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Decadal Climate Change Impacts on Carbon Cycling in the Gulf of Maine

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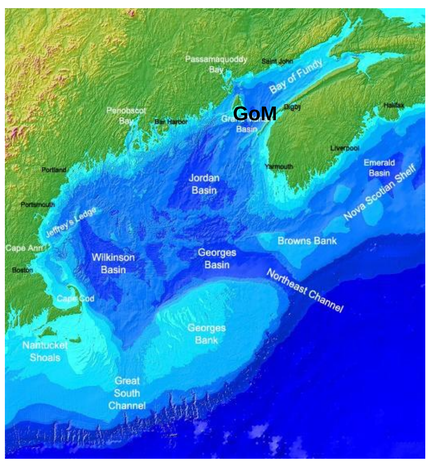
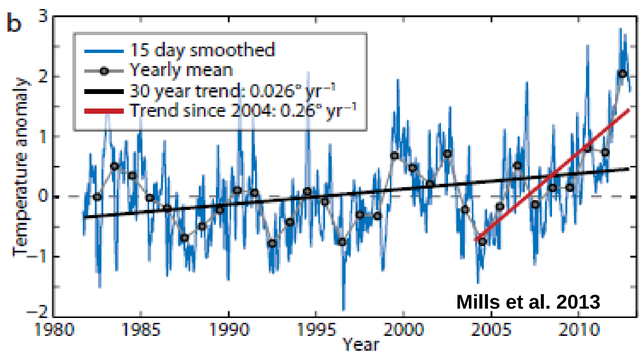
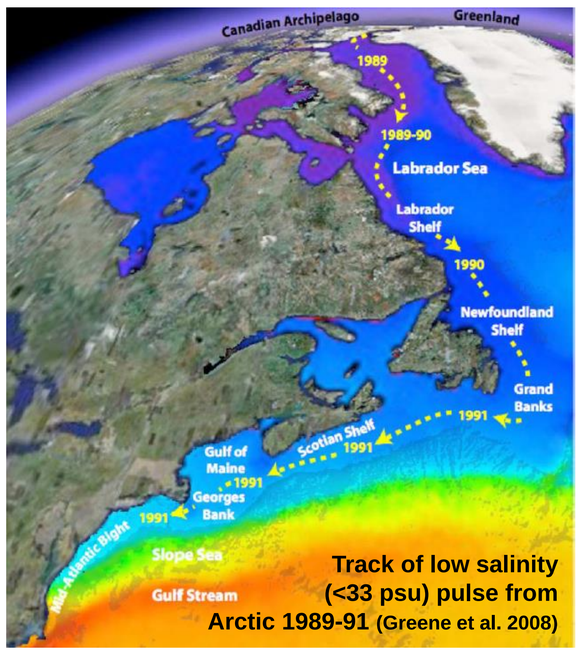
Abstract: Global anthropogenic warming has resulted in a considerable increase in Arctic ice melt and freshwater input to the North Atlantic. As a result, the Gulf of Maine is experiencing substantial decadal changes in water column hydrography, biogeochemistry and planktonic ecosystem structure. Gulf of Maine researchers have documented significant freshening, a nutrient regime shift, changes in production and plankton community composition, decreases in carbon delivery rates, and potential impacts on $CaCO_3$ precipitation/dissolution rates. We summarize multiple chemical and biological data sets obtained from time-series moorings, research cruises and satellite surveys to examine the linkages between drivers and specific impacts on the biogeochemical system.

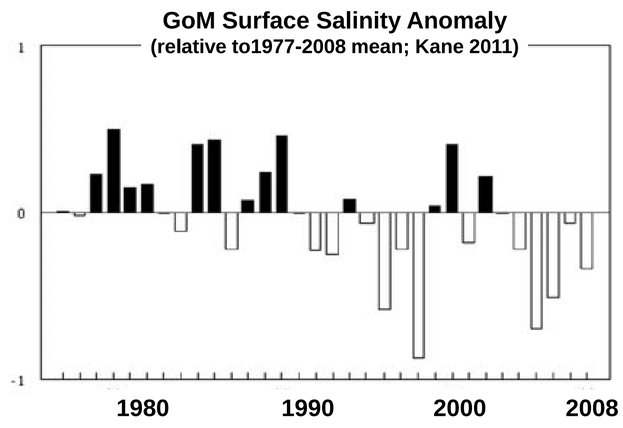
I. Climate-driven changes in Gulf of Maine (GoM)





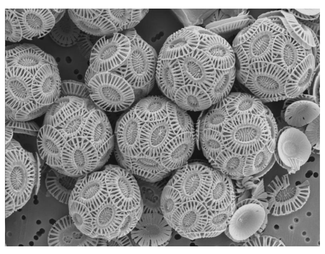
Intense warming of Arctic and No. Atlantic → 10-fold increase in GoM SST over past decade.



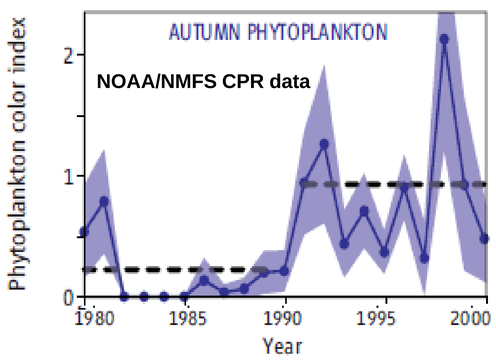


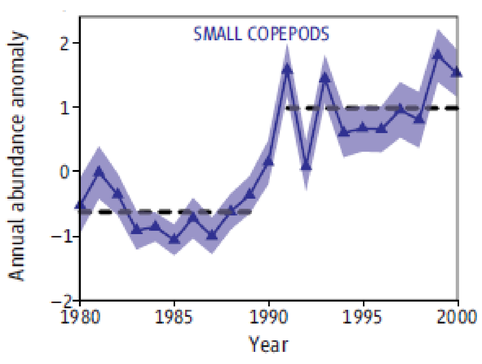
Warming-induced acceleration of Arctic ice melt → Increasing volumes of low salinity/low alkalinity water moving southward into NW Atlantic and GoM since 1990's.

II. Impacts on GoM plankton community and POC & PIC export



1990's → 2000's:
****Decadal decrease in surface water calcification rates and***
****10-fold decrease in surface productivity maxima (Balch et al. 2012) .***



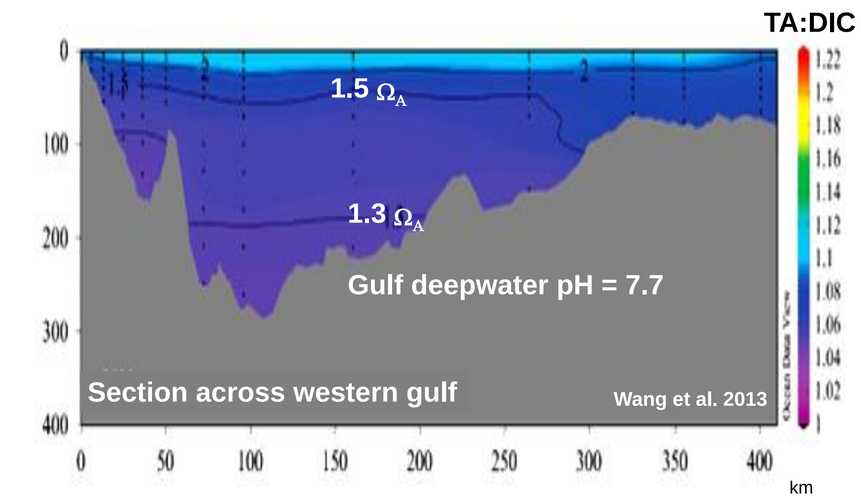


1990's → 2000's: Shorter duration spring blooms; longer autumn blooms; decreasing large copepod species abundance; increase in smaller species (Greene & Pershing 2007).

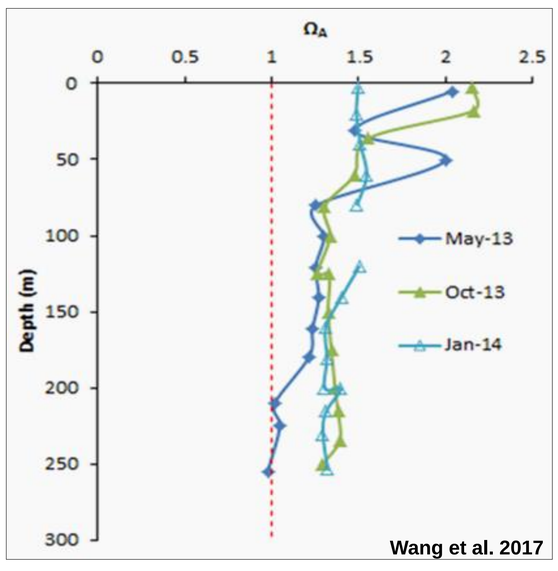
Times-series trap measured POC fluxes:
1990's → 2000's
20-50% decrease in sub-euphotic POC mass export.

Full-depth warming = higher rates of respiration & remineralization

III. Impacts on carbonate system parameters

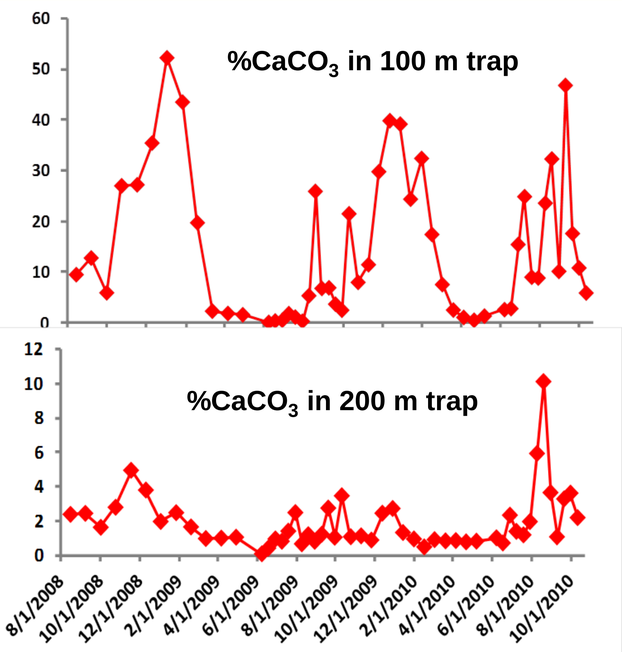


Low buffer capacity (TA:DIC), aragonite saturation state, and pH in deep GoM.



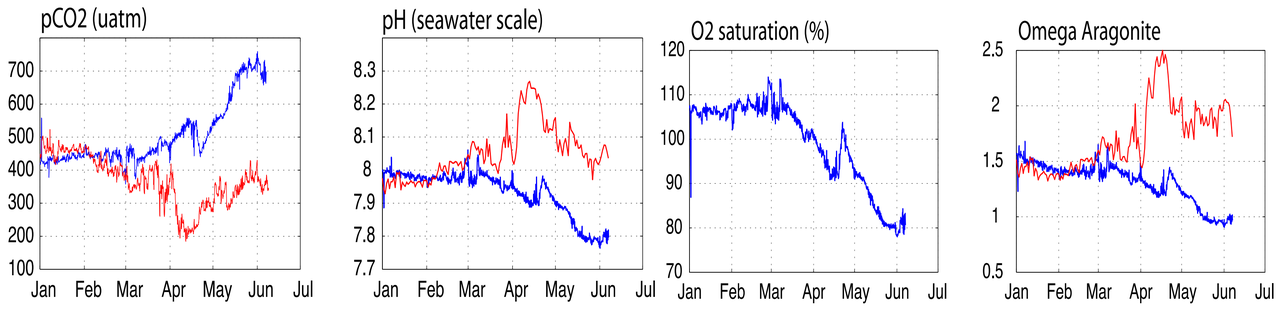
Reflected by %$CaCO_3$ in sinking particulates: decreases significantly 100 m → 200 m (Hayashi, 2014).

Limacina aragonite pteropod shells dissolve; calcite foram tests survive.



Evidence of seasonal, respiration & POC remineralization-driven aragonite loss in subsurface GoM water column: Post-spring bloom increase in pCO_2 and decrease in pH and Ω_A in pervasive benthic nepheloid layers (Pilskaln et al., 2014).

RED: Surface data **BLUE: 83 m data/in BNL**



SUMMARY:

Seasonal POC production regime changing; annual export declining over past several decades.

With continued warming and freshening of gulf waters, TA, pH and Ω_A expected to decline throughout the Gulf of Maine producing longer periods of low TA & pH throughout the water column.

Projected negative impacts on planktonic & benthic calcifiers → Reduction in ecosystem production with economic consequences for New England fisheries.