Southern Ocean food web research
&
Southern Ocean Sentinel

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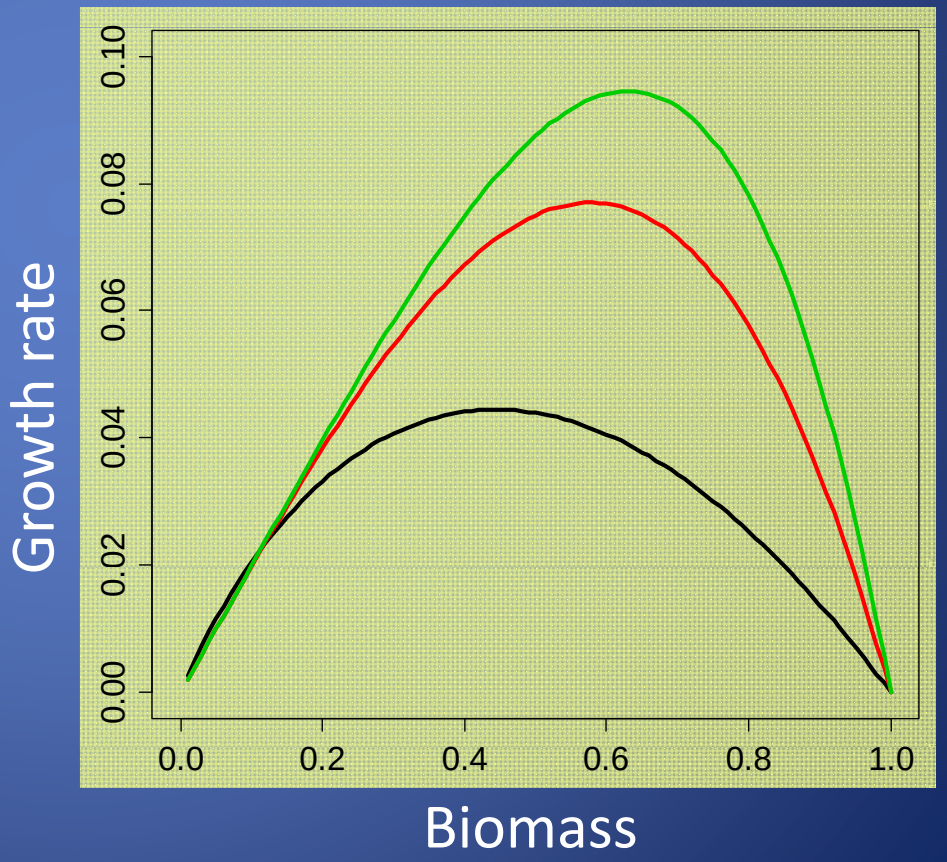
Thanks to many involved in ACE, AAD, CCAMLR, ICED, SOOS

(Gales)

History

- Constant rate functions do not yield good predictions

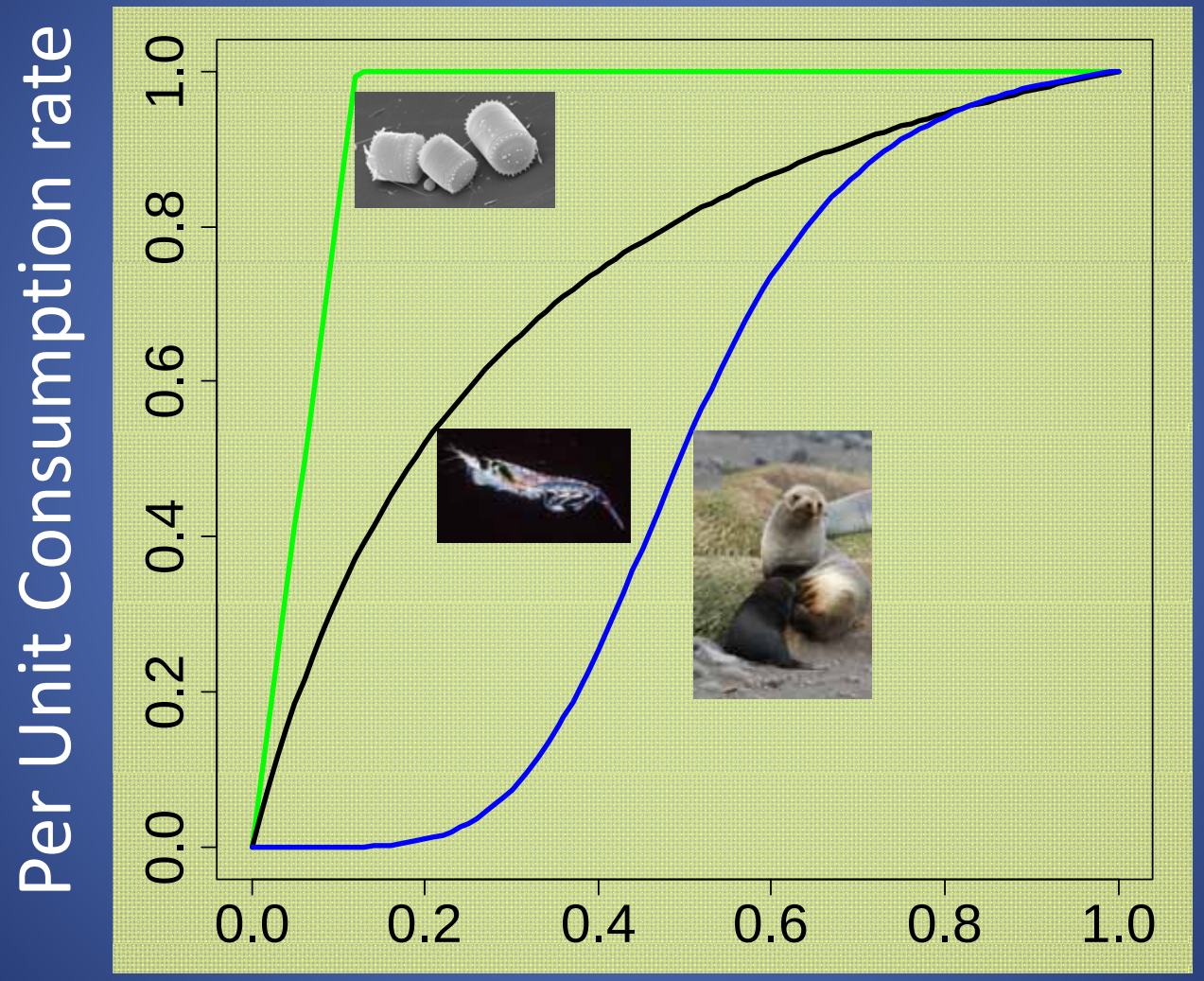
$$dB = rB\left[1 - \left(\frac{B}{K}\right)^{m}\right]$$



Ecological modelling

- Consumption, Production
  - **Lowest trophic levels**
    Consumption
    -> Production
    -> **Consumption**
  - **Rest**
    Consumption ->
    ->(Maintenance+Behaviour+Growth+Reproduction)
    ->**Consumption**
- Mortality
- Linkages - Generalist, serial specialist, specialist (obligate)
- Overlap
  - Spatial, temporal, behavioural
- Elephants in the food web
  - changing availability of consumables that cannot be corrected by behaviour
  - mortality unrelated to food
  - changing transport

Relationships, Responses



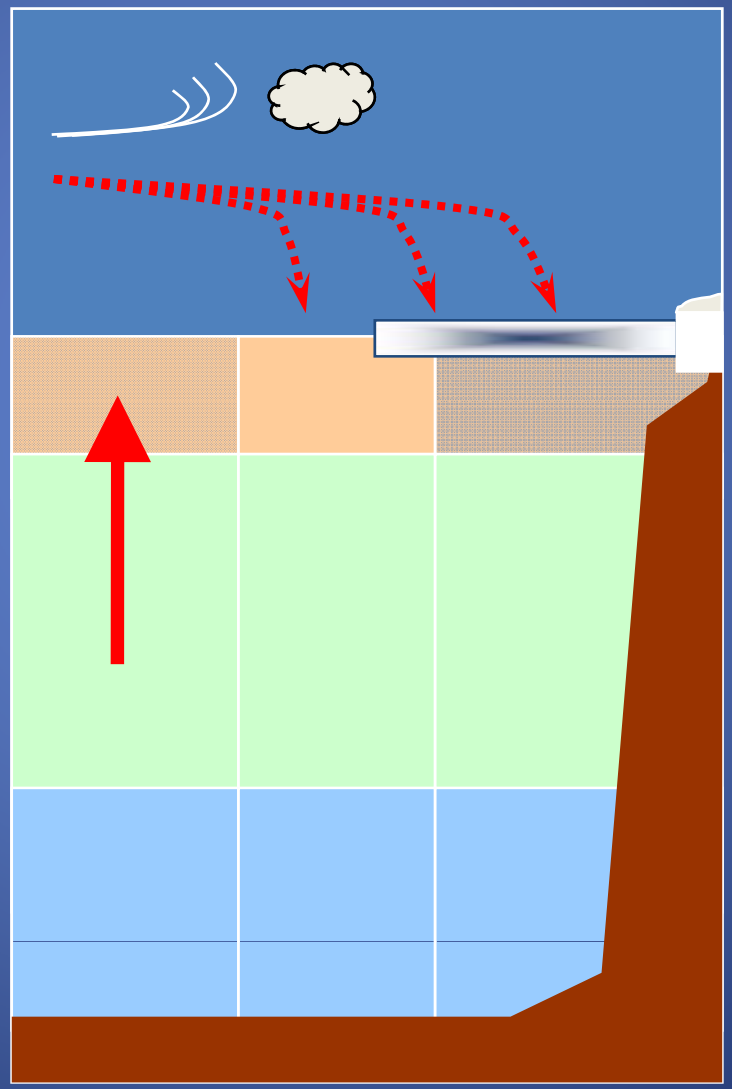
Physical habitat

- temp
- pH
- salinity

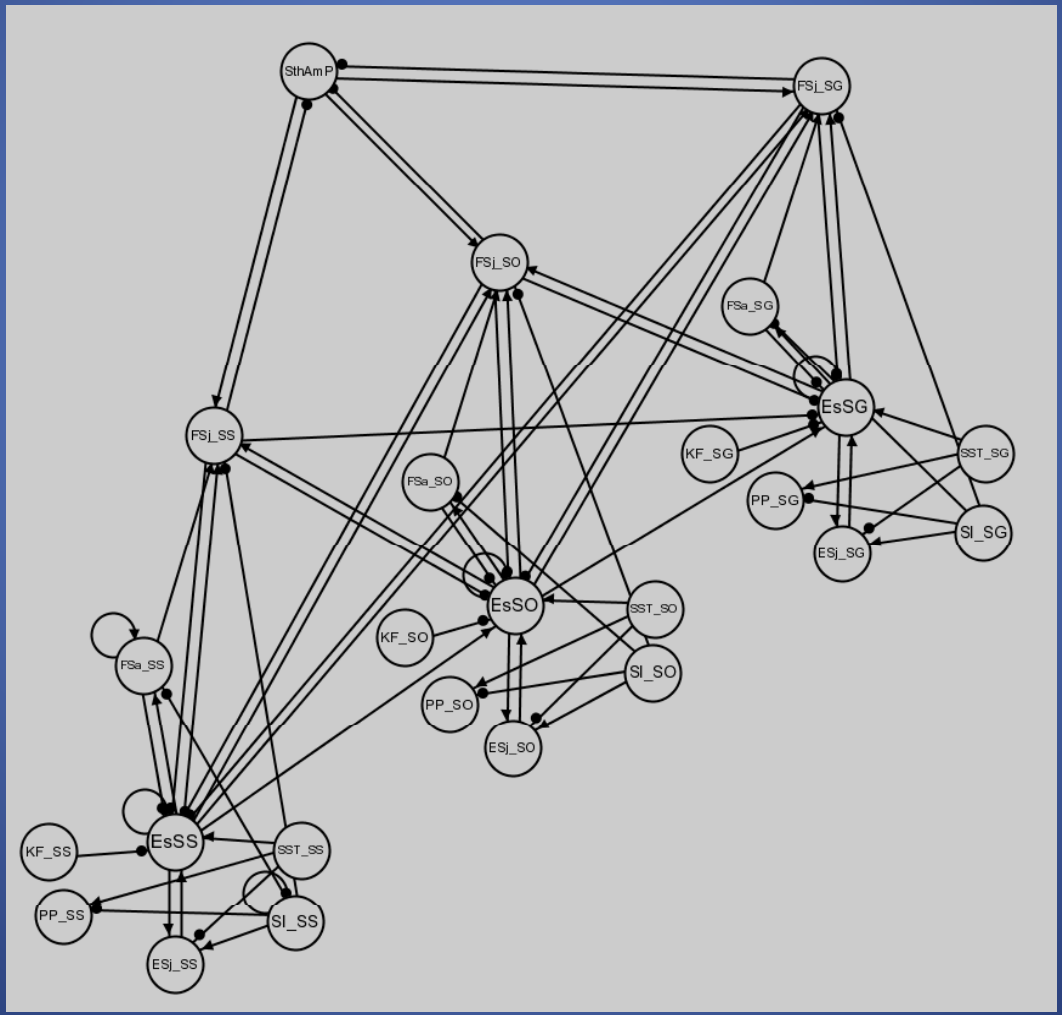
- wind
- fronts
- mixing

- sea ice
- fast ice

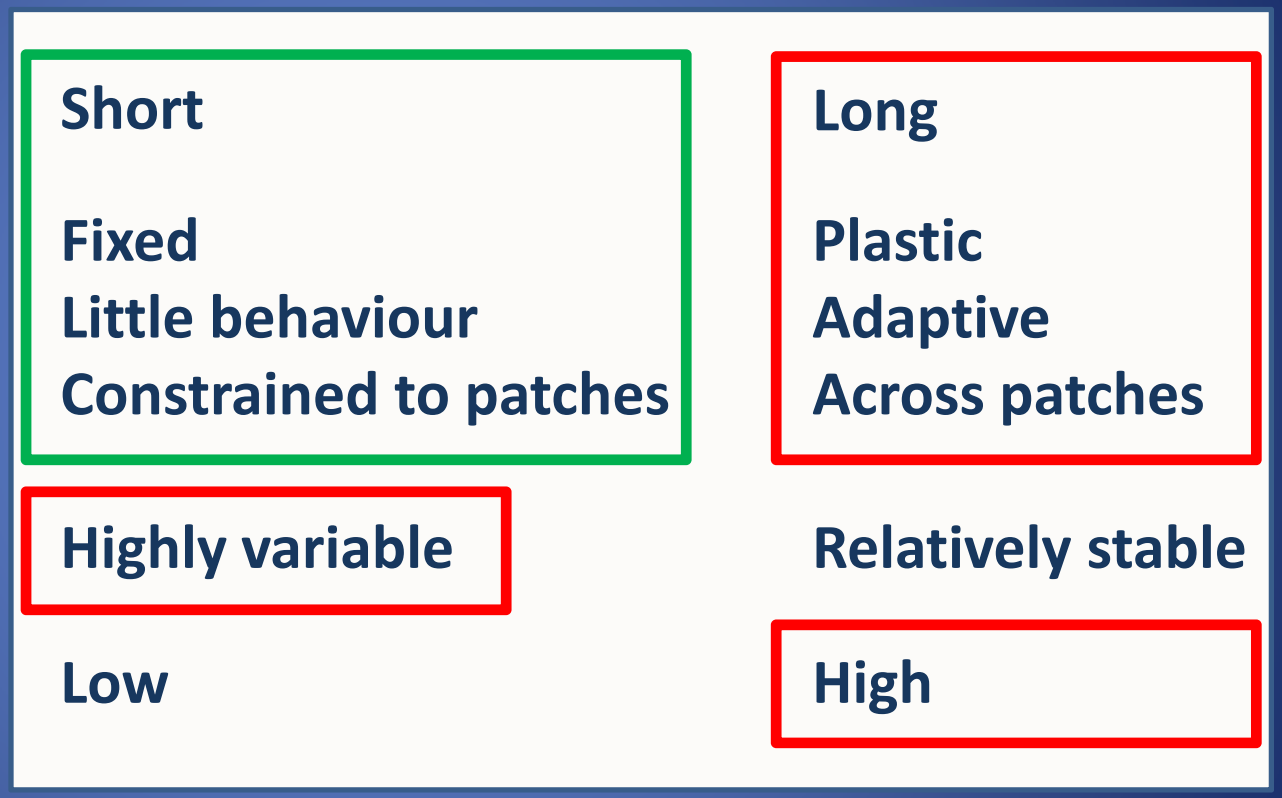
- nutrients
  - air
  - upwelling



Linkages are a greater challenge than physiology



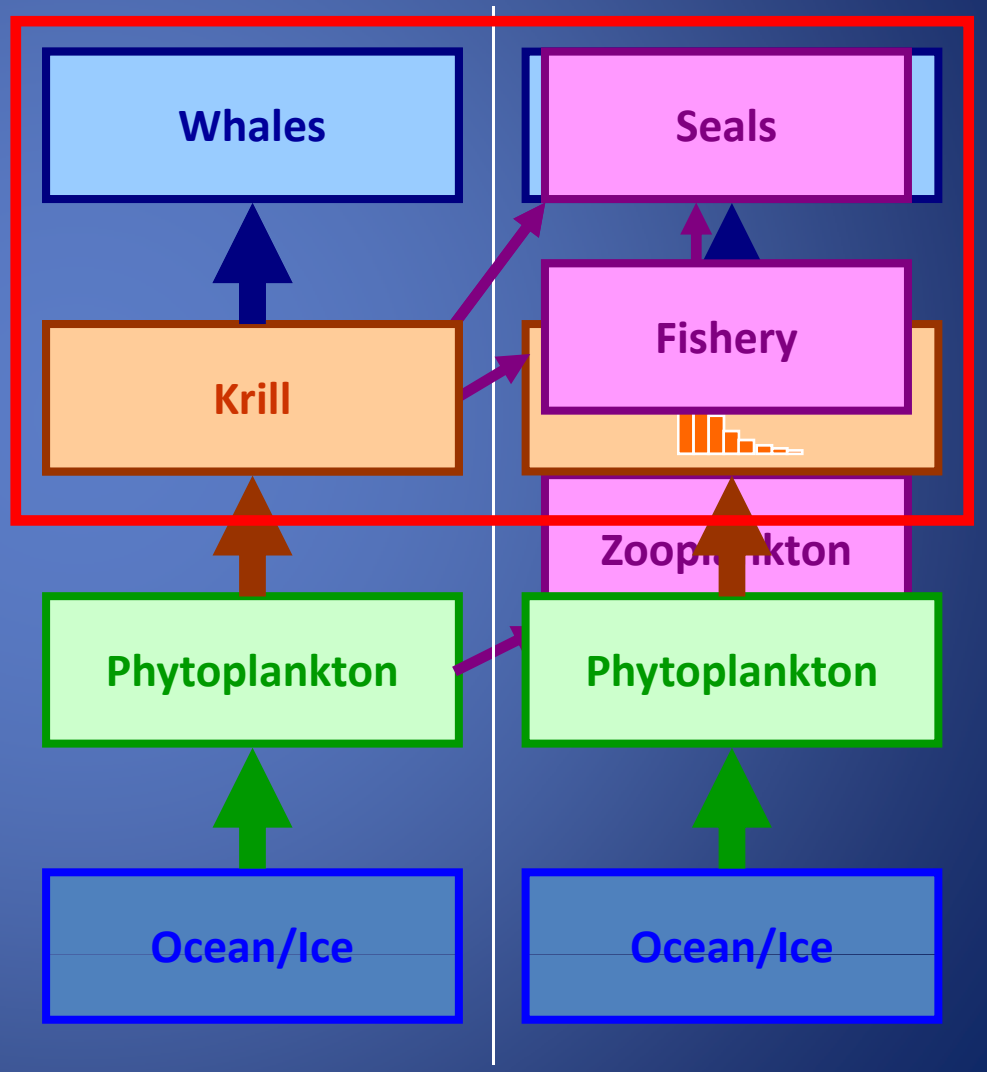
Summary of linkages



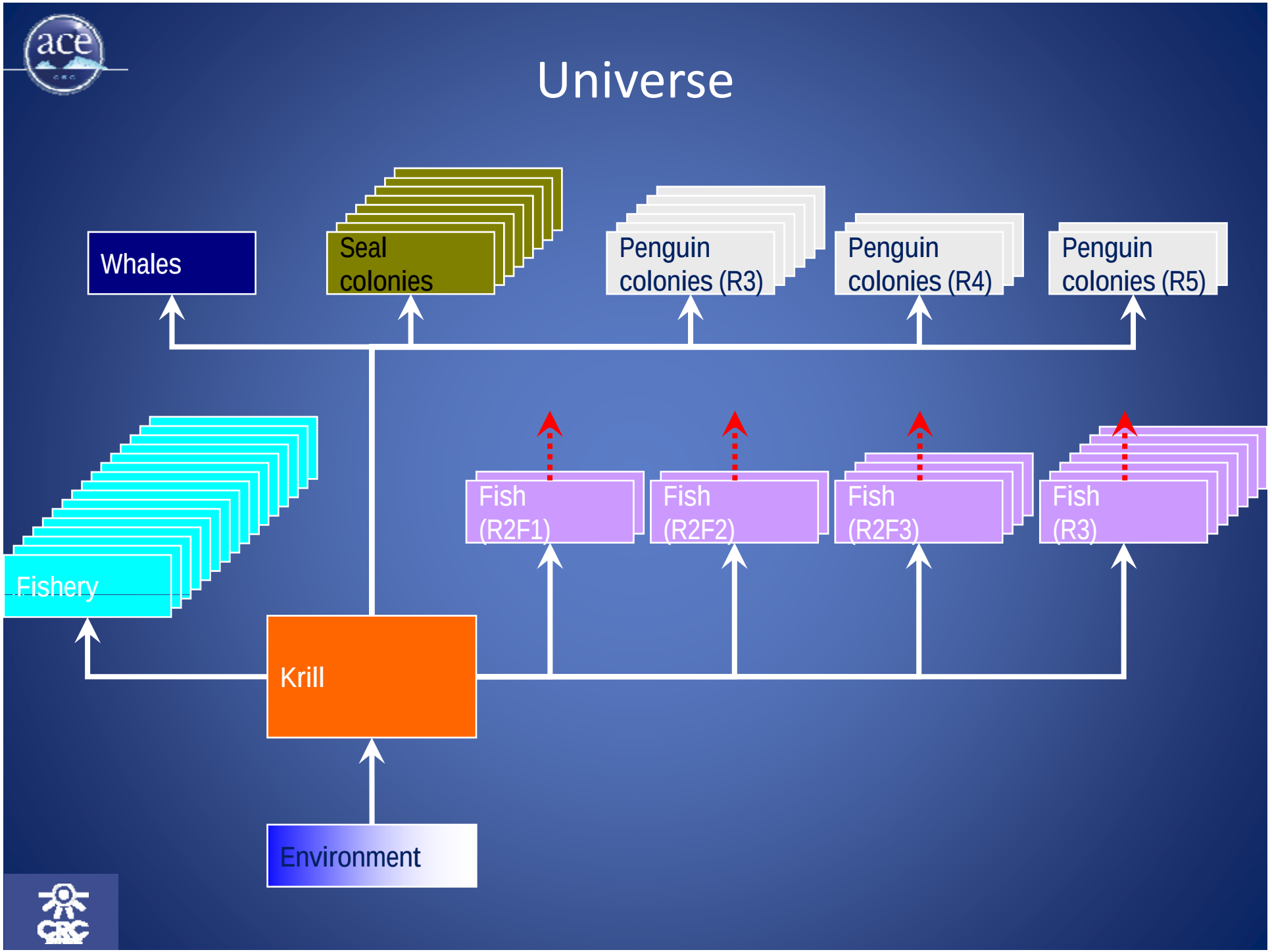
Modelling Framework

Ecosystem Productivity Ocean Climate (EPOC)

- ***Flexibility***
- Collaboration / Participation
  - Ecologically intuitive but unconstrained by theory
- Multiple scales (biota, space, time)
- Evaluation platform
  - field work
  - model efficiencies
  - management strategies

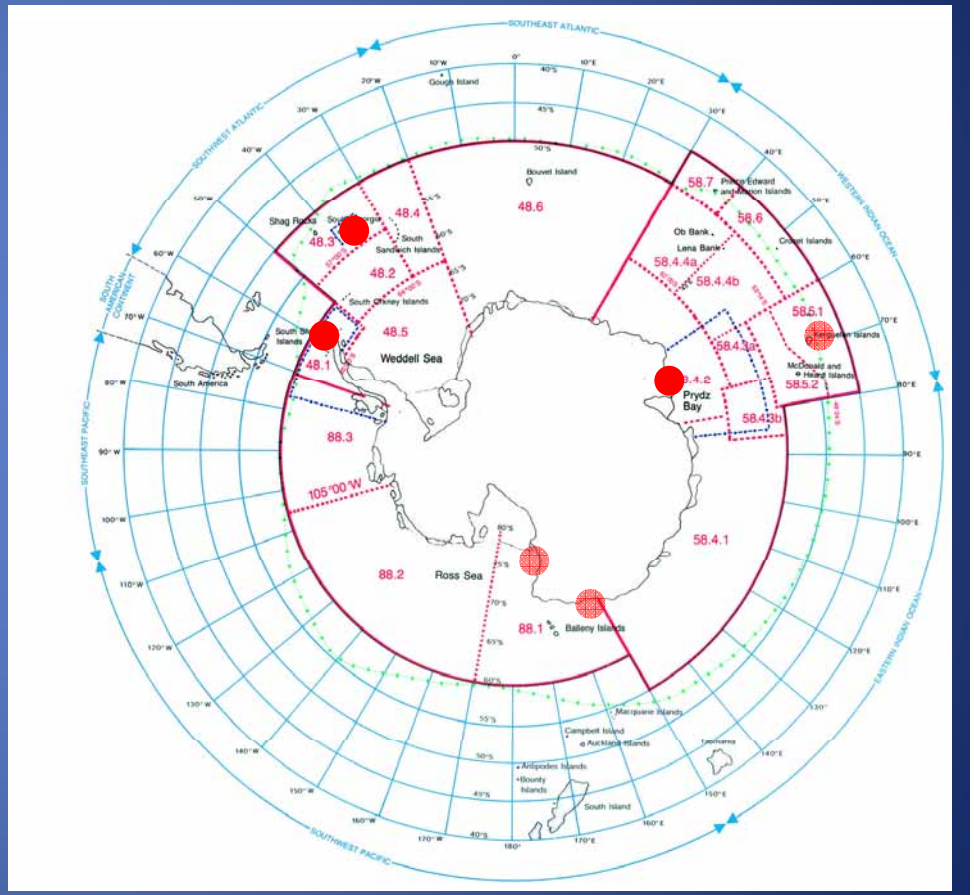


Universe

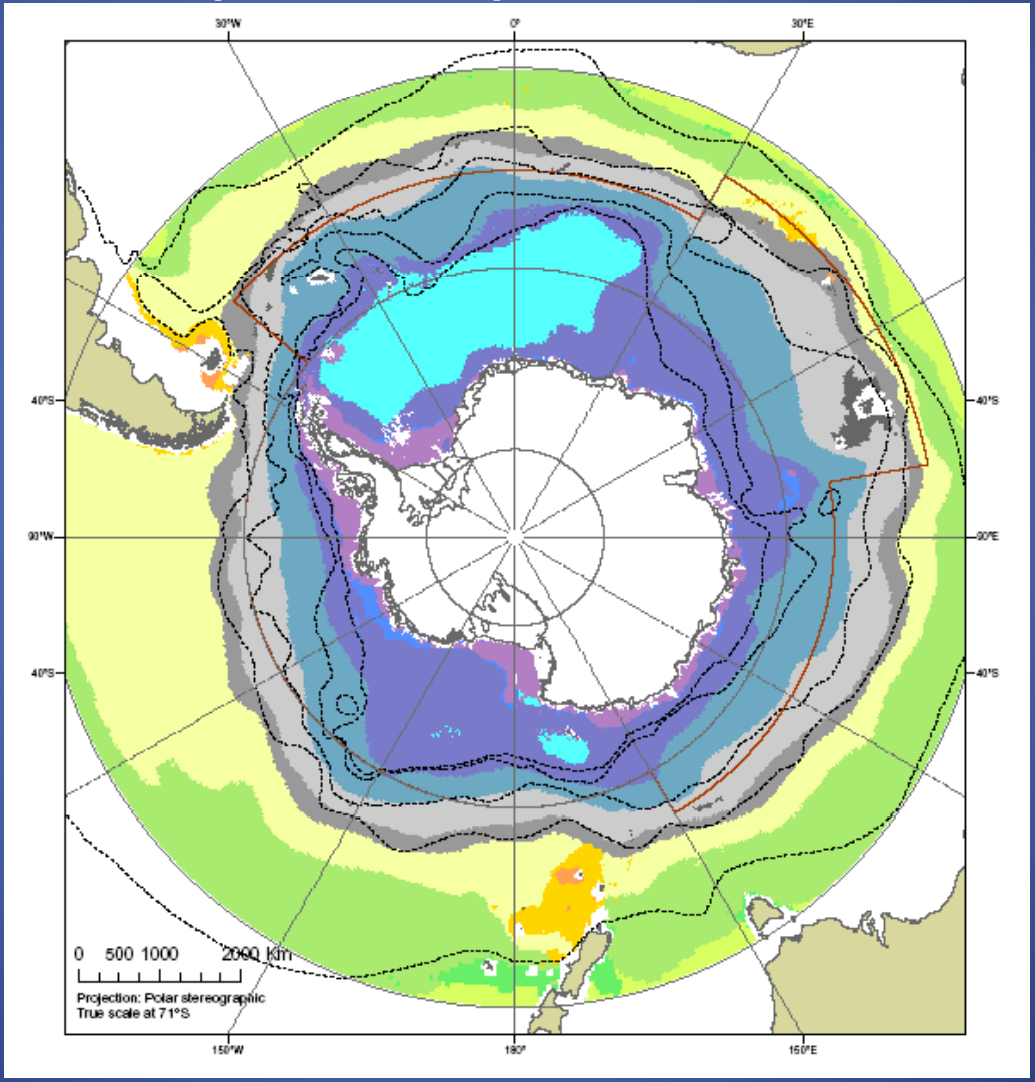

Whales
Seal colonies
Penguin colonies (R3)
Penguin colonies (R4)
Penguin colonies (R5)
Fishery
Fish (R2F1)
Fish (R2F2)
Fish (R2F3)
Fish (R3)
Krill
Environment

Food web research in CCAMLR-IWC

- Questions:
  - impacts of climate change
  - historical over-exploitation and potential for recovery
  - management and conservation measures
- Modelling Approaches:
  - evaluation (MSE)
  - estimation & prediction (hindcasting, forecasting)
- Data collection (CEMP)

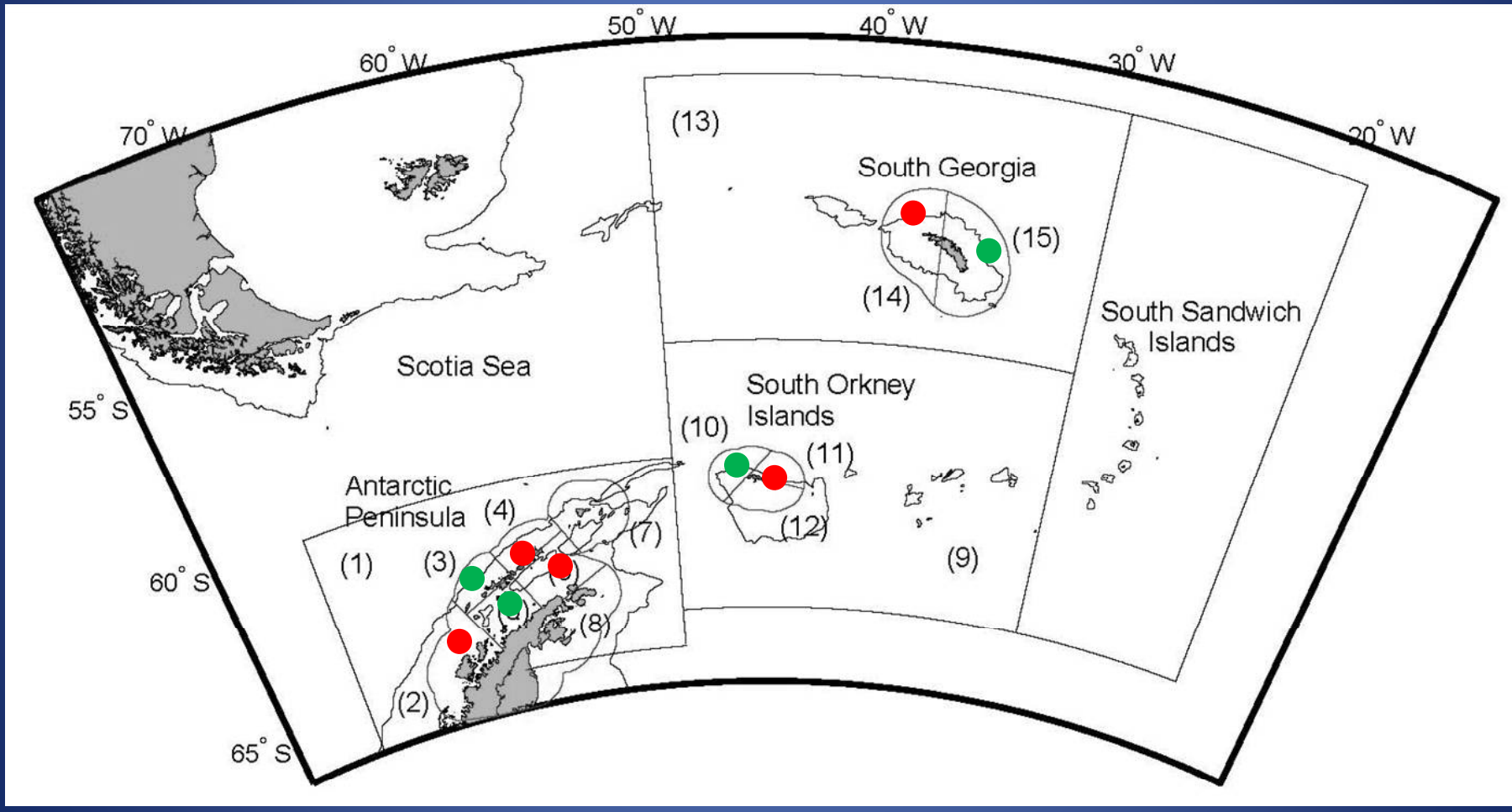


Regional variation in food webs & ecosystem processes

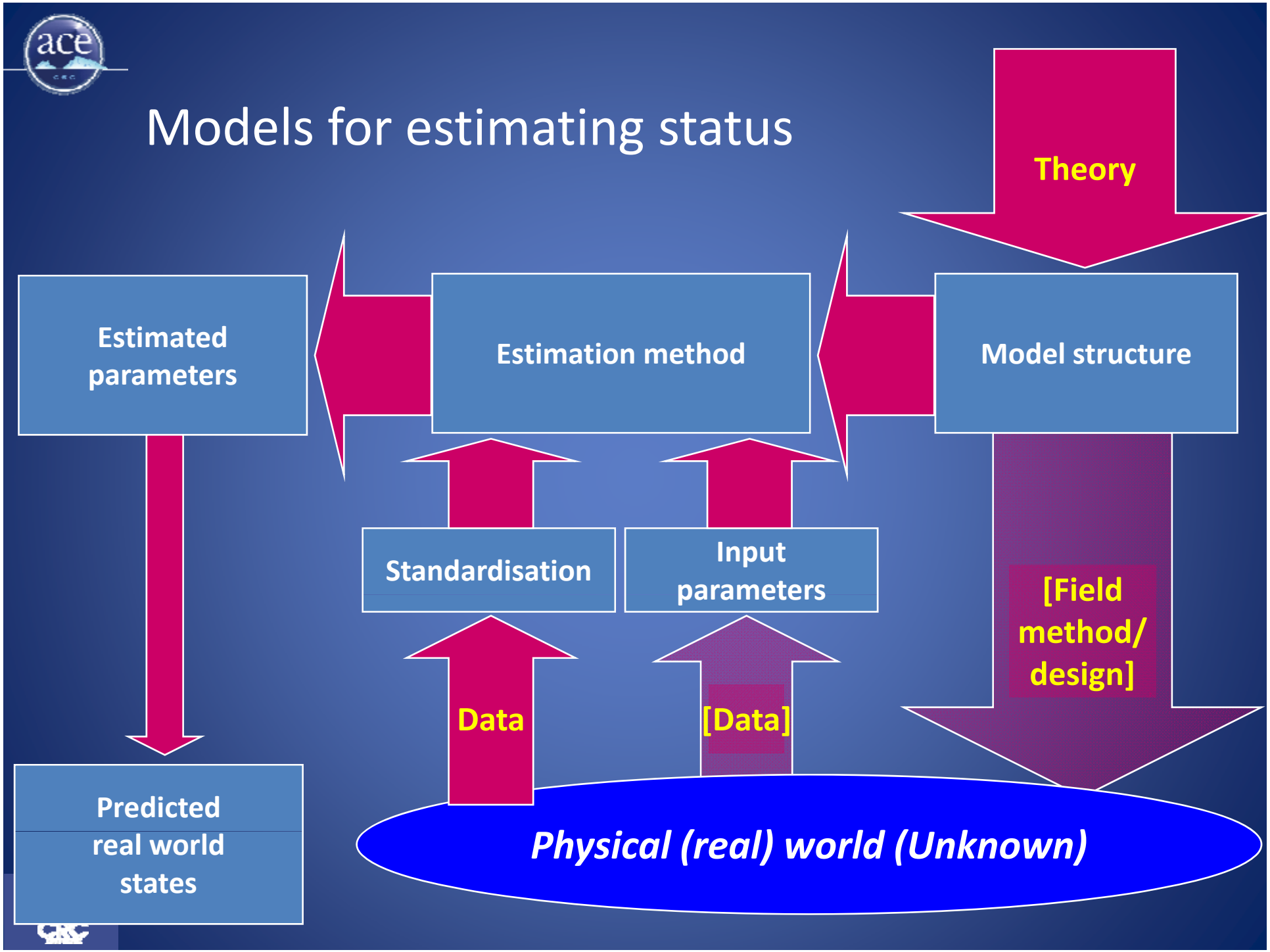


(CCAMLR primary bioregionalisation 2007)

Small-scale management (ecological) units



Models for estimating status



Integrated approaches for assessing climate change impacts

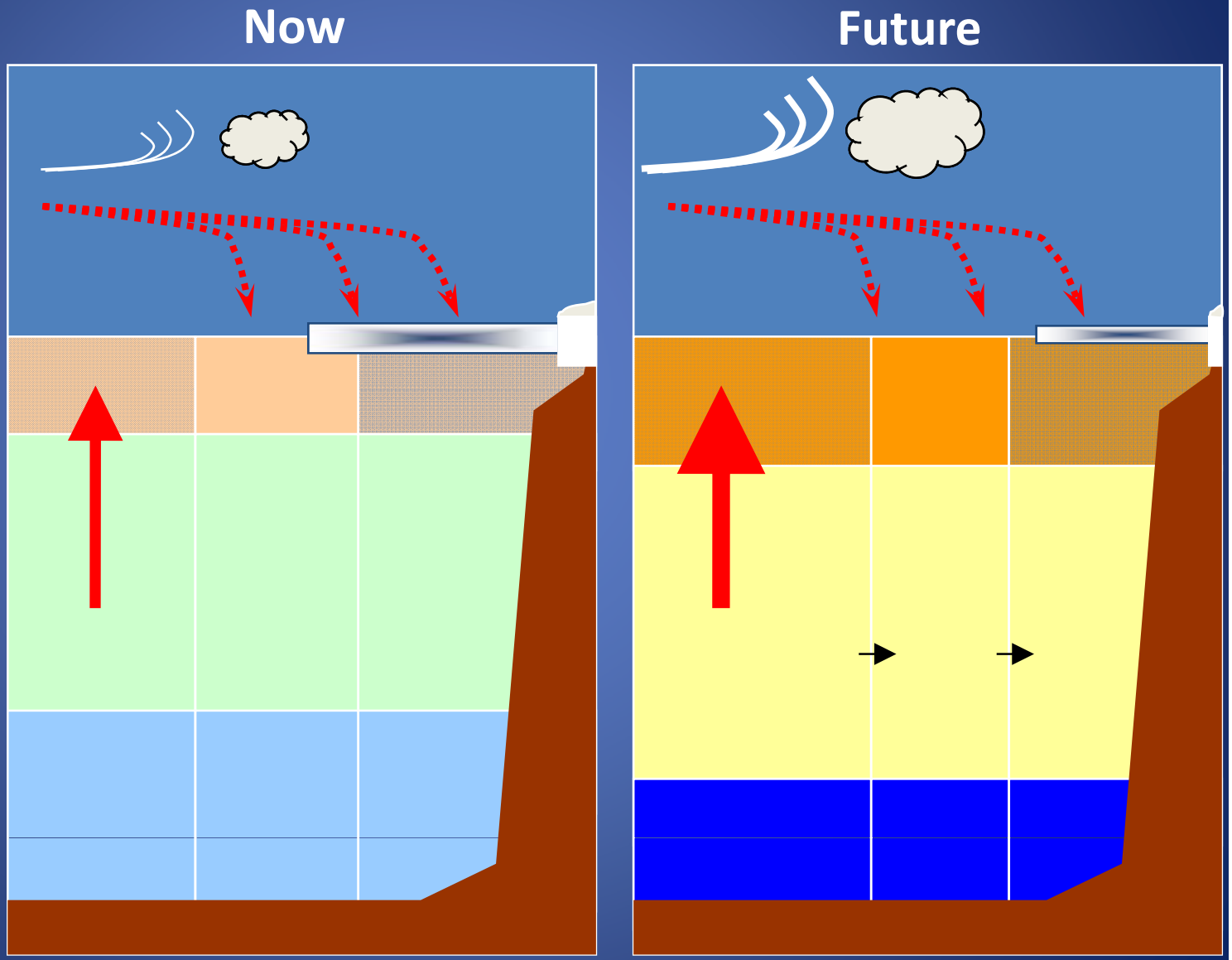
Changes in physical habitat

- temp
- pH
- salinity

- wind
- fronts
- mixing

- sea ice
- fast ice

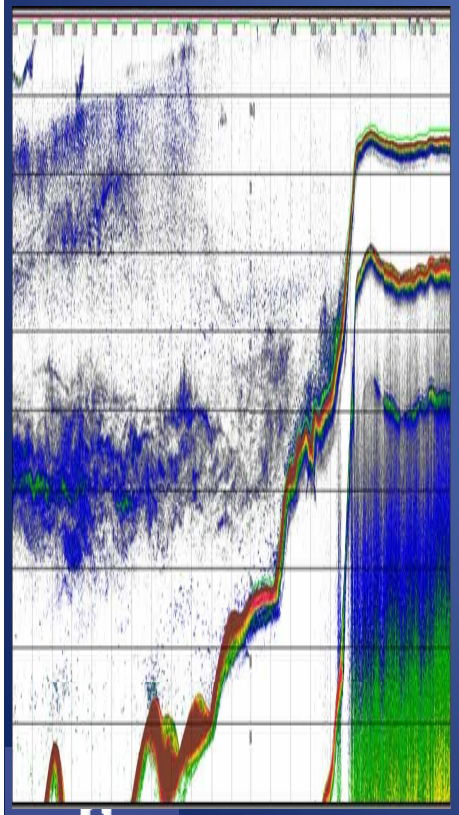
- nutrients?
  - air
  - upwelling



Biodiversity and habitats

Sea ice

Land / fast ice

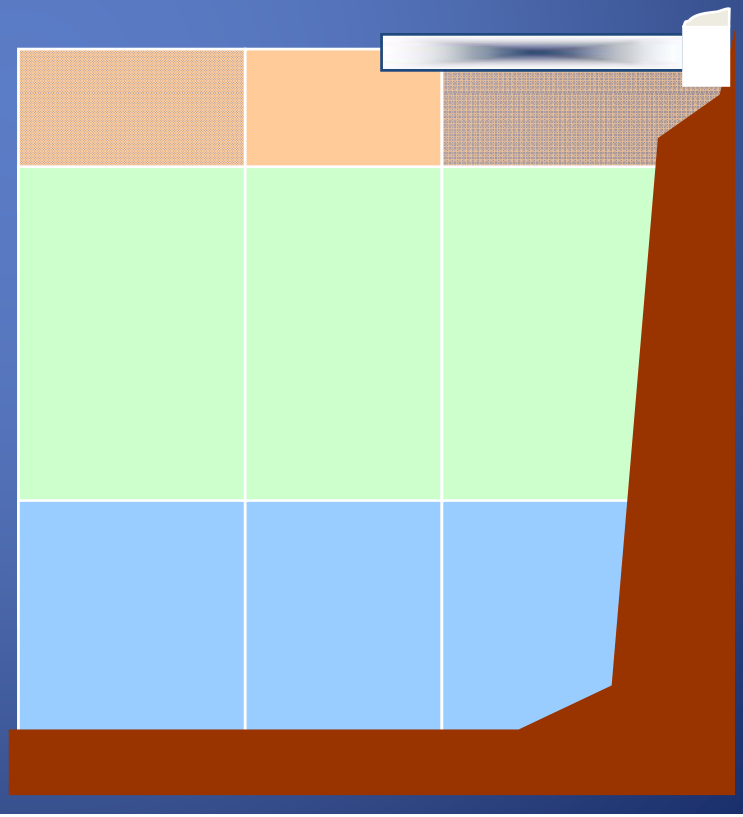


Pelagic

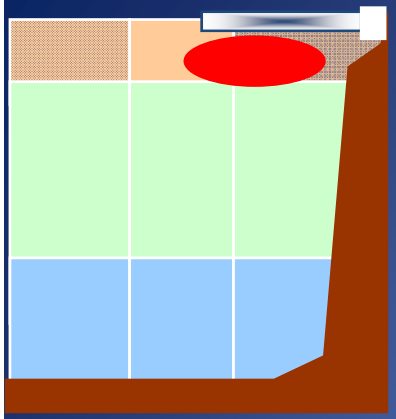
Benthic

Oceanic

Neritic



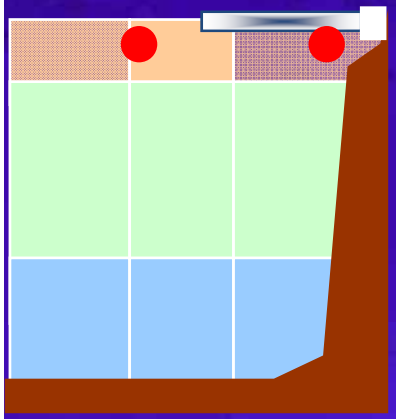
Impacts on species



Antarctic Krill

(Kawaguchi)

- temperature impacts on growth and reproduction
- decline in sea ice juvenile habitat
- reduced escapement from predators
- *less reproduction in low pH*

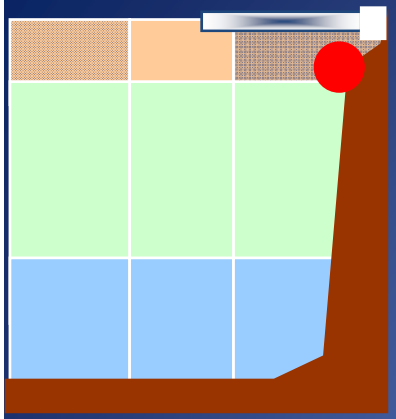


Icefish

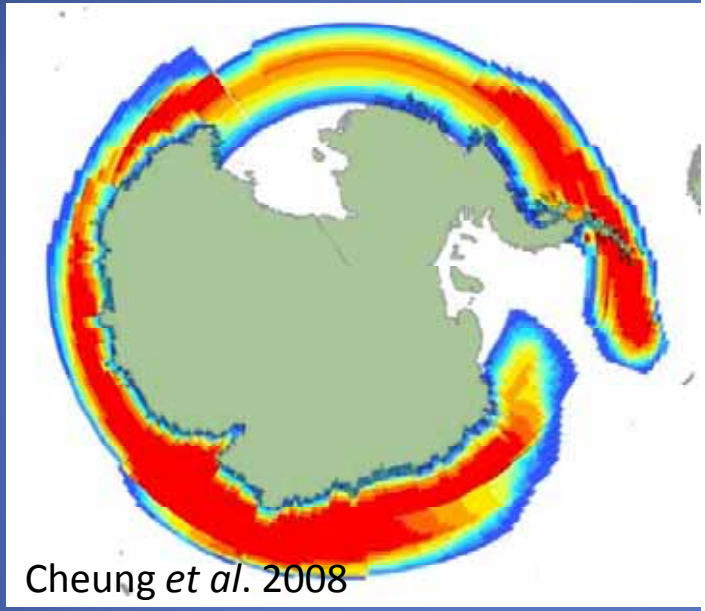
- increased temperature could move distribution south

(Koch)

Toothfish



Present



Cheung *et al*. 2008

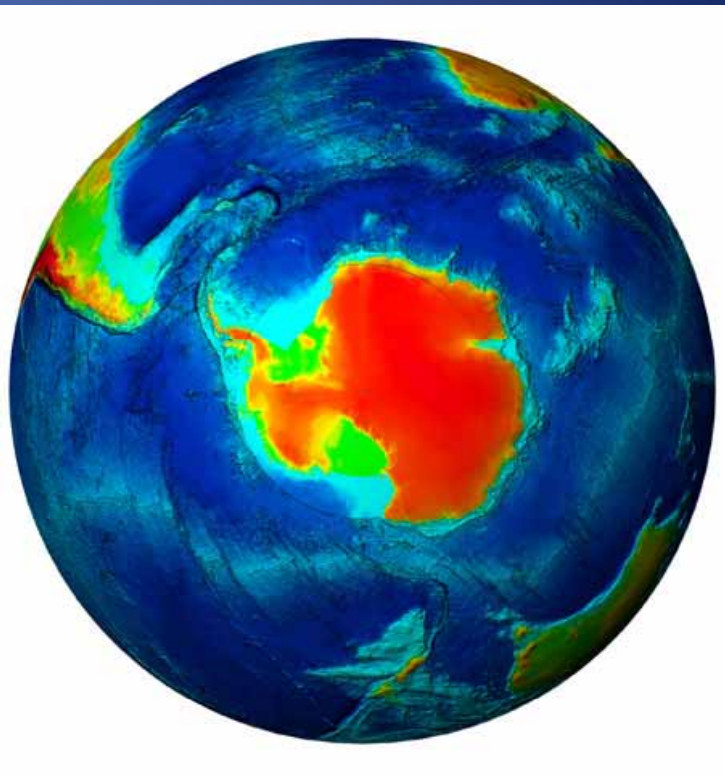
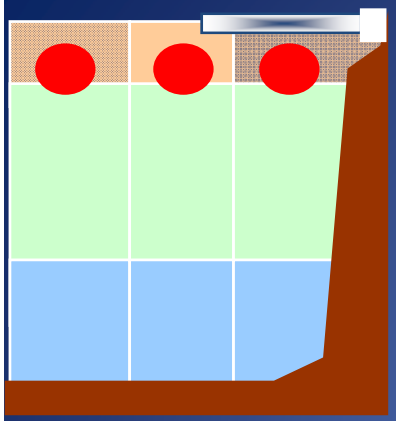


Photo: AFMA

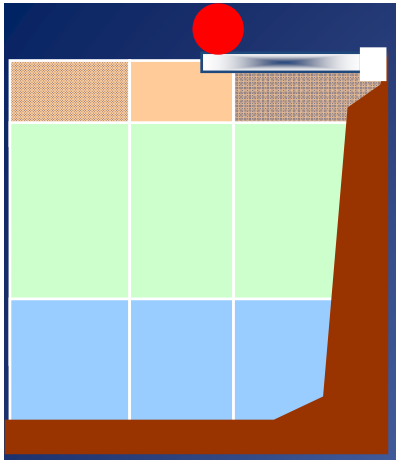


Zooplankton
Mesopelagic fish

- will they move with fronts
- sensitivity to changing environment conditions – temp, pH (e.g. pteropods)
- different energy pathways

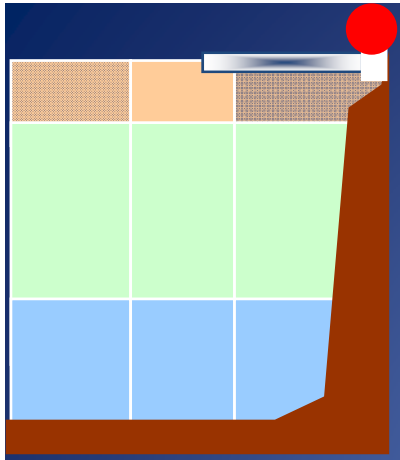

(Aitkenson)


(Koch)



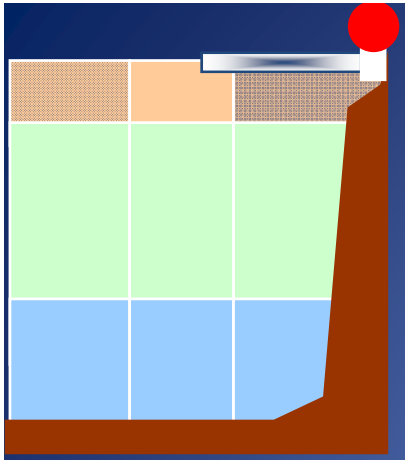
Pack ice seals

- sea ice breeding platform
- foraging platform / prey availability



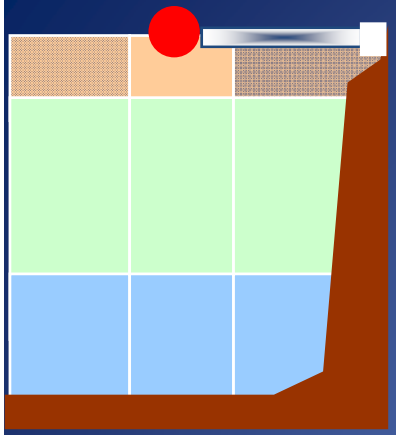
Emperor penguins

- fast ice breeding platforms
- summer access to feeding grounds through sea ice
- prey availability



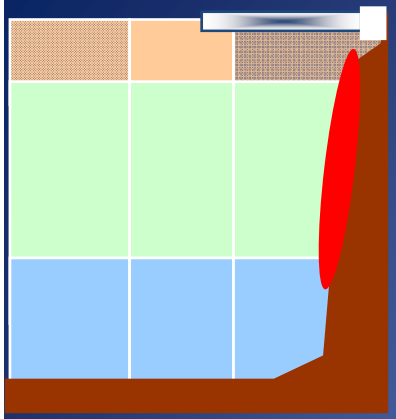
Adelie penguins

- summer access to feeding grounds through sea ice
- winter foraging platform
- prey availability



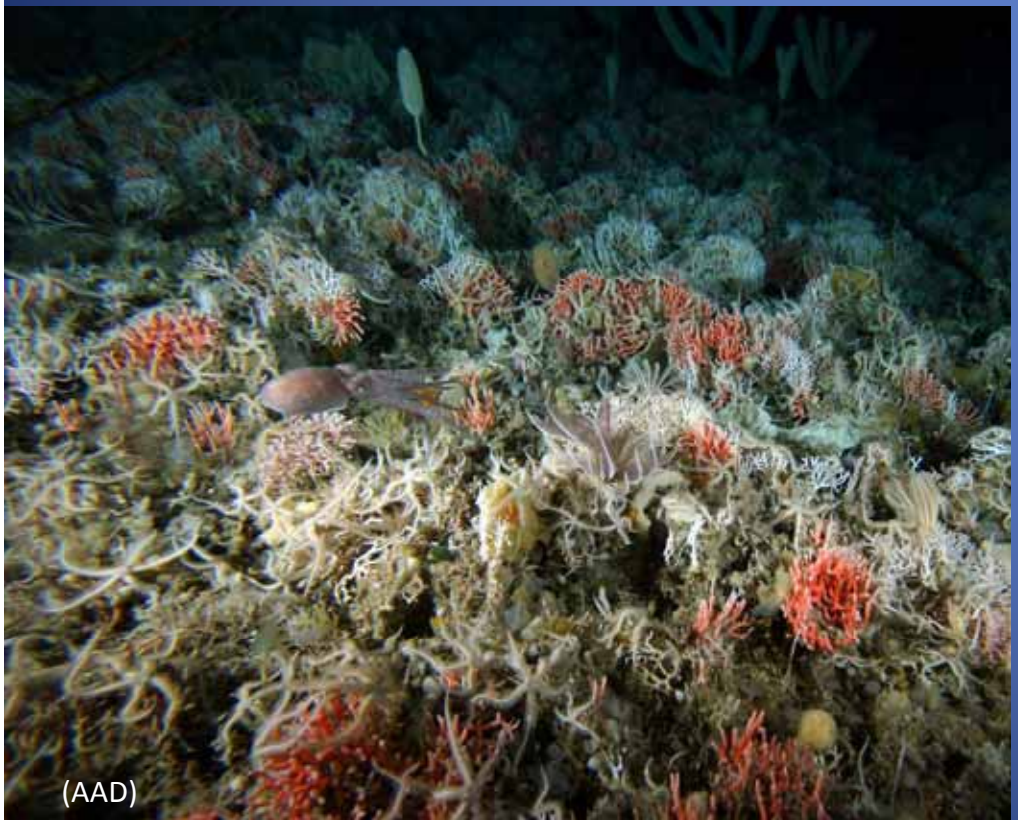
Baleen whales

- sea ice habitat and feeding locations
- prey availability



Benthos

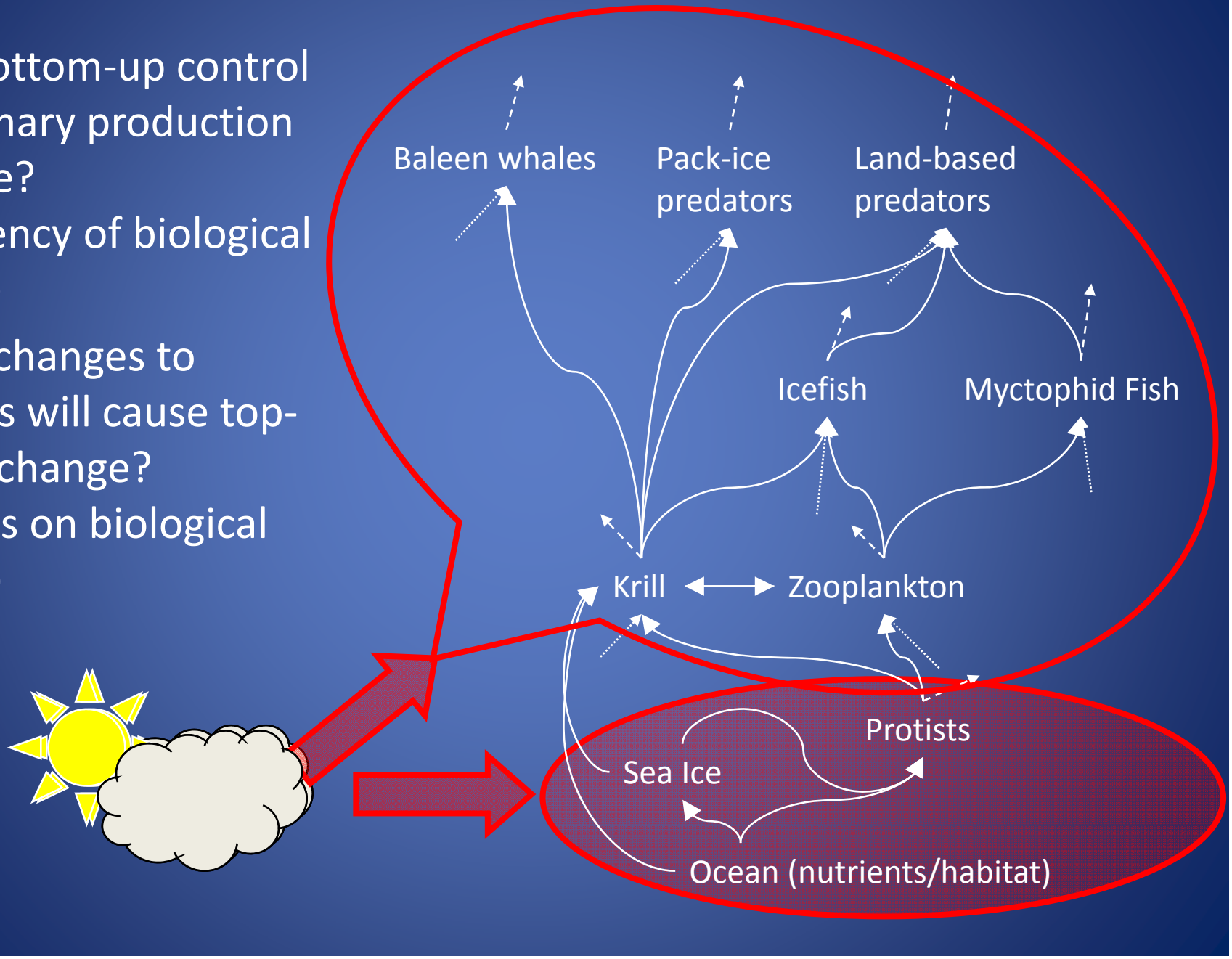
- temperature
- pH - calcification
- detritus availability (sea ice, pelagic)



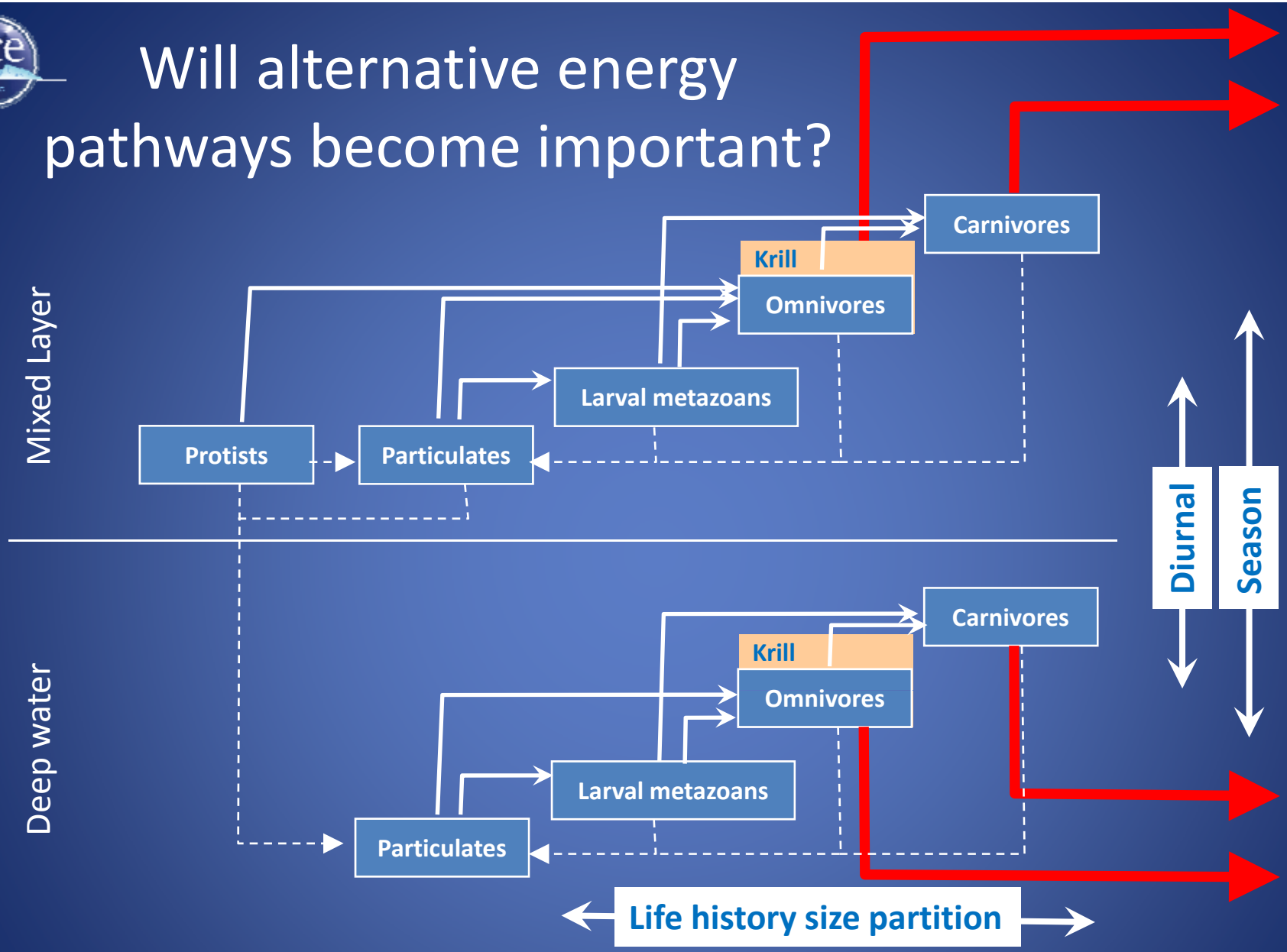

Impacts on food webs

Foodwebs

- Will bottom-up control of primary production change? (efficiency of biological pump)
- What changes to species will cause top-down change? (effects on biological pump)



Will alternative energy pathways become important?



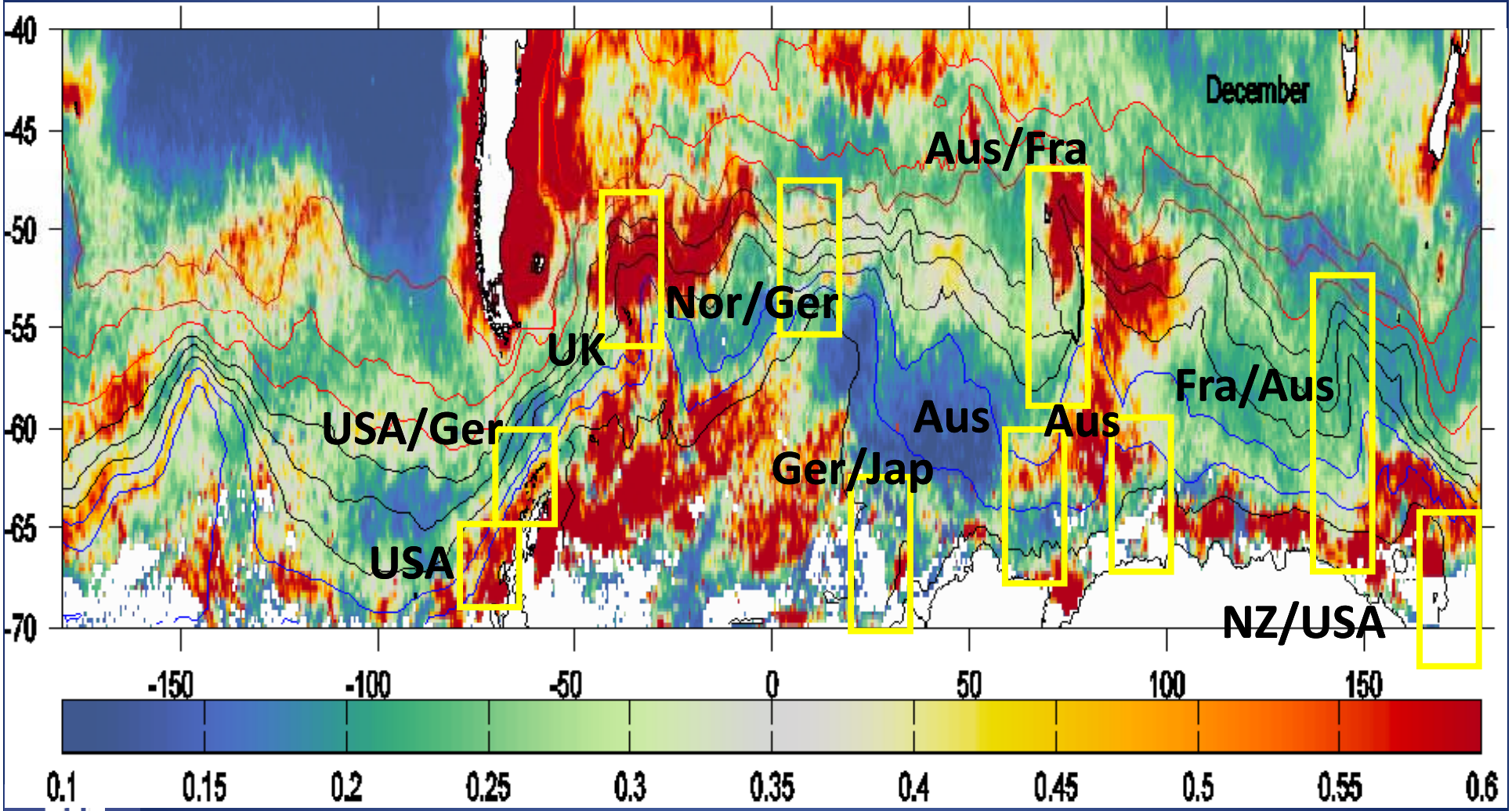
Very deep water

Krill

Key questions

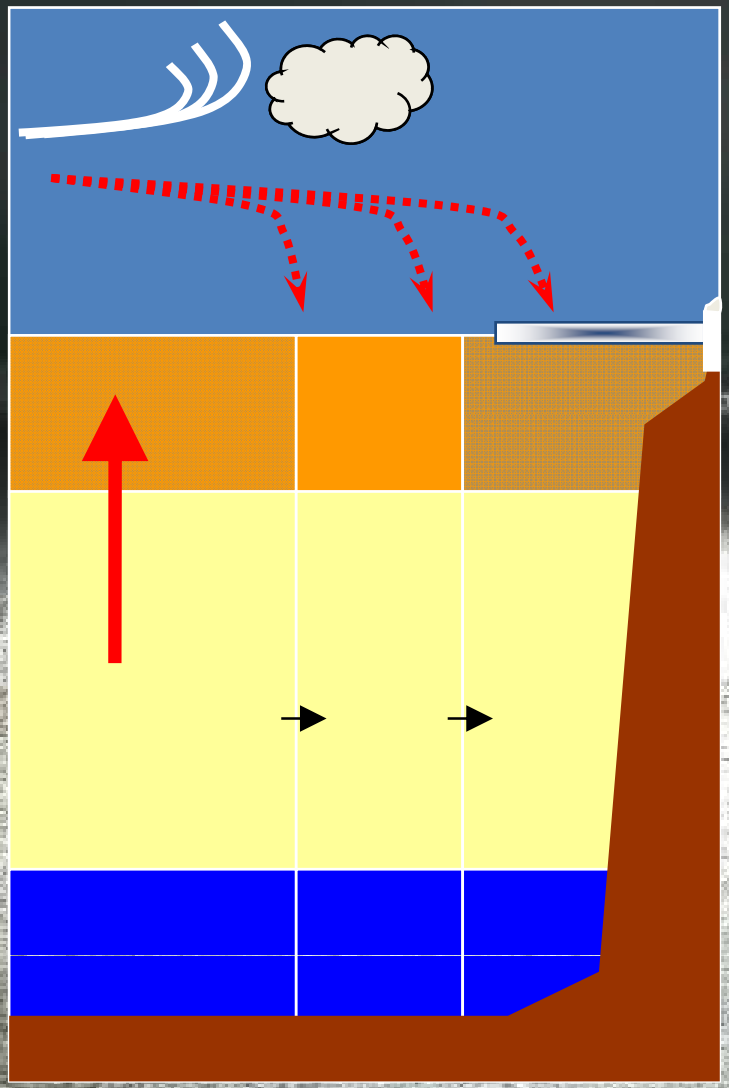
- Will climate change (and ocean acidification) bring
  - change in gross primary production?
  - top down impacts on biological pump?
  - change in commercial species and a requirement to alter management systems - krill, fish
  - change in the conservation status of species – whales, albatross, petrels
  - threats to biodiversity – emperor penguins, bryozoan reefs
- How fast are marine ecosystems (physical, biogeochemistry, biology, ecology) changing?
  - *which predictive model is correct?*

Testing models - measuring rates of change in food webs, biodiversity and ecosystems



Mean chlorophyll distribution in December - Sokolov & Rintoul (2007)

Key questions



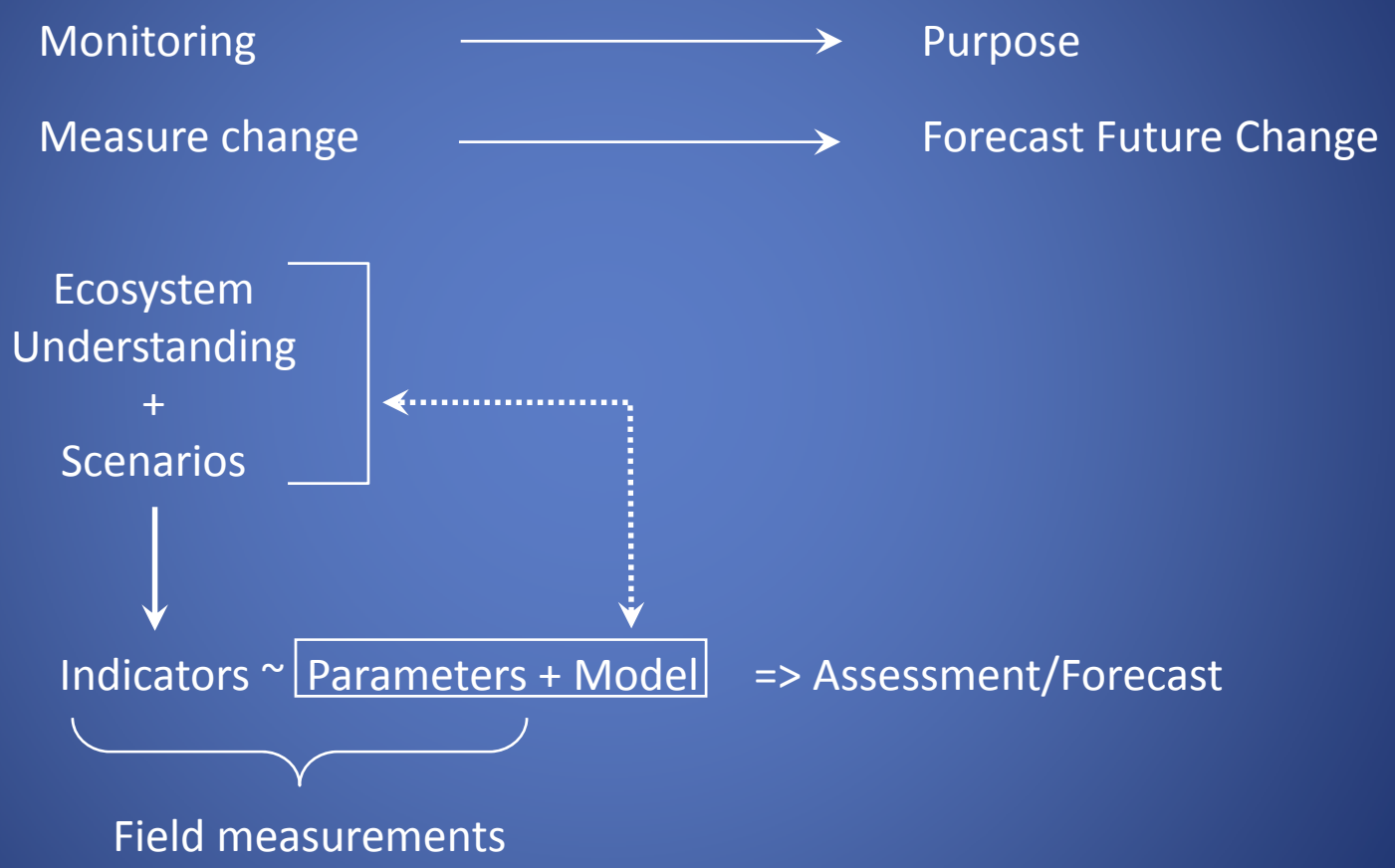
- How are physical habitats and their dynamics going to change?
  - input to ocean/ice/atmosphere models
  - predictions for ecosystems
- How will changes in biota impact on ocean ecosystem function?
- Use of different trajectories for biota to identify climate change trajectory for marine ecosystems?

www.acecrc.org.au/drawpage.cgi?pid=antractica_climate_change

Workshop Aim

- To consider how to measure, assess and provide early-warning detection of climate change impacts on the Southern Ocean and how these could be used to signal future impacts on marine and other ecosystems elsewhere in the world.

Southern Ocean Sentinel



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Considerations

- State of knowledge
- Scientific and technological research required to establish a Southern Ocean Sentinel monitoring program
- Linkages amongst programs e.g. ICED, SOOS

Questions

1. Changes in physical and chemical environment
2. Characteristics of marine biota that determine their resilience or susceptibility to physical changes
3. Expectations of future change in marine biodiversity, including species composition and ecological processes
4. Indicators of climate change impacts on ecosystems
5. Processes to develop international, multidisciplinary program to measure change
6. Research to reduce uncertainty in projections of future climate change and its impacts

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Mission

- The Southern Ocean Sentinel will be an international multidisciplinary scientific effort to provide early warning of climate change impacts on global marine and other ecosystems based on Southern Ocean ecosystem indicators and assessments of climate change impacts in the region.

Objectives

- Provide information on the impacts of climate change in the Southern Ocean
- Develop methods for predicting imminent and future change in Southern Ocean ecosystems
- Establish Southern Ocean ecosystem indicators as early-warning signals of future change in other global regions
- Establish an active, adaptive long-term field program (indicators, parameters)
- Present outcomes (e.g. system assessments), and synthesise, review and regularly update predictions.

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Linkages

- an ICED project (legacy program)
- field measurements **(SOOS)** to
  - indicate change
  - differentiate between models
  - refine parameters in models

www.acecrc.org.au/drawpage.cgi?pid=antractica_climate_change

Milestones

- 2009
  - Workshop conclusions (website)
  - Workshop report (July)
  - Assessment 1 (qualitative) (September)
  - Workshop outcomes (October)
  - Proceedings (well advanced)
- 2010 Workshop 2 (Focus groups, collaborations, science program)
- 2012 IPCC AR5 contributions
- 2014 Assessment 1 (qualitative) (September)
- 2017 Long-term program (outcome of ICED)


Thanks