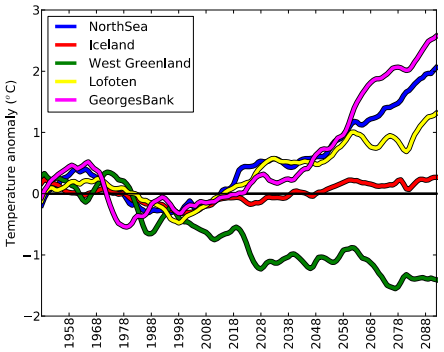
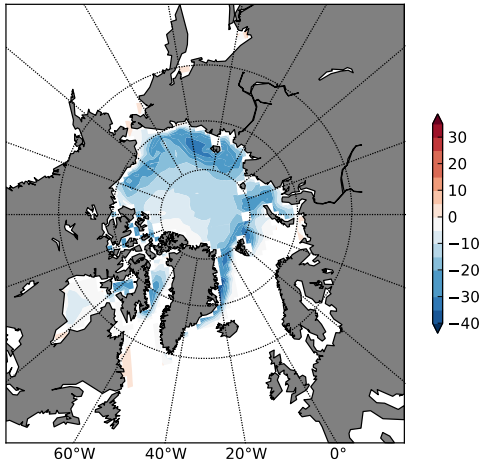
Analyzing warm and cold climate phases to understand differences in survival of larval fish: Potential implications of climate variability

Trond Kristiansen

Image: http://www.noaanews.noaa.gov





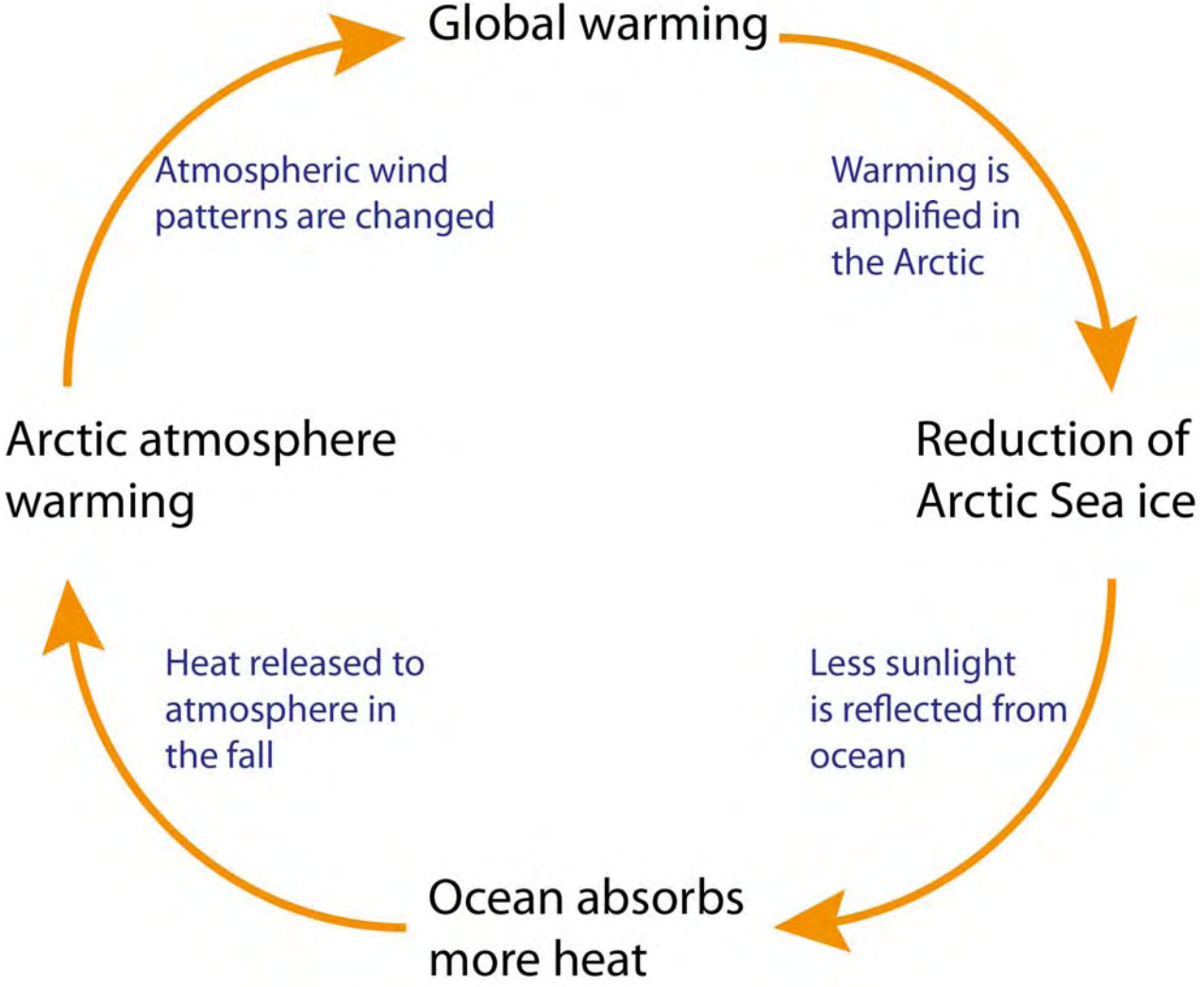
W1 Workshop Biological consequences of a decrease in sea ice in Arctic and Sub-Arctic Seas

May 22nd ESSAS OSM Seattle

Outline

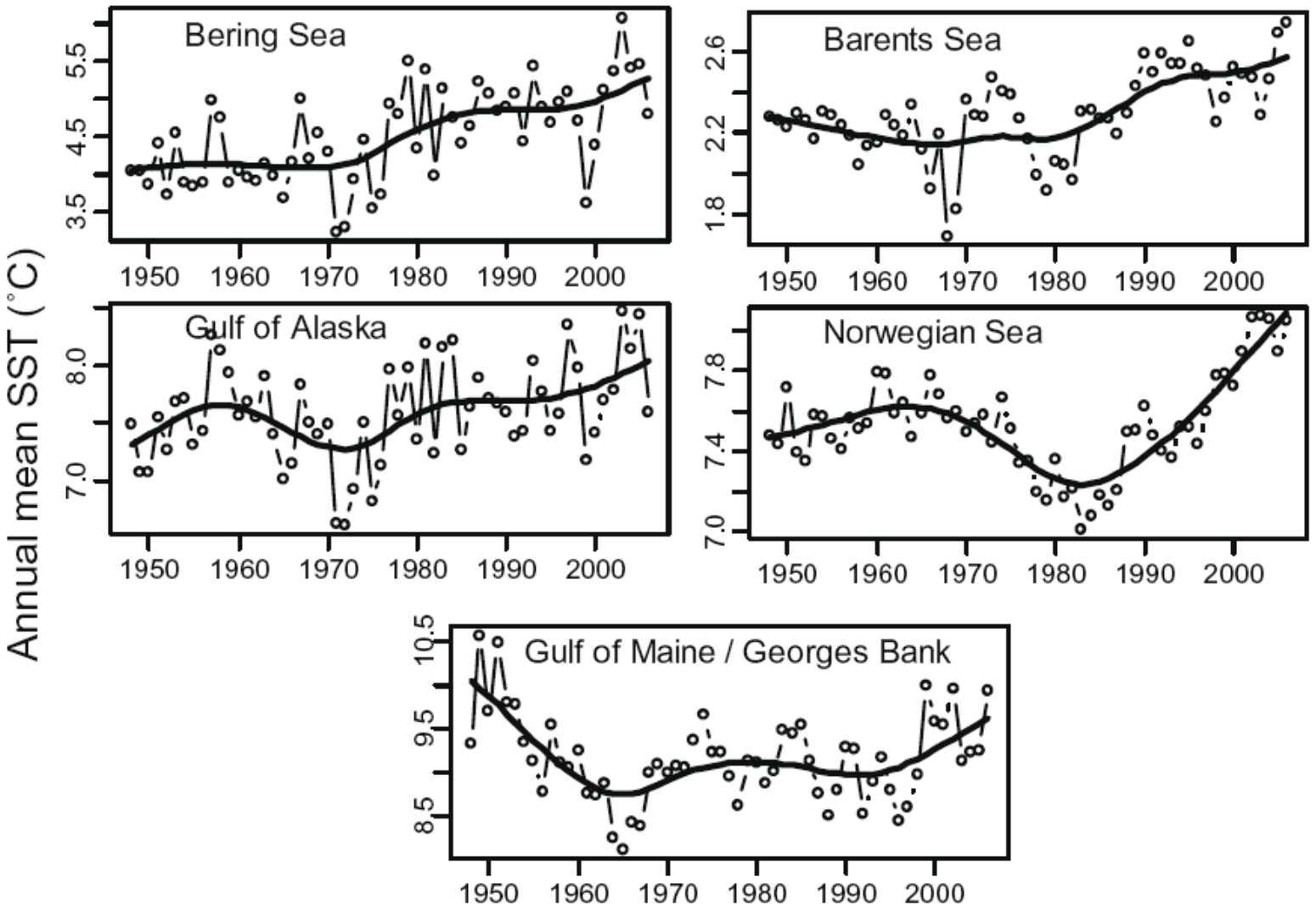
Image: http://www.oceanleadership.org

- Climate change impacts
- Comparative analysis of 4 spawning grounds
  - Differences between ecosystems
  - Individual-based modeling
  - Warm and cold phases and the effect on larval cod survival
  - Conclusions
- Future directions



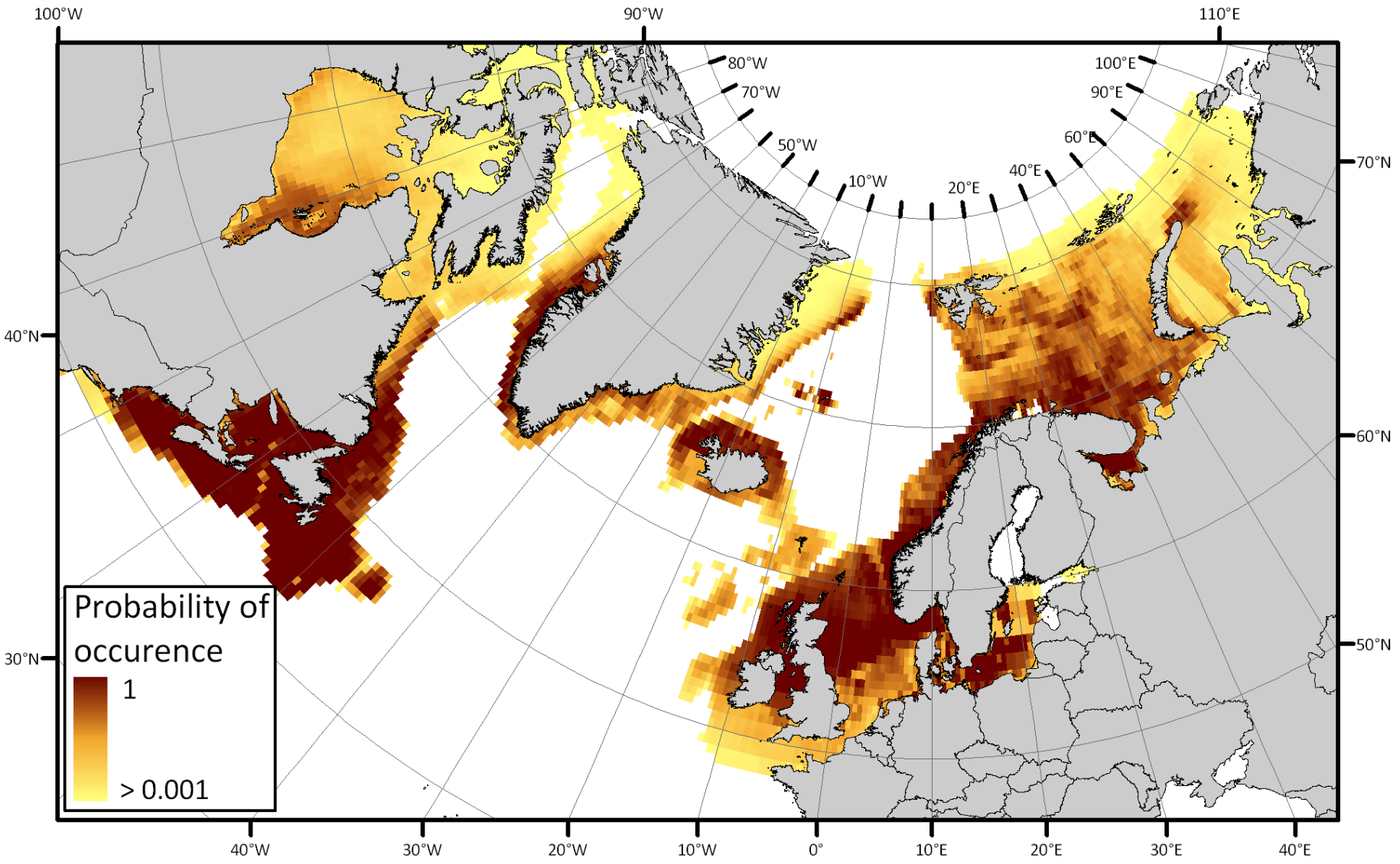
= Stronger stratification and reduced mixing of nutrients into surface layer

Climate change and variability



Mueter et al. 2009 PiO 81

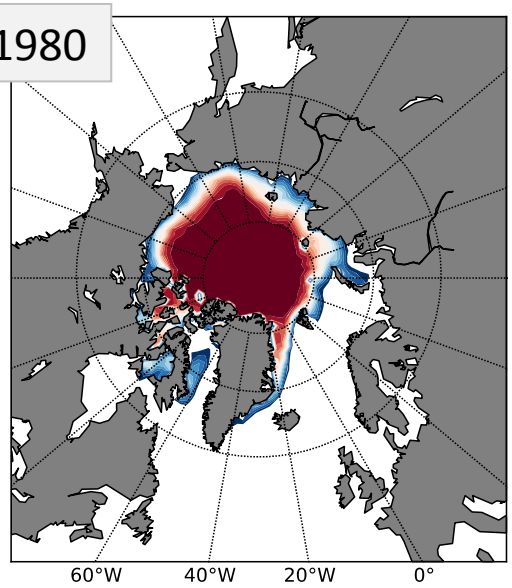
Cod distribution 2050



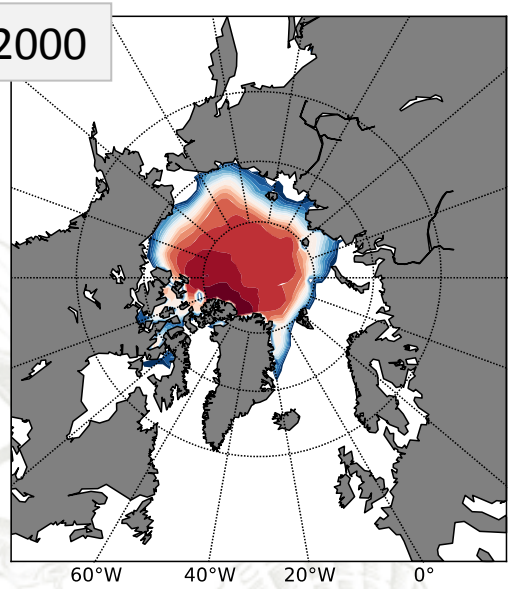
Data from Aquamaps

Observed changes in ice concentrations

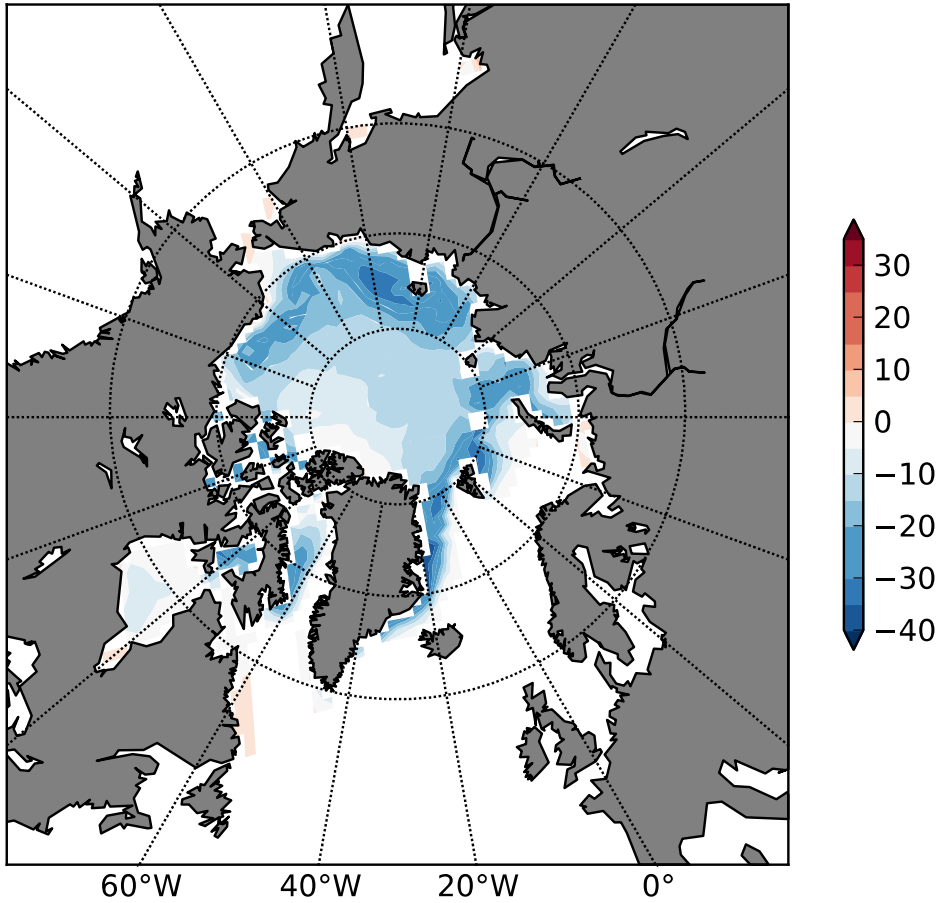
1961-1980



1981-2000



Ice concentration anomaly summer
1981-2000 vs 1961-1980

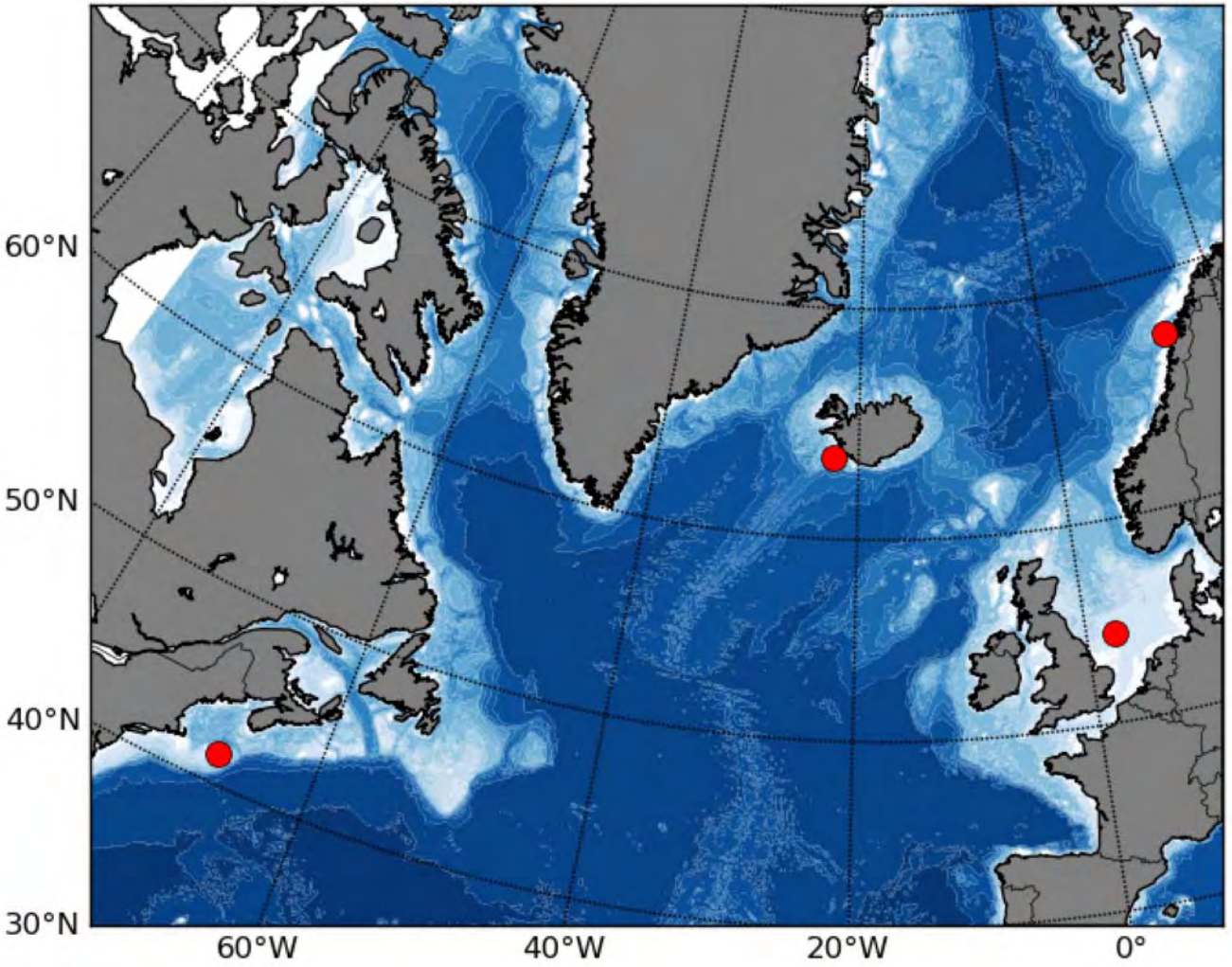


Datasource: Walsh & Chapman:
http://www.cgd.ucar.edu/cas/guide/Data/walsh.html

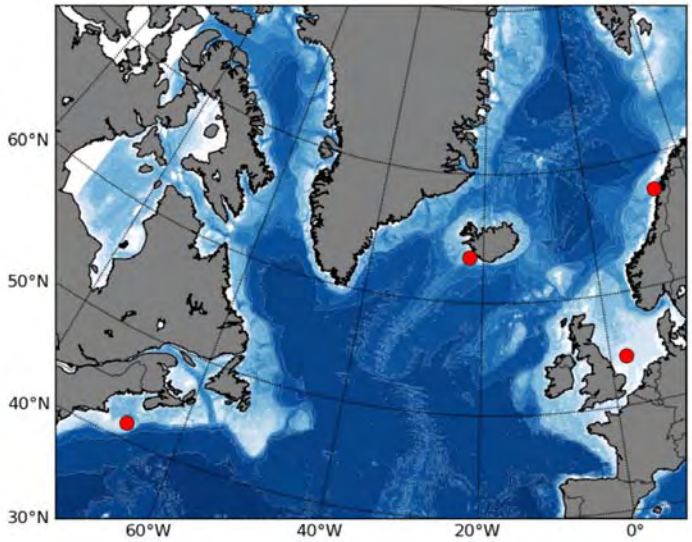
Comparative analyses

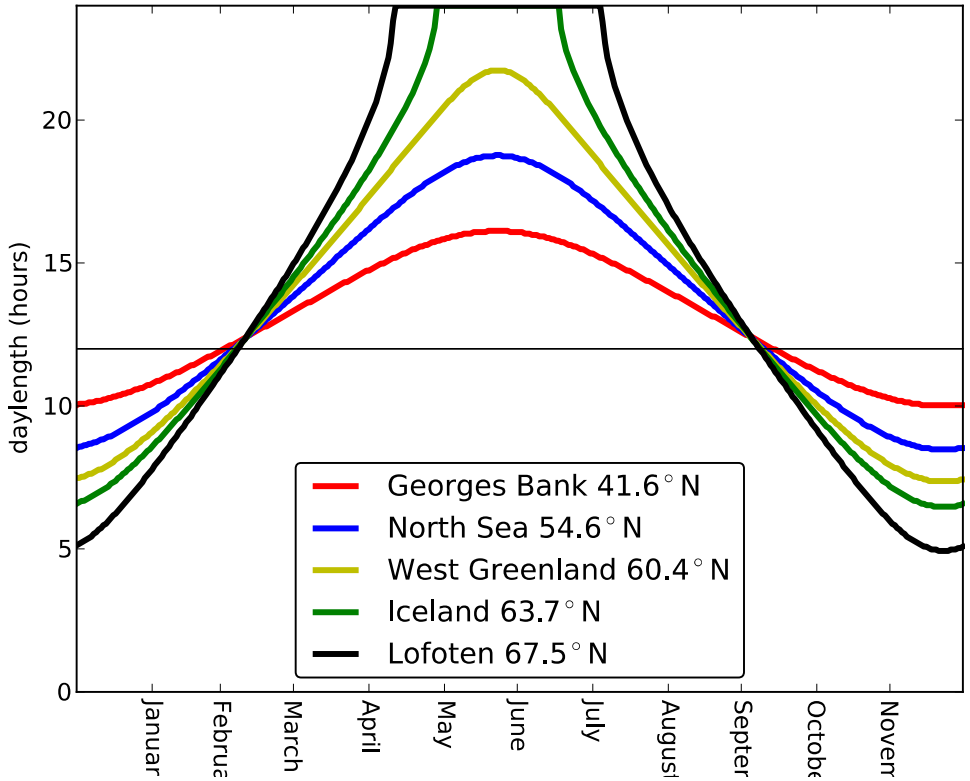
- Past conditions can help us understand future ecosystem dynamics
- Models may identify what drives changes in ecosystems (e.g. temperature, light, prey)
- What determines recruitment variability?

Important cod spawning locations

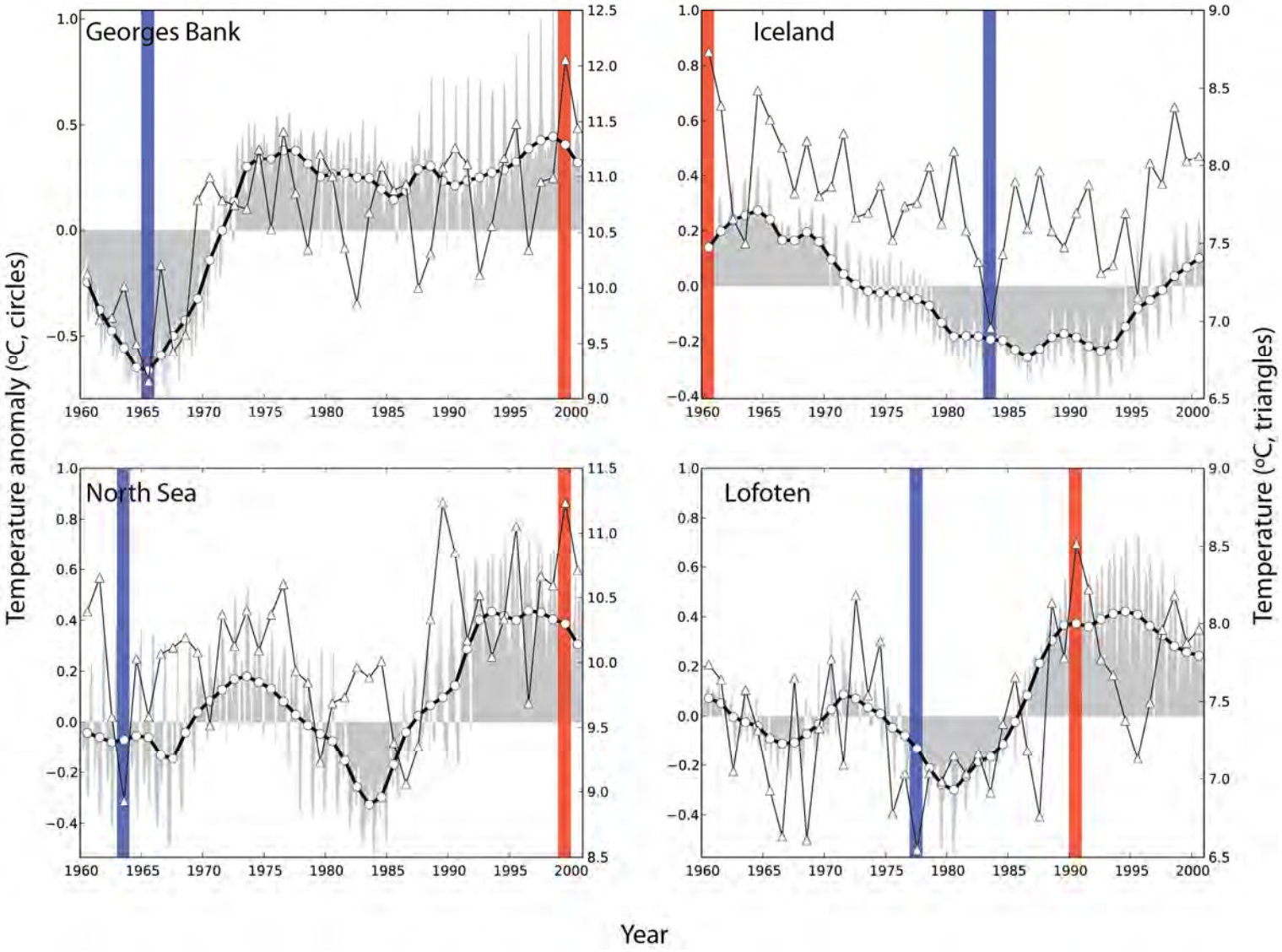


Light at spawning locations



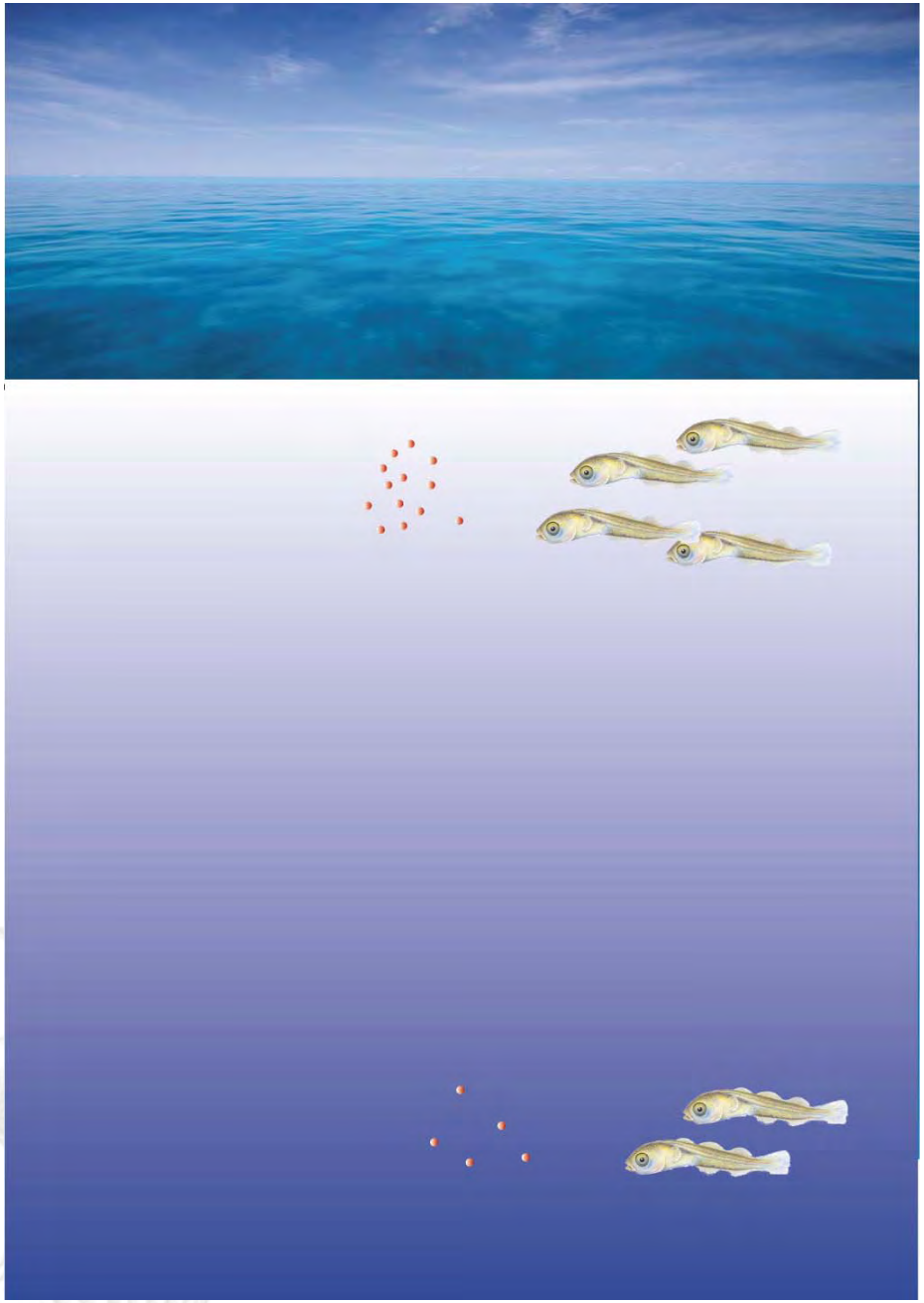


Temperature 1960-2002



T. Kristiansen , K. Drinkwater, R. G. Lough, and S. Sundby (2011).PLoS ONE 6(3):e17456. Recruitment Variability in North Atlantic Cod and Match-Mismatch Dynamics

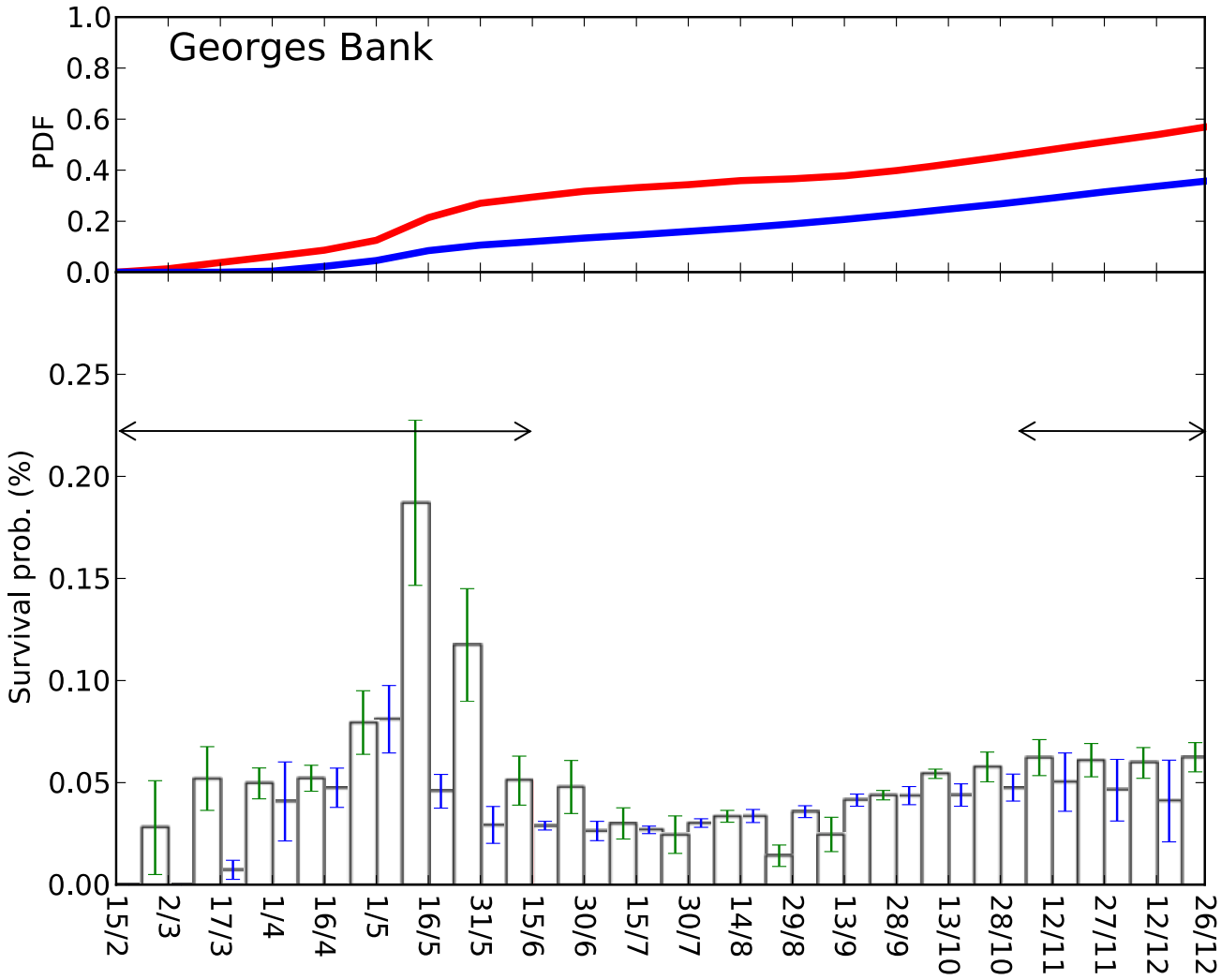
Mechanistic individual-based modeling



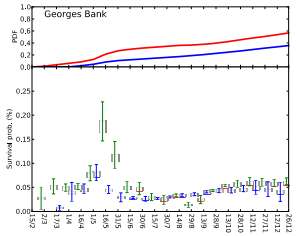
Mechanistic modeling considers the physical and biological properties that affect larval fish, e.g.

- light
- temperature
- turbulence
- contrast
- prey density
- prey size
- prey swimming speed
- ….

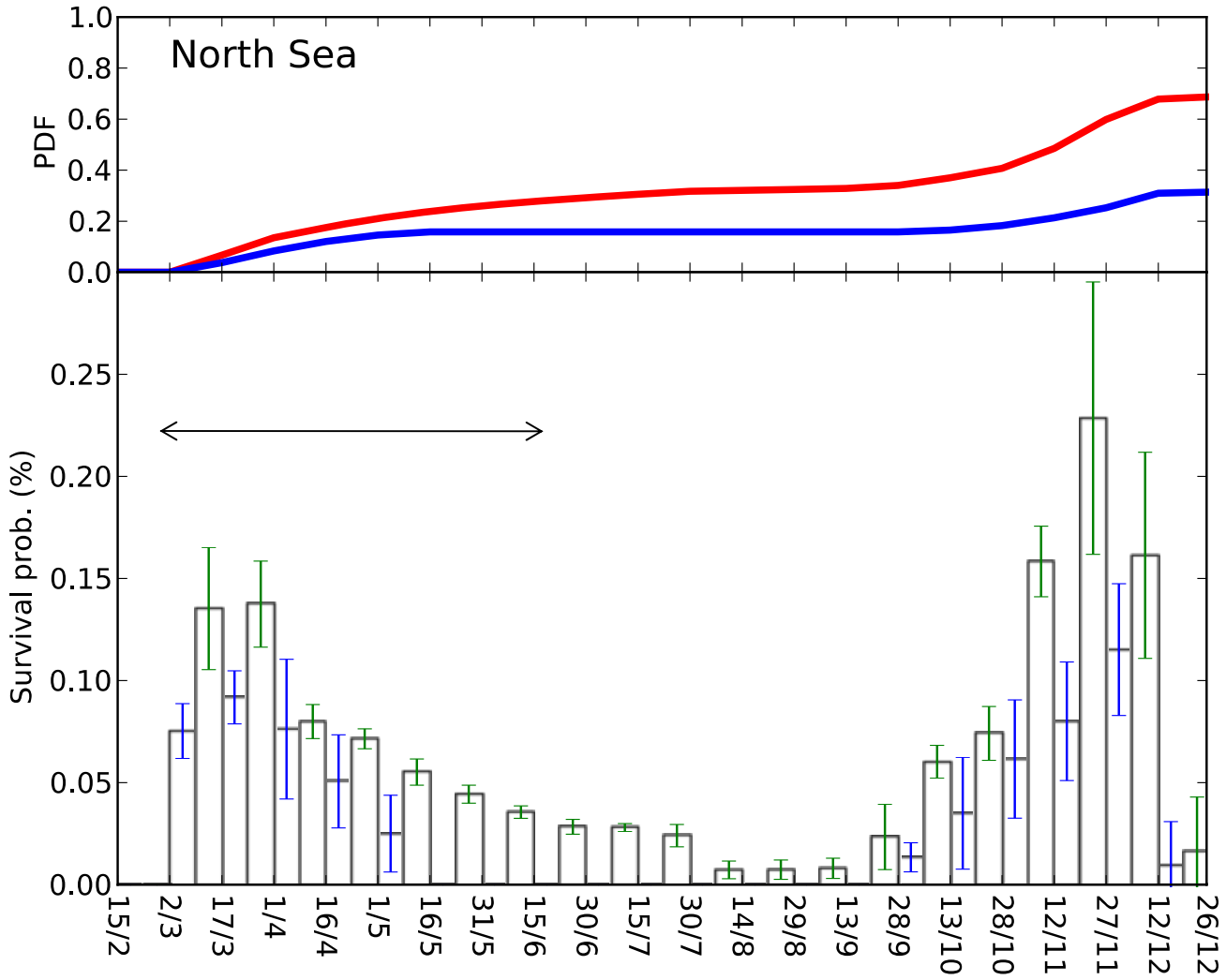
Georges Bank



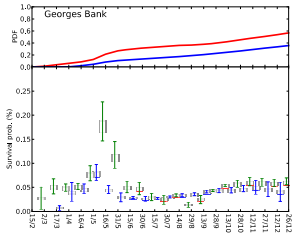
T. Kristiansen , K. Drinkwater, R. G. Lough, and S. Sundby (2011).PLoS ONE 6(3):e17456. Recruitment Variability in North Atlantic Cod and Match-Mismatch Dynamics

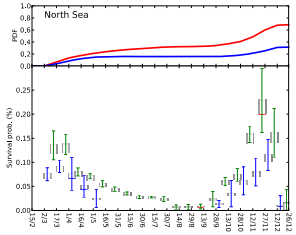

Georges Bank

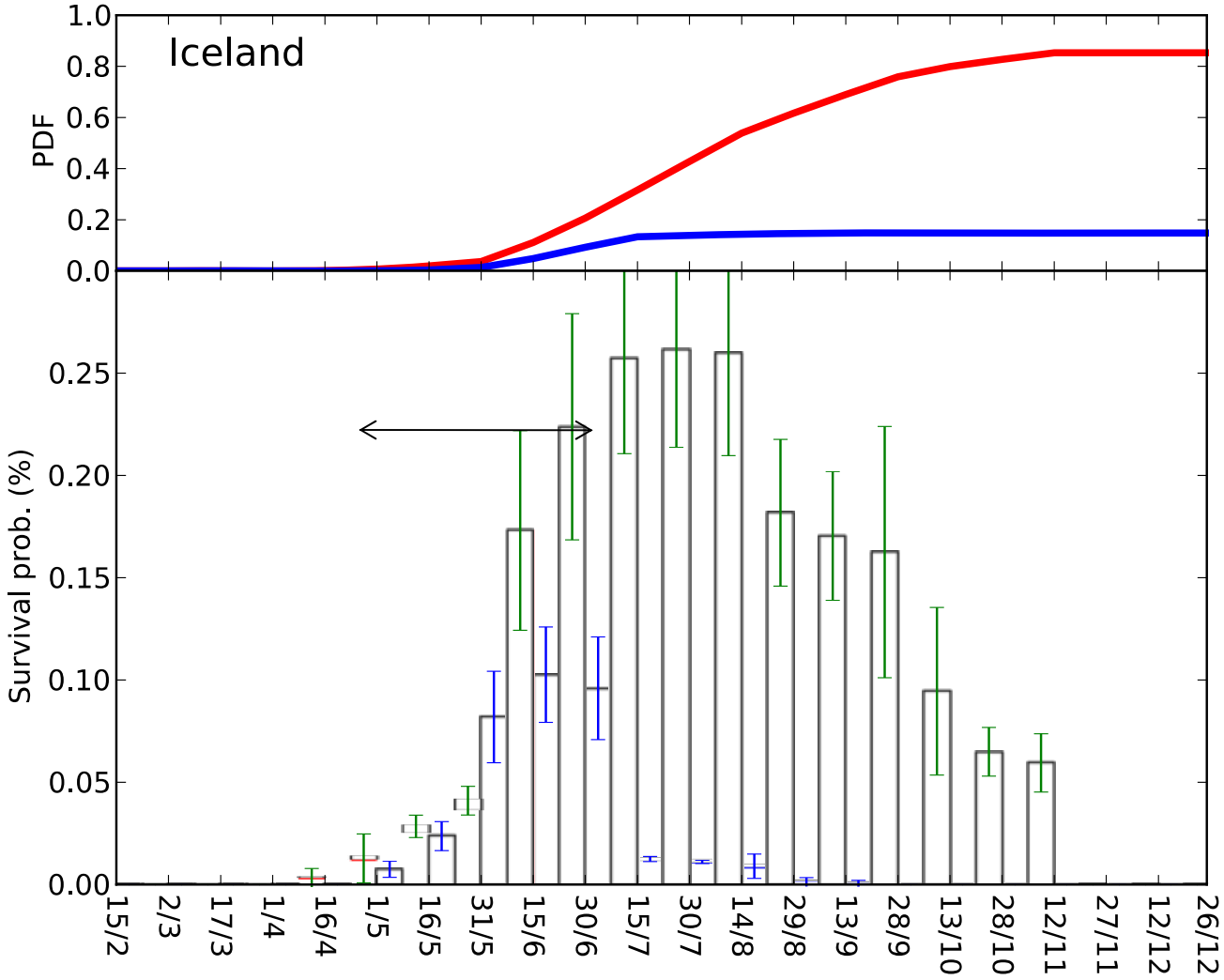
North Sea


North Sea
PDF
Survival prob. (%)
1.0
0.8
0.6
0.4
0.2
0.0
0.25
0.20
0.15
0.10
0.05
0.00
15/2
2/3
17/3
1/4
16/4
1/5
16/5
31/5
15/6
30/6
15/7
30/7
14/8
29/8
13/9
28/9
13/10
28/10
12/11
27/11
12/12
26/12

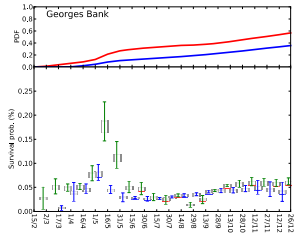
Iceland

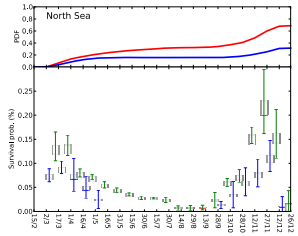

Georges Bank

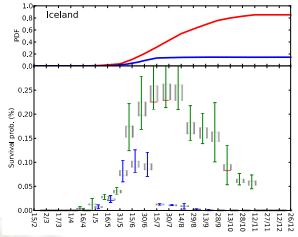

North Sea

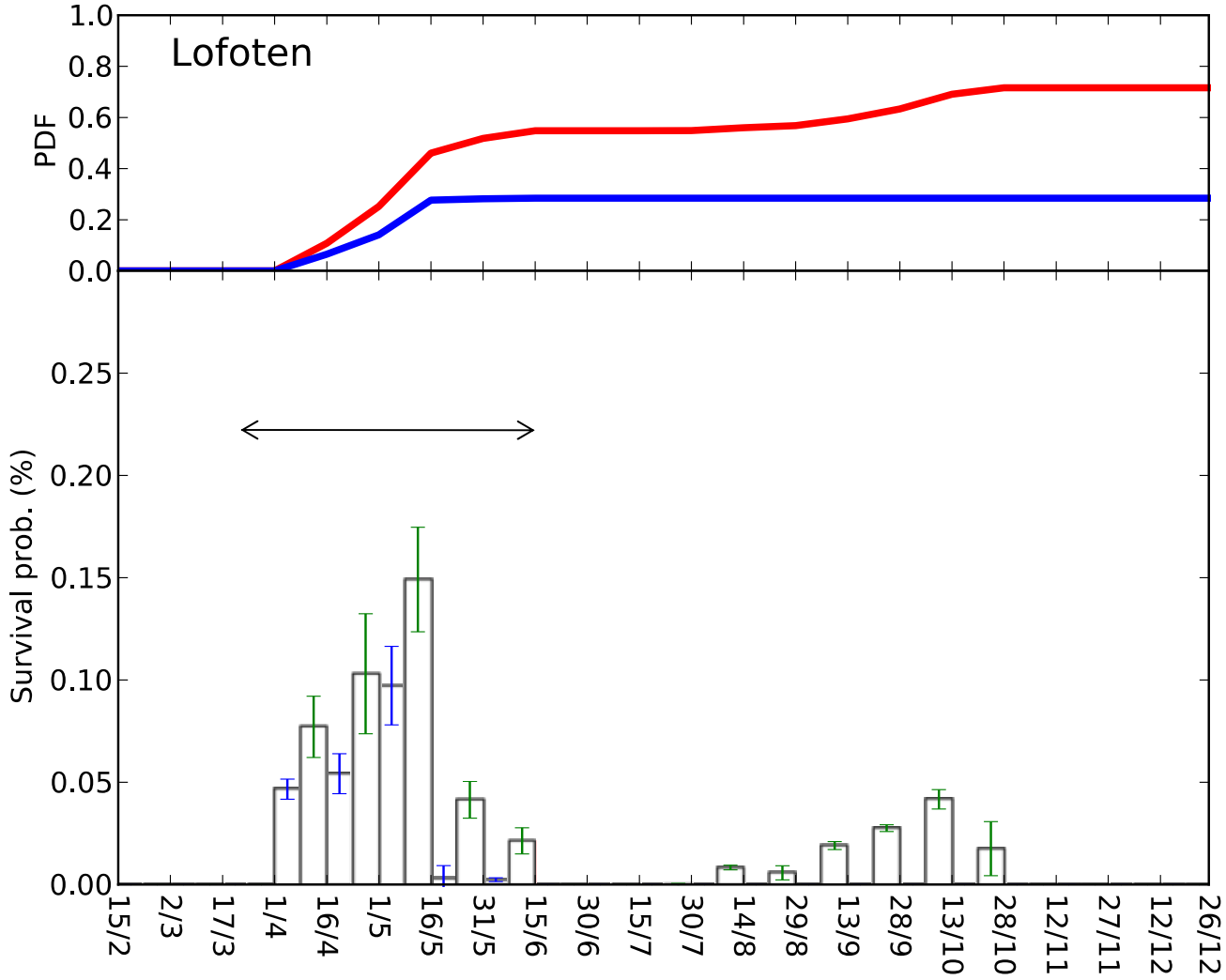

Iceland
PDF
Survival prob. (%)
1.0
0.8
0.6
0.4
0.2
0.0
0.25
0.20
0.15
0.10
0.05
0.00
15/2
2/3
17/3
1/4
16/4
1/5
16/5
31/5
15/6
30/6
15/7
30/7
14/8
29/8
13/9
28/9
13/10
28/10
12/11
27/11
12/12
26/12

Lofoten

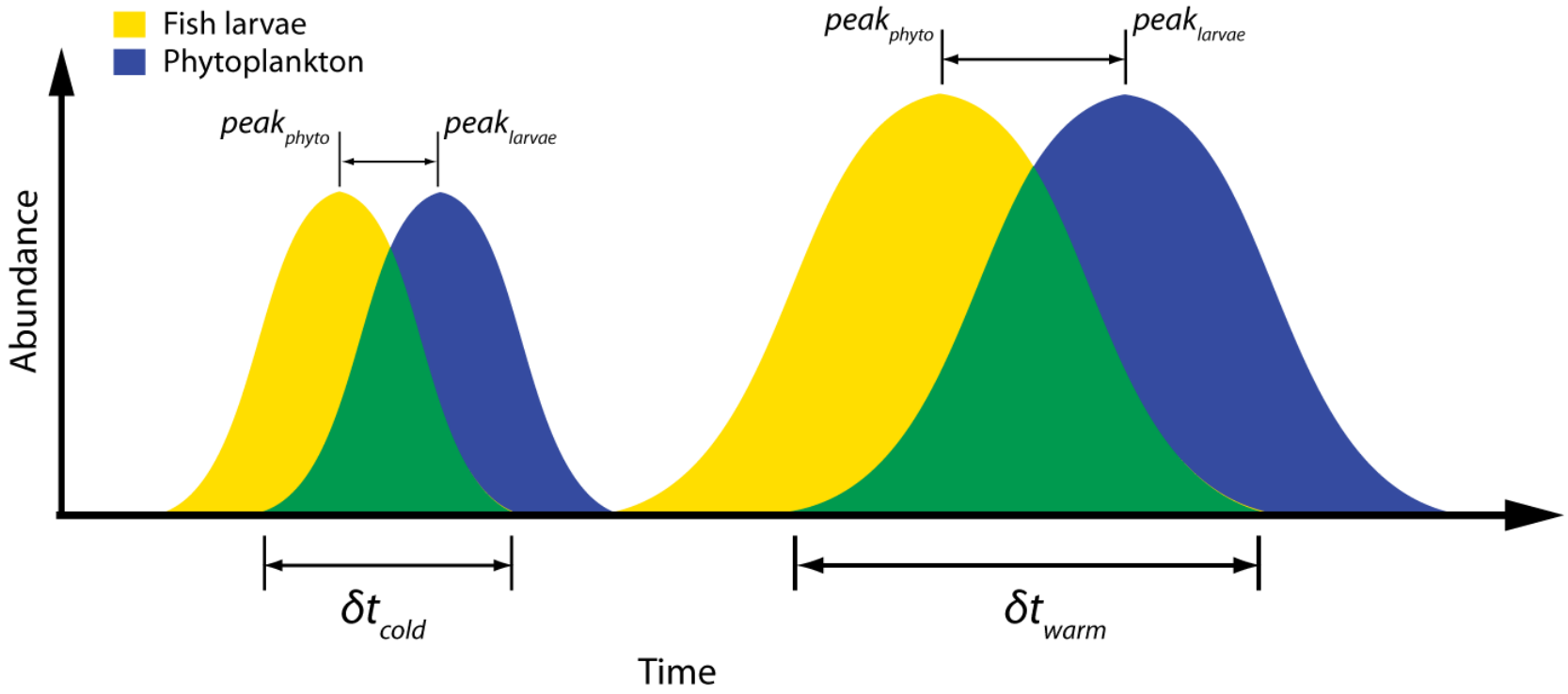

Georges Bank
PDF
Survival prob. (%)


North Sea
PDF
Survival prob. (%)


Iceland
PDF
Survival prob. (%)


Lofoten
PDF
Survival prob. (%)
1.0
0.8
0.6
0.4
0.2
0.0
0.25
0.20
0.15
0.10
0.05
0.00
15/2
2/3
17/3
1/4
16/4
1/5
16/5
31/5
15/6
30/6
15/7
30/7
14/8
29/8
13/9
28/9
13/10
28/10
12/11
27/11
12/12
26/12

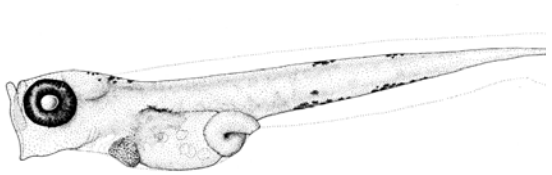
Match-mismatch



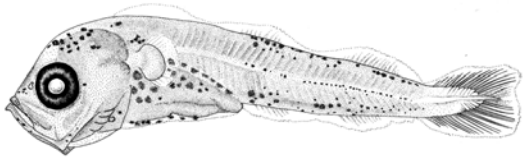
T. Kristiansen , K. Drinkwater, R. G. Lough, and S. Sundby (2011).PLoS ONE 6(3):e17456. Recruitment Variability in North Atlantic Cod and Match-Mismatch Dynamics

Conclusions

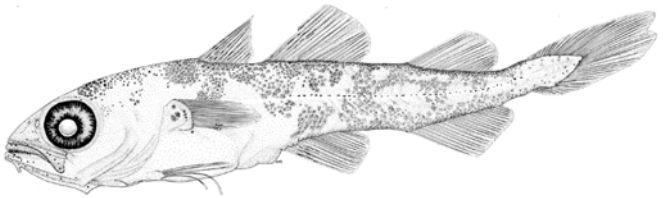
- Warm years favor high growth and survival
- Survival increased by 2x to 4x in warm years
- Importance of match-mismatch dynamics increases with latitude
- Warm years -> early onset of spring bloom -> increased duration of larval and prey overlap -> high survival



4 mm



8 mm



35 mm

Drawings by Elizabeth Broughton, NOAA, Woods Hole

Future directions

- Expand the comparative analysis to include Walleye Pollock and Pacific Cod for the Bering Sea
- Apply the comparative approach to investigate future changes (IPCC)
- Future production of large phytoplankton is suggested to decline
- How will future larval fish survival and thereby recruitment be?