

Comparisons of Southern Ocean Ecosystems

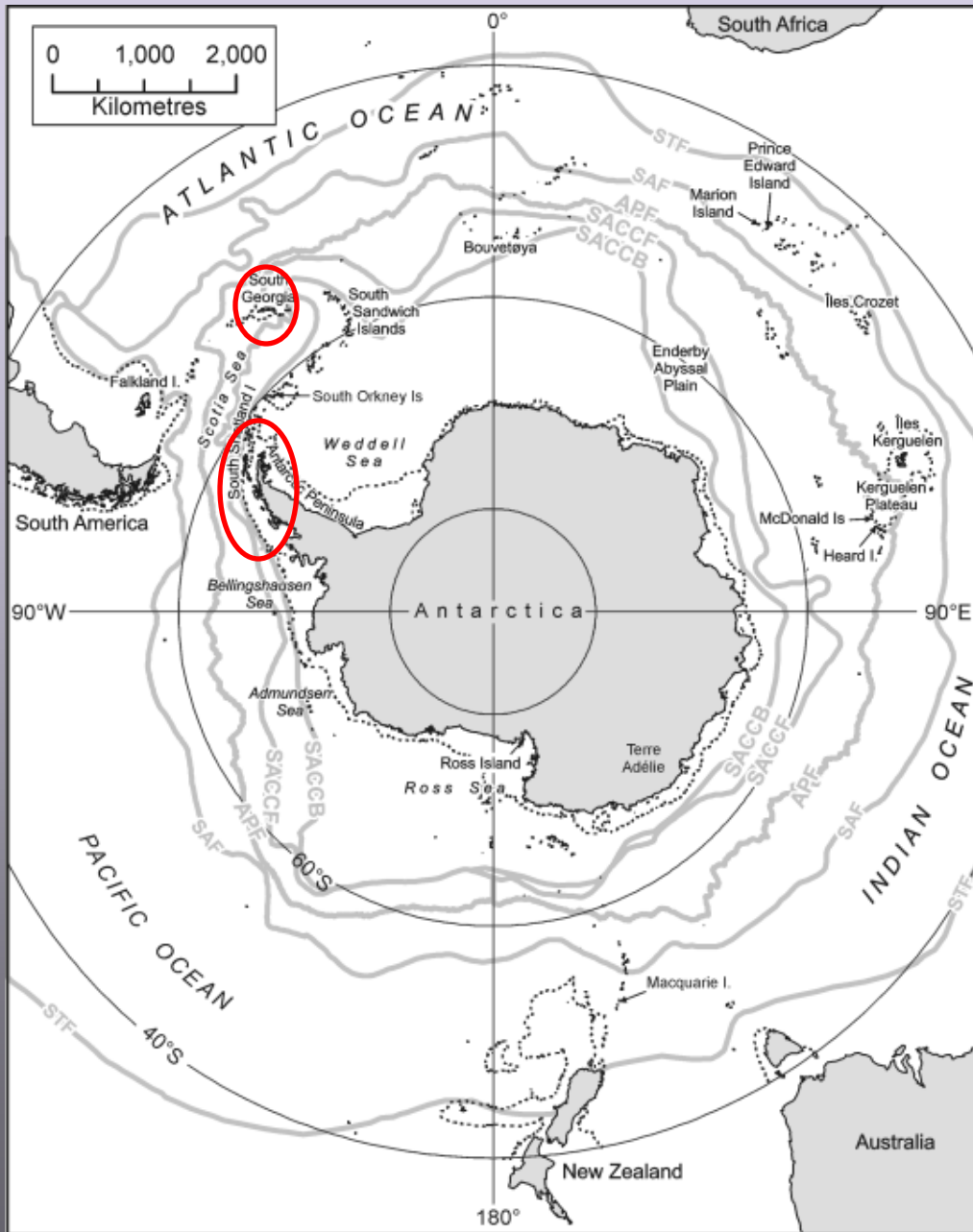
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SO GLOBEC and ICED Investigators



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



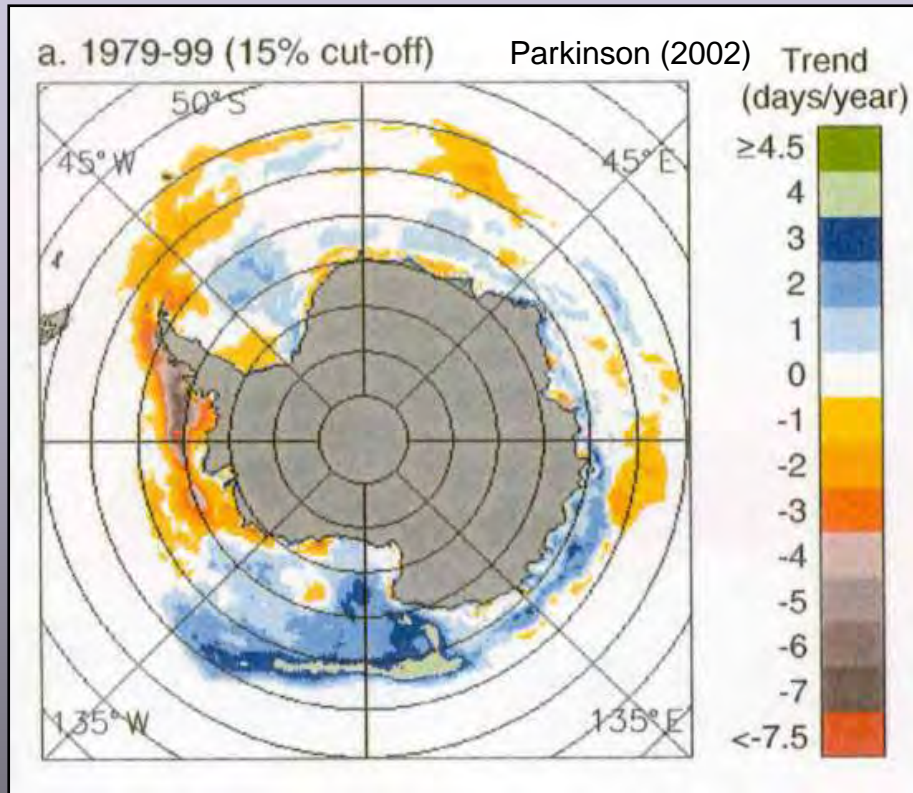
Circumpolar System

Not similar food web throughout

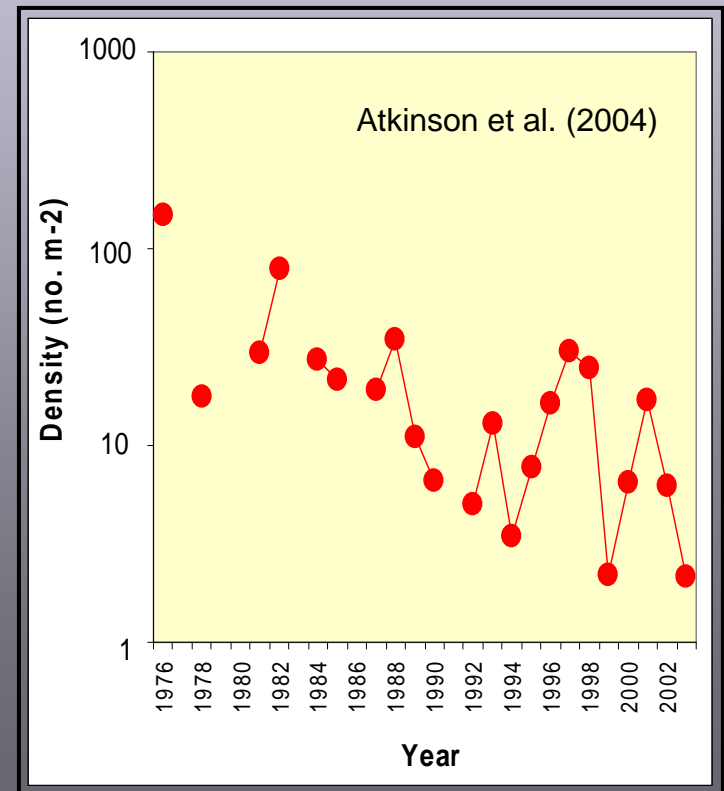
Considerable heterogeneity in forcing and habitat structure

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 1°C 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

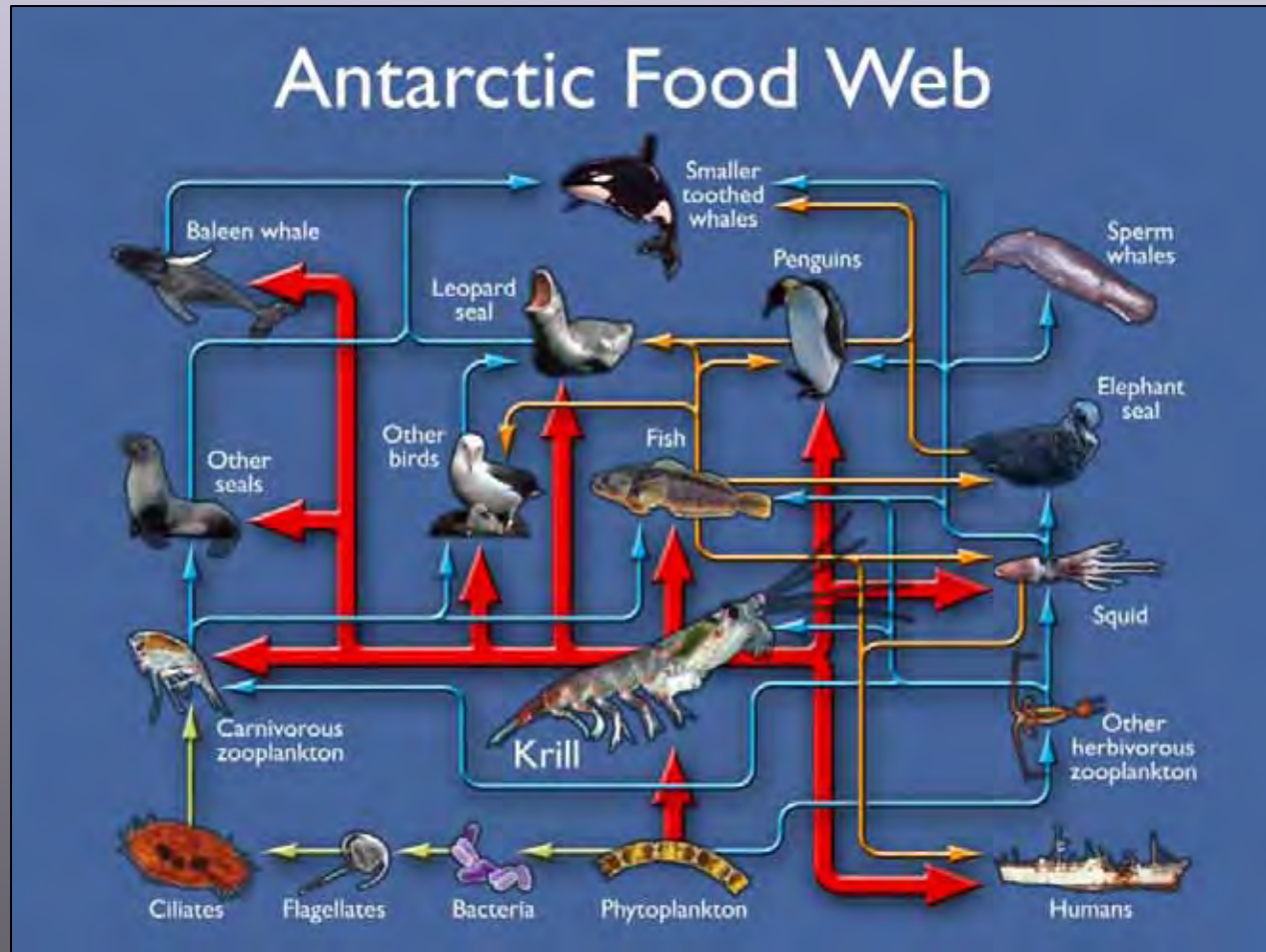
Fin-fish, krill

From late 1960s and continuing

Top-down effects => Krill surplus?



What is a Southern Ocean Food Web?



Not Only One - Range of Food Webs

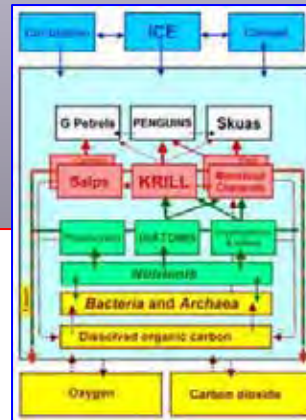
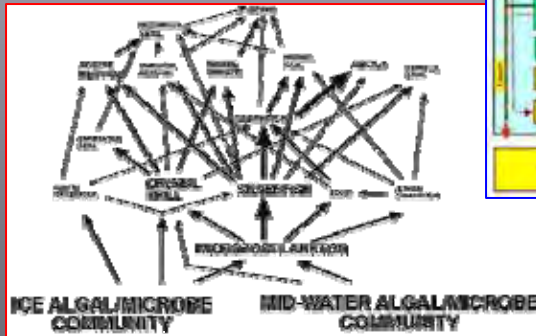
Seasonal length

Sub
Antarctic

High
Antarctic

Low
Production

High Production



Differences due to
Circulation
Sea-ice
Biogeochemistry
Production
Seasonality

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

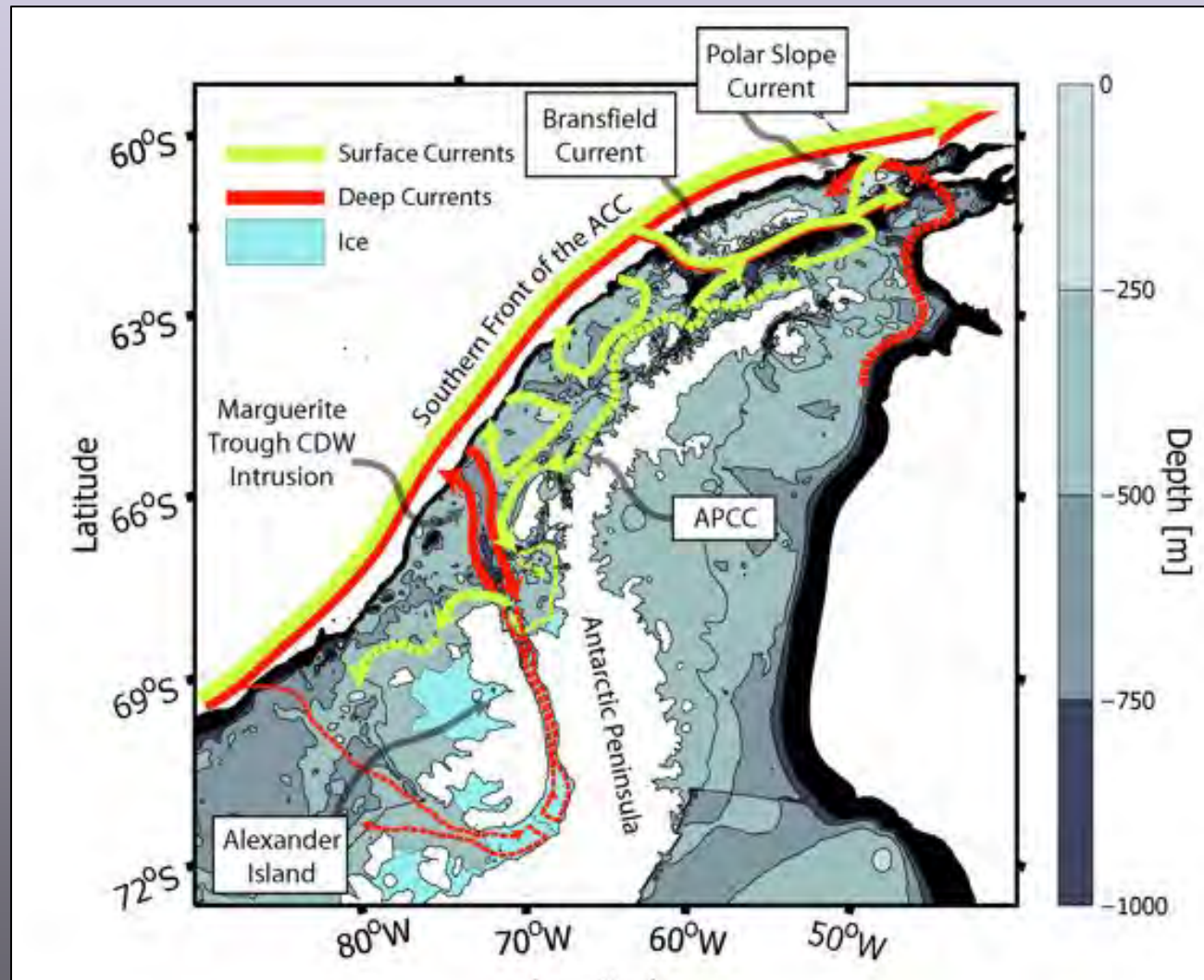
WAP Physical Environment

Depth ~400 m

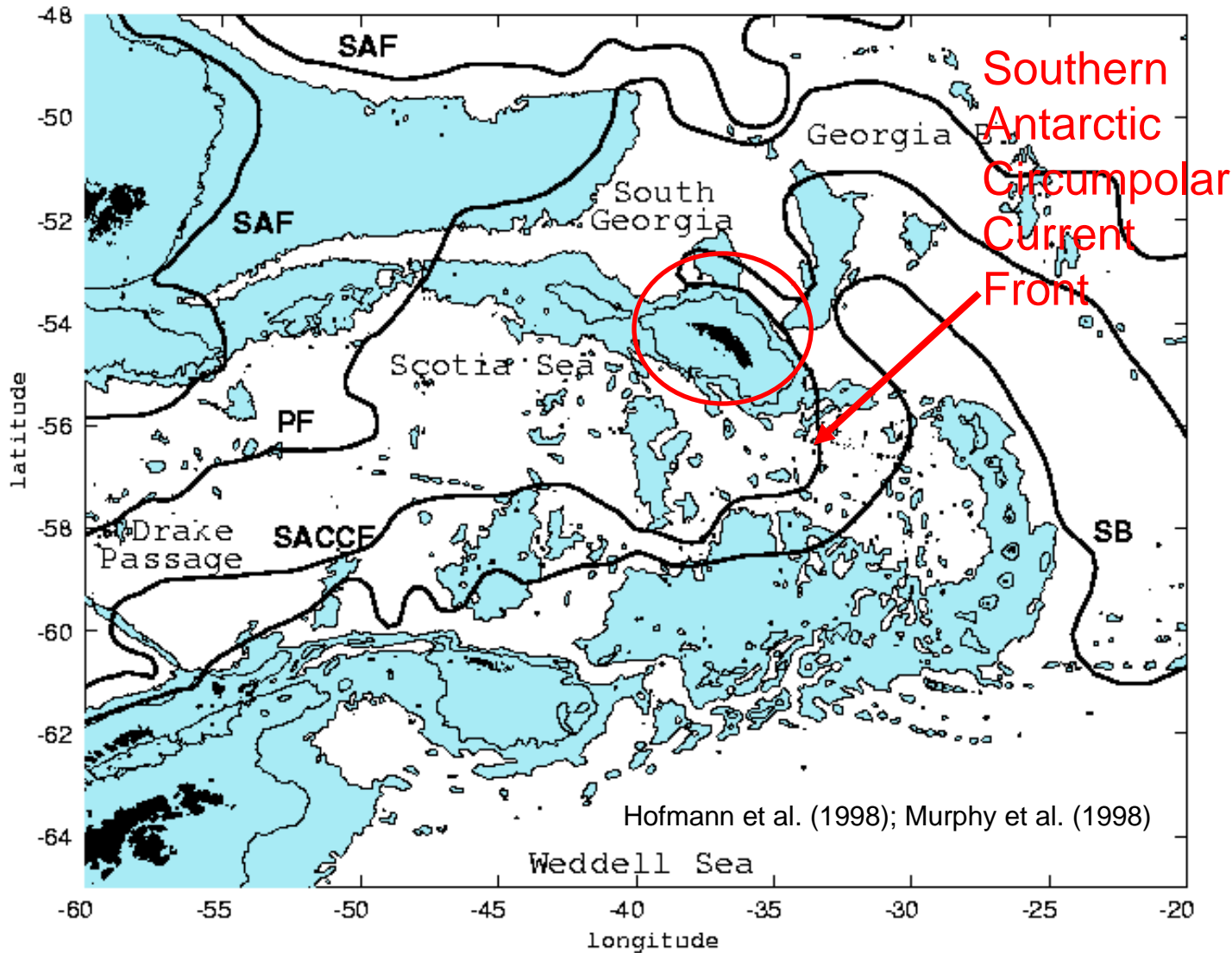
ACC flows along shelf edge

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

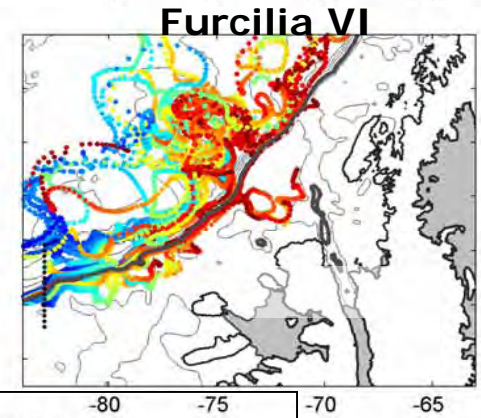
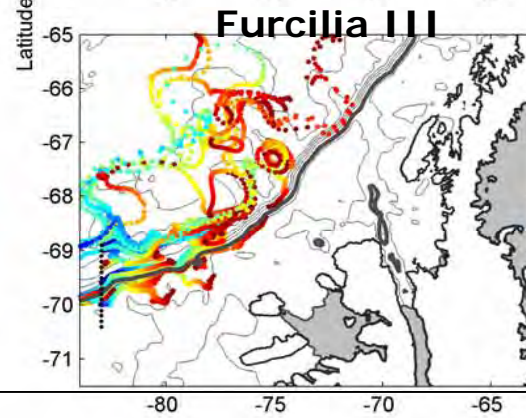
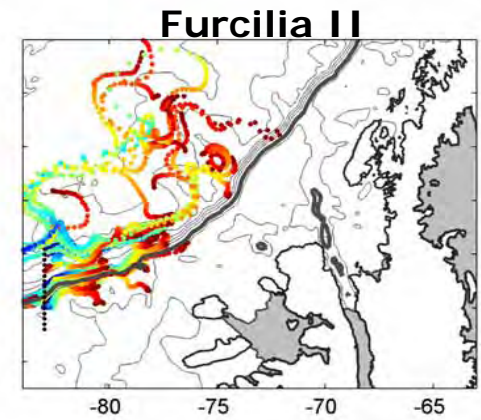
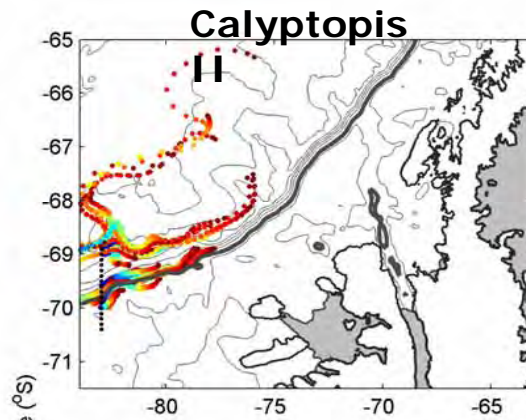
Strong ACC influence

Connectivity - WAP

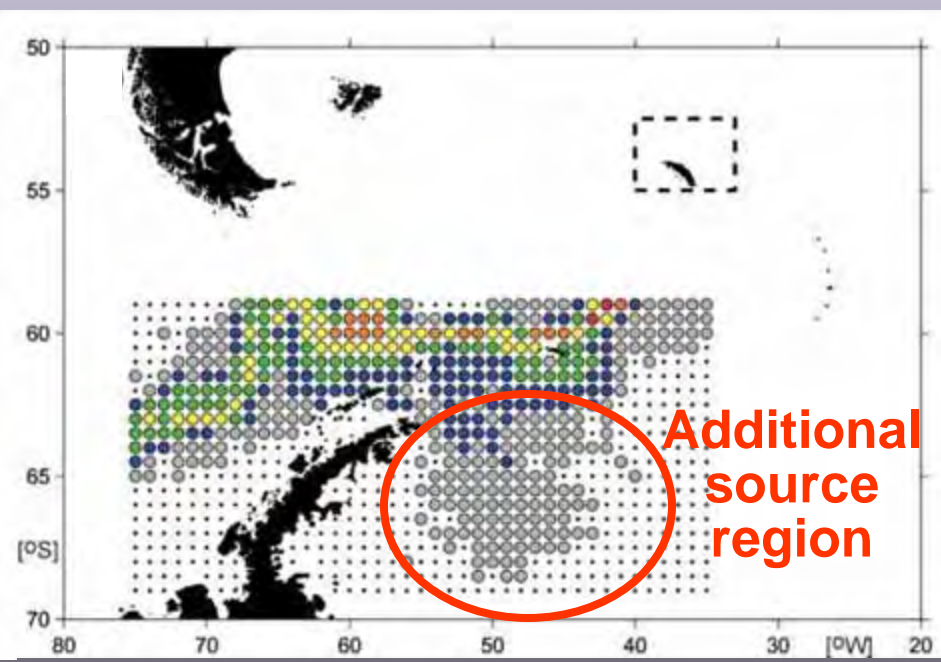
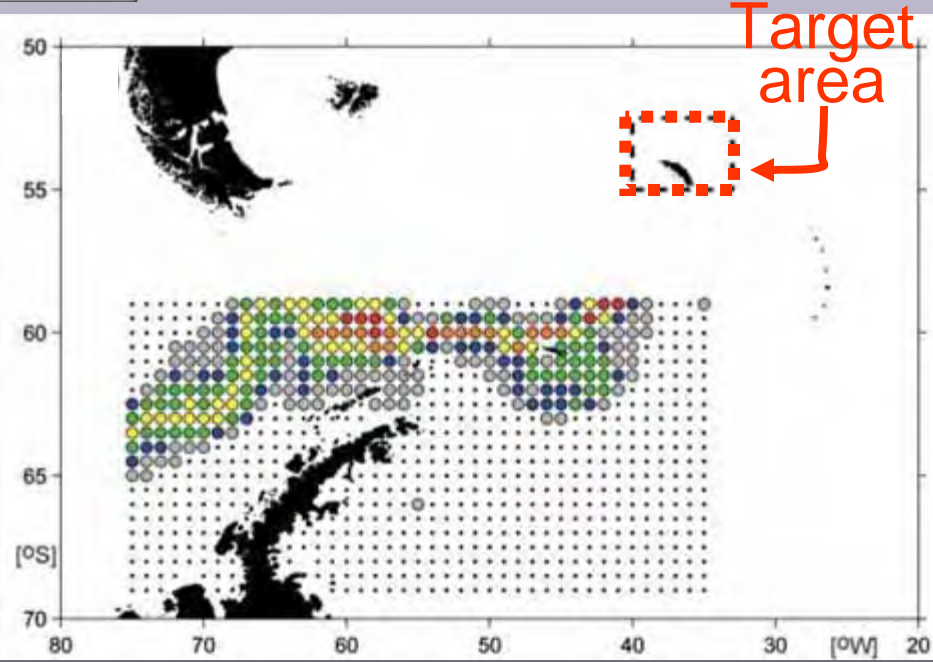
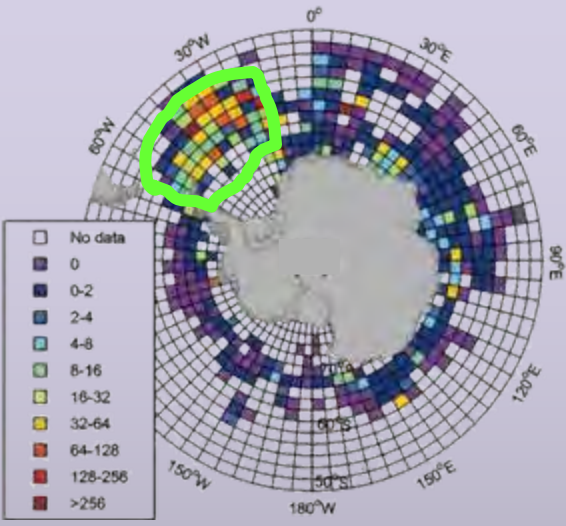
Lagrangian
Simulations

Upstream Remote
Inputs

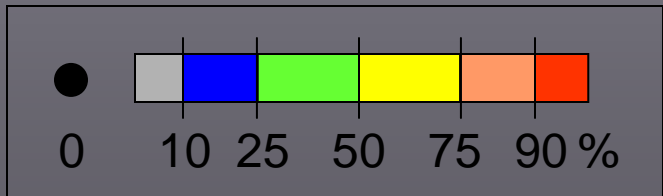
Local Inputs and
Retention



South Georgia - Connectivity Variability in Source Regions Lagrangian Simulations



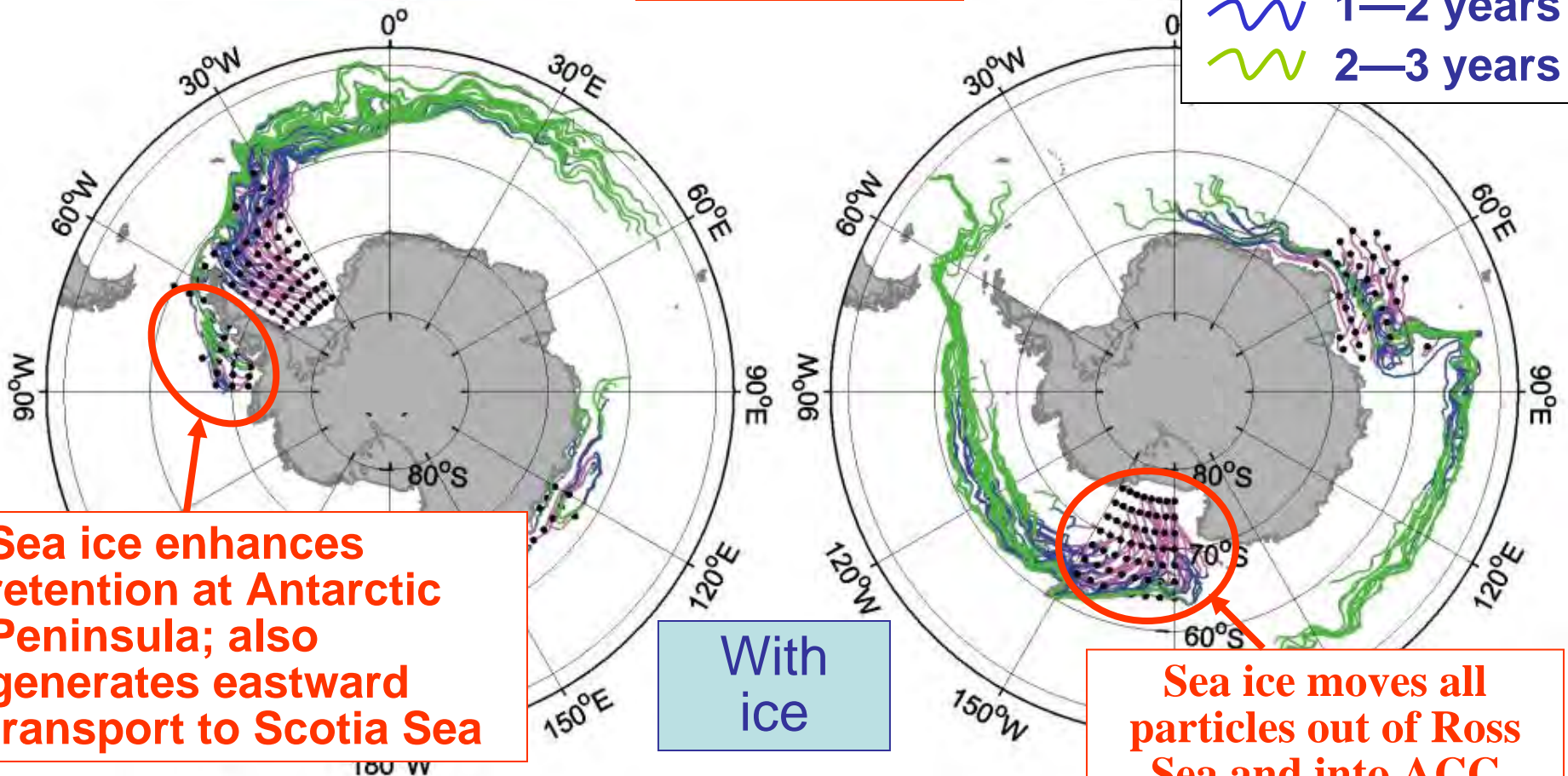
Ocean only advection



Ocean + sea ice advection

Circumpolar-scale dispersal

- 0—1 year
- 1—2 years
- 2—3 years



Sea ice enhances retention at Antarctic Peninsula; also generates eastward transport to Scotia Sea

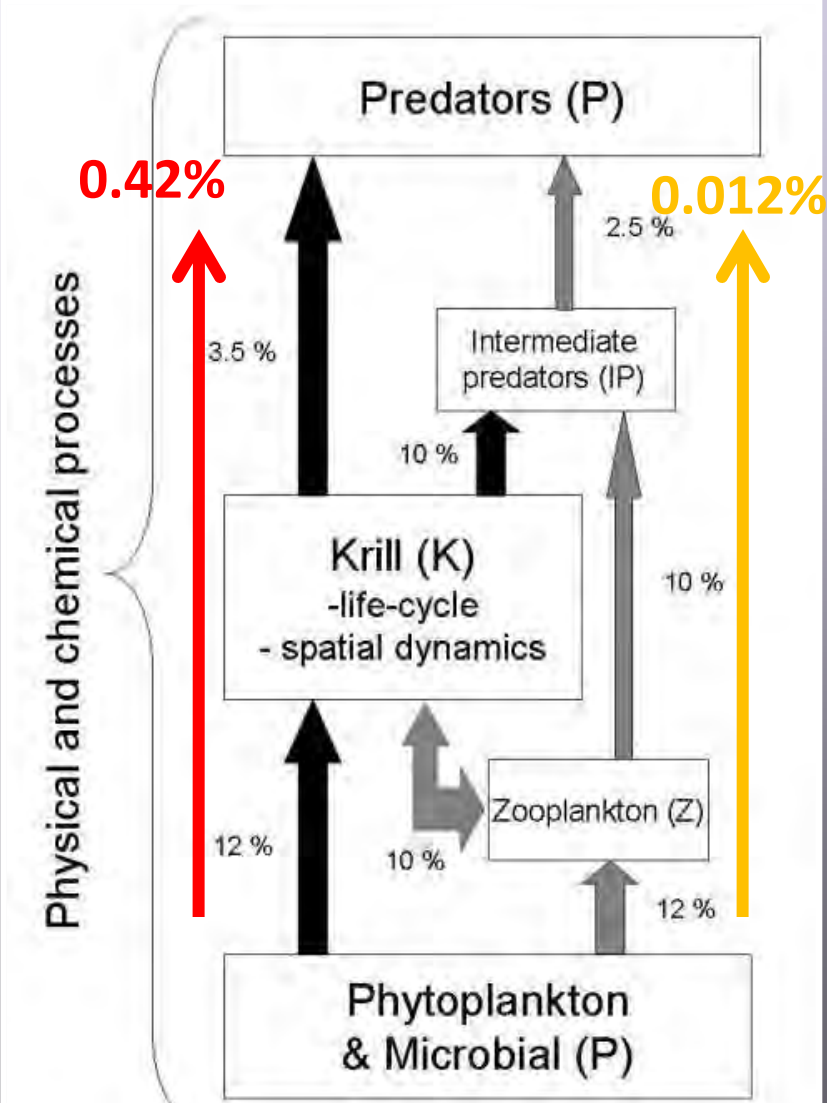
With ice

Sea ice moves all particles out of Ross Sea and into ACC

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

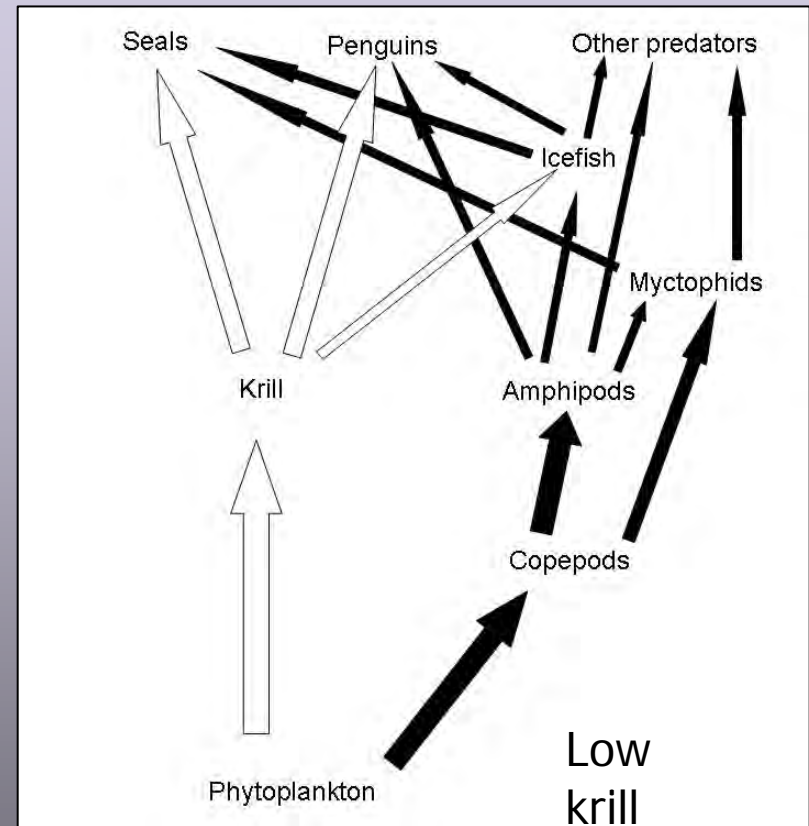
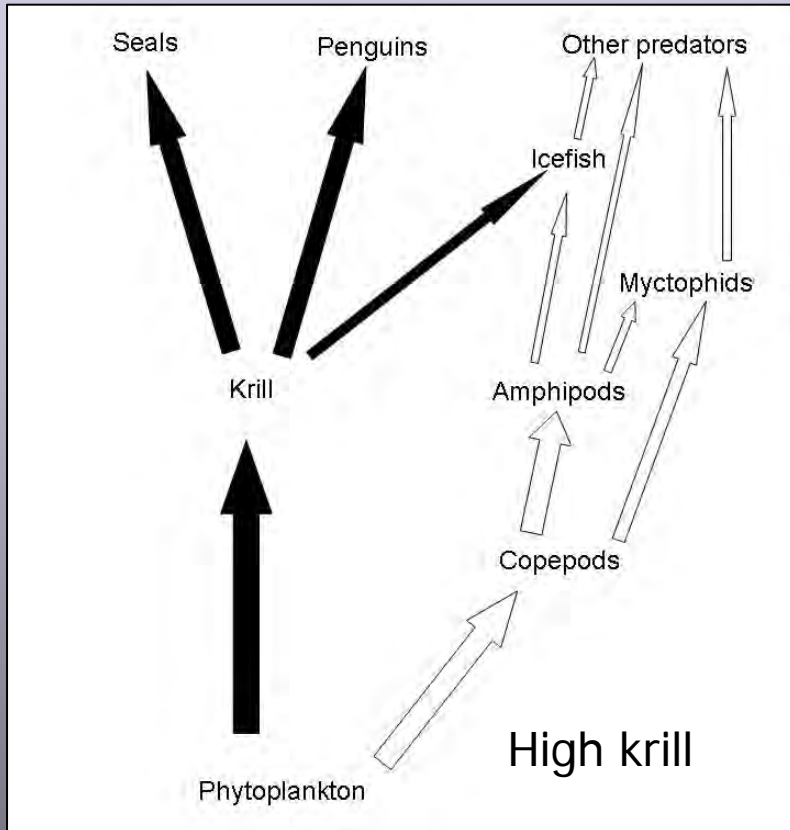
Two principal trophic pathways from primary producers to top predators for WAP and South Georgia

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 autotrophs
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

Loss of ice habitat → restricted to areas further south

Disruption of ice dependent life cycles

Impacts on seasonality. Disruption of phenology and generation mismatches in interaction timings

Enhanced poleward distribution of warmer water species



ecosystem transitions

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

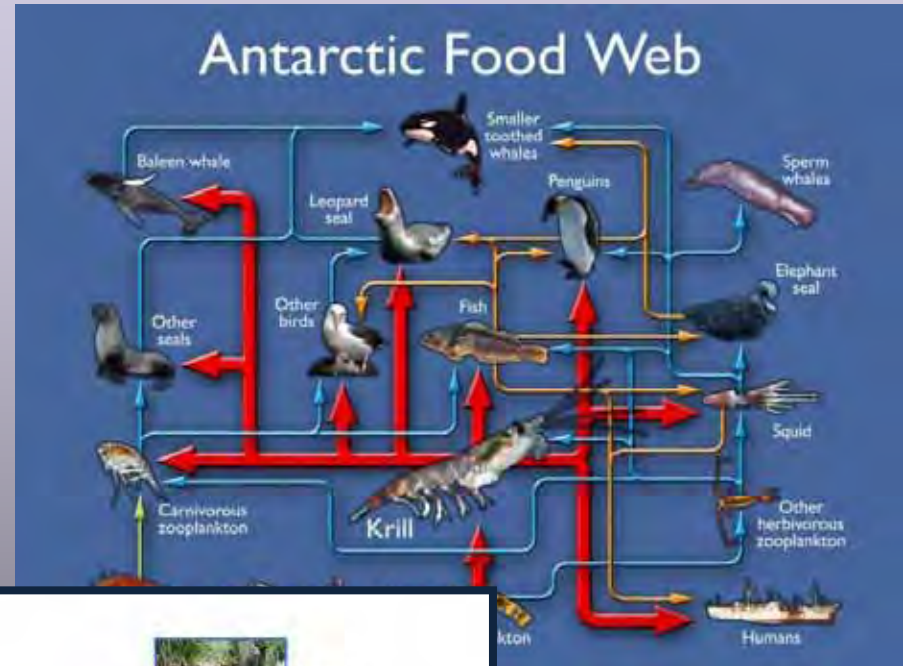
Change in fishing effort
high ---> small

Developing analyses of Southern Ocean food webs

How to deal with:

- Complexity ?
- Variability ?
- Uncertainty ?

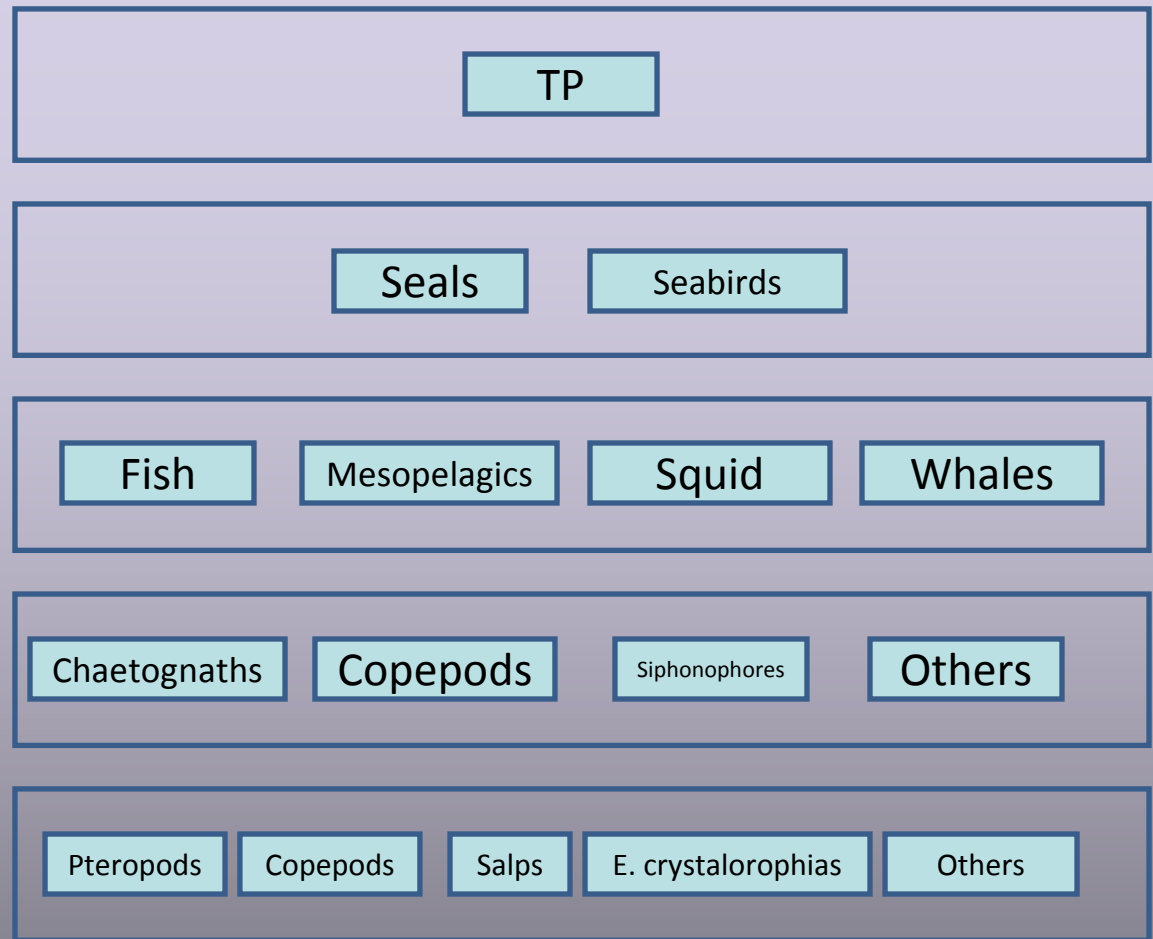
Importance of scale



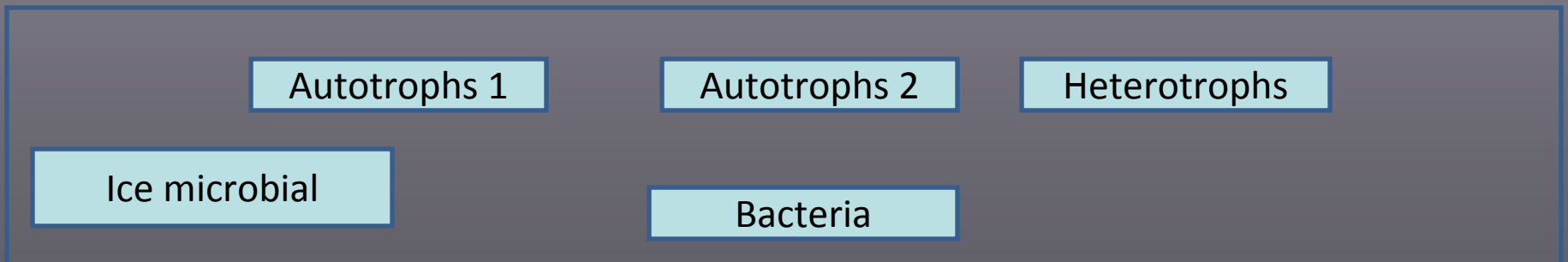
Developing generic models

Based on functional groups/key species/size

Apply same model structure in all areas

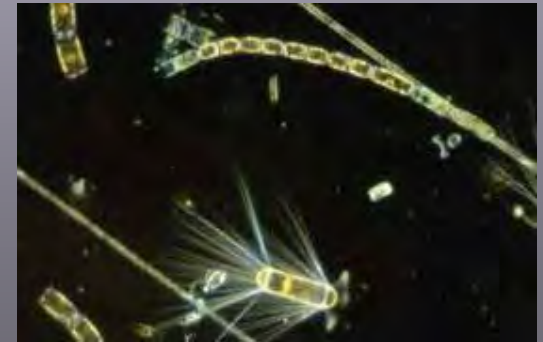


Pathways of energy flow change in different regions/times



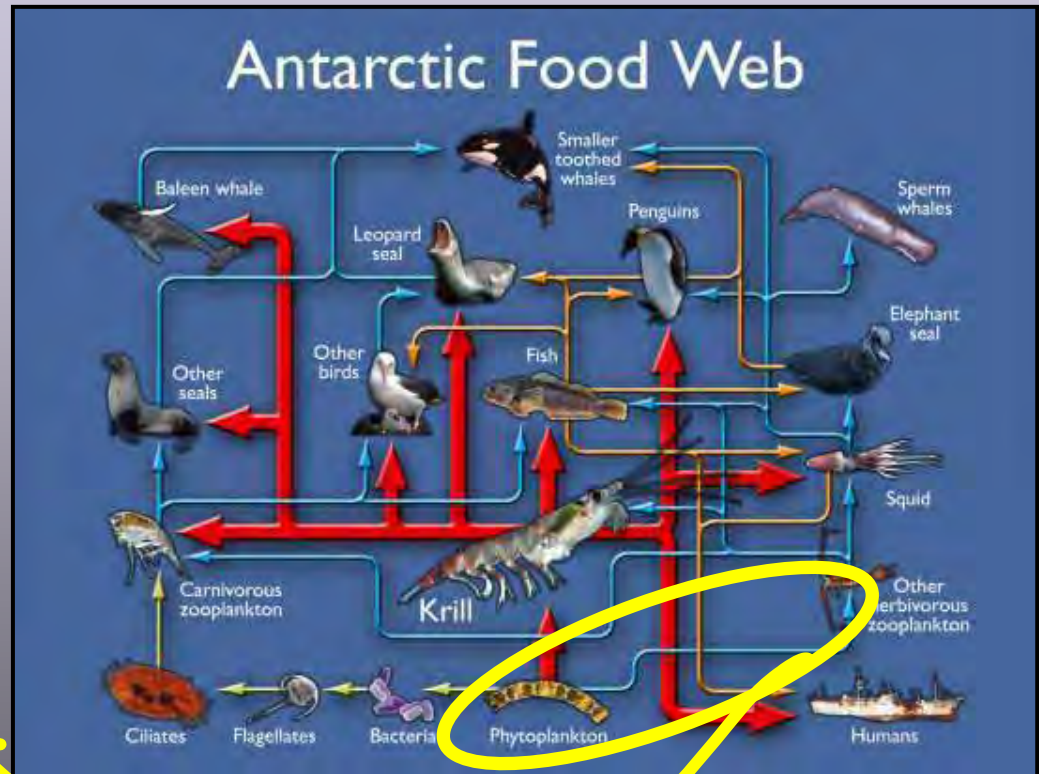
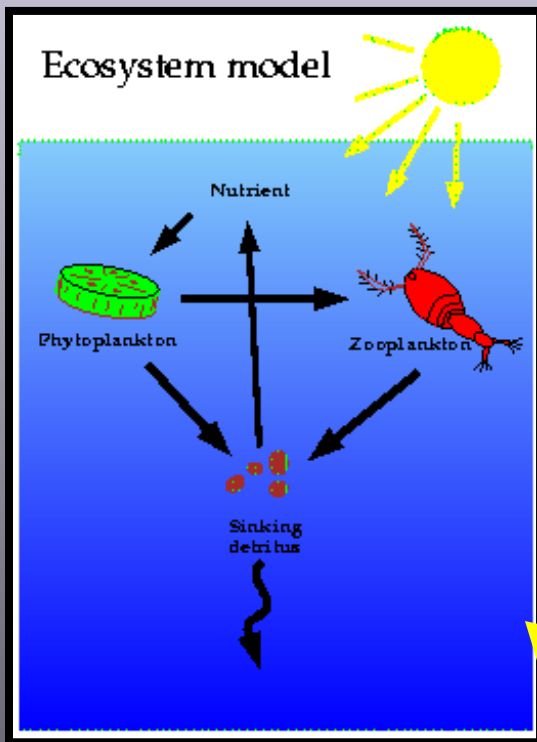
Southern Ocean Food Webs - Concluding Comments

- **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

Members' Login

ICED

Integrating Climate and Ecosystem Dynamics

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Integrating Climate and Ecosystem Dynamics in the Southern Ocean

ICED is a new international multidisciplinary initiative launched in response to the increasing need to develop integrated circumpolar analyses of Southern Ocean climate and ecosystem dynamics.

ICED has been developed in conjunction with the Scientific Committee on Oceanic Research (SCOR) and the International Geosphere-Biosphere Programme (IGBP), through joint support from the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) and Global Ocean Ecosystem Dynamics (GLOBEC) programmes.

The ICED vision is to develop a coordinated circumpolar approach to better understand climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles, and the development of sustainable management procedures.

What's New?

EUR-OCEANS International Polar Year film released
ICED contributed to producing a short [educational film](#) on the Southern Ocean.

Southern Ocean Food Web Modelling Workshop
The first ICED modelling workshop was held in April to begin to characterise the Southern Ocean food web - a first step towards improving the reliability of predictions of ecosystem dynamics. A report will be available soon. This [poster](#) presents a brief overview and preliminary outcomes. A [summary article](#) is available in the latest IMBER newsletter.

ICED Science Plan and Implementation Strategy

The ICED Science Plan and Implementation Strategy has been formally adopted and is now available to [download](#).

The ICED Science Plan and Implementation Strategy sets out an ambitious programme to address not only the significant scientific challenges of integrating Southern Ocean ecosystem, climate and biogeochemical research at a circumpolar level, but also the challenge of bringing together a multidisciplinary group of international scientists to ensure effective cooperation and communication in addressing the objectives of ICED.

For more information contact [ICED](#).

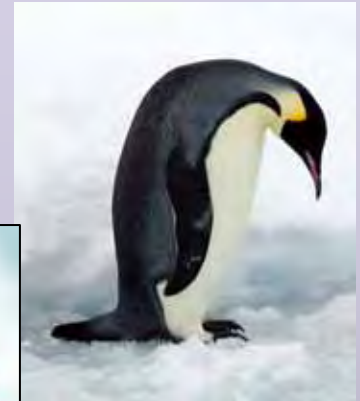
ICED on Google Earth

ICED Fieldwork Coordination
ICED is developing a Google Earth map layer to improve coordination of fieldwork activities. We are interested in all Southern Ocean ecosystem (and related) research being undertaken during the IPY and beyond. To view the map and to find out how to contribute please visit our [Feedback Web page](#).

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Thank you!



Photos Dan Costa

