# Ocean climate and river herring (temperature & acidification)

Jon Hare, NOAA NMFS, Narragansett Laboratory

- Why do we care
- Temperatures
- Acidification
- Next Steps

# Temperature - Why do we care

Temperature is a dominant factor affecting organisms

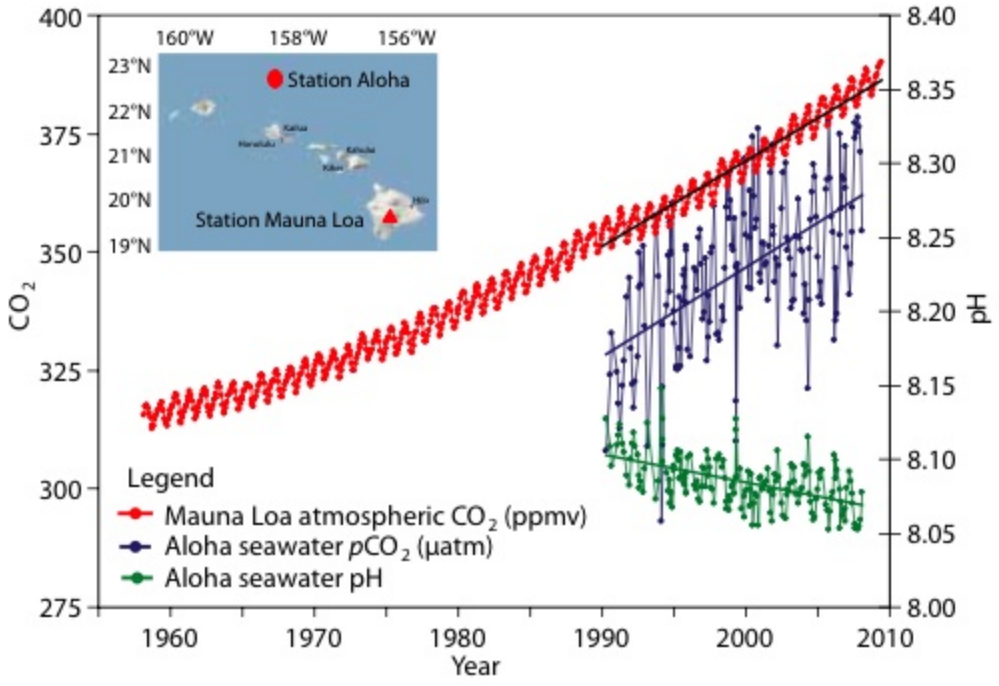
- Lethal factor: thermal limits
- Limiting factor: rate processes (e.g., gene expression, metabolism, and growth)
- Directive factor: behavioral, metabolic, and ecological responses to changes in temperature

Fry (1971) Fish physiology 6:1-98.

# Acidification - Why do we care

Carbonate chemistry is an important aspect of ocean chemistry and calcification

- Direct effects: development, olfaction
- Indirect effects: prey impacts, predator impacts
- Community effects: primary productivity




Doney et al. (2009) Oceanography 22:16-25

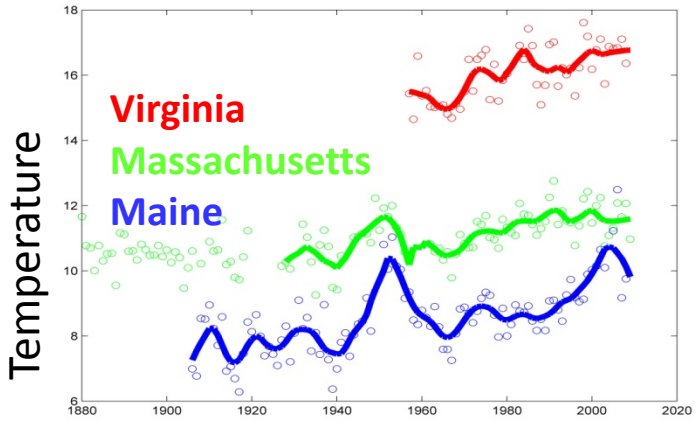
# Ocean climate and river herring (temperature & acidification)

- Why do we care
- Temperatures
- Acidification
- Next Steps

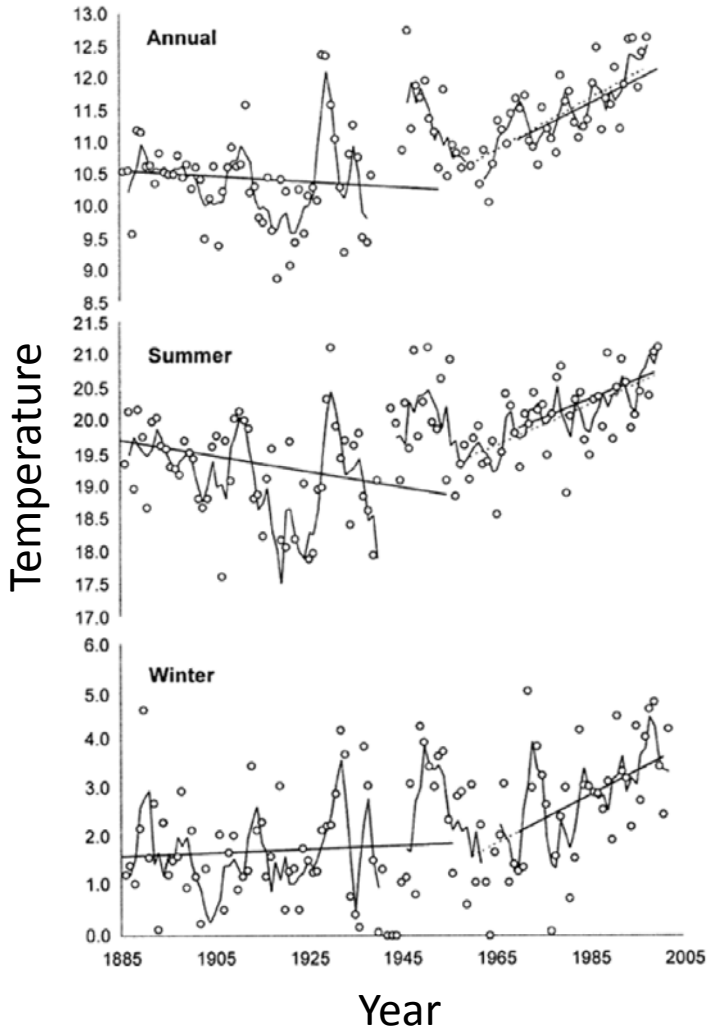
# Temperature – Historical Record

## Warming of coastal waters

- Increased temperatures at Woods Hole since ~1960
- Pattern repeated at coastal stations across northeast U.S.




Woods Hole, Massachusetts

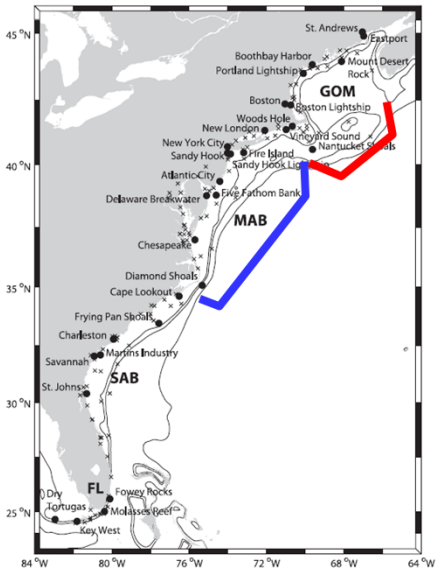


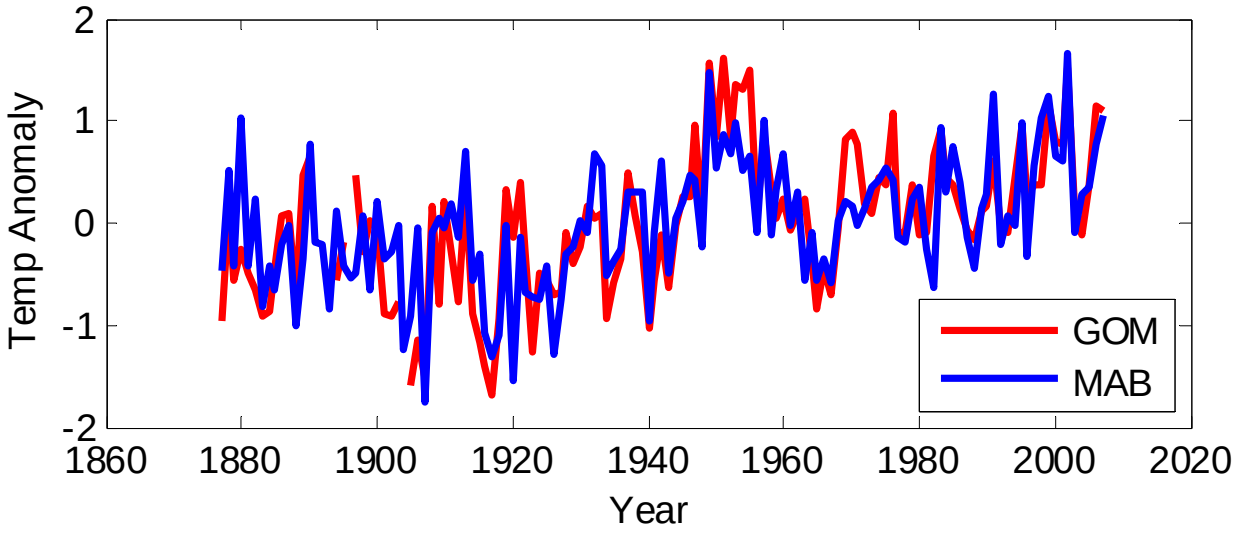

Nixon SW et al (2004) Estuaries 27:397-404

# Temperature – Historical Record

Shelf temperatures

- Evidence for variability
- Evidence for change (~ 1-2 $^{o}$C increase since 1920)

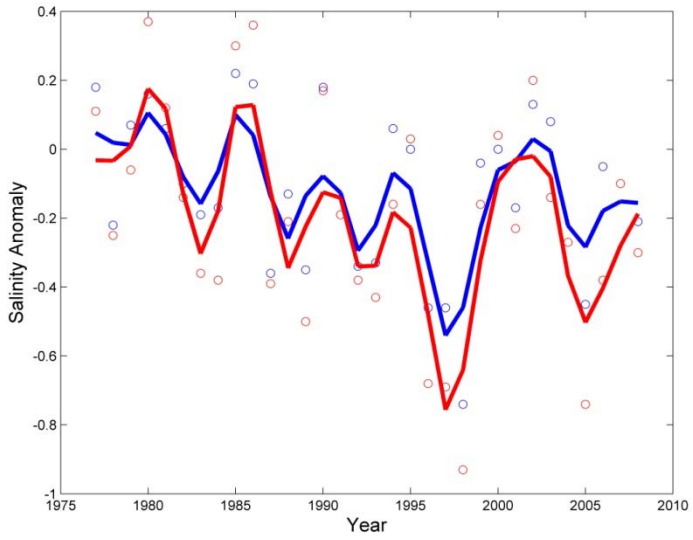


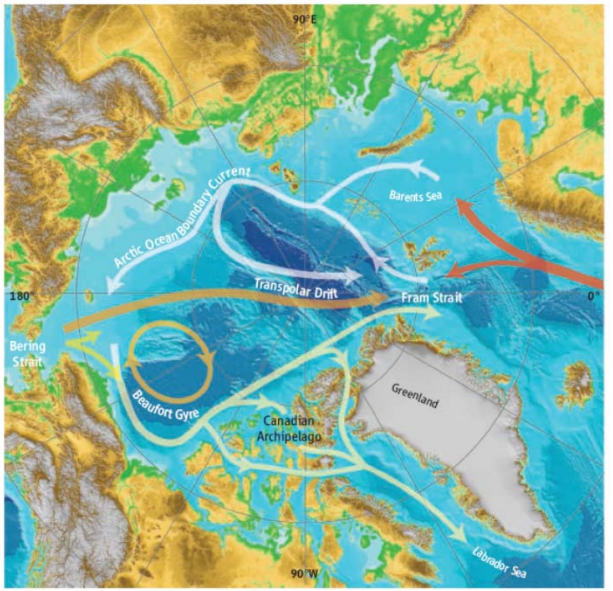




Shearman K, Lentz S (2009) Journal of Physical Oceanography 40: 1004-1017

# Temperature – Current Status

- Evidence for variability and change in salinity (~0.3 decrease since 1977)
- Linked to freshwater input from the north



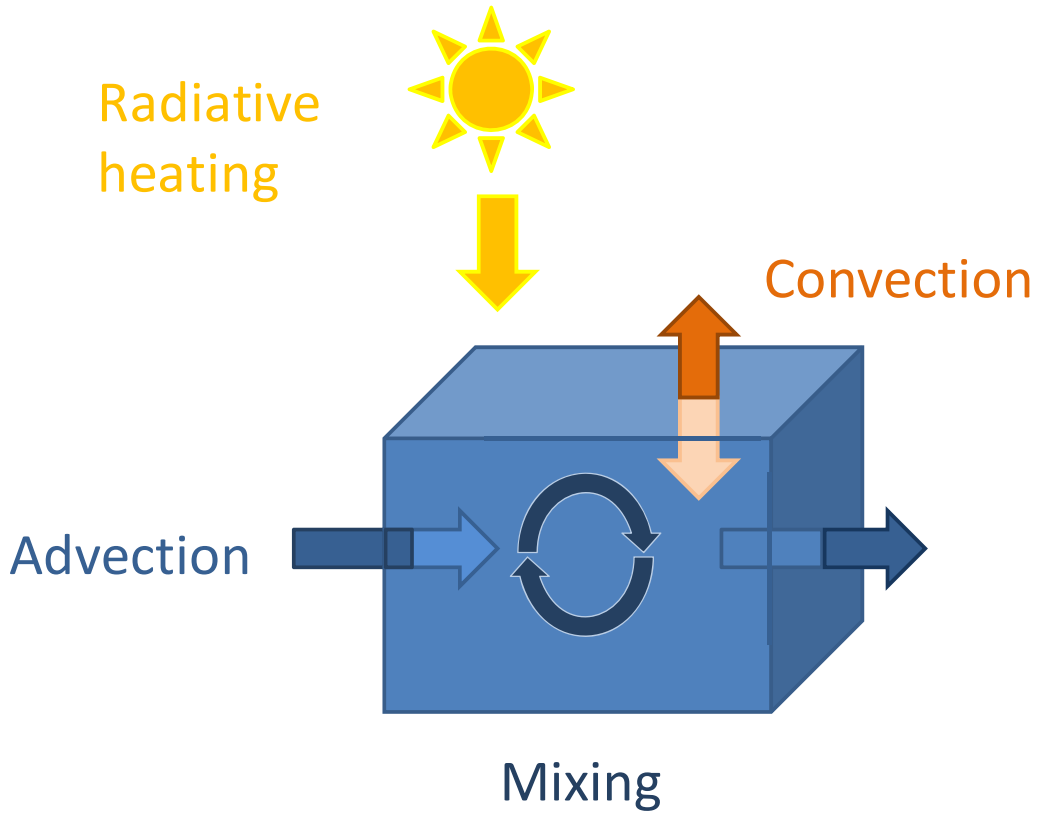




Mountain 2004 & http://www.nefsc.noaa.gov/publications/crd/crd0911/

Greene CH, Pershing AJ 2007 Science 315: 5815

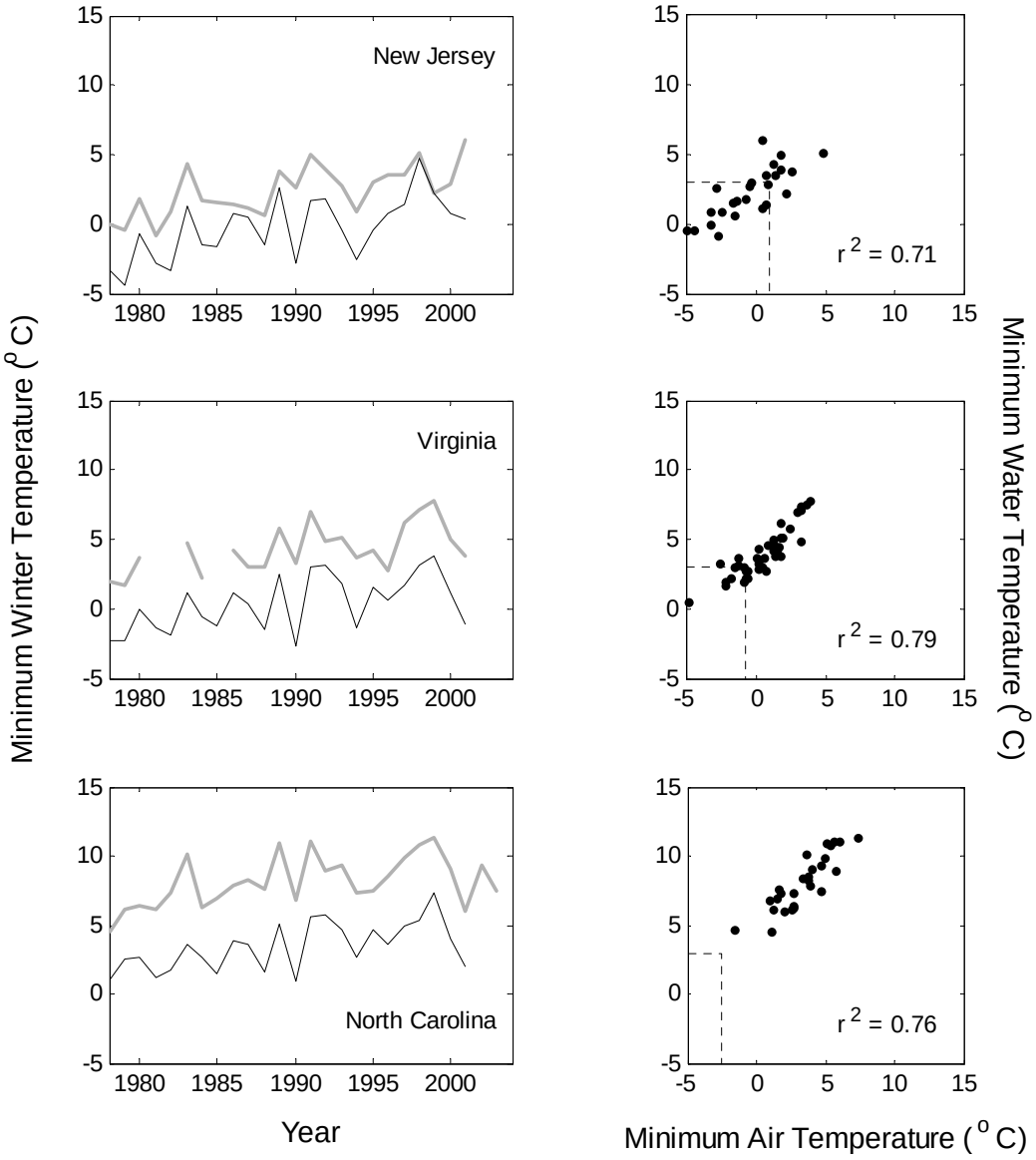
# Temperature – Current Status

- Advection from the north playing a role
- Importance relative to other factors unclear



# Temperature – Current Status

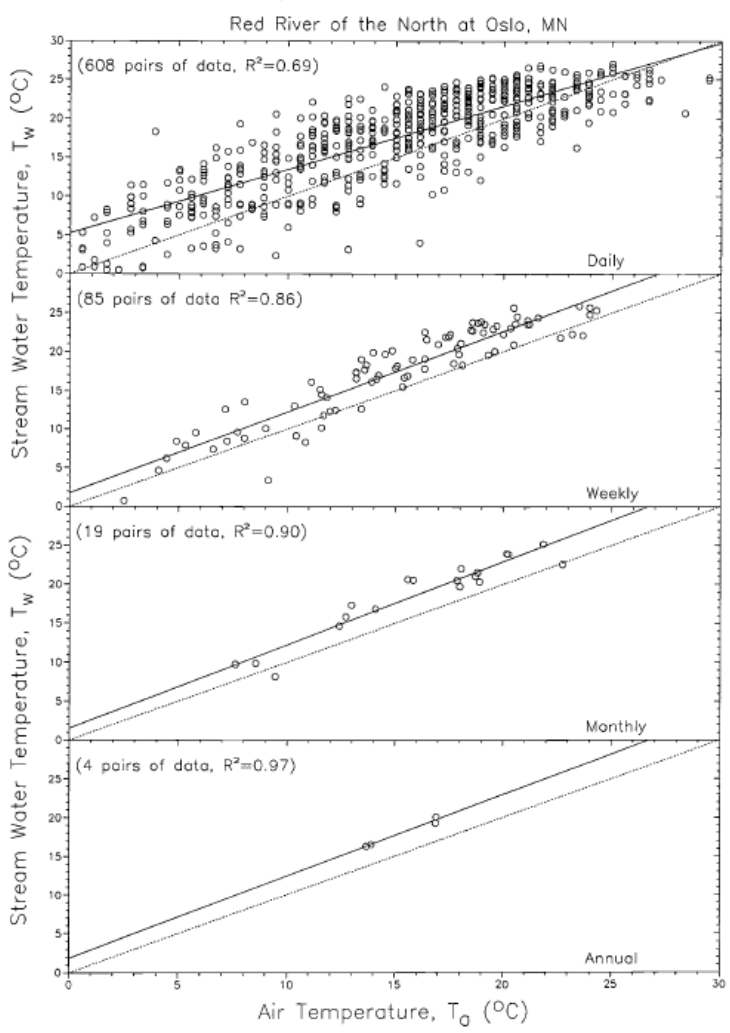
- Air temperatures significantly correlated with estuarine water temperatures
- Can use air temp as proxy for estuarine temp




Hare and Able (2007). Fisheries Oceanography, 16: 31–45.

# Temperature – Current Status

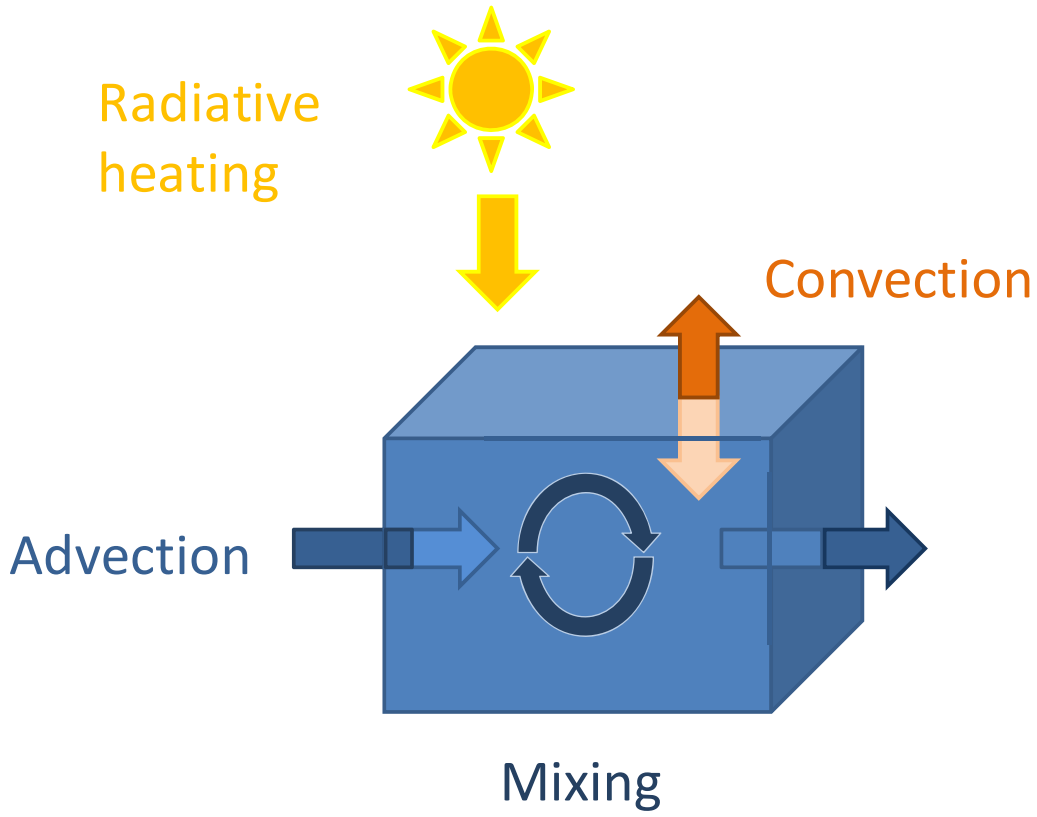
- Air temperatures significantly correlated with stream water temperatures
- Can use air temp as proxy for stream temp




Pilgrim et al. (1998) J. American Water Resources Association 34:1109-1121

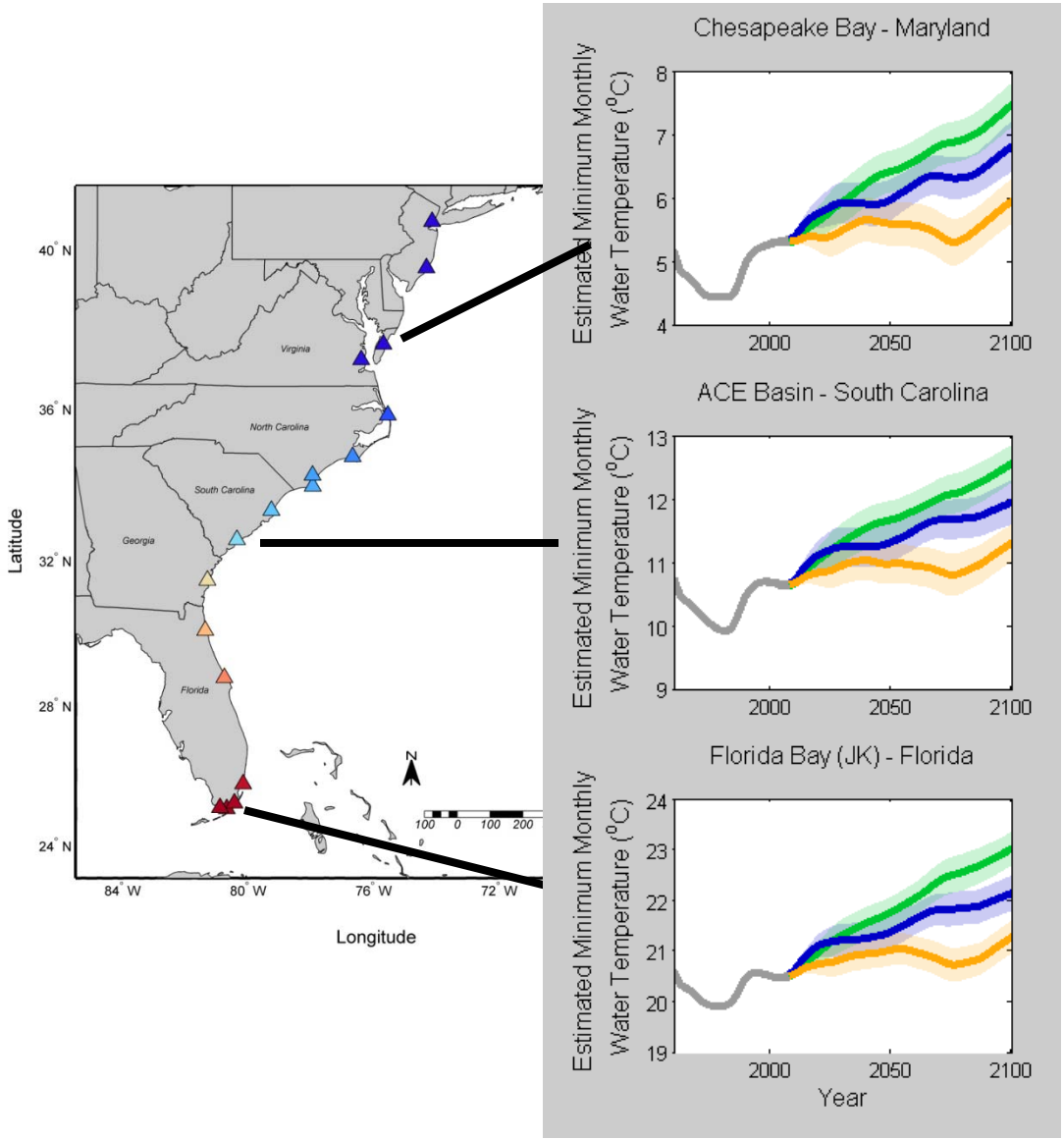
# Temperature – Current Status

- Shallower environments convection more important



# Temperature – Projected Trends

- Estuarine winter temp. rise with increased $CO_2$
- Based on a study examining gray snapper



# Ocean climate and river herring (temperature & acidification)

Jon Hare, NOAA NMFS, Narragansett Laboratory

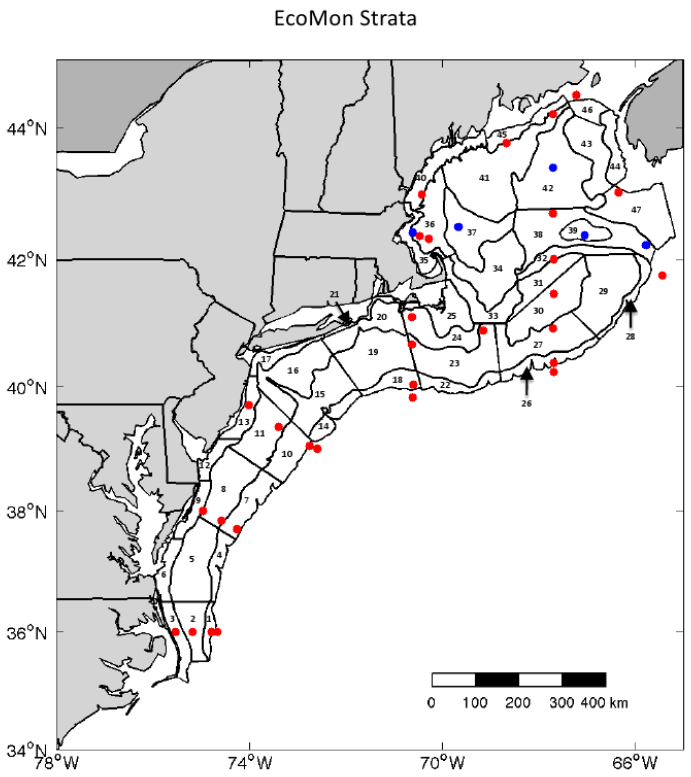
- Why do we care
- Temperatures
- Acidification
- Next Steps

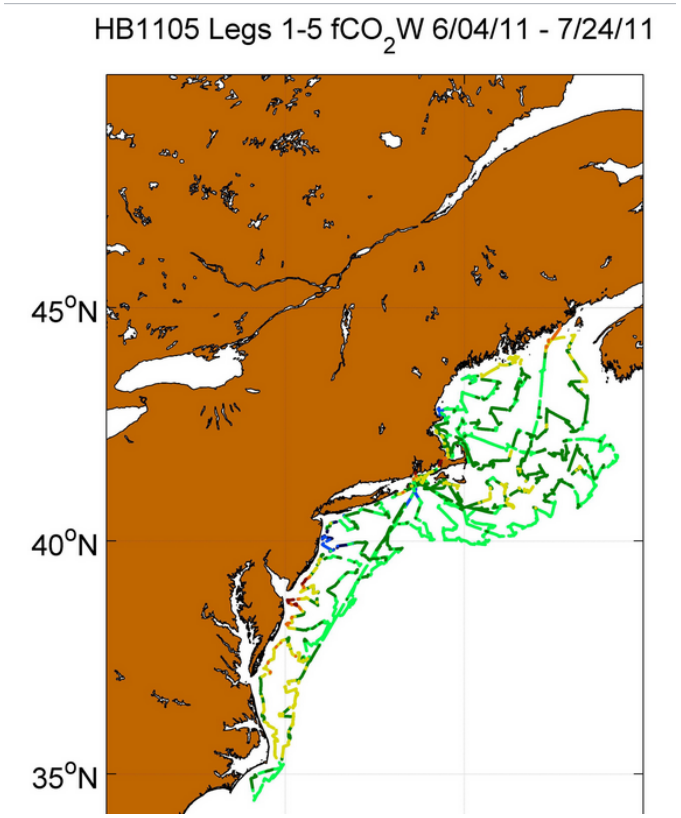
# Northeast Fisheries Science Center Ocean Acidification Program (lead Beth Phelan – Sandy Hook Laboratory)

- Develop a **monitoring** program to assess the current state of ocean acidification and track its development in the northeast U.S. shelf ecosystem;
- Conduct **laboratory and targeted field studies** to quantify the impact of ocean acidification **on primary producers**, which form the basis of fisheries productivity in the ecosystem;
- Conduct **laboratory and targeted field studies** to quantify the impact of ocean acidification **on resource species** including both direct effects on calcification and indirect effects on physiology, growth and mortality;
- Develop and implement **modeling** approaches to assess the effects of ocean acidification on single-species dynamics and overall ecosystem productivity;
- Provide a integrated **assessment** of the effects of ocean acidification on the northeast U.S. continental shelf ecosystem.

# Monitoring (in collaboration with AOML)

- Retrospective analyses of historical pH and TAlk measurements
- Current in situ sampling for DIC and TAlk (water samples at fixed stations)
- Current flow-through sampling for pCO2 (NOAA Ship Henry Bigelow, MV Rekyjfoss




Contact: jon.hare@noaa.gov

# Primary Producers

- Experimental Methodology and Development

- Effects of Ocean Acidification on Phytoplankton Physiology and
- Nutrition for Fishery-based Food Webs

- Effect of pH on natural phytoplankton communities in the northeast U.S. continental shelf ecosystem


Contact: shannon.meseck@noaa.gov

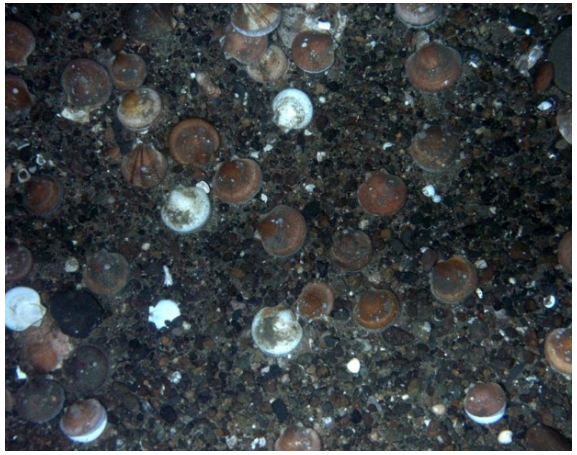
# Resource species (fish, shellfish)

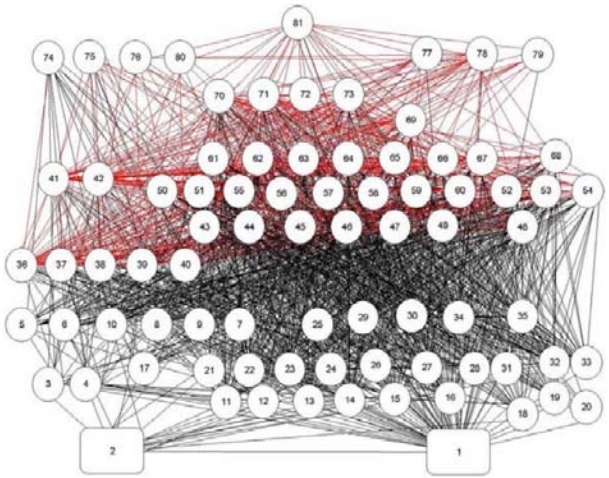
- Experimental Methodology and Development
- Effects of Ocean Acidification on Fish Early Life Stages
- Otolith Condition and Growth of Juvenile Scup
- Physiologic Effects on Atlantic Surf Clams

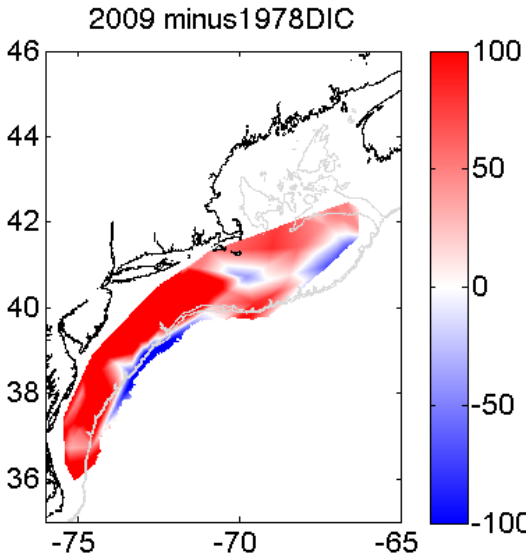
Contact: beth.phelan@noaa.gov

# Modeling

- Develop regional projections of ocean acidification based on climatologies and earth system model output
- Develop population models to examine effect on resource species (collaborators on NOAA funded project to WHOI examining sea scallops)
- Couple ocean acidification with ecosystem models to evaluate larger-scale effects



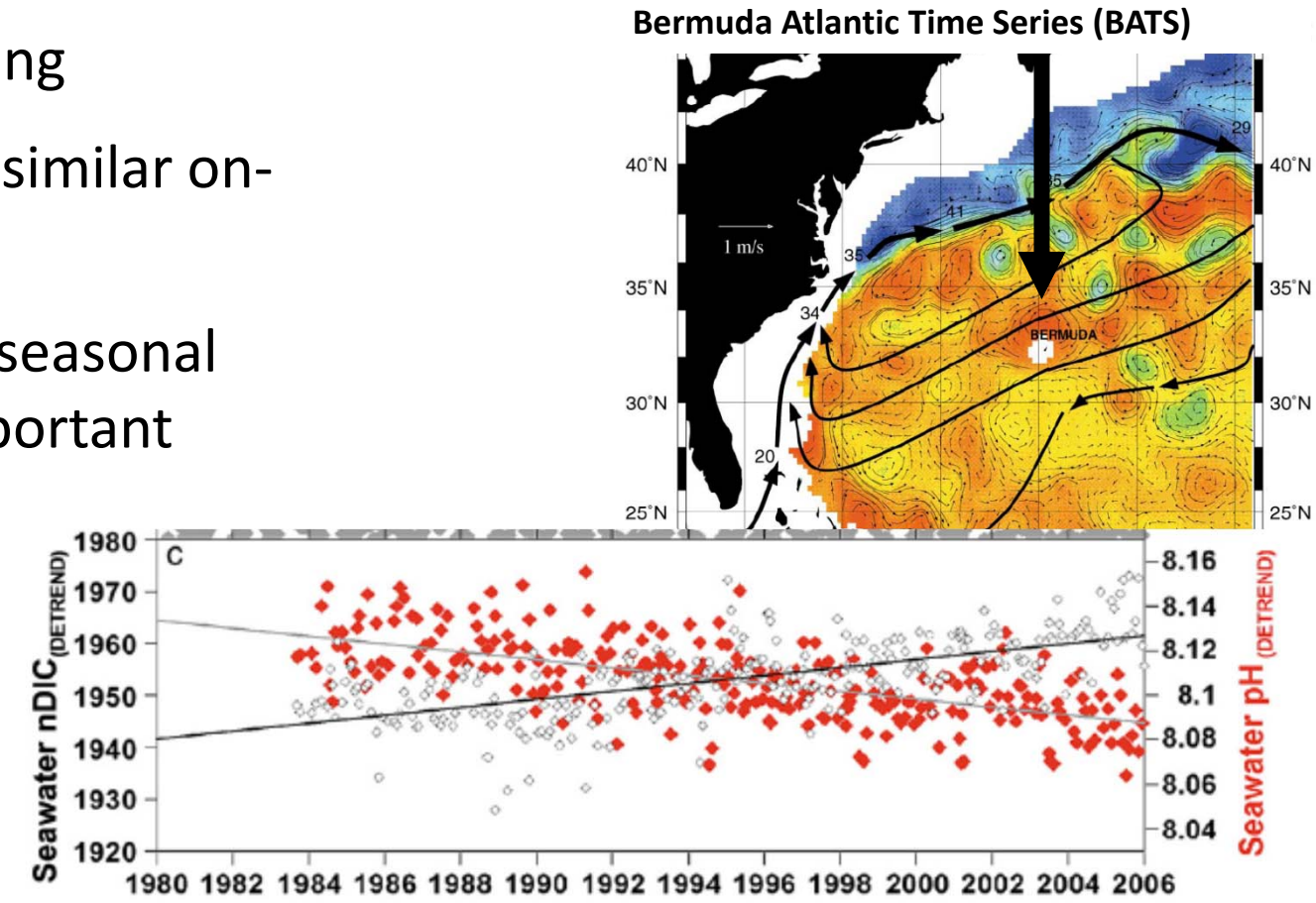





Contact: jon.hare@noaa.gov

# Assessment

- Dissolved inorganic carbon is increasing
- pH is decreasing
- Observations similar on-shelf
- Regional and seasonal variability important




Bates NR, Peters AJ (2007) Marine Chemistry 107:547-558
Rebuck N (in prep)

# Ocean climate and river herring (temperature & acidification)

- Why do we care
- Temperatures
- Acidification
- Next Steps

# Next Steps (at long time scales 2060-2100)

## Temperature and Streamflow Effects

- Temperatures will increase in ocean, estuaries, and rivers
- Streamflow will change
- Nye et al. project -Projecting the effects of climate change on river herring in both freshwater and marine habitat

## Ocean Acidification Effects

- No quantitative data related to river herring
- Potential olfactory effects
- Potential prey effects
- River herring experiencing large range (ocean to freshwater life history)