Moving Forward:

A Snapshot of U.S. Activities in Ecosystem-Based Fisheries Management

A report to the Lenfest Ocean Program at The Pew Charitable Trusts

By

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Introduction

This report provides a snapshot in time of efforts in the United States to begin implementing ecosystem-based fisheries management (EBFM) and describes some related initiatives within the scientific community to develop tools or provide a conceptual framework for implementation. It is not the product of a formal survey, and because of time and resource constraints it is possible that some interesting initiatives have not been included here. However, it should provide a "20,000 foot" overview of the major efforts underway as of early 2005.

The information in this report was collected on behalf of the Lenfest Ocean Program at The Pew Charitable Trusts. Any opinions expressed are those of the author, and do not necessarily reflect those of the Lenfest Ocean Program or The Pew Charitable Trusts.

Overall observations

By all accounts, ecosystem-based fisheries management (EBFM) and its close relative ecosystem-based management (EBM) are still in their infancy. The marine community is struggling to define EBFM, while at the same time sorting out how to do it. EBFM is clearly a subset of EBM, yet because of the dominant role of fisheries in current marine management, it appears to be a stepping-stone towards achieving the ultimate goal of EBM. It is clear that both of these difficult and complicated approaches are proceeding concurrently.

More science

EBFM in the United States seems to be very much driven by natural scientists at this stage. Marine scientists have embraced EBFM as the new paradigm, and are rushing in to fill the holes in scientific understanding and data. This is seen in the tremendous effort going into modeling marine ecosystems and simulating the impacts of policy choices (See report section I. Ecosystem Models). It is also seen in the emphasis in Fishery Ecosystem Plans (FEPs). FEPs to date, such as those in the Chesapeake Bay and the Western Pacific coral reef ecosystem, are largely compilations of data needs. They outline what sorts of ecosystem information should be considered in making fishery management decisions and identify a long list of data gaps that need to be filled. But while many scientists can identify *what* information is relevant to an ecosystem approach, there is little understanding of *how* to use it. FEPs to date fail to provide mechanisms for translating this mountain of information into fishery management decisions. Similarly, in the North Pacific, the annual Stock Assessment and Fishery Evaluation Report (SAFE) has included an impressive Ecosystems Consideration Chapter for years, in an effort to recognize other components of the ecosystem. Yet this information does not really factor into fishery management decisions such as setting catch levels. (See report sections II. Fishery Ecosystem Plans and III. North Pacific Fishery Management Council).

Translating ecosystem understanding and data into fishery management decisions requires the development of ecosystem indicators, reference points, and control rules,

analogous to those used in single-species fisheries management.[1] Performance indicators are measures of the status of the ecosystem with respect to goals. Target or limit reference points are measures of the ecosystem that are used as either a target for management or a limit beyond which the system is not allowed to go. Control rules are decision rules that spell out what management decisions will be made when indicators reach target or limit reference points. These concepts are standard practice in single-species fishery management. If EBFM is to mature, making this link between ecological understanding and management is crucial, and should be a priority for research.

Just do it

But EBFM can still be implemented in the meantime if a sufficiently precautionary approach is taken. California's Marine Life Management Act (MLMA) demonstrates this. In the absence of data – what it terms a data-poor environment-- MLMA's Nearshore Fishery Management Plan sets very precautionary catch levels to protect both fish stocks and ecosystem functioning. As understanding of stocks and ecosystem effects moves to a data rich environment, catch levels are allowed to go up as appropriate based on new information. This suggests that the major impediment to implementing EBFM is not gaps in ecosystem understanding, but political will. Other fishery management plans (FMPs) adopted under MLMA demonstrate this point as well: a supportive California Fish and Game Commission embraced the precautionary catch levels of the Nearshore plan, but subsequent Commissions with less sympathetic members approved FMPs with considerably less precaution and questionable catch levels. (See section VI. California's Marine Life Management Act.)

Given the complexity of marine ecosystems generally and the resources needed to fill all data gaps, this data-poor precautionary approach will likely be necessary and appropriate in many cases.

The human factor

Despite the importance of the decision-making process, relatively little effort is going into the human side of the equation: namely, developing effective governance regimes, mechanisms for interagency coordination, and community involvement and buy-in. For example, FEPs to date have been developed with little effort to identify stakeholder goals and objectives, and provide no guidance on interagency coordination. It is this side of the equation that might benefit from incorporating broader marine management approaches, such as regional governance and community-based management techniques. All of these management approaches share some common features: community involvement, the need for coordination across agencies and jurisdictions, and the desire to consider all aspects of the system – both ecological and human.

One of the most successful examples identified for this report relies heavily on community involvement. The San Juan County Marine Resources Committee has employed a bottom up community-based approach to protect local fisheries and other

[1] See Pikitch, E.K., C. Santora, E.A. Babcock, A. Bakun, R. Bonfil, D.O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E.D. Houde, J. Link, P.A. Livingston, M. Mangel, M.K. McAllister, J. Pope, and K.J. Sainsbury. 2004. Ecosystem-Based Fishery Management. Science (305):346-347. July 16, 2004.

marine resources (see section VIII. Other Ecosystem Efforts). One of the most effective ways to get EBFM implemented on the water could be to learn from this example and adapt it to other areas. San Juan County may be somewhat unique in the U.S. in terms of the interest citizens take in protecting marine resources, providing a particularly productive foundation for success. However, useful lessons learned here can be applied elsewhere, including (1) the power of widespread public involvement to generate solutions with community buy-in, (2) being proactive in generating needed scientific information, (3) partnering among government and private groups (such as NGOs), and (4) being familiar with and leveraging existing regulatory regimes.

Where next?

New England may be fertile territory for applying these approaches. Some fishermen in New England are embracing EBFM, and efforts such as the Downeast Initiative and Maine's Bay Management Study demonstrate a desire for more ecosystem and community-based approaches. Private organizations such as the Massachusett's Fishermen's Partnership and the Northwest Atlantic Marine Alliance are organizing partnerships between scientists and fishermen and promoting research that addresses local needs while building trust and buy-in. (See section VII. Implementation Efforts in New England).

Puerto Rico may also offer opportunities. Ongoing ecological and socioeconomic research by researchers at the University of Puerto Rico is laying the foundation for EBFM and EBM within a community likely to favor local over federal government control (see section IX. Additional Scientific Initiatives). The South Atlantic provides opportunities to build on existing mechanisms for cross-state interagency coordination to move towards a regional approach (see section V. South Atlantic Initiatives).

Fishery Management Councils

NOAA's Ecosystem Pilot Project in the four east coast Fishery Management Councils focuses on getting stakeholder input on goals and objectives – an important recognition of the primary role this plays in EBFM. But Fishery Management Councils present a challenge. Council members in many places remain unclear about what EBFM is, and one senses that in many places they are being pulled into this new paradigm with some skepticism and reluctance. (See section IV. NOAA-Fisheries Ecosystem Pilot Projects.)

In addition, a fundamental problem remains the makeup of the Councils: they do not represent all stakeholders. Like the unsympathetic California Fish and Game Commission that weakened MLMA implementation, Councils riddled by conflict of interest can undermine the greater public good. Broader representation on the Councils should be an important component of implementing EBFM, and reauthorization of the Magnuson-Stevens Act provides an opportunity to do so.

Lost in the fisheries forest

The heavy emphasis on collecting more data to understand ecosystems suggests a desire by many fisheries managers to continue fishing at the edge under EBFM. The difference under EBFM in this case may simply be that the edge (maximizing fisheries production)

has shifted to incorporate knowledge of ecosystem impacts. But scientific understanding of marine ecosystems will never be complete or perfect, and managing on the edge of that understanding provides little insurance against mistakes. With EBFM, the objective of sustaining ecosystem structure and function should supercede the objective of maximizing fisheries.[2] A sufficiently precautionary approach can help ensure this. But political pressures to maximize fisheries production will continue to be a counter force to precaution. A management approach focused too heavily on converting single-species tools to ecosystem-based management can feed into this. By allowing these technical issues to drive the debate on EBFM, we risk losing the forest for the trees.

The ecosystem objective may remain more clearly in focus by embracing the more holistic EBM approach, in which fisheries are clearly just one piece of the puzzle. For this reason, the debate on EBFM's role in the larger goal of EBM should be addressed sooner rather than later.

Priorities for action

- Focus scientific research on ecosystem indicators, reference points, control rules.
- Work towards adoption of truly precautionary control rules in the face of uncertainty, such as was done with MLMA.
- Focus on developing effective governance mechanisms.
- Advance community based approaches, possibly in New England or Puerto Rico.
- Advance interagency coordination and regional approaches such as in the South Atlantic.
- Reform Fishery Management Council structure to include all stakeholders.
- Begin the debate on the role of EBFM in EBM.

Conclusion

It's easy to get caught up in the data-chase. There will always be a need for more scientific information, and much-needed ecosystem research should continue to be supported. But overemphasis on filling the science gaps will delay implementation unnecessarily. Implementing EBFM in the short term requires making precautionary decisions in the face of significant uncertainty. This requires buy-in from stakeholders and an effective governance structure to do so. As former USCOP Ocean Commissioner Mark Hershman pointed out, things get solved by finding a process that works. More data alone rarely solves the problem. Ellen Pikitch of the Pew Institute for Ocean Science noted that it's not an issue of compiling data, it's an issue of deciding how we are going to use it.[3] And as many scientists and other conservationists recognize, we need to be thinking broader than fisheries.

[2] Pikitch, E.K., C. Santora, E. Babcock, A. Bakun, R. Bonfil, D. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Henemann, E. Houde, P. Livingston, M. Mangel, M. McAllister, J. Pope and K. Sainsbury. (2004). Response to letter, Fishery Management and Culling. *Science*: 306: 1892. December 10, 2004.
[3] Personal communication 2/22/05 and 3/9/05 respectively.

Report Focus and Approach

This report provides an overview of efforts in the United States to begin implementing EBFM, and describes some related initiatives within the scientific community to develop tools or provide a conceptual framework for implementation. It does not provide a review of past (or recent) efforts, and does not include an overview of applied scientific research in EBFM.[4] It is written assuming a basic level of knowledge about fisheries management policies.

The primary method for identifying initiatives was to contact knowledgeable people in the marine conservation and scientific fields to scope out interesting activities currently underway. The number of people contacted was limited primarily by time. Therefore, the reader should be aware that other activities of interest might exist.[5] Information was collected from early January 2005 through mid-March 2005.

Because of the common features that EBFM shares with EBM, community-based management, and regional governance initiatives, it is sometimes difficult to make distinctions. However, by necessity this report does. It focuses on ecosystem-based management activities with a strong fisheries component, but generally does not explore other ecosystem-based efforts. In a few cases, some of these other efforts are flagged and generally described for possible future reference. Similarly, this report does not examine regional governance work in detail. Professor Marc Hershman of the University of Washington currently is conducting a study of regional marine governance mechanisms to help structure such a mechanism in the U.S. Pacific Northwest. His work will examine existing models, and is discussed generally in section VIII. Other Ecosystem Efforts. In addition, marine consultants Michael Weber and Suzanne Iudicello-Martley have completed a report for the Ford Foundation on the potential of community-based management the U.S.[6] This report does not repeat the work of these other efforts.

Section I of the report discusses ecosystem modeling efforts to provide a basic understanding of this tool, which is used in many of the initiatives discussed throughout the report. Subsequent sections (II, III, IV and V) address initiatives involving the federal fisheries management structure, including various Fishery Management Council efforts and national initiatives within in the National Oceanic and Atmospheric Administration (NOAA). After addressing the federal system, the report examines activities taking place at state, regional, or local levels in sections VI, VII and VIII). It concludes with an overview of some initiatives within the scientific community to advance implementation of EBM (section IX).

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[4] Information on applied scientific research related to EBFM was provided to the Lenfest Ocean Program separately.

[5] The "road map" of players in EBM currently being developed by the Packard Foundation and COMPASS could help flesh out other activities.

[6] M.L. Weber and S. Iudicello-Martley. Opportunities and Obstacles for Community-Based Fisheries Management in the United States. A report to the Ford Foundation. August 2004.

I. Ecosystem Models

Given the incredible complexity of natural systems, computer modeling of how ecosystems function and how management decisions should affect them is a significant component of much of the EBFM work currently underway. Efforts specific to particular regions or initiatives are discussed in their relevant sections. However, general work in ecosystem modeling is presented here, along with a description of one of the more commonly used approaches, Ecopath with Ecosim.

EwE

Much of the modeling underway uses the Ecopath with Ecosim model (EwE), developed by researchers at the University of British Columbia's Fisheries Centre (UBC), including Villy Christensen, Carl Walters and Daniel Pauly. In addition to refining their models, Drs. Christensen and Walters have actively helped numerous other researchers develop models for their ecosystems. As a result, EwE is being developed in a variety of locales across the country (and the world). This includes the Chesapeake Bay, South Atlantic, North Pacific, Hawaii, and Florida Gulf Coast.

The foundation of EwE is an Ecopath model, which creates a static snapshot of the ecosystem and the relationships among different components of the food web. It is based on basic laws of thermodynamics and mass balance about the flow of energy and conservation of matter in an ecosystem. It relies on relatively accessible information such as biomass, mortality, and consumption estimates; diet composition and fishery catches. Ecosim provides the simulation capability, allowing researchers and managers to look forward in time. It considers changes in food web consumption and predation that might occur when food web structure changes, and how those changes affect the productivity of stocks. It allows the user to examine the impact of fisheries policy choices on different components of the ecosystem, such as by simulating various fishing rates over time and seeing the impacts on biomass, catches, and vulnerable species. The impact of policies can also be analyzed through optimization of four weighted policy objectives: (1) maximizing fisheries rent (2) maximizing social benefits (3) maximizing rebuilding of species and (4) maximizing ecosystem structure/health.

EwE is billed as a model that can be used to:

- Address ecological questions
- Evaluate ecosystem effects of fishing
- Explore management policy options
- Evaluate impact and placement of marine protected areas
- Evaluate effects of environmental changes

Limitations of EwE mentioned by some researchers are its limited ability to incorporate environmental (that is, nonliving) components of ecosystems, such as climate changes; and its inability to delineate ecosystem components spatially. For these reasons, some researchers are developing their own models, or modifying models. As part of its effort to develop decision support tools for EBFM, NOAA Fisheries is supporting an

evaluation of EwE. This is discussed under section IV. NOAA Fisheries Ecosystem Pilot Projects.

The Pacific Modeling Series

Overview: A variety of researchers have developed EwE models of the Pacific, and much of this has come together through multi-year, multi-investigator projects headed by Jim Kitchell at the University of Wisconsin. While the work has been funded by a variety of sources, and included researchers from a number of institutions, Dr. Kitchell leveraged these efforts by bringing key people together and stimulating new ways of thinking about developing and applying the models. Much of the focus of this work has been on addressing management questions and developing models that will be helpful for managers.

Description: Under an initial six-year National Science Foundation (NSF) funded project, Jim's group developed and refined a set of models that focused on trophic interactions in the Central North Pacific and their modification by fishery exploitation. The *modus operandi* of the project was to bring selected colleagues from a variety of institutions together in modeling workshops twice a year. This resulted in a series of publications and set the stage for subsequent work. A common theme of analyses was the ecological effects of longline fisheries for tunas, billfishes, and sharks. In addition to development of the models, one of the major results was confirmation that the longline fishery was the key component regulating the structure of the ecosystem in the Central North Pacific. The work from these efforts resulted in, or contributed to, 19 scientific publications.

This project has continued and expanded under a current NSF grant. Current project activities include: (1) developing models that can evaluate the role of fishery effects in food web dynamics, (2) expanding modeling to include interactions with large-scale environmental effects (such as Pacific Decadal Oscillation or climate change), and (3) using models to evaluate resource management policies that can change ecosystem structure and function. Much of the work has focused on bycatch reduction and the implications of reducing bycatch of billfishes and sea turtles. The team is continuing the workshop format, and involving many of the same people. Some of their findings include:

- Certain types of multi-species models provide better management advice than simpler models, despite potential bias.[7]
- Removing longline hooks in water less than 120 meters deep substantially increases marlin biomass, but reduces abundance of yellowfin tuna.[8]

[7] Essington, T.E. 2004. Getting the right answer from the wrong model: evaluating the sensitivity of multispecies fisheries advice to uncertain species interactions. Bulletin of Marine Science. Vol. 74(3): 563-582.

In addition, Jim Kitchell and Bob Francis of the University of Washington are now leading a National Center for Ecological Analysis and Synthesis (NCEAS) working group that is comparing EwE models in five different Pacific ecosystems to explore general principles that arise among the different systems, how ecology and climate affect productivity, and the policy implications of this. The five ecosystems are:

- Eastern Bering Sea
- Coastal Gulf of Alaska
- Northern California Current
- Eastern Tropical Pacific
- Central North Pacific

Students worked on developing the five ecosystem models, which includes the models for the Central North Pacific and Eastern Tropical Pacific developed earlier under the NSF grants and by Christofer Boggs and Jeff Polovina at the Pacific Islands Fisheries Science Center respectively, as well as new models for the Northern California Current (John Fields), the Gulf of Alaska (Sarah Geichas), and the Eastern Bering Sea. This working group has been meeting twice a year since the end of 2001 and will finish up in spring 2005. They will be producing a synthesis paper giving examples of comparative studies of these five systems. In addition, Bob Francis and his students are developing ways to make the biological outputs from these models more useful to managers. In short, they are trying to convert the biological outputs into socioeconomic metrics, by considering tradeoffs in fleet performance that would result from biological shifts.

Primary contacts:

James Kitchell, University of Wisconsin
Robert Francis, University of Washington
Tim Essington, University of Washington

Other collaborators include:

Christofer Boggs, Pacific Islands Fisheries Science Center, Honolulu
Jeff Polovina, Pacific Islands Fisheries Science Center, Honolulu
Steven Martell, University of British Columbia
Carl Walters, University of British Columbia
Sture Hansson, Stockholm University

[8] Kitchell, J. F., Kaplan, I.C., Cox, S.P., Martell, S.J.D., Essington, T.E., Boggs, C.H., and Walters, C.J. 2004. Ecological and economic components of alternative fishing methods to reduce by-catch of marlin in a tropical pelagic ecosystem. Bulletin of Marine Science. Vol. 74(3): 607-620.

West Florida and Tampa Bay

Overview: The Florida Fish and Wildlife Research Institute is undertaking two EwE modeling exercises: (1) an EwE model of Tampa Bay coupled with a hydrodynamic model to address fisheries management questions, and (2) an EwE model of the nearshore area of West Florida to evaluate forage fish abundance and fluctuation. Current work involves improving the Tampa Bay models by collecting additional field data. This tool is not yet ready for use by managers, and they expect to continue refining it for several more years. The West Florida forage fish model is being used to identify information gaps in fisheries management and additional research needs to manage forage fish effectively.

Description: Working with Carl Walters at UBC and using 50 years of historical data for Tampa Bay, Behzad Mahmoudi and his colleagues at the Institute are constructing an EwE model of the Tampa Bay ecosystem. The goal is to provide managers a tool for making decisions about fisheries, considering not only fishing pressure but nutrient loading from pollution as well as climate and oceanographic factors. The data include information on fish indices, fishing pressure, nutrient loading from polluted runoff, and primary productivity. They are now using the model to identify what additional areas of research are needed to calibrate it sufficiently. This information includes better information on diets, how productivity and energy move through the food web, and getting absolute numbers on fish biomass. Research and monitoring programs are underway to get this information. In addition, they are developing a hydrodynamic model to enhance the capabilities EwE model to allow them to consider physical factors in a spatially explicit way. They have contracted with the University of South Florida for some of this work.

Modeling of forage fish in West Florida reflects concerns within the Florida Fish and Wildlife Commission about declines in certain species in the late 1980's and early 1990's. The Commission is searching for information about the magnitude of the decline and how they can evaluate the impact of forage fish abundance and fluctuation on fisheries. The EwE model developed has been used to simulate the effects of fishing pressure on forage fish, and ultimately, how this fishing pressure then affects recreational fishing. Currently, there is no commercial fishing for forage fish. The model is being used now to determine what additional research is needed to better manage fisheries, including better information on fish diets and biomass. They have started some of this work, but are seeking federal dollars to help them expand their biomass work.

Primary contact:

Behzad Mahmoudi, Florida Fish and Wildlife Research Institute

Additional contact:
Carl Walters, UBC

Galveston Bay

Overview: There is interest in the Galveston Bay Estuary Program in developing an Ecosim model for Galveston Bay as a first step towards ecosystem-based management. So far, an initial workshop was held to educate local scientists and generate interest.

Description: The Research Coordination Board of the Galveston Bay Estuary Program has made development of an Ecosim model for Galveston Bay a goal to help move the estuary towards ecosystem-based management. Issues in the bay include habitat loss, water quality, wetlands restoration, and bycatch, and the impact this has on overall ecosystem productivity, health and integrity. Fisheries for shrimp and oysters are just one part of the management concern for the Estuary Program.

As a first step, Roger Zimmerman, director of NOAA's Galveston Lab and member of the Board, held a workshop in late 2004 with Carl Walters and Villy Christensen of UBC, to educate and interest key scientists in the region about how Ecosim could be used. Approximately 35 scientists from various management agencies and universities, including NOAA and Texas Parks and Wildlife, attended the workshop.

The next step is to hold a more hands-on workshop to get interested scientists more involved, compile existing data, and identify an organizer for this effort. Additional funding is needed to move forward with these steps. The Galveston Bay Estuary Program and Sea Grant provided some funding for the initial workshop, and the Board is looking to the Galveston Bay Foundation for additional support.

Primary contact:

Roger Zimmerman, NOAA Fisheries Galveston Lab

Additional contacts:

Villy Christensen, UBC
Carl Walters, UBC

Jerald Ault, University of Miami Rosenstiel School of Marine and Atmospheric Science

Overview: Jerald Ault has been developing ecosystem models of coral reefs for more than a decade. His work has focused on South Florida's reefs, but he has recently been asked to help in ecosystem modeling efforts in Hawaii and Puerto Rico as well.

Description: Jerald Ault's work focuses on modeling the coral reef ecosystem in South Florida in a "whole systems approach" to examine the impacts of management actions, including fishing, on coral reef species. His approach is to:

1. look at entire communities of coral reef fish
2. develop sampling programs and models
3. identify responses of reef communities to fishing and environmental effects
4. develop indicators of community response
5. provide insights into management.

His work includes 300 species associated with coral reefs, across the range of habitats, and includes distributions of different habitats and associated use by species. He does not use EwE, but develops various models (such as multispecies models coupled with biophysical models) that allow for more spatially explicit analysis that considers physical ecosystem components as well. Using these models, he tests various management scenarios to identify likely impacts and examine whether management actions taken are going in the direction intended. His work includes exploring community indicators (to help identify reference points for ecosystem-based management), sorting out ecosystem effects from various sources (such as natural vs. anthropogenic), identifying the different components of fishing mortality, and designing marine reserves.

He has used his approach in the past for the U.S. Army Corps of Engineers and the South Florida Water Management District to examine how the Everglades restoration project will affect nearshore areas. His current work includes evaluating Dry Tortugas reserves to examine their benefits to fisheries, examining the role of the Northwest Hawaiian Islands Coral Reef Ecosystem Reserve (NWHI) as a biological source for the Hawaiian Islands chain for the Western Pacific Fishery Management Council (see section II. Fishery Ecosystem Plans), and integrating ecological and socioeconomic data to examine management options for coral reef protection in Puerto Rico and the Virgin Islands (see section IX. Additional Scientific Initiatives).

Primary contact:

Jerald Ault, University of Miami, Rosenstiel School School of Marine and Atmospheric Science

II. Fishery Ecosystem Plans

A 1999 congressionally-mandated report set the stage for subsequent federal efforts to implement EBFM. In response to a congressional request, the National Marine Fisheries Service (NMFS) convened a panel of experts to assess the extent to which ecosystem principles are currently applied in fisheries research and management, and recommend how best to integrate these principles into future activities. This Ecosystem Principles Advisory Panel (EPAP) concluded that NMFS and the regional Fishery Management Councils do apply some EBFM principles, goals and policies, but don't apply them comprehensively or evenly. They attributed this to the lack of a clear mandate and resources to carry out EBFM, and the "considerable gaps in knowledge and practice"[9] of this new concept.

EPAP recommended that Councils continue to use Fishery Management Plans (FMPs) for single species and species complexes, but amend these to incorporate ecosystem approaches consistent with an overall Fishery Ecosystem Plan (FEP). The objectives of the FEP are:

- to provide Council members with a clear description and understanding of the physical, biological and human/institutional context of ecosystems;
- direct how that information should be used within FMPs; and
- set policies by which management options would be developed and recommended.

EPAP outlined eight elements that should be included in each FEP and recommended that the Magnuson-Stevens Act be amended to require FEPs. It urged the development of an initial demonstration FEP as a model to facilitate rapid implementation of a full FEP when ultimately required under Magnuson-Stevens. It also called on NMFS and the Fishery Management Councils to establish guidelines for FEP development.

To date managers in two regions of the country have made first attempts at developing a Fishery Ecosystem Plan: the Chesapeake Bay and the Western Pacific. Another region, the South Atlantic, is in the middle of developing an FEP (see section V. South Atlantic Initiatives.) These plans reveal the painfully incremental nature of moving towards data-rich EBFM, and show just how far we have to go to get there.

[9] National Marine Fisheries Service. 1999. Ecosystem-based fishery management: A report to Congress by the Ecosystem Principles Advisory Panel. U.S. Department of Commerce, NOAA, NMFS. Washington DC.

The 8 elements of an FEP according to EPAP:

1. Delineate the geographic extent of the ecosytem(s) that occur(s) within Council authority, including characterization of the biological, chemical, and physical dynamics of those ecosystems, and "zone" the area for alternative uses.
2. Develop a conceptual model of the food web.
3. Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web" and how they are considered in conservation and management measures.
4. Calculate total removals – including incidental mortality – and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure.
5. Assess how uncertainty is characterized and what kind of buffers against uncertainty are included in conservation and management actions.
6. Develop indices of ecosystem health as targets for management.
7. Describe available long-term monitoring data and how they are used.
8. Assess the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries and are outside of Council/Department of Commerce authority, and include a strategy to address those influences.

Chesapeake Bay FEP

Overview: Motivated by the 1999 EPAP report, some key individuals in NOAA's Chesapeake Bay Office (NCBO), and the Chesapeake Bay Program's Science and Technical Advisory Committee initiated a multi-year effort to create an FEP for the Chesapeake Bay. While their success at completing a product by organizing a mostly voluntary effort among the many players in the Chesapeake Bay region is impressive, this first step at an FEP reads mostly like a laundry list of what ecosystem information should be considered in making management decisions. The guidance it provides for how to use this information in developing FMPs is very general and fails to translate how this information should be used to influence fisheries catches. This likely reflects three realities: (1) the immature state of science on translating ecosystem information into fishery control rules, (2) the novelty and complexity of thinking about management in terms of ecosystems and (3) the sheer volume of information needed to address the eight EPAP elements.

Description:

FEP: The Chesapeake Bay Program's[10] recent Chesapeake 2000 Agreement explicitly includes a goal to revise and implement existing fishery management plans to incorporate

[10] The Cheseapeake Bay Program is a regional partnership to restore the Chesapeake Bay, consisting of the states of Maryland, Pennsylvania, and Virginia; the District of Columbia, the Chesapeake Bay Commission (a tri-state legislative body) the U.S. Environmental Protection Agency; and various advisory groups. It resulted from the Chesapeake Bay Agreement of 1983, which set a goal to restore the Bay's living resources and reduce nitrogen and phosphorus entering the Bay by 40% by 2000. Chesapeake Bay Fishery Management Plans coordinate management among the Bay-region jurisdictions, including states and regional management councils.

ecological, social, and economic considerations, multi-species fisheries management and ecosystem approaches by 2007. The Chesapeake Bay FEP process was undertaken in response to the 2000 Agreement and the 1999 EPAP report to Congress. In November of 2000, the NCBO appointed a FEP Technical Advisory Panel of regional experts to develop the FEP. The Panel was composed of experts from the University of Maryland, Virginia Institute of Marine Sciences, and the College of William and Mary among other institutions, specifically chosen for their expertise in each of the FEP major elements.

The FEP completed in 2004 tracks the eight elements outlined by EPAP and adds two additional components on social and economic factors. The plan states its limited role upfront, stating that the FEP calls attention to critical features and processes of ecosystems,

> "but is neither an ecosystem management plan nor a prescribed recipe to assemble an FMP. The FEP does not attempt to integrate all major elements of the fisheries ecosystem it discusses. Rather, it recognizes the critical role of each element in serving the needs of Chesapeake Bay fisheries and its value to the continuation of ecosystem services…"[11]

It states that it advises fishery managers on the necessary elements of ecosystem-based management in a way that allows managers to make informed management decisions, while providing recommendations for the research needed to support this approach. It stresses that it is a strategic, not a tactical, document and reiterates EPAP's statement that the FEP is an umbrella document to support ecosystem-based approaches in individual FMPs. Its purpose is to make managers aware of the effects of their decisions on the ecosystem, and the effects of various components of the ecosystem on fisheries.

At over 300 pages, the FEP includes a tremendous amount of information about the Chesapeake Bay, and it says all the right things in principle. It reflects a strong precautionary approach and includes consideration of most or all key aspects of ecosystem-based management, including coordination among agencies, multi-species interactions, habitat and abiotic ecosystem components and their affect on fisheries production, developing appropriate ecosystem indicators, accounting for uncertainty in management decisions, and more. But as an umbrella guidance document, the recommendations for EBFM are very general. For example, it calls for coordinating with other agencies with coastal management responsibilities, but does not provide guidance on how to do this. Research recommendations are also general, such as calling for determining how spatial arrangement of habitats affects managed species and members of their significant food web.

This clearly is just a first step in EBFM, and the FEP emphasizes that moving towards EBFM is an incremental process. Even its recommendations for "immediate steps" reflect this, often focusing on glaring basic information gaps such as improving data on total removals (including bycatch and discards), improving monitoring of fisheries,

[11] Chesapeake Fisheries Ecosystem Plan Technical Advisory Panel. 2004. Fisheries Ecosystem Planning for Chesapeake Bay. Prepublication p. 4.

identifying all important habitats, and examining how habitat degradation affects fisheries. Its main benefit appears to be identifying in one place the information needed to implement EBFM in the Chesapeake Bay, and introducing in general terms how it should be used in fisheries management. As one person closely involved in its development put it, this FEP is an attempt to get to the moon, whereas true EBFM is going to Mars.

Next steps: The first two items in the FEP identified as critical next steps are (1) obtain the formal endorsement and approval of the FEP by the Chesapeake Bay Program and the Bay fisheries management institutions and agencies with regulatory authority, such as the state agencies, and (2) develop an FMP or revise an existing FMP as an ecosystem-based FMP to provide "proof-of-concept," with input and guidance from the FEP panel on ways to incorporate recommended actions. As of this winter, FEP approval was moving its way through the Chesapeake Bay Program structure and its approval was expected. In addition, five (mostly) single-species FMPs are underway that are supposed to incorporate the elements outlined in the FEP. These plans are for: menhaden, striped bass, oysters, blue crabs, and the river herring and shad complex. Members of the FEP Technical Advisory Panel are involved in each of these FMP efforts to provide linkage to FEP requirements, and the panel has developed guidelines for developing plans. The goal, as outlined in the Chesapeake 2000 Agreement, is to complete these five plans by the end of 2005, although it does not appear that all the plans will be completed this year.

EwE: In concert with the FEP effort, NCBO contracted with the experts at UBC to assist with the development of an EwE model for the Chesapeake Bay, and hired an expert modeler with the Chesapeake Research Consortium to work on site. The hope is that the model will help support and guide multispecies management and research. Several workshops and training course have been held, open to all interested parties to evaluate and modify the model structure and to help local researchers use the model independently. Additional workshops in 2002 and 2003 refined and validated the model, and began addressing nine policy questions identified in earlier workshops. Partners involved in the Chesapeake Bay EwE include researchers at most of the local marine research facilities and agencies, including Virginia Institute of Marine Science, Maryland Department of Natural Resources, Chesapeake Research Consortium, and the Smithsonian Environmental Research Center, and various laboratories of the University of Maryland.

In addition, research and modeling work is looking into factors influencing forage fish in the bay such as menhaden.

Primary contacts:

Dr. Ed Houde, Chesapeake Biological Laboratory, University of Maryland , Co-chair of the FEP Technical Advisory Panel

Derek Orner, NOAA Chesapeake Bay Office, chair of the Chesapeake Bay Fisheries Steering Committee

Western Pacific Fishery Management Council FEPs

Overview: In 2001 the Western Pacific Fishery Management Council (West Pac) submitted to NMFS for approval what it touted as the "first ever ecosystem-based plan for fisheries developed in the U.S."[12] to address coral reef ecosystems. The plan tracks the eight elements for FEPs outlined in the 1999 EPAP report. However, as acknowledged by West Pac, so little is known about the ecology of the reefs that much of these elements simply isn't addressed. Management measures outlined in the plan to achieve its goals to "foster sustainable use of multi-species resources in an ecologically and culturally sensitive manner, through the use of the precautionary approach and ecosystem-based resource management"[13] are limited. There has been little movement to develop a research plan and fill information gaps since 2001. However, recent and planned activities suggest that West Pac is now moving forward in a more positive direction.

West Pac also recently announced that it will be developing archipelagic FEPs for each of the archipelago systems within its jurisdiction. This is in the early stages, but appears to be an effort to adopt community-based approaches in island communities.

Description:

Coral Reef FEP: The 2001 FEP amended FMPs for bottomfish and seamount groundfish fisheries, crustacean fisheries, precious corals fisheries, and pelagics fisheries, as they relate to coral reefs. Most of it was approved by NMFS. However, provisions relating to the Northwest Hawaiian Islands Coral Reef Ecosystem Reserve (NWHI) were rejected by NMFS to allow for the Sanctuary designation process to proceed without external prescriptions in place. This designation process is still underway and environmental and native Hawaiian groups currently are working to maintain protections outlined in President Clinton's Executive Order establishing the reserve,[14] in response to efforts by West Pac to allow certain fishing activities.

To emphasize its EBFM credentials the FEP stresses that it uses a precautionary approach, adaptive management, and makes extensive use of marine protected areas (MPAs) as a way to deal with uncertainty. But a review of the actual management tools used indicates that they have applied a limited interpretation of these principles.

The plan appears to establish no-take and low-take MPAs primarily in unpopulated, often remote island areas where little fishing occurs now. The low-use MPAs offer little new protection other than requiring vessels to have insurance. They grandfather in existing uses and even allow new fisheries under special permits. The permits mainly serve as a

[12] Western Pacific Regional Fishery Management Council. October 2001. Final Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region. Volume 1. p. iii.
[13] Ibid p. vi.
[14] Executive Order 13178 Establishing the Northwest Hawaiian Islands Coral Reef Ecosystem Reserve. Federal Register. December 7, 2000.

way to obtain fishery dependent data such as catch levels on any new fisheries, to help manage them in the future.

The adaptive management aspect of the plan focuses mainly on having a process for making rapid regulatory modifications if necessary to respond to major changes in five limited areas: (1) mooring buoy installation and anchoring prohibitions (2) a vessel monitoring system (3) the permit and reporting system (4) adding managed species to the plan and (5) designating indigenous sub-zones within low-use MPAs.

It is unclear how the precautionary approach is applied in this plan, other than in a limited way in setting overfishing limits and reference points. The FEP relies on fishery data on effort and catch per unit effort as proxies for independent data on biomass and fishing mortality to set these levels. In some cases, these proxies need to be estimated. The FEP makes clear that when multiple estimates are available, the more precautionary value will be used.

The stated impetus for the coral reef FEP was the 1999 EPAP report, and the plan tracks each of the eight elements. Of these, the FEP readily admits that it has not addressed two of them (calculate total removals and develop indices of ecosystem health as targets for management) because of lack of scientific information. It is clear that it also has not yet addressed a third element as well, namely, develop a conceptual model of the food web. Other elements, such as describing the habitat needs of different life history stages for all plants and animals that represent the significant food web, are also clearly inadequate due to lack of scientific data. As the plan notes: "…the basics, much less the intricacies, of coral reef ecosystems are poorly understood," therefore "Ecosystem-based management of coral reefs…is a long-term goal that can only be achieved as new information allows for improved understanding and decision- making."[15]

Management approaches in the coral reef FEP are:

1. designated no-take and low-take areas;
2. permitting and reporting requirements for monitoring take of coral reef resources;
3. prohibitions on the use of many destructive and non-selective fishing gears;
4. prohibitions on the take of coral and live rock (with some exceptions); and
5. requirements for vessel insurance to cover the cost of cleanup and wreckage removal in the event of a grounding.

Despite this lack of information, the list of research needs included in the FEP is relatively brief and very general**,** with no strategic research plan that prioritizes needs. There seems to be little reference to basic life history and habitat, ecological interactions, and stock assessment research that is fundamental to so much of what is lacking in this FEP. In particular, it is clear that management of these resources relies heavily on fishery dependent data in the absence of fishery independent data such as measures of fish

[15] Western Pacific Regional Fishery Management Council. October 2001. Final Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region. Volume 1. pp. 12-13.

abundance. But the plan then fails to push for substantially beefing up fishery independent data, which would be more reliable. For example, much of the existing data it relies on is catch data. The permitting system developed in the plan includes reporting requirements for fishermen consisting of logbooks, considered a relatively inaccurate source of fishery dependent data by many. Establishing a (fishery independent) survey and monitoring system of some kind would seem preferable.

Recent and planned West Pac efforts seem to be moving in the right direction to address the data problem. In November 2004 West Pac held a symposium on NWHI in an effort to re-engage the federal and state players involved in research in this area. This was a first step in an effort to develop a 5-10 year research plan to answer ecosystem science questions in the entire Hawaiian archipelago. In addition, an ecosystem science workshop planned for spring 2005 was to bring together scientists to advise West Pac on how to proceed with an ecosystem approach and to explore the use of computer models to help them. The workshop reportedly would spell out what information currently exists and how it is used, and ask the invited ecosystem science panel to advise the Council on what additional information is needed, how it should be used, and how models can help. The panel includes Carl Walters and Villy Christensen of UBC, as well as well-known scientists involved in EBFM efforts such as Steve Murawksi of NOAA Fisheries and David Fluharty, formerly of the North Pacific Fishery Management Council and a co-chair of EPAP. It also includes Jerald Ault of the University of Miami, who has been asked by West Pac to apply his coral reef modeling approach to the western Pacific, and in particular to examine questions regarding whether the main Hawaiian Islands rely on productivity originating in the NWHI (see section I. Ecosystem Modeling). As described by key staff at West Pac, their approach to EBFM is:

- Get the framework in place through an FEP
- Get experts to tell you what you need to implement EBFM
- Develop a research plan to feed data into models
- Do adaptive management over time.

There is some model development occurring now, but it appears to be very removed from West Pac management efforts. Frank Parrish of NOAA's Pacific Islands Fisheries Science Center is compiling data and refining a base model that Jeff Polovina of the Center developed years ago. This EwE model focuses on characterizing the coral reef ecosystem of French Frigate Shoals, particularly with regard to conservation of the endangered Hawaiian monk seal. With help from researchers at the University of Dalhousie, they currently are researching details about monk seal diets to help refine the model further. A key question is determining the carrying capacity of the ecosystem for monk seals. Once known, simulations of the effects of fishing on monk seal habitat can be carried out. These kinds of simulations are a couple years down the line yet.

Archipelagic plan: This appears to be an effort to adopt a new approach to management in Pacific Island areas such as the Northern Mariana Islands and American Samoa, where the centralized federal approach doesn't work well for cultural reasons and data and resource limitations. West Pac has contracted with Micronesian Archeologic Services to

reconstruct past baselines of human populations and resource use to inform this process. In addition, contractor Paul Bartram[16] reportedly has begun work in the Northern Marinas community as a first step in identifying strategies for management that allow the community to develop an effective plan that works for them, and establish institutions to monitor, enforce, and test strategies over time. The idea is that each distinct island group would have its own strategy about managing resources, and would have ownership over it, thus encouraging compliance and enforcement.

Primary contacts:

Jared Makaiau, Habitat Coordinator, Western Pacific Fishery Management Council
Frank Parrish, Pacific Islands Fisheries Science Center, Honolulu
Paul Bartram, Akala Products Inc.

[16] Paul Bartram could not be reached for this report.

III. North Pacific Fishery Management Council

Overview: The North Pacific Fishery Management Council (NPFMC) prides itself on using a precautionary, ecosystem-based approach to fisheries management. It points to its limits on bycatch, trawl closure areas to protect habitat, and reduced catch levels to account for uncertainty. Although it does not have an FEP, it has taken steps to integrate EBFM in its processes, with help from NOAA's Alaska Fisheries Science Center. These steps include an extensive Ecological Considerations chapter in its annual Stock Assessment and Fishery Evaluation (SAFE) reports, and substantial modeling efforts applying different types of models to different management questions. It has explicitly stated EBFM goals, and is reconstituting an Ecosystem Committee. However, despite these efforts, consideration of ecosystem factors remains ad hoc, and there is no mechanism for incorporating them into reference points and control rules for catch levels. Ongoing efforts at the Alaska Fishery Science Center could ultimately help develop these rules.

Description: The NPFMC maintains that it is developing and implementing EBFM now for its groundfish fisheries by applying conservative rules to its allowable catch, reducing bycatch and discards, establishing MPAs (primarily closed to trawling), and addressing concerns about marine mammals and seabirds. It is its own cheerleader for the relative success of its fisheries management, which by all accounts is better than the other regional councils. Few groundfish stocks have experienced overfishing or serious declines. While groundfish stocks remain healthy, the Council points to concerns about the impacts of fish removals on other components of the ecosystem as motivation to develop a more ecosystem-based management strategy.

In addition to reduced catches and bycatch provisions (see boxes below) NPFMC has closed large areas to bottom trawling and scallop dredging. This includes several areas closed in the Bering Sea, Gulf of Alaska and Kodiak Island to reduce crab bycatch and protect crab habitat (although this was largely put in place after major crashes and fisheries closures occurred) and large areas off Southeast Alaska and the Aleutian Islands closed to protect corals and other habitat. Under intense pressure from environmental groups for many years, and court orders to improve analysis and management, NPFMC adopted measures designed to protect the endangered Steller sea lion. This includes spreading out the Total Allowable Catch for sea lion prey (pollock and Atka mackerel) throughout the year, and prohibiting fishing near rookeries to prevent local depletions. Other precautions have been adopted for some federally protected marine mammals and seabirds as well, such as requiring deterrent devices on longline vessels to discourage seabirds from grabbing bait and drowning, and establishing bycatch limits for the endangered short-tailed albatross. But many of these efforts have been reactive to mandates in federal environmental laws.

Some of the catch rules the NPFMC deems precautionary are:

- Rules are more conservative when less information is available.
- Maximum Sustainable Yield (MSY) is treated as a limit, rather than as a target.
- For most stocks, the acceptable biological limit (ABC) is based on a rate less than or equal to the mortality rate estimated to result in a biomass level of 40% of an unfished state (F_{40}). In the fisheries biology literature, this apparently is considered conservative.
- Annual catch limits defined by the Total Allowable Catch (TAC) may be set lower than the ABC, and actual catch may be even lower than TAC because of other regulatory requirements.
- In the Bering Sea/Aleutian Islands the total annual TAC for all species must fall within a range of 1.4 to 2 million tonnes. This is often significantly less than the sum of the ABCs of each stock.

Bycatch and discards measures are better than most other management councils:

- Bycatch and discards are counted toward the TAC for that stock.
- One of the most comprehensive observer programs in the country counts bycatch of "prohibited" species (salmon, halibut, herring, crab).
- When a bycatch limit for prohibited species is reached, fishing in that fishery stops for the remainder of the season.
- Gear restrictions and modifications have been implemented to reduce bycatch.
- An "Improved Retention and Utilization Program" requires that more groundfish species be retained. (While this reduces the amount of fish that gets tossed back into the sea, it doesn't necessarily reduce the amount of fish removed.)

In general, NPFMC maintains that its precautionary catch levels - based on what is precautionary for target species - will also be precautionary for the entire ecosystem by leaving a substantial portion of the biomass of each species in the system to minimize ecosystem effects. In other words "(i)f fisheries are managed sustainably using a precautionary approach, it is likely that the overall ecosystem processes, ecosystem integrity, and biodiversity are also protected to some degree."[17] However, some environmentalists believe catch levels are not precautionary enough, and a scientific report evaluating the Council's approach called it "ad hoc" and noted "...it is not clear

[17] Witherell, D., C. Pautzke, and D. Fluharty. 2000. An ecosystem-based approach for Alaska groundfish fisheries. ICES Journal of Marine Science. 57:771-777. p. 776.

how the magnitude of this downward adjustment...is chosen, how much of it is attributed specifically to ecosystem considerations, and whether there are specific grounds for believing the magnitude is enough for those purposes."[18]

The Alaska Fisheries Science Center (AFSC) seems to be trying to move things to a more holistic and systematic approach. Pat Livingston at the Center has spearheaded an effort in the past ten years to include ecosystem indicators in the annual SAFE Report. These reports typically provide the latest stock assessment information to managers to inform their decisions about catch levels each year. AFSC has added an Ecosystem Considerations chapter to the groundfish SAFE with data on a wide range of ecosystem components, including climate and oceanographic factors, habitats, and status and trends of seabirds, marine mammals, and other types of marine life. This information is referred to as ecosystem status indicators. The intent is to bridge the gap between the stock assessment and ABC recommendation processes, and the ecosystem concerns that should be considered in these processes.

A tremendous amount of information is included here. However, there appears to be almost no guidance or mechanism to translate this mountain of information into fishery management decisions. Integration and analysis is limited. The list of indicators is essentially data on different ecosystem components, not a targeted list of factors that capture the overall state of the ecosystem. Its use so far has been limited. Stock assessment scientists reportedly began using these ecosystem indicators starting in 2002 to assess how factors such as climate, predators, prey, and habitat might affect a particular stock. The information in this chapter is presented to stock assessment scientists at a stock assessment meeting, so that they are aware of the information and use it as they see fit. In addition, this information gets presented to the NPFMC Scientific and Statistical Committee (SSC)[19] at the time the TAC recommendations are made. Therefore, the SSC has the opportunity to introduce more precaution into the ABC if it wanted to. Moreover, ecosystem chapter information feeds into the Environmental Assessment required to set annual TACs. As noted in the 2005 SAFE Report, "(i)ndicators of concern can be highlighted within each (stock) assessment and could be used by the Groundfish Plan Teams and the Council to justify modifications of allowable biological catch recommendations or time/space allocations of catch."[20] But this reportedly hasn't happened yet. While some information is trickling into some stock assessments, it has generally not influenced management decisions, or has done so only on an ad hoc basis.[21] To date, no target reference points at the general ecosystem level are being used, other than keeping the sum of Allowable Biological Catch limits for each stock within an Optimum Yield range, and an overall limit on catch in the Bering

[18] Goodman, D., M. Mangel, G. Parkes, T. Quinn, V. Restrepo, T. Smith, K. Stokes. 2002. Scientific Review of the Harvest Strategy Currently Used in the BSAI and GOA Groundfish Fishery Management Plans. Draft Report Prepared for North Pacific Fishery Management Council. November 21. 2002. p. 7

[19] The Scientific and Statistical Committee is an advisory committee of the Council composed of academic and other scientists to advise the Council on scientific matters.

[20] North Pacific Fishery Management Council. November 2004. Appendix C. Ecosystem Considerations for 2005. NPFMC Bering Sea/Aleutian Islands and Gulf of Alaska SAFE.

[21] Livingston, P.A., K. Aydin, J. Boldt, J. Ianelli, and J. Jurado-Molina. 2005. A framework for ecosystem impacts assessment using an indicator approach. ICES Journal of Marine Science. (In press).

Sea/Aleutian Islands to ensure sustainable levels for commercial catch. These limits are not based on any particular understanding of impacts on the food web.

In addition to the Ecosystem Considerations Chapter, scientists at AFSC are working on a tremendous amount of ecosystem modeling. These include models that look at how climate affects pollock recruitment and models of trophic interactions, such as:

- EwE models in the Bering Sea, Gulf of Alaska, and Aleutian Islands
- Multi-species Virtual Population Analysis models in the Bering Sea and Gulf of Alaska (the latter undertaken by the University of Alaska at Fairbanks).
- Multi-species bycatch model looking at what nontarget species catches might increase or decrease based on different fishing strategies.

These models can help evaluate the potential effects of fishing on a fuller complement of marine life.

In 1996, NPFMC created an Ecosystem Committee to discuss approaches for incorporating ecosystem concerns into the fishery management process. However, according to its Chairman, Dave Fluharty of the University of Washington, despite developing a draft policy for ecosystem-based management, the Committee did not substantially influence management decisions. It went defunct in 2000 as NPFMC became distracted by other ecosystem-related requirements, such as meeting habitat protection requirements in the Magnuson-Stevens Act and satisfying the legal requirements resulting from Steller sea lion lawsuits. This Committee is being reconstituted in 2005, with a general mandate from NPFMC to advise the Council on ecosystem management as new policy initiatives from NOAA, the Magnuson-Stevens Act, and the U.S. Commission on Ocean Policy evolve. Dave Fluharty will chair this once again. Other members include a representative from the environmental group Oceana, two NOAA fisheries scientists, and two representatives from the fishing industry.

Primary contacts:

Dave Fluharty, University of Washington
Pat Livingston, Alaska Fisheries Science Center
Janis Searles, Oceana

IV. NOAA Fisheries Ecosystem Pilot Projects

NOAA Fisheries is moving forward with efforts to develop EBFM through a multi-faceted Ecosystem Pilot Project. This project has two basic approaches (1) developing the tools and technology to help us practice EBFM and (2) beginning the process in the four east coast regional Fishery Management Councils through stakeholder initiatives. In addition, an overarching NOAA-wide initiative called the Ecosystem Goal Team seeks to find ways to improve coordination within NOAA and with other agencies.

Ecosystem Goal Team

Overview: The Ecosystem Goal Team is a NOAA-wide initiative to coordinate among NOAA offices as the agency moves towards EBM. It seems to be feeling out how to move toward a regional EBM approach, using regional workshops and examining regional governance structures as a start.

Description: The Ecosystem Goal Team reflects the goal of NOAA Administrator Admiral Lautenbacher to change the stove-pipe nature of NOAA's many offices, while at the same time meeting one of the four goal areas outlined in his 2003 Strategic Plan, namely, to protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management. The Goal Team is an effort to link the living resources side of NOAA with the physical side, so that both can be considered in EBM. The effort includes, but goes beyond, fisheries. It encompasses nine program areas, most of which are cross-cutting and include more than one line office: fisheries management, protected species, coastal and marine resources, aquaculture, corals, habitat, law enforcement, ecosystem observations (data collection such as surveys) and ecosystem research.

The goal, according to one team member, is to ultimately realize the regional ecosystem governance structure outlined in the U.S. Commission on Ocean Policy Report.[22] Its first step has been to define ecosystems. At a 2004 workshop the team agreed to use a modified version of the Large Marine Ecosystems concept as the foundation, and from there, work with stakeholders and other agencies to identify nested sub-systems. How they are progressing is unclear. Reportedly, two regional workshops have been budgeted for 2005 -- in the North Atlantic and in the Gulf of Mexico – and additional workshops will be planned in other regions in subsequent years. The goal of the workshops is to bring all of the players together (state and local government agencies, community interests, NGOs, fishermen businesses, etc.) and identify issues in the region, inventory the resources that currently exist for management, identify additional needs, and find ways to coordinate and leverage. They hope that these efforts will build on the fisheries ecosystem pilot projects in the east coast Councils, and lead to a broader EBM effort. However, the manager of the overall Ecosystem Goal Team effort indicated that they are

[22] U.S. Commission on Ocean Policy. *An Ocean Blueprint for the 21st Century*. Final Report. Washington DC. 2004.

still exploring how to proceed. He did note that they are looking at existing regional governance models such as the Great Lakes and the Florida Everglades restoration to understand effective mechanisms.

Primary Contacts:

Jack Dunnigan, Ecosystem Goal Team Manager, NOAA
Steve Swartz, Ecosystem Observation Coordinator, NOAA

Technical Development: Guidelines, EcoGIS, and Decision Support Tools

Overview: This component of the project focuses on providing the tools necessary to conduct EBFM. Unfortunately, the effort to develop Guidelines has been sidetracked for now. Decision Support Tool development and the EcoGIS effort focus heavily on making computer modeling and data usable for managers. The Decision Support Tool effort in particular includes some of the top scientific talent at the NOAA Fishery Science Centers.

Guidelines Description: Initially, NOAA Fisheries apparently planned to develop Guidelines for the Councils on how to develop an FEP, and draft guidelines of some sort were developed. However, the effort has shifted and been somewhat derailed. The task became focused on EBM rather than EBFM, in an effort to broaden the scope. However, because there currently is no statutory requirement to implement EBM (or FEPs), it was "sensitive" to develop guidelines and NOAA officials halted their development. It is now characterized as "internal ruminations" on what NOAA would do if it did have the authority. However, there is some indication that they are quietly consulting with some constituents on this issue.

Primary contacts:

Steve Murawski, Ecosystem Pilot Project Manager, NOAA Fisheries
Ned Cyr, NOAA Fisheries

***EcoGIS Description*:** NOAA seeks to develop advanced GIS (Geographic Information System) capabilities that will support ecosystem management and meet managers' and scientists' needs. After an initial workshop in fall of 2004 to scope out needs and create an initial laundry list, a steering committee is now formed to focus on these questions. A short-term goal of this effort is to demonstrate the capabilities of GIS and how it can be useful for addressing management questions.

The committee includes ecosystem staff members of each of the four east coast councils involved in the Ecosystem Pilot Project, scientists from the Northeast and Southeast Fishery Science Centers, Steve Murawski (Ecosystem Pilot Project Manager), and Steve Copps of the Northwest Regional Office to share his perspectives on using GIS for their Essential Fish Habitat work (see below). This committee had its first meeting in

February 2005 with the goal of identifying a few applications of GIS that are of immediate management interest to the Councils and can help the Science Centers meet their needs as well. These projects include: (1) area characterizations (in terms of features like critical habitat, fishing effort, species abundance etc.) (2) bycatch hotspots and (3) fishing effort mapping and displacement analysis to determine instances where fishermen changed locations or switched fisheries in response to management, market or natural shifts. The EcoGIS staff will try to complete these projects with feedback from the councils and Science Centers over the next 12-18 months.

They also plan to complete a report that outlines databases that will be needed in the future for EBFM, the cost, and the future state of GIS work as it relates to EBFM needs. Ideally, they would also like to complete an assessment of data needs based on the quality of data that currently exists for analyses identified by managers and scientists as priorities. However, it is unlikely that this gap analysis will be completed within the 18-month-year time line left on this project.

Primary contact:

Tim Haverland, Project Manager EcoGIS, NOAA

Decision Support Tools Description: Six projects have been funded by NOAA Fisheries at various NOAA Fisheries Science Centers to explore and develop computer models and other tools to advance implementation of EBFM. In addition, a workshop on ecosystem-based decision support tools for fisheries management was held in February 2005 to bring together government and academic scientists to produce an integrated overview and needs assessment of science in support of EBFM and regional ecosystem governance models for fisheries. The workshop focused on 6 topics:

- Indicators and reference points
- Data and Information Needs
- Functional Relationships
- Models
- Science Supporting Governance Systems
- Social Science Aspects Supporting Ecosystem Approaches

For each, participants were instructed to address the current state of the art; experiences demonstrating how research in this discipline can inform EBFM; new data, models or information management systems that might be required; and changes in policy, governance, or science administration needed to more effectively inform EBFM. Organizers expect publication of the proceedings in a prominent fisheries journal.

The six projects funded are:

1. *A Critical Evaluation of Ecopath with Ecosim as a Tool to Identify Optimal Policies in Fisheries Decision Analysis.*

This project is a formal evaluation of EwE performance as a tool for identifying optimal policies. The investigators maintain that the value of EwE models for gaining a fuller understanding of the ecological processes that give rise to fish production is undisputed. However, according to their proposal, there is concern about the "enormous prediction uncertainty accompanying such a complex model," particularly when there are limited data on the dynamics of the food web components of an ecosystem. While some of these problems arise because of limitations in our knowledge of food web structure, according to the investigators, scientists familiar with the types of ecological interactions common in food webs note that many important processes are not well represented in EwE models.

In this project investigators will create three hypothetical ecosystems. Experienced modelers with no knowledge of these hypothetical ecosystems will be asked to develop EwE models of the systems. In addition, experienced stock assessment modelers will be given the same simulated information, and asked to develop single-species stock assessments for harvested stocks. Both sets of modelers will be given scenarios of changes in management, such as harvest restrictions or shifts in fishing gear, and asked to use their respective analyses to predict system responses. The performance of the EwE and single-species models will be evaluated. Two key aspects of the project design enhance the validity of the results: (1) the modelers chosen are people who are well versed in the models, so that any errors resulting are understood to be problems with the models themselves, not with the modelers (e.g. Carl Walters and Villy Christensen are participants in the EwE part of the test), and (2) the hypothetical ecosystems will include key variables that are known to be important in ecosystem functioning, but are unavailable or rarely used in EwE.

Primary contacts:

Chris Harvey, Northwest Fisheries Science Center
Phillip Levin, Northwest Fisheries Science Center
Timothy Essington, University of Washington

Other collaborators include:
Carl Walters, UBC
Villy Christensen, UBC
Ray Hilborn, University of Washington
Andre′ Punt, University of Washington
Steve Martell, University of British Columbia
Mary Ruckelhaus, Northwest Fishery Science Center
Thomas Wainwright, Northwest Fishery Science Center

2. Analytical Framework Development for EFH

This project builds on the process used in NOAA Fisheries' Northwest Regional Office to advise the Pacific Fishery Management Council on developing alternatives for an Environmental Impact Statement (EIS) on Essential Fish Habitat (EFH). This process created a decisionmaking framework such that science is interpreted for policy makers based on a comprehensive risk assessment of habitat and risks to habitat. The tool relied heavily on the use of GIS, including developing coastwide GIS databases of habitat types, habitat use, and fishing and non-fishing impacts. Models using the GIS databases addressed the major policy and management questions to be examined in the EIS: EFH identification and description, Habitat Area of Particular Concern designation, and impact minimization. An EFH model assessed the likely importance of habitats for each life stage of each managed species in the FMP based on all available data sources. The first stages of an Impacts Model were also developed, which focused on identifying the relative impacts of bottom trawls on habitats by incorporating a habitat sensitivity index, a habitat recovery index, and fishing effort data.

In this project, EFH is viewed as a segue to EBFM. The task is to now take these tools and make them more accessible to decisionmakers, allowing managers and policymakers to query the system. This part of the process has not yet begun.

Primary Contacts:

Steve Copps, NOAA Fisheries Northwest Regional Office
Waldo Wakefield, Northwest Fisheries Science Center

3. Ecosystem Attributes and Adaptive Approaches During Stock Rebuilding

Marc Mangel of the University of California Santa Cruz is leading this work with Alec MacCall of NOAA Fisheries Southwest Fisheries Science Center. This work focuses on developing new methods for examining stock recruitment relationships and rebuilding scenarios, considering ecosystem and climatological changes that are likely to alter rebuilding trajectories. Using Bayesian statistics, they apply mathematical models to consider:

- How to recognize physical, oceanographic changes such as regime shifts that impact fish stocks, so that management can change appropriately in response;
- Quantitative criteria for evaluating progress toward rebuilding, and whether rebuilding is occurring faster or slower than expected;
- How to construct fishing mortality strategies (e.g. catch rates) to rebuild a stock given uncertainties affecting population dynamics;
- The nature of rebuilding targets in a multispecies fishery.

Primary contact:

Marc Mangel, University of California Santa Cruz

4. Development of Quantitative Performance Indicators for Ecosystem Management

Josh Nowlis at the Southeast Fisheries Science Center is heading this effort, which includes a graduate student at the Rosenstiel School of Marine and Atmospheric Sciences. He envisions three parts to this project, which focuses on clarifying uncertainties and tradeoffs in EBFM, and considering the reality of how people make decisions in the face of uncertainty and risk. The first part of the project is a concept paper that draws on classic ecological literature to highlight that in EBFM, we can't have it all. That is, we can't manage to maximize or optimize for everything. Often the tradeoffs involve short-term risk (such as economic impacts on fisheries from precautionary catch levels) or long-term risk (such as impacts on the stock and other ecosystem components from high catch levels). The paper will explore the nature of these tradeoffs and build on this with insights from the economic literature on the psychology of risk taking in people. That is, it will examine how people respond to risk, under what conditions they will take risks and under what conditions they will be risk averse. This understanding can help scientists adequately communicate risk to managers.

These concepts will also be explored in a modeling exercise that seeks to clarify the uncertainties inherent in large complex ecosystem models. By focusing on simpler models exploring interactions among four or fewer species, this exercise highlights the challenges of understanding interactions and will help identify areas where larger ecosystem/food web models can result in inaccuracies and uncertainty as more variables are estimated. It will also try to identify ecological patterns that lead to particularly sensitive, or particularly robust interactions among competing fisheries. In addition, focusing on Caribbean dolphinfish, the model will include a spatial component that tries to overcome the challenges of patchy databases, by using existing data to draw ecological inferences about where dolphinfish are likely to be found in the larger Caribbean and Atlantic region.

Ultimately, the goal includes incorporating performance measures into the model that characterize the tradeoffs involved in EBFM, by presenting outcomes in terms of probabilities or likelihood of occurring. Currently, most models don't include values for how likely an outcome is.

This is a multi-year project just getting started. NOAA funding covers only one year.

Primary contact:

Josh Sladek Nowlis, Southeast Fisheries Science Center

Other collaborators:
Kristin Kleisner, Rosenstiel School of Marine and Atmospheric Science, University of Miami
Carlos Rivero, Southeast Fisheries Science Center
Clay Porch, Southeast Fisheries Science Center

5. Ecosystem-Based Decision Support Toolbox

Researchers at the Northeast Fisheries Science Center are using the current suite of standard tools available for stock assessment as the conceptual model for what sorts of tools should be available and accessible for EBFM. After decades of development, single-species stock assessment techniques include well-established model structures with biological reference points, and standardized software with well established protocols for quality assurance. No such tools yet exist for EBFM, which is still being developed conceptually. This project will seek to provide convenient interface tools for accessing validated software packages for ecosystem-level analysis, while contributing to the conceptual development of EBFM through new modeling approaches and associated reference points.

It will involve a phased, modular approach. The phased approach will consolidate and make available existing software tools relevant to EBFM, while incorporating new model structures and management concepts as they emerge. The modules reflect the development of tools in four areas (1) multispecies dynamics, (2) habitat dynamics (3) ecosystem processes and energy flow and (4) indicators of ecosystem change. Developing tools in these separate areas serves two functions. First, considering a variety of models along a spectrum of complexity allows an examination of tradeoffs in complexity and uncertainty. (More complex models have higher levels of uncertainty, as additional variables have to be estimated.) Second, modular tools allow more detailed analysis of certain ecosystem components, which can be useful in making some management decisions. The multispecies dynamics component is most fully developed already, with existing models that are used in various NOAA Fisheries Science Centers that can be included in the toolbox. Tools for characterizing change in ecosystem indicators will also be included.

A single user interface will allow users to access all of these models. The analytic capabilities will be expanded as new modeling approaches emerge, and it will encompass those developed at other science centers over time, including EwE models. The project also includes a conceptual component. This component will examine options for operational guidelines and objectives for EBFM, including recommendations for reference points that are linked to the toolbox models and indicators.

This is a multi-year project. Current funded efforts will set the stage for future development.

Primary contacts:

Michael Fogarty, Northeast Fisheries Science Center
Jason Link, Northeast Fisheries Science Center

Other collaborators:
John Brodziak, Northeast Fisheries Science Center

Thomas Noji, Northeast Fisheries Science Center
William Overholtz, Northeast Fisheries Science Center

6. *A Spatially-Explicit Ecosystem Model to Examine the Effects of Fisheries Management*

This project is creating a model of the Northern California Current to examine ecosystem and population-level impacts of different fisheries management scenarios. Although an EwE model of the California current exists (developed by John Fields as a dissertation under Bob Francis at the University of Washington), the team is adapting an Australian model –ATLANTIS - to incorporate physical and spatial components in a way that EwE cannot. Developed by CSIRO in Australia, ATLANTIS incorporates not only food web interactions (initially drawn from Fields' EwE model) but integrates physical oceanographic and climatic factors, chemical factors, and fisheries dynamics in a spatially-explicit fashion. Spatially explicit sub-models simulate light and temperature driven changes in water and nutrients, biogeochemical factors driving primary production, food web relations among groups, and represent exploited species at a level of detail allowing evaluation of the direct effects of fishing. There are plans to have a socioeconomic component as well, but this has not been developed yet.

The team will consult with the Pacific Fishery Management Council to identify a list of management actions planned or proposed that could be simulated by the model. This is expected to include closing some areas to trawling and redistributing effort among others. This effort will provide an approach for estimating the effects of management on ecosystems and will help identify research necessary to reduce uncertainty. In addition, they will examine how these various management actions influence a number of ecosystem indicators such as average trophic level, diversity index, benthic habitat complexity, reproductive success of birds and mammals, fish biomass, and more. This work could provide insights into developing ecosystem reference points.

A pilot may be up and running by summer, but it will be at least a year before it will be ready to demonstrate to managers.

Primary contacts:

Phillip Levin, Northwest Fisheries Science Center
Timothy Essington, University of Washington

Other collaborators:

Chris Harvey, Northwest Fisheries Science Center
Elizabeth Clarke, Northwest Fisheries Science Center
Anthony Smith, CSIRO Marine Research
Elizabeth Fulton, CSIRO Marine Research

East Coast Council EBFM Pilot Projects

Overview: These pilot projects will force most of these Councils – the New England Fishery Management Council (FMC), the Mid-Atlantic FMC, and the Gulf of Mexico FMC -- to take the first steps towards implementing EBFM. The project focuses solely on the relatively painless, but critical first step of getting stakeholder input on goals and objectives for each ecosystem. Discussions with staff and members at three of these Councils suggest that most Council members are unfamiliar with EBFM at this point and are moving forward primarily because of funding and instructions from NOAA Fisheries. Very little activity has taken place so far at the Council level beyond limited efforts to educate Council members on EBFM through presentations, and Councils have not yet clearly defined their own goals for this process. The exception is the South Atlantic FMC, which had already embarked on an effort to transform their EFH FMP into an FEP. While the South Atlantic efforts include the items listed below, their advanced efforts go far beyond this and are discussed separately, in section V.

Description: Stakeholder participation is generally recognized as a critical component of EBFM, particularly in setting management goals and identifying needs. The NOAA Fisheries FMC Pilot Project focuses on this as a first step towards developing regional FEPs. It has four components: (1) an attitudes and values survey (2) public meetings with stakeholder groups for each regional Council, (3) a technical needs assessment, and (4) synthesis into a strategy for FEP development. Each Council must prepare a final report addressing each component. Each of the four regions received $225,000 to use through the end of calendar year 2005. Funding reportedly has not been secured for 2006. Each Council has hired or appointed staff as point person on EBFM, and has created an Ecosystem Committee to oversee the process.

Attitudes Survey: The attitudes survey is being developed at the national level by economists at NOAA Fisheries' Office of Science and Technology and other staff economists, with input from the Councils. Stakeholders in each region will respond to the same national survey. Project planners originally had hoped to design a survey that explicitly examined tradeoffs in EBFM, to identify what choices people would make between various goals and values. But after a preliminary workshop with Council staff in fall 2004, they determined that there was so much variation in perceptions about EBFM, and so little true understanding of it even in the Councils, that they substantially adjusted their survey goals. The survey now is designed to identify what people think is important, including what objectives they would like fisheries management to address, how management is doing now, and what they think EBFM can address. The survey includes a description of EBFM in the last section and then asks people specific questions to identify their expectations for EBFM. Ultimately, the survey staff would like to conduct follow-up surveys, including one in a more knowledgeable region like the South Atlantic, that address more explicit questions about tradeoffs. This work will depend on funding.

Council staff and members provided input on the survey questions, and as of spring 2005 the draft was at OMB waiting approval. Once it receives approval (within 6 months), it

will need to be pretested and revised in a focus group before being mailed to stakeholders.

Primary Contact:

Kristy Wallmo, Office of Science and Technology, NOAA Fisheries

Public meetings: Each Council is required to undertake a series of public meetings seeking input on ecosystem objectives for fisheries management from the full spectrum of stakeholders. Topics to be discussed include the adequacy of current approaches, specific issues that should be addressed in an FEP, and the nature of EBFM, among others. This is the main activity in the hands of the Councils.

The New England Council has hired a new staff person to oversee their EBFM work and expanded the duties of its Habitat and MPA Committee to include EBFM. This Committee has focused recently on a huge omnibus habitat amendment. It met to discuss EBFM for the first time in early spring 2005. Committee Chair Sally McGee of Environmental Defense (the only conservation NGO representative on a regional FMC), is concerned that EBFM will be competing for Council members' attention with important work underway on the habitat amendment. Fortunately, as a new hire specifically for this purpose, Chad Demarest will be able to focus his attention on EBFM initiatives. He has been active in various NOAA EBFM workshops and introduced the pilot project to the Council in February 2005. He expects public hearings to start in the summer and run through the fall. (In addition, separate from the pilot project, the New England FMC Research Steering Committee is planning to direct future research funds toward EBFM work.)

The Mid-Atlantic Council has assigned an existing staff person, Tom Hoff, Fishery Management Specialist, to be EBFM point person. An Ecosystem Committee was created in fall 2004. Since then, staff have been educating Council members on the Committee about EBFM, bringing in speakers from NOAA (including project head Steve Murawski) and the Chesapeake Bay effort. Tom has participated in various NOAA Fisheries EBFM workshops, including the survey and decision support tool workshops, and is reporting back to the Council about these initiatives. Council staff hope that hearings will start in late summer, and that hearings can be structured in a way to maximize their usefulness, overcoming the challenges of discussing such a broad complex subject. The chair of the new Ecosystem Committee, Charles Witek, noting the complexities of EBFM, has indicated that he hopes that the public meetings serve a true scoping function and examine the question of whether we can even do EBFM, in addition to exploring objectives.

The Gulf of Mexico has assigned existing staff person Steven Atran, Population Dynamics Statistician, to oversee EBFM efforts. So far they have created an Ecosystem Scientific and Statistical Committee, but as of late winter 2005 it had not yet met. Steve has participated in the NOAA EBFM workshops related to the survey and decision

support tools, and like Chad and Tom is on the steering committee for the EcoGIS effort. However, little other activity had occurred as of late winter 2005.

Technical Needs Assessment and Synthesis: There seems to be some confusion about how the technical needs assessments will get done and who will take the lead. Councils stress that they need the expertise of the Fishery Science Centers to advise on this, however, no formal process to coordinate had been developed as of late winter 2005. Councils have focused instead on organizing for the public meetings and trying to educate themselves.

Primary Contacts:

New England:
Chad Demarest, New England FMC Ecosystem Coordinator
Sally McGee, Chair Habitat and Ecosystem Committee

Mid-Atlantic:
Tom Hoff, Mid-Atlantic FMC, Fishery Management Specialist
Charles Witek, Chair Ecosystem Committee

Gulf of Mexico
Steven Atran, Gulf Council, Population Dynamics Statistician

V. South Atlantic Initiatives

South Atlantic Fishery Management Council FEP process

Overview: The South Atlantic FMC (SAFMC) is part of NOAA's four EBFM Pilot Projects, but is well ahead of the other three regions in moving forward. While the Pilot Projects as designed by NOAA Fisheries focus on getting stakeholder input and identifying technical needs, the SAFMC effort is using the opportunity to update its comprehensive habitat plan as a way to develop an FEP. The Council finalized an Action Plan in August 2004 that outlines how they intend to proceed and appears to be moving forward enthusiastically. Like all FEPs to date, this one will have gaps in information and understanding, and how information will be incorporated into fishery management decisions remains unclear. Perhaps most interesting about the South Atlantic is their ongoing efforts to coordinate management across agencies throughout the region and move towards a true regional approach.

Description: SAFMC is proceeding with updating and converting its 1998 Habitat Plan and Comprehensive Amendment addressing Essential Fish Habitat in Fishery Management Plans into an FEP with a goal of completing an initial FEP by the end of 2005 or early 2006. The Council created an Ecosystem Management Committee comprised of the chairs of all the other Council committees, to oversee development of the FEP. This structure was enacted so that decisions and approaches agreed to at this level could be taken back to the specific species level committees for incorporation into their activities.

Multiple workshops in 2003 and 2004 allowed the Council to integrate and update habitat, life history, and stock status information. Writing teams composed of Council staff, experts from universities and state and federal agencies, and Council Advisory Panel members, will review, update, and expand existing chapters of the Habitat Plan and incorporate this material into new chapters for the FEP, starting in 2005. The FEP will be used to develop a comprehensive Amendment/EIS for all FMPs.

The FEP action plan tracks the eight elements of an FEP laid out by the EPAP report, with some modifications, and indicates that it is taking action to fulfill some of the recommendations, while identifying critical research and monitoring needs to meet others. The plan emphasizes repeatedly where it needs additional resources to effectively carry out EBFM. It's unclear where these resources will come from at this point.

SAFMC has moved forward on a number of fronts, including substantial development of web capabilities to connect and access the spectrum of databases available on the South Atlantic ecosystem, partnering with other institutions such as The Nature Conservancy and the Florida Fish and Wildlife Research Institute for development and design of these capabilities. They are also undertaking cooperative mapping of coral habitat in partnership with the National Undersea Research Center at the University of North

Carolina at Wilmington. The initial focus will be on deepwater corals but they hope to expand mapping to other habitats with significant additional funds.

The Council has put efforts to develop a conceptual model of the food web through the development of an Ecopath model on hold because of funding constraints. They have held initial workshops, and they hope to use preliminary results from early models developed several years ago with UBC people. However, further development will likely not occur in 2005. In addition to providing insight into ecosystem function, they hope the Ecopath model will help identify long-term research needs to better understand interrelationships. The process to date seems to have involved scientists with a variety of expertise. The area to be modeled covers an extensive area from Cape Hatteras North Carolina through the Florida Keys, extending from the upper wetlands to a water depth of 300 meters off the shore. They hope to refine the model further with embedded submodels for key areas of interest such as the Oculina Bank Habitat Area of Particular Concern, the Keys, deepwater snapper grouper habitat, and Albemarle-Pamlico Sound.

In addition, they will hold at least two research and monitoring workshops in 2005 and 2006 to examine research needs for deepwater corals and larger ecological questions, bringing in people from The Nature Conservancy and UBC, among others, to explore these questions with them. Their research plan for EBFM will also include existing research plans for Oculina and other important habitat areas. SAFMC has a social anthropologist on staff that is compiling baseline social data to help identify future needs. A particular issue of interest is learning how fishermen switch their fishing activities in response to management measures, and exploring how to limit access.

To comply with the stakeholder input requirements of the Ecosystem Pilot Project funding, starting in 2004 all Council meetings that are open to the public have included an opportunity for public comment on EBFM. This includes meetings of both the Advisory Panels and the full Council. As required under the NOAA grant, they will compile all of the input in one place. By incorporating public input on EBFM in the context of specific topics being discussed at substantive meetings, rather than generally, SAFMC staff hope that this input will be more useful and meaningful. In addition, once the FEP is developed there will be extensive public hearings.

Two things stand out in conversations with SAFMC contacts: the strong importance the Council places on habitat protection as a basis for protecting fish stocks, and its coordination with other management bodies and agencies. For example, the Habitat Advisory Panel consists of representatives from other relevant state and federal agencies, and this panel generates policy statements on a variety of ecosystem issues beyond fisheries, such as beach erosion, oil and gas development and more. These policies typically are consistent with state policies, at times forming the basis for new state policies. This is perhaps most pronounced in the connection between North Carolina's Coastal Habitat Protection Plan (see below) and the SAFMC habitat plans that form the foundation for this. These efforts are a first step towards a regional approach to management. In addition, the Council is doing outreach to other agencies on some issues, such as meeting with agency staff in the state of Georgia to discuss EFH

requirements and provide information for use in permitting decisions for coastal development.

Primary contacts:

Roger Pugliese, Senior Fishery Biologist, SAFMC
Bill Cole, Chair of SAFMC Ecosystem Committee, U.S. FWS,
Doug Rader, SAFMC Habitat Advisory Committee chair, Environmental Defense

North Carolina's Coastal Habitat Protection Plan

Overview: North Carolina's Coastal Habitat Protection Plan reflects a coordinated effort among three state environmental regulatory commissions to protect fish habitat throughout the state. Recommendations are general, and the extent to which these agencies will effectively coordinate management to protect habitat remains to be seen.

Description: As a result of North Carolina's 1997 Fisheries Reform Act, three state regulatory commissions – the Environmental Management, Coastal Resources, and Marine Fisheries Commissions – developed and recently approved a Coastal Habitat Protection Plan to protect and restore fisheries habitats. The plan represents a coordinated effort among these three regulatory bodies, and includes information on the description, distribution, function, status and trends of important habitats; threats to those habitats; and recommendations to address the threats. The recommendations cover a wide range of strategies including no-take sanctuaries, protective buffers, improving water quality, and addressing shoreline stabilization and erosion. However, the plan is primarily a framework or umbrella document and recommendations are very general. The next step is to develop more specific implementation plans.

This state initiative includes two key components of ecosystem-based fisheries management: coordinated management among agencies and a holistic approach to habitat. The habitat covered includes all of the basic fish habitat types in the state and all eight of the river basins that drain the coast of North Carolina. However, it does not address other aspects of fisheries management, such as catch levels.

Primary contacts:

Doug Rader, Environmental Defense
Michele Duval, Environmental Defense

VI. California's Marine Life Management Act

Overview: California's Marine Life Management Act (MLMA) has introduced key EBFM concepts to California's management of its state fisheries. To date, four fishery management plans have been developed under the MLMA, including one for the previously unmanaged nearshore fishery. This plan incorporates a unique precautionary approach to fisheries management, developed by leading conservation scientists specifically for the MLMA, and designed to guide fisheries management from the current data-poor environment to data-rich environments with better ecosystem information. Other FMPs for white seabass and squid have been less consistent with the precautionary EBFM goals expressed in the MLMA. MLMA is connected closely with the Marine Life Protection Act (MLPA), relying on the MLPA process to address the need for MPA and marine reserves identified in MLMA fishery management plans. Despite severe state budget constraints, a network of private and public funders, research institutes and universities, and conservation groups have managed to keep this process moving forward. This includes monitoring and research on habitats, life history, fish abundances, and the benefits of MPAs.

Description: The MLMA became law on January 1, 1999, requiring that state fisheries adopt an ecosystem approach to management. It calls for comprehensive Fishery Management Plans (FMPs) to be developed for all of the state's major recreational and commercial fisheries to address habitat, bycatch and discards, overfishing and rebuilding, and basic fishery conservation measures, among other things. As a starting point, the MLMA called for the adoption of FMPs for the nearshore finfish fishery and the white seabass fishery, both of which have been completed to date. Other legislation calls for a squid management plan and an abalone recovery and management plan, which are completed or near completion. A Master Plan concluded that additional top three priorities for FMPs are sea urchins, California halibut, and nearshore sharks and rays. However, as of early spring 2005 there were no official plans to develop these FMPs.

MLMA goals:

- Conserve entire systems, not just exploited populations of marine life.
- Recognize non-consumptive values including aesthetic and recreational enjoyment, scientific study and education.
- Ensure that uses of fisheries and other marine life be sustainable so that long-term health is not sacrificed for short-term benefits.
- Maintain, restore, or enhance habitat of marine wildlife and minimize damage.
- Restore depressed fisheries.
- Limit bycatch to acceptable types and amounts.
- Recognize the long-term interests of people dependent on fishing and minimize adverse impacts of management measures on fishing communities.

Nearshore FMP: The quality of these plans is mixed. Conservationists agree that the Nearshore FMP is a top example of EBFM as outlined in the MLMA, and the abalone

recovery plan is on target. But the white seabass and squid plans fall far short. The Nearshore plan says all the right things about conserving the health and diversity of marine ecosystems and marine living resources through an ecosystem approach to management, considering species diversity, species interactions, food webs, and community structure; and ensuring that target catch levels reflect expected oceanographic conditions. It explicitly calls for MPAs to protect and restore ecosystems and help restore depressed fish populations. It also calls explicitly for identifying key habitats for nearshore species, and minimizing harmful fishing activities. It establishes a framework for adaptive management based on regular review of the management of the fishery. And the goals and objectives reportedly reflect consultation with constituents through various public meetings, meetings with advisory committees, a peer review panel, and the submission of public comments.

But the real meat of the EBFM process is the control rule. To meet its sustainability goal, the Nearshore FMP relies heavily on a precautionary fishery control rule process developed by conservation scientists Les Kaufman of Boston University, Burr Heneman of Commonweal, J. Thomas Barnes of California Department of Fish and Game and Rod Fujita of Environmental Defense.[23] This approach applies a precautionary rule to catch levels when uncertainty is high, which diminishes as uncertainty is reduced with increased scientific understanding. It identifies three tiers of information: Stage I reflects a data-poor environment, in which very little is known about the fishery, fish species' life history, and ecosystem effects of the fishery. At this stage so little is known about the effects of fishing that the allowable catch is set at a very precautionary level. For example, the Nearshore FMP identifies a precautionary level of essentially one-half of the proxy MSY (the proxy being average catch history in years when it appears abundance was not declining.)

At stage II moderate information is available, such as adequate abundance, density, recruitment, mortality, stock productivity, life history, landings, and habitat information that supports improved single-species management. But ecosystem effects are still largely unknown. The additional information on the fishery permits the allowable catch level to be less precautionary and may allow it to increase from stage I levels.

At stage III, substantial information on the fishery, ecosystem effects, and oceanographic information exist. This stage allows for the least precautionary approach as uncertainty is reduced. The Nearshore FMP notes that Stage III concepts have not been extensively researched or applied in practical management and so it does not anticipate a timetable for implementation.

Information on most of the nearshore species is very limited. For example, population size was not known for any species in the nearshore fishery at the time the FMP was developed, and information was largely limited to catch history and partial life history information. The California Department of Fish and Game (DFG) and the Fish and

[23] See Kaufman, L., B. Heneman, J.T. Barnes, and R. Fujita. 2004. Transition from low to high data richness: an experiment in ecosystem-based fishery management from California. Bulletin of Marine Science. 74(3): 693-708.

Game Commission reportedly have largely stuck to the control rule approach for the nearshore fishery in the face of limited information, and defended it against criticism. DFG has moved forward with implementation to complete stock assessments for several nearshore species that previously had no assessment, including California sheephead, cabizon, and black rockfish, helping to move these stocks out of the data-poor category.

In contrast, the white seabass and squid plans do not set precautionary catch levels as spelled out in the nearshore control rule. According to those familiar with MLMA activities, the difference appears to be politics. The makeup of the Fish and Game Commission that decides management measures was less favorable when the white seabass and squid plans were developed, suggesting that the effectiveness of MLMA depends heavily on who sits on the Commission.

Other important aspects of the Nearshore FMP are research and MPAs.

Research - CRANE and PISCO: The Nearshore plan was the impetus for a state coordinated survey and research program referred to as CRANE – Cooperative Research and Assessments of Nearshore Ecosystems – a cooperative effort among academics and federal agencies at the Channel Islands. CRANE started three years ago as the Nearshore FMP was developed, as a way to move the fisheries from "data-poor" to "data-rich". It consists of diver-based surveys of fish, invertebrates, algae and subtidal and nearshore habitats, along with physical characteristics, using standardized protocols. The goal is to have a coastwide survey to provide a baseline for what exists now, and potentially become a time series of changes over the years. Currently, about 90 sites are surveyed as part of CRANE, focusing heavily on the central California coast and Channel Islands. The standardized protocols among the partners allow their datasets to be compatible, however, currently there is no single repository or mechanism to access all the data collected. Very little state money has gone into this. Instead, academic and other partners have largely provided the resources to conduct the surveys.

PISCO has been the largest contributor to this. PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) is a collaboration among researchers at four west coast institutions -- University of California Santa Cruz, University of California Santa Barbara, Stanford University's Hopkins Marine Lab, and Oregon State University. PISCO research focuses on a sampling program that examines how variability in physical ocean processes affect marine life. It includes a monitoring component to address what it characterizes as a major impediment to conserving marine ecosytems – fundamental lack of understanding about the basic processes that govern marine systems. Its monitoring component focuses on intertidal and nearshore communities and dovetails nicely with MLMA needs. It also provides its data to other state and federal management agencies that request it.

PISCO work on larval dispersal and marine reserve design also feeds into MLPA needs and PISCO researchers Steve Palumbi at Stanford, Mark Carr at University of California Santa Cruz, and Steve Gaines of University of California Santa Barbara sit on the Science Advisory Panel for the MLPA Blue Ribbon Task Force (see below).

Monitoring of the Channel Islands Marine Protected Areas is a major component of EBM in California. After years of public debate, the Fish and Game Commission adopted a network of 12 MPAs in state waters within the Channel Islands National Marine Sanctuary. These areas remain controversial in some quarters, and their success in protecting biodiversity, providing useful scientific information, and possibly enhancing fisheries is considered critical for maintaining forward momentum on establishing MPAs in California. A monitoring plan has been developed with input from the scientific community and stakeholders to determine the effects of MPAs on species, ecosystems and fisheries in the northern Channel Islands Area. The plan includes dive, gear, ROV, and submersible surveys, as well as aerial monitoring and intertidal monitoring. Fisheries data from landing receipts, logbooks, and dockside surveys are part of this. This is a coordinated effort between the state and academic institutions. Much of the CRANE effort focuses here, including work by PISCO.

Other important components of MLMA implementation are GIS habitat mapping and fisheries characterization. DFG is collecting data on different habitat types, where they exist, and various baseline data associated with them. They are standardizing this information in a habitat classification scheme and pulling it together in one place. Some funding is going to academics to contribute to this. DFG is also compiling GIS data on fisheries, including where catches are occurring.

MLPA and MPAs: MPAs, combined with a precautionary control rule, are the primary mechanisms in the Nearshore FMP for addressing ecosystem protection. The plan defers to the MLPA process to establish a network of MPAs in California. The Nearshore FMP discusses factors that need to be considered in this process to ensure that nearshore fishery needs are taken into account, and calls for DFG and the Fish and Game Commission to annually review progress of the MLPA process in terms of the goals and objectives of the Nearshore plan.

Because of state budget shortfalls, implementation of the MLPA currently is occurring only through the donation of $7.5 million from the Resources Legacy Fund Foundation. Current activities are to develop a Master Plan and a pilot project along the Central Coast for a regional network of MPAs by December 2006. The pilot project work includes research and mapping of nearshore habitats, reportedly considering what needs will help implement the Nearshore FMP. In general, many of the people involved in implementing MLMA are also involved in implementing MLPA and the connection between the two is apparent in ongoing efforts.

Both the Master Plan and the Central Coast pilot project must be approved by a Blue Ribbon Panel overseeing the MLPA process, before going to the California Fish and Game Commission for implementation.

COPA: The California Ocean Protection Act (COPA) is the third state law in the California ecosystem troika. COPA creates an Ocean Protection Council composed of

the Secretary of Resources, the Secretary for Environmental Protection, and the Chair of the State Lands Commission, as a way to coordinate management among land, sea and air. Their first meeting was scheduled for spring 2005, and it's unclear at this time how this will work.

The Ocean Protection Council will be staffed by the Executive Officer of the State Coastal Conservancy, Sam Schuchat. About $10 million in COPA money is available for coastal projects over the coming year. Some projects being considered by the Coastal Conservancy to be put before the Ocean Protection Council include funding for CRANE, benthic mapping of central California to assist in MLPA efforts, and ocean observing systems.

Primary contacts:

Michael Weber, consultant and Senior Project Manager, Blue Ribbon Task Force for the California Marine Life Protection Act Initiative
Tom Barnes, California Department of Fish and Game
Burr Heneman, Commonweal

VII. Implementation Efforts in New England

The Downeast Initiative

Overview: The Downeast Initiative is a "bottom up" effort to improve federal management of groundfish by improving understanding of the ecology of groundfish, particularly cod, and applying local place-based management. It is driven by a consortium of fishermen in Downeast Maine, regional scientists, and conservationists concerned about localized depletion of cod stocks and management proposals that prohibit local Downeast fishermen from re-entering the fishery once stocks recover. Their proposal would fundamentally alter current federal management practices in New England that lump cod together in setting regional catch limits and allow pulse fishing throughout the region; while introducing the idea of local control to federal fisheries management. This initiative faces an uphill battle because it seeks to limit the access of large trawlers.

Description: The goals of the Downeast Initiative are long-term restoration of the groundfish stock and the development of a governance structure that gives local fishermen access to stocks and creates stewardship incentives. The details of how to achieve these goals are still being worked out, but the approach involves scientific research to better understand groundfish/cod ecology, community outreach with fishermen and others, and dialog with the New England Fishery Management Council (NEFMC). The group has some funding from the Kendall Foundation to advance their cause.

There are two central tenets to this effort. One is the emerging scientific thinking that some cod remain local residents in particular locations, creating separate stocks from the larger Gulf of Maine stock. This trait means that the traditional fishery management regime in New England, which sets catch levels throughout the entire Gulf, allowed the localized depletion of these separate stocks as boats moved to wherever they could find fish and then fished out those areas. The other is that local Downeast Maine fishermen should have primary access to cod in their area once these stocks recover. Groundfishermen in this area have small boats that force them to fish close to shore. They switched to lobster fishing when local stocks collapsed, and under the current management regime would be cut out from participation in the groundfish fishery because they have not been participants in this fishery for the past decade.

Representatives of the Initiative met with NEFMC staff in February 2005 to present their ideas and are revising them based on input they received. They continue to conduct outreach with Downeast fishermen for their input and buy-in, as well with fishermen from other parts of New England who fish in the area. They would like to establish the Downeast area (from Monhegan Island to the Hague line and Eastport, ME) as an experimental area for three years or so, during which time they would conduct scientific research, have some control over fishing, and develop a long-term plan for management.

Their challenge is devising a governance structure that gives local fishermen some control (much like Maine's lobster zones which are co-managed by fishermen and the state), provides them with primary access to local groundfish stocks and recognizes the ecology of the stocks, while overcoming inevitable opposition from outside fishermen. In short, their vision is to establish a management regime that recognizes local stocks and limits the mobility of larger trawlers from other regions, in order to protect stocks from pulse fishing and the depletion of forage species like herring.

Scientific workshops were started in December of 2004 to identify research questions related to oceanography, genetics, and behaviors of groundfish as well as socioeconomic studies, and to identify the most critical conservation questions. Scientists involved in the effort are also developing a white paper that presents the scientific argument for local stocks and the need to recognize local ecosystems and local conditions. This paper will be used in discussions with NEFMC as well as with NOAA and other potential funders. The University of Maine reportedly may seek a congressional earmark for funding some of this research.

The coalition includes an impressive and diverse list of players, including Jim Wilson, a professor of economics at the University of Maine; George LaPointe, Commissioner of the Maine Department of Marine Resources; Robin Alden, former Commissioner of the Maine Department of Marine Resources; Dennis Damon, state senator and Chair of the Joint Standing Committee on Marine Resources, numerous fishermen and a variety of scientists including Les Kaufman at the University of Boston. The primary conservation representative is Jennifer Atkinson of the Quebec-Labrador Foundation, however, the group is reaching out to other conservation groups as well. They recently hired a former staffer of Congressman Tom Allen, Jennifer Brewer, to conduct lobbying for them and help with outreach to the congressional delegation and NOAA Fisheries.

Primary contacts:

Jim Wilson, University of Maine
Jennifer Atkinson, Quebec – Labrador Foundation
Heather Deese, Northwest Atlantic Marine Alliance

Cooperative Research: NAMA Fisheries – Ecosystems Project and the Fishermen's Initiative for Scientific Habitat and Ecosystem Research (FISHER)

Overview: These are two different initiatives with a similar goal: to get scientists and fishermen talking to one another and create a shared understanding of what information is needed about fisheries in New England to move towards EBFM. They are both efforts to bridge the gap between scientists and fishermen and increase trust. Many see this as key step in moving toward EBFM.

Description:

NAMA Fisheries – Ecosystems Project: The Northwest Atlantic Marine Alliance (NAMA) is coordinating discussions between scientists and fishermen in two different sets of meetings looking the Western Gulf of Maine inshore fisheries, including Stellwagen Bank, Jeffrey's Ledge and inshore basins and harbors; and the broader Gulf of Maine fisheries. The project is focused on sharing knowledge to help identify which relationships and environmental factors are key for fisheries and their management, and what kind of science we need to move towards EBFM. It is viewed as a way for both scientists and fishermen to own the process and buy into research. As of late winter 2005, two of three meetings had been held on the Western Gulf of Maine inshore fisheries, and one meeting had been held for Gulf of Maine fisheries. The products of these meetings will include descriptions of ecosystems in illustrations and maps. These products will be used for discussions with policymakers and to build a common understanding of future research and management needs to move towards EBFM. NAMA is partnering with University of New Hampshire Coastal Ocean Observing and Analysis Group and the Gulf of Maine Ocean Observing System for these workshops. Workshop participants include a diverse mix of fishermen and academic and agency scientists with different types of expertise.

Fishermen's Initiative for Scientific Habitat and Ecosystem Research (FISHER): The Massachusetts Fishermen's Partnership is coordinating a research initiative that draws on both fishermen's and scientists knowledge to encourage collaboration and promote an ecosystem-based approach to fisheries management. Funding is provided separately by a variety of sources, but FISHER guides research by outlining goals of the program and facilitating cooperative research.

The goals of the FISHER program are to:

- Examine the role of sand eels in the marine ecosystem in and around Stellwagen Bank and the Massachusetts Bay area;
- Explore areas of common interest between scientists and fishermen and build strong research partnerships between them;
- Jointly conceive, prioritize, develop and review research projects, products and reports to increase levels of confidence in data sets and results for scientists, fishermen, and managers;
- Coordinate scientific research to avoid replication of effort and maximize use of resources; and
- Create new opportunities for expanding funding for collaborative ecosystem research based on the strength and breadth of this collaboration.

Several projects have been funded to date under the auspices of this program:

1. An Examination of Biological Processes of Sand Lance and Associated Species on Stellwagen Bank. This study looks at the ecology of sand lance to understand its possible role as a keystone species and understand its patterns and relationships. Sand lance are eaten by a variety of fish, marine mammals and

seabirds. Les Kaufman of Boston University, Cliff Goudey of Massachusetts Institute of Technology, and Captains Bill Lee and Phil Michaud are the investigators. They are using commercial fishing vessels as the research platforms.

2. Charting Anecdotal Information and Oral Histories from Local Commercial Fishermen. Local fishermen want to develop an accurate historical record of their use of Stellwagen Bank to serve as the basis for longer-term research and to inform development of the management plan for Stellwagen Bank National Marine Sanctuary. Investigators are Madeleine Hall-Arbor and Rhonda Rhyzner of Massachusetts Institute of Technology, and Captains Edward Barret, David Casoni, Phi Michaud, Tom DePersia, Bill Crossen, Jay Michaud and Lou Williams.

3. Habitat-Dependent Catch Composition and Food Web Dynamics with Respect to Long-Term and Rolling Closures on Stellwagen Bank. Les Kaufman of Boston University is working with Jason Link at the Northeast Fisheries Science Center and Captain Paul Vitale to examine the effects of trawling on food webs. They are comparing their survey catches over a variety of habitats in closed and open areas on Stellwagen Bank in the Western Gulf of Maine for differences. This includes examining food web characteristics such as food chain length and whether any given species or size class is higher in the food web than in comparable habitat outside of the closure. It will also compare data from year round closures with that from rolling closures. Food web analysis will involve looking at stomach contents and tissue isotope analysis (e.g. heavy nitrogen is enriched moving up the food chain). This information should inform fisheries management regarding the effects of closures, and may also contribute to ongoing research for ecosystem indicators.

Primary contacts:

Heather Deese, Northwest Atlantic Marine Alliance
Olivia Rugo, Massachusetts Fishermen's Partnership

Related EBM Efforts in New England

Although not specifically EBFM, these efforts in New England are ecosystem-based. They are described very generally here for possible future reference.

Stellwagen Bank National Marine Sanctuary: As part of its five-year management plan review process, Stellwagen Bank National Marine Sancutary created an Ecosystem Based Management Working Group. This group's final report recommended the creation of a Zoning Working Group to examine developing a zoning scheme that includes the use of fully protected areas in the Sanctuary. They also recommended a permanent ban on exploitation of sand eels to prevent a fishery on this forage species from forming, and raised the issue of maintaining an adequate forage base of species like herring, squid,

sand lance, and mackerel. In response, the Sanctuary has created a Zoning Working Group to begin work in spring 2005. The membership will most likely be the same as, or similar to the Ecosystem Group that developed the original recommendation. This group includes several fishermen, as well as scientists such as Les Kaufman, and conservationists such as Priscilla Brooks.

Primary contacts:

Priscilla Brooks, Conservation Law Foundation
Les Kaufman, Boston University
Ben Haskell, Stellwagen Bank National Marine Sanctuary

Massachusetts Ocean Management Initiative: In 2003 Governor Romney launched the Massachusetts Ocean Initiative as a way to comprehensively manage state ocean resources. The primary effort in this initiative has been a report completed by a Task Force charged with defining guiding principles for the use of ocean resources, examining state coastal policies and the adequacy of the legal framework, determining data requirements for managing state waters, and examining the organization of governance over state waters. The final report includes a list of general recommendations, including the need for a comprehensive Ocean Resources Management Act, the promotion of federal/regional/state cooperative ecosystem management, and a comprehensive ocean resources monitoring and research plan. As a result of this, a bill for a comprehensive ocean resource act that would mandate ocean management plans has been introduced in the state legislature (backed by Conservation Law Foundation and Massachusetts Audubon). Specific references to fisheries were explicitly left out of the bill because of turf and political battles. Bill proponents hope to shift the debate to more general values about sustainable development. The governor is expected to introduce a similar bill, and is creating a working group to examine criteria and a public process for designating MPAs.

Primary contact:

Priscilla Brooks, Conservation Law Foundation

Maine's Bay Management: Motivated by concerns about aquaculture and other changes in coastal Maine, the legislature called on the state Land and Water Resources Council to undertake a study of bay management. The Council was tasked with establishing goals and objectives for bay management, defining a range of approaches, establishing criteria and standards, identifying changes needed to regulatory structures, and identifying opportunities to create limited local authority for bay management. In addition to holding public meetings around the state, the Council is now funding two pilot projects for stakeholder groups to explore resource uses and methods for better management. These projects are: Muscongus Bay (overseen by the Quebec-Labrador Foundation and the Muscongus Bay Project Committee) and Taunton Bay (overseen by Friends of Taunton Bay). Very generally, these projects are compiling input from local residents about

issues of concern, characterizing the resources and their use in the area, and exploring community-based management approaches.

Primary contacts:

Jennifer Atkinson, Quebec – Labrador Foundation
Heather Deese, Northwest Atlantic Marine Alliance (and serving on the Bay Management Project Steering Committee)

VIII. Other Ecosystem Efforts

San Juan County Marine Resources Committee

Overview: San Juan County in Washington State created a Marine Resources Committee in 1996 in response to public concern, to address a series of marine resource problems. Since then, the Committee has initiated several projects to address bottomfish recovery and forage fish protection. Currently it is undertaking a broader approach to addressing conservation issues, by identifying protections needed throughout their county's Marine Stewardship Area through the development of a zoning scheme. This locally-initiated effort reflects a bottom-up community-based approach to protecting fisheries and other marine resources. Its success has largely resulted from the interest and buy-in from the community and provides a model for local initiatives elsewhere.

Description: San Juan County's Marine Resources Committee is an official advisory body to the County Board of Commissioners, composed of a diverse group of citizens, including scientists, politicians, fishermen, business owners, and the general public. One of their first initiatives was undertaking a public process to establish eight voluntary no-take sites for protection and recovery of bottomfish. Subsequently, they recognized the important role of forage fish in the recovery of bottomfish, salmon, and the health of marine mammal and seabird populations. Forage fish such as surf smelt and sand lance spawn on the beach, while herring lay eggs on eelgrass. Washington State law established a no net loss designation for such spawning grounds. With organizational and funding help through Surfrider Foundation, the county undertook a large-scale study with trained volunteers to identify spawning beaches and habitat. This study identified 200 new spawning sites in San Juan County, which immediately became protected as MPAs under the state's no net loss policy.

New scientific information commissioned through the Committee has indicated that the eight original no-take bottomfish recovery sites are too small to be effective. Although these sites reportedly have strong support within the community and are actively policed by citizens, their small size means that just a few violators can wipe out key reproducing fish. Re-examination of these areas is now occurring within the larger Marine Stewardship Area framework. In 2003, the Marine Resources Committee proposed, and the Board of County Commissioners subsequently agreed, that the entire county be declared a marine stewardship area based on regulations and voluntary protections already in place. The intent of this declaration was to make a clear statement that the county wants existing protections to stay in place, and to increase awareness of regulations and voluntary protections. As a second step the Committee is now holding community meetings throughout the county to develop specific objectives for protection and determine what additional protections are necessary to achieve those objectives. This effort is taking advantage of GIS data layers developed through their previous habitat studies and other initiatives, and bringing GIS maps to community meetings to facilitate discussions. The discussions examine what is important to residents and what they value, and input is incorporated into GIS maps as a basis for zoning.

At this stage the Committee is choosing pilot areas to explore what types of regulatory or voluntary approaches they can adopt that have the support of the community. Once they finish the pilot projects, they will do the same thing for the entire area. The county does not have blanket authority to regulate many resources such as fisheries, which are managed by the state and local tribes. But their strategy is to obtain such strong community support and specific involvement by the tribes in the zoning scheme, that regulatory bodies will be compelled to adopt regulations. The end result will be the designation of specific areas within the marine stewardship area with different types of protection that have substantial buy-in from the community.

The county received significant assistance and push from Surfrider Foundation, which helped organize community interest and volunteers and raise private funds for scientific studies and related efforts. In addition, the high level of commitment to marine protection by citizens in San Juan County may be somewhat unique in the United States. Nevertheless, useful lessons learned here can be applied elsewhere, including (1) the power of widespread public involvement to generate solutions with community buy-in, (2) being proactive in generating needed scientific information, (3) partnering among government and private groups (such as NGOs), and (4) being familiar with and leveraging existing regulatory regimes (such as state conservation laws).

Primary contact:

Kevin Ranker, Surfrider Foundation and (recently elected) San Juan County Board of Commissioners

Marine Interests Group of San Luis Obispo County

Overview: The Marine Interests Group is a grass-roots effort by elected officials and citizens in San Luis Obispo County to understand their coastal resources better and facilitate improved management. To date most of their activities have focused on increasing understanding within their community and advancing scientific understanding through collaborative research projects. As a next step they hope to identify ways to improve coordination among the multiple agencies with regulatory authority in the ecosystem.

Description: The Marine Interests Group (MIG) began in 2003 to promote understanding of the marine resources off the coast of San Luis Obispo and examine and recommend ways to sustain and enhance these resources. It includes elected officials, business people, conservationists, fishermen, scientists and members of the general public who volunteer their time to do this. Their first steps involved identifying shared hopes for the future of their marine resources, and holding eight in-depth fact finding workshops with experts to understand critical issues and scientific questions. These workshops were open to the public and broadcast on public access cable TV. One of the results of these workshops was recognition of the lack of information on the Central Coast, and the fragmented nature of the regulatory systems. They began conducting

collaborative research involving fishermen, environmentalists, and scientists to generate information on the status of local fisheries, and have begun undertaking additional steps with temporary (one year) funding from the Resources Legacy Fund. These include:

- Collaborative research on Central Coast rockfish, including data on toxins in fish flesh, water quality, and pinniped-fishing interactions;
- Analysis of rockfish recruitment in the nearshore environment as an indicator of whether catch rates of adults are sustainable;
- Collaboration with NOAA Fisheries on genetic studies to determine the role of the Central Coast as a source population or haven for rockfish; and
- Compiling existing data on marine resources and developing collaborative research initiatives to track other species of interest such as black abalone, steelhead, and pelagic birds.

In addition, they hope to link regulatory agencies, local interest groups and others to facilitate the flow of information and coordination. These coordination efforts are still to be determined. They are expecting a three-month planning grant to help them flesh this activity out further. The next step would be developing a proposal for a multi-year effort overseen by the Marine Interests Group and the Morro Bay National Estuary Program. This effort would involve engaging all of the state and federal regulatory bodies that affect the bay and the nearshore area and helping these agencies plan and coordinate on an ecosystem level.

Primary contact:

Don Maruska, Marine Interests Group

TNC Ecoregional Assessments

Overview: The Nature Conservancy's (TNC) Ecoregional Assessments are a valuable tool for conservation planning and EBM management. This approach combines species and habitat data on an ecoregional scale to identify the most important areas for conservation at least cost. It has generated a lot of interest among state and federal agencies, including NOAA's Ecosystem Goal Team. Much of the assessment work to date has been terrestrial, but a marine component exists for well over half of the U.S. As this effort continues to expand and be refined, it is likely the information will be used by a growing list of government and private partners to inform EBM decisionmaking.

Description: Ecoregional assessments combine the best biodiversity data available with an optimization model to produce ecoregional plans outlining the most "efficient" mix of areas for conservation. Maps, supporting data, and computer tools that allow the user to look more closely at certain factors add to their utility. Providing information on a full spectrum of life forms at an ecoregional scale clearly facilitate EBM by providing managers and others key information across the ecosystem.

The assessments do not catalogue all species in a region. Rather, teams of biologists identify the species, communities, and ecological systems that are the conservation

targets; that is, the elements of biodiversity that should be included in priority conservation areas. System targets reflect the major habitat types. By ensuring their full representation, the majority of species in the region should be represented as well. For each species and system target, all available information on location and status are collected and reviewed. Goals are set for each target, such as how many populations of a species or how much area should be conserved. Goals also address how occurrences of those targets are distributed across the ecoregion to ensure good representation of genetic diversity and prevent local extinctions. The specific goals are based on the literature, existing population viability analyses, or on basic rules of thumb, such as ensuring 20-40% of historical levels. Suitability and cost factors are then considered. These are things that affect the suitability of an area for protection and may make it more costly, such as a high human population density, pollution sources, boat ramps, or other human factors. All of this information is fed into an optimization model to identify the set of sites that will meet the goals for the most targets at the lowest cost. The analysis can include different scenarios with different goal levels or exclude certain targets. TNC takes their preliminary results to expert workshops to get feedback, inform potential users about the availability of this tool, and build partners for implementation.

To date there has been greater emphasis on terrestrial systems than marine, but the marine component is growing. This includes completed plans for the northern Gulf of Mexico and Pacific Northwest focusing largely on the nearshore environment, and Northern California to Baja California which includes the offshore environment. Plans are underway in the Southeast from the Virginia/North Carolina border through Florida to the Gulf and in the Northeast, which will go out to the edge of the continental shelf.

TNC has partnered with a number of state agencies in its assessment work. For example, in developing information for the Pacific Northwest, TNC worked with Washington State's Department of Natural Resources and Department of Fish and Wildlife. State agencies are now using this information in a variety of ways, such as in decisions about which nearshore areas should be made available for leasing and identifying locations for aquatic reserves for rockfish. TNC also has partnerships with the states of Oregon and Florida to help them in their Comprehensive Wildlife Conservation Planning processes (not an EBM approach, but a requirement for receiving federal monies).

Federal agencies such as the EPA, Army Corps of Engineers and NOAA's Ecosystem Goal Team have also expressed interest in using assessments in their work. For example, EPA's Coastal Management Branch is using assessment information to inform their work on habitat protection, smart growth, and addressing coastal areas that are outside of the National Estuary Program. NOAA's Ecosystem Goal Team is still developing its approach, but has expressed significant interest in this tool. NOAA's Coastal Services Center funded much of the Pacific Northwest plan as part of a study conducted by Marc Hershman at the University of Washington looking at regional governance approaches (see below).

Future work on ecoregional assessments includes finishing initial assessments, connecting assessments together so that they are seamless across regions, increasing focus on the land-sea interface, and increasing consideration of socioeconomic factors.

Primary contacts:

Lynne Hale, The Nature Conservancy
Mike Beck, The Nature Conservancy

Regional Ocean Governance Study

Overview: This study will pull together information and analysis on regional ocean governance approaches, while exploring how to develop this approach in the Pacific Northwest.

Description: Former USCOP Commissioner and University of Washington professor Marc Hershman is undertaking a one-year exploratory study to assess whether a pilot project in the Pacific Northwest could lead to a model for regional, ecosystem-based ocean governance. His study has three main components:

(1) Interviews with more than 90 key Pacific Northwest players regarding their priority issues and governance needs and challenges. This not only identifies priority issues that might form the basis for regional pilot projects, but also identifies potential leaders for a regional approach to governance. The study will include profiles of various groups in the region to identify clusters that might have common, cross-jurisdictional needs and might want to work together to form the basis for a regional approach.

(2) An analysis of regional governance efforts both outside the Pacific Northwest (such as the Chesapeake Bay, Gulf of Maine, and Great Lakes) and inside the Pacific Northwest (such as the many efforts to protect salmon), to inform a new effort in the Pacific Northwest. The review will examine the rationale behind regional cooperation, the methods and tools of governance that have been employed, and the strengths and weaknesses of initiatives. A number of states are undertaking state ocean policy efforts that incorporate a coordinated governance approach as well, including Massachusetts, California, Hawaii, Oregon, and Washington.

(3) Input from TNC on an integrated approach for harvesting, analyzing, and delivering useful information to decision-makers (e.g. TNCs Ecoregional Assessment).

The project will lead to a prospectus that outlines a strategy for how to proceed. In addition, Professor Hershman will be holding a working session on regional ocean governance at the Coastal Zone 2005 meeting, planned for July 20, 2005. The goal of the

session is to share information about regional activities, consider common approaches, and relate regional efforts to emerging federal policies.

Primary contacts:

Marc Hershman, University of Washington
Lynne Hale, The Nature Conservancy

IX. Additional Scientific Initiatives

This section describes some specific initiatives within the scientific community to advance our understanding of how to implement EBFM and EBM. It is not a comprehensive list of scientific activities. Rather, it highlights a few initiatives that could have broad implications for implementation.

Caribbean Research through the University of Puerto Rico

Overview: A five-year multi-faceted research program funded under NOAA's Coral Reef Ecosystem Studies (CRES) program is laying a foundation for EBFM in Puerto Rico and the American Caribbean. This program includes ecological components to examine the stresses on coral reefs, interviews and focus groups to examine the socioeconomic impacts on fishermen of MPAs as a management tool, and computer modeling to examine the impacts of management alternatives on reefs, their fisheries, and local communities.

Description: Very generally, the three project components are:

Coral Reef stresses: At three study sites in reefs in and around marine reserves at St. John, US Virgin Islands; and La Parguera and Culebra, Puerto Rico this project is assessing the impacts of fishery closure on the reefs themselves and on community and trophic structure. A range of studies will examine linkages within coral reef systems, including:

- land-water interactions, such as the effects of terrestrial runoff and coastal development on sedimentation and the role of mangrove/seagrass habitats as buffers,
- linkages among habitats and larger areas within the environment,
- trophic linkages – including fishing – and their effects on reef health and dynamics, and
- linkages between human activities and natural systems.

The data generated from this work plus information on community structure are used for developing models that can predict the impacts of management alternatives. Richard Appeldoorn, University of Puerto Rico is overseeing much of this work.

Socioeconomic impacts: This project component involves over 300 interviews and focus groups to identify key stakeholders, assess users' (e.g., fishermen, local business people, and recreational users) knowledge and perceptions, and assess policies promoting participatory approaches to management. The focus is on the establishment of MPAs as a management tool, but it could provide insights into the overall decision-making process. Questions explored include:

- How can communities, stakeholders and managers participate in a joint effort to develop MPAs? What policies are conducive for such a process?
- What interventions are needed?
- What applied/theoretical knowledge is required for MPA development?
- What historical, social and cultural factors contribute to the process?

By posing these questions across sites and cultures, a set of principles can be developed to allow managers to understand and use socioeconomic processes affecting resource conservation. Manuel Valdés-Pizzini[24], a social anthropologist at the University of Puerto Rico, is overseeing this work.

Impacts of management: Computer modeling will integrate the ecological and socio-economic results of this project so that managers can predict or assess the impact of a management strategy or suite of strategies within and outside MPA boundaries. This tool will be developed to be user friendly to managers to facilitate management decisions on protecting coral reefs. Jerald Ault of the University of Miami is overseeing this work.

This project has been underway for three years involving multiple researchers. Project leader Richard Appeldoorn hopes that upon its completion, some of this work can be carried forward through the Caribbean Coral Reef Institute, a joint initiative between the University of Puerto Rico and NOAA. He believes this work can contribute to implementing EBM/EBFM in Puerto Rico and the wider U.S. Caribbean. By necessity, EBM in this region would avoid a data intensive approach because of limited resources. As a result, the emphasis would be on adopting a sufficiently precautionary approach that allows for healthy ecosystems rather than focusing on maximizing catch. By not trying to maintain the fishery on the edge of top productivity, data needs are reduced. This approach to EBFM may be particularly appropriate in the Caribbean for a variety of reasons, among them: (1) data collection is difficult because of the diversity of fisheries in the region, (2) the commercial fishery is artisanal, (3) the majority of fishermen harbor a strong distrust of government, (4) coastal habitat protection is particularly important, (5) there are insufficient resources to analyze the data required for single-species assessments, let alone adding ecosystem components, (6) additional government funds to increase data collection are unlikely, and (7) fishing and related environmental conditions are likely to get worse over time.

Primary contacts:

Richard Appeldoorn, University of Puerto Rico
Jerald Ault, University of Miami, Rosenstiel School School of Marine and Atmospheric Science
Manuel Valdés-Pizzini, University of Puerto Rico

[24] Dr. Valdés-Pizzini could not be reached in time for this report.

NCEAS: Knowledge and Capacity-Building to Support EBM

Overview: With more than $2 million from the Packard Foundation, the National Center for Ecological Analysis and Synthesis at the University of California at Santa Barbara (NCEAS) is overseeing a three-year program to fill information needs and identify new tools and approaches critical to implementing EBM. Some key goals are to get scientists to talk about the minimal amount of scientific information needed to do EBM, what processes and institutional structures are needed, and whether NCEAS can be a hub for sharing information as implementation proceeds. The hope is to make the scientific knowledge developed through the program directly useful to managers and policymakers. The emphasis is on EBM in coastal marine systems, not EBFM.

Description: The program to date has two major components.

Distributed seminar: The first component is a distributed (coordinated) seminar involving seven universities around the world: Ben Gurion University in Israel, Florida International University, University of New Hampshire, University of California Santa Barbara, University of Queensland, University of Washington, and Virginia Institute of Marine Science. Starting in fall of 2004, each university held a graduate seminar in which each class gathers data on a local case study. Students comprehensively review all of the management plans governing the ecosystem (including, but beyond, fisheries), develop (standardized) food webs of the system, link trophic levels based on the literature, and make habitat connections among species. Students then analyze what ecological connections these plans are likely to affect. This exercise is designed to investigate how EBM is being practiced on the ground right now. There are very few areas where there is an active EBM approach. But the seminar examines what percentage of the components and connections in the system are covered, whether people are working cooperatively or competitively, and whether certain aspects of EBM are part of the plan, such as applying ecological principles, using a precautionary approach, or practicing adaptive management. Data from all case studies is combined in an NCEAS database. By combining case study results, the work will also reveal what attributes of the system seem to allow for nascent EBM. For example, are there certain conditions, events, or traits that seem to favor a more EBM approach?

RFPs for Working Groups and Post-doctoral researchers: NCEAS has solicited proposals for two working groups and two to three post-doctoral researchers. NCEAS Working Groups typically include approximately 15 people who come together in a series of meetings over the life of the project to collaborate on addressing the topic of interest. The Working Groups focus on the two following topics:

1. Identifying a limited set of information or types of information needed to support EBM. This project recognizes that it is impractical to wait until we have perfect information on which to base management decisions. It strives to find real-world

solutions with strong scientific foundations to provide the most critical information needed.

2. Examining policy processes and management structures that are needed to implement EBM. This project draws on terrestrial experiences with EBM that demonstrate that without adequate institutional structures, policy frameworks, and collaborative processes, no amount of scientific information will lead to successful EBM.

Post-doctoral researchers will be expected to conduct focused research on topics related to the scientific foundations of EBM in coastal marine systems.

Primary contacts:

Sandy Andelman, NCEAS
Julia Parrish, University of Washington
Barry Gold, The David and Lucile Packard Foundation

NCEAS: Ecosystem-based management for the oceans: The role of zoning

Overview: This Working Group brings together a mix of natural and social scientists to facilitate ocean zoning in an EBM context, by addressing issues that will help move it from a conceptual framework to implementation.

Description: This Working Group brings together ecologists and social scientists to develop the conceptual framework based on ecological and social data that will allow for successful ocean zoning. The Group will compile and synthesize information on existing systems of ocean governance; compile and synthesize available ecological and social data necessary to design and develop effective zoning systems; develop the concept of ocean zoning within the context of EBM; and design a set of principles and policies for creating sustainable ecosystem-based ocean zoning systems. The goal is to lay the groundwork for facilitating processes on the launching pad right now (such as Massachusetts' ocean planning process), and create the definitive document that outlines what it will take to realize the benefits of zoning within an EBM context. The products could include not only peer-reviewed publications but also a more accessible educational booklet for policymakers, managers, and other interested people.

This Working Group pulls together a diverse group of scientists with marine conservation expertise in the natural sciences, including organizers Elliott Norse and Larry Crowder, as well as John Ogden, Andy Rosenberg, and others. But it also includes what might be termed EBM practitioners: people on the cutting edge of new marine management initiatives, including economist Jim Wilson (a leader in the Downeast Initiative) and Robbin Peach (involved in Massachusetts' ocean planning initiative).

Primary contact:

Elliott Norse, Marine Conservation Biology Institute

COMPASS Scientific Consensus Statement on EBM

Description: On March 21, 2005 COMPASS (Communication Partnership for Science and the Sea) released a statement signed by over 200 scientists to help define and clarify EBM and express support for an EBM approach to management. The document addresses (1) what the term EBM means (2) what an ecosystem is (3) core scientific knowledge about ecosystems (4) key elements of EBM, and (5) actions consistent with an ecosystem approach. It also discusses the difference between EBM and EBFM, noting that they are complementary and that EBFM is necessary, but not sufficient for protection of all ocean values.

The statement was developed to accomplish several things:

- Provide a vehicle to get scientists within the scientific community thinking about EBM and ultimately agreeing on what it means;
- Provide tangible and usable language for the policy world, to move away from EBM being just a buzzword;
- Make clear that EBM is doable, and that we know enough scientifically to be doing this;
- Having a platform for discussion.

COMPASS will be mapping out plans to communicate this statement and develop other tools for explaining EBM, in the coming months, including in-person meetings, small gatherings, and a possible west coast conference with scientists, managers, and others.

Primary contact:

Brooke Simler, COMPASS

People contacted for this report

Dayton Alverson, University of Washington
Sandy Andelman, National Center for Environmental Analysis and Synthesis (NCEAS)
Richard Appeldoorn, University of Puerto Rico
Jennifer Atkinson, Quebec-Labrador Foundation
Steven Atran, staff, Gulf of Mexico Fishery Management Council
Jerald Ault, Rosenstiel School, University of Miami
Andrew Bakun, Rosenstiel School, University of Miami
Beth Babcock, Pew Institute for Ocean Science
Tom Barnes, California Department of Fish and Game
Mike Beck, The Nature Conservancy
Mary Bergen, California Department of Fish and Game
Chris Boggs, NOAA
Priscilla Brooks, Conservation Law Foundation
Marc Carr, University of California Santa Cruz
Villy Christensen, UBC Fisheries Centre
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Acronyms/Abbreviations

ABC	Allowable Biological Catch
AFSC	Alaska Fisheries Science Center
COMPASS	Communication Partnership for Science and the Sea
CRANE	Cooperative Research and Assessments of Nearshore Ecosystems
DFG	California Department of Fish and Game
EBM	Ecosystem-based management
EBFB	Ecosystem-based fisheries biology
EBFM	Ecosystem-based fisheries management
EIS	Environmental Impact Statement
EFH	Essential Fish Habitat
EPAP	Ecosystems Principles Advisory Panel
EwE	Ecopath with Ecosim
F_{40}	Catch rate less than or equal to the mortality rate estimated to result in a biomass level of 40% of an unfished state
FEP	Fishery Ecosystem Plan
FISHER	Fishermen's Initiative for Scientific Habitat and Ecosystem Research
FMC	Fishery Management Council
FMP	Fishery Management Plan
GIS	Geographic Information System
MAFMC	Mid-Atlantic Fishery Management Council
MLMA	Marine Life Management Act
MLPA	Marine Life Protection Act
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
NAMA	Northwest Atlantic Marine Alliance
COPA	California Ocean Protection Act
NCBO	NOAA's Chesapeake Bay Office
NCEAS	National Center for Ecological Analysis and Synthesis
NEFMC	New England Fishery Management Council
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NSF	National Science Foundation
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
ROV	Remotely Operated Vehicle
SAFE	Stock Assessment and Fishery Evaluation
SAFMC	South Atlantic Fishery Management Council
SSC	Scientific and Statistical Committee
TAC	Total Allowable Catch
TNC	The Nature Conservancy
UBC	University of British Columbia
USCOP	U.S. Commission on Ocean Policy
West Pac	Western Pacific Fishery Management Council

About the author

Amy Mathews Amos is an independent consultant working on marine conservation and other environmental issues with more than 19 years experience in environmental science and policy. In her previous positions as Vice-President and Program Director for the non-profit Marine Conservation Biology Institute and Policy Analyst for Sierra Club Legal Defense Fund, she worked closely with scientists in academia and elsewhere to address emerging marine conservation issues, and developed and implemented advocacy campaigns. As Senior Evaluator for the U.S. General Accounting Office (GAO) she evaluated federal environmental programs for the U.S. Congress and developed recommendations for improving government management and enhancing environmental protection, particularly in the areas of water policy and ecosystem management.

Amy's experience combines knowledge of environmental advocacy, the natural sciences, and public policy, with expertise as an independent evaluator. She was named an Environmental Hero by the National Oceanic and Atmospheric Administration in 2000 and consistently received Special Recognition for Outstanding Performance while at GAO. She received her undergraduate degree from Cornell University's Department of Natural Resources and holds graduate degrees in both environmental science and public policy from Indiana University's School of Public and Environmental Affairs.

Full disclosure:
Two environmental groups mentioned in this report, Environmental Defense and Oceana, are current or previous clients of the author.