

Vice President for Research and Public Service Discretionary Research and Outreach  
Scholarship Fund

**A collaboration between UNH and NAMA (Northwest Atlantic Marine Alliance) for  
the application of coastal ocean observing science to the conservation and  
stewardship of the Gulf of Maine inshore fisheries**

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Final Report  
October 18, 2005

### ***The project***

The Coastal Observing Center at the University of New Hampshire contributes to regional collection of physical and biological information documenting changes due to climate or land-based anthropogenic forcing on marine ecosystems in the Gulf of Maine. The acquisition of observing data in coastal oceans is stimulating efforts to interpret and forecast trends in marine biodiversity and coastal ocean productivity through the development of sophisticated computer models of predator- prey interactions and planktonic production in relation to changes in temperature, circulation and winds. How to use this information in an ecosystem based management approach to fisheries management remains an active area of discussion and research. Our goal was to facilitate knowledge exchange between the scientific research and fishing communities in order to (1) develop new conceptual understanding of the application of coastal observation and analysis tools in fisheries management and (2) work toward mutual understanding in the two communities of ecosystem concepts that should be part of ecosystem-based approaches. In May, 2004, The Vice President for Research and Public Service Discretionary Research and Outreach Scholarship Fund awarded \$8,903 to carry out this project.

### ***The method***

We held three, 6-hour long discussion meetings in which fishermen and scientists participated (Table 1). The meetings were kept small (10-13 participants) in order to facilitate exchange. An agenda with discussion topics was prepared for each meeting (Appendices 1-3). The discussions were focused on the development of information sheets that summarize the consensus knowledge of the group and could be disseminated to the fishing community, including the fisheries management council

**Table 1. Meeting dates, locations and participants for exchange sessions.**

Meeting Date	Location	Participants
December 7, 2004	Portsmouth, NH Meadowbrook Inn	<b>Fishermen:</b> C. Pendleton, G. Littlefield, D. Goethel <b>University Research:</b> J. Runge, L. Incze, L. Kaufman, T. Hartley, H. Deese <b>Marine Educators:</b> A. Holt-Cline, E. Goethel
February 19, 2005	Portsmouth, NH Meadowbrook Inn	<b>Fishermen:</b> D. Goethel, R. Gauron, C. Pendleton, F. Mirarchi, R. Taylor, N. Vine <b>University Research:</b> J. Runge, H. Deese <b>NAMA:</b> J. Levin
March 5, 2005	Rockport, Me Maine Fishermen's Forum	<b>Speakers:</b> C. Pendleton, D. Goethel, J. Runge <b>Attendees:</b> Approx. 70 fishermen/scientists/others
May 16, 2005	Portsmouth, NH Urban Forestry Center	<b>Fishermen:</b> D. Goethel, R. Gauron, C. Pendleton, F. Mirarchi, R. Taylor, N. Vine, C. Demarest (NEFMC) <b>University Research:</b> J. Runge, L. Incze, P. Stevick,, H. Deese <b>Marine Educators:</b> A. Holt-Cline <b>NAMA:</b> J. Levin

In addition to the three exchange sessions, the project was presented as part of a 90-minute session at the Maine Fishermen's Forum on March 3, 2005. During this session, three of the project participants (Table 1) gave introductory presentations, after which the audience was divided into four breakout groups for discussion of themes that were identified as priorities during the first two exchange session meetings. Rapporteurs for these break out groups recorded the discussions for inclusion in the project information sheets where appropriate.

Final design and layout of draft information sheets will be done by Ethan Nadeau (Biodiversity, Amherst, MA).

The effectiveness of the knowledge-exchange and Fishermen's Forum sessions was evaluated by questionnaires provided to participants. In addition, participants gave summary oral evaluations at the end of the third meeting held at the Urban Forestry Center.

### ***The results***

- Three priority themes were identified during the knowledge-exchange meetings (Meeting Notes, Appendices 1-3):
  1. Characterization of food web interactions in space and time in the western Gulf of Maine (WGoM). Identify as much as possible what are the keystone species and the important predator-prey interactions that define the Gulf of Maine ecosystem and when and where these occur. Show these interactions graphically with the idea that this could inform, stimulate discussion and serve as one perspective of the wGoM ecosystem for studies of biodiversity.
  2. Identification of spawning and (as much as possible) juvenile habitats in the western Gulf of Maine, with a focus on cod and herring. This would be very helpful to research on how variation in circulation (due to winds or upstream hydrography) influences the distribution of eggs and larvae. The working hypothesis is that only the larvae that make it inshore of the coastal current are the ones that recruit into the local population.
  3. Description of changes that have occurred in the habitat and water quality of the nearshore environment of the western Gulf of Maine and how these changes might impact the distribution of spawning and of juvenile and adult fish. Exchange knowledge about the connection between nearshore processes and the life cycles of fish and invertebrates. The working hypothesis is that the inshore habitat is critical for the development and survival of early life stages of fish and shrimp.
- The Fisherman's Forum exchange session (Session notes, Appendix 4) offered a larger and more diverse mix of fishermen provide experiential knowledge (used where appropriate in the information sheets) during the breakout discussion sessions. This session was a clear demonstration of the great wealth of experiential knowledge

that could serve as a foundation for any number of research projects. The feedback questionnaire (Appendix 4, Attachment 2) from this session was overwhelmingly positive. It was commonly expressed that more sessions such as this one would be appreciated by the community

- Over the course of the sessions and during subsequent follow-up in summer, 2005, the knowledge exchange on these three themes were developed into three information sheets (Appendices 5-7). These information sheets are presently in draft form; publication and distribution are planned for later in the fall. The first two sheets (food web interactions and identified spawning aggregations of Gulf of Maine cod) have been contracted to a graphic artist for final development. After further review by the participants, they will be available for distribution to members of the New England Fisheries Management Council as well as to the fishing community at large.
- Dr. Martin Huret (University of Massachusetts, Dartmouth), in collaboration with J. Runge (UNH) and Dr. Changsheng Chen (Univ. Mass., Dartmouth), is presently using the information provided on location and timing of cod and herring spawning sites (Appendix 6) in coupled physical-biological models of the transport and survival of cod and herring larvae hatched in the western Gulf of Maine.
- Finally, the discussion of the nearshore-offshore connections (Draft Information Sheet, Appendix 7) has stimulated the organization of a theme session by the Regional Association for Research on the Gulf of Maine (RARGOM). Initial organization of this session will be undertaken by J. Runge (UNH) and L. Incze (Univ. S. Maine) and is scheduled to take place in the latter half of 2006.

### ***Project evaluation and next steps***

#### ***Accomplishments***

The NAMA-UNH Coastal Observing Center partnership succeeded in bringing together small groups of local fishermen and scientists in a focused exchange of knowledge and discussion on themes related to the development of ecosystem based approaches to fisheries management in the Gulf of Maine. In addition to the three meetings that were planned in the original proposal, the project participants also organized a special session at the Maine Fishermen's Forum, an event that attracts several thousand people from fishing-related businesses and occupations, government agencies, universities and public and non-profit organizations. This provided exposure of the project's themes to a broad spectrum of the region's fisheries community. The two information sheets that will be published as an outcome of these meetings represent first versions of consensus knowledge on the subject area. Feedback from members of the community will be encouraged. We foresee the need and utility of revised information sheets in the future. The subject of the third information sheet on connections between nearshore habitats and fish and invertebrate life cycles is of great interest to coastal managers as well as researchers. A research-oriented perspective paper that will include information and concepts developed during our meeting discussions is planned if funding can be obtained.

### *Project assessment*

A questionnaire (Appendix 8) distributed at the second meeting session had very low return. However, the informal feedback from participants was very positive, as confirmed by closing comments at the third meeting ("Parting Shots", Appendix 3). Participants felt that this format for bringing together forward-looking experts industry and university research in small discussion groups was very worthwhile. They were particularly encouraged that there will be concrete products synthesizing consensus knowledge, from which we can move forward. There was a common belief in the importance of cooperative, multi-disciplinary (including experiential knowledge of fishermen) approaches to ocean and fisheries studies. These meetings demonstrated the value of bringing together a diversity of scientific specialties to sit down with fishermen to discuss how the Gulf of Maine ecosystem functions and can be managed to conserve its resources.

The questionnaires distributed at the Fishermen's Forum sessions yielded a number of responses representing approx. 25% of all participants (Appendix 4, Attachment 2). Based on these responses and conversations with individuals after the meeting, there was great support for the process of bringing together fishermen and scientists for knowledge exchange. Participants expressed enthusiasm for the process of recording the fishermen's experiential knowledge and integrating it into the research process, as well as for the effort of synthesizing consensus about what we know in a way that gets back to the community. A common request was for more sessions like this one.

The project was also evaluated through J. Runge's participation in the University of New Hampshire Outreach Scholars Program. A listening team composed of other Outreach Scholars provided feedback after listening to a presentation of the project. Several suggestions were made:

- 1) Plan for a more in depth assessment of the effectiveness of the products from the meeting. For example, is the target audience assimilating the take home message? Are the information sheets achieving the goals for which they were produced? How well are they received and what improvements do they suggest?
- 2) Plan for some assessment of how well the NAMA-UNH partnership worked, and how it could be improved in the future.
- 3) The Evaluative Research and Evaluation Capacity Building (EREC) program at NSF was suggested as a source of funding, although this addresses evaluation in the context of STEM (science, technology, engineering and mathematics) education.
- 4) Involve students, especially undergraduates, in the process. Providing opportunities for undergraduates to listen to the knowledge exchange would be a valuable educational experience for them. There is also the potential for undergraduate, as well as graduate, research projects involving interviews and synthesis of knowledge provided by fishermen and scientists.

### *What next?*

The next steps were discussed at the third meeting held at the Urban Forestry Center. Once a finished layout of the information sheets is done, they should be distributed to meeting participants for a final check on format and information content. The information sheets can then be distributed, with the expectation for more feedback, from which a second, revised version could be prepared.

A funding sources for extension of the project may be Sea Grant (ideally, as a regional proposal). The suggestion was made to select some concepts for in depth knowledge exchange to provide detailed products for target audiences, e.g. Fisheries Council members.

The process is also amenable to undergraduate and graduate student research projects. Possibilities for undergraduate honors fellowships and graduate research fellowships could be explored by university faculty (at UNH or elsewhere) on research themes requiring systematic recording of experiential knowledge of local fishermen. Subject material may include: 1) identification and characterization of spawning areas of fish stocks (Cod, herring, haddock, pollock, etc) now and historically (perhaps tying in with the HMAP project), 2) spatial and temporal patterns in predator-prey interactions in the Gulf of Maine ecosystem, and 3) historical analysis of shifts in distribution of fish and habitat and ecology in nearshore environments (e.g. Ipswich Bay).

### *Acknowledgements*

The project PI's gratefully acknowledge all participants (listed in Table 1) for their contribution of time and expertise to the project. A special thank you to Amy Holt Cline for her effort and abilities in creating the maps describing spawning aggregations, and to Jen Levin for her skill in recording the meeting discussions.

## **Appendix 1: Meeting agenda and minutes for Meeting 1**

Western Gulf of Maine Inshore Fisheries – Ecosystems Project  
Meeting #1 (of 3)  
Co-hosted by COOA & NAMA  
Meadowbrook Inn, Portsmouth, NH  
December 7, 2004: 9:30-2:00

**Agenda Item 1: General Introduction:** (Jeff Runge & Craig Pendleton) 9:30-9:35  
History of the Project & Longer term goals (see notes below)

**Agenda Item 2:** Specific Project Introduction & Objectives (Heather) 9:35-9:40  
(see notes below)

**Agenda Item 3:** Plan for today and Meetings #2 and #3 (Heather & Jeff) 9:40-9:45  
(see notes below)

**Agenda Item 4:** Roundtable introduction (everyone) 9:45-10:30  
What thoughts and experiences are you bringing to this process? What would you like to get out of it? What do you hope we produce together and how it could be useful to people?

**Agenda Item 5: Topic 1: brainstorming “food webs”** 10:30-12:00-Can we agree to start at plankton and work up the food chain to humans instead of vice versa-? Group brainstorming, developing pictures and notes. Species associations (what species do you find together - E.g. shrimp and whiting; winter flounder/blackbacks and monkfish? Does this change by season? depth? Other factors? WHY?); Food webs and feeding habits (changes by season? by depth? How strongly or weakly to species rely on particular prey? WHY?)  
OUTPUT: Some diagrams and description showing food web relationships and some pages of text to go with it

**Agenda Item 6: Topic 2: brainstorming “inshore habitats”** 12:30-1:45  
Group brainstorming, developing pictures and notes:  
Inshore habitats & water quality: (E.g. winter flounder/blackbacks – what happened to them? how come never came back inshore? Shrimp – e.g. highest catches in river mouths – why?); Species movements & association with particular habitats /environmental associations  
OUTPUT: Some diagrams and description about fish life history use of inshore habitats

**Wrap-up** 1:45-2:00  
Plan for meeting #2: Decide sub-groups and date for next meeting. (try Urban Forestry Center). Meeting #2 on a weekend? This scheduling is better for fishermen (?)  
Everyone list issues or questions:  
What are the types of information you don't see being used in fishery management?  
What do you see as the types of science that work best in fishery management?  
What areas do we not have the science we need?

### **Agenda Item 1: History of the Project & Longer term goals (see below)**

Key goals:  
Bring fishermen and researchers together to build descriptions of ecosystems – at least the key elements and the ways they interact. Summarize the discussion results into concrete products that can be referred to and revised with more observation, research and discussions. These products should inform future research and 'ecosystem-based' management – not just managing fisheries, but other human activities that impact the fish.  
A critical first step in spelling out what needs to be included in the science and management of the future --- 'ecosystem-based approaches' in the Gulf of Maine

Companion goals:

Bring in expertise, experience, and capabilities of range of scientific research communities in the Gulf of Maine whose expertise is not currently being tapped for fisheries issues.

Strengthen and develop new conceptual understanding of the relationship between coastal observing science and the need for ecosystem-based management. (Long-term biological data collection in the Gulf of Maine becomes critical in light of increasing evidence for change in climate in the northern hemisphere)

Demonstrate for other regions how to make the collection and interpretation of environmental data more relevant to fisheries management.

Do this from a community-based perspective, building bridges for direct communication between science researchers and fishing communities for the purpose of developing new approaches.

**Agenda Item 2: Project Objectives:**

Graphic illustrations and descriptions ('straw men') of key ecosystem components related to fisheries (species, environment, relationships, movements) on two topics (food webs & inshore habitats) for Western inshore Gulf of Maine area.

Presentation at Fishermen's Forum on progress (by fishermen-scientist team between 2<sup>nd</sup> and 3<sup>rd</sup> meeting)

End of project published documentation (GoM publication?) that can be referenced.

Graphic products (posters, handouts), for participants and project leaders to circulate throughout New England interested parties.

Plan for future work.

How we imagine this project could make a difference:

Fishermen and researchers who took part will have some agreed descriptions they are proud of and represent the best knowledge of the subject. One way to 'put some meat' on the talk about 'ecosystem-based management'

Having an agreed overall picture of the system could help prioritize future research, and clarify how existing understanding and information could or should be used in fisheries management or management of other human impacts.

Fishermen and researchers can use the products to 'drill in' further to specific issues, and see which parts of the ecosystem might be leverage points – places to focus effort.

Scientists who design and use computer ecosystem models will use the outputs to help steer their design.

Provide fishing industry another way to have a say in research directions

Build cooperation that may lead to increased support for research and development in the Gulf of Maine on issues for which there is mutual agreement.

**Agenda Item 3: Plan for Today and Meetings #2 and #3**

Aim to share knowledge: Two way exchange. Inform and help to drive link between coastal ocean observing and ecosystem based management and fisheries management.

Start the first meeting with developing the big pictures – graphic illustrations of the ecosystems (species, environments, relationships) that we think are most important

We will need to be careful to constrain discussion within some bounds, otherwise we could spend all day talking about too many things to make any concrete progress. Note we will open it up at the end to find out what other issues are on people's minds. These could be subjects of future discussions and projects like this one.

So, brainstorm together and draw diagrams focused on two topic areas:

Food webs

Inshore habitats (estuaries, nursery areas)

Setting out and agreeing on the context and the 'big picture' ('straw man' or hypothetical frameworks / descriptions) and a specific plan and structure for discussions in detail at meeting #2.

2<sup>nd</sup> meeting: drilling into the details of each topic area – split up into two groups, one focused on food webs and one on inshore habitats.  
(present draft products at Maine Fishermen's Forum?)

3<sup>rd</sup> meeting: review and comment on draft products. Use feedback from Fishermen's Forum and group discussion to further refine. If time allows, could focus discussion on elements of ecosystem descriptions that are key priorities, put together advice in terms of items for research or future management efforts.

***Specific notes from discussion with fishermen so far:***

In general recreational fishermen will have good knowledge of feeding habits since on smaller boats they clean the fish for customers.

Cod in WGOM closure fall 2004 have lots crab in bellies (Randy Gauron, told by rec guys)  
Cod near Jeffreys FULL of herring fall 2004 (Randy Gauron, based on his fishing)  
Cod were not around as much in August 2004, but back now in higher numbers – Sept-Oct 2004, some guys think this movement is related to the numbers of bluefish in the area (Randy Gauron)

Dogfish would be hard to talk about feeding, because sold in round, fishermen don't usually split their guts. (Randy Gauron)

Haddock would be an important stock because their numbers are coming back. (Craig P)

Pollock with 'eyebait' in their stomachs would almost be 'eating away the flesh' when caught certain places (Craig P)

Winter flounder (black back) have not ever come back in Gulf of Maine, why? Water quality inshore? (Craig P)

Shrimp feeding, movements, timing interesting (Craig P)

Western Gulf of Maine Inshore Fisheries – Ecosystems Project  
Minutes of Meeting #1 (of 3)  
Co-hosted by COOA & NAMA  
Meadowbrook Inn, Portsmouth, NH  
December 7, 2004  
9:30-2:00

Meeting Notes

Attendance:

Craig Pendleton, NAMA, fishermen  
Ellen Goethel, marine educator  
George Littlefield, fishermen  
David Goethel, fishermen  
Jeffrey Runge, COOA plankton ecology  
Amy Holt-Cline, COOA, marine research  
Heather Deese, NAMA, marine research  
Lew Incze, fisheries oceanography and Census of Marine Life  
Les Kaufman, BU fish ecology  
Troy Hartley, UNH (observing for social science study)

**Introduction, Welcome, Plan for Meetings & Project:**

Jeffrey Runge, Craig Pendleton, Heather Deese:

This set of meetings provides an opportunity to step back and have a constructive discussion outside the pressure of management decisions or research funding cycles. We hope this will be a chance to work towards points of agreement, a positive discussion. NAMA's involvement follows on our history of bringing people together for discussions, nurturing collaborative research, expanding education and community initiatives. COOA's interest as a regional ocean observing and modeling group in targeting their research to make it useful for fisheries.

We have thought about focusing on two topics: 1) feeding relationships between key species and 2) inshore environments. The focus area is inshore Western Gulf of Maine (from the coast through the WGOM closed area – from Portland south to Provincetown).

We have been motivated by:

Ecosystem-Based Management – what will it mean for us specifically, concretely, in this region? What are the real research questions we need answered? – How do we diagnose the problems in the 'system'?

We will have three meetings. Meeting 1 today for brainstorming on the topics and deciding the general form and purpose for the products. Meeting 2 we'll review draft straw men of illustrations, flesh out the details. Then possibly seek further comments from other researchers and fishermen. Meeting 3 to expand and incorporate feedback.

We hope to present results at Maine Fishermen's Forum, or other appropriate forums related to research and management (e.g. NEFMC), depending on what we all decide as a group.

**Group Introductions:**

Heather Deese. NAMA science director. Background in physical oceanography, and also working for the national government in Australia with different types of scientists, interface scientists and policy people. Learned importance of communication between government policy folks, different types of scientists, politicians, developed sets of graphic ecosystem illustrations

working with various scientific disciplines to help communication. Will play role of facilitator for this meeting.

Les Kaufman. fish biologist at BU. Trying to “invent” EBM in his lab – what are the diagnostics – the things you can actually measure. History of habitat work, now working on food webs, changes in food webs related to protected areas on Jeffreys and Stellwagen. Using stable isotopes, which show how high in the food web the animal was when it died.

Amy Cline. COOA. Background teaching marine science and fisheries in Nova Scotia. Used GIS, had fishermen and scientists teach in her classrooms, inspired seeing changes in students and parents departments. Enthusiastic about translating science to educators that can use it, how you teach people about the ocean, expand education, get people excited and seeing results of their actions. Mentioned a course Andy Rosenberg in teaching at UNH on EBM.

Lew Incze. biological oceanographer at USM / Census Marine Life. Focus on larval ecology - how physics influence production in marine communities, larvae of crustaceans and fish. Involved GLOBEC work on Georges Bank, study lobster life stages. Census of Marine Life focusing on biodiversity, ocean and biological processes, and EBM – how do you link these together? Definitions of EBM reviewed and discussed by David Packer (on coml. Website)

George Littlefield commercial fishermen. Family history. Fishes from Hampton. Started gillnetting, now dragging. Working with Jeffrey Runge, enjoys the research. In terms of this project, would be good to have something concrete to give the Council or others to help them understand and help them make decisions.

Jeffrey Runge biological oceanography. Studied zooplankton (*Calanus* species) on west coast, in Canada and now in Gulf of Maine. Very interested in zooplankton in general, especially relationships to climate cycles, relationships to fish. Enjoys working with physicists and biologists together, including coupling of understanding of life histories of copepods and fish larvae to circulation and climate models for Gulf of Maine. For this project, particularly interested in determining what the important issues and research projects are.

Ellen Goethel marine educator, invertebrate biologist. Did research for a year. Conservation commission and wetlands policy for coastal areas in NH, saltwater and community impacts on nearshore areas. Around commercial fishing many years. Perspective on the state and federal government fisheries issues.

David Goethel fishermen, biologist. Now on New England Fishery Management Council. Educating people at council level, you have to get past the politics. He has a lot of ideas for what he thinks this project could offer. Knows what would be useful. In order to brief people effectively Maximum 1.5 pages, hopefully mostly pictures. Long history and dedication to collaborative research, better products.

Craig Pendleton fishermen, now boat owner. Discouragement with fisheries management in the 90s and opportunity to meet Dee Hock, visa credit card inspired him to get involved with building a new organization with fishermen and environmentalists together focused on decisions made at most local level possible. Had to stop fishing and come ashore. Now his Captain, Mike, also involved with collaborative research as well. NAMA staff now include Craig, Heather, Mike Crocker who writes newsletter ‘Collaborations’ on fishermen-scientist research in New England. Now working on ‘fleet vision’ project. Brining on another staff person for directing operations.

Troy Hartley here as social scientist to observe the discussion. looking at how to describe and measure success of discussion between fishermen and scientists.

**Discussion of our intentions as a group and the types of products we want to develop:**

What we want the illustrations to include:

- Illustrating basic life history, species associations and interactions
- Start from single species (fished species) – but illustrating how to manage more than one species at a time.
- Pelagic and benthic predator prey diagrams
- Spatial – geographic focus
- 3-d?
- Nested set of more and more detailed illustrations.
- Somehow show first order, and second order effects.
- How non-commercial species play in, including environment, habitat, waters.
- Simple pictures – but capture essence of the variability (e.g. food webs change by month, or habitat)
- Analogy of the food web as a complex circuit board – not all channels carrying energy at all times, but all important at some times in some places. Make sure no parts of the circuit go dead.
- A flow chart would be very helpful for managers and legislators to follow and visually show them different species and how they are connected to other small species.
- Diagrams are more powerful than statements. People will look at pictures before they will read the text if they have to study something quickly.
- NMFS is the center of data for management decisions – so what do they need?
- Predator Prey relationship information is NEEDED.
- If would also be excellent to know more information about density dependent effects on feeding.

Issues:

- Amount of detail depends on your audience – who is our audience (Council?) Council eventually will need extremely detailed numbers on why, how much of a particular species needs to be allowed at each level
- NMFS set up for 100 years to count fish – is there an evolutionary shift going on within the organization?
- Council gearing up to leave certain amount of feed fish (herring) in the ocean (not fish).
- Herring 220,000 tons allowable biological catch, but council allowed only 200,000 tons TAC.

AUDIENCE	PRODUCT
Policy makers	Diagrams, short, clear, to the point
Research community	Detailed diagrams and documentation. (Possibly write up some clear statement on what we know and what we need to know; more detail and scientific references)
Fishermen	a clear product which they agree with – so they can say “yes when I set out from the dock in the morning those are the things I have in my head that steer where and how I go try to catch fish”.

Reminder of Goal:

Working together to develop models/images useful for decision makers.

- Keep in mind that, the level of detail needed for each audience is very different.

Discussion of possible approaches:

- Start with an issue – and show how the decision would have been made differently under an ‘ecosystem-based approach’ (e.g. herring would have included numbers needed by other predators besides humans)
- Say something with more certainty – the uncertainty of 50% is pretty hard to hear – the list of knowns versus unknowns.
- Develop scenarios based on best knowledge of the system – start with pictures and mind models, maybe eventually develop some simple computer models.
- Alternative systems and food web shifts: what has happened in alternating herring / sand lance years. Seabirds and whale shift based on whether it is sand lance or herring

- Seek comments and feedback on our products from research and fishing communities.

Future meeting:

Invite a marine mammal feeding expert. Mason Weinrich or Peter Stebeck (follow up with Lew)

**Butcher board notes:**

Goals for the project and today's meeting:

- Share Knowledge fishermen – scientists
- Ecosystem relationships for fisheries
- “EBM” practical, specific examples, definitions for our area --- could encompass and direct towards: research priorities, management of fisheries and other marine activities, gear, water quality
- Concrete products:
- Illustrations
- Text with references appropriate to broad scientific audience.
- Publish material in appropriate place
- Posters and handouts for participants and other to use as see fit.
- Present at Fishermen’s Forum (early March)?
- Present at Council and appropriate related groups.

**1. Food web interactions**

**Story: Herring and Whiting alternate abundance in different years.**

	Herring	Whiting	Sand Lance (Sand eel)
Feeding habits	Grazing, cruising	Ambush, Omnivore Note feed on larger prey as they grow	
Prey	Smaller stuff <i>Calanus finmarchicus</i> and other copepod species Euphausids Shrimp or shrimp eggs, larvae, juveniles? See below	Arthropods Euphausids Fish – maybe herring Maybe sand lance? Could be that whiting are moving up into water column to feed on sand lance and therefore fishermen do not see abundances of sand lance / whiting?	
Predators (or species with high abundance corresponding)	Tuna (and higher quality flesh, fatter than when feeding on sand lance or whiting) Cod (will take whiting) Monkfish (find dense groups feeding on herring on the bottom during diurnal migration, otherwise dispersed, difficult to catch)		
Abundance notes			Hampton / Seabrook river has had more in past few

			years than 10-15 years ago.
Behavior notes	Herring are sometimes found in nearshore during shrimping season (March) are they feeding on shrimp / eggs / larvae?		

Maps of western Gulf of Maine area – focus on Stellwagen – changes in whales, seabird distribution and abundance patterns in various years associated with abundance of sand lances and herring. Sand lance found mostly (or at highest densities?) in sandy southern part of Stellwagen. Herring more on the ledges and fingers northern Stellwagen.

Why variability in abundance?  
 Fronts, upwelling?  
 Interannual temperature changes (NAO?)  
 Currents?

Lots of Longhorn Sculpin are found nearshore year round, but some seasonal movement in and out. Are seen by fishermen during shrimp season because that is when fishermen are nearshore.

Red Hake – possible indicator species

- An interesting species from a feeding perspective – possibly as an indicator species for what type of prey are available / abundant at any particular time
- Omnivore
- Guts are always full
- Prey type depends on size
- Interesting relationship with scallops (small juveniles live inside scallops, larger juveniles hide under scallops)
- Typical hake: 8 pounds, 30 inches length
- Found in featureless mud bottom, 30-50 fathoms

Dogfish – important species in food web

Found now throughout water column through day and night

Used to migrate diurnally (surface night, bottom day)

Omnivore feeding habits (is this point of contention scientific realm?)

Has there been a change in what they are eating? Is this related to any interactions with fishery? (bycatch thrown overboard?)

## 2. The inshore environment of the western Gulf of Maine

Definition (up to beach, within 3 mile, estuaries and salt marshes, up rivers)

Get copies of chart # 13278 – note references below

Note – definition ‘inshore’ here is very nearshore (within 3 miles). ‘Offshore’ in the notes below still within 10-15 miles of shore(?)

Fishes of the Gulf of Maine – cod spawning sites show near mouth of Merrimack, they would go inside the dirty mouth and spawn.

Comparing shifts of species presence from “known” stories from fishermen to data from power plants, looking at the mass inshore fishery data which has history.

Need water quality testing over long period of time compared with fish guts and other data. Use fish species (specific species) as indicators of effects of change.

The loss of wetlands has created drastic effects due to development; the areas are now a raging river where there used to be large clam flats and sediment for habitat. Species move because of the changes in habitat.

Haddock, cod, yellowtail flounder, "Dabs"- (American Plaice), These fish have changed from inshore species to off shore 1970's the fish began to disappear to the mid 1990's.

Species gone or moved offshore (started in 1970s – mid 80s complete)

Mackerel, blue back (marine river herring), these are not see in shore but off shore. Striped bass, bluefish (found inshore, occasionally)

Blackbacks (NH and Maine?). Mystery. Spawn salt marshes in April and May. Found up to brackish water. Juveniles way up into fresh water in rivers. As grow, every year migrate further offshore. Possible not found inshore since rivers have been cleaned? Power plant impacts with heat? They lived in a polluted river environment; now that the river is cleaner they have disappeared. How does the water quality affect the population of the species? The chlorination of the sewer aligns with the disappearance of the horseshoe crabs What happened there?

- Horseshoe Crabs – disappeared from Hampton/Seabrook area in early 1970s (corresponds to when started using chlorine in waste water).
- Mouth of Merrimack River generally less diverse fish community in recent years.
- Cod used to spawn right up in mouth of Merrimack (depth? See Bigelow & Schroeder) – no spawning in different areas, deeper (30-35 fathoms) in Ipswich Bay.
- Mackerel (David used to catch when? Size? Depth? Habitat? Season?)
- Haddock – example from Merrimack river where Haddock spawned same inshore location for 5 years and then never came back.
- Yellowtail Flounder
- Pollock – juveniles especially used to be inshore in very high numbers. Juvenile Pollock like rock bottom but in many areas the rocky bottoms inshore have been changed due to the effects of coastal development. Fishermen used to have to work hard to avoid them and treated them as nuisance bycatch. The large Pollock used to come west to spawn at thanksgiving. Now these large ones just stay offshore. Seasonal patterns are 'mirror image' to cod. (offshore spring, onshore spawn in fall). Juveniles like ledge, rock, boulder environs in less than 60 fathoms, also river mouths. See chart 13278, relatively inshore high spots (edge of 'light blue on chart) for the areas you used to find juveniles between June 1 and November 30 each year, see offshore spots (prong, northern edge) for where you find juveniles now (same season?). Spawning also occurs offshore now and not inshore. (did it always occur offshore?)
- Dabs (American plaice) – now not found within 40 fathoms.
- Herring
- Alewives
- Blueback river herring
- Ocean pout (Congo eel) – preferred habitat is sand bottom

Species high numbers:

- Crab
- Lobsters
- Sculpin
- Bluefish seasonally (every year or less predictable?)
- Striped Bass (seasonally?)
- Blackbacks (lower numbers) because they have to spawn inshore.
- Longhorn Sculpin

Longhorn Sculpin - Possible indicator species:

- Numerous
- Medical studies
- Nearshore
- Suspect fairly stationary
- During winter smaller fish caught, during summer, larger fish
- Shorthorn sculpin found further east and north (in Maine)

Description inshore habitat change Ipswich Bay, Merrimack, Seabrook, Hampton (similar elsewhere along coast?):

- Loss of marsh grass (spartina) and peat
- Loss of mud flats
- Loss of clams and worms
- Depleting forage based for fish which used to come inshore to feed in salt marsh, on mud flats, at high tide (on clams and worms?)
- In total, loss of wetland buffer (does this lead to different storm effects or other changes in physical environment? Nitrogen sources, storage? Nutrient movements?)
- Deeper, faster water flows in river and estuaries (less shallows)
- More surface water erosion on land
- In general, estuaries are environment with high 'P/B ratio' which is ratio of production to biomass, in other words, a lot of primary productivity, as well as high growth rates for the invertebrates, but also high turnover (short life spans, fast growing species)

Why inshore species community changes?

- Feeding conditions for adults have changed
- Feeding, habitat or other conditions have changed for juveniles unfavorable
- Survival of eggs and larvae (including food availability for larvae feeding on zooplankton – fish larvae prey on phytoplankton, zooplankton, including larvae of benthic invertebrates “meroplankton”)
- Reduced population size overall
- Temperature and salinity changes
- Benthic habitat change: intro of exotic algae
- Benthic habitat changes: intro of various invertebrates (green crab, Japanese crab, tunicates, sponges)
- Note most of these species migrate onshore-offshore seasonally
- Could physical oceanographic factors be influencing choice of spawning locations (retention might be better inshore?) could local alongshore / across shore currents have changed during this period and be influencing spawning behavior?
- Factors in general affecting spawning location (local evolution, physical retention of eggs and larvae, prey for larvae, physical conditions for larvae survival – temperature, salinity)

**Possible story: Changes in water quality related to human activities have changed inshore distribution of fish and impacted recruitment success**

- The hypothesis that there were changes to water quality in late 70's and early 80's (introduction of toxics, pharmaceuticals or other chemical issues that altered adult migrations or inhibited spawning and recruitment success)

Possible data sources for inshore water quality / Inshore benthic and pelagic surveys:

- Power plant records
- Seabrook
- Pilgrim
- Newington
- Millstone
- Braedon Bay
- Mass Inshore survey data
- Maine / NH occasional surveys

- Bigelow long term data
- Meghan Tyrell, Well Estuarine Research Reserve – Lew Incze contact
- Larry Harris (UNH?)
- Jim Carlton, Williams College
- John Teal (ask Les) shoreline change

### **3. Interannual variability 2003, 2004 as examples**

General:

- Cold water - What are the affects of change in temperature on fish. Fish pool in deep parts trapping to stay warm.
- Where fish hang out is changing according to temperature and food source
- How do fronts set up from year to year?
- Climatological influences need to be factored out when considering how fish respond...??
- A good year for larvae- how does it compare with the temperature, currents, salinity, plankton blooms, circulation, etc.  
Goal – show the environmental conditions that interact with the species

Dec 2003 strong ecological shift:

- Herring came back “inside” Jeffreys Ledge on cold years. - Herring in high numbers ~ whiting in low numbers (Herring depths? Seasons?)
- Salinities on the bottom of Ipswich Bay were 24ppm - Storm caused mixing that caused record low salinities within Ipswich Bay resulted right after large storms, mixing of cold fresh surface waters down to 50 fathoms, extremely unusual)
- Cod have not come inside Jeffreys for the first time in years – they moved to east of Jeffreys into deeper areas last winter (late 2003 – early 2004) (due to cold?) and never really returned this summer.
- Dogfish ‘normally’ stay at surface until approx. 6°C, at which point the fish go down to warmer water (depths? Seasons?).
- More monk fish in colder water – have moved south with the colder water, finding more in this area inshore of Jeffreys this year and less to the north off Portland. (are they also still in offshore basins?)
- White-sided dolphins – high numbers
- Fin whales – medium numbers, more than last year
- Humpback – fishermen not seeing any
- Minke – very few

#### **Possible story: Fish larval stage food needs**

Influences: timing of spring phytoplankton bloom- early bloom related to high recruitment of haddock on the Scotian Shelf

Food needs for larval stage - Plankton, especially copepods

Climate – temperature, currents, upwelling

Note importance in how we frame this --- may not be feasible to predict recruitment, because of the many factors involved in determining year class strength, but could be possible to understand whether environmental conditions (Climate, bloom timing, copepod production, winds and currents affecting distribution of fish larvae) were (or will be) very good, average or very bad for recruitment .

Satellite data – sea surface temperature, sea surface color indicates phytoplankton. (and possibly zooplankton ?). Satellite data can also show position and timing of fronts, which may promote aggregations of copepod prey and forage species.

Species of interest:

Gulf of Maine Cod – spawn in Ipswich Bay May 15 – June 15, and also in December. – where do the eggs and larvae go – south and east from Ipswich Bay around Cape Ann – moving through lower salinity water at mouth of Merrimack, either entrained in Cape Cod Bay or not depending on variability. see David's hand drawn map of local current patterns. Harvard groups, U Maine groups, or U Mass Dartmouth may be able to do particle tracking models. David notes that he sampled for UNH fecundity study in past and they found that the fish spawning at the end of the spawn – late June, higher fecundity.

GoM Cod: Where do the larvae go after they spawn? When do they spawn? At what depth do they spawn? Spawn May 15- June 15 in Ipswich Bay (species?, shrimp? cod?)

Georges Bank Cod

Georges Bank Haddock – 2003, 1999 good year classes

**4. Another Possible subject: fish movements seasonally related to bottom temperature?**

Coldest bottom temperature is in March

Shrimp – female movement inshore during winter, lay eggs, then move back into deeper waters in early spring / throughout spring and mix back up with smaller males. Shrimp aggregate tighter during colder years. Shrimp settle in different depths to lay eggs depending on water temperature. Shrimp let go of their eggs in the water column During February-April, the shrimp release their eggs. Are herring eating the shrimp eggs?

**5. Another possible subject: how to set biological catch targets from ecosystem basis**

Basing on ecosystem states, not simply population models; (incorporating food needs of other species besides humans).; environmental variability. Etc.

Topic for further set of meetings?

## Appendix 2: Meeting agenda and minutes for Meeting 2

Western Gulf of Maine Inshore Fisheries – Ecosystems Project  
Meeting #2 (of 3)  
Co-hosted by COOA & NAMA  
Meadowbrook Inn, Portsmouth, NH  
February 19, 2005

### **The purpose of these series of meetings:**

Discussion and knowledge sharing about ecosystem dynamics and interactions in relation to fisheries in the inshore Western Gulf of Maine. There are two main objectives:

- 1. Create products, in the form of short, graphic handouts describing relevant, shared ecosystem knowledge to inform people in policy or marine environmental decision-making roles. The content of these products will be developed out of discussions on the three subject areas for today's meeting.*
- 2. Write up, in the form of short communications or perspective papers, more technical summaries and analysis based on this knowledge exchange. They can serve to:*
  - point out shared knowledge and perspectives relevant to ecosystem based management for policy makers and community decision making.*
  - identify knowledge gaps, stimulate more knowledge sharing and collaborative research between the scientific and fishing communities*
  - generate relevant questions and inform hypotheses for research projects.*

### **The goals for this meeting**

1. Get out as much information as possible on the three subject areas, especially filling out of diagrams and figures started at the last meeting and answers to the specific questions.
2. Prepare for a session at the Maine Fisherman's Forum on Friday, March 4.

### **AGENDA**

#### **9:00-9:30**

Welcome and Introductions

#### **9:30-10:00**

Overview and review of discussions at Meeting 1 in December – overview of the draft product ideas. The rest of the day will be focused on looking over draft products NAMA and COOA staff have pulled together based on discussion at Meeting 1. We will focus on group editing, revising, helping to rework or redesign graphic illustrations, maps, etc.

#### **10:00-11:00**

**Fish reproduction** – specific discussion of recruitment success for cod and other species in the western Gulf of Maine – locations, timing of spawning, juvenile habitats, fine-scale currents and environmental factors within the area.

#### ***Specific questions:***

*What are the exact locations of the spawning areas for cod, herring and other species in the western Gulf of Maine and when do they spawn?*

*What do we know about the role of the inshore shelf and nearshore environment as a nursery area for each of these species?*

*How can the emerging observing system for the Gulf of Maine be of use in ecosystem based management?*

**11:00-12:00**

**Food Webs** – key roles of whiting, herring, and sand lance; yearly and seasonal variation and feeding behaviors in different areas

***Specific questions:***

*How important is herring as a keystone species in the western Gulf of Maine?*

*What are other keystone species in the western Gulf of Maine ecosystem?*

*What is the structure in space and time of these food web interactions?*

**12:00-12:30** : Working lunch

**12:30-2:00**

**Environmental change and interactions with fish distribution and abundance** -long-term changes to the near-shore environments and fish communities, year-to-year changes in fish species correlated with weather – e.g., 2004 cold year.

***Specific questions***

*What changes have you observed to the nearshore environment in the past 20-30 years, especially around Ipswich Bay?*

*How important are the very nearshore environments to the life cycles of fish species in the western Gulf of Maine?*

*What do we know about changes in distributions of fish related to weather and changes in distribution of their prey (e.g. Calanus, herring, cod, tuna and whales on Jeffreys Ledge from year to year; interannual and longer term changes to distributions of juveniles and adults in Ipswich Bay)?*

**Western Gulf of Maine Inshore Fisheries-Ecosystems project  
(NAMA/COOA hosts)  
Portsmouth, NH  
February 19, 2005  
Minutes of the Meeting**

**ATTENDED**

Randy Gauron	Frank Mirarchi
Jeff Runge	Heather Deese
Craig Pendleton	Jen Levin
Norman Vine	Richard Taylor
Ellen Goethel	David Goethel

\*\*NOTE initials in these notes denote speaker where we deemed reference could be helpful to individual's knowledge or experience.

**AGENDA**

Project goals: scientists and fishermen meeting to share knowledge and ideas about ecological relationships relevant to our fisheries. Prepare a series of concrete Ecosystem Illustrations based on discussion and with scientific references – aimed at policy and manager audience. We want products we will all be happy to have our names on – all participants.

Goal for today to review DRAFT ecosystem illustration products developed on basis of discussion at Meeting 1 in December 2004. Feedback, Comments, fill in the gaps. After receiving this feedback, we'll work with a graphic artist to make nicer illustrations. These will be reviewed with all of you at a third meeting in spring 2005.

Plan today to discuss three topic areas:

- 1) Food Webs – key roles of whiting, herring, and sand lance; yearly and seasonal variation and feeding behaviors in different areas
- 2) Fish reproduction – specific discussion of recruitment success for cod and other species – locations, timing of spawning, juvenile habitats, fine-scale currents and environmental factors within the area
- 3) Environmental changes and interactions with fish species distributions and abundance (long-term changes to the near-shore environments and fish communities, year-to-year changes in fish species correlated with weather – e.g., 2004 cold year).

**DISCUSSION & RESULTS**

We spent a lot of time working over charts, recording fishermen's knowledge of where and when they encounter and observe particular species. These notes are being incorporated into digital maps for putting together our ecosystem illustrations.

We discussed many aspects of species feeding relationships, as well as species distributions at different times of year. The focus was on herring, whiting, and sand lance, but we discussed many other species as well (see notes on FOOD WEBS, below)

We also discussed aspects of fish reproduction – spawning, eggs & larvae, juveniles. Interactions with currents. Scientists current efforts to model ocean circulation on computers and how this resource could be used in future work together (e.g. tracking possible transport of eggs and larvae 'seeded' into the model at specific locations / times). (see notes on FISH REPRODUCTION, below)

There was very little time to discuss Topic 3, but some discussion of environmental factors and changes of concern or interest, and also a recent cooperative research study on the effects of trawl gear on benthic habitat. (see Discussion at end)

These notes stand as a DRAFT record of the meeting – pending any comments and corrections by participants. NAMA and COOA staff are working now to incorporate drawings and notes into updating out ecosystem illustration products – to be discussed at Meeting #3 in April or May 2005.

#### 1) FOOD WEBS discussion

General note: many of these species fishermen do not cut on board and so only see gut contents if they break open in fishing process. Also many of these notes only apply to particular locations and seasons when fishermen are engaged in particular species – so not to say these species are NOT present during other seasons.

Benthic community: More depends on what goes on under the sea bed than we realized. There's a whole system that goes on under the sea floor. There's a biomass down there that likely equal what's swimming around in the water column. I spent two years in my cellar counting bugs in mud. There are billions per square mile. High total biomass. Rapid turnover rates (two or three times per year)/ short life cycles. There have been recent cooperative research projects on effects of gear on benthic habitat  
(FM partner)

#### Comments on “draft generic food web diagram”

We're really talking about energy transfer from sunlight to detritus and back. We should have an energy transfer diagram before the food web, show energy gets recycled in the near shore environment. (DG)

There is always a constant amount of biomass in the ocean, but the question is how that gets distributed. It's fairly constant over the whole earth. The Gulf of Maine extraordinary as an energy trap (due to water transport) which is what makes places like the Gulf of Maine so special. (NV)

#### Comments on species specific food webs:

It's eat or be eaten and it's important to communicate that it's not so pretty in the ocean. The diagrams do a good job of conveying what it is you're trying to convey. (DG)

Try lists ranking the predator/prey relationships as preferred, non-preferred, incidental and then get into seasonal details later. (DG)

General: Need to incorporate larval predation on various species. (FM) Combat current management approach that fish don't exist until they are 1 year old (DG). Ctenophores devour fish larvae. (Are we getting blooms of jellies due to nitrification) (FM)

Herring, Whiting: Incorporate euphausiids – very important to the south (NV)

Herring behavior: unusual patterns in two areas – off Ipswich Bay and in Cape Cod Bay, last two years. Herring like a carpet on the bottom during the day – anomalous because usually they rise in schools and then disperse as they go deeper (DG, FM)

Herring would be up off the bottom at night – possibly feeding on Calanus (JR, DG)

Herring could be on the bottom to find feed during the day?

?Herring could be on the bottom to avoid dogfish – predator avoidance (RG) But the herring and dogs have been mixed together solid. You could get them in the boat because enough herring they'll split. (DG)

When you're looking for the codfish, you look for the herring bottom. (NV)

Herring predators: Squid eat herring, mackerel and swordfish.

Harbor porpoise go for herring; (RG)

Herring distribution quite changeable – for example on Jeffreys, the western edge has sporadic events during late spring to late summer. At the same time there are krill events, hard to say what kind of krill. Stuff is here today, gone tomorrow – you'll go out and have a great day and the next day it's like nothing ever lived there (DG). The curl of Jeffreys will have a higher amount.

Herring is definitely not predictable. Big biomass is fairly predictable. But location unpredictable. Usually more up around Chatham than south of Cape Cod - should have called it Cape Herring – (NV)

Whiting: Important to convey that whiting eat other whiting. (DG)

Whiting prey: favor feeding on Euphausiids, bellies full – during summer season which is when I see them. Between June and leave by October is when I see whiting. In the winter the whiting move offshore into deeper water (where I don't fish over 45 fathoms) (DG)

Whiting prey: prodigious feeders and they eat herring and definitely other whiting. We saw sculpin, red hake, juvenile cod, juvenile pollock. (FM); Whiting do eat cod they eat 50 metric tons of juvenile cod a year. (DG)

Whiting fishing takes place in limited geographic area and only in Oct-Nov, small amount in December in Cape Cod Bay. Depths of 25 fathoms. Relatively shallow water and it cools off quickly and the whiting move off to deeper water and when they do we can't follow them. Whiting will be intermixed with herring and alewives – presume these are the primary food for whiting during these months / areas, don't know about rest of year (FM)

Whiting probably eat smaller shrimp, definitely catch whiting with shrimp (RG)

Whiting feeding habits: do they have filter feeding? From Bigelow & Schroeder (whiting both filter and attack feeding)

Whiting: catch whiting while jigging for bait while tuna fishing. Jigging is for larger whiting. (DG)

Whiting: Predator avoidance: whiting clearly avoid the dogfish (DG)

Whiting: never seen a dogfish with a whiting in stomachs -- Dogfish are an omnivore they'll eat about anything, but I don't see them as a major predator of whiting. (DG) I disagree because the dogfish were so bad they wiped out the whiting -- the whiting disperse because they don't like to be around the dogfish. I have seen some whiting in dogfish stomachs, but I couldn't tell you if they are a major predator of whiting. Could be just found in same areas and times (FM)

Whiting key predators: Cod, tuna, possibly squid (DG); definitely squid (FM); White Hake eat a lot of whiting, almost like curdles in the stomach – white hakes always have full stomachs (CP, DG); Whiting predators of whiting, see them in stomachs (FM)

NOTE: Squid is a little known spp that we don't understand all that well (JR)

Squid eat herring, mackerel and swordfish. Cause problems for tuna fishermen (DG)

NOTE: White hake might be interesting species to look at for feeding – stomachs always full. (HD) Red Hake will also eat anything the swims by, including other hake (DG)

Sand lance: discussion about inshore and offshore species – are we all talking about the same thing?

Sand lance: very important for humpback (HD); I think everything eats a sand lance. They're small enough and dense enough so that small and large fish can eat them. (NV)

Sand lance huge variation in numbers year to year – why? What triggers these explosions in their population? Every ten or twenty years there will be this incredible explosion for a couple three years. (FM) Some years miles and miles of bottom carpeted with sand lance, other years no. (still the adaptable fish species can adapt to something else when sand lance are absent.) (FM) The few years you see them you see them in the same predictable places

Saco Bay does get sand lance, chased by mackerel and striped bass. (CP)

On Jeffrey's I've seen them on the sandy eastern side and I've seen them on the fingers but I haven't seen them anywhere between. (DG)

In Ipswich Bay area their time is April to November (DG)

Mammals: check NMFS observer stomach contents data for marine mammals. (RG)

Seals eating where the flounders are (FM).

Check with Bill Lee Rockport – video of seals sitting by the grate just chowing fish out of net.

Seals follow your boat when you're herring fishing. (EG)

Pilot whales will occasionally grab fish right out of net (FM)

Manta rays, pilot whales, dolphins chasing your net in great south channel (NV).

Minke whales anywhere there's anything fishy to eat. If the minkes are there, there are some kind of fish for them to eat. (DG)

Birds: huge change recent decades: resurgence of fish-eating birds – with DDT clearing out? must be having an effect on marine food webs? A hundred times more than I recall from earlier years. They each have a particular feeding niche and some of the fish are commercially important and others might not be but might be food for the ones that are commercially important Check Manomet bird observatory (FM)

Cormorants are merciless. Feed on small winter flounder. Feed shallow and prefer things that are in the harbors like alewives. In fall when water cools cormorants leave for winter.

Merganser ducks that spend their entire winter feeding constantly on winter flounder.

Mergansers eat only fish apparently.

Terns don't dive they just grab things right at the surface – maybe herring, probably whatever is available. (FM)

Other species notes:

Shrimp feeding on benthic fauna? (FM) Shrimp eating detrital material (FM)

Cod prefer other foods, but if you take away their typical feed, they will go down and start feeding on benthic material. (FM) Cod eat sand eels when they are abundance (Sand eel abundance varies greatly) (FM) Cod are omnivores and can eat whatever is available. They are very resilient. The cods niche in the ecosystem is not dependent on any one thing which is what makes it such an important food fish and important in the ecosystem. (FM) Cod behavior unusual: 2004 lower temperatures all summer in the deeper waters to the west of Jeffreys, the top of Jeffreys stayed relatively warm – that's why the cod stayed pretty much on Jeffrey's – even though the water on Jeffrey's on top was cold, was not as cold as the deeper water where they should've been going. (DG)

Haddock Distribution: in March, look for bottom temperature increasing with depth as you go offshore. Between 30-37F inshore, when you get deep enough to find 40F water, you'll find haddock (DG)

Smelts: The smelt fishing is pretty much nonexistent compared to what they used to be. In the Piscataquis and the Saco River. (DG, CP) They have a little bit of a smelt season but they're only catching like six. (RG)

Calanus: Mackerel have Calanus in them all summer (DG). We don't necessarily know after June, no indicator (RT). Higher numbers of Calanus in the spring than in summer and fall (DG).

Calanus go down deep in Wilkinson basin until February (diapause) so makes sense wouldn't see them in winter (JR). This stage –WHICH STAGE? - in Calanus is really lipid rich and that's when the mackerel and herring are going to want it (JR).

Calanus interannual variability: Research project on Jeffreys two summers in a row (late July – Sept) found Calanus year 1, but not in year 2 – why? (JR) Could this be due to Temperature change – cold in 2004? (EG).

## 2) FISH REPRODUCTION

Jeff Runge showed example of an oceanographic circulation model. Scientists build computer models to try to replicate the flow in an area using what we know of the physics and the observations of wind, etc. The examples shown illustrates what happens to a group of neutrally buoyant trace particles you 'seed' in the model in a particular location – how their location changes over 30 days or 60 days. The examples showed how particles would be carried by the currents in the area of Ipswich Bay.

Group found this model very interesting. Did a pretty good job of showing currents they would expect. Circulation models have been used in relation to sewage outfall work in Massachusetts, Mass Water Resources Association (FM)

Specific Comments on the example circulation model:

Currents look approximately right offshore of about 50 fathoms (DG)

Inside of 50 fathoms, currents are not what we would expect. What you see inside the 50 fathom line is that water recirculates, gets 'trapped' – how do the different tides (easterly/southern or east to west) affect recirculation? How do these currents carry eggs from spawning areas? (DG)

Cod spawning in Cape Cod Bay: cod spawning sites are scattered along mass and Cape Cod bays in places where you wouldn't expect them, but probably placement is due to low disturbance in these areas so they had a chance to grow to a size where they were able to defend themselves. The circulation patterns show eggs and larvae would move counter-clockwise along the western side of Cape Cod and up onto Stellwagon bank. (FM)

Cod Juveniles: All along inshore waters (DG)

Cod distributions: on south side of Cape Cod, not finding them in the sounds. Finding blackbacks instead – where sounds meet the ocean. They've come back because no one's been fishing them for twenty years. They are impacted by pond water and water quality. (NV)

Are nutrients or other factors related to outflow of Saco river affecting spawning grounds in Saco Bay? Could you track nutrients, river outflow and relate to where fish might be found? Army Corps of Engineers have a detailed river outflow model (CP)

How does river outflow influence the timing and location of the spring bloom in Saco Bay? (CP)

What are the interannual differences in river characteristics, can we link with spawning? (CP)

FINAL DISCUSSION -- Some notes on inshore-offshore links and environmental changes:

One thing that fishermen might not think about, is the changes in atmosphere have impacts on water quality. Carbon dioxide, nitrogen (FM)

Note PCBs and DDT are still having impacts on flora and fauna, especially in ocean ecosystems because they are so pervasive. (JL)

These factors could stress fauna and flora, not directly kill? (JR)

They could be stressed and might not just be killed. (JR) impacts on ability to reproduce (EG).

What is the impact of ultraviolet light? On eggs and larvae? Due to ozone hole? (RT)

Canada DFO study on this topic, sophisticated research, they found dips in the ozone layers and see the differences that made in cod eggs and Calanus. The UV that's in natural sunlight would kill the eggs at the surface of the water within 15 minutes. When you do the model, they did uv penetration through the water in the Gulf of St Lawrence. They conclude that it's a factor if that uv is significantly variant. (JR)

Water being too clean -- clearly distinct areas where things were dead where lobstermen didn't have kelp and seaweed and other things growing on their buoys. Chemicals are coming from bottling plants and from sewage treatment plants. We don't see things like we did in the 70s. Saco River, Merrimac River (CP, EG)

Merrimac River, several factors. The chlorine is one factor and even if it's in precipitous form, it's on the bottom. Even though the water is potable, there are chemicals that do not occur naturally in the ocean. You also have oxygenation. You get super saturation if the water is flowing down. (EG)

Discussion of collaborative research project on Effects of Fishing on Benthic Habitat (Frank Mirarchi updated the group on their recent findings):

Results: impacts are subtle and elusive. Fishing does change bottom habitat, but the changes are so subtle, it's difficult to say whether they're caused by fishing gear or by natural causes. One of the things we quickly learned is that when you fish over a bottom that you think is homogeneous and uniform, it's far more complex and subtle and really a matrix of micro habitats. In some areas the dominant factor that works the bottom is the current. In other areas it's boulders left from glaciation. In the deeper basins there is a lot of biogenetic activity - burrowing animals and lobster and crabs that move into holes dug by something else. There is so much variability on the

bottom, every time you try to quantify the changes, you're looking at differences from a couple of meters to the next.

The gear itself doesn't impact the bottom necessarily. Each kind of gear has a different 'signature'. You can see the path of the trawl on the bottom, but you go into there with a video camera you don't see it because the change is a few centimeters down. If you take a cross section of the sediment, there is a noticeable scour in the bottom and the sediment is sheared away and there are profound changes at the bottom, you look at the oxygen rich areas and mixing them with the anoxic areas. The top detrital material might be swept away but... If you have discs, each disc makes a striation. You try to quantify the impact on organisms on the bottom. There are so many different types of benthic fauna and epifauna and there are things that live in burrows and holes beneath the bottom and you get different indices of changes over time depending on what you're looking at. Some of these things will replace themselves within a couple of weeks. It's hard to say whether there's an enormous negative impact. There's definitely an impact, but there's not much to say it's that severe, or how severe it is. We do tip things over, but so does nature.

This report is on a web site from [www.crenvironmental.com](http://www.crenvironmental.com).

### **Appendix 3: Meeting agenda and minutes for Meeting 3**

Western Gulf of Maine Inshore Fisheries – Ecosystems Project  
Meeting #3 (of 3)  
Co-hosted by COOA & NAMA  
New Hampshire Urban Forestry Center, Portsmouth, NH  
May 16, 2005  
9:00-3:00

#### **INVITED**

David Goethel, Fisherman  
Bobby Nudd, Fisherman  
Frank Mirarchi, Fisherman  
George Littlefield, Fisherman  
Randy Gauron, Fisherman  
Peter Kendall, Fisherman  
Dale Martel, Fisherman  
Scott Swicker, Fisherman  
Richard Pramns, Fisherman  
Mike Stinchfield, Fisherman  
Tim Tower, Charter Boat Operator  
Richard Taylor, Fishery Data Expert, Former Fisherman  
Ellen Goethel, Marine Educator  
Norman Vine, Fishery Data Expert, Former Fisherman  
Peter T. Stevick, Bioscience Research Institute, U of Southern Maine  
Lew Incze, Bioscience Research Institute, U of Southern Maine  
Les Kaufman, Boston University Fish Ecology  
Jason Link, Woods Hole Research Center  
Chad Damarest, New England Fishery Management Council

#### **HOSTS**

Heather Deese, NAMA, Marine Research  
Jeffrey Runge, COOA, Fisheries Oceanography  
Craig Pendleton, NAMA, Former Fisherman  
Jen Levin, NAMA  
Amy Cline, COOA

#### **GOALS OF THE MEETING**

- 1) Get a final check and approval on the draft products.
  - a. Trophic relationship / feeding (emphasizing herring, cod, and krill).
  - b. Cod reproduction.
  - c. Near shore/offshore links, including changes in the near shore.
- 2) Fill in the blanks on the more detailed mapping products.
- 3) Gather more information on shrimp reproduction and herring reproduction and geography.
- 4) Discuss next steps with future meetings and/or outreach education steps.

#### **AGENDA**

9:00-9:30

Welcome and Introductions

9:30-10:00

Overview and review of discussions at Meeting 2 in February and Fisherman's Forum in March—overview of the draft products NAMA and COOA staff have pulled together based on discussion at Meetings 1 & 2. We will focus on group editing, revising, helping to rework or redesign graphic illustrations, maps, etc.

10:00-11:00

FACT SHEET 2: “Geography of Cod reproduction in the Western Gulf of Maine” – locations, timing of spawning, juvenile habitats, fine-scale currents and environmental factors within the area.

11:00-12:00

FACT SHEET 3: “Food webs and key species in the Western Gulf of Maine” – focus on herring, whiting and sand lance.

12:00-12:30

Working lunch

12:30-1:30

FACT SHEET 1: “Near shore environments” – focus on changes over the past thirty years, and the many factors affecting near-shore, and importance for fish.

1:30-2:00

Shrimp and herring reproduction – more detailed mapping?

2:00-3:00

Next steps (setting up meetings with NEFMC and NEFSC staff)

Outreach and education ideas.

Wrap-up

**Western Gulf of Maine Fisheries-Ecosystems Meetings (3 of 3)**  
**Northwest Atlantic Marine Alliance (NAMA) &**  
**University of New Hampshire, Center for Ocean Observation and Analysis (COOA)**  
**New Hampshire Urban Forestry Center**  
**May 16, 2005**  
**Minutes of the Meeting**

**Present**

David Goethel, Fisherman, New England Fishery Management Council member  
Norman Vine, Fishery Data Expert, Former Fisherman  
Lew Incze, Bioscience Research Institute, U of Southern Maine  
Richard Taylor, Fishery Data Expert, Former Fisherman  
Chad Demarest, New England Fishery Management Council  
Peter Stevick, Bioscience Research Institute, U of Southern Maine  
Randy Gauron, Fisherman  
Jeff Runge, COOA  
Heather Deese, NAMA Science Advisor  
Amy Cline, COOA  
Jen Levin, NAMA

**Goals of Today's Meeting**

- 5) Get a final check and approval on the draft WGOM Fisheries-Ecosystem products.
  - a. Trophic relationship / feeding (emphasizing herring, whiting and sand lance).
  - b. Cod reproduction.
  - c. Near shore/offshore links, including changes in the near shore.
- 6) Fill in the blanks on the more detailed mapping products.
- 7) Gather more information on shrimp reproduction and herring reproduction and geography.
- 8) Discuss next steps with future meetings and/or outreach education steps.

**UPDATE SINCE LAST NAMA/COOA MEETING (February 2005)**

**Summary of This Project**

UNH gave some funding to support these three meetings with the idea of developing products that get information out to folks through graphic interpretations. We're planning to have versions out by the end of the summer. The funding for this project formally ends after this meeting. There seems to be a great deal of interest and it seems that this is valuable. Our target audiences for the products are management and decision-making bodies like the NEFMC. We would also like to develop a presentation or white paper for the research communities because these products and discussions could really be helpful in spurring research. Additionally, an informational format for the fishing community for a straight-faced test would be appropriate. We could also get into web-based materials.

**Maine Fishermen's Forum**

NAMA, COOA and GoMOOS staff worked together on a session at the Maine Fishermen's Forum titled: "Gulf of Maine Fisheries & Ecosystems: fishermen and researchers scoping out Ecosystem-Based Management". David Goethel, Craig Pendleton, and Jeff Runge gave short presentations, followed by 45 minutes of small-group discussions. Over 100 people attended, and over 50 stayed for the discussion session during which we broke the room up into four groups with a facilitator and note taker in each. Groups were tasked with discussing ecological interactions they saw as relevant to fisheries in the Gulf of Maine. There was a lot of interest in this process and the feedback from the session was really positive. Participants really liked the process of recording the experiential knowledge that's there and integrating it into the research process, and then ultimately getting it out to the community in some systematic way. One outcome could be some sort of forum or series of meetings to follow up with the large number of tuna fishermen who attended and their interest in food web interactions.

### **NAMA/GoMOOS Partnership**

Since January 2005, NAMA has also partnered with the Gulf of Maine Ocean Observing System in Portland to hold a set of meetings with their staff, researchers, and fishermen and develop a series of products communicating ecosystem relationships. This project has been similar to the NAMA/COOA project. We had two meetings, with really good groups and interesting discussions. Funding came from GoMOOS outreach monies and due to funding deadlines, these meetings happened rapidly in the winter and spring and the graphic artist we're working with on both projects has finalized NAMA/GoMOOS products over the last six weeks. (These were available on Heather's laptop for people to look at).

### **MPA Executive Order**

There is an executive order to establish a national system for Marine Protected Areas, and NOAA now has an MPA section. An MPA Federal Advisory Committee of stakeholders has been meeting for the past year (Barbara Stevenson and George LaPointe are on this group) and is meeting in Portland for the next three days. The MPA office is holding a public comment opportunity tonight at GMRI 7:30-9:30 to coincide with the Federal Advisory Committee meeting. This is the only public comment opportunity for all of New England. They are looking for input on what an MPA system might look like, how big, where, and so on (they do not currently have the authority to create any new MPAs).

### **New England Council related MPA activities**

There have also recently been two different two-day workshops hosted by the New England Fishery Management Council looking for public input in developing their own MPA policy. Two weeks ago in Mass, and last week in Ogunquit. These were designed as listening sessions with fishermen. The Council plans to develop their MPA policy in coming months. On a related topic, the Council will be considering a range of options for habitat protection areas under the upcoming Omnibus Habitat Amendment, which will update the habitat protection measures under each of the separate Fishery Management Plans. They have recently called for proposal for Habitat Areas of Particular Concern (HAPCs) under this process. Those that are not scientifically determined are being put aside and not considered. This process will be going on for a few years.

### **State related MPA activities**

Massachusetts and Maine are working on management plans for multiple users. "Massachusetts Ocean Management Initiative" has lead to draft legislation on ocean planning at the state house, and another task force working on MPAs at this point. In Maine there's a Bay Management pilot project that is thinking about different issues around managing activities like fishing, conservation, as well as community power sharing. The NAMA/COOA meetings will hopefully be very relevant because of the near shore information we've compiled from this group.

Group discussion of MPA issues included concerns over whether a 'whole system' perspective would be applied to how MPAs are assigned or not. Concerns amongst group about the long-term cycles in abundance of marine species, and whether that is ever considered in conservation decisions. Examples included the herring abundance at very low numbers in 1930s (Norman Vine) and sitings of marlin off Alaska due to climate variations (work of Gary Sharp raised by Richard Taylor). RT also noted Norwegian fisheries example of explicitly acknowledging how many more pounds of prey species they had to forego fishing in order to be able to fish on a cod stock (e.g. leave 5-10 times as many lbs of capelin and herring in the water as cod you end up catching).

Another long-term climate cycle of interest was the North Atlantic Oscillation. Scientists lately have been looking at correlations of the NAO with plankton (copepods), right whale calving rates, lobster settlement, northern shrimp abundance.

## GRAPHIC #2: COD GEOGRAPHY AND SPAWNING

### Questions:

- Should we include pictures of cod on a map? If so where?
- Should we include depth lines?
- Should we incorporate juvenile habitat? Where are the juvenile habitats elsewhere in the region?
- What's the main message we want to convey?
- Is it the relationship with currents? Does this change in space and time?

### Notes on Information Sheet:

- The colors are confusing, can't tell difference between pink and purple. (DG)
- Suggest instead of "fact sheet" call it "information sheet". (JR)
- Juvenile habitat stretches along the whole coast, waters less than 25 fathoms. (DG)
- Not feasible to draw everywhere cod spawn, it is too disperse and unpredictable. Instead identify major events (which we've already done in this version), and make a general statement about the rest. (DG)
- Suggestion for title: *Identified Cod Spawning Aggregation Areas*. Too be clear that there are more areas, we haven't identified them all. (LI?)
- Include a life history of the cod, (eggs, larvae, settlement, juveniles, adults), how long phases last (minimum and maximum times, which depend on temps and availability of food), to put these charts and maps in context. (RT)
- Jeffreys should be juvenile habitat and adult feeding habitat (feeding on the herring spawn), not spawning. Would say that the edges of Jeffreys is good for spawning, but mostly it's a known juvenile aggregation area. The larger cod (over 10 inches) are outside 25 fathom, they ripen on Jeffreys but move south and West (possibly to Mass Bay or Cape Cod Bay or Tillies) to spawn in January. Jeffreys and Middlebank are pretty much devoid of life in the winter because it's so rough, fish move deeper when shallower waters get cold.(DG, NV, RT)
- Note spawning areas: Wells Bay and Flore River are regular events with older fish (older than 8 years)
- Might want to show a series of images from a circulation diagram to show the fine-scale features?

### Main messages:

**Juvenile Habitat** exists throughout the region. If we think substock structure is important, it's essential in order to convey what you need to protect the coastal fishery. (LI)

**Spawning general message:** the number of different ingredients needed for spawning success. Monthly, and interannual variability importance Local structures are important and currents are important. Multiple needs for success of recruitment. We want to convey that this is evolution driven by currents and plankton production

- Suspect larvae don't settle on Jeffrey's. Spawn happens off of Jeffreys, larvae settle closer to shore and then the older juveniles swim out to Jeffrey's. DG
- Much debate and unknowns about where exactly the cod spawn when they move off Jeffreys. One known example of a large aggregation of pre-spawning cod in the mid-water, feeding on herrings (early 1980s, mid-winter) RT.
- Cod spawn all year round, but the majority spawn in the colder months (February-March on Georges). NV, JR
- Cod clump very close together when they spawn, usually around a bottom feature (rocks or a wreck). You will catch 10s thousands pounds together instead of a few thousand when they are bunched up spawning. Within broader aggregation areas indicated on maps, there are fine-scale definite spawning spots NV
- Message about spawning should include fine-scale spatial structure, importance of local retention. It appears from modeling work on lobsters that there's much more retention

than we previously thought. Do the cod come in near-shore to spawn because of local retention? The population has preserved different phenotypes. It's easy to identify the groupings and the big spawning aggregation events, but it's not an accident that there are different types of spawning behavior in the system. Look at it as a phenotype and not as a strategy, then it's a little less anthropomorphic. LI

Discussion of how the spring spawning behavior for Gulf of Maine cod is unusual compared to populations of cod elsewhere in Canada or European waters – why do the cod spawn in spring in the western Gulf of Maine?

Feeding behavior and avoiding predators probably both influence where the fish go when, and therefore influence spawning behavior. LI

Message should be that the successful populations are the survivors, so the combination of behaviors have worked for them, they've avoided death in the past, and that includes fishing predation. NV

#### **Other Notes**

- Numerous oceanographers have created computer models of the circulation in the region:
- Huijie Xue, modeler at University of Maine in Orono – a modeler has circulation model of the whole Gulf of Maine.
- Regina Wakeley did a model with U Mass Dartmouth group focused on the western Gulf of Maine. There is an interactive web-page where you can see what happens if you put 'drifters' into their modeled circulation.(RT)
- Perhaps what we need to communicate is that these models do exist and you can look at them to answer these questions (rather than the details or differences between models). HD

#### **GRAPHIC #3 – Key Prey species – feeding relationships and distributions**

##### **Notes:**

- For 'generic' food web diagram: group like the number of arrows indicating complexity in the top diagram. Replace sailing boat with modern fishing boat. The diagram may visually over-emphasize the importance of marshes in the overall trophic system for this area LI. Maybe don't include specific species names in this 'generic' one, so as to keep the messages clear, not get caught up in unknowns or details of the GoM food web. Add birds and mammals to generic figure.
- Messages: many species are generalists, but nonetheless, some species may play important roles in the system as a whole. So really good years could depend on a couple of important factors.
- Generally feeding diagrams for all species look good. Some specific changes
- Indicate other prey besides herring, whiting, sand lance, importance prey switching and nutritional impacts. (euphysiids, squid, mackerel)
- Suggest saying that the relationships are dynamic or fluid.
- Changes in abundance of various species at all trophic levels can be affected by climate
- Message: need for monitoring of the system, periods of change over decades. JR
- The first statement could be a statement that systems change based on natural and anthropomorphic variables. LI
- One graphical concept that's missing is a timeline of when these species have been higher or lower over the years. Like sand lance being high in the late 70s. HD
- Mike Fogarty has a graph of abundances of a bunch of species that shows for the last 20 years. DG

##### **Adding Birds and Mammals to feeding diagrams:**

- Cormorants feed on whatever happens to be in the estuary. They eat an enormous amount. RT Very high numbers of terns on south side of cape Cod this year (2005) NV

- Whiting for mammals are relatively unimportant (which is shown correctly in draft figures). Wouldn't expect to see mammals or birds congregated around whiting, would associate humpbacks with sand lance and fin whales with herring. PS
- Birds feed on juvenile herring in the near shore area. (these may be blueback herring, alewives, shad, as well as Atlantic herring). Birds are actively feeding near-shore during fledging periods when chicks are in nests (spring), The petrels travel much farther, they forage off the edge of a shelf. The terns and the puffins forage much more locally. This is usually finished (birds have fledged their chicks) by late June or early July. PS
- Have been hypotheses about changes in bird populations to changes in prey species abundances. Not as much work on this as on other factors like weather that are more easily observed PS
- If you were to look at the larvae of the alewives and the bluebacks, that's where the birds will congregate. They're eating on little fish. It's mostly sand eels they feed on in our river. DG

General discussion of North Atlantic Oscillation, the complexity and unknowns about how it affects the regions weather, ocean water masses, and currents, as well as marine life from plankton to other species. Discussed importance of monitoring environmental variables and some basic biological variables so we can begin to understand the environmental variability, and human-activity related affects so we can manage within context natural variability.

## **INFO SHEET #1 – INSHORE ENVIRONMENTS**

### **Questions:**

- What do we want to show about the importance of this inshore area?
- Should we indicate the differences over time and talk about some reasons why that might be? (e.g. changes in the mix of species found in the late 70s compared to the last five years)
- Is there a story like winter flounder that we could use as a poster species of the move from nearshore to offshore in the table in the front?

### **Notes on Information Sheet:**

- Suggest adding Boston harbor to list of near-shore environments. NV
- Add another row within the table for 'then' and 'now' land use / human activities, adjacent watershed use.
- Define near-shore coast to 25 and 30 fathoms. DG. Ocean changes at this depth, comes alive at that point, species move along at that point, corresponds to lowest sea level since the last ice age. NV Bottom above that depth rockier than deeper (HD) Note 'top of Jeffrey's considered down to 30 fathoms, below that a 'different world' (DG).
- On the bullets (AKA "dot points" ☺) – I think "Brayton" is misspelled. DG
- Focus on one area as an example of observations with question marks about why people are observing these changes, including land use changes. Some of these things occurred after the rivers were cleaned up. Juvenile habitat in close there and maybe not focus on one species but on one geographical spot and observations based on people's experience and that are well documented in the literature. JR
- Let's add menhaden to the "then" list and as a filter feeder they haven't been here for a number of years. It might tell you that there is a lack of plankton. DG
- Other changes to species: 1975 -76 we suddenly started seeing blue fish which we never saw before, and we caught them by accident NV
- Environmental changes: the peak time of river outflow has changed by like three weeks in the past years. The temp was warmer and there wasn't so much ice melt LI
- Potential data sources: Andy Rosenberg's recent work reconstructing landings numbers for the ground fishery during the 1900s. we would like to get more into this, but we just don't have the time. HD Could look at locations of the old weirs from photos and other records of their landings of commercial fish very near shore NV, RT.
-

**Messages:**

Our motivation with this information sheet is that the inshore seems to be an important habitat for juveniles, and there are a lot of changes that have occurred, and to communicate how these changes have impacted species.

What happened to change the fish community since 1970s?

- Inshore phenotype may have been fished out (if the near shore and the offshore fish are/were different phenotypically). It's possible you've exterminated the memory of that set of species. It could also be a combination of water changes and overfishing. LI
- Inshore fish may have moved offshore (due to water changes, or overall contraction in range to 'ideal habitat' with decreased overall populations within Gulf of Maine). HD
- It depends on what the main message is about this near shore compared with a specific area. For specific species you could hypothesize which would be most important and how this might look different for each species.

What is it about the near shore that makes it of particular importance?

- Juvenile habitat is an obvious one HD
- Is it important habitat for adult life stages? For spawning? (Winter Flounder are spawning in estuaries and near-shore DG).
- Are the same things happening inshore that are happening out on Georges bank at the same depths? HD

**Notes on Ecology of near-shore area:**

- Used to be lots of Pollock. You had to move to avoid them there were so many, even if the mackerel were there. DG
- Are the sea herring laying down spawn in the near shore? HD The sea herring show up more in the fall and you're looking at something that you might be able to use for lobster bait. DG
- Spring – birds congregate around alewife and blueback herring larvae, as well as sand eels DG
- Maybe juvenile (Atlantic) herring are drawn near-shore by high concentrations of zooplankton. JR
- Herring are in estuaries at the seawater/fresh water front at the high salinity curve, cited cruise with hundreds of targets per frame versus two or three target per frame. NV
- The fluke go in to the sounds in the south and then when the water hits freezing they head out. They're big when they migrate in to spawn. NV
- Water temperature is the biggest determiner. You can follow blackbacks (winter flounder) out of near-shore in fall and back in the spring pretty much by water temperature..
- The reproductive cycle is being spurred by a lot of things: photo period, temperature...there's an overlap of things that might delay or accelerate it. LI
- There used to be a lot of fish weirs from the cape south so you might want to look at those. Some of the pictures of the old fish weirs, the amount of fish on the beach was just amazing. They thought nothing of 100k lbs of striped bass in a day. NV
- Pay attention to things like lobster shell disease in Long Island Sound – what were the shore-side land use issues relationships? DG
- Controversy within scientific community about role that water quality could or has played in changing marine species. LI
- Decline in bird species along the Maine coast PS
- What we need to do is determine what the impacts are from various things...not necessarily whether they have an impact, but what that impact is. LI

**NEXT STEPS (see notes above on summary of this project)**

- What would you like to see happen next?
- What are some ideas for other topics or groups?

- Are there particular formats that work best?
- What are some ideas for prioritizing research?

### **New England Fishery Management Council**

Chad Demarest is the ecosystems pilot project coordinator for the Council. They're trying to integrate EBM into the Council process. With regard to EBM, he's interested in the things that involve linkages and dependencies, and establishing a life history that had temporal and spatial ranges as well as what factors have what influences on spawning and distribution. The Council needs to know who its stakeholders are and what they want out of management. One aspect of EBM on the social side is finding out what people more locally want to see. The Council needs to figure out if they're talking about ecosystem approaches to fisheries management or about the structure and function of the ecosystem or about ecosystem approaches to management of all human activities (fishing, shipping, whale-watching, etc).

### **Notes on Needed Research:**

- Research prioritizing is a major process in itself, need to have the prep work and the right expertise involved to know all of the research that has been done and is underway to effectively identify the gaps
- NEFMC has an intern working this summer on documenting the importance of inshore areas for commercial species. (identify species that use inshore or spawn inshore, how they're susceptible to coastal pollution, and where those areas are).
- Regional Association of Research on the Gulf of Maine 'RARGOM' hosts theme sessions as part of its activities. meetings coming up:
- RARGOM July 2005 meeting on GoM observing system – biology as well as oceanography
- RARGOM fall 2005 or 2006: Theme session meeting on near-shore/off-shore connections.
- Jeff Runge is looking at how to connect these efforts with the NAMA-COOA project.
- Note upcoming research project to video long transects throughout the region NV

### **Other Communications – wrapping up this project and getting our products to people**

- Suggest contacting the trade papers with highlights.
- The council should hear a summary report at a council meeting.
- Planning face to face meeting with NMFS scientists in woods hole and NMFS managers in Gloucester to share what we have done with them, learn more about what they are doing, plan future work. Participants from this project encouraged to come to any of these meetings in their areas.
- It would be great if universities and high schools got an info packet to get people thinking about these types of concepts.
- Contact Sea Grant to ask if these can be mixed in with their fact sheets they hand out for free. Maybe we could get them to do ours as well.
- NMFS scientists: suggest meeting with Jason Link, Mike Fogarty, David Mountain
- NMFS managers: Suggest meeting with Lou Chiarella and David Stevenson for definitions of Essential Fish Habitat
- Think carefully about how to bring all the different efforts going on together into a coordinated effort of some kind as we move toward EBM in the region – how will we all contribute and work together?

The first next step is to get this into a finished form, get us all to sign off on the finished form and then take the forms out to get feedback from others.

### **PARTING SHOTS**

RT a lot of this is warm fuzzy. We go to too many meetings, and we're getting somewhere with this. We're not just moving bricks. You've gotten over this initial thing of what are we trying to do. We would like to get the best of the best to bring the most experience to it possible. Get everyone who has been looking at stuff to come up with better consensus stuff instead of just saying I think it's this way. It's important to have agreement from the people who know best.

NV it's been a pleasure. It was great to hear how successful the forum was. You need a melting between industry and academia, but you've got more industry folks than the others.

PS thank you for having me... it was intriguing to learn a little more about cod.

RG I think it's exciting because for me it's uncharted territory. You get diverse input and then to come out with a formal report. I'm confident that it's going to be very good in the end.

LI this has been great, I'm glad to be a part of it. Be sure that this report is a tight nugget of information. Something on next steps should be included. Somehow to make that statement. Will be very useful. Then people will see how this plugs in as a step.

HD thank you for continuing to be involved.

DG personally the multi-disciplinary approach to ocean studies is the way to go. It's done on a cooperative basis and this is a model I want to move forward. This is a way I've wanted to see things done...with a number of disciplines sitting down together having these discussions. This demonstrates that we have combined a number of different specialties sitting with fishermen. We don't have them all, but we do have a diverse group.

JR thank you all for coming and for your time. It's not possible without your participation and we really appreciate your taking a whole day for these meetings. It's now time for us to get to some sort of closure. I'm really happy that there's so much encouraging support for moving forward with this.

AC I've learned a ton. I've been very happy to be here and very happy to have contributed something with GIS support. A lot of the stuff that David was getting at is what I also really like about this I appreciate seeing what we do know and what we don't know.

Appendix 4: Notes from session at the Maine Fisherman's Forum

**Gulf of Maine Fisheries & Ecosystems:  
Fishermen and researchers scoping out  
Ecosystem-Based Management  
Maine Fishermen's Forum  
Saturday, March 5, 2005, 1:00-2:30  
Session Notes**

Notes from this session include:

- Introduction and Overview
- Notes from small groups discussions (a summary followed by individual group notes)
- List of participants

**Heather Deese, Northwest Atlantic Marine Alliance (NAMA): Introduction**

Welcome and thank you for coming. We are so glad to see so many of you here at this session. Ecosystem-Based Management is a hot topic, and most of us would agree it the direction we should be moving towards for fisheries and oceans activities generally. But at this point there are still many ideas out there about what EBM should look like in theory and ideas, questions, and concerns about what it will actually look like here in the Gulf of Maine. We've started working on some projects designed to help start answering some of these questions from the bottom up – 'what does the ecosystem look like – including the fishery'?

The projects we are working on are aimed at bringing fishermen and scientists together to combine their knowledge and learn from each other. Both projects have been aimed at developing useful, colorful 'Ecosystem Illustrations' to map out species relationships and environmental factors, to try to give the big picture, and specific details about species distributions, interactions, who eats who, how the environment affects the animals, the role of the fishery and effects of other human activities, etc. Ultimately, the resulting diagrams, maps, charts, and reports will enable managers to make more sophisticated ecosystem-based decisions

So far we have partnered with the UNH Center for Excellence in Coastal Ocean Observing and Analysis (UNH, COOA) and the Gulf of Maine Ocean Observing System (GOMOOS) to get researchers and fishermen in a series of meetings. For UNH, COOA and GoMOOS, their goals in these projects are to better understand how they can improve their science and systems (additional measurements, information products, modeling) to make it useful to fishermen and others concerned about ecosystem management

The NAMA-UNH, COOA project is focused on the Inshore Western Gulf of Maine. We have had 2 meetings so far, at which scientists and fishermen brainstorming and discussing specific topics. We take detailed notes, including drawing on charts, and then

use the notes to develop Draft Ecosystem Illustrations. We'll meet once more this spring and produce a series of 'fact sheet' type handouts with the graphics, text, and references.

NAMA-GoMOOS project is focused on the broader Gulf of Maine, with emphasis on seasonal and yearly changes. We have met once, in Portland, and will have another meeting in early April. Products will be on the GoMOOS website and in hardcopy handouts.

We are very interested in setting up more projects, involving as many fishermen and scientists as possible, and focusing on topics of interest to different folks.

Today's session will be mostly spent in small groups brainstorming and discussing issues you all are concerned about or are interested in exploring together. First, we will have three speakers very briefly present a few of their thoughts about the topic, why they believe EBM is important, why they are involved with this project. They're supposed to finish in five minutes each, so they better be brief!

- Craig Pendleton, NAMA, coordinating director, former fisherman
- Jeff Runge, UNH, marine ecologist specializing in zooplankton that plays a crucial role in the food webs in the area.
- David Goethel, fisherman from NH, NEFMC member, and participant in the NAMA-UNH,COOA collaborative project

The rest of the session (45 minutes) will be small groups for discussion of two topic areas. This is intended to give a flavor for the types of discussions and insights that can arise from these brainstorming sessions, we won't have time to get into topics in much detail, but we'll keep notes in each group and hopefully we'll work with some of you in the future to organize more time for these types of discussions.

The break-out groups will discuss::

- 1) What ideas, questions, and concerns do you have about the nearshore areas and links between near-shore and off-shore for fisheries?
- 2) What ideas, questions, and concerns do you have about food webs, species feeding relationships, and 'key' species in food webs in the Gulf of Maine?

Audience Questions:

Q. Where is the funding coming from for this work?

A. Each project so far funded separately. Don't need a big budget to do this, need enough to pay for the meeting, for meals, for people's travel and a per diem for fishermen to participate. Staff time to organize meetings and put together the products and graphics. These two projects: UNH internal funds – Jeff and Heather applied for. GoMOOS outreach funds.

Break-out session met for 45 minutes. There were four groups, with 10-12 people in each groups. (See participant names at Attachment 1). The discussions followed some common themes and so we have combined notes and observations from each group into an overall record under topic headings.

### Feeding relationship:

- Herring can be the dominant life form that attracts everything. Herring plays a key role in the food web; many species rely on them as food, including commercial species, lobster fishery, whales, sea birds. Tuna feed on herring. Many fish eat herring eggs – which herring spawn in October/November on Jeffrey’s Ledge.
- The “quality” of the herring in the GOM is highest in the summer. Herring traditionally feed on pink krill in the spring and summer and white krill in the fall (JJ). Zooplankton that herring eat is in lower numbers in recent years (RF). Herring will have krill in stomachs. Calanus (zooplankton copepod, important to fish all over the north Atlantic). Cod -> herring -> Calanus (zooplankton)
- Tuna feed on Herring. Tuna used to feed on pogies inshore – fishermen would follow the bait to find the fish. Since pogies fished out, Tuna feed more on herring (RG) Tuna were feeding on lobsters 1998-1999. Tuna diet may have changed in recent years; Fat/oil content in tuna reduced in recent years (current project at UNH) – fish that are brought in are given a grade in four categories and analyze the grades after they are given a number value – look at year values and by size categories if there is enough data, we can also compare month to month (Walter Golet – UNH) Fishermen are looking at Tuna stomach contents now to learn about diet
- Cod will eat herring, shrimp, brittle stars. Cod eat whiting – if you are whiting fishing and catch cod, will have whiting in stomach. Cod are opportunists
- Stripers eat whiting. Stripers are eating the juvenile lobsters. Lobstermen watch the stripers devour the undersized lobsters as they throw them back. Some lobstermen have resorted to leaving the short lobsters in their traps and resetting the trawls in hopes that they will survive the striper onslaught and crawl out of the trap, can see them around fishing boats discarding lobsters; will eat lobster of any size – will sometimes only eat lobster tails.
- Dogfish feed on flounder and mackerel
- Bluefish feed on pogies. Bluefish eat tails off lumpfish (source of caviar). This is one way you know bluefish are running – you see lumpfish with bite marks in tails. Bluefish eat stomach out of grey sole (witch flounder) leaving a distinctive circular mark – another way to know bluefish are running in an area.
- Whiting important predator and prey- whiting eat euphausiids, many fish eat whiting
- Menhaden was forage fish, cyclical in Gulf of Maine -- they are like herring but more inshore, estuarine, could impact dynamics of coastal area, menhaden eat phytoplankton,\
- Squid are important

### Migrations – Feeding - Spawning:

- Herring make daily runs from inshore to offshore waters (?)
- Herring used to have two spawning runs on Maine Coast (different months?). Maine Coast study looking for herring spawning grounds (egg mats on bottom). Did not see herring spawning grounds between Boothbay and Grand Manan. Did see two specific pieces of bottom with herring eggs between Grand Manan and

Cutler. In shoal waters, 40-10 fathoms (80-20 meters). Generally over the same pieces of bottom (Ben Neal – marked chart). Years ago there were similar reports of herring returning to same spots

- Herring come to Ipswich Bay – Apr-May, they spawn between end of August and December in 45-50 fathoms off Cape Ann– sometimes the herring are stopping in a few places to spawn. (David G). Monhegan – Herring arrive late August- stay through October (Matt T). Records of historical movement of the herring from the west to the east along the coast. Spawn on Jeffrey’s Ledge – can see spawn mats.
- Tuna have a daily routine (diurnal migration). Tuna follow ‘bait’ (herring) during the day into deep water. Tuna and herring surface together at night. (RG)
- Historical pattern was that tuna would be leaner in winter, fatten up by mid-summer. Mid 1990’s there was a steady decline in the quality of the tuna i.e. there was a decreasing fat content. 1996-1997 The Tuna came into the Gulf of Maine skinny and stayed thin right into August.
- Tuna, herring, whales, and all types of sea birds usually show up in June on Jeffrey’s Ledge, Platts, the Kettle. (RF) From Gulf of Maine, fish move up to South-western Nova Scotia and Halifax during (month?) (RF) Whales and dolphins follow the herring (JJ) Shearwaters follow the herring (JJ). Examples from closed areas (opening June 2003) – “millions of shearwaters” near southeast corner of Platt’s (JJ)
- Cod: Inshore Western Gulf of Maine has good amount of fish –although distribution unusual past two years – see above. Some more small cod seen around Monhegan recently. Cod-tagging study has shown some site fidelity – fish mix on wintering grounds, re-sort themselves to specific spawning grounds. Cod-tagging study has also shown general migration patterns in the Gulf of Maine and Georges Bank – example is a pattern showing fish moving between Bay of Fundy and eastern Georges Bank. Cod-Tag studies shows adult cod moving over large distances. Could be two types of adults, some take up residence, some move around, are cod territorial? What evidence that cod are territorial? What evidence for inshore-offshore migration of cod?
- Bluefish & stripers: changes in distribution patterns; Ipswich Bay bluefish – arrive mid-June, leave fall. Cannot tolerate warmer waters, they are coming earlier in the year now (since when?). Bluefish came through middle bank in 1991 after the tuna moved on. Bluefish were feeding on sand eels. (JJ)

#### Coastal /Land issues and In-shore shallow habitats:

- Concern about summer homes, manicured lawns, chemicals, fertilizers, pesticides – what exactly are the chemical being used? What effects do they have in marine environment?
- Increase siltation rates from run-off could effect spawning of nearshore species
- Sewage treatment plants do not deal with medicines, hormones, antibiotics, etc. other drugs getting into ecosystem, all end up in estuaries, which are important places for many species.
- Cod juveniles are caught right near the beach, along inshore Mass in the Mass DMR inshore trawl survey. One year old cod, very shallow, 30 ft or less, 3-inch long tiny cod/. Found along beaches and in little coves, you can see shoals of fish,

- fingerlings – many different species in these inshore schools. --- Could nearshore population be impacted by contaminants?
- Herring numbers have been low in Penobscot Bay since purse seining began, since the midwater trawl fleet began there are even less. (RA)
  - In general, a significant loss of fish in the inshore system (e.g. Alewives).
  - Used to find herring spawn inshore on lobster traps, don't find them so much more on the wire traps.
  - Seem to be less herring inshore than years ago

#### Coastal shelf:

- Inshore cod spawning areas largely gone. Used to fish Boothbay area for Cod from Mid-May (apple blossom time) until August. Fish not here anymore. Cod tagging efforts for past few years to tag spawning fish along Maine coast mostly fruitless. Between Lubec and Monhegan, could only find one spot where you could reliably catch spawning cod near-shore (spot near Eastport – reported by Ben Neal) – fisherman in the area has always believed this was a local sub-population.
- Inshore Western Gulf of Maine has good amount of fish –although distribution unusual past two years – see above.
- Some species like lobsters have spawning patterns, and juvenile recruitment patterns clearly influenced by local currents – need to learn more about these
- Coastal current patterns are very complex – do not show up in the long-term averages or the off-shore computer models. Example in Ipswich Bay, current flows to North inshore, East (north of Cape Ann), and South offshore.
- Coastal currents play a major role in distribution of eggs and larvae. Seems to be in indication in Western Gulf of Maine that any larvae which are caught in prominent southward coastal current will get swept out through Great South Channel into open Atlantic – could be larvae that make it into local coastal recirculation are the ones that make it into juvenile stages? (JR)
- Coastal shelf along Maine is a large area with 100s of miles in the 0-20 fathom zone, on Georges Bank this is a relatively small zone? (RT)
- Dogfish: in very high numbers right now. Staying in some areas for more of the year (example, used to come to Monhegan suring spring and fall in separate runs, now they stay throughout the summer). Coming in shallow as well as deep areas – “practically on the beach” Spreading out into colder waters where you didn't used to see them. (Used to only find dogfish in waters warmer than 43F, now they are adapted to waters as cold as 39F – David G). Seems to be a resident population of dogfish in Jeffrey's Basin (100 fathoms) in the 1990s. (possibly able to stay all year because of warmer bottom temperatures during this period?) These fish finally left this area in 2004 (possibly due to colder bottom temperatures in winter?)

#### Jeffrey's Ledge as a unique interesting area.

- How and Why does Jeffreys have and retain the small fish? Does it have to do with a recirculation northward current off Cape Ann? In line with model results?

- Jeffery's ledge is special in the Gulf of Maine system - does it accumulate prey? Why does life happen there?
- See lots of whales outside edge of fingers in summer.
- Herring as dominant species – attracts many predators. Also every year oct/nov fish full stomachs with herring eggs. After big storm in fall, the fish generally head south. Are herring disappearing from Jeffreys? What drives herring migration, is it aggregation of Calanus, does it relate to fronts? Or bathymetry peaks important - herring would hang out in clumps behind peaks
- What effect does directed herring fishery have on other species – especially the herring fishery on Jeffrey's at night in summer? Affecting amount of food available (for species that prey on herring)? Or causing habitat disturbance? Limiting fecundity if switching prey? Or ability to prey because of interactions with gear? Could be subtle effects? (JW)
- Jeffrey's Ledge still see good amount of cod fish
- Do different fisheries (seining, mid-water trawling, tuna fishing) affect the different species differently? Some species seem to react to specific gear (e.g. cod go away when mid-water trawling - JW)
- Observe large numbers of herring on Jeffrey's Ledge in 1991 (JJ)
- Herring spawn (egg mats) seen on Jeffrey's Ledge, with cod eating the herring eggs.

#### Long-term changes:

- Fish numbers have changed along the coast
- Still the same numbers of fish overall, but the types have changed
- Distribution has changed, more of the groundfish are found offshore than near the coast (ex. Isle of Shoals region, Ipswich Bay, Boothbay Harbor)
- Fishing has moved offshore as well – used to fish for cod in day boats near shore, small boats now have to go further offshore
- Maine coast still plentiful lobsters and shrimp. Lobsters possibly less susceptible to pollution or environmental changes? (Exoskeleton)
- Less deep-sea charter fishing?
- Less groundfish along inshore. Used to fish Boothbay area for Cod from Mid-May until August, then fish Flounder for the fall. Not anymore.
- Shoreline development rampant since 1960s; Affects estuaries, eel grass; How impact groundfish? Nursery areas? Chem.-lawn, roads, salinity.
- Used to see many more flounder in many shallow areas (caught them in traps in 1970s in Taunton Bay);
- Use to catch haddock from the bridge across Penobscot Bay in Bucksport – have not been any haddock here for years – possibly due to changes in the river from pollution, paper companies?
- Paper companies in Maine date from 1890s. Effects have been around since then. Some of them are not around anymore, but sawdust and pollutants, including chlorine, added to the rivers when they were operating will be around for a long time.

- Could changes to Penobscot river from industry have knocked out haddock and cod spawning areas in Penobscot Bay? What was the role of fishing on these spawning aggregations? Is it a combination of effects?
- Isleboro –people believe clam populations have been affected by paper mill effluent in Penobscot River entering the Bay.

Changes over the last ten years:

- Small cod are showing up in traps this year (16-20 inches) (first time in awhile?)
- Monhegan Island feels like a wasteland with few fish until the dogfish show up in summer
- Herring numbers declining over the past 5-6 years. There used to be more herring in mid-coast in especially in the fall. (see notes on herring, below)
- More dogfish everywhere (see notes on dogfish, below)
- Changes in Eelgrass in Taunton Bay – possibly resulting from river-run-off, changes in precipitation Eelgrass beds have fluctuated drastically –both increasing and decreasing huge amounts. 90% of eelgrass in Taunton Bay was lost during 1990s (probably due to a prolonged drought?). Eelgrass rebounded and peaked in year 2000 (probably due to high snowmelt that year which decreased salinities into a range eelgrass like?)

Recent years, weather and other issues:

- Winter 2004 was cold
- All year 2004 unusual patterns for fish in western Gulf of Maine – example from Ipswich Bay, cod never came inside Jeffrey’s Ledge this year, which they usually do in spring and stay until fall. On the other hand, there was a very large aggregation of spawning cod in Cape Cod Bay and Massachusetts Bay – are these the same fish that normally are found to the north in Ipswich Bay?
- Possible causes of changes in Cod spawning aggregations in Ipswich Bay in 2004? (Major storms in October 2003 overturned water, fresh, cold water on the bottom, which fish don’t like? Colder water? Fresher or saltier water? Overfishing? – charter-party boats are the only ones fishing in the area during the spring due to rolling closures)
- Changes in distribution seem to affect multiple species of finfish at once – many of the groundfish are displaced by dogfish, stripers, and bluefish. Why? (could be because these species are plentiful right now. Could be because some species are tolerant of a wider range of temperature and salinity?)

Winter 2005 notes:

- Monhegan surface temperatures right now are coldest for 32 years (34-35F).
- Nothing is moving on the bottom
- All GoMOOS buoys are showing lower salinity than normal, both surface and bottom measurements throughout the Gulf of Maine – maybe due to different mix of water coming from Scotian Shelf and Northeast Channel? How will lower salinity affect the fish this summer?

Changes in species numbers and concerns:

- NMFS says there are same numbers of herring, they are just showing up in different places. Fishermen disagree with these assessments, citing high numbers of herring caught by less efficient fishing boats in the 1960s. (NMFS says there are more fish now than there were then) (RF)
- 1996 the herring had bulging bellies. The tuna, cod were so full of herring they would spit them out on deck when caught.
- Tuna fishery and Herring fishery have both been around a long time. Concerns that changing methods in the herring fishery (e.g. mid-water trawlers) are leading to a decline in numbers of herring and numbers of tuna. (RF) Recent years (late 1990s) tuna looking leaner in the spring, not fattened up by summer or fall Individual events recounted when intense herring fishing seemed to have disbursed large aggregations of herring, tuna, and other animals (e.g. June 2003, summer 2004) (RF). As a note there are no midwater boats allowed in Canada, Ireland or Japan. (JJ) Concerns that mid-water trawling for herring disturbs daily routine of the tuna (RG)
- Less tuna fish in the past 4-5 years, seems to be the area doesn't have the ability to support as many as before
- Previously rich areas (tuna//cod/herring), not as many fish now
- Concern about whether small boat traffic disturbs the fish (herring and tuna) and Concerns that some fishermen are shooting seals.
- Spiny dogfish in large numbers ("a blanket") feeding on mackerel during Tuna season (summer/fall) for the past few years. (RF, JW). Spiny dogfish feed on flounder (JW)
- Groundfish Collapsed 30 years ago, have been rebuilding since (RG) The gill-netters, trawlers etc all follow the bait to find the fish(groundfish)
- Harbor seal populations increased dramatically recent years. Example Nantucket Sound so many seals that you can't find 'bait' there anymore (small fish).
- Reduction in the number of marine mammals in the area; mammals require large amounts of food. If the food were there, the whales would be there. (DL) Fishermen out of winter harbor have the same observations.
- Concerns that fish populations are changing in reactions to fishing pressure: Genetically altering body size/structure of the fish populations; Early maturity of the fish

#### Variability in the Gulf of Maine:

- Seem to be some observations and evidence in data sets that North Atlantic Oscillation signal in middle of GoM is opposite on the coast, continuous plankton recorded measurements on ferries show Mass Bay and Narraganset Bay has signal response opposite to central gulf (PW)
- Haddock rebounding well – why?
- Fine scale processes are important

#### Possible factors impacting changes in species populations:

- Could be a pollution problem; a theme that comes up repeatedly with fishermen is the pollution of coastal areas. River seem much more polluted than they were 40-50 years ago.

- Could be the ability of the directed herring fishery to catch huge biomass very quickly, 'clean out an area' (LK)
- Could be shifts in temperature -- Herring are very temperature sensitive and when the water gets warm the herring disappear. If you can find an inshore cool water area that is close to an offshore warm area you have a good chance. They make daily runs from inshore to offshore.
- What else is contributing to the decline of herring? Should it really all be attributed to the fishing? Don't forget about the *Calanus finmarchicus* (zooplankton is a preferred Herring food); There used to be balls of herring and mackerel and there used to be many euphausiids that aren't around anymore. There isn't a huge resource of food anymore.
- Herring are very temperature sensitive, do not like warm water
- Cod: Why are cod in Gulf of Maine recovering better than on Georges Bank? (We have had 12 years of recruitment failure on GB; strong fishing pressure in GoM, yet robust spawning in SW GoM with high success; little or no spawning along the eastern coast of Maine – why?). Northeast coast of Maine may be tied ecologically to GB. Salt marshes to south, glacial till sediment, SW Gulf maybe good habitat for spawning (JW). GB spawning for cod maybe not successful because if cod spawn in western area, subject to advection problem – transported out open sea (PW)

#### General discussion:

- We must come to the realization that everything is connected in some way.
- Inshore-offshore connections – how do things that happen along the coast affect offshore and vice-versa?
- Species interactions – feeding relationships and 'key' species in food webs?
- Seasonal changes, Yearly changes, and decadal changes – what have people noticed? Have the fish changed? Has the environment changed? What is causing what?
- Indirect effects of environmental changes, human activities on the fisheries?
- Concerns that other fisheries and species are not considered in before decisions are made on herring fishery rules, and they should be.
- Sustainable development needs to be the goal – the Whitewater to Blue water type initiatives, all the national commissions and reports --- we need to discuss the whole decision process, not just the science (BT)
- Fishermen tend to worry about pollution and other indirect effects, there has been a history of bureaucrats telling them not to worry about this and just control fishing.
- Offshore environmental issues are very different from coastal areas. Example is the role that fronts and offshore nutrients and plankton play, quite different dynamics controlling the productivity than along the coastal shelf.

#### Future research and improving fishery management:

- How do we integrate casual observations of fishermen and integrate that into the science?

- Follow-up with the fishermen. Go to meetings and listen to what the fishermen think and what factors they build into their decision making. Know what their perspective is and integrate the science into the livelihood of the fishermen
- Fishermen want to help work with the scientists, fill the gaps in the information so that we can be part of it.
- Can the fishermen standardize the data that they are collecting? It might be more telling to use fishermen information that is on a finer scale than the gulf-wide data models.
- Fishermen could ID and record pockets of herring and when they come and go.
- GoMOOS buoys are to start recording biological data. Logbooks to record data near the buoys could be correlated with this. I would love to see more buoys out there.
- Timmy tower (vessels-bunny clark) in Ogunquit, could give you story about cod in his area. Takes out deep sea fisherman , knows area around to caches, specialty putting people on trophy size fish, has been watching population for 30 years

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ATTACHMENT 2:

**Feedback Comments from the Maine Fishermen's Forum breakout session,  
"Gulf of Maine Fisheries and Ecosystems: Fishermen and researchers scoping out  
Ecosystem-Based Management"**

**Question 1: What questions/subjects would you like to see addressed?**

Comments:

1. In season, and between season, variability's in fish/mammal/lobster distribution
  - a. impact of existing regs on changing/redistributing fishing effort
2. I thought the questions being addressed were good ones
3. Indirect effects – pollution, mid water trawling
  - a. Crustacean – fin fish interactions
4. Thermal pollution (nuclear cooling, sewage treatment)
  - a. atmospheric deposition
  - b. alewife trends
  - c. eels
  - d. eelgrass trends
  - e. shoreline/watershed development including roads, septic fields, buffers of nature vegetation
  - f. tannery sites
5. How can we differentiate actual trends in the ecosystem from random events which may not reflect that trend? How could fishermen use their records to provide accurate data on trends they see?
6. Improving respectfulness between fishermen and science
  - a. Reasons working .....see hand writing on card
7. Is there a place, based on this ecosystem science, for nearshore permanently closed areas – not just closed for spawning?
8. What key information should fishermen and scientists collect to contribute to ecosystem understanding?
9. a more complete rundown of the various currents (?) that exist in the Gulf of Maine
10. Has there been a consideration of forthcoming cooperative research – i.e. Cashes ledge closure study – to back and fill your map with hard data?
11. Other specifics on squid, menhaden
12. "Seasons" timing and spatial of different species, spawning, migrations
  - a. We started to touch on it and maybe you already have in part or its part of the intended products
13. Location of spawning grounds and effects on time of hatch on recruitment
14. Do the fishermen record observations of spawning fish?
15. Pollution
16. Species model compatibility
  - a. Herring species primarily within an interspecies management scheme?
17. Who allowed the pair trawlers fishing to expand?
18. Herring Abundance issues
19. Over harvest by pair/midwater trawl of herring

20. Why are we allowing herring to be taken in large amounts?
21. Herring tuna be gone (?)
22. Herring/midwater trawlers

**Question 2: How could this session be improved?**

1. Charts/maps on boards or otherwise visible to group
2. Get more fishermen to participate
3. More time – great for the time involved!
4. No comment
5. No comment
6. Ask specific questions for interested parties to respond to
7. No comment
8. We need a broader group of participants to obtain a general ecosystem view
9. Force the group to sit a little closer together so we can all hear on another better.
10. Tighter circle – very noisy with surrounding groups
11. Balance of fishermen (recreation and commercial) and science
12. Somehow the distribution between scientists and fishermen between the different groups that broke up
13. Maybe a tighter group so everyone can be clearly heard, there's a lot of good input
14. In the break-out groups, the ratio of fishermen to scientists could have been more even across groups
15. No comment
16. More of them!
17. Great job!
18. It was good use of information to current management
19. More time needed
20. Longer
21. Hard to hear

***Western Gulf of Maine Inshore Fisheries-Ecosystems project***

***A collaboration of fishermen and scientists***

***Feeding relationships in the Western Gulf of Maine –  
focus on three key prey species: Herring, Whiting, and  
Sand Lance***

**Layout:**

- 2 page opening booklet type layout (front and back of 2 pages – 4 pages total)
- First page: generic food-web w/ secondary consumers highlighted to show that is the focus on this info sheet, illustration of each focus species, text-box with main messages. New graphic showing changing population levels of key species over recent decades (herring, cod, dogfish, zooplankton, sandlance)
- Second & Third page: 1 map showing distribution of all three species, 3 food-webs focused on each of the three species, text box with main messages.
- Back page: project information, participant names and credits for images, etc.?

**First page content:**

**Main messages:**

- Feeding relationships among marine species are complicated and dynamic. Analogy to complex circuit board – not all channels carrying energy at all times, but all important at some times in some places. Make sure no parts of the circuit go dead.
- Number and mix of species change in time at all trophic levels. (show timeline)
- Changes to one species may have unexpected effects on others.
- The potential for trophic cascades, in which changes at one trophic level also have impacts on successive trophic levels, either up or down.
- Many fish species are generalists but have preferred food, and if they can't find it and end up feeding on something else, this may have nutritional impacts – and indirectly affect other species.
- There may be key species that play important trophic roles in the overall ecosystem (e.g. plankton, herring, whiting, sand lance) as food for commercial fish and many other species (as well as being commercially fished themselves).

- **Climate or human-induced changes affecting key species can lead to effects on the overall system, including trophic cascades**

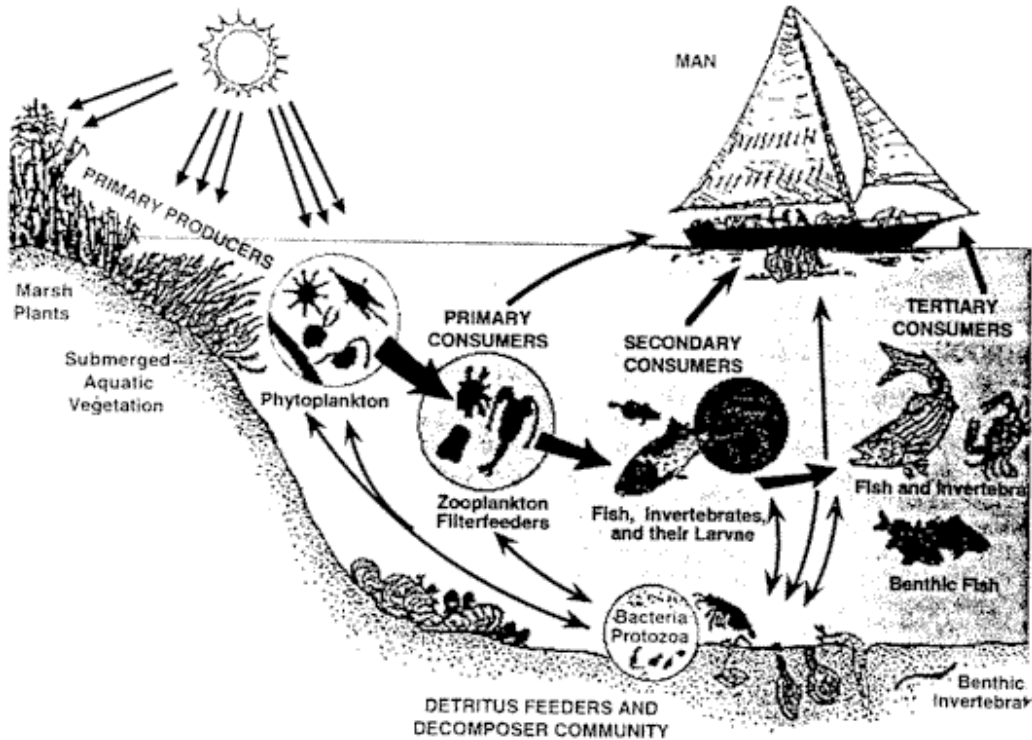
Main Messages:  
 Complexity  
 Trophic levels  
 Step down in energy  
 Human role  
 Species from GoM

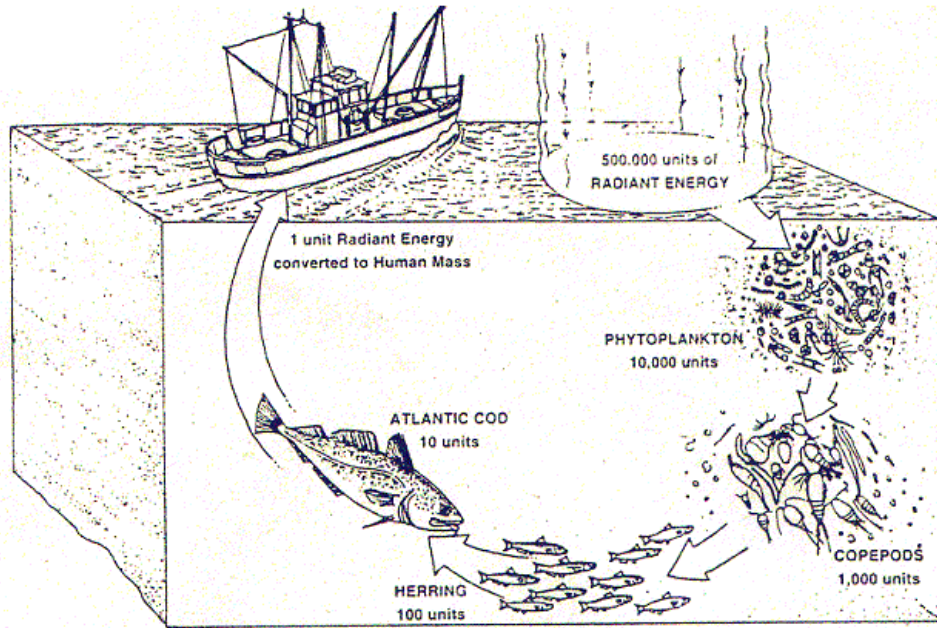
**Notes for design of ‘generic’ food web diagram: Include the following groups of species types:**

<b>Trophic role</b>	<b>Species type (illustrate 1 of species for each type)</b>	<b>Energy captured</b>
<b>Primary producers</b>	<b>Phytoplankton (diatom) Aquatic vegetation (seaweed)</b>	<b>1 whole</b>
<b>Primary consumers</b>	<b>Zooplankton (Calanus finmarchicus, euphausids)</b>	<b>10%</b>
<b>Secondary consumers</b>	<b>Fish &amp; invertebrate larvae Benthic invertebrates (clam) Small fish (herring) Invertebrates (squid)</b>	<b>1%</b>
<b>Tertiary and higher level consumers</b>	<b>Pelagic fish (tuna) Benthic fish (cod) Mammals (seal) Birds (illustrate seagull) Humans (illustrate boat)</b>	<b>(1/10)%</b>
<b>Detritivores (&amp; Decomposers?)</b>	<b>Bacteria Protozoa</b>	<b>?</b>

- **If there is room to include three pieces of information about each general ‘type’ of plant or animal, would be good to include 1) generic name (e.g. benthic fish, zooplankton), 2) level in food web (e.g. primary producer, tertiary consumer), and 3) some representation of how much of the sun’s initial energy makes it to each level (if numbers take up too much space, maybe a pie chart or some other symbol to show how the energy is lost at each trophic level?)**
- **Show multiple pathways to emphasize complexity, ‘food web’ not ‘food chain’ (as in example 1). Especially note pathways from ALL food web levels to Humans**
- **Do not ‘name’ specific species (e.g. label as ‘fish’, ‘invertebrates’, ‘zooplankton’ as in example 1, rather than ‘Atlantic cod’ as in example 2)**

- Include a fishing boat that looks modern (as in example 2)
- Put more emphasis on phytoplankton as primary producers and less on seaweed/seagrass (example 1 puts too much visual emphasis on these shore-based producers); we might include shoreline at all depending on graphic layout.
- Have the primary producers, primary consumers, secondary consumers, and tertiary+ consumers arranged from right to left or left to right in the diagram to make it visually easier (example 1 tries to do this, but is too cramped; example 2 does it well, but doesn't include enough groups)





## Second & third page content:

### Main Messages:

- Herring, whiting, and sand lance thought to be important species – focus of this info sheet
- Important to realize there are other important prey species for commercial species in the region, including mackerel, squid, euphausids – while these are not the focus of this info sheet, note prey switching, changes in population sizes, predation pressure, nutritional impacts on different predators.

### Issues and concerns:

- How do changes in abundance of each species affect their predators?
- Do fish predators switch from herring to whiting based on abundance of each?
- Do whales, seabirds, and other sand lance predators change migratory behavior depending on sand lance abundance?
- Does prey type affect nutritional value and predator growth?
- Do these forage fish depend on the same or similar prey?
- What drives changes in species abundance? (Climate change affecting phytoplankton and zooplankton production cycles (bottom up) vs. Fishing pressure affecting higher level predators (top down).
- Interaction between high fishing mortality and climate variability (e.g. temperature and circulation changes) affecting fish recruitment, growth rates and distribution: recipe for stock collapse?

### Herring food web:

**Change layout to allow for more predators (don't need a horizontal line separating predators/prey, bend it up to right and left?)**

**Add finback whale predator or Minke whale**

**Add fishing boat as human**

**Add porpoise**

**Add tern or cormorant**

**Add species labels**

**Fin whales also eat herring**

**Remove Euchaeta (copepod with blue egg sac)**

**Whiting food web:**

**Terns are very dependent on juvenile whiting and herring for food**

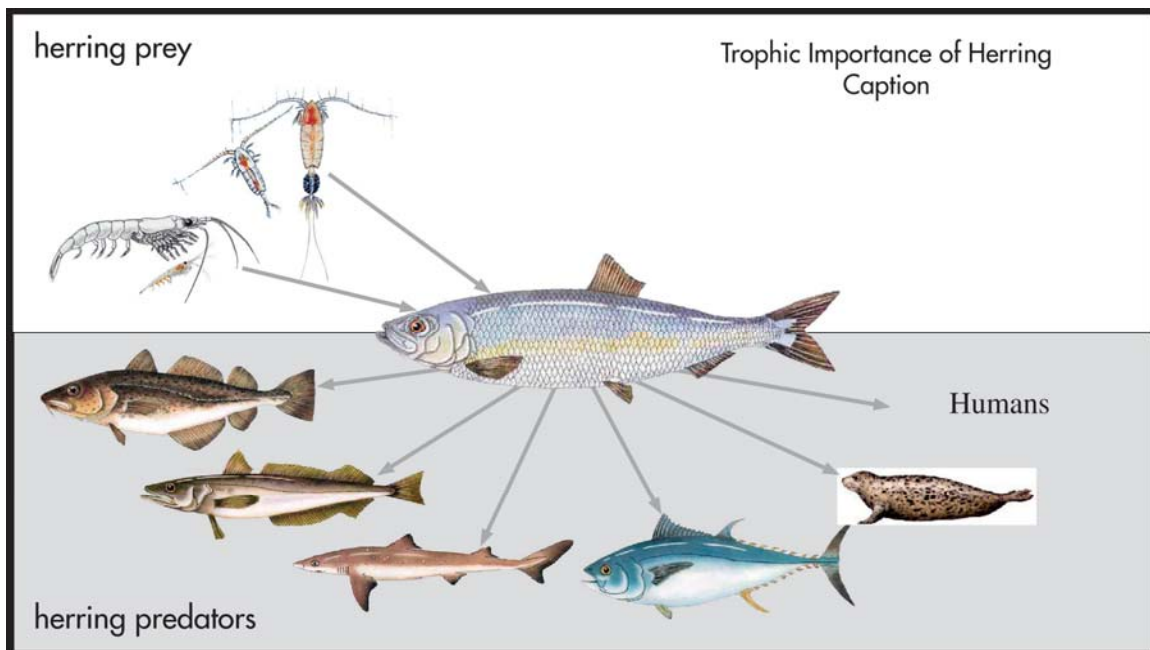
**Emphasize that mammals do not depend on whiting as much as they do on herring and sand lance.**

**Sand lance food web:**

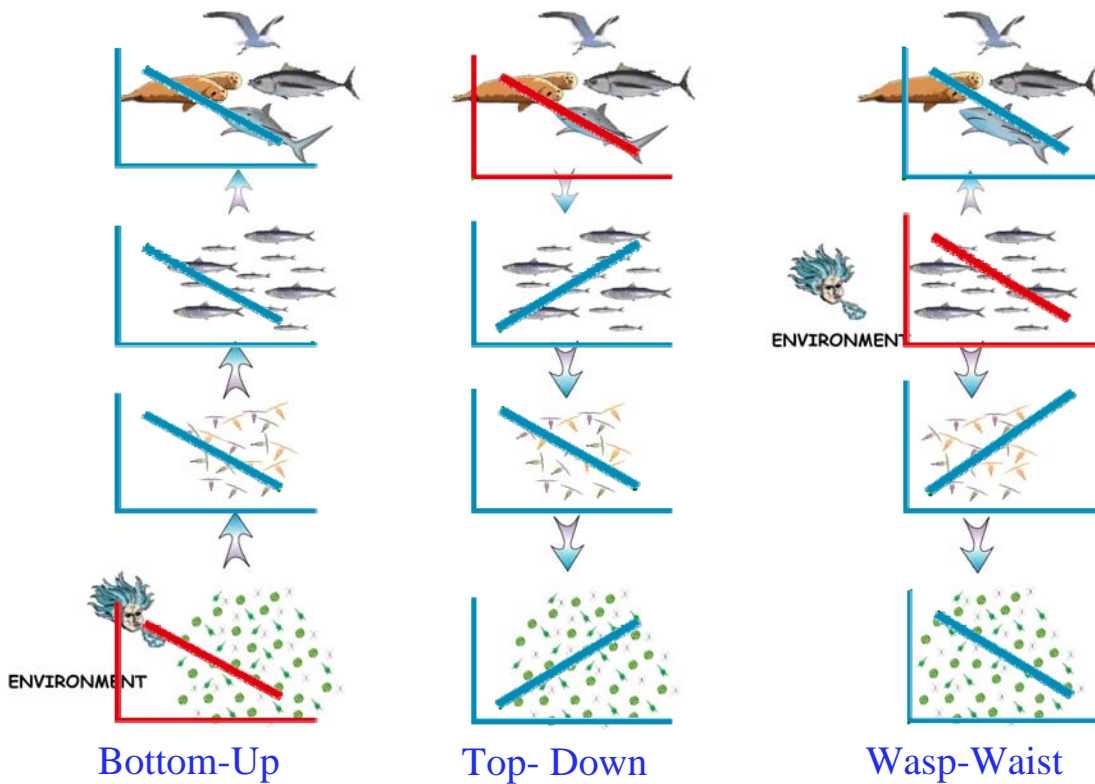
**Remove euphausiids from prey. Copepods should be primary prey (show these). List others.**

**Remove finback whale**

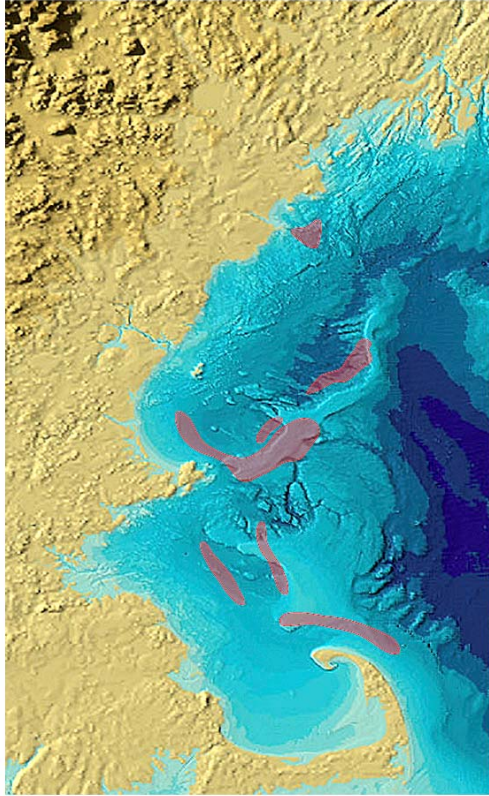
**Remove porpoise**







**Examples of trophic cascades: a) effects on zooplankton, forage fish and top predator abundances of environmental influences decreasing primary production (Bottom-up); b) increased fishing pressure that lowers abundance of top predators resulting in higher forage fish abundance, decreases in zooplankton prey and in phytoplankton on which zooplankton graze (Top -down); c) environmental or fishing impacts on abundance of forage species, with corresponding changes to top predators and zooplankton and phytoplankton (Wasp-waist). Illustration credit: Philippe Cury.**



#### **FOURTH PAGE CONTENT:**

**Project overview**

**List participants**

**Thank funding sources**

**Contact details for more information, or if you are interested in participating in future fishery-ecosystem discussions**

**Links to websites for more details**

## **BACKGROUND NOTES ON PREDATOR/PREY RELATIONSHIPS:**

### **HERRING:**

#### **Predators:**

**B&S list: Silver Hake (whiting), Atlantic Cod, and Spiny Dogfish as major fish predators of Atlantic Herring. Many other fishes (pelagic and demersal), marine mammals, and seabirds noted to feed on herring. Herring also supports substantial commercial fishery.**

#### **Personal communication (Project participants):**

**Monkfish: (dense groups feed on herring on bottom during day otherwise dispersed, difficult to catch); Tuna - higher quality flesh, fatter than when feeding on sand lance or whiting; Herring are sometimes found in nearshore during shrimping season (March) are they feeding on shrimp / eggs / larvae?**

**Prey: Bigelow & Schroeder note herring are zooplanktivorous. ID Copepods (specifically *Calanus finmarchicus*) and euphausiids shrimp as the major prey items for herring (but also list many other important prey, depending on size of herring and season. For example, barnacle larvae particularly important in early spring, as well as mollusk larvae, fish eggs, some fish larvae – e.g. sand lance, cladocerans). Juveniles may rely more on copepods and adults on euphausiids shrimp.**

**Personal communication (Project participants): Herring are sometimes found in nearshore during shrimping season (March) are they feeding on shrimp / eggs / larvae?**

### **SAND LANCE:**

**Find large abundances for a few years at a time and then gone again for a number of years (decadal population oscillations?) When numbers are low, find remnants in coastal sandy areas (or is this a different set of inshore species?)**

**Stellwagen Bank and all along ocean shore Cape Cod high numbers – extend middle of North Bank, almost to Hatchers, also occasionally along Plum Island.**

#### **B&S:**

**Schooling important (school with herring post larvae)**

**Burrow in sandy / pebbly bottoms**

**Migrations not well known. (may move inshore seasonally to spawn? May move daily migrations to feed – particularly older individuals?)**

**Food: copepods, mysids, euphausiids, chaetognaths, salps, urocordates, animal eggs and larvae, dinoflagellates and diatoms, fish fry. Adult feeding not well known?**

**Possibly filter feeding and selective feeding.**

**Predators: fin and humpback whales; Atlantic harp seals, porpoise, spiny dogfish, winter skate, silver hake, haddock, red hake, white hake, halibut.**

**Hampton / Seabrook river has had more in past few years than 10-15 years ago.**

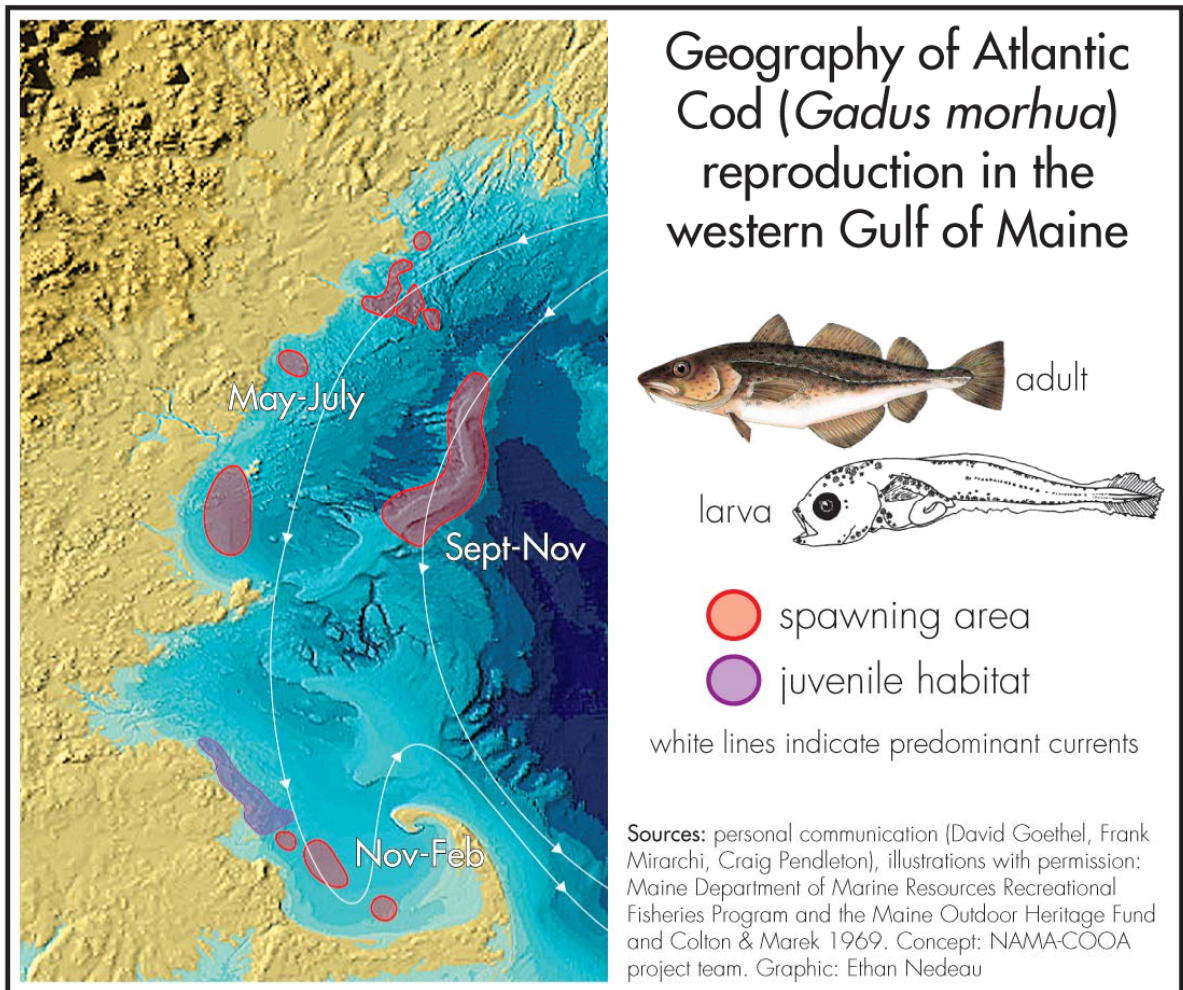
Appendix 6: Draft content for information sheet on spawning aggregation areas in the western Gulf of Maine

**Western Gulf of Maine Inshore Fisheries-Ecosystems project**

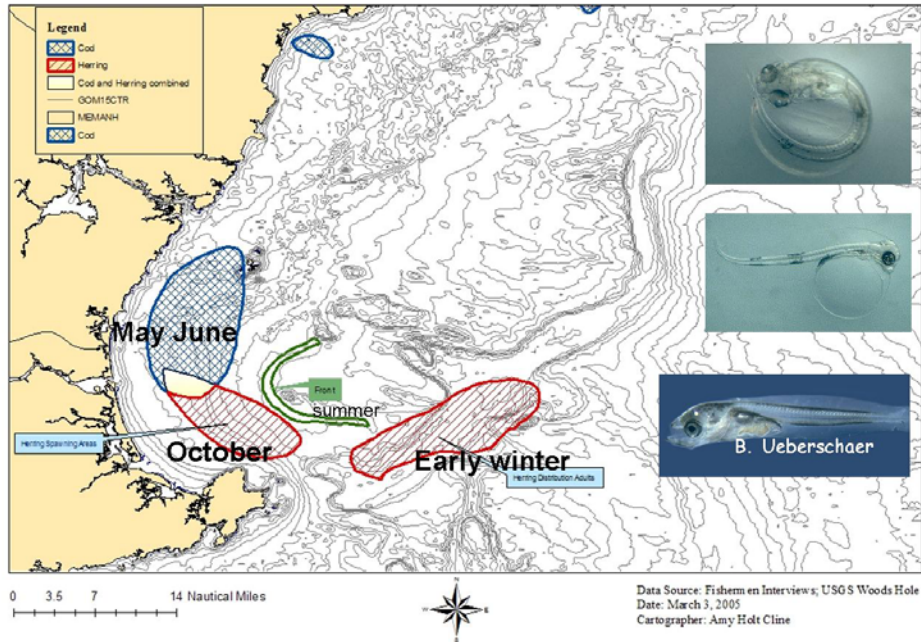
**A collaboration of fishermen and scientists**

\*\*In all of these products (maps and other illustrations), the intention is to show visually which information is known and which is suspected (e.g. shading / dotted / solid lines, etc.) to give indications of uncertainty and directions for research focus throughout.

**Geography of Cod and Herring Reproduction in the Western Gulf of Maine**



Herring and Cod Distribution Areas  
South  
Cape Ann to Cape Porpoise, Maine



**Why to cod spawn where and when they do?**

Species may adapt to local conditions and choose spawning grounds and seasons based on:

- Local currents which control retention of eggs and larvae are known to change due to weather patterns and interannual and seasonal cycles
- Availability of food for larvae (e.g. timing relative to plankton blooms)
- Temperatures, salinities and other conditions for larvae survival and growth

Other input: currents carrying eggs/larvae, near-shore juvenile habitat areas?

Spawning areas indicate timing and location of major spawning aggregations. The patchy-ness of these areas is probably due to the fishes adaptations to specific local conditions.

By combining maps of spawning areas with computer models of local currents, scientists and fishermen may be able to learn more about how the eggs and larvae travel during the weeks or months before they typically settle down to the bottom to begin their juvenile life stage. This information can be compared with juvenile cod areas identified by fishermen and research surveys.

Other possible input:

Effects of interannual variability on cod reproduction:

Note importance in how this is explained: may not be feasible to predict recruitment, because of the many factors involved in determining year class strength, but could be possible to understand whether environmental conditions (Climate, bloom timing, copepod production, winds and currents affecting distribution of fish larvae) were (or will be) very good, average or very bad for recruitment .

Satellite data – sea surface temperature, sea surface color indicates phytoplankton. (and possibly zooplankton ?). Satellite data can also show position and timing of fronts, which may promote aggregations of copepod prey and forage species.

Example of hypothesized year-class success on environmental variables: Georges Bank Haddock – 2003, 1999 good year classes

- Overview of North Atlantic Oscillation effects in this region: regional slope water temperature index; local effects.
- Interannual variation in timing of winter spring bloom
- Interdecadal variation in zooplankton abundance
- Interannual temperature patterns have been used to successfully predict recruitment many years later in some fisheries (e.g. Australian Western Rock Lobster).
- We might be able to predict ‘bad’ recruitment years, but not necessarily ‘good’ years (weather is necessary, but not sufficient.)

Gulf of Maine Cod – spawn in Ipswich Bay May 15 – June 15, and also in December. – where do the eggs and larvae go – south and east from Ipswich Bay around Cape Ann – moving through lower salinity water at mouth of Merrimack, either entrained in Cape Cod Bay or not depending on variability. see David’s hand drawn map of local current patterns. Harvard groups, U Maine groups, or U Mass Dartmouth may be able to do particle tracking models.

Appendix 7: Draft content for information sheet on nearshore-offshore connections in the Gulf of Maine

**Western Gulf of Maine Inshore Fisheries-Ecosystems project**

**A collaboration of fishermen and scientists**

\*\*In all of these products (maps and other illustrations), we should work on ways to show visually which information is known and which is suspected (e.g. shading / dotted / solid lines, etc.) to give indications of uncertainty and directions for research focus throughout.

**Near-shore environments in relation to fisheries in the Western Gulf of Maine**

Near-shore environments in the Western Gulf of Maine include Saco River, Saco Bay, Wells Bay, Piscataqua River, Ipswich Bay, Hampton River, Merrimack River, Massachusetts Bay, Cape Cod Bay). The shallow bays, estuaries, salt marshes, and rivers of the near-shore are crucial not only for resident marine species, but for many others who migrate into the areas during certain seasons. Depths in these bays are generally less than 40 meters or 20 fathoms (???)

Near-shore environments are intimately linked to the somewhat deeper areas of the coastal shelf and interior Gulf of Maine through species movements and currents. Many commercially fished species in the Western Gulf of Maine that spend some critical life history stages in near-shore environments, including cod, winter flounder, and haddock.

**Changes in mix of species found near-shore since 1970s<sup>1</sup>**

	<b>THEN (1975-1980)</b>	<b>NOW (2000-2005)</b>
<b>Near-shore</b> (within a mile or two of the coast – these observations from vicinity Merrimack River mouth)	Spawning cod Spawning haddock Juvenile and Spawning Pollock Dabs (American Plaice) Herring River herrings (alewives and blueback) Ocean pout (Congo eel) Mackerel Striped bass Bluefish Horseshoe crabs* Spawning and juvenile winter flounder	Bluefish Striped Bass Lobster Crabs Longhorn Sculpin Spawning winter flounder

Dabs (American Plaice), spawning and juvenile pollock, spawning cod, spawning haddock, and yellowtail flounder were once common in these areas are now found exclusively in deeper waters (more than a few miles from the coast).

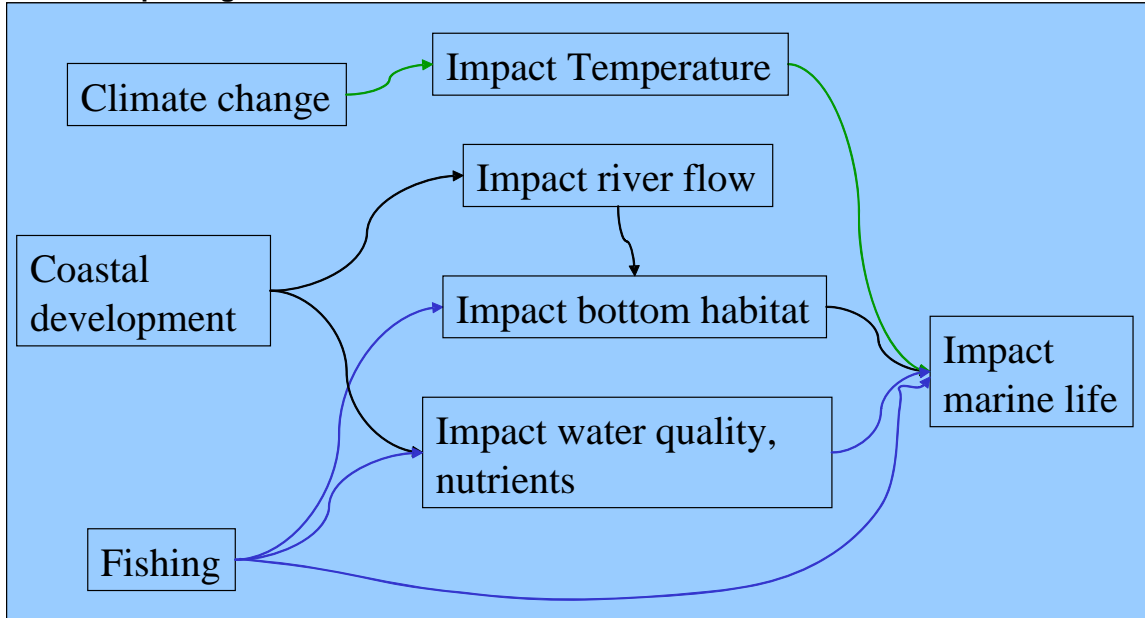
This absence could be due to many factors, including:

- Feeding conditions or habitat change for adults or juveniles. Changes to the physical habitat could include temperature and salinity or benthic habitat change such as the

<sup>1</sup> Not a comprehensive list of species found in the area, but rather prominent species observed by fishermen

- introduction of exotic algae or invertebrates (green crab, Japanese crab, tunicates, sponges)
- Spawning conditions change (could local alongshore / across shore currents have changed during this period and be influencing spawning behavior?)
- Eggs and larvae survival decrease (could be due to food availability for larvae feeding on zooplankton – fish larvae prey on phytoplankton, zooplankton, including larvae of benthic invertebrates “meroplankton”)
- Reduced population size overall within Gulf of Maine and species have reduced ranges
- Changes to water quality could have affected eggs, larvae, juveniles, or adults (see below)

### Factors impacting on Near-shore marine environments



Near-shore marine environments are impacted by many factors, including fishing and other activities on the water, near-shore development, upland development, and climate variations.

#### Coastal Development since 1975

- Many power plants have been built along coastal areas, which impact water quality and temperature (Seabrook, Pilgrim, Newington, Millstone, Braedon Bay)
- Development of housing and roads has led to higher river flow, which changes mix of mud flats, salt marsh, and other habitats.
- Water quality has changed (chlorine from municipal waste water treatment, toxics and pharmaceuticals from local or upland industry and waste-water)

**Credits:** This Fact Sheet was developed by participants in the “Western Gulf of Maine Inshore Fisheries-Ecosystems project”, which has hosted by the Northwest Atlantic Marine Alliance (NAMA) and University of New Hampshire, Center for Excellence in Coastal Ocean Observation and Analysis (UNH, COOA). Participants: Fishermen from New Hampshire and Massachusetts (David Goethel, Frank Mirarchi, George Littlefield, Randy Gauron); NAMA staff (Heather Deese, Craig Pendleton, Jen Levin); COOA staff (Jeff Runge, Amy Cline); Scientists and invited guests (Les Kaufman, Lew Incze, Peter Stevick, Ellen Goethel, Richard Taylor, Norman Vine)

#### Possible other messages to highlight in additional graphics:

- Near-shore-off-shore links – through species movement and water flows
- Shorter-term changes in fish communities (e.g. interannual)

Species movements:

\*\*note Pollock seasonal pattern is “mirror image” to cod (offshore spring, onshore spawn in fall). Juveniles like ledge, rock, boulder environs in less than 60 fathoms, also river mouths. See chart 13278, relatively inshore high spots (edge of 'light blue on chart) for the areas you used to find juveniles between June 1 and November 30 each year, see offshore spots (prong, northern edge) for where you find juveniles now (same season?). Spawning also occurs offshore now and not inshore. (did it always occur offshore?)

\*\*Longhorn Sculpin - Possible indicator species: Numerous, Medical studies, Nearshore, Suspect fairly stationary, During winter smaller fish caught, during summer, larger fish, Shorthorn sculpin found further east and north (in Maine)

Possible follow-up projects and historical datasets:

Compare species community shifts recounted from fishermen, from surveys conducted by power plants, and inshore Mass survey?

Compare water quality testing over long period of time compared with fish guts and other data?

Use fish species (specific species) as indicators of effects of change?

Possible hypothesis that there were changes to water quality in late 70's and early 80's (introduction of toxics, pharmaceuticals or other chemical issues) that altered adult migrations or inhibited spawning and recruitment success

Possible data sources for inshore water quality / Inshore benthic and pelagic surveys:

Power plant records ()

Mass Inshore survey data

Maine / NH occasional surveys

Bigelow long term data

Meghan Tyrell, Well Estuarine Research Reserve – Lew Incze contact

Larry Harris (UNH?)

Jim Carlton, Williams College

John Teal (ask Les) shoreline change

**Appendix 8: Evaluation questionnaire for knowledge-exchange meetings of the Western Gulf of Maine Inshore Fisheries – Ecosystems Project**

Were the goals of today's meeting clear and achieved?

What information do you think we should be providing council members?

What was the most valuable thing you got out of today's meeting?

What was the least valuable or felt was a waste of time during today's meeting?

Is there an important issue you don't think is getting attention and should?