Gulf of Maine Council on the Marine Environment

Working Group Briefing Packet

Version 1

Eastland Park Hotel, Portland ME ♦ December 6-7, 2010

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Gulf of Maine Council on the Marine Environment

Working Group Meeting
December 6-7, 2010
Eastland Park Hotel, Portland ME
Agenda

Monday, December 6, 2010 – Eastland Park Hotel, Portland Maine

7:30 am	**Committee Meetings**
8:30 am	Welcome, introductions, and overview of objectives for the meeting *Theresa Torrent-Ellis – Maine Coastal Program / Maine State Planning Office – Working Group Chair*
8:40 am **pp. 1-21**	**Accept consent agenda** • Working Group October 2010 meeting summary • Committee and Subcommittee reports • Contractor report • Indirect and budgets • US/CA Collaboration consent agenda • Other Reports as needed
9:00 am **pp. 22-37**	**Guest Presentation: Public Beliefs About Climate Change in the Gulf of Maine Region** *Lawrence Hamilton, PhD – Department of Sociology, University of New Hampshire*
9:30 am **pp. 38-50**	**Guest Presentation: Combining observing and modeling to understand climate change influences on the subarctic copepod, Calanus finmarchicus and the links to GOM fisheries** *Jeffrey Runge, PhD – School of Marine Sciences, Gulf of Maine Research Institute, University of Maine, Portland*
10:00 am	**Break**
10:15 am	**TAPAS Update and Review** *Cindy Krum, U.S. Gulf of Maine Association*
10:25 am **pp. 51-58**	**Committee Updates with Work Plans for the Next Twelve Months: Wrapping up the Current Action Plan** **Background:** Committees are entering the final twelve months of the current Action Plan. They will share with the WG their status and what they plan to achieve in the next year and what resources are needed to move forward. **Outcome/Desired Action:** Better understanding of Committee status and activities.
11:00 am **pp. 59-72**	**Moving Forward Our Actions – Steps for Building Fundable Project Ideas: Part 2** *David Keeley-Development Coordinator, Theresa Torrent-Ellis and Guest Presenter*
12:00 am	Lunch on our Own – Menu will be provided in the morning with in-house lunch options
1:00 pm **pp. 73-85**	**Action Planning for the next five years and developing the Gulf of Maine twenty-year vision statement: Part 1** *Theresa Torrent-Ellis, Michele Tremblay, Council Coordinator; and David Keeley, Development Coordinator* **Background:** In December 2009, the Council decided to document 2007-2010 Action Plan accomplishments and revise the current Action Plan. The revision will be reflective of the GOMC current capacity and unique qualities that we bring to these goals. It was also decided that we frame this five-year Action Plan within a twenty-year vision statement that reflects our goals for the future sustainability of the GOM.

	• Refine rationale for participating in the GOMC • Review and Comment on 20-year vision statement • Finalize 2012-2017 Action Plan Priorities by Goal Area – The Logic Model and Revisit Our Critieria **Outcome/Desired Action:** Adopt a twenty-year vision statement for Council approval and prepare Action Plan recommendations for tasks/activities for Council review.
3:00 pm	**Break**
3:15 pm	**Action Planning for the next five years and developing the Gulf of Maine twenty-year vision statement: Part 2** • Cross-cutting and Emerging Issues • GOMC Watch List
5:00 pm	Adjourn
6:00 pm	Meet in the hotel lobby for group dinner in Portland

Tuesday, December 7, 2010 – Eastland Park Hotel, Portland Maine

	Updates:
8:00 am	**Northeast Regional Ocean Council - Gulf of Maine Council Memorandum of Understanding: Discussion of WG recommendations for GOMC in implementing the MOU** *Betsy Nicholson, NOAA*
8:30 am	**State of the Gulf of Maine Report – Recommedations from the Steering Committee to WG** Tim Hall, Department of Fisheries and Oceans
9:00 am	**Action Planning for the next five years and developing the Gulf of Maine twenty-year vision statement: Part 3** • Recommendations and Questions for Council • Finalize January to June,2011 Schedule
11:30 am	lunch on your own – Committee Meetings
1:00-5:00pm **pp. 86-95**	**Working Group and Council** **Gulf of Maine Council Forum on Transboundary Marine Spatial Planning**
6:00-8:00pm	**Working Group and Council** **Reception and Annual Gulf of Maine Council Awards Ceremony – Eastland Ballroom**

Gulf of Maine Council on the Marine Environment Working Group
Meeting DRAFT Summary
Portsmouth, NH
October 4-5, 2010

Working Group Members Present
Debbie Buott-Matheson, Environment Canada; Robert Capozi, NB Department of Environment; Ted Diers, NH Department of Environmental Services; Jennifer Hackett, DFO Maritimes (via conference call), Tim Hall, Department of Fisheries and Oceans, Gary Lines, Environment Canada; Betsy Nicholson, NOAA; Ann Rodney, US EPA; Jackie Olsen, Environment Canada; Susan Russell-Robinson, USGS; Theresa Torrent- Ellis, Maine State Planning Office; and Peter Wells, Dalhousie University.

Others Present
Adrianne Harrison, NOAA; David Keeley, The Keeley Group; Cindy Krum, Krum Steele Consulting (via conference call); Peter Lamb, GOM Councilor; Carolyne Marshall, Environment Canada; Ru Morrison, NERACOOS; Matt Nixon, GOMC Administrative Assistant from the Maine State Planning Office; Kathryn Parlee, Environment Canada; Judith Pederson, MIT Seagrant College; and Michele Tremblay, naturesource communications.

Consent Agenda
The Subcommittee reports should be removed (items 2 and 3 will be moved for further discussion for later today).

Decision: *The Working Group accepted the consent agenda.*
Action: *The Working Group will review its decisions and actions at the end of each meeting day via a PowerPoint presentation and then they will be provided with a list of participants via the Working Group listserve.*

Theresa Torrent-Ellis suggested that there may be a funding need for future Gulf of Maine Times editions. Michele Tremblay distributed a sign-up sheet indicating each member's organization's funding source to use as match to leverage additional funding. The total needed is approximately $5,000.

MONDAY, OCTOBER 4th, 2010

Possible Reasons to Participate In The Gulf of Maine Council
Theresa Torrent-Ellis began discussion on trying to understand the nature of each organization's involvement in the Council. Theresa highlighted reasons that participating may be difficult (time constraints, travel and budget issues, etc) and then suggested a few possible reasons to start the conversation:

- Members have new access to new people and resources that enable them to enhance their day job
- Facilitates trans-boundary issue discussion
- Knowledge of new and innovative approaches to particular issues
- Support for Cross Boundary Initiatives
- Other Reasons (Working Group Member Suggestions):
    * Networking capacity and nature facilitates a response to new issues that may arise. Theresa suggested that there is an Emerging Issues Document that would be useful for this particular reason.

* International communication and coordination
* The Council Is not just focused on habitat. It's a comprehensive package for many organizations
* Friendly, collaborative, bilateral collaboration

One issue that was raised was the usefulness of specific products and documents developed by the Council. The State of the Gulf of Maine report was used as an example.

Another issue that came up was the seeming inability for the Group to accomplish anything regionally outside of process. Funding and national issues are frequently discussed, though regional problem solving and actions seldom occur. What should develop is some type of focus group to identify the gap between members who are "on the edge", so to speak, in terms of council usefulness, and from members who are content with the Council's current function.

Following the break, Theresa reviewed next steps interpreted from the previous session:

Decision: *The Working Group will evaluate Outputs and Outcomes*
Action: *Working Group members will make more specific their earlier identification of jurisdictional priorities*

Decision: *Communication must be better coordinated.*
Action: *Management and Finance will re-visit committee communications (e.g., gaps in 2007-10 activities, what actions they would like to continue, soliciting full membership for ideas)*

Decision: *Establishment of a "Hot Topics" list by Working Group Members*
Action: *The Working Group will work with their members to prepare narratives on their 6-10 suggested Hot Topics*

Subcommittee Reports and Accomplishments

David Keeley reviewed subcommittee updates specifically focusing on outcomes:

- GOMMI – Hired a coordinator, prepared a brochure, identified mapping priorities, conducted Cashes Ledge project, held two workshops;
- Habitat Restoration – Funded 94 Projects: Reopened 144 miles of rivers and streams for herring, salmon, etc, rehabilitated 500 salt marsh acres, maintained web portal, promoted use of stream barrier;
- Restoration Monitoring – supported habitat monitoring beta-website, produced Salt Marshes in the State of Maine;
- Habitat Conservation – completed documentation of coastal and marine managed areas in the CA portion of the GOM, disseminated info on American Eels, organized and produced workshop proceedings about sub-tidal habitat classification methodologies;
    * Dissemination and distribution of materials was identified as an issue. Much time and work is spent on specific problems and then no distribution followup (or plan)
- Gulfwatch – data reconciliation, data collection for 2007, 2008, and 2009
- Sustainable Industries and Communities – Prepared Industry Engagement with the GOMC report with recommendations, Organized and awarded Sustainable Industry Awards
- Climate Change – organized kick off event in NB, produced an invasive species report
- ESIP fact sheet on 22 indicators, communications plan, improvements to ESIP Monitoring,
- Other – State of the Gulf web site, Awarded 10 Action Plan Grants, evaluation methodology creation
- Outreach – supported the GOM times, coordinator provided a wide range of in-house support

- IT Management Committee – Supported IT needs of the Committees and Council
- Next Steps – Continue to work with committees on tasks for 2011, and for 2012 to 2017, and prepare for the December Council Meeting

Discussion then focused on how to communicate these accomplishments. Accomplishments need to be discussed, not just in quantitative terms, but exactly why these terms are important, and how they were accomplished. Are measurement protocols thought of before the project is funded and undertaken – because a process laid down prior to implementation with measurable goals can be compared to the final outcome and what did get accomplished from the initial goal statement. It was decided that it was important for Slade Moore to relay these outcomes and methods to the Working Group and the Council.

Betsy Nicholson spoke to considerable efforts and work accomplished by the GOMMI Subcommittee and how much of it is in the form of un-captured effort by subcommittee members.

Conversation then focused on how many blanks could possibly be filled in today as there was not ample enough opportunity for members to comment on Subcommittee Reports and outputs. Theresa said that the next step for the outcome documentation was to take it to the entire respective subcommittee as opposed to just the Subcommittee Chair.

To wrap up, Theresa said that some information is missing and some members indicated that it would be useful to identify what type of information would be needed for complete information. Theresa indicated that it would be good to have a follow-up conversation within the Management and Finance Committee.

David Keeley asked the Group how to communicate what has been accomplished to the Council. Jackie Olsen indicated that project PI should be the presenters as they possess the most excitement and knowledge on their particular topics.

One way to facilitate communication would be to bring the entire Working Group together. Theresa indicated that it would be important to conduct an assessment of why people cannot make it to meetings. Theresa will make a commitment to talk to members who were unable to attend today's meeting and find out why they could not attend and to make a push for their attendance at the December Council Meeting.

One last piece that is missing is the storyline that binds the work and accomplishments of the Working Group and the Council. Key messages and documents must be developed for distribution to Councilors and Working Group members so everyone is working from the same page.

Decision: *The Gulf of Maine website is confusing at times and difficult to navigate.*
Action: *Jennifer Hackett, Jim Cradock, Theresa Torrent-Ellis, Susan Russell-Robinson, Debbie Buott-Matheson, Tim Hall, Carolyne Marshall, and Michele Tremblay will offer recommendations to de-clutter www.GulfofMaine.org (particularly the home page) and explore other site architectural options*

Decision: *The reason for non-participation by some Working Group members must be determined.*
Action: *The M and F Committee will work with the OC to draft a survey and focus group process for those who are no longer involved with the Council and those whose participation has been reduced.*

Twenty Year Vision Statement Discussion

The Action Plan Working group has been looking at sample vision statements from similar organizations. Using these statements, the Action Plan Working Group highlighted sections of each of these statements that might be applicable to the Gulf of Maine. David Keeley then reviewed those highlighted words and

terms with the group. In addition to these, some members have provided new mission and vision statements for the Council.

Questions ensued on the format and setup of a vision statement. The Vision Statement, as defined by Susan Russell-Robinson, is an outcome. Should the vision statement be about the Council or about the Gulf of Maine? The Council should probably start with what is its own vision, which will eventually lead to a Gulf vision. Tim Hall mentioned that it might be useful to weave both together. Susan Russell-Robinson identified Gardiner's Principles of Education as a source for vision statement wording.

How Do We Assess and Evaluate

One of the issues that the Group must now grapple with is to assess goals laid out in the current Action Plan – which was developed with a much larger appropriations amount in mind – and how to adapt these goals to the current funding level.

David Keeley covered the improbability of the Council accomplishing all of its goals as currently constituted. This was the premise behind the Subcommittee reports and outcomes. The Action Plan Working Group tried to identify specific themes in the reports and outcomes. The Group needs to figure out what are some hard-hitting statements that meet the criteria (funding, etc) that can be incorporated into the next five year plan.

Betsy Nicholson asked: *"What are we actually tweaking here? Are we allowing the Council's actual activities to drive the workplans? Or is it the theme or problem statement that's driving the issue?"*

Theresa summarized by saying that we need the subcommittees to develop two to three sentence problem statements from each theme with subsequent options for each of the actions.

David suggested that Working Group Members need to develop statements to engage and excite their respective agencies and agency leads. At the next Council Meeting, we need to talk about the short and medium term issues – something that will slow things down as the Council will have to review.

Theresa suggested we bring a list for discussion to the Group meeting tomorrow which may help us develop a process that will inform the steps for the next couple of months leading up to the full Council Meeting in December.

This morning, the Group has identified some key gaps in terms of communication with the subcommittees, and that there is probably a role that the chair has to take in revisiting communication with members who are not at the table, develop a list of actions centered on new hot topics, develop a retrospective on short term outputs and groundtruthing. The Group will "test drive" this tomorrow.

Peter Wells highlighted the issue of identifying emerging issues and how we deal with them. He used invasive species as a particular example and how the Council can only do so much in terms of these broad, generalized issue.

Theresa then provided an overview of the rest of the afternoon's proceedings. A suggestion was made that the Group should bypass the boat ride and work on pressing issues identified today. As there is already a commitment to the boat provider, the schedule will stay as is.

Review of Coastal and Marine Spatial Planning

Betsy Nicholson reviewed the planning process for a Coastal and Marine Spatial Planning Forum in December:

Outcomes

- Encourage and advance transboundary thinking by considering GOM as a bioregion in our spatial planning efforts
- Identify lessons learned and recommendations for success at a regional scale based on experience at smaller scales
- Determine some first steps on how to advance our work to be compatible and comparable

Critical Considerations

- Participants will view MSP with a transboundary lens considering GOM as a bioregion
- Participants will think beyond the GOMC to broader collaborative approach between countries, with the GOMC playing some role in that
- Make sure fisheries interests (i.e., US-CA Transboundary Steering Committee members) are represented on panels and in audience to ensure fisheries is part of our discussion
- Premature in our discussions (both individually and transboundary) to extend invitation to industry sectors at this time

Outline

I. Status of US and CA Efforts in Marine Spatial Planning
   a) Major policies/mandates on MSP
   b) Planning processes underway
   c) Funding appropriated to support MSP

Session intent: this *brief* session will put the forum in context of current initiatives to ground our discussions and take advantage of momentum built around recent policy developments, particularly in the US.
Format: Brief Presentations

II. What have we learned to date that can guide us toward bioregional approach to MSP?
   a) Lessons learned, gaps and challenges, what have we done well (successes)
   b) Recommendations on how to stitch together smaller scale efforts, and expand those efforts to benefit a regional scale

Session intent: Experts in ocean planning will reflect on their experiences (e.g., MA, RI, ESSIM) and based on those lessons learned, comment on what managers in the GOM should be considering when trying to advance MSP at a regional scale (both as separate countries i.e., U.S. New England waters, and on transboundary scale). Could ask speakers to address more specific aspects of MSP (e.g, identifying uses and mitigating conflict, identifying ecologically sensitive areas, jurisdictional boundary issues, how to incorporate fishing interests).
Format: Panel

III. How can the GOMC, U.S. and CA work together to advance true ecosystem-based management through marine spatial planning?
   a) What should be the considerations for the US and CA as we move forward with MSP on either side of the border?
   b) Where can our separate work be synced so methodologies and results can be comparable and tell transboundary story?

c) What real input should each country have on management in waters adjacent to them? Are there real collaborations that would make a difference?

Session intent: Investigate how we would advance cooperative CMSP across the bioregion?
Format: Panel? Facilitated discussion?

IV. What actions should we take and what questions should we consider as each country moves forward with MSP?

a) What are we missing? What do we want this forum to do?
b) How can GOMC, NROC and RCCOM play a role in better coordinating our regional efforts?
c) Joint statement to advance compatible approaches to marine spatial planning in shared bioregion?

Session intent: Set up agenda for subsequent discussions on different aspects of transboundary MSP (e.g., legal, uses, ecological, fisheries)
Format: Facilitated discussion, concluding remarks

Comments focused on making sure the Census on Marine Life forum was not conflicting with the proposed date of December 7th. Forum attendance due to travel restrictions was also an issue that was flagged. Jackie Olsen suggested that the agenda may be a bit ambitious for the time frame allotted. One suggestion to counter this issue was to break the forum into two separate meetings.

David Keeley asked Betsy's opinion on the scope of invitation. He suggested that Theresa ask all Committee Chairs to suggest three NGO members who should be invited and made aware of this event.

Susan Russell-Robinson asked if the Council was prepared to include CMSP in their upcoming work plan. While not specifically endorsing CMSP currently, the Council identifies it as a significant issue with the need for additional dialogue.

FFO Review

Betsy Nicholson then reviewed the most recent FFO delivered by NOAA on developing and funding regional ocean partnerships. Questions focused on whether or not Canadians could apply for the funds (probably yes, through the Council though). The Management and Finance Committee will potentially be working on a response to an RFQ for fiscal agent selection for the FFO. This will be an upcoming task for the Committee.

Something to also consider is that the money for this FFO has not been included in a Senate Appropriations Bill as of yet (though efforts are underway to reintroduce the funding).

Northeast Great Waters Initiative

Peter Alexander then covered several models for ecosystem-based management including the Great Lakes Model which incorporated Multiple Stakeholder Involvements, State and Federal Agency cooperation, and shared investment in success. 2010 - $475M is authorized.

He identified the name of the Great Waters Initiative for the Gulf which is *The U.S. Gulf of Maine Habitat Restoration and Conservation Plan: A Needs Assessment for Maine, New Hampshire, and Massachusetts*. This plan quantifies the needs for water quality, science communications, monitoring, etc. The plan development has also involved state/federal agencies, NGO's, and businesses.

The target release date of the report would tentatively be around Thanksgiving (U.S.). Promoting the release of this report is key. A considerable amount of work has been done on this project and the opportunity should not be wasted.

It would seem that the broader audience of the Gulf of Maine Times would not need convincing of this initiative, it would be the legislators and the Governors. This almost seems like a planned campaign.

Acting Chair Robert Capozi adjourned the First Day's Meeting proceedings in preparation for the boat trip.

TUESDAY, OCTOBER 5th, 2010

Opening Remarks
Theresa Torrent-Ellis began the second day's proceedings with a quick overview of the agenda. David Keeley suggested each Working Group Member vote for their top two choices relevant to the *New England-Canadian Maritime Collaboration and Planning Initiative*.

State of the Gulf of Maine
Tim Hall provided an update to the *State of the Gulf Report* and distributed a document indicating projected funding needs for future report drafts and products. DFO Maritimes has committed to continuing in the *State of the Gulf's* coordination role for at least the next year and a half. Theresa asked if the numbers provided in the "indicative funding" section reflected the complete development of the State of the Gulf report.

David Keeley asked if there was a communications plan to distribute the report outside of the usual channels. Tim Hall agreed that a different strategy was need for dissemination and monitoring. Discussion then focused on how to capture comments and monitor the report's use. Tim Hall was curious as to how we see the *State of the Gulf* website being used. Allowing comments and blog-style discussion on the website is useful and important, however, if there is not an initial "push" to advertise the report's presence and utility, the website features will not be put to good use.

Theresa Torrent-Ellis asked about the architecture of the website and who was involved. Tim Hall suggested that the working Group develop a "canned email" highlighting the presence of this report. The Group agreed that this was a good idea. To summarize final actions, Ted and Theresa will develop posters and advertisements for the report. The Group wants to be able to capture comments, add updates, and that there will be a communication method developed.

The Working Group should be looking at the State of the Gulf reports and use them to a degree as a means for Action Plan Items. Susan Russell-Robinson suggested that Jay Walmsley submit an abstract for Coastal Zone 11. Would it be worth developing an entire session at CZ11 on the *State of the Gulf*? A café format might be a good method for discussing the report. The Working Group seemed very interested in a Transboundary Café.

Tim Hall then asked a question about the review process. He has not heard any negative feedback about the process and the final product to this point, and if anyone has any concerns about the process, etc, Tim Asked that they raise these issues as soon as they can to either himself of Jay Walmsley. Ted Diers suggested that the report's theme papers may not necessarily line up with the Gulf's needs assessment. He took full responsibility for this issue and suggested that there has to be a higher level of review to try

to bring all the moving pieces of the Council into alignment with the report text. Theresa suggested that a possible means to circumvent this extra level of review is to inform the authors of the theme papers of the "50 thousand foot view" prior to the "pen to paper moment".

Cross Cutting and Service Committees

Theresa began discussion. Debbie suggested that there should be some money devoted to website architecture and possibly changing the layout and design of the Gulf of Maine Council Website. David Keeley suggested that two or three volunteers step forward to assist the IT Committee. Tim Hall suggested that the website redesign be part of the overall communications strategy theme that has purveyed this afternoon's discussion.

Jennifer Hackett suggested that a usability study needs to be conducted to determine who the audience is. If the audience is the Council and its immediate satellites, there is not much too much of a need to revamp the layout. If the audience is the general public, the site could benefit from additional work. Debbie, Theresa, Susan, Carolyne, and Michele all volunteered to assist in the website redesign.

Steps For Building Fundable Project Ideas for the Private Foundation Sector

David Keeley and Peter Lamb began a presentation on how to potentially raise funds from the private sector and how to interpret foundation personalities. David also highlighted the fact that proposals are becoming more and more numerous to these foundations so anything submitted on behalf of the Council must be very competitive.

Nearly half of the funds raised today com from Government Grants. The types of proposals for these grants are not necessarily applicable to private foundation grants. Peter Lamb then reviewed non-profit trends over the last year. Foundations frequently like to see streamlining, alliances, or mergers in applying non-profits.

Peter Lamb discussed small grants and the actual utility of these smaller funds. This, he said, is where funders begin to look at alliances and where it may be prudent for grantees to consider sharing resources on a particular initiative. Funders are starting to change the way they operate as well. Some of these shifts come from a decrease in assets. Others are a narrowing of mission to a very specific topic. It's also important to consider the back stories of some of these foundations.

There are two perspectives when writing a proposal: the **applicants perspective** (creating a clear and compelling case, who else is working on this issue, what is the level of collaboration, how will you know if you succeeded, and how is the work connected to a larger issue), and the **funder's perspective** (funders want to be engaged, is the proposed work geographically and mission-oriented, is there the possibility for seed money, is the format correct).

The grantee should discuss the funder's interests in the proposed work and what challenges the funder's organization has faced. Also ask if there are other funding sources that may be conducive to your proposal.

David Keeley suggested that the Group should begin to discuss targeting different foundations. Peter Lamb said that there are approximately 15 different foundations that the Council could possibly target to obtain funding. Peter said that the transboundary nature of the council is a positive for the Council.

Cindy Krum raised the issue of a significant web presence at helping an applicant in the funding process.

Judy Pederson asked if the Council leadership would be taking a role in relationship-building with these funders. Theresa seemed to think that there would be. Peter also suggested that it was critical for funding applications that were rejected to follow-up with the funder to see why the application was rejected. Olsen wants the Working Group to look at successes and failures in the past in terms of funding applications.

The communication issue was again brought up in terms of briefing materials. Jackie Olsen suggested that if the next agenda was approved, Working Group members should each take responsibility for one agenda item and continue to follow-up with the person who's job it is to provide the requisite materials and briefing notes.

Decision: *Followup is needed for Briefing Materials*
Action: *Working Group members will individually take responsibility for specific agenda items so that briefing notes and other updates are submitted on time and the subsequent briefing book will be delivered at least two weeks in advance of each meeting*

Climate Change Initiative

Gary Lines began reviewing Climate Change network initiatives. Gary Lines considers the current resolves of the most recent Network events are not up to par. He suggests that the Action Plan, in terms of climate change, is to stay with what is currently included and not change the current approach (no coordinator, etc). He said that currently the network is stagnated at the status quo, and for any significant change to occur, funding will have to be provided. Where Gary does see actual movement is in terms of coastal resiliency.

Susan suggested that Ellen MaCray is very interested in growing the Climate Change Network, and that she would like to serve as U.S. Co-Chair of the Climate Change Network. Ellen is currently the NOAA Climate Change coordinator for the northeast region.

Theresa asked if the "additional funding" suggestion brought up by Gary would be funding for a coordinator. Gary said that part of the funding would go towards paying for actual projects and also to project support (coordination). The Network mission is articulated in the TAPAS, though as Gary has said, it must have some type of financial support in order to work.

Gary's closing thoughts were: "what would you like the network to do". And plan accordingly.

Decision: *A US Co-Chair of the Climate Change Committee is needed*
Action: *Ellen Mecrary, NOAA Regional Climate Services Director is willing to serve as the US Co-chair of the Council's Climate Change Committee. Gary Lines, Carolyne Marshall, and Michele Tremblay will work with her to help her with your new responsibilities*
Decision: *A CA Co-Chair of the Climate Change Committee is needed*
Action: *Michele will work with Carolyne Marshall to help her determine her willingness to serve as the CA Co-chair of the Climate Change Committee*

Update On the Gulf of Maine Regional Ocean Science Initiative

Judy Peterson provided an overview of the background and envisioned role of the initiative. Please see Ms. Pederson's presentation here http://www.gulfofmaine.org/council/internal/presentations/201010/

Theresa asked if NEOSEC had been involved in this process. Judy said no.

Proposed Action Items
Michele Tremblay gave a brief update of jurisdictional priorities that are aligned with the Action Plan. Please click here for Michele's summary: www.gulfofmaine.org/council/internal/presentations/201010/

Theresa suggested that the Task at hand now is to bring personal or agency perspective to what an action item would be based on Michele's new topics. The Group will choose a couple of the topics and then discuss for the afternoon session.

NERACOOS Update
Ru Morrison, who is also the new NH Counselor, provided an overview of the Northeast Regional Association of Coastal and Ocean Observing System and its many components. After providing a quick summarization, Ru began discussion on the New England- Canadian Maritime Collaboration and Planning Initiative. Please click here for Dr. Morrison's presentation http://www.gulfofmaine.org/council/internal/presentations/201010/

Committee Updates

- ESIP – Susan Russell-Robinson provided an update for ESIP: Please see the corresponding documents here: http://www.gulfofmaine.org/council/internal/presentations/201010/. Susan wants ESIP to be the definitive source for information regarding the Gulf in the Northeast. She proposed several vehicles for the advertisement of ESIP including prominent magazines throughout the Northeast. ESIP's funding goals are to engage governmental organizations to provide a broader funding base.

- Outreach – Debbie Buott-Matheson gave an overview of the how the Outreach Committee hopes to use the 2012 action plan as a chance to take a step back and take stock of what the group has accomplished and how to "breath life" into the group which is really the senior on the circuit, so to speak. The Committee will also be reviewing the Council website to try and comment on its current setup. The Committee will also provide a survey to all Working Group members asking them how they view the Gulf of Maine. A suggestion was made to send this to council members as well. Tim Hall wants to know if we should be describing to the Council what we are doing within the Working Group and make more of an effort to communicate these efforts. Theresa provided a list of Outreach and Communication Subcommittee Members.
    * One issue that was brought up was whether or not it was necessary to continue with three habitat subcommittees. Theresa was hoping that the three subcommittees would sort things out amongst themselves.
    * Susan suggested that after this, Theresa sent out an email to the council about the current plans to assess committee redundancy, etc.

- Monitoring Subcommittee – The Committee is continuing to do presentations on the Gulfwatch program, samples for the 2010 season have been collected, there is a significant push for papers from members from the committee on both sides of the border, and the Committee is keeping an eye out to see how relevant their work is to the Gulf of Mexico oil spill.

- NROC Update – Ted Diers provided a restatement of the FFO that Betsy had covered yesterday. Adrianne then brought up the recent release of NROC's work plan and suggested it be compared to the developing GoMC Action Plan.

Councilors and Priorities

Jackie Olsen reviewed a copy of the sheet previously distributed by Michele Tremblay showing councilor priorities and guidance on issues which Jackie and Debbie had filled in by adding Action Plan Priority Goals. Please see both Action Plan Goals and the Counselor Priorities sheets here: www.gulfofmaine.org/council/internal/presentations/201010/

- Susan asked if Fisheries Management also included aquaculture. This had been identified by councilors but was not in the Version 5 Document.
- Tim Hall asked what the intention was to use the edited document. Was it going to be accepted as a new document or as qualified edits to the old one.
- Ted Diers suggested cutting everything below the number "1" on the Counselor Priority sheet. Susan agreed and suggested that Theresa's committee go back and look at what "1" topics can be absorbed by higher numbers.

Overview of Winnowing

Theresa began the session overview by identifying coastal cleanup/trash in the oceans as an example issue (Marine Debris). She then asked what would be some compelling action statements related to the issue.

1. Identify the Problem – Impact on Wildlife of plastic debris (scope and the scale of the problem)
    a. ACTION: Characterize the scope and scale of the impact of plastic on wildlife in the Gulf of Maine and Bay of Fundy including

David Keeley then provided an explanation of the proposed criteria to determine the contents of the new action plan. David suggested a scenario examining what the Group thought regarding several possibilities: each state conducting their own marine debris mitigation or conducting a region-wide response. The Criteria Order is:

Regional Response → Council Capacity → Council Role → Resources

- Debbie asked if it was the Council's role to advocate against marine debris practices or to illustrate the causal links to between cause and effect. It is not the Council's job to advocate locally (marine debris is a local issue, not a regional issue). The Council is in a good position to illustrate regional impacts of what we do.
- Susan wanted to verify that Marine Debris was a regional, local, or state issue. Theresa suggested that it could be framed differently but it was primarily a regional issue.

Ted Diers suggested that after this process, if our Action Plan is 100 pages long, the planning process will have failed. If it's 10 pages long, there may be a possibility that the group might be able to succeed. Tim Hall said that just because something is not necessarily in the Action Plan, does not mean we cannot acknowledge the issue, we can simply acknowledge that it exists and then point to who was currently working on the issue in question. Discussion then centered on the final two criteria: "Council Role" and "Resources Available". Gary Lines suggested a fifth criteria – **can the Council measure its success on the issue?**

Process Review

Matt will have the minutes distributed to all working group members within five days. The Secretariat will be accepting comments for two days and then will not accept any further comments. Jackie suggested that all Subcommittees distribute minutes to the Council and Working Group Members.

Additional Process Actions

Action: *Cindy Krum will provide to Michele agenda items and supporting documents for the October 13, 2010 Management and Finance conference call including codifying the USGOMA fiscal agent/indirect rate for the NROC fiscal agent proposal, drafting a letter from the GOMC that contains comments on the draft NROC work plans, and a draft of suggested edits on the CMSP and governance work plan from the GOMC—including roles the Council play in a proposal.*

Action: *Working Group members will email to Michele the documents that they referenced along with other resources before the end of this week so that she can post them on the Council's meeting website. Michele will email to the Working Group a notification when the resources are posted.*

Action: *Marine Spatial Planning will be added to the December Council Meeting.*

Action Items Overview

Michele then covered action items that had been decided upon during the meeting. Please see the Action Item at the end of each previous header. The Group also had some discussion about how the record-taker should portray decisions from each header. Matt should place a "Result" bullet or bullets under each of the headers.

Census on Marine Life

Theresa gave a brief update on the Census on Marine Life and how they feel the Gulf of Maine Council is a very important audience member. They would like to brief the Council on December 9th at the Abromson Center after the next Council Meeting. David Keeley suggested it be considered part of the Council meeting. Tim Hall suggested that the presentation be moved into the actual proceedings. It's important to have the CoML make the link between their program and the GoMC Action Plan.

Decision: *Additional information from the CoML should be included in the upcoming Council Meeting.*
Action: *The Council meeting agenda will include time for a Census of Marine Life on Thursday, December 9 in Portland, ME with John Annala and Rob Stephenson to provide a briefing for the Council on the importance of being there—notification will be sent now for travel arrangement purposes.*

Prepared by Matthew Nixon, Maine State Planning Office, Gulf of Maine Council Administrative Aid

Habitat Restoration Subcommittee

Update

Activity has focused primarily on supporting key goals of the GOMC-NOAA Habitat Restoration Grant Partnership. Activities included:

1. GOMC-NOAA Partnership Coordination

Partnership members continue to engage in monthly conference calls on the first Tuesday (1:00-2:00 pm) of each month to discuss gulf-wide restoration activities, issues associated with restoration grant management, and other topics of relevance to restoration in the GOM. The Partnership includes NOAA Restoration Center staff (John Catena, Matt Bernier, Mat Collins, Eric Hutchins, and Jack Terrell), U.S. Gulf of Maine Association contractors (Cindy Krum and Lori Hallett) and Liz Hertz of the Maine State Planning Office. The Partnership's Jurisdictional Representatives are:

- Canada: Anita Hamilton – GOMC Habitat Restoration Subcommittee Co-Chair, Habitat Assessment Biologist, Department of Fisheries and Oceans
- Maine: Slade Moore – Habitat Restoration Coordinator, Maine Coastal Program
- Massachusetts: Hunt Durey – Acting Deputy Director, Division of Ecological Restoration, Massachusetts Department of Fish & Game
- New Hampshire: Ted Diers – Director, New Hampshire Coastal Program

2. Contracting of 2010 RFP habitat restoration projects

Six of the eight projects selected from the 2010 GOMC-NOAA Habitat Restoration Partnership RFP round have undergone contracting. A summary of 2010 project information is included in the table below:

GOMC-NOAA #	State/ Prov	Project Name	Applicant Organization	Amount Requested $	Award $	Non-Fed Match Amt $
10-01	MA	Broad Cove Restoration Project Feasibility Analysis, Hingham, MA	Town of Hingham in partnership with Derby Academy	45,000	45,000	45,000
10-02	MA	Clark Pond Tidal Restoration	The Trustees of Reservations	22,775	22,775	100,000
10-03	ME	Thomas Bay Marsh Culvert Replacement	University of Southern Maine, Casco Bay Estuary Partnership	40,463	40,463	44,000
10-04	ME	Montsweag Brook Dam Removal	Chewonki Foundation	100,000	59,651	95,056
10-05	ME	Muscongus Brook Culvert Replacements: Pre-construction	Kennebec County Soil & Water Conservation District (KCSWCD)	100,000	23,000	23,000
10-06	ME	Kennebec Barrier Survey	Kennebec County Soil & Water Conservation District (KCSWCD)	20,000	23,000	23,000
10-07	NH	Exeter River Great Dam Removal Feasibility Study	Town of Exeter, NH	40,000	40,000	45,000
10-08	NS	Clementsport Dam Restoration Planning	Clean Annapolis River Project (CARP)	34,974	34,982	52,643
			Totals	403,212	288,871	427,699

3. Administration/Oversight of Ongoing Habitat Restoration Projects

Since its inception, the GOMC-NOAA Habitat Restoration Partnership has awarded 94 projects (totaling $3.25 million) across all jurisdictions of the Gulf, including Maine, Massachusetts, New Hampshire, New Brunswick and Nova Scotia. Together, these projects re-opened access to 144 miles of rivers and streams for river herring, Atlantic salmon and American eel, re-established access to 2,400 acres of alewife spawning habitat, and rehabilitated over 500 salt marsh acres.

As of the drafting of this document, 18 active projects are being administered by USGOMA and the Partnership. Active projects occur within all five jurisdictions of the Gulf of Maine (MA, NH, ME, NB, and NS). Technical support is provided to these projects through a team approach. A NOAA Lead, a jurisdictional Technical Lead and the Jurisdictional Representative for each of the jurisdictions provide technical and administrative oversight for each project. The Habitat Restoration Coordinator and USGOMA provide additional, cross-jurisdictional administrative support to grant recipients.

4. Development and release of the 2011 GOMC-NOAA Habitat Restoration Grants Program RFP

The Partnership revised and released the RFP for 2011 habitat restoration projects in early October. The announcement was distributed via multiple outlets, including the GOMC web page, GOMC distribution lists, and other restoration-focused networks. The deadline for Letters of Intent is November 29, 2010. The period for uploading Full Applications to the website is February 2 – March 16, 2011.

5. Refinement of a web-based grant tracking system

The web-based grant tracking system continues to be refined. This system is intended to enhance efficiency and accountability of grant management by integrating functionality and data capture of three distinct web screens, namely:

a) The Grantee's GOMC-NOAA Project Webpage, which is the clearinghouse for grant administration information, reporting and invoice templates, and project documentation for each individual subaward. It is where grantees and Partnership staff upload relevant documents such as contracts, reporting materials, invoices and other files of interest. Both grantees and Partnership members have access to each of these pages.

b) The Grant Tracking At-A-Glance page, which is a tool for Partnership members to rapidly assess the status of all grants on one screen. This page provides functionality to flag recent uploads (a new function), tardy reporting by grantees, late response on the part of Partnership members to review reporting/invoices, and other situations warranting action. It also provides links to relevant files.

c) The Grant Tracking Sheets, which provide for each grant detailed information and fields for Partnership staff to indicate approval of submitted materials. It too, provides links to relevant files.

6. Refinement of grantee compliance measures and Partnership protocols

Guidance materials for promoting enhanced grant administration and grantee compliance continue to be updated. These included the Grantee's Primer for Grant Administration and the Partnership Protocols. Automated email notifications of grantee uploads, which are sent to key Partnership members assigned to each restoration subaward project, now have attached instructions for review of GOMC subaward reports and invoices. Grantees are also sent automated notifications alerting them of upcoming or past-due project reporting dates.

7. The Gulf of Maine Restoration and Conservation Initiative

GOMC-NOAA Partnership members have been key participants in providing technical information, developing assessments of need and other functions in support of this initiative's "Plan". It's anticipated that the Partnership will continue to provide support to this initiative. Information on this initiative and a draft of the Plan are available at http://www.gulfofmaine.org/documents/gom-restoration-plan/

8. Support of the GOMC action planning process

The Partnership has participated in this process by reviewing and revising the "Committee Rapid Assessment and Recommendations" language as it pertained to HRSC tasking for the next Action Plan and by attending GOMC sessions and conference calls on the Action Plan. The Partnership's review was distributed to the entire HRSC email list (which has been updated annually since 2009) for response. Of the 40-odd recipients, only one responded with comments. That person was actually a member of the Habitat Restoration Partnership.

Possible activities and/or next steps

1. Continue GOMC-NOAA Habitat Restoration Partnership coordination

With renewed NOAA funding for this program, developing and administering new Partnership subaward projects will remain the primary focus of the Habitat Restoration subcommittee over the next 3-4 years. Likewise, coordination of the Partnership will remain the primary responsibility of the Habitat Restoration Coordinator.

2. Support GOMC Action Plan development

The Partnership will continue to support HRSC-focused Action Planning activities as needed.

3. Increase Maine's restoration capacity and coordination

With recent progress made in refining the Partnership's operations for maximum efficiency and grantee compliance, there is now an opportunity to better support the Maine jurisdiction's restoration potential, which has suffered from a persistent lack of capacity and coordination. Efforts to reverse this trend have recently been reinvigorated by development of the Maine Stream Connectivity Work Group, which is co-chaired by the Partnership's Habitat Restoration Coordinator (Slade Moore). Through the efforts of state, federal and NGO participants, this Work Group seeks to dramatically improve coordination of aquatic restoration activities and the rate of restoration within Maine. To date, the Work Group's progress includes:

- embarking on the design a statewide restoration database populated by rigorously-obtained watershed-scale barrier inventories
- initiating the design of restoration prioritization and decision-making tools
- exploring funding options and organizational structure alternatives for a formalized and functional state habitat restoration program
- Release of the "Year-One Report and Recommendations" – contact Slade Moore for additional information.

The work of this group represents a long overdue milestone in the evolution of Maine's restorative potential. Given the state's historical and evolving capacity to re-establish some of the GOM's most abundant diadromous fish runs, ongoing development and progress of the Work Group should figure prominently in the Habitat Restoration Subcommittee's efforts of regional importance.

4. Coordinate development of a "Restoration Summit"

Ecologically-meaningful habitat restoration, both at the local and ecosystem scales, requires adaptation to address advances in methodologies and restoration science. In the latest application to NOAA for habitat restoration funding, the Partnership committed to organizing a "restoration summit" that is intended to provide a forum for restoration practitioners to exchange the latest in methods and theory.

5. Continue to support development of the Gulf of Maine Restoration and Conservation Initiative

Implementation of the "Plan" is a high priority and will likely remain a focus of Habitat Restoration Subcommittee activities.

6. Frame GOMC's habitat restoration activities in the context of climate change projections

We intend to begin addressing the implications of climate change by assessing how they are likely to influence target habitats and habitat restoration policy and priorities.

Contractors for the Gulf of Maine Council on the Marine Environment as included in July 1, 2010-June 30, 2011 Budgets

Contractor	Contract End Date	Title	Funds
Krum Steele Consulting (Cindy Krum)	06/30/2011	U.S. Association Executive Director	Indirect/Reserve
Lori Hallett	06/30/2011	U.S. Association Finance Assistant	Indirect/Reserve
The Keeley Group (David Keeley)	12/31/2010 New contract planned for 01/01/11--6/30/11	Core Services Fund Development/Support for Action Plan/Additional projects	Dues ME SPO JB Cox Fund
The Keeley Group (Michele Tremblay)	12/31/2010 New contract planned for 01/01/11--6/30/11	Core Services Council Coordinator/Support for Action Plan	Dues Reserve/Indirect ME SPO
The Keeley Group (Jim Craddock)	12/31/2010 New contract planned for 01/01/11–6/30/11	Core Services Information Technology/Additional projects	NMFS Dues JB Cox Fund
The Keeley Group (Nancy Griffin)	12/31/2010 New contract planned for 01/01/11–6/30/11	Core Services Gulf of Maine Times	JB Cox Fund Donations USGS DFO NH Charitable Fund
Biological Conservation (Slade Moore)	06/30/2011	Habitat Restoration Project Coordinator	NMFS *ME DOT* Dues JB Cox Fund
UNH (Steve Jones)	03/31/2011	Gulfwatch Program Coordination	EC
Steve Jones	04/30/2011	Gulf of Maine Report - Microbial Pathogens and Toxins Theme paper	NH DES
Lawrence LeBlanc	03/31/2011	Gulfwatch 2009 Data Report	EC
Christine Tilburg	01/31/2011	ESIP Program Manager	USGS EC DFO
Talking Conservation (Peter Alexander)	12/15/2010	Coordination and Product Production -New England Cross-border Conservation Initiative	JB Cox Fund
Waterview Consulting (Peter Taylor)	12/15/2010	Conservation and Restoration Strategy-writing and design	JB Cox Fund

Submitted by Cynthia Krum, US Gulf of Maine Association

Adopting a Indirect Rate for 2011

ISSUE: The Council needs to accept a new annual Indirect Rate that would be used by the Association of US Delegates to the Gulf of Maine Council on the Marine Environment (USGOMA).

Background: The July1, 2009 through June 30, 2010 USGOMA audit is complete. The auditor has recommended a new administrative rate of 20.61%. The new administrative rate would go into effect for new proposals and or contracts as of December 9, 2010 and remain in effect until the 2011 December Council meeting. In December 2009 the Council approved a 19.24% administrative rate for all funds flowing through the USGOMA. In December 2008 the Council approved a 16.59 % rate. These rates were recommended by the auditor using the "look back" method which is set by reviewing the prior fiscal year. Our auditors have used this method for the past seven years. Following is text explaining the method from the "Indirect Cost Letter" from Marshall and Libby, LLC, the auditors for the USGOMA.

> "There are various acceptable alternatives to calculating and negotiating indirect costs under federal regulations. We have set up your allocation using a simplified method, which separates direct costs of programs from indirect costs, then divides the total allowable indirect costs by direct costs. This means for every dollar of direct expense the Association incurs, it needs to raise an additional 20 cents to cover the indirect costs."

RECOMMENDATION: Recommend Council approval of the new 20.61% rate to go into effect December 9, 2010 through the December Council meeting, 2011.

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Final Budgets for July 1, 2010 – June 30, 2011 (Fiscal Year 2011)

Background: The July1, 2009 through June 30, 2010 USGOMA budgets and summary have been sent as separate documents, attached to the email alerting Councilor's to the availability of the December, 2010 Council meeting briefing packet. These budgets have been updated to reflect additional funding since the Council's approval of the provisional Fiscal Year 2011 budgets at their June, 2010 meeting.

RECOMMENDATION: Recommend Council approval of the Fiscal Year 2011 budgets.

Submitted by Cynthia Krum, US Gulf of Maine Association

Report on Discussions between the Gulf of Maine Council's US and Canadian Associations

Background: To date, two conference calls have been held to discuss the Association of US Delegates to the Gulf of Maine Council on the Marine Environment (US Association) and the Association of Canadian Delegates to the Gulf of Maine Council on the Marine Environment (CA Association) collaboration, efficient management and support of the Gulf of Maine Council. After drafting problem statements the ad-hoc group will draft recommendations to address the most prominent issues. The ad-hoc group is comprised of: Don Hudson (President, US Association), Justin Huston (Secretariat to the CA Association), Theresa Torrent-Ellis (current Working Group Chair), Robert Capozi (upcoming Working Group Chair), and Ted Diers (US Association Executive Director Contract Manager). Cynthia Krum (US Association Executive Director) provides contractor support.

Actions:

- Discussions will be held at the US Association and CA Association meetings
- Additional conference calls of the ad-hoc group will be held as needed
- Draft recommendations will be provided to the Working Group in March 2011
- Final recommendations will be provided to Working Group and Council in June 2011

Submitted by Cynthia Krum, US Gulf of Maine Association

CARSEY INSTITUTE

NEW ENGLAND
POLICY BRIEF NO. 4
SUMMER 2010

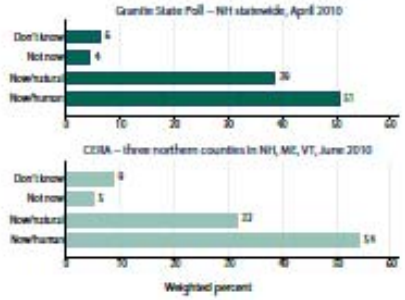
Is New Hampshire's Climate Warming?

LAWRENCE C. HAMILTON, BARRY D. KEIM, AND CAMERON P. WAKE

Introduction

In April 2010, the Granite State Poll asked a representative sample of 512 New Hampshire residents what they personally believe about climate change or global warming.[1] Is it happening now, caused mainly by human activities? Is it happening now, but caused mainly by natural forces? Or is it not happening now? The upper graph in Figure 1 shows results from this poll. Almost 90 percent believed that climate change is happening now, whether natural or human caused.[2] A separate poll taken in June 2010, for the Community and Environment in Rural America (CERA) project, asked the same question of 1,852 residents in three northern counties of New Hampshire, Maine, and Vermont. The CERA poll found similar results, shown at bottom in Figure 1: 86 percent believed that climate change is happening now.[3]

FIGURE 1. WHAT DO YOU PERSONALLY BELIEVE ABOUT CLIMATE CHANGE?



Note: Margins of error are plus or minus 4.5 percent for the Granite State Poll and 2.5 percent for CERA.

Key Findings

Recent surveys find that most New Hampshire residents believe the climate is changing, whether due to natural or human causes (Figure 1). In this brief, we look at some objective indicators to see whether New Hampshire's climate really has changed and how local trends compare with global patterns. It turns out that New Hampshire seasons, and winters in particular, have been warming at faster-than-global rates. The following are some examples:

- Annual temperatures at First Connecticut Lake, a rural site in far northern New Hampshire, warmed an average of .34 degrees Fahrenheit per decade, from 1895 to 1969, and about .54 degrees Fahrenheit per decade (faster than the global rate) since 1970.
- Winter temperatures in both northern and southern New Hampshire are warming even more steeply, especially through the past forty years.
- Using "temperature anomalies," instead of simple temperatures, helps to make comparisons of trends across places with seemingly much different climates, such as Durham and Mount Washington.
- Ice-out dates on New Hampshire's large lakes provide other indicators of winter warming, which follow patterns similar to those measured for temperature.
- Snowfall responds to temperature change in more complicated ways and often with inconsistent trends.
- Sea level in northern New England, as globally, is now rising at an accelerating rate.

These shifts in New Hampshire's climate, if they continue into the future, will have broad implications for our ecosystems, infrastructure, and economy.

UNIVERSITY of NEW HAMPSHIRE

New England's recent experiences with floods (2005–2007, 2010) and relatively warm winters (2002, 2006, 2010) probably influenced public opinion. Spring arrived early in 2010.

Of course, there have always been unusually cold or warm seasons, but is something different happening now, compared with earlier decades? Is New Hampshire's climate really changing, as most people seem to believe? In this brief we look back on a century of records from different seasons and different parts of the state. The aim is not to conduct another detailed climate study but to provide some long-term perspective on recent trends.[4]

New Hampshire and Global Climate

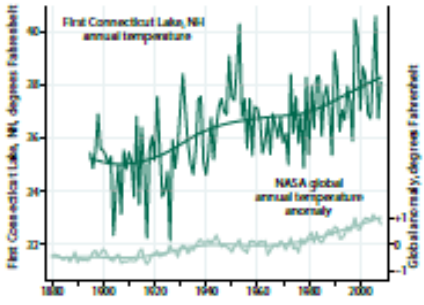
Each month NASA scientists calculate an index of global temperature based partly on historical records from weather stations around the world, such as those maintained by the United States Historical Climatology Network (USHCN).[5] Five New Hampshire stations—Bethlehem, Durham, Hanover, Keene, and First Connecticut Lake—contribute to USHCN. The upper curve in Figure 2 shows annual temperatures from the most isolated of these stations, First Connecticut Lake, located near the Canadian border in northern New Hampshire.[6] The lower curve shows global temperature anomalies calculated by NASA, taking into account the five New Hampshire stations along with thousands of others.[7]

From 1895 until 1970, annual temperatures at First Connecticut Lake rose at an average rate of .34 degrees Fahrenheit per decade, although most of the actual rise occurred in just two decades, 1920 through 1940. The three decades from 1940 to 1970 saw a slight cooling. After 1970, a more sustained period of warming began, at .54 degrees Fahrenheit per decade, well above the global rate (.30 degrees Fahrenheit per decade since 1970). Wide year-to-year variations in temperatures from the single New Hampshire station contrast with relatively small year-to-year variation in global temperatures averaged across thousands of places. The New Hampshire station matches a global pattern, however, of warming between 1920 and 1940, followed by a mid-century cooling, and then sustained warming since 1970.[8]

This general pattern of warming, slight cooling, and then steeper warming since 1970 has been observed in both southern and northern New Hampshire and in all four seasons. It has been most pronounced in the wintertime—about .20 to .35 degrees Fahrenheit per decade between 1900 and 1969, as graphed in Figure 3.[9] From 1970 to 2009, the average rate of winter warming steepened considerably to 1.06 degrees Fahrenheit per decade in northern New Hampshire and .88 degrees Fahrenheit per decade in the south.

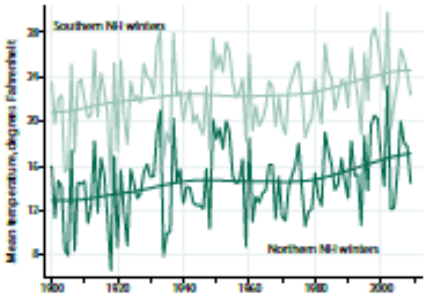
Southern winters are warmer, but the two regions generally move together. That is, a relatively cold winter for the south tends to be relatively cold for the north as well. Such patterns of parallel movement, despite different average temperatures, provide scientists with a way to see global climate change.

FIGURE 2. ANNUAL TEMPERATURES AT FIRST CONNECTICUT LAKE IN NORTHERN NEW HAMPSHIRE, COMPARED WITH GLOBAL TEMPERATURE ANOMALIES



Note: Vertical (degree) scales are the same, although the two series have different "0" points. Smoothed curves summarize patterns underlying the jagged year-to-year variations.

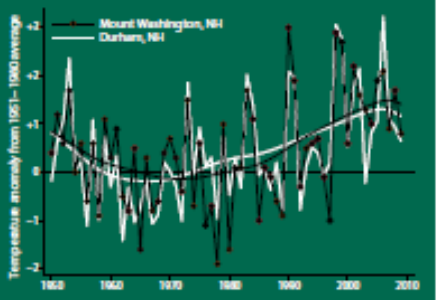
FIGURE 3. WINTER (DECEMBER TO FEBRUARY) TEMPERATURES AVERAGED FOR STATIONS IN SOUTHERN AND NORTHERN NEW HAMPSHIRE



What Are Temperature Anomalies?

Temperature changes over time are not always measured by changes in averages but also by changes in temperature anomalies. Weather stations record local temperatures in degrees Fahrenheit or Celsius. To describe larger regions or the whole world, climatologists re-express these as "temperature anomalies." A temperature anomaly equals the difference between measured temperature and a baseline temperature, typically defined as the mean for some historical period. For example, the global temperature anomalies graphed in the lower curve of Figure 2 range from –0.73 to +1.13 degrees Fahrenheit, relative to the mean for 1951 to 1980 (baseline years chosen by NASA climatologists). Positive anomalies occur in years warmer than the 1951 to 1980 baseline, and negative anomalies occur in colder years. Trends in temperature anomalies reveal patterns of change. Thus, rates of changes, like the slopes of curves shown in Figures 2 and 3, will be identical even if we choose a warmer or cooler baseline period.

FIGURE 4. ANNUAL TEMPERATURE ANOMALIES ON MOUNT WASHINGTON AND IN DURHAM



Estimates of global temperature anomalies, such as the lower curve in Figure 2, are derived from local temperature anomalies, which in turn use data from weather stations around the world. For example, First Connecticut Lake reported a 2008 mean annual temperature of 38.3 degrees Fahrenheit. The average temperature from that station from 1951 to 1980 was slightly cooler, at 36.7 degrees Fahrenheit. So the annual temperature anomaly for 2008 is 38.3–36.7 = 1.6 degrees Fahrenheit, indicating that 2008 was 1.6 degrees Fahrenheit warmer than the baseline period average. Monthly or daily anomalies can be defined in a similar fashion.

Temperature anomalies help us make reasonable guesses about conditions beyond the immediate vicinity of a weather station. For example, temperatures at higher elevations in New Hampshire's mountains tend to be cooler than those at lower elevations. Although a low elevation or coastal weather station's actual temperature would be a poor guess for the mountaintops, its temperature anomaly might provide a surprisingly good guess. To illustrate this point, Figure 4 graphs anomalies from two far-apart stations: Durham, just 80 feet above sea level in southeastern New Hampshire; and the summit of Mount Washington, 6,288 feet above sea level and 100 miles to Durham's north. Mount Washington is famously cold. Although temperatures in these two places are worlds apart, their temperature anomalies more often than not move together.

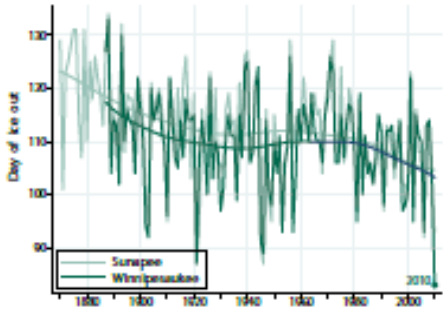
Using additional weather stations or ones closer to the mountain, we could make even better guesses about anomalies on Mount Washington. Climatologists apply this principle in a more sophisticated way to estimate temperature anomalies of areas between weather stations, checking their estimates against satellite or other available data.

Ice and Snow

Although the temperature trends shown in Figures 2–4 are real, their magnitude is too small for most of us to notice, compared with large day-to-day variations in weather. When average temperatures move, however, some more visible things change as well. For example, in a warming climate, very warm seasons become more common, and very cold ones become less common. In Figures 2–4, you can see both high and low extremes shifting up or down with the averages. Another result of warming is that winters become shorter, affecting forests, wildlife, farms and gardens, winter sports, and many aspects of everyday life. A rising fraction of winter precipitation falls as rain rather than snow.[10]

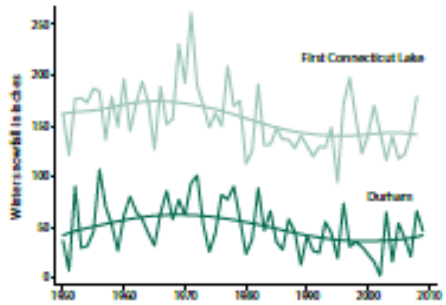
If we did not know about the temperature trends seen in Figure 3, historical ice-out dates for New Hampshire's big lakes could tell a similar tale of winter warming (Figure 5). Ice-out dates have been recorded for Lake Sunapee since 1869 and for Lake Winnipesaukee since 1887.[11] These dates mirror the larger climate trends shown by temperatures: early-twentieth-century warming, followed by a slight cooling in mid-century, and then steeper warming since about 1970. The ice-out date for Lake Winnipesaukee in 2010, March 24, was the earliest ever recorded. Lake Sunapee's 2010 ice-out (April 4) was only the fifth earliest, but the downward trend there has been equally clear.[12]

FIGURE 5. ICE-OUT DATES ON LAKES SUNAPEE AND WINNIPESAUKEE



Although it might seem logical that warmer temperatures should mean less snow, the actual response is more complicated. At temperatures far below freezing, air holds less moisture and substantial snowfall becomes less likely than it is when air is closer to, but still below, the freezing point. Consequently, it is possible for some cold places (such as Antarctica, or higher elevations in New Hampshire) to experience more snowfall despite warming temperatures. That pattern reverses when it warms above freezing, of course. New England winter storms often arrive with a moving rain/snow line, and the path of this line can determine whether nearby areas get rain, snow, or an unpleasant mixture of both.

FIGURE 6. WINTER SEASON SNOWFALL AT DURHAM AND FIRST CONNECTICUT LAKE

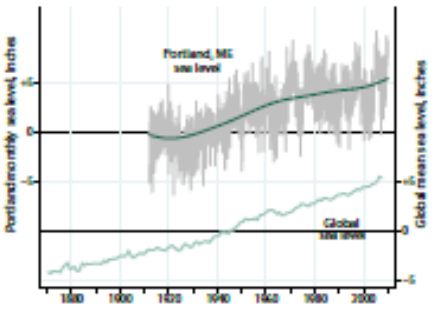


As a result of these complications, and also the difficulties of finding consistent measurements, snowfall trends have been less clear-cut than temperature. Figure 6 shows the up and then down patterns of annual snowfall recorded at Durham and First Connecticut Lake (winters of 1949–1950 to 2008–2009). Snowfall at these stations has declined about one inch per year since 1970. The similar rates are interesting because snowfall events for these two locations have different climate influences. Coastal conditions particularly affect Durham, while continental storm tracks have more influence at First Connecticut Lake. Weather stations at Bethlehem, Keene, and Hanover, however, recorded no significant snowfall trends over this period.

Sea Level

Storm erosion and coastal flooding particularly worry towns along New Hampshire's brief seacoast. These problems will increase if sea levels rise. A study for the Office of State Planning noted that a two-foot rise in sea level, which the Intergovernmental Panel on Climate Change (IPCC) has estimated could arrive before the end of this century, would make the flooding from ten-year storms (storms expected to arrive, on average, about every ten years) greater than that of last century's 100-year storms.[13] Melting glaciers and the expansion of warming seawater have been raising sea levels worldwide. Figure 7 shows sea level recorded at Portland, Maine, together with global sea level anomalies that follow nearly the same slope.[14]

FIGURE 7. MONTHLY SEA LEVEL AT PORTLAND, MAINE, COMPARED WITH THE YEARLY GLOBAL TREND



Note: Both curves in this graph are drawn with the same vertical scale with different "0" points.

Figure 7 shows New England and global sea levels rising at a relatively slow rate through the twentieth century (around eight inches per century). In the first decade of the twenty-first century, however, the rates of ice loss from Greenland and Antarctica increased, and sea level rose more steeply. The IPCC sea level projections made in 2007 now appear too conservative. Twenty-first century increases on the order of 2.5 to 6 feet appear possible, with correspondingly greater storm flooding.[15]

Oceanographers employ anomalies to estimate global sea level change from tide-gauge records around the world, similar to what climatologists do to estimate global temperature change from weather station data. Error checking and conversion to standard revised local reference (RLR) data occur as raw individual tide-gauge reports from hundreds of places, such as Portland, Maine, are collected by a global databank called the Permanent Service for Mean Sea Level, in England. Further adjustments for geologically rising or subsiding coastlines and calibration with satellite data are part of the careful process for combining tide-gauge based data into estimates of changes in global sea level. Tide gauge or satellite-derived sea level measurements thus provide further indicators, independent of weather stations, showing signs that the world is warming.

New Hampshire's Future Climate

New Hampshire temperature trends have been similar to or steeper than trends seen for the globe as a whole. They are consistent with results from climate models, which have shown that natural forces alone (such as the effects of volcanoes, solar variation, or climate oscillations like El Niño) cannot explain recent global changes in climate.[16] A large body of scientific evidence shows that climate change has been influenced by human activities, including deforestation, land use or urbanization, and the 26 billion tons of carbon dioxide we are adding to the atmosphere each year. The recent warming trend equivalent to about 5.4 degrees Fahrenheit per century observed at First Connecticut Lake (Figure 2) is already approaching twenty-first-century forecasts of six to fourteen degrees Fahrenheit for the northeastern United States.[17]

Climate change has local effects that include not just warming but also shifts in precipitation, seasons, winds, and storms. In addition to already-observed changes in seasonal warming, spring stream flow, snow depth, growing seasons, and bloom dates, we have future projections of shifts, including less snow cover, more frequent droughts, and longer low-steam flow periods in summertime.[18]

Impacts on sea level are among the most obvious local consequences of a warming climate. The 2001 *New England Regional Assessment* and 2007 *Northeast Climate Impacts Assessment* point out others.[19] A 6 degrees Fahrenheit rise in average annual temperature would give Boston the climate of Atlanta. New Hampshire forests have adapted over centuries and millennia to their northern climate but would struggle to adapt now to rapid climate change. Health of forests, animals, and humans would likely suffer from the onslaught of insects formerly checked by cold winters. Low-rain summers are not good for fall foliage or maple syrup, nor do warming winters help winter sports—signature parts of the state's economy.[20] Detailed analyses of how climate changes will affect coastal infrastructure, marine resources, agriculture, winter recreation, forests, birds, and human health are given in several recent reports.[21] The overall pace of change is expected to increase through the century, due to "positive feedbacks," by which warming begets more warming.[22]

Policy Options

What might be done to prevent or soften such changes? U.S. greenhouse gas emissions for many decades outpaced the world. Although China recently surpassed the United States as the highest-volume source, we stand out on a per-person basis. Per-person emissions of carbon dioxide equaled about nineteen metric tons in 2006, so one American had the carbon impact of about one and a half Europeans, four Chinese, or ten Brazilians.[23] With such high levels of consumption, there exists much room for improvement. Better efficiency would bring long-term economic benefits from development and sale of new technologies, as well as lower costs from climate and sea level changes and less dependence on foreign oil. Serious U.S. efforts to reduce emissions would not only clean domestic skies but also strengthen our case for asking (or through technology exports, helping) other nations to reduce their emissions.

The New Hampshire Climate Action Plan, a 2009 report for the state Department of Environmental Services, identified ways in which New Hampshire could boost economic development while at the same time reducing greenhouse gas emissions. The report noted, "The most significant reductions in both emissions and costs will come from substantially increasing energy efficiency in all sectors of our economy, continuing to increase sources of renewable energy, and designing our communities to reduce our reliance on automobiles for transportation."[24]

Better energy efficiencies nationwide could be motivated by government mandates such as automobile and electrical appliance standards and subsidies for new technologies. Alternatively, they might be motivated through higher prices, the market mechanism preferred by some economists.[25] For example, a "carbon tax" on fossil fuels would create market incentives for efficiency that would benefit both the environment and our balance of trade.

This brief began with a look at some results from recent polls of public opinion about climate change. Two years earlier, we had asked some other climate-related questions in a similar New Hampshire poll. One question mentioned a gas tax:

In order to help reduce energy use in the United States and to help slow global warming, some people have proposed that the federal government increase the gas tax by 50 cents per gallon. Do you favor or oppose that proposal, or are you unsure?

The response was strongly negative: 75 percent opposed such a tax, and most of those opposed said they would be "very upset" if the tax occurred anyway. Thus, whatever its theoretical advantages, this policy option faces strong opposition and little public support at present.

New Hampshire citizens, like climate scientists, can see that their climate is changing. More than a century of temperature and other records support this perception. Citizens agree less than most scientists, however, about what is causing climate change. To many people, scientific explanations of the greenhouse effect seem less tangible than the signs of earlier spring. Scientists face challenges in communicating their research to broad audiences. Future Carsey Institute briefs will track public opinion on this issue over time and also look at how it varies from place to place.

Endnotes

1. Pollsters often ask about "global warming," but many scientists prefer to speak of "climate change" instead, because global warming is misunderstood by some non-scientists to imply steady warming all over the globe (giving rise to the objection, "But it's cold here today!"). The scientific research on climate change involves many things besides temperature, such as shifting precipitation; frequencies of storms, droughts, or other extreme events, and even regional cooling in some places while the global average moves up.

2. For a more detailed look at the Granite State Poll results, see Lawrence C. Hamilton, "Do scientists agree about climate change? Public perceptions from a New Hampshire survey," Issue Brief No. 22 (Durham, NH: Carsey Institute, University of New Hampshire, 2010).

3. Other evidence for northern New Englanders' heightened awareness of climate change in their region can be seen in results from a 2007 CERA survey: Lawrence C. Hamilton and Barry D. Keim, "Regional variation in perceptions about climate change," *International Journal of Climatology* 29 (15) (2009): 2348–2352.

4. More detailed studies of climate change in New England or the northeastern United States include the following: K. Hayhoe et al., "Past and future changes in climate and hydrological indicators in the U.S. Northeast," *Climate Dynamics* 28 (4) (2007): 381–401; T. G. Huntington et al., "Climate and hydrological changes in the northeastern United States: Recent trends and implications for forested and aquatic ecosystems," *Canadian Journal of Forest Research—Revue Canadienne de recherche Forestière* 39 (2) (2009): 199–212; NECIA (Northeast Climate Impacts Assessment), *Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment* (Cambridge, MA: Union of Concerned Scientists, 2006); ———, *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions* (Cambridge, MA: Union of Concerned Scientists, 2007); NERA (New England Regional Assessment Group), "Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change," *New England Regional Overview, U.S. Global Change Research Program* (Durham, NH: University of New Hampshire, 2001); Cameron P. Wake et al., eds., "Special Issue: Assessment of Climate Change, Impacts, and Solutions in the Northeast United States," *Mitigation and Adaptation Strategies for Global Change* 13 (5–6) (2008), 419–660.

5. All of the climate data used in this report are freely available to the public. The NASA global temperature anomaly index, called GISTEMP, is published here: http://data.giss.nasa.gov/gistemp/; United States Historical Climatology Network (USHCN) weather station data are available from their Web site: http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.html.

6. For panoramic views of the First Connecticut Lake site, which is far from urban heat, see http://gallery.surfacestations.org/main.php?g2_itemId=4622.

7. Smooth curves shown in Figures 2–7 were calculated by a statistical method called lowess regression, with bandwidths set at 30 to 60 percent of the data (narrower bandwidths were used with longer records). For a practical introduction to lowess smoothing, see Lawrence C. Hamilton, *Statistics with Stata*, updated for version 10 (Belmont, CA: Brooks/Cole, 2009), 233–236.

8. The mid-century cooling seen in New Hampshire and global data has been a subject of detailed research. In the years during and after World War II, airborne pollutants measurably reduced the amount of sunlight reaching the earth's surface, particularly in northern mid-latitudes. This "dimming" effect temporarily offset the warming influence of carbon dioxide, which was steadily increasing. After the 1970s, reductions in air pollution over Europe and North America let more sunlight through, carbon dioxide continued to build up, and global temperatures began rising again. For an example, see M. Wild, A. Ohmura, and K. Makowski, "Impact of global dimming and brightening on global warming," *Geophysical Research Letters* (2007): doi:10.1029/2006GL028031.

9. Northern and southern New Hampshire winter temperatures were estimated for Figure 3 by averaging the USHCN stations within each region, as suggested (in preference to possibly biased U.S. Climate Division

summaries) by Barry D. Keim, et al., "Are there spurious temperature trends in the United States Climate Division database?" *Geophysical Research Letters* 30 (7) (2003): 1404–1408. For a more detailed analysis of northeastern winter climate trends, see E. A. Burakowski et al., "Trends in Wintertime Climate in the Northeast United States, 1965–2005," *Journal of Geophysical Research*. 113 (2008): D20114, doi:10.1029/2008JD009870.

10. T. G. Huntington et al., "Changes in the proportion of precipitation occurring as snow in New England (1949–2000)," *Journal of Climate* 17 (2004): 2626–2636.

11. Ice-out dates are defined by local observation and custom but have been recorded for more than a century. For example, according to www.winnipesaukee.com, "Ice-Out on Lake Winnipesaukee occurs when the ice that has covered the Lake since late December or early January melts enough to allow the M/S Mount Washington cruise ship to navigate between Alton Bay, Center Harbor, Weirs Beach, Meredith and Wolfeboro." For more information about Lake Winnipesaukee, see http://www.winnipesaukee.com/index.php?pageid=iceout; For the ice-out on Lake Sunapee, see http://www.town.sunapee.nh.us/Pages/SunapeeNH_Clerk/ice.

12. For a more comprehensive study of ice-out dates across New England, see G. A. Hodgkins, I. C. James III, and T. G. Huntington, "Historical changes in lake ice-out dates as indicators of climate change in New England, 1850–2000," *International Journal of Climatology* 22 (2002): 1819–1827.

13. New Hampshire Department of Environmental Services, "Sea level rise," New Hampshire Department of Environmental Services. http://des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/sea_level.htm (accessed May 31, 2010); I. G. Ward and J. R. Adams, *A Preliminary Assessment of Tidal Flooding Along the New Hampshire Coast: Past, Present, and Future*, Final report submitted to the New Hampshire Office of Emergency Management and the Office of State Planning, 2001, http://des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/sea_level_rise_report.pdf.

14. Portland values graphed are RLR (revised local reference) data minus 7,000, from Proudman Oceanographic Library, "Permanent Service for Mean Sea Level," Proudman Oceanographic Library, http://www.pol.ac.uk/psmsl/datainfo/ (accessed July 21, 2010); For global sea level, our source is J. A. Church and N. J. White, "A 20th century acceleration in global sea-level rise," *Geophysical Research Letters* 33 (2006): doi:10.1029/2005GL024826; For an update and more about global sea level index, see http://www.psmsl.org/products/reconstructions/church.php; Purely satellite-based data showing sea level rise since 1992 is available from the University of Colorado at http://sealevel.colorado.edu/results.php.

15. M. Vermeer and S. Rahmstorf, "Global sea level linked to global temperature," Proceedings of the National Academy of Sciences, http://www.pnas.org/content/106/51/21527.full.

16. Intergovernmental Panel on Climate Change, "Climate Change 2007—The Physical Science Basis," Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge: Cambridge University Press, 2007).

17. NECIA, *Climate Change in the U.S. Northeast*, 2006.

18. K. Hayhoe et al., "Past and future changes in climate," 2007; NECIA, *Climate Change in the U.S. Northeast*, 2006.

19. NERA, "Preparing for a Changing Climate," 2001.

20. Lawrence C. Hamilton et al., "Warming winters and New Hampshire's lost ski areas: An integrated case study," *International Journal of Sociology and Social Policy* 23 (10) (2003): 52–73; Lawrence C. Hamilton, B. C. Brown, and Barry D. Keim, "Ski areas, weather and climate: Time series models for New England case studies," *International Journal of Climatology* 27 (2007): 2113–2124; T. G. Huntington et al., "Climate and hydrological changes," 2009.

21. T. G. Huntington et al., "Climate and hydrological changes," 2009; NECIA, *Climate Change in the U.S. Northeast*, 2006; Cameron P. Wake et al., eds., "Special Issue," 2008.

22. For example, warming sea and air temperatures have dramatically reduced summer ice cover on the Arctic Ocean. White ice reflects sunlight and insulates the ocean, whereas dark water absorbs heat and warms up. Thus, reduction of Arctic summer ice is changing the heat balance of the planet, which in turn affects winds, currents, and weather to the south.

23. United Nations, "Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita (CDIAC)," United Nations Statistics Division, Department of Economic and Social Affairs, http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=.

24. New Hampshire Climate Change Policy Task Force, *The New Hampshire Climate Action Plan* (Concord, NH: New Hampshire Department of Environmental Services, 2009),

http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/documents/nhcap_final.pdf.

25. For example, M. Chinn, "Getting serious about the twin deficits" (New York: Council on Foreign Relations, 2005), http://www.cfr.org/content/publications/attachments/Twin_DeficitsTF.pdf.

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WINTER 2010

Ocean Views: Coastal Environmental Problems as Seen by Downeast Maine Residents

THOMAS G. SAFFORD AND LAWRENCE C. HAMILTON

Through the Community and Environment in Rural America (CERA) initiative, Carsey Institute researchers have conducted surveys in selected regions across the United States. The goal is to learn how a broad cross section of Americans view the social and environmental changes affecting their lives and rural communities. We report here on the environmental views of 1,500 residents in two rural counties along the northeast coast of Maine. This region has historically depended on fisheries and forestry but more recently has experienced growth in tourism and second homes, making both traditional and new economic activities dependent on environmental conditions.

Most respondents express at least some concern about the impact on their family or community of environmental problems, such as pollution of beaches, contamination of seafood, depletion of fishery resources, and rising sea levels. Across a wide range of environmental issues, political party affiliation is associated with level of concern about environmental problems. Nonetheless, some degree of consensus exists over government responses to these problems. In a question asking whether the government should be doing more or less to regulate commercial fishing and lobstering, the most common answer was that government regulators should "leave the rules as they are"—even among those who work in the fishing industry. These findings suggest that managers and public officials should consider ways to more effectively use existing regulations to address coastal environmental problems while supporting the communities that depend on marine resources for their economic and social well-being.

Key Findings:

In August and September 2000, Carsey Institute researchers surveyed 1,500 residents of northeastern (Downeast) Maine about coastal environmental issues and government efforts to address them. Key findings include the following:

- **Loss of fishing jobs or income ranks highest among environment-related issues affecting the respondents' communities (Figure 1).**
- **Water pollution, loss of forestry jobs, sprawl or rapid development of the countryside, and climate change also rank high (Figure 1).**
- **The coastal environmental problems that most concern Downeasters are pollution of beaches or shellfish beds, contamination of seafood, and overfishing (Figure 2).**
- **Most respondents express some concern about environmental issues, but a significant partisan division exists. Across all issues, those who self-identify as Republicans are less concerned than Democrats or Independents (Figure 3).**
- **Regarding government regulation of commercial fishing or lobstering, more people of all political persuasions favor leaving the rules as they are rather than regulating either more or less (Figures 4-5).**

The Changing Face of Rural Coastal Communities

From the Atlantic to the Pacific, coastal regions of the United States are coping with dramatic social and environmental changes. Coastal counties are home to 53 percent of the nation's population, yet, excluding Alaska, they account for only 17 percent of land area in the United States.[1] Nonetheless, most of this population is concentrated near urban centers, and a significant portion of America's coast retains its rural character. The desirability of living and vacationing on the coast has made these rural areas targets for development, drawing new residents and economic activities to previously isolated communities.

Alongside these demographic and economic shifts have come alterations in coastal and marine environments. Changing ocean and climate conditions, together with inad-

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equate management strategies, have led to sharp declines in harvestable marine resources. In addition, expanding development has damaged sensitive estuarine and coastal habitats, while both air- and waterborne pollutants have impaired the aquatic ecosystems on which human and biological communities depend.[2] Policy makers and community leaders struggle to find adequate responses to the scale, complexity, and speed of these changes. Understanding how residents of rural coastal communities view these emerging social and environmental problems will help to inform both governance and management decision making.

Since 2007, researchers at the Carsey Institute of the University of New Hampshire have been investigating these types of changes through the CERA initiative. The CERA research team is conducting surveys and analyzing socioeconomic and environmental trends to better understand common patterns across rural America. A key goal of this effort is to provide decision makers and community organizations with information that can assist in promoting social and environmental resilience.

CERA's initial stages in 2007 and 2008 included random-sample telephone surveys with 8,800 residents in twenty-four rural counties in ten states across America.[3] In the summer of 2009, Carsey researchers began a new phase, looking specifically at coastal communities. As a first step, we surveyed 1,500 residents of two rural coastal counties (Hancock and Washington) in Maine to gauge their views on social and environmental conditions in their region. This policy brief presents initial findings from the survey, highlighting important patterns in community perceptions of economic changes, marine environmental issues, and potential policy solutions.

The Social Importance of Marine Resources in Maine

The coast of Maine is a microcosm of broader social and environmental change in rural coastal communities across the United States. The two easternmost counties, Hancock and Washington, make up what is known locally as Downeast Maine. This region is composed primarily of small towns scattered along the coast and neighboring islands. In 2008, the population of Hancock County was 53,137, while Washington County's population was 32,499.[4] Current economic conditions in this area are mixed. In 2008, 12.6 percent of Maine residents lived below the poverty line. In comparison, Washington County had the most severe poverty in the state, with 19.4 percent of the population living below the poverty line, while Hancock County fell slightly below the state average at 10.0 percent.[5]

Historically, fishing and marine commerce have been the lifeblood of the Downeast region. Today they represent a decreasing share of the economy, but the docks and fishing boats along the shore are emblematic of coastal Maine's identity. Rapid increases in tourism, declining fisheries, and growing threats from pollution are bringing both social and environmental change to Downeast towns and villages. Figure 1 outlines Hancock County and Washington County residents' views of how an array of environment-related issues have affected their communities.

FIGURE 1: HAVE THESE ENVIRONMENTAL ISSUES HAD NO EFFECT, MINOR EFFECTS, OR MAJOR EFFECTS ON YOUR FAMILY OR COMMUNITY OVER THE PAST FIVE YEARS?

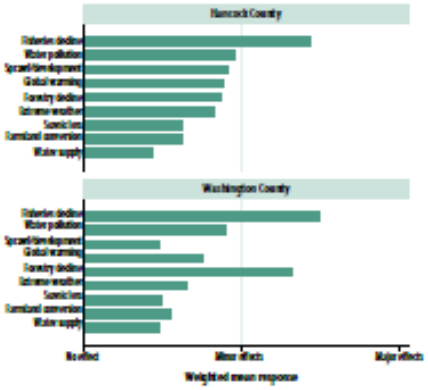


Figure 1 shows that people from both counties most frequently cited "loss of fishing jobs or income" as an issue affecting their family or community. Among Washington County respondents, where forestry remains an important part of the economy, "loss of forestry jobs or income" came in a close second to fisheries. Survey responses indicate that water pollution and the impacts of sprawl and development also are substantial concerns, particularly in Hancock County where scenic areas around Acadia National Park have fueled growth in tourism and new housing development.

Maine has the highest percentage of housing units classified as second homes (15.6 percent) in the United States.[6] Although most seasonal homes are in southern Maine near metropolitan centers, second homes are becoming widespread in the more distant Downeast counties as well. Of the state's sixteen counties, Hancock is among the three fastest growing, driven partly by second-home development. The county now has more than 10,000 seasonal housing units.[7] Washington County remains one of the areas least affected by this trend, but interest in coastal properties has meant that even in this remote coastal area of Maine, the effects of development are arriving. The survey results show that residents of both counties are concerned with declines in

traditional extractive industries and changing patterns of development, which have implications for how they view marine environmental concerns and policy responses.

The Social and Environmental Implications of Economic Change in Coastal Maine

Local concern about the loss of fishing jobs and pollution effects on water resources reflects changing socioeconomic and environmental conditions in Hancock and Washington counties. Maine's fishing industry has declined dramatically in the past thirty years, and the declines have been especially difficult for rural Downeast communities, which are considered to be the most fishery-dependent in all of New England.[8] Cod harvests, one of Maine's most important commercial species, have fallen in value from over $16 million in 1991 to $3.7 million in 2008. Sea scallops have declined from $15 million in 1981 to $1.2 million in 2007.[9] Depletion of fish resources is considered a serious problem. In New England, numerous fish stocks, such as Georges Bank cod, have been found to be overfished and in need of rebuilding.[10] Internationally, the United Nations Food and Agriculture Organization reports that 52 percent of fisheries stocks worldwide are "fully exploited," meaning no expansion is possible without collapsing the resource, and a further 27 percent are overexploited, depleted, or recovering from overexploitation.[11]

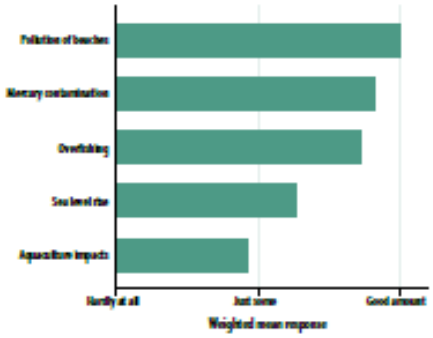
Although the most severe drops in fish harvests occurred in the late 1990s, the last three years have seen continued steady declines in both Hancock and Washington counties.[12] Even lobster, which has been Downeast Maine's most stable fishery, has declined both in pounds caught and total value from 2006 to 2008.[13] Although the number of vessels and individuals involved in fishing has stabilized in recent years, overfishing remains a concern. Federal, state, and local government officials have struggled to find methods for managing fisheries that meet the needs of fishing communities while also sustaining marine ecosystems.

As fishing in Downeast Maine declines, other coastal and ocean-related enterprises have become increasingly important. The scenic beauty of the coast attracts thousands of visitors to the region, and tourism is now one of the most important industries in eastern Maine. Hancock and Washington counties have also experienced significant growth in both salmon and shellfish aquaculture. This industry has brought needed revenue and jobs to the fishing sector. However, studies have uncovered new environmental problems resulting from the effluent of fish farming operations.[14] In addition, some residents and coastal towns have raised questions about whether aquaculture operations might affect the scenic qualities of the area and thus impact tourism.

Pollution from aquaculture operations is not the only environmental problem in coastal Maine. Many scientific reports, from local to global in scale, have documented worrisome levels of mercury, dioxin, and other contaminants in fish and the potential health effects on humans.[15] Contaminants such as PCBs, dioxin, and mercury have been found in ocean fish, such as striped bass, bluefish, and tuna.[16] Red tide algal blooms, linked to changing climatic conditions, have affected commercial and recreational shellfish harvesters across the state. In Downeast Maine, concerns about waterborne pollutants have led to closures of shellfish beds and affected aquaculture operations.[17] These pollution issues are important concerns in small communities that rely heavily on harvesting blue mussels, quahogs, periwinkles, and soft-shell clams.[18]

The CERA survey asked several questions to assess the extent of concern among Downeast residents regarding these emerging marine issues (Figure 2).

FIGURE 2: WOULD YOU SAY THAT YOU ARE CONCERNED ABOUT THESE OCEAN-RELATED ISSUES HARDLY AT ALL, JUST SOME, A GOOD AMOUNT, OR A GREAT DEAL?



The greatest concern among those surveyed is pollution's impact on beaches and clam beds followed by contamination of seafood and depletion of fisheries by overfishing. Rising sea levels due to global warming worries fewer people. Adverse impacts of fish farming ranks lowest among the possible problems we posed to respondents. Concern about overfishing tends to be greater among residents of coastal than inland towns, likely reflecting the connections of these communities to fishing. Hancock County residents are generally more concerned than those from Washington County about the other marine issues in Figure 2. This finding may in part reflect the larger number of tourism-related businesses in Hancock County, which could be heavily affected by adverse environmental changes.

The CERA team also examined whether different segments of these communities share similar levels of concern. For example, we consistently found political party preference to be the strongest predictor of concern about environmental issues. Earlier CERA surveys had, less surprisingly, detected partisan divisions over the nationally debated topic of global warming. However, we did not expect to find similar divisions on more local topics, such as beach pollution or seafood contamination in Downeast Maine. A clear partisan pattern nevertheless emerges across all five of our ocean-related issues. On each issue, Republicans express lower levels of concern than Independents or Democrats do, as seen in Figure 3a–e. For comparison, Figure 3f depicts responses to a general question about global warming, another environmental challenge that, through weather, sea level, and ecosystem effects (including fishery declines and red tides), could impact these coastal communities substantially in the future.

FIGURE 3A–E: WOULD YOU SAY THAT YOU ARE CONCERNED ABOUT THESE OCEAN-RELATED ISSUES HARDLY AT ALL, JUST SOME, A GOOD AMOUNT, OR A GREAT DEAL?

Figure 3A: Pollution of beaches and clam beds

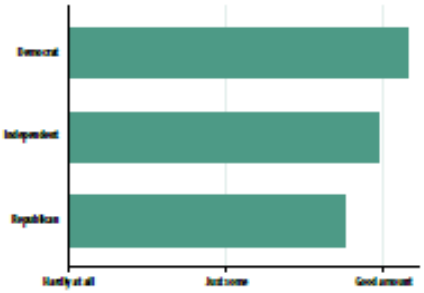


Figure 3B: Mercury contamination of seafood

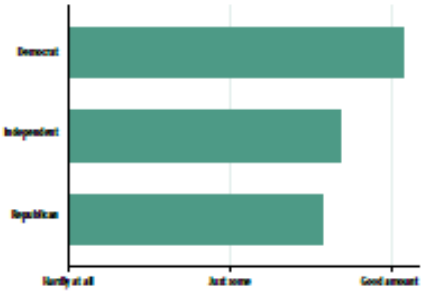


Figure 3C: Depletion of fish through overfishing

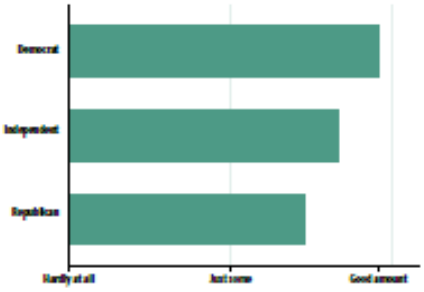


Figure 3D: Rise in sea level due to climate

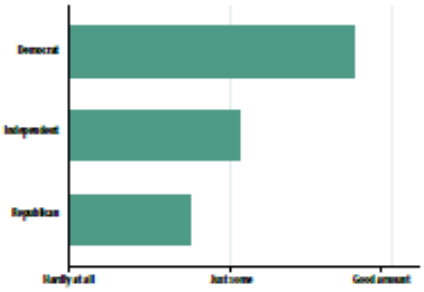


Figure 3E: Environment/scenic impacts of aquaculture

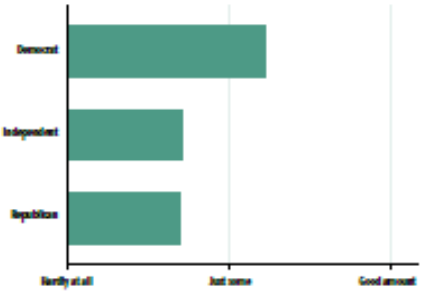


FIGURE 3F: DO YOU BELIEVE THAT GLOBAL WARMING WILL POSE A SERIOUS THREAT TO YOU OR YOUR WAY OF LIFE IN YOUR LIFETIME?

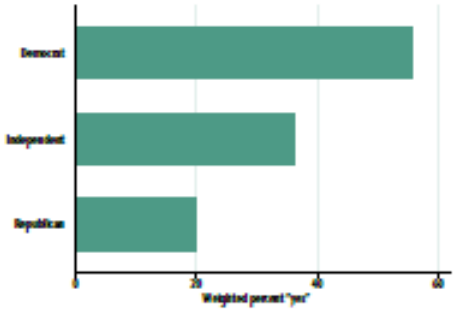
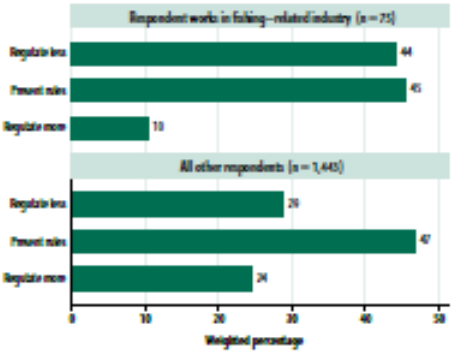


FIGURE 4: DO YOU THINK THE GOVERNMENT SHOULD DO MORE TO REGULATE COMMERCIAL FISHING AND LOBSTERING, SHOULD IT DO LESS, OR SHOULD IT LEAVE THE RULES AS THEY ARE?



The relationships seen in Figure 3 between political party identification and levels of concern about marine environments remain statistically significant even after we account for age, gender, education, and other background factors. This partisan divide will have implications for policy makers as they seek community-wide participation in responding to both economic and environmental challenges.

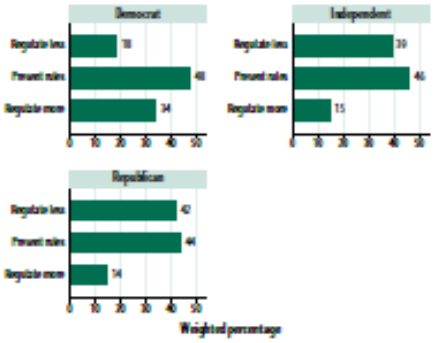
Policy Responses to Marine Environmental Concerns

Survey results in Figures 1, 2, and 3 reveal considerable concern among Downeast residents of all party affiliations about water pollution and the contamination of beaches and clam beds. The greater agreement regarding pollution suggests this is one area where policy makers and community members can find common ground on developing solutions. The considerable concern about loss of fishing jobs and the impacts from overfishing, however, creates a conundrum for fishery managers who want to maintain the economic viability of fishing while also ensuring the sustainability of the resource. The economic downturn in the fishing industry, as well as the depletion of fisheries resources, both seem to call for government intervention. To assess how Downeasters view potential government action, we asked respondents whether they favored more or less government regulation of commercial fishing. Results are in Figure 4.

Despite the broad concern about both economic and environmental conditions related to fishing, a majority of respondents believe fishery regulations should remain unchanged. Those who work in fisheries are much more likely than others to believe the government should regulate less. However, relatively few people in the random sample of respondents (fewer than 5 percent) say they or a member of their family works in a fishing-related industry. A minority thinks that additional regulation is needed, but this opinion is more than twice as common among those not involved in fishing-related industries.

Residents in Hancock and Washington counties differ little in their views about fisheries regulation. There are distinctions, however, along party lines. Overfishing and fisheries management have not been prominent in mainstream political discussions, but more versus less government regulation certainly has been. It is therefore perhaps not surprising that the partisan divide over government regulation in general carries over to the specific topic of fisheries, even in places that have experienced firsthand the precipitous declines in fish stocks. Figure 5 illustrates that, as with concerns about overfishing (Figure 3c), party affiliation also strongly influences views on government regulation of fisheries.

FIGURE 5: DO YOU THINK THE GOVERNMENT SHOULD DO MORE TO REGULATE COMMERCIAL FISHING AND LOBSTERING, SHOULD IT DO LESS, OR SHOULD IT LEAVE THE RULES AS THEY ARE?



Only 18 percent of respondents who identified with the Democratic Party favor less fisheries regulation, whereas 34 percent favor more. In contrast, 42 percent of Republicans favor less regulation, and only 14 percent favor more. Although there are clear differences in residents' views along party affiliation, the relatively high degree of support for maintaining current fishing rules suggests that government officials should focus on more effectively using existing regulations to achieve socioeconomic as well as conservation goals.

The Future of Rural Coastal Communities in Maine

The rapid development of coastal areas across the United States has brought significant social and economic change, as well as new environmental problems. Just as traditional agricultural communities have struggled with their new suburban character, rural coastal communities face previously unknown challenges as second-home development and tourism increase. Changes in Downeast Maine are emblematic of these national patterns. The character of this region is still strongly tied to extractive industries, making the loss of fishing or forestry jobs sharply felt. In areas experiencing development, sprawl is increasingly worrisome, as it threatens scenic areas that attract thousands of visitors to the region. Aquaculture is also an important new component of the economy of coastal Maine, and both the environmental and social implications of these operations require further study.

Potential impacts of pollution and seafood contamination are of broad concern. These are areas where civic groups and governmental agencies could find common ground and work toward addressing the sources. Fishing-related issues, on the other hand, appear more divisive and challenging. Fishing's importance economically and culturally underlines the potential troubles raised by overfishing and the impacts of extractive activities on marine ecosystems. The survey results indicate that although there is general opposition to additional regulations, most Downeast residents prefer to maintain existing fishery management regimes. This leaves open the door for policy makers and community groups to work within existing regulatory frames to devise novel solutions to the economic and environmental challenges related to fishing.

In recent years, federal, state, and local managers have struggled to find a model for managing fisheries that meets the needs of fishing communities and sustains marine ecosystems. Increased community engagement and local input into management activities and decision making has been proposed as a pathway to more effective solutions. At the present time, the National Marine Fisheries Service is working with fishermen and community and governmental leaders in the region to forward new "area management" approaches that would directly engage fishers in devising and overseeing locally relevant management strategies within existing regulatory frameworks.[19] The CERA results appear encouraging for this approach given that Downeast Maine residents and those involved in fishery-related industries, in particular, oppose additional government regulation of fishing.

Finally, one of the most challenging aspects of social and environmental change in Downeast Maine is the emerging partisan divide. Growing polarization in public support for environmental protection has been apparent on national surveys since the late 1990s, as campaigns by conservative political leaders and activists have reshaped environmental issues, such as climate change and land conservation, into political wedge issues. Arguments against taking climate change seriously, in particular, became the focus of hundreds of conservative-movement documents, accompanied by press conferences, policy forums, media presentations, and congressional testimony.[20] Our Maine survey suggests that the national campaigns are having local impacts. That opinions about regional problems as diverse as contamination of seafood, overfishing, and loss of scenic beauty fall along partisan lines suggests that the national dialogue shapes opinions about not only global issues, such as climate change, but also community-level concerns, such as beach pollution.

For local leaders and policy makers, this division introduces new challenges as they attempt to engage communities in addressing environmental problems. A partisan divide regarding the importance of regulation in the management of marine fisheries is not surprising. However, the observations that overfishing and seafood contamination are becoming

partisan issues suggests that efforts to merely educate individuals about the existence of environmental problems will not be enough to build consensus on solving them. Government efforts promoting local engagement in environmental management may have greater success given that they build on shared values regarding the social and natural character of coastal Maine communities. Ongoing research under the CERA initiative will continue to map this terrain, examining realities and perceptions about socioeconomic and environmental change in these and other rural coastal communities.

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Understanding climate impacts on recruitment and spatial dynamics of Atlantic cod in the Gulf of Maine: Integration of observations and modeling

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ABSTRACT

We put forward a combined observing and modeling strategy for evaluating effects of environmental forcing on the dynamics of spatially structured cod populations spawning in the western Gulf of Maine. Recent work indicates at least two genetically differentiated complexes in this region: a late spring spawning, coastal population centered in Ipswich Bay, and a population that spawns in winter inshore and on nearshore banks in the Gulf of Maine and off southern New England. The two populations likely differ in trophic interactions and in physiological and behavioral responses to different winter and spring environments. Coupled physical–biological modeling has advanced to the point where within-decade forecasting of environmental conditions for recruitment to each of the two populations is feasible. However, the modeling needs to be supported by hydrographic, primary production and zooplankton data collected by buoys, and by data from remote sensing and fixed station sampling. Forecasts of environmentally driven dispersal and growth of planktonic early life stages, combined with an understanding of possible population-specific predator fields, usage of coastal habitat by juveniles and adult resident and migratory patterns, can be used to develop scenarios for spatially explicit population responses to multiple forcings, including climate change, anthropogenic impacts on nearshore juvenile habitat, connectivity among populations and management interventions such as regional fisheries closures.

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1. Introduction

One objective of recent initiatives to establish observing systems for the coastal ocean in the United States (e.g., NOPP, 2006) is acquisition of observing data for application in ecosystem approaches to fisheries management. The 2006 Magnuson Stevens Fishery Conservation and Management Reauthorization Act (Section 406) calls for a study of the "state of the science for advancing the concepts and integration of ecosystem considerations

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in regional fishery management". While the need for including environmental change (and by implication, climate change) in management decision making has been identified, the integration and interpretation of environmental data into useful products for fisheries managers has remained an elusive goal (National Marine Fisheries Service, 2009).

A major pathway through which environmental change influences fish population dynamics links bottom-up forcing to recruitment processes (Cushing, 1982; Runge, 1988). Evidence indicates that environmental forcing has a large influence on recruitment variability in groundfish and pelagic fish stocks in the northwest Atlantic, implying that such forcing is an important factor to incorporate into regional fishery management (Fig. 1). For example, Castonguay et al. (2008) report that mackerel recruitment in the southern Gulf of St. Lawrence is significantly related to copepod egg production rate (Fig. 1a), a proxy for availability of nauplius stages to the planktonic mackerel larvae. Using available satellite ocean color data, Platt et al. (2003) estimated the timing of the spring phytoplankton bloom on the Nova Scotia shelf. They found that the highest recruit per spawner indices for Scotian Shelf haddock, including the exceptional years of 1981 and 1999, occurred when the spring bloom was initiated unusually early (Fig. 1b). These observations are consistent with the match–mismatch (Cushing, 1990) and growth–mortality hypotheses (Anderson, 1988; Cushing and Horwood, 1994). The common theme of both hypotheses is that food availability during the period of planktonic larval feeding determines how many and how quickly larvae pass through the window of high mortality rates. These hypotheses imply that variability of relative year class strength is usually determined in the larval phase (Myers and Cadigan, 1993). For both the Scotian Shelf haddock and southern Gulf mackerel populations, auspicious conditions for planktonic food availability were linked to the formation of exceptional year classes, which can sustain fisheries for many subsequent years.

While prey availability may be a necessary condition for determining larval survival, recruitment to any fish population involves complex processes that may either counteract or enhance the link of planktonic prey production with growth and survival of larvae. For example, the recent strong year classes of Georges Bank haddock, including the exceptional 2003 year class, are strongly correlated with the magnitude of the fall phytoplankton bloom preceding the successful year class (Fig. 1c, from Friedland et al., 2008). This correlation is consistent with a hypothesis that high and prolonged fall blooms sustain benthic food production (brittle starfish, amphipods and polychaetes) for adult haddock, which in turn enhances adult condition, fecundity and egg quality, leading to higher larval survival. Alternatively, increases in copepod egg production driven by the higher fall–winter primary production (e.g., Durbin et al., 2003; Greene and Pershing, 2007) may have contributed to higher growth and enhanced survival of planktonic haddock larvae. In either case, the evidence points to forcing by climatic variability acting on bottom-up processes. Change in

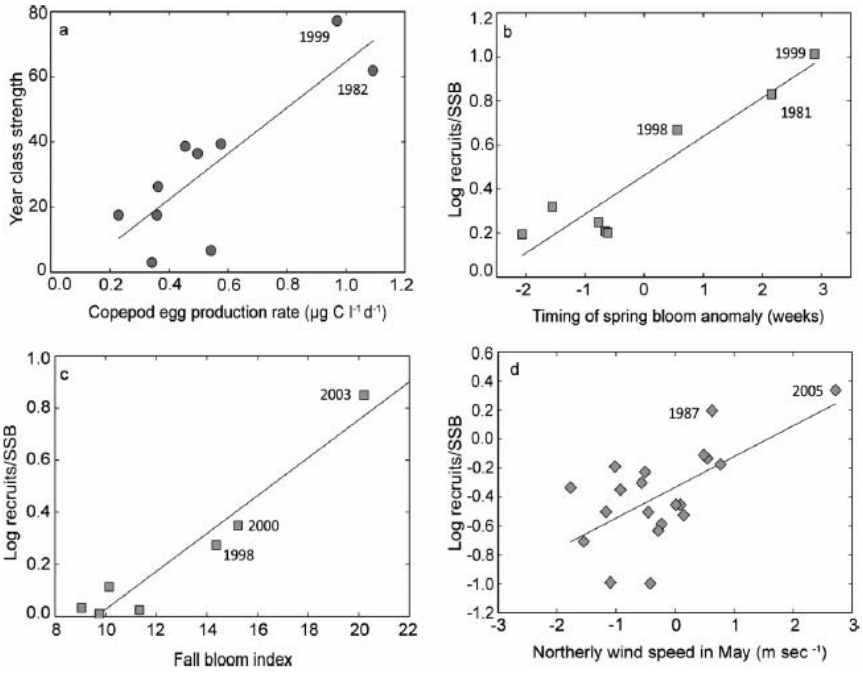

Fig. 1. Evidence for strong linkage between environmental conditions and fish recruitment in the coastal northwest Atlantic. (a) Mackerel recruitment (estimated from year class strength of corresponding 3-year olds, as percentage of total population) in the southern Gulf of St. Lawrence is related to total copepod egg production rate during the larval feeding period. The data include two exceptional year classes of 1982 and 1999 (adapted from Castonguay et al. (2008)). (b) Recruits per spawner index (log transformed) of Scotian Shelf haddock (including exceptional year classes in 1981 and 1999) is correlated with the timing of the spring bloom, estimated from analysis of satellite images of sea surface color (adapted from Platt et al. (2003)). (c) Recruits per spawner index (log transformed) of Georges Bank haddock (including the exceptional year class in 2003) is related to the magnitude of the fall phytoplankton bloom prior to spawning (adapted from Friedland et al. (2008)). (d) Recruits per spawner index (log transformed) of western Gulf of Maine Atlantic cod (including strong year class in 2005) is related to downwelling winds in May between 1985 and 2005 (adapted from Churchill et al. (in press)). All regression lines are significant ($P \leqslant 0.003$).

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predation pressure during fish early life history, at the egg, larval or juvenile stage, may also influence recruitment success. This may result from changes to the abundance and diversity of predators at interannual or longer time scales or at seasonal scales related to changes in timing of spawning and hatch (e.g. Fortier and Quiñonez-Velazquez, 1998; Wieland et al., 2000; Lapolla and Buckley, 2005; Husebø et al., 2009). These changes may be related to variability in environmental forcing, but not necessarily.

In addition to biological factors influencing early life stage survival, recruitment success may be directly related to physical processes in the atmosphere and ocean (Hjort, 1914; Sinclair, 1988). Eggs and larvae spawned along the coastal Gulf of Maine are subject to advection by the southwestward coastal Gulf of Maine current. There is significant potential for interannual to inter-decadal variation in wind forcing, freshwater runoff, and hydrographic conditions external to the Gulf to affect dispersal of the planktonic cod eggs and larvae and successful transport to nursery areas. In the Gulf of Maine, Churchill et al. (in press) found a significant correlation between Atlantic cod recruitment success and mean velocity of northerly winds during the May spawning period (Fig. 1d), consistent with the hypothesis that wind-driven downwelling favors transport of buoyant planktonic larvae to nearshore nursery areas where juvenile survival is enhanced.

The complex set of processes determining larval survival mandates the use of integrative models to better understand and predict the consequences of change in environmental conditions on recruitment success and connectivity among populations. An approach was developed in the GLOBEC (Global Ocean Ecosystem Dynamics: http://web.pml.ac.uk/globec) program, in which physically-forced biological models of varying trophic level resolution were used to develop a mechanistic understanding of underlying correlations between environmental variability and fish productivity (GLOBEC, 1992; Wiebe et al., 2002; de Young et al., 2004). Runge et al. (2005) discuss the concept of an integrative system of linked, coupled physical–biological models (LCMs: Fig. 2). They review the status of, and challenges confronting, each coupled physical biological component.

Here we explore the feasibility of using coupled physical–biological models as an integrative tool for understanding climate forcing of Atlantic cod and other fish populations, using the Atlantic cod stock in the Gulf of Maine as an example. Drawing on results of the GLOBEC Georges Bank/Northwest Atlantic program and other research in the Gulf of Maine over the past decade, we review the present status of coupled physical–biological modeling as it applies to Atlantic cod in the western Gulf of Maine ecosystem. We examine existing observing data and explore the potential for the future regional observing system to supply data needed for model development, operation and validation. We develop a vision for integration of observing activities with coupled physical–biological modeling to provide forecasts of environmental conditions for recruitment in the context of the present understanding of the spatial structure of the Gulf of Maine Atlantic cod stock. As detailed below, there is evidence of genetically distinct populations within the Gulf of Maine cod stock, leading us to consider recruitment processes as part of the broader spatial dynamics of Gulf of Maine Atlantic cod, including population-specific juvenile habitat and connectivity among populations.

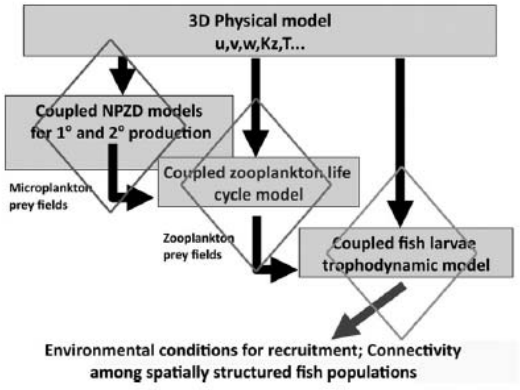

Fig. 2. Proposed structure for a system of linked, coupled physical–biological models to integrate data from observing systems, experimental studies and process oriented field studies. The rhomboids represent focus of each coupled model on one of three broad trophic levels, as discussed in de Young et al. (2004) and Runge et al. (2005).

2. The structure of Atlantic cod in the Gulf of Maine

Recently, a paradigm shift has occurred in the conceptualization of population structure of marine species (Hauser and Carvalho, 2008). Populations of many marine species traditionally viewed as panmictic, with high connectivity, have now been shown to exhibit population structure on fine geographic and temporal scales. Population subdivision on small spatial scales has been well documented for Atlantic cod across its range. For example, along the Norwegian Skaggerak coast, genetically distinct resident populations of cod have been detected within distances of <50 km (e.g., Jorde et al., 2007). Furthermore, there is now evidence of four genetically distinct populations of Atlantic cod in the North Sea (Hutchinson et al., 2001), and of at least two distinct spawning components occurring in waters surrounding Iceland (e.g., Pampoulie et al., 2006). The findings of these and other genetic studies show Atlantic cod to be a population-rich species (Sinclair, 1988).

In the Gulf of Maine, Atlantic cod populations also appear to be structured on a fine scale, via the presence of spatially and temporally divergent spawning populations, some of which are genetically distinct (Wirgin et al., 2007; Kovach et al., 2010). Analysis of historical data by Ames (2004) suggests that there were once multiple sites of cod spawning along the Gulf of Maine coast. These spawning aggregations could be indicative of a number of subpopulations or one larger mixed population with multiple spawning sites. The number of active spawning sites has contracted considerably over the past few decades, however. Currently, known sites of consistently active spawning within U.S. waters (the Gulf of Maine, southern New England, and Georges Bank region) are limited to Ipswich Bay, Massachusetts Bay, Nantucket Shoals/ Chatham, Block Island/Cox Ledge, and the northeastern flank of Georges Bank (Lough et al., 2005; Fig. 3). Small spawning aggregates are also found on nearshore banks in the western Gulf of Maine, such as Stellwagen Bank and Jeffreys Ledge.

Recent research using microsatellite and single nucleotide polymorphism DNA markers reveal that the majority of the genetic variation among cod spawning populations in the Gulf of Maine stock can be explained by two major groupings: a northern spring coastal complex and a southern complex (Kovach et al., 2010; Fig. 3). The northern spring complex spawns in coastal Gulf of Maine waters from Massachusetts Bay to Bigelow Bight in the spring and summer. The southern complex spawns within the inshore Gulf of Maine in the winter, and also at different offshore locations and seasons within the Gulf of Maine and southern New England waters. Thus, these temporally divergent spawning groups overlap spatially: cod that spawn in Ipswich and Massachusetts Bays in the spring are genetically distinct from cod that spawn in the same bays in the winter. A third population representing the Georges Bank stock spawns on the northeast peak of Georges Bank in the

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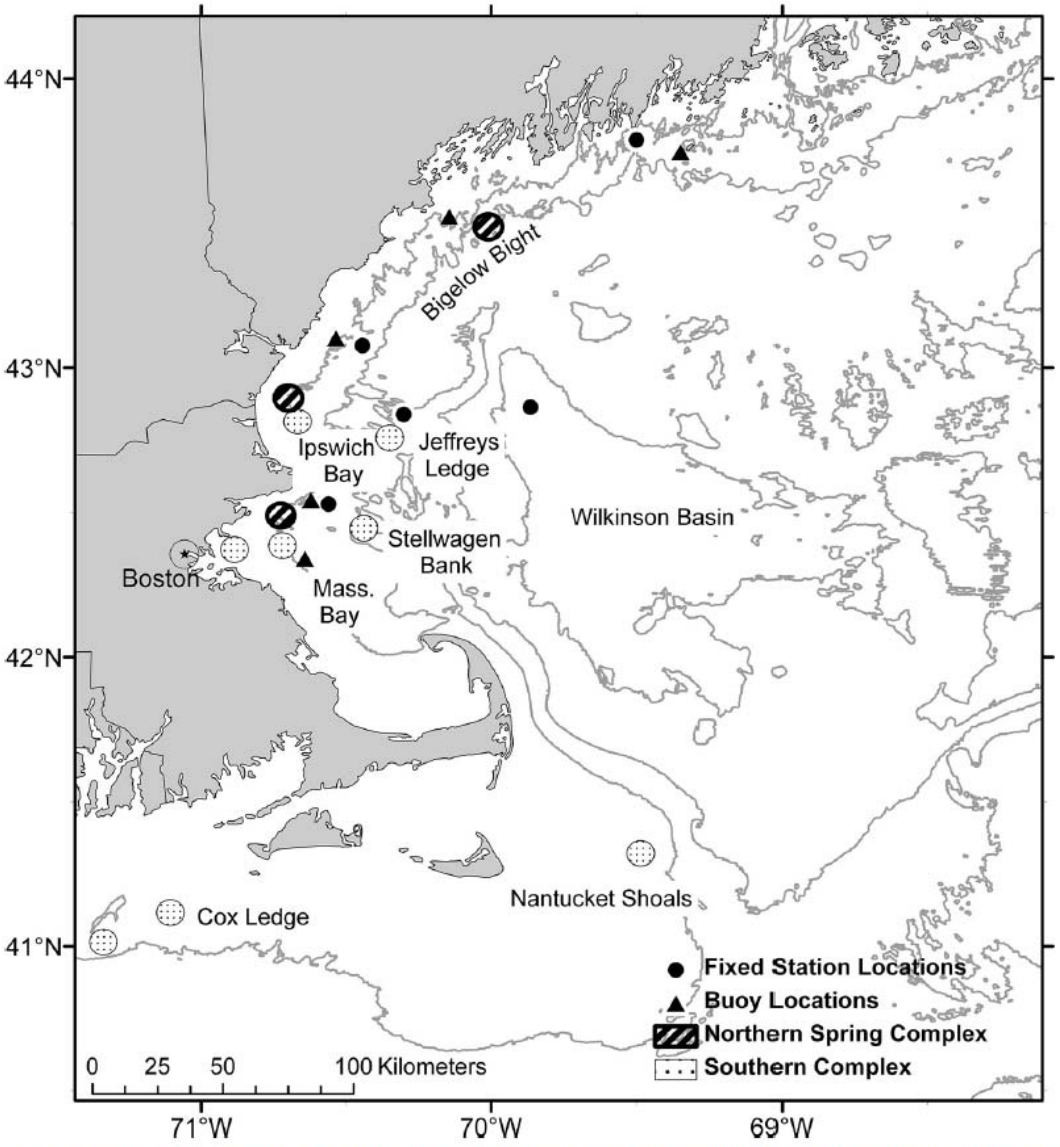

Fig. 3. The western Gulf of Maine (50, 100 and 200 m contours) showing locations of NERACOOS and NOAA buoys (triangles) and representative fixed sampling stations (sampled between 2003 and 2009 during the University of New Hampshire COOA and Northeast Consortium PULSE programs) proposed for long-term observing of zooplankton in coastal waters. The northeastern flank of Georges Bank is not shown. The genetic composition of spawning adults captured in the western Gulf and southern New England Bight is indicated. Large circles represent presence of one or both populations, but do not show spatial extent of spawning areas or relative spawning biomass at each location. Present understanding (Huret et al., 2007; Hoffman et al., 2006, 2007; Kerr et al., 2009) indicates that the main spawning area supporting most of the northern spring (May–June) spawning biomass is located in Ipswich Bay, and that the main spawning area for the fall–winter spawning components of the southern complex is located in Massachusetts Bay.

late winter. Fish within this spawning complex are differentiated from the southern Gulf of Maine complex, but only weakly differentiated or similar to fish of the northern spring complex. This genetic population structure is inconsistent with the current management model, which recognizes two stocks in US waters: a single Gulf of Maine stock and another stock consisting of cod from Georges Bank and adjacent areas to the south. Cod movement data from recent tagging studies also contradict the two-stock management model (Tallack, 2009), as did the results of earlier genetic studies (Lage et al., 2004; Wirgin et al., 2007).

The development of modeling tools to understand and predict bottom-up forcing of recruitment processes in Gulf of Maine

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Atlantic cod must take into account this fine scale population structure. The environmental conditions influencing maternal condition as well as the transport and survival of planktonic early life stages are likely to be different among populations. Furthermore, it is clear that environmental conditions constitute only part of the processes that lead to successful recruitment; other factors, such as juvenile survival and population fidelity determining connectivity among populations, also contribute. We address these issues in the following sections. In Section 3, we examine the present status of observing activities needed to provide data on present status and change of Gulf of Maine environmental conditions relevant to the Atlantic cod stock complex. In Section 4, we review the present status of physical–biological modeling relevant to the two Gulf of Maine populations. In Section 5, we discuss what needs to be done to integrate the observations and modeling into to assess and forecast environmental conditions for recruitment. In Section 6, we explore modeling of the spatial dynamics of Gulf of Maine Atlantic cod, in which environmental conditions for recruitment is part of the total life history of the cod populations.

3. Environmental forcing in the Gulf of Maine: components of an observing system

Strategies for long time series observations of the Gulf of Maine are presently evolving under the auspices of the Northeastern Regional Association for Coastal Ocean Observing Systems (NERACOOS). We review here components of observing system data that can provide understanding of the environmental contrasts influencing cod recruitment along the coastal Gulf of Maine. In addition to results from the GLOBEC Georges Bank/Northwest Atlantic program (e.g. Wiebe and Beardsley, 1996; Wiebe et al., 2001, 2002; Beardsley et al., 2003; Wiebe et al., 2006 and articles therein; Mountain et al., 2008), much of the hydrographic, nutrient, phytoplankton and zooplankton data time series collected in the coastal western Gulf of Maine originate from the GoMOOS (Gulf of Maine Ocean Observing System) buoy data, from ship based collections by the University of New Hampshire Coastal Observing Center and Northeast Consortium supported projects (precursors to the present NERACOOS), and from moored and ship collected data in Massachusetts and Cape Cod Bays, funded by the Massachusetts Water Research Authority.

3.1. Physical dynamics

At present, the principal source of physical data within the Gulf of Maine is the NERACOOS Gulf of Maine array. Essentially a successor to the GoMOOS buoy array (Pettigrew et al., 2008), which included instrumented buoys at as many as 11 locations, the NERACOOS array currently consists of seven instrumented buoys distributed throughout the Gulf of Maine. Measurements of temperature, salinity and current velocity are acquired at each buoy site and made available to the public in near real time. The NERACOOS measurement suite also includes high resolution distributions of surface current derived from Coastal Ocean Dynamics Applications Radar (CODAR), a land-based high-frequency radar system for determining ocean surface velocity (Lipa and Barrick, 1983; Chapman and Graber, 1997; Kohut and Glenn, 2003). At present, the University of Maine maintains three CODAR stations within the Gulf of Maine region. When fully operational, this array will provide surface current measurements over the coastal region extending from the Bay of Fundy to Casco Bay. Data from the Gulf of Maine CODAR and buoy arrays should be particularly useful in determining how the coastal circulation in the Gulf of Maine responds to variations in climatic forcing.

Of particular interest to the study of cod larval transport in the Gulf of Maine is the extent to which the various branches of the Gulf of Maine Coastal Current (GMCC) are connected. Despite its name, the GMCC is not bound to the coast but is often observed centered near the 100-m isobath (Churchill et al., 2005; Keafer et al., 2005; Pettigrew et al., 2005). Flowing clockwise around the perimeter of the Gulf of Maine, it consists of multiple branches with varying degree of flow from one to another (Lynch et al., 1997; Pettigrew et al., 1998, 2005; Manning et al., 2009). Also of importance to larval cod recruitment is the extent to which the Gulf of Maine coastal plume, flowing shoreward of the GMCC (Churchill et al., 2005; Keafer et al., 2005), is impacted by changes in climatic forcing.

Another important source of physical data in the Gulf of Maine is the Environmental Monitors on Lobster Traps (eMOLT) program (Manning and Pelletier, 2009). Established in 2001, eMOLT is a collaboration of ocean scientists and lobster industry participants. The publically available eMOLT data base currently consists of more than 3.5 million hourly records of temperature, 80 thousand hourly records of salinity, and 260 thousand satellite drifter fixes. The relative low cost required to deploy and maintain the eMOLT sensor array, and the sustained interest of the fishing community, make it an ideal means of acquiring a long-term data base for assessing the impact of climatic variations on water properties in the Gulf of Maine.

3.2. Nutrients and primary production

Nutrient-rich, deep Slope Waters that enter the Gulf of Maine through the Northeast Channel are the primary source of dissolved inorganic nutrients that support the relatively high rates of primary production in the Gulf (Ramp et al., 1985; Schlitz and Cohen, 1984; Townsend et al., 1987, 2006; Townsend, 1991, 1998; Townsend and Ellis, 2010). Over the last four decades, the nutrient regime in the Gulf of Maine has been changing. Townsend et al. (2010) provide evidence that since the 1970s, the deeper waters in the interior Gulf of Maine (>100 m) have become fresher and cooler, with lower nitrate but higher silicate concentrations. They argue that these changes are related to accelerated ice melting in the Arctic, influencing the relative proportions of shelf and slope waters in the Gulf, with implications for the timing, magnitude and species composition of future phytoplankton production.

Since 1998, surface nutrients have been observed in the Gulf of Maine, on a semi-monthly to monthly frequency between late spring and early autumn, as part of the Gulf of Maine North Atlantic Time Series (GNATS: Balch et al., 2008). This time series is derived from samples collected at 1–2 m along a transect between Portland, Maine and Yarmouth, Nova Scotia. A long term (9 year to date) time series of nutrients has also been collected in Casco Bay by D. Townsend (http://www.grampus.umeoce.maine.edu/dave/homepage.htm). The Massachusetts Water Resources Authority (MWRA) time series, ongoing since 1992, includes measurement of nutrients, as well as salinity, temperature, chlorophyll concentration and other observations, at a suite of stations ranging in depth from 25 to 80 m in Massachusetts Bay (e.g. Libby et al., 2009).

The most temporally and geographically complete record of changing phytoplankton biomass within the Gulf of Maine is derived from bio-optical properties and calculated chlorophyll concentrations from satellite-derived ocean color data. At present, two US funded operational satellites (SeaWiFS and MODIS) cover the Gulf of Maine each day. Satellite-derived chlorophyll time series begin in late 1997, providing quantification of climatological seasonal patterns (e.g., Thomas et al., 2003) and interannual variability (e.g., Thomas et al., 2003; Ji et al., 2008a,b). These chlorophyll time series show that the dominant events of primary

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productivity in most regions of the Gulf of Maine are the spring and fall blooms. The chlorophyll time series reveal strong interannual variability in both the timing and the spatial pattern of the blooms (Fig. 4). In regions close to shore, and in shallow regions of episodic resuspension events, colored dissolved organic material (CDOM) and suspended sediment potentially bias the satellite-derived chlorophyll. Continued research into bio-optics in these regions, as well as in situ sampling programs to validate satellite signals and provide vertical structure, are required.

3.3. Secondary production

The planktonic early life stages of Atlantic cod feed primarily on copepod eggs and nauplii (Heath and Lough, 2007). Time series observations of copepod and other zooplankton species in the Gulf of Maine are being acquired by the US National Marine Fisheries Service using the Continuous Plankton Recorder (CPR) and seasonal bongo net surveys (ECOMON), and by the Canadian Department of Fisheries and Oceans under the Atlantic Zonal Monitoring Program (AZMP). These time series have shown shifts in zooplankton community structure (Pershing et al., 2005; Kane, 2007). These shifts are hypothesized to be primarily the result of increased stratification in fall, driven by surface freshening from the Scotian Current, which leads to more intense and longer duration fall phytoplankton productivity and subsequent increases in relative abundance of small copepod species (Pershing et al., 2005; Greene and Pershing, 2007).

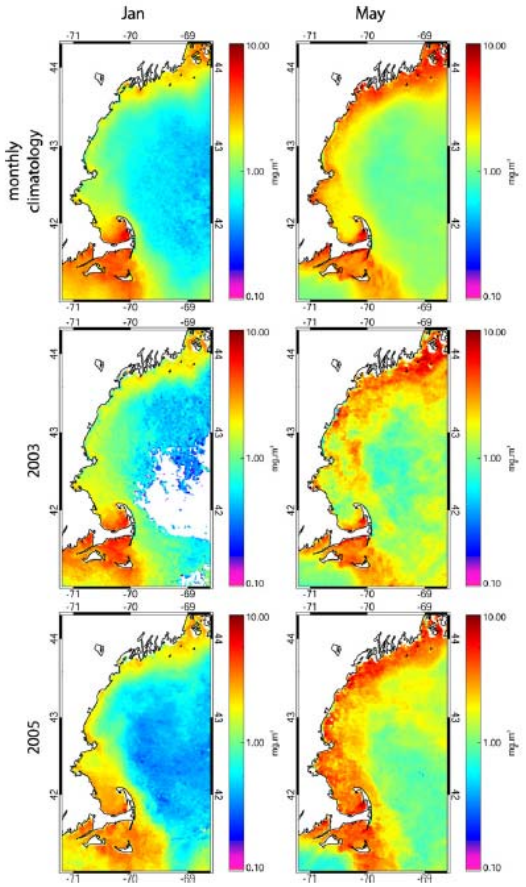

Fig. 4. Monthly composites of satellite-measured surface chlorophyll concentrations in the western Gulf of Maine in winter (January) and late spring (May). The top panels show the 11-year (1998–2008) mean climatological pattern, and the middle and bottom panels show the climatological patterns in 2003 and 2005, respectively.

The present long-term zooplankton sampling series, however, do not necessarily represent zooplankton variability in the near coastal regions. Measurements of shorter duration (2–6 years) time series of zooplankton abundance and composition, employing sampling protocols similar to the AZMP time series, have been carried out between 2003 and 2008 as part of the University of New Hampshire Coastal Observing Center and Northeast Consortium PULSE programs. Collection with vertical, ring net casts were made at fixed stations located in the planktonic feeding habitat of the western Gulf of Maine Atlantic cod populations (e.g., Fig. 3). The time series includes data from 2004–2006, among the wettest years on record for the western Gulf of Maine. The results (Runge and Jones, in press) show dominance of a few species of planktonic copepods, including *Pseudocalanus* spp, *Centropages typicus* and *Calanus finmarchicus*, as well as an order of magnitude interannual change in coastal abundance. The frequency of sampling (2–3 times per month) allows for smoothing of variability at individual sample dates and allows depiction of seasonal variability in abundance and species diversity in the coastal plankton. These coastal time series can be used to calculate the production rate of the copepod prey field, similar to Castonguay et al. (2008, Fig. 1a) for validation of the output of the copepod life cycle models described below.

3.4. Juvenile habitat

Young-of-year (YOY) cod (0 age class) typically settle, after dispersal during the planktonic life stages, in relatively shallow water and move to deeper water with age (Swain, 1993; Linehan et al., 2001). They are thought to settle indiscriminately and suffer disproportionate mortality in relatively featureless habitats (Gotceitas and Brown, 1993). Laboratory investigations of habitat usage by YOY cod in the northwest Atlantic showed that they prefer structured habitats (i.e. cobble, sea grass, kelp, and sponge habitats) when predators are present (Gotceitas and Brown, 1993; Gotceitas et al., 1995; Lindholm et al., 1999). Field surveys from inshore sites in Atlantic Canada have confirmed that YOY cod associate with structured habitats such as sea grass beds and cobble/boulder habitat with high relief (Keats et al., 1987; Tupper and Boutilier, 1995; Gregory and Anderson, 1997; Cote et al., 2001). In most cases, habitats with protective cover promote higher cod recruitment, and coastal cod probably recruit to habitats that are both highly heterogeneous and the same color of recruiting cod (Gregory and Anderson, 1997). Although juvenile cod may become more exposed to visual predators at shallow depths, many of the refuge habitats (i.e., seagrass beds, kelp) noted above that promote higher cod recruitment occur at these shallow depths. In general, predation risk is high during the early life-history stages of cod, which is reflected in their depth distribution and habitat use patterns.

Time series observations of juvenile cod are conducted by the National Marine Fisheries Service (NMFS), the Maine Department of Marine Resources and the Massachusetts Division of Marine Fisheries. The Maine-New Hampshire and Massachusetts Inshore Trawl Surveys provide data on the density and size-frequency distribution of juvenile cod from coastal regions of the Gulf of Maine in the spring and fall. These data can be used to examine how the habitat and depth preferences differ for YOY fish from different spawning periods, because the YOY (i.e., <10 cm fish) caught in the spring likely originate from winter spawners, whereas those

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captured in the fall likely originate from spring spawners. Information on juvenile cod provided by the NMFS Trawl Survey covers a much longer timer period, beginning in 1950, but is limited in inshore waters. These time series can be used to assess habitat associations for juvenile cod by superimposing trawl data onto substrate maps of the Gulf of Maine and Georges Bank.

Spatially continuous high-resolution substrate data collected via acoustic surveys are an integral part of monitoring cod nursery habitat. The Commonwealth of Massachusetts recently completed multibeam acoustic surveys of the waters of coastal Massachusetts, and are in the process of developing substrate maps. Efforts focused on using remote physical measurements such as rugosity as a proxy for seafloor substrate and complexity are available in some areas. Collection of spatial high resolution data every 5–10 years will permit monitoring of anthropogenic impacts such as global climate change and environmental degradation on the distribution and abundance of essential fish habitats in the nearshore environment.

4. Coupled physical–biological modeling

Here we review present status of modeling to integrate observing system data for understanding bottom-up forcing of the western Gulf of Maine ecosystem and environmental conditions for cod recruitment, as outlined in Fig. 2.

4.1. Physical modeling

There are a number of individual groups actively modeling the circulation of the Gulf of Maine. The Marine Ecosystem Dynamics Modeling Laboratory at the University of Massachusetts, Dartmouth (http://www.fvcom.smast.umassd.edu/, Chen et al., 2007) utilizes the Finite Volume Coastal Ocean Model (FVCOM) to model the regional dynamics for a number of applications, including larval tracking studies (e.g., Huret et al., 2007). The Oceanographic Modeling and Analysis Laboratory (http://www.smast.umassd.edu/modeling/; also at U. Mass Dartmouth) employs the Harvard Ocean Prediction System in a model of Gulf of Maine dynamics (Brown et al., 2007a,b). As part of the Gulf of Maine Ocean Observing System (GoMOOS), the Ocean Modeling Group at the University of Maine has developed a regional hydrodynamic model (based on the Princeton Ocean Model) for hindcast and forecast studies (http://www.rocky.umeoce.maine.edu/GoMPOM/). This model was recently applied to examine connectivity among lobster populations in the Gulf of Maine (Xue et al., 2008). The Ocean Observing and Modeling Group at North Carolina State University (http://www.4.ncsu.edu/~rhe/) has developed a Regional Ocean Model System (ROMS)-based model of the Gulf of Maine for studying, and predicting, the transport of harmful algal blooms (He et al., 2008). The Northeast Coastal and Ocean Data Partnership (www.necodp.org) has established a modeling committee to encourage discoverability, accessibility and interoperability of model output in the Gulf of Maine. It has recently launched the "Gulf of Maine Interoperability Pilot Project" (http://www.necodp.org/committees/modeling-committee/gulf-of-maine-model-interoperability-pilot-project) whose purpose is to promote easy and standardized access to the output from these various circulation models.

4.2. NPZD modeling

Considerable progress has been made in developing coupled physical and Nutrient–Phytoplankton–Zooplankton–Detritus (NPZD) component models for the Gulf of Maine/Georges Bank region. Ji et al. (2008a) developed an NPZD model coupled to a high resolution 3-D coastal ocean circulation model (FVCOM) to examine mechanistically the influence of local and external forcing on phytoplankton bloom dynamics and primary production (Fig. 5). They used the model to examine local and external processes that control nitrogen and phytoplankton dynamics on Georges Bank. In addition to the potential to simulate the spring bloom and chlorophyll fields to force copepod egg production on Georges Bank and elsewhere in the Gulf of Maine, the model can be used to investigate the potential influence of nutrient-poor Labrador Slope Water,

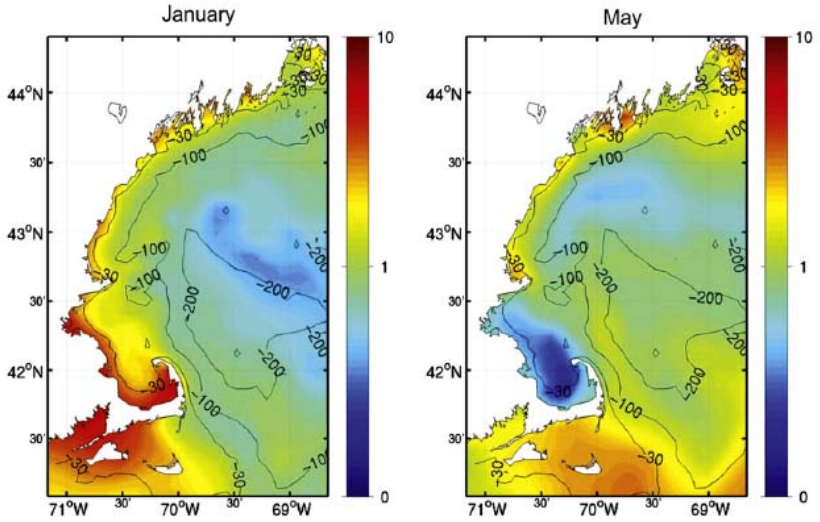

Fig. 5. Model-computed distribution of January (left panel) and May (right panel) monthly mean chlorophyll concentration (mg m^{-3}) in the western Gulf of Maine. The model was initiated using December climatology of nitrogen and chlorophyll concentration, and forced with surface and open boundary conditions for year 1999.

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driven by climate forced events in the Arctic (Greene and Pershing, 2007), on the timing and magnitude of the fall bloom, connecting a mechanistic analysis of the fall bloom to Georges Bank haddock recruitment (Friedland et al., 2008). Three-dimensional physical–biological models have also been developed to estimate the spatial and temporal variations of phytoplankton biomass in the western Gulf of Maine (e.g., Liu et al., 2008; Ji et al., 2008b).

4.3. Copepod life cycle modeling

In addition to the NPZD models, a number of recent advances in the modeling of copepod population dynamics (e.g., Gentleman et al., 2008; Record and Pershing, 2008; Hu et al., 2008; Neuheimer et al., 2009; Ji et al., 2009) allow for the possibility of simulating the abundance and production of the dominant copepods in the Gulf of Maine. Ji and colleagues at the Woods Hole Oceanographic Institution and the U. Mass. Dartmouth have developed a continuous, whole-year model simulating abundance, egg production and distribution of *Pseudocalanus* spp. in the Gulf of Maine (Ji et al., 2009: Fig. 6a–d). Pershing (University of Maine) and colleagues have developed a coupled, 2-D life cycle model of *Calanus finmarchicus*, and applied it with forcing from satellite-derived temperature and surface chlorophyll to predict arrival date of the northern right whale, which feeds primarily on *Calanus*, in the western Gulf of Maine in spring (Pershing et al., 2009; Fig. 6e–f). A mechanistic hypothesis explaining diapause of *Calanus* has been put forward (Johnson et al., 2008) and successfully applied to reproduce *Calanus* demography. These coupled physical life cycle models can be used not only to predict larval cod prey fields in the western Gulf of Maine, but also to evaluate potential distributional shifts in dominant copepod species, such as the lipid rich *Calanus finmarchicus*, under climate change scenarios.

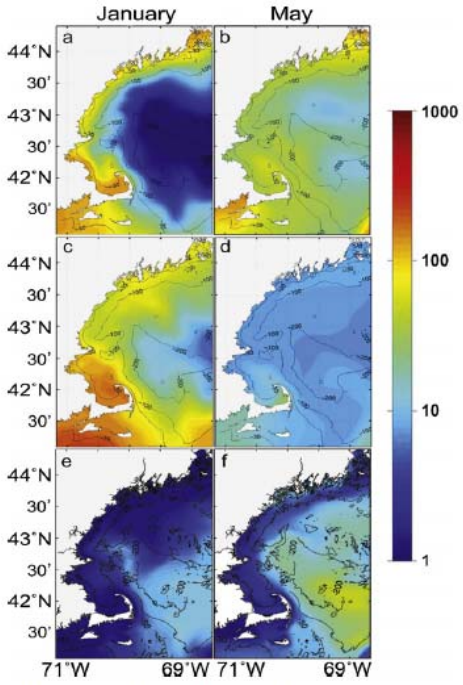

Fig. 6. Model-computed adult planktonic copepod distributions in the western Gulf of Maine for the months of January (left panels) and May (right panels) 1999. Panels a and b illustrate monthly mean *Pseudocalanus* spp. abundance (No. m^{-3}), and panels c and d illustrate monthly mean *Centropages typicus* abundance (No. m^{-3}). In both cases, the model was initiated using December climatology of species abundance and forced with 1999 surface and open boundary conditions (adapted from Ji et al. (2009)). Panels e–f represent climatological modeled abundance and distribution of adult female *Calanus finmarchicus* (No. m^{-3}) based on a stage-resolved copepod model (Pershing et al., 2009). The climatology couples 2D climatological flow fields with satellite imagery and a biological model, and includes the years 1998–2006. In these images, near coastal *Calanus* distribution is not resolved; work is in progress to more accurately simulate coastal *Calanus* abundance using year-specific, high-resolution FVCOM flow fields plus data assimilation (Record et al., University of Maine, unpubl.).

4.4. Larval fish trophodynamic modeling

A critical element in modeling cod recruitment dynamics is the coupled Individual-Based Model (IBM) that simulates transport of egg and larval stages to nursery areas, accounting for cod mortality as well as the feeding, growth and mortality rates of larval cod. The dispersion of cod eggs and larvae from the western Gulf of Maine spawning areas has been simulated using flow fields generated by FVCOM (Chen et al., 2006a,b). The initial study (Huret et al., 2007) was confined to the 1995 spawning period. More recently Churchill et al. (in press) have expanded on this work to investigate factors influencing the year-to-year variation in transport of larvae spawned during spring within the Ipswich Bay spawning area. They found that the successful transport of buoyant eggs and early-stage larvae to suitable juvenile habitats was strongly influence by the interaction of the wind-driven transport with the larger-scale Gulf of Maine circulation, which includes a strong coastal current that tends to bypass Ipswich and Massachusetts Bays (Fig. 7). Eggs released during times of northward winds tend to be transported eastward by the surface Ekman flow into the coastal current, which carries them rapidly out of the western Gulf. In contrast, eggs released during times of southward (downwelling favorable) winds tend to be carried westward by the surface Ekman flow into coastal nursery areas of Ipswich and Massachusetts Bays (Fig. 7).

Several IBMs of cod feeding and growth have been developed by Lough et al. (2005), Vikebø et al. (2007), Kristiansen et al. (2009a,b) and Petrik et al. (2009). The core of the trophodynamic model is the standard bioenergetic supply–demand function, in which growth is represented as the difference between the amount of food absorbed by a larva and the metabolic costs of its daily activities. Kristiansen et al. (2009a) concluded that larval cod prey selection on Georges Bank is dependent on light, ease of capture and relative abundance of its prey. Kristiansen et al. (2009b) further showed the dependence of larval cod growth on daylength and temperature in addition to prey abundance. Larval mortality may be estimated as composed of size-dependent invertebrate predation and predation from visual piscivores that changes with light intensity. These models may be supplied with forecasts of the copepod prey fields and estimates of predator fields to indicate environmental conditions for growth and survival of the early cod life-history stages.

5. Integration of modeling and data: application to Atlantic cod in the Gulf of Maine

Our brief overview has attempted to outline the state of understanding of several components needed to understand potential environmental influences on population-rich species such as Atlantic cod on time scales of months to several years. We have shown that these components have now been developed and may be applied towards understanding the spatial dynamics of recruitment variability in the coastal and bank systems of the Gulf of Maine. We believe that a multidisciplinary synthesis effort,

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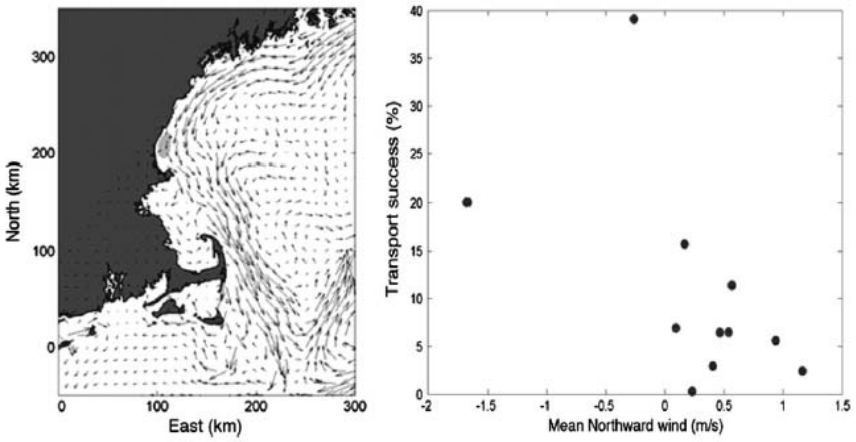

Fig. 7. Left panel: Mean surface currents generated by the first-generation FVCOM in the western Gulf of Maine during May 1995. This representation approximates mean flows not driven by the local wind stress, as the mean wind in May, 1995 was negligible. The area shaded represents the modeled region of May egg release from the Ipswich Bay spawning area. Right panel: interannual variability in simulated larval transport success to Ipswich Bay and Massachusetts Bay nursery areas between 1995 and 2005, in relation to estimated mean northward wind velocity measured in the month of May at NOAA buoy 44013 off Boston Harbor (adapted from Churchill et al. (in press)).

involving oceanographers, fisheries scientists and those involved in fisheries management decisions, is now warranted in order to assess how the research advances can be translated into useful information for management. Synthesis activities should address questions such as: Which aspects of the modeling and observing systems might be made operational into decision/information support tools in the near term? Which research directions need to be encouraged to support development of information support tools in the longer term? What data time series that support fisheries management should be sustained or established as part of the emerging regional observing system?

While we are not aware of a Linked Coupled Model (LCM: Fig. 2) system that has been fully implemented, some modeling efforts are coming close to this goal (e.g., Hermann et al., 2001; Daewel et al., 2008; Ji et al., 2008a, 2009). We believe that the components are now in place to develop LCMs for both the coastal Gulf of Maine and Georges Bank. The skill of the coupled models and LCM system can be evaluated in hindcast mode and refined over time with the addition of the new observational data collected each year. The models then can be used to project environmental conditions for recruitment over the medium term (i.e. within a decade) using regional forecasts of ocean and climate conditions from larger-scale ocean and climate models. This approach to understanding spatial dynamics of recruitment variability in Atlantic cod would serve as a model and proof of concept for understanding spatial recruitment dynamics for other population-rich species, such as herring and other forage and groundfish populations.

5.1. Needs for developing coupled modeling capacity in the Gulf of Maine region

Coupled multidisciplinary models serve to integrate multiple data sets in the analysis and interpretation of physical and ecological processes, and can provide valuable insight and information for ecosystem approaches to management. Over the past three decades, a number of regional workshops have addressed the need to develop and coordinate regional modeling activities to support the detection and understanding of changes in the Gulf of Maine ecosystem. The results of these workshops are summarized in a report of a meeting convened in 2005 by the Regional Association for Research on the Gulf of Maine (RARGOM), which was focused on modeling needs related to the regional observing system (Runge and Braasch, 2005). Highlighted was a critical need for regional infrastructure that would: (1) facilitate regional model evaluation, including skill assessment, evaluation of uncertainty, and model ensemble approaches to predictions; (2) serve to link data analyses, modeling and prediction capabilities to specific regional management needs; (3) facilitate coordination among government agencies, research institutions, and universities; and (4) develop and demonstrate environmental analysis and forecast products that could be implemented operationally. Recommendations included establishment of a Regional Modeling Center, which may involve a coordinating entity (NERACOOS) and distributed output of observations and modeling to desktop computers of researchers and resource managers via standards-based tools, and/or a Gulf of Maine Experimental Environment Forecast Center, whose primary objective would be to develop, test and refine forecast models that could then be adapted for delivery to decision-makers after tailoring of output to end-user needs. The word "experimental" refers to forecast models that are not operational, but rather can be seen as precursors for the development of operational models, in that the experimental forecast predictions may be expected to fail. Experimental environmental forecasting encourages a critical feedback process, in which model forecasts can be readily compared with new data, which in turn can lead to refinements in both models and the observing system which result in improved predictive capabilities in future model iterations.

Models may also enhance observing system design through simulations aimed at maximizing return on observing investment for various infrastructure scenarios. A recent study used the model output, together with the Variance QuadTree (VQT) optimization algorithm, to minimize the root mean square sampling error in plankton survey designs (Lin et al., 2010). The model was used in an observation system simulation experiment (OSSE) to determine the optimal plankton sampling locations. More generally, numerical models can be used to gain insights into optimal temporal and spatial sampling of biological and physical variables. The models also can be used to examine which variables and parameters are most important to measure. Once the observing system is in place, the 3-D coupled model can then interact with the observing

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system, assimilating the data and directing the observing system as to when and where to sample. Development of this interaction between the model and observing system will enable efficient acquisition of key data and improve model forecasting.

5.2. Data needs and developments in regional NERACOOS

The US Integrated Ocean Observing System (IOOS) envisions a nationwide system of coastal ocean data collection and analysis organizations that can provide timely predictions of coastal ocean changes and their consequences for the public (US IOOS, 2002, 2006). NERACOOS is part of the coastal component of IOOS representing the Gulf of Maine and southern New England Bight. Planning for NERACOOS started in 2005 with formal incorporation in 2008. As a regional association, NERACOOS has the capacity to institute observing time series covering a broad range of oceanographic and ecosystem variables. Current infrastructure has revealed spatial and temporal variability in key physical processes in the Gulf of Maine at unprecedented resolution. Observations contribute to modeling capability via assimilation of real-time information and hindcast assessment of modeling skill, which can improve model forecasts. Sustained monitoring is essential for detecting, understanding, and ultimately predicting effects of climate change on ecosystems. Future enhancements of observing infrastructure, given sufficient funding, will enable sustained and improved monitoring of critical biological variables, including distribution and abundance of key species over time. The multidisciplinary modeling/observational synthesis discussed here will serve to maximize the observing system value to ecosystem-based fisheries management, particularly in responding to the impacts of climate change.

The current set of observations, however, only partially meets the needs of coupled physical and biological models, such as the modeling system proposed here for Atlantic cod. Four categories of model data needs have been recognized (Runge and Braasch, 2005): (1) key pieces of information about biological processes that are currently not well studied and therefore cannot be modeled accurately; (2) high resolution time series of physical and biological data from the Gulf of Maine to inform and evaluate models; (3) fixed time-series stations located strategically in the coastal Gulf of Maine (e.g., Fig. 3) to observe seasonal as well as longer temporal change and to acquire data needed for model parameterization (operations at such stations should include repeat visits by research vessels for sampling of zooplankton and ichthyoplankton abundance and diversity as well as for routine sensor and system maintenance); (4) key physical and biological observations in Canadian waters for information about the upstream boundary conditions. In the near term, capacity for modeling physical–biological processes in the Gulf of Maine can be enhanced by the addition of available and developing technology to the present observing system, as well as establishment of several strategically located coastal fixed stations. In particular, the addition of in situ nutrient and chlorophyll sensors to the NERACOOS Gulf of Maine array would clearly benefit efforts to model nutrient fluxes and primary productivity in the Gulf. Development of these types of sensors for mooring systems is rapidly advancing through the efforts of academic and industry researchers, often working in partnership (Dickey et al., 2009). Modeling the transport of cod eggs and larvae would be enhanced by the expansion of the NERACOOS CODAR array to cover the entire coastal region of the Gulf of Maine. CODAR data would be particularly valuable in evaluating, and improving a model's capability of capturing the interaction of wind-driven transport and the larger-scale Gulf of Maine circulation, an interaction that Churchill et al. (in press) found to be critical in controlling the extent to which larval cod spawned in the western Gulf of Maine are delivered to habitats suitable for early stage juvenile development (Fig. 7). The need to acquire high resolution data on potential larval cod predators (e.g. euphausids and herring) in certain areas in response to significant events, such as the appearance of a spawning fish aggregation, could be met by surveys with broadband acoustic systems operating at the upper range of resonance frequencies (e.g. Stanton et al., 2010) in combination with the addition of acoustic systems installed on remotely controlled autonomous vehicles to the part of the NERACOOS suite of instrument systems. A small number of fixed stations visited semi-monthly (following the Canadian AZMP protocol) would contribute time series of physical, chemical and biological variables not presently amenable to acquisition by available technology. These include regular salinity, temperature and pH profiles, particulate carbon and chlorophyll a by conventional methods (for ground truthing of satellite sensors and data processing methods), and assessment of zooplankton abundance and diversity, for life cycle analysis and documentation of changes in biodiversity and phenology (e.g., Ji et al., 2010).

6. Modeling the spatial dynamics of Gulf of Maine cod populations

Predicting changes in the demography of a fish stock that has a complex life history, such as Atlantic cod, in response to changes in environmental conditions or fishing pressure requires a full life-cycle approach that addresses habitat, growth, movement and mortality of fish beyond the planktonic larval phase. Andrews et al. (2006) and Heath et al. (2008) recently developed spatially and physiologically explicit approaches to modeling the demography and distribution of Atlantic cod populations residing on the northern European continental shelf.

Given the current and future direction of research on Atlantic cod in this region, construction of a spatially and temporally explicit population model of western Gulf of Maine Atlantic cod that incorporates the ecological differences between winter and spring spawning populations across life stages is a feasible goal (e.g., Kerr et al., 2010). This type of model can be used to examine the response of the spring- and winter-spawning cod stocks to varying conditions of climate, fishing intensity, and exchange of individuals across the stocks. The model could be informed by ongoing or planned research by collaborators on cod research in the region. For example, the movement, growth, and survival of eggs and larvae, up to the time of settlement, could be informed by the previously described coupled IBM trophodynamic models. Field and laboratory studies could inform juvenile habitat preference and growth as a function of habitat type. Seafloor maps of the region created using multibeam and photographic surveying can then be used to define habitat available for settlement of juveniles. Life history parameters of each population at the adult stage can be estimated from measurements (length, weight, maturity, and age data) collected from adult sampling planned for winter and spring in the western Gulf of Maine, and supplemented with data collected by the NMFS bottom trawl survey. Distinguishing the spawning group of origin of adults is possible through genetic and otolith chemistry analysis. Adult habitat use can be specified from tagging data and otolith chemistry studies may provide further resolution regarding the spatial scale of movement of winter- and spring-spawning fish. Connectivity among groups can be incorporated in the model as a straying rate, estimated from genetic differences (pairwise F_{ST} values) between the two spawning stocks. Once the basic model is constructed, it can be run under different scenarios extending over the time period of IBM simulations and include a range of climatic conditions.

The consequences of various life history differences between the two western Gulf of Maine cod populations, including differences in vital rates, larval dispersion and survival, fecundity,

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migration patterns, natural and fishing mortality, etc. can be evaluated in the framework of this model. This research effort would constitute a new, integrative approach to understanding spatial dynamics of Atlantic cod in the Gulf of Maine. The modeling approach would have applications for fisheries management and for assessing the possible impact of environmental perturbations (such as those caused by a changing climate) on a regional fish stock. Before such an approach can be applied with confidence, a number of issues will need to be resolved, including further collection of data required to properly parameterize a model of this regional fish stock and testing the validity of model predictions. This approach could be adopted as part of a Gulf of Maine regional modeling/experimental environmental forecasting center.

7. Concluding remarks

Our conclusion is that it is feasible to develop forecasts of environmental conditions for recruitment into Gulf of Maine Atlantic cod populations by integrating observations acquired from a regional observing system with linked coupled physical–biological models that provide mechanistic understanding of key Gulf of Maine ecosystem properties and species dynamics. This combination of observations and modeling provides a mechanistic characterization of many processes not directly represented in stock assessment models and therefore represents a complimentary view of cod early life history that could aid in the interpretation of the stock assessment results.

The linked coupled model system addresses time scales of months to a decade in terms of outlook for recruitment success. The accuracy of forecasts will depend on the abilities of basin-scale ocean climate models or statistical analysis of trends based on climate indicators to provide reasonable climate scenarios over these time scale, which can then be downscaled to project conditions in the northwest Atlantic. While this remains a challenging frontier of climate science, recent research indicates substantial improvements in predictive skill over the medium term (Smith et al., 2007; Keenlyside et al., 2008). Additional sources of error include the ability of the model system to capture interannual and longer term changes in mortality of cod eggs and larvae due to predators, although this source of error can be constrained by inclusion of observed trends in abundance of dominant predators (e.g. herring and euphausids) and timing of spawning in forecast scenarios. The combination of forecasting of environmental conditions for recruitment with an age structured cod life history model that includes population specific dynamics, behavior and connectivity among populations would have value for spatial management of Atlantic cod and protection of individual populations from overexploitation (Reich and DeAlteris, 2009; Kerr et al., 2010).

In order to implement this integration of observations and modeling in the Gulf of Maine, changes would be needed to the regional research infrastructure. Development of increasingly sophisticated multidisciplinary models with forecasting capability integrated with an observing system and the complex process of transitioning these research models to management applications are beyond the scope of regional academic research activities, although these play an important role. Ways forward, discussed at a number of regional workshops (Runge and Braasch, 2005), involve establishment of organizational infrastructure as discussed in Section 5.1. This new infrastructure may be possible through collaboration of relevant US government agencies, in particular the National Oceanic and Atmospheric Administration (NOAA), with NERACOOS, the regional observing association, and CINAR (Cooperative Institute for the North Atlantic Region), a NOAA cooperative institute of academic institutions.

While the time scale envisioned here is medium term, the analysis by Rothschild (2007) also suggests a role for an integrated model-observing system in the Gulf of Maine/Northwest Atlantic to understand environmental and plankton changes on the interdecadal scale as well. Coherent, decadal-scale increases and declines in spawning stock biomass in populations of cod across the Northwest Atlantic occurred during periods of relatively low fishing mortality and the major declines occurring between 1985 and 1992 were associated with reduced growth rates, implying a strong negative environmental signal, perhaps due to dynamics of the plankton. Looking forward, testing of decadal-scale environmental hypotheses involving plankton to explain major fluctuations in cod population abundance becomes possible with adequate observing of changes in the plankton combined with coupled physical–biological models continuously refined to account for changes in dominant planktonic species. The observing–modeling system we have outlined here would contribute to tests of this environmental hypothesis for the Gulf of Maine and Georges Bank; conceivably a similar system could also be developed in other regions, for example the Scotian Shelf. In general, by providing a mechanistic characterization of the impact of physical conditions on cod, the observing–modeling system could be used to detect and understand periodic regime-shifts observed in these populations. Driven by global scale general circulation and climate projections, the models have the potential to provide estimates of population responses to long-term climate change. These long-term projections are beyond the scope of empirical stock assessment models.

Finally, we have focused here on Atlantic cod populations in the Gulf of Maine as an example application of integrated observations and modeling. A similar approach could be adopted to address environmental conditions for recruitment and spatial population dynamics of other key species in the regional ecosystem, e.g. Atlantic herring. The physical, ecosystem and zooplankton life cycle models as well as the data requirements supporting them are basically the same; the models depicting larval trophic dynamics, transport, and spatial population dynamics (e.g. Kerr et al., 2010) would be particular to the species in question.

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Council Committees

Progress in Implementing Committee work plans 2007 - 2010

GOM Mapping Initiative

- Hired Coordinator to perform GOMMI tasks (research, outreach, support)
- Prepared GOMMI brochure;
- Identified sea floor mapping priorities;
- Supported collaborative seafloor mapping project on Cashes Ledge;

GOMMI (continued)

- Organized, convened and reported out on two workshops – *Integrating seafloor mapping and benthic ecology into fisheries management in the GOM*; and "Survey Methods for Shallow Water Habitat Mapping in Northeast National Parks, Wildlife Refuges, & Estuarine Research Reserves"

Habitat Restoration

- 94 projects funded. Together, these projects 1) re-opened access to 144 miles of rivers and streams for river herring, Atlantic salmon, and American eel, 2) re-established access to 2,400 acres of alewife spawning habitat, and 3) rehabilitated over 500 salt marsh acres.

Restoration (continued)

- 65 projects - January 1, 2006 through June 30, 2010 = $ 1,914,784 & $2M in non-federal matching funds
- Maintained web portal operation
- Released and promoted use of the stream barrier removal guidelines by awardees and organizations/agencies
- Amended grant requirements to address climate change issue

HRSC accomplishments

- Barrier Removal guidance document http://www.gulfofmaine.org/streambarrierremoval/

Restoration Monitoring

- Co-produced flyer: "Salt marshes of the Gulf of Maine: Long-term monitoring to assess human impacts and ecological condition" and distributed to members of the Gulf of Maine community as an insert to the Gulf of Maine Times. (with Science Translation). Available online at:
- Co-produced "Salt Marshes in the Gulf of Maine: Human Impacts, Habitat Restoration and Long-term Change Analysis" (with Science Translation, Habitat Restoration Subcommittee). Available online at:

Restoration Monitoring

- The results from the regional eelgrass conference were distributed online:
- Neckles, H. A., A. R. Hanson, P. Colarusso, R. N. Buchsbaum, and F. T. Short (eds.) 2009. Status, Trends, and Conservation of Eelgrass in Atlantic Canada and the Northeastern United States: Report of a Workshop Held February 24-26, 2008, Portland, Maine.
- In addition, newspaper coverage of the workshop delivered important information to a broader audience ("eelgrass decline may be a sign of pollution", Portland Press Herald, 2/26/2008, online at

HMSC accomplishments

- Supported habitat monitoring beta-web site;
- Produced Salt Marshes in the Gulf of Maine: Human Impacts, Habitat Restoration and Long-term Change Analysis

HMSC accomplishments

- Developed a pilot web-based information system to enable the regional sharing, integration, and use of coastal habitat data. This pilot served as a proof-of-concept: http://www.gomoos.org/gomc/map/
- Distributed a user-needs survey to guide full-scale development of online habitat information system. The needs assessment was summarized in the attached file: *GOMC Dbase Needs Assessment-Summary responses.doc*

HMSC accomplishments

- Organized a regional conference on "Status, Trends, and Conservation of Eelgrass in Atlantic Canada and the Northeastern United States", February 24-26, 2008, Portland, ME.
- The workshop was attended by over 100 representatives of all sectors of eelgrass science and management in eastern Canada and the northeastern United States. Participants included federal, state, provincial, and municipal resource managers; researchers; coastal planners and decision makers; members of environmental organizations; consultants; students; and concerned citizens. Presentations and discussions over the course of two days focused on eelgrass change around the region, factors controlling ecosystem change, current and emerging management issues, and regional examples of eelgrass conservation efforts. Although a formal evaluation of the workshop was not conducted, comments from participants were overwhelmingly and uniformly positive and affirmed that the workshop was effective

Habitat Conservation

- Completed documentation of coastal/marine managed areas in the CA portion of the GOM, created user portal and uploaded data to GOM site;
- Organized and produced workshop proceedings about sub-tidal habitat classification methodologies
- Disseminated info on American Eels

Gulfwatch Contaminants Monitoring

- Supported 12-year program peer-review by RARGOM & report;
- Collected and analyzed 2007, 2008 and 2009 samples;
- Reconciled past data &1993-2006 now on the server
- Produced data reports (07 & 08)

Gulfwatch Contaminants Monitoring Accomplishments

- http://www.symposcience.org/ext-php/cadcap.php?MODELE=vues/symposcience_-_colloque___consultation/home.html&VUES=symposcience_-_colloque___consultation&EQUATION=WHERE_COL_REF=REF00000064

Sustainable Industries & Communities Committee

- Prepared *Industry Engagement with the GOMC* report with recommendations
- Organized and awarded Sustainable Industry Awards

Climate Change Network

- Organized Climate Change Network kick-off event in New Brunswick;
- Produced *Identifying Coastal Habitats at Risk from Climate Change Impacts*
- Produced *Identifying the Possible Effects of Extreme Precipitation and Other Climate Change Impacts on Streamflow and Water Quality*

Climate Change Network

- Produced Identifying the Possible Effects of Climate Change on Invasive Species

Ecosystem Indicators

- Produced fact sheet on 22 Indicators;
- Completed communications plan;
- Made improvements to ESIP Monitoring Map and Reporting Tool;
- Presented at workshops/conferences;
- Produced reports (climate change Mass & Atlantic Canada, Casco Bay rpt)

Ecosystem Indicators

- ESIP has "grown" into seven active and effective subcommittees focused on: aquatic habitats, aquaculture, climate change, coastal development, contaminants, eutrophication, and fisheries.
- Produced a fact sheet introducing ESIP to our audience. The fact sheet is available electronically at: http://www2.gulfofmaine.org/esip/factsheet-01.php
- Completed a communications plan focused on effective delivery of indicator information.

Ecosystem Indicators

- Presented at a wide variety of regional and international meetings including: Coastal Zone 08, Coastal Zone 09, Coastal Zone 10, RARGOM, Fishermen and Scientists Research Society.
- Significantly improved up ESIP Monitoring Map (http://www2.gulfofmaine.org/esip/map/) and ESIP webpage. Usage has increased alongside these improvements. In 2007 the ESIP pages received 17,414 hits as opposed to 2010 hits (does not include November and December at the time of writing: 42,782 hits.

Ecosystem Indicators

- Produced reports (climate change Mass & Atlantic Canada, Casco Bay report)
- Released the ESIP Indicator Reporting Tool (www2.gulfofmaine.org/esip/reporting) to provide all data utilized for the priority Indicators.

Ecosystem Indicators plans

- More thoroughly engaging ESIP's target audience with focused workshops and presentations to increase use of and improve delivery of ESIP indicator data and tools.
- Realizing a larger regional audience through targeted articles and advertisements in regional publications (electronically as has been done previously with the Gulf of Maine Times and Fishermen and Scientists Research Society newsletters) and in other more traditional publications (such as Downeaster, Yankee Magazine, Sailscapes, etc).
- Providing information on ESIP's tools and the Gulf of Maine through kiosks at regional science centers (examples include Huntsman Marine Center, Seacoast Science Center, Bedford Institute of Oceanography, and the New England Aquarium).

Ecosystem Indicators plans

- Designing and fabricating several traveling kiosks for use with community colleges, public libraries, community and regional festivals to tap into local interest in environmental ocean, coastal and watershed issues.
- Building arch-type scenarios for the Environmental Intelligence Center by detailing out the relationships between the priority indicators through focused cross interactions between ESIP subcommittees and by working with specific communities which are arch-type localities.
- Continuing to support State of the Gulf Report with data and analysis where the efforts coincide between the ESIP subcommittees and the State of the Gulf team.
- Developing funding strategy especially for the outreach and communication components of ESIP 2.0.
- Completing a master plan for ESIP 2.0 - the Environmental Intelligence Center with robust alternative futures scenarios.

Other

- Produced and released State of the Gulf web site;
- Awarded 10 Action Plan grants ($95,000), received products, and conducted assessment of 2006-2007 Action Plan grants;
- Created evaluation methodology

Outreach Committee

- Coordinator provided wide range of in-house marketing & communication services;
- Supported Council programs (e.g., restoration, ESIP, Gulfwatch, SIC, Action Plan Grants, etc.)
- Supported the GOM Times

Outreach Committee

- Drafted and released survey to Working Group and Council members to gain feedback on GoMC outreach efforts.
- Committee drafting a strategic communications plan - based in part on survey results and feedback - to guide the Gulf of Maine Council as an organization in its outreach efforts, including media relations, the promotion of program actions/outcomes and proactive outreach.

Outreach Committee

- Committee members with expertise in education & outreach reviewing GoMC current offerings to outline a strategy/recommendations going forward. This strategy/recommendations will go hand-in-hand with the communications strategy.
- Supported Council programs (i.e. ESIP, Gulfwatch, etc.) on many fronts, including the review and editing of documents for public release.

Outreach Committee plans

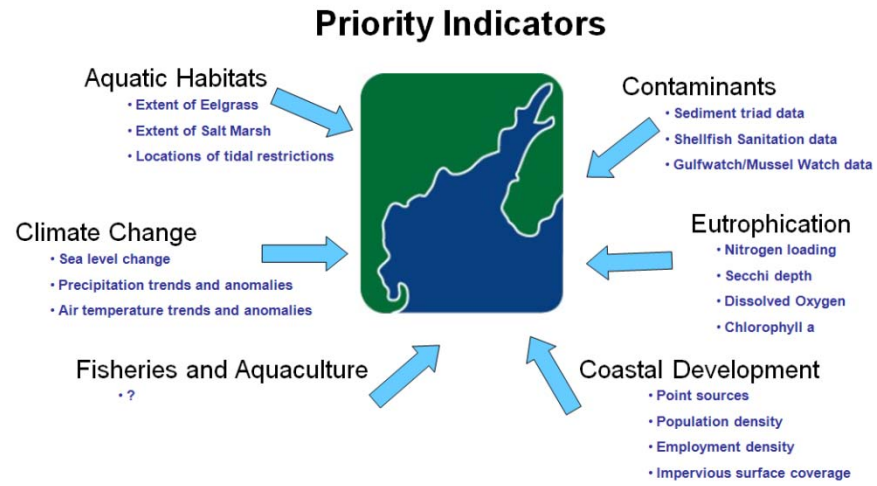
- Support the other committees will continue
- Be more active "stewards" of the Gulf of Maine Council brand through the promotion of the 2012 Action Plan and the organization in general

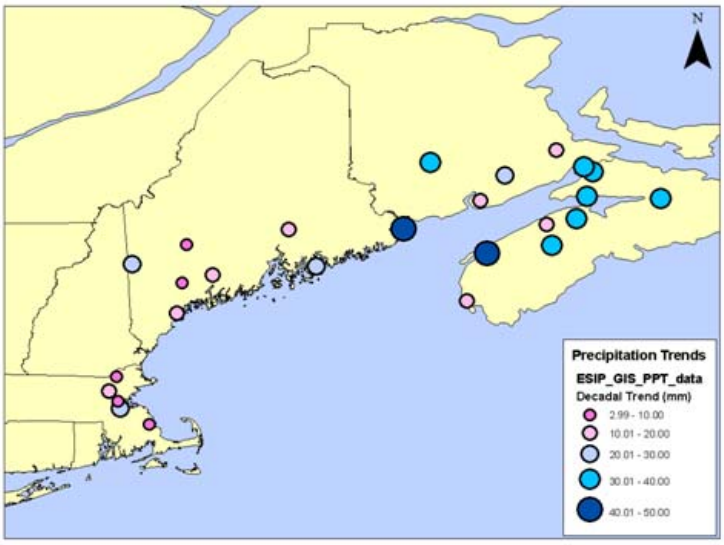
Information Management Committee

- Insert

ESIP and the Delivery of Ecosystem Indicators

ESIP continues our thorough work on ecosystem indicators with meetings in the past year at RARGOM (New Brunswick, 2010), Maine Coastal Waters (Maine, October 2010), ACZISC (New Brunswick, February 2010), Fishermen and Scientists Research Society (Nova Scotia, February 2010), National Monitoring Conference (Colorado, April 2010), Coastal Zone Canada (PEI, July 2010) and RARGOM (New Hampshire, October 2010). ESIP's annual Steering Committee meeting in June was also successful and focused on our workplan and efforts for the next 18 months. Along with these discussions, committee chairs from other Council efforts were invited to participate in the morning as we worked on ways to strengthen our collective work.





Aside from the important work of extending ESIP's presence in the Gulf of Maine and beyond, ESIP has continued to revise and improve upon our general webpages and, in particular, the Indicator Reporting Tool (www2.gulfofmaine.org/esip/reporting) with almost three times as many webhits for all of the ESIP pages between May - October of 2010 than the same months of 2009.

Work has continued in all of the ESIP Subcommittees with fact sheets out for both Aquaculture and Climate Change in the coming months (Aquaculture December 2010 and Climate Change January 2011).

ESIP has secured the assistance of two graduate student interns to work on some data analysis for the aquatic habitat subcommittee and the eutrophication subcommittee. One student from Dalhousie is looking at tidal restrictions in the Gulf of Maine. A separate student from the University of Southern Maine is working on locating samples for chlorophyll a and water clarity.

Workshop Prospectus

Ecosystem Health Indicator: Strengthening Regional Collaboration & Effectiveness

Background
The Northeast Regional Ocean Council, the Massachusetts Ocean Partnership, COMPASS, NERACOOS and the Gulf of Maine Council, with support from a workshop steering committee, are finalizing plans for a regional indicator workshop.

Date
Mid-March 2011 (TBD) – 2 days in Worcester

Audience
Representatives from nearly 20 regional indicator programs

Needs Assessment
In 2010 the Massachusetts Ocean Partnership, through the Urban Harbors Institute of the University of Massachusetts Boston, conducted interviews with indicator programs. Program selection was guided by the workshop steering committee and heavily weighted to include programs from within the region in order to gather regionally relevant information and engage potential workshop participants. The information gained through these interviews is being used to inform the goals, outcomes and agenda for the conference.

Goals and Outcomes
Over fifteen organizations in the northeast are working collaboratively to enhance region-wide indicator capacity and coordination with the objective of advancing integrated and adaptive management while maximizing the provision of critical ecosystem services for ecological and human well-being.

Workshop Goal 1: To strengthen coordination and integration of regional indicator initiatives to better meet users' needs by finding efficiencies of scale and refining processes that benefit all.

Example Outcomes (not prioritized):
- Improved understanding of the indicator initiatives and their data
- Coordination of data acquisition
- Identification of shared end-user management needs and collaboration methods to better inform and meet those needs
- Understand/record processes for indicator selection
- Leverage financial/staffing resources

- Define projects to work on collaboratively
- Enhance credibility and authority for all initiatives
- Develop data series to measure socio-economic aspects of coastal areas and ocean dependent industries in New England

Workshop Goal 2: Strengthen regional indicator communication methods, products, and evaluative techniques. Convey consistent messages and visualizations to key audiences and better understand how indicators are being used, their effectiveness and create and/or enhance user-driven indicator processes, products, and tools.

Example Outcomes (not prioritized):

- Communication methods and tools based on available research about how people learn and make decisions. Use indicators as a learning tool.
- Frame messages to more explicitly link indicators and ecosystem services and ecosystem health
- Develop best practices for creating use-inspired reporting products and visuals for more effectively communicating data
- Develop regional formative and summative evaluation protocol and techniques for better understanding the evolving needs of users and behaviors and communication products' ability to adapt to evolving values, attitudes, and perceptions.
- Create/compile examples and case studies of indicator successes and failures

Research Goals (Clark University and Brown University): Use one indicator program (such as the NEPs) as a case study to learn what messages they want to get across and to which audiences. Use a concept mapping approach to identify inconsistencies in mental models among NEPs and misperceptions and gaps in understanding among audiences to ultimately refine and reframe messages to be more consistent among programs and more relevant and clear to users.

Collaboration Opportunities: Foundations with shared interests of the Council

Background – During the "development work session" at the October 2010 Working Group meeting there was some discussion about Council project priorities, the preparation of competitive proposals, and possible foundations the Council might seek to work with. The following is a compilation of New England and national foundations.

Jane's Trust

Area of giving: meaningful and innovative contributions to the protection of critical or historically significant rural or urban natural resources AND efforts that have a beneficial impact on the quality of life of underserved populations; annual grants total $9M with range from $50,000 to $1,000,000. Average size is $130,000; spend-down trust; makes multiple year-awards; geographical focus is Florida, Massachusetts and northern New England; Jane's Trust cover sheet, concept papers, proof of federal exemption and budget due January 25 and July 15.
www.hembar.com/selectsrv/janes/

Davis Conservation

Areas of giving: wise use, protection and advancement of our physical environment and the different natural forms of life – projects related to wildlife, wildlife habitat, environmental protection and outdoor recreation, projects that strengthen volunteer activity and outreach/community involvement; Highest geographic priority is northern New England, particularly projects involving the northern forest and the Gulf of Maine; April 10 and October 10; 1-year grants; $5,000 to $50,000/award and $875,000 awarded in 2008 for 50+ projects.
www.davisfoundations.org

Elmina Sewall Foundation

Areas of giving: conservation of the natural environment and the well-being of animals and humans in Maine, support issues and priorities that cut across areas of interest, support capacity building of grantees, seek to leverage other resources; operating, project and capital grants; no multi-year awards; environment – encourage local/regional land conservation, support habitat protection, restoration and related public education, provide opportunities for people to remain connected to the land, protect Maine's working lands and waters; Letters of Inquiry – February 1st; in 2009 grants ranged from $3500 to $1M for a total of $7.5M.

Merck Family Fund

Areas of giving: The program "Protecting the Natural Environment" recognizes the need for and practice of sustainable forestry; supports the participation of people living in or near the

impacted area; and the protection and preservation of ecologically valuable land in the northern forests of New Hampshire and Maine. Letters of interest may be submitted. http://www.merckff.org

John Merck Fund
Areas of giving: Promoting adoption of clean, renewable energy options in New England; and Implementing New England's strong climate policies, such as the Regional Greenhouse Gas Initiative.
www.jmfund.org

Sudbury Foundation
Areas of giving: The Environmental Program makes grants to nonprofit organizations with headquarters or branch offices located in the Northern Forest and the Gulf of Maine who are working at the nexus of ecosystem protection and community economic sustainability. Because solutions developed with local input are often the most effective and enduring, the Foundation favors community-based efforts to conserve resources and enhance quality of life. The heart of our approach is to support groups who give voice to local stakeholders seeking to balance marine and forest resource management with community sustainability. (The fisheries and coastal communities of the Gulf of Maine, which encompasses 36,000-square miles of ocean and connects the New England states of Massachusetts, New Hampshire and Maine with adjoining Canadian provinces.)
http://sudburyfoundation.org/environmental.html

Jessie B. Cox Charitable Trust
Areas of giving: education, environment (preservation of fresh and marine waters through natural habitat conservation, protect terrestrial and marine habitats and wildlife crucial for biodiversity, support eco-regional planning, habitat assessment, smart growth, strengthen citizen-based networks and alliances, science-based tools to support conservation) and health; focus on six New England states; concept papers due March 15 and September 15; average award of $50K/year.
www.jbcoxtrust.org

Northeast Utilities Foundation
Areas of giving: the emphasis of the Environmental Leadership & Stewardship is on protecting, preserving, or improving the environment; natural habitats and biological diversity, and renewable energy in their service area.
http://northeastutilitiesfoundation.org/what/index.html

Irving Oil Foundation
Area of focus: Environmental programs in Atlantic Canada and New England
www.irvingoil.com/community/charity.asp

Community Foundations

The Maine Community Foundation, the NH Charitable Foundation, the Fundy Community Foundation and the Cape Cod Foundation all support environmental/conservation and education programming through existing programs or donor-advised funds.

State/Provincial Foundations
The Maine Outdoor Heritage Program, the Massachusetts Environmental Trust and the New Brunswick Environmental Trust all support environmental/conservation and education programming.

Island Foundation
RNAV Foundation
Thaxter Foundation
Kendall Foundation (in transition)

Gordon and Betty Moore Foundation
Areas of giving: environmental conservation, science and San Francisco Bay; in 2008 awarded 134 grants totaling $261M; no unsolicited proposals.
www.moore.org

Ittleson Foundation
Areas of giving: innovative pilot, model and demonstration projects that will help move individuals, communities, and organizations from environmental awareness to environmental activism by changing attitudes and behaviors. They particularly seek to encourage and nurture environmental action through:

- Supporting the present generation of environmental activists, whether professionals or volunteers through education, training and other activities
- Educating and engaging the next generation of environmentalists with a special interest in supporting the training of those who are teaching that generation
- Strengthening the infrastructure of the environmental movement with a particular focus on efforts at the grassroots and statewide levels
- Activating new constituencies, particularly those focused on environmental equity issues

www.ittlesonfoundation.org

Pew Charitable Trust Environmental Program
Areas of giving: reduce the generation of greenhouse gases that contribute to global warming, conserve living marine resources with a particular emphasis on fisheries and protect critical forest habitat and wilderness on public lands in North America. The Trust accepts letters of inquiry on an open basis. If the proposed project appears to be eligible for Trust consideration, a full proposal will be requested. Average - $300,000.
www.pewtrusts.com

Rockefeller Brothers Fund

Areas of giving: The Sustainable Development program supports environmental stewardship that is ecologically based, economically sound, socially just, culturally appropriate and consistent with intergenerational equity. The program has two components: Combating Global Warming, which supports strategies to combat global warming, and Protecting Ecosystems and Conserving Biodiversity, which seeks to conserve terrestrial and marine biodiversity by protecting and restoring ecosystems and by fostering sustainable communities that pursue locally appropriate development strategies. Letters of inquiry are accepted on an ongoing basis. Invitations for full proposals are issued by the Fund. Average $75,000.
www.rbf.org

Surdna Foundation
Areas of giving: The Environment Program's goals are to prevent irreversible damage to the environment and to promote more efficient, economically sound, environmentally beneficial and equitable use of land and natural resources.
The program has four principal areas of interest: biological diversity and the human communities that depend on it, realigning human and natural systems, transportation and urban/suburban land use and energy. Letters of inquiry are reviewed year round. Grants are approved three times per year: in February, May and September. Requests must be received three to four months ahead of time for staff review.
www.surdna.org/grants

Gulf of Maine Council

June 2010 to December 2010 Development Report

Context for Development Initiative

1. Council fund development priorities (Climate Change, ESIP, GOM Times, IT, and Habitat Restoration)
2. Tough economic conditions and highly competitive funding environment
3. Team effort of Working Group, Committees and contractors working to secure funds for Council tasks (Highlighted for emphasis)
4. Pursued new development approaches (engaged Councilor to attend Working Group meeting sessions on fund development; solicited GOMT sponsors to make annual contributions; engaged DC Hill staff in discussions of creating a Gulf of Maine Program Office and corresponding authorization; worked with USGOMA to prepare and submit proposals to the Northeast Regional Ocean Council (e.g., serve as fiscal agent for marine spatial planning grant, contribute coastal and marine spatial planning services)

2010 Assessment & Return on Investment

January – December 2010

Total Requested	$1,248,920
Funds Raised	$658,920
Total Declined	$198,000
Total Pending	$362,000
Fund Development Expenses	$40,050

Note: A detailed breakdown of funds raised, declined, and pending is available in the December 2010 meeting packets

Level of Effort, Results and Next Steps

- **Climate Change Adaptation**
  - Effort – Used 2010 GOMC climate change needs assessment; Engaged Coastal Training Programs, ICLEI, five state coastal management programs, Provincial RAC members, Roger Williams University, Cool Air- Clean Planet and StormSmart Coasts in preparing and submitting $280K proposal to NOAA/CSI Coasts with $500K+ in cash and in-kind match
  - Result – expect NOAA decision by May 2011
  - Next steps – Review needs assessment and prepare funding proposal(s)
- **Ecosystem Indicator Partnership (& SOG reporting)**
  - Effort – Recruited interns to assist with data discovery and mining; Explored collaboration with NEIWPCC; Submitted $82,000 proposal to support 2 years of services; Pursued $6,500 request for offshore ecosystem paper
  - Result – Secured $15,000 grant for March 2011 Workshop; ESIP leadership secured $4,000 from Council agencies for coordinator
  - Next steps – Choose project(s) from draft 5-year ESIP plan and prepare funding proposals
- **GOM Times**
  - Effort – Cultivated and solicited 8 organizations to become ongoing sponsors; Worked to increase circulation/readership; increased web site functionality;
  - Results – Raised $9,225 from Census for Marine Life, CLF, DOI/National Park Service, EC, DFO , ME SPO, and NERACOOS;
  - Next Steps – Engage additional organizations to become ongoing contributors
- **Information Technology**
  - Effort – Funding proposals contained IT support
  - Results – Proposals pending
  - Next steps – Continue to include IT in proposals
- **Habitat Restoration Coordinator & Strategy**
  - Effort – Supported Canadian contractor documenting restoration programs and policies; Reported release of US GOM Restoration Plan to funders (e.g., Cox Trust, NH Charitable Foundation and Maine Community Foundation); Secured commitment by National Wildlife Federation (NWF) to act as fiscal agent for the Northeast Great 'waters Coalition; Prepared funding analysis with NWF development staff and identified priority funding sources; Prepared case statement for the Northeast Great Waters Coalition as basis for funding proposal(s); Assisted NWF to submit $30,000 proposal to the Davis Conservation Foundation for Plan advocacy
  - Results – Awaiting response by Davis Conservation
  - Next steps – Work with Congress on an implementation strategy for the US GOM Plan
- **US Federal Appropriation Initiative**
  - Effort – Work focused on implementation of the US GOM Restoration and Conservation Assessment (see above)
  - Results – Hill staff receptive to a FY 2011 request
  - Next steps – Continue to engage Hill staff & members of Congress
- **Cultivate foundations**
  - Effort – Engage foundation community in Council activities;
  - Results – Increased knowledge of 10+ foundations about the Council and its work
  - Next steps – organize Council - foundation events

Gulf of Maine Council Proposals – factors for success

This informal assessment provides some insights into the Council's 2010 fund development efforts. It is intended to support discussions about ways to strengthen fund development by improving Council, Working Group, and Committee engagement and preparing more competitive proposals. (This table reflects proposals prepared for GOMC priorities that the Council participated in preparing. Some funds have or will flow through other organizations.)

Purpose	Funding Source	Amount	Funded Yes/No	Comments
Gulf of Maine Times	NB Environmental Trust Fund	$28,000	No	Huntsman Marine Science Center & GOMC developed joint proposal; $15K for GOMT; NB Environment encouraged proposal; Favorable reviews but not funded.
	CLF, DOI/NPS, DOI/USGS, EC, DFO, Chewonki, UMass Boston, Census for Marine Life, New England Aquarium, NERACOOS, Northeast Consortium, MSPO, Mass Ocean Partnership, NH Charitable Foundation,	$17,500	Yes	Three levels of donations and benefits from $500 to greater than $2,000; expectation these are ongoing annual contributions; one-on-one solicitation; time consuming (securing commitments, obtaining sponsor materials for posting to GOMT site)
Restoration Grants/ Coordinator Match	NOAA/NMFS MA DER, CWRP, ME SPO	$450,000 35,000	Yes Yes	Year one of fourth 3-year partnership
Ecosystem Indicator Partnership/SOE	NERACOOS	$15,000	Yes	Documented alignment between NERACOOS/GOMC data and information management objectives;
	NERACOOS	$82,000	Pending	Build on current regional effort; ESIP to collaborate with other indicator efforts in New England; present region-wide information
	Agency contributions EPA, EC, DFO, USGS, MSPO, NHDES	$14,700	Yes	Substantial in-kind support
	DFO/HOTO,	NA	Yes	DFO demonstrated exemplary leadership with strong advisors;
	EPA/GEOSS Program	$170,000	No	Highly competitive program; incomplete EPA guidance
Climate Change	NOAA/CSI Coasts	$280,000	Pending	Highly collaborative proposal engaging five state agencies, three non-profits and a university that will perform the work; secured in excess of $500K in cash and in-kind match

Restoration & Conservation Plan	NH Charitable Foundation, Maine Community Foundation and Cox Charitable Trust, DFO	$110,000	Yes	Able to prepare compelling narratives. DFO provided $10,000 to support Canadian contractor working on Canadian programs.
Council priorities	US Congress	NA	Pending	Prepared GOM Program Office authorization and appropriation language for DC Hill staff in the fall.
Gulfwatch	EC	16,720	Yes	
	Total Requested	$1,248,920		
	Total Funded	$658,920		
	Total Declined for Funding	$198,000		EPA/GEOSS & NBETF
	Total Pending	$362,000		$30,000 NWF funds not included in pending total

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NORTHEAST REGIONAL OCEAN COUNCIL

May 28, 2010

Regional Climate Change Project Proposal Ideas

Adaptation involves making adjustments in our decisions, activities, and thinking in response to observed or expected changes in climate, with the goal of moderating harm and taking advantage of new opportunities that may be presented by

Background: The Gulf of Maine Council's Climate Change Network and the Northeast Regional Ocean Council's Coastal Resiliency Committee are collaborating in the development of several climate change adaptation funding proposals that would benefit the region extending from Long Island Sound to the Bay of Fundy. The organizations are interested in projects that will take 12-18 months to complete, are $50-$250,000 in value, meet multiple jurisdictional needs, benefit from a regional approach, and build on existing efforts. Our audiences for these projects are decision-makers and coastal managers. The basis of the projects ideas described below were synthesized from recent state, provincial and federal climate change forums, meetings, user needs assessments and reports.

Current Situation: In April and May 2010 over twenty climate change experts from throughout the Gulf of Maine region reviewed and contributed suggestions to the initial synthesis. Their consensus priority project recommendations are:

Priority Ideas for Projects (see highlights below)
➢ Promote climate change exchange
➢ Expand StormSmart Coast
➢ Enable community infrastructure assessments
➢ Offer municipal guidelines
➢ Summarize adaptation policies
➢ Disseminate and use LiDAR tools
➢ Develop climate change regional monitoring strategy

Category 1: Growing the capacity of local and provincial/state leaders to more effectively respond to climate change

Local, provincial/state and non-profit leaders from Long Island Sound to the Bay of Fundy are developing and applying creative climate change adaptation strategies – often in isolation of each other. At the national level CEQ is poised to release a national adaptation strategy. There are a number of ways we might accelerate the learning and implementation of effective adaptation responses. Examples include:

a. Promote climate change "exchange" – Develop and effectively disseminate a routine e-correspondence tool for coastal managers (e.g., local, state, provincial and federal representatives, non-profits, legislative staff, etc.) engaged in climate change issues. Use existing communications tools (e.g., Gulf of Maine Times, monthly e-newsletters, etc.) and integrate/adapt existing materials (e.g., CZMA Climate Change, Coastal Hazards E-News from NOAA, etc.) **(Priority Idea)**

Next steps

- *Solicit state, provincial and federal climate change managers to learn where they get their information, priority needs, perceived gaps, and recommended delivery methods (e.g., frequency, detail, sources, etc.);*
- *Compile directory of leading climate change sources of information pertinent to the region;*

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- *Commence immediately circulating these sources to existing outlets (e.g., Gulf of Maine Times, State CZ newsletters, etc.) for re-distribution;*
- *Develop new materials responsive to climate change managers needs & disseminate;*

Partners to engage

Northeast Federal Partners, Environment Canada, NRCAN, ICLIE, NESCAUM, Regional Adaptation Collaborative

b. Expand StormSmart web presence – several states are in the midst of providing community-level decision-makers, via the StormSmart Coasts Network, with information to better prepare and recover from natural disasters such as storms and sea-level rise. http://stormsmartcoasts.org/ Parallel Provincial materials are being organized. The region's ocean observing assets can also make important contributions. Collectively these efforts need to be augmented and sustained. **(Priority Idea)**

Next steps

- *Enable the New England states that have yet to complete content for their state pages/sites to finish this work;*
- *Speak further with Wes about incremental improvements to individual New England state pages/sites (e.g., 6-month update process for the states to keep pages "fresh"; create a listserve for interested parties to join and send documents, updates, etc. A listserve moderator can then upload information to the website if relevant; actively promote the site to target audiences via the CSC magazine, Coastal Connections and other methods;*
- Learn from the NB and NS members of the Regional Adaptation Collaborative *about their comparable web development projects and needs and assess next steps (They have confirmed their interest in StormSmart.);*

Partners to engage

NOAA/CSC, State coastal hazard leaders (e.g., floodplain & emergency management programs, coastal management, geological survey, etc.), ICLIE, RAC

c. Support networking of climate change professionals -- support mechanism to coordinate and communicate data and decisions across sectors; foster communication and coordinated policy recommendations; achieve broad consistency in the region about the common elements for adaptation planning strategies, etc.

d. Organize annual climate change networking event -- A content rich, annual event that brings practitioners together to discuss accomplishments, share approaches and strategize collaborative ideas for the coming year. Possible participants include state/provincial climate adaptation officials, NEIWPCC, NESCAUM, GOMC, NROC, ICELI (local government), regional fish & wildlife staff, forestry experts, transportation officials, academia and federal partners.

e. Offer adaptation workshop(s) – compile existing workshop materials and results (e.g., fall 2010 NOAA/NESCAUM, ICLEI, etc.) and offer additional opportunities for natural resource management professionals, including state/provincial and local resource managers, planners, and program administrators to be more informed about climate change. Workshops would target foundational and process content and skills to support integration of climate adaptation planning in communities and planning processes. (Topics include comprehending the science, governance -integrating climate adaptation, engaging stakeholders for the long-term, communications -considering perceptions and applying principles, risk assessment - understanding methods and interpreting results, adaptation planning -identifying and prioritizing actions, adaptation implementation and monitoring - considering changing conditions)

f. Develop shared messaging and communication: develop materials to engage communities, local officials, legislatures, Governors/Premiers and media that communicate climate literacy and the benefits of taking actions today, even in the midst of a tough economic climate. Understand current attitudes and awareness

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of the target audience (e.g., 2010 Clean Air – Cool Planet report). Commence work by engaging environmental agency education staff to document lessons-learned.

Adrianne – status of NOAA/NESCAUM work on shared messaging and communication?

Category 2: Terrestrial projects that prepare for and increase resilience to the most likely foreseeable impacts of climate change

The coastal zone has a unique set of challenges and opportunities associated with climate change adaptation planning. For example, anticipated rise in sea level is a primary concern in planning how the region's coast could become more resilient. However the effects of higher sea surface levels will be compounded by the increase in significant storm events. Increases in precipitation that result in greater storm-water runoff have a coastal impact because most of the additional runoff reaches the major rivers that flow through and into estuaries and wetlands, bringing with it sediments and pollutants. These climate effects drive beaches, dunes, marshes, and wetlands "inland". In many places they are unable to migrate to new locations and we risk losing the benefits of systems that provide protection for our communities and vital natural resources.

A. Enable community infrastructure assessment: Enable communities to prepare climate change assessments that support comprehensive planning and capital improvements. Initially this would involve developing criteria for assessing natural communities and infrastructure for response and resilience to likely climate impacts, including a mechanism for evaluating vulnerability. Look for the intersection of water utilities and transportation corridors. These should recognize the unique ecological, social, and economic qualities of different areas of the coast, and should be used to guide investments in infrastructure repair, protection, and land conservation and restoration. **(Priority Idea)**

Next steps

- *Conduct literature review for criteria used to assess natural communities and infrastructure for their response and resilience to likely climate impacts;*
- *Engage New England and Maritime hazard and municipal planning managers to understand their needs and likely applications of the criteria (see recent NS Climate Change Centre needs assessment);*
- *Adapt criteria and/or develop new criteria as needed;*
- *Work with managers to implement on pilot basis, evaluate and expand effort.*

Partners to engage

State coastal hazard leaders (e.g., floodplain & emergency management programs, coastal management, geological survey, climate change program leaders, etc.), NESCAUM, RAC, professional associations (e.g., engineers, architects, planners, etc.)

B. Organize municipal guidelines: Assemble and present materials for protective zoning/regulation and conservation in coastal areas that allow for the movement of natural areas and species in response to anticipated climate effects. Present metrics to identify priority locations based on best scientific forecasts of highest risk of loss from sea level rise and related impacts, and promote opportunities for state/provincial and local partnerships to develop creative approaches to respond to anticipated climate effects. **(Priority Idea)**

Next steps

- *Conduct a literature review of protective zoning/regulation and conservation in coastal areas that allow for the movement of natural areas and species in response to anticipated climate effects and assess effectiveness. Draw on current Canadian Institute of Planners work on a*

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planning guide, the earlier Canadian Climate Impacts and Adaptation Research Network manual for Canadian municipalities; pending NOAA/OCRM Planning Guide for State Managers; etc.

- *Develop 1-2 pilot projects in the region that are exposed to the highest risk of loss from sea level rise and related impacts. Implement and evaluate results.*

Partners to engage

Leaders from a few areas in the region that are exposed to the highest risk of loss from sea level rise and related impacts; respective federal, state and provincial hazards managers; chapters of Associations of Planners;

C. Summarize adaptation policies: Prepare a regional white-paper/briefing that identifies a range of municipal adaptation policies and standards for publically-owned properties, infrastructure and investments in the coastal zone. This could include guidelines that smaller communities and rural areas could use to evaluate current and projected hazards vulnerability and emergency preparedness. **(Priority Idea)**

Next steps

- *Conduct a literature review of municipal adaptation policies and standards for publically-owned properties, infrastructure and investments in the coastal zone and related evaluations;*
- *Produce synthesis of applicable policies and standards for the region;*
- *Disseminate and promote their use/application*

Partners to engage

NE Federal partners, RAC, state hazards managers,

D. Produce LiDAR products and maps: In 2010 a $1.4M ARRA funded collaborative light detection and ranging (LiDAR) program was launched by the New England states in cooperation with USGS, FEMA and other federal partners to develop 2-meter point-spaced LiDAR files at +/- 15-cm vertical resolution (and metadata) for the New England coastal region to better inform shoreline management decision-making. Once the data are collected (projected "leaves-off" fall 2010) and processed (likely delivery in June 2011) the real work begins (e.g., maps produced, priority products/interpretations prepared for coastal managers, etc.) It can then be used to create inundation and sea level rise scenario maps using Digital Flood Insurance Rate Maps or standardized digital flood zones; delineate current and future resources areas, especially salt marshes; use first return DEMs to calculate canopy coverage and development footprints; etc. (These same data can be used in a variety of other ways -- map wildlife habitat, predict erosion, model suitability of potential wind energy sites, choose locations of cell towers or wireless broadband equipment, and predict forest types.) **(Priority Idea)**

Next steps

- *The New England states develop a strategy (e.g., applications/uses, methods, timeline and funding plan, etc.) for "data crunching, derivative map and tool generation, etc. " for the most vulnerable regions in New England (e.g.,* beaches, low marsh areas, bluffs, etc.).

Partners to engage

LiDAR project participants and end-users (e.g., towns, COGs, planning commissions, watershed associations, utility districts, nonprofits, etc.)

E. Municipal technical assistance: Strengthen municipal land use ordinances, building codes, and community capacity to respond climate change. Examples of this work includes amending local ordinances, bylaws,

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hazard mitigation plans, emergency planning, design standards and codes to go beyond the minimum; developing informative materials about the rationale/need for municipal amendments that address sea level rise and coastal inundation; and scaling down regional inundation materials to the local scale & convening regional workshops; etc.

F. Make vulnerable municipal infrastructure more storm resilient: Assist municipalities adapt shoreline municipal infrastructure to be more storm resilient through design, site planning, engineering and permitting. Examples of this work includes adapting existing shoreline stabilization structures, flood-proofing, address highly erodible bluffs that have associated municipal infrastructure, incorporate soft/green solutions; reengineer sewer lines, elevate structures, relocate frequently damaged roads, raise manholes, elevate outfalls, sand dune enhancements to improve buffering, architectural and design changes to reduce flood impacts, etc.

G. Document priority thresholds: Assemble regional experts to assess and report-out on where the thresholds of key natural systems in the region are at risk of disruption and critical data gaps. Exceeding these have the potential to cause abrupt ecosystem changes that are able to produce significant risks/hazards. Examples of these thresholds could be:
   - ocean acidification for sensitive marine organisms;
   - terrestrial plant and animal species sensitive to temperature and precipitation;
   - warming that creates new opportunities for human diseases that were previously inhibited by our cold climate.

H. Habitat restoration & climate change considerations: engage regional partners (e.g., NOAA, TNC, etc.) in developing regional climate change criteria for evaluating habitat restoration projects (e.g., whether to fund a project, how to design a project, how to set project restoration goals that fully consider a changing climate and establish achievable baselines, etc.). The goal could be to about what standards to address (e.g. 2 or 3 sea level rise scenarios for marshes; higher coastal floodplains for roads, bridges, higher tidal flow through culverts, infrastructure elevation or capacity for stomwater, etc.).

I. Wastewater facility adaptation: Engage the engineering and architect community in developing materials specific to publically-owned wastewater treatment facilities (POTW's) that assist such facilities to consider the effects of changing precipitation and/or sea level rise on their infrastructure, and support decisions needed for capital planning, disaster mitigation, etc.

J. Prepare Critical Infrastructure Protection Plan: Based on the 2007 Portland/Vancouver Urban Area Critical Infrastructure Protection Plan initiative (and their lessons-learned) select a priority area (e.g., inter-state, complex metropolitan area, etc.) and develop a definition for critical infrastructure specific to the area; identify private and public critical infrastructure that meet the regionally specific definition; develop a method to prioritize the region's critical infrastructure; and identify existing standards for protection of each critical infrastructure sector that can be used for public- and private-sector planning. (Convene a series of "interdependencies workshops" (e.g., dams, utilities and energy providers; transportation, shipping and military; etc.) to not only look at what was the most critical infrastructure within the region but also how they related to each other.)

K. Inventory vulnerable natural areas: Identify (1) undeveloped low-lying coastal areas for wetland migration through up-dated mapping and evaluation of coastal marshes, dune systems, and other wetland types having the capacity to buffer against storm events; and (2) undeveloped up-lands that protect these systems and offer potential for eventual inland migration of these systems. The inventory should identify potential areas of loss and gain, including economic, ecological, and cultural value, and design and/or enhance robust monitoring systems to track change and vulnerability over time. Identify landscapes to which tidal wetlands are likely to migrate in response to SLR.

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L. Health considerations: As data on climate-related health impacts are gathered and assessed, information for health providers and the public will need to be revised and made available. A focus may be on vulnerable populations (e.g., elders, children, indigenous people, disabled/handicapped people, low income groups, refugees/migrants) and communities of special concern when viewed through the lens of climate.

Category 3: Marine environment responses

The marine environment has a profound effect on the region's climate, weather, quality of life for wildlife and humans, and economy. Impacts with the likelihood of most significant impact to the ocean are:

- Changes in ocean circulation patterns, especially open ocean current changes that have an impact on the transport of deep cold waters into the Gulf from the Atlantic;
- Changes in seawater chemistry, including nutrient levels and acidification;
- Changes in amount of freshwater delivery to the Gulf from melting ice in the Arctic, which would impact stratification and in turn productivity;
- Changes in seawater temperature, which may differ between in-shore and open ocean; and
- Changes in off-shore wind patterns, a matter of importance in light of current efforts to utilize wind energy.
- changes in near-shore wind patterns are intensifying hypoxia in LIS and will affect long-shore sediment transport patterns (and thus the efficacy of existing erosion control structures.

Given the extreme complexity of ocean chemistry, it is not yet clear just what changes such as acidification, calcification, or nutrient transport and availability will have on the marine ecosystem and the species it supports. These are already stressed by other human impacts, especially storm-water runoff, which may be exacerbated by climate change. The entire marine food-web is expected to undergo changes in both plant and animal species, including the increased risk of invasive species, with corresponding changes to the region's ocean fishery.

A. Develop a regional monitoring strategy for key marine climate change indicators: Secure seed-funds to prepare and promote federal implementation of a Gulf of Maine to Long Island Sound sustained climate change monitoring framework that coordinates the acquisition and exchange of scientific knowledge. This effort would determine what is required to initiate and maintain a suite of monitoring programs in the marine environment. (LISS and CT DEP/UConn are developing a sentinel monitoring strategy for climate change.) For the estuarine and marine ecosystems, climate change affects the physical and chemical properties of Gulf of Maine waters, which in turn alters physiological processes, food webs, and distribution and migration patterns of marine organisms. Robust monitoring programs are needed to monitor atmospheric and water properties, circulation patterns, distribution and abundance of marine organisms (phytoplankton to marine mammals and sea birds, including invasive species), changes to habitats, impact on the economic and social systems, etc. (Examples of current initiatives to draw on include the Gulf of Maine Monitoring Inventory & ESIP Monitoring Map, the emerging Gulf of Maine Restoration and Conservation Initiative, the Massachusetts Ocean Plan, NOAA ocean acidification implementation report, and the Long Island Sound Study.) (Priority Idea)

Next steps

- *Form ad-hoc steering committee of bi-national climate change and monitoring experts to scope the content and cost of a regional monitoring strategy for key marine climate change indicators;*

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- *Prepare a seed-funding grant to assess existing monitoring programs, develop the scope of the monitoring strategy and prepare implementation recommendations*

Partners to engage

RARGOM, BoFEP, the region's climate change leaders (e.g., state/provincial climate change program managers, NOAA/OAR, etc.)

Reasons to be involved

As the scope and content of the 2012 – 2017 Action Plan is defined it is very important to articulate what the participating agencies (and individuals representing the agencies) need from the Council and the value they place in it.

Background

During the past twenty years agency representatives on the Gulf of Maine Council, in the face of competing requests for time and resources, have needed to make choices (and respond to inquiries) about why they participate in this transboundary organization.

Given the slow but steady growth of regional coordination mechanisms in Canada and the US over the past 10-years there is an ongoing need to be really clear about the benefits of participation in the GOMC. In October 2010 the WG discussed and created the following list of rationale for participation.

Reasons to participate

1. Easier to do daily tasks within the agency
   - Participation in the GOMC is a mechanism to get things done. The Working Group, Councilors and committee members have access to people, networking and new resources. This transboundary work makes agency work more productive and interesting. These resources can be used to address agency priorities.
2. Address transboundary issues
   - Each state, province and federal agency can use the GOMC to address issues of regional concern that are not dealt with through other regional collaboration mechanisms.
   - The Council allows each country to engage the other in issues of common concern.
3. Learn of innovative approaches
   - Council/WG meetings provide a forum to exchange information
   - In-person, friendly and electronic professional networking opportunities
4. Support cross boundary initiatives
   - Determine important activities (and projects) that require cross boundary approaches such as indicators and state of the Gulf reporting, restoration, Gulf of Maine mapping, monitoring, climate change, communications and outreach
   - Leverage resources that would not be available to individual organizations

Assessing and evaluating the effect of Council activities

Background

In October, 2010 the Working Group reviewed a compilation of 2007-2010 accomplishments of the Gulf of Maine Council and its committees in implementing the current Action Plan. In the ensuing discussion the following questions were raised:

- How effective was the Council in disseminating the products (and marketed) to the end-users;
- What data and information does the Council have on user satisfaction and/or concerns;
- How do these products align with the short and mid-term objectives in the current Action Plan;
- Did any of the products contribute to attaining the respective mid-term and long-term objectives;
- How would the Council's experience in creating and using these products guide development of the new five-year Plan;
- What is the experience of the Council agencies in using these products and services;
- How might the Council promote the use of these products in the next 12-months;

The Working Group concluded that it was important to pursue these evaluation and assessment questions (and others) and to develop some recommendations for Council consideration in December.

2007-2010 Products

GOMMI

- Seafloor mapping brochure
- Seafloor mapping priorities
- Cashes Ledge mapping
- *Integrating seafloor mapping and benthic ecology into fisheries management in the GOM*; and
- Survey Methods for Shallow Water Habitat Mapping in Northeast National Parks, Wildlife Refuges, & Estuarine Research Reserves

Habitat Restoration

- 65 projects - January 1, 2006 through June 30, 2010 = $ 1,914,784 & $2M in non-federal matching funds
- Maintained web portal operation
- Released and promoted use of the stream barrier removal guidelines by awardees and organizations/agencies
- Contributed to US GOM Habitat Restoration and Conservation Plan

Habitat Monitoring

- Supported habitat monitoring beta-web site;
- Produced Salt Marshes in the Gulf of Maine: Human Impacts, Habitat Restoration and Long-term Change Analysis

Habitat Conservation

- Completed documentation of coastal/marine managed areas in the CA portion of the GOM, created user portal and uploaded data to GOM site;
- Organized and produced workshop proceedings about sub-tidal habitat classification methodologies
- Disseminated info on American Eels

Gulfwatch

- Supported 12-year program peer-review by RARGOM & report;
- Collected and analyzed 2007, 2008 and 2009 samples;
- Reconciled past data &1993-2006 now on the server
- Produced data reports (07 & 08)

Sustainable Communities

- Prepared *Industry Engagement with the GOMC* report with recommendations
- Organized and awarded Sustainable Industry, Longard, Snow-Cotter and Visionary Awards

Action Plan Considerations: Factors to Determine Contents of New Plan

Background: The Working Group and Council have identified issues that are important to their respective agencies (e.g., within their mandates) as well as being important to them as individuals. (These materials reflected jurisdictional priorities, hot topics and emerging issues.) Collectively these issues are within "the Council's sphere of concern". In preparation for the December 2010 Council meeting these issues were refined to focus on those that align with the Council's mission and roles. These are the Council's "sphere of influence".

Council's Terms of Reference articulates what it does:

a. Facilitators of integrated watershed, coastal and ocean management – The Council fosters an ecosystem-based management approach. It works to ensure decision-makers possess the necessary information to manage human effects on the ecosystem, to preserve ecological integrity and to sustain economically and socially healthy human communities.

b. Enable the region's governments be more effective stewards – By working together in a regional forum the states, provinces and federal agencies learn from each other, try new approaches and as a result are better stewards of the resources they are legally responsible for.

c. Sustain strong partnerships – The Council works to be an effective partner and build the capacity of local and regional organizations that are addressing issues of regional concern.

Possible Criteria

The determination of what items will be included in the new Plan will be guided by a host of considerations such as: what was the Council able to accomplish in the past four years; what are its lesson-learned from previous Action Plans; what resources/capacity might the Council plausibly have to implement the Plan; how might it partner with others; etc. Based on this situation the following criteria are proposed:

1. **Regional Response** -- Does the issue require or substantially benefit from a regional response?
   For successful resolution of the issue in the Gulf of Maine region must the provinces, states and federal agencies work cooperatively? (It is more than just the issue occurring in some or all of the states/provinces. Rather it requires a coordinated response to effectively address the issue.)
2. **Council Capacity** -- Is the Council uniquely positioned (given its members, geography, mission, Terms of Reference, etc.) to address the issue?
   As a transboundary entity does the Council have special capabilities to address an issue? Is it organized appropriately (or could we put a mechanism in place)?
3. **Council Role –** Can the Council narrow the wide range of possible transboundary issues so as to focus its attention successfully on a few?
   Can the Council choose a few issue? Can it be agile in responding to new issues?
4. **Resources** – Does the Council have (or can it get) the people and money to address the issue? Is it important enough to collectively marshal the resources required?

Next Steps/Needs

Finalize the criteria, apply them to the issues, and begin the shape the contents of the Plan.

2012 – 2017 Priorities

Sources of information: 2007-2012 Action Plan; jurisdictional priorities; GOMC "hot topics brainstorm"; SOG Emerging Issues paper; October 4th Working Group meeting products; 2010 climate change needs assessment; NE/Maritime Partner Collaboration;

Goal 1: Protect and Restore Habitats – Coastal and marine habitats are in a healthy, productive and resilient condition			
2007 – 2012 Activities	Proposed 2012 – 2017 Activities	Possible Tasks	Outcomes/Results
Invasive Species ▪ Assessing risks posed by invasive species in the Gulf of Maine. ▪ Setting priorities and supporting efforts to minimize and/or prevent harmful marine invasions.	NA	NA	NA
Land-based Activities ▪ Disseminating materials that increase awareness about effects of land-based activities on the coastal environment. ▪ Identifying and assessing the long-term economic, social, and ecological implications of projected coastal development patterns in the region.	NA	NA	NA

Habitat Restoration ▪ Disseminating information on the need for coastal habitat restoration. ▪ Funding restoration activities. ▪ Creating tools that managers need to accelerate habitat restoration.	▪ Disseminating information on the need for coastal habitat restoration. ▪ Funding restoration activities. ▪ Creating tools that managers need to accelerate habitat restoration.	▪ Produce articles in GOMT ▪ Offer restoration grants (fish passage, salt marshes, etc.) ▪ TBD	▪ Implementation of US GOM Rest/Con Plan ▪ Restore habitat functions and values
Marine Habitat Conservation ▪ Communicating how ecosystem-based management can be accelerated in the Gulf of Maine. ▪ Developing the ecosystem-based tools that managers need. ▪ Building the capacity of managers for integrated approaches to management.	▪ Communicating how ecosystem-based management can be accelerated in the Gulf of Maine. ▪ Developing the ecosystem-based tools that managers need. ▪ Building the capacity of managers for integrated approaches to management.	▪ Produce articles in GOMT ▪ Promote the need for high-resolution seafloor maps for highest priority areas ▪ Support documentation of the spatial extent and intensity of human uses of the ocean ▪ Collaborate in preparation and implementation of ecosystem health communication strategy ▪ Support marine spatial planning	▪ Enhanced awareness; materials exchanged; ▪ Seafloor maps produced ▪ Better management decisions ▪ Enhanced awareness ▪ Better management decisions

Creating a Vision Statement for the Gulf of Maine

Background: In June 2010 the Council agreed that the 2012 – 2017 Action Plan should be based on a 20-year vision for the Gulf of Maine. With a vision in place the Council can then determine what actions it can pursue to attain it.

A **vision statement** is a vivid idealized description of a desired outcome that inspires, energizes and helps to create a mental picture of your target. It defines the desired or intended future state and provides a strategic direction.

Current Council Mission: maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations

Proposed Vision Statements for the Gulf of Maine

Option #1 -- A healthy, thriving, and resilient Gulf of Maine ecosystem that supports a range of human activities.

Option #2 – A prosperous and healthy Gulf of Maine where conservation, productivity and resource use are sustainable.

Appendix -- Research to inform Council deliberations

The following vision statements may help to identify "words, phrases and concepts" that the Council may want to have in its 20-year vision statement for the Gulf of Maine. (Items highlighted are suggested priority words from the AP Work Group.)

Maya Mountain Marine Corridor Conservation Goal [LINK]
The MMMC will continue to be a place of national importance to Belize and international importance to the greater Gulf of Honduras because of its economic, environmental and geopolitical significance.

Puget Sound Partnership (Vision in progress?) [LINK]
Despite its size, *Puget Sound is ecologically delicate;* and while its symptoms of trouble are not easily visible, they are undeniable and getting worse. **Our goal is to make Puget Sound healthy again, and create a roadmap for how to get it done.** If we work together, we can have both a thriving Puget Sound economy and a clean and healthy Puget Sound ecosystem.

Chesapeake Bay Foundation [LINK]
Our vision is that the Chesapeake Bay and its tributary rivers, broadly recognized as a national treasure, will be highly productive and in good health as measured by established water quality standards. The result will be clear water, free of impacts from toxic contaminants, and with healthy oxygen levels. Natural filters on both the land and in the water will provide resilience to the entire Chesapeake Bay system and serve as valuable habitat for both terrestrial and aquatic life.

Chesapeake Bay Program – Executive Order DRAFT Vision [LINK]
We work toward a Chesapeake Bay watershed with clean water that is swimmable and fishable in streams, rivers and the Chesapeake Bay; with sustainable, healthy populations of blue crabs, oysters, fish and other wildlife; and with a broad network of land and water habitats that support fish and wildlife and are resilient to the impacts of development and climate change. We work toward a Chesapeake Bay watershed with abundant forests and thriving farms that benefit both the economy and environment; with extensive areas of conserved lands that protect nature and the region's heritage; with ample access to provide for public enjoyment; and with cities, towns and neighborhoods where citizens are stewards of nature.

Great Lakes Restoration Initiative (No vision statement?) [LINK]
This Great Lakes Restoration Action Plan (Action Plan) outlines methods and actions to advance implementation of the Initiative through FY 2014 and will help protect and restore the chemical, physical and biological integrity of the Great Lakes Basin ecosystem.

Five principal focus areas have been identified which encompass the most significant environmental problems in the Great Lakes (other than water infrastructure) for which urgent action is required. These include:

- Toxic Substances and Areas of Concern
- Invasive Species
- Nearshore Health and Nonpoint Source Pollution
- Habitat and Wildlife Protection and Restoration
- Accountability, Education, Monitoring, Evaluation, Communication and Partnerships

Florida Coastal Wildlife Conservation Initiative [LINK]
Vision: Ensure the long-term conservation of native wildlife in coastal ecosystems throughout Florida in balance with human activities.

Lower Columbia River Estuary Partnership [LINK]
Mission: To preserve and enhance the water quality of the estuary to support its biological and human communities. Guiding Principle: The health of the river will not significantly improve if new problems continually emerge even as old ones are addressed and solved.

Colombia River Basin – Columbia River Inter-Tribal Fish Commission [LINK]
The tribal vision for the future is one where people, fish, wildlife, plants and other natural and cultural resources are once again biologically healthy and self-sustaining.

United Nations Environment Programme [LINK]
Vision: Prosperous and healthy oceans and coasts where conservation, productivity and resource use are sustainable.

Yellowstone to Yukon Conservation Initiative [LINK]
Y2Y's vision is that the entire Yellowstone to Yukon region will be managed so that this world-renowned mountain ecosystem and its inhabitants (both wild and human) remain healthy and connected for centuries to come.

Great Barrier Reef Marine Authority, Keppel Bay [LINK]
The broad objective and vision of the GBRMPA is to provide for the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity, through the care and development of the Great Barrier Reef Marine Park.

Great Barrier Reef Marine Authority (#2) [LINK]
In the Great Barrier Reef World Heritage Area in 25 years there will be:

- A healthy environment: an area which maintains its diversity of species and habitats, and its ecological integrity and resilience, parts of which are in pristine condition.
- Sustainable multiple use

- Maintenance and enhancement of values
- Integrated management
- Knowledge-based but cautious decision making in the absence of information
- An informed, involved, committed community.

Florida Reef Resilience Program [LINK]
The FRRP seeks to improve ecological conditions of Florida's reefs, economic sustainability of reef-dependent commercial enterprises, and continued recreational use of reef resources.

Florida Everglades Coalition [LINK]
Our Vision for 2020 includes ten specific Visions, which capture those objectives we feel are critical to successful restoration. These ten Visions are summarized below:

1. By 2020, lands that are necessary for restoration are brought into public ownership to expand the spatial extent of wetlands and prevent development that undermines the greater Everglades ecosystem.
2. By 2020, abundant and diverse native plant and animal life in the greater south Florida ecosystem meets or exceeds the 10 year recovery goals of federal and state conservation plans for listed species and their habitats.
3. Assure sufficient clean freshwater for the Everglades and the Estuaries.
4. Adequate storage exists in the Everglades Agricultural Area and North of Lake Okeechobee to provide clean water to the Everglades and its estuaries during dry periods and sufficient conveyance capacity exists in the Everglades Agricultural Area to facilitate a natural response to wet events.
5. By 2020, the ecological decline of Lake Okeechobee will be measurably reversed and infrastructure improvements to eliminate destructive discharges to the estuaries and to enable water to flow south into the Northern Everglades will be in significant stages of design, bid or construction.
6. The Southern Everglades is on its way towards full restoration of sheetflow and wildlife recovery as initial key projects are completed.
7. In the Western Everglades, maintain and recreate the connectivity of water and wildlife movement, and the greater ecosystem, while promoting wise growth management.
8. Science remains the driving force for decision support in CERP and related project implementation, as well as the basis of CERP policy, including all steps in the scientific method, peer review, and incremental adaptive management.
9. Florida's energy choices do not compromise land and water supply critical to Everglades' restoration efforts.
10. Everglades restoration sees substantial progress with support and full commitment at the highest levels of the federal and state governments.

Gulf of Mexico Governors Alliance [LINK]
The Alliance is committed to a Gulf of Mexico region that includes healthy beaches and

seafood, sustainable natural communities, productive marine ecosystems, and resilient coastal communities.

Irish Sea (Department of Environment, Food and Rural Affairs) [LINK]
Our vision for the marine environment is clean, healthy, safe, productive and biologically diverse oceans and seas. Within one generation we want to have made a real difference.

West Coast Governors Agreement [LINK]

- Priority area 1: Ensure Clean Coastal Waters and Beaches
  - Vision: Clean coastal waters and beaches where marine life thrives and where people can safely enjoy swimming, fishing, and other activities without the detrimental effects of pollution and marine debris.

- Priority area 2: Protect and Restore Ocean and Coastal Habitats
  - Vision: Estuarine, marine, and coastal habitats are ecologically healthy and allow for public enjoyment and sustainable use.

- Priority area 3: Promote the Effective Implementation of Ecosystem-Based Management
  - Vision: A healthy, thriving, and resilient marine and coastal ecosystem along the entire West Coast that supports a range of human activities.

- Priority area 4: Reduce Adverse Impacts of Offshore Energy Development
  - Vision: No new offshore oil and gas leasing and development shall occur in state tidelands or within the federal Outer Continental Shelf. The energy potential of wind, wave, and tidal currents is appropriately and safely considered along the West Coast.

- Priority area 5: Increase Ocean Awareness and Literacy Among Citizens
  - Vision: The West Coast has an informed citizenry that understands the value of ocean and coastal resources, processes, and ecosystems and acts consistently to conserve and enhance them.

- Priority area 6: Expand Ocean and Coastal Scientific Information, Research, and Monitoring.
  - Vision: A sustained research and monitoring program for the entire West Coast that provides timely and relevant information to support coastal and ocean management programs.

- Priority area 7: Foster Sustainable Economic Development in Coastal Communities
  - Vision: Coastal communities are economically and environmentally sustainable over the long term.

Other suggestions

- Accountability, Education, Monitoring, Evaluation, Communication and Partnerships

Mission statement
"The council will nurture strong partnerships among, local, regional, and national organizations and will foster innovative approaches to sharing information and enhancing collaboration."

Vision statement
"The Gulf of Maine Council will partner, collaborate and communicate in order to enhance the region's quality of life in the Gulf of Maine marine, coastal and watershed environment though integrating economic, social and ecological values into the conservation."

- compared to other great waters, the GoM may appears pristine, but to the people living and working within the GoM and its watershed, evidence of degradation is becoming apparent
- two countries, # levels of government and stakeholders working together in the spirit of sustainability
- better understand the GoM and its watersheds and ensure a healthy ecosystem and thriving economy through wise use, conservation and restoration of this natural wonder of North America (Bay of Fundy has been identified as one of the natural wonders of North America)

Finalizing the Action Plan: January to December 2011 schedule

Background – The Council's intent is to release the 2012-2017 Action Plan at its December 2011 meeting in New Brunswick. To meet this deadline the following needs to occur.

Months	Activity	Comments
January – February	Conduct internal agency engagement/securing buy-in; begin collaboration discussions with regional partners (e.g., this is what we want to work on, how do you want to be involved, what can you contribute, etc.)	
March	Complete AP priorities, tasks, activities; describe logic model approach; finalize public consultation approaches including internal agency participation; produce draft 2007-2012 "accomplishments" report-out;	
April	Commence initial public consultation (30-comment period – broad strokes) via Constant Contact	
May	Tabulate and assess results for June meetings	
June	Approve content and initial presentation/design ideas; approve layout and production; review draft roll-out strategy	
Fall	Provide final materials to writing and layout team; create "elevator speech" about the plan, relevance to agency objectives, etc.; grow capacity of committees (e.g., secure co-chairs, recruit new members, etc.)	
December	Release 2012-2017 AP in New Brunswick & in each jurisdiction	

DRAFT AGENDA

Gulf of Maine Council Forum on Transboundary Marine Spatial Planning

December 7, 2010 • Portland, Maine

1:00 pm	**Welcome and Introductions – Mel Cote (EPA) & Jackie Olson (EC)**
1:15 pm	Current Policy and Governance Backdrop for Marine Spatial Planning (Session Chair – Susan Russell-Robinson) *Betsy Nicholson (NOAA) and Ted Diers (NH)* *Tim Hall (DFO) and Russ Henry (NB)* Brief presentation and discussion of current policy and operational initiatives in the US and Canada that support coastal and marine spatial planning.
1:35 pm	**Lessons Learned to Guide Future Bioregional Efforts (Session Chair – Priscilla Brooks)** *John Weber (MA)* *Grover Fugate (RI)* *Glen Hebert (DFO)* *Kathleen Leyden (ME)* A series of 15 minute presentations followed by a plenary discussion. The panelists will summarize their key lessons learned through experience and provide thoughts on how individual initiatives might be linked through a regional process.
3:00 pm	**Health Break**
3:15 pm	**Working Together to Advance Marine Spatial Planning (Session Chair – Betsy Nicholson)** *Transboundary Organization Perspective:* *Linda Mercer (GOMMI)* *John Annala and/or Rob Stephenson (RARGOM)* *Ru Morrison (NERACOOS)* *Manager Perspective:* *Pete Colosi (NOAA NMFS)* *George LaPointe (ME DMR)* *Odette Murphy (DFO)* The panelists will provide their perspectives on how science and fisheries interests can best be considered and integrated in a bioregional spatial planning process.
4:15 pm	**Advancing Marine Spatial Planning in a Transboundary Bioregional Setting (Session Chair – Tim Hall)** This will be a facilitated plenary discussion in which the participants will be asked to consider the transboundary aspects of marine spatial planning in the Gulf of Maine bioregion from a policy and technical perspective. They will then be asked to consider what would be an appropriate role for the Gulf of Maine Council. An anticipated outcome would be the development of a statement on this issue for Council approval.
5:00 pm	**Adjourn**

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PLoS BIOLOGY

Community Page

Making Marine Life Count: A New Baseline for Policy

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From the start, ocean use and resource exploitation by humans proceeded with limited knowledge of marine life and habitats. Even in the last century, biological knowledge of the oceans remained more limited than that of physical ocean processes such as storms, tsunamis from undersea earthquakes and teleconnections, like El Niño. Yet, human exploitation of the oceans is accelerating, reaching greater depths (Figure 1) and having greater impacts on marine life. Many uses interact, as when ports displace fishing, chemical industries contaminate marine life, and greenhouse gases in the atmosphere acidify and warm the oceans. Sustainable, science-based ocean policies that mitigate human impacts urgently need enhanced knowledge of marine life.

The Origin and Work of the Census of Marine Life

Launched in 2000, the decade-long Census of Marine Life partnership (CoML or the Census - http://coml.org) converged with advances in information, communication, genetic, sensory, and acoustic technologies to spur knowledge of marine life. It sought to expand the known, shrink the unknown and set aside the unknowable. The Census received core funding and intellectual guidance from the Alfred P. Sloan Foundation. Its strategic goal was to comprehend the diversity, distribution and abundance of marine life, from microbes to whales. The Census spanned all ocean realms, from coast to abyss, from the North Pole to Antarctic shores, from the long past to the future (Figure 2). It systematically compiled information from new discoveries and historic archives and made it freely accessible. It employed conventional research ships and sampling, divers and submersible vehicles, genetic identification, electronic and acoustic tagging, listening posts and communicating satellites [1].

More than 2,700 scientists from more than 80 nations and 540 scientific expeditions using $650M (est.) from nearly 500 sources of funding and in-kind contributions mobilized around 17 Census and five affiliated projects, each headed by leading scientists. Census governance balanced strategy and coordination with project management that gave experts the freedom to innovate and ensured global reach. The Census, through its international oversight bodies, projects, and 13 National and Regional Implementation Committees spanning the globe (Figure 3), has already contributed 2,600 papers to the scientific literature, many in special editions of specialist journals.

The Census partnership produced results on a scale never before achieved for marine life and created a new baseline of knowledge. From Census specimens, more than a thousand new species, several new genera and a new family have already been named and more than 5,000 new candidates have been collected and are waiting to be named [2–4]. Using acoustic technologies, Census scientists discovered a shoal of herring as large as Manhattan off the coast of New Jersey [5] and tracked Pacific salmon from their natal rivers to Alaska [6]. Amidst the new discoveries, however, are sobering insights into historical depletions. From historic records, the Census showed that people have depleted populations of marine species worldwide over hundreds and sometimes thousands of years, changing the structure of marine-life communities, the profitability of harvesting and the ability to recover [7]. Emerging discoveries on the diversity and distribution of microbes, the largest source of marine biomass [8], will be central to tracking the impacts of more acidic, warmer, low oxygen oceans under climate change.

The Census is bequeathing such legacies as the Ocean Biogeographic Information System (OBIS – http://iOBIS.org), which is now incorporated into UNESCO's International Oceanographic Commission as part of the International Oceanographic Data and Information Exchange (IODE). The Census stimulated ongoing partner projects including the Encyclopedia of Life (a webpage for every

The Community Page is a forum for organizations and societies to highlight their efforts to enhance the dissemination and value of scientific knowledge.

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Competing Interests: The authors are members of the Census of Marine Life partnership through its Scientific Steering Committee (members and ex-officio members), International Secretariat and projects. The Public Library of Science has also received funding from the Alfred P. Sloan Foundation, to develop a Biodiversity Hub, which will feature some content from the Census of Marine Life.

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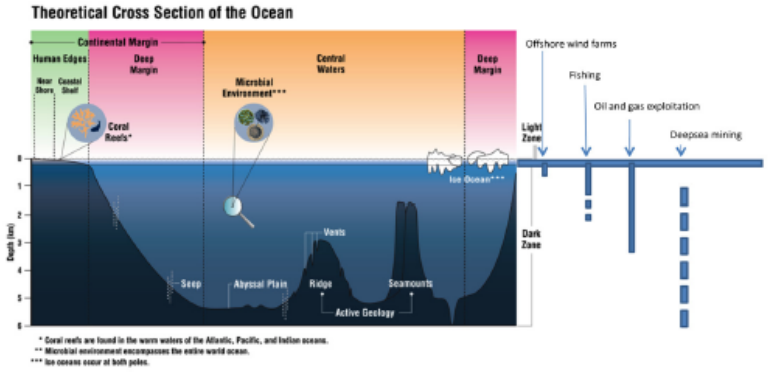

Figure 1. Schematic cross-section of the ocean indicating ocean realms and current (solid line) and proposed (broken line) depths of exploitation for fishing, oil and gas, deep-sea mining, and wind-farms. Wind farms: to 220m, plus offshore floating turbines anchored at greater depths (http://en.wikipedia.org/wiki/Wind_farm, accessed 25 May 2010). Fishing: current commercial fishing occurs between 1000 to 1400m; fishing deeper than 1500m is not constrained by technical limitations and vessels could modify equipment to suit. (F. Chopin, FAO, personal communication). Oil and gas: 3,000m (*The Economist*, March 4 2010). Deep-sea mining: 1,000–6,000m (*Technical Study No. 2*, International Seabed Authority 2002). Image: CoML and Meryl Williams. doi:10.1371/journal.pbio.1000531.g001

species), the Barcode of Life (short DNA identifiers for every species), and the Ocean Tracking Network (observations of animal movements spanning the globe). Some Census field projects will continue in different forms. For example, two animal tracking projects have joined forces and provided prototype technology for the Ocean Tracking Network; the six deep-sea projects have collaborated on the Synthesis of the Deep-sea projects of the Census of Marine Life (SYNDEEP); and the Gulf of Maine Area Program has borne an offspring called Canada's Healthy Ocean Network. The History of Marine Animal Populations has spawned a new field of study that integrates scholars in social and natural sciences and humanities, and the work of the Future of Marine Animal Populations will continue through

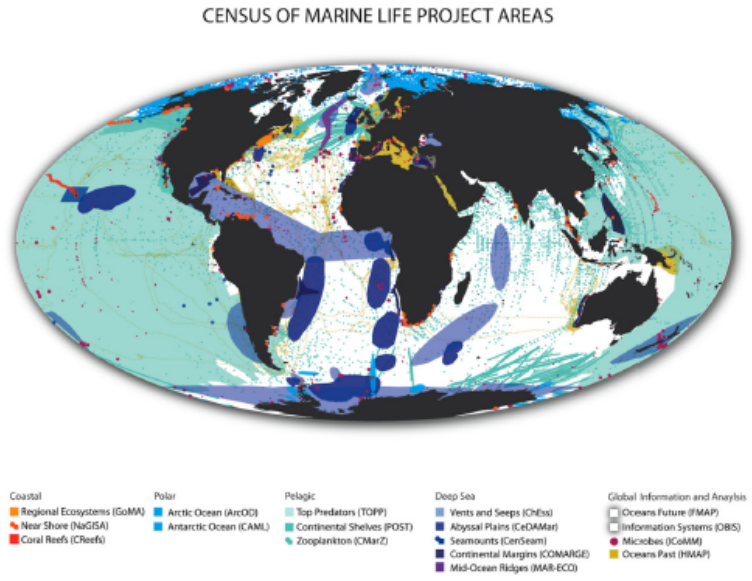

Figure 2. Census of Marine Life project areas. Image: CoML. doi:10.1371/journal.pbio.1000531.g002

a team at Dalhousie University. Another continuing collaboration is the Global Ocean Biodiversity Initiative (GOBI – http://www.gobi.org), which involves the International Union for Conservation of Nature (IUCN), the German government, several United Nations and non-government agencies, and many Census projects that are identifying places in the open oceans and deep sea deserving protection.

Successful policy acceptance and adoption requires a solid foundation of public awareness. To achieve this, Census discoveries were brought to public notice. The Census made extensive use of new media so that, for example, millions of people watched "great turtle races" tracking turtle migrations on live TV. Aided by press releases, Census discoveries have earned global media attention. The Census cooperated with the cutting edge team of Galátee, Inc., led by Jacques Perrin and Jacques Clouzaud, to produce the film *Oceans*, which premiered in 2010 and is already one of the highest grossing documentaries ever.

What was unpredicted at the start of the Census was the depth of policy interest in the results. Already, the Census results have started to influence policies and management in such bodies as the International Seabed Authority. Three examples of the uses of Census expertise are: (1) assisting the Convention on Biological Diversity (CBD) as it defines potential protected areas in the open ocean and deep seas, (2) supporting marine planning for regions and ecosystems, and (3) contributing marine biology observations for the Global Earth Observing System of Systems (GEOSS) of the intergovernmental Group on Earth Observations (GEO).

Convention on Biological Diversity Addresses the Open Oceans

The Census' discovery, mapping and counting of species measures biodiversity. The international legally binding treaty on biodiversity is the Convention on Biological Diversity (CBD) adopted in Rio de Janeiro in June 1992. A decade later in 2002, the World Summit on Sustainable Development (WSSD) agreed upon 2012 as the target year to establish an international network of representative marine protected areas [9].

The CBD enshrined national sovereignty over biodiversity, but this left marine life in the 64% of the oceans outside national jurisdictions largely unprotected. Several regional fisheries management organizations and regional coastal and ocean

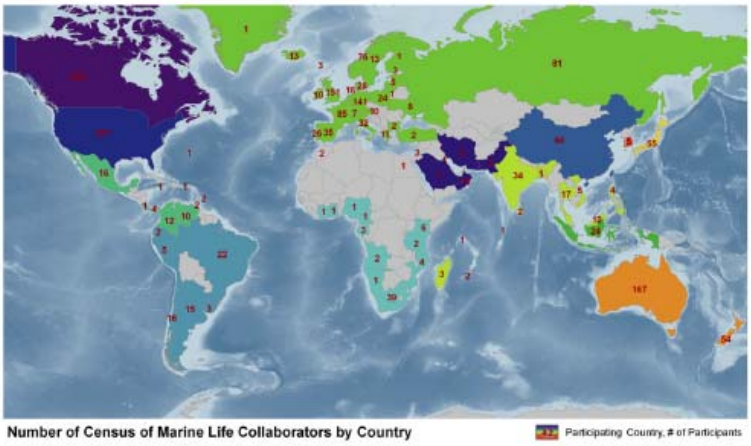

Figure 3. Participation by country and region. Countries coded with the same color collaborate in a regional implementation committee and numbers within country borders indicate the number of collaborating Census scientists for that country. Image: CoML
doi:10.1371/journal.pbio.1000531.g003

management agencies have been established in recent decades and are working towards regulating use of shared species and ocean regions, including areas of the open ocean and deep seas. However, marine biodiversity protection is only lately entering the considerations of most of these bodies, often with reference to WSSD [9]. The CBD is also redressing this neglect of biodiversity outside national waters and has established scientific criteria for "ecologically and biologically significant areas" (EBSA) [10]. The EBSA scientific criteria are: (1) uniqueness or rarity; (2) special importance for life history of species; (3) importance for threatened, endangered, or declining species and/or habitats; (4) vulnerability, fragility, sensitivity, and slow recovery; (5) biological productivity; (6) biological diversity; and (7) naturalness. The EBSA criteria were then tested by pilot illustrations for 15 different areas/species.

Here is where CoML comes in. In collaboration with the Global Ocean Biodiversity Initiative, Census researchers contributed several critical pilot illustrations from OBIS and Census-led field and service projects: CenSeam (seamounts), MAR-ECO (Mid-Atlantic Ridge), TOPP (Tagging of Pacific Predators), OBIS, and the Mapping and Visualization (M&V) project.

This pilot exercise demonstrated the importance of organized publically accessible data portals such as OBIS that were able to deliver up the results of over 800 existing, quality controlled data collections, including all the data gathered by Census projects. For example, CBD's Criterion 6 concerning biological diversity defines an EBSA as an area containing relatively more diversity of ecosystems, habitats, communities, or species, or an area with more genetic diversity. To investigate global scale patterns, Census scientists provided the CBD with analysis of the more than 22 million records then in OBIS. They estimated several biodiversity indices corrected for intensity of sampling and for broad global patterns of marine biodiversity already known (Figure 4). EBSA Criterion 7 (naturalness) used the example of the southeast Atlantic seamounts. This illustration combined inputs from Census projects, such as seamount and historical trawl fishing locations from CenSeam, and biological sampling from OBIS/Seamounts Online, with human impact compilations [11,12].

Input from Census researchers was also important in FAO discussions on management of deep-sea fisheries on the high seas, providing background information to national delegates formulating the final set of international guidelines [13,14].

Planning for Regions and Ecosystems

Akin to land and urban planning, marine planning has arisen to provide order and predictability to the multiple ocean uses at scales smaller than those of the global conventions such as the United Nations Convention on the Law of the Sea and the CBD. The ecosystem and precautionary approaches to planning and management have developed to encompass conservation objectives. These approaches are enshrined in recent global instruments, especially the 1995 United Nations United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations Fish Stocks Agreement), wherein article 5f is binding on signatories to maintain biodiversity, and the 2002 Plan of Implementation of the World Summit on Sustainable Development.

Plans for multiple uses and with multiple objectives are displacing simple plans for single uses and objectives, e.g., plans for conserving ecosystems like coral reefs, seamounts, regions like Australia's Great Barrier Reef, the Mediterranean and Baltic Seas, and the United States of America's ocean coasts and Great Lakes have become more common [15]. Ecosystem approaches and marine spatial planning both require useable knowledge of marine-life diversity, distribution, and abundance, coherent across environment and industry decision-making frameworks [16]. The Census approach emphasized validated, geographically and time-referenced biological data, and technologies that capture the dynamics of individual organisms and animal populations throughout seasons and life cycles and through history.

For example, data from Census projects CeDaMar (abyssal plains) and CenSeam (seamounts) fed into designing a "Preservation Reference Area" network in the Clarion-Clipperton Fracture Zone of the central Pacific Ocean by the International Seabed Authority to manage potential mining for polymetallic nodules [17]. Through modeling, Census scientists have predicted the likely distribution of deep-sea corals that are indicator species and highly vulnerable to impacts from fishing or mining [18]. Regional fisheries management organizations, such as the South Pacific Regional Fisheries Management Organization, have used indicator species to predict where habitats sensitive to fishing might occur in data poor regions [19].

Census researchers played a major role in the development of the UNESCO Global Open Oceans and Deep Seabed (GOODS) biogeographic classification. The classification is designed to identify where industrial uses of the ocean are incompatible with biodiversity conservation and to protect representative marine life and ecosystems and thus aids marine planning [20].

International Ocean Observation Systems

The intergovernmental Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System

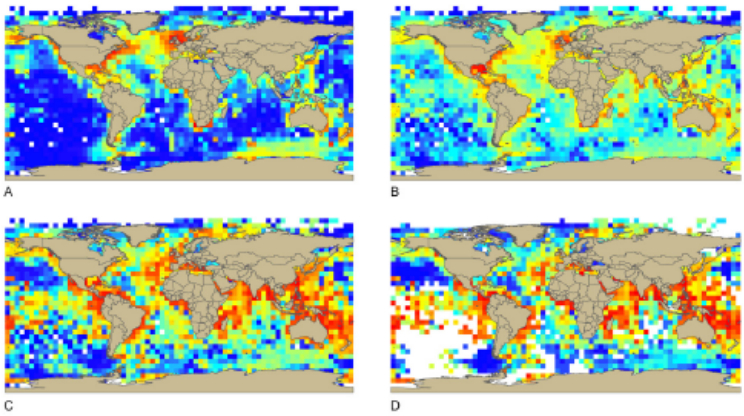

Figure 4. Four maps used for Convention on Biological Diversity Ecologically and Biologically Significant Areas Criterion 6, Biological diversity (Annex of reference 11). (a) total records in OBIS, corrected for differences in surface area between squares on different latitude; (b) the total number of species, corrected for differences in surface area between squares on different latitude; (c) Shannon Index; (d) Hurlbert's Index, *es(50)*.
doi:10.1371/journal.pbio.1000531.g004

of Systems (GEOSS). In 2008, GEO established a Biodiversity Observation Network (GEO-BON) as one of nine Societal Benefits Areas (http://www.earthobservations.org/geoss_bi.shtml) [21]. Effective and efficient observation of more than 200,000 species of marine animals and perhaps tens of millions of types of marine microbes present great scientific and technological challenges. Existing long-time series of marine life are rare and narrow in scope, such as the Continuous Plankton Recorder in the North Sea and North Atlantic (Sir Alistair Hardy Foundation for Ocean Science, http://www.sahfos.ac.uk/sahfos-home.aspx, since 1931), long-term fisheries surveys for North Sea groundfish (the International Bottom Trawl Survey (http://www.ices.dk/datacentre/datras/survey.asp, since 1960), the United States of America (since 1963) [22], and intermittent surveys from the 1920s in Asia [23]. The paucity of biological time series contrasts with the more numerous marine chemical and physical data series captured by remote sensing and such tools as drifting buoys and active float systems.

By making the oceans more "transparent" and accessible, new technologies such as demonstrated by the Census are relieving this deficiency for biology [1,24]. For example, individual Pacific salmon (*Oncorhynchus* spp) were tracked over thousands of kilometers using tags that emit individually coded acoustic pulses to coastal receivers [6]. Via tags, how marine mammals use major oceanic features such as frontal zones under ice has been mapped [25]; new rapid genomic techniques and databases (e.g., DNA barcoding, 454-pyrotag sequencing [26] and MICROBIS – http://icomm.mbl.edu/microbis/) are rewriting knowledge of marine biodiversity and marine-life abundance. The CReefs project of the Census developed a new automated structure, (Autonomous Reef Monitoring Structures (ARMS)), 500 of which are now deployed in the Pacific and Indian oceans and the Caribbean, collecting specimens and ecological data to monitor tropical coral reef biodiversity [27].

Notwithstanding the urgency to monitor marine life, scientists and policy makers have yet to implement a set of core observing systems for a comprehensive "Bio-GOOS" [28]. The outputs from the Census will be a valuable input to such a comprehensive system.

Reflections

With the wisdom of hindsight, what could the Census have done differently for greater policy impact? Two aspects come to mind: the possible effects of earlier policy engagement and earlier globalization.

The Census engaged with end-users relatively late in the decade. As the Census was primarily a discovery program and was not policy-directed, we were surprised at the demand for the Census to help inform policy. The demand partly derived from international commitments such as the growing list of CBD provisions, the 2002 WSSD and national laws that now oblige maritime countries to assess the status and outlook for marine life in their waters and oceans beyond. The other drivers for Census-type information were increased evidence of impacts and raised public awareness. Broader partnerships with bodies outside scientific research agencies are vital in science-policy engagement. For example, the Census partnership with IUCN has been successful on several levels, as has the Memorandum of Cooperation the CBD. These complementary partnerships enabled the Census to stay focused on unbiased science while still being able to link into the policy sphere.

Possibly, broadening the delivery model beyond scientific publications and public outreach could have had earlier impact. For example, Census scientists who engaged in delivering policy-relevant advice on high seas and seamounts fisheries [18] learned the importance of thinking outside their national objectives. They had to look at the bigger picture and access other ideas, other data, and the demands of other than their home countries. To arrive at robust advice, they had to consider generic drivers of ecosystem change on seamounts and more international and global management issues. Further, having started late in deriving the policy relevance of Census results, scientists have had to be creative to explain post hoc the usefulness in policy-relevant terms. However, neither the Census nor other bodies could have readily agreed program policy targets in advance without risking too much dispersion and losing sight of the essential science vision of the Census. Perhaps a breadth of vision in collecting basic knowledge is essential in meeting the future needs of marine management and policy?

The second aspect was underestimating the challenge of moving from expeditionary science focused on global questions delivered by scientists from established institutes to a global initiative that involved scientists from many coastal countries. National and regional scientists will have long-term carriage of policy advice to decision makers. Capacity building was not an explicit objective of the Census and yet a great deal of capacity was built. However, more focus on NRICs, and/or more NRICs, could have led to more lasting policy impacts from the Census.

With these reflections on possible improvements and the overall achievements of the Census, we conclude that investing in scientific knowledge of marine life, new discovery, and monitoring technologies and extensive databases within and across ocean use and conservation helps meet the growing demand for better ocean policies.

Indeed, a significant opportunity remains to continue this work in an international and cooperative manner post the first 10 years of the Census.

Acknowledgments

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