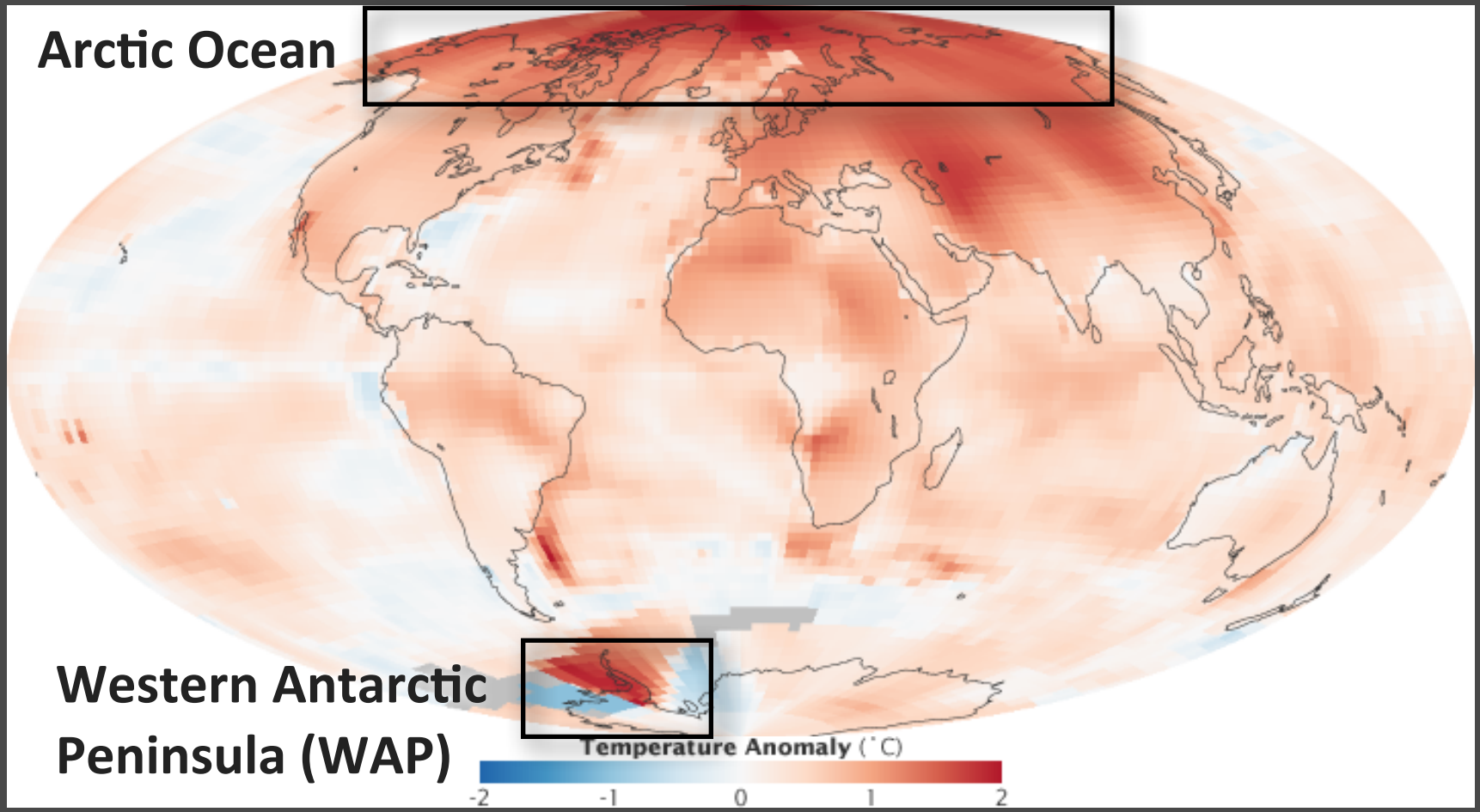
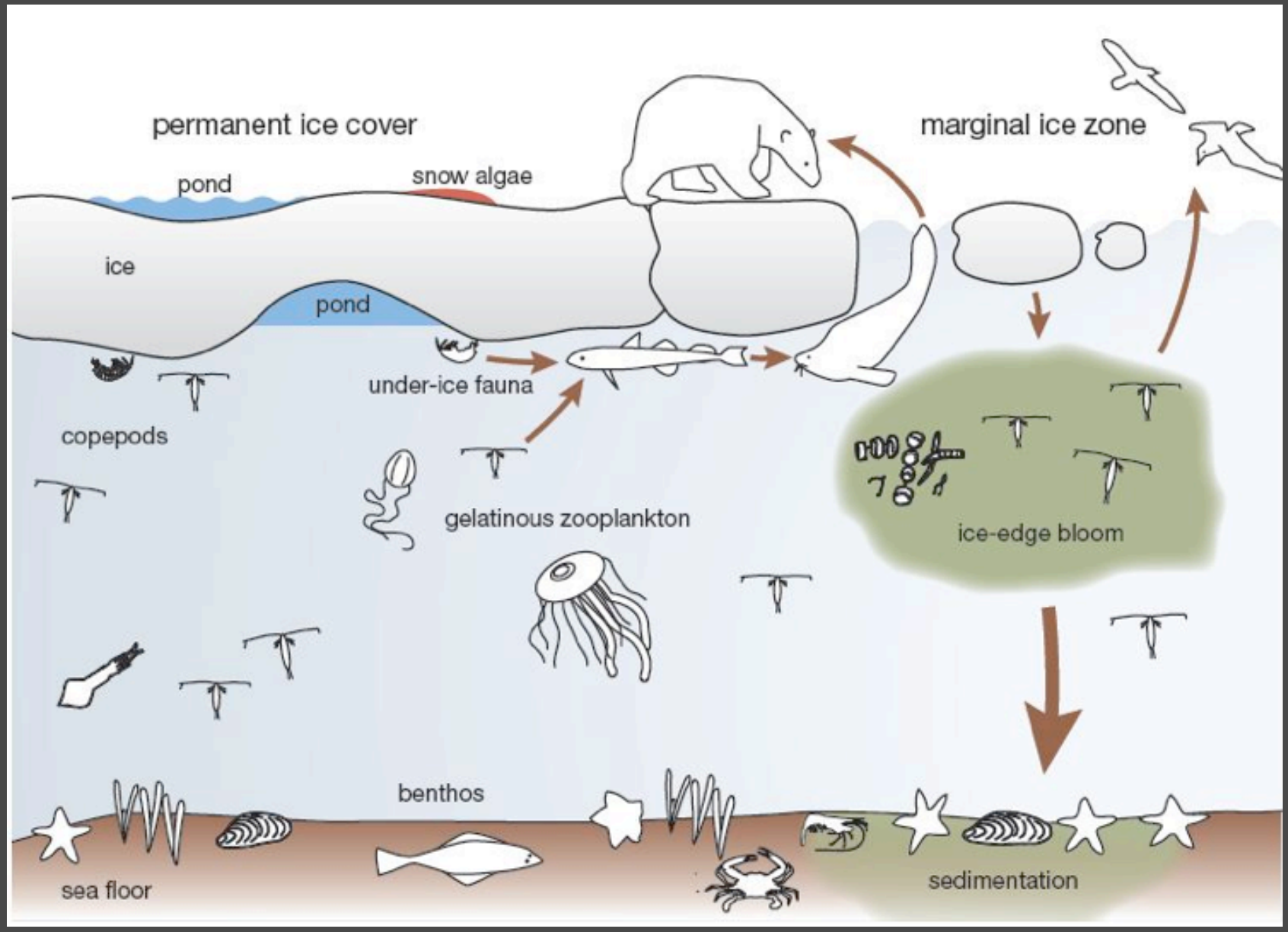
Marine Ecosystem Impacts in Polar Regions



Strong and fast climate changes at the poles

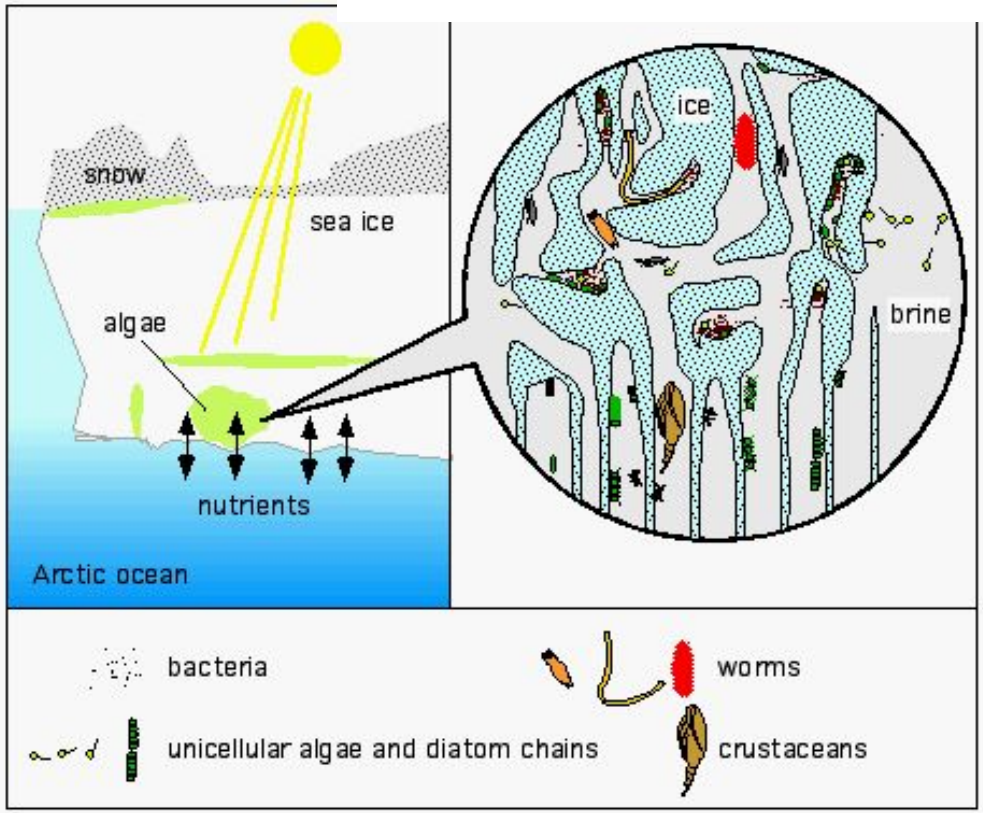
Polar Ecosystem and Sea-Ice

Arctic Ecosystem & Food Web



Sea ice: a refuge for life in polar seas

Life within Brine Channels



Sea Ice Algae

Ice Algae are 57% to the total Arctic marine primary production

source: http://www.arctic.noaa.gov/essay_krembsdeming.html

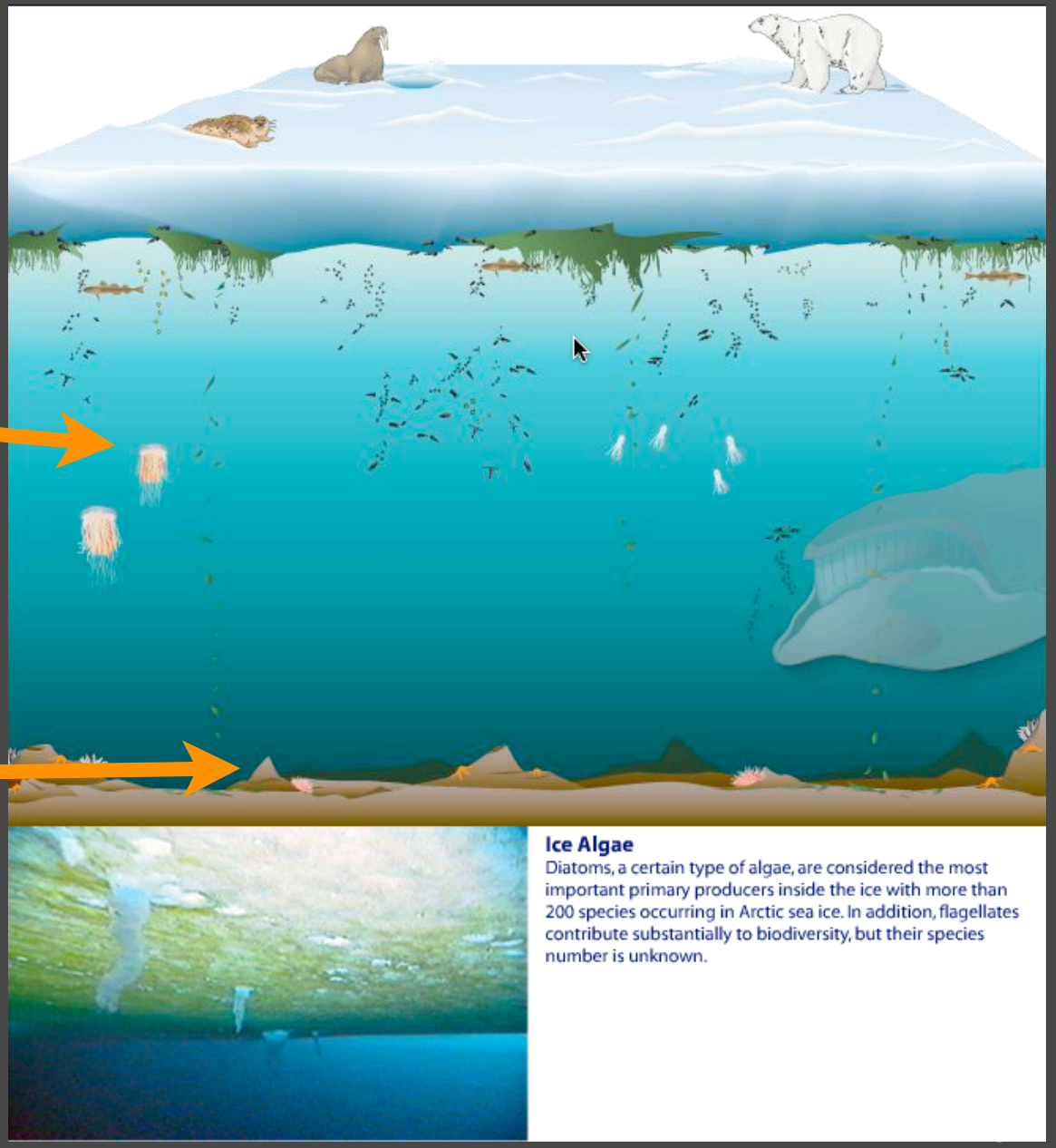
Sea ice: a refuge for life in polar seas

Sea Ice Algae support both the

Pelagic

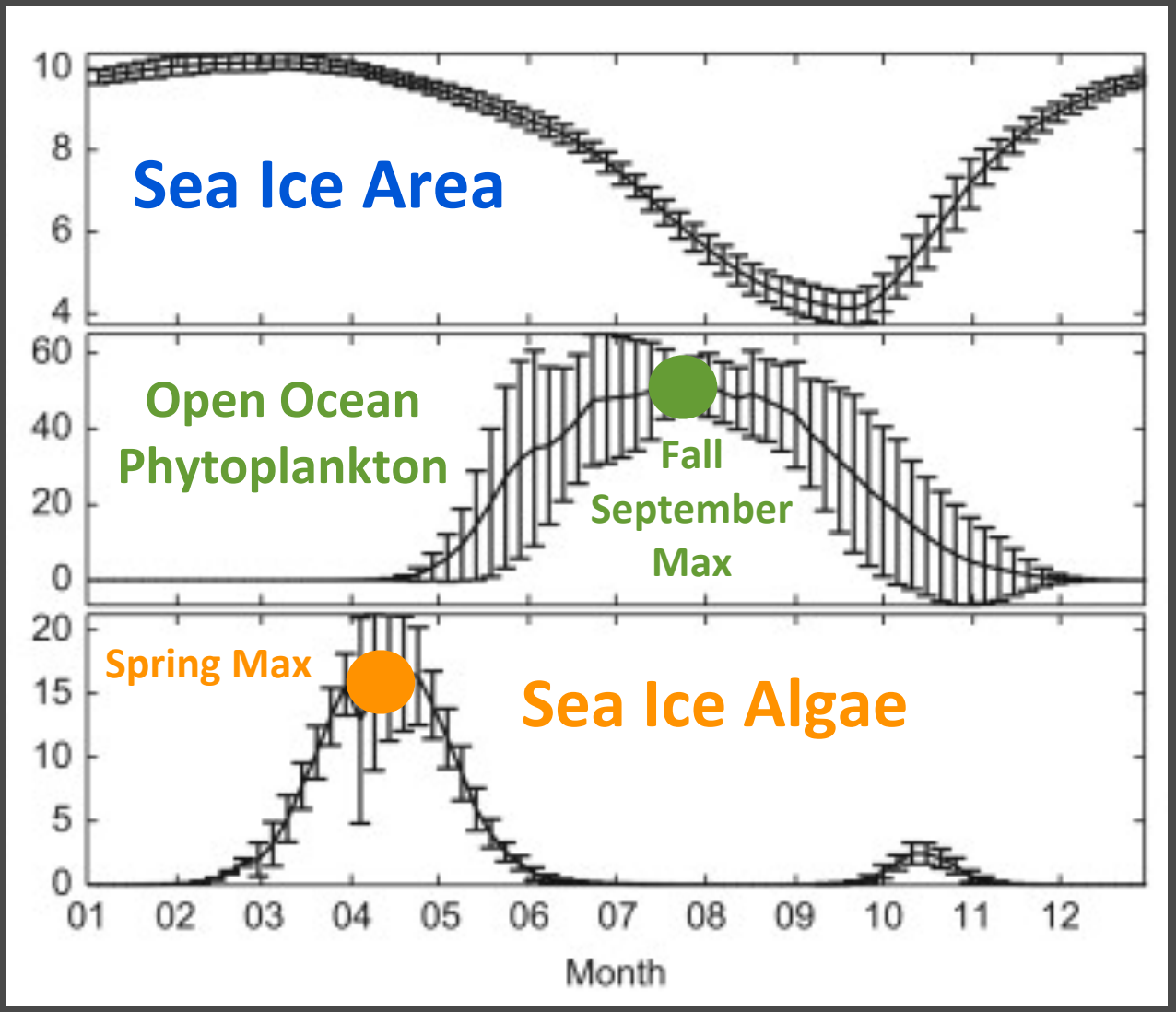
&

Benthic Environments

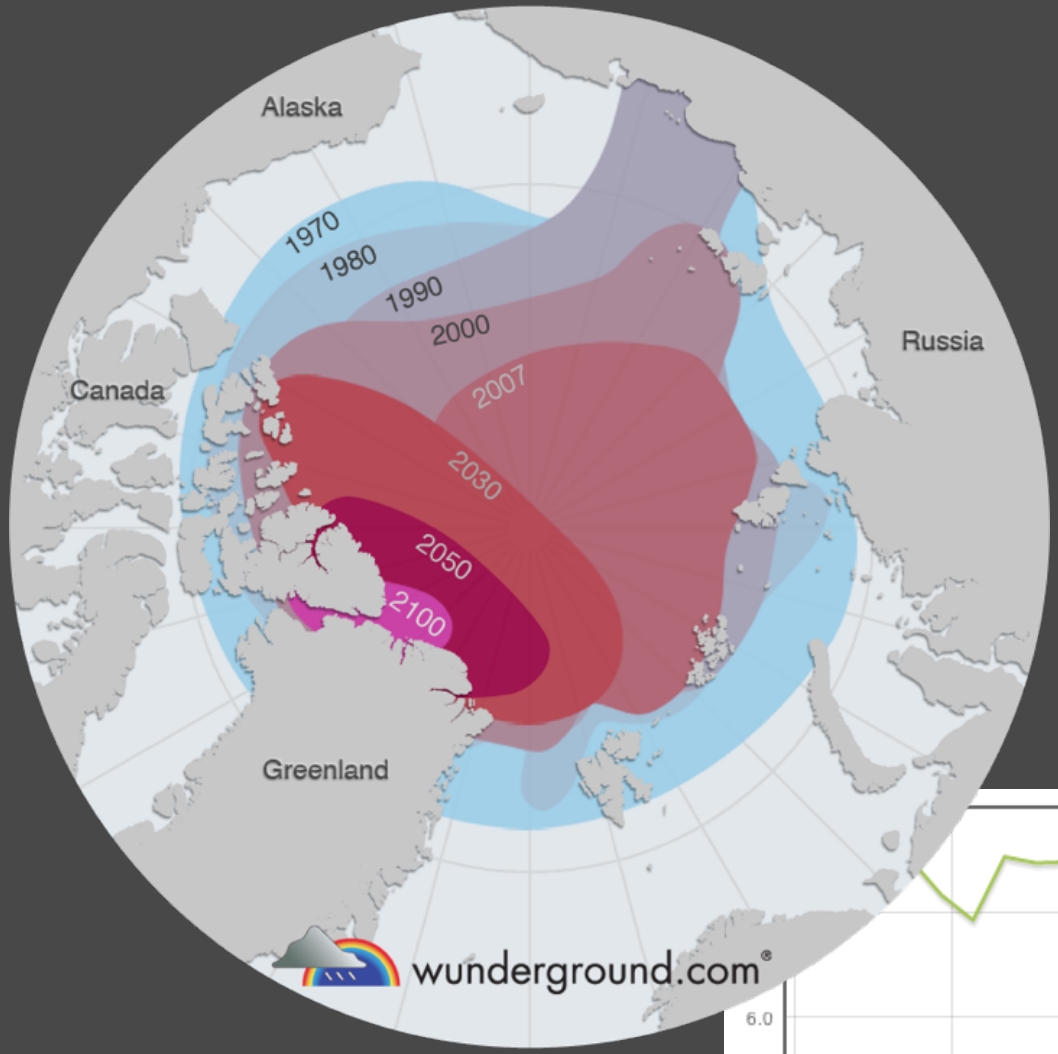


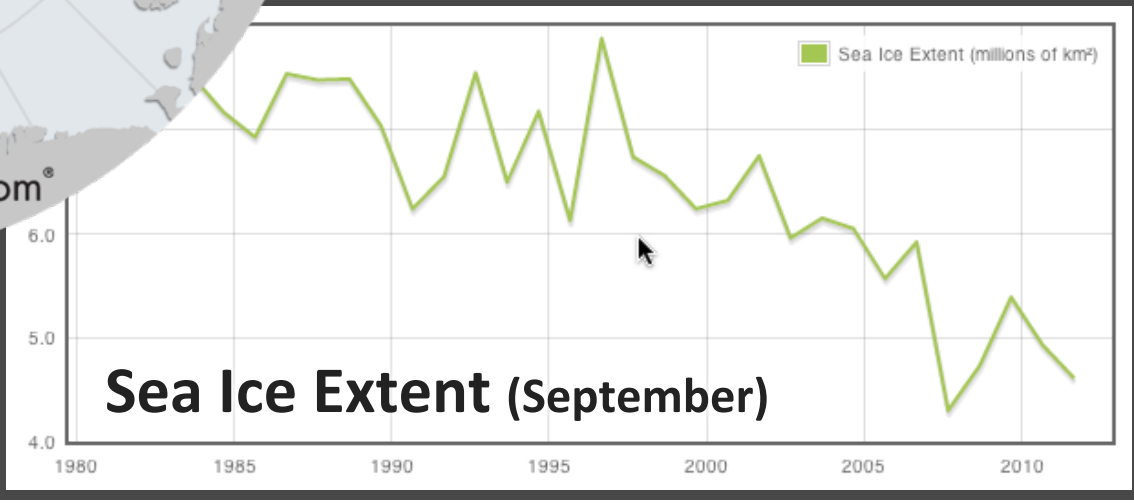
Ice Algae
Diatoms, a certain type of algae, are considered the most important primary producers inside the ice with more than 200 species occurring in Arctic sea ice. In addition, flagellates contribute substantially to biodiversity, but their species number is unknown.

The Arctic Seasonal Cycle



Warming Temperature & Arctic Sea Ice Retreat

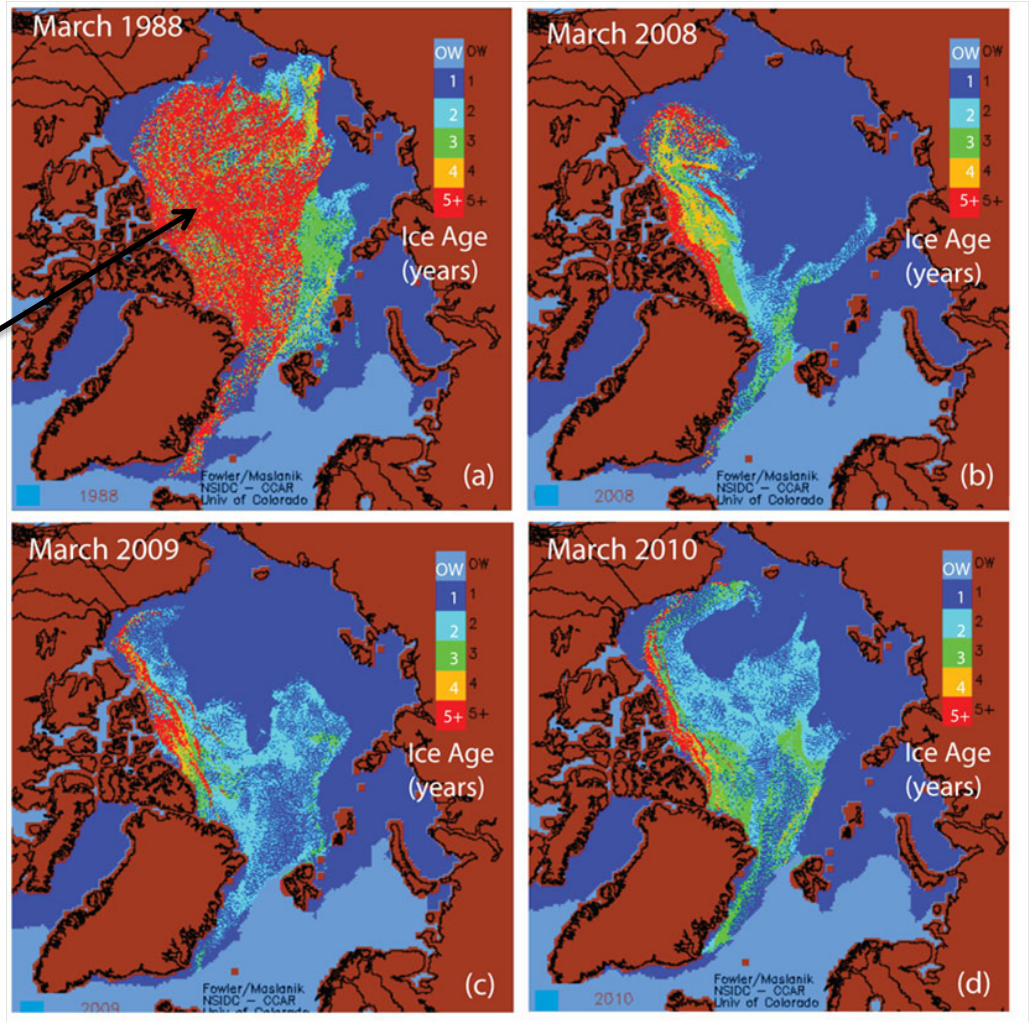




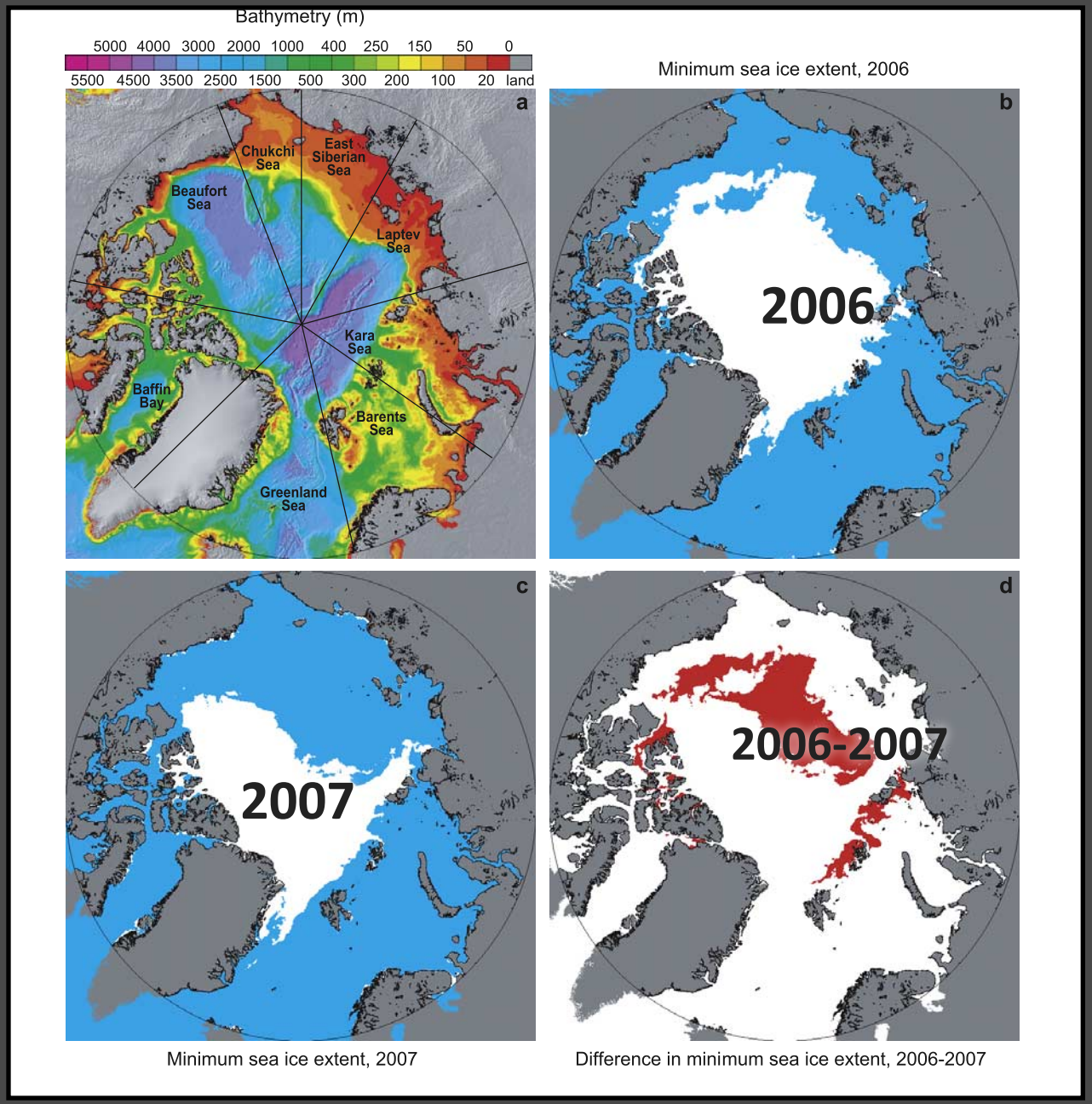
Old Arctic Sea Ice vanishing!

Blue: 1 year ice

Red: 5+ year ice



Arctic Sea Ice retreat

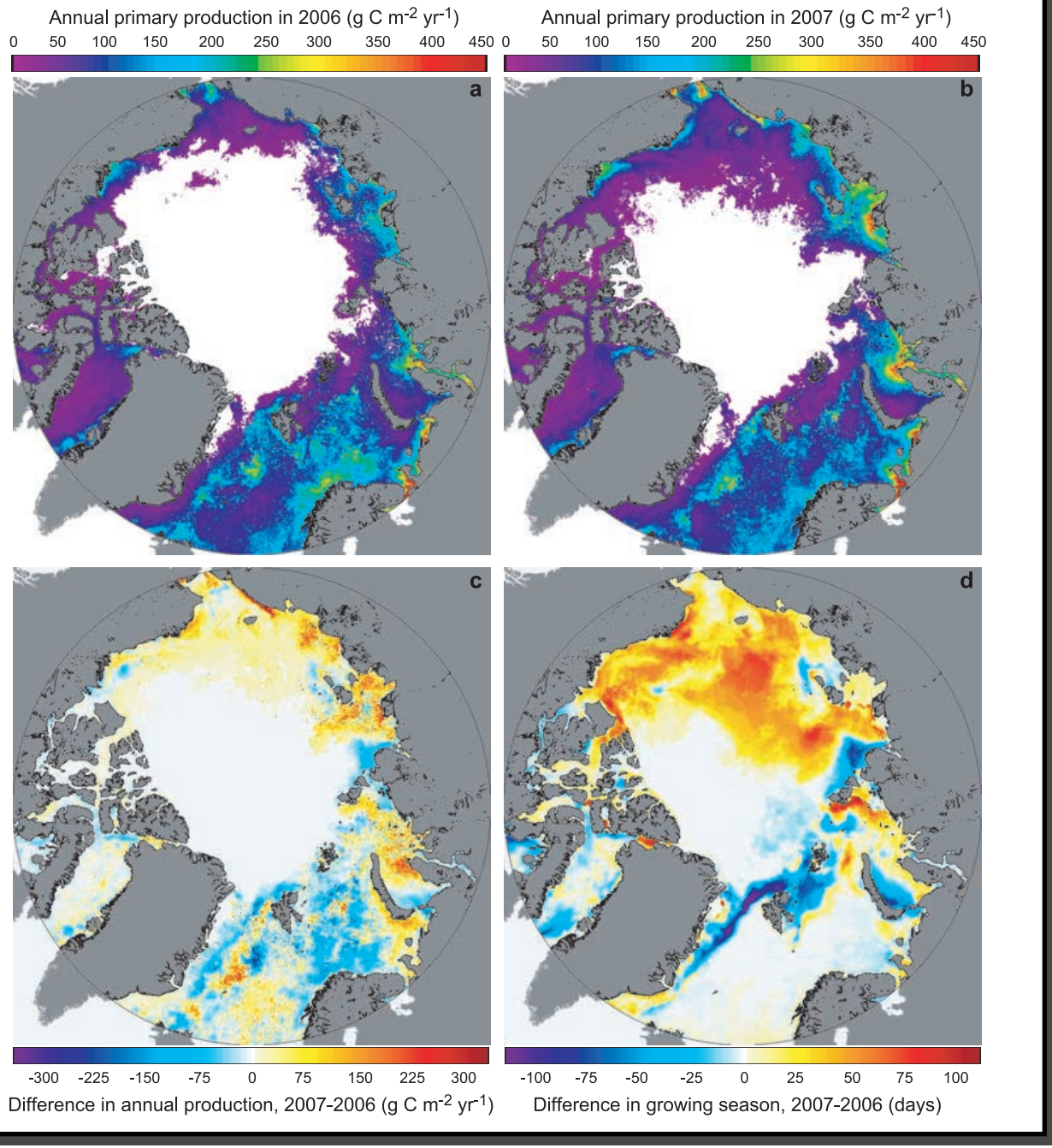


Arrigo et al. 2008

Impacts of Sea-Ice changes on Ecosystem Productivity

Primary Production 2006

Primary Production 2007



Difference Production

Difference Growing Season

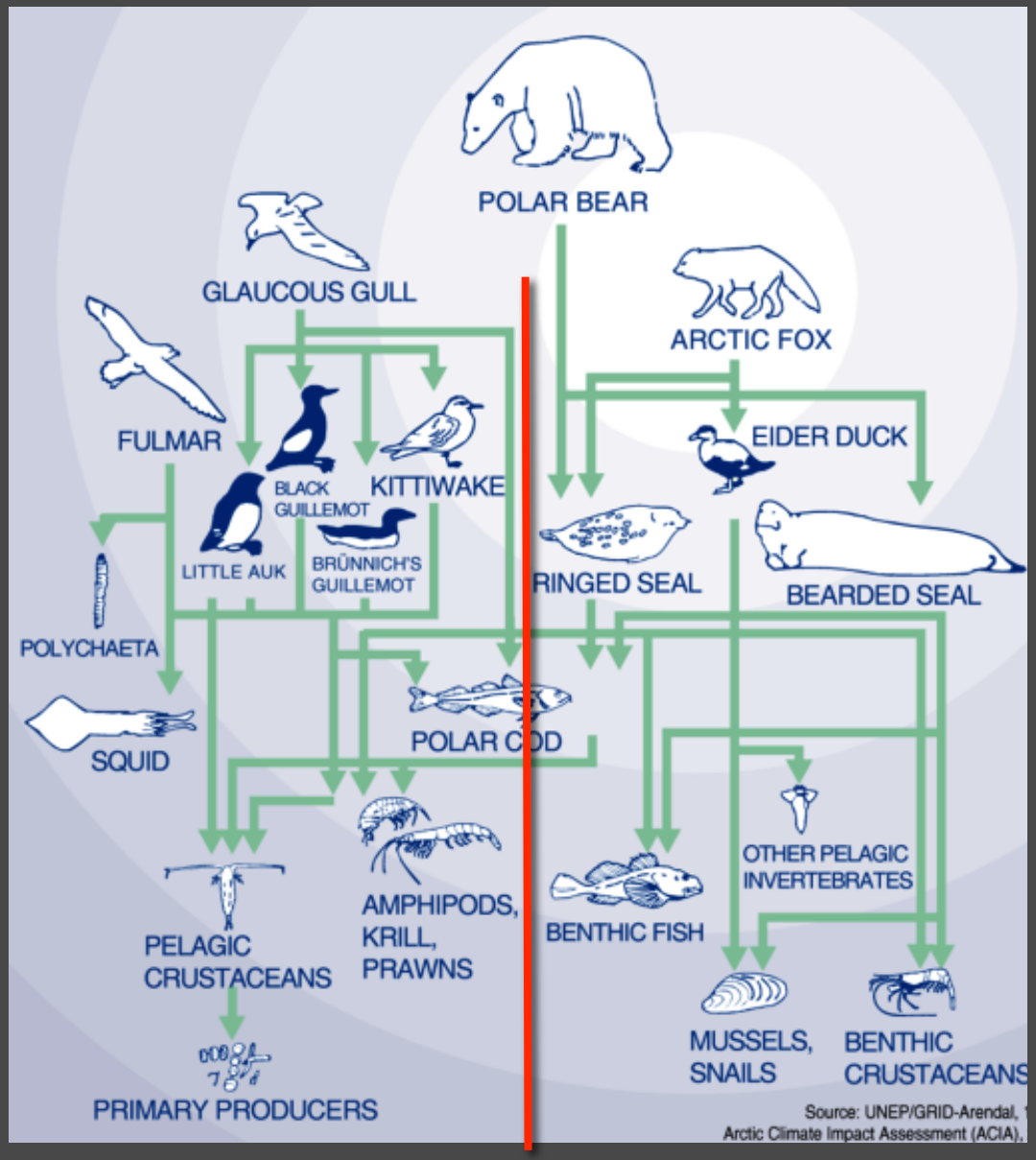
Arrigo et al. 2008

Changes in Arctic Food Web from Warming & reduced Fall Sea Ice

Enhanced open ocean primary productivity

↓

favor **Pelagic Subarctic System**

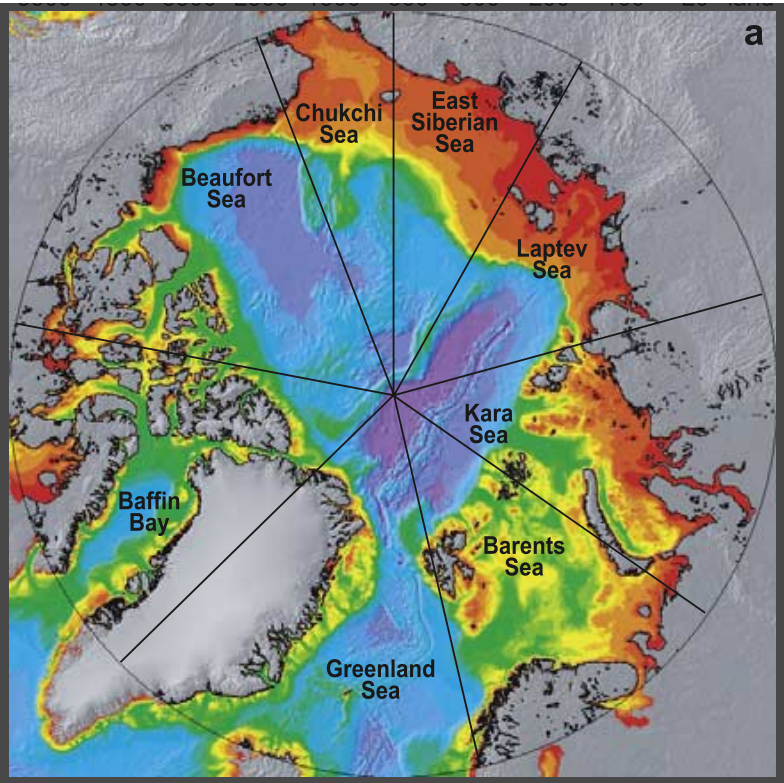


Loss of ice-algae from sea ice edge

↓

reduce **Benthic Arctic System**

Effects of Sea Ice changes on Plankton



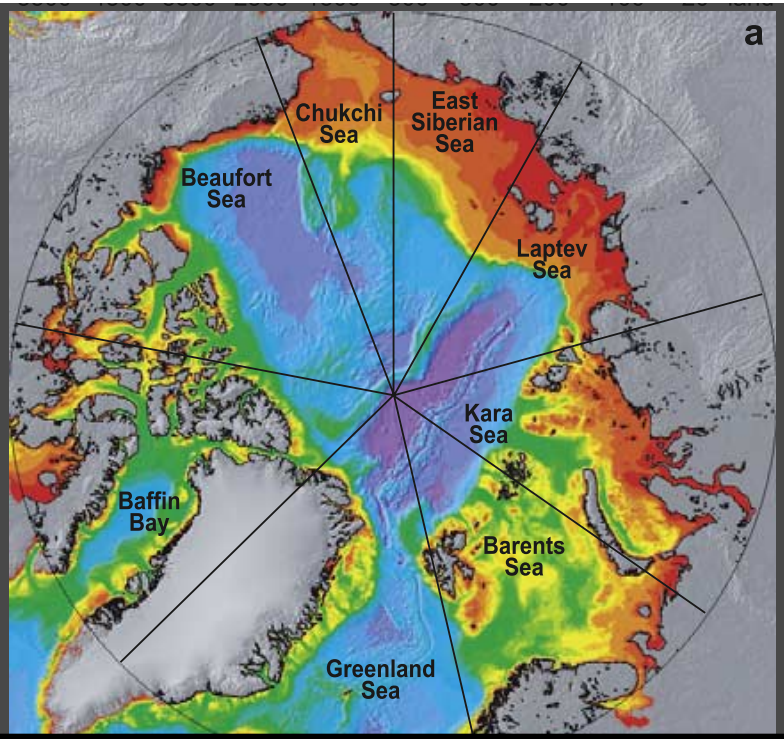
Wassmann et al. 2011

Table 1 Reports of changes in Arctic plankton in response to climate change showing the organism and region investigated, the period of observation, and the response observed

Subject	Region	Climatic driver	Footprint	References	Code
Primary production	Arctic Ocean	Ice changes	Increased annual primary production	Arrigo *et al.* (2008)	1
Phytoplankton biomass	Barents Sea	Ice changes	Increased phytoplankton biomass	Qu *et al.* (2006)	2
Primary production	Arctic Ocean	Ice changes	Increased primary production	Pabi *et al.* (2008)	3
Planktonic diatom	Labrador Sea	Altered circulation	Range shift of *Neodenticula seminae*	Reid *et al.* (2007)	4
Primary production	Beaufort Sea	Ice changes	Increased primary production	Mundy *et al.* (2009)	5
Amphipods	Kongsfjord, Svalbard	Altered circulation	Increasing proportion of *Themisto abyssorum* to *T. libellula*	Hop *et al.* (2006)	6
Zooplankton community	West Greenland	Warming	Changes in zooplankton abundance and composition	Pedersen & Rice (2002)	7
Copepods	Kongsfjord, Svalbard	Altered circulation	Increasing contribution of smaller copepods	Hop *et al.* (2006)	8
Jellyfish	Bering Sea	Warming	Increase in jellyfish biomass	Brodeur *et al.* (1999)	9

The code number identifies the corresponding symbol in Fig. 3

Effects of Warming on Fish



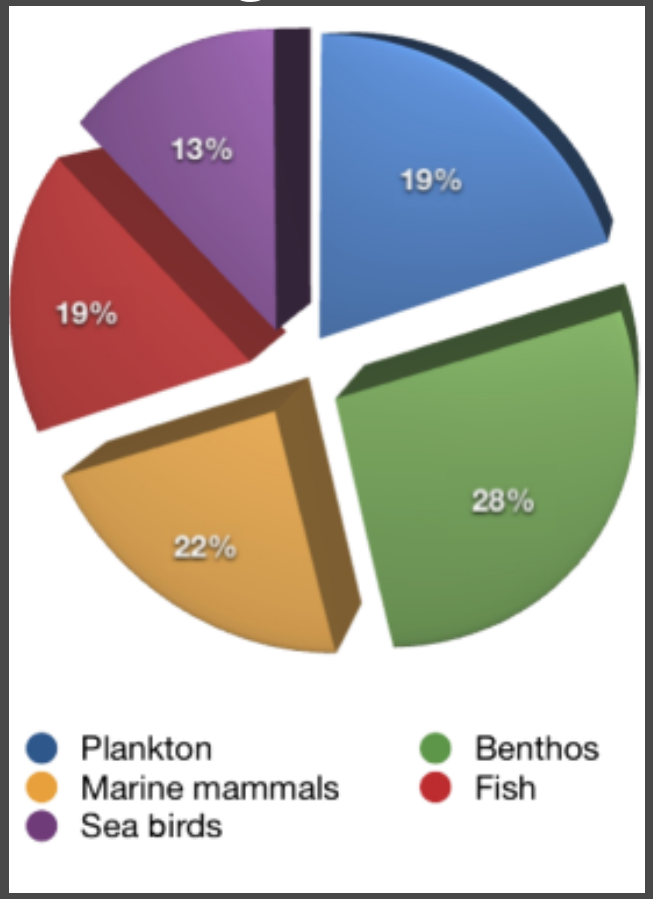
Wassmann et al. 2011

Table 3 Reports of changes in Arctic fish in response to climate change showing the organism and region investigated, the period of observation, and the response observed

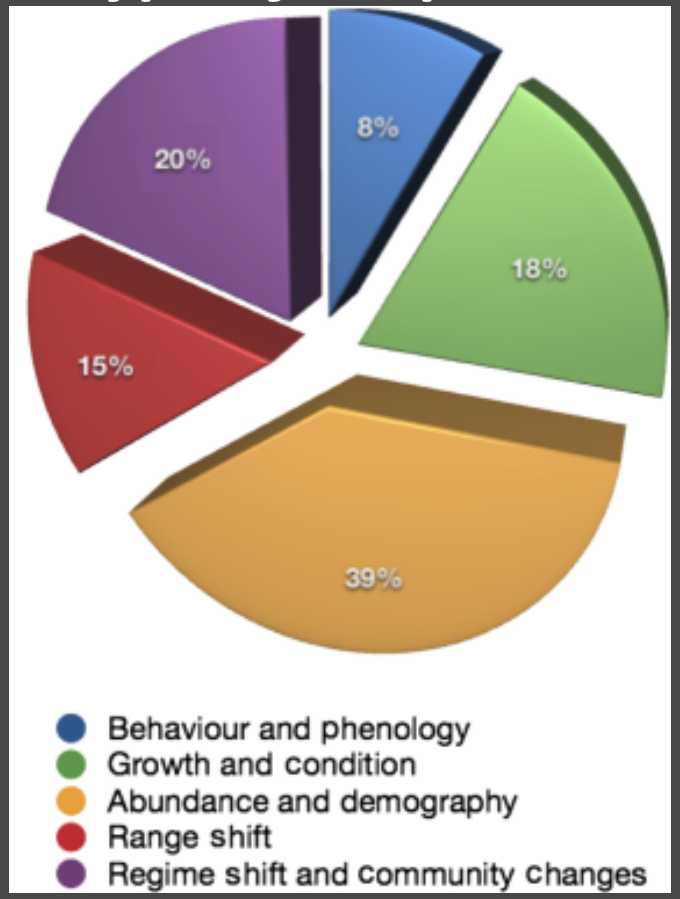
Subject	Region	Climatic driver	Footprint	References	Code
Cod	Barents Sea	Warming	Increased cod recruitment and length	Overland *et al*. (2004)	24
Cod and Shrimp	West Greenland	Warming	Replacement of cod by shrimp	Hamilton *et al*. (2003)	25
Greenland Turbot	Bering Sea	Warming and ice changes	Increased spawning biomass	Overland & Stabeno (2004)	26
Pacific Cod	Bering Sea	Warming and reduced sea ice	Reduced spawning biomass	Overland & Stabeno (2004)	27
Cod	North Atlantic	Warming	Northward spread and increased spawning stock biomass and recruitment	Drinkwater (2009)	28
Cod	Barents Sea	NAO/temperature	Positive relation between cod recruitment and temperature	Ottersen & Stenseth (2001)	29
Snake Pipefish	W Svalbard	Warming	Northward range shift	Fleischer *et al*. (2007)	30
Walleye Pollock	Chukchi and Bering Seas	Warming	Northward range shift	Mecklenburg *et al*. (2007)	31
Walleye Pollock	Bering Sea	Warming and ice changes	Increased biomass	Overland & Stabeno (2004)	32

Documented changes on
Arctic Ecosystem & Food Web

Organisms



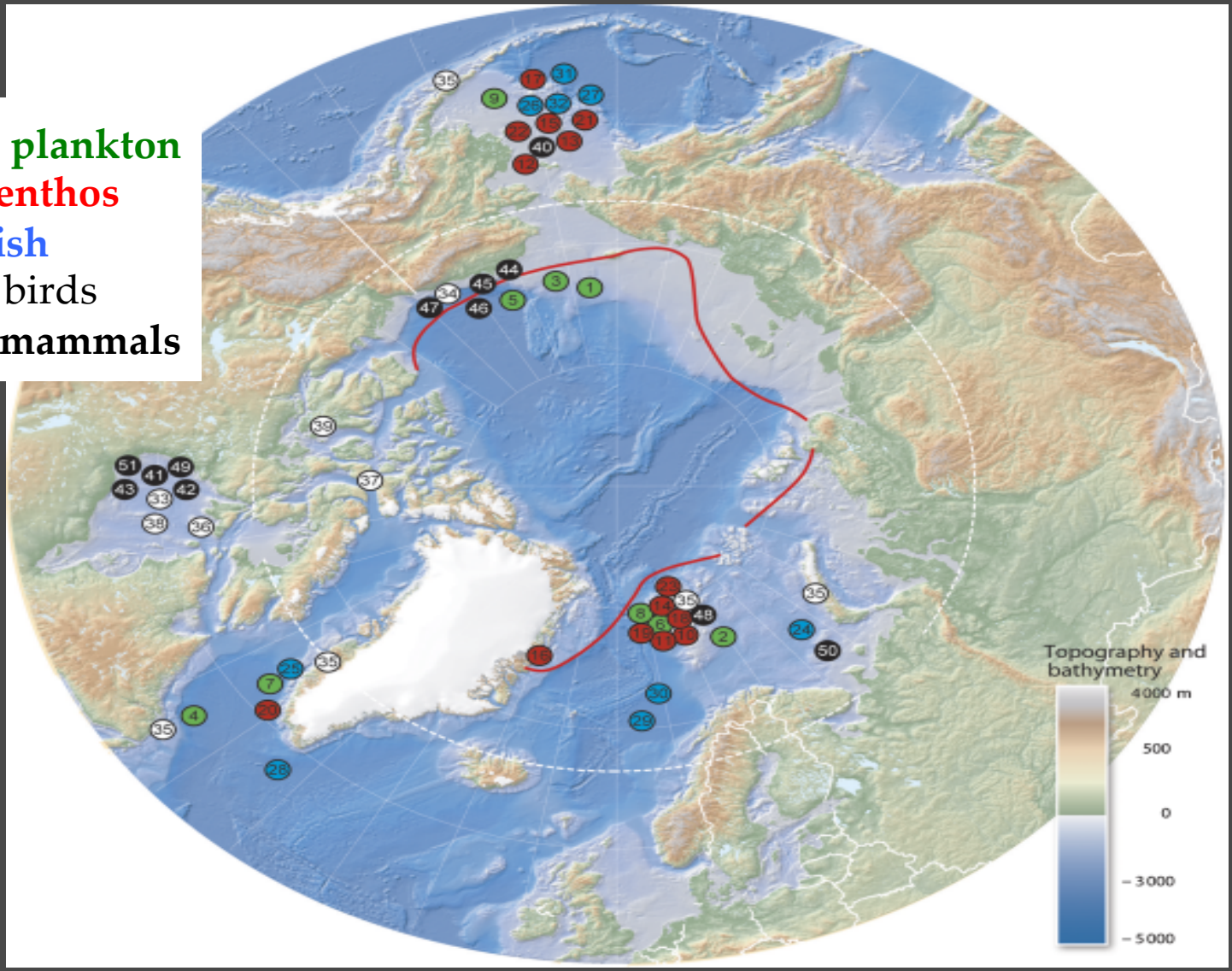
Type of Response



Wassmann et al. 2011

Documented changes on
Arctic Ecosystem & Food Web

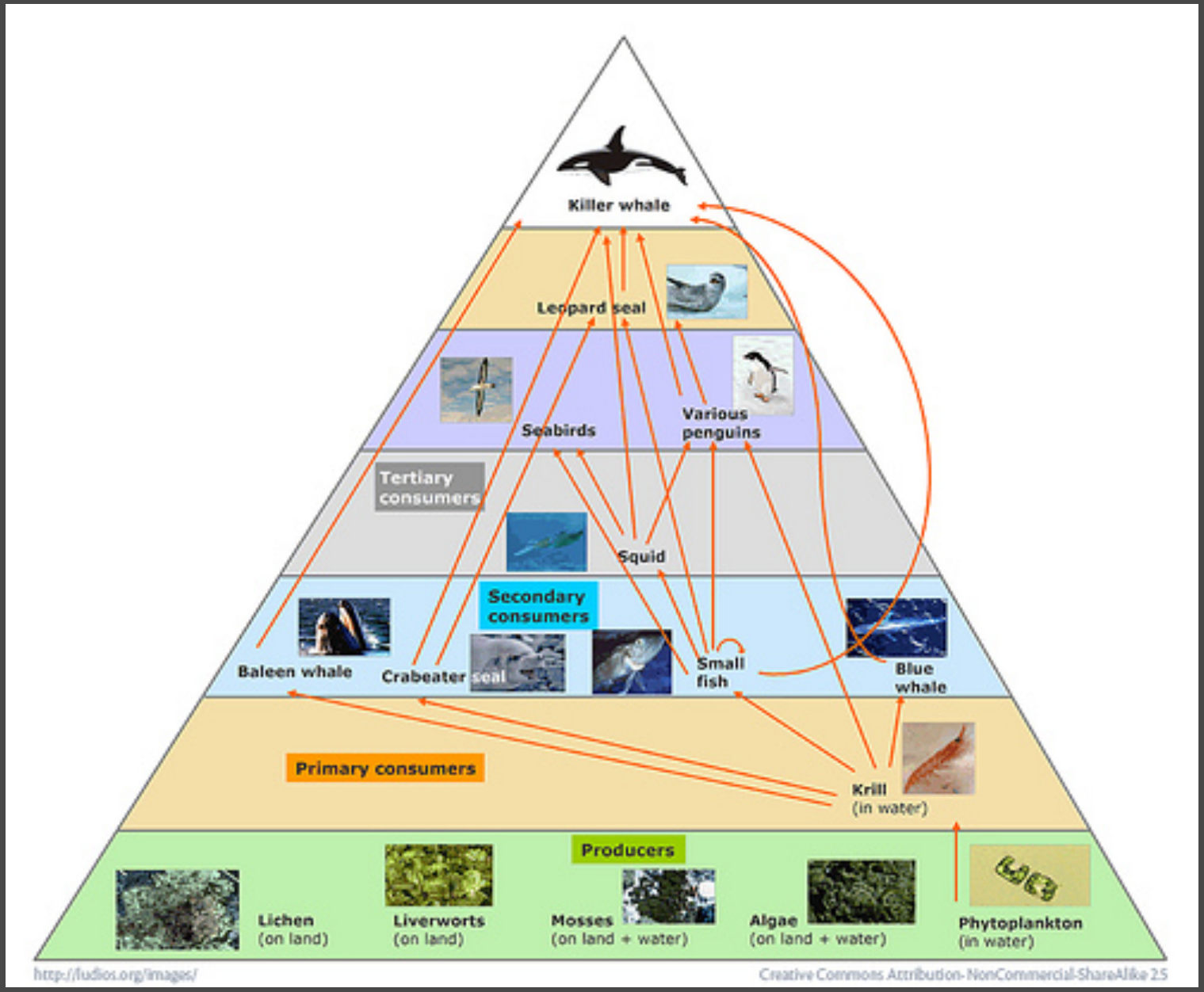
Green: plankton
Red: benthos
Blue: fish
White: birds
Black: mammals



Wassmann et al. 2011

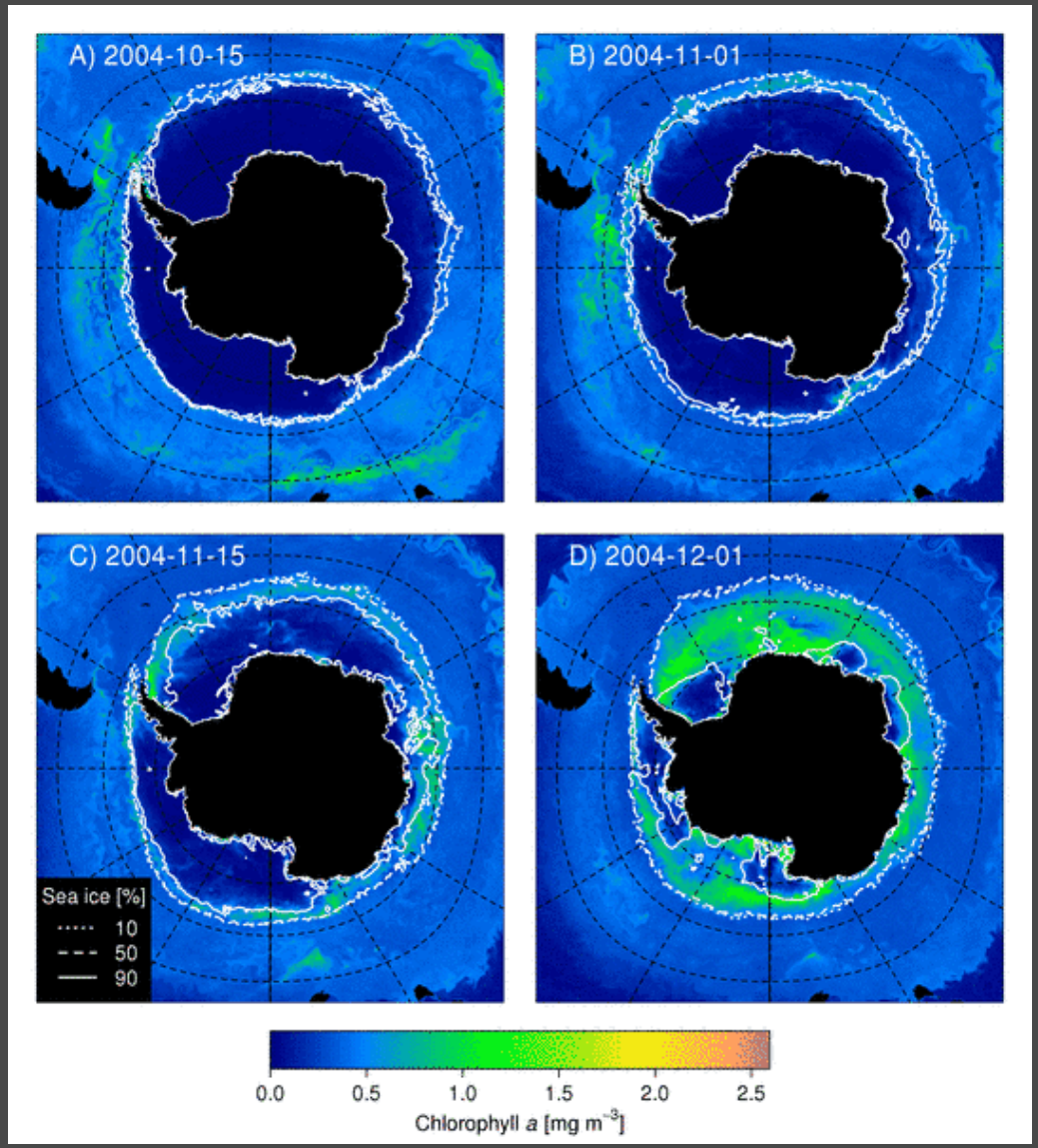
The Antarctic

Antarctic Ecosystem & Food Web



Antarctic Sea Ice and Productivity

Seasonal Ice retreat (**white contours**) and development of Phytoplankton Blooms (**color**)

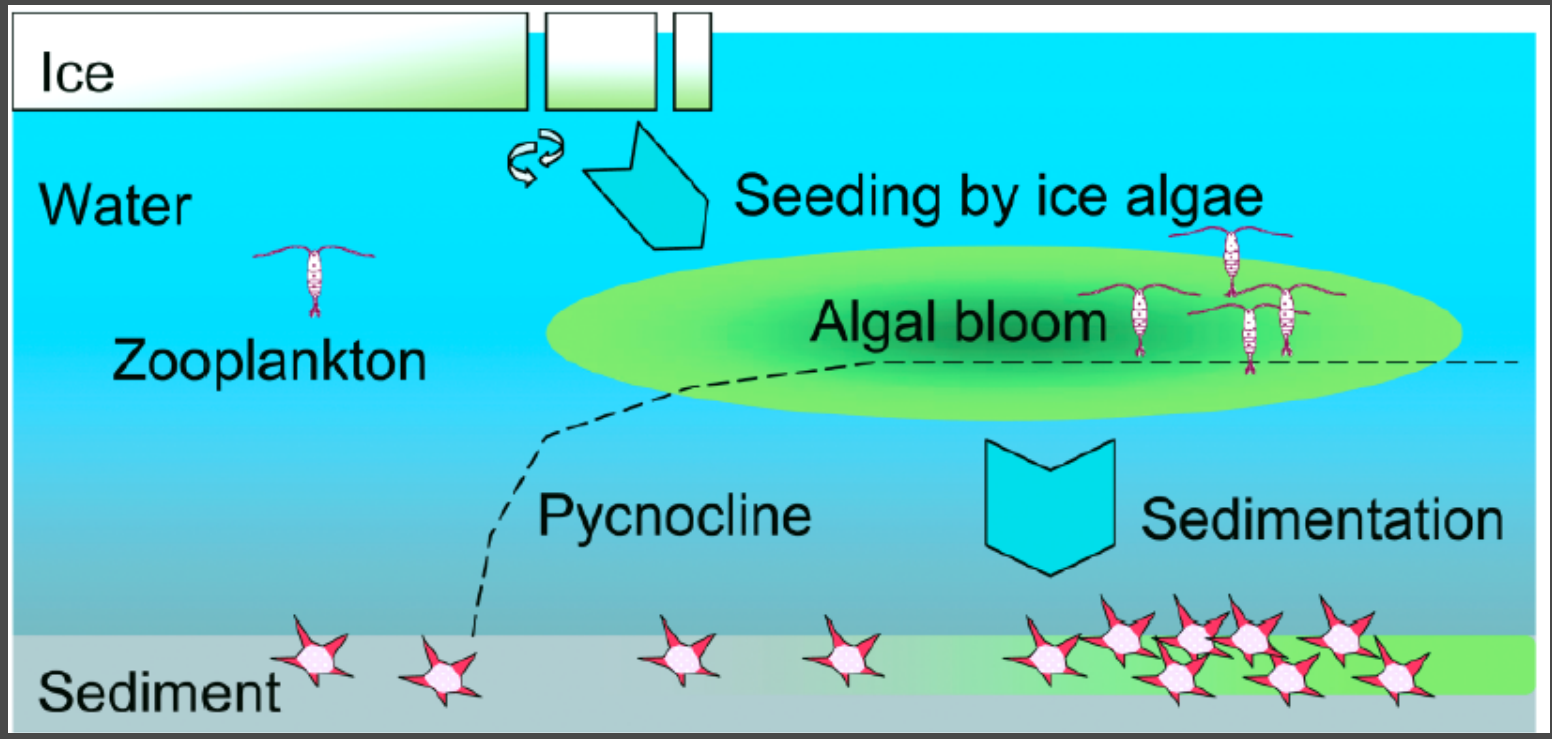


Antarctic Sea Ice and Productivity

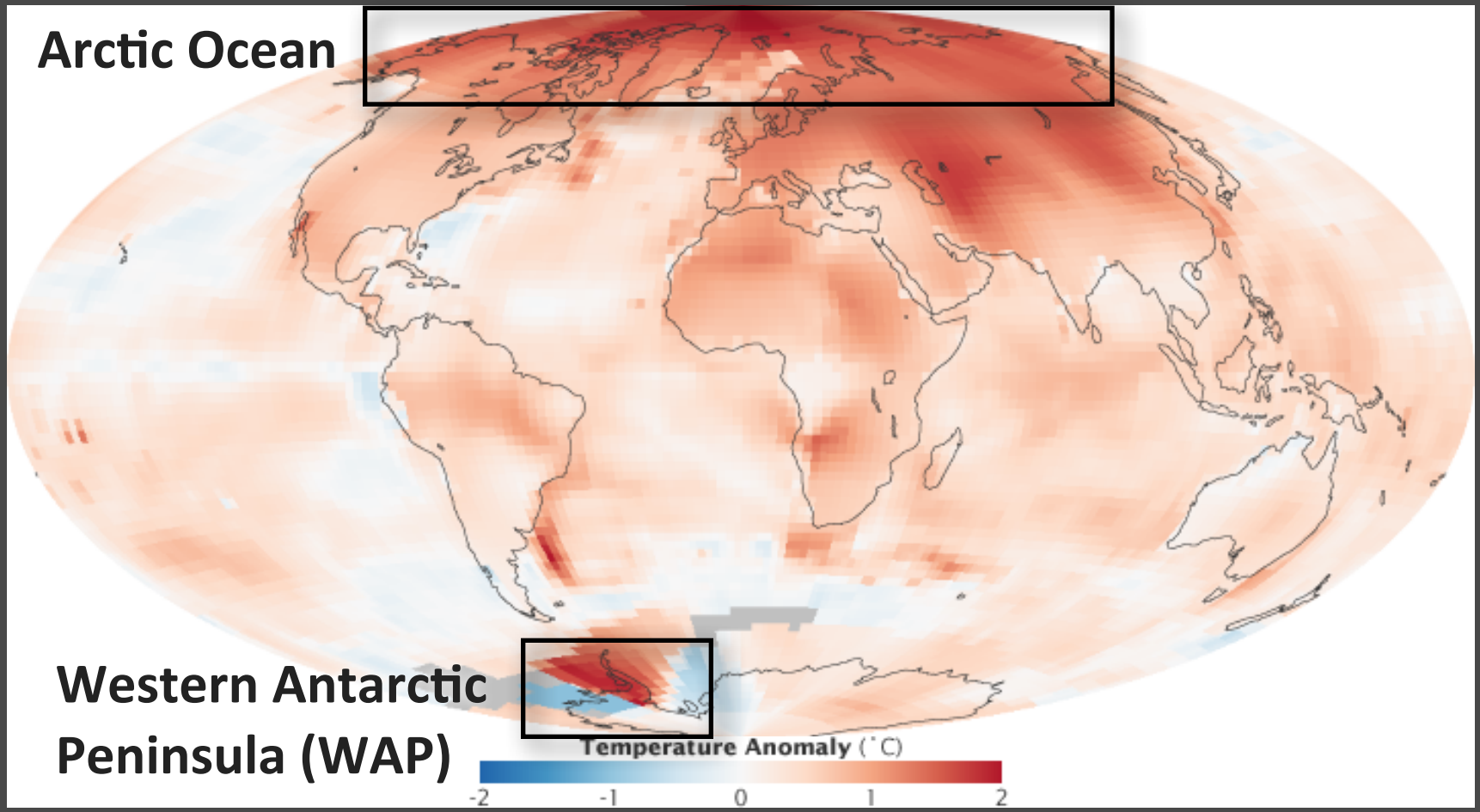
Blooms are favored by:

1) shallow and stable pycnocline from melting ice (fresh water)

2) higher light environment and high nutrient conditions

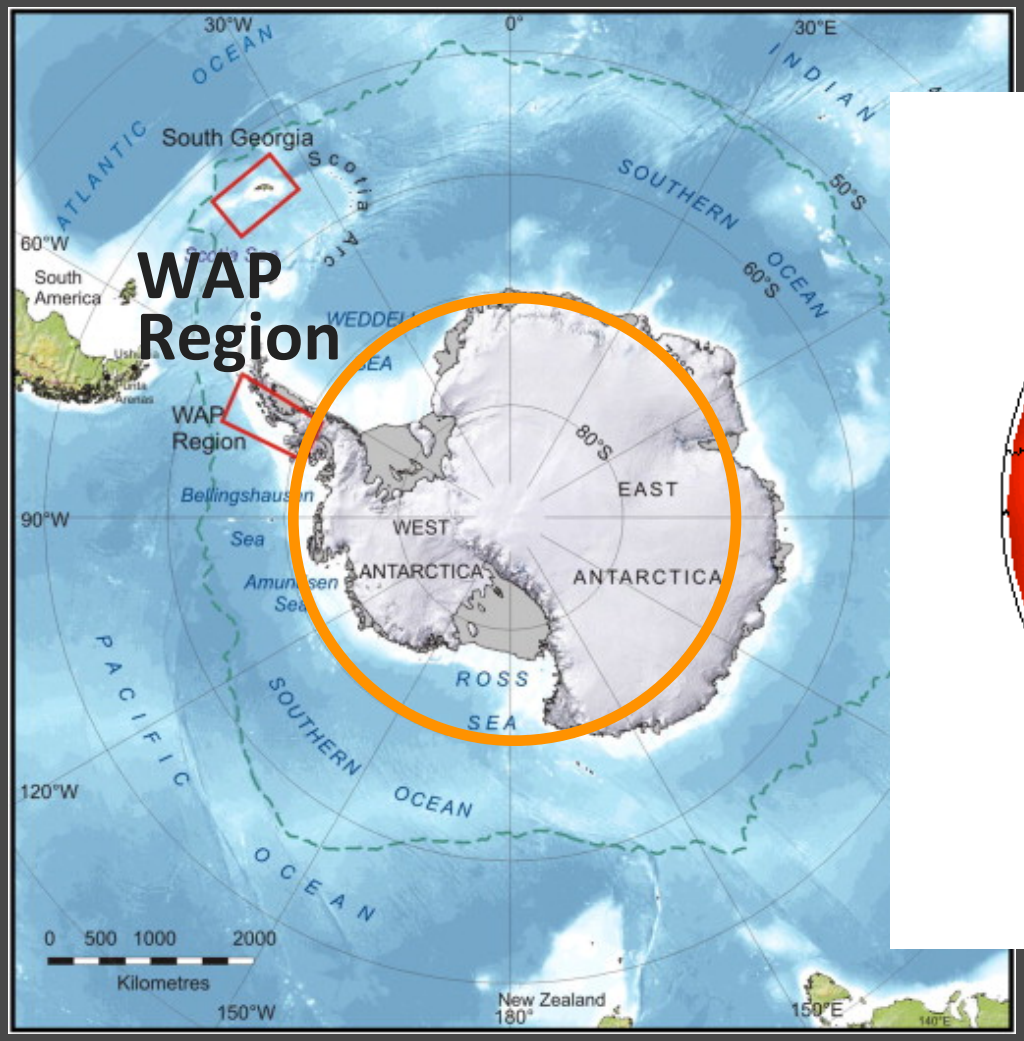


Changes in Polar Ecosystem

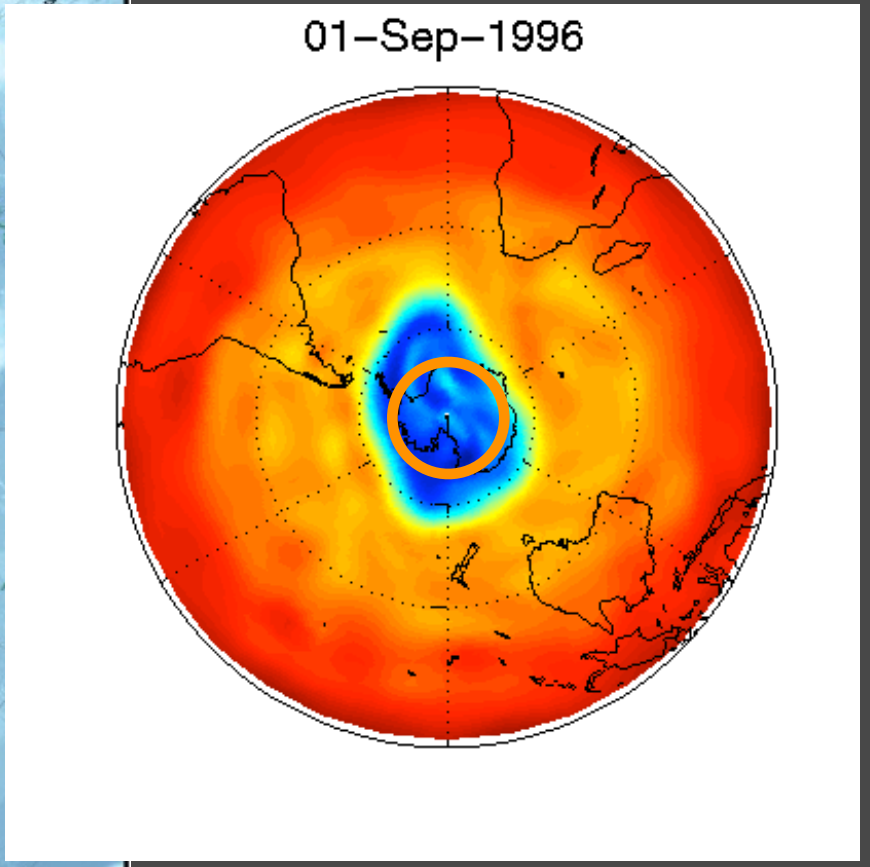


Why does WAP exhibits strong changes?

The Antarctic polar vortex

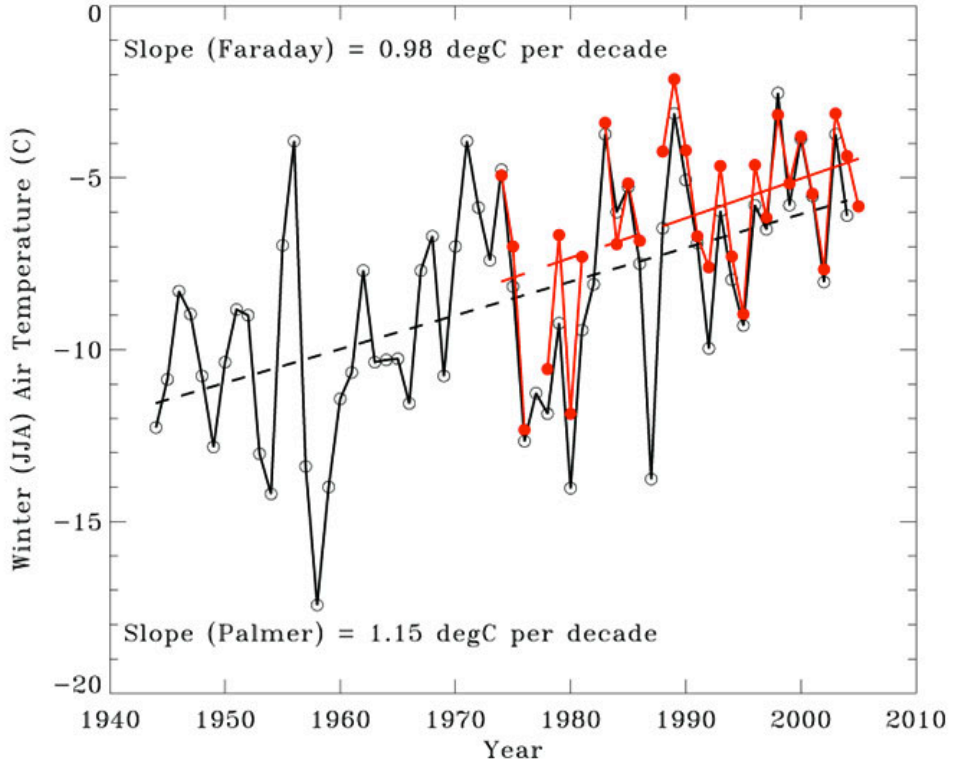


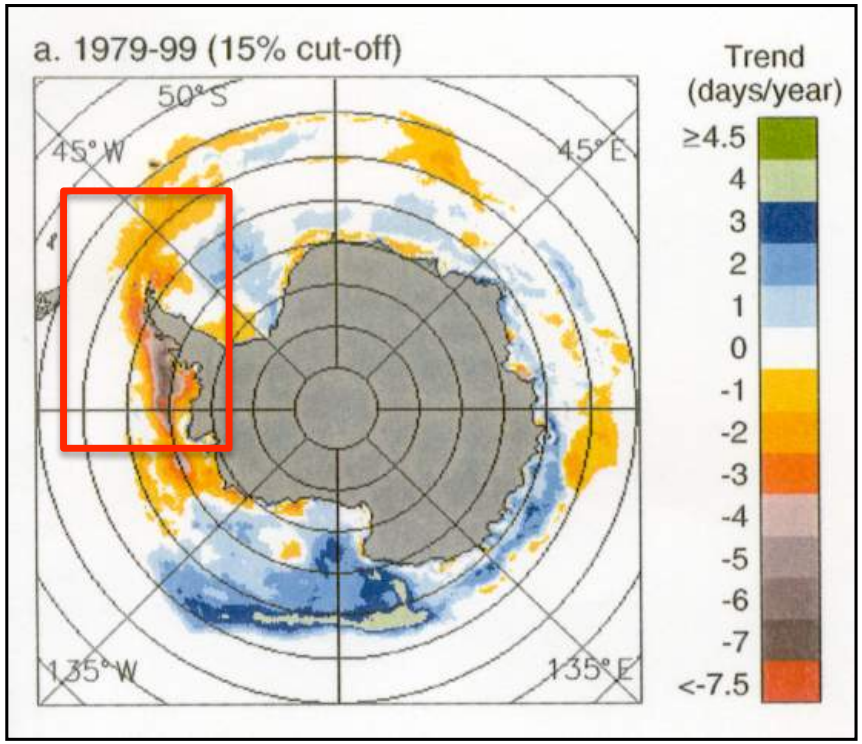
Polar vortex animation



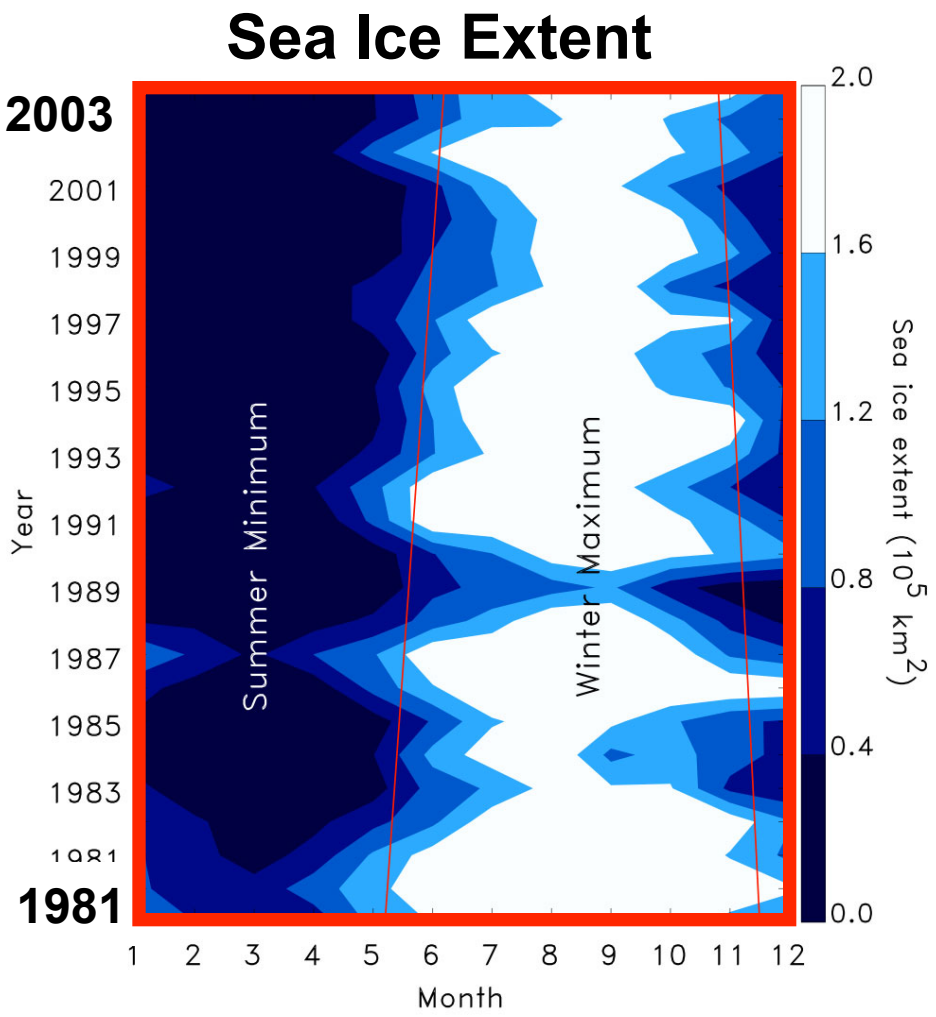
Polar Vortex is intensifying inducing loss of seasonal sea-ice and land ice in the Western Antarctica Peninsula

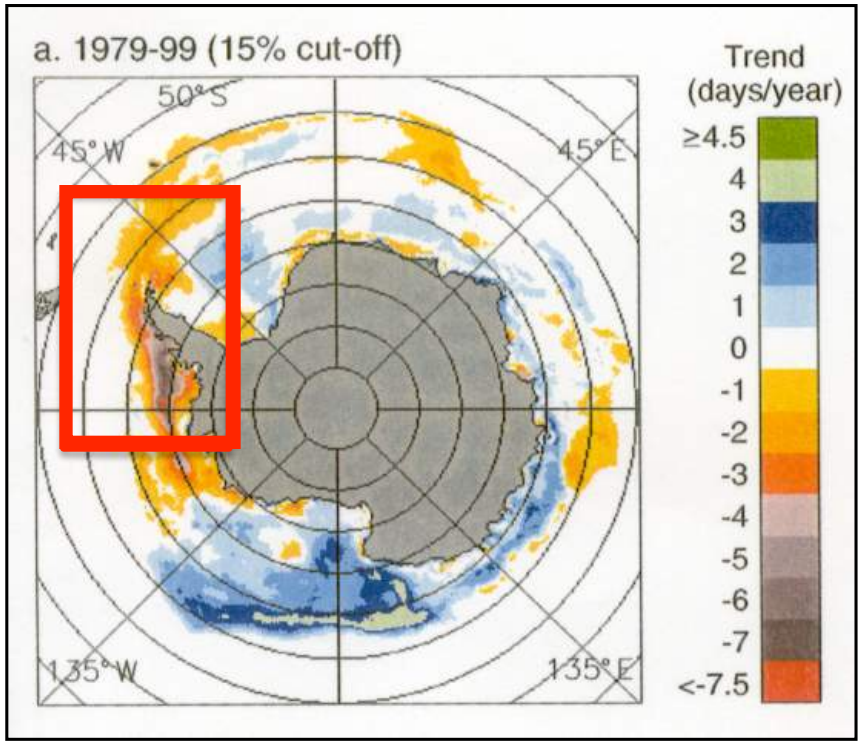
Antarctic Warming & Sea-Ice Retreat





Antarctic Warming & Sea-Ice Retreat

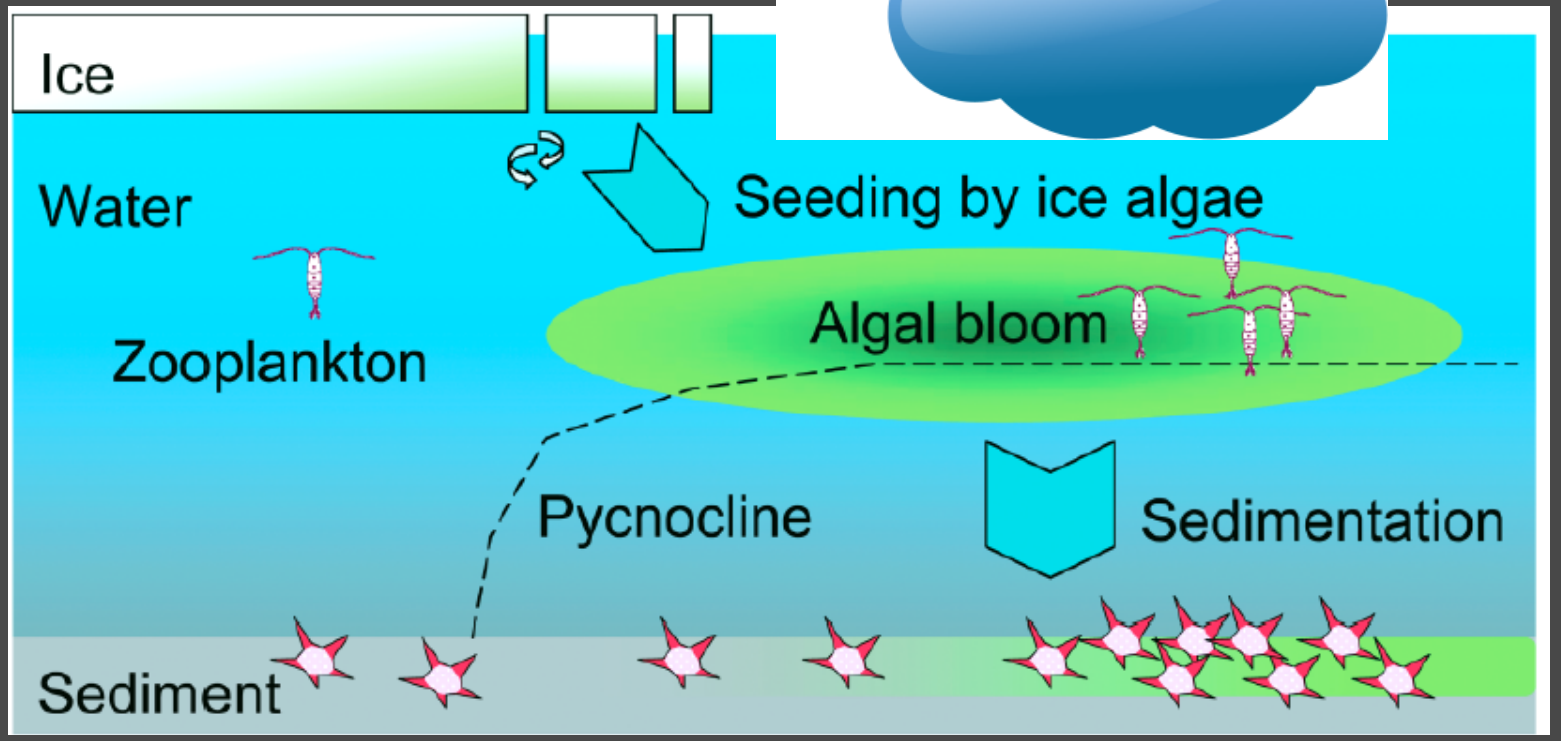




Antarctic Sea Ice and Productivity

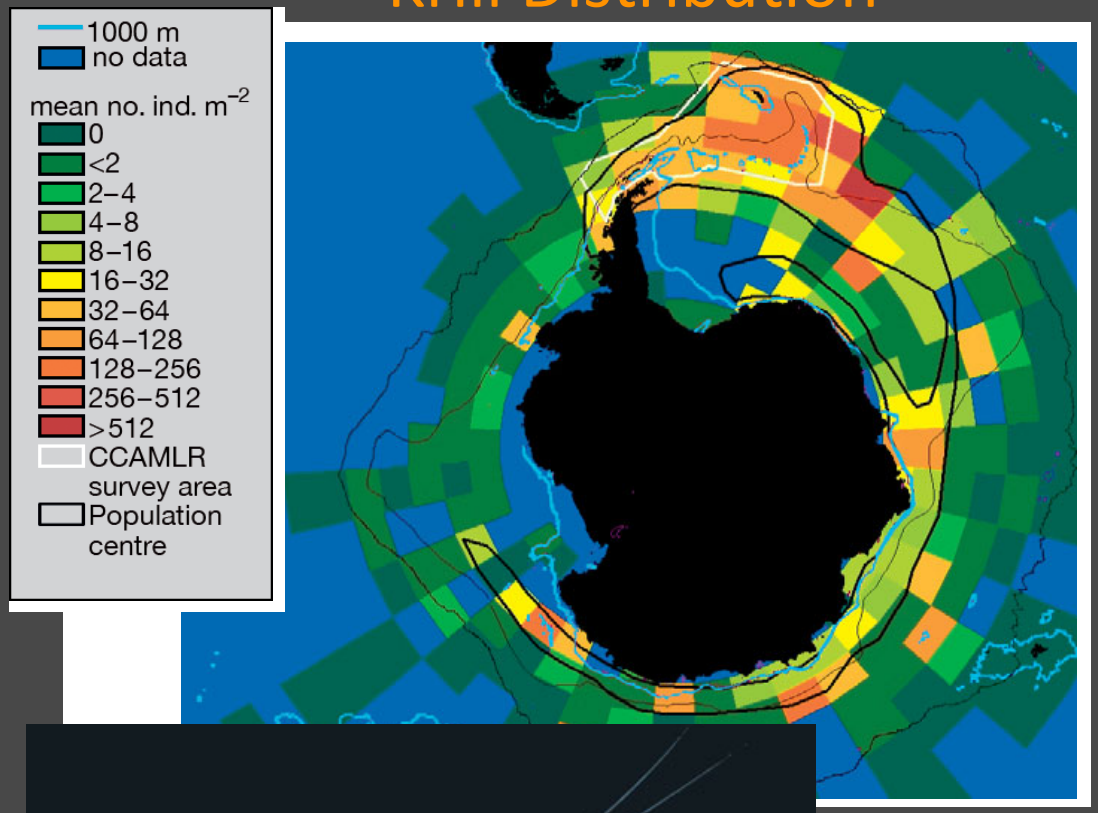
Blooms reduced by 12% due to:

- Deeper mix layer forced by stronger winds
- Reduction in marginal ice
- More cloud cover less light



Antarctic Warming & Sea-Ice Retreat

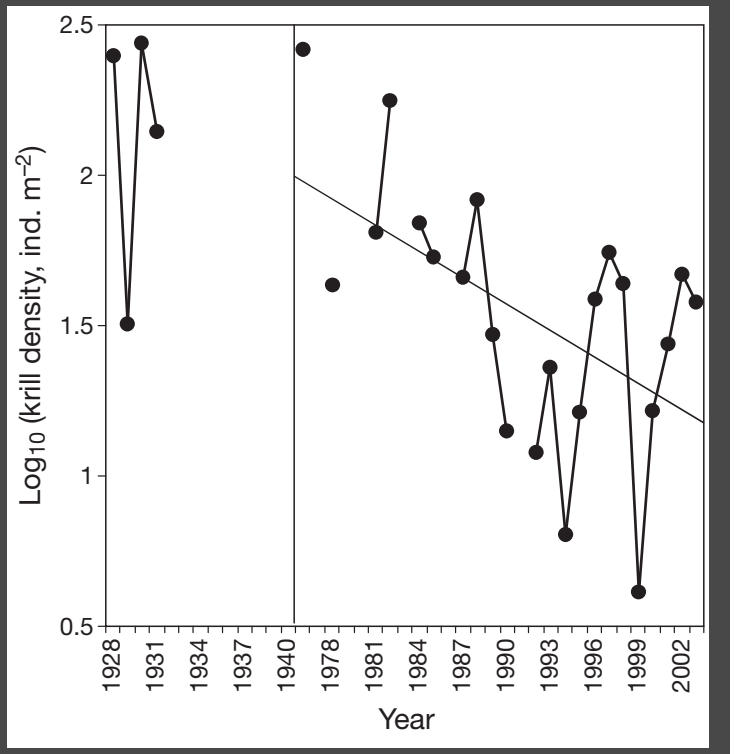
Krill Distribution



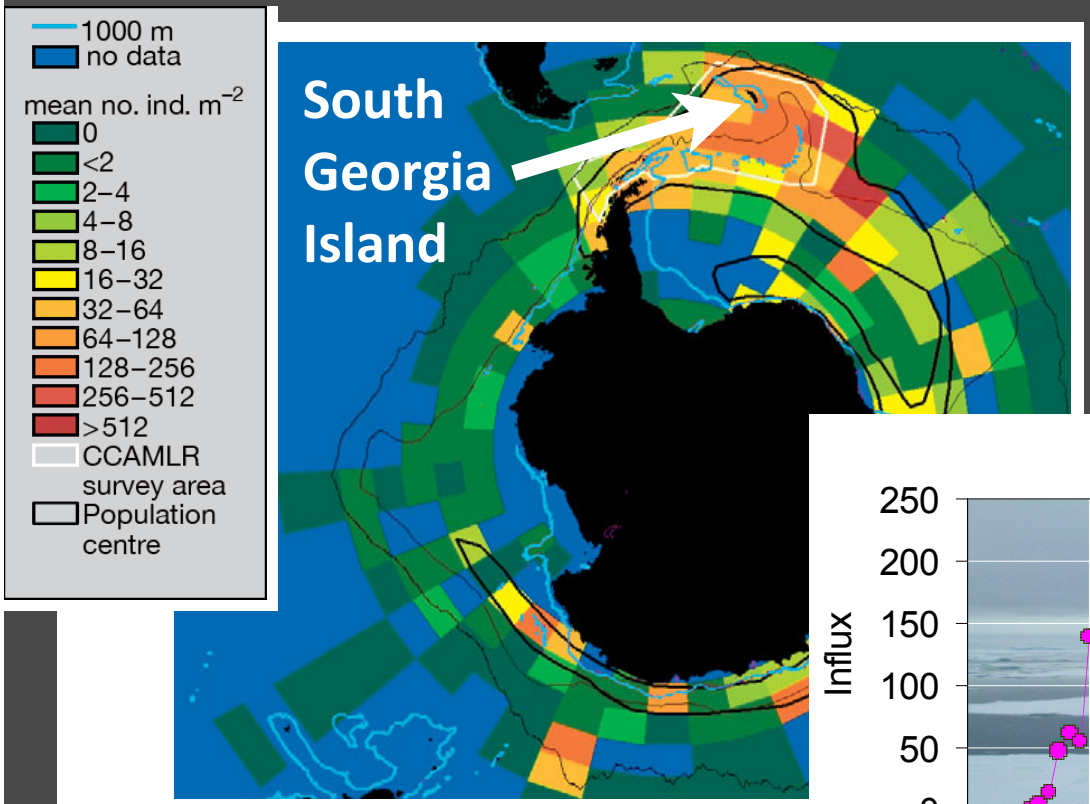
Impacts on Krill

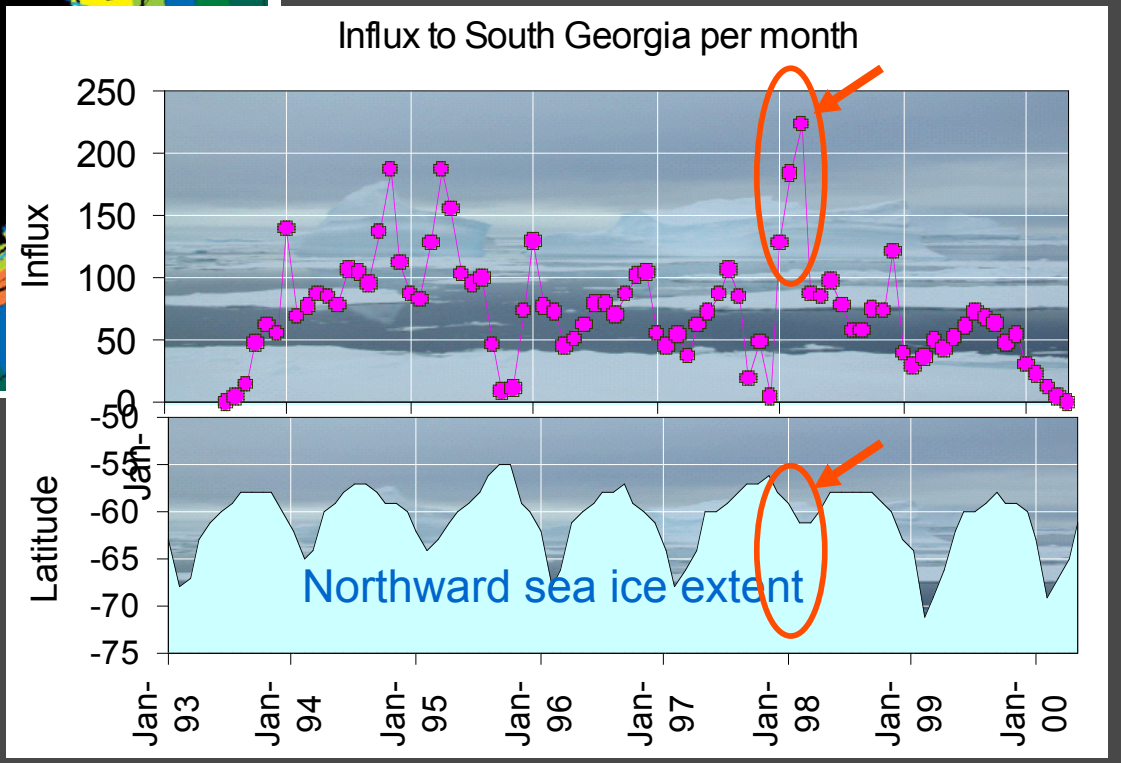
Decreasing winter ice in the major spawning and nursery areas affects krill density

Krill Decline

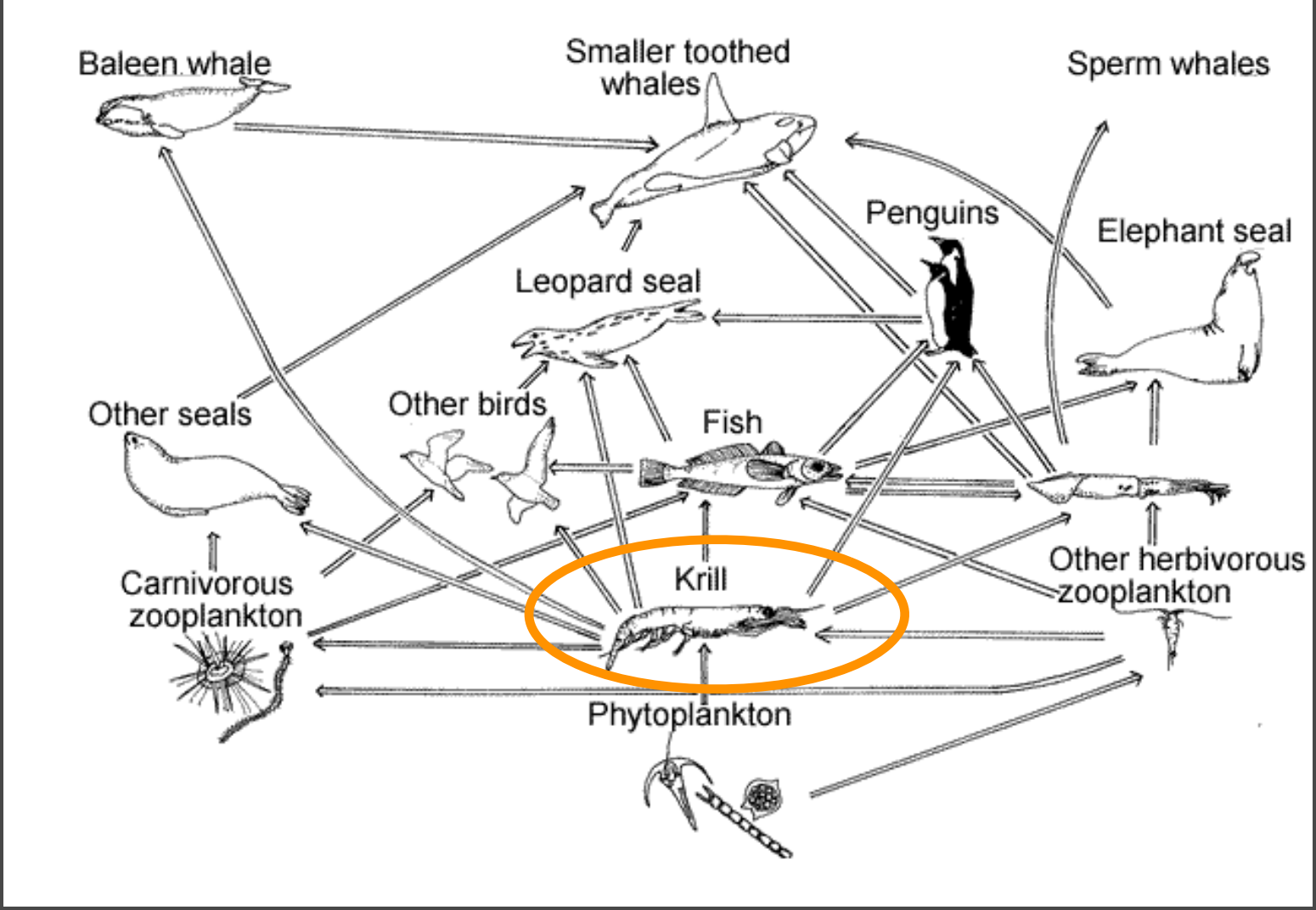


Changes in Sea-Ice impact Transport and Connectivity of Krill



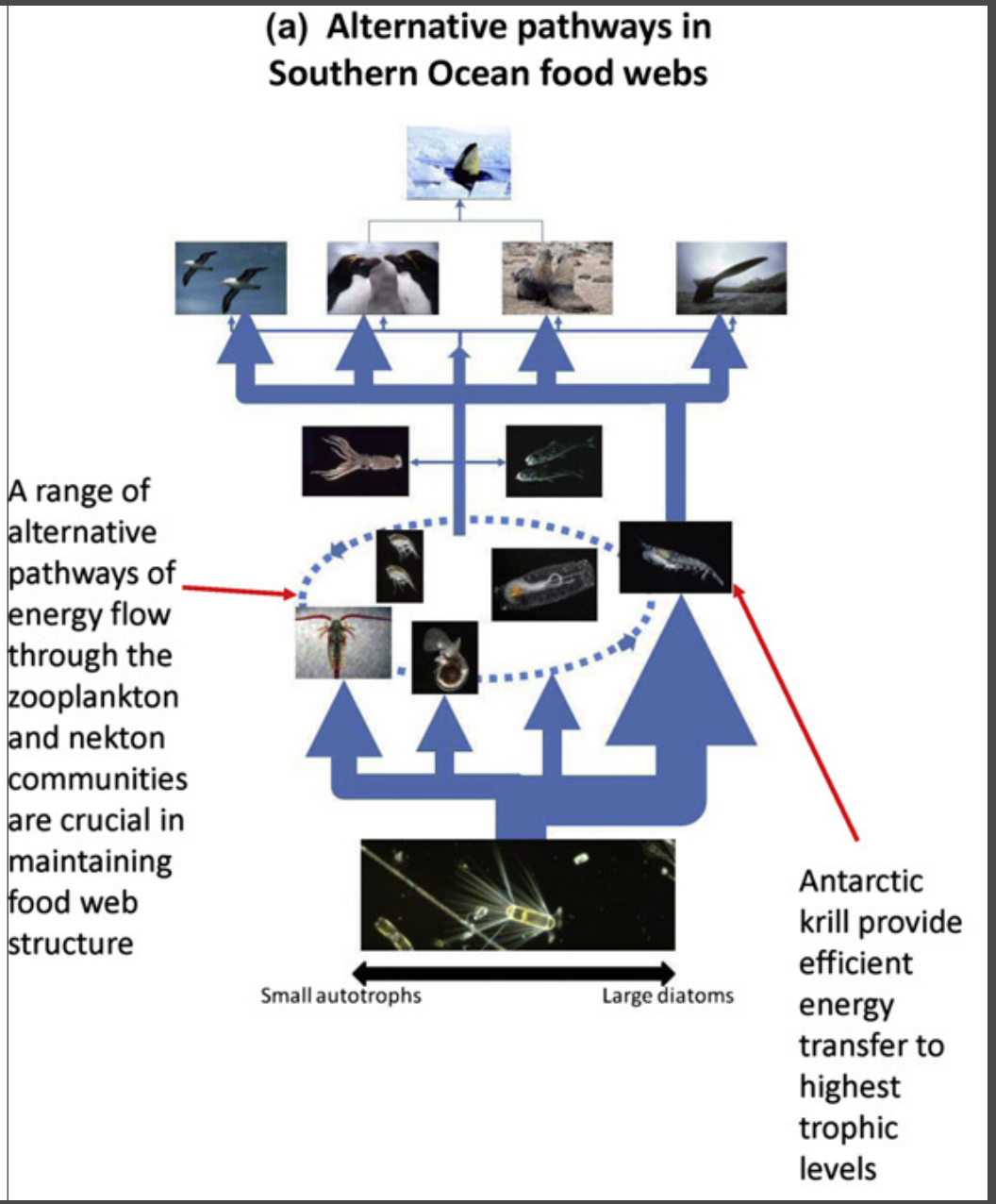


Antarctic Krill and Food Web



Krill is the base of the Antarctic Food Web

Shifts in Antarctic Food Web

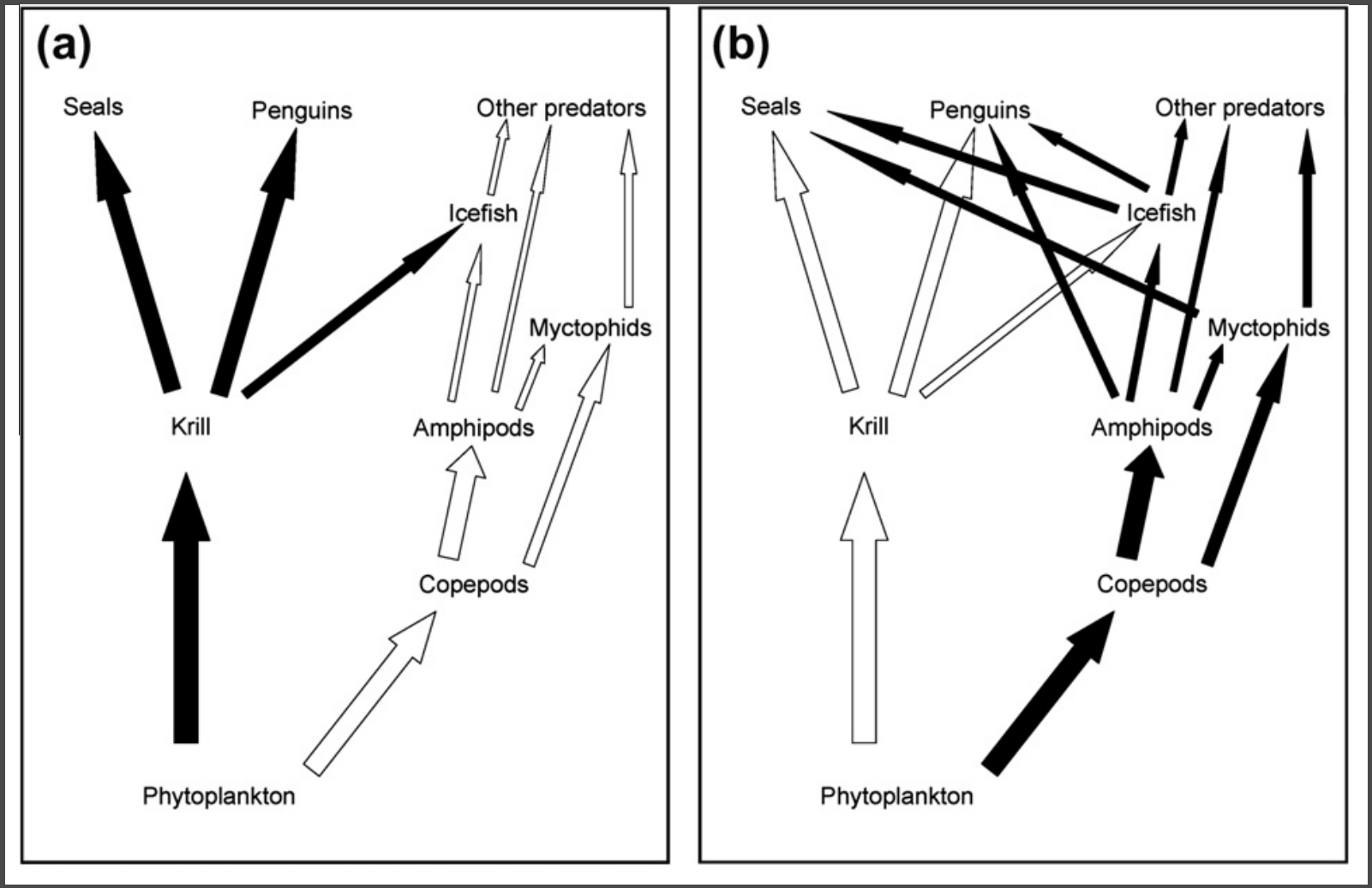


Murphy et al. 2012

Shifts in Antarctic Food Web

Krill Dominated

Zooplankton Dominated



Murphy et al. 2012

Shifts in Antarctic Food Web

Krill Dominated

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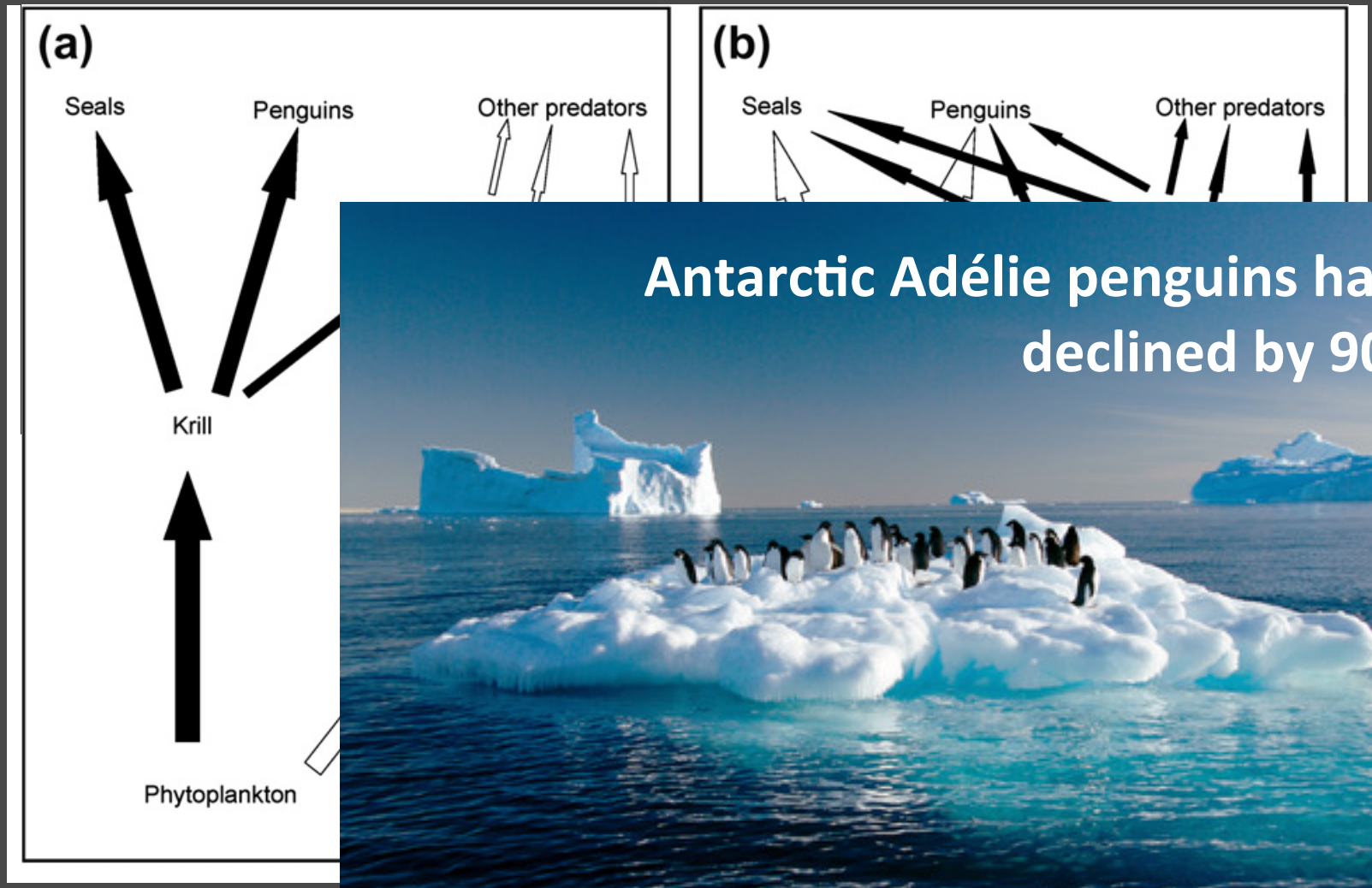
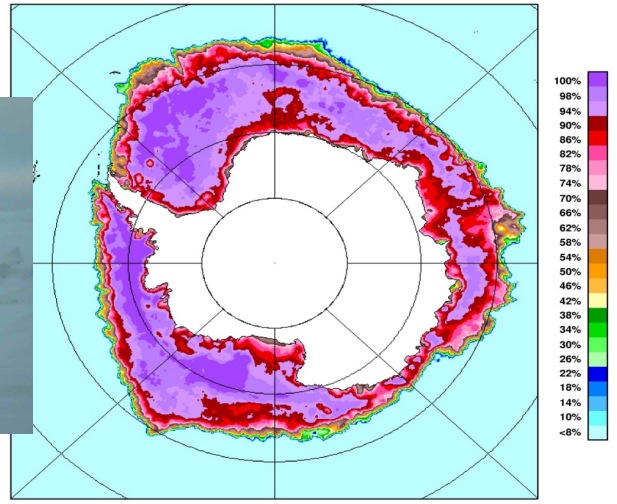


Antarctic Penguins changing

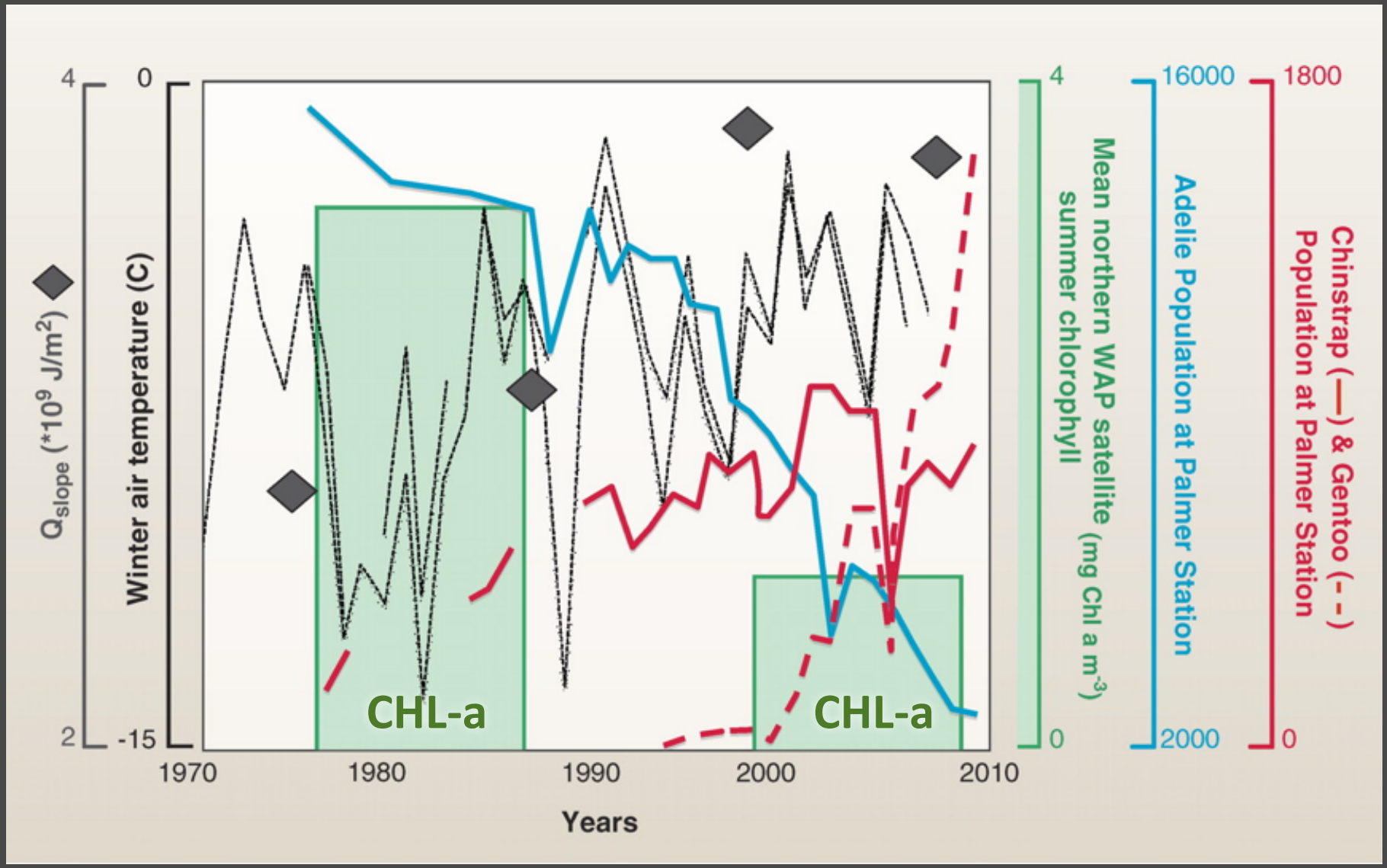
Adélie

Chinstrap and Gentoo



Maximum extent of sea ice 2001

Antarctic Ecosystem Summary



Schofield et al. 2010

End of Class