Effects of climate change on the fish stocks in the high north seas

ScanBalt Academy Meeting 2010, Svalbard
Recent Ecological, Biological and Medical Challenges in the High North

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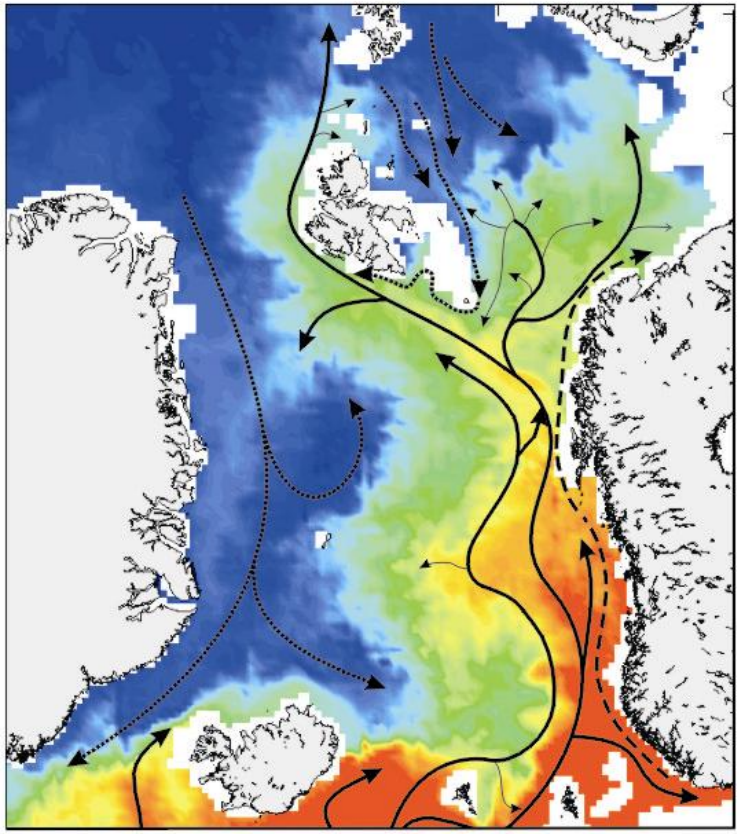
Overview

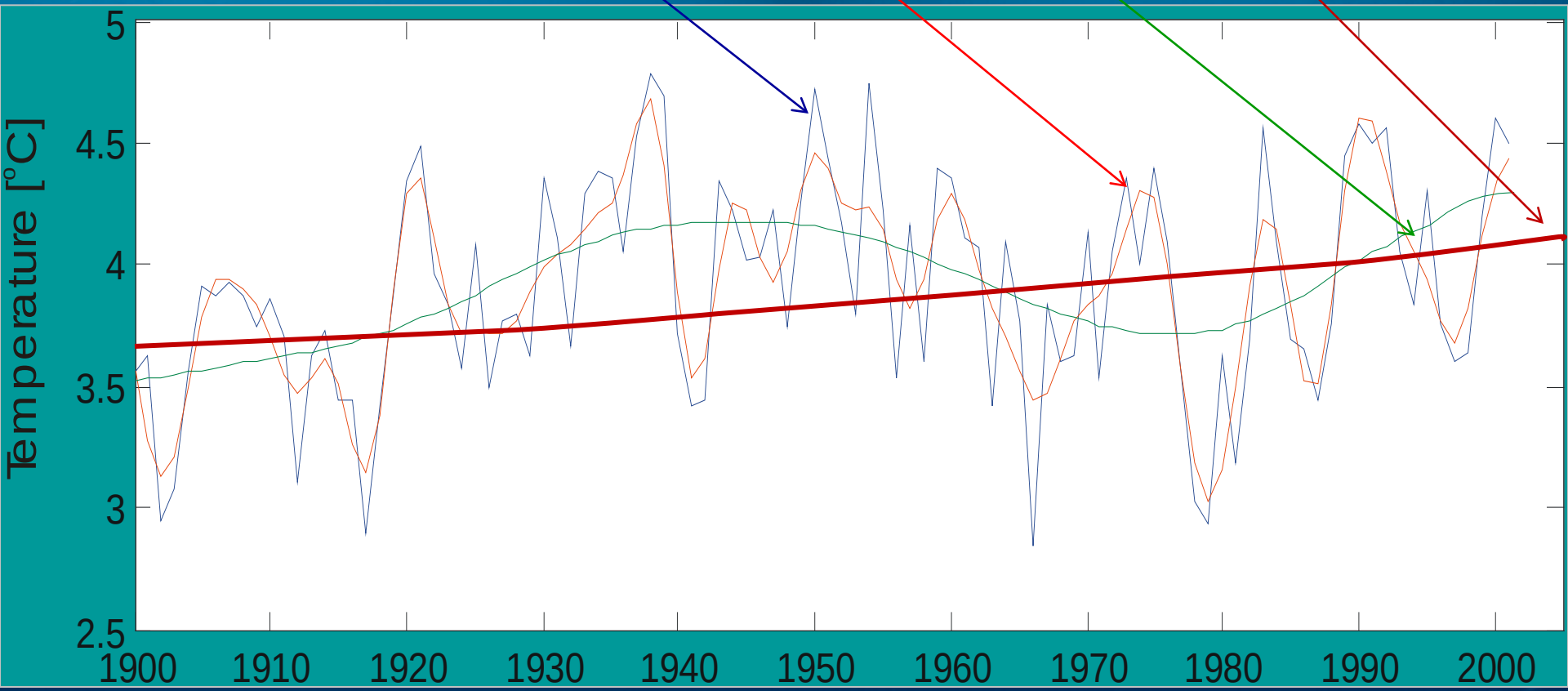
- Focus on the Barents Sea
- Climate variation on different time scales
- Important fish species
- Effects of climate variation
  - Geographical distribution
  - Biological production
- Climate variation and the marine ecosystem
- Possible consequences for the fisheries

Where two climate regimes meet

- In the Arctic warm and cold waters meet
- Cold waters is ice covered during winter
- Climate change impacts differently on these regions
- The biological communities differ between these regions
- Boreal fish species vs. arctic fish species

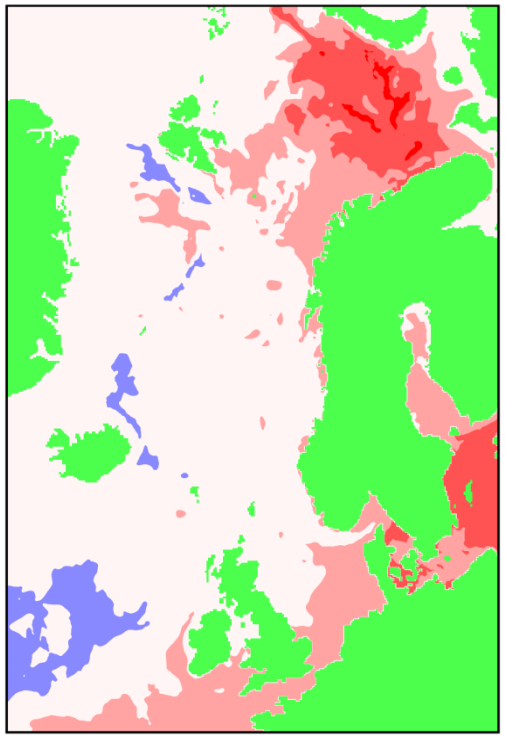


Climate variation at different time scales

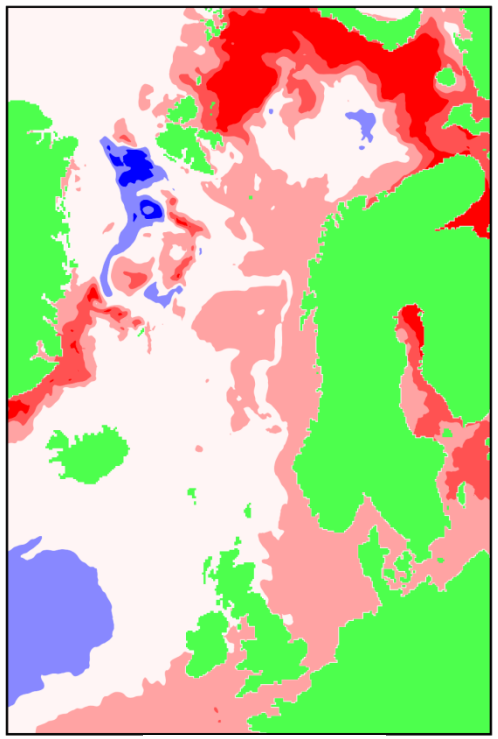


Heating of the Barents Sea

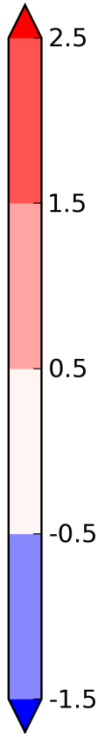
Change from present to 2050-2065



Winter



Summer

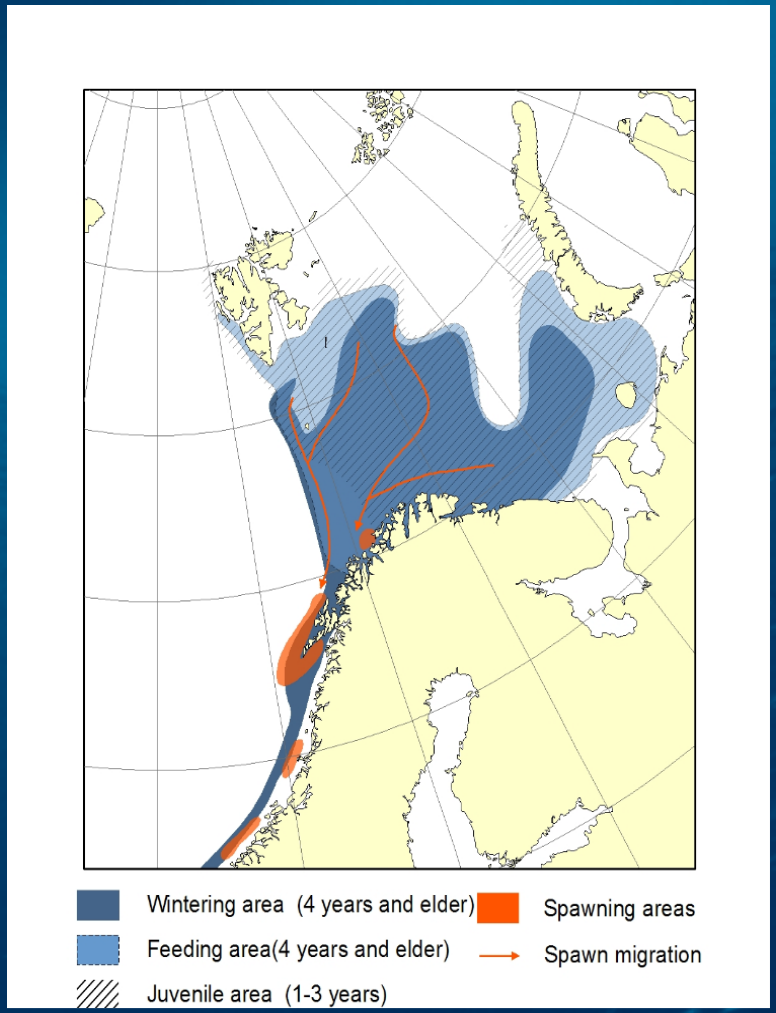


Fish species in the Barents Sea

- More than 200 species from 70 families have been registered
- Boreal vs. Arctic species
- Pelagic vs. benthic species
- Several of them have parts of their life cycle outside the Barents Sea

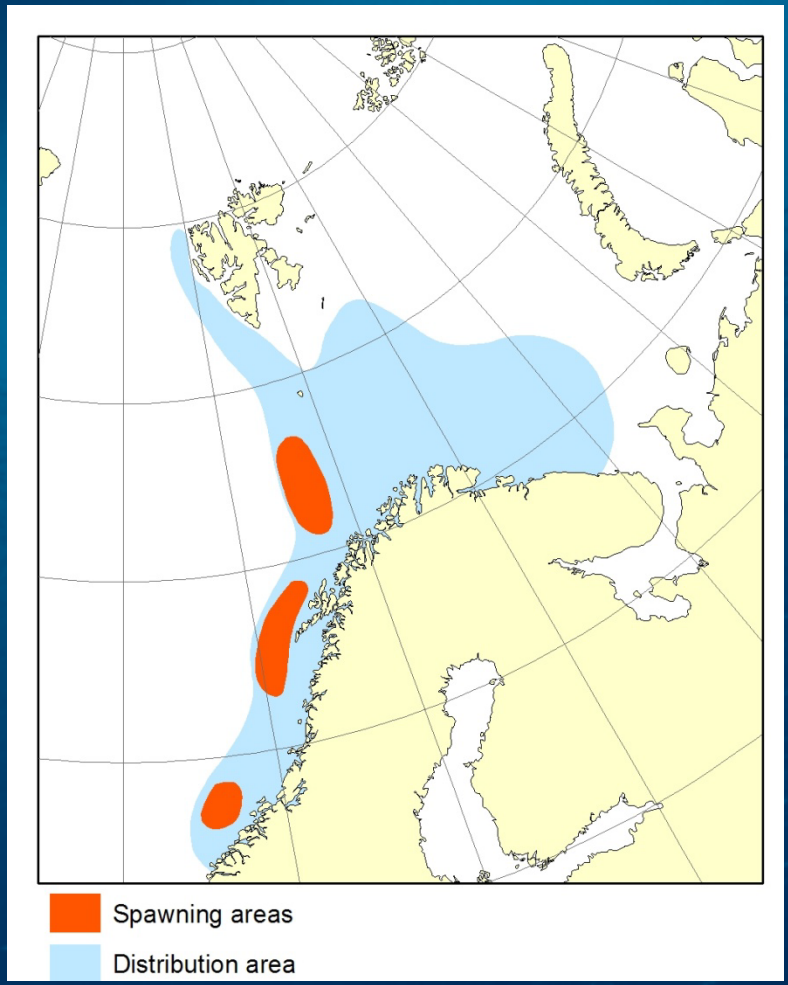
Boreal species

- Northeast Arctic cod (*Gadus morhua* L.)
- Important predator in the system
- Benthic to bentho-pelagic



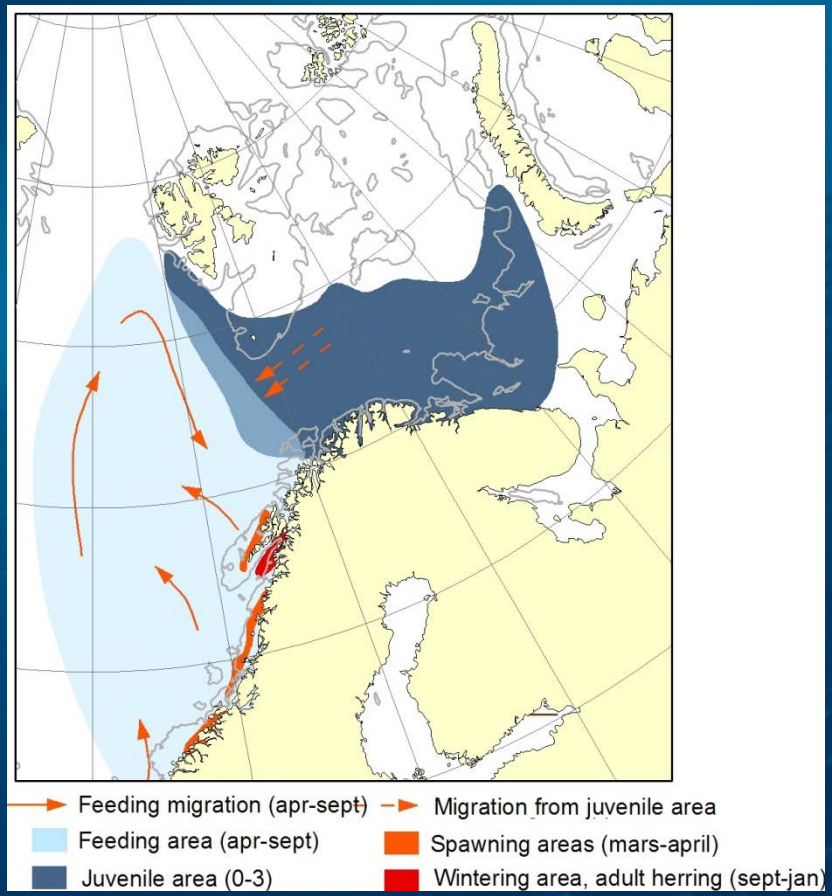
Boreal species

- Northeast Arctic haddock (*Melanogrammus aeglefinus* L.)
- Benthic to bentho-pelagic



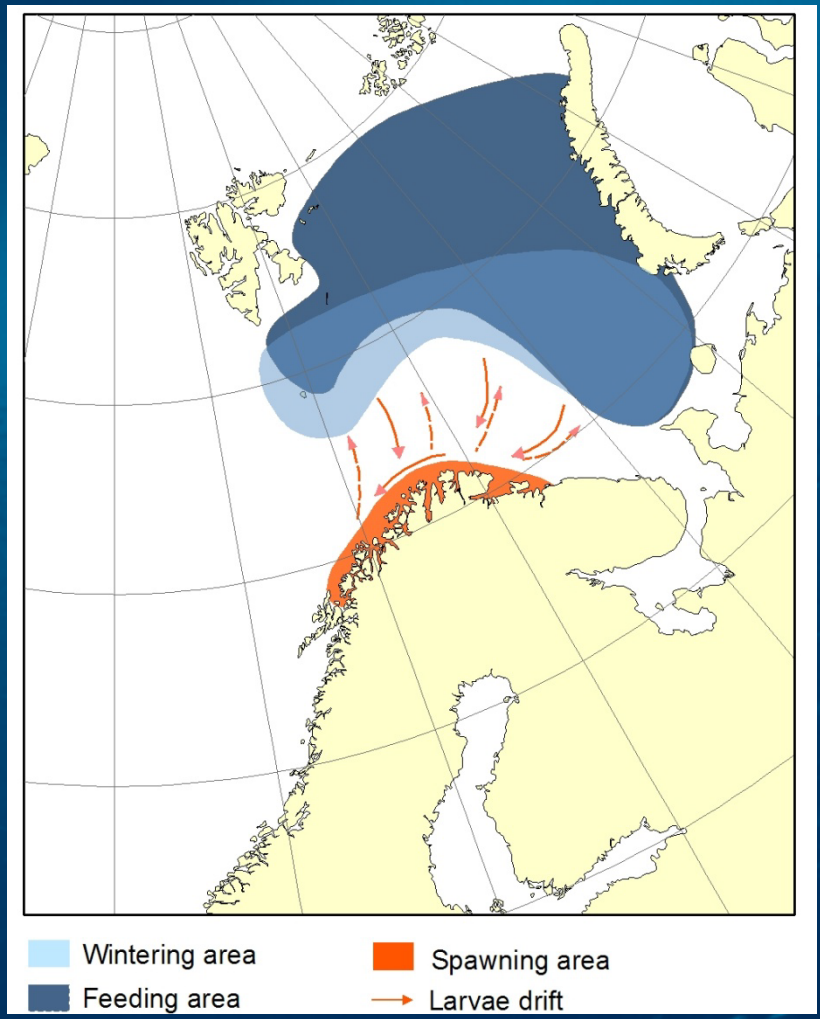
Boreal species

- Norwegian spring-spawning herring (*Clupea harengus* L.)
- Barents Sea only as nursery area



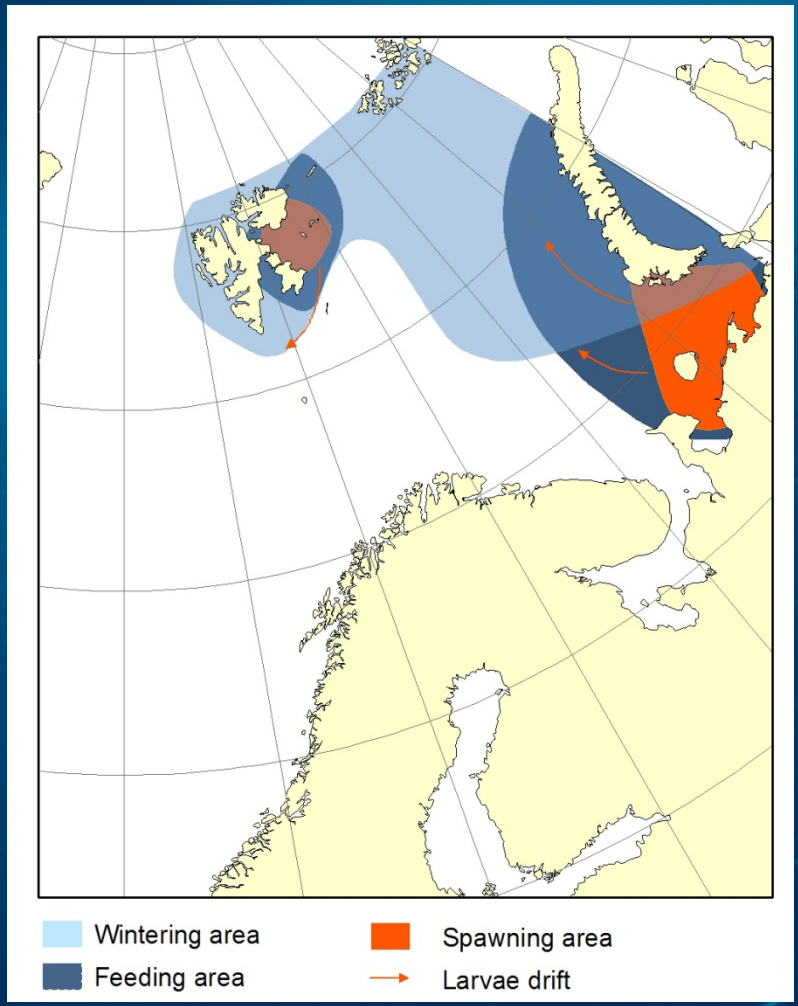
Arctic species

- Capelin (*Mallotus villosus* Müller, 1776)
- Important forage fish for several predators
- Pelagic



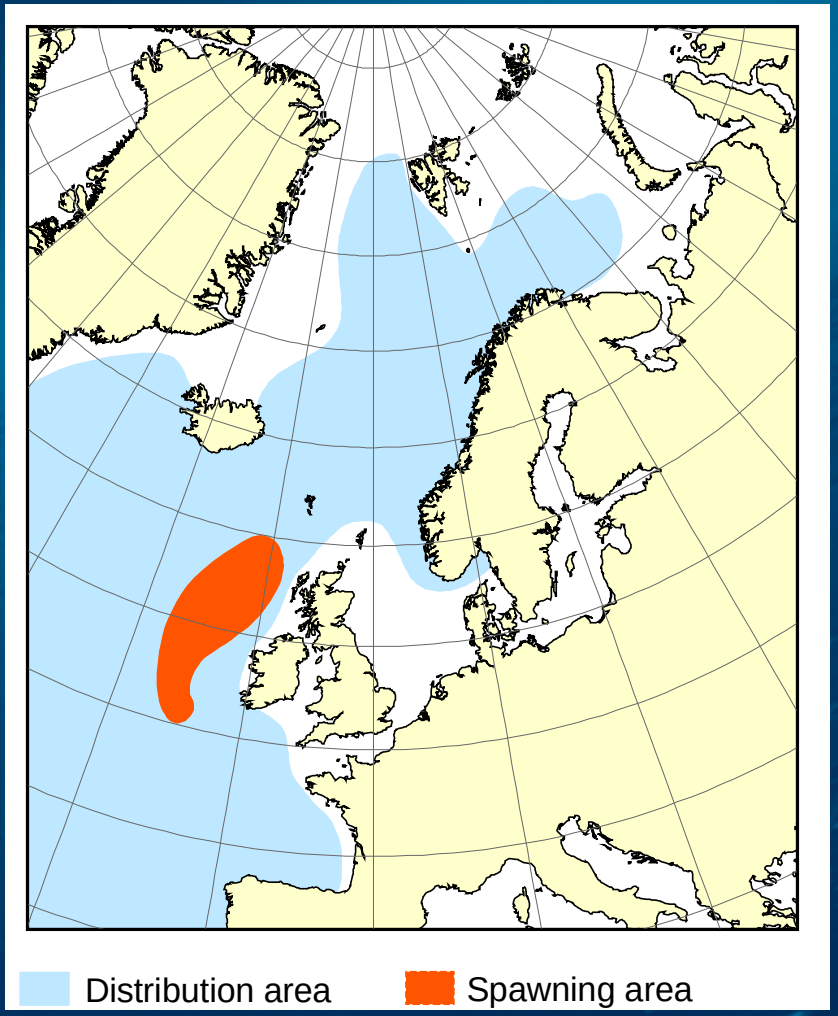
Arctic species

- Polar cod (*Boreogadus saida* Lepechin, 1774)
- Pelagic fish
- Important at the ice edge



Other interesting species

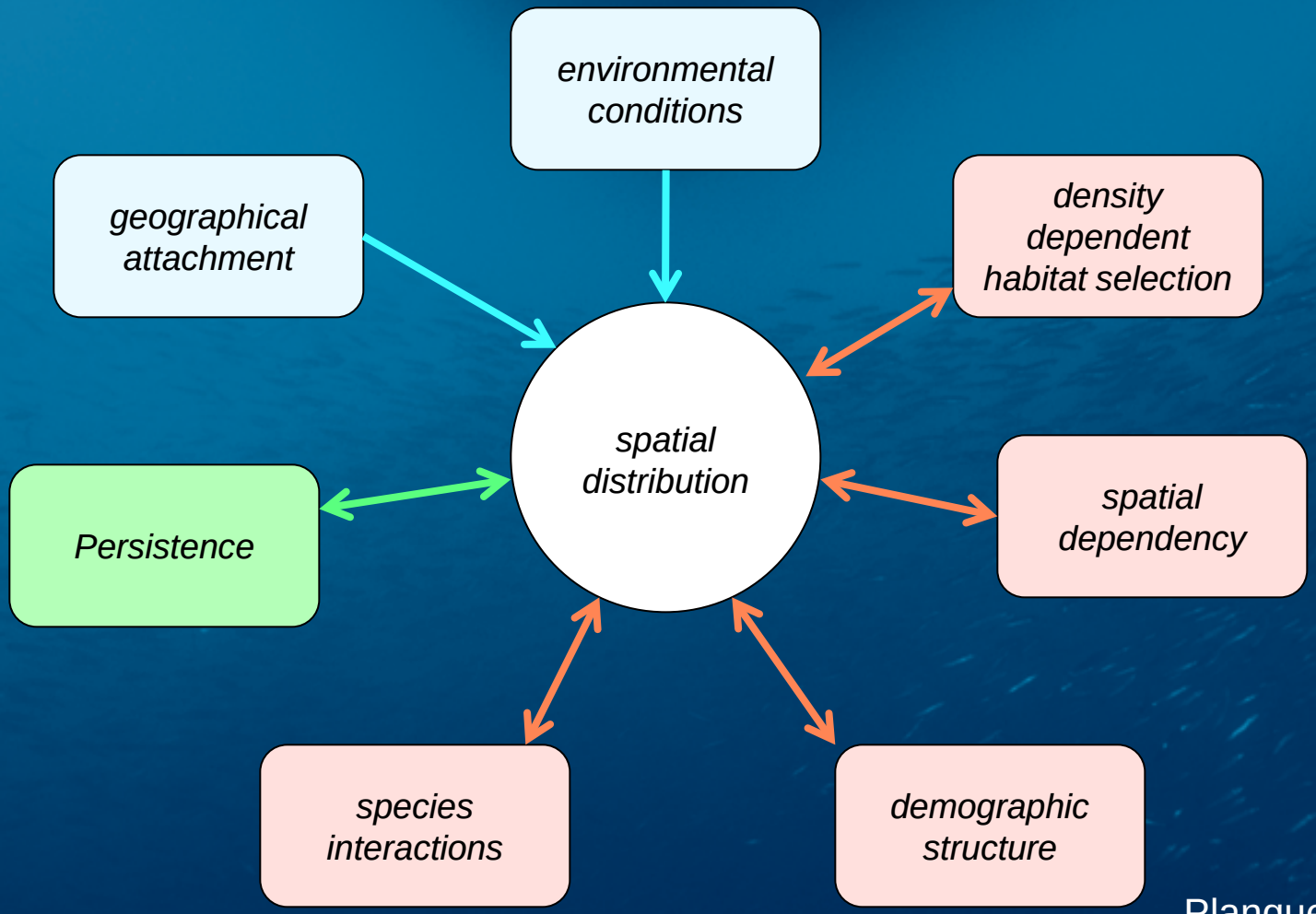
- Blue whiting (*Micromesistius poutassou* Risso, 1827)
- Entering the BS from south-west
- High abundance in 2001-2007
- Interact with other species



Other interesting species

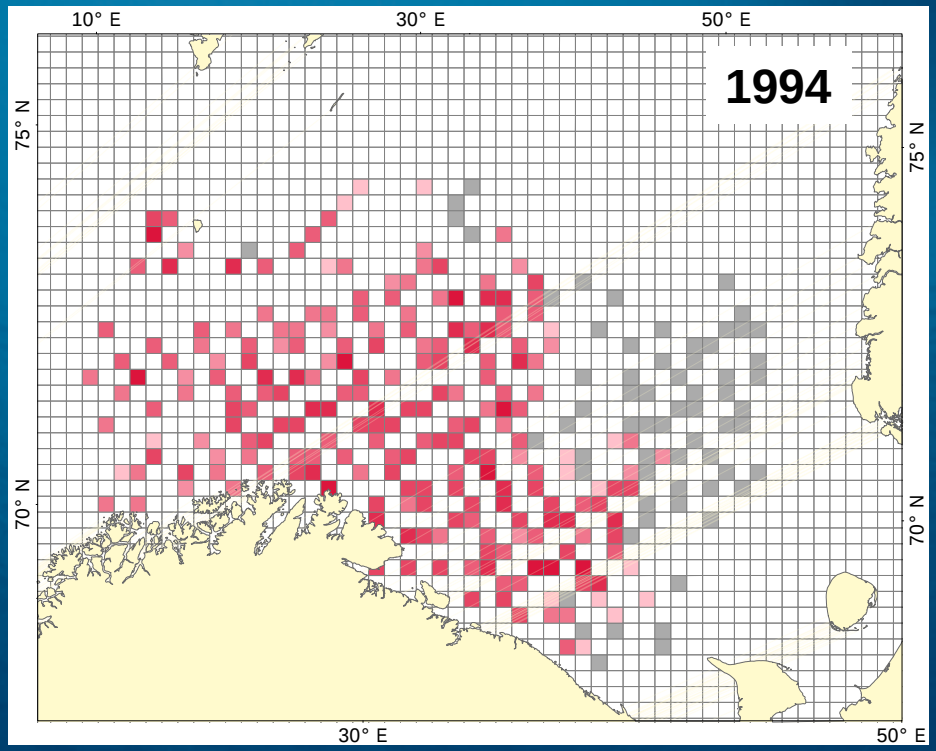
- Atlantic mackerel (*Scomber scombrus* L.)
  - Observed at least as north as 74°N
  - Recently caught off the Murman coast
- Several fish species related to benthic habitats (e.g. eelpouts (*Zoarcidae*) and sculpins (*Cottidae*)
  - Habitat specific
  - Sensitive to temperature variation

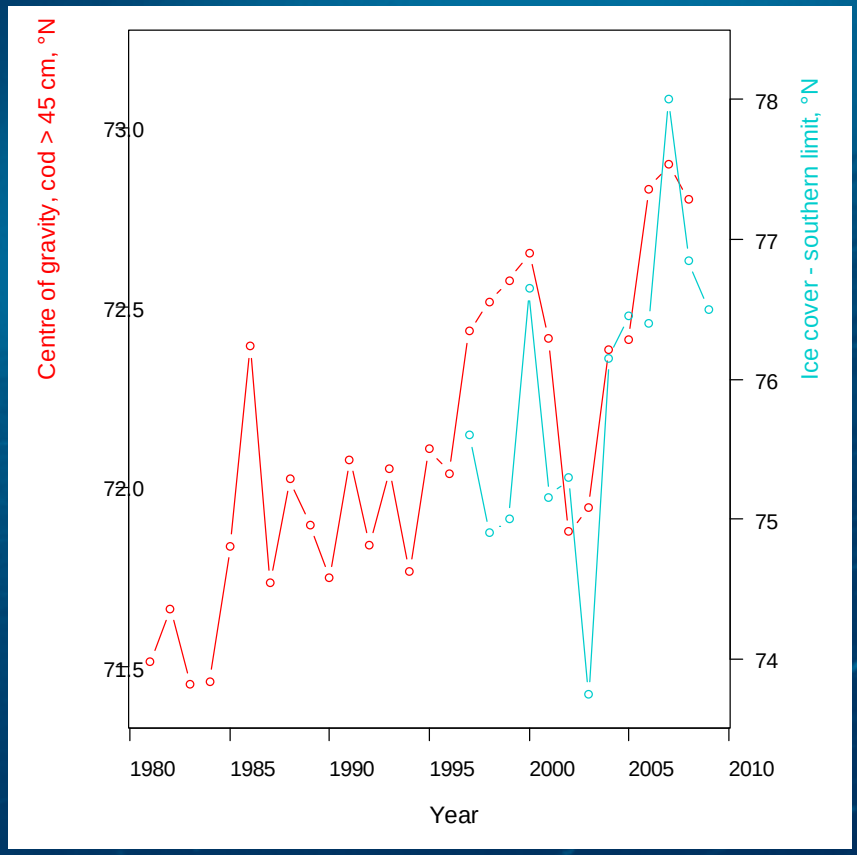
Factors influencing geographical distribution



Planque et al. 2010

Distribution of NEA cod





Distribution of NEA cod

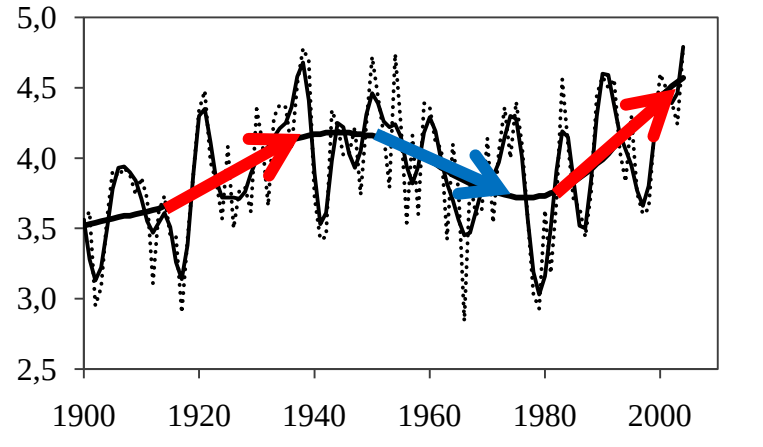
In the Barents Sea, cod appeared in large quantities on Bear Island Bank in response to the warming of the early 20th century, resulting in the reestablishment of a cod fishery there after an absence of almost 40 years (Blacker, 1957). Cod also penetrated farther east to Novaya Zemlya and north of West Svalbard, during the 1920s (Beverton and Lee, 1965). Similar effects at west Greenland and Iceland.

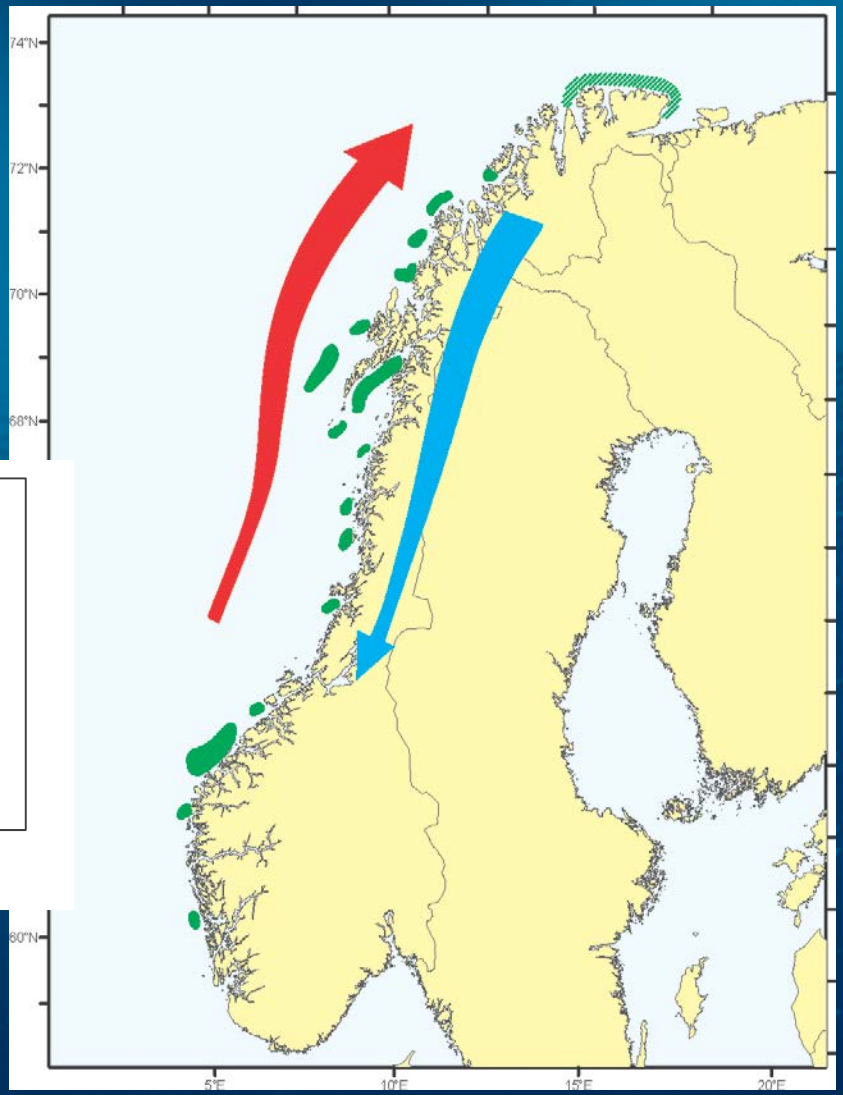
Drinkwater 2005

Spawning sites of NEA cod

Hot periods
- Northwards displacement
- Increasing spawning biomass

Cold periods:
- Southwards displacement
- Decreasing spawning biomass



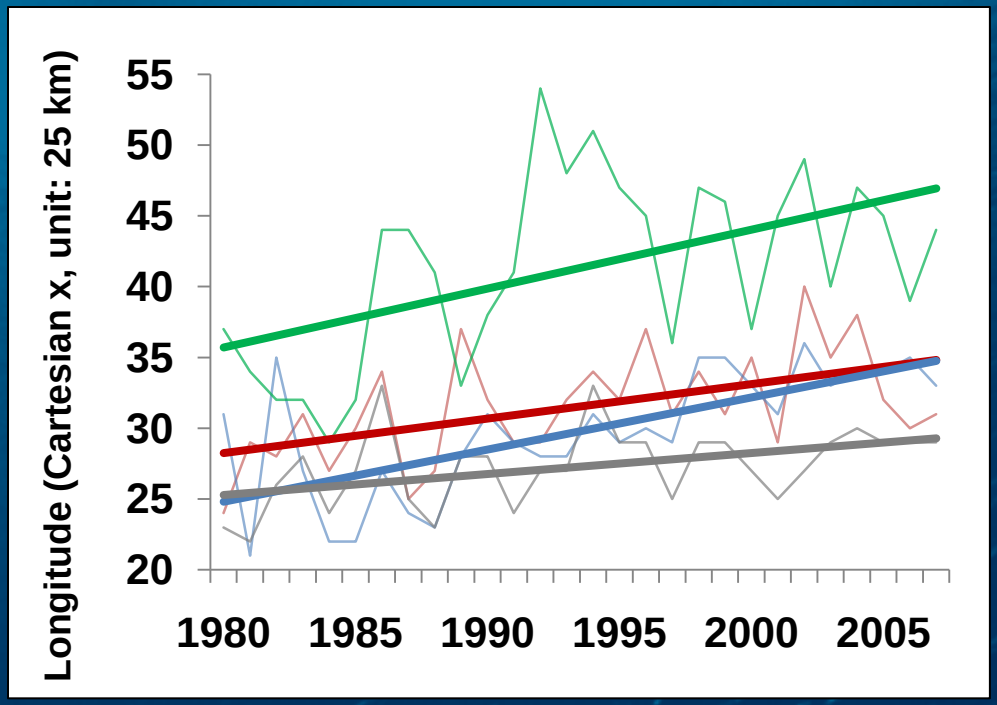


Sundby and Nakken (2008) IJMS

NEA cod the first year of life

- Easterly shift in centre of distribution during the period 1980–2007
- Magnitude of shift:
  - Cod: 120 km
  - Herring: 160 km
  - Haddock: 90 km
  - Capelin: 220 km

Centre of distribution (east) of 0-group cod, haddock, herring, and capelin

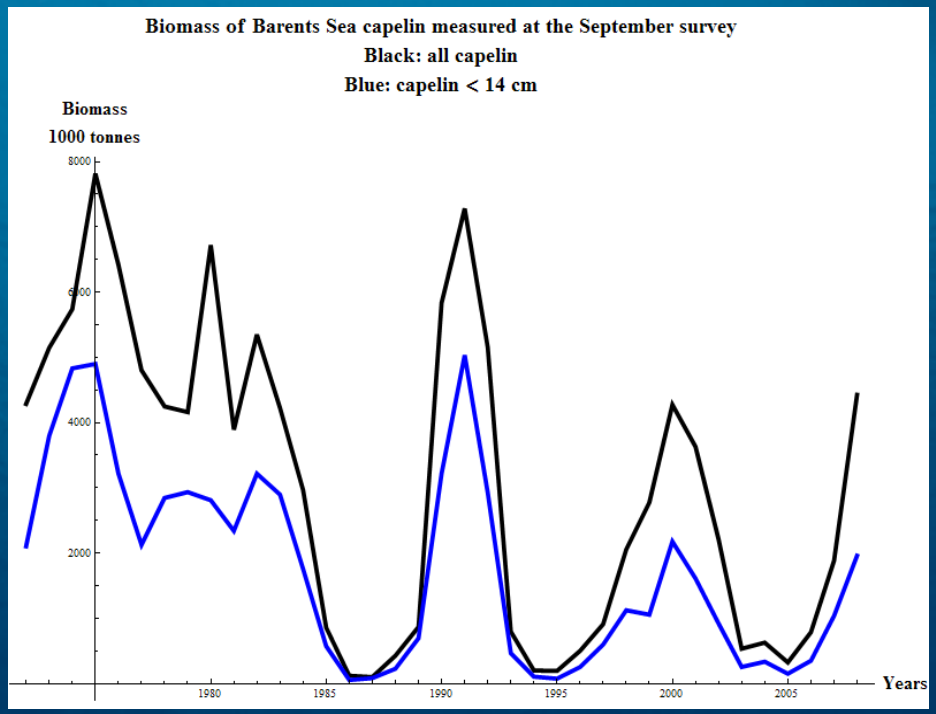


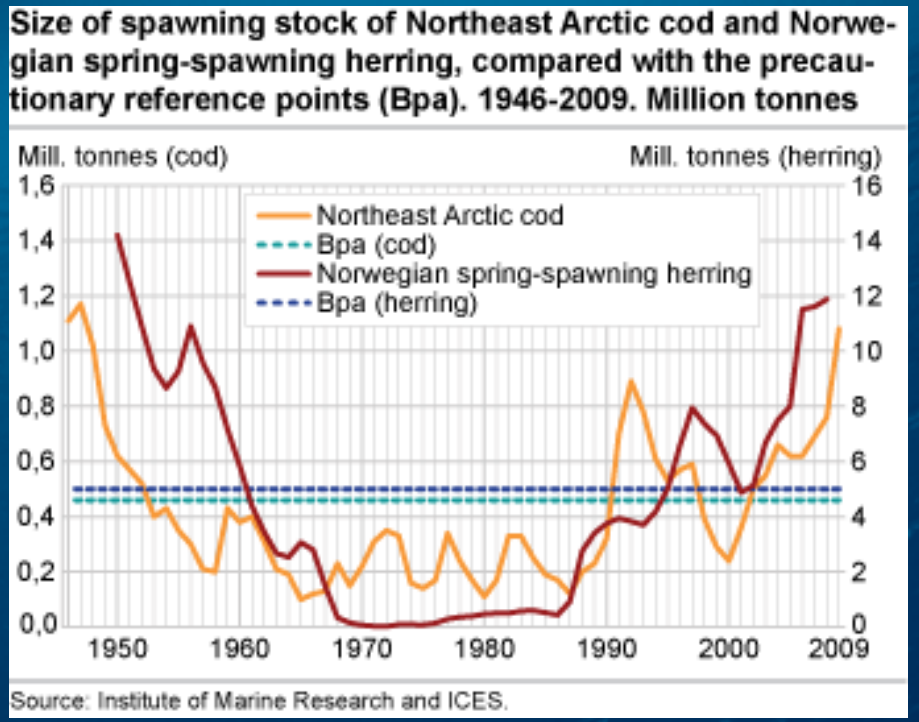
Marine organisms are ecto-thermic

- Marine organisms are embedded within in the physical environment
- Bio-physical coupling: the organisms interact with the physical environment
- Marine organisms have the same body temperature as their environment (except marine mammals)
- Direct effects of environmental temperature on metabolism and body functions

Stock abundance and production

- High abundance of cod, haddock and herring

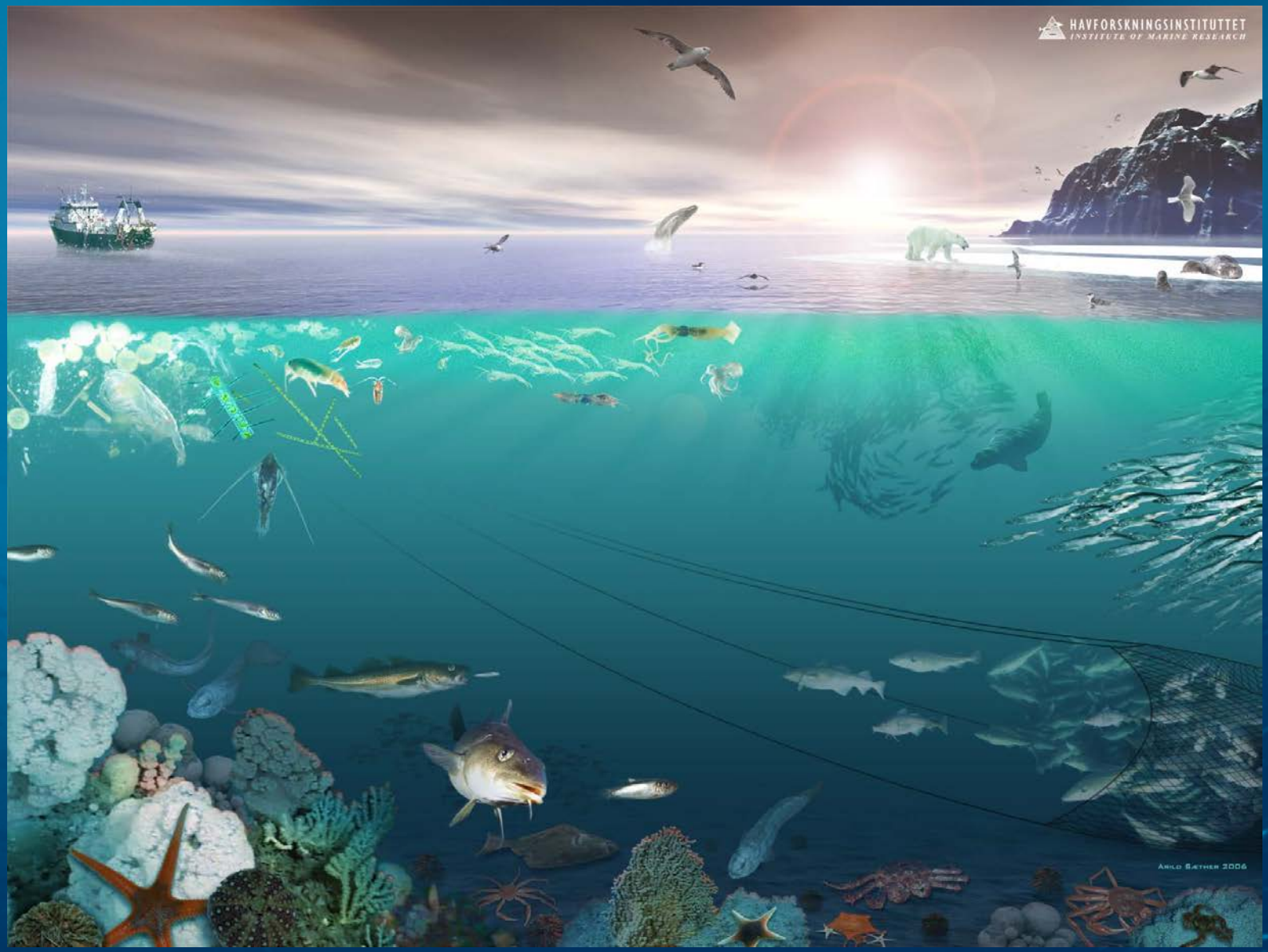




Stock abundance and production

- Increased production in northeastern seas
- High stock biomass is due to a combination of low mortality and high growth rate
- Note that high growth rate depends on sufficient food!
- Lack of food at high temperatures can seriously affect the stocks
  - Energy allocated to metabolism and digestion

The ecosystem



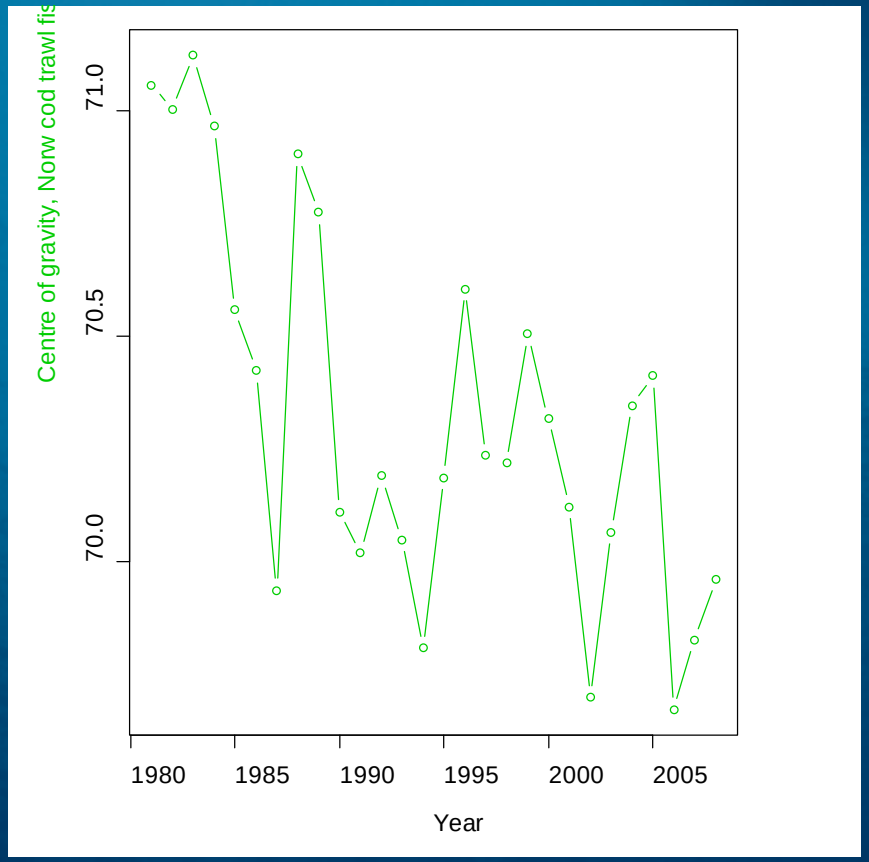
A complex interplay

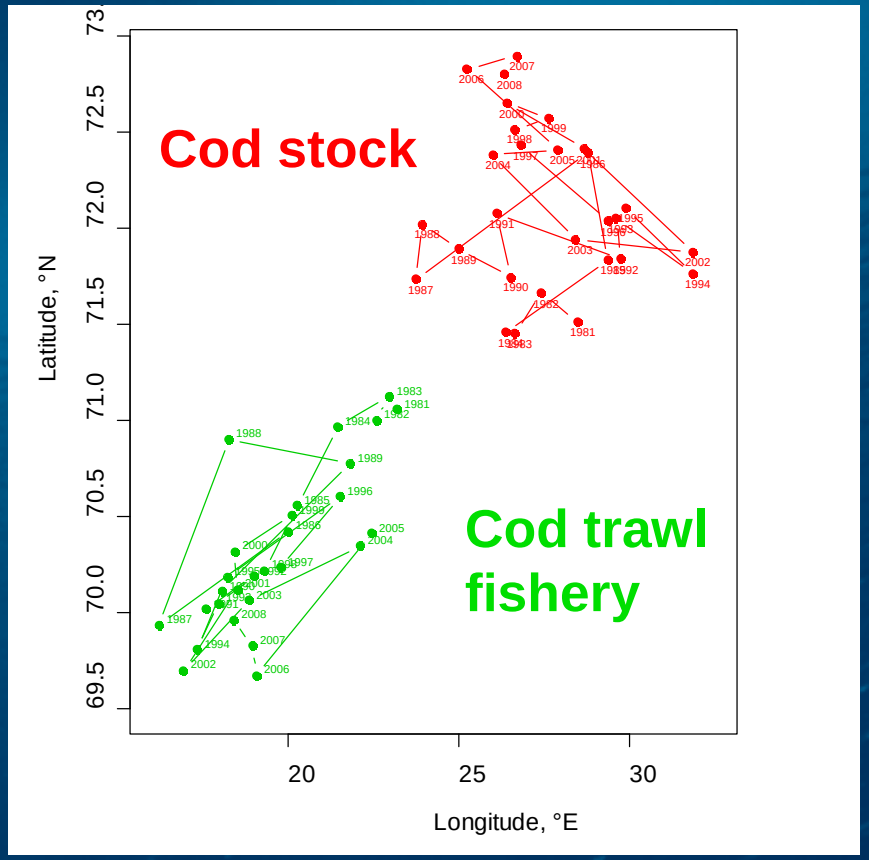
- Direct effects of temperature
  - Modified through the complex interplay in the ecosystem
    - Between organisms and physics
    - Between different species
- Food availability and recruitment of fish
  - Vertical distribution of copepods
    - Timing important for transport
    - Important for the geographical distribution
  - Availability to juvenile fish
    - Spatial coherence between fish and copepods

Fisheries and global warming

- The ecosystem is dynamic
  - It is not given that a temperature increase leads to the expected movement of the fish or increased production
- What is the relationship between geographical distribution of fish and fishermen?
- Do they follow each other tightly?

Fisheries and global warming

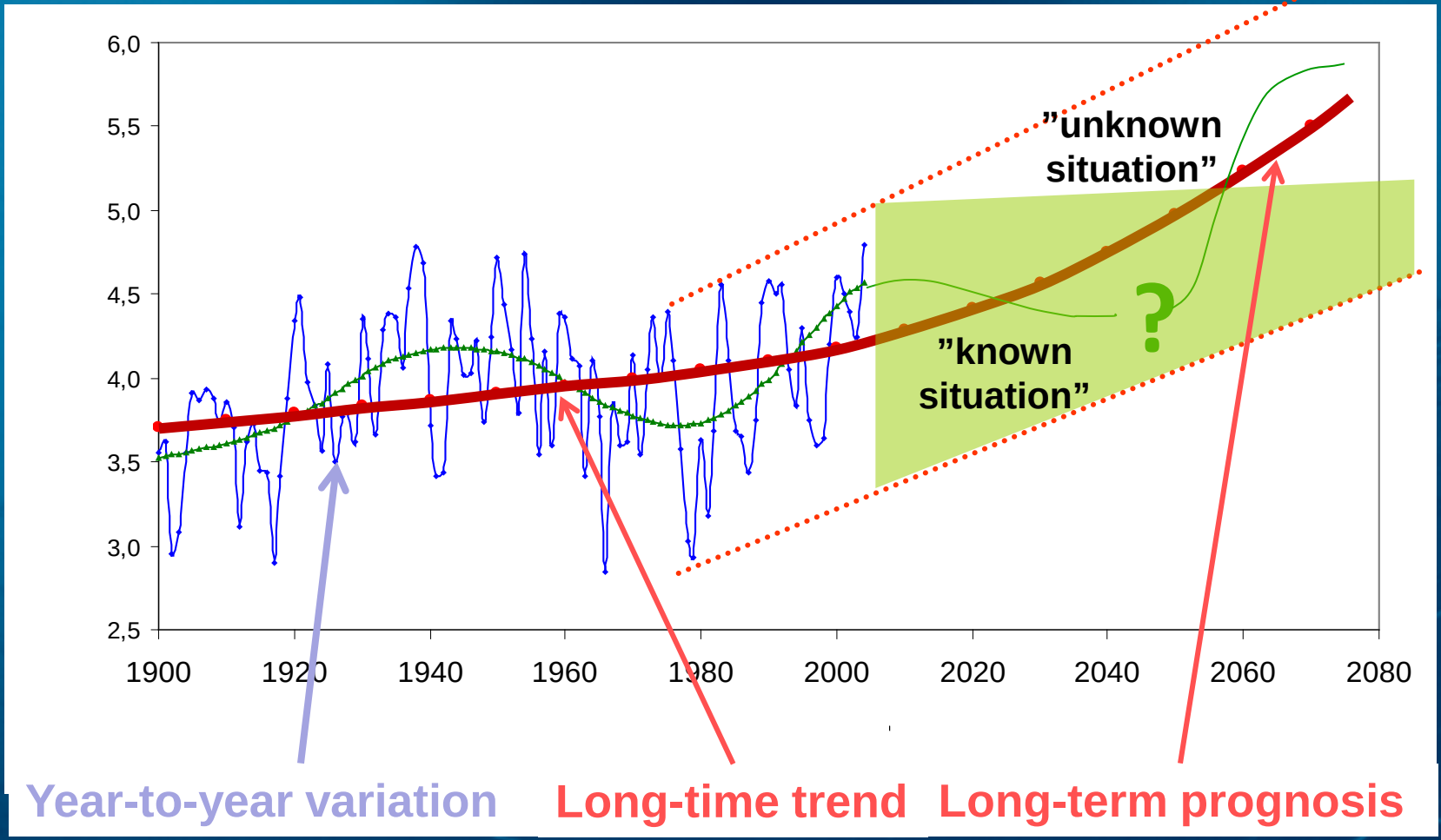




Fisheries and global warming

- The fishery is influenced also by other parameters than just availability of fish
  - Distance to landing sites and home port
  - Traditional fishing grounds
    - Bottom type must be suitable for trawling
  - Size and species available in the area
    - Avoiding by-catches
  - Distribution of other stocks
    - Trawlers may shift between different target species, e.g. cod and saithe
  - Fuel expenses, time spent travelling and catching

Temperature in the Kola hydrographic section



“Prediction is very difficult, especially of the future”

Niels Bohr, Danish physicist (1885 - 1962)