

UiT  
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# Climate change impact on Arctic ocean ecosystem

## A New Arctic Ocean?

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**Increasing interest in the Arctic**





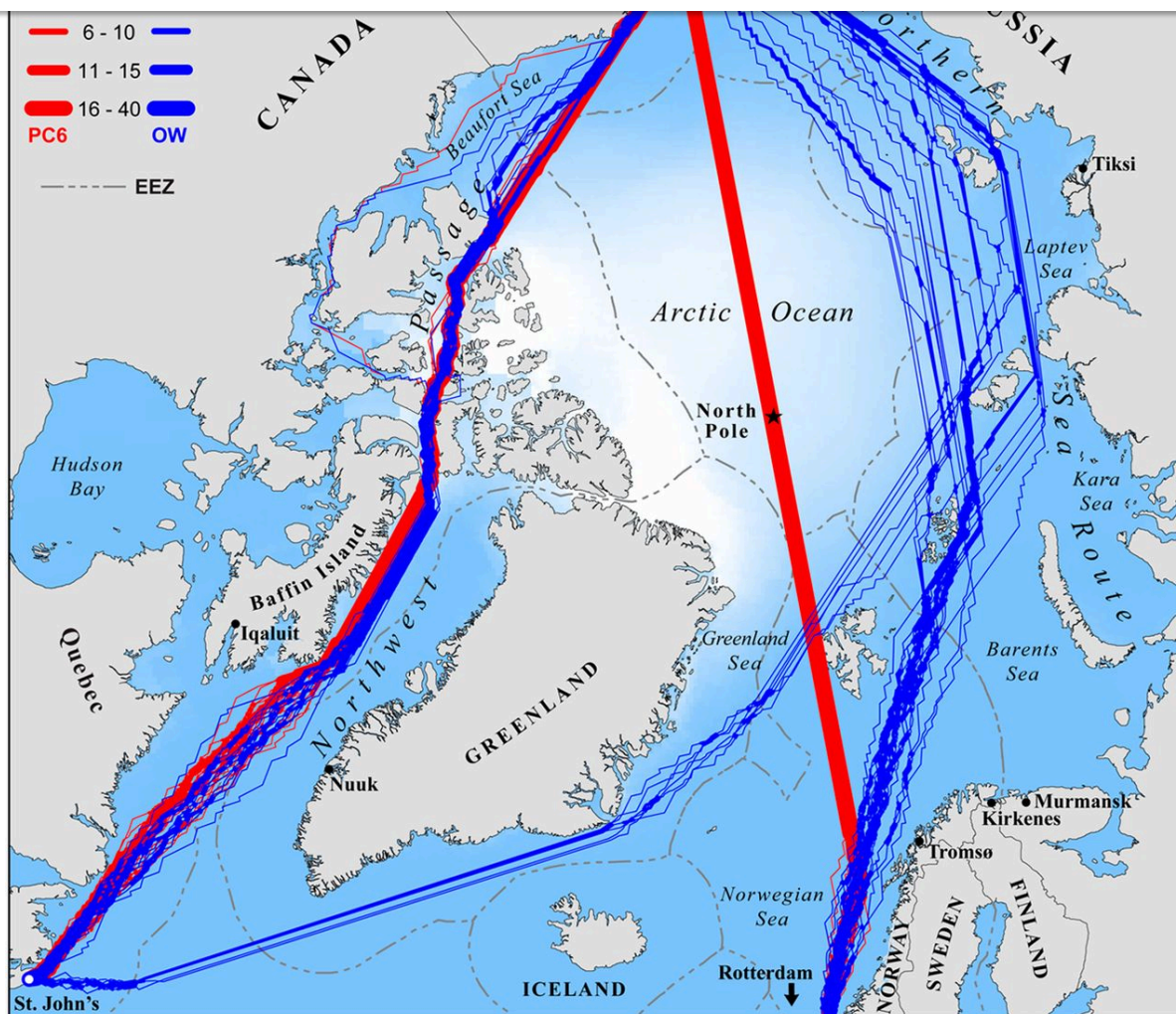
Drill for oil and gas



Transport cargo, oil and gas to/from Asia



# Shipping



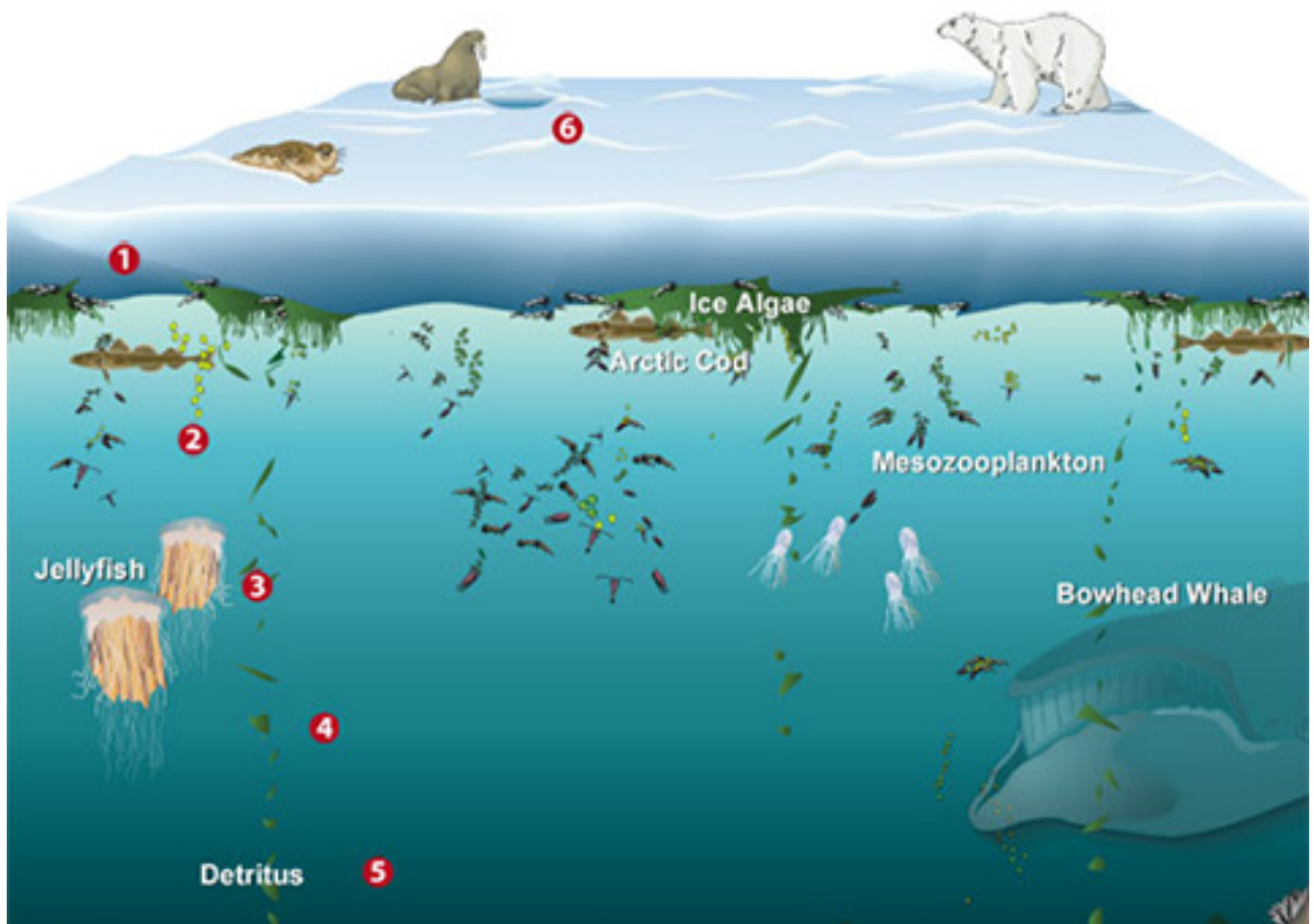


New industries





Mining options



# Bioprospecting

(discovery and commercialization of new products based on biological resources)



## Environmental interests: Spectacular wild life











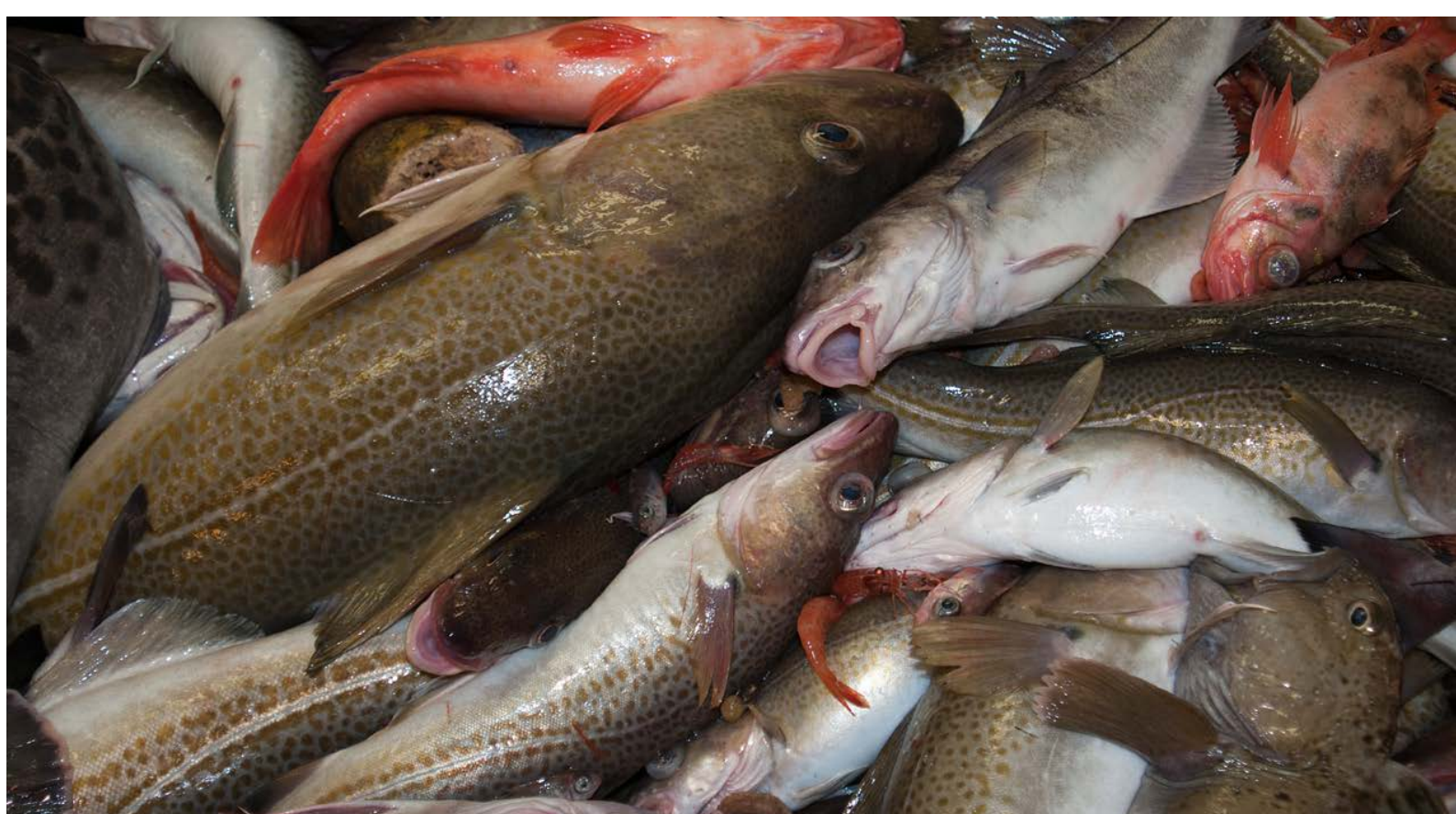




Of particular interest:



# Fisheries



Will we keep the old or get a  
new Arctic Ocean?

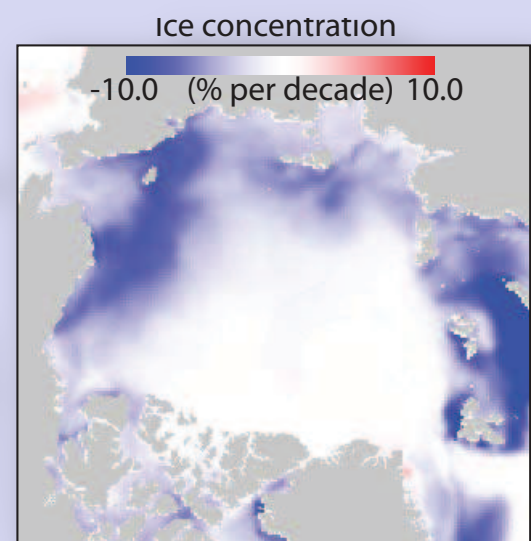
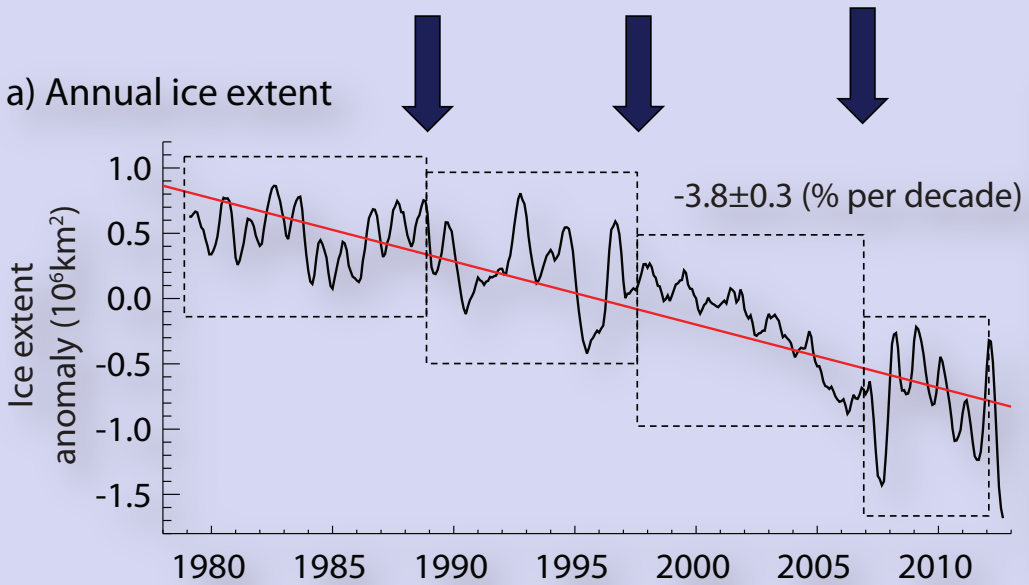


**The loss of Arctic sea ice has emerged  
as a leading signal of global warming**



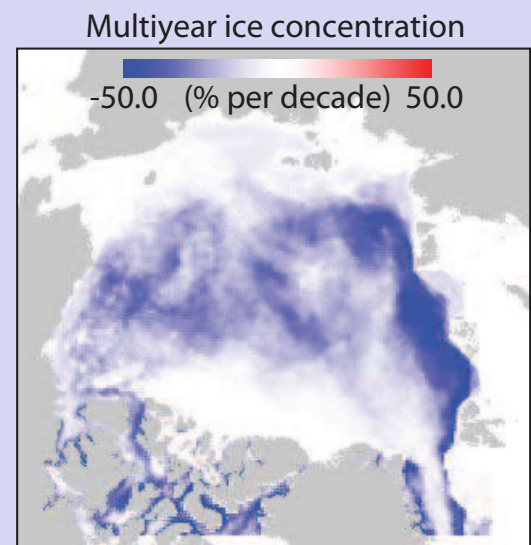
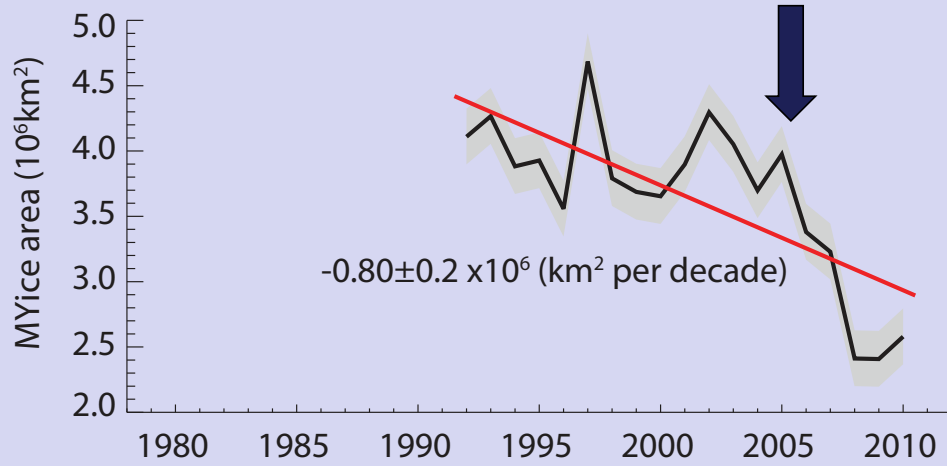


## Reduced Summer Extent



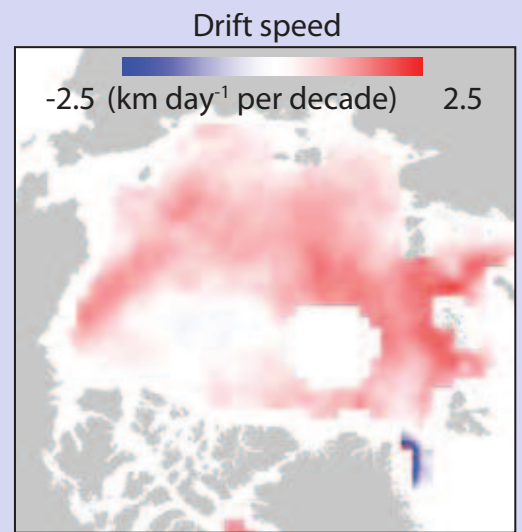
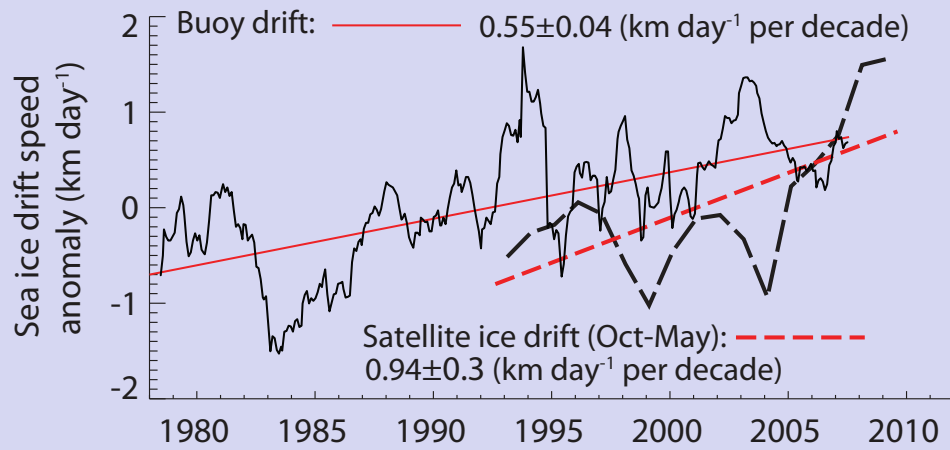
## Reduced Multiyear Fraction

b) Multiyear ice coverage (Jan-1)



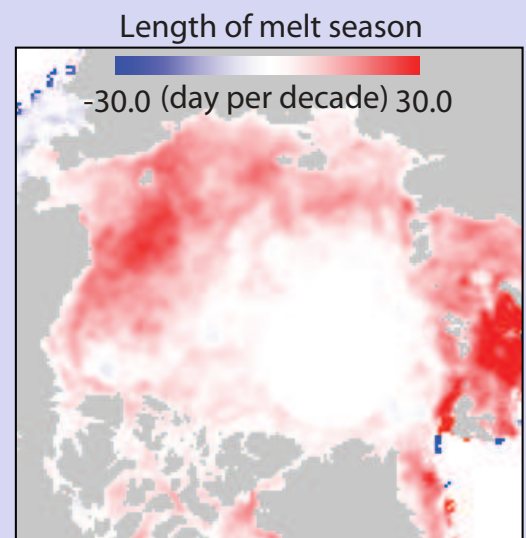
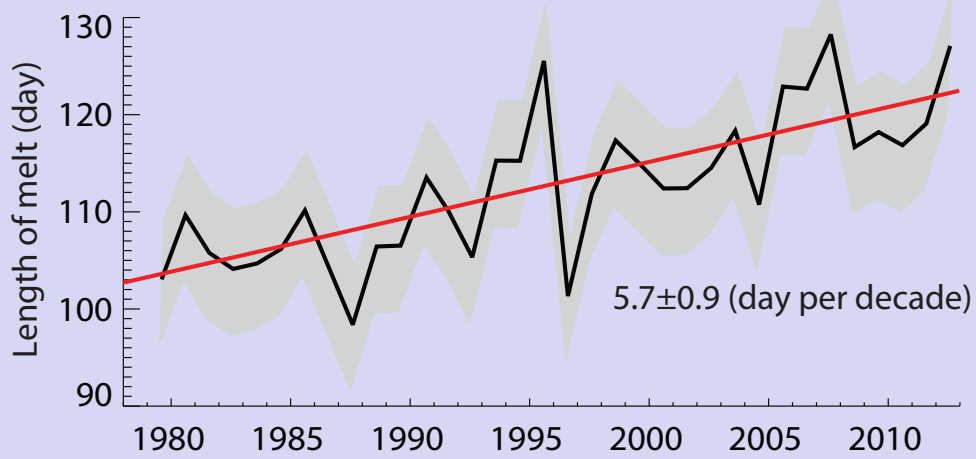
## Faster Drift Velocities

### d) Sea ice drift speed



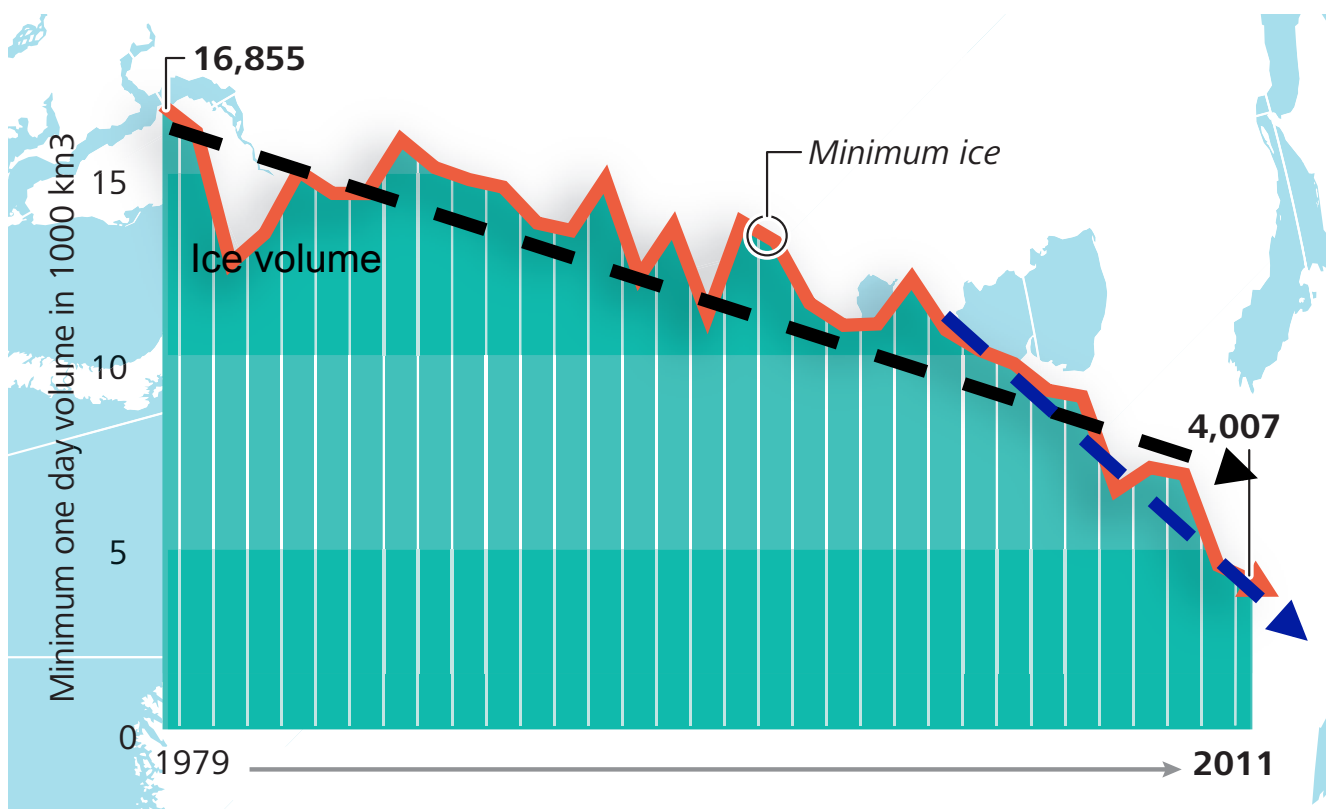
## Longer Melt Season

e) Average length of melt season



## Ice loss

In the last 30 years we have lost about 75 % of ice volume in the Arctic Ocean.

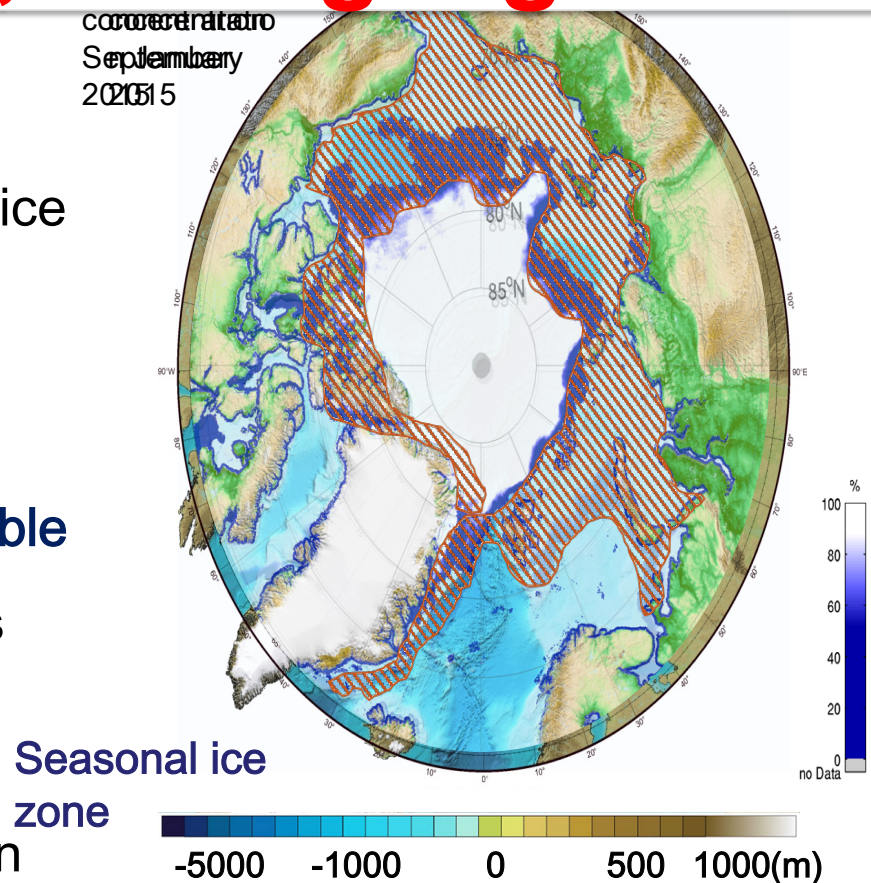


# Loss of Arctic sea ice opens up a new ocean

- Thinner ice, more ice-free water, more radiation
- Easier ship operations
- Reduced risks for oil and gas exploitation
- Increased access to harbors and mineral resources
- More primary production and more fisheries
- Biodiversity, ecosystem loss
- What do we know will happen?

# Transition, dynamic, vulnerable, strong signal

- Seasonal ice zone
- Is the **transition** between the open ocean and sea ice
- Is very **dynamic** due to rapid changes in sea-ice conditions
- It supports many **vulnerable** environmental processes
- It is here climate change provides the **strongest signal** in the World Ocean





The seasonal ice zone of the Arctic Ocean  
is **not**



It is not a bellwether



It is like the



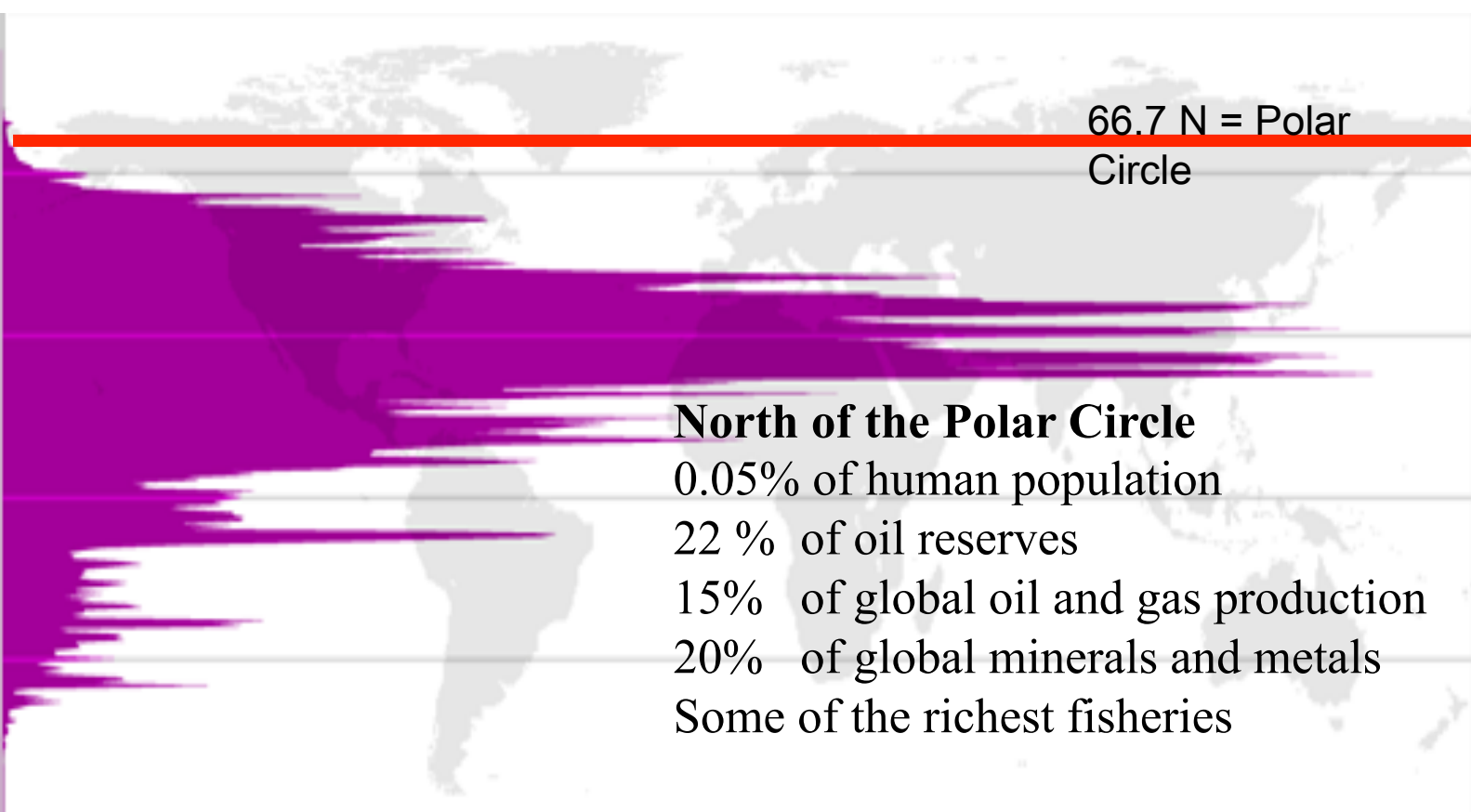


That rings with the worlds biggest bell

## To whom the bell tolls.....

- It tolls to us, loud and clear
- But the Arctic Ocean is far away for people in general
- And many use hearing protection because it is so comfortable to experience silence
- My research group attempts to make people hear, with UiT as the base
- “He who has an ear, let him hear” (Matthew 11:15)
- People in the Arctic face a challenge

# Distribution of humans on the planet





How can we stop an overpopulated, resource-hungry world to use the Arctic when “nobody lives there”?



What is so spectacular with the seasonal ice zone?

- Let us consider the circum-arctic seasonal ice zone based upon the term **landscape**

# What kind of “scapes” do we face in the seasonal ice zone?

- Four fundamental “scapes” will deviate strongly from the present “landscape”
- Ice-scape
- Light-scape
- Warming-scape
- Freshening-scape
- Unprecedented changes are taking place in the seasonal ice zone and we need to get our hands on them
- Some like drama



# The four apocalyptic riders of climate change in the Arctic ice belt



For most the four riders are well-known companions that have been and will be there, all the time



We will investigate the behavior of our companions under climate stress

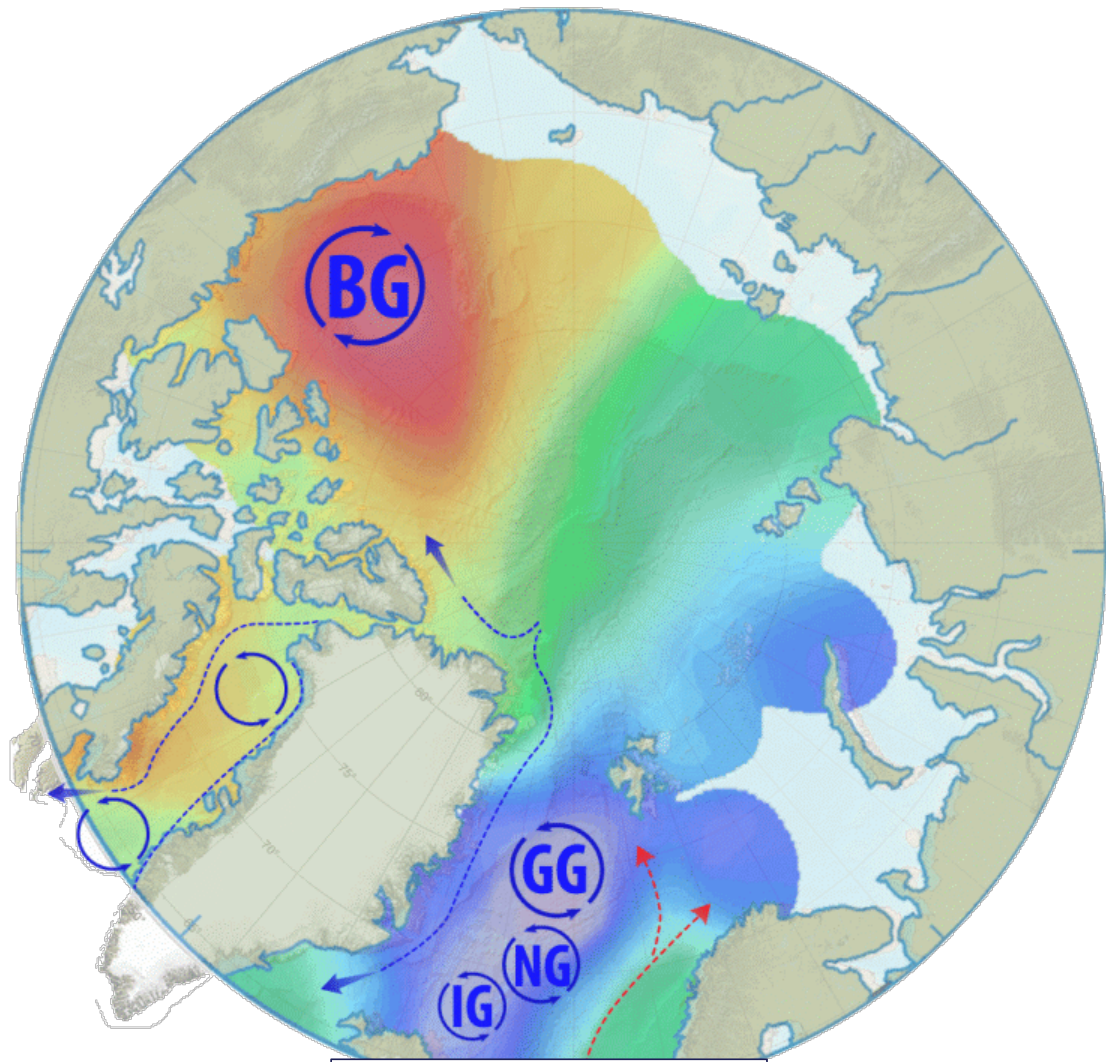
# Basic knowledge from hitherto ice-covered regions

- Increases steadily, but far too small to support sustainable resource and ecosystem management
- The basic question for economists, politicians, sciences and environmentalist:
- How can we manage the only new ocean humanity ever will get?
- And how do we exploit resources and support businesses when we have utterly inadequate knowledge of this new ocean?

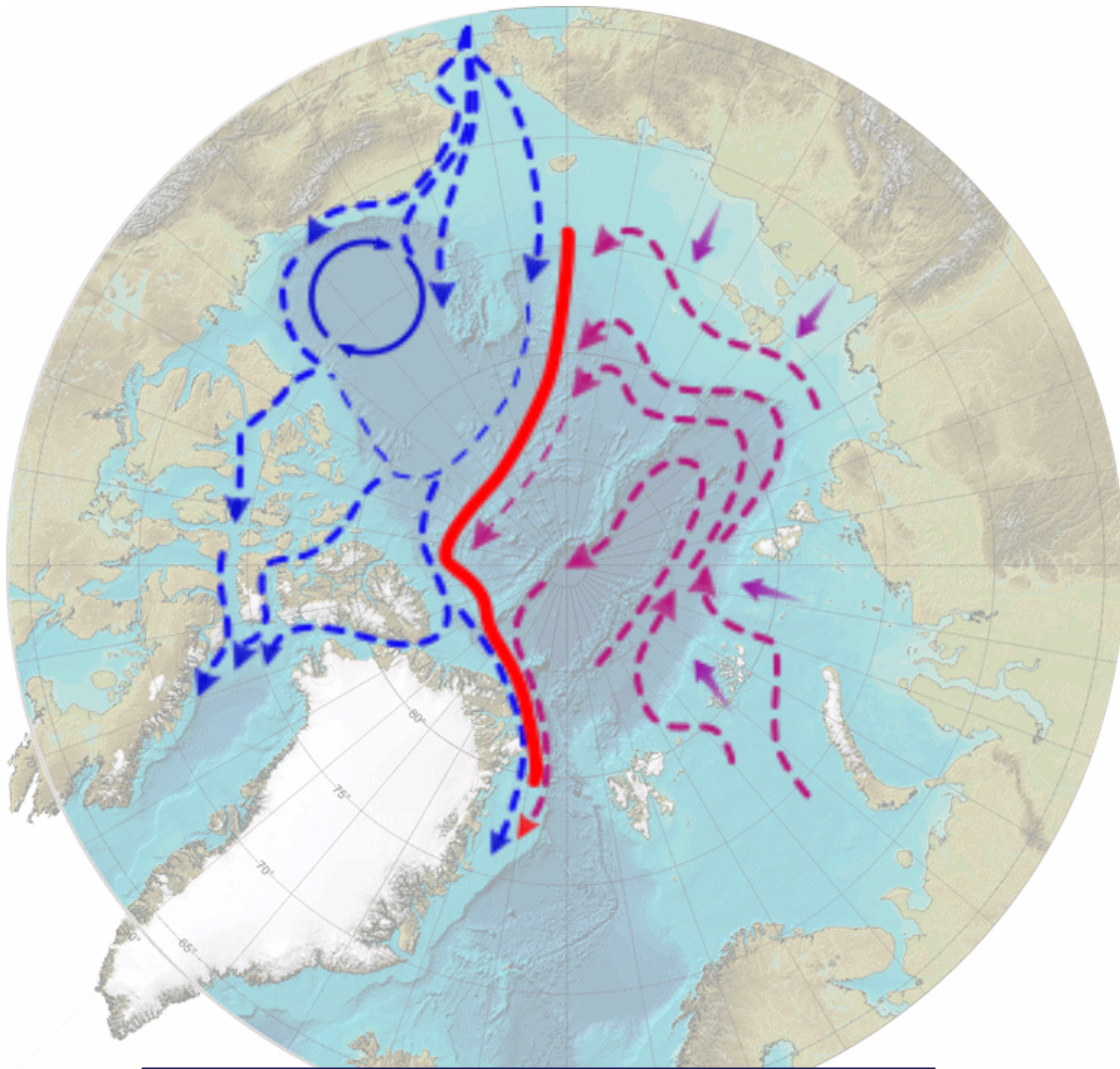


# Knowledge for wise and sustainable resource- and ecosystem management

- What do we know?

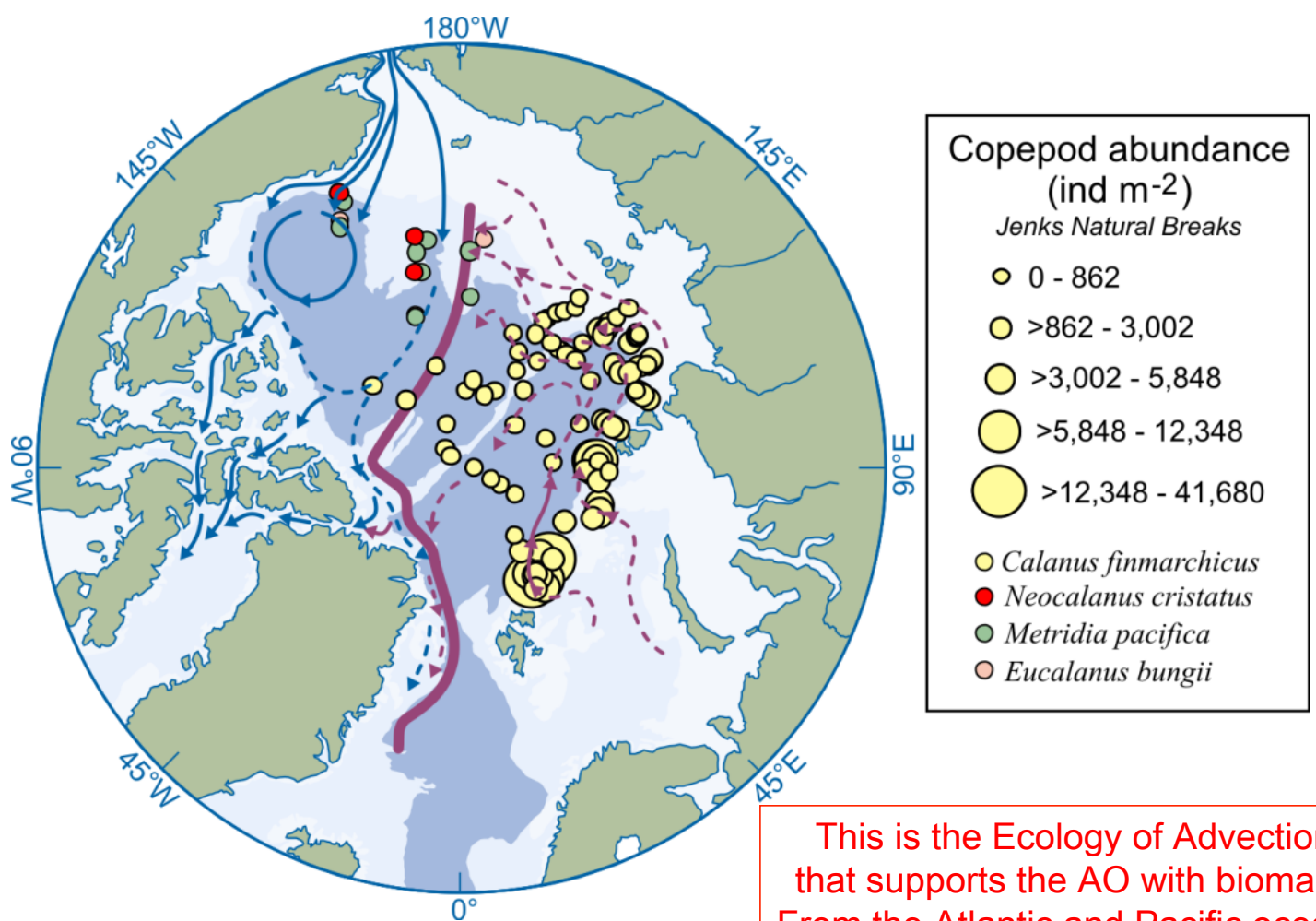


Surface Currents

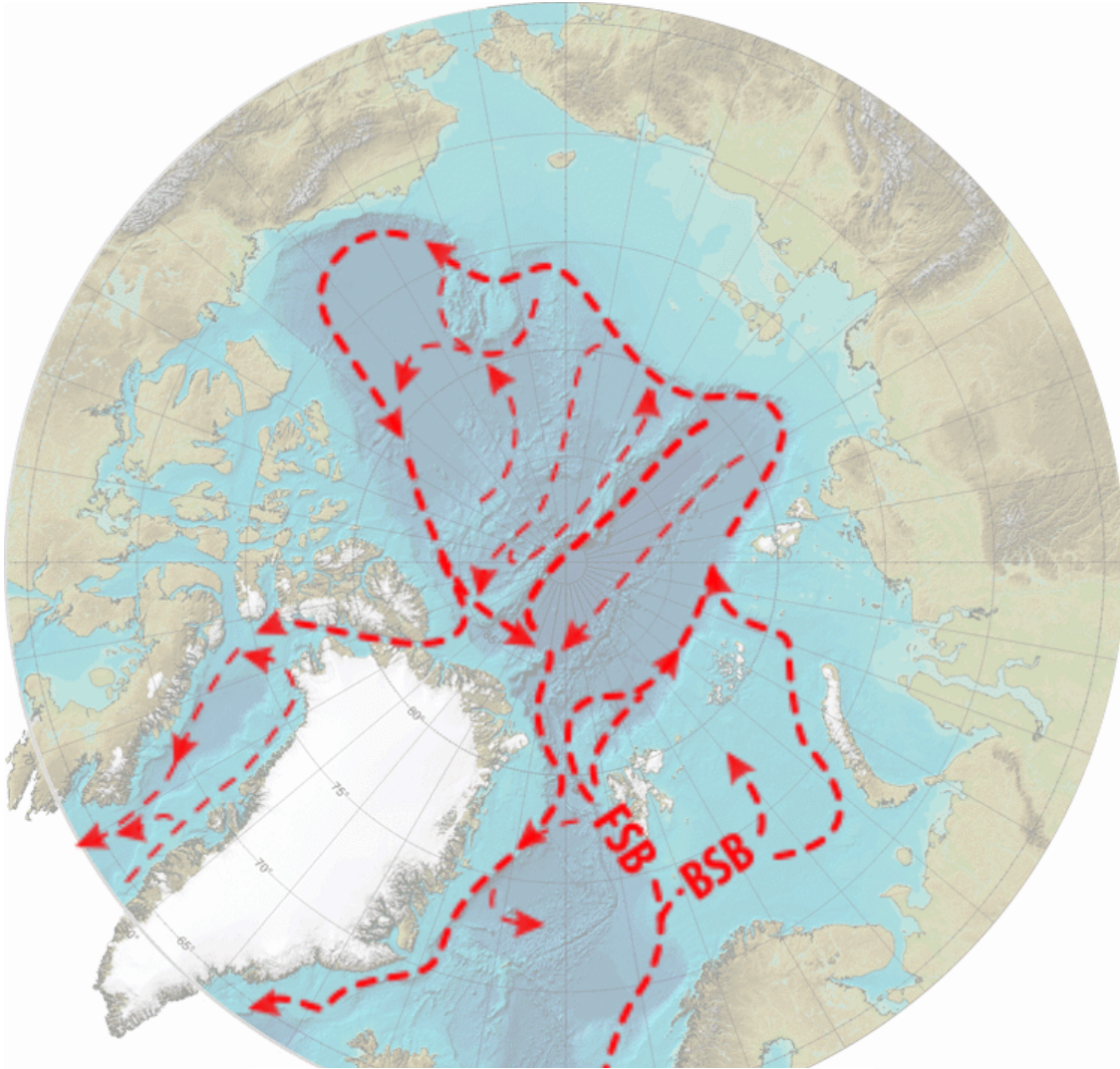


Halocline Waters (~ 50 – 200 m)

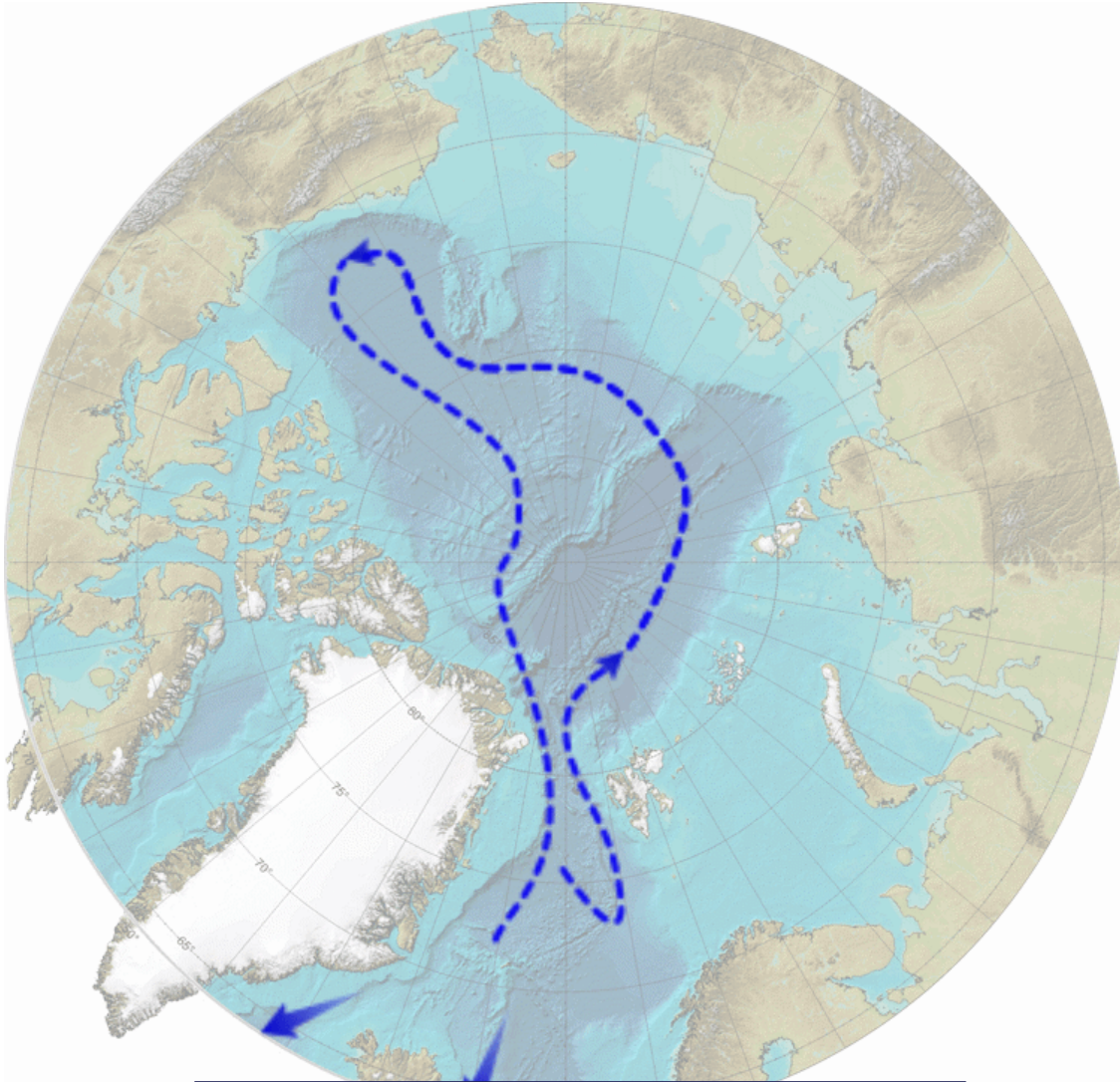




Bluhm/Kosobokova/Carmack, 2015

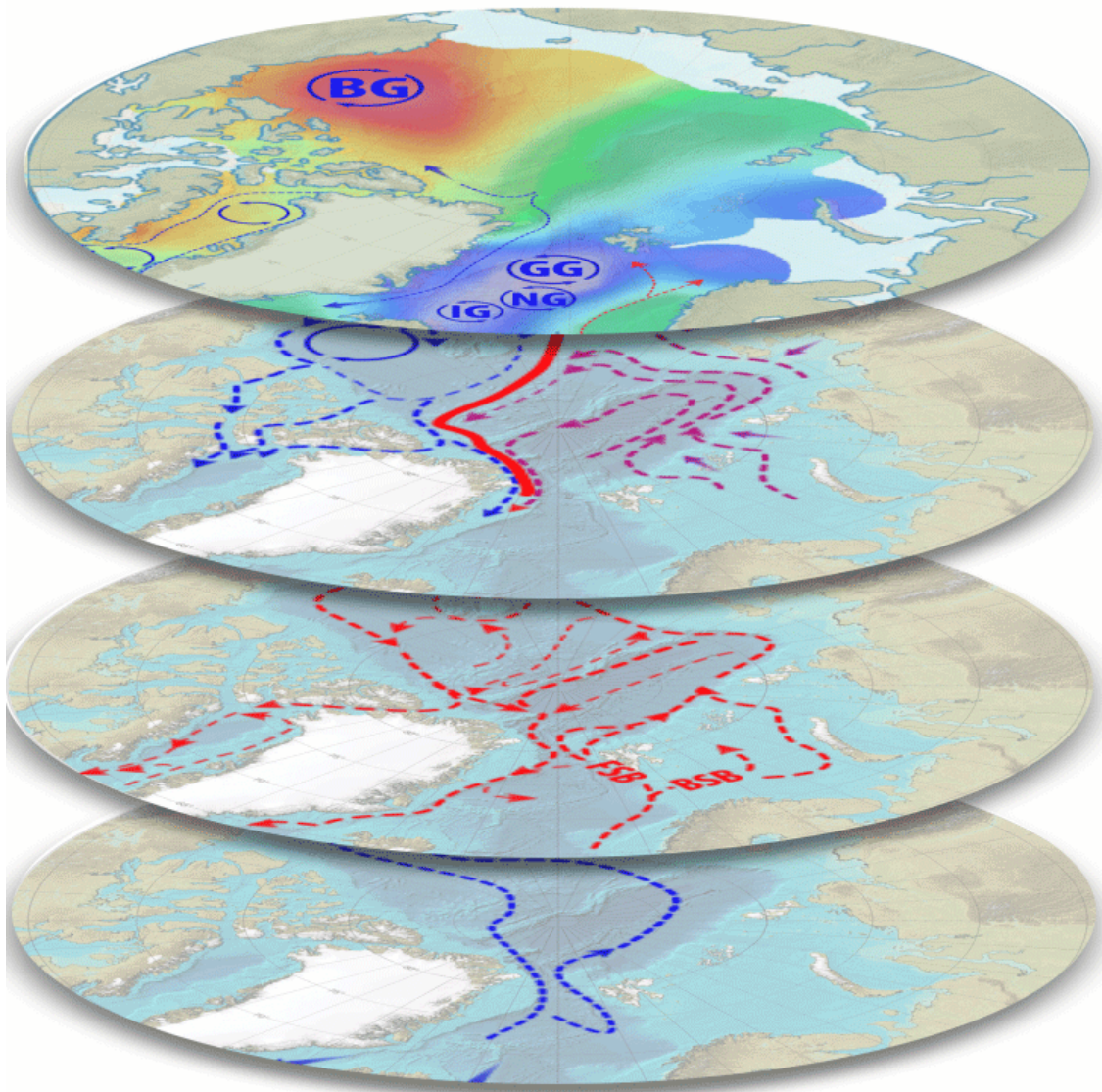


**Atlantic Layer 200-800 m**



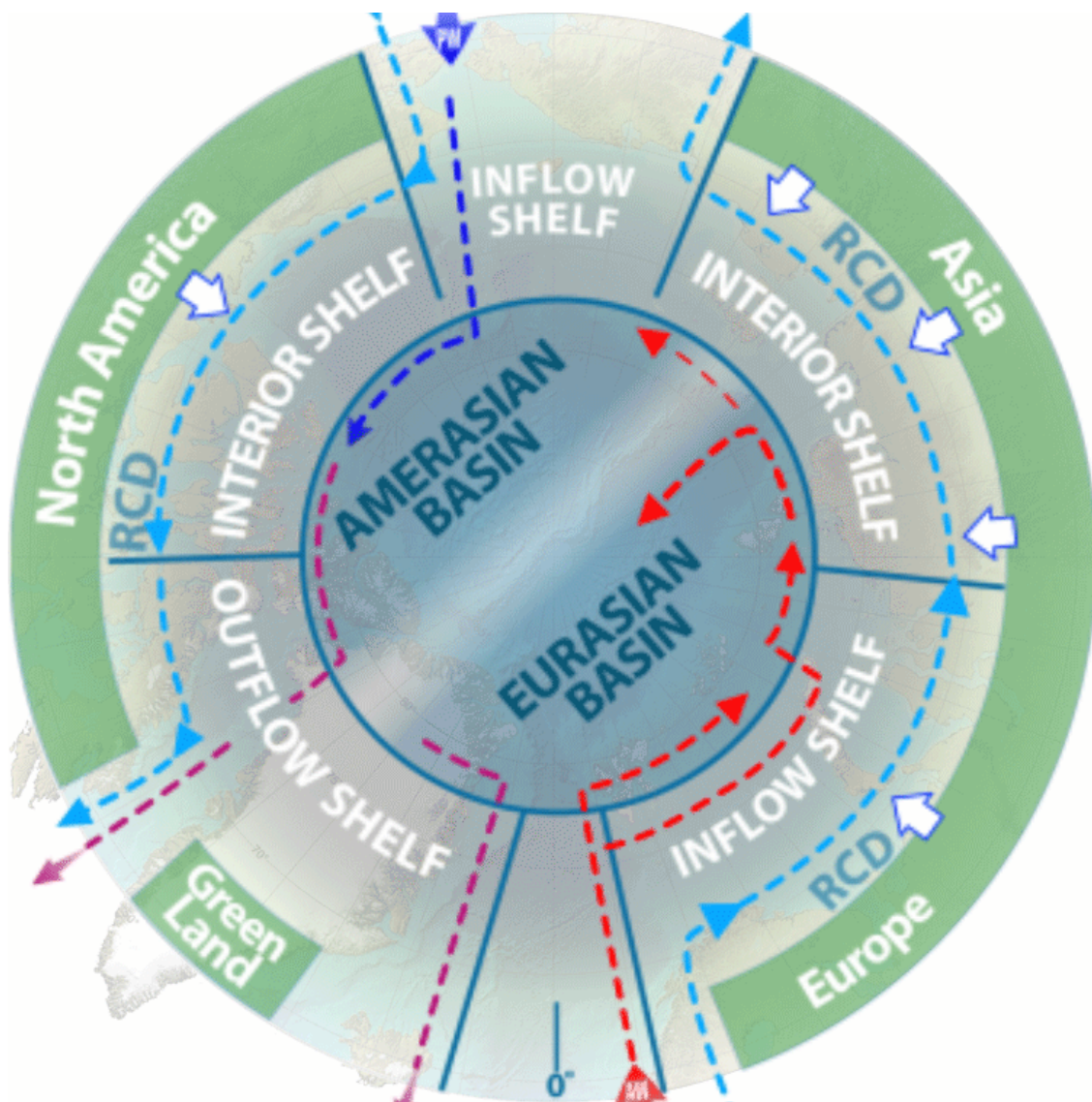
Deep Waters (below ~ 2000 m)





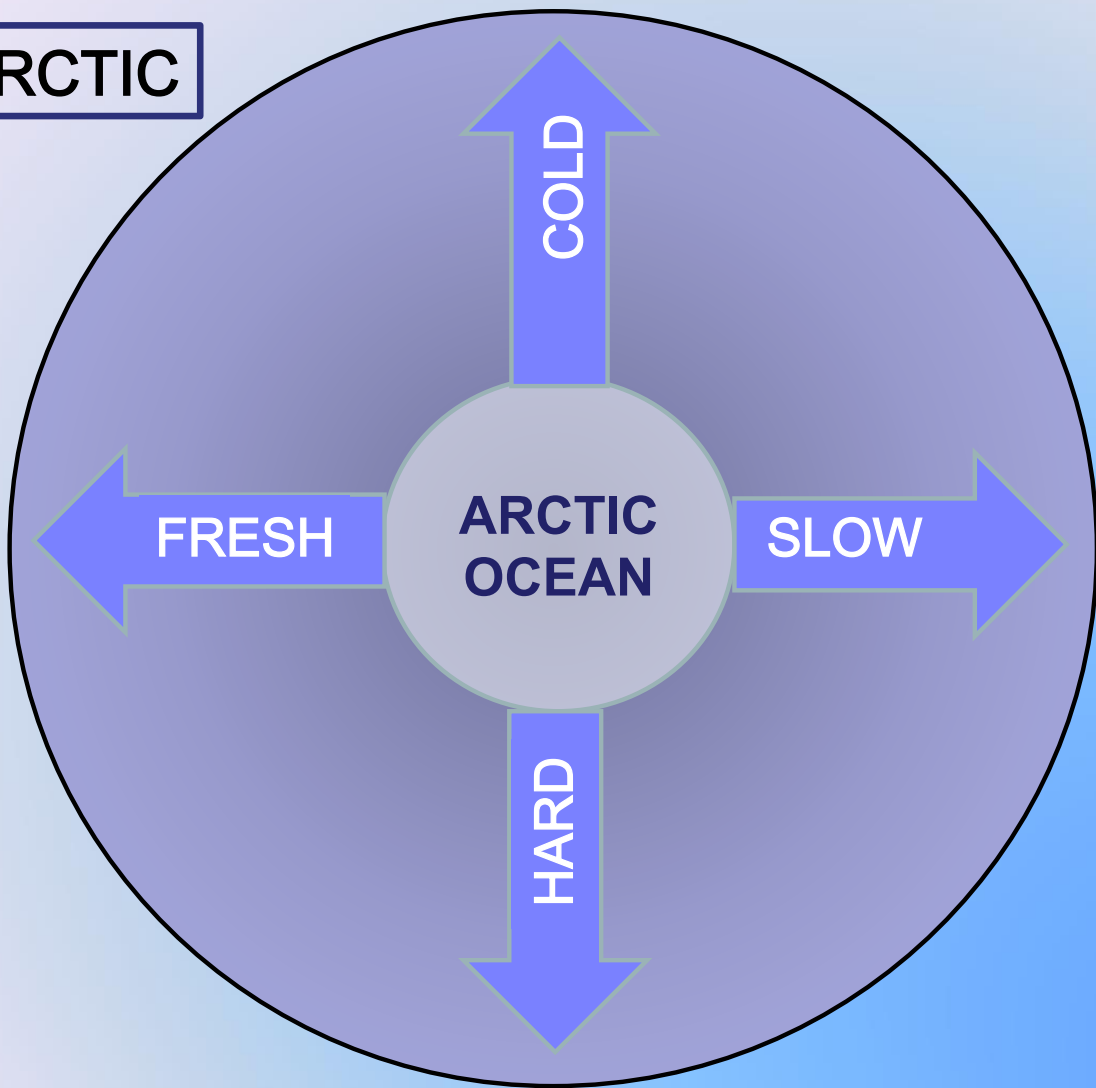
# We know some of the basics

- Physical circulation
- The principle shelf and basin function
- The connectivity between the Pacific and Atlantic oceans
- Supporting the conceptual features of the Arctic Ocean that now become discernable

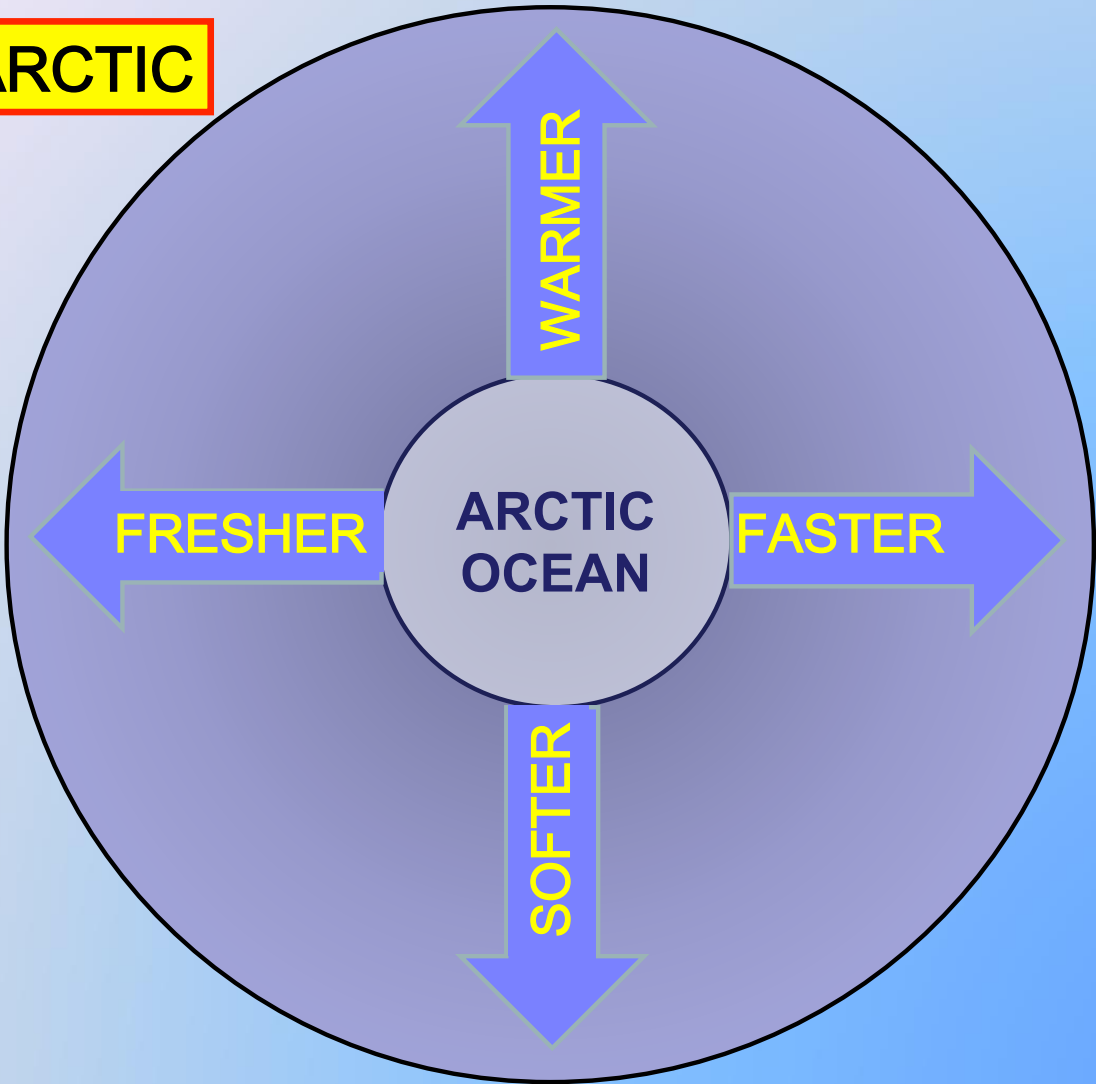




OLD ARCTIC



**NEW ARCTIC**



# Some suggestions and first results on productivity



# What really goes on on the Arctic Ocean: Tequila Sunrise hypothesis

Ice melt and surface  
warming result in  
increasing  
stratification that  
prevents vertical  
mixing

Low nutrient supply  
to surface and thus  
low harvestable  
production



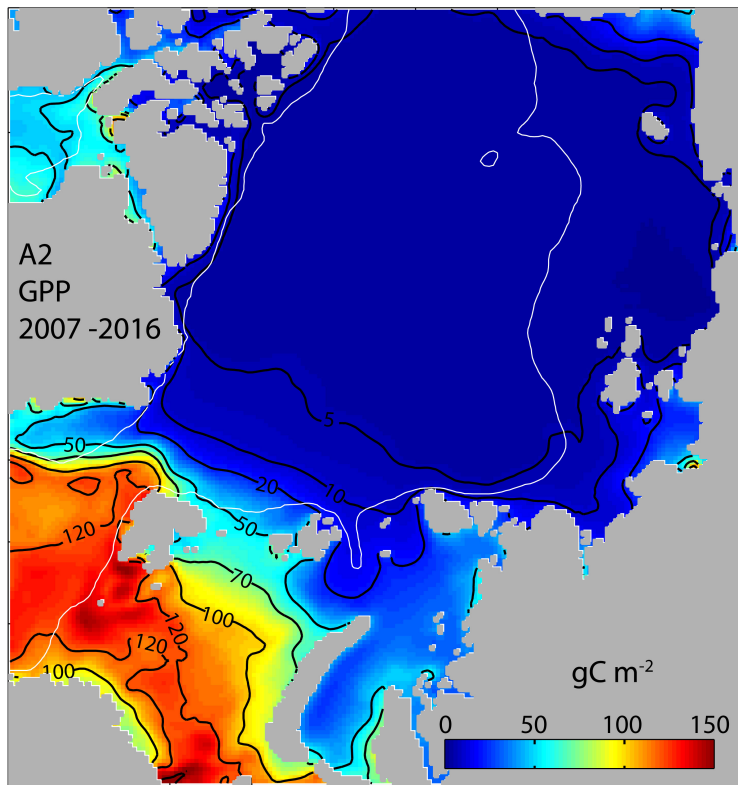
# What do models say about productivity?

- SINMOD (Slagstad, Wassmann, Ellingsen)

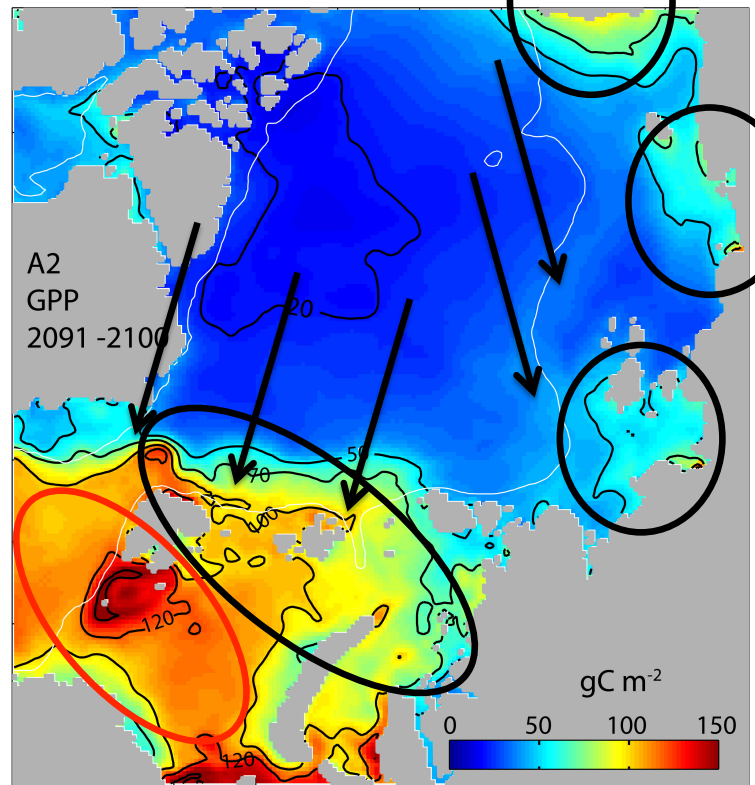
# IPCC A1B scenario (+3.8°C by 2100)

## Change in annual gross primary production

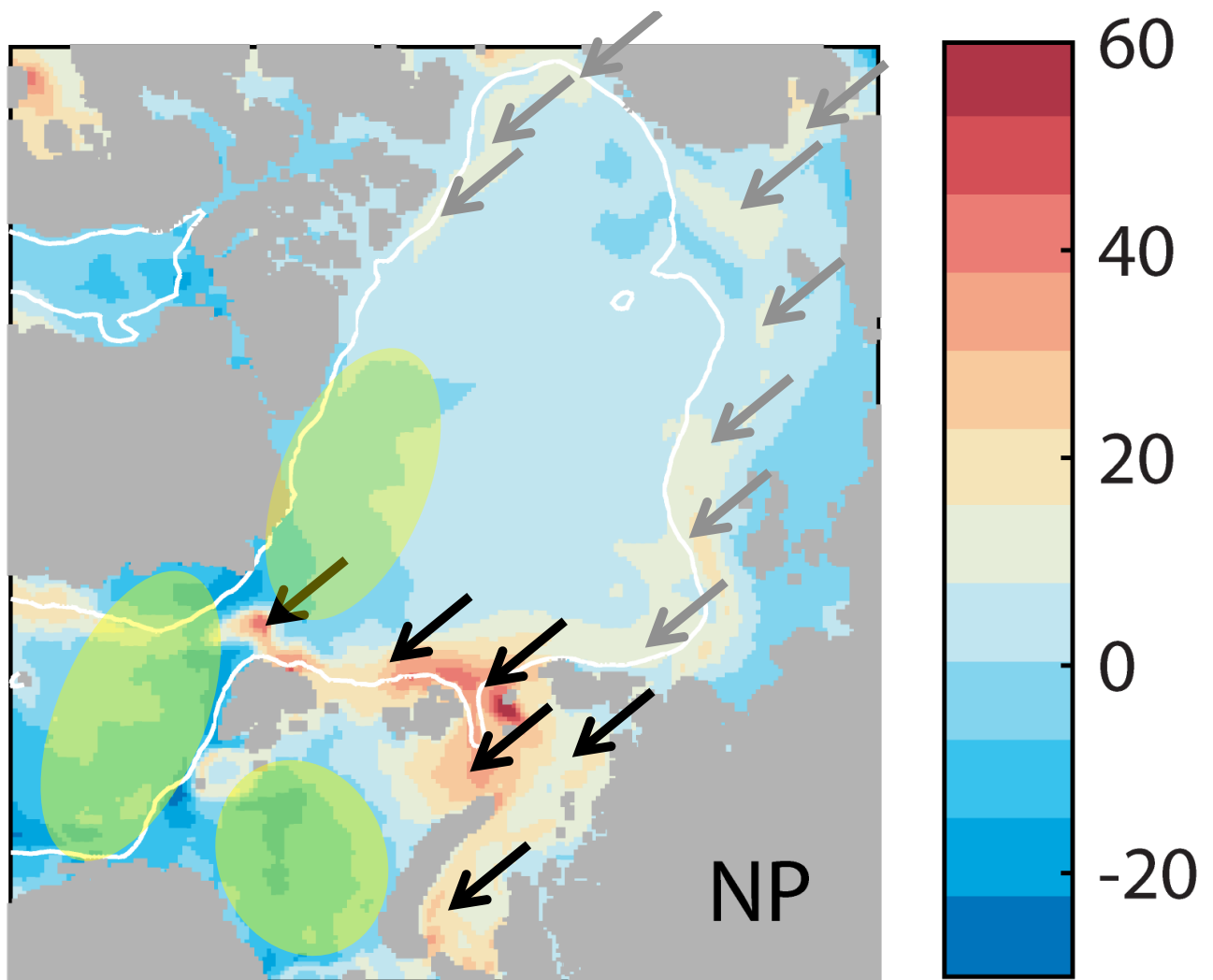
2007-2016



2091-2099







Difference in harvestable production at the end of this century ( $\text{g C m}^{-2} \text{ y}^{-1}$ ) (2100 minus today)

# Biological production in the Arctic Ocean

- Harvestable production may increase on average by  $20 \text{ g C m}^{-2} \text{ y}^{-1}$  on the Eurasian shelves.
- It stays low and seemingly decreases on the Greenlandic side, the Fram Strait and the Barents Sea

# Increased fisheries in the Arctic Ocean?

- To be expected north of Svalbard, in the Kara Sea and adjacent shelf
- Which commercial significant organisms will benefit from the increased production?



- The foreseeable future looks bright!

- Increased fisheries
- Shorter ship transportation
- Increased oil/gas and mining options
- How can we make sure that **shorter, increased and more** results in sustainability?





- The foreseeable future looks dark!

- The curse of the Cassandra syndrome
- How can this curse be lifted from the shoulders of climate change researchers?

# All human activities leave ecological footprints

- Ecosystem-based management of a changing Arctic Ocean



You cannot manage ecosystems  
that you do not measure and  
understand

Without understanding the present  
there is no sustainable future



# Ecosystem-based management of a changing Arctic Ocean

- Our ecological comprehension of the Arctic Ocean, even from the better-known regions, is inadequate
- Knowledge-based ecosystem management starts **before** environmental impact, not after.
- This procedure represents the meaning of the term sustainability



Let us investigate and understand  
ecosystems so that we can  
manage them





# Thank you

Photo: A. Sveen

# During extreme changes in climate science has difficulties to predict future states of ecosystems

- Extent of changes and speed of change is outside the "empirical window": there are no historic analogies
- Ecosystem models: predictive power when system is close to equilibrium, not when system is outside
- New and strongly disturbed ecosystem may arise, with unknown qualities.
- Climatic changes are accompanied by new infrastructure, new industries, new pollution sources: cumulative effects are notoriously difficult to predict



## With extreme changes in climate research of Arctic ecosystems ought to change modus

- More focus upon extensive and precise real-time observations than theoretical model projections
- More long-term and continuous than short-term campaigns and programmes
- More holistic and ecosystem-based than fragmented and indicator based programmes
- Changes in biological resources and diversity happens often through "cascade effects" along food chains



# How can we achieve a better ecosystem-based management in a changing Arctic Ocean?

- Time series in all major ecosystems of the Arctic Ocean
- More long-term and continuous than short-term campaigns and programmes
- More holistic and ecosystem-based programmes
- Our commitments ought be **as long-lasting as climate change continues**

- We should also consider an approach founded in **resilience thinking** to allow scattered local residents to participate in the indispensable long-term observation.
- This will improve their adaption and - if necessary - transformation of the social-ecological system within which they live

