Consequences of Ocean Acidification for Fisheries

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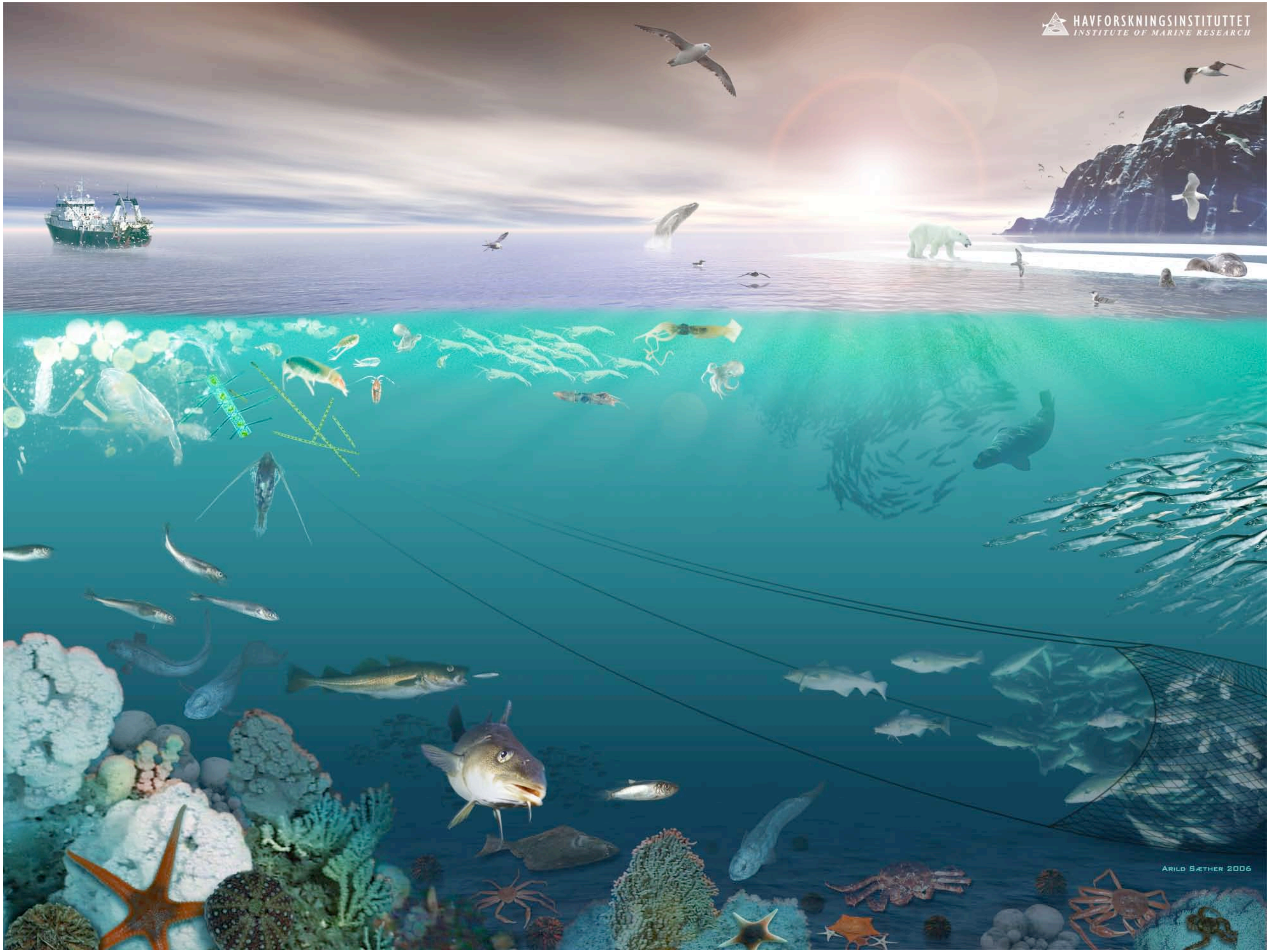
HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH
ARILD SÆTHER 2006

Talk outline

Distribution of globally important fish stocks in relation to OcAc

What regulates fish stocks?

Possible effects of ocean acidification

Lessons to be learned from collapsed fish stocks

Case study: Atlantic herring food web

Case study: fish habitat degradation

The role of fishery management

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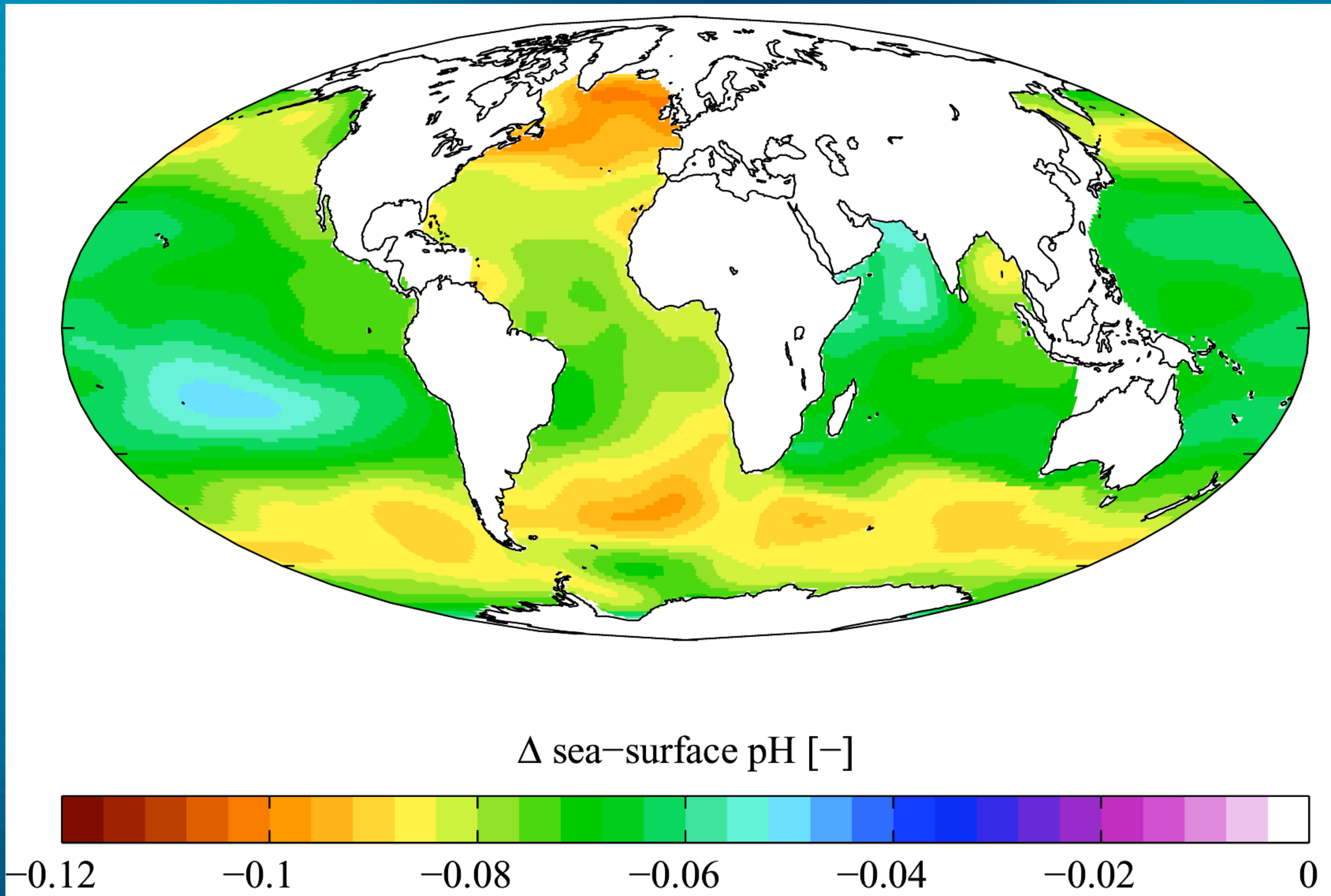
Change in sea surface pH caused by anthropogenic carbon dioxide increase since the beginning of the industrial revolution



GLODAP

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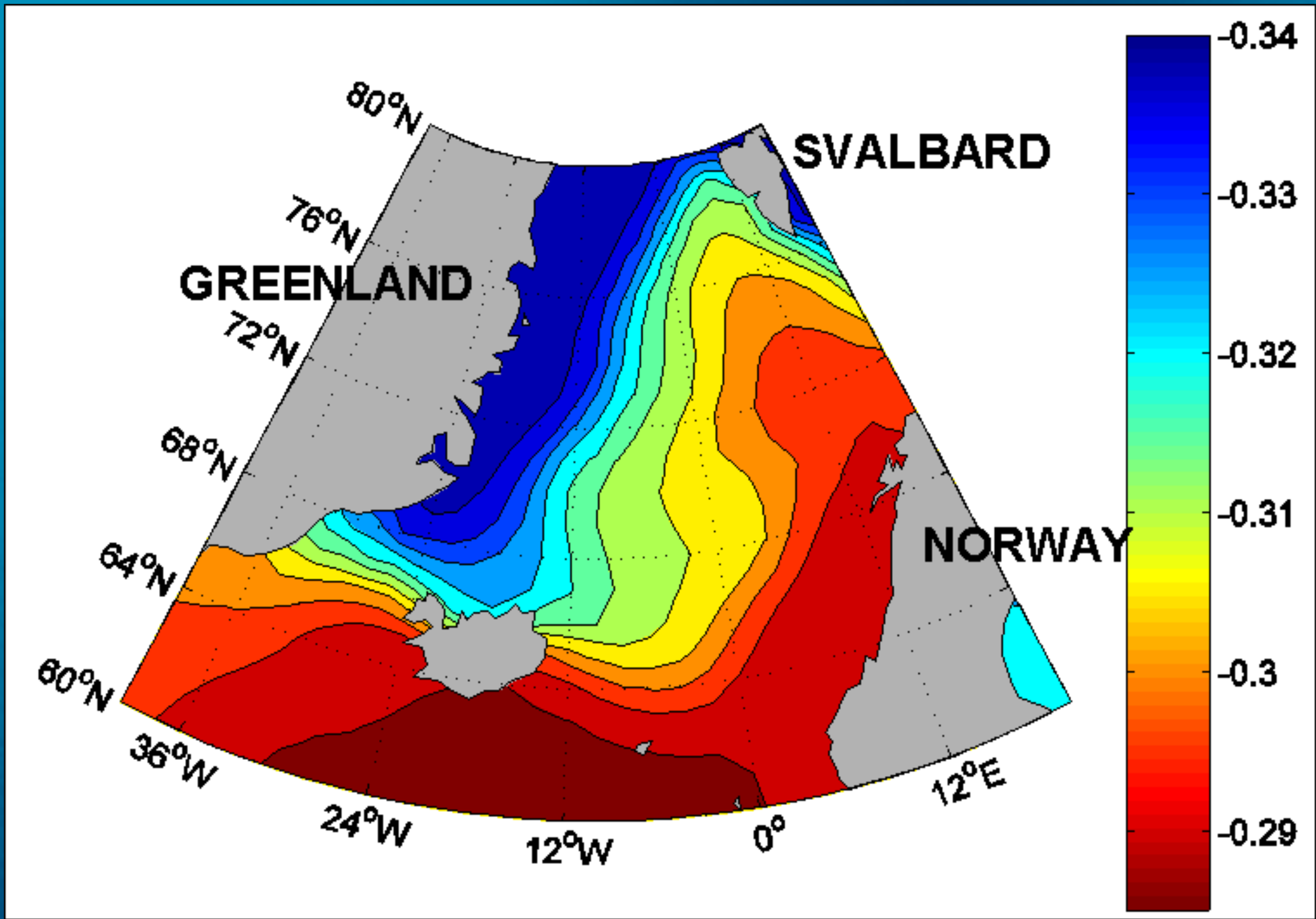
Reduction in pH is expected to be largest in the sub Arctic and Arctic and it will vary within the region



Larger

Large

Changes in surface-pH through the 21 century

Bellerby et al. (2005)

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Alaska pollock

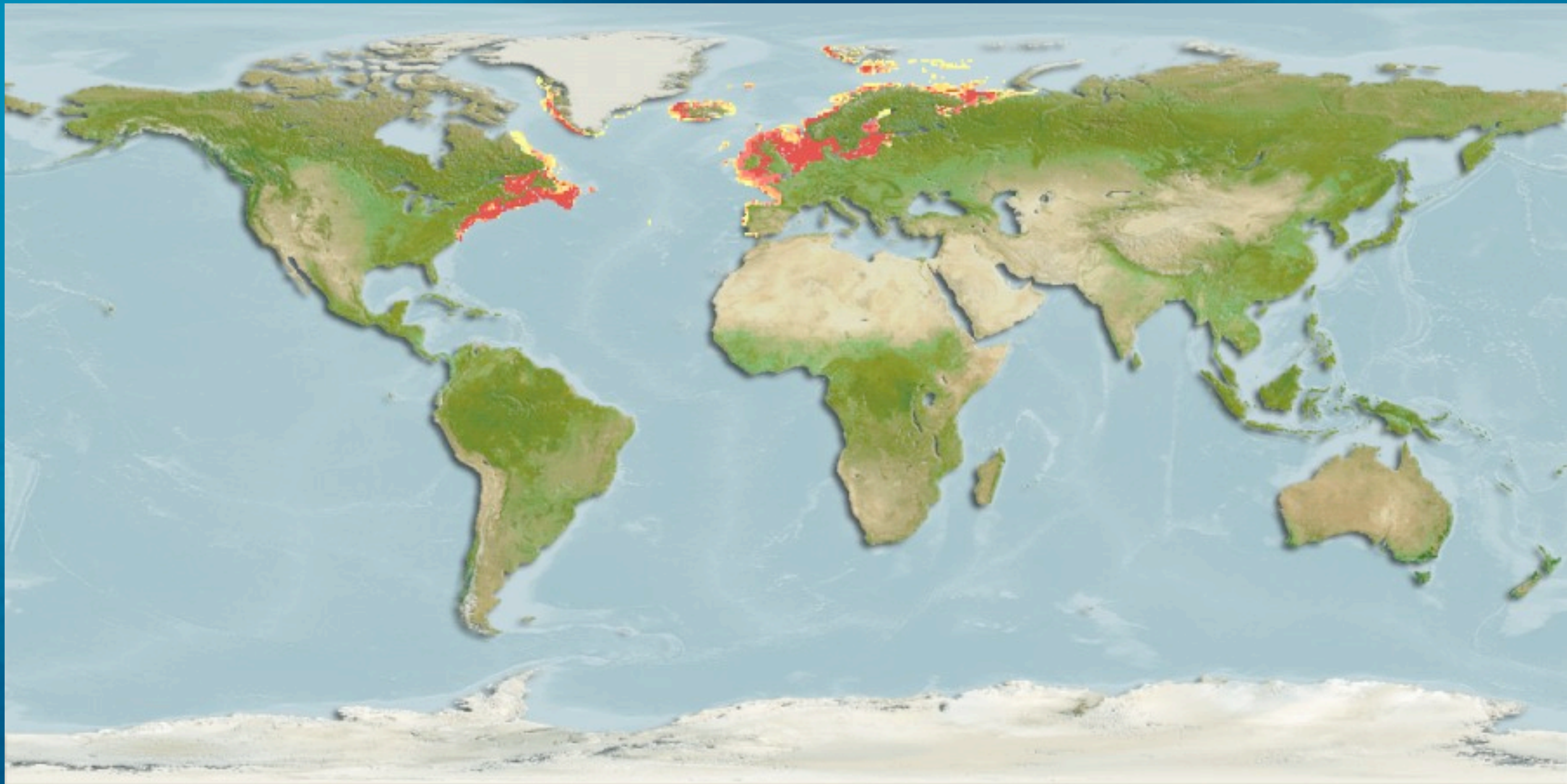
Theragra chalcogramma

No 2. 2.9 mill tonnes

Source: FAO

Atlantic herring

Clupea harengus



No 4. 2.2 mill tonnes

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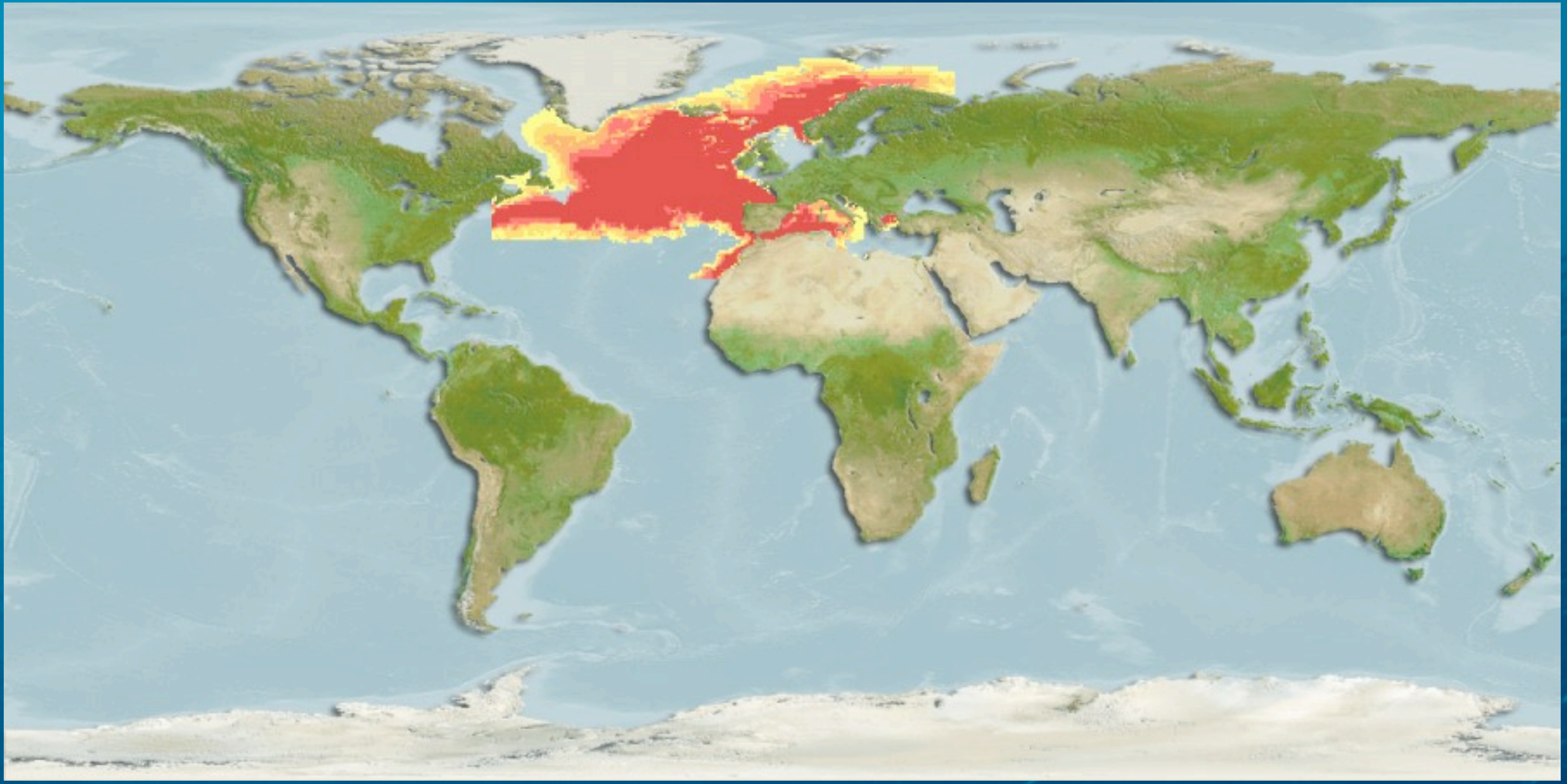
Source: FAO

Blue whiting

Micromesistius poutassou



No 5. 2.0 mill tonnes

Source: FAO

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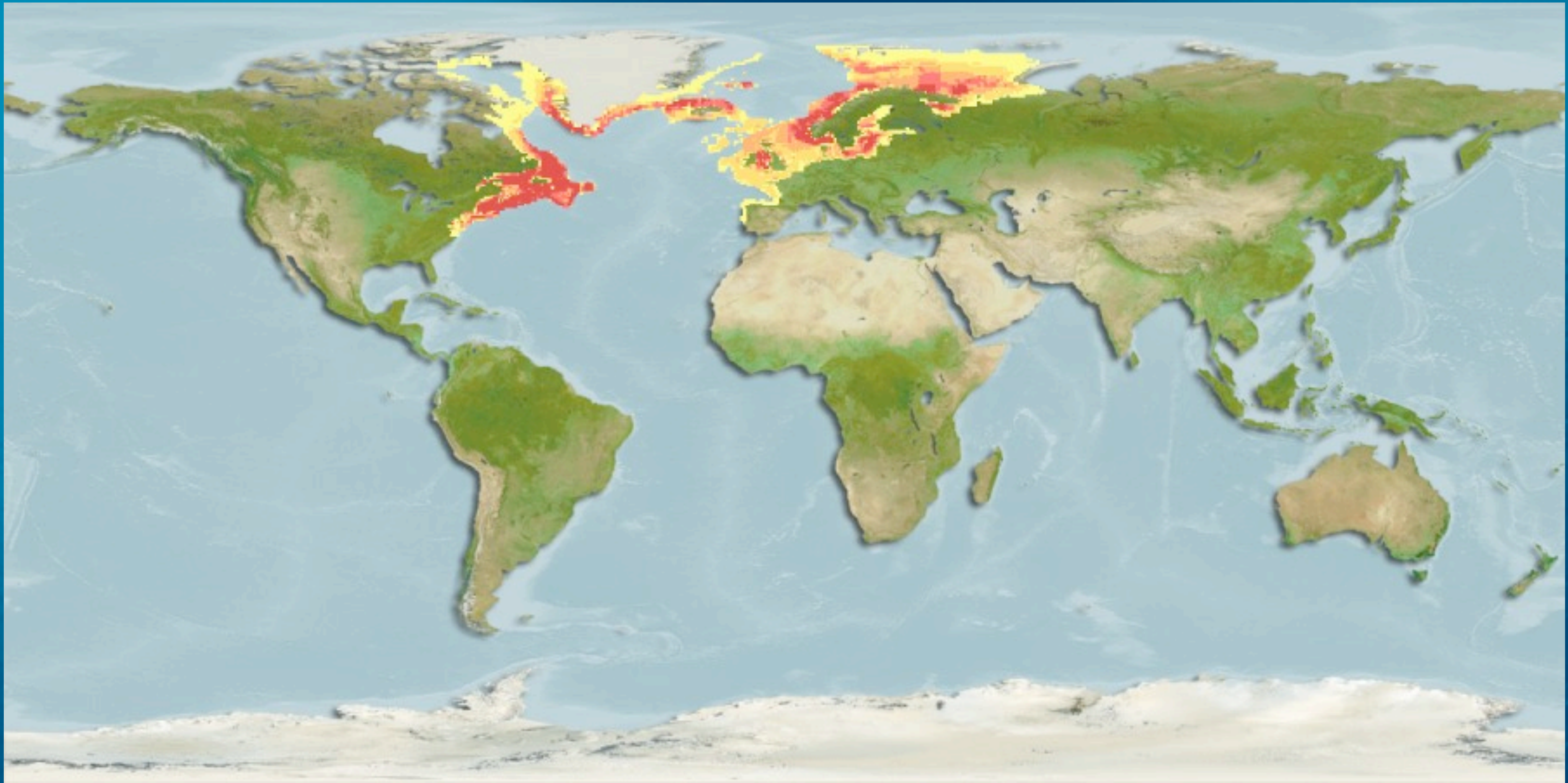
Atlantic cod

Gadus morhua



No 13. 0.8 mill tonnes

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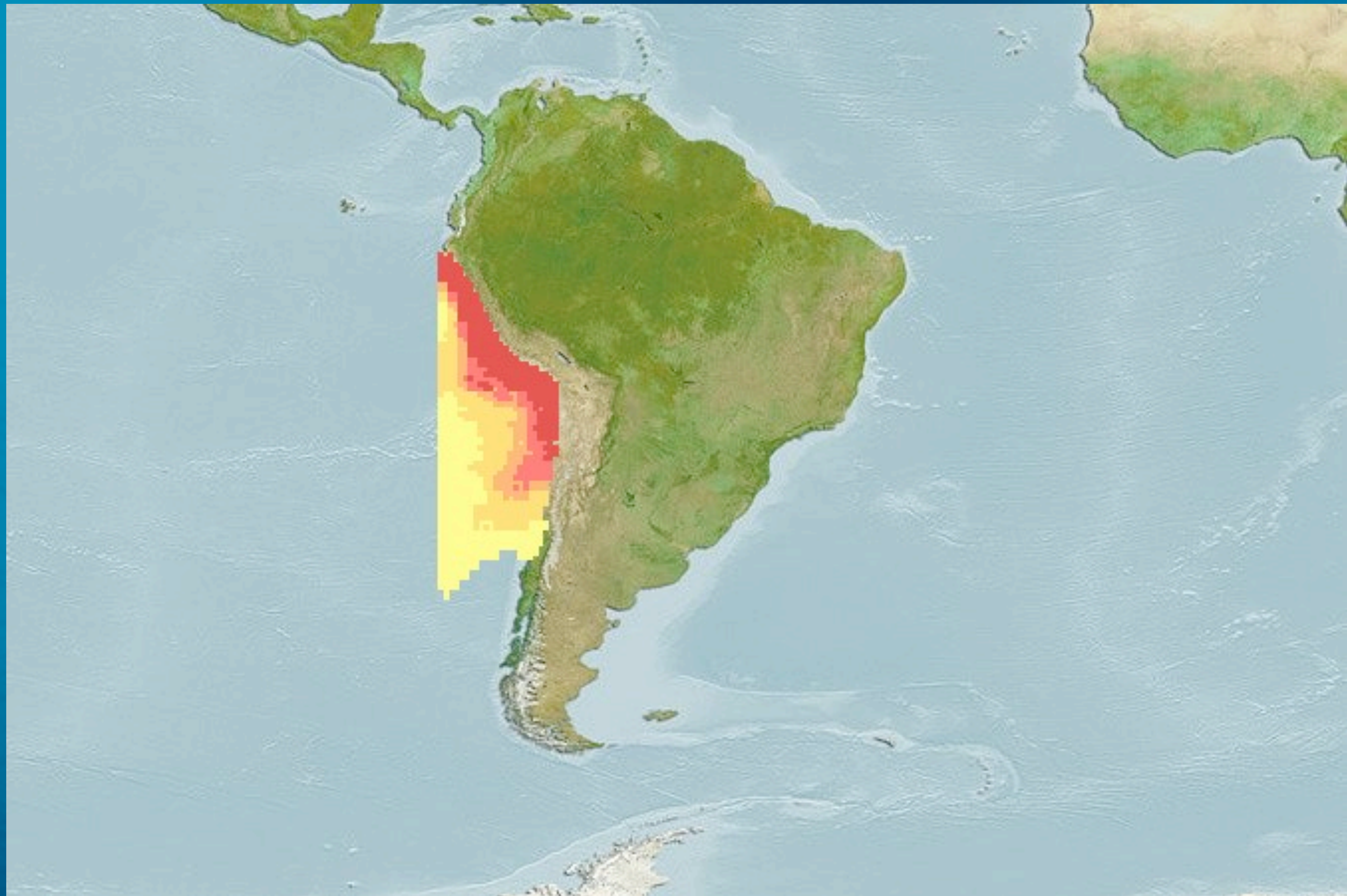
Source: FAO

Anchoveta

Engraulis ringens



No 1. 7.0 mill tonnes

Source: FAO

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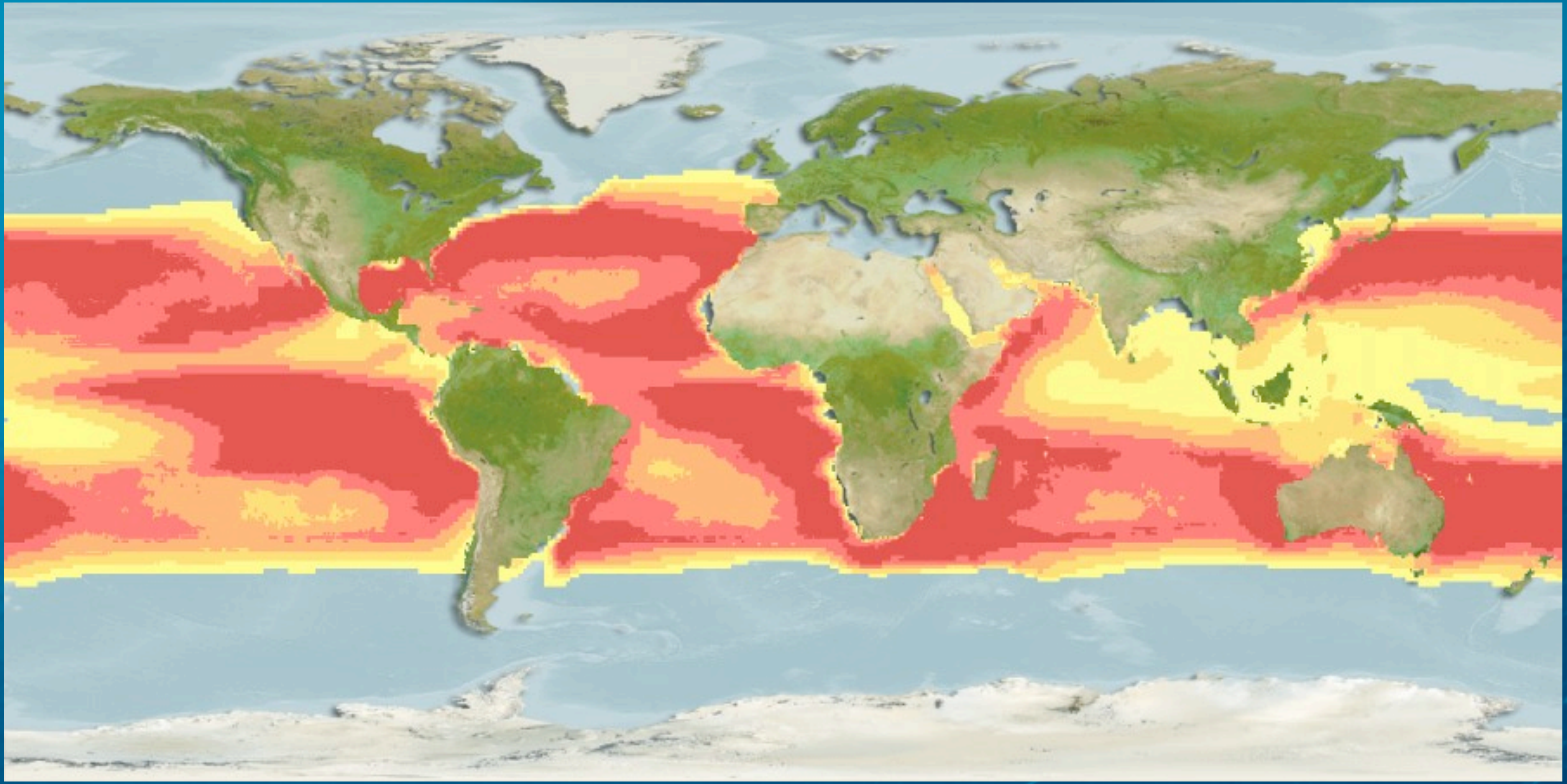
Yellowfin tuna

Thunnus albacares



No 10. 1.1 mill tonnes

Source: FAO

What regulates the size of fish stocks?

- Recruitment
- Growth
- Mortality
- Migration

Recruitment stands out as the most variable parameter in stock assessments

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Fisheries are directly affected by

- Change in stock biomass
  - long-term effects from overfishing
  - reduced productivity in the ecosystem
  - Habitat degradation
- Change in availability
  - Due to shift in distribution, migration, or behaviour

Acidification – Effects on fish stocks and fisheries

- Nature and degree of effects are largely unknown
- Both direct and indirect effects are anticipated
- Effects likely to be highly diverse, depending on, *i.a.*, ecosystem, fish species, state of exploitation
- Effects may be confounded by effects of climate change and overfishing

How can acidification affect fisheries?

- **Through recruitment**
  - Early life stages of fish (eggs, larvae) are likely to be vulnerable to change in pH
  - Changes in the plankton community may reduce survival in the early life stages due to:
    - Food quality
    - Food quantity
    - Timing – match/mismatch
    - Predation

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How can acidification affect fish/fisheries?

- **Through growth**
  - Ecological effects
    - Change in food quality, quantity, timing
    - Reduced growth may affect the fertility
    - Reduced growth may reduce survival
  - Direct physiological effects?

- **Through mortality**
  - Physiological effects?

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Case study

Norwegian Spring Spawning Herring

Clupea harengus

Stock collapse and the causes for the collapse

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From
Toresen and Østvedt (2000)

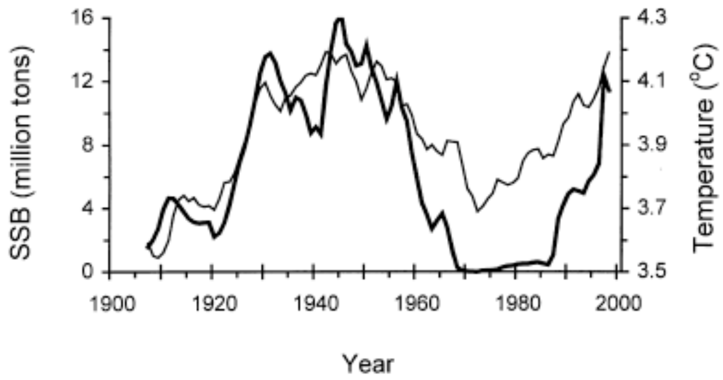

Figure 3 Fluctuations of spawning stock biomass (SSB) of Norwegian spring-spawning herring (thick line) and mean annual (moving average over 19 years) temperature (thin line) at the Kola section (Bochkov 1982), 1907-1998.

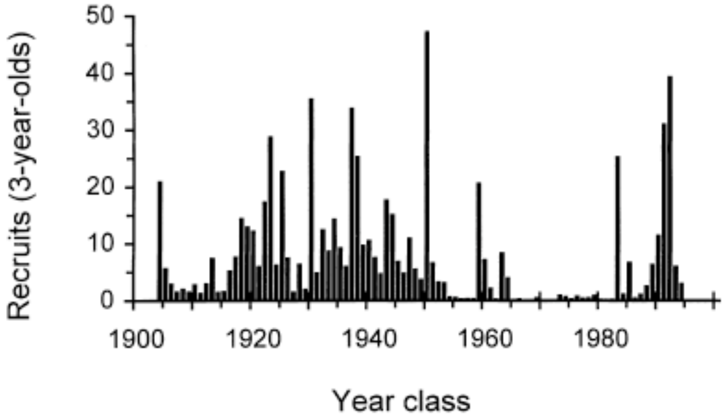

Figure 4 Number of 3 year-olds ($n \times 10^{-9}$) of Norwegian spring-spawning herring, 1904–1994.

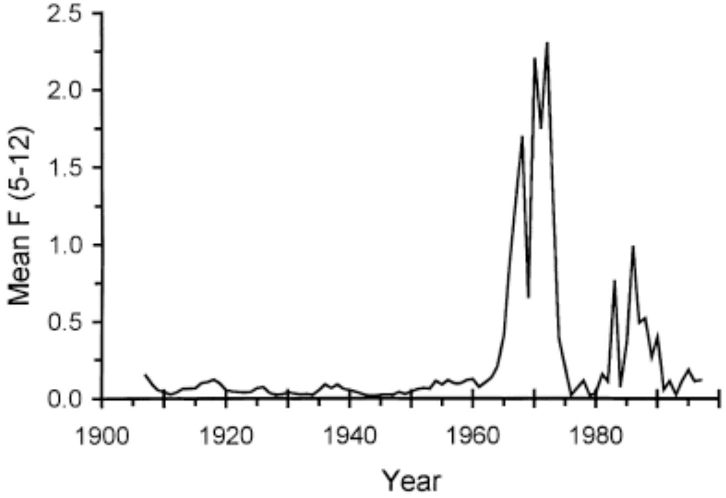

Figure 5 Mean instantaneous rate of fishing mortality (*F*) for age groups 5–12 years, 1907–1997.

Case study

Northern Cod (Grand Banks Cod)

Gadus morhua

Stock collapse and the causes for the collapse

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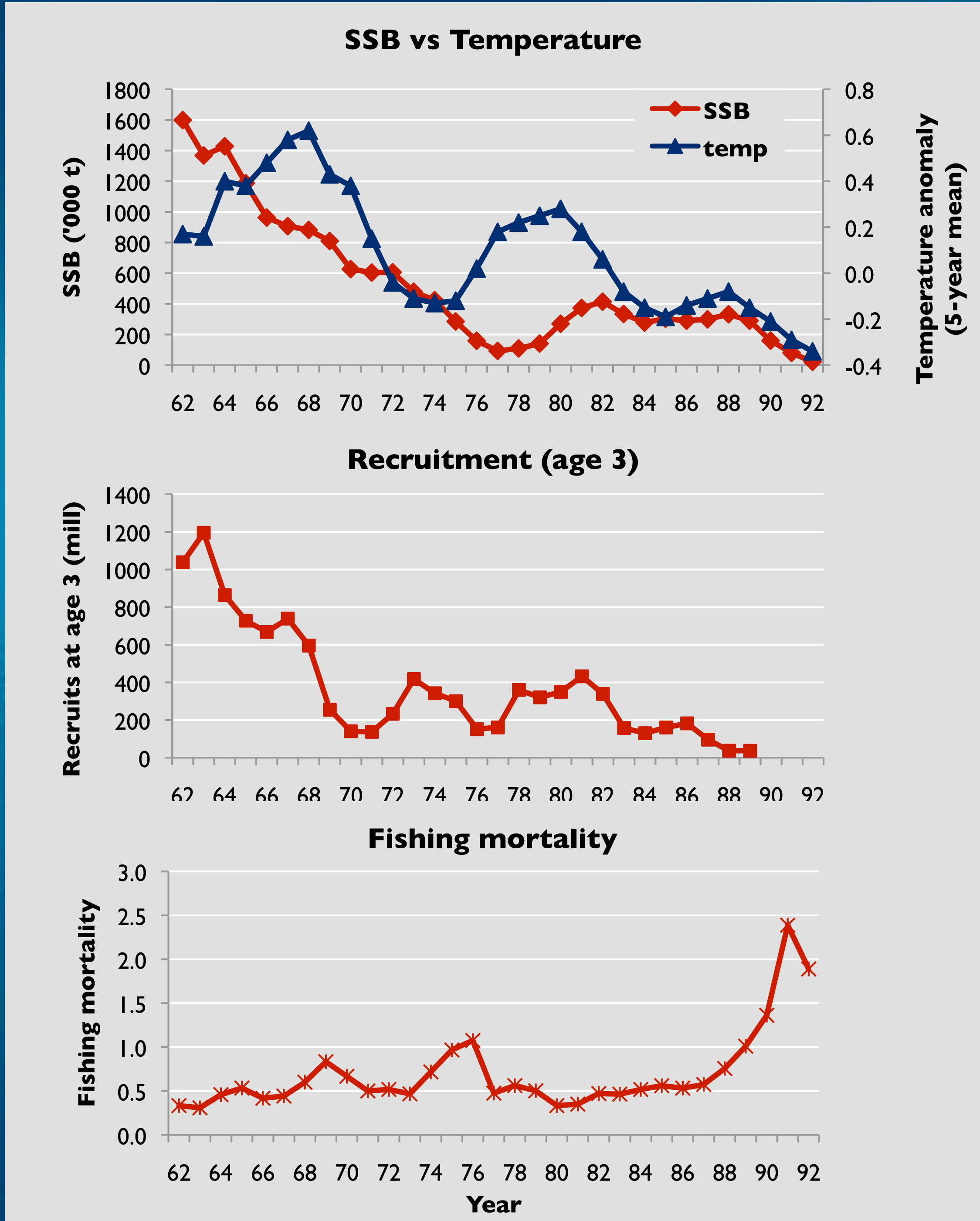
Source fish data
R.A. Myers (pers. com)

Source temperature
Colbourne and Fitzpatrick (1994)



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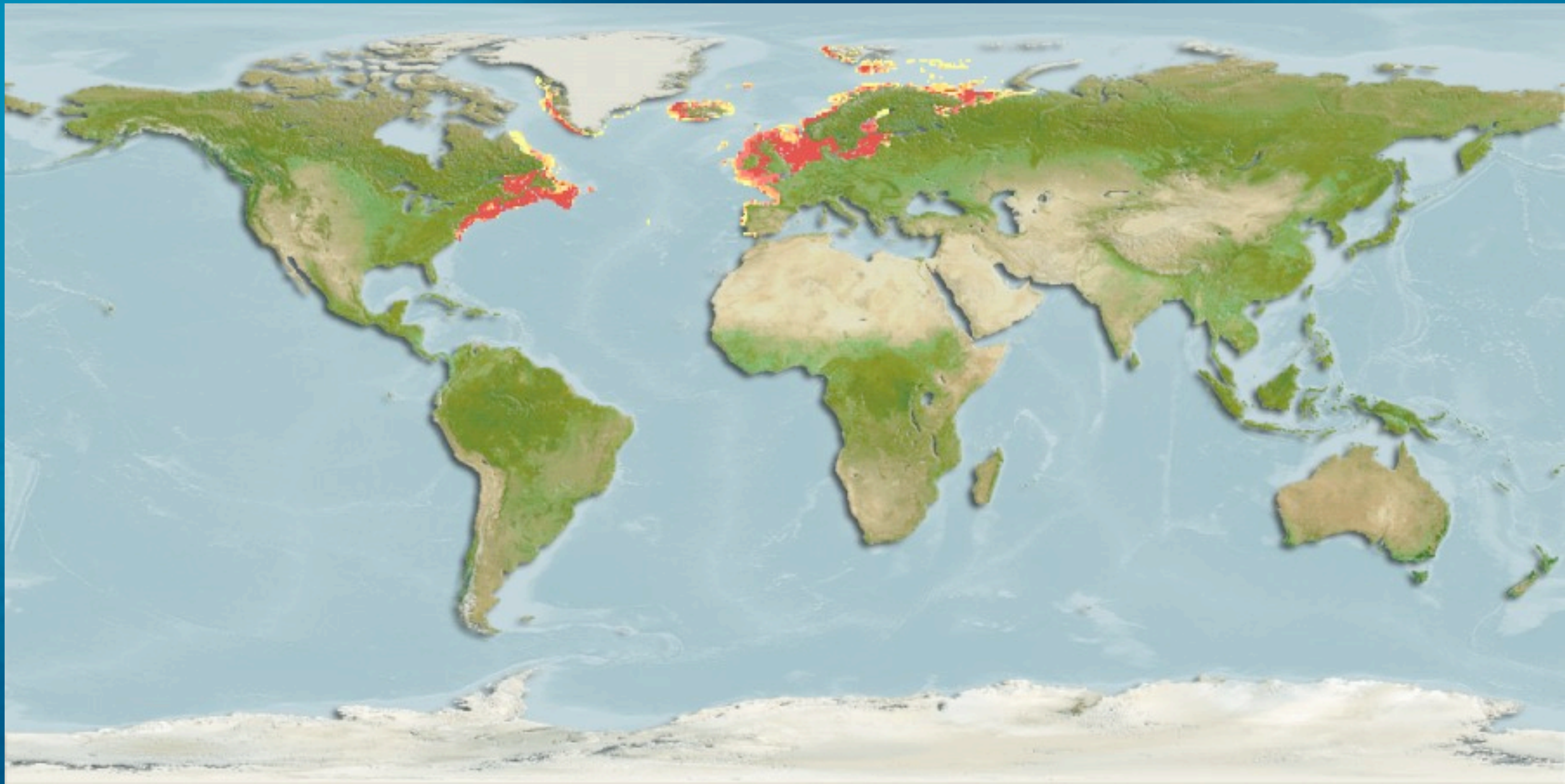
Stock collapse is usually caused by a combination of unfavourable environmental conditions (effecting recruitment) and overfishing (mismanagement)

We are now facing a future with lower pH and higher CO_2 that in combination with a rising temperature most likely will be unfavourable - at least for some species in some ecosystems

Atlantic herring

Clupea harengus



No 4. 2.2 mill tonnes

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Source: FAO

Main food of the herring and key species in the pelagic food web

Copepod: *Calanus finmarchicus*

Copepod: *Calanus hyperboreus*

Amphipod:
Themisto compressa

Krill: *Tysanoessa inermis*
Meganychtiphanes norvegica

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Courtesy of AWI

Sea butterflies

Limacina retroversa
In the Norwegian Sea 2000 ind m^{-3}

Peaks in August-September after *Calanus finmarchicus* has started its decent into the deep to over winter

Herring
Limacina can constitute a significant portion of the food at certain times of the year and in certain watermasses

Mackerel
can feed heavily on, and show a preference for pteropods

Food of the herring (and mackerel)

Herring

Russ Hopcroft, NOAA

Sea butterfly
Limacina helicina

Sea Angel
Clione limacina

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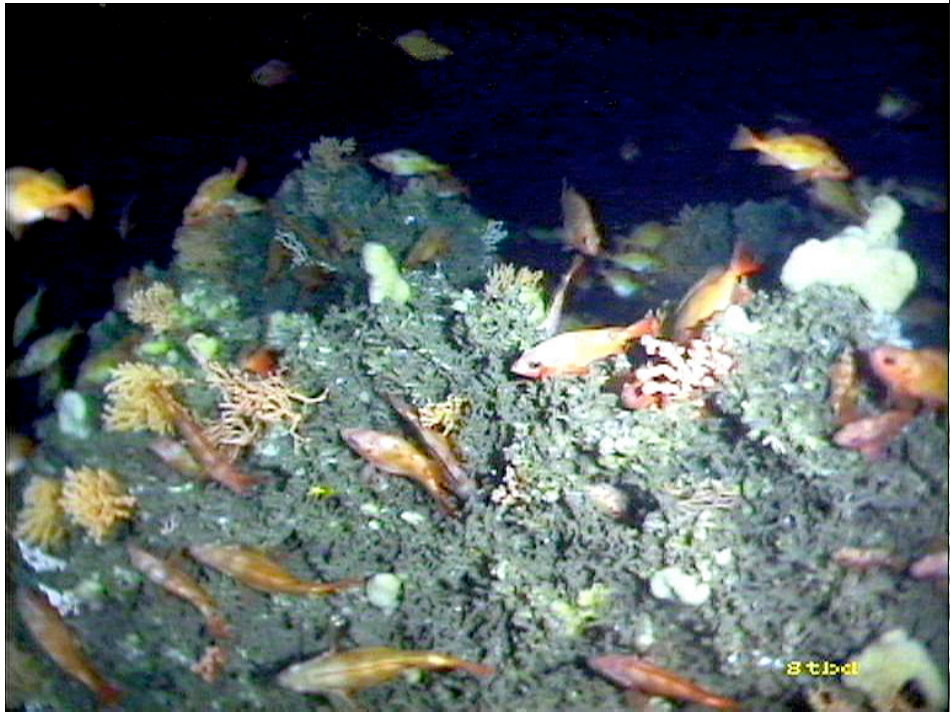
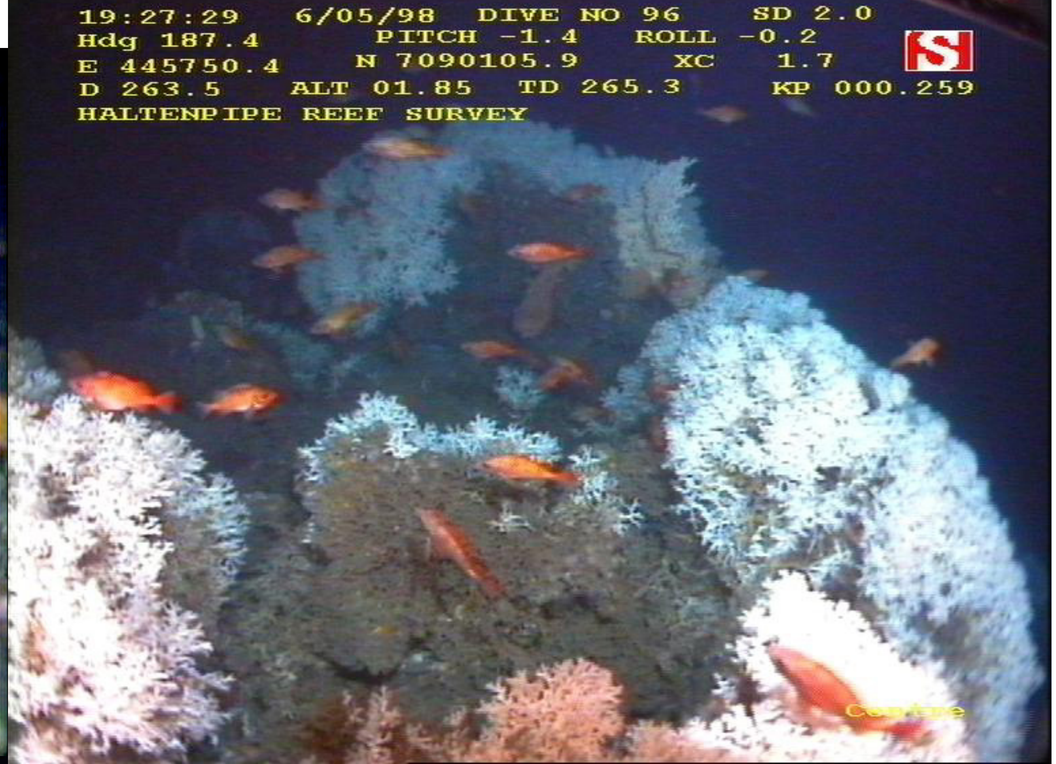
Case study

Fish habitat degradation

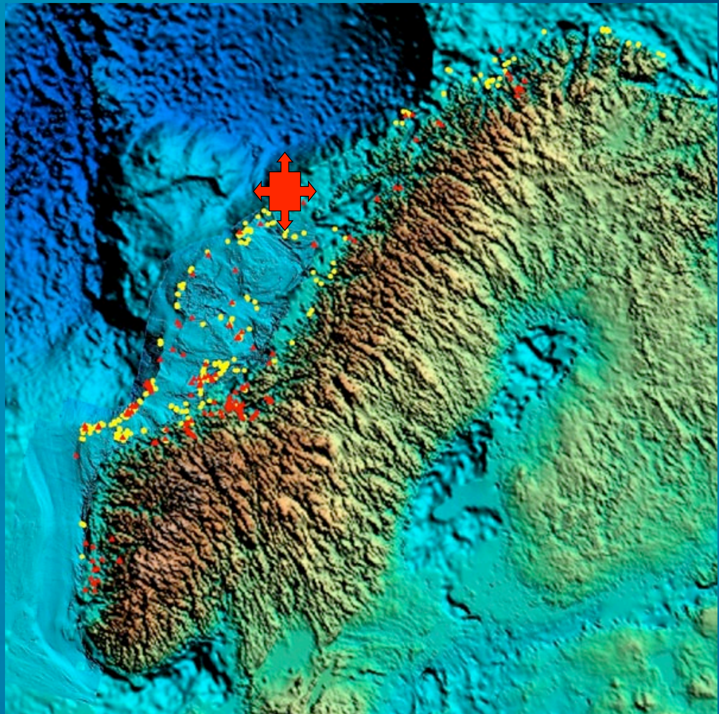
Norwegian Cold Water Coral Systems





Fish in Lophelia coral reef habitat

Case study: Norwegian Cold Water Coral Systems



The Røst Reef

The largest cold water coral system in the world

At about 300 m depth

A fish habitat and fishing ground for longline

Protected from bottom trawling

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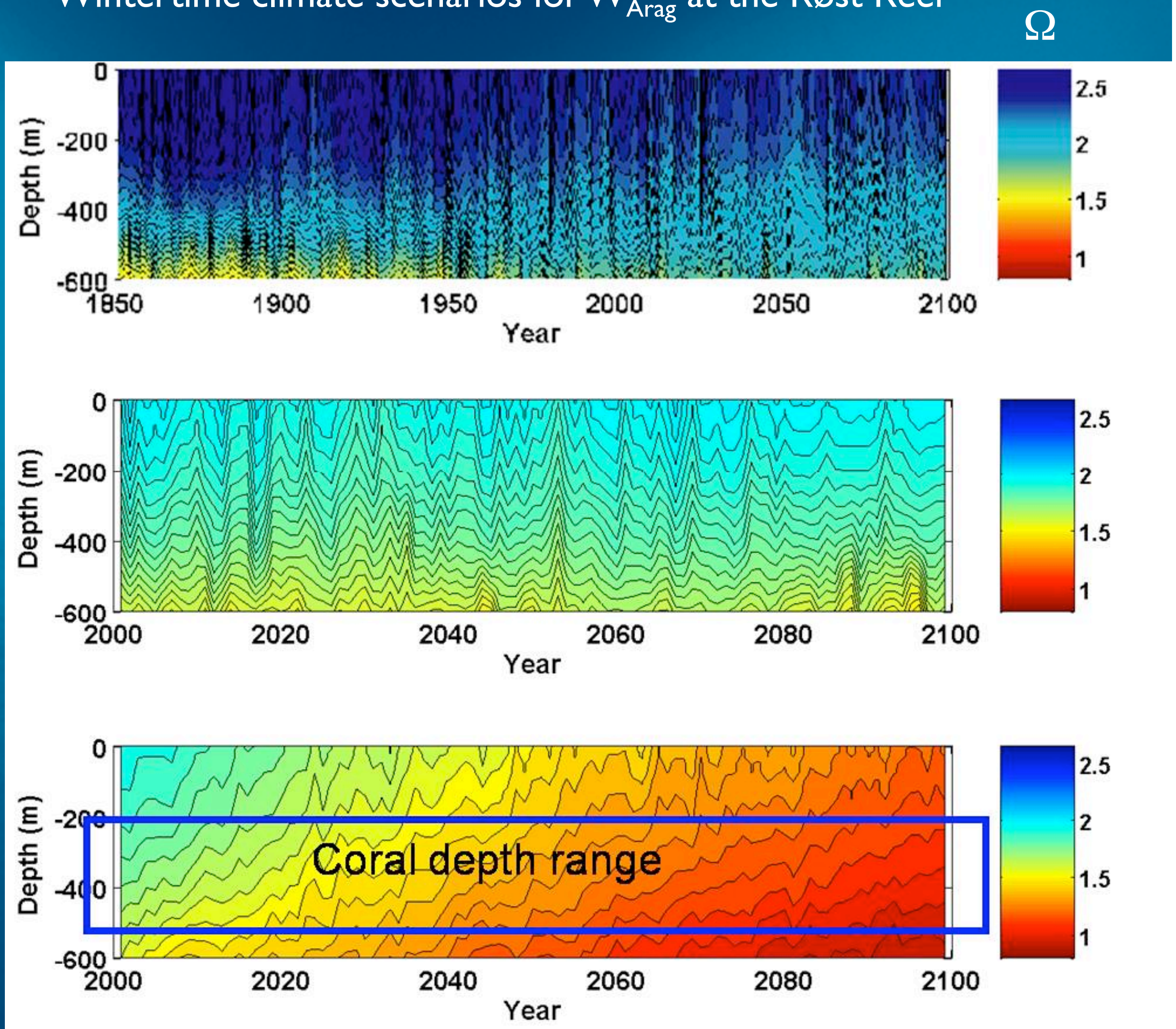
Case study: Norwegian Cold Water Coral Systems

Wintertime climate scenarios for W_{Arag} at the Røst Reef



Model scenario

PIcntrl
No anthropogenic carbon release

COMMIT
Atmospheric CO_2 at year 2000 levels

SRESA1B
Atmospheric CO_2 to increase by 1%.yr^{-1} until 2100

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Priority research topics

• Physiological effects of increasing CO_2 on fish (early life stages)

• Carbon and nutrient cascading and energy flow along food chains

• Rate of change of pH on a regional and local scale relevant to important biomes and fisheries

•Develop more informed ecological models

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The role of fishery management in mitigating effects of acidification

Ocean acidification cannot be changed by fisheries management, but negative effects can be reduced

In a changing environment management should aim at maintaining strong an robust fish stocks

By robust we mean stocks that are not overfished and has suffered a minimum loss of genetic diversity (don't fish out local stocks)

The management system needs to be adaptive and respond quickly to new environmental observations and scientific knowledge

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Thank you
Pilot whales
Northern Norway