and understand feedbacks

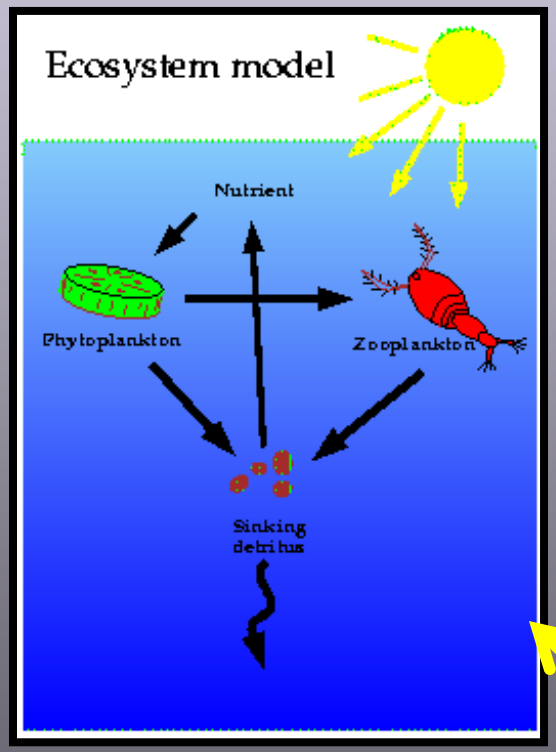
- **Analyses of structure & function are being developed**
  - Need to develop large-scale views
  - Requires systematic quantification – major gaps in knowledge
  - Focused process studies for key regions

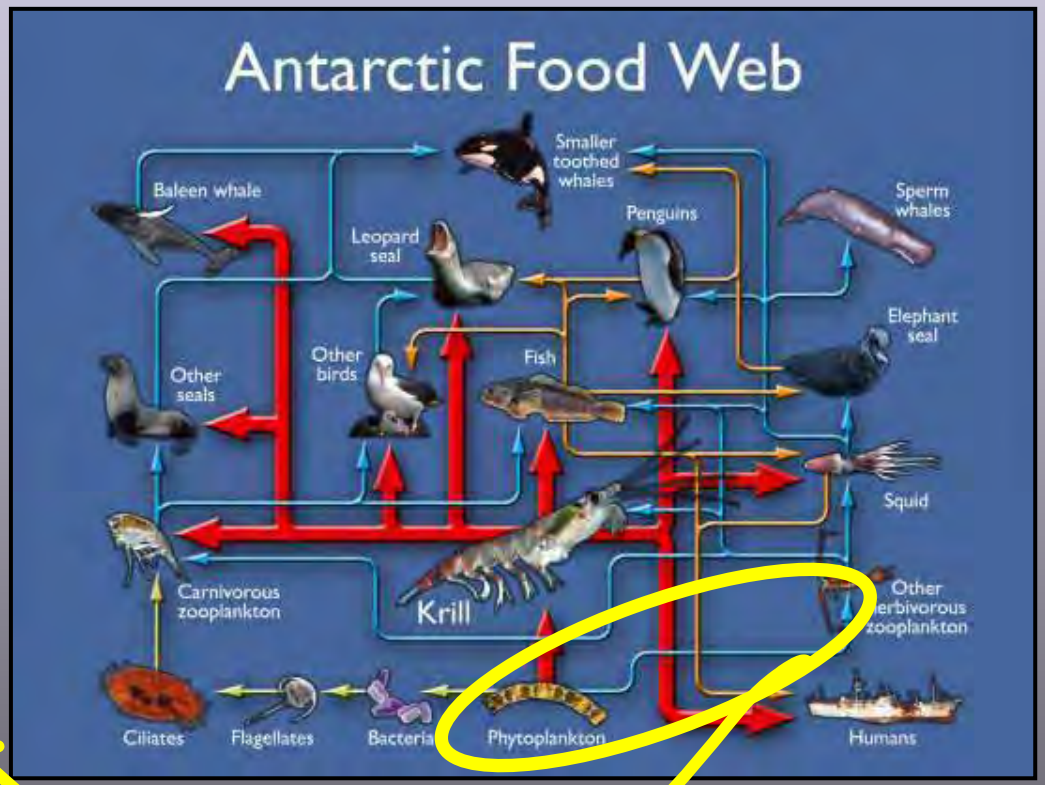


- **Analyses of variability & change**
  - Analyse responses => mechanisms

Relevance to Global Ecosystems

Global carbon budget models lack biological detail





Current models do not capture what is known about SO ecosystems

- **Web page for information on activities: meetings, workshops and science development**
- **Two posters at ESSAS OSM**
- **ICED Contacts**

visit www.iced.ac.uk

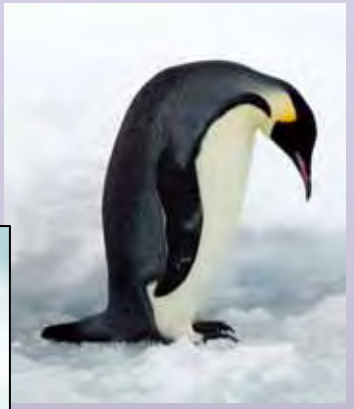
email iced@bas.ac.uk

IMBER Integrated Marine Biogeochemistry and Ecosystem Research

GLOBAL CHANGE IGBP International Geosphere-Biosphere Programme

SCOR

SCAR



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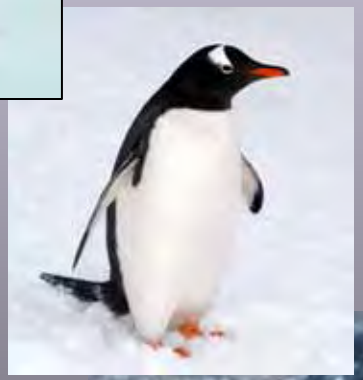

Photos Dan Costa