Climate Change in the World's Oceans
Washington, D.C.
4-8 June, 2018

BELMONT FORUM

Some possible climate change impacts in the NE Atlantic transition zone between the Subarctic and Arctic

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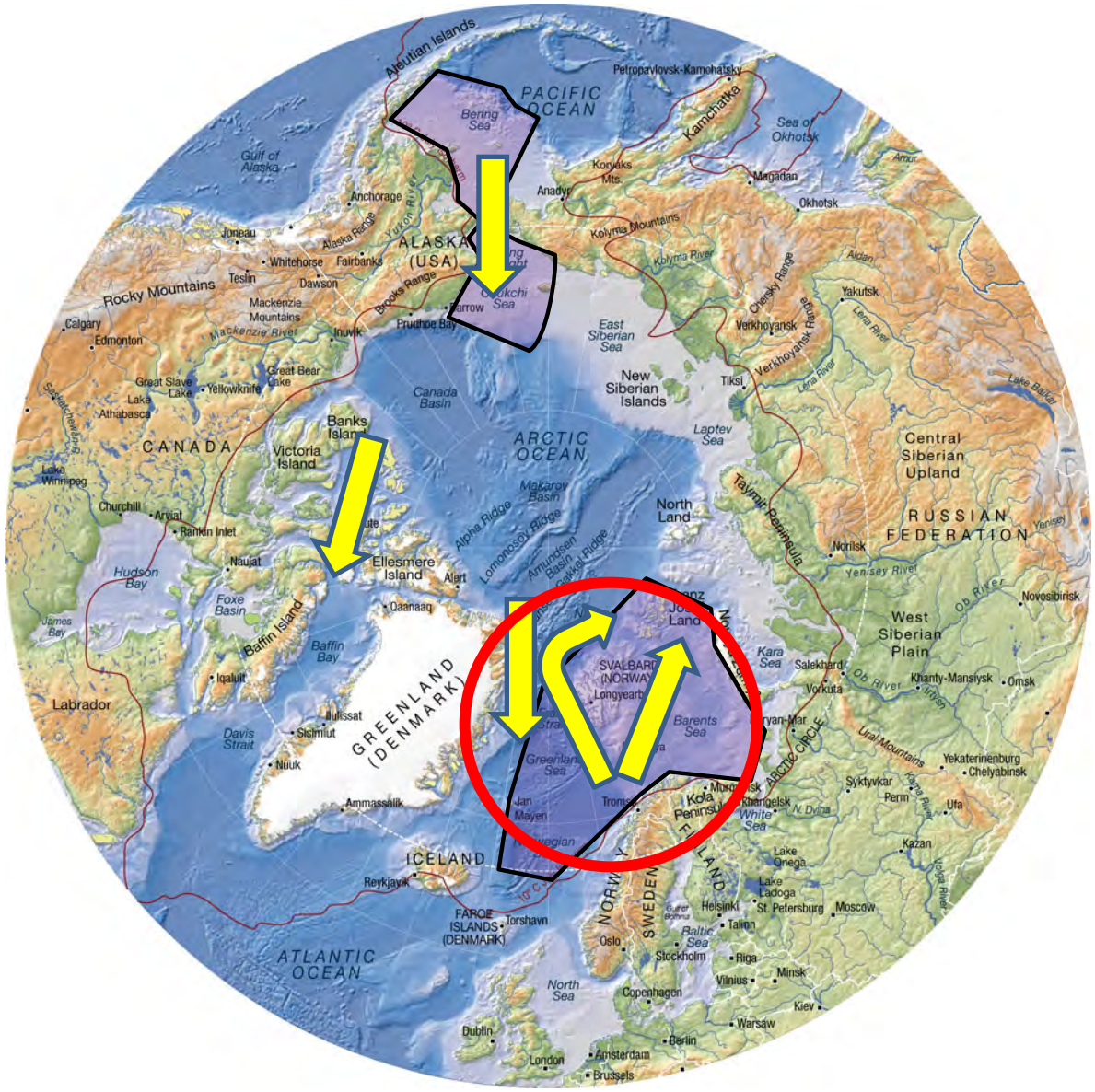
Ecosystem Studies of Subarctic and Arctic Seas
ESSAS

IMBeR
Integrated Marine Biosphere Research

RACArctic

- Resilience and Adaptive Capacity of Arctic marine ecosystems under a changing climate
- Synthesis project funded by the Belmont Forum
- ESSAS project jointly undertaken by scientists from Japan, USA and Norway
- Aim is to examine recent trends and future projections of climate and ocean acidification in the transition zones between the Arctic and Subarctic and what impact they will have on marine ecosystems from plankton to marine mammals and seabirds.

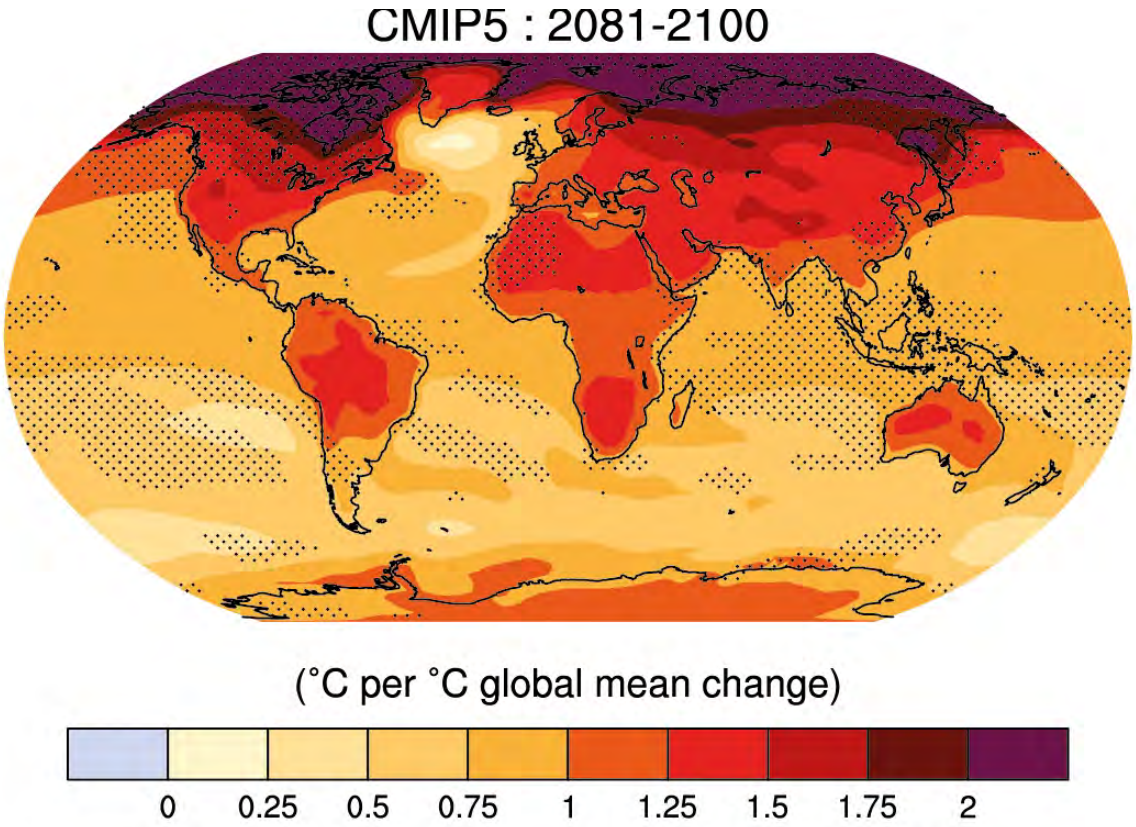
Geographic Focus of RACArctic



Pacific Sector:
Bering Strait, Bering Sea, Chukchi

Atlantic Sector:
Fram Strait, Barents Sea, Norwegian Sea, Greenland Sea

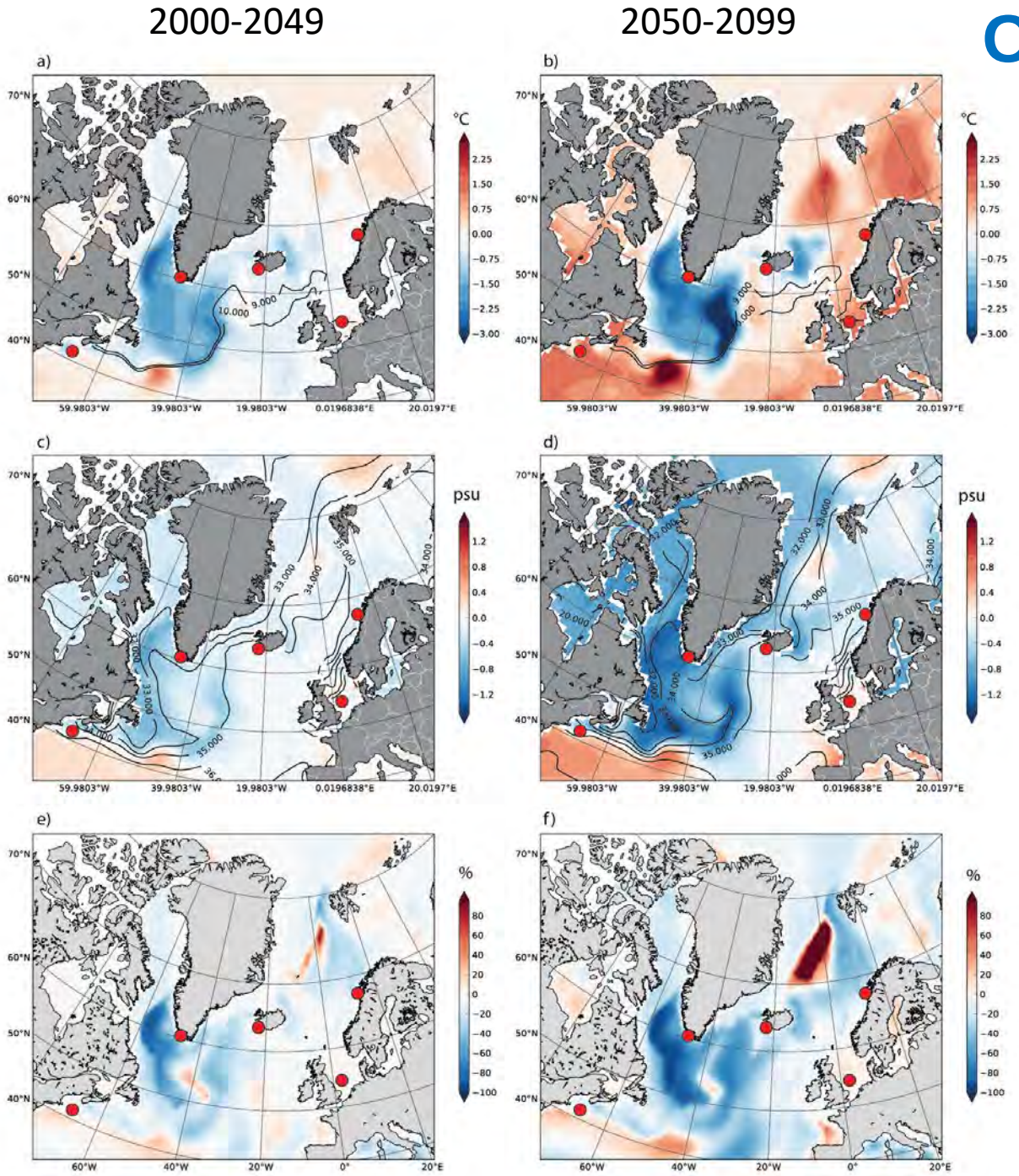
Future Air Temperatures



IPCC, 2013

Air Temperatures are projected to increase most in the Arctic and to continue through to at least the end of the present century.

Ocean Conditions



GFDL ESM
rel. 1950-1999

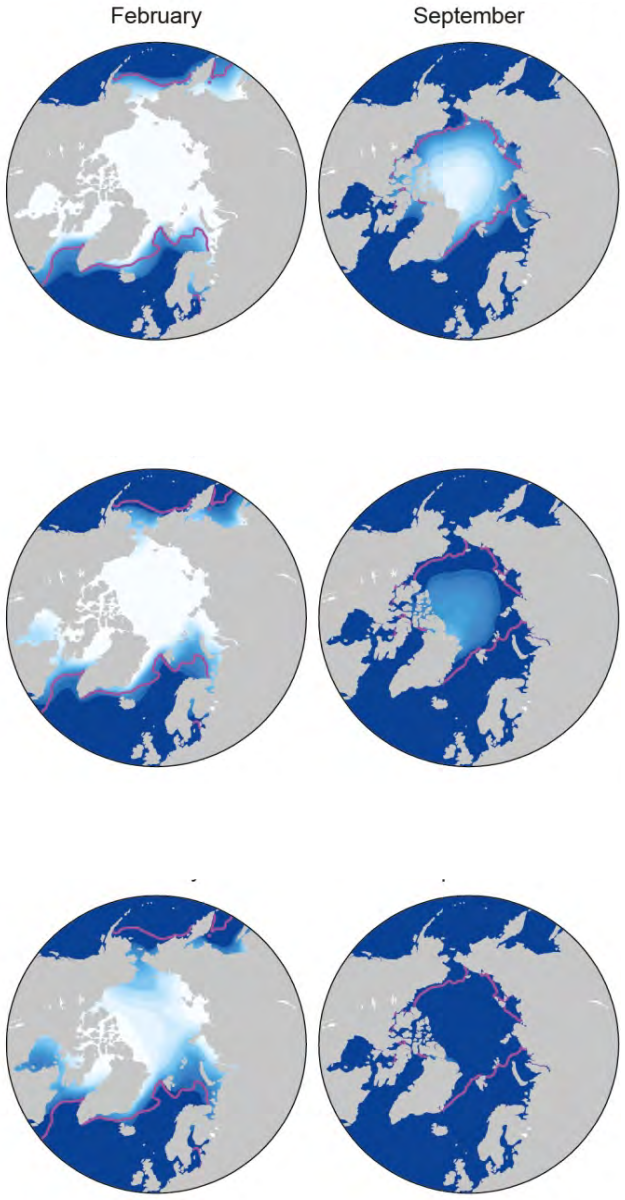
Surface Temperature

Surface Salinity (melting ice, higher precip.)

Depth of Mixed Layer

Kristiansen et al., 2014

Sea Ice



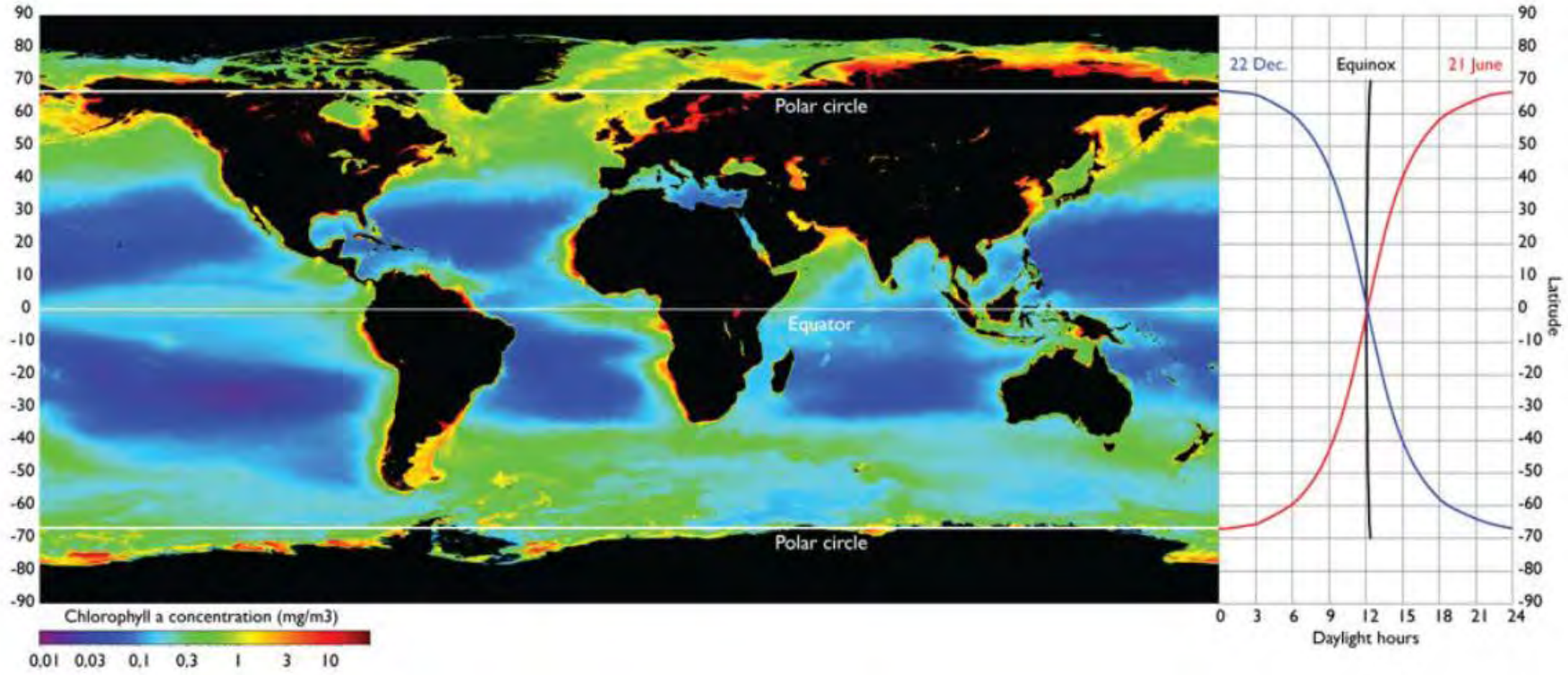
Sea ice will continue to decline but will remain especially during winter in the Arctic and some regions of the subarctic but is expected to dis-appear from the Arctic during summer, as early as 2030-2050.

Phenological Changes:
Earlier ice breakup;
Later ice formation

IPCC, 2013

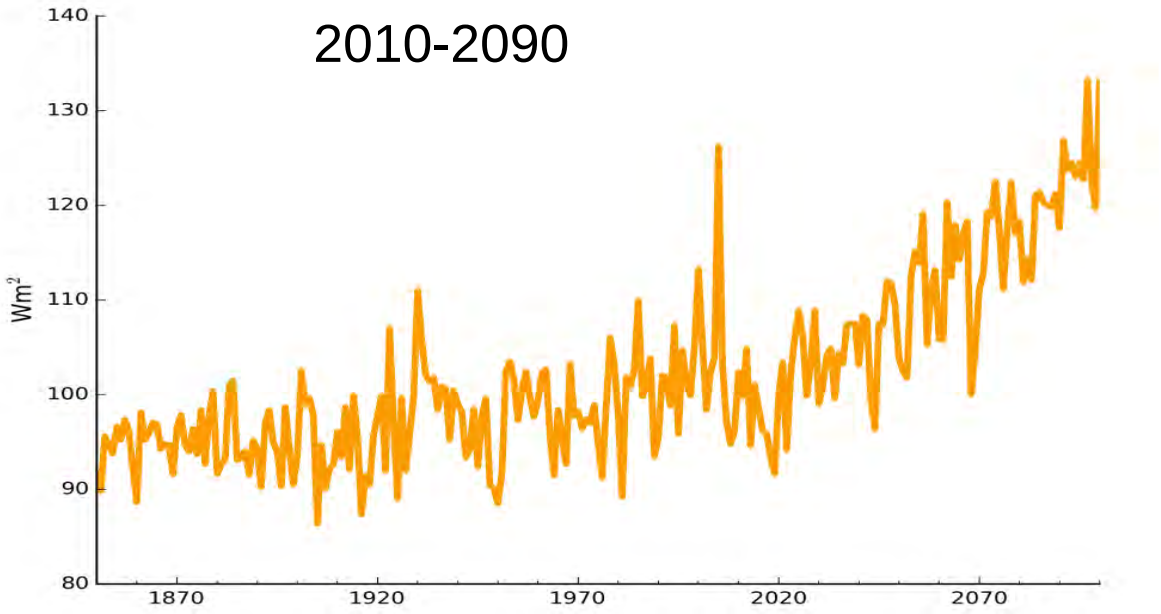
However,…

- Ocean temperatures will remain relatively cold in winter, especially in the Arctic.
- There will still be no light in winter and 24 hours of sunlight in summer north of the Arctic circle.



Changes in light in the top meter of the water column

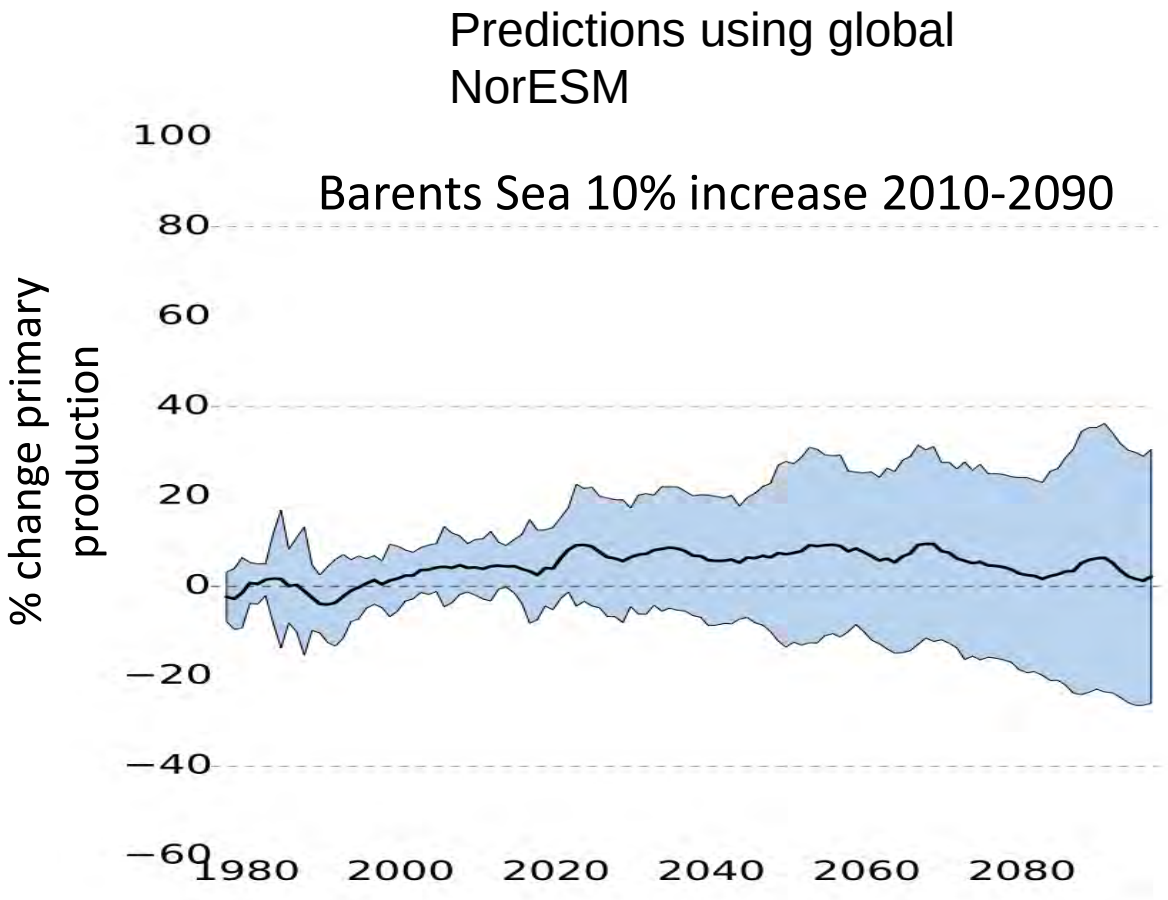
Barents Sea 27% increase
2010-2090



Changes in light calculated from NorESM predicted changes in sea-ice concentration, sea-ice thickness, albedo, and snow depth.
Expected to have consequences for time of spawning, availability of prey resources and biodiversity.

T. Kristiansen, unpublished

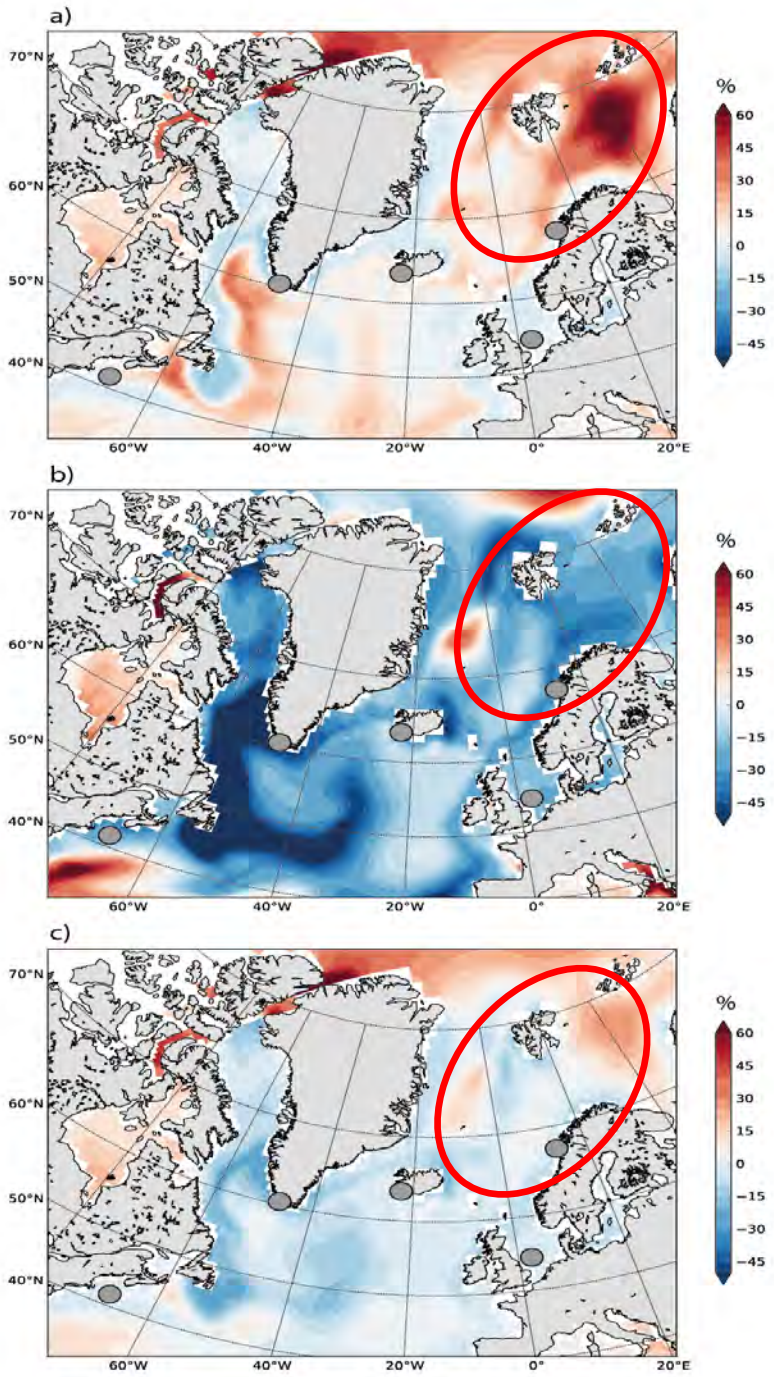
Expected future responses in primary production



T. Kristiansen, unpublished

Generally robust result but % change varies with model:
8% increase over 65 yrs (Ellingsen et al., 2008);
No trend in PP under 1-8°C (Slagstad et al., 2011);
36% increase 2046-2064 compared to 1981-1999 (Skaret et al., 2015).

Phytoplankton Size

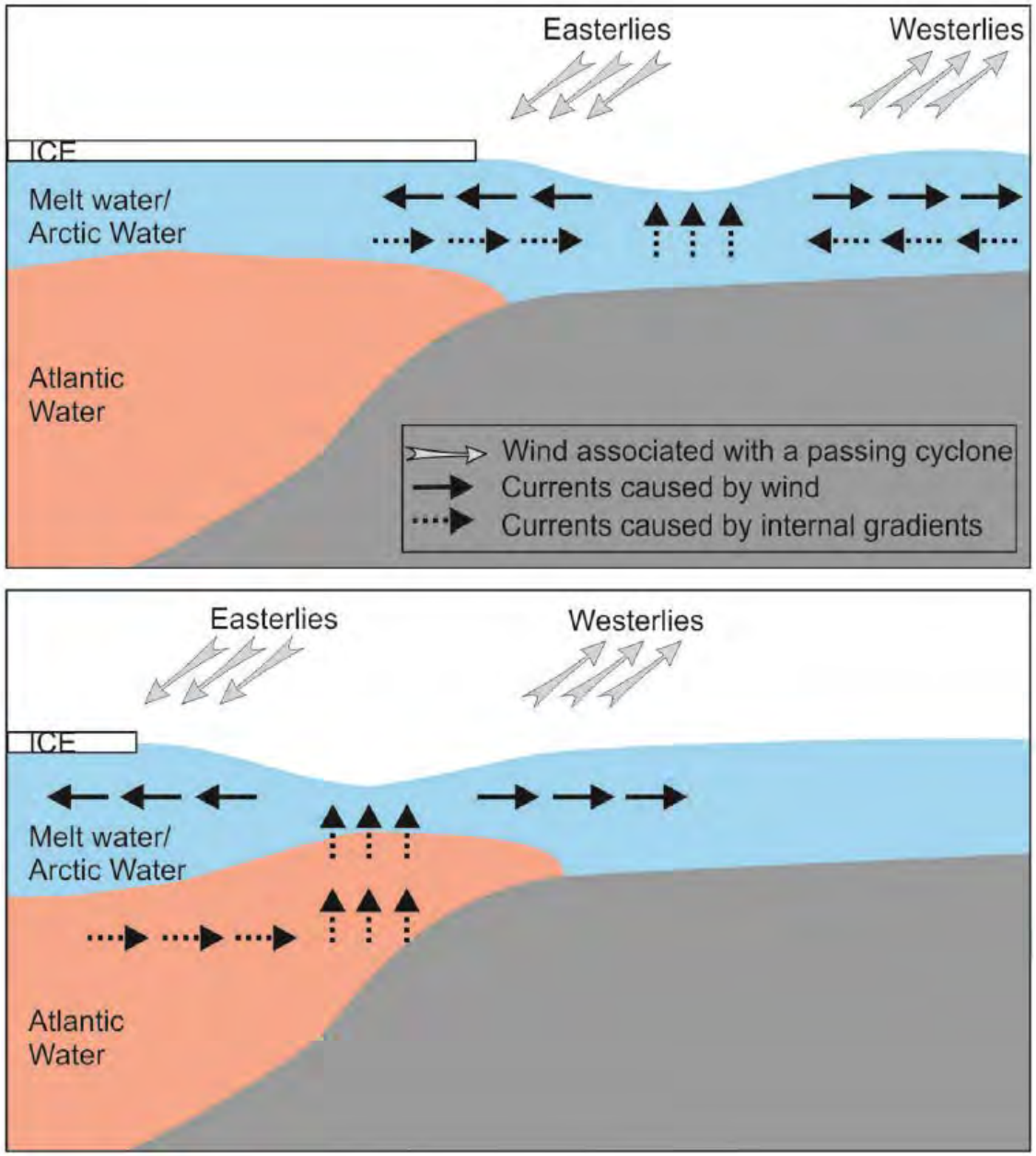


% change in Phytoplankton between 1950-2000 and 2051-2099 from GFDL ESM

General loss of large and increase in small phytoplankton. Slight increase in Barents Sea and increase in the Arctic

Kristiansen et al., 2014

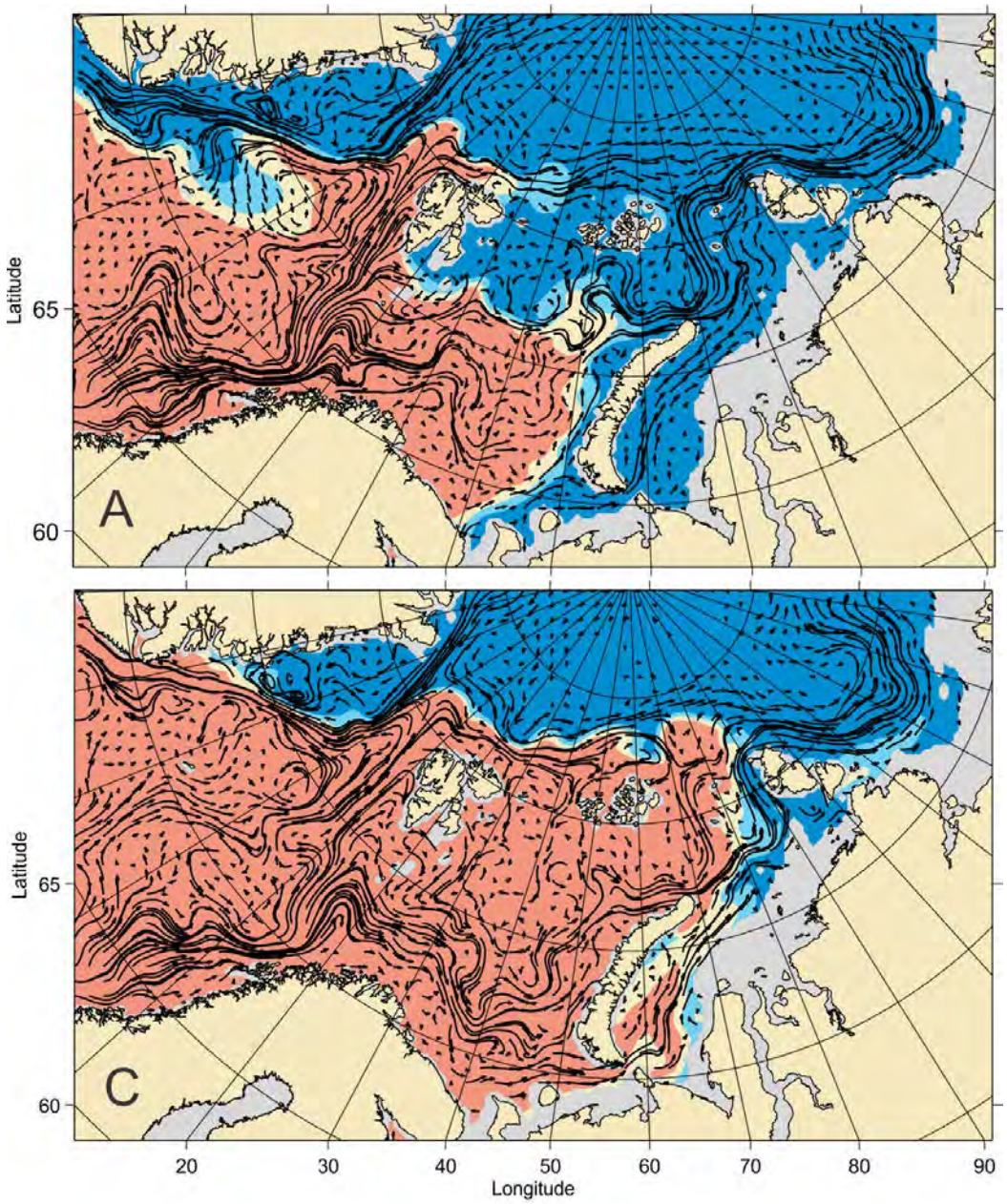
Upwelling



Haug et al., 2017, Fish. Res.

- As ice retreats from continental shelf break, increased upwelling results (Chapman and Carmack, 2003).
- Tends to lead to increased primary and secondary production at shelf break.
- Occurred north of Spitsbergen in the 18th century, which supported a large whale fishery, and is beginning to be seen again (Falk-Petersen et al., 2015).

Potential Movements of Ocean Fronts

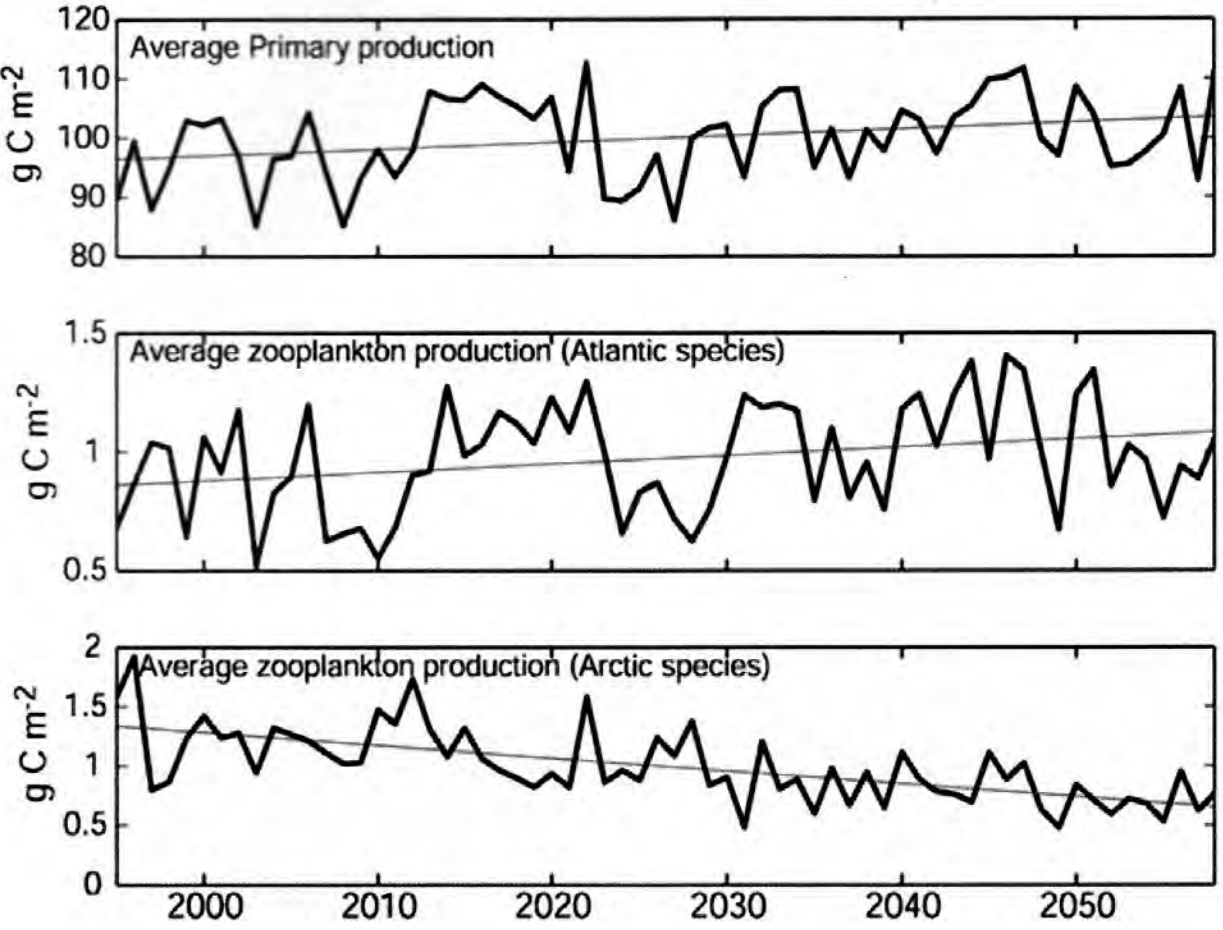


Recent modelling studies suggest that the Polar Front separating Arctic and Atlantic waters in the Barents Sea may move as far north as the northern edge of the Sea resulting in a disappearance of Arctic waters from the entire Barents Sea.

Caveat: This is based on temperature only and does not take into account salinity.

Wassman et al., 2014

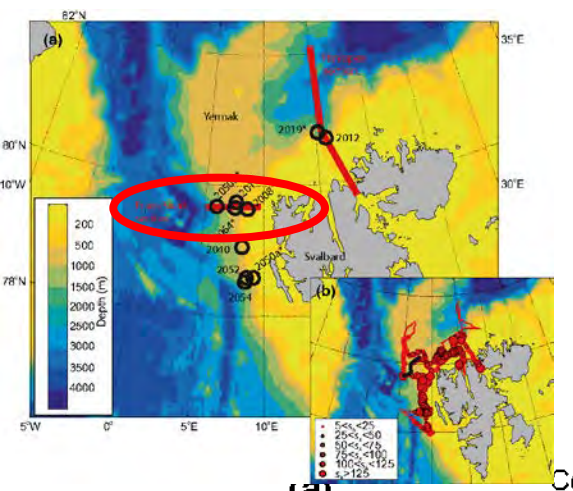
Future Climate Projections-Plankton



Zooplankton- Increased secondary production (SP) by about 20% in Atlantic waters of Barents Sea with more *Calanus finmarchicus* but lower SP (by about 50%) in N Barents due to retreat of Arctic species. Total production is reduced.

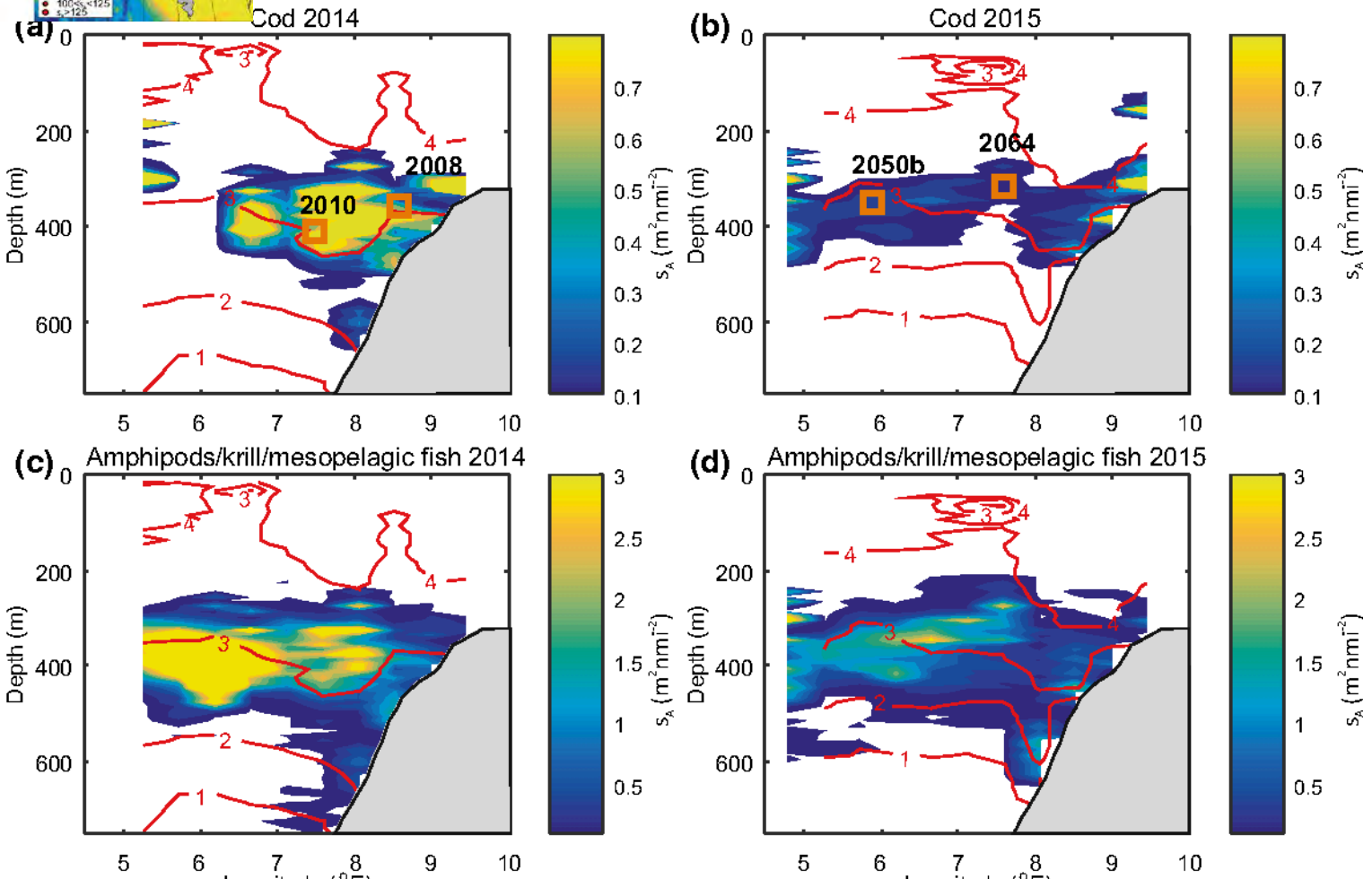
Arctic species from Barents may move into Arctic waters and in combination with increased upwelling at the shelf break and on the shelf could increase their abundance levels.

Atlantic Cod feeding in the Deep Arctic Basin in Fram Strait



Cod

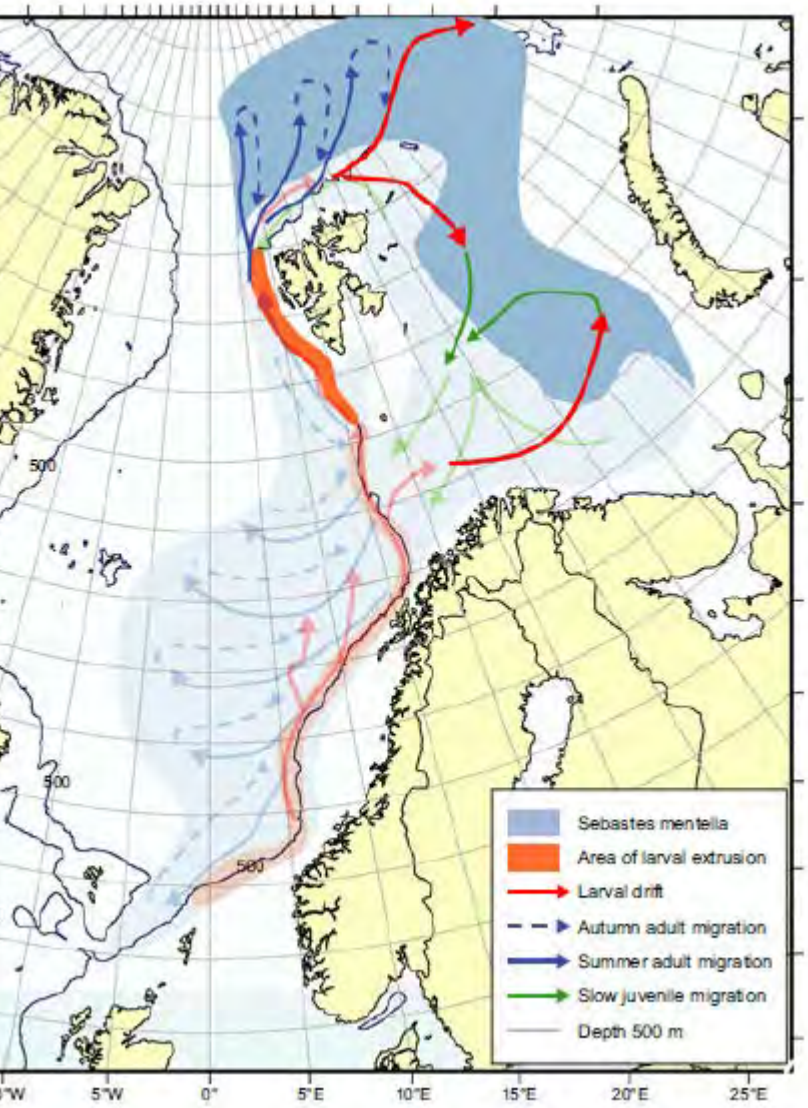
Prey



Ingvaldsen et al., 2017, Polar Biology

Potential Arctic Invaders

Redfish



Snow Crab

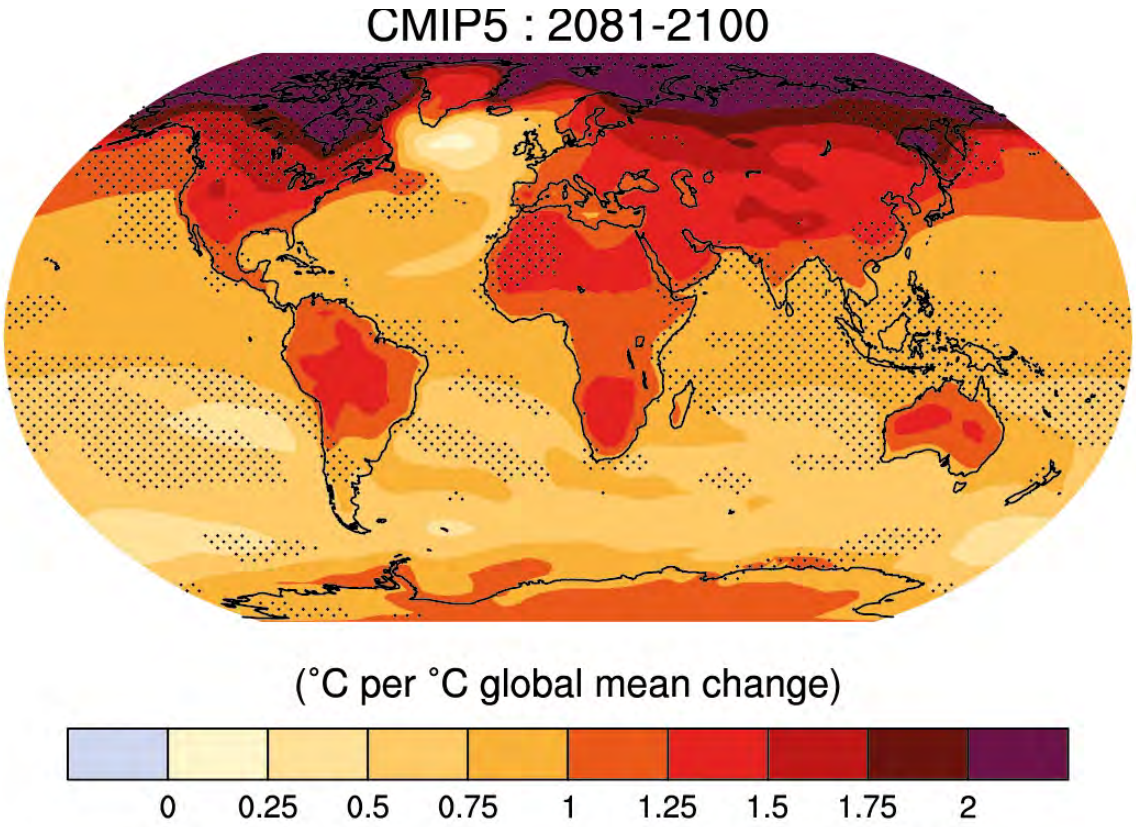
Arctic Skate

Greenland Shark

Polar/Arctic Cod

Hollowed et al. 2013

Difficulties in Attribution



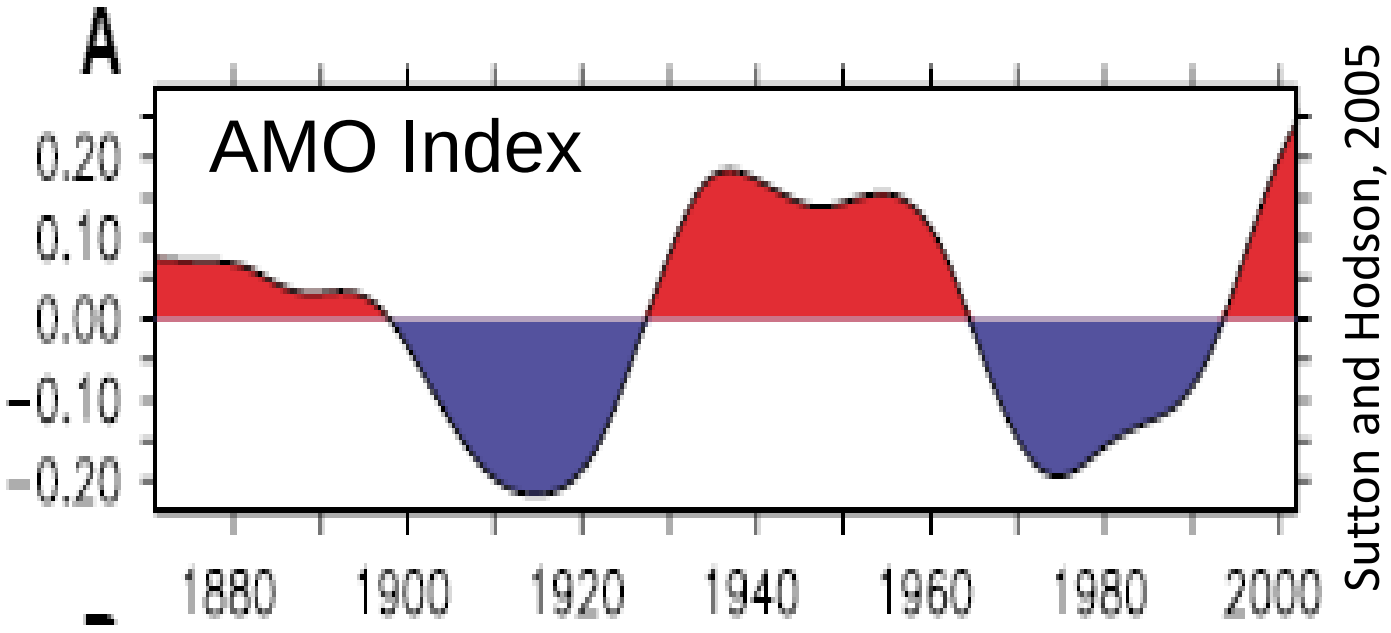
IPCC, 2013

… but also large climate variability (e.g. NAO, AO, AMO, PDO). Thus, the signal-to-noise ratio is not high, especially at present and into the near future. This makes it difficult to attribute many observed changes unequivocally to climate change.

Global Warming or Natural Variability?

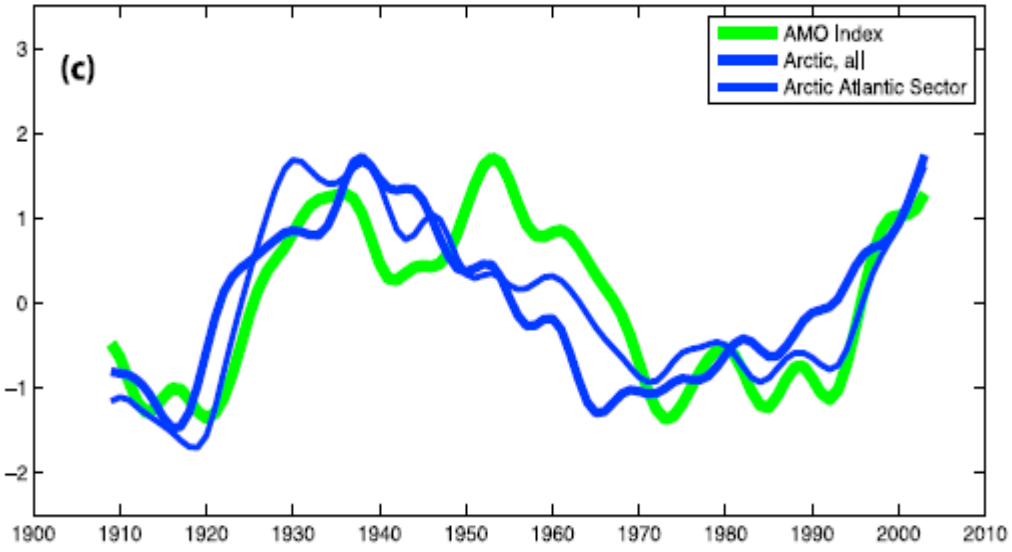
Smoothed Ave. N. Atlantic SSTs equator to 60-70°N

°C

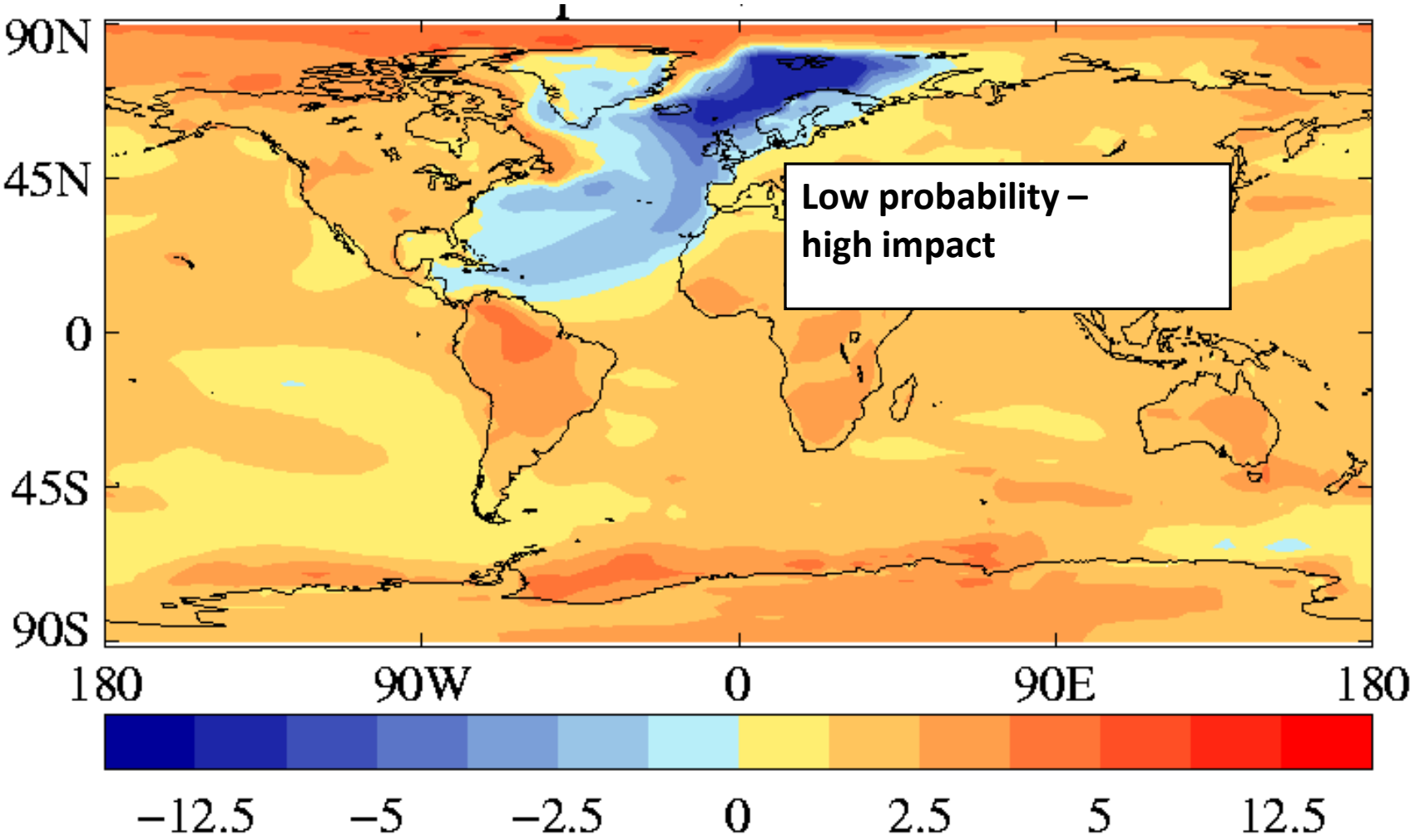


Low-pass filtered and detrended AMO index, GISTEMP Arctic (air temperature) record and Arctic Atlantic record.

Schnedider & Noone., 2012



Possible effect of global warming and shut down of the Atlantic thermohaline circulation



Wood et al. 2003

Climate change does not occur in isolation therefore we need to consider other effects such as fishing.


Bergy Bits off Cape Farewell,
Greenland, May 2013
Thank you for your attention.
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