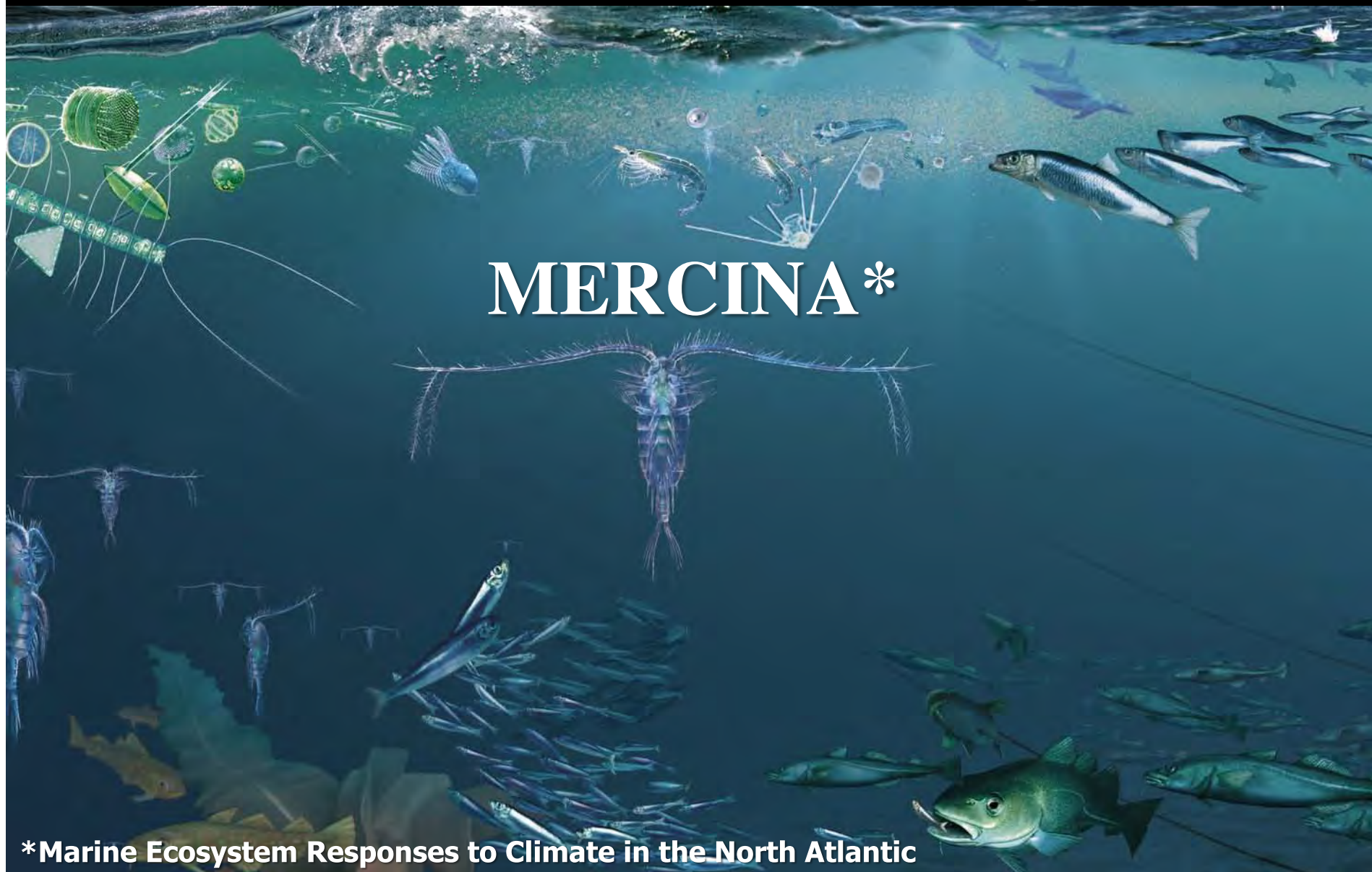
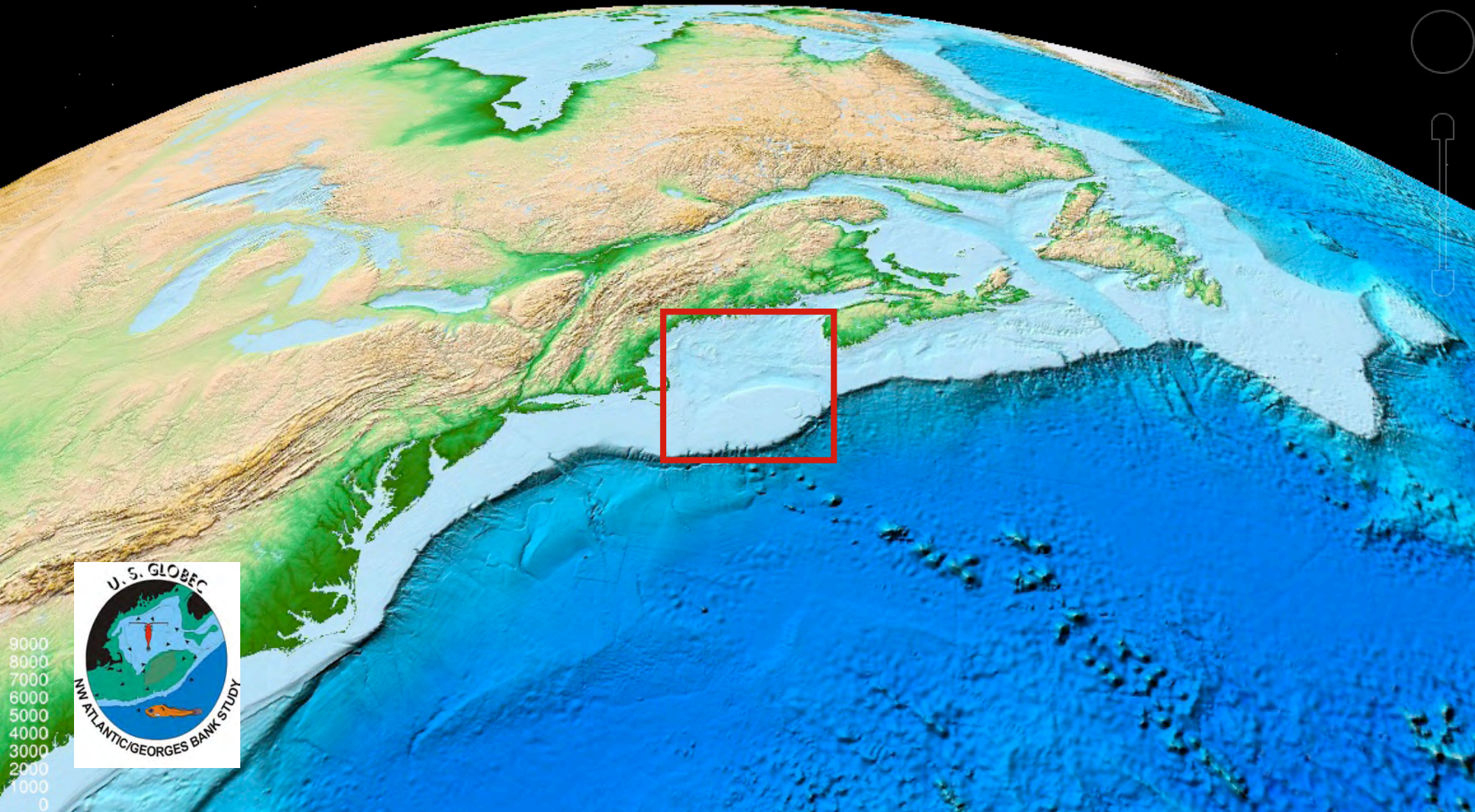


Remote Climate Forcing of Northwest Atlantic Shelf Ecosystems



*Marine Ecosystem Responses to Climate in the North Atlantic

US GLOBEC NW Atlantic/Georges Bank Field Study

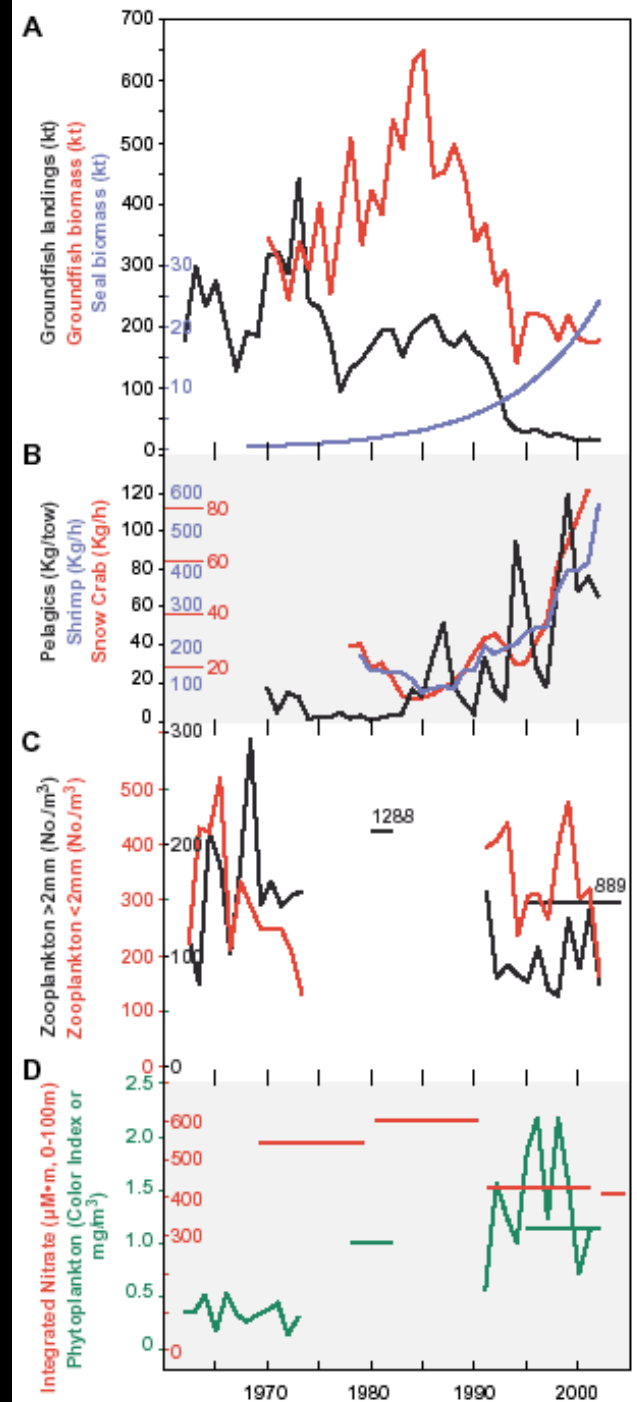


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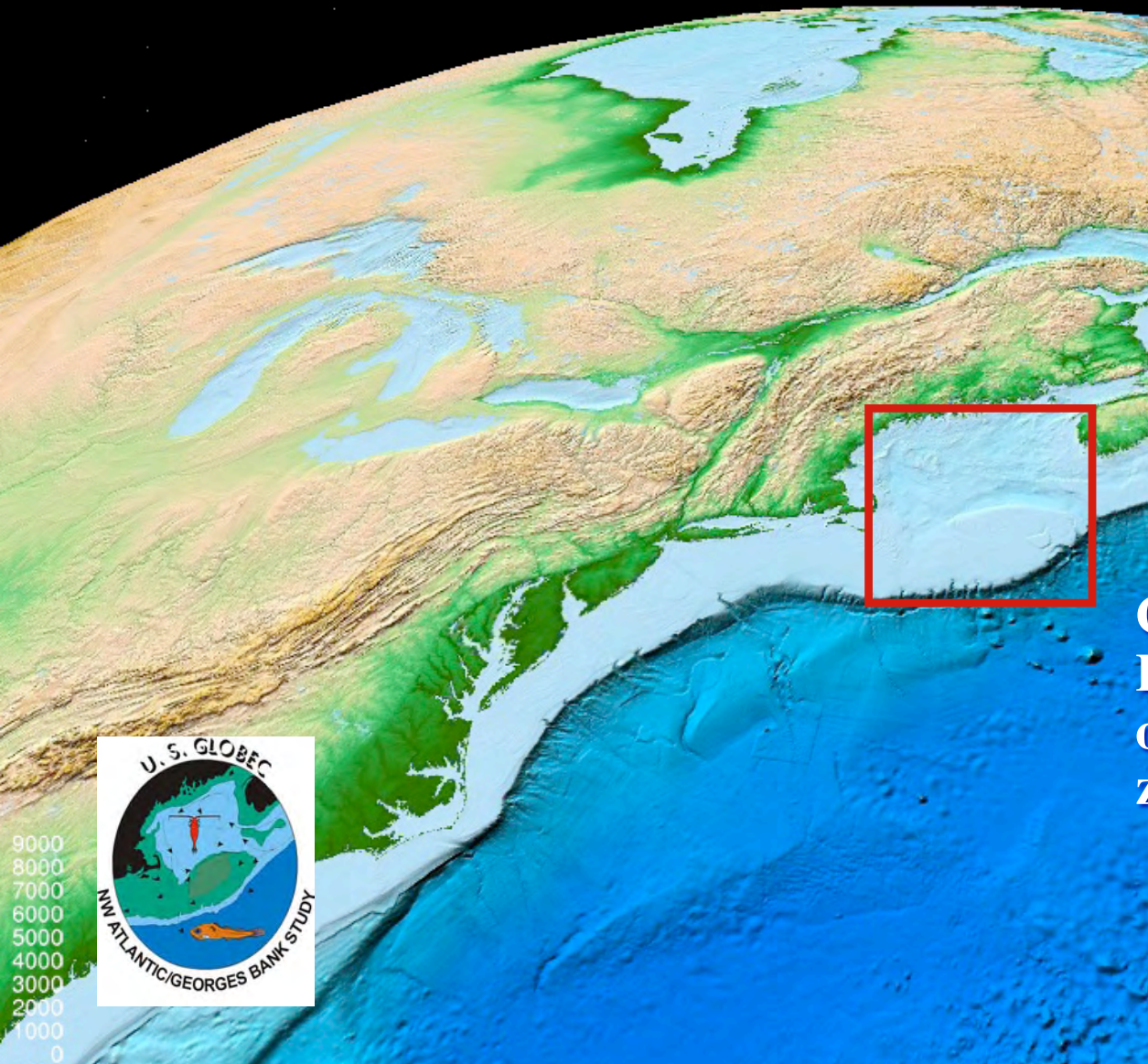
Regime Shifts in the NW Atlantic: Trophic Cascades?

Top-Down Structuring of NW Atlantic Shelf Ecosystems

Frank et al. 2005. Trophic cascades in a formerly cod-dominated ecosystem. *Science* 308: 1621-1623.



US GLOBEC NW Atlantic/Georges Bank Field Study

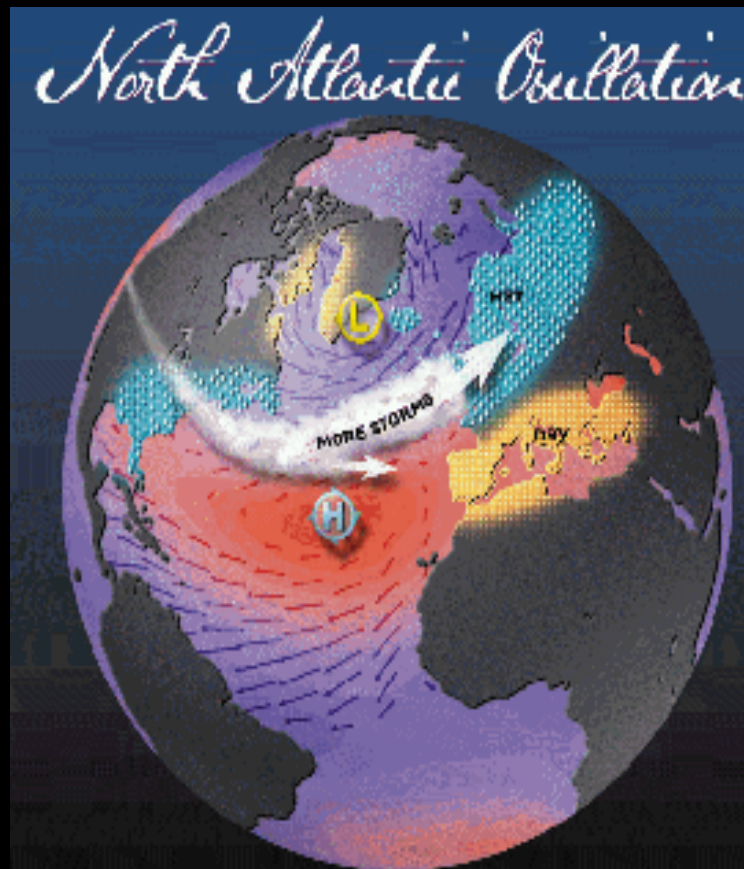


Gulf of Maine/Georges Bank region is an oceanographic transition zone in the NW Atlantic.



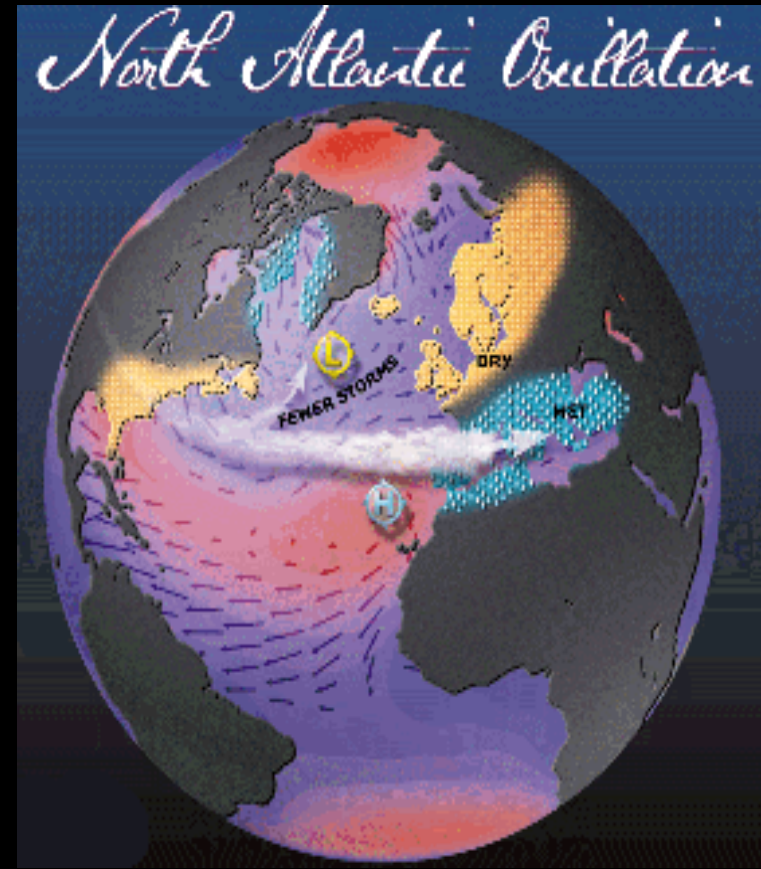
9000
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The North Atlantic Oscillation (NAO)



NAO +

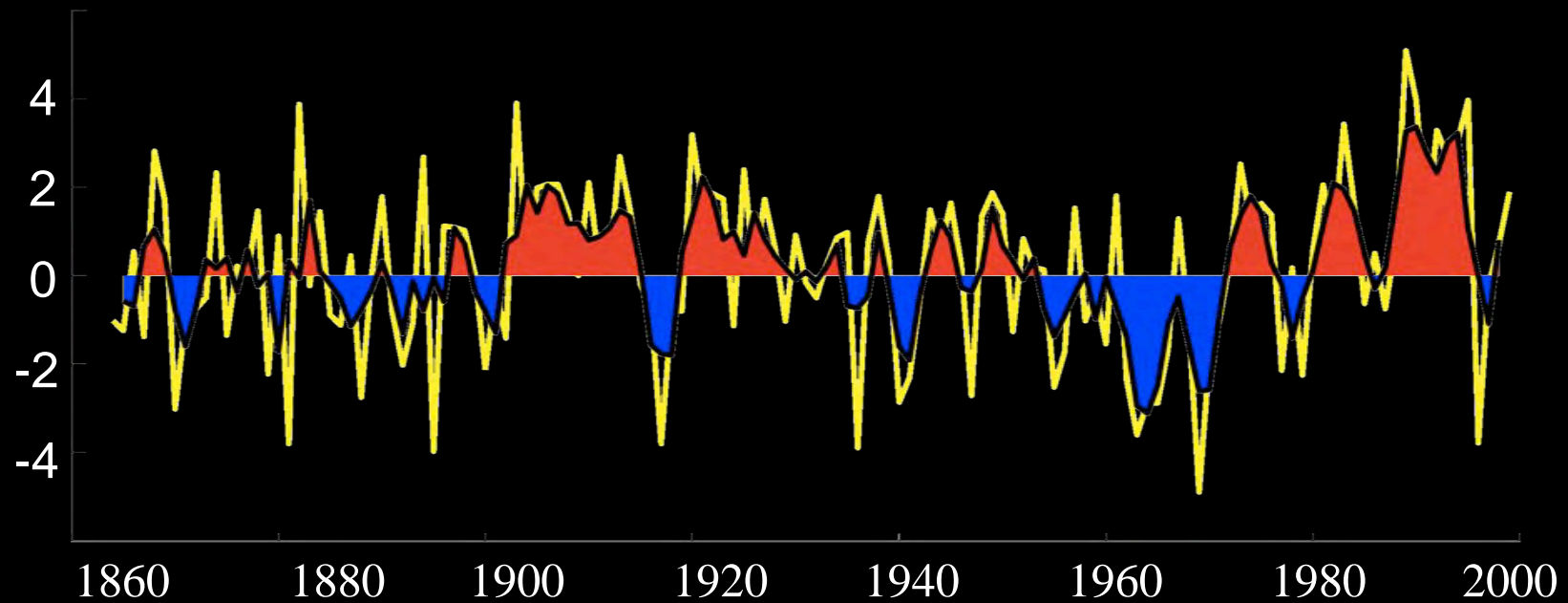
- Strong H and L pressure cells
- Westerlies strengthen
- Storm track shifts North



NAO -

- Weak H and L pressure cells
- Westerlies weaken
- Storm track shifts South

The Winter NAO Index



North Atlantic Ocean Circulation Responses to the NAO

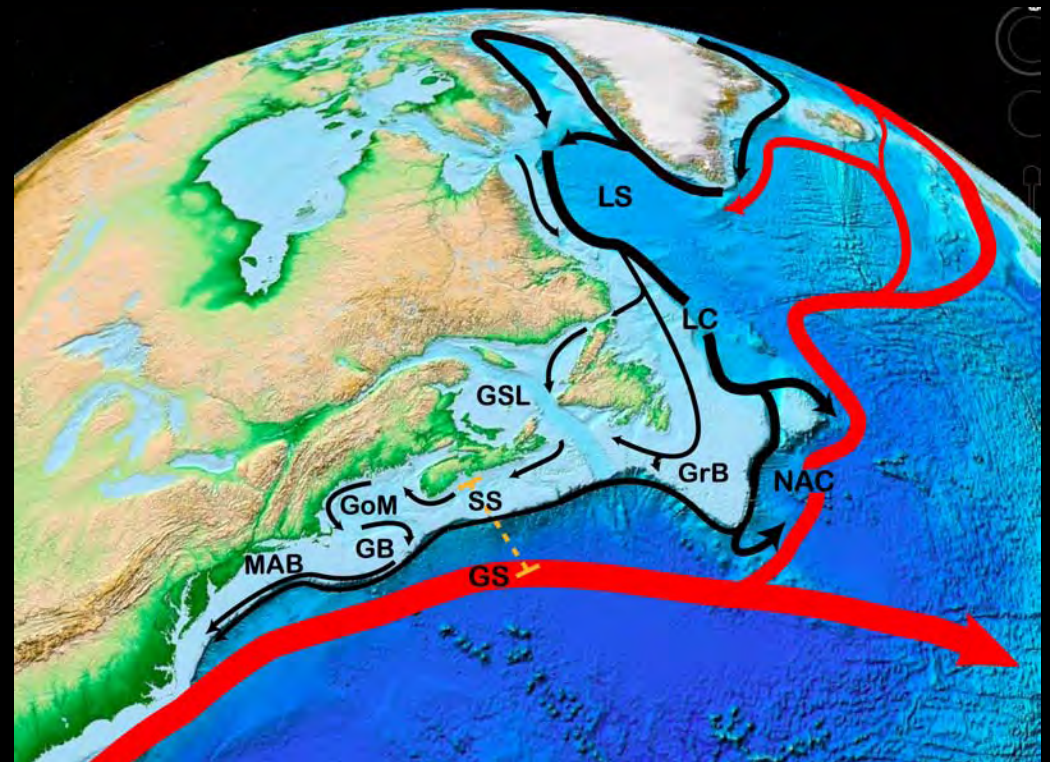
Emphasis on NW Atlantic

NAO +

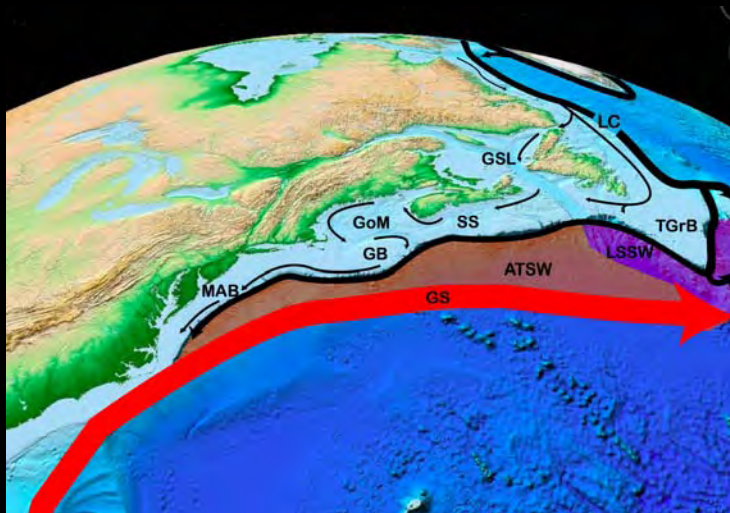
- Strong deep convection in Labrador Sea and enhanced production of LSW
- Labrador Current transport around Tail of Grand Bank is weak
- Gulf Stream north wall shifts North

NAO -

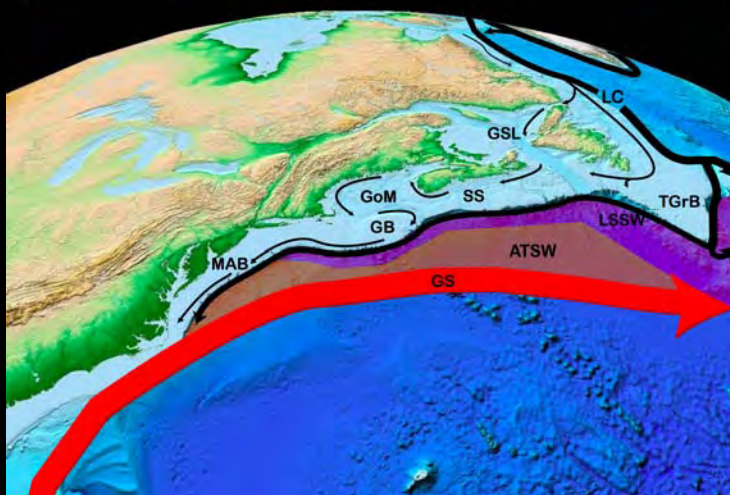
- Weak deep convection in Labrador Sea and reduced production of LSW
- Labrador Current transport around Tail of Grand Bank intensifies
- Gulf Stream north wall shifts South



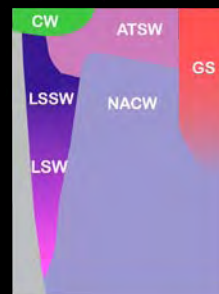
NW Atlantic's Coupled Slope Water System



- **Maximum Modal State**
Associated with NAO +



- **Minimum Modal State**
Associated with NAO -

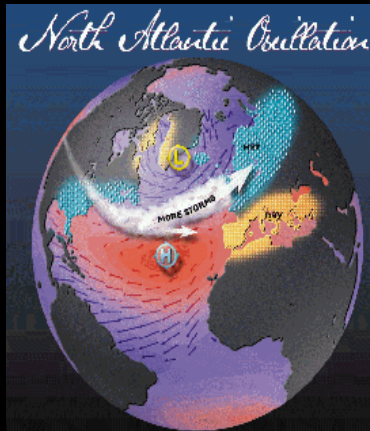


MERCINA, 2001. Oceanographic responses to climate in the Northwest Atlantic. *Oceanography* 14: 77-83.

Complex Linkages

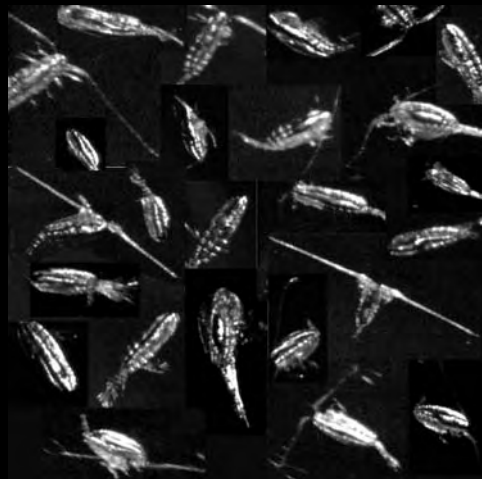
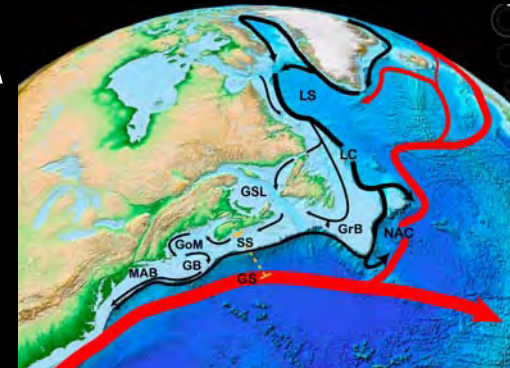


right whales



climate

physical
oceanography

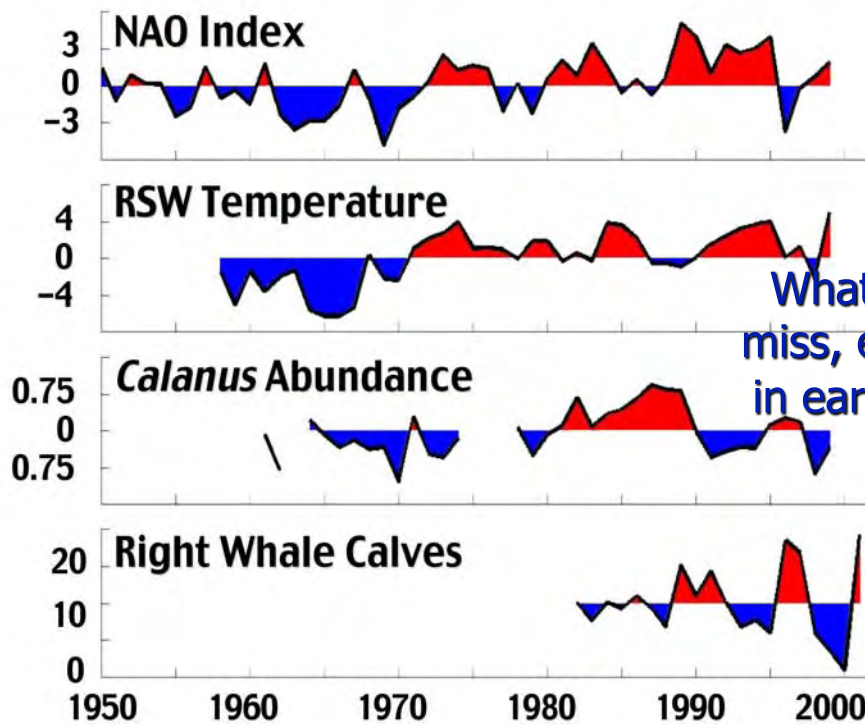


Calanus

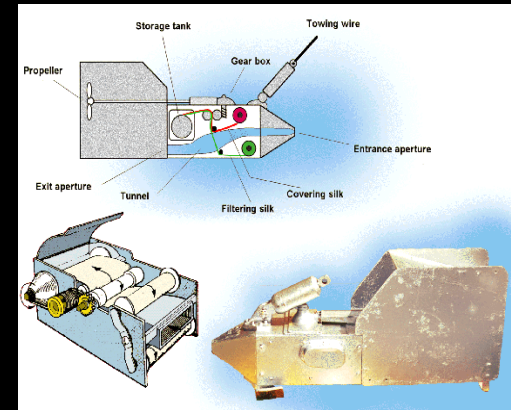
North Atlantic Time Series



North Atlantic Time Series



What did we miss, especially in early 1990s?

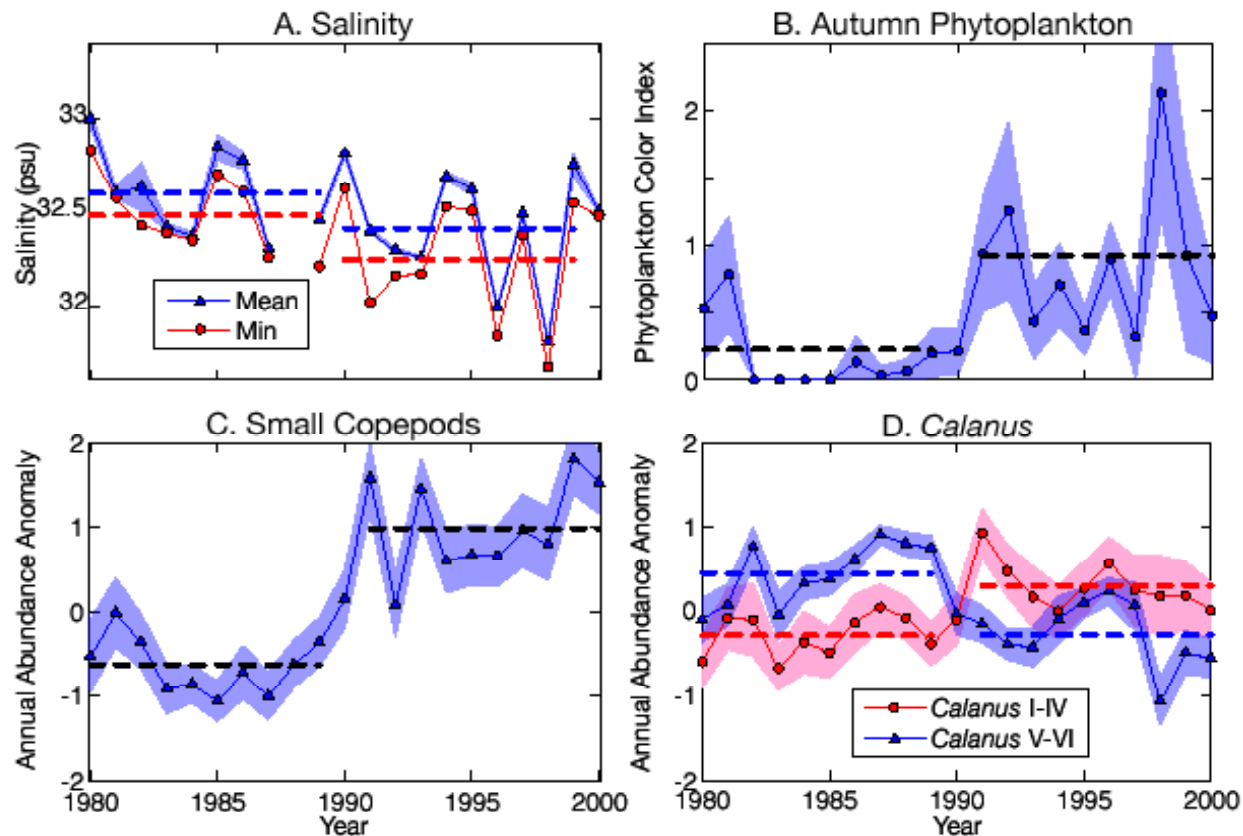


Gulf of Maine CPR survey conducted by NMFS.

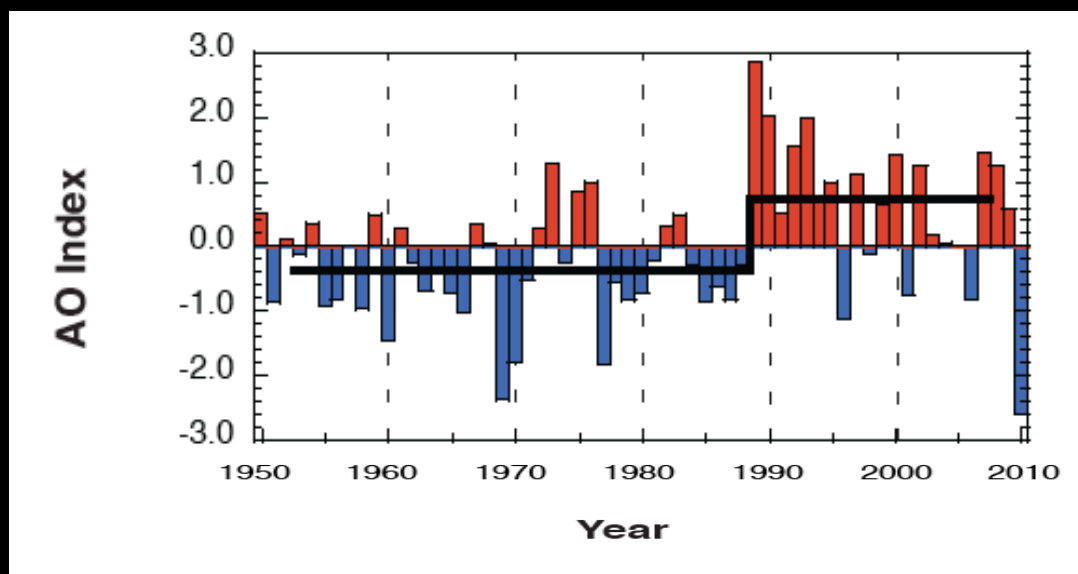


Right whale survey conducted by New England Aquarium.

Ecosystem Regime Shift in the NW Atlantic



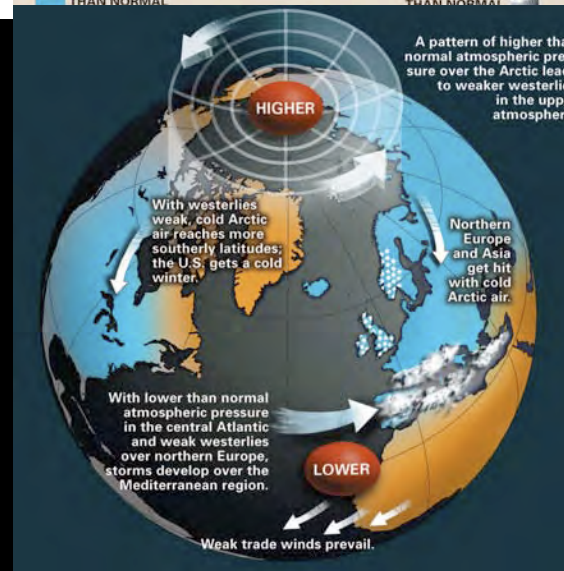
Arctic Oscillation



- Dominant pattern of winter sea-level pressure (SLP) variations in high latitudes of Northern Hemisphere.



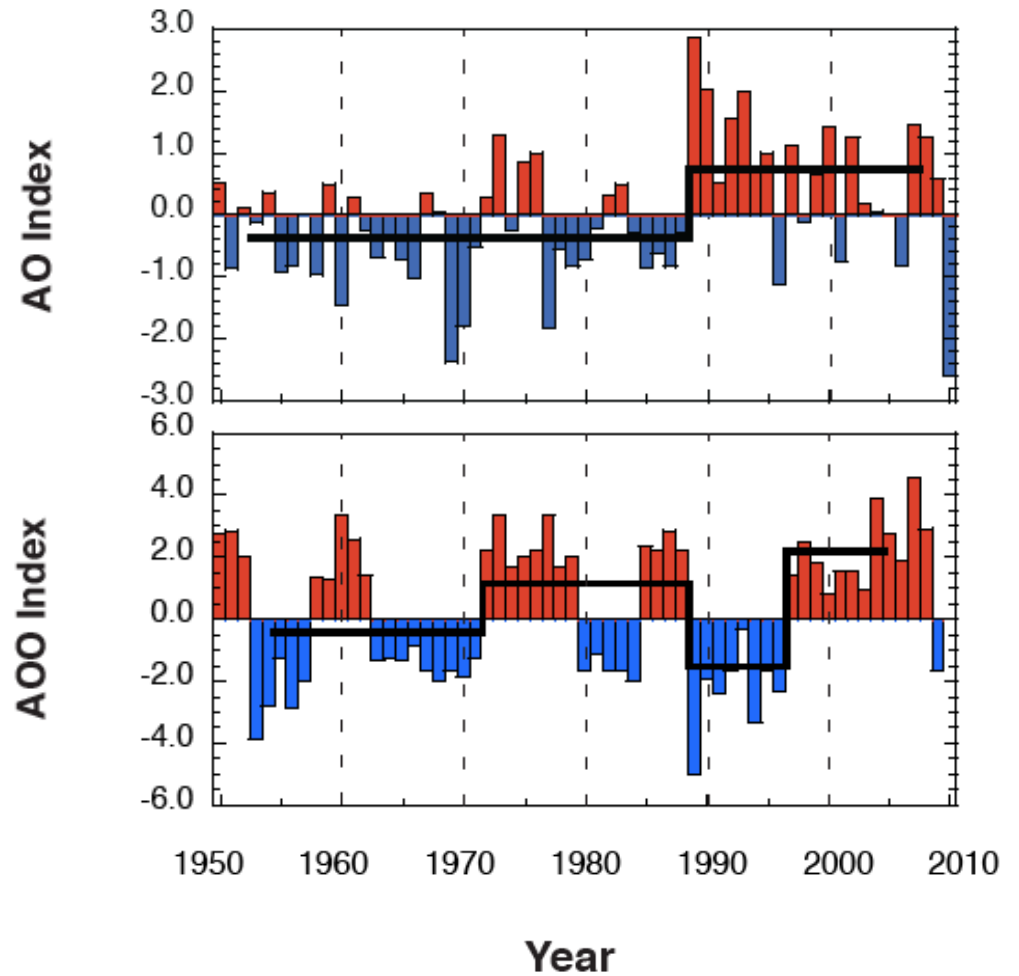
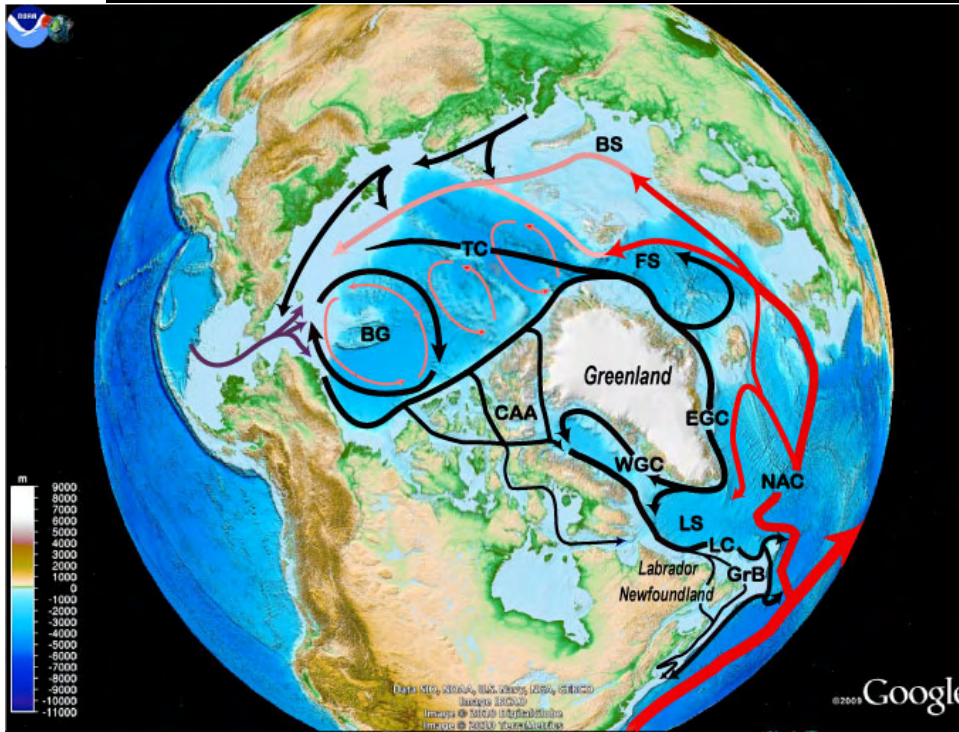
AO+



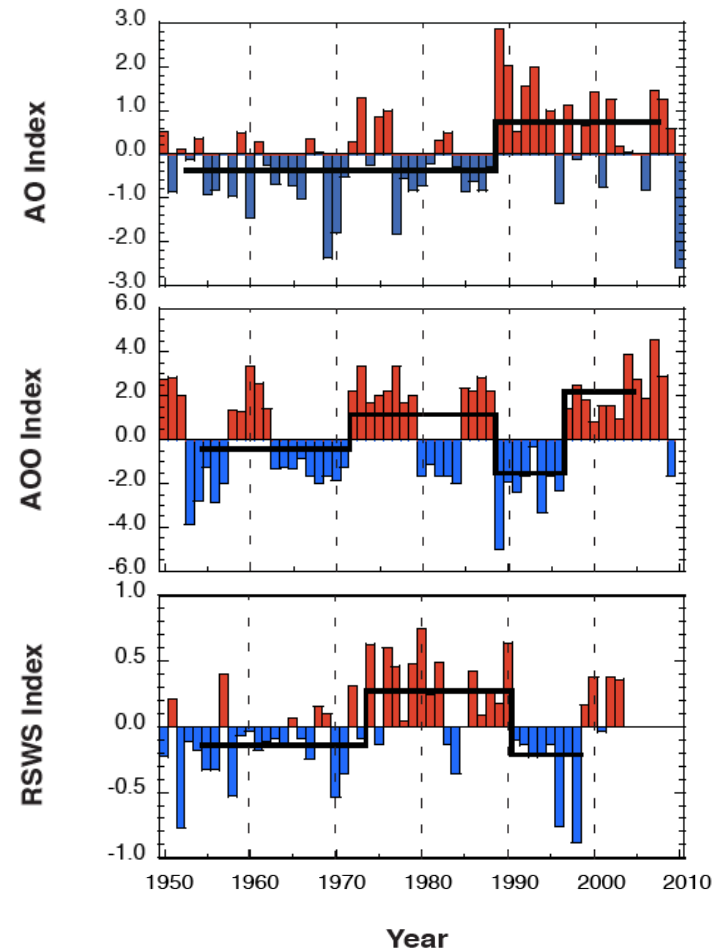
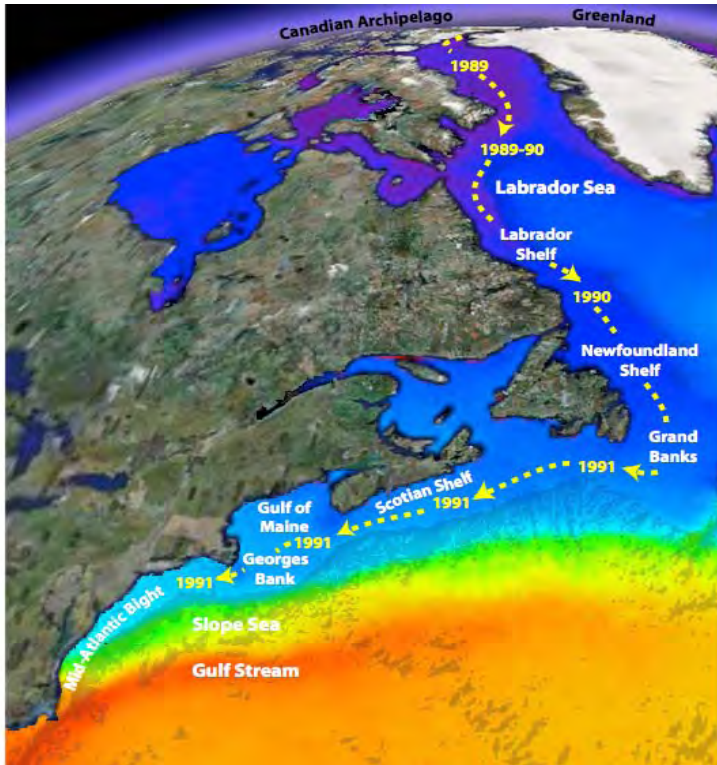
AO-



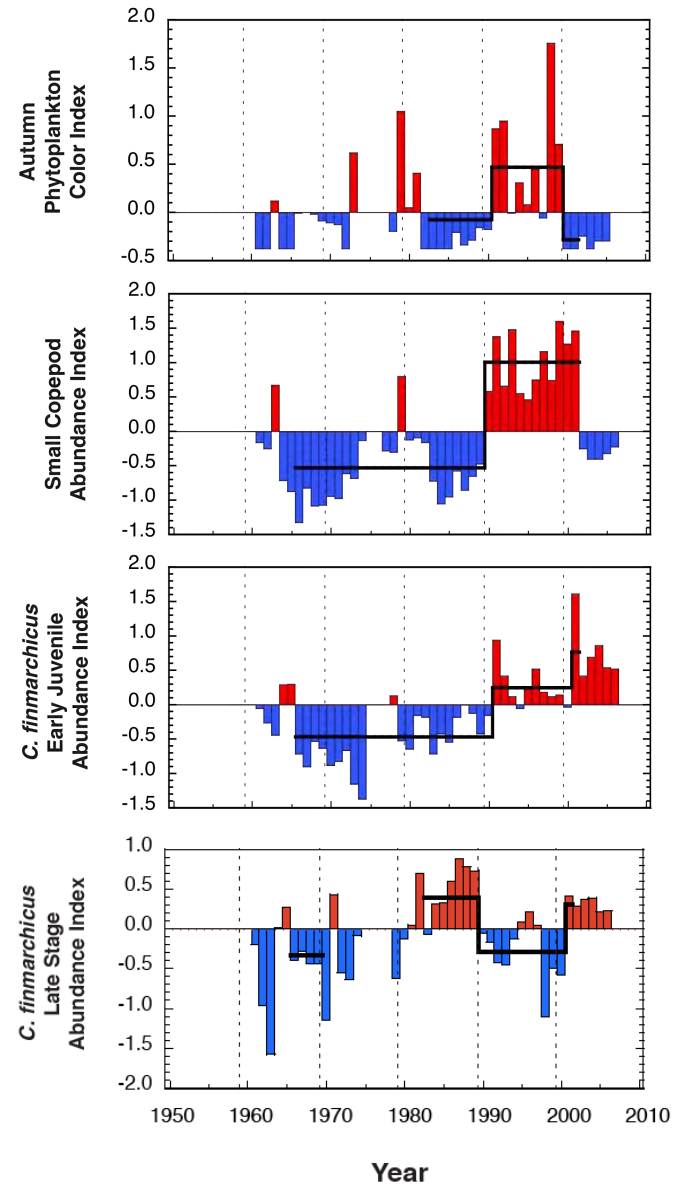
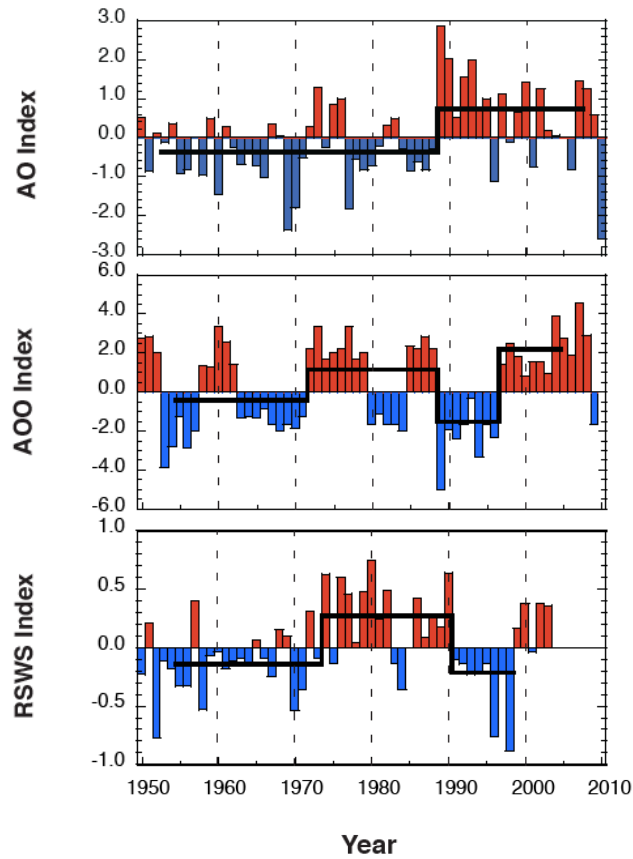
Arctic Climate Regime Shift



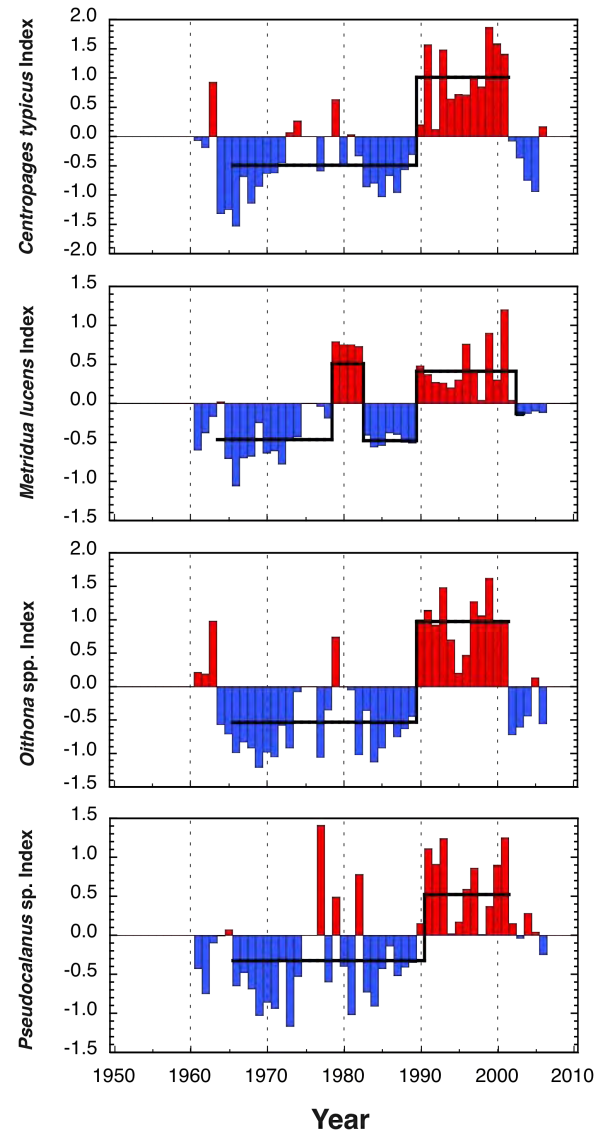
1990s Great Salinity Anomaly



Ecosystem Regime Shifts in the NW Atlantic



Small Copepod Shifts in the NW Atlantic



Regime Shifts in the NW Atlantic: Trophic Cascades?

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