FIRST DRAFT

Maine Ocean Acidification Commission
State of the Science/Research & Monitoring Priorities Subcommittee Meeting
August 15, 2014

Attendees:

Susie Arnold
Bill Mook
Mark Green
Joe Salisbury
Larry Mayer
Meredith White
Jesica Waller (from the public)

State of the Science/Research & Monitoring Priorities Outline

1. Acidification of Maine Waters: Causes and Trends
    a. Increasing atmospheric CO2 (+2 ppm/year from Mauna Loa, but Joe has seen something similar in Gulf of Maine) – use language from WA/NOAA reports
        i. Rate of CO2 increase in water will increase over time (i.e. +2 ppm/year could be +50 ppm/year in 50 years or so)
        ii. Introduction to Gulf of Maine: Clarify that Maine waters can be considered 'surface ocean' exposed to a well-mixed atmosphere and the system is affected remotely. Gulf of Maine has warmed more that the global ocean over recent years
    b. Freshwater influences (this is also a climate change problem – increase in rainfall in last 50 years)
        i. Direct freshwater influence from land (low pH freshwater mixing with higher pH seawater) Runoff from land
            1. Dilution by low pH fresh water (low TA/DIC)
            2. Acid deposition (remnants of acid rain/dry deposition)
            3. Organic acids from soil (Gelbstoff – tannins?)
            4. Products of mineral weathering
        ii. Remote freshwater sources
            1. Inputs from Scotian Shelf
            2. Slope water
    c. Decoupling photosynthesis/respiration leading to acid production (This is likely to be a very local phenomenon.)
        i. Nutrient addition (eutrophication) leads to blooms that aren't grazed down in place (this could help larvae that are in water column and need food!)
        ii. Stratification (Separates photosynthesis/respiration)
            1. Vertical mixing – destratification brings DIC from deep waters in winter

iii. Sediments (there is a carbon-rich section in the nepheloid benthic layer, but there isn't a lot of respiration going on there – the carbon is coming from the mud)

d. Spatiotemporal geography of forcings
   i. Timing and spatial extent of freshwater inputs
      1. Pelagic vs benthic (different habitats for different animals)
      2. What is the trend for salinity patterns in Gulf of Maine?

e. Summary: Why is the Gulf of Maine particularly susceptible to OA?
   i. Increased and increasing freshwater input
   ii. Poorly buffered due to remote forcing, local fresh water, intense productivity cycle (speculate that remineralization occurs over 1 year)
   iii. Warming waters, but still relatively cold, therefore affecting solubility of CO2 (cold Scotian Shelf, and cold deep water mixing, cold windy winters that remove heat)

2. Impacts on Maine Fisheries
   a. How acidification can impact organisms
      i. Mechanisms (consult the WA Blue Ribbon Panel Doc)
         1. Calcification
         2. Other direct effects of carbonate parameters (narcotic effect of CO2, acidosis, pH affects organisms in context of proton pumps)
      ii. Acidification in the context of other stressors
         1. Temperature, hypoxia, salinity, toxins, disease, fishing pressures, minimum population size, predation pressure, food availability can all have negative impacts. When coupled with OA, these impacts can be additive or synergistic with OA. It is also possible that some environmental changes can reduce the impacts of OA.
         2. Acidification of the coastal ocean is arriving in a relative gradual fashion (decadal time scale). Because many studies of biological impacts have shown that acidification impacts are additive along with other stresses (e.g., low oxygen –see Talmage & Gobler ref), Maine will likely observe these biological impacts in connection with other environmental changes. It is also possible that some environmental changes will slow the impacts of acidification. Initial observed negative events will likely involve multiple stressors.
   b. Effects on Maine Commercially Important Species
      i. Table summarizing OA response of commercially important species. List landings & what is known about OA impact (use data from NECAN table – only include commercially important species and rank in order of dollar value). For each species: vulnerable stage, geography of habitat, mechanics of issue (List below is in landings order from 2013)

1. Lobsters
2. Elvers
3. Softshell Clams
4. Herring
5. Groundfish (Cod, Haddock, Yellowtail Flounder, Plaice, Witch Flounder, Winter Flounder, Redfish, White Hake, Pollock, Halibut, Monkfish, Cusk)
6. Bloodworms
7. Green Urchins
8. Sea Scallops
9. Eastern Oysters
10. Blue Mussels
11. Less than 1%: Shrimp
12. Quahogs
13. Surf Clams
14. Macroalgae (farmed and harvest)

ii. Discussion of species' responses
1. Multiple life stage in one study (carry-over effects)
2. Parental exposure affects offspring response
3. Multiple stressors (synergistic effects)

c. Ecosystem Effects (Busch reference – Puget Sound ecosystem)
i. OA will perturb part of a trophic level or habitat that is critical to commercial species
ii. In addition to direct effects, we anticipate that OA will cause indirect effects on commercially important species through interactions with other components of the ecosystem.
iii. It is likely that major impacts of OA will be more severe and more complicated than the direct impact on a species: Expect the unexpected. (give example: i.e. the phytoplankton species whose biochemical composition changed (Leu reference), which can affect copepod predators, which could propagate up the food chain, possibly to commercially important fish)
iv. Make a reference to past acidification events in geological record (see WA report), i.e. methane release in PETM. Which taxa survived, which went extinct? How does the rate of change then compare to the rate of change now?
v. Species adaptation while preserving commercial value

3. Research and Monitoring Priorities
a. Summary of gaps
i. Demonstration that Maine waters have already acidified. Can we use boron isotope as proxy for pH, or other biomarkers? (see 2007 Koster reference regarding Kennebec River biomarkers in sediments)
ii. Carbonate chemistry of estuarine and benthic environments, and of incoming source water to the Gulf of Maine

DRAFT

iii. Direct impacts on commercially important species with few studies thus far
iv. Indirect effects of OA on ecosystem function affecting commercially important species

b. Current status of monitoring/research
   i. NERACOOS buoys have been collecting data: temp, salinity, oxygen, currents (but mainly temp has been analyzed)
   ii. NGOs: Friends of Casco Bay (DO), St. George's River Valley (DO), Maine Coastal Observing Alliance, Friends of the Penobscot Bay
   iii. UNH-PMEL-NERACOOS Acidification Buoy: carbonate chemistry
   iv. GNATS (Barney Balch)
   v. UNH Wilkinson Basin and Maine Coastal Transect
   vi. Mook Sea Farm
   vii. Southern Maine Community College
   viii. pH-DO relationship (historic DO data can be used to assess past pH)

c. Monitoring and Research Priorities for Maine (not in any order)
   i. Increase estuarine and offshore benthic, as well as incoming source water (eg. Buoy N), monitoring of carbonate chemistry
   ii. Measurements of primary production, respiration, and calcification rates in those same locations
   iii. Monitoring of freshwater sources to coastal waters (chemistry, volumes). Is dilution of ocean waters with freshwater driving the reduced saturation state (we have lower TA river water on average)?
   iv. Further analysis of previous data sets, including building models that assess forcing functions (build off of DO models)
   v. Review existing data from observation stations (NERACOOS – temp, salinity, oxygen, currents). How many low-salinity events in a year? Can any given low salinity event be correlated with a decline in a lobster settlement cohort?
   vi. Biological response research needs
      1. Expand studies of commercially important species which have been poorly studied thus far
      2. Adaptive capacity
      3. Trophic interaction
      4. Complete life cycle studies
      5. Identify bottlenecks in commercially-important species that would be affected by OA (spat success, etc.)
      6. Target key ecosystem interactions likely to be affected
      7. Ecosystem model with OA input
   vii. Lobster research needs:
      1. Very few OA studies of *H. americanus* as relevant to the Gulf of Maine – increase study numbers
      2. Are recruits just moving deeper and therefore being missed in surveys or are they actually decreasing in number?

DRAFT

3. What is the salinity tolerance of lobsters at different life stages? (Winn Watson says that adults can survive down to 10 PSU, but larvae are less tolerant: see Charmantier reference)

DRAFT