Fishing
in Arctic Waters

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Danmarks Grundforskningsfond
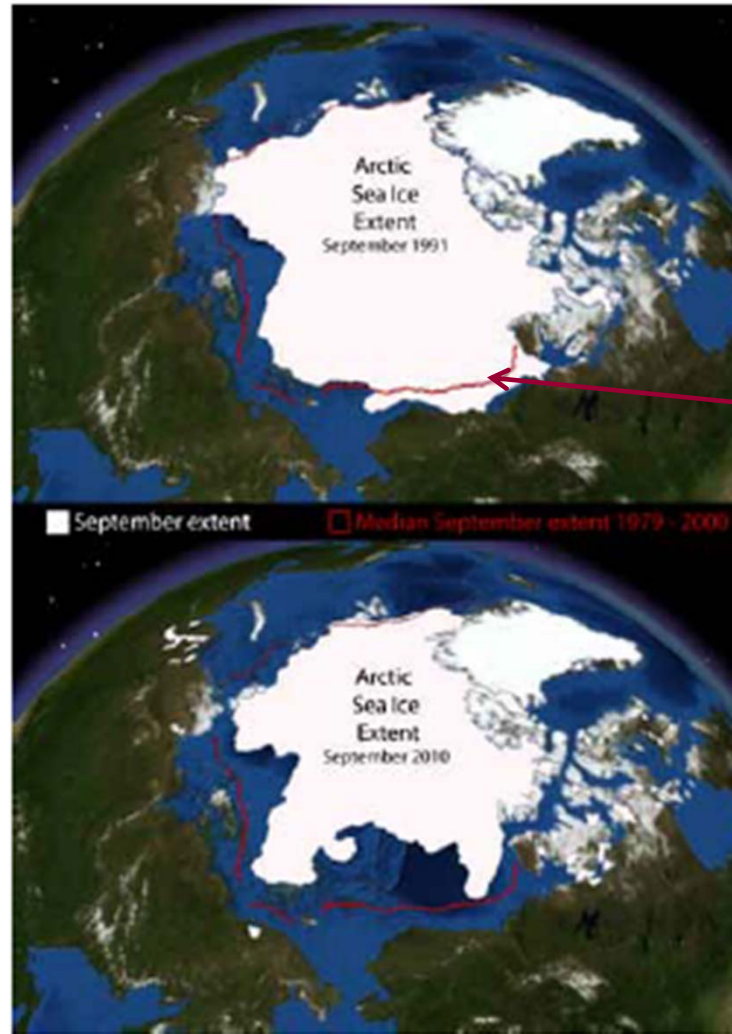Danish National Research Foundation
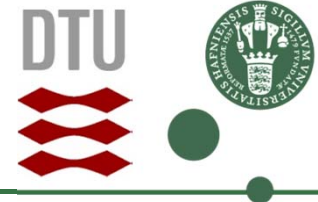
Center for Macroecology, Evolution and Climate

National Institute for Aquatic Resources (DTU Aqua)

Technical University of Denmark

Arctic Sea Ice is Melting

September Arctic Sea Ice Extent

-35% since 1992
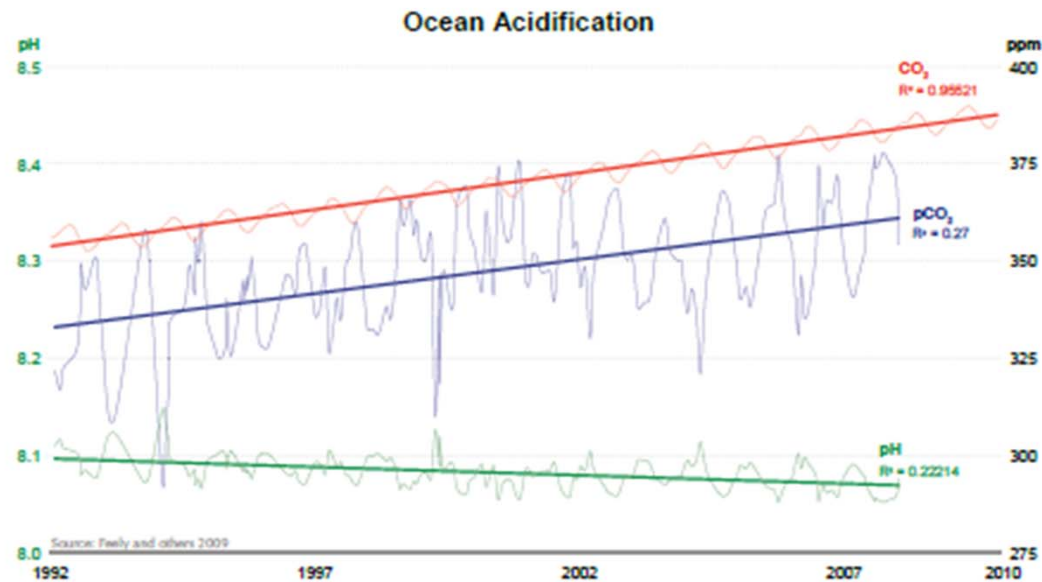
Source: NSIDC
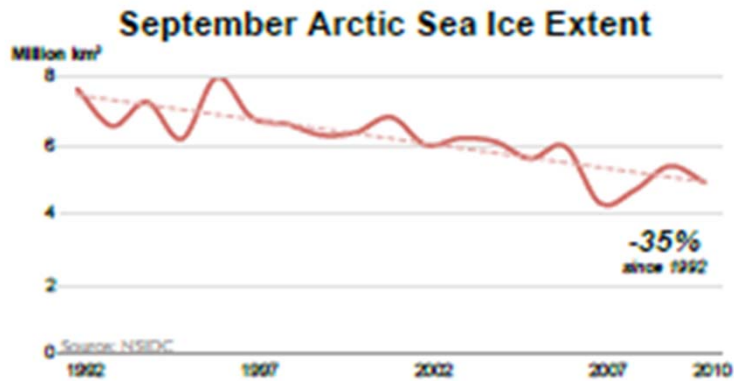
1991

Median 1979-2000

2010

UNEP 2012

Oceans are Becoming More Acidic

Oceans are becoming more acidic, with negative
implications for corals and other marine life

UNEP 2012

pH is falling…

Climate Change Impacts on Fish Populations

Climate change is expected to have significant direct and indirect impacts on fish populations at various stages in their life histories, including:

-distribution and migration (timing, location, duration)

-stock size/abundance

-spawning and reproduction

  -growth

  -natural mortality (vulnerabiltiy to predators, diseases)

-creation of new suitable habitats (areas with favorable T, S, currents, etc.)

-catchability, availability = fishing possibilities

MacKenzie et al. 2007 Glob. Ch. Biol.

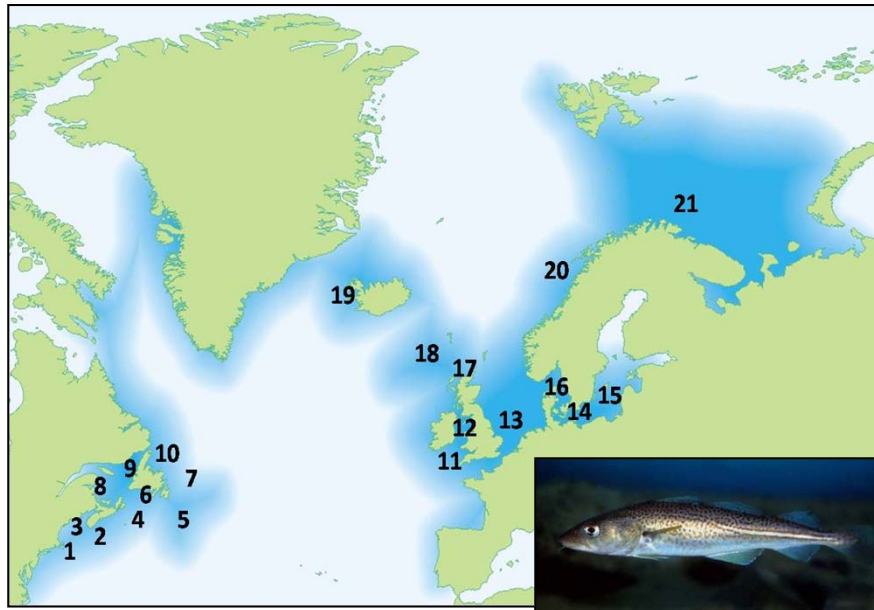MacKenzie and Brander 2009

Fishing in the Sub-Arctic

Fisheries are one of the economically
most important maritime activities
in sub-arctic areas

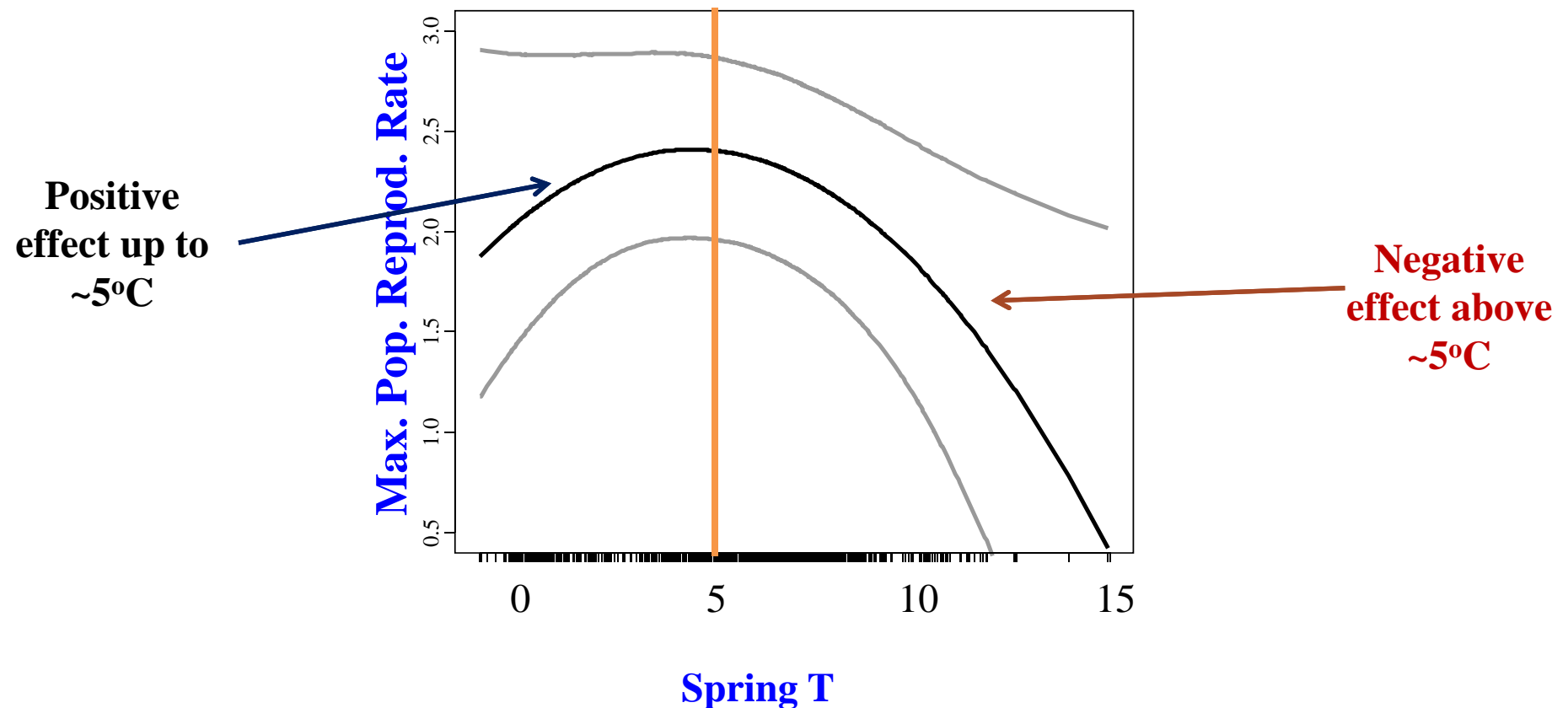-is likely to increase and expand north.
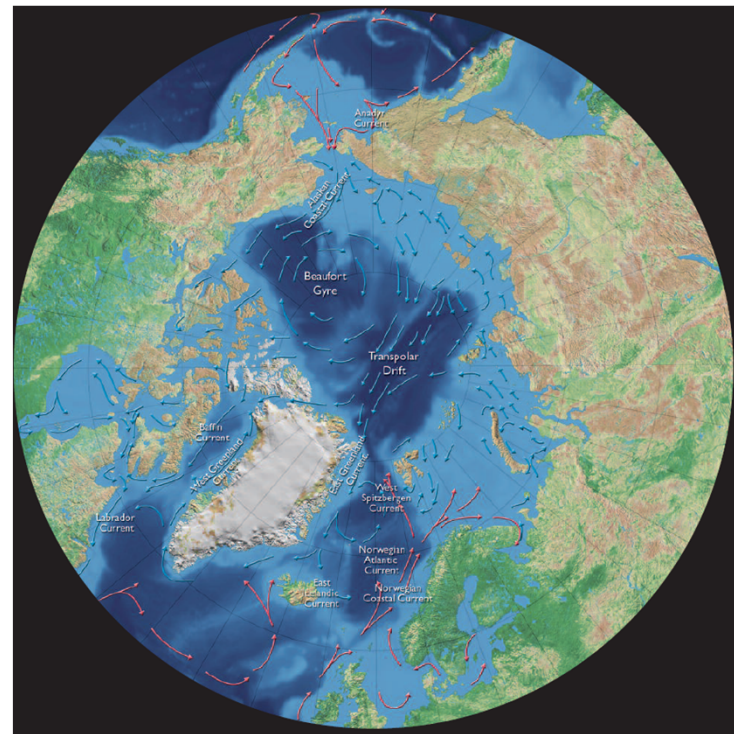
Cod Population Growth Rate and Temperature

20 Cod Populations in North Atlantic:
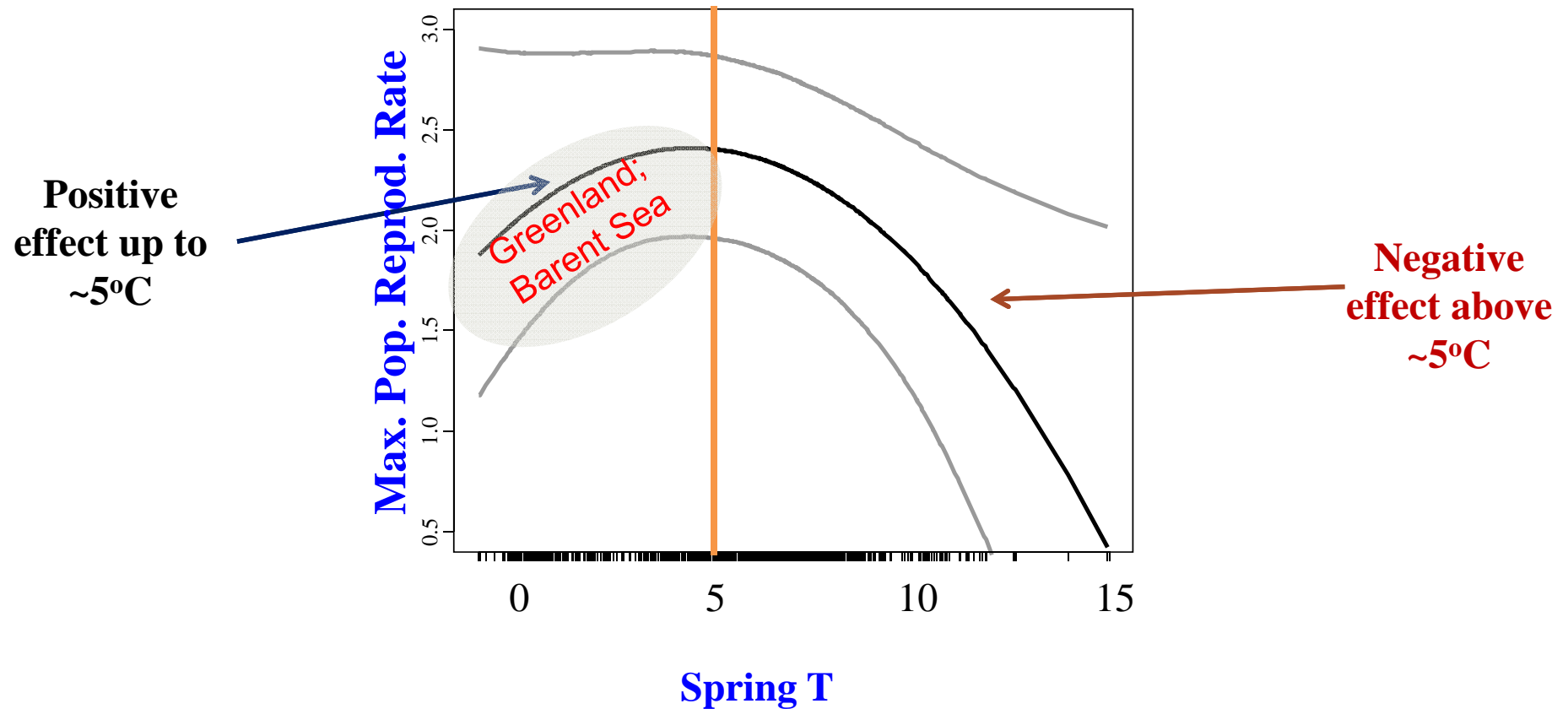

– each with different temperature conditions

- past population dynamics can be considered a natural comparative experiment

Effects of Temperature on Max. Reproductive Rate in 20 Cod Pops.

Positive effect up to ~5°C

Negative effect above ~5°C

Max. Pop. Reprod. Rate

Spring T

Mantzouni et al. 2010 ICES J. Mar. Sci.
Mantzouni & MacKenzie 2010, Proc. Roy. Soc.

Effects of Temperature on Max. Reproductive Rate in 20 Cod Pops.

Positive effect up to ~5°C

Greenland; Barent Sea

Negative effect above ~5°C

Max. Pop. Reprod. Rate

Spring T

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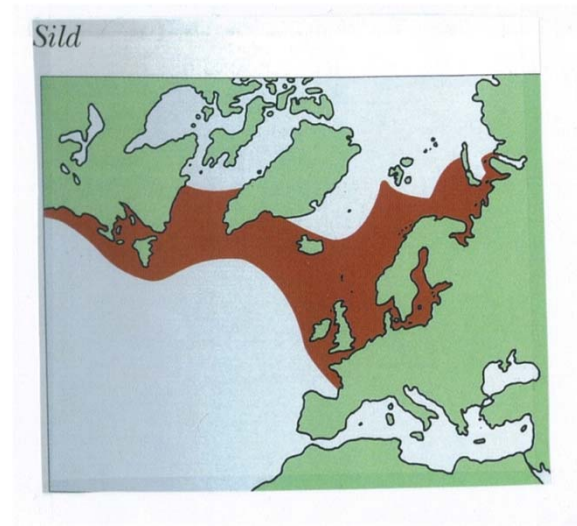Mantzouni & MacKenzie 2010, Proc. Roy. Soc.

Geographical Ranges of Some Commercially Important Fish Species
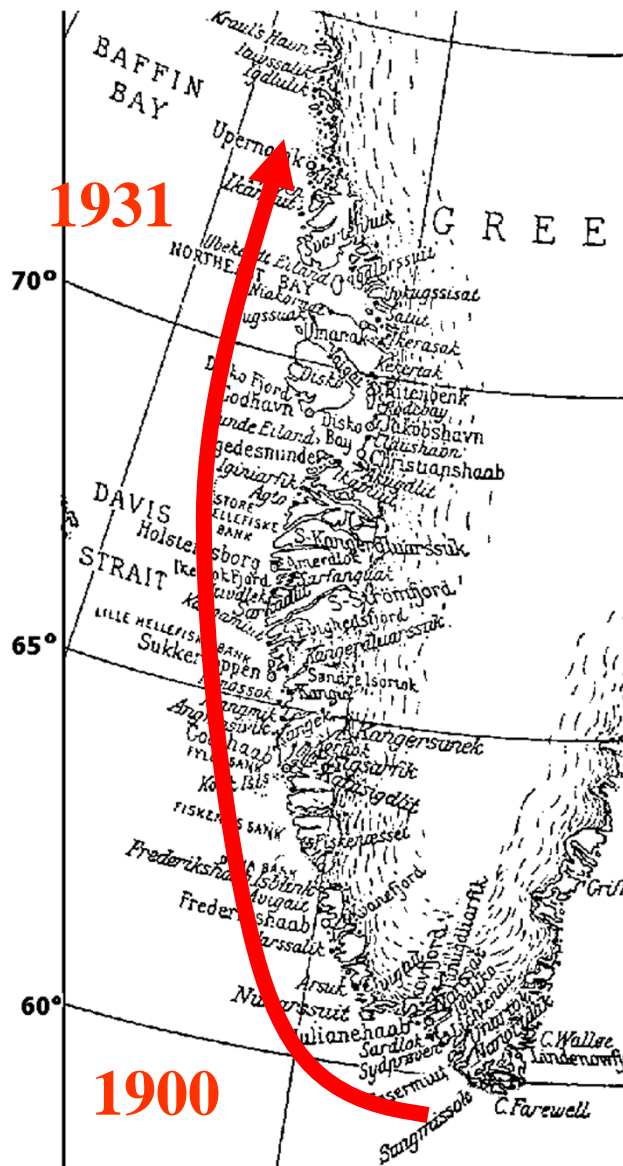
Cod
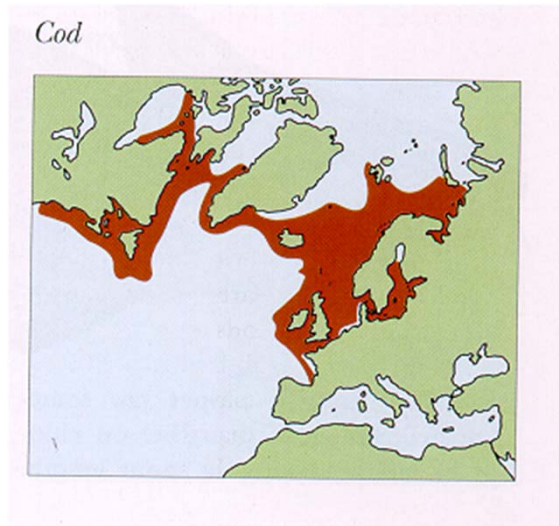
Herring

Muus et al. 1999

-can expect northward shifts in ranges as temperatures increase

Distribution of Cod at West Greenland

➤ 1900 Cape Farewell & Fiskenæs Bank

➤ 1917-18 Frederikshaab

➤ 1919 Godhaab

➤ 1922 Sukkertoppen

➤ 1927-30 Christianshaab og første direkt bevis for gydning (DANA 1925)

➤ 1931-36 Umanak

➤ Late 1930's Upernavik

➤ Late 1960 decline and retreat

Change in geographic distribution = 1000 km during 30 years

Jensen 1939,
K. Brander, DTU Aqua

Projected Changes in
Catch Levels and Distributions

Change in catch from 2005 to 2055 (t/km^{-2})
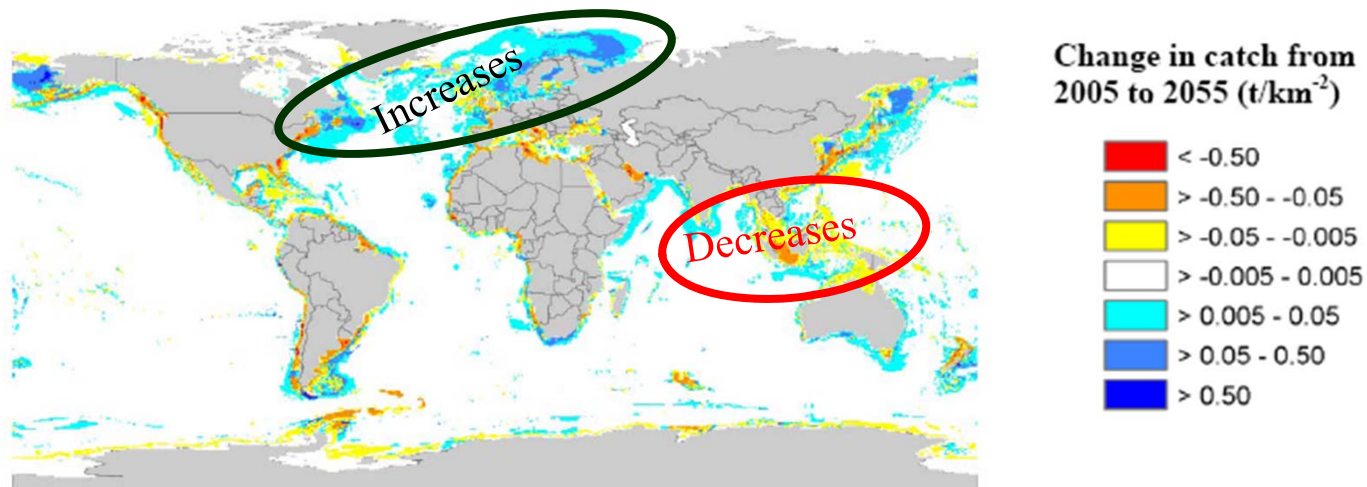
Biggest decrease expected in region with highest human population

-consequences for global fish trade?
-consequences for a future Arctic fishing industry?
-consequences of international fisheries management?

Cheung et al. 2009
GCB

Atlantic Salmon Migration
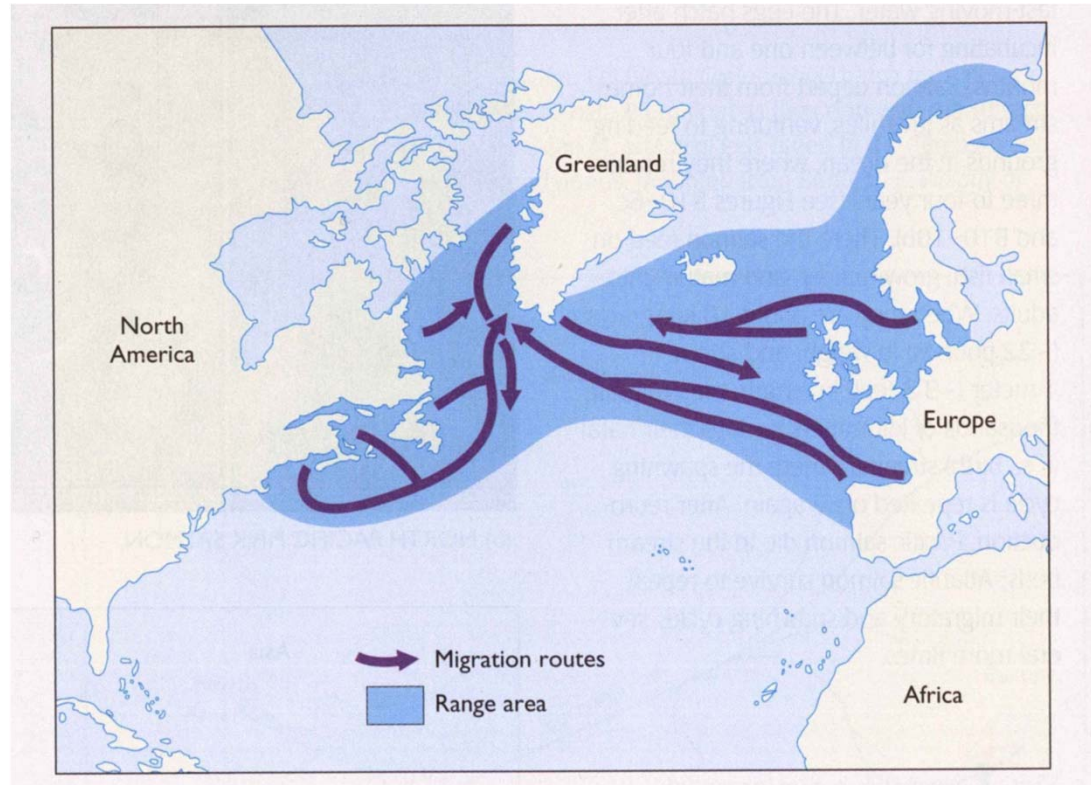
-how will these migration routes, feeding areas and spawning sites differ when temperatures are 2-4 C warmer?

Pinet 2009

Some Basic Fisheries Ecology…(1)

Several species which have the largest landings and fisheries on global basis are found in boreal/northern waters:

Pelagic (open-water) species such as
-herring, capelin, mackerel, blue whiting

Demersal (sea bottom) species such as
-cod, w. pollock, flatfishes (halibuts, plaice, flounders)
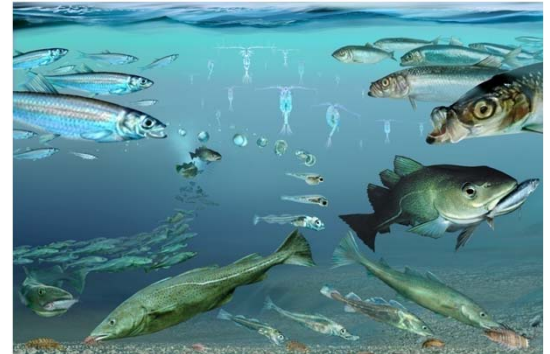
But these species presently are not abundant in the Arctic Ocean.

Some Basic Fisheries Ecology…(2)

Where do the most commercially important fish species live?

-mostly on continental shelves and their slopes to the deep ocean:

ca. 90% of global commercial landings are made on continental shelves even though these areas represent only 7% of ocean area
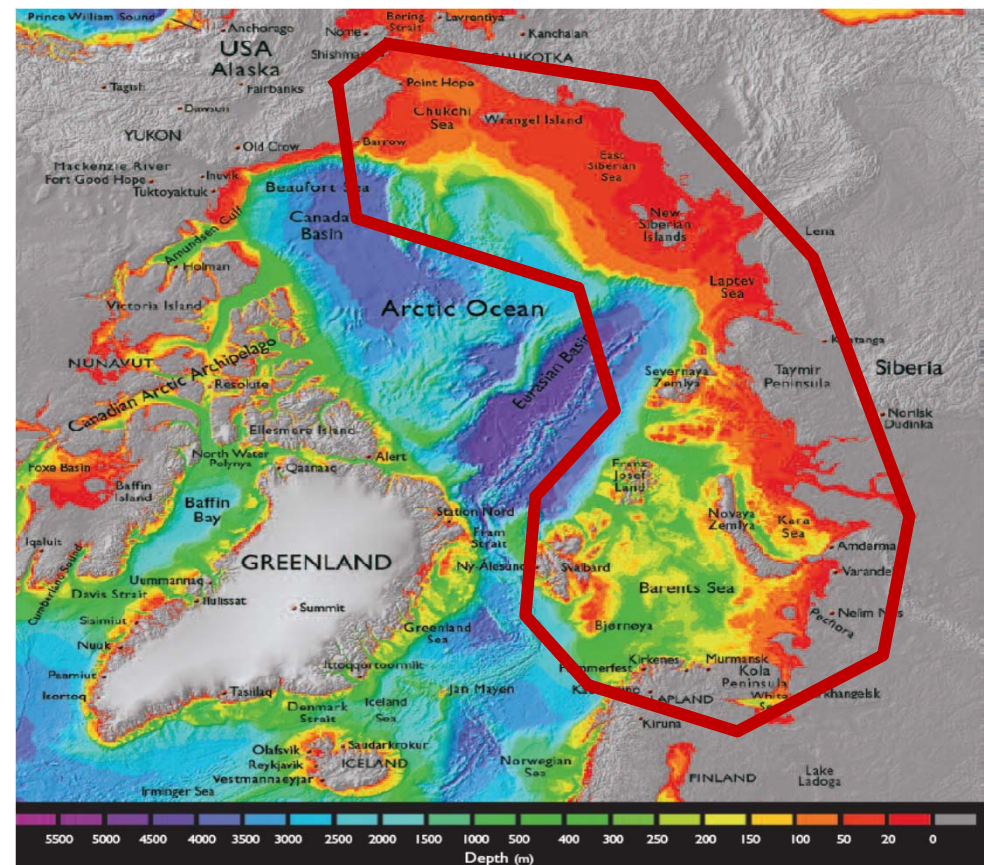
(Postma & Zijlstra 1988)

Where are continental shelf regions in the Arctic Ocean?

Continental Shelf Areas as Fish Habitat

-shallow shelf areas (0 – 200 m) will become more important fish habitat as the Arctic Ocean warms.

-the largest shelf area in the Arctic Ocean lies north of Norway and Russia

EFARO 2009

Fisheries and Fish Biomass in the Arctic Ocean

For fisheries to be commercially viable, there must be large biomasses of marketable species (e. g., cod, pollock, flatfishes, herring).

Most existing species in the Arctic Ocean support minimal fisheries.

In future, the main commercial species to the south will likely spread into parts of the Arctic Ocean.

How large could those biomasses be?

Future Fish Biomass in the Arctic Ocean?

Can be estimated using various modelling and ecological approaches.

Sizes of continental shelves could be indicators of potential abundance
   i. e., "area-abundance" relationships based on existing data in other
      areas

   e. g., consider cod and its mean biomass in 20 different
   regions of the North Atlantic

Cod Abundance-Area Relationship
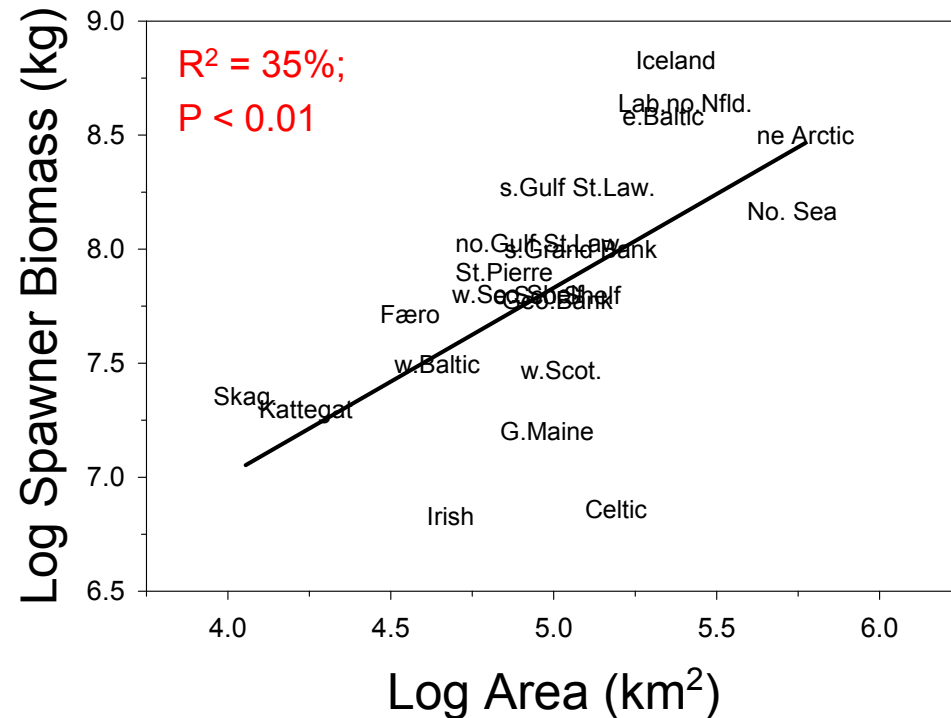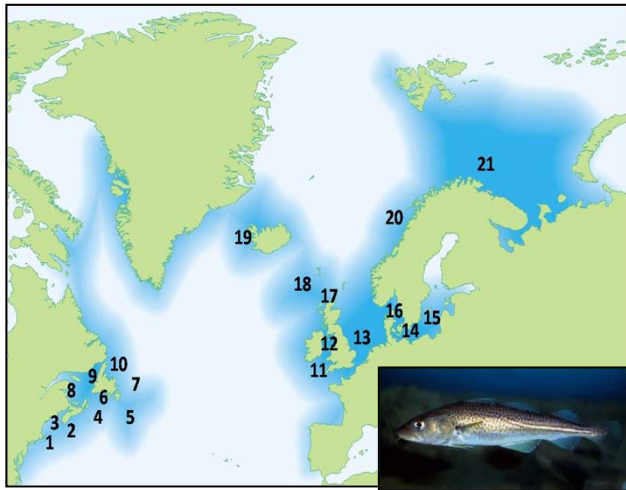
Mean cod spawner biomass in 20 stocks
is related to habitat area

MacKenzie et al. 2003
MEPS 248: 209-220

Baselines and Conservation Issues

Conditions in the Arctic are presently changing due to climate change

Ecological knowledge is scarce – the region is understudied compared to southern regions

-many new species waiting to be discovered

-abundances of discovered and undiscovered species not known

-habitats (e. g., spawning, nursery areas) not mapped, etc….

Fishing Impacts on Species and Ecosystems

-reduction of population sizes to unsustainable levels
→ lower yields, lower economic returns

-destruction of habitats due to towed fishing gear
→ loss of habitat-forming species such as
cold-water corals, kelps, seaweeds

-changes in foodweb structure in ecosystems
→ increased vulnerability to other perturbations (e. g., climate change, invasive species) and to decline and collapse

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Urgently need to develop baselines for detecting and documenting future changes and attributing causes.
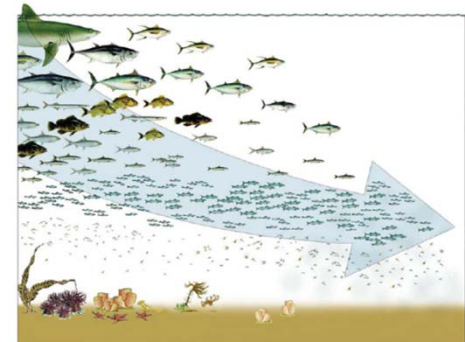
Research Needs

"Scoping" surveys – find out what species and habitats are present and
where they are located

Create baselines of abundances and distributions so changes due to
fishing, climate change and other human activities can be detected
and attributed

Improved ecosystem monitoring – develop data monitoring and
observational abilities and infrastructures (e. g., in situ measuremments,
Satellites, ships, etc.)

Develop oceanographic, population and ecosystem modelling capabilities

Sustainable Fisheries Depend on Renewable Resources

Need good international stewardship and governance to ensure a balance between exploitaiton and reproduction

if no reproduction $\longrightarrow$ no new fish $\longrightarrow$ populations collapse

*That's why fish populations are **renewable** resources and oil, gold, and diamonds are not!*

→ Must ensure that fishing and other human impacts don't reduce reproductive capacity of populations.

Conclusions:

-fisheries in northern waters and the Arctic may greatly benefit from predicted temperature increase

-can expect dramatic shifts in distribution and abundance of commercial fish and shellfish stocks
- -in and out of national jurisdictions and through international waters
Candidates: mackerel, herring, capelin, cod, northern shrimp, king crab, Pacific species, etc.

-limited knowledge on dynamic changes that may and are taking place
- -scaling up and far reaching *international cooperation in research and monitoring* is a necessary basis for future management because these are vast ocean areas

Thank you