

**Increasing Community Resilience to Ocean
Acidification in Maine:
Analyzing and Responding to the Economic, Cultural, and
Social Impacts**

A Workshop in the Island Institute's Climate of Change Series

October 7, 2014

**Maine Maritime Museum
Bath, Maine**

*Organized and Hosted by: The Island Institute and The Natural Resources Defense Council
Facilitated by: Heather Deese, Island Institute & Laura Taylor Singer, SAMBAS Consulting*

ISLAND INSTITUTE



About the Island Institute

The Island Institute works to sustain Maine's island and remote coastal communities, and to exchange ideas and experiences to further the sustainability of communities here and elsewhere. Many islanders are fishermen, relying heavily on shifting ocean resources for their livelihoods. Changes in climate and ocean chemistry are making the future of traditional fisheries uncertain. To address this uncertainty, we bring together experts who can help us understand the potential impacts of climate change on our fisheries, explore options for local mitigation, remediation, and adaptation, and help fishing communities prepare for the future.

During the summer of 2013, we initiated our *Climate of Change* workshop series to address how the changing climate and ocean chemistry may impact Gulf of Maine fisheries and the communities that depend upon them. We also produced a series of short videos, each of which explores specific, climate-related impacts on fishing communities. To view the results of these efforts, please go to: www.islandinstitute.org/climateofchange

The image shows two handwritten signatures in black ink. The signature on the left is 'Susie Arnold' and the signature on the right is 'Nick Battista'. Both are written in a cursive, flowing style.

Susie Arnold, Marine Scientist & Nick Battista, Marine Programs Director
Island Institute

About the Workshop

Overview

The Island Institute, in partnership with the Natural Resources Defense Council (NRDC) hosted a workshop at the Maine Maritime Museum on October 7, 2014 to discuss potential impacts of ocean acidification (OA) on coastal communities, learn about vulnerability assessment techniques, and discuss mitigation and adaptation strategies for Maine to consider. The workshop attracted 71 participants from a variety of backgrounds including researchers, legislators, fishermen, aquaculturists, and staff of municipalities, state agencies, NGOs, and water quality groups.

Primary Goals of the Workshop

- 1) Raise awareness in Maine about tools and data that can be used to assess social and economic vulnerability to OA
- 2) Explore mitigation and adaptation options and demonstrate how the results of a vulnerability analysis can be used to focus these efforts
- 3) Solicit feedback on the methods of existing vulnerability assessments and identify local data and information needs for mitigation and adaptation to inform future priorities for Maine.

Table of Contents

About the Island Institute	2
About the Workshop.....	2
Overview	2
Primary Goals of the Workshop	2
Executive Summary	4
Recommendations from the Workshop	6
Mitigation.....	6
Remediation.....	8
Research & Monitoring.....	8
Policy, Planning, & Adaptation	9
Public Education & Dialogue.....	11
Key Qualities Valued by Participants and Potential Indicators	13
Qualities Valued.....	13
Indicators.....	14
Data Needs.....	17
Data Available	18
Current Initiatives and Next Steps.....	20
APPENDIX I: Agenda	21
APPENDIX II: Presentation Notes	22
Introduction to Ocean Acidification - Nichole Price (Bigelow Laboratory).....	22
What is vulnerability? How and why is it evaluated? - Julie Ekstrom (NRDC).....	23
National Ocean Acidification Social Vulnerability Assessment Results - Julie Ekstrom (NRDC).....	24
Ocean Acidification and Alaska’s Fisheries: A Risk Assessment – Sarah Cooley (The Ocean Conservancy)	24
Social Indicators of Fishing Community Vulnerability and Resilience - Lisa Colburn (NE Fisheries Science Center).....	25
Maine Fishermen’s Perspectives of Community Resilience - Teresa Johnson (UMaine).....	26
Governance and Other Options for OA Mitigation and Adaptation - Lisa Suatoni (NRDC).....	26
Local Ocean Acidification Response Strategies - Brad Warren (Global Ocean Health)	27
APPENDIX III: Partial List of Existing Data Sources to Help Determine Environmental and Community Vulnerability to OA	29
APPENDIX IV: Participant List.....	33

Executive Summary

Ocean acidification (OA) can have profound impacts on marine ecosystems and human communities that depend on marine resources. The impact of ocean acidification has become a major focus for fishermen, scientists, and policy makers who are concerned about the threat to commercially important fisheries and the aquaculture industry. Unfortunately, the cold temperatures and relatively large freshwater inflows to the Gulf of Maine and high dependence on fisheries make Maine's coastal communities particularly susceptible to ocean acidification. In April 2014, the Maine legislature created a commission to study the effects of ocean and coastal acidification on species that are commercially harvested and grown along the Maine coast and provide policies and tools to respond to OA.

Recent collaborations among researchers, nonprofit organizations, government agencies, industry members, and private citizens have made progress in better understanding the potential environmental impacts of OA. However, less work has been done to assess the social and economic vulnerability of communities to OA. *Increasing Community Resilience to Ocean Acidification in Maine: Analyzing and Responding to the Economic, Cultural, and Social Impacts* was held as part of the Island Institute's *Climate of Change Series* to raise awareness in Maine about the various tools and data being used in vulnerability assessments. Co-hosted by the Natural Resources Defense Council (NRDC), the workshop featured the work of Drs. Lisa Suatoni and Julie Ekstrom (NRDC) who recently completed a national assessment of communities' vulnerability to ocean acidification. Maine exhibited high sensitivity to OA because of dependence on shellfish and aquaculture, and high social vulnerability in Downeast areas.

Workshop participants were asked to prioritize valued *environmental or socioeconomic qualities* of a healthy coastal ecosystem or coastal community and to develop a list of indicators that Maine may want to use to assess the ecosystem or community's vulnerability to OA. They then identified data that is available and data that is needed to track these indicators.

Environmental Qualities Valued:

- water quality
- species diversity
- ecosystem health and services
- habitat diversity
- sustainable fisheries

Socioeconomic Qualities Valued:

- cultural identity
- economic and social sustainability of communities
- controlled growth
- thriving working waterfront
- sustainable fishing industry

Participants came up with numerous Maine-specific indicators to measure these qualities. Some of the data needs identified in order to complete a vulnerability assessment included environmental data such as: carbonate chemistry time series data at more locations (co-located with commercially important species and adjacent to point sources- in estuaries, mud, open ocean, surface, sea floor), more comprehensive data on species (specifically lobster); and

socioeconomic data such as: the breakdown of licenses/landings by community, sector, activity and time of year, margin between costs and income, number of fishermen holding second jobs, new entrants into fisheries, etc.

The workshop also explored mitigation, remediation, and adaptation options and demonstrated how the results of a vulnerability analysis can be used to focus these efforts. While the primary cause of OA is carbon emissions being absorbed by the ocean, there are local actions we can take to mitigate coastal acidification, such as reducing polluted runoff from farms, lawns, and septic systems that are causing coastal waters to acidify more rapidly, and preserving marine photosynthesizers, like eel grass, that may reduce local acidification.

Workshop participants made a series of recommendations to address OA. Although not refined or prioritized, they can serve as a starting point for further conversations about OA in Maine.

Mitigation

- CO₂ reduction- reduce energy waste and consumption
- Reduce nutrient input to coastal waters
- Establish and update criteria and standards

Remediation

- Increase pH in mudflats
- Increase CO₂ and nutrient uptake in coastal waters and estuaries

Adaptation

- Diversify local economies

Research & Monitoring

- Work closely with the Northeast Coastal Acidification Network (NECAN)
- Monitor pH levels
- Identify location and extent of nitrogen input
- Develop technological solutions
- Document impacts of OA

Policy & Planning Initiatives

- Increase state planning efforts
- Expand local planning and use of model ordinances

Public Education & Dialogue

- Expand communication networks and planning forums
- Increase outreach and communication to the public
- Actively engage the fishing industry

Next immediate steps in Maine include the release of the Maine OA Commission's report on December 5, and a NECAN-hosted stakeholder meeting at UMaine's Darling Marine Center on December 10. At the federal level, reauthorization of the Federal Ocean Acidification Research and Monitoring Act (FOARAM) will hopefully include funds for expanded research on commercially important species, including lobsters, and localized community vulnerability assessments. NOAA's OA Program will be releasing awards for research on OA and hypoxia, and the EPA is responding to a lawsuit filed by the Center of Biological Diversity to update pH criteria.

Recommendations from the Workshop

Throughout the workshop, presenters and participants contributed a wealth of ideas and recommendations. In general, participants encouraged finding local, non-regulatory solutions that draw upon Maine's use of innovation and collaboration. It was recognized that Maine's comprehensive planning at the municipal level provides an opportunity for change that should be utilized to address ocean acidification. The recommendations presented below provide a basis to inform future conversations about ocean acidification and suggest actions that can be taken to mitigate and plan for the impact of ocean acidification on Maine's coastal communities.

Note: The ideas and recommendations are presented in a strategic planning framework to provide a general structure, but this does not necessarily reflect how they were framed during the discussions. In general, the "strategies" articulate a broad statement or approach to the identified problem or need. The "actions" are more specific next steps. In addition, there was not enough time in the workshop to gain a consensus about these recommendations and to establish priorities. Therefore, the following recommendations are not in any rank order and may not reflect the opinion of all participants.

Mitigation

→ CO₂ reduction- reduce energy waste and consumption

Strategies:

- Create more point of use power generation (i.e., increase efficiency of power by decreasing transmission needs)
- Promote energy conservation (e.g., change light bulbs, appliances, insulation, weatherization, carools, etc.)
- Increase Maine's use of non-carbon source energy (e.g., solar, wind, and geothermal)

Recommended Actions:

- Increase public education efforts and incentives regarding energy conservation
- Strengthen and support efforts of Efficiency Maine
- Establish and strengthen local energy conservation boards (e.g., Town of York Energy Steering Committee) and improve organization of state efforts through participation in networks such as the New England Local Energy Network
- Implement and promote state and federal energy credit programs that provide incentives to move away from fossil fuels by converting to non-carbon sources (i.e. reinstate alternative energy credits)
- Create an inventory of programs currently available for emissions reduction
- Encourage Congressional and State support of national carbon markets
- Create local carbon cap and trade markets between private entities
- Develop creative marketing strategies – solar energy micro-grids (i.e., buy into solar installations that are within your neighborhood)
- Invest in and foster new technologies with a focus on those that address multiple problems and challenges (e.g., capturing heat from effluent stream to lower power costs and minimize pollution)
- Encourage private investment and partnerships to develop new technologies

- Provide funding for agricultural methane digesters and encourage more biogas facilities (e.g., Exeter Agri-Energy in Exeter, Maine)

→ Reduce nutrient input to coastal waters

Strategies:

- Decrease use of fertilizers on private landscapes
- Re-evaluate nutrient input from wastewater treatment plants
- Capitalize on Farms for Future, Food Security Plan
- Encourage strategies to reduce storm water pollution (pervious surfaces, rain gardens, etc.)

Recommended Actions:

- Develop programs to increase outreach and encourage the use of pervious surfaces, rain gardens and other Best Management Practices (BMPs)
- Use ‘Lawns to Lobsters’ and ‘Healthy Casco Bay’ as a framework to expand current programs
- Update BMPs in light of new storm events
- Invest in new technologies for storm water improvement that could be integrated into existing or new projects
- Provide small business grants for technology development of mitigation strategies
- Reduce the number of storm water combine sewage overflows (CSOs) that bypass to estuaries
- Work with new and expanded farms on implementing BMPs to minimize nutrient input from agriculture (note: revised standards may be needed)
- Support funding for USDA animal waste programs and remediation of non point source pollution
- Expand availability of marine pump out stations – year round
- Enforce existing laws and regulations (i.e., DEP and local code enforcement officers)
- Figure out more cost-effective way to test and improve septic system effectiveness (on a more frequent basis- every 5 years?)
- Encourage legislation to implement setbacks as a buffer zone for fertilizer (e.g., Maine Lake Protection Act – LD 1744)

→ Establish and update criteria and standards

Strategies:

- Review current water quality criteria to be sure standards are appropriate and are targeted to the sources of nutrient input

Recommended Actions:

- Collect baseline data on the existing regulations
- Set nutrient criteria for nitrogen and phosphorus (N, P) and other total maximum daily loads (TMDLs) based on science and evaluation (note: DEP is already starting to work on this, as is EPA)
- Support funding for science needed to establish appropriate criteria

Remediation

→ Increase pH in mudflats

Strategies:

- Build on pilot programs (i.e., Darcie Couture, Resource Access International) to distribute calcium carbonate (CaCO_3) in low pH mudflats (could be crushed shells) and increase clam recruitment

Recommended Actions:

- Establish a collection program of shells from restaurants
- Explore changes needed in DMR and DEP regulations for clam flat restoration efforts (e.g., to distribute invertebrate body parts intertidal areas)
- Identify impacts on other species like mud worms, sand worms, through bioturbation and O_2 in sediment

→ Increase CO_2 and nutrient uptake in coastal waters and estuaries

Strategies:

- Increase acreage of beneficial marine plant/algae species
- Utilize bivalves as nutrient filters

Recommended Actions:

- Investigate site-specific plant/algae species and develop natural science knowledge for their effective use
- Create market-based incentives for aquaculture that includes multiple species such as mussel and kelp
- Simplify state regulations to encourage aquaculture projects that address OA and develop policies to place a higher priority on multi-species aquaculture leases
- Develop distribution infrastructure to aid people in growing multiple species
- Increase demand for algae as a food through marketing efforts
- Increase efforts to replant eelgrass (note: potential collaboration with green crab remediation efforts)

Research & Monitoring

→ Work closely with the Northeast Coastal Acidification Network (NECAN)

→ Monitor pH levels

Strategies:

- Increase standardized water quality monitoring and coverage

Recommended Actions:

- Establish Best Practices/toolbox for how to monitor carbonate chemistry in hatchery, aquaculture sites, clam flats
- Explore use of less expensive sensors being developed
- Develop and implement a program to place instruments on lobster traps to monitor pH
- Conduct focused pH survey of important commercially producing clam flats, reseeded projects

- Increase citizen science coverage and standardization of water quality monitoring (build on efforts underway; e.g. Maine Coastal Observing Alliance)
- Collaborate with shellfish harvesters on research and monitoring efforts

→ Identify location and extent of nitrogen input

Strategies:

- Sample coast to learn more regarding nitrogen ‘hot spots’
- Map where nutrient input is in relation to resources

Recommended Actions:

- Increase funding for more research on nitrogen connection to OA coastally and identify which sources are the greatest problem
- Utilize citizen groups and graduate students for help with data collection and monitoring
- Eliminate barrier that currently exists between land data collection and ocean data collection efforts – need coupled systems approach to understand where nutrient input from land affects coastal acidification

→ Research and development for technological solutions

Strategies:

- Increase research and development initiatives to provide technological solutions for mitigation and adaptation strategies

Recommended Actions:

- Complete a comparison of storm water treatment/capture systems to identify promising systems for Maine
- Develop expertise regarding algal drawdown of CO₂ and N
- Support work on biofuels, buffers and pervious surfaces
- Encourage federal and state grants to add OA for points in reviewing grant proposals

→ Document impacts of OA

Strategies:

- Continue research into species specific impacts of OA

Recommended Actions:

- Develop and support focused research on the potential impacts of OA on Maine’s lobster resource
- Conduct research with hatcheries to determine stocks that are resistant to poor water quality and acidification

Policy, Planning, & Adaptation

→ Increase state planning efforts

Strategies:

- Establish climate change adaptation and mitigation plan that includes ocean acidification, temperature, and sea level rise
- Encourage U.S. EPA to designate waters as threatened or impaired
- Educate leaders to understand the link between OA and the economy/jobs

Recommended Actions:

- Look at state's climate action plan and climate adaptation plan (i.e., don't reinvent the wheel)
- Revisit existing regulations and policies, analyze and understand if they are working, lack of enforcement (e.g., state greenhouse gas emissions goals)
- Promote stronger state goals for emissions reductions
- Collaborate with U.S. EPA to initiate water designation process ASAP
- OA state commission initiate process with U.S. EPA
- Reach out to other states – NH, MA, CT, RI
 - National caucus of environmental legislators
 - New England Regional Ocean Council – coordinate actions and data

→ Diversify local economies

Strategies:

- Business development and labor training
- Diversified access to marine-related livelihoods and/or employment

Recommended Actions:

- Explore aquaculture as a potential option (note: diversifying into shellfish aquaculture is a problem if OA has a major negative effect on these species)
- Look at licensing structures to allow diversification

→ Expand local planning and use of model ordinances

Strategies:

- Promote and support local actions to address OA
- Encourage broad community planning to reduce vulnerability to OA and other stressors

Recommended Actions:

- Encourage local ordinances that require or incentivize permeable surfaces
- Require OA and sea level rise in municipal comprehensive plans (e.g. York and Bowdoinham comprehensive plans have OA and SLR incorporated; see <http://www.yorkmaine.org/LinkClick.aspx?fileticket=Y-RZTBdyMqY%3d&tabid=177> and http://www.bowdoinham.com/files/Comprehensive%20Plan_adopted_06-11-14.pdf)
- Review outcomes of current study on how sea level rise is affecting six coastal communities; OA is coming up in the discussions
- Encourage regional planning efforts (i.e. Boothbay Harbor Sewer District pilot project growing kelp adjacent to sewage outfall - <http://www.boothbayregister.com/article/heavy-rains-challenge-pipe-system/2978>)
- Promote model fertilizer ordinance through outreach/education
- Build on and support funding of Maine Community Vulnerability assessment model involving local leadership and appropriate to local context (e.g. Midcoast coastal hazard resiliency planning - <http://midcoastcog.org/projects/coastal-hazard-resiliency-sea-level-rise/>)

- Encourage creative partnerships – non-profits as a lead-in; NECAN and other networks
- Explore lessons learned from inundation work by NERACOOS and the town of Hampton, NH
- Utilize output from municipal culvert management project in Ellsworth by UMaine’s Sustainable Solutions Initiative and Cooperative Extension project (<http://umaine.edu/maineclimateneews/archives/spring-2014/research-highlights/>)

Public Education & Dialogue

→ Expand communication networks and planning forums

Strategies:

- Accelerate learning crucible among different stakeholders, industry, regulators, but in a non-regulatory environment to find the multiple-problem solutions (note: need to consider trust and gentrification issues)

Recommended Actions:

- Conduct interdisciplinary future environmental scenarios for business planning and community planning (i.e. change in estuarine acreage, change in vegetated area, carbonate chemistry, temperature, sea level rise)
- Plan forums to discuss options for building solutions and best practices
- Continue leadership among community NGOs, and promote university programs to train interdisciplinary marine resource scientists (i.e., UCSB; UMO dual degree in Marine Policy and Marine Science) that keep these issues at the forefront

→ Increase outreach and communication to the public

Strategies:

- Communicate climate change and OA to appropriate audience to initiate action by fishermen and other groups (local leaders and trust)
- Communicate OA with a sense of urgency that individuals and communities can do something about (i.e. provide hope and encouragement)
- Build awareness by capitalizing on local value structures and focus on mutual benefit
- Craft the message so that people respond to it

Recommended Actions:

- Improve broad community education about detergents, lawn care, permeable surfaces (i.e., enrich and build on current outreach efforts)
- Promote local approaches for education and awareness (dual approach with private, public, NGOs and state)
- Communicate solutions and specific actions (BMPs) that people can enact at local level
- Create model to engage users (e.g. Friend of Casco Bay - <http://www.cascobay.org/wp-content/uploads/2013/01/You-Can-Make-A-Difference-Bay-Paper-Friends-of-Casco-Bay-2014.pdf>)

→ Actively engage the fishing industry

Strategies:

- Develop additional ways to engage fishermen in education about OA and adaptation dialogue

Recommended Actions:

- Offer educational opportunities that are an efficient use of fishermen's time
- Organize fishermen exchanges on various topics including OA and climate change
- Focus on engaging lobster industry specifically

Key Qualities Valued by Participants and Potential Indicators

During the workshop, participants were divided into nine tables with a variety of stakeholders represented at each table. The groups were asked to prioritize either *environmental or socioeconomic qualities* of a healthy coastal ecosystem/community and to develop a list of indicators that Maine may want to use to assess the ecosystem's/community's vulnerability to OA. (*i.e. How will we know if there is a problem and which components of the marine environment or communities are most vulnerable to OA?*)

The discussions were rich and lively. Several groups covered both environmental and socioeconomic areas and all the groups generated a variety of indicators and identified data that is available (see Appendix III for list of existing data sources) and data that is needed to track these indicators. Below is a brief summary of the discussions to provide an overview of the main qualities valued by the workshop participants and potential indicators with a focus on the key data needs in order to assess vulnerability to OA.

Qualities Valued

There were common themes among the groups as they discussed both environmental and socioeconomic qualities they value in Maine's coastal communities and those they would like to see fostered.

Environmental Qualities Valued

Good Water Quality

Species Diversity

- Including traditional and economically important species

Ecosystem Health and Services

- Robust, diverse ecosystems tied to low coastal population density

Habitat Diversity

- Different mosaic of habitats along the coastline

Biologically Sustainable Fisheries

Socioeconomic Qualities Valued

Cultural Identity

- Sense of place that includes demographic and economic diversity
- Innovation, opportunity and optimism for the future
- Fishing as way of life
- Strong fishing community identity – independent/self-reliant/local seafood available

Economic and Social Sustainability of Community

- Viable coastal economy - young people and families; ability to earn a living wage/economic security
- Controlled growth (i.e. land use, water access, agriculture)
- Carbon neutral
- Healthy, sustainable fishing industry – access to fisheries

- Thriving working waterfronts

Community Engagement and Communication

- Education and acknowledgement of problem
- Community perception of water in their community
- Strong relationship supporting flow of knowledge and communication
- Communication network between all groups (fisheries, scientists, residents)

Indicators

The workshop participants generated an expansive list of indicators to assess Maine's vulnerability to OA. Some of the indicators were tied directly to specific environmental and/or socioeconomic qualities while many were broad in scope and potential application.

Environmental Indicators

Water Quality Parameters

- DO, pH, nutrient content, TSS, turbidity, temperature, pollutants, E. coli
- Changes in water quality parameters
- Nutrient inputs, algal blooms, pH of mud

Species Diversity

- Shannon index
- Diversity of exposure threshold – chemical and thermal thresholds, ratio of high thresholds – a lot of animals that can take the heat
- Value of landings
- Effort needed for harvest (CPUE)
- Population trends (new species/loss of species – abundance trajectories – population trends at the species)
- Seasonal/interannual variability
- Timing of spawning and recruitment
- Availability for harvest - timing of presence in waters off of Maine and abundance
- Diversity of life history
- Genetic diversity

Ecosystem Health and Services

- Absence/presence of marine invasive species; abundance of indigenous species; health of species (stressed, diseased, etc.)
- Sea level rise – coastline concerns, erosion, habitat loss, flood impact, impact to salt marshes
- Lower trophic level fish stocks
- Shifts in size/age of populations
- Temperature data (niche specific over time)
- Productive shellfish habitats
- Stable (or increased) pH
- Stable (or declining) water temperatures
- Presence of traditional species
- Dissolved oxygen and salinity
- Ocean health index

Habitat Diversity

- Shifts to habitat – habitat loss/changes, erosion, sea level rise, flood impacts, coastline concerns
- Shifts in size/age populations of a given species (or developmental issues)
- Inshore habitats and ecosystems, fishery locations, etc.

Socioeconomic Indicators

Community Engagement and Communication

- Mitigating OA or protecting certain areas along the coast – being proactive with protection
- Organizations around the state that can serve as boundary organizations and links to groups that are not able to attend meetings/workshops
- Information exchange (relationships) between fishermen and scientists
- Trust between scientists and resource users
- Use of and respect for traditional ecological knowledge and scientific knowledge
- More meetings with diverse groups at the table
- Engagement of seasonal population in fishing issues
- Community participation in conferences/workshops
- Increased funding available for monitoring programs

Family Well-being Indicators

- Rates of domestic violence
- Dropout rates
- Teen pregnancy
- Divorce rates
- Rates of substance abuse
- Satisfaction and optimism
- Parental warning

Community Health Indicators

- *Governance/Engagement*
 - Community participation and civic engagement
 - Participation in meetings/organizations
 - Diversity in political views
 - Action on issues
 - # zoning that supports working waterfront
 - Proactive efforts at protection and decision making at all levels
 - # of ordinances in place
 - Adherence to ordinances (i.e. fertilizer bans)
 - # of fishermen on town councils or positions of power
- *Population/Social*
 - % of retirees
 - Seasonal residence
 - # people relying on food bank and social services (% of population)
 - # people losing homes
 - Community population sustainability

- Community happiness
- Size of school population
- Presence of community organizations/civic organizations/churches
- # of supporting NGO, etc.
- Income/wealth distribution
- *Infrastructure*
 - Presence/absence of facility
 - Affordable housing
 - Broadband access
 - State of school
 - Vibrant community center

Community Economic indicators

- Jobs
- Debt to income ratio
- Ratio of loan default
- % economy that is resource based
- Margin between costs and income (federal level)
- Kids leaving/staying in coastal community
- Concentration of wealth and power (i.e. second homes)
- Resilience indicator/planning – business or otherwise
- Willingness to adapt to change – individuals and by sector
- Presence/absence of facilities
- # of people employed – unemployed (exists at state level but maybe not at town level; confidentiality issue for access)
- Revenue generated/value (National Ocean Economics Program - <http://www.oceaneconomics.org>)
- Multiple economic sectors - capturing value chain and diversity of value chain

Fishing Industry Indicators

- # licenses, pounds landed
- % dependent on fishing
- # fishermen with second jobs
- Average age of fishermen and age distribution (multi-generational participation)
- New entries in fishing
- Diversification in fisheries
- Participation in fishing and auxiliary industries
- Flexibility to adapt to job market
- Fishermen's opinions
- # fishing cooperatives
- # fishermen's associations
- # fishing boats and trends
- # boats for sustainable fishery
- # boats for sale

Marine Business Indicators

- Market dynamics (local and away)
- # community supported fisheries and local products in market (ME food strategy)
- Per capita seafood consumption
- % jobs based on marine resources (under reported)
- % economy from fishing industry
- # waterfront and fishing related businesses
- Working waterfront access
- Existence of supporting businesses and industries - ocean product processing capacity
- Access to fuel
- Access to social capital
- New aquaculture leases or lease renewals
- New market items: kelp, green crabs, etc.
- Tourism numbers

Data Needs

Environmental Data Needs

- Clearinghouse of related OA data
- pH of mud and nutrient data
- Ocean testing at a variety of point sources not just waste water
- Comprehensive datasets over time vs. smaller research projects
- CO₂ system data
- Lobster, other taxa response to OA (population dynamics)
- More comprehensive data on species
- Coastal and benthic surveys and monitoring
- Compilation of fishermen's observations
- Northeast Sentinel Monitoring Network
- Need carbonate chemistry time series – fine resolution, more than pH, synoptic, located with vulnerable species
- NO_x – terrestrial relationship
- Species richness
- Bycatch surveys
- DMR stock assessment surveys
- Aquaculture harvest records, pounds/species per month
- System to collect data on multi-cropping at aquaculture facilities
- Surveys by fisheries managers for inshore habitats, ecosystems and fishery locations
- Monitoring of high risk locations (i.e., mudflats with shellfish)
- Funding for these monitoring programs, new grants?

Socioeconomic Data Needs

Fishing Industry

- Current demographics and social data of the fishing industry
- Oral histories
- Breakdown licenses/landings by community, sector, activity and time of year
- Fisheries business model

- Representation of how fishermen see the world – not sectoral – parse by community
- Interviews with fishermen on opinion of OA
- # boats necessary for a sustainable fishery
- # boats for sale
- New entrants into the fisheries
- Diversification in fisheries (number of active licenses)
- Number of fishermen holding second jobs
- # of fishing boats in a harbor, ratio of fishing boats to sail boats
- Terrestrial and aquatic relationship (retail, process, wholesale supply, sport)
- Tracking market for global and local target species
- % of dependence on local versus distant markets (demand scaled to supply)
- Margin between costs and income
- Debt levels at fishermen level/micro-enterprise level
- Quality of portfolio livelihood options – can you afford to take a hit on the resource?
- Level of illegal, unregulated and unreported fishing

Community

- Finer-scale data at community or individual scale
- Study of other natural resource losses (e.g. mills)
- Demographic of leadership positions
- Parental warning (qualitative; statistical sample)
- Number of kids leaving community
- Number of people relying on food bank
- # of community events
- Survey data to gauge “sense of place” and optimism
- Surveys to evaluate levels of trust among fishermen, scientists, etc.
- Community/school based sampling
- Public opinion surveys regarding OA
- Number of OA educational programs in schools
- Number of students going through educational programs
- Concentration of wealth
- Length of residence for fishing license holders
- Bills submitted, who sponsored it, organizations involved and outcome

Data Available

Environmental Data Available

- NERRS water quality at WERR
- Casco Bay Estuary Partnership
- Invasive species
- Bird surveys
- Landings data (but need finer scale)
- State and federal surveys
- RARGOM ecosystem drivers annual conference
- Fishermen observations as early warning

Socioeconomic Data Available

- Census data
- DMR license and landings, including residence of license holder
- NOAA economics data
- Number of fishermen associations and cooperatives
- Length of residence (# years)
- School age population
- % homes for sale/vacant
- School population
- Number of fishing boats
- Local zoning and ordinances that support the working waterfront
- Number losing homes (foreclosure)
- % of jobs based on marine resources
- % economy that is resource based
- Domestic violence (if reported)
- Divorce rates
- High school graduation rates
- # of CSF's (Maine Food Strategy)

Current Initiatives and Next Steps

Beth Turner, NOAA, Ocean Acidification Program

- Hoping reauthorization of the Federal OA Research and Monitoring Act (FOARAM) includes expansion of lobster studies and community vulnerability studies
- Supporting ongoing laboratory studies of the root impacts of OA
- Extramural opportunities – request for proposals on OA and multiple stressors due Oct. 23
- Northeast Coastal Acidification Network (NECAN)
 - Planning a series of outreach meetings in Maine, Massachusetts and Connecticut to bring in a lot of lobster fishermen; Maine scheduled for December 10
 - Venue to bring NECAN information and information from this meeting to other stakeholders
 - Wants to create a structure for increased monitoring and research

Matt Liebman, EPA Regional 1 Office

- Lawsuit filed by Center of Biological Diversity to update pH criteria (current marine pH criteria is within range of 6.5 to 8.5, with a change of no more than 0.2 units); waiting for results coming out of WA, ME, and NECAN before updating pH and impairment criteria
- Working with NEROCOOS and others on sensor data, including UNH to put new sensor in Casco Bay
- Limited by budget and recent loss of research vessel
- National Estuary Program – Casco Bay Estuary Partnership – updating plan next year

Representative Mick Devin, Co-Chair Ocean Acidification Commission

- OA Commission's task is to understand potential issues and craft strategies
- Perfect example of governmental/non governmental cooperation
 - August 1 – Sea Grant organized a science day
 - Today – Island institute has spent the day looking at vulnerability
 - Already have 1 ½ more days worth of work than we could have without these efforts
- Work today will directly apply to Commission work
- It is time to take the lead in New England on something that is quintessentially Maine- our seafood and our coastal communities

Heather Deese, Island Institute

- Several members of Maine's Ocean Acidification Commission were participants in the workshop and contributed to the recommendations
- A summary of the workshop recommendations was provided to the OA Commission and the full report will be made available
- Other forums for discussion in the region including:
 - NECAN regional outreach meetings – ME (December 10th), MA, and CT
 - Island Institute Predictive Capabilities Workshop – December 18th

APPENDIX I: Agenda

Increasing Community Resilience to Ocean Acidification in Maine: Analyzing and Responding to the Economic, Cultural, and Social Impacts *A Workshop in The Island Institute's Climate of Change Series*

MORNING SESSION - Focus on Assessing Vulnerability

- 9:00 - Welcome and Introductions – Susie Arnold & Heather Deese (Island Institute)
- 9:15 - Introduction to Ocean Acidification (a brief overview) – Nichole Price (Bigelow)
- 9:40 - Community Vulnerability to Ocean Acidification
- What is vulnerability, how and why is it evaluated? – Julie Ekstrom (NRDC)
- 10:00 - Community Vulnerability Assessment Case Studies
- National OA social vulnerability assessment results – Julie Ekstrom (NRDC)
 - OA risk assessment for Alaska's fishery sector – Sarah Cooley (The Ocean Conservancy)
 - Social indicators of fishing community vulnerability and resilience – Lisa Colburn (NE Fisheries Science Center)
 - Maine fishermen's perspectives of community resilience – Teresa Johnson (UMaine)
- 11:00 - BREAK
- 11:15 - Participants' Break-out Session #1- Explore Indicators and Data to Assess Vulnerability
- 12:15 - LUNCH** - National OA Vulnerability Assessment Bill - Congresswoman Pingree's Office

AFTERNOON SESSION - Focus on Mitigation and Adaptation Strategies

- 1:15 - Report Back from Break-out Session #1 – Laura Taylor Singer (SAMBAS Consulting)
- 1:30 - Governance and Other Types of Options for OA Mitigation and Adaptation- Lisa Suatoni (NRDC)
- 1:50- Community Approaches and Emerging Adaptive Tools- Brad Warren (Global Ocean Health)
- 2:10 - Participants' Break-out Session #2- Mitigation and Adaptation Needs for Maine Local
- 3:10 - BREAK
- 3:25 - Report back from Break-out Session and Generate List for Mitigation and Adaptation to Increase Resiliency for Maine
- 4:15 - Next Steps and Outputs - Report to inform OA Commission, NECAN, and NOAA
- 4:30 – Cocktail Hour for Continued Informal Discussion

APPENDIX II: Presentation Notes

The workshop included several presentations to set the context for the group discussions. A brief summary of the presentation is provided below but these should not be considered abstracts of the presentations. Copies of many of the presentations and other background material can be found at www.islandinstitute.org/OceanAcidification

Introduction to Ocean Acidification - Nichole Price (Bigelow Laboratory)

- Major cause of ocean acidification is rising CO₂ in the atmosphere from emissions; the rate at which CO₂ it is rising is increasing rapidly and it is reaching unprecedented levels
- International Panel for Climate Change put together various scenarios based on changes in fossil fuel emissions
- Rise in CO₂ with corresponding drop in pH
 - 0.1 units pH corresponds to 30% increase in acidity since 2000
 - Projected to drop another 0.3 – 0.4 units in the next 100 years
- CO₂ emissions is the major contributor on a global scale, but there are other local sources:
 - Stormwater run-off
 - River water is more acidic naturally
 - Upwelling
- Marine life susceptible to ocean acidification:
 - Reduced shell formation
 - Habitat loss
 - Less available prey
- Consequences of ocean acidification:
 - Shelled animals use CO₂ as a building block for calcium carbonate
 - OA is making it difficult to build shell and can cause dissolution of existing shells (osteoporosis)
 - Organisms with calcium shells include -
 - Coral reefs
 - Zooplankton
 - Phytoplankton
 - Mollusk
- At risk in Maine:
 - Oysters, clams and scallop larvae are particularly susceptible
 - Mussels a little more resilient but the byssal threads lose strength and can fall off rocks
- Who benefits from more CO₂?
 - Seaweed and seagrasses absorb CO₂
- Seaweeds and sea grasses as a buffer?
 - Need to understand how effective it is in the environment.
 - Depends on local circulation, how long water resides over kelp beds
 - Sea grasses are better at sequestering

- Seaweeds – release CO₂ over time when they die
- Matching scope of kelp farm with how much water to buffer and timing of harvest so that it doesn't end up back in the water
- Work needed to target which species would be most effective and where
 - Lots of single species work, multi species work is something that is needed
- Socioeconomic impacts – Pacific NW case study
 - Oyster farmers have seen > 90% of their oyster spat die off in low pH waters
 - Hatcheries in Oregon and Washington have been struggling to adapt
 - Within 50 years, waters may be corrosive year-round
 - Total estimated economic impact to shellfish aquaculture in Washington is \$270 million and 3,200 jobs

What is vulnerability? How and why is it evaluated? - Julie Ekstrom (NRDC)

- Understanding vulnerabilities on the ground is key for developing localized, specific actions. No regrets strategies that are Maine based.
- *Three components go into understanding vulnerability-*
 1. Exposure - the assets in the path of the disturbance and likely to be impacted (shellfish, lobster or other marine organisms); where will OA reduce these assets (global model projections designed to project when an area will reach a level of aragonite saturation state that will threaten shell builders- this is projected to be between 2043-2062 for mid-coast Maine, 2006-2030 east of Schoodic)
 2. Sensitivity - some people are more sensitive to the impacts of OA than others; the people's reliance on fishing (estimated commonly by indicators like the number of fishing licenses and revenues for all fish, etc.); Eastern Maine and Knox County are particularly sensitive
 3. Adaptive Capacity - the ability for people to cope with, prepare for, or adapt to extreme events such as declines in catch (commonly measured by education level, access to marine lab, etc.)
- OA impacts are disproportionate based on where you are and social characteristics (i.e., education, financial security, social cohesion, etc.)
- *Why do a vulnerability assessment?*
 - To develop site specific adaptation strategies within the priority areas that are identified
 - Want to understand vulnerability to assess the full spectrum of the problem
 - Gives an opportunity to think about and plan for intervention points to reduce vulnerabilities
 - Can make communities more resilient by focusing on exposure and sensitivity
 - Phases of disaster
 - Decision level: household – community – region – state – national

National Ocean Acidification Social Vulnerability Assessment Results - Julie Ekstrom (NRDC)

- Assessment of mollusks only
- Used nationwide datasets because they were doing nationwide study
- Marine Exposure + Social Vulnerability (sensitivity + adaptive capacity)
- Indicators used:
 - Exposure - globally driven acidification, rivers (geology and flow), eutrophic estuaries, upwelling; used bioregions to mark out the coast (E=problem estuary and R=problematic river)
 - Sensitivity (shellfish and aquaculture) - shellfish landed value, # of licenses, & % landed value from shelled mollusks
 - Adaptive Capacity - science capacity (Sea Grant budget, # of marine labs), political action (legislative action, climate adaptation plan), alternative job options (shellfish diversity, industry employment diversity)
- Moving forward – gives inventory of what is available nationally for data, socially-relevant OA research, focus regions and potential local actions
- In general, Maine exhibited high sensitivity to OA because of dependence on shellfish and aquaculture, medium adaptive capacity, and high social vulnerability in Downeast areas
- This study could be revised relatively easily using much finer scale data

Ocean Acidification and Alaska's Fisheries: A Risk Assessment – Sarah Cooley (The Ocean Conservancy)

(see article in Progress in Oceanography: <http://dx.doi.org/10.1016/j.pocean.2014.07.001>)

- Central question- *How could OA affect Alaska's communities?*
- What information do we have?
 - ocean forecasting models (Alaska has the advantage that they can use global scale models because they are so big), and present day measurements
 - harvest quantities/locations (commercial, subsistence, and recreational), and
 - social science information (education, employment at the community level)
- What information do we lack?
 - how local and global factors interact to alter OA in specific fishery areas
 - how all AK harvested species respond to OA
 - whether additional specific social factors amplify/minimize harm from OA
- Ranked census areas against each other into one vulnerability index, so could show how areas rank against each other

Social Indicators of Fishing Community Vulnerability and Resilience - Lisa Colburn (NE Fisheries Science Center)

- To see the social indicators used to measure community well-being in the face of climate change see: <http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index>
 - Used data that was available (census data and NMFS data); no resources for additional surveys
 - 2917 communities across 19 states on the East and Gulf coasts, 75 variables from census data, 7 secondary sources including NMFS fishing data, 1000 recreation/commercial fishing
- One community might not have high vulnerability but could be surrounded by highly vulnerability communities
- Examples of NOAA social indicators:
 - Social Vulnerability*
 - Poverty – relationally lower/higher
 - Labor force - number of people in the workforce, not actively in workforce, receiving social security – not occupational diversity but the overall health of the workforce in Maine
 - Housing Characteristic*
 - Gentrification pressure indices – threat to loss of viable commercial waterfront
 - Natural amenities
 - Retiree migration
 - Housing disruption
 - Urban sprawl
 - Fishing Dependency*
 - Recreational fishing and commercial fishing
 - Used both engagement (#permits + #dealers) and reliance (takes engagement data and adjusts it for the population in the community)
 - Lots of high to moderately engaged communities – more comprehensive than pounds landed
 - Reliance index takes information and adjusts for population – lots of small communities that are highly reliant on fishing for livelihood.
- Jon Hare (NEFSC) has been working on ranking of species to derive an indicator of the level of vulnerability for different fish species to climate change (temperature and OA are two big variables)
- Lobsters are only moderately vulnerable to climate change but sea urchins are higher in case study of Lubec

Maine Fishermen's Perspectives of Community Resilience - Teresa Johnson (UMaine)

- Focused on qualitative data (interviews, site visits, oral histories)
- Communities: Eastport/Lubec and Rockland/Port Clyde
- Population reductions and outmigration
- Interviews were across age groups and both active and retired, etc.
- Five qualitative indicators of resilience:
 1. Survival - an indicator that they are resilient is that they are in fact, still fishing
 2. Diversification
 - Within fisheries - developing new fisheries and new markets
 - Outside of fishing - cutting wood, charter, but jobs that they can still go fishing
 - Loss of diversification = loss of resilience (e.g. lobsterman have all eggs in one basket)
 3. "Getting by" - living within your means, ability to keep a good budget, knowing how and when to tighten your budget
 4. Community/social identity – if they view themselves as fishermen, they will want to continue; being part of the shared identity
 5. Optimism - willing to invest in the future, having hope, trying to do something is a sign of more resilience; concern about reaching a tipping point
- Social resilience - the ability of groups or communities to cope with external stresses and disturbances as a result of change
- See *In Their Own Words* - Maine Sea Grant publication (http://www.seagrant.umaine.edu/files/pdf-global/InTheirOwnWords_062314.pdf)
- Fishermen's recommendations for improving resilience:
 - Need fish - better science, management
 - Increase diversification options
 - Maintaining social identity and optimism
 - Working waterfront preservation

Governance and Other Options for OA Mitigation and Adaptation - Lisa Suatoni (NRDC)

- A hypothetical coastal community in Maine:
 - Hazard/Exposure*
 - Northern cold
 - Proximity to sewage plant
 - Discharge of acidic river waters
 - Sensitivity*
 - High reliance on marine resources
 - Capacity*
 - Low science investment
 - Low employment density
- Opportunities for action:
 - Reduce exposure by reducing nutrient pollutant

- Invest in breeding programs
 - Build partnerships with local scientists
 - Work to increase employment diversity
 - Reduce CO₂ into atmosphere
- Regulatory options to reduce nutrient input (from Kelly & Caldwell 2013):
- Clean Water Act-*
- Point Sources-
- Establish more stringent standards for Concentrated Animal Feeding Operations (CAFO), upgraded Publicly Owned Treatment Works (POTW)
 - Revise water quality criteria for pH allowances
 - Set new criteria (total alkalinity, aragonite saturation or dissolved inorganic carbon)
 - Total maximum daily loads for a given water body
 - Creative designated uses of a water body (ex. must be able to buffer incoming pollutants, must be able to sustain a healthy bivalve population)
- Non-point Sources-
- 319 CWA/306 CZMA offers incentives to develop non-point source management plans and best management practices
 - State could pursue designation of a National Estuary Research Reserve
 - Smart growth
 - Revise National Environmental Policy Act (NEPA) and build in OA
 - Revise state clean air – NO_x and SO_x

Local Ocean Acidification Response Strategies - Brad Warren (Global Ocean Health)

- “Harm reduction methods, not solutions.”
- Three Examples:
1. Biogas Digesters
 - Takes dairy manure and produces methane
 - Reduces nutrients, captures methane emissions and generates power
 - Saves on waste hauling costs
 - Can co-locate with greenhouses that will take peat from digester for maximum agronomics management
 - Partnership between farmers and Tribe – built digester
 2. Coastal vegetation and OA
 - Phytoremediation potential of coastal vegetation
 - Seagrasses and kelp to sequester CO₂
 - 3-4 studies underway on west coast and 1 study on east coast looking into different dimensions of this opportunity
 3. Pilot on Sea Level Rise vs. Ocean Acidification
 - Sea level rise may result in more salt marshes and therefore CO₂ sequestration
 - 1 m sea level rise would result in expansion of coastal vegetation and habitats the size of New Jersey

- With good high resolution can get within 15 cm of certainty regarding sea level rise impacts and enable communities to anticipate whether sea level rise will flood the house or expand the marsh and sea grass habitat
- May be able to think about expansion area as a positive

APPENDIX III: Partial List of Existing Data Sources to Help Determine Environmental and Community Vulnerability to OA

Environmental Data Sources:

I. Carbonate Chemistry

Global and regional models providing projections of how carbonate chemistry will change given fossil fuel emissions:

- Basin scale model: Ruben van Hooidonk ensemble of six global climate models: Van Hooidonk R, Maynard JA, Planes S. 2013. Temporary refugia for coral reefs in a warming world. *Natural Climate Change* 3: 508-11
- Basin scale model: CESM1-BGC model. Moore, J.K., Doney, S.C., Lindsay, K., 2004. Upper ocean ecosystem dynamics and iron cycling in a global three-dimensional model. *Glob. Biogeochem. Cycles* 18 (4), GB4028, doi:10.1029/2004GB002220.
- Regional scale model including coastal and central GOM: Previdi et al., 2009. *Journal of Geophysical Research*, VOL. 114, G04003, doi:10.1029/2008JG0

Maine-specific:

Current direct measurements:

- UNH-PMEL-NERACOOS acidification buoy at Appledore Island- sub-daily surface measurements studying variation in pCO₂ and Omega
- UNH-Coastal Marine Lab NERACOOS OA assets at the mouth of the Piscataqua Estuary measuring pCO₂, alkalinity, and DIC
- UNH-Stellwagen National Marine Sanctuary Benthic Observatory. Operated from 2011 to 2013, measuring CO₂ and pH on the bottom at 90 meters depth
- Casco Bay Estuary Partnership observing system- to be deployed in Casco Bay at Southern Maine Community College to measure pH, pCO₂, O₂, T, and S. UMaine has funds for 6 more buoys.
- NERACOOS Buoy N in NE channel maintained by UMO, UNH, Univ. of Montana- periodically since 2008 instrumentation deployed to measure dissolved CO₂ and O₂ (SAMI-CO₂ sensor and Aanderra Instrument Oxygen Optode 3835; see Hyde et al. 2011) and will have a nutrient sensor
- Mook Sea Farm monitoring instrumentation measuring pCO₂, pH, T, S, and O₂
- Other pertinent data sources where we could build off of (dissolved oxygen to get at pH and carbonate chemistry)- NERACOOS buoys (temp, salinity, oxygen, currents); Darling Marine Center's Dr. Mary Jane Perry (10 year dataset)
- Bigelow GNATS (Gulf of Maine North Atlantic Time Series) cruises from Portland to Yarmouth, Nova Scotia- 3 years of OA measurements in GoM- pH, alkalinity, DIC, aragonite and calcite saturation states; much longer time series (35 years) for other variables, including coccolithophores (calcifying phytoplankton)
- GOMECC NOAA cruises- NH transect includes the Gulf of Maine and sampled carbonate parameters (TA, DIC, pH, and fCO₂); 2007- www.aoml.noaa/ocd/gcc/GOMECC ; 2011- http://www.aoml.noaa.gov/ocd/gcc/GOMECC2/Cruise_Report_June2014.pdf

- NOAA AOML R/V Bigelow cruises- pCO₂, continual, March- November: <http://www.aoml.noaa.gov/ocd/ocdweb/occ.html>
- NOAA AOML M/V Skogafoss cruises- pCO₂, continual, year round (Portland-Iceland): http://www.aoml.noaa.gov/ocd/gcc/skogafoss1_data2007.php
- NOAA Eco-Mon cruises- TA, DIC, pH, pCO₂: <http://www.nefsc.noaa.gov/HydroAtlas/>

II. Eutrophication/water quality

National:

- National Estuarine Eutrophication Assessment
<http://www.noaaneews.noaa.gov/stories2007/s2898.htm>
- Nutrient loading estimates USGS SPARROW model:
<http://cida.usgs.gov/sparrow/#region=ME:const=Nitrogen:modelid=51>
- EPA's Nitrogen and Phosphorus Pollution Data Access Tool- incorporates Discharge Monitoring Report data where nitrogen monitoring has occurred (uses the SPARROW model and is somewhat a reiteration of what you will see with the SPARROW Decision Support tool): <http://www2.epa.gov/nutrient-policy-data/nitrogen-and-phosphorus-pollution-data-access-tool>

Maine-Specific:

- Data available from Maine DEP's Environmental and Geographic Analysis Database (EGAD) at <http://www.maine.gov/dep/gis/datamaps/index.html#egad> for the following (among others):
 - MS4 areas (municipal stormwater)
 - wastewater facilities and outfalls
 - marine sewage pumpouts
 - bacteria monitoring
 - overboard discharges
- Ecosystem Indicator Partnership's Indicator Reporting Tool:
<http://www2.gulfofmaine.org/esip/reporting/gmap2.php?new=true>
- EPA Region 1 completed research cruises along the coast of Maine during the summers of 2004, 2005, 2009, 2010, 2011 and collected vertical CTD profiles and nutrient grabs at multiple water column locations. Contact Angie Brewer (DEP) for details.
- Some site-specific eutrophication assessments are available in this report for some southern Maine embayments: <http://ccma.nos.noaa.gov/publications/TMNCCOS20.pdf>
- Nitrogen level- see DEP 2008 report. Development of Nutrient Criteria for Maine's Coastal Waters. http://maine.gov/dep/water/nutrient-criteria/nutrient_criteria_report_2008.pdf
- DEP has some ambient nutrient data (mostly Total Nitrogen) in Maine estuaries, mostly from Casco Bay. Data not currently in map form but available.
- Impaired waters and TMDLs: <http://www.northeastoceandata.org/maps/water-quality/#>
- Wells National Estuary Research Reserve has data on water quality every 15 minutes at four sites since 1995- parameters include water temperature, salinity, conductivity, pH, dissolved oxygen, depth, and turbidity; monthly nutrient grabs are analyzed for orthophosphate, combined nitrate/nitrite, silica, ammonia, and Chl-a. Data is online at www.nerrsdata.org

- Data from groups within the Maine Coastal Observing Alliance:
 - Friends of Casco Bay- water column pH, DIN, TN at 10 offshore sites in Casco Bay for ~10 years and 35 nearshore sites for ~20+ years (including sediment pH more recently)
 - Damariscotta River Association- monitor DO, salinity, temperature, nitrates, and water clarity at seven locations in the Damariscotta River estuary 2x/mo. from May to October
 - Georges River Tidewater Association- monitor pH, DO, and nutrients in the St. George estuary since 2012
 - Kennebec Estuary Land Trust- monitor pH, DO, salinity, and temperature at nine sites in Georgetown (2013-2014) and ten sites in Phippsburg (2014) between May and October

III. River Water

- Flood Information: USGS Current Water Data for Maine- includes real time stream and ground water flow data: <http://waterdata.usgs.gov/me/nwis/rt>
- Urban impaired streams: <http://www.maine.gov/dep/gis/datamaps/index.html#egad>
- Alkalinity and DIC data for the Kennebec, Androscoggin, Penobscot, Pleasant, and other rivers- UNH Coastal Carbon Group

IV. Marine Resources

- Spatially explicit data sets are available from Maine Office of GIS at <http://www.maine.gov/megis/catalog/> for the following (among others):
 - molluscan shellfish areas
 - eelgrass beds
 - mussel seed conservation areas
 - national wetlands inventory
 - wetland characteristics
- Spatially explicit data sets are available from NROC for the following:
 - fish density and diversity: <http://www.northeastoceandata.org/maps/fish-and-shellfish/>
 - aquaculture lease sites and eelgrass beds: <http://www.northeastoceandata.org/maps/aquaculture/>
- Eelgrass maps: <http://www.maine.gov/dmr/rm/eelgrass/> (including changes between 2001 and 2010)
- DMR's annual spring and fall trawl survey data (surveys began in 2000)- contact DMR for access

V. Maine Geophysical:

- Data available from Maine Office of GIS at <http://www.maine.gov/megis/catalog/> for the following (among others):
 - Gulf of Maine bathymetry
 - elevation_contours

- hurricane surge inundation
- flood zones
- surficial geology
- watershed boundary

VI. Land use:

- planning maps that include information about shellfish and shoreland zoning in **Washington County**. (Available through the Washington County Council of Governments: <http://www.gro-wa.org/planners-maps.htm#PlannersMaps>)

Social and Economic Data:

I. Commercial Fisheries

- Maine commercial fish landings, revenues, and licenses: Maine Department of Marine Resources: <http://www.maine.gov/dmr/comfish.htm>
- Northeast Data Ocean Portal: <http://www.northeastoceandata.org/maps/commercial-fishing/> includes VMS data for the following fisheries:
 - multispecies fisheries
 - surf clam/quahog fishery
 - scallop fishery
- NOAA's Community Social Indicators- includes indicators for social vulnerability, gentrification pressure, and fishing engagement and reliance <https://www.st.nmfs.noaa.gov/humandimensions/social-indicators/map>
- GMRI's Evaluation of the Maine Limited Entry System for Lobsters and Crabs (Nov. 2012)- contains demographic and economic background for coastal Maine counties- http://www.gmri.org/sites/default/files/resource/evaluationoflobsterlimitedentry2012_2.pdf

II. Demographic data

- Maine census data center- www.maine.gov/economist/census
- Island Indicators site- www.islandmap.org

This list is not exhaustive and is designed to be a starting point. It does not contain numerous data sets collected by academic institutions or private companies. An up-to-date list of all published studies documenting impacts of OA on marine species in the Gulf of Maine has been submitted for publication in the special issue of Oceanography on OA to come out in 2015.

APPENDIX IV: Participant List

Name	Affiliation
Amy Winston	legislative staff
Angela Brewer	Maine DEP
Anne D. (Andy) Burt	Enviro. Justice Program, ME Council of Churches
Beth Turner	NOAA National Centers for Coastal Ocean Science
Bob Earnest	Chebeague Island Shellfish Committee
Bob Hoyt	Chairman, York Sewer District
Brad Warren	Director, Global Ocean Health, NFCC & SFP
Brescian Lander	Acadia Park Kayak Tours
Caitlin Cleaver	Hurricane Island Foundation
Carla Gunther	Penobscot East Resource Center, Senior Scientist
Cassie Stymiest	NERACOOS
Chris Johnson	State Senator
Chris Rector	Regional Representative Sen. Angus King, Jr.
Courtney Neumann	Coastal Monitoring Assistant, MERI
Daniel Hildreth	Diversified Communications
Darcie Couture	Resource Access International
Don Witherill	Director, Div of Environmental Assessment; DEP
Elisabeth Maxwell	University of Maine
Elizabeth Hertz	Dept of Agriculture, Conservation and Forestry
Elizabeth Stephenson	New England Aquarium
Emily Norton	Maine Coastal Program
Erin Love	Casco Bay Estuary Partnership Island Fellow
Fran Bodell	Marine advocate
Heather Deese	Island Institute
Ivan Fernandez	UMaine Climate Change Institute
Ivy Mlsna	Environmental Protection Agency
Jeff Dennis	Biologist DEP
Jeff Watters	Ocean Conservancy
Jennifer Atkinson	Tera Nova Consulting
Jeremy Bell	The Nature Conservancy
Jeremy Miller	Wells National Estuarine Research Reserve
Jessica Balukas	University of Maine
Joe Higdon	Island Institute
Joe Payne	Casco Baykeeper
Jon Lewis	Maine DMR
Joseph Salisbury	Ocean Processes Analysis Laboratory, UNH
Julia Maine	Bowdoin College
Julie Ekstrom	Natural Resources Defense Council
Kathleen Bell	University of Maine
Kathleen Leyden	Maine Coastal Program/ME DACF

Kyle Molton	Office of Congresswoman Chellie Pingree
Laura Taylor Singer	SAMBAS Consulting, LLC
Leigh Habegger	Congresswoman Pingree
Lisa Colburn	Anthropologist, NOAA Fisheries
Lisa Suatoni	NRDC
Lucy Van Hook	Maine Coast Fishermen's Association
Margaret Snell	University of Maine
Matt Liebman	US EPA Region 1
Megan Wibberly	Island Institute
Meredith White	Bigelow Laboratory for Ocean Sciences
Michelle Loquine Brown	Gulf of Maine Research Institute
Mick Devin	Maine State Representative
Nancy Prisk	University of Maine, Graduate Student
Nate Johnson	Ocean Renewable Power Company, Long Island
Nichole Price	Senior Research Scientist, Bigelow Laboratory
Nick Battista	Marine Programs Director, Island Institute
Rebecca Clark Uchenna	Island Institute
Richard Nelson	F/V Pescadero
Roger Kellett	
Ru Morrison	NERACOOS
Ruth Indrick	Kennebec Estuary Land Trust
Sally Perkins	Island Institute
Sam Belknap	UMaine Dept. of Anthropology
Sarah Cooley	Ocean Conservancy
Sarah Schumann	Eating With The Ecosystem
Stacy Knapp	Adjunct Faculty (MMA); PhD Candidate (UMO)
Susanne Miller	Maine DEP
Susie Arnold	Island Institute
Teresa Johnson	University of Maine
Tim Haskell	MEWEA, Superintendent York Sewer District

*Highlighted participants are Maine OA Commission members