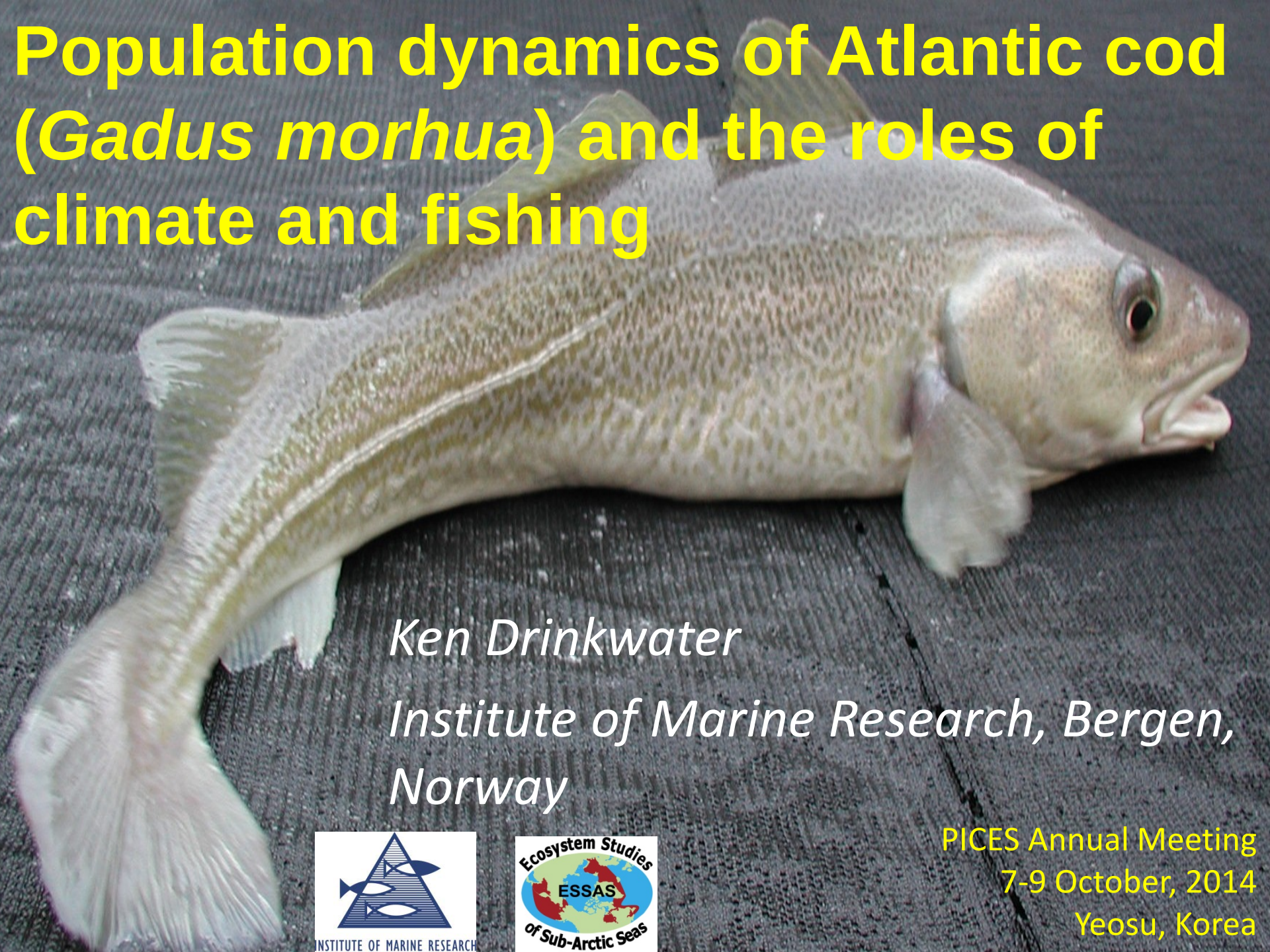
Population dynamics of Atlantic cod (*Gadus morhua*) and the roles of climate and fishing



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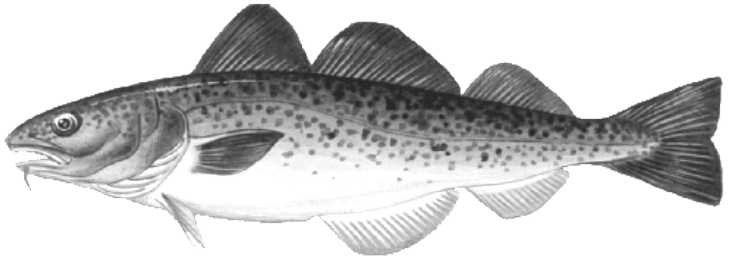
INSTITUTE OF MARINE RESEARCH

Ecosystem Studies of Sub-Arctic Seas ESSAS

PICES Annual Meeting
7-9 October, 2014
Yeosu, Korea



Inter Basin Linkages

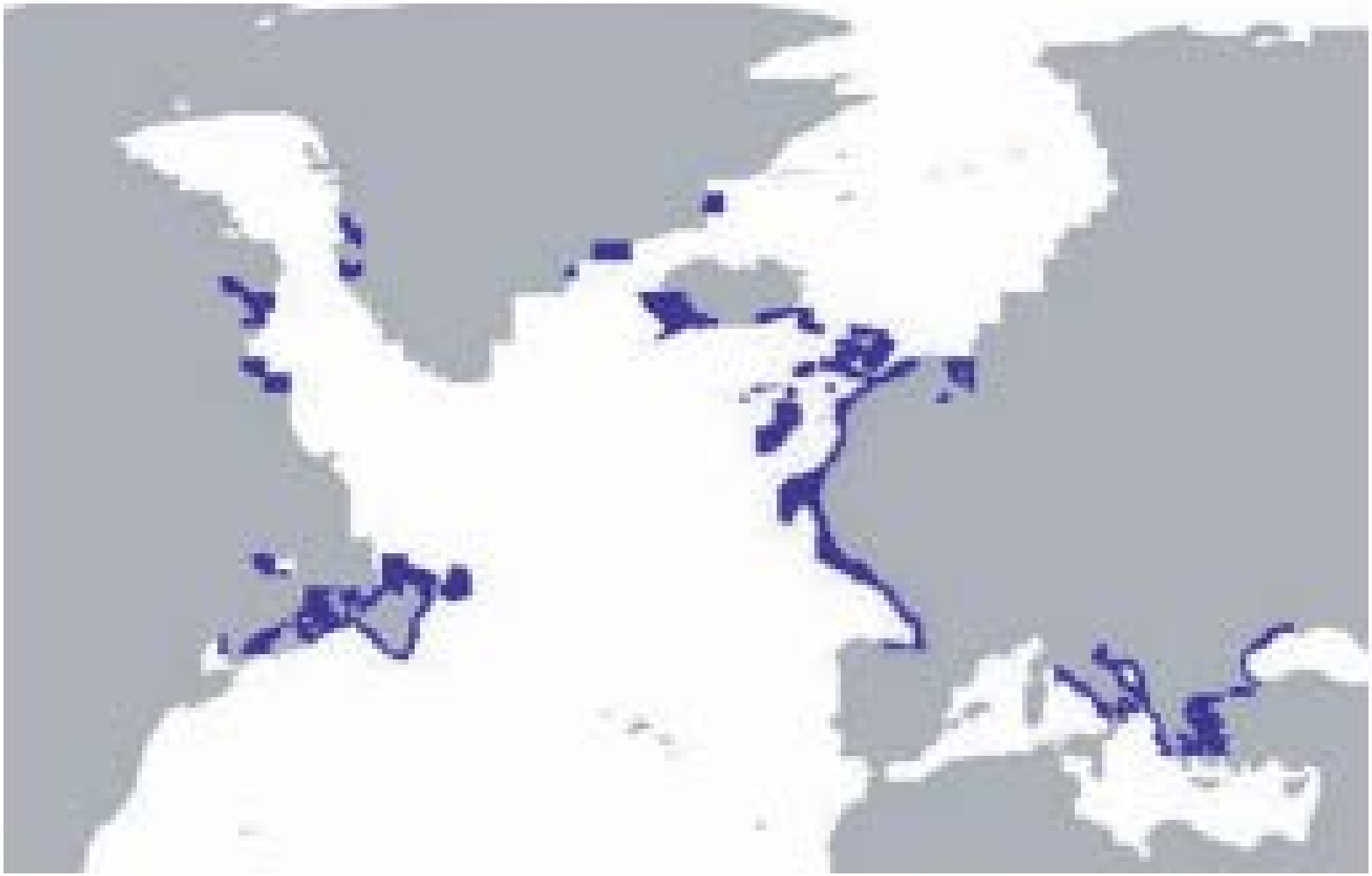
•Both Atlantic (*Gadus morhua*) and Pacific cod (*Gadus macrocephalus*) are descended from an Atlantic lineage that invaded the Pacific at least 3.5 Myr ago, when the Bering Strait was open and the Arctic was ice free.

•The Atlantic cod invaded the Pacific a second time approximately 2 Myr ago and eventually evolved into the morphologically distinct walleye pollock (*Theragra chalcogramma*).

•During the last inter-glacial period ca 100 Kyr ago, the Pacific cod re-invaded the Atlantic and became the origin of the Greenland cod *Gadus ogac*.

Bigg et al., 2007

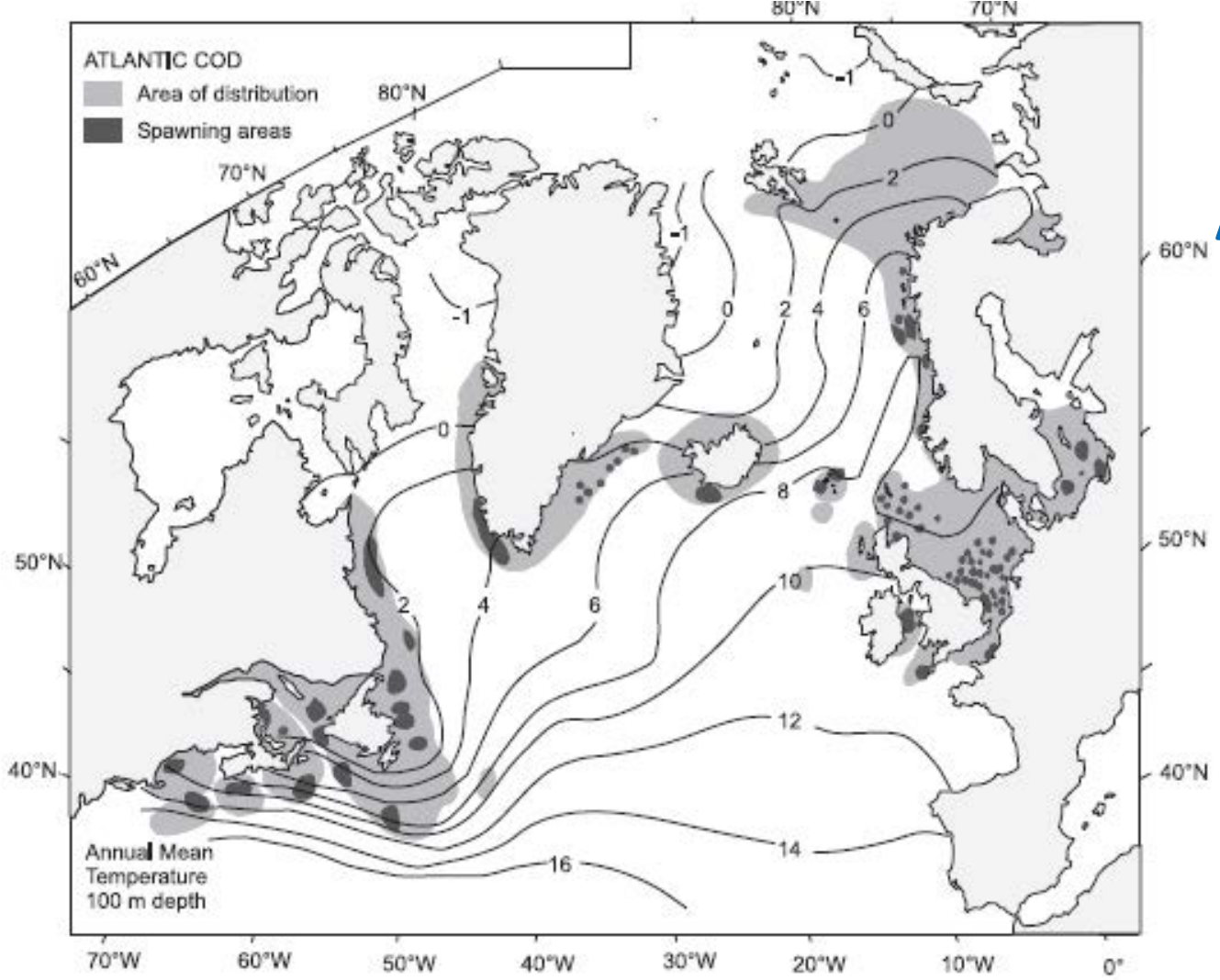
Modelled Potential Cod Habitat during the Last Glacial Maximum 21 Kya



Based from applying ecophysiological parameters to ocean model data.

Bigg et al., 2007

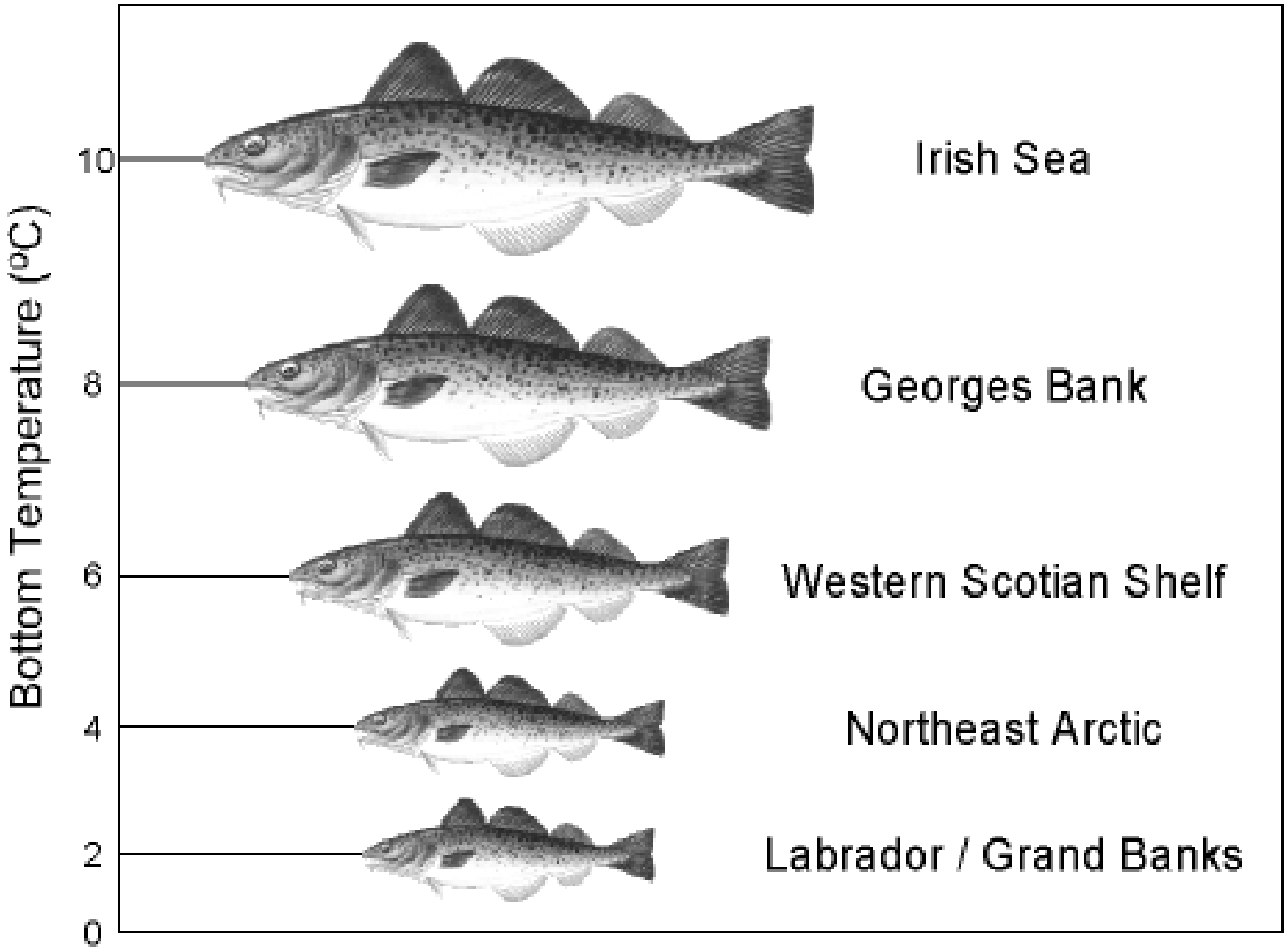
Present Day Atlantic Cod Stocks



Present day Atlantic cod inhabit mainly shelf regions around the northern North Atlantic under widely different environmental conditions.

Sundby, 2000

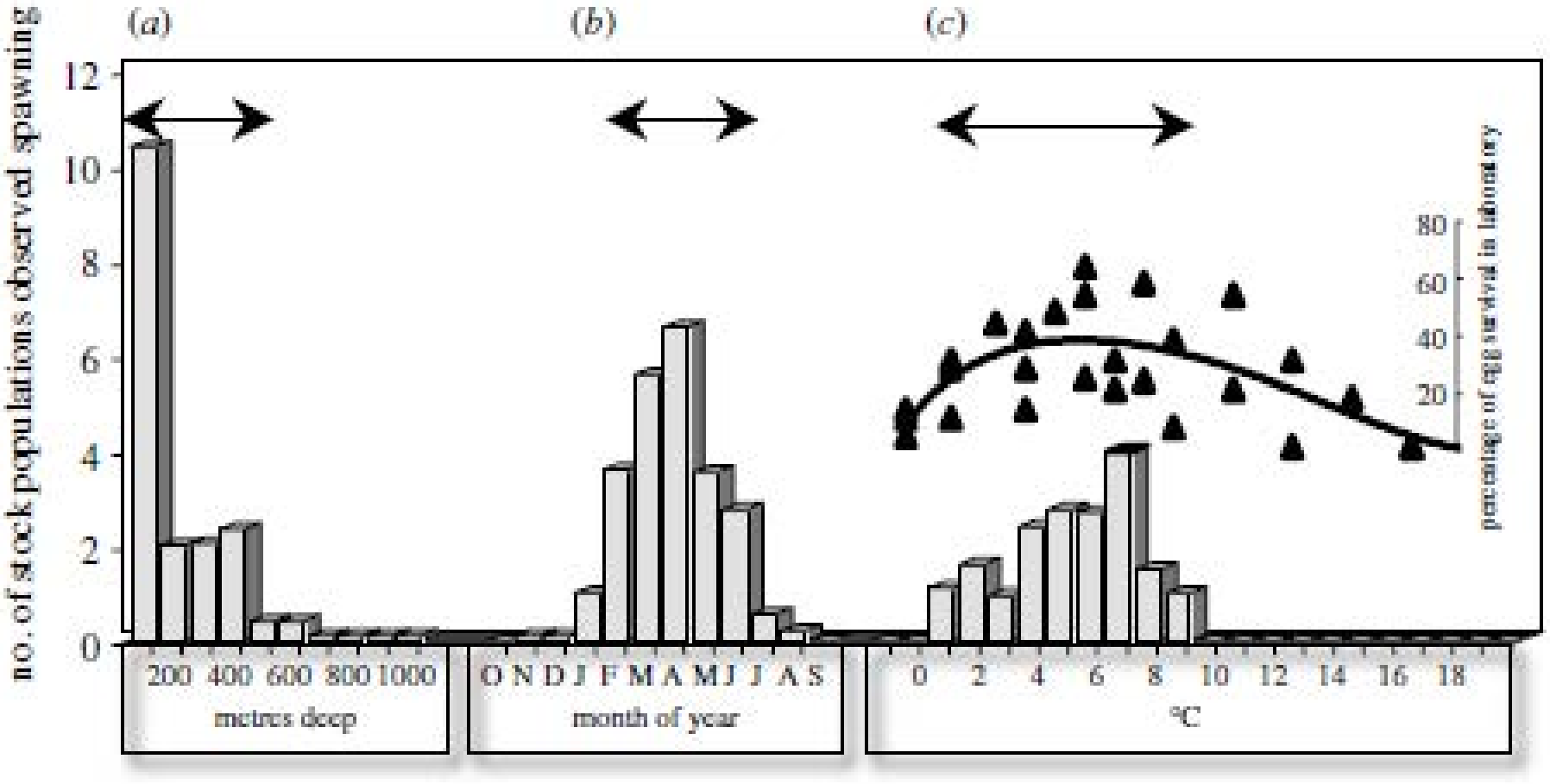
Growth



Relative size of a 4-year old Atlantic cod in different locations.

Drinkwater, 2000

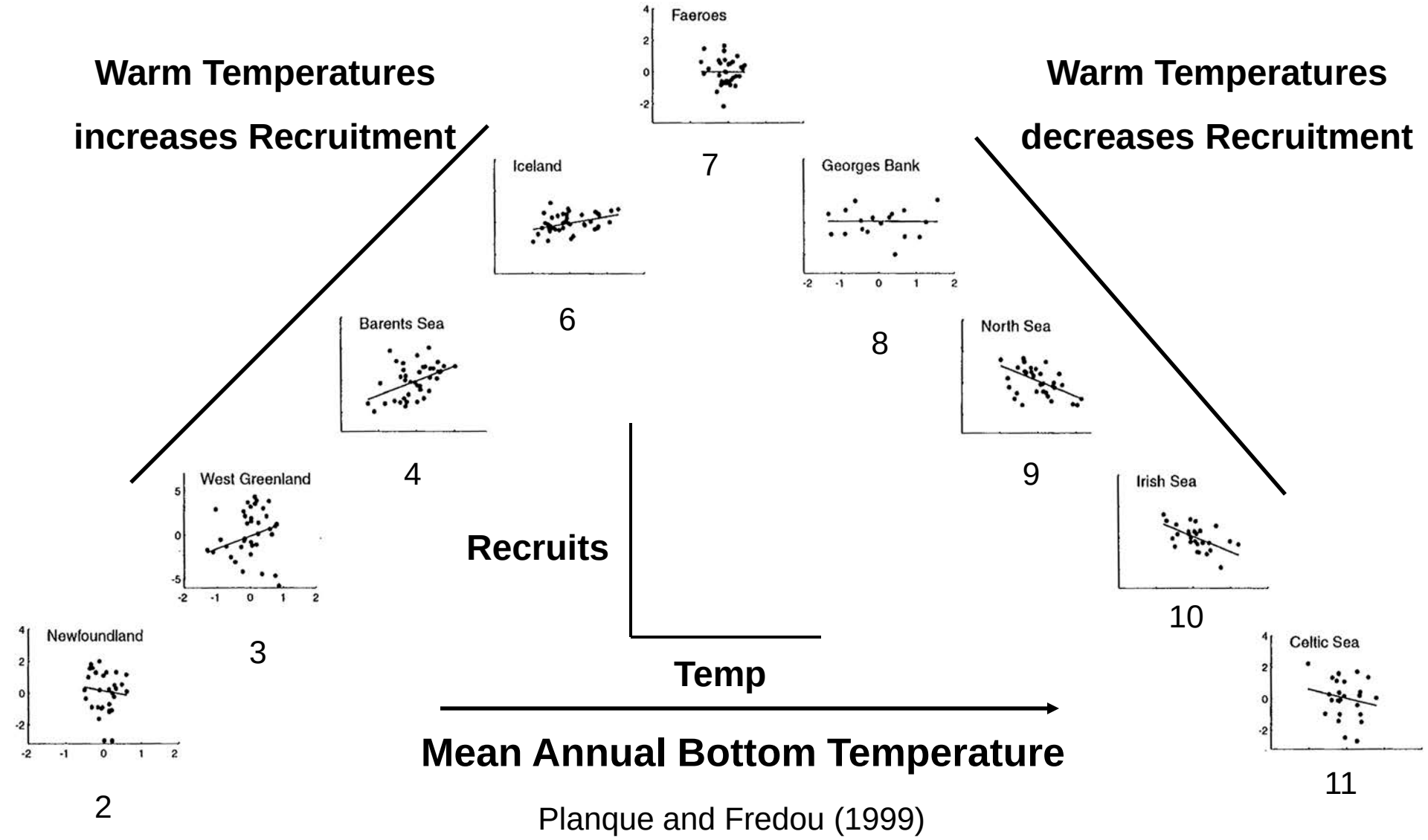
Spawning Characteristics



Shallow Spring Cool

Bigg et al., 2007

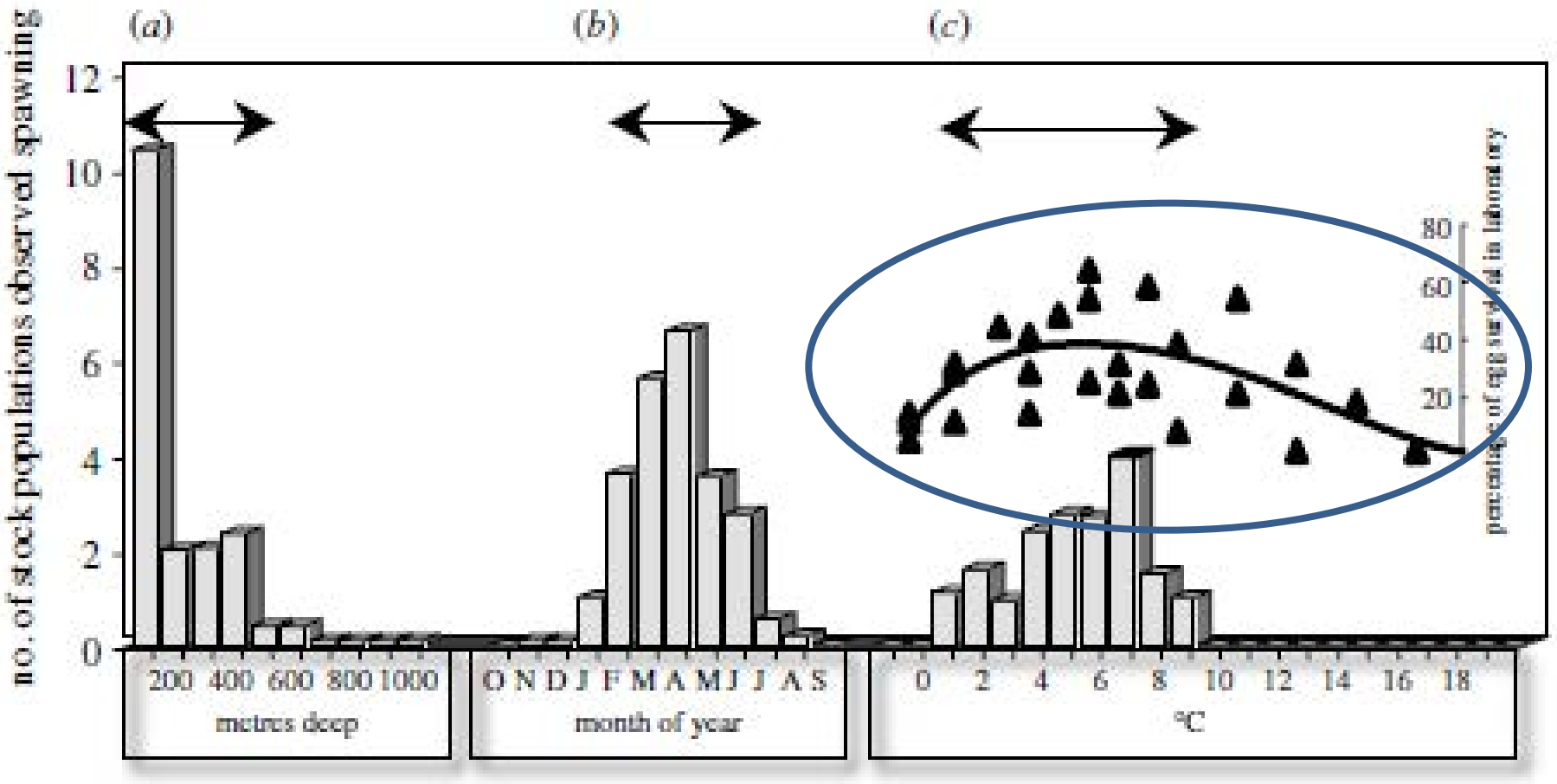
Cod Recruitment and Temperature



Planque and Fredou (1999)

Drinkwater, 2005

What is the Mechanism?

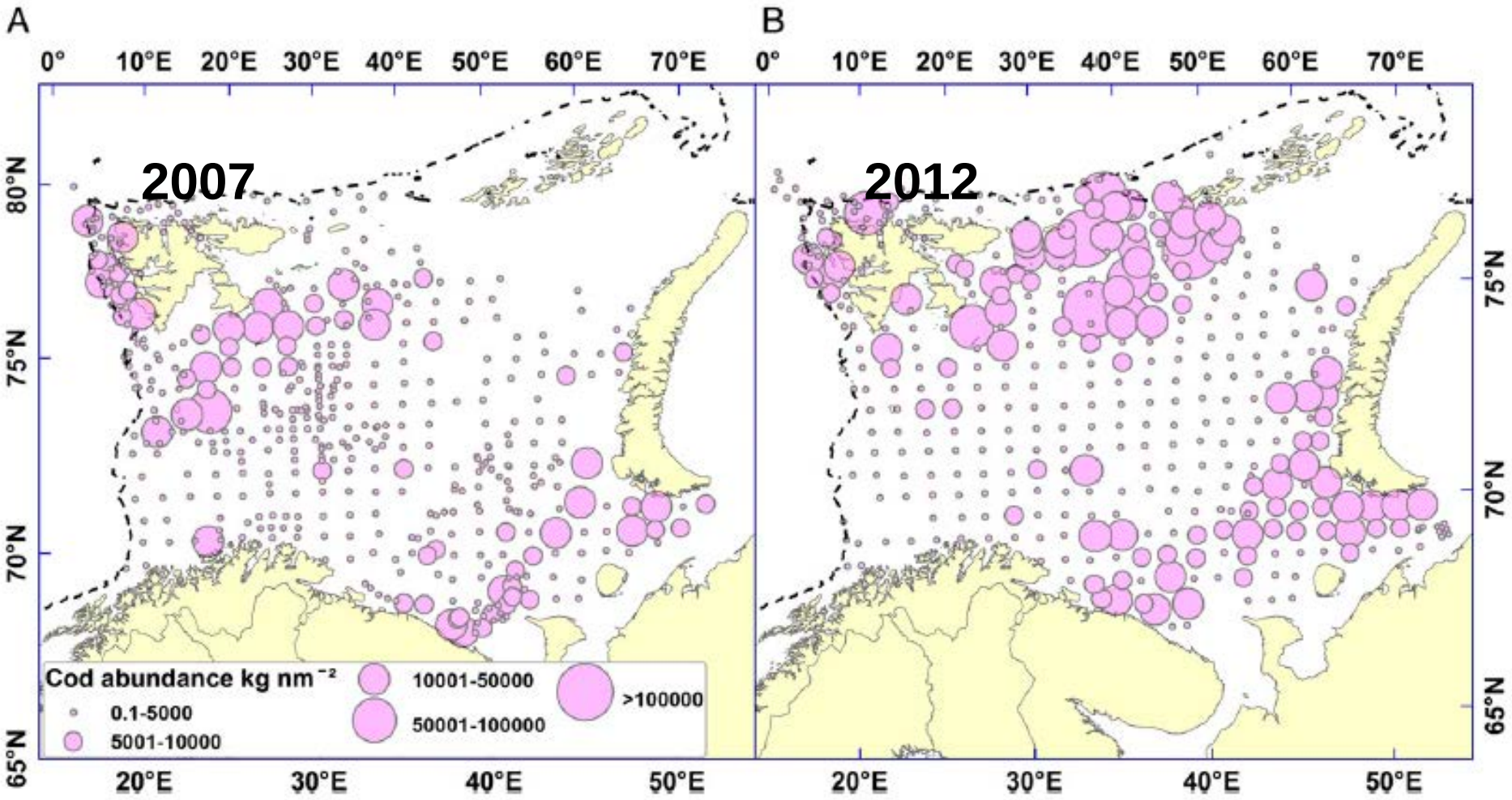


Could it be temperature effects on egg mortalities?

Bigg et al., 2007

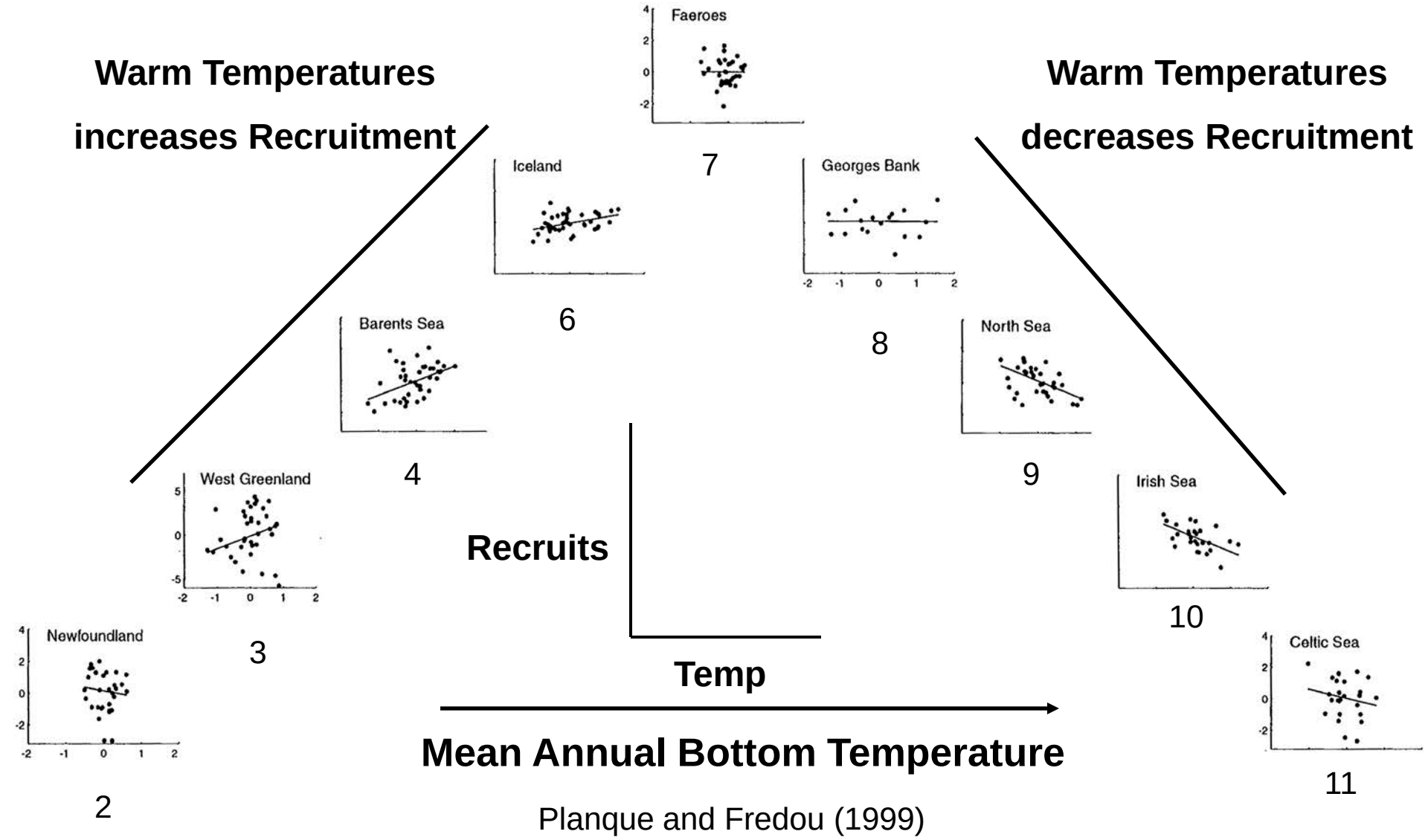
Distributional Changes

Barents Sea Cod



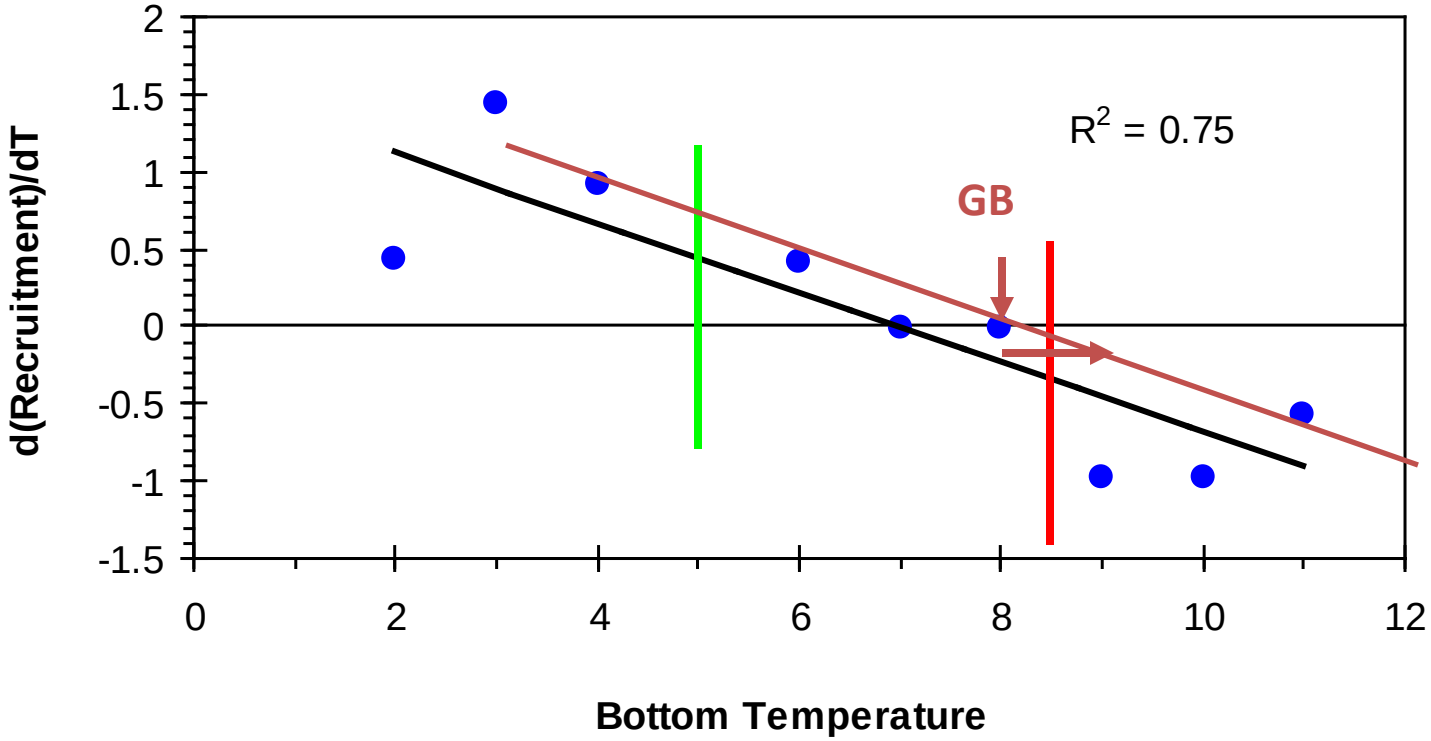
Kjesbu et al., 2014

Response to Future Climate Change



Planque and Fredou (1999)

Drinkwater, 2005



If BT < 5° and T warms stock recruitment generally increase

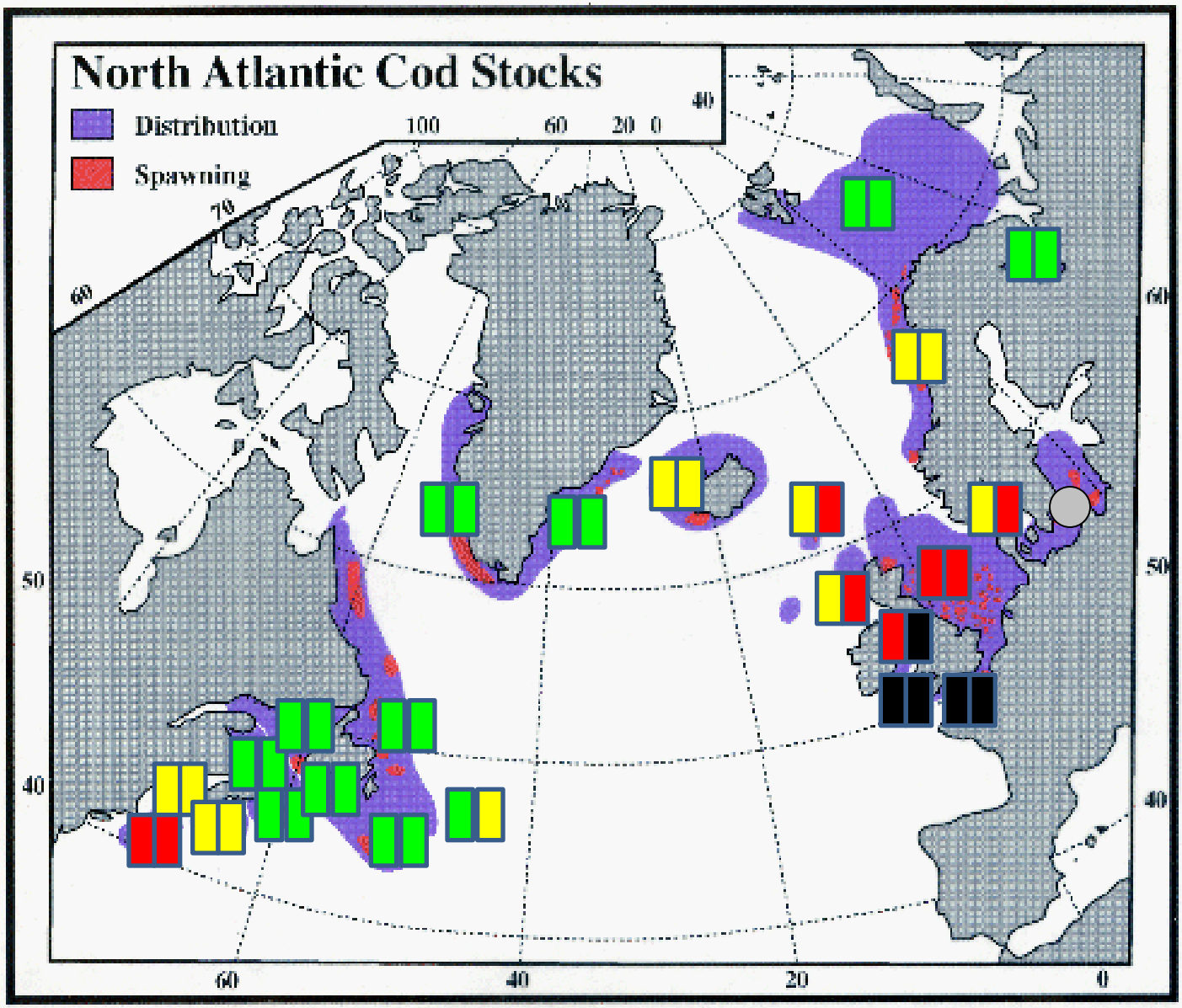
If BT between 5° and 8.5°C little change in recruitment

If BT >8.5°C recruitment generally decreases

If BT 12°C we do not see any cod stocks

Drinkwater, 2005

Effect on Recruitment of 1/2°C increase



12

Increase

No trend

Decrease

Collapse

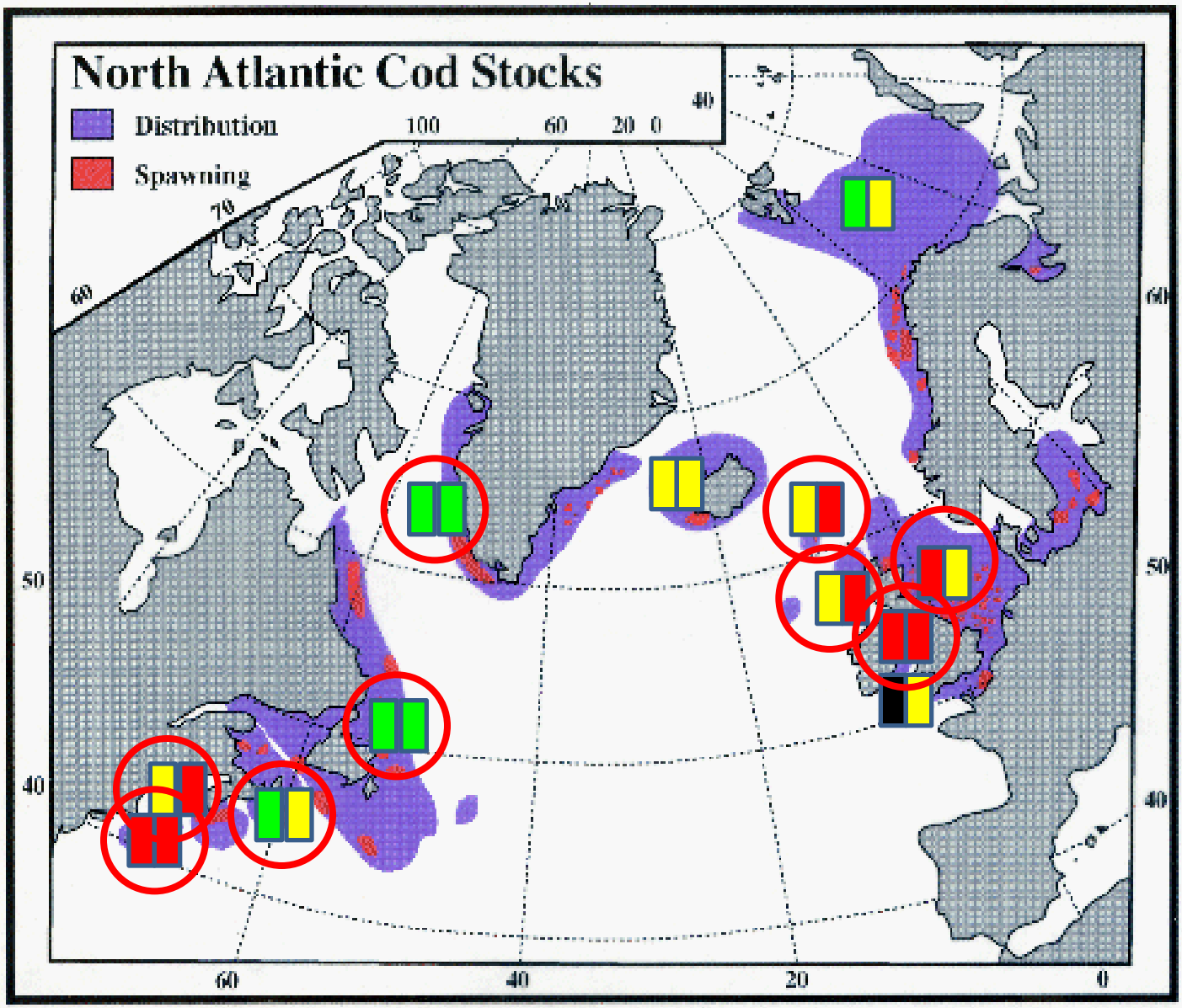
?

Warm Water Stocks in Trouble; Cold Water Stocks do much better

Many caveats!

Comparison of observed and modelled recruitment

First bar is modelled trend and second bar is observed trend.



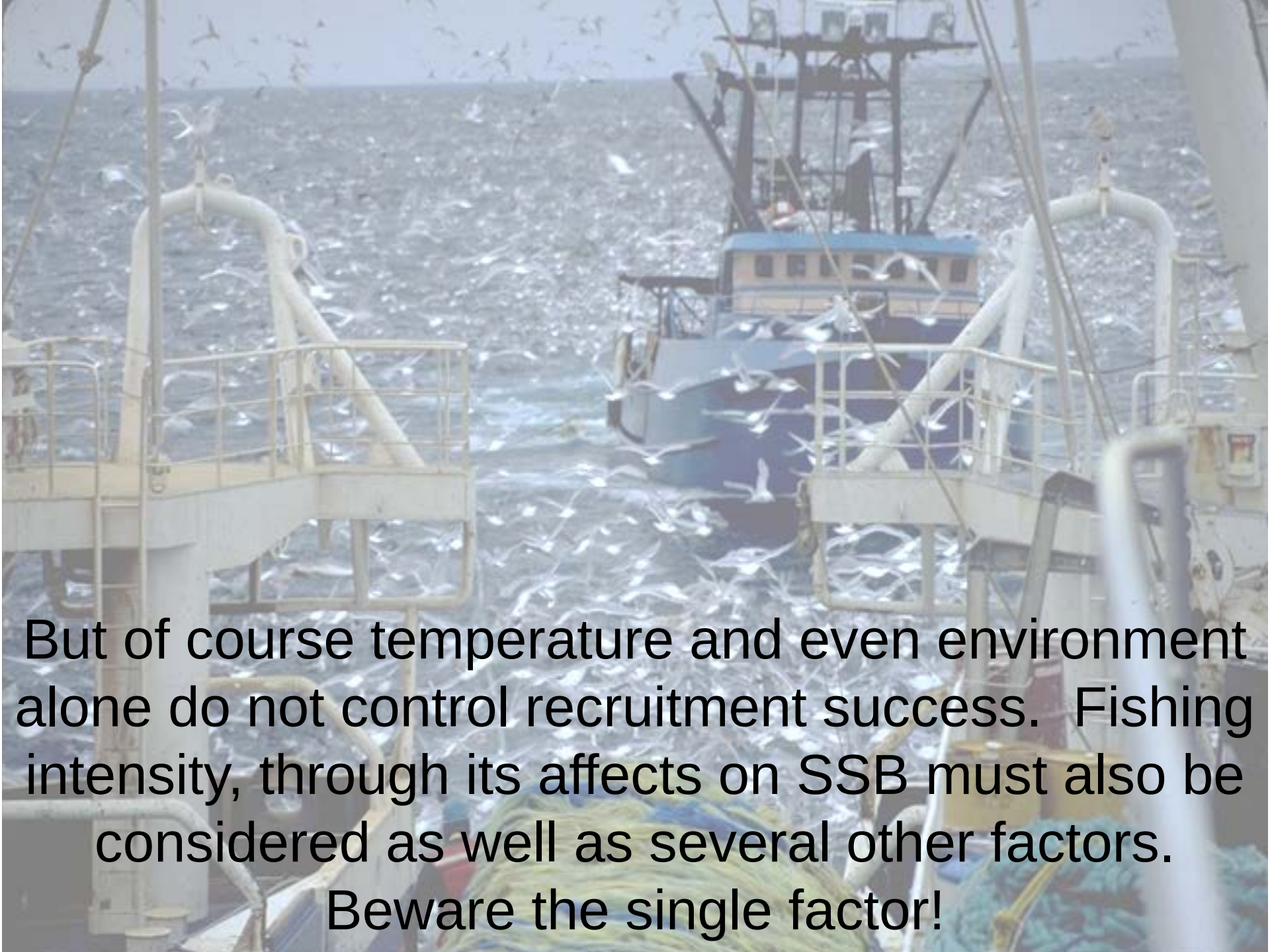
Increase

No Trend

Decrease

Collapse

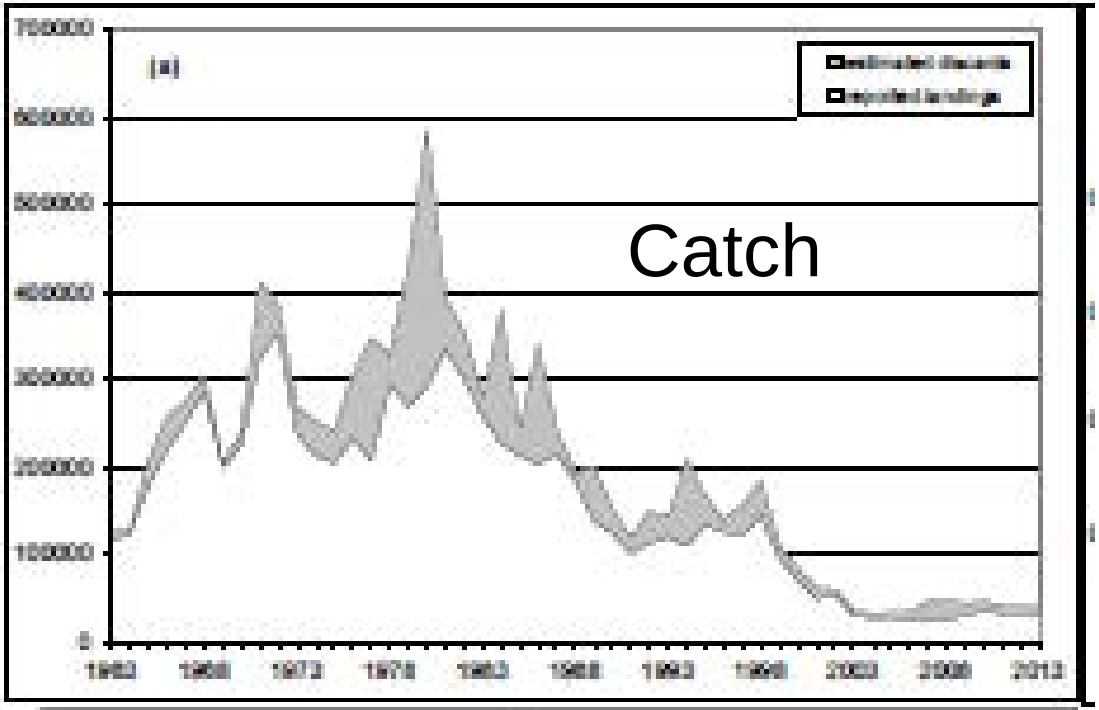
5 of 12 similar
3 declined when expected no trend
2 showed no trend when expected increase
1 showed no trend when expected decrease
1 showed no trend when expect collapse

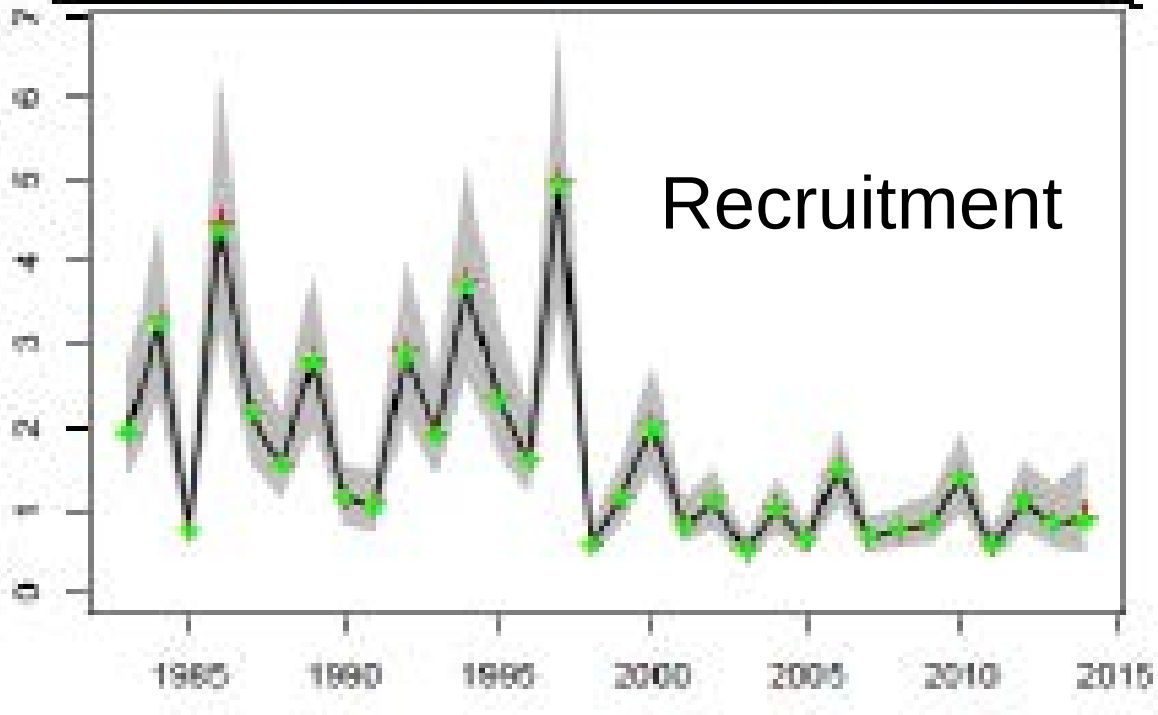


But of course temperature and even environment alone do not control recruitment success. Fishing intensity, through its affects on SSB must also be considered as well as several other factors. Beware the single factor!

Examination of a few cod stocks in more detail.

North Sea Cod

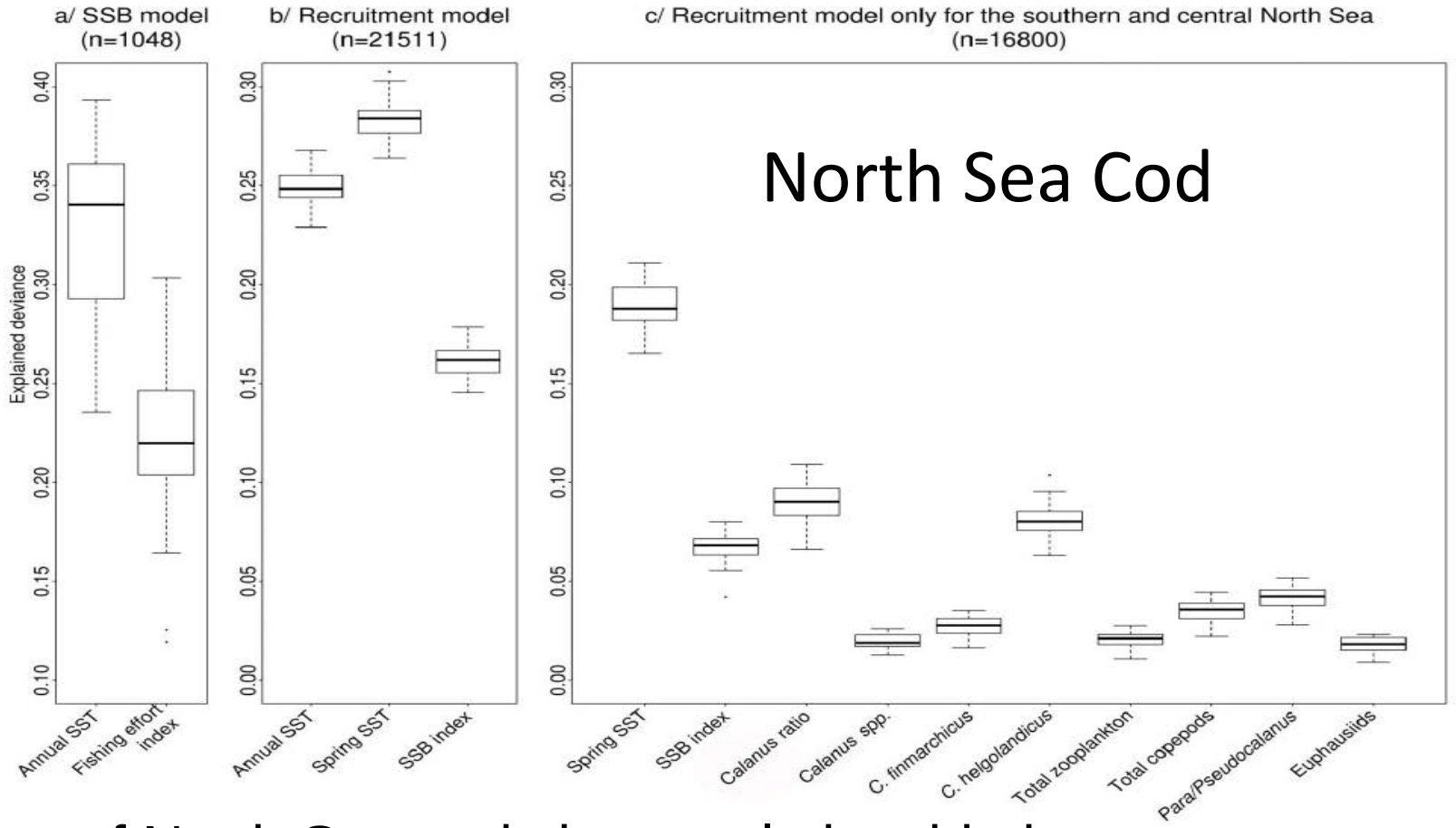




Catch and recruitment at or near minimum values in recent years.

ICES, 2014

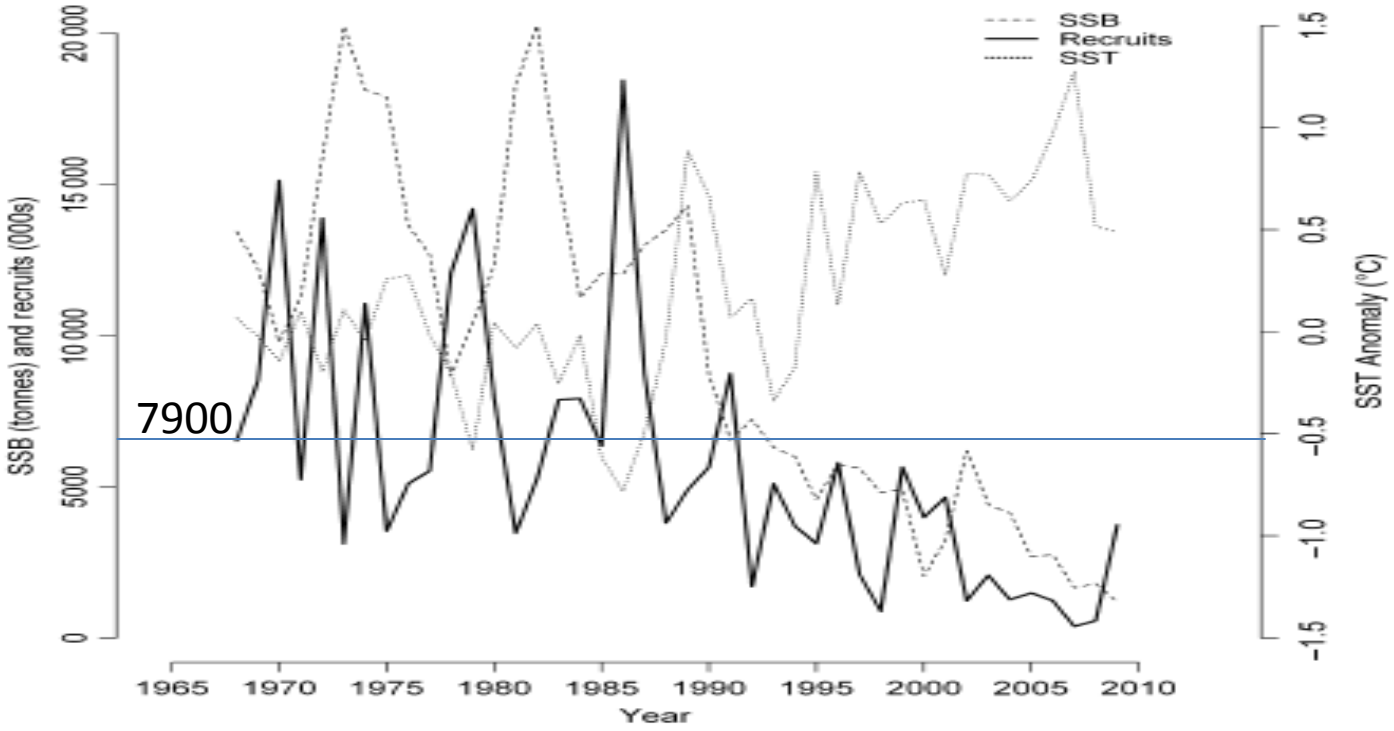
North Sea Cod



Nicolas et al., 2014

Studies of North Sea cod shows relationship between temperature and recruitment and stronger relationship than with SSB. However, temperature only accounts for 30% of the recruitment variance, which implies other factors are important.

Irish Sea

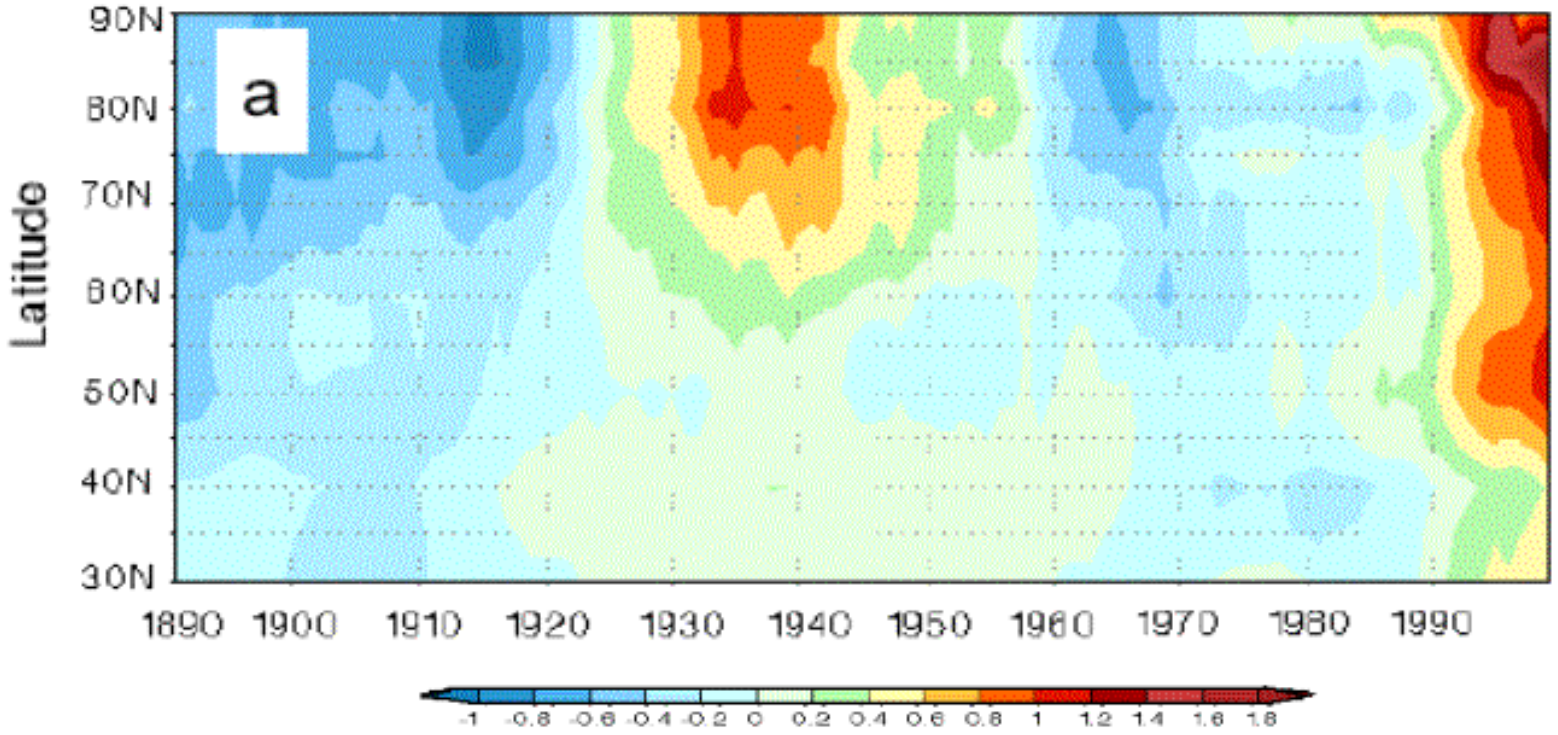


A threshold was identified between recruitment and SSB at approximately 7900 t. The analysis suggested a threshold shift in the relationship between recruitment and SSB in Irish Sea cod, with cod recruitment being more sensitive to climatic variability during low SSB regimes.

Begg et al., 2013

West Greenland Cod Stock

During the 1920s and 1930s there was rapid warming of the atmosphere and oceans primarily north of 60ºN that produced temperatures as warm or warmer than the present.

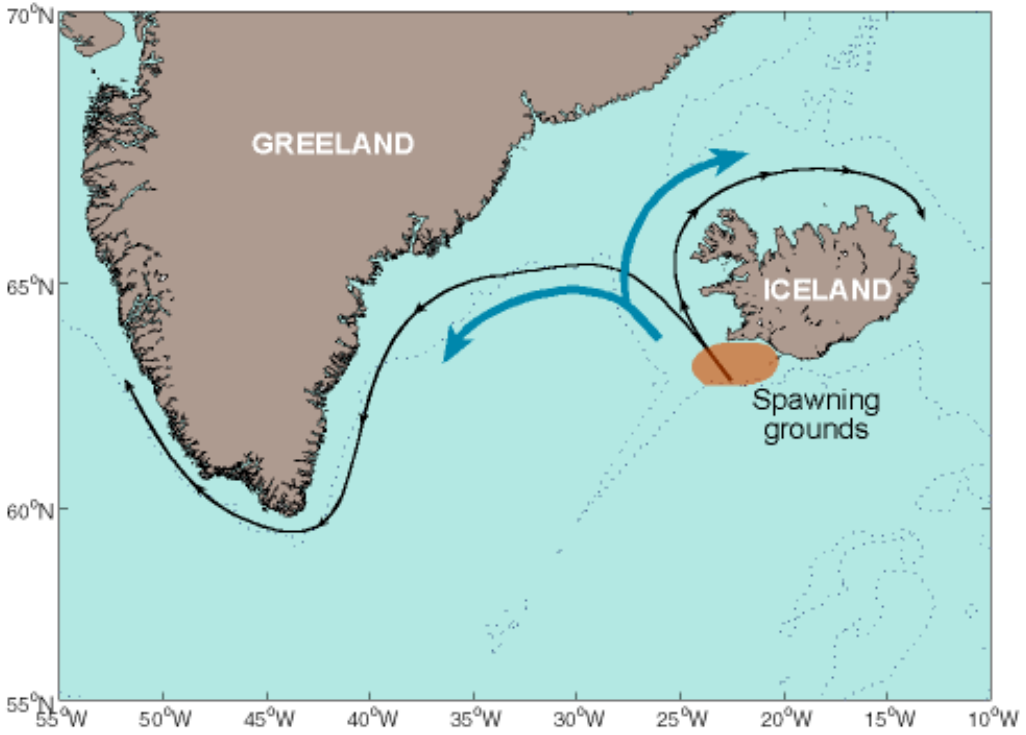


Johannessen et al. 2004. Tellus

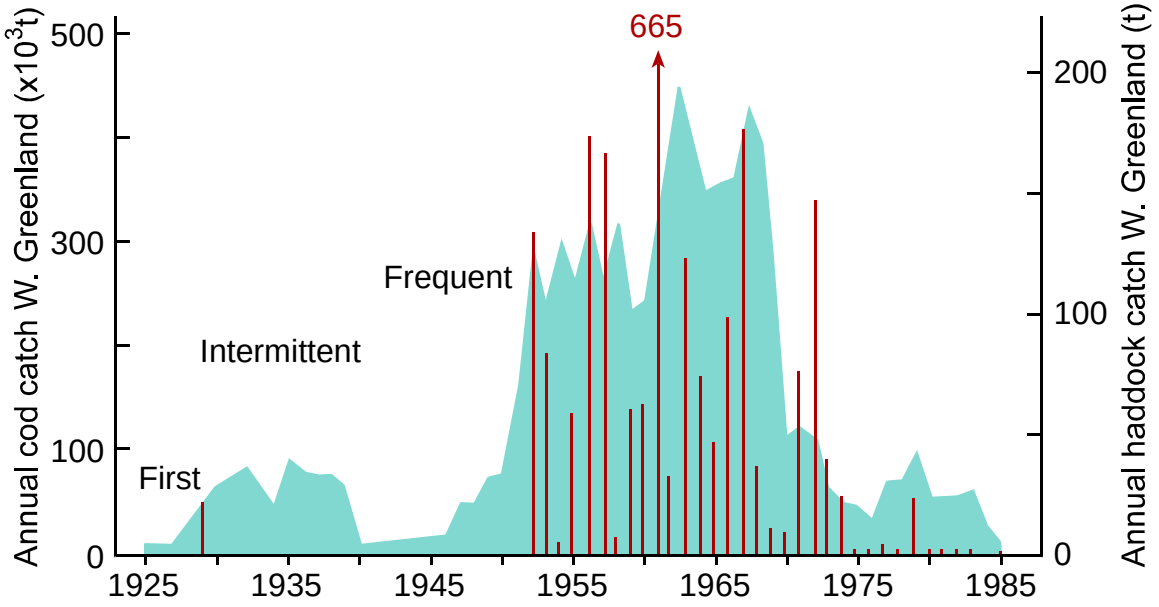
West Greenland

Iceland Connection

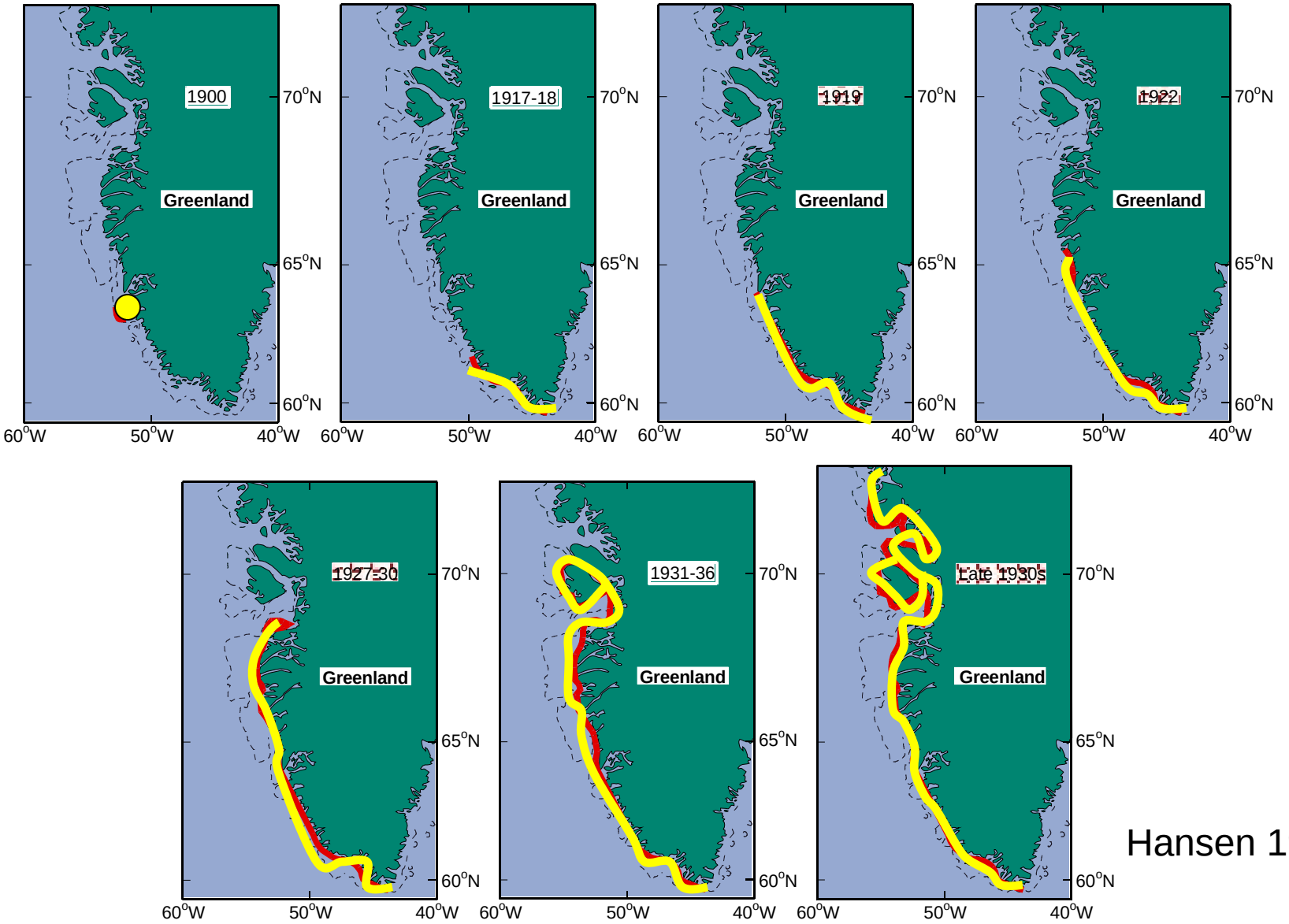
Under certain conditions cod larvae drift from Iceland to West Greenland



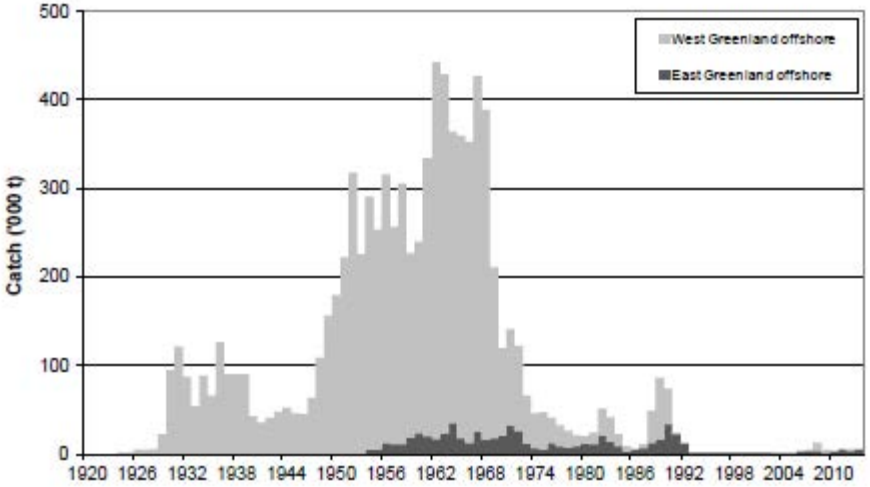
Conditions in 1920s resulted in the drift of larvae from Iceland to West Greenland and their survival.

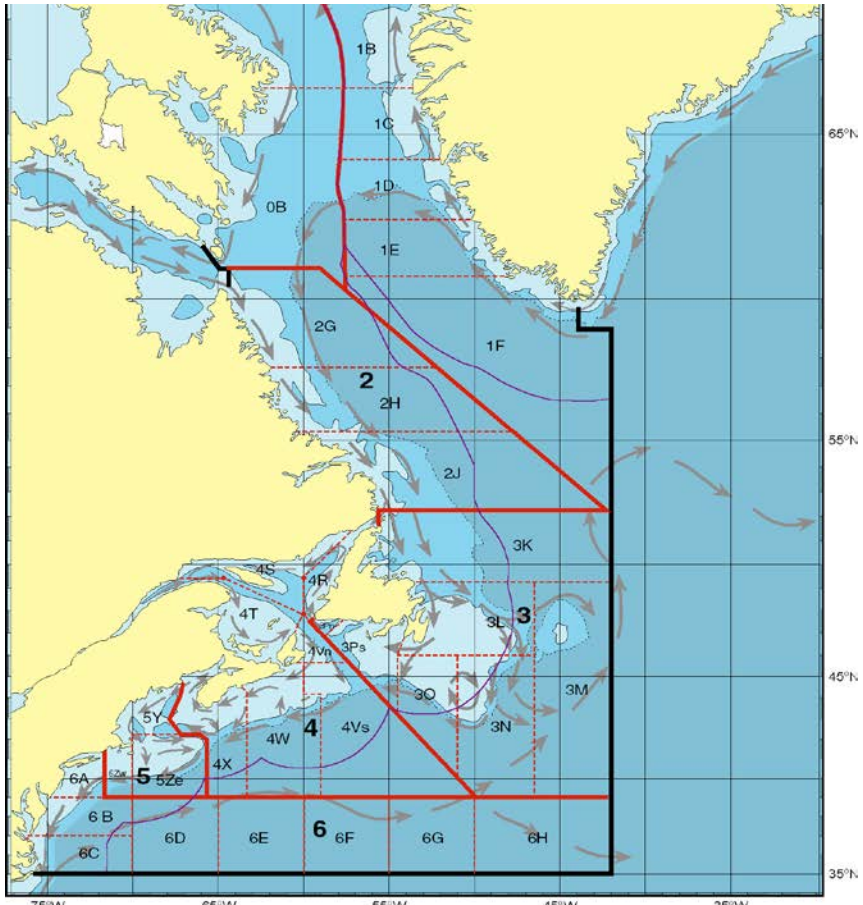


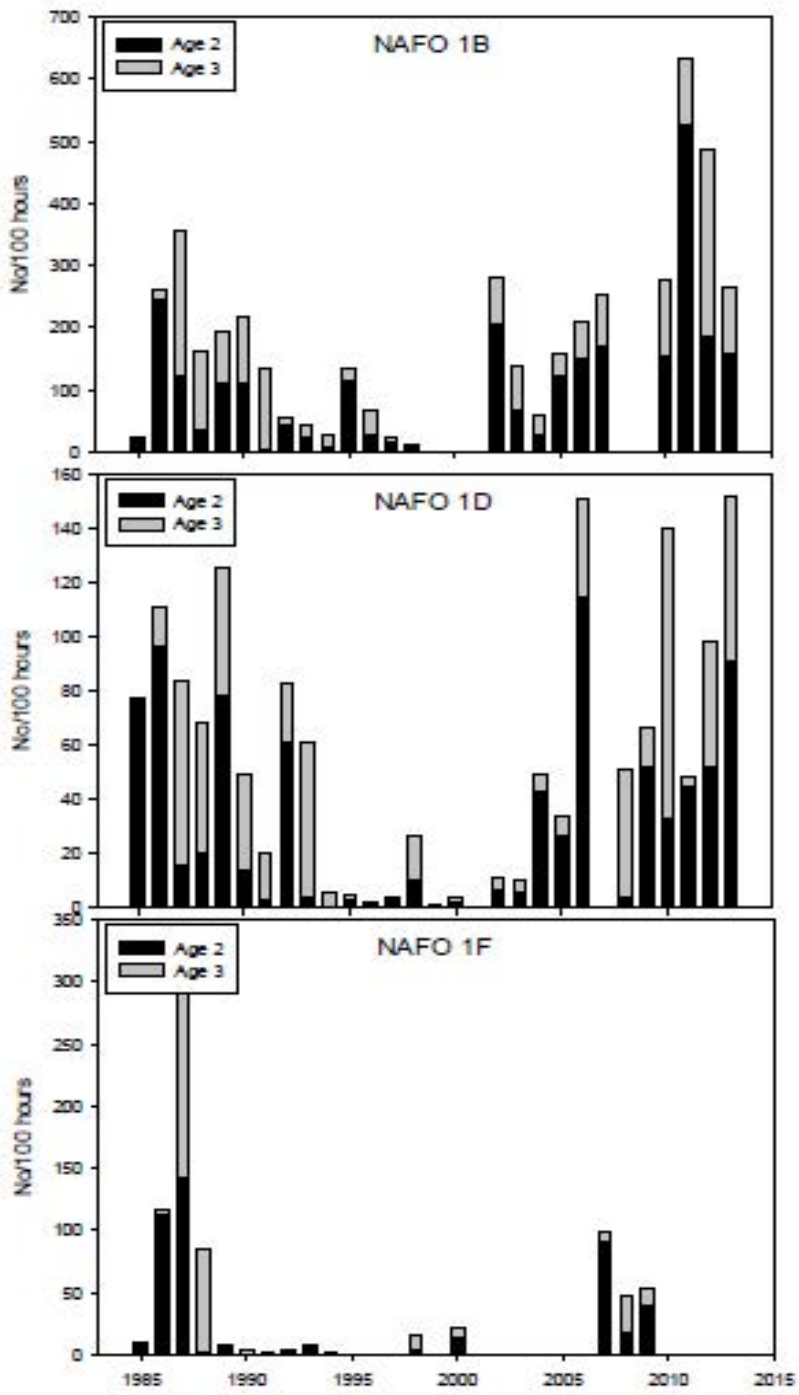
Atlantic cod moved northward by 1500 km in response to warming.



Hansen 1940

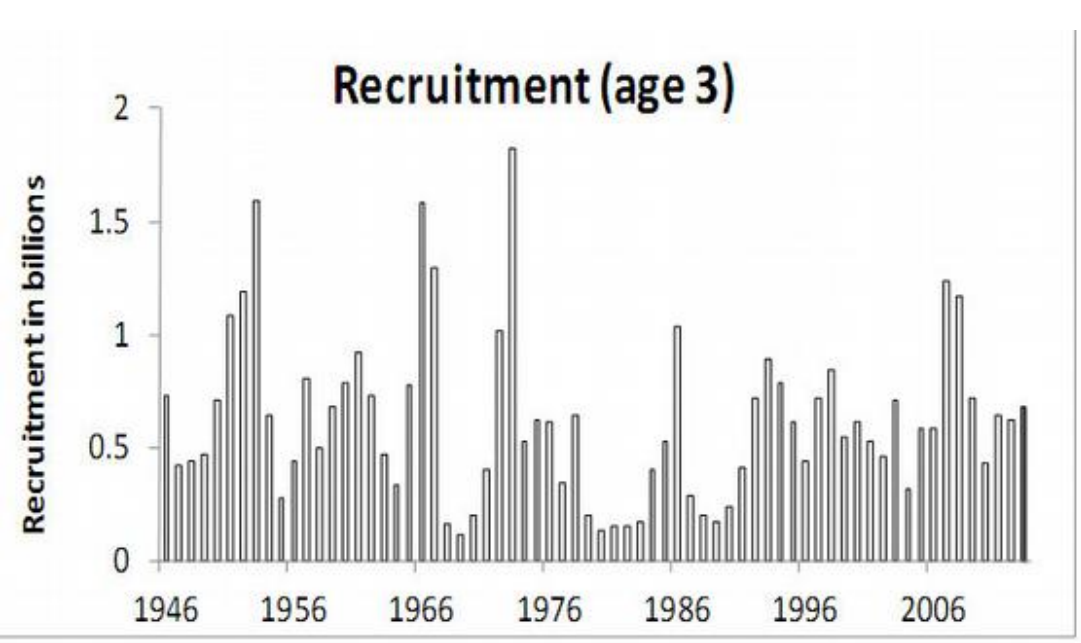


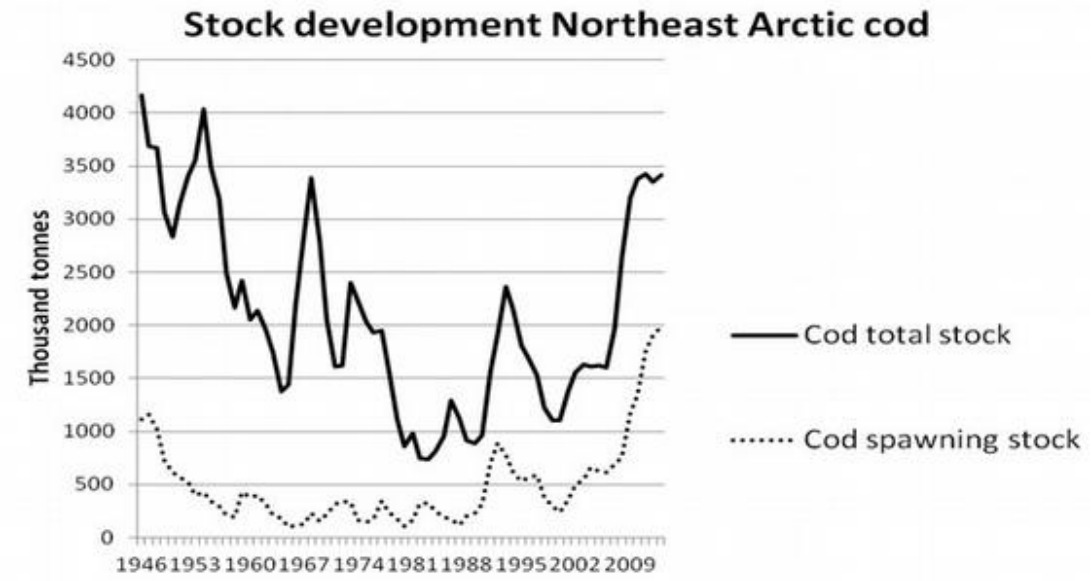




ICES NWWG, 2014

Barents Sea





Recruitment in recent years has been stable and relatively strong. This has contributed to an increase in the SSB and the total stock. SSB is higher than in the mid 20th Century warm period. It is presently the largest Atlantic cod stock. This has been attributed to cautious management and good environmental conditions.

A few concluding remarks

- Atlantic cod are high resiliant.
- Climate plays a significant role in the variability of their production and distribution
- So does fishing

I think that a comparative study between Atlantic and Pacific cod would be worth pursuing.


Thanks for your attention.