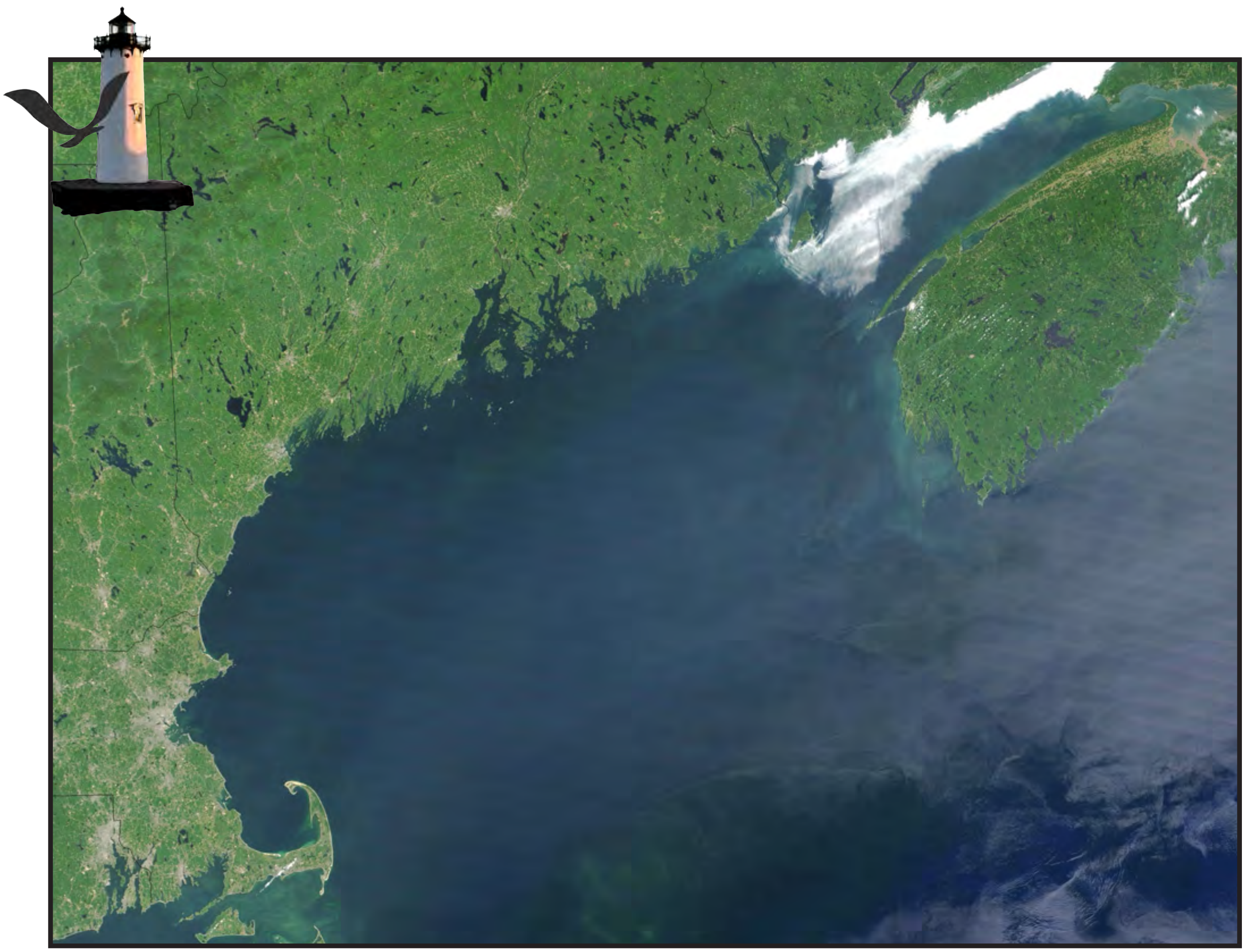
Gulf of Maine Regional Science Priorities Workshop

Impacts of Stressors on Coastal Ecosystems



The New England Center
Durham, NH
June 10-11, 2009

Gulf of Maine Regional Science Prioities Workshop

Impacts of Stressors on Coastal Ecosystems

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This publication was supported by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA Grant #NA060AR4170109. The views expressed herein do not necessarily reflect the views of any of those organizations.

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UNHMP-R-SG-10-02

Forward

The Northeast Sea Grant Programs (NESG), the New Hampshire Sea Grant College Program, the NOAA Center for Sponsored Coastal Ocean Research (CSCOR), and the GOM Regional Ocean Science Initiative sponsored a one-and-a-half-day workshop entitled:

Gulf of Maine Regional Science Priorities Workshop:
Impacts of Stressors on Coastal Ecosystems

The goal of the workshop was to develop a research agenda for the workshop theme that relates directly to management needs and current critical issues. The products are focused descriptions of several scientific ideas in the form of RFP issue statements and objectives that can help to guide funding agencies in focusing resources for supporting the scientific work required to address regional priorities.

The workshop followed the recently released Gulf of Maine Strategic Regional Ocean Science Plan, published through the Gulf of Maine Regional Science Ocean Initiative and supported by the National Sea Grant Office. While the Science Plan identifies a broad range of large regional issues, the purpose of the workshop was to come up with a targeted plan of action for more specific regional issues under the general theme of Impacts on Coastal Ecosystems. Participants included scientists, managers, agency personnel, non-governmental organizations (NGOs) and others who have knowledge and expertise on specific issues that relate to this theme. Participants also included representatives from funding and advocacy entities who may be able to support the ideas that emerge from the workshop.

The following is a summary of the workshop, with details from all discussions and summaries to help move this effort forward. A glossary of acronyms can be found at the end of this document.

Workshop Summary

Day 1 Agenda: Issue Identification

Purpose & Overview of the Meeting [Jon Pennock & Beth Turner]

Landscape of Regional Entities and their Relative Interests and Strengths [Betsy Nicholson]

Overview of Sea Grant/Regional Ocean Sciences Initiative Effort and Previous Findings from Other Regional Planning Efforts [Judy Pederson]

Thematic Group Discussions

The workshop steering committee set out the following themes to be discussed:

1. Integration of coastal and watershed processes, and their influences on important coastal habitats and ecosystem processes;

2. Invasive species and biodiversity issues and their effects on coastal ecosystems, and the influence and impacts of climate change; and

3. Cumulative impacts of multiple stressors to estuarine and coastal ecosystems.

The participants, discussions and products from working groups focused on each of these topics are presented in the following three sections of this report.

The formats vary for the different theme summaries, a reflection of the discussion dynamics for the individual participants who were present.

Thematic Group Discussion Summary

#1: Watershed and Coastal Ocean Processes

Beth Turner, Facilitator

Participants:
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Will Wollheim, UNH
Steve Zeeman, UNE

Ted Diers began the discussion by noting that the major issues facing the NH Coastal Program in the next five years were nutrient management from watersheds to estuaries and issues around diadromous fish passages on rivers. Discussion ensued on each of these areas, and the following report is divided into these sub-themes. Another sub-theme emerged from discussions related to a scenario-building approach with a longer horizon, looking at decadal changes on a regional scale. Although discussion was divided into sub-themes for convenience, it was recognized that these three issues are not independent – they are intertwined at all scales. Furthermore, there is an overall need for coordinated data collection at a regional scale, regardless of the sub-theme. Finally, it was noted that for all of these sub-themes, the most successful projects link fieldwork with modeling for synthesis, and include management input to outline appropriate questions and approaches for the optimal delivery of information.

Sub-theme: Nutrient Management

Which management groups would utilize results?
State management agencies and many local watershed groups require information related to nutrients and other water-borne constituents. These managers are dealing with issues such as how and where to treat inputs in the watershed. They need to identify where the "hotspots" are of input and the susceptibility of specific watersheds to water-borne inputs.

Management issues and general discussion
The group noted that the nutrient question can be expanded to include other water-borne constituents (pollutants, pharmaceuticals). Furthermore, these issues extend beyond the individual fluxes themselves to the downstream effects (e.g., blooms, eutrophication).

Many questions remain on nutrient reduction standards and regulations – what are the most appropriate and effective standards? Similarly, questions arise around building new sewage treatment plants vs. developing more regional water savings systems that would lessen the load on existing plants. Some of these issues may need to be addressed on a watershed-by-watershed basis, but there is concern that there needs to be an overall regional perspective. The replacement of sewage treatment facilities in New Hampshire alone is $1B issue, so the need is urgent and immediate.

Major Science Gaps
- Need to understand how water flows through watershed
- Need synthesis of existing information
  What is actionable scientific information?
- Need to be able to evaluate tradeoffs – where is the best bang for the buck in terms of managing nutrients?
- Where are sensitive points in the watershed? In coastal and ocean waters?
- Interactions between river/watershed and coastal/ocean endpoints
- New observational systems needed to provide data for decisions
- What does the flux of nutrients, pollutants and pharmaceuticals do to ecosystem health in fresh water and sea water ecosystems?
- Currently, hypoxia is not an issue in northern New England estuaries – why not?
  Comparison to more southerly estuaries (e.g., Narragansett Bay) may be enlightening.

Scale/scope of research:
- Management/user involvement is important
- Multi-investigator approach needed
- Multi-agency stakeholders

Defining a specific study
Discussion revolved around developing a case study in a particular estuary/coastal watershed for which management actions are imminent (e.g., the Great Bay Estuary in New Hampshire) and where critical science gaps could be identified and priorities addressed. Such an effort would not only fill prioritized science gaps, but would serve as a model for how best to infuse new research findings into case specific management needs.

Sub-theme: Diadromous Fish

Which management groups would utilize results?
Many dams in New England are owned privately or by a municipality, and their management falls to state water resources or environmental management agencies. These agencies are struggling to find a unified approach to dam removal and river restoration. The Federal Emergency Management Agency, the US Army Corps of Engineers, and the Environmental Protection Agency all have interests in dam removal on the Federal level. In addition to management agencies, non-governmental organizations (The Nature Conservancy, American Whitewater) have direct and visible interests in dam removal. Decisions are being made now regarding dam removal. An assessment of where dam removal will have the greatest positive effect on diadromous fish populations is a critical issue.

The corresponding issue of diadromous fish contributing to coastal fish stocks is critical to Federal agencies – the Atlantic States Marine Fisheries Commission and NOAA Fisheries are concerned with protecting Atlantic salmon stocks under the Endangered Species Act, as well as sustaining and rebuilding coastal fish under the Magnuson-Stevens Fishery Management Act.

Management issues and general discussion
Gulf of Maine groundfishery managers and groundfishers are faced with changes to management resulting in reduced time at sea for the fishers and a probable movement to sector management. At the same time, states and municipalities are removing dams and restoring river flows for diadromous fish protection and restoration. These issues are intertwined in complex ways, as diadromous fish link the top of the watershed to the ocean ("white water to blue water"), and can trace energy flow throughout the entire system. Effects may be felt initially in the freshwater and inshore ecosystems, but can propagate to the oceanic ecosystem farther offshore.

Both fishery management and river restoration are regional issues and directly affect the coastal waters of the entire Gulf of Maine. River restoration assessment should consider not just dam removal, but wider issues such as changing land use, water quality and suitable habitat availability, among other issues. Moreover, managers need to make intelligent decisions about tradeoffs between dam removal and fish passage vs. hydro power.

Many questions remain concerning diadromous fish restoration and its linkage to coastal ecology.
1. How would a program of enhanced restoration of diadromous fishes affect rebuilding of groundfish stocks and stocks of other fishes in the coastal waters of the Gulf of Maine?
2. How does the current reduced population level of diadromous species affect the forage base for coastal fishes?
3. What areas targeted for diadromous fish restoration within the region would have the greatest impact on population sizes of the restored species?

Major Science Gaps
1. Many aspects of the life history/basic biology of diadromous species, especially the anadromous species, are unknown once they enter the estuaries as juveniles. What is essential fish habitat for each species? What is the habitat use in estuaries and coastal waters by juveniles of anadromous species?
2. Historical ecology issues relating to levels of diadromous fish historically, and their function in both the riverine and estuarine/ocean ecosystems: To what extent did historical populations of diadromous fish enter

the trophic webs of the coastal ecosystem? What populations and species of fishes are missing in the near-shore ecosystem compared with the historical ecosystem? Why?
3. How much do current populations contribute to the coastal food web? What effect(s) will enhanced restoration have on food webs in coastal waters (including nutrient delivery as well as diadromous fish runs)? Will enhanced stocks of diadromous species translate into higher individual and population growth of coastal fishes?
4. How is the base of the food web for diadromous and other coastal fishes affected by natural and anthropogenic sources of nutrients? What are the types and quality of nutrients delivered from watersheds?
5. How prevalent are contaminants reaching the coastal ocean in seaward migrating fishes, and how do they accumulate in coastal species through trophic transfer?
6. An assessment of features of fish passage structures common to successful structures and common to unsuccessful structures is needed. Combined with that is the need for studies of the behavior of adult and juvenile diadromous fishes in the vicinity of passage structures. Then a fluid-dynamics analysis might result in development of better upstream and downstream passage structures.
7. A region-wide inventory of impact of dams, water intakes, water extraction and flow control on survival of larval and juvenile diadromous species is needed. A region-wide map of suitable fish habitat for river/estuarine/coastal life stages is needed.
8. As tidal power gains interest, what will be the effect of tidal turbines on estuarine fish, especially migrating adults and juveniles of diadromous species?

Defining a specific study
A combination of multi-agency ($$$), multi-investigator ($$), and individual-investigator ($) scale projects is envisioned. Whatever the scale, there should be a synthesis component and a predictive component. Management entities should be involved in developing the questions and/or directly in the research itself.

Discussion was mixed on the question of whether the human dimension needed to be included in natural science projects, or whether they should be stand-alone studies done in conjunction with the natural science. A suggestion was made that a MIMES-type model could be used in some cases to address the interaction of scientific and socioeconomic factors. Integrated Ecosystem Assessments (IEA) were also mentioned as encompassing both natural science and human dimension information.

Sub-theme: Future Scenario Building

Which management groups would utilize results?
State management agencies and watershed management groups have difficulties in adopting long-term approaches to regional management and suffer a lack of synthetic information to guide management decisions. Much information is available, but it is not always in forms that are immediately useful for management. There is a need to create a mechanism for testing multi-criteria tradeoffs in future scenarios, and to identify promising regional management approaches. The Northeast Regional Ocean Council (NROC) of the governors of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut is actively seeking a common framework for their focus areas of ocean and coastal ecosystem health, ocean energy siting and planning, and coastal hazards resilience.

Management issues and general discussion
The Northeast/New England region has unique characteristics in hydrology, nutrient loads, pollutants, etc. that require a regional perspective. New England watersheds will not behave the same way as Gulf of Mexico

or Mid-Atlantic estuaries, which have received more scientific attention. In addition, there are large societal issues that impact regional ecosystems in the Northeast. Crop production is moving closer to Northeast markets, leading to increased clearing of land for crop growth instead of forest. This will have implications for carbon management and carbon trading. Climate-driven change in precipitation patterns and timing could lead to reduced snowpack, increased rain and spring flooding. Increasing pressures for development will mean that permitting activities by management agencies will be increasing at the same time as resources are shrinking or transforming.

Management and the regulatory structure focus on a state-by-state basis, or perhaps watershed-by-watershed basis. We need to look beyond this to determine the regional implications of local decisions and the cumulative impacts of individual decisions. In order to do this, managers need decision support tools that can inform regional management and provide a wider perspective. We need to be able to predict future trends and relate future benefits to current management and societal actions. How will decisions made today influence conditions 50 years from now (what are legacy effects)? If we are to ask citizens to change their behavior, we need to connect to incentives for current action. What are the ultimate societal benefits? Questions exist about whether current management actually benefits the coastal environment. Can we assess the impacts of management actions in an objective way?

Major Science Gaps

What problems can be defined and addressed at a regional scale? Some issues (e.g., sea level rise) must be addressed at local scales, but we need to look regionally in order to understand the local impacts. How can we take site-specific studies and generalize to a regional scale? How can we take regional information and make it useful for local management? This is especially an issue for climate information, where the smallest scale of information is usually regional, but people are interested in localized effects.

• See where we are today, project future scenarios
  Trends in land use, population growth, alternative energy proposals (hydropower, wind farms), climate-driven changes (precipitation, sea level rise), carbon-management scenarios
• How will these change the way the region looks and works?
• What are next steps for these issues, and how can we address them holistically?
• What will be the tradeoffs (issue-by-issue, east vs. west in Northeast region, upstream vs. near coastal processes)?
• What information collected now could inform decisions for the future?
• How to move from visioning exercise to practical value for today?

Defining a specific study: A regional visioning exercise for watershed-to-coastal linkages across the northeast corridor/Gulf of Maine

A Northeast Corridor-GOM Visioning Exercise is proposed, with three supporting objectives, to:
1. Identify the major strategic factors likely to be put into play in the 21st century watershed-coastal zone system;
2. Unite scientific and management perspectives to create plausible scenarios of the 21st century upland-coastal zone regional system; and,
3. Create a mechanism for testing multi-criteria tradeoffs and to identify promising management pathways at the fully regional scale.

Potential questions to be addressed:

• What are the implications of a resurgence in the use of biofuels that support national mandates on carbon sequestration but change land-to-coastal fluxes given the carbon cycle's strong links to water and hence run-off, streamflow and dilution capacity of rivers?

• How do nutrient reduction strategies differ in Connecticut, for example, with high levels of atmospheric deposition from the Midwest versus eastern Maine, far from such sources?

• How do contrasting governance systems and economic incentives play into these nutrient control strategies, with the presence of trans-state pollution in one case versus local source containment in another?

• What are the implications of optimizing hydroelectricity production in the context of diadromous fisheries restoration?

The proposed visioning exercise would be executed through a working team structure, similar to groups convened by the National Center for Ecological Analysis and Synthesis (www.nceas.ucsb.edu). A group of experts would convene to address the three objectives above, and develop a synthetic basis of information that could be used to construct scenarios useful to current and proposed future management activities. These would take a comprehensive view of ecosystems, including airshed, watershed and coastal processes.

Thematic Group Discussion Summary

#2: Biodiversity and Invasive Species Impacts

Lew Incze, Facilitator
Judith Pederson, Rapporteur

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We were asked to consider what issues would provide the greatest understanding in addressing biodiversity and invaders in the context of ecosystems and communities. The discussion identified the importance of invaders as one of several forces or perturbations on communities. We also spent time reviewing how diversity is defined.

Major management issues that can be addressed within this theme

Management groups that will be able to utilize research results
The managers who are most affected by invasive species impacting communities and ecosystems are: Coastal managers who are most involved with clean marina programs, near shore aquaculture, beach fouling and areas with high shipping and boating traffic; and both state and federal fisheries managers as introduced diseases affect shellfish and aquaculture. The costs include industry resources lost to predation and pathogens, fouling of aquaculture cages and gear, and alterations of ecosystems. Managers address these issues by focusing on prevention of new introductions and maintaining healthy ecosystems.

Scope of the Problem in the Gulf of Maine

Invaders are pervasive along the coast primarily by (1) fouling communities, impacting marinas, hulls of ships, aquaculture facilities, fishing gear and cages, (2) causing diseases in fish and shellfish, (3) impacting offshore fisheries areas; and altering community structures.

• The impacted areas are frequently artificial structures (e.g., floating docks, piers, jetties and other artificial structures) but many non-native species have invaded hard bottom substrates.

• Economic impacts of marine non-natives species are poorly documented, but include predation by crabs (e.g., green crab in GOM); diseases (e.g., MSX and QPX), damage to wooden structures (e.g., ship worms), and altered functions of communities, etc.

• Non-native species continue to arrive and cause problems.

The group identified other perturbations: Climate and anthropogenic forcing, both of which are relevant to the rate of invasion, the spread of invaders and range expansion.

It was agreed that the consequences of invaders on ecosystems/communities were difficult to define, especially in terms of ecosystem goods and services, but these issues are what the management community cares about. Thus, an underlying question is: What specifically are the links between ecosystem changes as a result of invasions (and other perturbations) and ecosystem services? The challenge for management is to anticipate the problem(s), detect change(s) and respond appropriately

Major Science Gaps That Exist

This section identifies major science gaps that exist in our knowledge of non-native species impacts and other influences on biodiversity.

1. Impacts to diversity from perturbations in nearshore and offshore areas is related to several issues: (1) marine invaders are most likely to impact nearshore communities, (2) alteration of habitats affect native species and may foster non-native species, and (3) global climate change will impact diversity. Examples of impacts include *Didemnum vexillum*, which has impacted cobble-pebble habitat of Georges Bank as well as impacting near shore environments. Where it is found, *Didemnum* is one of the most abundant species. Other examples of species impacts nearshore communities is *Sesarma reticulata*, a crab whose northern range may have expanded as a result of warming trends and that feeds on roots of salt marsh grasses. It appears to cause salt marsh die off. *Potamocorbula* in San Francisco Bay was an introduced bivalve that eliminated summer blooms of plankton that in turn has significant impacts on the ecosystem.

• Test the hypothesis that a food chain is impoverished by *Didemnum*, both nearshore and offshore.

• Development of a predictive model for Georges Bank *Didemnum* colony impacts and the coast. Spatial coverage, temperature, spread and causes of spread (fishermen, currents), environmental impacts (temperature, salinity, currents) and predation (or lack thereof).

• Does replacement or the loss of *Modiolus* or other bivalves by invaders (through competition or predation) impact the ecosystem?

• Do invaders impact recruitment of fish and shellfish?

• What are the economic impacts of marine invaders (pathogens, diseases, direct competition and predation)?

2. Measuring diversity over time and space has been challenging because we don't have a single measure of diversity that can be used as an index. Species richness most often used, and a variety of other indices, but these do not account for abundance.

• We need to have a strategy to detecting change. One option is to identify indicator species (example is the UK MARLIN project, where four species have been followed for years in England). For the GOM, we need to choose species that are sensitive to invasion, perturbation or play a role in causing change. In the Gulf, native species that have shown change over the last 25-30 years include decrease in mussels (native), change in hydroid distribution (many are native), increase in sea squirts (many are invaders, 50% of nearshore tunicates are non-native), changes in crab abundance (both native and non-native; non-native species dominate (e.g., *Hemigrapsus sanguineus* and *Carcinus maenas*).

• Identify other factors that influence change in biodiversity and separate this from invasive species (e.g., temperature, salinity, etc., other anthropogenic influences, and climate change).

• Elucidate the role of artificial structures that serve as stepping stones for introduced species. Liquid natural gas (LNG) tanker terminals, wind farms, docks and piers, etc. Some research looking at offshore structures to predict spatial variation in invaders, community changes.

• Range expansions related to temperature changes and invasive species impacts.

3. Top down control of community structure is understood and we can show changes occur. Unfortunately, it has been more difficult to demonstrate in relation to fisheries.

• Overfishing may influence community structure. Trawling impacts on benthic communities (e.g., changes in Cobscook Bay) have distinct loss of biota related to this mode of fishing. What is missing is the quantitative link between community structure changes and ecosystem services (such as fish production).

4. Ecological valuation of the bottom of the ocean is another area where standardized metrics are not widely accepted. Managers need data that would "stand up in court" and without metrics, this has been difficult.

• Some of the data needed includes mapping, habitat definition and critical habitats for specific communities and fishing stocks.

5. Non-native species have economic impacts on aquaculture. For example, Prince Edward Island (PEI) mussel farms are impacted by sea squirts that overgrow the mussel rope facilities. Diseases affect finfish cage aquaculture and nearshore shellfish cultures.

• Need to identify ways to control or eradicate species.

• Need to identify and minimize vectors that introduce species.

Cross-cutting issues

1. Monitoring (recommendation to treat sharing of data like publications), example is Seprowski's Paleontology database

• RFP could be used to develop a long-term strategy for an efficient and effective monitoring program. Several specific habitats are proposed: Cobscook Bay, Great Bay, WNERR and others. And identifying specific species that are good indicators.

• Long-term data sets on temperature, salinity, etc. Need to ramp up from our current start on metadata availability (GoMODP) to full data access, especially as research projects each represent fragments of the whole puzzle. Good West Coast progress using Ecological Metadata Language and Knowledge Network Biocomplexity.

• The relationship between nearshore and offshore is not well understood and likely to change with climate impacts. There is a need to study, contrast and understand linkages between shoreline and offshore. This

would include scaling issues: from local to large-scale effects, both a scientific (scaling) and a management (incremental effects) challenge.
• Although not recommended as a research need in this section, validated climate change scenarios (temperature, salinity, alkalinity, circulation, phenology, lower part of food web-NPZD) for the GOM shore and open Gulf would serve as the underpinning for research needs.

Management tools for decision support

1. Managers do not visualize biodiversity. Less than 7% of managers identified biodiversity as an important issue (>90% ecosystem-based management and how to implement). Therefore the greatest challenge is to make abstract concepts real, i.e. provide a mental representation or mental map of biodiversity, community structure and function.
• Visualizations of ecosystem function-service relationships
• Visualization of scenarios of change (convey understanding of processes and consequences to managers and the public)
• Risk assessment for introduced species

2. There is a need for management strategy evaluation
• How to manage for biodiversity/function conservation (also needs visualization)
• Cognitive research on environmental decision making
• Vectors that transport invasive species

Thematic Group Discussion Summary

#3: Cumulative Effects of Multiple Stressors

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Kathy Mills, GBNERR
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John Sowles, ME DMR

The discussion was wide-ranging and the group found it challenging to become specific because of the multiple dimensions of this topic.

Cumulative effects of multiple stressors (CEMS) need to be taken into consideration for a wide range of management decisions. There was a consensus that it is extremely challenging to measure cumulative effects of multiple stressors in general, and equally difficult to make one measurement to represent all stressors and effects. This makes design of monitoring to address this topic difficult. One example is fish stocks and the assessments being made to integrate data for multiple stressors and effects.

Which Management Groups Would Utilize Results?

Many management groups would utilize the results of studies on CEMS, including those involved in decision making on wetlands and habitat loss, energy facility and aquaculture siting, dredging areas, storm water-runoff impacts to water quality, shellfish and beach managers, etc.

Management Issues and General Discussion

The group recognized that for addressing CEMS for any management issue, there is a need to define what is being managed, i.e., resources or human activities and thresholds/limits for stressors and effects. If making policy is the goal, then impairment needs to be defined, who uses the resource or is involved in the human activity, who/what is affected, what may be the positive and negative effects of any management, how to measure success or failure, how to manage decision makers, and how overcome the difficulties of synthesizing data using science.

Hypoxia was discussed as an example management issue. The information needed to address CEMS and hypoxia include climate change, water flow, contaminants, life histories of marine biota, human activities and a range of environmental variables.

Climate change was then discussed as a possible regional project. Although climate change influences "everything," the group discussed hydrological forcing onto coastal zones and how there is a need to apply scientific findings to change management approaches for coastal development, among other issues. The consensus was that we lack the scientific ability to evaluate contributions from multiple sources in terms of defining whether an effect or stressor is bad, how much of it is bad, how much is in effect/present, and, in the end, what the environmental impacts of climate change are, specifically?

As one set of tools available to address many management issues, natural resource assessment methods exist and can be implemented in the Gulf of Maine. For climate change impacts on coastal resources, it is then necessary to figure out how to prevent damage and to quantify damage or potential using integrative indicators. Deciding on where to start is a challenge. Recognizing that all estuarine systems are affected by wide-ranging CEMS, the question becomes do we focus on a set of critical problems or do we focus on multiple stressors or effects?

At this point the group recognized a critical need to define what might be a framework for addressing the overall topic of CEMS. The example of "built structures," such as wind farms and LNG terminals, was discussed. Structures would most likely be considered as stressors, though they may be positive influences as well, like for some fisheries and the potential to integrate with aquaculture uses. Built structures and many other issues can have cumulative effects to a region through multiple projects and activities, and this is a critical consideration for regional planning and also points to the need for general models for life cycle impacts and behavior for species of interest in response to development of a structure or structures. The cumulative effects of structures may have adverse effects on migration in a different way that for just one project. Thus, it is critical to determine how to evaluate effects of multiple projects in different time frames.

For local management, there are needs for quantification of impacts, assigning values both societal and in dollars. Wetlands development projects are good examples of local CEMS issues, and also for cumulative effects of multiple projects/impacts. It is important to educate local decision makers with information that is understandable and useable, i.e., credible, relevant and legitimate. Conservation commission and planning board members are not environmental experts and are volunteers who are susceptible to local and external social pressures. There is a more critical and common problem as well of the cumulative effects of local decision-making affecting multiple wetlands in different municipalities and across state borders.

There are many challenges for coming up with a model framework for evaluating CEMS. Such a framework needs to be comprehensive, ranging from complete resource evaluations to considering social capital. Data are available for many useful measures of effects and stressors, and can be mined to pull out information that does not exist at present to inform the scientific and management communities. There is a challenge, however, in evaluating data from different sources, that is its "fitness for use." Decision support tools would be useful for attributing value to datasets. Long-term databases are generally considered to be invaluable, yet each requires insight to define how long to perpetuate data collection and maintain support for its continuation. In the final application of any framework, one strategy may be to use one representative, regionally significant species to evaluate trade offs of any development or other human activity. The goal of a CEMS assessment might be to sell a project based on societal values (economics, social, etc.).

Another dimension is assessment of barriers such as those that may make stormwater management and smart growth efforts less effective. Evaluations of the institutional capacities for dealing with any issues are critical and institutional ineffectiveness can render management ineffective even with "good science." A recurring theme is the potential for synergy between stressors, such as toxic contaminants, and infectious agents, such as mercury and PCBs, nutrients and toxic contaminants, or toxic contaminants and diseases. On a more general level, trade-offs between the environmental project and carbon emissions to the atmosphere should also be considered.

Revisiting the goal of identifying management questions and applications that could be supported with better scientific information and understanding of CEMS, the group listed the following issues:

- Fisheries
- Water quality
- Energy resources
- Coastal development
- Specific degraded resources
- Loss of coastal wetlands

The latter was discussed in more detail and stressors identified, including upland development, stormwater management, sea level rise, nutrients and more generally by climate change.

Modeling was then discussed as a critical tool to help in understanding CEMS. To address water quality issues, the water quality itself could be modeled along with the effects of best management practices (BMPs), general effects on the ecosystem and specific effects on organisms, the effectiveness of integrative variables such as impervious surfaces, the relative importance of humans compared to non-human influences, and then move the analysis toward a cumulative impacts study at different spatial and temporal scales in an integrative fashion as well as for specific resources. Modeling could also help measure change and predict impacts of removing stressors such as nutrients, sediments, toxic contaminants and infectious disease agents.

Major Science Gaps

Further discussion of the effects of multiple structures on the region recognized the lack of integrative information on environmental conditions and the biology of species of interest and biodiversity in general within the GOM. A regional data repository with many linkages, including that between estuaries and watersheds, would serve scientific needs and inform management decisions. A challenge is how much is unknown, where data are completely missing. To a great extent, we know little or nothing about sensitive aspects of sentinel and all species to stressors, and which species are sensitive to which stressors. Modeling can help, but their applicability depends on the quality of input and the usefulness of the output for understanding impacts, e.g., stock assessments are not that useful for planning purposes. Other data needs include integrative models of near shore circulation in the GOM and the identification of sensitive areas for critical species and their life stages, especially in the context of sensitivity to stressors.

The issue of data needs was discussed in terms of conducting a science gap analysis for the GOM. The approach could first involve broad questions and then focus on sentinel species (to be determined). It would be extremely useful to conduct an analysis to see where known linkages exist and to explore where other as yet unknown linkages may occur.

There are no good existing approaches to capture what managers know is needed, i.e., we know some of the effects for some species, we know nothing about most species and end points. The managers present expressed desire to have desktop decision-making tools to assess CEMS.

Defining a Specific Study

The group finally focused on discussing the need for a process for addressing CEMS, i.e., the framework that was mentioned earlier. The major points in this process are:

Cause and effects science, i.e., risk assessment. Quantify what stressors contribute to impacts, develop threshold values, identify sources, determine the magnitude of direct and indirect effects, interactions among stressors, how does stressor exert impacts, severity and irreversibility of effects, evaluate indicators, determine if there is an effective management action and define acceptable risk. There are different types of cumulative effects; multiple stressors on one end point versus many end points with different responses to stressors/ the intensity of the stressors (i.e., one wind turbine versus a wind mill farm versus many farms).

For determining the site suitability of energy facility development:
• What are the resources in those areas?
• What are the current stressors?
• What effect will the development have on critical species in terms of stress?
• Cumulative effects of expansion, what is impact of one site, how distributed in space?
• Is there a better regional approach to address multiple sites?
• The learning process: integrate what has been learned from previous situations?
• Stakeholder meetings and education are needed?

Data management-availability-quality issues with an intense desire by all participants to have resources and support for filling data gaps and defining human uses and effects, mining of existing data to discover new information and meet management needs for information, overcoming accessibility and interoperability issues, and maintaining high quality long-term data collection programs that address focused and important management issues and scientific questions.

What data are imperative for determining the site suitability of energy facility development?
• Impacted resources in the context of regional importance
• Different valued areas, ruined areas versus valued areas
• By convening group to discuss
• Post-development/recovery phase assessment with new ecosystems

• Environmental and societal benefits
• Platforms for food production and observation
• Financial data

In addition, we recognized the unique importance of the need to explore a process for addressing CEMS on a regional basis.

We focused on developing such an approach on specific issues like wetlands and habitat loss, location suitability for energy facility sites, stormwater runoff impacts to water quality, recovery of ecosystems (i.e., "reverse engineering").

A RFP would be for scientists, managers and stakeholders to work together to develop a transferable process and apply it to a model problem.

Day 2 Agenda: Implementation

Purpose & Overview of the Meeting [Jon Pennock & Beth Turner]

Landscape of Regional Entities and their Relative Interests and Strengths [Betsy Nicholson]

Overview of Sea Grant/Regional Ocean Sciences Initiative Effort and Previous Findings from Other Regional Planning Efforts [Judy Pederson]

Thematic Group Discussions

Participants:
Steve Adams, NHSG
Jim Ammerman, NYSG
John Annala, GOMRI
Curtis Bohlen, CBEP
Bob Branton, Ocean Tracking Network, Dalhousie
Ken Brink, WHOI
Todd Callaghan, MA CZM
Chrys Chryssostomidis, MITSG
Ames Colt, RI Bays, Rivers and Watersheds
Barry Costa-Pierce, RISG
Sylvain Deguise, CTSG
Verna DeLauer, COMPASS
Ted Diers, NH Coastal Program
Michele Dionne, Wells NERR
Mike Dowgiallo, NOAA
Meggan Dwyer, MERI
Larry Harris, UNH
Steve Jones, NHSG
David Keeley, The Keeley Group
Rich Langan, CICEET
Jim Manning, WHOI
Jim McCleave, UME
Ru Morrison, NERACOOS
Betsy Nicholson, NOAA
Judy Pederson, MITSG
Jon Pennock, NHSG
Andrea Rex, MWRA
Dwight Trueblood, CICEET
Beth Turner, NOAA/NOS CSCOR
Megan Tyrell, MERI
Page Valentine, WHOI
Linda Wade, NHSG
Theodore Willis, USM
Becky Zeiber, NHSG

The second day featured discussions on how to implement the ideas that emerged from Day 1. The guiding questions for all discussions were:

• Which of these research concepts have the most potential to engage other partner activities?
• What areas/sub-themes will require the engagement of academic researchers and other scientists with partner agencies? What is the best strategic use of academic expertise?
• What would be some key elements of a regional partnership engagement strategy?

There were presentations representing the Northeast Sea Grant directors and CSCOR visions for how the workshop results would be useful to each of these programs. There followed a review of ROSI Ocean Science Plan for the benefit of the attendees who were not present on Day 1.

Following these introductory presentations, discussions were then initiated to include the whole group. The discussions were based on brief presentations of the Day 1 results for each of the three topic areas, and included summaries of the full Day 1 discussions and the resulting ideas for critical and timely scientific studies. The following section integrates the results of the morning discussions.

The Way Forward

There are clear needs for the adaptation and development of new science and technology for applications to address regionally specific problems and conditions. Expanding our knowledge in basic sciences is a critical underpinning for understanding ecosystems and species, process and predictive modeling, future climate scenarios, threshold values and monitoring data analysis and interpretation.

The following common themes emerged from all three sub-theme discussions and help to conceptualize what is needed as we move forward with efforts to focus resources on regional science priorities. The text is certainly not comprehensive in addressing all aspects of these themes. Rather, it includes some specific issues that were discussed at the workshop.

1. **Lack of integrative information that is useful for management**
For almost every issue discussed, there are data gaps and a lack of integrated information that make decision making difficult for managers. Researchers also need integrated information, particularly for development of ecosystem models. Integrated information is also critical for understanding the potential effects of actions and decisions on non-focus areas. For example, barrier (culvert) removal to enhance flushing for salt marshes can increase fecal bacterial contamination and the bioavailability of trace metals, and thus affect the management of shellfish harvesting and beach posting. This could also happen with other barrier removal actions undertaken for habitat restoration.

Several other specific regional issues were discussed in this context. Stormwater management in the region requires consideration of combined sewer overflows (CSOs) and urbanized landscapes relative to runoff, the connections to fish and stream habitats, the mechanisms for recapture of rainfall, and a range of other factors. In addition, currently available stormwater technologies do not always work in colder climates like northern New England. Specific studies have been conducted that address one or maybe two of these factors, yet management requires integrated information on all critical factors.

As nutrient criteria are developed in the region, these need to be transferred into actions at the watershed level. To meet criteria, managers will need integrated information to enable effective use of limited resources to address this and other existing and pervasive water quality limitations like bacteria and toxic contaminants. For management targets like eelgrass restoration, the question of cause/effect between eelgrass and nutrients should be considered. The impacts and biology of invasive tunicates are another specific research topic requiring integrated information. Temperature and nutrient effects, vectors (recreational boats) and other research needs were identified. This could be studied at un-impacted and impacted areas in the GOM and elsewhere (PEI) to identify areas at risk.

All of the regional issues discussed have needs for integrated information to inform local to regional management decision making, planning and where best to focus support for research and science. Buffers are a critical topic, both at the local level and from a regional approach. Where are the areas most at risk and where are the areas where potentially effective management actions could be taken? These questions are especially critical in relation to invasive species and cumulative effects of multiple stressors (CEMS).

In some cases, critical issues are not regarded as such because of a lack of integrated information. For example, managers tend to have the perception on issues related to biodiversity and invasive species that they are a relatively low priority for management. There are several key data gaps that, if filled, could help to increase awareness and understanding of this important issue. Other issues are complicated and intrinsically difficult to understand. The development of science needs typically has a focus that does not adequately address topics like CEMS. A lack of adequate integrated information makes it difficult to be honest with impacts and assessment success of CEMS on ecosystems. A useful focus for research and support would be on the resilience of ecosystems to CEMS, with a goal to identify thresholds for stressors and effects.

Assessing the impacts of CEMS and associated ecosystem resilience is difficult and poorly understood, with inadequate approaches for integrating needed information. There is a critical need for developing the right approaches for integrating information for this and other science issues. Current reporting on the status and trends on key issues through the use of indicators is limited because of a need for better understanding of the underlying science questions and integration of existing data. There are some good starts such as the EPA National Coastal Assessment (NCA) Program and the Bricker reports, as well as those of National Estuary Programs (NEP), National Estuarine Research Reserves (NERRS), NOAA National Centers for Coastal Ocean Science (NCCOS), NOAA National Status and Trends (NS&T) Program and others by EPA. A great degree of integration of what are typically issue-specific reports to address a wider array of related issues would help to inform regional management decisions.

In summary, management responses require simple answers and approaches to complex problems associated with CEMS and other regional issues. A general lack of these simple answers and adequate approaches for integrating existing information into effective management strategies has contributed to what is now a high level of failure.

2. **Need for high quality long-term data collection programs**

High quality long-term data collection programs produce highly valuable information that is nonetheless difficult to maintain over time. These programs are especially critical for indicator development. Government strategic planning agencies should be responsible for developing and using indicators, and thus long-term data collection programs. There are some good starts such as the NOAA/NS&T and Gulfwatch and Massachusetts Water Resources Authority (MWRA) programs, as well as those of NEPs, NERRS, NCCOS and others by EPA. Several NCA and the Bricker reports are also good examples of the integration and use of these data collection efforts to inform management.

Long-term data collection programs also serve specific issues, like nutrient management. The GBNERR SWMP program, and more recently NERACOOS, has served Great Bay (NH) in monitoring for water quality. These efforts produce data that have served managers in addressing bacteria and other issues through the years, and more recently relative to eelgrass resources. MWRA also has long-term data on nutrients, plankton, sediment quality, benthos, bacteria, etc. Boston Harbor wastewater treatment now involves nitrogen removal, and they have observed some return of eelgrass that may be linked to this management action. The Ocean Data Partnership is building a database for the GOM. Data mining could help to discover new information and to bolster our present understanding of many issues and justify and focus needs for more data collection. Databases that could be targeted include anadromous fish surveys and data on toxic contaminants in the NCA database. There still needs to be ongoing support of work and effort to generate new data to populate and maintain the relevance of such organizations.

3. **Need for basic life-history and ecological information for certain species**

There is a huge need for basic life history and ecological information on all marine and estuarine species. Management issues ranging from fisheries to stormwater management would be much better informed by a greater understanding of these areas, though biodiversity and invasive species is the workshop theme that probably most needs this information. Data on life history and ecological information would help to inform managers on biodiversity and invasive species in relation to (1) economic issues, (2) use of decision analysis approaches that combine ecology and economics, (3) relating fisheries to biodiversity, (4) highlighting climate change impacts on diseases, (5) assessing impacts, (6) identifying effective prevention and eradication strategies, and (7) how should invasive species in the freshwater coastal areas be addressed?

Habitat restoration, CEMS and nutrient management are also issues that would greatly benefit from a better understanding of life histories and ecological information. For example, Massachusetts has a contract with UMass Dartmouth for modeling estuaries for eelgrass restoration to address management of this issue for situations like the Chatham wastewater treatment facility.

4. **Data management-availability-quality issues**

This is a critical theme that has been raised as part of the other previous and following theme discussions, especially theme #2.

5. **Need for prediction, hind-casting and multiple stressor modeling**

Some of the critical modeling needs are to determine cumulative impacts of human activities, climate change and temperature effects on coastal ecosystems and species, and impacts and assessment success of CEMS on ecosystems. One approach for making an assessment is to choose a sentinel species and put it through the modeling and assessment process. It would also be useful for modeling efforts to focus on the resilience of ecosystems to CEMS, with a goal to identify thresholds for stressors and effects. Major gaps in knowledge exist for assessing both the impacts of CEMS and coastal ecosystem resilience responses.

The utility of models includes sensitivity modeling and analysis, and the ability to identify and point out data gaps. For several issues, there are data and information gaps that could be addressed with support to enable having better input to models.

6. **Develop/identify future climate scenarios and threshold values**

a. Where are sensitive points (both geographically and within ecosystem)?

One critical need is for developing future climate scenarios using available long-term data and integrating multiple sources of information. Which areas are most at risk to invasive species? What are the threshold amounts for nutrients and what are the attenuation processes? These are questions that were discussed that relate to future climate change issues and threshold values for ecosystem conditions. Given the existing levels of coastal development, natural attenuation processes will probably be inadequate to respond to the effects of climate change and increased contaminant loading. The identification and development of future climate scenarios would help in the development of effective management strategies to address these and other emerging issues. For nutrients, strategies to be investigated include economically feasible separation of runoff from sewage systems, top-down approaches for nutrient removal, and new technologies to remove nutrients at sources, the latter being the topic of a recent (12/09) Long Island Sound Study workshop.

7. **Need to be able to evaluate tradeoffs among management decisions**

Efforts should be made to incorporate research results into multi-sector management deliberations/decisions/operations. For example, most current technologies for treating wastewater require large amounts of chemicals and electricity, so there should be consideration of energy tradeoffs, sea level rise and siting. Sometimes one restoration activity can affect non-targeted issues. As previously mentioned, barrier removal (example was for culvert but could also apply to dams, etc.) to enhance flushing for salt marshes can increase fecal bacterial contamination and the bioavailability of trace metals, and thus affect the management of shellfish harvesting and beach posting.

We have already seen mitigation funds from new hard structures (e.g., LNG terminal off of MA) as sources of funding for ecosystem-level studies. In the future, these funds could support studies on invader dispersion, biodiversity impacts and models of spread, though beneficial to aid in the understanding of other critical regional issues. This is one way to help to acknowledge and address the need for tradeoffs as energy needs are addressed along with their ecological impacts.

8. **EBM tools needed: Challenge to make abstract concepts real with regard to EBM**

To enable EBM concepts becoming more commonly integrated into regional management plans, the underlying, relatively abstract concepts require simplification so managers can better understand them. Of particular need are tools that will provide clear visualizations of ecosystem function-service relationships, risk assessments and scenarios of change. This relates back to the previously discussed more general need to develop effective ways to integrate information. Given these tools, efforts could then be made to increase the potential for EBM-related science to be incorporated into management deliberations/decisions/operations. Again, it is the management response to complex problems that requires tools and understandable explanations of scientific findings to avoid failure.

How Can Regional Entities Work Together to Address These Needs?

Some discussion at the end of Day 2 focused on how to utilize the scientific capacity, funding capabilities and specific strengths of multiple regional partners. For each of the theme areas and proposed research issues, potential partners were identified (Table 1).

	NOAA	States	NGOs	Other Feds	Academic	other
Watershed-Coastal Ocean	NWS River Forecast Ctr, NMFS, NERRS, NOAA IEAs	NROC, MA Div Marine Fisheries, ME DMR, NH DES	Watershed groups, river restoration groups	USFWS, USACE, EPA NEP, USGS	USM Casco R. project, UMass Dartmouth modeling of eelgrass restoration	Penobscot River Restoration project, NERACOOS
Biodiversity-Invasive spp	NE Consortium	State fisheries/aquaculture	NAMA, Island Institute	Individual NSF projects		
Cumulative Effects – Multiple Stressors	NERRS, NOAA IEAs	NROC, MWRA		EPA NEP	UNH Stormwater Center, COMPASS	NERACOOS

Table 1. Potential for partnerships in each theme

Several integrative bodies are in place in the Gulf of Maine region. The GOM Regional Ocean Science Council has developed a Strategic Regional Ocean Science Plan. With joint funding from the Sea Grant programs, several regional projects have been initiated and serve as a model of cooperation and collaboration among regional researchers to address specific problems. The GOM Council provides a clearinghouse for many activities related to ocean and coastal conservation and management. Driven by a state-federal partnership interested in addressing management issues that require a regional solution, the Northeast Regional Ocean Council (NROC) is beginning to consider integrative approaches to the issues of ocean and coastal ecosystem health, coastal community hazard resilience, and ocean energy planning and siting. Researchers coordinate many of their activities through the Regional Association for Research in the Gulf of Maine (RARGOM). All of these bodies play an important role in identifying important regional issues and communicating among states, provinces and federal agencies in a regional context. However, they are generally hampered by a lack of implementation funds and, in some cases, common political will.

Funding and research infrastructure is available through other channels. The regional Sea Grant programs hold bi-annual competitions for research. The NOAA Center for Sponsored Coastal Ocean Research has a branch that deals with Regional Ecosystem Research, which holds periodic competitions. NOAA Fisheries and USGS have important research centers in the region. NOAA has National Estuarine Research Reserves in Wells (ME), Great Bay (NH) and Waquoit Bay (MA). NOAA also supports a National Marine Sanctuary at Stellwagen Bank. EPA supports three National Estuary Programs in the Gulf of Maine in Maine's Casco Bay, New Hampshire and Maine's Great Bay/Hampton Harbor, and Massachusetts Bay. The Integrated Ocean Observing System has a Northeast Regional Association (NERACOOS) making regular coastal observations and developing data and information products that are needed to solve management problems. Funded by the Moore Foundation, the Massachusetts Ocean Partnership (MOP) supports integrated multi-use ocean management in Massachusetts state waters, including an integrated data network, ecosystem and economic modeling, and the development and use of ecological and socioeconomic indicators. The Packard and Moore foundations support Communication Partnerships for Science and the Sea (COMPASS) in the Gulf of Maine, which supports science activities and communication strategies focusing on Ecosystem-Based Management of coastal waters. Coordination of all of these different program activities around central themes such as those discussed at this workshop will allow the whole to be greater than the sum of its parts and for our collective progress to be tracked over time.

Sea Grant and CSCOR are exploring opportunities to issue either a joint announcement or coordinated announcements for research in the Gulf of Maine. For both Sea Grant and CSCOR, management participation in the research formulation and implementation is key to successfully transitioning research results to applications. Several of the themes brought out in the workshop could be developed into requests for proposals, and work is ongoing to hone the themes to hit specific regional management needs.

Future workshop ideas:
• A useful workshop would be one that focused on the resilience of ecosystems to CEMS, with a goal to identify thresholds for stressors and effects. We are not good at assessing impacts, then resilience.
• Coastal and Marine Spatial Planning (CMSP) is a high level priority for the Obama Administration, which will call for a regional CMS Plan for New England waters over the next three to five years. A workshop exploring how to conduct a regional assessment (e.g., human uses, physical, biological, ecological characterizations) would be helpful, including identifying existing and outstanding scientific information and products to support this charge.
• Climate scenario modeling is urgently needed for many coastal management applications. Developing downscaled predictions of climate impacts on community infrastructure and coastal habitats is essential to allow management agencies to factor climate into their planning activities. A workshop or joint activity to develop climate scenarios, with associated uncertainties, would benefit many different users.

The group concurred that a common vision for a future approach was needed to allow us to make collective progress in tight financial times. Specific recommendations included:
• Designate a point person to continue this regional dialog;
• Involve community groups in the Gulf of Maine to inspire collaboration among community foundations in support of shared issues;
• Develop a "master plan" to advance our work in the Gulf of Maine, which would include recognition of different entities' responsibilities, functions and strengths;
• Develop a social network analysis of our connectivity around specific research and management issues to better understand our regional institutional roles, our interdependencies for information, and possible weaknesses in maximizing our collective capacities; and
• Study how organizations in other regions work together to collectively advance their progress on priority issues.

Workshop participants acknowledged that there is a need to change the way we do business. In short, we must find ways to increase our communication and clarify our collective vision to secure the funds (i.e., grow the pie) and track the progress we need to make to solve our greatest regional research and management challenges.

Regional Workshops since June 2009

GOM Symposium: Advancing ecosystem research for the future of the Gulf St. Andrews, NB, Oct. 4-9, 2009. Organized by RARGOM, DFO SABS, GOMRI, COMPASS and GoMA/CoML; GOM ROSI held a workshop on research priorities for the Gulf of Maine in association with symposium, **http://www.rargom.org/Symposium2009/**

The Ecology of Marine Wind Farms: Perspectives on Impact Mitigation, Siting, and Future Uses 8th Annual Ronald C. Baird Sea Grant Science Symposium, Newport, RI, Nov. 2-4, 2009; GoM ROSI held a workshop on research priorities for alternative energy in the ocean in conjunction with the symposium.

International Workshop on Bioextractive Technologies for Nutrient Remediation UConn/Stamford, Dec. 3-4, 2009. Sponsored by LISS, NOAA, NEIWPCC and UConn, **http://www.longislandsoundstudy.net/conf.htm**. A synthesis report of speaker and panel recommendations for implementation of these technologies in the coastal environment is being developed and will soon be made available.

Maine Coastal Waters Conference 2009: Climate, Energy and our Coastal Communities Northport, ME. Oct. 28, 2009, **http://namanet.org/events/maine-coastal-waters-conference-2009-climate-energy-and-our-coastal-communities**

Glossary of Acronyms

BMP – Best Management Practice
CBEP – Casco Bay Estuary Partnership
CCNY – City College of New York
CEMS – Cumulative Effects of Multiple Stressors
CICEET – Cooperative Institute for Coastal and Estuarine Environmental Technology
CMSP – Coastal and Marine Spatial Planning
COMPASS – Communication Partnership for Science and the Sea
CSCOR – Center for Sponsored Coastal Ocean Research
CSO – Combined Sewer Overflow
CTSG – Connecticut Sea Grant
DFO – Fisheries and Oceans Canada
EBM – Ecosystem Based Management
GBNERR – Great Bay National Estuarine Research Reserve
GOM – Gulf of Maine
GOMA/COML – Gulf of Maine Census of Marine Life
GOMODP – Gulf of Maine Ocean Data Partnership
GOMRI – Gulf of Maine Research Institute
IEA – Integrated Ecosystem Assessment
LISS – Long Island Sound Study
LNG – Liquified Natural Gas
MA CZM – Massachusetts Coastal Zone Management
MBL – Marine Biological Laboratory
ME DMR – Maine Department of Marine Resources
MERI – Marine Environmental Research Institute
MIMES – Multi-scale Integrated Models of Ecosystem Services
MITSG – Massachusetts Institute of Technology Sea Grant
MOP – Massachusetts Ocean Partnership
MSX – (Multinucleated Sphere Unknown) disease is caused by a single-celled Protozoan parasite, *Haplosporidium nelsoni*. MSX is lethal to the eastern oyster (*Crassostrea virginica*).
MWRA – Massachusetts Water Resources Authority
NAMA – Northwest Atlantic Marine Alliance
NCA – National Coastal Assessment program
NEIWPCC – New England Interstate Water Pollution Control Commission
NEP – National Estuaries Program
NERACOOS – Northeastern Regional Association of Coastal Ocean Observing Systems
NERR – National Estuarine Research Reserve
NESG – Northeast Sea Grant Programs
NGO – Non-Government Organization
NHDES – New Hampshire Department of Environmental Services
NHSG – New Hampshire Sea Grant
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NOAA/NOS – NOAA's National Ocean Service
NPS – National Park Service

NPZD – Nutrients-Phytoplankton-Zooplankton-Detritus model
NROC – Northeast Regional Ocean Council
NSF – National Science Foundation
NS&T – NOAA's National Status and Trends Program
NWS – National Weather Service
NYSG – New York Sea Grant
OCRM – NOAA's Office of Ocean and Coastal Resource Management
PCB – Polychlorinated Biphenyl
PEI – Prince Edward Island
PREP – Piscataqua Region Estuaries Partnership
QPX – (Quahog Parasite Unknown) Protozoan parasite of hard clams, *Mercenaria mercenaria*.
RARGOM – Regional Association for Research on the Gulf of Maine
RFP – Request for Proposals
RISG – Rhode Island Sea Grant
ROSI – Regional Ocean Science Initiative
SABS – St. Andrews Biological Station
SBNMS – Stellwagen Bank National Marine Sanctuary
SWMP – NOAA's NERR System Wide Monitoring Program
TNC – The Nature Conservancy
UCONN – University of Connecticut
UK MARLIN – United Kingdom Marine Life Information Network
UME – University of Maine
UNE – University of New England
UNH – University of New Hampshire
URI – University of Rhode Island
USEPA – US Environmental Protection Agency
USGS – US Geological Survey
USM – University of Southern Maine
WHOI – Woods Hole Oceanographic Institution

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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