ECOSYSTEM-BASED FISHERY MANAGEMENT AND THE RE-AUTHORIZATION OF THE MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON FISHERIES CONSERVATION, WILDLIFE AND OCEANS

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C O N T E N T S

ECOSYSTEM-BASED FISHERY MANAGEMENT AND THE REAUTHORIZATION OF THE MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Thursday, June 14, 2001
U.S. House of Representatives
Subcommittee on Fisheries Conservation, Wildlife and Oceans
Committee on Resources
Washington, DC

The Subcommittee met, pursuant to notice, at 9:35 a.m., in Room 1324, Longworth House Office Building, Hon. Wayne T. Gilchrest, [Chairman of the Subcommittee] presiding.

STATEMENT OF THE HONORABLE WAYNE T. GILCHREST, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MARYLAND

Mr. GILCHREST. The meeting will come to order. I want to welcome all of the witnesses here this morning. We look forward to your testimony to discuss a rather fascinating, sometimes mysterious issue that we are referring to as Fisheries' Ecosystem Plans, and are they possible? Do we have the technology? Can they or we put this into the Magnuson Act so that the councils will implement this policy, this scientific understanding? It is my perspective that one of the most important things we can do to save the fisheries in the Nation's oceans is to, as best as we can, continue to try to understand the complex dynamics of the mechanics of natural processes in all of their infinite, varied forms.

And so I guess since E.O. Wilson, in his book "Consilience," said that we have a brain that is the most complex organism in the known universe, we are up to the task. So we have had a series of hearings on the Magnuson Act, and we will continue to do so that we understand all of the various aspects of that rather extraordinary piece of legislation, and we want to make sure that all parties are treated equally and fairly, whether it is nymphs or NOAA, the fish processors, the fishermen themselves, the scientists, everybody involved in this issue.

So we will do everything we can to make sure that we collect the best data and that the best data and pieces of information that we have are disseminated to every interested party, even if that means holding not only workshops for scientists, but workshops for the fishermen to explain, for example, the process of a Fishery

Ecosystem Plan. And one of the examples of that is agriculture. Nutrient management plan, best management practices all over the country, scientists and farmers almost routinely get together to discuss those issues, and so this is no less important.

But welcome, all of you, and we look forward to your testimony.

I yield now to the gentleman from Guam, Mr. Underwood.

[The prepared statement of Mr. Gilchrest follows:]

Statement of The Honorable Wayne Gilchrest, Chairman, Subcommittee on Fisheries Conservation, Wildlife and Oceans

I would like to welcome our witnesses to the third of what I hope will be a number of hearings on the important topic of the reauthorization of the Magnuson–Stevens Fishery Conservation and Management Act.

This hearing will focus on the important issue of ecosystem-based management in fisheries. To further this discussion, Congress asked the National Marine Fisheries Service (NMFS) to establish an Ecosystem Principles Advisory Panel to assess the extent that ecosystem principles are currently used in fisheries management and research, and to recommend how such principles can be further implemented to improve our Nation's management of living marine resources.

I think this report provided a good outline for incorporating ecosystem-based principles into federal fisheries management. While there is seemingly broad agreement on the need for ecosystem-based fisheries management, there may be debate on how best to implement such measures into existing fishery management plans and research programs. This debate is healthy and I hope that today's hearing will provide some examples of how ecosystem-based management is currently incorporated into fisheries management and provide suggestions for improving fisheries management through the use of ecosystem-based principles.

I look forward to hearing from our witnesses.

STATEMENT OF HONORABLE ROBERT A. UNDERWOOD, A DELEGATE TO CONGRESS FROM THE TERRITORY OF GUAM

Mr. UNDERWOOD. Thank you, Mr. Chairman, and thank you for pointing out that all of us have a brain.

[Laughter.]

Mr. GILCHREST. I was going to say something, but it would sound partisan, so I won't say it.

[Laughter.]

Mr. UNDERWOOD. We have bipartisan brains.

Thank you, Mr. Chairman, I am pleased that you have raised the issue of ecosystems, and the ecosystem base management of natural resources. As we all know, everything in the ecosystem is mutually dependent on everything else, and it seems logical that we apply this concept to fisheries management. The question is whether we have the capability, and the knowledge, and the willpower to do so.

Unfortunately, ecosystems are not that easily defined. It takes vast amounts of time and money to conduct accurate research of where boundaries are between ecosystems and how the living resources within them interact. Research is further complicated by some species that cross ecosystem boundaries, which may be great for them, but make things infinitely more difficult for us as we work to utilize these species in a sustainable manner.

The true interconnectedness of ecosystems is only beginning to be researched. Over the past 30 years, when total allowable catch quotas have been set, only the impact of these catches on the stock itself were evaluated. We are now learning that catching fish not only affects the species being caught, but their predators and prey

as well. We, as fishermen, can throw off the balance of an ecosystem even if fishing only one species.

My own experience with ecosystems is predominantly through coral reefs. Coral reefs of the Pacific not only enhance the beauty of the region, but also add to the economy through tourism and fishing industries. For the good of all people dependent upon them, as well as for those who have yet to have the thrill of seeing them firsthand, we must manage the resources of the coral reefs and the reefs themselves in a sustainable manner. This includes the need to engage in sustainable development and exploration.

The natural benefits of reefs may extend much further than ever expected into areas of pharmaceuticals and other research. And if we do not work to keep what now exists, how would we know what the future might find and hold for us. And current science leads to the conclusion that the best way to insure the future is through managing the ecosystem as a whole. We must learn about the relationship between fishes, between prey and predators, between the environment itself, and the living resources and our own impact on that environment.

The ecosystem includes weather phenomena, tides and currents, and human impact such as pollution, runoff particularly affects coral reefs, as it does all ecosystems that are in the water. Only by furthering our understanding of these actions can we truly begin to utilize our resources in a sustainable manner.

As we are constantly reminded by marine scientists, right now we know more about the moon than we do about our ocean. Finding future uses for what lies within them is much more than just a possibility, it is a near certainty. But as I mentioned above with coral reefs, we must act to conserve now because we might never know what we have missed if the ecosystems are altered irreparably before we can fully explore in a sustainable manner their potential.

We will hear views today about the possibility of incorporating ecosystem management into a fisheries management regime. The witnesses before us will discuss how costly it may be, how long will it take for fisheries management councils and the National Marine Fishery Service to formulate plans of ecosystem management and how much research has been done and how much more is needed. If ecosystem management will improve the conservation and management of our resources, then it is incumbent upon us to address these issues head on.

I want to thank the Chairman for holding this very important hearing.

Thank you.

Mr. GILCHREST. Thank you, Mr. Underwood.

Again, thank the witnesses for coming this morning. We look forward to your testimony.

Dr. Hogarth, you may begin.

STATEMENT OF WILLIAM T. HOGARTH, PH.D., ACTING ASSISTANT ADMINISTRATOR FOR FISHERIES, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Dr. HOGARTH. Thank you, Mr. Chairman and members of the Subcommittee. It is nice to be here today to talk about an extremely important issue for the future of fishery management. I am Bill Hogarth, the Acting Assistant Administrator for Fisheries for the National Oceanic and Atmospheric Administration.

Landings of many marine fisheries worldwide have declined in recent years. The causes of these declines include overharvesting, habitat alteration and loss, pollution, and natural environmental change. Fisheries managers are increasingly required to address the potential direct and indirect impacts on fisheries from protected resources and other values and services the oceans provide.

In addition, we are required to address the impacts of fisheries operations on protected resources such as sea turtles and marine mammals. Ecosystem-based management is one approach that will improve upon single-species management to ensure sustainability of fisheries and a healthy marine environment. Viewing fisheries in the ecosystem context, we can begin to understand how multiple factors affect fisheries and how our fishing activities affect the broader ecosystem.

Implementing ecosystem-based management requires a more comprehensive understanding and approach to fisheries research than traditional single-species management approaches. The stock assessment models are limited only by our ability to collect and assimilate the relevant data. Successful implementation of ecosystem-based management requires considerations of such things as habitat requirements, hydrography, environmental and climate changes, predator-prey relationships, and physical and biological processes. It will also require adaptive management and a precautionary approach for recognizing the limits to our understanding of ecosystems.

Information on human influences and impacts is as important as that for natural systems and must be included in any ecosystem research and management efforts. In particular, we need to more broadly implement economically and socially efficient management programs like the cooperatives in the Alaska factory trawling fleet or the Individual Fishing Quota (IFQ) system in the Pacific halibut sable fish fishery. These programs allow the industry to apply the appropriate level of capital investment and to make market-based allocations with unnecessary interference from the Federal Government.

A reduction in capitalization will lessen the pressure to overfish, will reduce economic impacts, and will increase the safety of fishermen at sea. The complicated legislative and institutional framework that governs resource management decision-making poses a significant challenge for implementing ecosystem-based fisheries conservation and management.

Although the Magnuson-Stevens Act is the principal legislation governing U.S. marine fisheries, other Federal laws, including the Marine Mammal Protection Act and the Endangered Species Act (ESA), as well as international agreements and state laws, provide

for the conservation and management of marine resources. Coordination of these responsibilities, as well as the appropriate involvement of all stakeholders in the decision-making processes, is critical if we are to implement an ecosystem-based approach.

Two recent reports, the National Research Council's (NRC) "Sustaining Marine Fisheries" and NOAA's Fisheries' "Ecosystem-Based Fishery Management," provide some excellent insights and recommendations on ecosystem-based management, which are outlined in my written testimony.

NOAA Fisheries applauds the panel's efforts to develop pragmatic suggestions to incorporate ecosystem approaches in the existing framework of the NOAA Fisheries Council system. NOAA Fisheries will be looking to these reports, and elsewhere, for ideas, as we continue to move toward ecosystem-based fishery management.

NOAA Fisheries is also beginning to implement ecosystem-oriented approaches to the management of a few living marine resources, including the Fisheries Ecosystem Plan being developed for the Chesapeake Bay, the Coral Reef Ecosystem Management Plan that is being developed by the Western Pacific Management Council, and the ecosystem-related provisions of all Fishery Management Plans (FMPs), particularly relating to essential fish habitat and ecosystem-based habitat restoration.

Last July, the NOAA Chesapeake Bay Office convened a number of regional and national expert scientists and managers to build a framework and establish the guidelines of a Fishery Ecosystem Plan (FEP). Since then, the NOAA Chesapeake Bay Office and the interagency Chesapeake Bay Program have appointed a technical advisory panel of 16 prominent Bay scientists to guide the development of the FEP. The draft plan will include such important elements as ecosystem boundaries, a conceptual model of the food web, and indices of ecosystem health.

Ecosystem effects of fishing and economic and social aspects also will be included. The draft is expected by the end of 2001, with a completed FEP by the spring of 2002. The FEP will undergo continual development, as understanding of the Bay ecosystem increases.

Mr. Chairman, details of other ecosystem-based management plans that I mentioned are also included in my written testimony.

Finally, I want to emphasize where we go from here. Based on good direction from the National Research Council's and the NOAA Fisheries, reports on the merits of an ecosystem approach to fisheries management, plus lessons learned from the Chesapeake Bay, the Bering Sea and the Northeast, I have asked my staff to host a national workshop this fall to develop the technical guidelines for marine ecosystem-based management. This workshop will lead to a better initial discussion and product as we pursue the ecosystem approach.

As my testimony outlines, while we have a considerable way to go in conducting the types of research that would support true ecosystem management plans, some important steps have been made. I look forward to making additional progress in this area.

Mr. Chairman, this concludes my testimony. However, Dr. Steve Murawski and Ms. Patricia Livingston, both of whom are well-known experts in the field, will provide a more detailed analysis of

what NOAA Fisheries is doing in ecosystem management, as well as a more thorough discussion of the mechanism of this approach to fisheries management.

Again, thank you for this opportunity, and we look forward to answering any questions you may have.

Thanks.

[The prepared statement of Dr. Hogarth follows:]

Statement of William T. Hogarth, Ph.D., Acting Assistant Administrator for Fisheries, National Marine Fisheries Service, U.S. Department of Commerce

Mr. Chairman and Members of the Subcommittee, thank you for inviting me to this hearing on ecosystem-based fishery management. I am William T. Hogarth, the Acting Assistant Administrator for Fisheries for the National Oceanic and Atmospheric Administration.

ECOSYSTEM–BASED FISHERY MANAGEMENT

Landings of many marine fisheries worldwide have declined in recent years. The causes of these declines are complex and include overharvesting, habitat alteration and loss, pollution, and natural environmental change. At the same time, fisheries managers are increasingly called upon to address the potential direct and indirect impacts of fisheries on protected species and other values and services the ocean provides. Ecosystem-based management is one approach that is being developed to improve upon single species management to ensure sustainable fisheries and a healthy marine environment. By viewing fisheries in an ecosystem context, we can begin to understand how these multiple factors affect fisheries, and how our fishing activities affect the broader ecosystem.

A basic premise of ecosystem-based management is that the relationships among living marine resources and the ecosystem within which they exist must be addressed. This requires a more comprehensive understanding and approach to fisheries research than is necessary for traditional single-species management approaches, although single-species stock assessments have become increasingly sophisticated and some now incorporate environmental parameters. The stock assessment models are only limited by our ability to collect and assimilate the relevant environmental data. Successful implementation of ecosystem-based management will require consideration of, among other things, habitat requirements, hydrography, environmental and climate changes, predator-prey relationships, and physical and biological processes. It will also require adaptive management and implementation that recognizes the current limits of our understanding of ecosystems.

Humans, too, are part of the ecosystem. The interests, values, and motivations of participants in a fishery and others who use or benefit from the ocean must be understood and factored into fishery management decisions. Information on human influences and impacts is as important as that from natural systems and must be included in any ecosystem research and management effort. In particular, we need to more broadly implement economically and socially efficient management programs like the cooperatives in the Alaska factory trawling fleet or the individual fishing quota system in the Pacific halibut fishery. These programs allow the industry to apply the appropriate level of capital investment and to make market-based allocations without unnecessary interference from the federal government. A reduction in capitalization will reduce the pressure to over fish and its attendant economically disastrous side effects and increase the safety of fishermen at sea.

In developing an ecosystem approach to research and management, it is important to recognize that a good deal is already known about marine ecosystems. Research into the oceans' role in climate variability has unlocked new understandings about how marine ecosystems function. However, this scientific information is not consistently applied in current management efforts, is insufficient data to construct the necessary models from which management frameworks can be derived. Therefore, emphasis must be placed on what new information is required and on how to effectively apply existing information. It must also be recognized that both science and management are ongoing processes and that new scientific, social, cultural, economic, and institutional information must be incorporated into the management process as it becomes available.

The complicated legislative and institutional framework that currently governs resource management decision-making poses both a significant challenge to, and an opportunity for, the implementation of ecosystem-based fisheries conservation and management. Although the Magnuson–Stevens Fishery Conservation and

Management Act (Magnuson–Stevens Act) is the principal legislation governing U.S. marine fisheries, other Federal legislation including the Marine Mammal Protection Act and the Endangered Species Act, as well as state laws and international agreements, provide for the conservation and management of marine resources. Coordination of these legislative and institutional responsibilities, as well as the appropriate involvement of all stakeholders in the decision making process, is currently conducted on a case-by-case and often ad hoc basis. Implementing an ecosystem-based management approach requires making this coordination far more integral and explicit.

Ecosystem–Based Management Reports

Two recent reports addressed the use of ecosystem-based management in marine fisheries. The National Research Council published Sustaining Marine Fisheries and the National Marine Fisheries Service published Ecosystem–Based Fishery Management. I will briefly highlight the findings from both of these reports.

The National Research Council's Sustaining Marine Fisheries Report

The National Research Council's Ocean Studies Board established the Committee on Ecosystem Management for Sustainable Marine Fisheries (Committee) to assess the current state of fisheries resources; to determine the basis for success and failure in marine fisheries; and to evaluate the implications of fishery activities for ecosystem structure and function. The Committee's findings are contained in its 1999 Sustaining Marine Fisheries report. The Committee concluded that the most comprehensive and immediate ecosystem-based approach to rebuilding and sustaining fisheries and ecosystems is a significant overall reduction in fishing mortality. The Committee also recommended an ecosystem-based approach to fishery management that addresses overall fishing mortality. The Committee's specific recommendations were to use a conservative approach to single-species management; incorporate ecosystem considerations into management; deal with uncertainty; reduce excess capacity and use assignment of rights; use marine protected areas; reduce bycatch and discards; develop institutional structures; and get a better understanding of the structure and functioning of marine ecosystems.

The NOAA Fisheries Ecosystem Principles Advisory Panel Report

An amendment to the Magnuson–Stevens Act in 1996 directed NOAA Fisheries to establish an Ecosystem Principles Advisory Panel (Panel) to provide expert guidance on how to incorporate an ecosystem approach in NOAA Fisheries' research, conservation and management activities.

Composed of individuals with expertise in the structures, functions, and physical and biological characteristics of ecosystems, as well as representatives from the Fishery Management Councils, states, fishing industry and conservation organizations, the Panel produced a report that outlines basic principles, goals, and policies necessary to implement an ecosystem approach. It includes specific recommendations, including the adoption of Fishery Ecosystem Plans (FEP) for each ecosystem under the Regional Fishery Management Councils' (Council) areas of authority. The FEP is envisioned to be a document that serves as an umbrella under which individual Fishery Management Plans (FMPs) would be developed and with which they must be consistent. An FEP would contain information on the structure and function of the ecosystem in which fishing activities occur, so that managers can be aware of the effects that their decisions have on the ecosystem, and the effects other components of the ecosystem may have on fisheries. The adoption of this approach would help to ensure that individual FMPs do a better job of incorporating ecosystem considerations. The report concluded that the ultimate benefits of adopting ecosystem-based fishery management and research would be more sustainable fisheries and marine ecosystems, as well as more prosperous coastal communities.

The Panel specified several steps that Councils should take to develop FEPs. These include: delineate the geographic extent of the ecosystems that occur within the Council's authority; develop a conceptual model of the food web; describe the habitat needs of the significant food web; calculate total removals, including incidental mortality; assess stock assessment uncertainty; develop indices of ecosystem health as targets for management; describe available long-term monitoring data and how they are used; and assess elements of the ecosystem that most significantly affect fisheries. Taken together, these provide the information necessary for a Council to make fisheries decisions in an ecosystem context.

NOAA Fisheries' Response to the Reports

Based, at least partially, on the Panel's report and on the NRC's report, "Sustaining Marine Fisheries," the concept of ecosystem-based fishery management is gaining momentum. Taken as a whole, NOAA Fisheries applauds the Panel's effort

to develop pragmatic suggestions to incorporate ecosystem approaches into the existing framework of the NOAA Fisheries/Council system. NOAA Fisheries is developing plans for a workshop to develop technical guidelines for implementation of the Panel's recommendations. NMFS will be looking to these reports and elsewhere for ideas as we continue to move toward ecosystem-based fisheries management.

For example, NOAA Fisheries focused its National Stock Assessment Workshop last year on ecosystem based management. About 100 NMFS and academic scientists attended the workshop and evaluated where we are in developing ecosystem based management, and what research must be done. The research needs are broad and include economic analyses on the desirability of alternative ecosystem states; effects of changes in ocean conditions on species and the ecosystem; how fishing affects productivity; effects of discard of undersized or unwanted species on the target species and on energy flow in the ecosystem. They noted the importance of long-term, fishery independent ecosystem monitoring and research, and on observer programs for tracking ecosystem changes and building predictive models. Because there is much information needed, they noted the need for partnerships to collect and share data from comprehensive ecosystem monitoring programs. To have effective ecosystem based management, there is much we will need to learn and understand about ecosystems.

NOAA Fisheries and the eight Councils have already begun investigating how ecosystem considerations can be incorporated into the existing fisheries management structure. Generally, the approach is to conduct detailed single-species assessments and embed them in an ecosystem context. In other words, consideration of ecosystem effects tends to be qualitative or semi-quantitative, rather than fully quantitative. Multi-species and ecosystem models are being developed in all NOAA Fisheries Science Centers and by a few academic institutions, but they are usually difficult to validate and frequently suffer from lack of adequate baseline biological and environmental data. Extensive monitoring programs for federally managed species, associated and dependent species, oceanographic data, habitat mapping, and climate effects are needed to completely fulfill the data requirements of ecosystem models.

To address such needs and to implement the recommendations of the National Research Council report Improving Fish Stock Assessments, NOAA Fisheries is currently preparing a Stock Assessment Improvement Plan. The Stock Assessment Improvement Plan identifies three "Tiers of Excellence." In brief, these Tiers are to enhance stock assessments using existing data, to elevate all assessments to nationally acceptable standards (which, among other things, will require adequate baseline monitoring for all managed species), and to develop and conduct "next generation" assessments involving ecosystem considerations and environmental and spatial effects. As part of the fiscal year 02 Budget Request, NOAA Fisheries has requested funding that will enable achievement of Tier 2, which includes adequate baseline monitoring of all managed species. When Tier 2 of the NOAA Fisheries Stock Assessment Improvement Plan is achieved, an important step towards ecosystem-based fisheries management will have been made. The next step will be to conduct the assessments needed to incorporate the baseline information into the decision making process for ecosystem and fishery management planning.

Examples of Ecosystem Approaches to Fishery Management

Although fishery management based on an ecosystem approach is still a relatively new and evolving concept, NOAA Fisheries is beginning to implement ecosystem-oriented approaches to the management of a few living marine resources. Some examples of ecosystem-based approaches are: the FEP being developed for the Chesapeake Bay; the Coral Reef Ecosystem FMP being developed by the Western Pacific Council; the ecosystem-related provisions of all FMPs, particularly relating to essential fish habitat (EFH); and the ecosystem-based restoration planning that guides many of our habitat restoration projects.

Development of a Chesapeake Bay Fisheries Ecosystem Plan

NOAA is a strong Chesapeake Bay Program (CBP) partner and is relied upon as an objective voice of science. The NOAA Chesapeake Bay Office (NCBO) is leading an exciting initiative to develop an FEP for the Bay that will result in gradual implementation of ecosystem-based fishery management. The Chesapeake Bay FEP will clearly describe the structure and function of the Bay ecosystem, including key habitats and species interactions. It will recommend actions to gradually implement ecosystem-based approaches to fisheries management for Bay resident and coastal species, and specific research needed to acquire knowledge of the ecosystem and its fisheries that will achieve long-range management objectives.

In response to the Ecosystems Advisory Panel's recommendation to develop a demonstration FEP, and commitments in the Chesapeake 2000 Agreement, the

NCBO, together with the Program's Scientific and Technical Advisory Committee, convened regional and national experts, scientists, and managers to participate in the Chesapeake Bay FEP Workshop to build the framework and establish guidelines from which to develop an FEP for the Chesapeake Bay.

As follow-up to the FEP Workshop, NCBO has appointed an FEP Technical Advisory Panel of sixteen prominent Bay scientists to: (1) develop an FEP for the Chesapeake Bay (with strong support from NCBO), (2) guide the implementation of ecosystem-based management of Chesapeake Bay fisheries, and (3) foster the continual development of the FEP to reflect expanded knowledge of the ecosystem.

A draft of the initial FEP, which will include such important elements as ecosystem boundaries, a conceptual model of the food web, indices of ecosystem health, ecosystem effects on fishing, and economic and social aspects, is expected by the end of 2001, with a completed FEP by spring 2002. The FEP will be an iterative process; it will undergo continual development as understanding increases of the Bay fisheries within an ecosystem context.

Draft Coral Reef Ecosystem Fishery Management Plan

The Western Pacific Fishery Management Council, with the assistance of NOAA Fisheries, is preparing a new Coral Reef Ecosystem Fishery Management Plan (CRE–FMP). Over 90% of coral reefs under U.S. jurisdiction are in the Pacific Ocean. However, the Council foresees a significant expansion of new fisheries for food, aquarium fishes, corals, and pharmaceuticals, especially given the increasing overfishing occurring in state waters. Addressing the potential ecosystem impacts of fisheries on protected species such as the Hawaiian monk seal is also an increasing concern. Key approaches that are being incorporated in the draft CRE–FMP are: including all reef species not currently covered by existing FMPs; using a precautionary approach based on a system of permits and reporting; incorporating zoning, which includes fully protected marine reserves as an integral component; prohibiting fishing gears known to damage coral reef habitats; and providing a framework for adaptive management. The Council hopes to finish work on the CRE–FMP in the near future.

Essential Fish Habitat

The EFH provisions of the Magnuson–Stevens Act emphasize the importance of habitat in sustainable fisheries and the need to address unintended adverse effects of fishing activities on important habitats. The EFH provisions require every FMP to identify and describe EFH, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH.

NOAA Fisheries and the Councils have identified EFH for all 41 existing FMPs. The EFH designations take an ecosystem approach, consistent with the definition of EFH in the Magnuson–Stevens Act, by encompassing habitats needed throughout the full life cycle of managed species. Thus EFH designations include important habitat areas for all life stages of fish and not just the spawning grounds or the areas where adult fish are found in high densities. To provide additional focus for conservation and management, NOAA Fisheries encourages Councils to identify Habitat Areas of Particular Concern (HAPCs) within EFH to highlight priority areas that have especially important ecological functions, and/or areas that are particularly vulnerable to degradation. Importantly, the Councils are beginning to use EFH and HAPC information in fishery management decisions. For example, when the New England Council voted to reopen closed areas on Georges Bank to scallop harvesting, the Council specifically decided to exclude an HAPC for juvenile cod as well as other hard bottom habitats that are susceptible to impacts from scallop dredging. Likewise, the North Pacific Council last year approved a measure to prohibit directed fishing for corals and sponges because it recognized that those living substrates provide essential habitat for a variety of fishery resources. These types of ecosystem considerations are becoming increasingly important to the sustainable management of our nation's fishery resources.

Habitat Restoration Planning

NOAA Fisheries is also applying ecosystem principles to our habitat restoration planning. Through the NOAA Restoration Center, we work with other agencies, industries, and interest groups to develop regional restoration plans at the spatial scale of a watershed or larger ecological unit. We are using regional restoration plans to restore important coastal and anadromous fish habitats in Washington State, New York, and Florida. These bay-wide approaches address habitat restoration needs in a comprehensive and systematic fashion, prioritizing and linking individual projects to increase the effectiveness and efficiency of restoration activities.

SUMMARY

The need for a much more comprehensive understanding of living marine resources and the ecosystems that support them is clear. While we have a considerable way to go in conducting the types of research and implementing integrated and adaptive decision making processes that would support true ecosystem management plans, some important steps have been made. I look forward to continuing to work with the House Resources Committee and a wide range of stakeholders to make additional progress in this area.

CONCLUSION

Mr. Chairman, this concludes my testimony. With me on the panel today are two of NMFS's finest scientists, Dr. Patricia Livingston and Dr. Steve Murawski. Dr. Livingston is the leader of our fishery ecosystem research in the Bering Sea and Gulf of Alaska. Dr. Murawski is our chief stock assessment scientist for our northeastern fisheries. They will each give you a synopsis on the state of our ecosystem knowledge and research in their respective geographic areas. Again, I want to thank you for the opportunity to testify today and discuss ecosystem management. I am prepared to respond to any questions that you and other Members of the Committee may have.

Mr. GILCHREST. Thank you, Dr. Hogarth.

Dr. Fluharty, welcome.

STATEMENT OF DAVID L. FLUHARTY, PH.D., CHAIRMAN, NATIONAL MARINE FISHERIES SERVICE ECOSYSTEMS PRINCIPLES ADVISORY PANEL, UNIVERSITY OF WASHINGTON

Dr. FLUHARTY. Thank you, sir. Mr. Chairman, members of the Subcommittee, I am Dave Fluharty, associate professor, School of Marine Affairs, University of Washington, also a member of the North Pacific Fishery Management Council.

I have prepared three topics that I think may be of interest. I had the distinct honor to chair the panel that developed the Ecosystem Based Fisheries report for you in Congress, and I am very pleased to have an opportunity to be here to discuss it with you; secondly, I wanted to touch on some of the implementation difficulties that we are experiencing and are likely to experience, as we move ahead with developing Fisheries Ecosystem Plans; and, finally, I would like to touch on some of the recommendations of where to go from here.

The Ecosystem Principles Panel deliberately chose the term "ecosystem-based fishery management," as opposed to "ecosystem management," because we felt that that was something that we could actually get our hands around, that we didn't have to let the perfect be the enemy of the good, in terms of our understanding of the scientific basis and social basis for developing Fisheries Ecosystem Plans. We felt that ecosystem-based management, where we actually used the knowledge that we do have at the present time, is a way to get moving much more quickly than waiting until we have finished everything up. We, of course, acknowledged that there are many difficulties, many holes that we need to fill in with research.

Secondly, and very importantly, ecosystem-based fishery management does not substitute for good fishery management. We need good fishery management measures such as have been developed and are being implemented under the Sustainable Fisheries Act to actually make progress to go beyond single species approaches and into a more ecosystem-based approach. So it is an absolute pre-

requisite to have full implementation of the Sustainable Fisheries Act.

Our goal as a panel was not to produce another report that would land up on the shelf and get dusty. We wanted this one to get wet, to get in the water, and to make pragmatic recommendations that could be put into effect immediately, and we think that the Fisheries Ecosystem Plan is one of those measures.

Our goal of sustaining ecosystem health is a shorthand way of basically expressing a desire for an improved state of the environment compared with today. We didn't define it, as you probably have seen, in any great detail, but we did try to make it very clear that the goal is important. It is one that fishing interests and environmental interests can attach to and find a great deal of meaning in.

The Fisheries Ecosystem Plan that we propose is a way of starting to move regional fishery management councils, through existing institutions and processes, into consideration of ecosystem-based management, and I think will let Dr. Livingston's testimony explain how that is being done in the context of the North Pacific Council.

While it should be possible to institute ecosystem-based management in the United States without additional legislation, the fact is it sometimes is necessary, one, to make clear the intent of Congress; two, to develop enforceable pathway to implementation; and, three, to provide a vehicle for funding and oversight.

The biggest impediment that we see right now in terms of the development of a Fisheries Ecosystem Plan is the backlog of compliance with some of the basic environmental and administrative laws, as well as with the Sustainable Fisheries Act. I observe, and I think many people would also agree with me, that the Agency is working flat out. It is overtaxed, and I don't know quite how we get around this, but it has been given a lot of major tasks and has had relatively level funding. And this combination has made us very vulnerable to not doing the job that we do. I am speaking of this as a council member right now, watching in the North Pacific just how difficult it is to get Essential Fish Habitat in places, to comply fully with the National Environmental Policy Act, and with developing all of the measures that we need to, to properly manage the fisheries.

This is really something that it is hard to expect the Agency to do more, in my opinion, if we don't provide it with adequate resources, and that is definitely a concern when it comes to the issue of whether or not to add or how to add the Fisheries Ecosystem Plan.

In conclusion, I would say that I very much support the recommendation of Mr. Gilchrest and Dr. Hogarth to have more workshops, not only for the fishing industry, but for the council members and others with interest in fisheries management. All of us need to come to a better understanding of how ecosystem-based fishery management works. We are transitioning from a basically flawed system into one that will help us manage fisheries much better, and it is going to take some time, it is going to take resources, and it is going to take a lot of education.

The most critical step I think right now is for Congress to understand, and that is what I understand is the purpose of this hearing, the need to move forward with developing ecosystem-based fisheries management. A good coach know what a team needs to motivate it and to fuel its performance, and a coach also recognizes when it is necessary to raise the bar higher, to challenge, but not discourage the team.

Thank you, sir.

[The prepared statement of Dr. Fluharty follows:]

Statement of David Fluharty, Associate Professor, School of Marine Affairs, University of Washington

Thank you for the opportunity to testify on ecosystem-based fishery management and Reauthorization of the Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA). I am David Fluharty, Associate Professor, School of Marine Affairs, University of Washington and voting-member since 1994 of the North Pacific Fishery Management Council (NPFMC). I had the distinct privilege to serve as the Chair of the Ecosystem Principles Advisory Panel developing the report to Congress, Ecosystem–Based Fishery Management. Most recently, I was a member of the study committee of the National Research Council that produced the report, Marine Protected Areas: Tools for Sustaining Ocean Ecosystems. This combination of academic orientation and practical, direct involvement in fisheries management gives me a unique perspective to offer this Committee. The NPFMC has subvened my travel costs to this Hearing. However, the views I express are my own. While many of my views are informed by my work in the North Pacific area, I think there are similar issues and opportunities in the context of other regional fisheries management councils.

I have prepared a series of talking points that touch on three main topics in response to your invitation to address the benefits and difficulties of developing and implementing ecosystem-based fishery management plans. First, I review some of the intent and rationale of the Ecosystem Principles Advisory Panel. Next, I discuss status of implementation of ecosystem-based fishery management with a focus on impediments to achieving that goal. Third, I will make observations about the steps and time frame needed for transition to ecosystem-based fishery management.

The basic theme of this testimony is how to make the "E" word stand for Excellence in fishery management and Excellence in care for the environment. Ecosystem-"anything" tends to scare the fishing industry. Similarly, ecosystem-"anything" tends to give false comfort to the environmental community. I believe it is time that we translate ecosystem-based management from an abstract concept into practical management measures. In so doing, I detect that is a very important need to recognize a common goal, i.e., to maintain ecosystem health and sustainability. A healthy ecosystem is good for fisheries and good for the environment.

I regard the benefits to be derived from ecosystem-based fishery management to be a perpetual, but limited, supply of fish for commercial and recreational use and an ecosystem that sustains biodiversity and habitats as well as other non-monetary conceptions of the environment. In the most simplistic sense, a conservative yield of fish from a healthy ecosystem is most likely greater than the yields currently extracted from stressed and overfished ecosystems. Even within the natural variability of ecosystem regimes there is greater resilience to effects of fishing and other uses under healthy versus stressed ecosystems. It is my view that experience over the last 25 years under the MSFCMA in fisheries off Alaska demonstrates this point, however, fishery management there is still working hard to more fully incorporate ecosystem concerns [Attachment]. What achieves success in fishery management in terms of sustained yield may still have effects on other ecosystem components. Fishery management is increasingly being called to address these other interactions. I am convinced that the current fishery management institutions if given the right kinds of legislative mandates, incentives and support can make the transition to sustainable fisheries in an ecosystem context.

Ecosystem–Based Fisheries

The previous speaker summarized very well the Ecosystem Principles Advisory Panel report. Some background on the Panel deliberations and intent may be useful to add. The Panel consciously chose to use the term "ecosystem-based" fishery management instead of "ecosystem management." To us, ecosystem-based" fishery management means using what is known about the ecosystem in the management of

fisheries. Ecosystem management is much broader in scope and less defined in terms of management—especially for the marine environment. Using what is known about the ecosystem is a main component of scientific fishery management. The Panel is very aware of the inadequacies of fisheries and ecosystem data. We advise that precautionary policies be adopted where there is high uncertainty. What we are calling attention to is the failure to use what we know about ecosystems and the way they function. Overfishing is a "no-brainer" as far as ecosystems are concerned. At the same time fisheries managers, using fisheries dependent and independent data, do have a good understanding of how the fisheries work in an ecosystem context. Thus, ecosystem-based fishery management is using ecological knowledge to advise the policies under data limited conditions. Clearly, the Panel advises to avoid making perfect knowledge of the ecosystem the enemy of using the good knowledge we have.

A second precept of the Panel was that ecosystem-based fishery management is not a substitute for full implementation of the fishery management requirements under the MSFCMA and especially the amendments in the Sustainable Fisheries Act of 1996. The SFA challenges fisheries managers to end overfishing, rebuild overfished stocks, address Essential Fish Habitat and fishing effects, account for and reduce bycatch, etc. If these basic fishery management functions are not carried out, there is no hope for an ecosystem-based approach being implemented. Ecosystem-based fishery management is not a panacea and it has prerequisites.

Third, the Panel's goal was to make pragmatic recommendations that could be put into effect immediately without additional legislation and within the existing framework of fishery management councils.

Fourth, the Panel's goal of sustaining ecosystem health is a shorthand way of describing a more desired state than the current one in most marine ecosystems in the United States. At a minimum, the benefits of a healthy ecosystem in terms of fisheries are modest but continuous yields from abundant fish stocks instead of low yields from overfished stocks. Managing to maintain abundance of fish means stocks have greater resilience to all forms of stress.

Fifth, while much of the emphasis on ecosystems relates to biological and social processes, the socio-economic and institutional dimensions of fisheries management are, in some, respects more important especially with regard to managing human activities, like fisheries. Without the right kinds of incentives to conserve, fishing interests tend to ratchet up levels of fishing to compete with each other and this results in a downward spiral of fish stocks and eventually overfishing. Much discussion has been focused on the combined economic and political pressures to overfish under current management. The Panel observes that with political support, the necessary measures to start ecosystem-based management are largely economic and social dealing with allocating fishing rights and responsibilities. The Panel recommendation is very broad in this respect "to make local incentives compatible with global goals". We did not emphasize this as much as we might given the other charge given to the National Research Council under the SFA to investigate this component of fishery management [See NRC 1998, Sharing the Fish ; OECD 2001, Sustaining Marine Fisheries]. Transition to healthy ecosystems demands making tough decisions, having adequate funding and people committed to making the system work. The strategy for implementing ecosystem-based fishery management depends heavily on economic and social as well as ecological understanding to inform the choice of measures

Finally, the Panel's basic recommendation is the development of Fishery Ecosystem Plans [FEP] for each of the US ecosystems under fishery management. These FEPs provide directions for management into which the regular Fishery Management Plans could be assessed. The reason why the Panel did not choose to utilize the FMP process is because the FEP must look more broadly at ecosystem trends and the linkages between fisheries and the ecosystems. Cumulative effects of fishing for all species must be considered to the best of our knowledge while FMPs focus on species or groupings of like species..

While it should be possible to institute ecosystem-based management in the United States without additional legislation, the fact is that it is sometimes necessary 1) to make clear the intent of Congress, 2) to develop an enforceable pathway to implementation and 3) to provide a vehicle for funding and oversight.

Impediments to Implementing Ecosystem–Based Fishery Management

While there are scientific and other questions about how to move forward with ecosystem-based fishery management, I believe the largest set of issues concerns the backlog of implementation of basic environmental and administrative measures as well as the MSFCMA measures. How much additional work can be expected from an agency that is, in my view, overtaxed? Further, I believe there is confusion about

the management goal for fisheries and ecosystems that needs resolution or, at least, additional direction. I will focus on the situation with which I am most familiar, the NPFMC region but I think that much of what I note can apply or soon will apply to other regions.

Repeated law suits have demonstrated that the National Environmental Policy Act [developing of PEIS, SEIS] is not fully implemented in the current fishery management context in both its procedural and substantive aspects. NMFS is making compliance a top priority based on the statements of its leadership. This is a major task and one that in many cases is overdue. In the North Pacific Fishery Management Council we are literally wrestling with a 3,400 page document weighing in at 27.5 pounds Draft Programmatic Supplemental Environmental Impact Statement for the Bering Sea/Aleutian Islands and Gulf of Alaska Groundfish. This is the second update from the first document prepared in 1978 and redone in 1988 although Environmental Assessments of discrete management actions like annual setting of TACs and amending the management plans were done. Full Programmatic EIS work had not been done.

This effort, being done under court order has produced this a tremendous reference document on the fisheries in this region and their management. The process which produced it and will lead to decisions on policies will help us move further toward ecosystem-based fishery management. Why did it take a legal challenge to push us into doing this review? I would argue that it has mostly to do with two factors. First, the perception that Council/NMFS NEPA was compliant given its string of EAs and high reliance on scientific analysis and advice in the management process. Second, given the enormous work load on Council and NMFS staffs it seemed a luxury we could ill-afford in terms of staff tasking. Development of full programmatic review of the groundfish fisheries is at least a 3-year process involving nearly every staff member of NPFMC, NMFS Regional offices and Science Centers, Consultants, staff from the States of Alaska and Washington and we hope that it will pass muster. Why, because, I believe, this same undertaking will be expected for every major fishery in the United States—as soon as possible. This is reality. While dealing with this major effort, nothing was taken off of the Council/NMFS plate and more was added.

A second package of issues is very actively raised by Endangered Species Act and Marine Mammal Protection Act challenges with respect to Steller sea lions. I will not dwell on this issue as it is very complex and controversial but I will say that efforts to deal with findings of jeopardy in three fisheries has required a huge amount of effort in the development of Reasonable and Prudent Alternatives. This process also requires the completion of a NEPA EIS to precede final decisions. Again, not an easy set of responsibilities under other circumstances. This illustrates the point that conservative scientifically based fisheries management may not take into account the broader ecosystem issues that would be done in an ecosystem-based approach. Also, not having the NEPA Programmatic EIS from which to tier off, makes it difficult and somewhat redundant to perform a separate analysis simultaneously

Again, with a focus on the NPFMC at the same time we were ramping up on the NEPA compliance issues, SFA was passed with its many requirements to upgrade fishery management. Implementation of Essential Fish Habitat provisions is a major stretch for the agency and for the NPFMC in particular. Even before the formal regulations were approved the Council and NMFS started to devote a large amount of effort to identifying EFH and amending all FMPs to take it into account. The initial focus was on getting the first part of the requirements done. I know that finishing the first part was seen as a major accomplishment by the NPFMC. We felt our record with respect to setting up no trawl habitat areas for red king crab in the Bering Sea [30,000 square nautical miles, which is considered twice the area of Georges Bank NPFMC Draft PSEIS 2001] and no trawl zones in the Southeast Gulf of Alaska [45,000 square nautical miles], plus requirements to use pelagic trawls, and an FMP banning fisheries on forage fish was a good start. We planned [and are] building further under the EFH provisions concerning Habitat Areas of Particular Concern. However, as was quickly pointed out in litigation, the fishing effects identification and mitigation components of EFH were performed inadequately. Now we are engaged in a major scoping process and NEPA process for actions to further define and mitigate fishing effects.

The foregoing EFH discussion raises a very important point where policy direction is needed. The EFH and HAPC mechanisms can move the development of Marine Protected Areas ahead in the fishery management process. I am aware that new protective measures have been developed with regional fishery management council involvement in the Florida Keys National Marine Sanctuary [Dry Tortugas] and are under way in Channel Island National Marine Sanctuary. Further, the State of

California has a major initiative to establish a network of marine protected areas in State waters. More and more interest is being expressed in the use of MPAs in fisheries management [NRC 2001 Marine Protected Areas: A Tool for Sustaining Marine Ecosystems]. Time and area closures and gear restrictions have long been part of fishery management and many measures taken have been significant. These types of areas are familiar to fishing interests and are one of the many types of MPAs recognized by the IUCN and in the MPA Executive Order of May 25, 2001. However, there is a large amount of pressure to discount any MPA that is not a "fully-protected", i.e., "no-take" zone in terms of fisheries. Clarifying the role of NMFS in developing MPA measures under the EFH/HAPC process could be very beneficial.

Response to the SFA requirements to halt overfishing and to develop rebuilding plans is another key provision but one that takes time and resources to accomplish. Fortunately none of the groundfish stocks in the NPFMC area are overfished under the SFA definition [one crab species meets the overfishing definition and is so declared, despite scientific questions about the applicability of the definition to invertebrate stocks]. Formal procedures necessitate a couple of years to develop regulations, get regulations approved, develop rebuilding plans, get them approved and implemented. Then it takes time for the fisheries to respond. Most groundfish species require 3–10 years before results can be observed in the fisheries and, in some cases, much more time than that is necessary due to the life histories of the fish. In addition, favorable or unfavorable environmental conditions can accelerate or depress rate of recovery even without fishing taking place.

Implementing the full force of the MSFCMA has proved problematic and the experience from SFA amendments should be instructive as we contemplate the more integrative step of ecosystem-based fishery management. This litany of just some of the environmental, administrative and MSFCMA issues before councils and NMFS is provided to illustrate the daunting realities facing fisheries managers [e.g., bycatch, observer programs, Vessel Monitoring Systems, etc. See Council Chair's Report on MSFCMA Reauthorization, June 2001]. More importantly for the standpoint of this hearing, it shows how many of the actions are building the information base and understanding that is needed to take the next steps toward ecosystem-based fisheries management. And they point to how ecosystem-based fisheries management could be useful in providing a strategic focus for what right now seems like a series of disparate actions.

Steps to Ecosystem–Based Management

The United States is a leader in the development of theoretical and empirical studies of fisheries ecosystems. I would venture to say that we have more ecologically trained fisheries managers than any other nation. Does that translate into full use of what we know? Unfortunately, it does not. What we found in the Panel is there are very good examples of use of ecosystem knowledge but the application is inconsistent.

The Fishery Ecosystem Plan is a logical extension of fishery management under the regional council process. The Panel has provided a sketch of what we believe to be key elements of how such a FEP could be constructed and put into use. We anticipate that, as with any new approach, it makes sense to phase-in the FEP concept by a process that allows experimentation and innovation at the regional level. The NPFMC Ecosystem Chapter, a part of the annual stock assessment and fishery evaluation documentation is an important example of what could be done. Ideally, Congress could encourage the further development and implementation of this concept. However, it is important to keep in mind that the success of ecosystem-based fishery management is contingent upon substantially complete implementation of the Sustainable Fisheries Act of 1996 an other environmental and administrative mandates. Fortunately, full implementation of these laws provides the building blocks for ecosystem-based fishery management.

Adequate funding is critical for success. I do not know much about budgetary processes or allocations. I can observe that before SFA in 1996 I felt the agency was already overtaxed in terms of work. SFA added a number of additional tasks and some modest increases in funding, which, due to budgetary cycles was not in agency hands until a significant amount of time had passed. In addition, since 1996, the urgency to deal with the backlog of NEPA compliance has become more acute. Please understand. This is not a whine. I understand and support the full implementation of federal laws and I believe that the fishery management system is equally committed, but frankly, NMFS, the Councils, the fishing industry and environmental advocacy groups are swamped with efforts to rapidly respond to the backlog and the new responsibilities.

One discreet measure that would give Councils and NMFS more control over things that go on in the ecosystem would be to do as a few states have done and preclude new fisheries for species not under an FMP. Councils and NMFS could open these areas under experimental fishing permits or similar regulations with reporting and other controls that would identify the benefits and costs [ecological and economic] and would avoid rapid swings of effort into such fisheries

Another set of measures that needs to be considered as well are those that focus on the human dimensions of fisheries and the need to develop the right kinds of incentives for support for ecosystem-based management. This is being dealt with in other legislative proposals, e.g., the IFQ proposal of Senator Snowe and Sen. McCain. Suffice it to say that the Ecosystem Principles Advisory Panel strongly urges the interrelationships to be recognized.

The most critical step is for Congress to understand what is needed to move all of us forward who are involved in developing ecosystem-based fishery management—forward as a team. A good coach knows what the team needs to motivate it and fuel its best performance. Above all, a coach recognizes when it is necessary to raise the bar higher to challenge but not discourage the team.

Raising the bar. Congress needs to keep the pressure on fisheries management reform and to be a great coach for the ecosystem-based fishery management team. With time, financial support and legislative incentives, I believe US fisheries are already turning the corner and we will have healthy and sustainable marine ecosystems from which all of the natural service benefits can be supplied. Already there are signs of progress but it takes a lot of pressure, consistently applied, over substantial time to turn a large ship.

Mr. GILCHREST. Thank you very much, Dr. Fluharty.

Dr. Murawski?

STATEMENT OF STEVEN A. MURAWSKI, PH.D., NORTHEAST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

Dr. MURAWSKI. Good morning, Mr. Chairman

Mr. GILCHREST. Good morning.

Dr. MURAWSKI. Thank you very much for the opportunity to testify before the Committee. My name is Steven Murawski, and I am the chief stock assessment scientist for the National Marine Fisheries Service in the Northeast Region. Today, I would like to discuss with you and share some insights about the role of ecosystem-based management and what it can, and perhaps has done in the past, specifically related to the Northeast Region.

The Northeast shelf ecosystem supports about four dozen important species that contribute to the fisheries. These include species groups such as New England groundfish, summer flounder, sea scallops, monkfish, surfclam, ocean quahog, and a variety of other species. These species occur in perhaps one of the most well-studied ecosystems in the world. We have the benefit of a very long-time series of fishery monitoring data that has collected information about the abundance of fish species across the board for nearly four decades. As well, we have significant programs that Congress has funded in GLOBEC and NOAA's Coastal Ocean Program that have generated information on how various species interact between themselves and also with the environment.

One of the most compelling issues relating to these four dozen species is that almost all of them have undergone bouts of serious decline and overfishing in the last two to three decades and one would ask the question whether the lack of an ecosystem approach has contributed to that. Generally speaking, it is well-understood now that had fishery managers followed prescriptive advice for

single-species management, we probably wouldn't be in the circumstances we are. Nevertheless, there is a very compelling reason for us to go to some form of ecosystem-based management for this system, and there is a lot of things that are contributed by the development of Fishery Ecosystem Plans that we simply can't get out of the current system.

There seems to be a general consensus forming around four basic questions that we, as fishery scientists and managers, have as it relates to the potential contributions of an ecosystem basis rather than simply doing more single-species work. The first of these is what might be accomplished by developing criteria for defining ecosystem overfishing and what could we get in addition to effective single-species management?

Secondly, are single-species recovery strategies possible or desirable for complex ecosystems? Can we really restore the fishery biomass and yield potential on a species-by-species basis, given the limits of ecosystems.

The third question we have is can fisheries research provide a quantitative basis for defining ecosystem overfishing, as opposed to single-species overfishing, and what are the standards by which we could measure ecosystem overfishing, and this is a challenge for us as scientists.

And, fourth, what are the additional monitoring and research needs that would be necessary to support an ecosystem basis for fisheries management?

To the first question, what might be accomplished, we really see four major things that can be accomplished in a Fishery Ecosystem Plan, as opposed to the single-species and species group approach. First of all, we can take a better look at predator-prey relationships. The way that Fishery Management Plans are done in New England and the Mid-Atlantic, they tend to focus around groups of interrelated species that are caught together, and that leaves predator-prey relationships and the tradeoffs between predators and prey in the margins. A Fishery Ecosystem Plan could certainly help there.

Secondly, bycatch management. We have numerous examples where we have target species that are managed in one FMP that generate bycatch interactions that are regulated in another FMP, and that is not well-done.

A third issue that we could address in this context is the issue of comprehensive effort control. We have seen effort regulated, for example, in New England groundfish and scallops, with the excess effort being pushed off to different fisheries to create other problems. A comprehensive approach is certainly necessary.

And last, the inclusion of accounting for impacts of mobile fishing gear is certainly important to issues of habitat research, and that is not well-covered in the current management approach.

To the second question, single-species recovery strategies, we certainly need to look more deeply at issues related to the possibility to have BMSY and MSY values for all individual species and is the whole less than the sum of its parts, which is an important question.

Now, as far as canned fishery science, provide us new insights, on a quantitative basis, for ecosystem overfishing definition. This

is an area of current active research. There are a whole host of things like species diversity indices that have only started to be applied to these kinds of problems. We see this as an area of great importance, and certainly in terms of the definitions, a very critical issue.

And last, what new research should we do? First of all, we think that predation studies need to be improved and completed, and that includes things like food habits, estimates of consumption not only by the fish species, but also marine mammals and other species, and a greater reliance on the spatial processes that happen, rather than looking at fish, as a group, as if they didn't spread out and interact at the margins.

Secondly, we need to develop quantitative measures of biodiversity. We hear a lot about managing for increased biodiversity, but we, as scientists, and certainly the managers don't really have a good working definition of that.

Third, we need more field studies of the Marine Protected Areas (MPAs) and other closed areas that currently exist. In our region, we have about 20,000 square kilometers closed. These are providing new insights into the potential use of MPAs as an ecosystem tool. We need to improve our models of species and habitat interactions and, last, we need to improve our monitoring capabilities to work across the trophic levels.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Murawski follows:]

Statement of Steven A. Murawski, Ph.D., Chief Stock Assessment Scientist, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts

Thank you, Mr. Chairman, for your kind invitation to provide testimony regarding ecosystem-based management and specifically aspects related to the Northeast United States continental shelf. My name is Steven Murawski, and I am the Chief Stock Assessment Scientist for the Northeast Fisheries Science Center, in Woods Hole, Massachusetts. In my oral and written testimony I will detail a case history of overfishing on an ecosystem-wide basis. The Northeast shelf ecosystem is one of the best-studied areas of the world's oceans. Fishery-independent monitoring programs have been in place for nearly four decades, and the predator-prey interrelationships and effects of variation in the marine environment on species of the Northeast have been extensively studied. Had prescriptive scientific advice, based on traditional models and data, been followed, many of the difficulties we now face in stock rebuilding could have been avoided. Nevertheless, there is a critical need for the inclusion of ecosystem considerations in the management of this system, and ecosystem issues will have an increasingly important and central role in setting biomass rebuilding targets, optimizing yields from interrelated species and fisheries, minimizing habitat damage caused by gear, and in dealing with overcapacity of a mobile, efficient, and adaptable fishing fleet.

The Northeast USA: A Case History of Ecosystem Overfishing

Off the Northeast USA (Cape Hatteras to the Canadian Maritimes) there are about four dozen important finfish and shellfish stocks that require intensive monitoring and scientific advice to support fishery management plans. These stocks include New England groundfish (a complex of about 15 species and 25 managed stocks), summer flounder, sea scallop, Atlantic herring and mackerel, striped bass, surfclam and monkfish, to name a few. Virtually all of these important stocks have undergone dramatic population declines during the past two or three decades, necessitating the development of restrictive management measures to address overfishing (Exhibit 1). In a number of important cases these plans, which have usually been developed for individual species or sets of species caught together when fishing, have resulted in some level of stock rebuilding. Thus, for example, we have seen increases in the stock sizes and landings of striped bass, summer flounder, sea scallop, and some stocks in the groundfish complex. Rebuilding of these stocks has

required substantial cuts in fishing mortality through the imposition of strategies to reduce fishing pressure (effort), the closure of large areas of productive ocean waters to fishing, in some cases the adoption of low annual landings quotas, and other measures.

It is often suggested that the depletion of these Northeast fishery resources (and more generally those throughout the nation and the world) stems in part from our failure to adopt an holistic "ecosystems approach"—fisheries management and resource conservation being too focused on single-species stock status and control strategies (Murawski 2000). The primary cause of the collapse of many Northeast stocks clearly was excessive fishing—scientific advice from single-species stock assessments predicted as much. Nevertheless, it is appropriate to consider how systems might be assessed and managed, and what additional benefits could be expected from an explicit ecosystem orientation. The important questions in this regard are, then:

- What might be accomplished by developing criteria for defining ecosystem-level overfishing and management measures that could not be accomplished under effective single- or multiple species fishery management plans?
- Are single-species recovery strategies possible or desirable for complex marine ecosystems, and if so, what characteristics of ecosystems should be considered when developing stock rebuilding targets and thresholds?
- Can fisheries research provide a quantifiable basis for defining ecosystem overfishing and acceptable standards to measure progress against those definitions?
- What additional monitoring and research would be necessary (over and above that necessary to support species management) to support ecosystem-based fishery management?

The situation off the Northeast USA provides some useful insights into these questions; as a case history, these fisheries are often regarded as a prime example of ecosystem-level overfishing (Hall 1999; Fogarty and Murawski 1998).

While overfishing of some species was evident as early as the late 1920s (i.e., Georges Bank haddock and Atlantic halibut), overfishing on an ecosystem scale did not occur in the Northwest Atlantic until the early 1960s, with the massive influx of effort from European and later Asian distant-water fleets. The scale of the effort increases in the 1960s and early 1970s was so massive that the system showed rapid and broad-scale declines in the fish populations off the coast (Exhibit 1). These fleets of large vessels could not survive on low catch rates and thus the distant-water fleets engaged in a strategy of switching from one abundant target species to another in a now classic pattern termed "sequential depletion" (Orensanz et al. 1998). In this fishing pattern, multispecies catch rates are maintained, for a while, by re-targeting fisheries to abundant or valuable resources, with fishery management structures unable to anticipate or keep up with the changes in fishing patterns. The severe depletion of traditional USA groundfish species such as haddock, whiting (silver hake), red hake, and yellowtail flounder was followed by shifts and collapses in herring, mackerel, and other species important to the functioning of the fish component of the ecosystem (Exhibit 1; Fogarty and Murawski 1998). The fishery initially focused on predators and other high level consumers, and later on fish species of lower position in the food web (Sissenwine et al. 1984), consistent with a strategy of "fishing down the food web" (Pauly et al. 1998). The collapse of herring and mackerel stocks—primary prey for a number of predators such as cod, whiting, dogfish, and pollock, resulted in substantial shifts in diet composition and consumption rates by these predators (Overholtz et al. 2000), and resulted in substantial increases in other species including sand eels (Fogarty et al. 1991).

A comprehensive fishery research strategy to index all the marine fish components of the Northeast ecosystem was introduced in the early 1960s, coincident with the influx of distant-water fleet effort. The delivery of the R/V Albatross IV in 1962 provided for the first time an adequate platform from which to mount system-wide bottom trawl surveys in the nearly 250,000 km2 Northeast continental shelf ecosystem. These surveys, undertaken in a statistically rigorous manner for nearly 40 years, provide the basis for single-species stock assessments and other data about the ecosystem. It is these data (Exhibit 1) that documented clearly the impacts of fishing on individual stocks and species groups. In addition to abundance and biological measurements of individual stocks, stomach sampling information obtained from the surveys has allowed for modeling of the impacts of predator-prey interactions (Overholtz et al. 2000).

Fishery management in the 1970s was primarily undertaken through the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Eventually ICNAF adopted comprehensive quota management systems for primary target species, and an overall cap on fisheries removals (similar to that now in effect

in the Bering Sea) to address predator-prey and bycatch problems. This regime ended in 1976 with the adoption of the Magnuson Act.

With the adoption of domestic management programs, most quota-based management of finfish resources was phased-out in the early 1980s in favor of "indirect" controls on fishing such as minimum fish and mesh sizes. Although stock assessments showed increased fishing mortality rates and declining biomasses of the valuable stocks, fishery management responses were too slow to respond and generally inadequate. Landings of groundfish stocks increased in the early 1980s due to good recruitment from the mid 1970s, but later declined severely due to high harvest rates and recruitment failure (Exhibit 2). Beginning in the early 1990s, fisheries management again instituted systems of direct controls including "hard" quotas for a number of Mid–Atlantic species (summer flounder, surfclam, ocean quahog, mackerel, scup, squids), and effort control for New England groundfish, sea scallop, and monkfish. Combined with the large scale closure of productive fishing grounds in New England (Exhibit 3), management has achieved lower mortality rates for most valuable stocks and abundance has improved.

For some stocks such as herring and mackerel, domestic fisheries have never generated fishing mortality rates as high as those achieved under the foreign fishing regime, and these stocks increased rapidly to very high levels after 1976 (Exhibit 1). Currently, herring and mackerel are abundant and relatively productive, and are consumed by a wide variety of fish, seabirds, and marine mammals. The recovery of these species was an early indication that the effects of ecosystem-level overfishing were not necessarily irreversible—that important components of the ecosystem could be recovered despite the complexity of species interactions and fisheries.

Studies of the food web supporting the shelf fisheries have demonstrated just how complex the system is (Link 1999). However, despite this complexity, research has demonstrated that the system is not so tightly bound that recovery potential is severely limited by dominant predator-prey relationships. One of the most important observations of the Georges Bank GLOBEC research program is that environmental variability has a significant influence of the survival of young fish (Fogarty and Murawski 1998). Other recent studies have also shown that there are substantially greater odds of getting strong replenishment of groundfish occurring when spawning biomasses are high (Brodziak et al. 2001). The empirical observations of the recovery of prey species like herring and mackerel, combined with information demonstrating the importance of adequate spawning biomass, and the roles of oceanographic variability, have all strengthened the case for aggressive management for stock recovery and eventual fisheries sustainability at levels approaching MSY.

The Role of Ecosystem Considerations

All of the stocks regulated under Federal FMPs have, as their fundamental basis, the definitions of overfishing and attendant control rules set so that fishing mortality rates do not exceed the level that is necessary to achieve maximum sustainable yield (MSY). Further, biomass targets are established for each of the major stocks, based on the likely recovery potential by using analyses of historical fisheries and research data. It is clear that the establishment of target biomasses under the single species approach leaves many unanswered questions. A primary question of great current importance is: what is the biomass and yield potential for stocks that have been chronically overfished throughout the period for which there are landings and population data? It is possible that the yield potentials of some stocks, like Georges Bank haddock and yellowtail flounder, sea scallop, and summer flounder are different than those indicated by single-species models of stock recovery and yield. In these cases we simply may not be able to ascertain these quantities de novo from the historical data—an adaptive, cautious management approach to exploring the yield and biomass potentials of stocks may be required. By the same token, a comprehensive approach to defining biomass necessary for MSY for each stock individually may not be feasible given the limits on fish biomass and yield imposed by primary production (photosynthesis) and zooplankton production. Simply stated, the whole may be less than the sum of the parts. It is clear that the current approach, as implemented in Northeast FMPs for individual species and species assemblages, has no mechanism to incorporate ideas regarding predator-prey relationships and the feasibility of biomass goals and possible trade offs. Likewise, bycatch interactions, wherein the target fisheries regulated in one FMP generate bycatches of species controlled by another, are also not now addressed in a systematic manner. An umbrella fisheries ecosystem plan would be a valuable addition to address these concerns.

Another issue that could be better addressed with an ecosystem focus to FMP development is the effect of effort control programs on non-target species. The deple-

tion of groundfish and other high values species was followed by a more recent round of shifting fisheries to alternative target species (Exhibit 4). In this scenario, effort from the traditional groundfish and scallop fisheries was diverted to non-traditional stocks including monkfish, spiny dogfish and squids. In the case of groundfish, effort was halved in the mid–1990s, with some of the remaining effort flowing to these alternative targets. Managers have had to play catch up to address overfishing concerns of these secondary target species. This scenario could have been addressed through a comprehensive approach to fishing effort and capacity management—the current system recognized the potential of effort movement between fisheries but has not managed capacity in a comprehensive manner. Clearly, recognizing that fishing effort can be deployed in flexible and efficient ways should be an important consideration in managing fishery ecosystems.

Fishery managers in New England and the Mid–Atlantic have been among the first to adopt the use of large-scale year round fishery closures in order to achieve management goals for target species (Exhibit 3; Murawski et al. 2000). Large areas (over 20,000 km2 in the case of groundfish closures) of productive fishing grounds were closed beginning in 1994. These areas have proved to be a significant element in the plan to increase groundfish abundance. At the same time, the enactment of these areas have had serendipitous effects demonstrating the value of closed areas as a strategy for increasing the abundance of sea scallop and other species (Murawski et al. 2000). These closures, although enacted for very specific and limited fishery management goals, have coincided with a heightened interest worldwide in the use of marine protected areas (MPAs). Although most monitoring studies have focused on the overall status of regulated stocks, some limited field study conducted by the NEFSC and academic partners have revealed changes in the benthic community structure and habitat associated with the closures (Collie et al. 1997). Prior to the limited resumption of scallop dredging in portions of the groundfish closure areas, comparative habitat studies were initiated—the results of which are only now being interpreted. Based on preliminary analyses, it is clear that the cessation of fishing in these habitats has had measurable effects on the biota in the closed areas. We do not yet know the significance of these changes to either the target species (improved juvenile survival?) or on other non-resource species. There is an indication of increased biodiversity of the fish component of the resource since the adoption of these closures, and there are some similar effects outside the closures (Exhibit 5; Brodziak and Link 2001). However, intensive studies of the effects of these closures and their roles within the broader ecosystem have not been initiated. Closed areas (rotational, seasonal, year-round, and marine reserves wherein no fishing activity at all is allowed) will be a significant component of fishery and ecosystem management in the years to come, and programs to evaluate the potential costs (through lost fishing opportunities) and benefits of such closed areas are a priority. Fishery closures in New England have resulted in trawl fishing effort moving into habitats that heretofore were not as heavily utilized (Exhibit 6). These effects need to be better understood as MPAs become more widely established as fishery and ecosystem management tools.

Summary

Overfishing of Northeast fishery resources occurred primarily as a result of the lack of direct controls on fishing mortality. As a wider array of species comes under intensive management, and stocks begin to recover, there is an even greater need to address ecosystem considerations. It is not clear that we can achieve biomass targets determined based on single-species models and data for all managed stocks simultaneously, and it is likely that species interactions will increasingly modify the rates of recovery of stocks. Fishery management plans for individual species and species groups do not allow a convenient forum in which to assess inherent tradeoffs due to predator-prey or bycatch interactions. Furthermore, the current structure does not allow a comprehensive effort control and management system. Comprehensive effort management has been identified as an essential component of ecosystem-based fishery programs. The effects of mobile fishing gears on the characteristics and productivity of benthic habitats has also been identified as a priority, but studies of these phenomena and their importance in managing exploited ecosystems has not been adequately assessed anywhere in the world. The Northeast USA shelf ecosystem has been intensively trawled and dredged for 100 years, and changes in these habitats have no doubt occurred. Marine protected areas have the potential to mitigate some of these effects, but the extent and direction of habitat changes with the cessation of trawling and dredging is only now beginning to be appreciated, especially in New England. This issue will take on a central role in fisheries management and research in the years to come.

In the absence of a quantitative understanding of species interactions and impacts of habitat alterations, there is a growing consensus of scientific opinion that prescriptive management provided by conservative single-species approaches will provide the balance among ecosystem components and high and relatively sustainable fishery yields. A better understanding of these issues will allow managers to assess the potentials and tradeoffs that will result from more active management of the various components of the ecosystem.

Research Needs to Support Ecosystem Considerations:

Ecosystem approaches, whether implemented as perspectives on traditional overfishing approaches, or through explicit ecosystem-based definitions, require research and advisory services not typically provided by fish stock assessment science. Regardless of the approach, additional ecosystem monitoring and research is necessary with increased emphasis on species interactions, diversity (at all levels of organization) and variability (at various temporal and spatial scales). However, this does not necessarily imply that traditional programs collecting fishery-dependent and fishery-independent information should be abandoned. On the contrary, existing programs will need to be expanded to allow monitoring of catches and abundances of a wider array of species, to complement research and modeling on trophic interactions and other processes. Such research is necessary if ecosystem considerations are to assume a greater role in resource management, particularly as habitat protection becomes a priority, and measures such as marine protected areas are used more widely to enhance resource and non-resource species protection. Specifically, I foresee added research emphasis in these areas:

- predation studies
- measures of species diversity and their relation to harvesting
- field studies of closed areas (emphasizing their role as essential fish habitat)
- models of species and habitat interaction (spatially explicit)
- enhanced capabilities to comprehensively monitor components of the ecosystem through fishery independent surveys

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[Exhibits attached to Dr. Murawski's statement follow:]

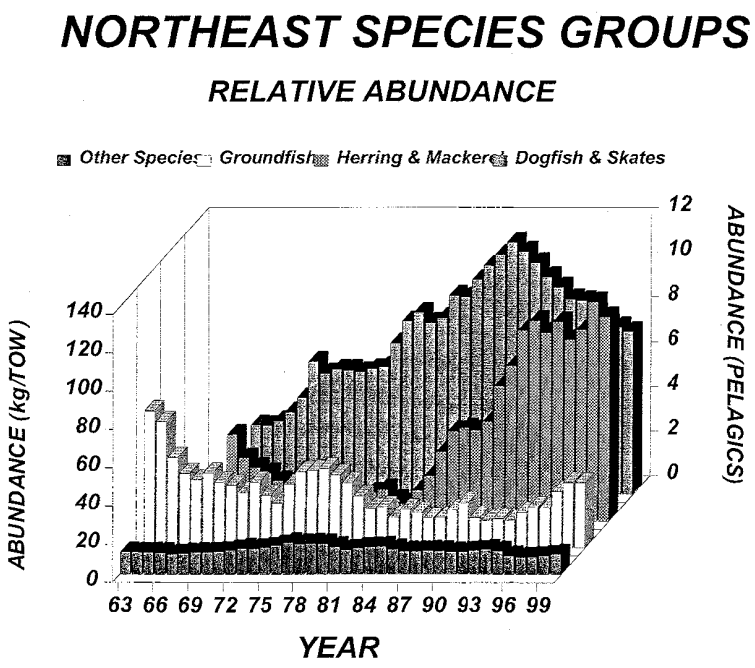


Exhibit 1. Trends in the relative abundance (expressed as kilograms per half-hour trawl tow) for four major species groups off the Northeast USA, 1963-2000. Data are collected from National Marine Fisheries Service bottom trawl surveys.

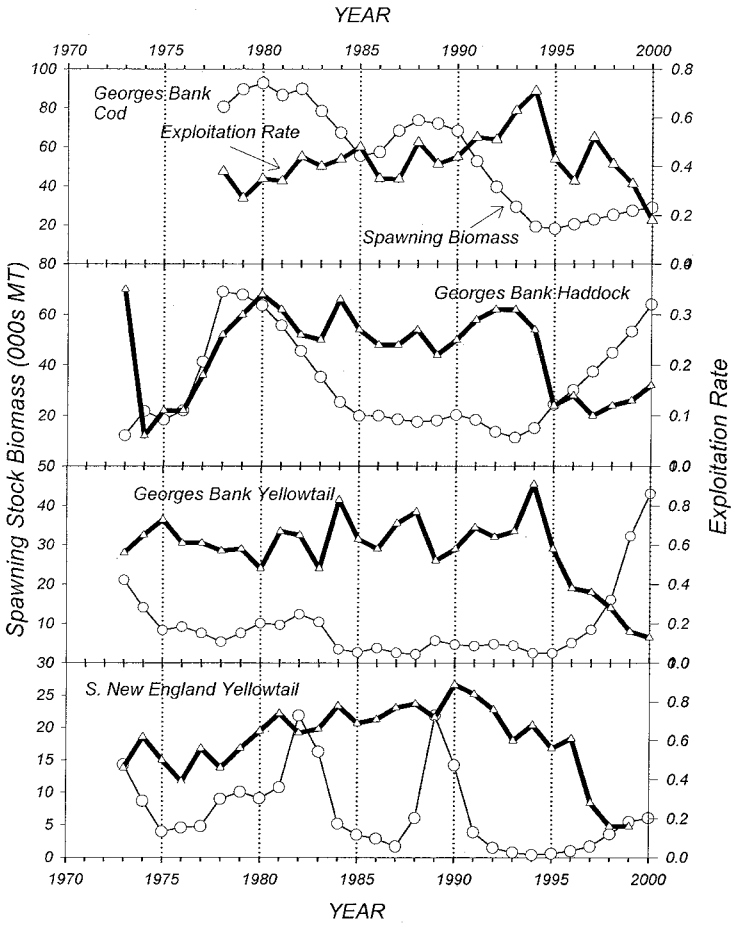


Exhibit 2. Trends in the exploitation rate (proportion of the stock killed by fishing) and spawning stock biomass for four important Northeast groundfish resources.

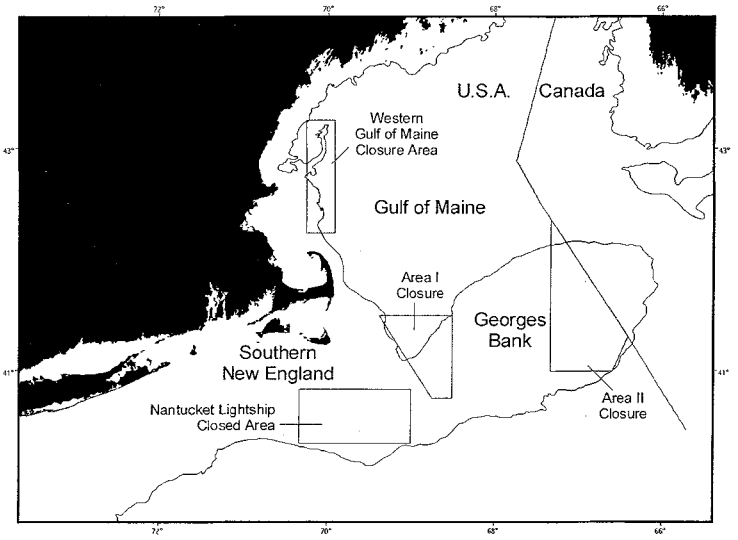


Exhibit 3. Groundfish closed areas off New England.

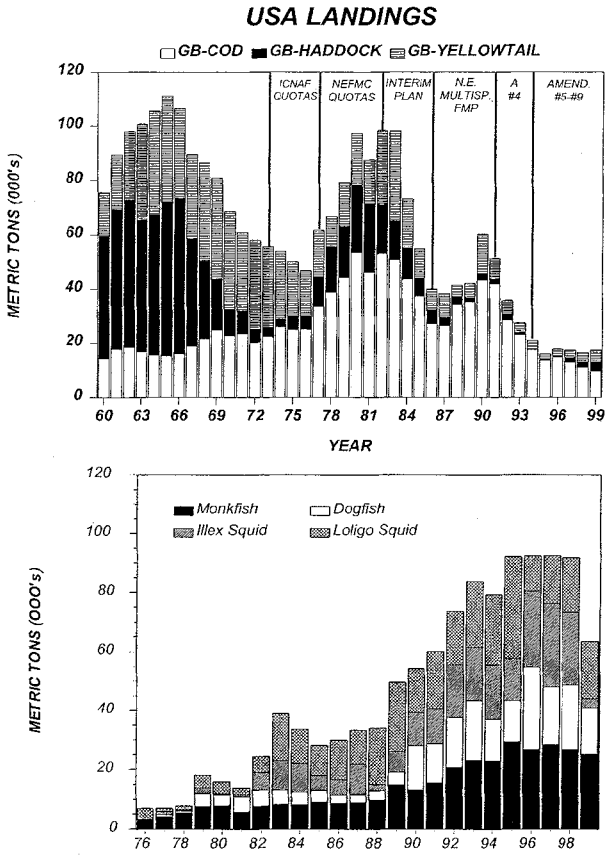


Exhibit 4. Trends in fishery landings for three important traditional New England groundfish stocks (above) and four non-traditional species (below)

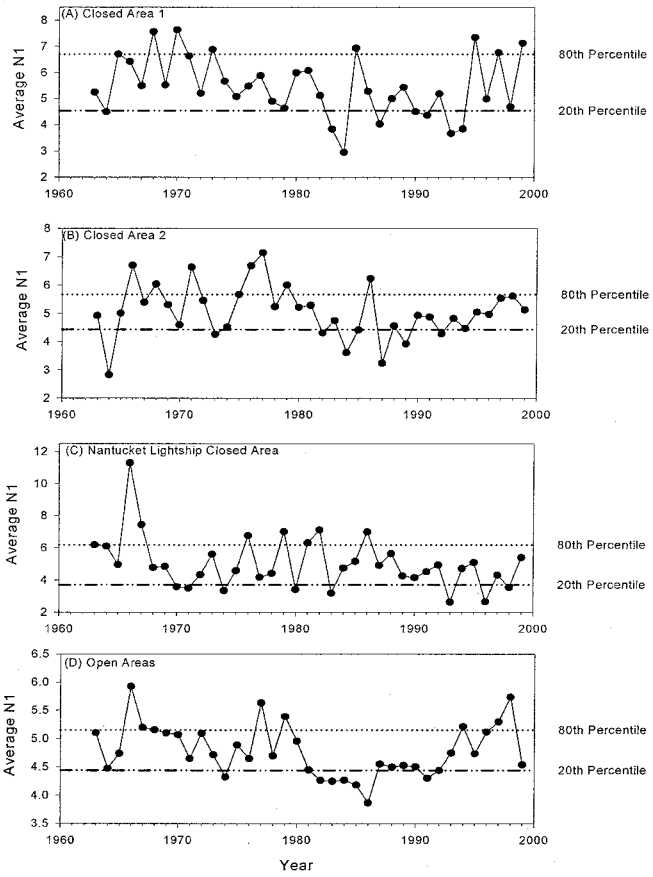
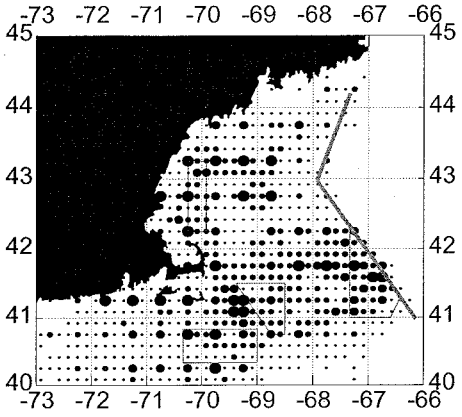


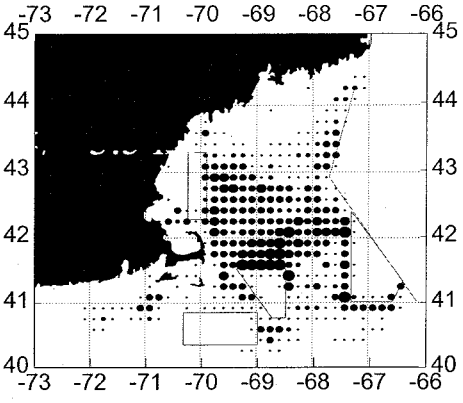
Exhibit 5. Trends in a species diversity index (N1) for three groundfish closed areas (Exhibit 3) and all open areas, 1963-1999. Note that the areas were closed in 1994. Data are based on fish catches from NMFS bottom trawl surveys.

1991-1993



1991-1993

2000



2000

Exhibit 6. Changes in otter trawl fishing effort before (1991-1993) and after (2000) closure of groundfish areas off New England. Data Prior to 1994 are days fished based on port agent interviews, data from 2000 are based on position locations from satellite data for 36 vessels participating in the vessel monitoring system (VMS) program

Mr. GILCHREST. Thank you very much, Dr. Murawski.
Ms. Livingston, welcome.

STATEMENT OF PATRICIA A. LIVINGSTON, ALASKA FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

Ms. LIVINGSTON. Thank you, Mr. Chairman and members of the Subcommittee. I appreciate being invited to this hearing on ecosystem-based fishery management. I am Patricia Livingston, the program leader of the Resource Ecology and Ecosystem Modeling Program at the Alaska Fisheries Science Center of NMFS. Today, I want to tell you a little bit about the Alaskan experience with implementing ecosystem-based management.

Our challenge in the last year or so has been how to summarize our ecosystem knowledge and bring it to the attention of fisheries management. We have produced three different analyses this last year that attempt to do that.

The first one is the Ecosystem Considerations Chapter that accompanies our Stock Assessment and Fishery Evaluation Reports that provide single-species stock assessment advice to the North Pacific Fisheries Management Council. In this ecosystem chapter, we have attempted to provide information on the status and trends of various ecosystem components and ecosystem indicators, including ecosystem management indicators, that we can relate to the ecosystem-based goals of the Council, which include maintaining diversity, habitat sustainability, and humans as components of the ecosystem.

For example, we can compute an index looking at the trophic level of the catch to see if we are fishing down the food web, which is an issue related to diversity and sustainability. What is lacking in this effort is its link to real quantitative ecosystem-based management objectives. Right now it is serving more of an information service.

We have also produced programmatic Alaska groundfish, SEIS. It was a very broad-based ecosystem assessment, and it contains virtually all of the elements of a Fishery Ecosystem Plan, as envisioned by the NMFS Ecosystem Principles Advisory Panel. It covered a broad range of issues from habitat to predator-prey interactions, protected species, target and nontarget species, ecosystem effects of fishing and socio-economic benefits.

It was clear when we evaluated the present fishery management regime, using the performance standards of the Sustaining Marine Fisheries Report of the NRC, that we have made progress in ecosystem-based management. We have conservative single-species-based management. Our catches are below the allowable biological catch levels recommended by scientists. We have established substantial no-trawl zones. There are significant controls not only on target species discards, but also on the bycatch of prohibited species. We have an overall cap on total catch. There is a prohibition on new fisheries for forged species, and we have designated sensitive bottom organisms, such as corals and sponges, as prohibited species.

When we took the next step and tried to identify future possible improvements to the system, with regard to protecting various ecosystem components or improving socio-economic benefits, it really

highlighted our lack of quantitative knowledge with regard to ecosystem processes. For example, when we tried to recommend future habitat protection, it was unclear, in a quantitative way, how that might translate into increased fish production. We required more information on the effects of fishing on habitat. We had inadequate space/time resolution of our predator-prey information and abundance. We need more information on nontarget species distribution, taxonomy and life history and improvements in our fishery catch statistics so that we can track nontarget species catches.

The final document we worked on was our Comprehensive Biological Opinion, looking at groundfish fisheries from an ESA perspective. Again, this was a qualitative analysis that highlighted our lack of knowledge of the seasonal distribution of key Steller sea lion prey, such as walleye pollock and Pacific cod, and the seasonal distribution and foraging needs of Steller sea lions.

In that opinion, we provided some conservation recommendations that we hope would help us avoid future adverse effects. The primary one was to expand our stock assessments to consider the space and time distribution of stocks, and the removals, and how those overlap with protected species, and also to include environmental influences on fish stock distribution and abundance. These are some of the same recommendations that have been made in the NMFS Stock Assessment Improvement Plan.

So it is clear that we have made incremental progress toward ecosystem-based FMPs with various plan amendments we have had. We have identified some possible policy directions for future improvements. We require improvements in stock assessments, as identified by the NMFS Stock Assessment Improvement Plan. We need to continue in and enhance our long-term monitoring of ecosystem components, and we need more quantitative ecosystem-based objectives in order to move forward.

I think the key elements here are the involvement of a broad spectrum of scientific experts to reflect the concerns beyond target species and enhancing our research to reflect those concerns.

Thank you very much.

[The prepared statement of Ms. Livingston follows:]

Statement of Patricia A. Livingston, Program Leader, Resource Ecology and Ecosystem Modeling, Alaska Fisheries Science Center, National Marine Fisheries Service, U.S. Department of Commerce

Mr. Chairman and Members of the Subcommittee, thank you for inviting me to this hearing on ecosystem-based fishery management. I am Patricia A. Livingston, Program leader of Resource Ecology and Ecosystem Modeling at the Alaska Fisheries Science Center of the National Marine Fisheries Service (NMFS).

Implementing Ecosystem–Based Fisheries Management: The Alaskan Experience

Implementing ecosystem-based fishery management requires an expansion of our fishery management advice beyond assessments of species that are targets of fisheries. Although there have been advances in multispecies and ecosystem modeling approaches, these approaches have not yet been completely embraced by the scientific community for purposes of fishery management. In some cases this is so because of the difficulties in validating these models and in other cases because of the lack of sufficient data and knowledge of the critical processes to develop an appropriate model.

We are making progress, however, in providing ecosystem advice to managers while we wait for these approaches to mature. There are many GLOBEC and GLOBEC-like research efforts going on throughout the world, which bring oceanographers, marine ecologists, and fisheries scientists together to examine the potential

impact of global climate change on ocean ecosystems. Coordinated ecosystem research programs along these lines are being conducted in the Gulf of Alaska through the U.S. GLOBEC program, which is seeking to understand effects of climate variability on marine production, particularly looking at salmon and zooplankton. NMFS and NOAA's Office of Oceanic and Atmospheric Research have been working together in Alaska to understand the effects of climate on pollock production through its Fisheries Oceanography Coordinated Investigations joint program. These programs have highlighted the significant gaps in knowledge in the link between zooplankton and fish production. There is also increasing emphasis on habitat research, ongoing trophic interactions work, and long-term monitoring of non-commercial species, which all provide useful information on ecosystem status and trends. Some of this ecological information can be used to gauge the success of various management schemes that have been put in place to meet ecosystem-based management goals that have been put forward by the scientific community.

The Alaska Fisheries Science Center and other collaborators have provided the North Pacific Fishery Management Council (NPFMC) with some of this ecosystem research information in an Ecosystems Considerations document that accompanies the traditional single-species stock assessment advice to the Council. We have also just completed a draft programmatic Supplemental Environmental Impact Statement (SEIS) for our Alaskan groundfish fisheries that provides a comprehensive analysis of our present knowledge of the effects of the groundfish fisheries on the environment. This draft programmatic SEIS takes a broad view of the present fishery management regime and examines policies and potential future actions from a variety of environmental perspectives. A comprehensive Biological Opinion on Alaskan groundfish Fisheries provides a protected species impacts analysis and management approaches to be used to avoid jeopardy under the Endangered Species Act. A broad range of scientific expertise is required to provide the ecosystem-based advice in these types of documents. I will discuss aspects of these documents, their relationship to development of ecosystem-based fishery management plans, and some of the present gaps in our scientific knowledge.

Ecosystem Considerations Chapter

The North Pacific Fishery Management Council's Groundfish Plan Teams began in 1994 to broaden the scientific information provided to the plan teams beyond the single-species stock assessment advice contained in the Stock Assessment and Fishery Evaluation Report (SAFE) provided to the Council. A new Ecosystem Considerations Chapter was added to this SAFE document. Originally, the chapter contained information summarizing ecosystem-based management objectives from recent research articles, status and trend information of protected marine mammal species such as Steller sea lions and northern fur seals, and research summaries of a variety of ecosystem-related research. There was not much standardization of the content of the report from year to year. However, it served as information to the plan teams and as a vehicle for discussing research priorities.

Three years ago, NMFS proposed that the chapter serve as an ecosystem status and trends document with a more standardized content from year to year. The idea was to draw upon a broad range of scientific experts in the areas of physical oceanography and climate, biological oceanography, habitat and effects of fishing research, marine pollution, predator-prey interactions, forage fish and other non-target species, and marine mammals and seabirds. Information would be presented on the time trends of these ecosystem components in the document and discussion would include the possible factors influencing change. Experts providing information to this chapter include those from NMFS, other NOAA components, state agencies, U.S. Fish and Wildlife Service, academia, and those representing native or other local-based knowledge groups.

The purpose of these ecosystem status and trends indicators is to 1) bring the results of ecosystem research efforts to the attention of stock assessment scientists and fishery managers in order to provide stronger links between ecosystem research and fishery management and 2) bring together many diverse research efforts into one document, which would spur new understanding of the connections between ecosystem components and the possible role that climate, humans, or both may have on the system.

In addition to the ecosystem status and trend information, NMFS proposed that the document also contain ecosystem management indicators. These indicators would be ones that measure how we are meeting ecosystem-based management goals. The indicators would: 1) provide early signals of direct human effects on ecosystem components that might warrant intervention by management or 2) provide evidence of the efficacy of previous management actions. The North Pacific Fishery Management Council adopted an ecosystem policy that has the following four eco-

system-oriented management goals and the indicators are arranged to measure aspects of the management system that could influence achievement of those goals.

1. Maintain biodiversity consistent with natural evolutionary and ecological processes, including dynamic change and variability.
2. Maintain and restore habitats essential for fish and their prey.
3. Maintain system sustainability and sustainable yields for human consumption and non-extractive uses.
4. Maintain the concept that humans are components of the ecosystem.

For example, Exhibit 1 shows an ecosystem measure, trophic level of the catch, that can be used to examine whether we are "fishing down the food web," an issue related to system biodiversity and sustainability. We have now completed two annual revisions of the more standardized ecosystem considerations document of the NPFMC (Livingston 1999, 2000). The documents are available on the web at:
http://www.refm.noaa.gov/docs/ecocons99.pdf
http://www.refm.noaa.gov/docs/Ecocon2000.pdf

NMFS is working closely with the North Pacific Fishery Management Council to apply ecosystem level information to fishery management decisions. The Ecosystem Considerations Chapter now contains some parts of a Fishery Ecosystem Plan such as ecosystem status and trend information for many ecosystem components. It also has management indicators such as: amount of habitat closed to fishing, changes in the amount of fishery discards over time, and trophic level of the catch. The document provides a way for ecosystem research scientists from a variety of organizations to inform stock assessment scientists of their results and for managers to link management actions with ecosystem observations and ecosystem-based management goals such as protection of habitat, maintaining diversity, and sustainability.

Future work includes the development of more quantitative management objectives and ecosystem indicators linked to management triggers. Semi-quantitative approaches, such as those used in Environmental Impact Analysis, linked to a prenegotiated set of management actions are now being discussed by the scientific community (e.g., Caddy 1999; Koeller et al. 2000). This is a key step needed to advance this ecosystem considerations chapter beyond research communication towards a true ecosystem assessment that triggers ecosystem-based management actions.

Draft Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement (SEIS)

The National Environmental Policy Act (NEPA) requires federal agencies to analyze potential impacts of federal actions on the environment. The draft SEIS examines the impacts of the authorization of the groundfish Fisheries off Alaska. It is an ecosystem-based assessment in that it covers the broad range of issues from the effects of groundfish Fisheries on the decline of sea lions and other protected species, the effects of fishing gear on benthic habitat, excess fishing and processing capacity, target and non-target species effects, and the effects of harvesting on the North Pacific marine ecosystem. The programmatic SEIS identifies and evaluates combinations of management tools available for improving the fishery management regime with respect to protecting and conserving various ecosystem components and increasing socioeconomic benefits.

The SEIS document also contains virtually all of the elements of a Fisheries Ecosystem Plan as outlined by the Report of the NMFS Ecosystem Advisory Panel including:

- Delineation of the ecosystems within Council authority, including characterization of the biological, chemical and physical dynamics of those ecosystems (Chapter 3)
- Description of the food webs of the ecosystems (Chapter 3)
- Description of the life history characteristics and known habitat needs of different life stages of animals (Chapter 3)
- Total fishery removals including incidental mortality and assessment of how those relate to ecosystem effects (Chapters 2 and 4)
- A description of the Fisheries management plan policy statements, goals, and objectives that includes how uncertainty is included in conservation and management actions (Chapter 2)
- Ecosystem indicators are used in the assessment process (Chapter 4)
- Description and, through the cumulative effects analysis, an assessment of the ecological and human elements of the ecosystem which most significantly affect Fisheries (Chapter 4)

The status quo fishery management regime is explained and evaluated with respect to the performance standards for fishery management outlined in the Sustaining Marine Fisheries report of the National Research Council. It is clear from this evaluation that Alaska has already accomplished a great deal in terms of eco-

system-based management through conservative single species management (Exhibit 2), establishment of substantial no-trawl zones (Exhibit 3), programs to reduce overcapacity , significant controls on discards and monitoring of bycatch (Exhibit 4), and reducing fishery interactions with protected species. The North Pacific Fishery Management Council has established an Ecosystem Committee, whose purpose is to discuss and recommend possible approaches to incorporating ecosystem concerns into the fishery management process and to provide the Council and stakeholders with information on ecosystem-based management in the North Pacific Ocean. Other precautionary measures that have been taken include a 2 million mt per year optimum yield upper limit to restrict total allowable catch of the Bering Sea groundfish complex, a prohibition on new Fisheries for forage fish species, and designating sensitive bottom organisms such as corals and sponges as prohibited species.

It is intended that the programmatic SEIS will serve as the central environmental planning document for both the BSAI and GOA Groundfish FMPs, which are presently not oriented to promote ecosystems. The full document can be viewed on the web at: http://www.fakr.noaa.gov/sustainablefisheries/seis/intro.htm

The SEIS is Alaska's most complete analysis to-date of our scientific understanding of the effects of groundfish Fisheries on the environment and it highlighted many of our gaps in knowledge in determining ecosystem effects, particularly in a quantitative way. We had incomplete knowledge of the seasonal distribution and habitat needs of important groundfish in order to make determinations of how protection of habitat might improve stock abundance. Similarly, lack of knowledge of both the seasonal foraging requirements of Steller sea lions and the seasonal changes in distribution of key prey stocks such as walleye pollock and Pacific cod prevented us from making quantitative assessments of the effect of fishing removals of these species on Steller sea lions. The effects of fishing on benthic habitat research is just beginning and we require additional work to understand how fishing gear and fishing removals affect benthic diversity. Increased benthic habitat mapping in conjunction with fishing gear experiments are needed. Although we have a variety of predator-prey models, we need data at finer space and time scales and better knowledge of the space/time distribution of prey, particularly forage fish and zooplankton to determine how predators may switch according to prey availability. More research on non-target species distribution and taxonomy in association with improvements to our fishery reporting system are needed to move some of these species into tier 1 assessments defined in the NMFS Stock Assessment Improvement Plan. Moving towards more quantitative or semi-quantitative analyses on which to base our ecosystem-based management advice and to advance our stock assessments beyond tier 1 will require additional research along these lines.

Comprehensive Biological Opinion on Alaska Groundfish Fisheries

NMFS has put considerable effort into analyzing ecosystem level impacts of Fisheries pursuant to the requirements of the ESA. On November 30, 2000, NMFS released a biological opinion which evaluates the impacts of Alaskan groundfish Fisheries on listed species. The purpose was to determine if the FMP framework contained the necessary conservation and management measures to insure protection of listed species and their critical habitats. The scientific analysis in this opinion was qualitative and highlighted our lack of understanding of seasonal distribution of key Steller prey and the seasonal distribution and foraging needs of Steller sea lions.

The comprehensive biological opinion provides conservation recommendations to minimize or avoid adverse effects of a proposed action. Key conservation recommendations were first to expand stock assessments to consider space/time distribution of stocks and removals and include environmental influences on fish stock distribution and abundance. Multispecies considerations and risk analyses would also be included as part of the growing trend towards a "comprehensive assessment" process. Fishery rationalization programs for all groundfish Fisheries were also recommended to reduce the "footprint" of Fisheries at smaller time/space scales. Appropriate improvements to the existing catch monitoring programs (i.e., observer program, reporting and record keeping requirements, and vessel monitoring programs) would also be necessary. Many of these recommendations are also being made under the NMFS Stock Assessment Improvement Plan.

Relationship to Ecosystem-based Fishery Management Plans

As we discussed in the analysis contained in the programmatic SEIS, we are moving incrementally towards ecosystem-based fishery management plans with various ecosystem-based plan amendments. Both the programmatic SEIS and Comprehensive Biological Opinion for Alaska Groundfish Fisheries have identified possible policy directions for further improvement of ecosystem-based management under

NEPA and ESA and showed the qualitative status of our ecosystem-based scientific advice. With the addition of a more structured assessment framework similar to that used in the programmatic SEIS, the Ecosystem Considerations Chapter of our SAFE has potential for providing year-to-year advice in meeting our NEPA obligations for TAC setting. Improvements in stock assessments identified by NMFS will advance our ecosystem-based management advice and allow single-species stock assessments to be embedded in an ecosystem context in a more quantitative way. Key to all these activities is involvement of a broad spectrum of scientific expertise to reflect concerns beyond species that are targets of Fisheries and enhancing our research to include those broader concerns.

Research and Data Gaps

Some important research and data gaps identified in the programmatic SEIS, comprehensive Biological Opinion, and Ecosystem Considerations Chapter include research and data collection on:

- structure and functioning of marine ecosystems (including: the role of habitat, predator-prey interactions, factors affecting stability and resilience including mechanisms at the population and community levels of organization, and effects of fishing on benthic habitat and overall ecosystems)
- long-term research and fishery independent monitoring programs on target and non-target species, oceanography and climate, and habitat mapping
- development of fishery stock assessment models that incorporate unobserved fishing mortality, environmental variability, spatial distribution of fish and Fisheries removals, and multispecies interactions
- biological effects of fishing on gene pools and population structures
- marine protected areas and using MPAs as research tools
- extent and nature of Steller sea lion foraging habitat
- effects and effectiveness of various forms of rights-based management approaches
- improvement in the observer program, reporting and record keeping requirements, and vessel monitoring programs
- overall improvement in the research and data collection efforts with regard to understanding processes at finer time and space scales

Summary

The Alaska region has done extensive work on analyzing and incorporating ecosystem-based management objectives into its Fisheries management but we still have far to go. These analyses have many of the components identified in a Fisheries Ecosystem Plan as envisioned by the NMFS Ecosystem Advisory Panel Report. We have identified policy directions and management actions that need to be taken to make substantial progress in moving towards more prescriptive and adaptive ecosystem-based fishery management plans. We are broadening our stock assessment advice to include ecosystem-based research and will be working towards identifying more quantitative ecosystem-based management objectives and ecosystem indicators linked to management triggers and actions. Increased ecosystem-based research and involvement of multidisciplinary analysis and management teams are key to the process.

Conclusion

Mr. Chairman, this concludes my testimony. Again, I want to thank you for the opportunity to testify today and discuss ecosystem-based management. I am prepared to respond to any questions that you and other Members of the Committee may have.

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[Exhibits attached to Ms. Livingston's statement follow:]

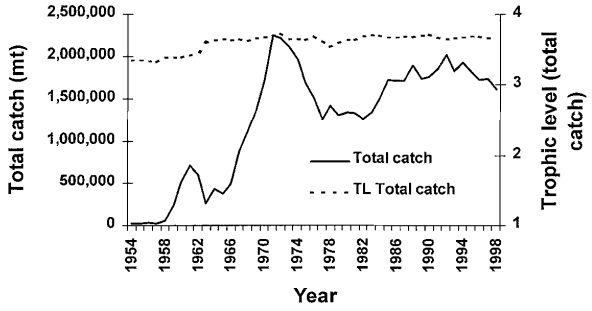

Exhibit 1. Historical estimates of the total groundfish (including halibut and herring) and shellfish catch and trophic level (TL) of the catch in the eastern Bering Sea.

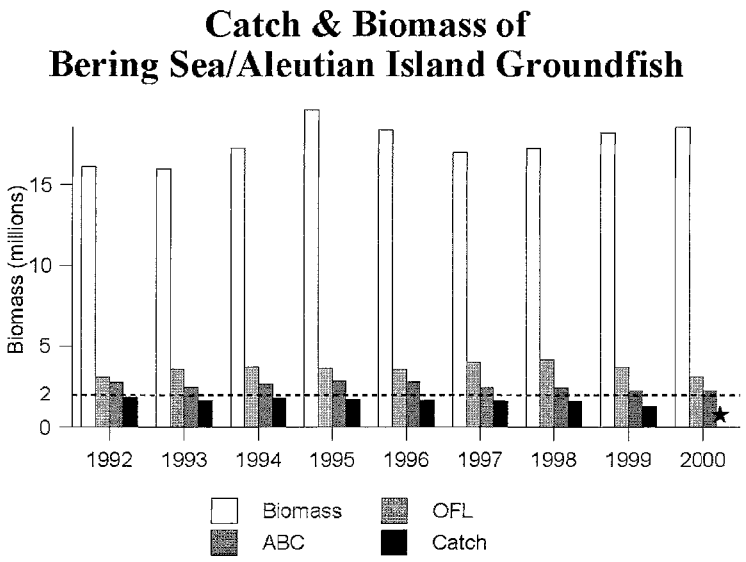

Exhibit 2. Exploitable biomass and catch specifications for Bering Sea and Aleutian Islands groundfish complex, 1992-2000. The dashed line shows the 2 million t optimum yield limit.

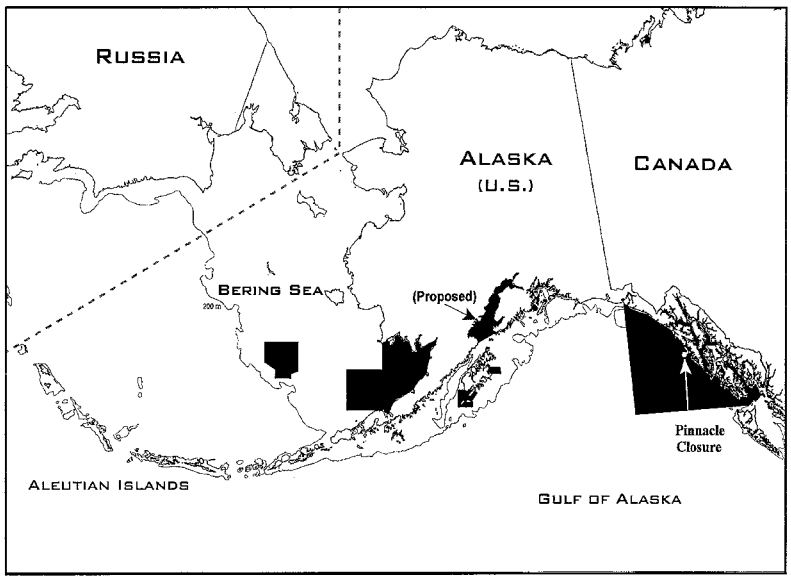

Exhibit 3. Location of year-round trawl closure areas established to protect fish and crab habitat.

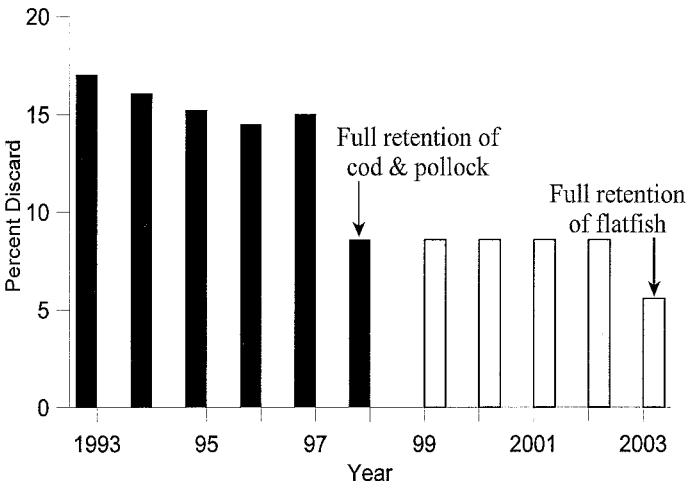

Exhibit 4. Total discard rates of Alaska groundfish, all areas and species combined, 1993-1998, with projections through 2003.

Mr. GILCHREST. Thank you, Ms. Livingston.
Dr. Crowder?

STATEMENT OF LARRY B. CROWDER, PH.D., PROFESSOR, DUKE UNIVERSITY MARINE LAB

Dr. CROWDER. Thank you, Mr. Chairman, members of the Committee. I appreciate the opportunity to testify at this hearing on ecosystem-based management and the reauthorization of the Magnuson Act.

Fisheries in the U.S. have been managed with increasing rigor over the past 25 years since the Magnuson Act was passed, but they continue to be plagued with problems, including overfishing, habitat damage, and bycatch of valuable resource species, as well as protected species.

We need to begin thinking about any comprehensive approach to fisheries management, including ecosystem-based management, by critically assessing the issues of capacity and resource allocation in the fishery. One year after the Magnuson Act was originally passed, Peter Larkin, eminent fisheries biologist, published his famous epitaph for the concept of maximum sustainable yield, but we continue to make decisions that put severe pressure on these resources and fail to buffer the fish and the fishing industry from variability rocked by both natural forces and human hands.

Structural engineers have much better reputations for designing reliable systems. Our society approves of building safety factors into these manmade systems. Credible engineers simply would refuse to build the "Minimum Sustainable Bridge." Why do we not require similar caution with designing management regimes for complex ecosystems that support fisheries?

Productive fisheries rely on healthy marine ecosystems. Degraded habitats cannot produce fish. Healthy marine ecosystems provide society with a wide variety of valuable ecosystem services that can be altered by a suite of factors, including nutrient enrichment, fishing invasive species and climate change. Fishing that focuses on removal of large predatory fishes and bottom fishes can lead to marine food webs that enhance small fishes. In highly compromised systems, like we have seen in the Black Sea, they can become dominated by jellyfish predators, yielding little benefit to humans. In the U.S., enriched systems like Chesapeake Bay, the Albemarle-Pamlico estuary, and the Gulf of Mexico are already showing similar signs of stress.

If we are to respond to interactions among multiple stressors, like fishing pressure and eutrophication, we must use an ecosystem perspective. Managers must also take a precautionary approach. This will come at a cost. Building safe bridges simply costs more than tossing up minimum sustainable ones.

Ecosystem-based approaches to management will have to construct strategies that are robust to both natural and anthropogenic changes. I want to share with you a case study that I worked on closely, and that was the estuarine-dependent fishes of North Carolina estuaries. It shows the impact of eutrophication on fish and fisheries in the context of environmental variation on a scale from day-to-day changes in the weather to large-scale effects of hurricanes.

North Carolina's coastal rivers drain into Pamlico Sound. This estuary supports 90 percent of North Carolina's commercial fishing and commercial fishing along much of the Atlantic Coast. Pamlico Sound is also a major fishing ground in North Carolina. All of the blue crabs, most of the shrimp, and much of the fisheries' take occurs inside the estuary. The Pamlico Sound is a large lagoonal system that is highly impacted by water inputs and nutrient inputs from upstream. We have all seen the headlines about the impacts on the coastal rivers in North Carolina, the Neuse and the Pamlico, but until recently, the Pamlico Sound itself was assumed to be relatively unaffected.

I want to focus today on the effects on the blue crab fishery itself, which is the most valuable fishery in North Carolina, worth $40.5 million in 1998. The state developed a Fishery Management Plan modeled after the sorts of things that are required in the Magnuson Act. Stock assessments were completed which showed that the fishery was managed at or near capacity. Many managers expressed doubts about how close to the edge the fishery might be, and the crabbers resisted effort controls. This was a fishery operating at a full speed in a compromised environment. Like the crew of the Titanic, we were watching for icebergs, but not expecting a problem.

In the fall of 1999, however, North Carolina was struck by three hurricanes, which led to 40 inches of rainfall in the watershed. Coastal rivers that were at half seawater became fresh for 2 months. Flood waters displaced 80 percent of the volume of Pamlico Sound, depositing at least half the annual nutrient load in a 1-month period. The responses that followed included bottom water hypoxia, physiological stress due to rapid salinity change, algal blooms, displacement and death of many fishes, crabs and their food, and an unprecedented rise in fish disease.

By spring 2000, the blue crab fishermen were reporting reduced catches. Recently released data for fisheries landings in 2000 showed blue crab takes were down 30 percent Statewide and 50 percent in the Neuse River. Blue crabbers reported financial losses, many stopped fishing, changed fishing operations or took second jobs.

We have entered a period of increasing storm frequency. We need to better understand how climate change will interact with eutrophication and fisheries production, but we also need to manage these systems with appropriate safety factors to buffer both the fishes and the fishers from the impact of natural and anthropogenic stressors.

To manage exploited populations in the context of healthy marine ecosystems, we will need additional research to better understand the linkages between fish populations and their variable environment. Fisheries are supported by ecosystems that are under assault from multiple stressors that can interact in unpredictable ways, but the stressors are also managed by different Government agencies.

From a scientific perspective, watersheds are part of marine ecosystems, and degraded landscapes yield inputs to the coastal marine ecosystems that can compromise fisheries production. Solutions will require both enhanced scientific understanding and

changes in governance, including increasing cooperation across boundaries.

Thank you very much for the opportunity.

[The prepared statement of Dr. Crowder follows:]

Statement of Larry B. Crowder, Stephen Toth Professor of Marine Biology, Duke University Marine Laboratory, Nicholas School of the Environment and Earth Sciences, Duke University

Introduction

My name is Larry Crowder and I appreciate the opportunity to testify at this hearing on ecosystem-based management and the reauthorization of the Magnuson–Stevens Fishery Conservation and Management Act. My formal training is in quantitative ecology and since the late 1970s I have conducted research on population and community ecology, fisheries, and marine conservation. My interests have centered on predator-prey interactions and marine food webs, but I have also conducted research on fisheries recruitment, bycatch, and fisheries/protected species interactions. I was the lead investigator on a joint NOAA/Academic research project, the South Atlantic Bight Recruitment Experiment (SABRE), which examined the influence of environmental variation on year class strength of estuarine-dependent fishes of the South Atlantic Bight. I have been studying food webs in North Carolina estuaries for over 15 years. I have also examined bycatch in trawl and longline fisheries and worked with NMFS on population assessments of threatened and endangered sea turtles. I served on the NOAA Coastal Ocean Program Scientific Advisory Panel on Coastal Fisheries Ecosystems and the NMFS Expert Panel on the Status of Sea Turtles. I currently serve on the Science Steering Committees for the Global Ocean Observing System (GOOS), the Global Ocean Ecosystems Program (GLOBEC), and was recently appointed to the Ocean Studies Board for the National Research Council. I am testifying today as an individual, not representing any organization or interest group. I will comment upon the importance of an ecosystem perspective for successful fisheries management and outline some of the key issues that may impede implementation of this approach.

Fisheries—The Problem

Fisheries in the US have been managed with increasing rigor over the past 25 years, but they continue to be plagued with problems including overfishing, habitat damage, and bycatch of valuable resource species as well as protected species (Ecosystem Principles Advisory Panel 1999, NRC 1999). Many of these problems are related to overcapacity in various fisheries. Assessments have suggested that we could enhance the value of many of our fisheries by fishing less and allowing stocks to rebuild. Any comprehensive approach to fisheries management (including ecosystem-based management) must critically address the issues of capacity and resource allocation. We continue to manage these resources extremely close to the edge. One year after the Magnuson Act was passed, Peter Larkin published his famous—An epitaph for the concept of MSY (Maximum Sustained Yield)". But we continue to make decisions that put severe pressure on these resources and that fail to buffer the fish (and the fishing industry) from variability wrought by both natural forces and human hands. In general, structural engineers have much better reputations for designing reliable systems. This is because our society approves of building safety factors into these man-made systems—credible engineers simply would refuse to build the "Minimum Sustainable Bridge". Why do we not require similar caution with designing management regimes for the complex ecosystems that support fisheries?

Ecosystem–Based Solutions

Because of failures to successfully manage fisheries populations, we began casting about for solutions. These took two routes—those that sought to control fishing effort and provide for fair and equitable allocation of fisheries resources and those that sought to understand what supported (or constrained) excess production of fish for removal by humans. I will focus here on the second point. Productive fisheries rely on healthy marine ecosystems—degraded habitats cannot produce fish. The Magnuson–Stevens Act (1996) required that Fisheries Management Plans designate Essential Fish Habitat. Habitat that supports fisheries has been compromised by a number of factors including direct effects of fishing gear, marine pollution, invasive species, and climate change. But habitat itself is but one of the structural features of a healthy marine ecosystem—we must also be concerned with the functional aspects of ecosystems.

Healthy marine ecosystems provide society with wide variety of valuable ecosystem services (NRC 1999) that can be altered by a suite of factors including nutrient enrichment, fishing, invasive species, and climate change. Fishing that focuses on the removal of large predatory fishes and bottom fishes leads to shifts in marine food webs, often enhancing yields of small fishes. Highly compromised systems can become dominated by jellyfish predators and yield little of use to humans as we have seen in the Black Sea (Caddy 2000). In the US, enriched systems like Chesapeake Bay, the Albemarle–Pamlico estuary and the Gulf of Mexico are already showing similar signs of stress (NRC 2000, Boesch et al. 2001). If we are to respond to the interactions among multiple stressors, like fishing pressure and eutrophication, we must manage fisheries resources not only in a multispecies context, but also with an ecosystem perspective. Further, managers must take a precautionary approach that will buffer both fish populations and the fishing industry from unexpected changes in the ecosystems that support them. This will come at a cost to both the industry and to the management infrastructure—building safe bridges simply costs more than tossing up "minimum sustainable" ones. But given that some very costly changes in fisheries ecosystems (like Georges Bank) may be difficult or impossible to reverse, this cost is fully justified.

Marine Protected Areas provide one tool for protecting the structure and function of marine ecosystems. MPAs are a valuable part of a comprehensive strategy of ecosystem-based management that could provide substantial fisheries benefits (NRC 2001). But some caveats are, again, necessary. MPAs as with other ecosystem-based approaches can only be successful if overall fishing effort is constrained. As commonly proposed, MPAs would be promulgated in addition to (rather than in place of) current fishing regulations. No-take marine reserves (one kind of MPA) close portions of the marine ecosystem to fishing. But displaced fishing effort could do further damage to the structure and function of the fisheries ecosystem that remains open to fishing. As the citizens of the US become increasingly aware of the whole range of goods and services provided by ocean ecosystems we will need to more seriously consider the need for zoning or space-based management of these systems.

As we consider ecosystem-based approaches to management we will have to construct strategies that are robust to other natural and anthropogenic changes. Recruitment variability due to environmental variation from year-to-year is a challenge for managers and particularly for fishers who would prefer to operate their businesses in a more stable, predictable world. But recruitment variability is a fact of life in fisheries. We can seek to understand it and even to predict it, but we are unlikely to be able to control it. Recruitment variation is, however, a far less difficult problem for the industry than the wholesale structural changes that occur due to longer-term climatic variation. At scales from El Nino–La Nina to Pacific Decadal Oscillations, ocean ecosystems alter the distribution and abundance of fishes in ways we are only beginning to understand. These changes often come unexpectedly and fishermen and managers simply have to cope. However, fishing itself can also play a role in restructuring fisheries ecosystems either through habitat damage from mobile gear or through food web alternations that may be difficult or impossible to reverse.

A Case Study: The Neuse–Pamlico Estuary, North Carolina

I want to share a case study that I have worked on closely, the estuarine-dependent fisheries of North Carolina estuaries. It shows the impact of eutrophication on fish and fisheries in the context of environmental variation on the scale of day-to-day changes in weather to large-scale effects of three hurricanes that crossed the North Carolina coast in fall 1999 (Paerl et al. 2001).

North Carolina's coastal rivers drain into Pamlico Sound, the US" second largest estuary. This system is a major fish and shellfish nursery for the entire Atlantic coast. It supports more than 90% of North Carolina's commercial and 60% of recreational finfish and shellfish catches. In addition to serving as a nursery habitat, it is also a major fishing ground in North Carolina. All of the blue crabs, most of the shrimp and much of the fisheries take occur inside the estuary. Pamlico Sound is a large, shallow lagoonal ecosystem with very limited water exchange with the Atlantic Ocean through four narrow inlets. Although nutrient enrichment has led to water quality problems, algal blooms, hypoxia, and fish kills in the Neuse and Pamlico rivers that have made headlines for 20 years, the Pamlico Sound was assumed to be relatively unaffected. However, the system traps particulate and dissolved materials, retaining and processing nutrient inputs from the entire watershed. Nutrient loading and subsequent water quality and fish effects link directly to landscape modification and to activities in the watershed. We have recently shown that intermittent hypoxia, which occurs chronically in this system, can substantially reduce the growth rates of fish in this critical nursery habitat. Fish and

crabs respond to low oxygen by crowding into the edge of the system where competition and predation can compromise their productivity.

The blue crab fishery is the most valuable in North Carolina. In 1998, hard crab landings totaled 27 metric tons and were worth $40.5 million. In the same year, the state developed a fisheries management plan, modeled after those required in federal waters under Magnuson. Stock assessments conducted by university scientists suggested that the fishery was being managed at or near capacity. In fact, removals had exceeded the estimated MSY for several recent years. Although the crabbers recognized they were fishing harder for fewer crabs, the state took no action to control the number of pots individual crabbers could fish. Many managers expressed doubts about how close to the edge the fishery might be and the crabbers resisted effort controls. This was fishery operating at full speed in a compromised environment. Like the crew of the Titanic, we were watching for icebergs, but not expecting a problem.

In fall 1999, North Carolina was struck by three sequential hurricanes, Dennis, Floyd and Irene. They dropped almost 40 inches of rainfall in the watershed, causing 50–500-year flooding. Coastal rivers that were at salinities of half-strength seawater became completely fresh for at least two months. Floodwaters displaced nearly 80% of the volume of Pamlico Sound, depositing at least half the annual nutrient load in a little over a month. Carbon loading doubled relative to normal conditions. A series of responses followed including bottom water hypoxia, physiological stress due to rapid salinity change, algal blooms, displacement or death of many fishes, crabs and their food, and an unprecedented rise in fish disease (Paerl et al 2001). Large blue crabs appeared to move ahead of the flooding—smaller ones may have died. Larval blue crabs that should have been re-entering the estuary in the fall were met with freshwater flooding out the inlets.

By spring 2000, blue crab fishermen were reporting reduced catches. Bottom oxygen concentrations continued to be reduced in both the Neuse River and Pamlico Sound. Although salinity had returned to normal, it is likely that benthic foods eaten by young fish and crabs were still suppressed. Our fishery independent data suggested that crab populations were down by a factor of ten in the most impacted areas. Recently released data for fisheries landings in 2000 showed blue crab takes were down 30% statewide and nearly 50% in the Neuse River. Blue crabbers reported financial losses; many stopped fishing, changed fishing operations or took second jobs. The good news was that the shortage of crabs led to higher prices to fishermen, but the excess fishing effort potentially pushed the crab populations still lower.

The only period of record in North Carolina with similar hurricanes and flooding was in 1955, when NC was also struck by three hurricanes bearing a similar amount of rainfall. Analysis of landings data from that period also suggest reduced landings of 6 of 9 most commonly taken fishes. For most of them landings peaked in 1952–53 and declined through the rest of the 1950s. Oldtime fishermen remember the losses of the 1950s, and draw parallels with the 1999 storms. These declines in the 1950s landings were likely to be related to declines in fish populations as fishing effort over this period remained fairly stable.

If the climatologists are correct, we have entered a period of increasing storm frequency (and perhaps intensity). We need to better understand how climate change will interact with eutrophication and fisheries production. But we also need to manage these systems with appropriate safety factors to buffer both the fishes and the fishers from the impact of natural and anthropogenic stressors..

Summary

Ecosystem-based management will be critical to supporting fisheries in the 21st century. In order to manage exploited populations in the context of healthy marine ecosystems, we will need additional research to fully understand the linkages between fished populations and their variable environment. We will also need to understand the linkages between target populations and other key species in their food web. Finally, we will need to develop management strategies that are robust to both anthropogenic and natural environmental variability. These are all topics that will need additional research investment to avoid costly losses to fisheries.

We will also need to consider some significant reorganization of the governance structure. Fisheries are supported by ecosystems that are under assault from multiple stressors that can interact in unpredictable ways. But these stressors are also managed by different government agencies. For example, landscape development is managed by cities and counties, nutrients and other pollutants are managed by Departments of Natural Resources at the state level and regulated by the EPA, fisheries are managed by Departments of Marine Fisheries, by the regional councils and by NMFS. From a scientific perspective, watersheds are part of marine ecosystems

and degraded landscapes yield inputs to coastal marine ecosystems that can compromise fisheries production. Solutions will require both enhanced scientific understanding and changes in governance including increased cooperation across boundaries. I would be pleased to answer any questions regarding this testimony, or to supply additional testimony or information.

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[An attachment to Dr. Crowder's statement follows:]

Ecosystem impacts of three sequential hurricanes (Dennis, Floyd, and Irene) on the United States' largest lagoonal estuary, Pamlico Sound, NC

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Communicated by Ellis B. Cowling, North Carolina State University, Raleigh, NC, February 26, 2001 (received for review July 5, 2000)

Three sequential hurricanes, Dennis, Floyd, and Irene, affected coastal North Carolina in September and October 1999. These hurricanes inundated the region with up to 1 m of rainfall, causing 50- to 500-year flooding in the watershed of the Pamlico Sound, the largest lagoonal estuary in the United States and a key West Atlantic fisheries nursery. We investigated the ecosystem-level impacts on and responses of the Sound to the floodwater discharge. Floodwaters displaced three-fourths of the volume of the Sound, depressed salinity by a similar amount, and delivered at least half of the typical annual nitrogen load to this nitrogen-sensitive ecosystem. Organic carbon concentrations in floodwaters entering Pamlico Sound via a major tributary (the Neuse River Estuary) were at least 2-fold higher than concentrations under prefloodwater conditions. A cascading set of physical, chemical, and ecological impacts followed, including strong vertical stratification, bottom water hypoxia, a sustained increase in algal biomass, displacement of many marine organisms, and a rise in fish disease. Because of the Sound's long residence time (~1 year), we hypothesize that the effects of the short-term nutrient enrichment could prove to be multiannual. A predicted increase in the frequency of hurricane activity over the next few decades may cause longer-term biogeochemical and trophic changes in this and other estuarine and coastal habitats.

Six major hurricanes, magnitude 2 or greater on the Safford–Simpson scale, have made landfall in North Carolina between 1996 and 1999. Hurricanes Dennis (September 4–5) and Floyd (September 16), which passed through North Carolina during a 12-day period in September 1999, and Hurricane Irene, which passed near the North Carolina coast on October 17, 1999, led to unprecedented rainfall and prolonged record flooding in eastern North Carolina. The floodwaters inundated coastal rivers and impacted the hydrologic and chemical characteristics of Pamlico Sound (PS), the United States' second largest estuarine ecosystem (Fig. 1). PS is a major fish and shellfish nursery for the entire Atlantic coast. It supports more than 90% of North Carolina's commercial and 60% of recreational finfish and shellfish catches (1).

PS is a shallow lagoonal ecosystem (mean depth = 4.5 m, maximum depth = 7.3 m) with a vast surface area of 5,300 km (2) and limited water exchange with the Atlantic Ocean through four narrow inlets (2). The ratio of the volume of the sound (26 billion m^3) to the average annual inflow (910 $m^3 s^{-1}$) yields a theoretical freshwater replacement time of about 11 months (3), far exceeding the replacement time of most temperate estuaries (4). Actual residence time is likely to be longer for much of the inflow because of restricted circulation in sheltered areas and the position of the tidal inlets relative to major tributaries (5).

During typical hydrologic conditions, elevated late winter–early spring water and nutrient inputs promote high spring–summer primary productivity, especially in the Chowan River, Pamlico River, and Neuse River (Fig. 1), estuarine tributaries of PS (1, 6). These estuaries typically serve as effective traps for particulate and dissolved materials (7), retaining and processing a large portion of the nutrient inputs from upland areas (8–10), and acting as a filter for PS inflows. Reduced summer–fall inflows result in stable salinities in the estuaries and PS during critical life-history stages of the biota (1, 2). Together, the long residence times, low currents and tidal amplitudes (0.3–0.5 m), shallow depths, high primary productivity, and stable salinities provide an ideal nursery habitat for diverse finfish and shellfish populations. However, the long residence time of PS also ensures that elevated freshwater and nutrient loadings, resulting from high-flow events that move quickly through the estuarine "filter," likely remain in the open Sound for relatively long periods. These inputs could support continued elevated primary production that may overwhelm assimilation by grazers and higher fauna, enhancing the potential for bottom-water hypoxia (11).

Despite its ecological and economic importance, very little monitoring and research have been conducted in PS. This is likely related to the long-held assumption that the vast size of this system acts as a buffer against climatic, hydrologic, and biochemical perturbations. Fortunately, some environmental data were collected on several occasions during 1998 as part of university instructional activities and a water quality monitoring feasibility study (12). These data provided a critical baseline against which we tested the hypothesis that PS is susceptible to significant hydrologic, biogeochemical, and ecological alterations resulting from floods associated with hurricanes. In response to the unprecedented flooding in the fall of 1999, we initiated a collaborative study to examine and evaluate ecosystem-level responses to the floodwater inputs to PS. Here, we report on the magnitude of the flooding, and the short-term water quality and habitat effects and longer-term ramifications for the Sound.

Methods

The environmental data used in this study were collected before and after the three 1999 hurricanes through ongoing cooperative watershed and estuarine-based monitoring programs in the tributaries of PS. The Neuse and Pamlico River estuaries, the two largest tributaries of PS, are sampled at weekly to biweekly intervals (see http://www.marine.unc.edu/neuse/modmon) and monitored continuously via instrumentation (see http://nc.water.usgs.gov).

Three continuous monitoring platforms are located in both the Pamlico River estuary and in the Neuse River estuary; an additional platform is located near the mouth of the Roanoke River. Near-surface and near-bottom pH, water temperature, salinity, and dissolved-oxygen concentration are measured at

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Abbreviations: DIN, dissolved inorganic nitrogen; DOC, dissolved organic carbon; PS, Pamlico Sound; psu, practical salinity unit(s); R/V, research vessel; USGS, U.S. Geological Survey.

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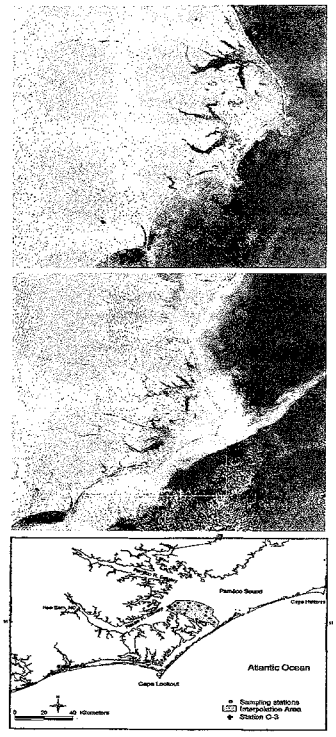

Fig. 1. SeaWiFS satellite-based image of PS, before (*Top*) and after (*Middle*) hurricane Floyd. For comparative purposes, mid-September 1998 (*Top*) and 23 September 1999 (*Middle*) images are shown. Note the brown-stained floodwaters entering PS following Floyd. Large turbidity plumes can also be seen escaping PS and advected into the coastal Atlantic Ocean waters by the Gulf Stream (*Middle*). The area within the yellow rectangle contains the grid of sampling stations (*Bottom*) for examining hydrological and ecological impacts of Hurricanes Dennis, Floyd, and Irene in western PS. This grid includes station C-3, a reference location (35° 7.22′ N, 76° 28.66′ W) that has been monitored since September 1998.

15-min intervals by using *in situ* sensors. Instruments are serviced and calibrated at 1- to 2-week intervals. Some of these platforms were removed in advance of Hurricane Dennis, but they were reinstalled in early October 1999.

PS proper has not been routinely monitored. However, during 1998 and in 1999, before the hurricanes, Duke University researchers conducted nine instructional cruises in western PS. They collected data along a series of four transects including a site termed "C-3" (35° 7.22′ N, 76° 28.66′ W), which is near the mouth of the Neuse River estuary and which has been sampled since September 1998 (Fig. 1). Shortly after the passage of Hurricane Floyd on September 16, 1999, an additional grid of 15 sampling locations, including C-3, was established by University of North Carolina at Chapel Hill researchers (Fig. 1). This grid, which was based on the remotely sensed mixing plume of Neuse River estuary water into PS (Fig. 1), was sampled monthly since early October 1999.

Sampling approaches and analytical methods were as follows.

Freshwater Inflows. Freshwater inflows to the estuaries and to PS were determined from data collected at the U.S. Geological Survey (USGS) network of stream gauges in North Carolina and Virginia, and from estimates of flow in ungauged areas. Streamflow from 67.7% of the land area draining to PS is gauged. Rainfall on the surface of Albemarle Sound and PS was estimated from rain gauge and Doppler radar measurements. Average inflow to PS was computed from long-term monthly mean streamflow records. The period of streamflow record at the various stream gauges used in the analysis ranged from about 15 years to more than 100 years (13).

Flood Recurrence Intervals. Flood recurrence intervals for Hurricane Floyd flooding at stream gauges in the PS watershed were computed by using established procedures (14). Recorded peak flows from this event and associated flood recurrence intervals are available on the USGS web site (http://water.usgs.gov/pubs/wri/wri004093/)and in ref. 14.

Hydrological, Oxygen, Salinity, and Nutrient Dynamics. The 15 sampling stations in western PS (Fig. 1) were surveyed at monthly intervals by both the R/V (research vessel) *Susan Hudson* and the R/V *Capricorn*. Hydrocasts were made at each station with a Sea-Bird Electronics (Bellevue, WA) 25–03 Sealogger CTD (conductivity, temperature, depth) equipped with a Sea Tech (Wet Labs, Inc., Philomath, OR) *in situ* fluorometer, a Sea Tech transmissometer (0.5 m), a Biospherical Instruments (San Diego) QSP-200PD 4π photosynthetically active radiation (PAR; 400–700 nm) sensor, and a Yellow Springs Instruments 5739 DO (dissolved oxygen) probe. The diffuse attenuation coefficient (k_d) and the depth limit of the photic zone ($z_{eu} = z$ at 1% I_o, surface irradiance) were determined from PAR profiles by using the Beer–Lambert Law. Surface-water samples were taken with a cast bucket, and bottom-water samples were taken with General Oceanics (Miami) 5-liter Niskin bottles attached to the CTD.

Dissolved nutrient samples were prepared by filtering freshly collected PS water through precombusted Whatman GF/F filters. If not analyzed immediately, samples were frozen at −20°C until analysis. Dissolved inorganic nitrogen (DIN) concentrations were determined by colorimetric methods by using a Lachat Instruments (Milwaukee) Quickchem QC 8000 autoanalyzer. The following methods were used: ammonium, nos. 31-107-06-1-A and 31-107-06-1-C; nitrate/nitrite, no. 31-107-04-1-C (Lachat Instruments). DIN concentrations were measured at weekly or biweekly intervals; linear interpolation was used to calculate concentrations for days not sampled. Daily DIN loading to the Neuse River estuary was calculated as the product of DIN concentrations and daily mean discharge. Daily loading values were summed to obtain monthly or yearly loading. The 1999 loading estimates used concentration data from a station near the head of the Neuse River estuary at New Bern and the sum of daily discharge data from three streamflow gauging stations that together measure streamflow from 97% of the Neuse River basin upstream from New Bern. Floodwater loading was calculated for the period 1 September to 25 October 1999. The 1994–1997 loading was derived from concentration data collected 15 km upstream from New Bern, and from discharge data measured at Kinston, and prorated to the nutrient sampling site (11).

Dissolved organic carbon (DOC) and particulate organic carbon measurements were made by using high-temperature combustion techniques (15) using a Shimadzu 5000A total organic carbon analyzer (DOC) and a Perkin-Elmer 2400 Series II CHN analyzer (particulate organic carbon).

Chlorophyll *a* Measurements. Fifty-milliliter water samples were gently filtered through 25-mm Whatman GF/F filters while a few drops of aqueous $MgCO_3$ (1%) were added (six samples per station, three surface and three bottom). The filters were extracted 90% acetone overnight at −10°C. Fluorescence was measured on a Turner Designs (Sunnyvale, CA) 10AU fluorometer (F_o), and then two drops of 10% HCl were added to the acetone extract and fluorescence was measured again (F_a). The fluorometer was calibrated with a chlorophyll *a* standard, the concentration of which was determined with a Perkin-Elmer Lambda 3B spectrophotometer and the trichromatic equation of Jeffrey and Humphrey (16).

Fish Surveys. Fish surveys accompanied the hydrological, chemical, and chlorophyll time series measurements. We sampled fish at station C-3 with short trawls (5 min, 2–3 knots) using a 9-m headrope mongoose trawl (4.8-cm inch bar mesh wings and body with a 1.2-cm tail bag mesh). After each trawl, all fish were identified to species and counted, measured (total length, in mm), and examined for external signs of disease (i.e., lesions or bloating caused by bacterial infection). Fish catch was standardized by calculating a catch per unit effort as the number of fish per 100 m trawled. Distance towed was estimated from the speed of the boat and trawl time and checked with positions taken at the start and end of each trawl with a Garmin (Olathe, KS) GPS.

Results and Discussion

Hydrology. Hurricanes Dennis, Floyd, and Irene occurred within a 6-week period between September 4 and October 17, 1999, and brought heavy rains to the PS watershed, which includes the Neuse, Tar-Pamlico, Roanoke, and Chowan River basins, as well as coastal drainage located primarily to the north and south of Albemarle Sound (see Fig. 6, which is published as supplementary material on the PNAS web site, www.pnas.org). The central part of the Tar-Pamlico River basin received 96 cm of rain during September and October, or about 85% of the average annual rainfall. The central and lower Neuse River basin received about 75 cm of rain during September and October, and more than half of the average annual rainfall fell during September alone (see Fig. 7, which is published as supplementary material on the PNAS web site). Most of the rainfall reporting stations in eastern North Carolina received at least half of the average annual rainfall during September and October (13).

All of the river basins draining to PS experienced flooding in at least one location at the 500-year recurrence interval (Fig. 6). Record high water levels were measured at 11 of the 12 USGS stream gauging stations in the Tar-Pamlico River basin, including Tarboro, where the recorded level was about 3 m higher than previously recorded in more than 100 years of records and the peak flood flow was about double the previous maximum flow (13). The most prolonged flooding occurred in the Neuse River basin. Water levels were above the National Weather Service flood stage at Kinston continuously from September 10 through October.

Freshwater inflow to PS during September and October 1999 was equivalent to about 83% of the total volume of the Sound. Typically, mean inflow volume for these two months is ≈13% of the Sound volume (Table 1). The Neuse and Tar-Pamlico River basins, which together comprise about 31% of the drainage area to PS, contributed about 44% of the inflow to the Sound in September, and more than half of the inflow in October. Inflow volume to the head of the Pamlico River estuary during September was more than 90% of the mean annual flow volume (13). Inflow to the Neuse River estuary was slightly less than to the Pamlico River, with September inflow volume equivalent to 55–60% of average annual inflow (13). In response to the exceedingly high discharge associated with floodwaters, estimated water residence times were only about 7 days for the Pamlico and Neuse River estuaries during September, compared with a more typical mean value of about 70 days (17, 18).

Table 1. Freshwater inflow to PS during September and October 1999

		Freshwater input to PS			
		Expressed as 10^9 m^3		Expressed as % of PS volume	
Basin	Drainage area, km^2	Sep–Oct 1999	Normal	Sep–Oct 1999	Normal
Roanoke	25,400	2.49	0.93	9.6	3.6
Chowan	12,820	3.32	0.33	12.8	1.3
Neuse	14,560	5.58	0.54	21.4	2.1
Tar-Pamlico	11,190	4.61	0.31	17.7	1.2
All others	16,320	5.63	1.30	21.6	5.0
Total	80,290	21.63	3.41	83.1	13.2

"All others" refers to drainage other drainage to Albemarle S and PS, as well as direct rainfall to the surface of Albemarle S and PS. "Normal" values are based on data from Giese *et al.* (3).

During normal hydrologic years, more than 60% of the annual rainfall and river basin discharge occurs during the November–March rainy season. The high spring water and nutrient loading accompanying this discharge supports large winter–spring phytoplankton blooms (11). This pattern was drastically altered during the fall of 1999, when approximately half of the annual water discharge occurred during a 6-week period in early fall instead.

Salinity. Weekly monitoring along the axis of both the Neuse and Pamlico estuaries following Floyd and Dennis floodwater discharge (late September 1999) revealed freshwater conditions [salinity < 0.2 practical salinity units (psu)] stretching from the headwaters to the mouths of these major tributaries. A comparison of pre- and posthurricane salinity regimes throughout these estuaries can be found on the Neuse River Modeling and Monitoring (ModMon; http://www.marine.unc.edu/neuse/modmon) and USGS (http://nc.water.usgs.gov) web sites.

Historic late summer salinities are typically at their maximum of 10–13 psu near the mouths of the two systems (17, 18), whereas surface salinities in southwestern PS also reach maximum values from 15 to 20 psu in September (19) (Fig. 2). The week before Hurricane Floyd, surface salinities at stations in the western PS ranged from 18 to 20 psu. Two weeks after the

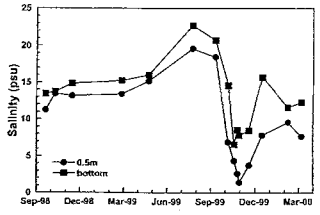

Fig. 2. Surface and bottom water salinities (in psu) at station C-3 in the western PS.

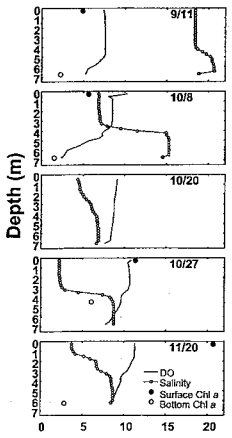

Fig. 3. Vertical distribution of salinity (psu) and dissolved oxygen (mg liter^{-1}) profiles, and surface- and bottom-water chlorophyll *a* concentrations (mg m^{-3}) from station C-3 for 11 September (pre-Floyd), 8 October (post-Floyd), 20 and 27 October (post-Irene), and 20 November 1999. Chlorophyll *a* samples were not obtained on 20 October.

passage of Hurricane Floyd, surface salinity in PS averaged 8.9 ± 1.4 psu, or less than half of typical values, with the lowest salinities reported at the shallower locations.

The mass and momentum of the inflow created vertical stratification and a well defined pycnocline at a depth of ≈5 m by early October (Fig. 3). Strong stratification was accompanied by development of bottom water hypoxia (<4 mg liter^{-1} O_2). The difference between surface and bottom salinity (stratification) for southwestern PS averaged 6 psu in October 1999, which is 2–3 times greater than normally encountered at that time of the year (12). Stratification greater than 3 psu is usually sufficient to stimulate hypoxia and anoxia below the pycnocline in this system (11).

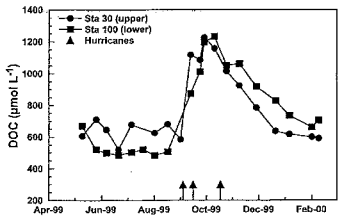

Fig. 4. Surface water DOC concentrations measured biweekly at two locations in the lower Neuse River estuary near its juncture with PS. Dates of landfall for Hurricanes Dennis, Floyd, and Irene are shown.

Reduced salinity and vertical stratification, combined with a high organic matter content and resulting hypoxia existed in PS for ≈3 weeks, beginning after floodwaters reached the Sound in late September. The stratification and hypoxia persisted until Hurricane Irene (16 October) destratified, re-aerated, and further freshened the Sound to ≈6 psu. The Sound subsequently restratified (Fig. 3), demonstrating the continued strong influence of freshwater inflows.

A comparison of 1998–1999 salinity data before landfall of the hurricanes with posthurricane data at station C-3 shows the initial and sustained depression of salinity imposed by "freshening" of this long residence time system (Fig. 2).

Biogeochemical and Ecological Considerations. The DIN load at the head of the Neuse River estuary in September and October 1999 amounted to over 800 Mt of nitrogen, which was 71% of the 1994–1997 average annual DIN loading. This high load translated into elevated concentrations of ammonium and nitrate throughout the estuaries and PS. DIN concentrations are usually less than 1 μM at the Neuse River estuary mouth in late summer (6, 8, 10, 11), but ammonium and nitrate concentrations at this location were greater than 10 μM and 2 μM, respectively, in early October. DIN concentrations in the open Sound were elevated (0.71–11.06 μM nitrogen) and atypically similar to Neuse River estuary concentrations (6.64–15.56 μM nitrogen). In contrast, DIN in the Chesapeake Bay, after flooding associated with Hurricane Agnes, increased only at the head of the Bay, not throughout the Bay (20).

The hurricane floodwater was greatly enriched in organic matter. The DOC concentration in the Neuse River estuary near its entrance to PS rose from prehurricane values of 500–700 μM C to more than 1,200 μM C after the storms (Fig. 4), whereas particulate organic carbon concentrations rose from 80 to >200 μM C (data not shown). The highly colored (brown) organic material influenced water column irradiance and potentially phytoplankton photosynthetic rates in PS. This was evident as a substantial increase in the diffuse attenuation coefficient (K_d) from 0.5–0.8 m^{-1} in August (prestorm), to >1.6 m^{-1} after the storms.

Phytoplankton biomass, as chlorophyll *a*, increased 3- to 5-fold relative to prehurricane conditions (Fig. 5). Chlorophyll *a* concentrations were several times higher in the surface water than in the bottom water, most likely a consequence of strong vertical stratification that accompanied the huge amount of freshwater inflow (Fig. 3, Table 2). Interpolation of surface chlorophyll *a* values in the transect area during early October 1999 indicated that highest concentrations existed near the center of the western basin of the Sound (Fig. 5). Chlorophyll *a* concentrations remained elevated in the Sound well into 2000 (Fig. 5), indicative of protracted enhancement of primary production in this highly retentive system. Previous nutrient-productivity studies throughout this system have shown consistent stimulation of productivity in response to nitrogen additions (21–23). Therefore, we believe that the upsurge in phytoplankton production in the surface water reflects the large infusion of nitrogen into a shallower-than-normal near-surface mixed layer.

Rapid declines in salinity and oxygen have been shown to have direct short-term physiological effects on estuarine macrofauna and greatly reduce the habitable area for resident fish and shellfish species in this system (24, 25). Dissolved oxygen concentrations less than 2 mg O_2 liter^{-1} are stressful to most motile finfish and shellfish species and fatal to sessile biota (26–28). On 8 October, after Floyd and before Irene, dead and dying shrimp and blue crabs were collected from below the pycnocline where dissolved oxygen was consistently less than 4 mg O_2 liter^{-1} (hypoxia) and in places reached less than 2 mg O_2 liter^{-1} (anoxia). In contrast, blue crabs apparently were unaffected by floods following Hurricane Agnes in Chesapeake Bay (20).

Catches of many species (e.g., croaker, spot, bay anchovy, and shrimp) declined by 50% or more in the Neuse River estuary

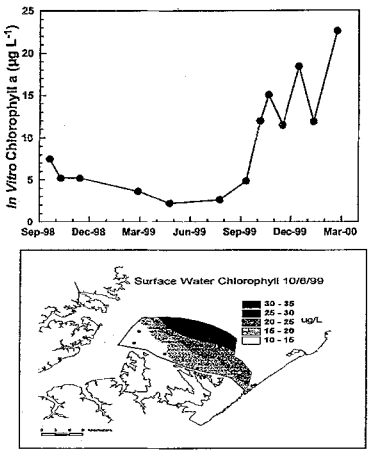

Fig. 5. (*Upper*) Continuous record of surface-water chlorophyll *a* concentrations at station C-3. (*Lower*) Interpolated surface chlorophyll *a* values for the western basin of the PS. Data were derived from the transect stations shown in Fig. 6.

compared with samples taken before the flooding. Catches were also reduced substantially relative to fall catches in 1998. In PS, the number of live finfish and crabs caught during each of three trawls in the western Sound was about 3-fold higher than the number caught before the flooding, although species richness was lower (Table 2). Peak catches in October 1999 were more than 5 times higher than peak catches at the same time in 1998. Thus, it appeared that many of the motile species moved out of the estuaries with the influx of freshwater, but sessile benthic invertebrates were stressed or killed by exposure to low-salinity, hypoxic water. Diseased fish were first noted in the Neuse River and propagated downstream; by 27 October, disease increased substantially in the PS, when about 10–20% of three common species (pinfish, 17%; spot, 20%; and croaker, 14%) had lesions, sores, or sloughing skin; 50–70% showed signs of systemic bacterial infections (E. Noga, North Carolina State University, personal communication). During the same period in a nonhurricane year (October 1998), the incidences of external sores in the Neuse River estuary were 0.18% in spot (n = 566) and 0.14% in croaker (n = 718); there is no data for pinfish.

The shallow depths and long residence time of PS suggest that a large proportion of the allochthonous and autochthonous organic input during 1999 was deposited in the sediments. Preliminary examinations of the Sound's surface sediments indicate organic matter enrichment from both nutrient-enhanced primary production and sediments transported to the Sound from the riverine tributaries by flood flows. Increased rates of oxygen consumption and inorganic nutrient release from sediment diagenesis have been observed in the Neuse and Pamlico estuaries in response to organic matter enrichment (8, 10, 29). The inorganic nutrient release should further stimulate primary production, as occurred in Chesapeake Bay after Hurricane Agnes (20). Spring and summer of 2000 proved to be very windy, preventing strong vertical stratification and persistent bottom-water hypoxia in the open Sound; however, high rates of primary production were maintained, and hypoxic bottom-water conditions were observed in portions of western PS from June to October 2000. During the same period, increased aerial extent and frequencies of hypoxia and elevated (relative to 1994–1999) rates of primary production were observed in the more sheltered (from wind mixing) lower Neuse River estuary (6, 11, 25, 30). These findings suggest lingering effects of nutrient and organic matter enrichment to the system. This, combined with long water residence time, represents a mechanism that could extend the short-term nutrient enrichment effects of the floodwaters to multiannual enhancement of primary production and nutrient cycling of PS. We conclude that the sustained elevated chlorophyll *a* levels thus far observed are indicative of longer-term nutrient (specifically nitrogen) retention and recycling within this system.

On the multiannual time scale, microbial denitrification may help purge the system of the large nitrogen load associated with the floodwaters. However, denitrification measurements thus far completed in the Neuse River estuary indicate that annually, this process may remove only about 20% of its external nitrogen load (S. Thompson *et al.*, unpublished results). Therefore, we do not expect denitrification to be a mechanism capable of rapidly "cleansing" the Sound of elevated nitrogen loading associated with floodwater discharge.

Phytoplankton community compositional changes in response to freshwater discharge, depressed salinity, and nutrient enrichment could additionally influence primary production, nutrient cycling, and trophodynamics of this system. Preliminary evidence, based on microscopic observations and HPLC analyses of photopigments diagnostic for major phytoplankton functional groups, indicate that the enhanced stimulation of phytoplankton production was distributed among taxa normally dominant in this system (dinoflagellates, diatoms, cryptophytes, and cyanobacteria) (31). However, a noticeable upsurge in the relative dominance of cyanobacteria was observed in the lower Neuse River estuary and PS (L. Twomey *et*

Table 2. Summary of PS ecosystem responses to 1999 hurricanes at station C-3

Date (1999)	Salinity, psu		Chl *a*, mg m^{-3}		Bottom O_2, mg l^{-1}	No. of fish species	Fish CPUE	Fish disease
	Surface	Bottom	Surface	Bottom				
11 Sep	19.1	20.3	4.8	2.2	4.6	8	11.5	L
8 Oct	9.0	14.2	5.6	1.5	3.9	3	38.5	L
27 Oct	5.6	9.5	11.3	6.0	8.8	8	124.2	H
31 Oct	4.0	8.3	NA	NA	9.6	7	218.2	VH
20 Nov	5.5	9.1	20.7	2.8	8.7	8	23.2	M
17 Dec	8.4	17.1	12.2	3.2	8.4	8	3.5	L

Salinity is reported as practical salinity units (psu). CPUE is catch per unit effort in number of fish per 100 m trawled. Number of fish species counted were at least 1% of the total catch. Fish disease categories are low, medium, high, and very high (L, M, H, and VH). Data not available are listed as NA.

al., unpublished results). A reduction in salinity accompanied by nutrient enrichment is known to stimulate cyanobacterial dominance in the upper Neuse River estuary (32). Furthermore, cyanobacterial dominance in this system can alter zooplankton grazer community structure and function (33), indicating the potential for trophic changes associated with shifts in phytoplankton community structure.

Phytoplankton community changes could affect both food web structure and nutrient flux. If, for example, zooplankton consumption of phytoplankton is reduced in response to an increase in cyanobacterial dominance (34), relatively less phytoplankton biomass will be transferred to higher trophic levels. As a result, relatively more phytoplankton-based organic matter will be transferred to the sediments, enhancing microbial decomposition, oxygen consumption, and nutrient regeneration. In long residence-time systems like the PS, this scenario would ensure a long-term response to episodic nutrient-loading events accompanying hurricanes.

As the PS ecosystem recovers from the flooding effects, its nursery function is also expected to recover. With sustained bottom salinities nearly fresh for months, we expect most of the sessile marine benthos in the Neuse River was killed. Indeed, in May 2000 we observed newly set clams that were killed by low oxygen in the mouth of the Neuse River estuary. Given the direct effects of depressed salinity and low oxygen on shellfish and finfish as well as indirect effects mediated through their benthic prey, one might expect reduced densities of these organisms with potentially detrimental effects on fisheries. The most profound fisheries effect was on blue crabs, for which Neuse fishermen reported reduced catches beginning in May 2000. Neuse River estuary sampling during summer 2000 shows blue crab abundances reduced by at least a factor of 10 relative to catches in the same period during 1997–1999. Fishermen also report reduced oyster and clam landings in the affected area. We expect time lags in the expression of these effects commensurate with the period before young-of-year fish and shellfish recruit to the fisheries.

Concluding Remarks

The hurricanes of 1999 have provided perspective on how intense meteorological events on the scale of multiple hurricanes can induce both short- and longer-term biogeochemical and ecological changes in a large coastal ecosystem. It is possible that the observed and hypothesized estuarine responses provide a glimpse into effects of future climatic trends on the structure and function of coastal ecosystems. Increased tropical storm and hurricane activity is predicted over the next few decades, and the hurricanes of 1999 may be indicative of this phenomenon (35, 36). Such a trend merits close scrutiny from both intensive monitoring and research perspectives, because it could be indicative of long-term disruption of ecosystems critical for fishery resources, economic development, and habitability of the coastal zone.

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Mr. GILCHREST. Thank you, Dr. Crowder.
Mr. Hinman?

STATEMENT OF KEN HINMAN, PRESIDENT, NATIONAL COALITION FOR MARINE CONSERVATION

Mr. HINMAN. Thank you, Mr. Chairman and members of the Subcommittee. I, too, very much appreciate this opportunity to speak with you about a subject to which I have devoted a large portion of my time over the last 4 years.

My name is Ken Hinman. I am president of the National Coalition for Marine Conservation. Since 1973, my organization, and our efforts to ensure a healthy future for ocean fishing, have co-evolved along with the Nation's fishery management system. I am here today because we believe that an ecosystem-based approach to management is a natural progression in the evolution of fishery management. It is a natural outflow of our increasing knowledge of the ocean and our expanding circle of concern for all marine species. Its time, we believe, is now.

Mr. Chairman, I am also here today as a co-chair of the Marine Fish Conservation Network, an alliance of 105 fishing, environmental, and scientific organizations working to reform the Magnuson-Stevens Act. My remarks reflect the position of our many allies in the Network.

In 1996, Congress, as was mentioned, appointed a panel to look at ecosystem principles in fisheries management. As a member of that panel, and since the publication of that panel's report in 1999, I have spent considerable time writing and traveling to meetings and workshops in an effort to promote its recommendations. In my conversations with policy makers, fishery managers and congressional aides, the three most frequently asked questions about ecosystem-based fishery management are: do managers want to manage fisheries on an ecosystem basis; can they do it; and will they do it, and more specifically, how will they do it?

The short answer to the first question, do they want to do it, is yes. Indeed, they have already begun. As some of the previous speakers have noted, there are some pretty concerted efforts to move toward ecosystem-based management being begun by some State and Federal organizations. Fishery scientists and managers alike recognize the need to address ecological considerations, and the question is not do fishery managers want to do this, they don't really have a choice. Ecosystem-based management is gaining increased attention and interest because the effect that fishing of one species has on other related species is an issue in a number of current fishery management debates.

We have the interactions among striped bass, menhaden, and blue crab in Chesapeake Bay; the perceived competition between cod and dogfish sharks up in the Northeast; the effect of high harvests of horseshoe crabs on migratory shore birds; questions about removing an entire tier at the top of the food chain, the large pelagic predators, swordfish, tunas, large coastal sharks, marlins, all overfished, some severely depleted; and the related concern of increasing catches of squid and herring, a dominant food source for all of these species, as well as some in-shore species, such as cod

and bluefish. Each of these is managed separately, and in some cases by different management agencies.

The reality is that ecosystem-based management will occur, already is occurring, shaping not only perceptions about the wisdom of our management decisions, but also the decisions themselves, and in each of these and in other debates, fisherman and conservationists are demanding action, sometimes conflicting action. Unfortunately, sound responses have been hampered by questions or misperceptions about the nature and extent of predatory-prey interactions, inadequate or unavailable data, and most of all, the lack of an established process for taking interspecies relationships into consideration.

Mr. Chairman, we are obliged to make sure that ecological issues are addressed correctly, based on science and agreed-upon goals, adhering to a process that we can all understand and believe in. So it is a not a question of whether we take on this challenge, but how. The most dangerous course is the one that we are on right now, forced, as we are, to deal with these issues, but with no guidance as to what information is needed, and most importantly, how it should be used in the real world of making fishery management decisions.

The next frequently asked question is can we manage on an ecosystem basis, and again I think the answer is yes. The body of information available to fishery scientists and managers is large and constantly expanding. There is an immensity of raw data out there that has not been synthesized or analyzed for ecosystem-based purposes. There are also new tools for ecosystem modeling, such as ECOPATH, into which this information can now be plugged. In many instances, there is adequate information, if made available to fishery managers, and the modeling tools necessary to predict fundamental ecological responses to fishing removals and to make informed decisions that might minimize the adverse impacts of fisheries on trophically-related species.

Ecosystem-based management is an ambitious goal, no question about it, and we will never know or understand everything about how fisheries operate in an ecosystem context. But as the Ecosystems Principles Advisory Panel stressed, this is not an acceptable excuse to delay implementing an ecosystem-based approach. Significant relations, in many cases, are known and understood. We know enough right now to ask the right questions, identify the critical information and information needs, and to establish a context for considering what we know and applying it to fishery management decisions. Right now fishery managers have the authority to consider predatory-prey and interspecies relationships in fishery management. They are not explicitly required to do so, however, nor are they provided with any guidance as to how.

What we believe Congress needs to do, therefore, is provide both drive and direction to this process, and by that I mean amending the Magnuson Act to require that the National Marine Fisheries Service and Regional Fishery Management Councils, A) carefully consider the effects of fishing each species on other species in the food web, and B) begin devising Fishery Ecosystem Plans to serve as overarching guidance and a context for future management decisions.

We believe that Congress should require that all Fishery Management Plans be reviewed and revised to consider predatory-prey interactions, assess how associated species are affected by fishing allowed under each FMP, and establish conservation measures that will protect associated species and their respective roles in the ecosystem as well as the health and integrity of the ecosystem as a whole.

Fishery ecosystem plans, as was pointed out earlier by another witness, would not be intended as a substitute for Fishery Management Plans, but rather as a means to augment their effectiveness. The FEP would be an umbrella document, which would include information on the structure and function of the ecosystem in each region where fisheries are managed, so that fishery managers are aware of the potential impacts of fishing on the various components of the ecosystem, as well as how changes in the ecosystem might affect certain fisheries. Councils would continue to employ FMPs as the primary regulatory vehicle for managing marine fisheries, however, each council FMP should be required to demonstrate that its objectives and conservation and management measures are consistent with the findings and the recommendations of the FEP.

We, also, along with other witnesses, urge Congress to authorize sufficient funds, new funds, to assist the Secretary and the councils in applying ecosystem principles to fisheries research and management under the Act.

In our written statement, we have a number of specific recommended changes to the Magnuson Act that reflect these overall goals. But if I may, in one final comment, I do want to emphasize that considering fisheries in an ecosystem context, despite what some people have said, does not diminish the need to regulate fishing conservatively or downplay the effect of fishing on fish populations. It cannot be used to justify overfishing one species in order to maximize yields of another species, nor does it diminish the need to fish selectively to avoid bycatch and minimize bycatch mortality.

It supports taking the precautionary approach to conserving and managing marine fisheries, especially when the ecosystem effects of fishing are uncertain or unknown. It is our firm belief that an ecosystem-based approach cannot and should not substitute for aggressively implementing existing mandates to prevent overfishing, minimize bycatch, and protect essential fish habitat. In fact, it makes achieving these goals and doing more to achieve them even more critical.

Thank you for considering our views, and we look forward to working with the Subcommittee and staff during the reauthorization to improve management of all marine fish.

Thank you.

[The prepared statement of Mr. Hinman follows:]

Statement of Ken Hinman, President, National Coalition for Marine Conservation

Mr. Chairman and members of the Subcommittee, I very much appreciate this opportunity to speak with you about a subject to which I have devoted a large portion of my time over the last four years—promoting ecosystem-based fishery management.

My name is Ken Hinman and I am President of the National Coalition for Marine Conservation, the nation's oldest public advocacy organization dedicated exclusively to conserving ocean fish and their environment. Since 1973, my organization, and

our efforts to ensure a healthy future for ocean fishing, have co-evolved along with the nation's fishery management system. We would like to think we have played a role in shaping that system for the better.

I am here today because we believe that an ecosystem-based approach to management is a natural progression in the evolution of fishery management. It is a natural outflow of our increasing knowledge of the ocean and our expanding circle of concern for all marine species. It's time, we believe, is now.

Mr. Chairman, I am also here as a co-chair of the Marine Fish Conservation Network, an alliance of over 100 fishing, environmental and scientific organizations working together to reform fisheries management, specifically by strengthening the Magnuson–Stevens Fishery Conservation and Management Act. My remarks reflect the position of our allies in the Network, as laid out in its "Agenda to Protect, Restore and Conserve the Nation's Marine Fish."

It is widely believed that some fishery declines, or difficulties in restoring overfished species, are caused at least in part by violations of basic ecosystem principles. In 1996, Congress directed the National Marine Fisheries Service to establish an advisory panel to review and recommend application of ecosystem principles to federal marine fisheries management. As a member of that panel, I saw how our goal of developing "fishery ecosystem plans" to guide management decisions would come about only through an incremental strategy. Not in one giant leap, but in carefully measured steps. The first step is to understand and preserve the interdependency of key predator and prey species.

Since publication of the panel's Report to Congress, entitled "Ecosystem–Based Fishery Management," in 1999, I have spent considerable time writing and traveling to meetings and workshops, in an effort to promote its recommendations. In my conversations with policy makers, fishery managers and Congressional aides, the three most frequently asked questions are:

(1) Do managers want to manage fisheries on an ecosystem-basis?

(2) Can they do it? and

(3) Will they do it? More specifically, how will they do it?

The short answer to the first question, do they want to do it, is yes. Indeed, they have already begun. The state and federal agencies that co-manage the fisheries of Chesapeake Bay are in the initial stages of developing a multispecies, or ecosystem plan for the bay's living resources. The South Atlantic Fishery Management Council, which oversees many valuable commercial and sport fisheries from North Carolina to the Florida Keys, has also started this process.

The fact is, fishery scientists and managers alike recognize the need to address ecological considerations, with emphasis on "need." Actually, the relevant question is not, do fishery managers want to do this; they really don't have a choice. Ecosystem-based management is gaining increased interest and consideration because the effect that fishing for one species has on other, related species is receiving attention in a number of current fishery management debates.

The reality is that ecosystem-based management will occur—already is occurring—shaping not only perceptions about management decisions but also the decisions themselves. Decisions are already being made, often based on misperceptions about ecological relationships, because there is no established process for making such decisions. For example:

- The resounding success in rebuilding striped bass along the Atlantic coast has been followed by worries that the newly resurgent bass are finding too little to eat because harvests are too high on one of their most important prey species—menhaden. In Chesapeake Bay, the problem is compounded by fears the low availability of menhaden is causing stripers to increase consumption of blue crabs, already in low supply due to over-harvest.
- Concerns about high, unregulated harvests of horseshoe crabs in the mid–Atlantic area, largely for use as bait in other fisheries, have been heightened by fears that depleted populations of horseshoe crabs would leave shore birds that feast on the crabs' eggs without enough fuel to complete their long migrations. State and federal agencies are moving to limit the number of horseshoe crabs commercial fishermen may land, limits that traditionally are set according to the bait needs of the fishing industry.
- Some New England fishermen and fishery managers have argued that the target population level in the rebuilding plan for dogfish sharks should be lowered, and thus restrictions on fishing for dogfish relaxed, because dogfish consume significant amounts of cod, a higher-value species that is also in need of restoration. Significant predation on cod, however, has not been supported by analyses of dogfish stomach contents. In fact, scientists advising the Regional Fishery Management Councils determined that adult cod are more significant predators of juvenile cod than are dogfish. Nevertheless, the perception of dogfish as an

"undesirable" species, whose abundance jeopardizes the abundance of other, more desirable species, not only persists but may influence decisions, even if at a subliminal level.

- Questions have been raised about the ecosystem effects created by the fisheries that remove some of the ocean's apex predators. In the Atlantic Ocean, swordfish, the large tunas (bluefin, bigeye), blue and white marlin and large coastal sharks are overfished, with several species considered severely depleted. By removing so many of these predators, we are weakening an entire tier at the top of the food chain, which may have dire biological consequences throughout the ecosystem. (Predator removal may be more disruptive than prey removal, since predators are generally longer-lived than their prey, and are thus slower to respond to changes in their environment, or to fill niches left by the disappearance of other predators.)
- An additional concern is the effect of increased harvest of pelagic forage species on their large pelagic predators, many of which are overfished and the object of national as well as international rebuilding programs. Increasing harvests of squid and herring on the northeast Atlantic shelf raise questions about how this unprecedented growth in fishing mortality might impact the effectiveness of recovery efforts for species for whom squid and herring are a dominant food source.

In these and other debates, fishermen and conservationists are demanding action, sometimes conflicting. Unfortunately, sound responses have been hampered by misperceptions about the nature and extent of predator-prey interactions, inadequate or unavailable data about them, and the lack of an established process for taking inter-species relationships into consideration.

We are obliged to make sure that ecological issues are addressed correctly, based on science and agreed upon goals, adhering to a process that we can understand and believe in. So it is not a question of whether we take on this challenge, but how. The species-by-species approach cannot address certain critical issues and problems that will no longer be ignored. The most dangerous course is the one we're on now, forced as we are to deal with these issues, but with no guidance as to what information is needed and, most importantly, how it should be used in the real world of making fishery management decisions.

The next frequently asked question is, can we manage on an ecosystem basis, at least in an informed and effective manner? Again, the answer is yes. The body of information available to fishery scientists and managers is large and constantly expanding. Most recently, the new bycatch and essential fish habitat provisions of the Magnuson–Stevens Act have prompted the gathering and synthesis of available information on a wide range of species and habitats, from a broad range of sources.

There is an immensity of raw data out there that has not been synthesized or analyzed for ecosystem-based management purposes. There are also new tools for ecosystem modeling, such as ECOPATH, into which this information can now be plugged. In many instances, there is adequate information -- if made available to fishery managers -- and the modeling tools necessary to predict fundament ecological responses to fishing removals and natural predation, and to make informed decisions that might minimize the adverse impacts of fisheries on trophically-related species.

Ecosystem-based management should strive to include as much information as possible on the structure and function of the ecosystem in which fishing activities occur, including its biological, physical and chemical dynamics, a description of the significant food web, and the habitat needs of different life stages of species that make up the significant food web. This is an ambitious goal, and we will never know or understand everything about how fisheries operate in an ecosystem context. But as the Ecosystem Principles Advisory Panel advised, this is not an acceptable excuse to delay implementing an ecosystem-based approach. Significant relationships are known and understood. We know enough, right now, to ask the right questions, identify the critical information and information needs, and establish a context for considering what we know and applying it to fishery management decisions.

As I said earlier, some fishery management bodies are already taking the first steps toward an ecosystem-based approach. That's because they already have the authority and the discretion, without any changes to current law, to consider predator-prey relationships and species interactions in fishery management plans. They are not explicitly required to do so, however, nor are they provided with guidance as to how.

What Congress needs to do, therefore, is provide both drive and direction to this process. By that I mean, amending the Magnuson–Stevens Act to require that the National Marine Fisheries Service and the Regional Fishery Management Councils:

(A) carefully consider the effects of fishing each species on other species in the food web; and

(B) begin devising Fishery Ecosystem Plans to serve as overarching guidance and a context for future management decisions.

We believe that Congress should require that all Fishery Management Plans (FMP) be reviewed and revised to consider predator-prey interactions, assess how associated species are affected by fishing allowed under each FMP and establish conservation and management measures that will protect associated species and their respective roles in the ecosystem as well as the integrity and sustainability of the ecosystem overall. This will require determining the effects of fishing on the food web, setting optimum population levels to account for ecological factors, and justifying total allowable catches with respect to interspecies relationships.

As the Ecosystems Principles Advisory Panel recommends, Fisheries Ecosystem Plans, or FEPs, would not be intended as a substitute for Fishery Management Plans, but rather a means to augment their effectiveness. The FEP would be an umbrella document which would include information on the structure and function of the ecosystem each region's managed fishing activities are occurring in, so that fishery managers are aware of the potential impacts of fishing on the various components of the ecosystem, as well as how changes in the ecosystem might affect certain fisheries. The FEP would also establish indices for measuring ecosystem health. Councils would continue to employ FMPs as the primary regulatory vehicle for managing marine fisheries, however, each council FMP should be required to demonstrate that its objectives and conservation and management measures are consistent with the findings and recommendations of the FEP.

We also urge Congress to authorize sufficient new funds to assist the Secretary and the councils in applying ecosystems principles to fisheries research and management under the Act.

Needed Changes to the Magnuson–Stevens Act:

Following are recommended amendments to the Magnuson–Stevens Act supported by the National Coalition for Marine Conservation and the members of the Marine Fish Conservation Network:

- Add consideration of ecosystem principles in fisheries management to the Purposes and Policy section of the Act
- Amend the definitions of optimum yield and overfishing to make more explicit the directive to consider impacts on ecosystems, including predator-prey relationships, in the setting of total allowable catch levels
- Amend the Act to require that all fishery management plans or amendments describe and assess the likely effects on other species in the ecosystem
- Amend the Act to require that each council develop a Fisheries Ecosystem Plan for the major ecosystem(s) under its jurisdiction
- Appropriate necessary funds for the application of ecosystems principles to fisheries research and management.

Finally, it is essential to emphasize that considering fisheries in an ecosystem context does not diminish the need to regulate fishing or downplay the effect of fishing on fish populations. It cannot be used to justify overfishing one species in order to maximize yields of another species. Nor does it diminish the need to fish selectively to avoid bycatch (the incidental capture of non-target species) and minimize bycatch mortality. In fact, ecosystem-based fishery management supports taking the precautionary approach to conserving and managing marine fisheries, especially when the ecosystem effects of fishing are uncertain or unknown. It is our firm belief that an ecosystem-based approach cannot and should not substitute for aggressively implementing existing mandates to prevent overfishing, minimize bycatch and protect essential fish habitat.

Thank you for considering our views, and I look forward to working with the Subcommittee members and staff during the reauthorization to improve management of all marine species.

Mr. GILCHREST. Thank you very much, Mr. Hinman.

The first question I have any single person or anybody on the panel can certainly answer. Basically, the question is what does ecosystem-based management mean? Now let me sort of give you a frame of reference upon which my perspective is for ecosystem management, and we would like to be able, as a result of this hearing and maybe a few more, to put language in the Magnuson Act

that will move us in a very clear, specific direction that will, I don't want to say accelerate, but begin the process of implementing and incorporating Ecosystem Management Plans, Fisheries Ecosystem Plans with that umbrella concept. So the Fishery Management Plan can draw on this information to better manage the fishery.

So what does Ecosystem-Based Management Plan mean? Dr. Crowder, you mentioned Pamlico Sound, the problem in North Carolina. We heard that about a billion fish died with this huge outbreak of what some people are calling Pfiesteria, and we've had similar incidents in the Chesapeake Bay with menhaden, and the NOAA Office of the Chesapeake Bay Program Office is sort of implementing this pilot project I guess I could describe or Ecosystem Management Plan in the Chesapeake Bay.

Now, my simple understanding of an ecosystem approach is let's take menhaden, for example. You have a population of menhaden, which is a food source for rockfish. Menhaden also are filter feeders for the Chesapeake Bay, and they eat I guess phytoplankton. Do they eat zooplankton, too?

Dr. CROWDER. When they are small they do.

Mr. GILCHREST. When they are small.

So the problem with phytoplankton and zooplankton is that the Bay has become too rich in nutrients, and there has been problems with oxygen, hypoxia, and then the next step is the growth of dinoflagellates, which live in a different water quality regime, which means the menhaden don't get the type of nutrients they need because dinoflagellates are less nutritious.

And so if we manage the Chesapeake Bay, we want to make sure a number of things; one, that land use is a part of the ecosystem for the fishery, and what are you going to do with the nutrients being washed into the Bay? So that is an aspect of it. If the menhaden population goes down, the rockfish don't have as many to eat, and they will be looking for a new food source, which could be crabs, which could be something else. So human activity comes in, and then we sort of, not to mention the huge reduction of oyster population over the last 100 years, and list of things to understand and pursue, and then put into a recognizable form so that you can come up with a Fisheries Management Plan seems, I don't want to use the word "daunting," I want to use the word "stunningly curious" to pursue this fascinating issue of the mechanics of creation.

And so some of what I remember about managing the Bay, especially menhaden, Chesapeake Bay, is that the commercial fishermen will get an allocation of menhaden. The rockfish will get an allocation of menhaden. The Bay itself, for filtering water quality, will get an allocation of menhaden, and so on down the line.

Is that some semblance of an Ecosystem-Based Management Plan that councils would undertake and pursue?

Dr. CROWDER. I would like to comment on that, Mr. Chairman, you have a very thorough understanding of what is going on in these systems. They are complex, and there are really two alternatives, in terms of trying to manage fisheries in that context. What we have done historically is manage fisheries as if they are isolated from all of those other effects that you catalogued. Clearly, that is not working.

The two alternatives I see from there are to ignore all of those other issues, but make fisheries management decisions that are extremely conservative. In other words, we need to buffer ourselves against all of those uncertainties we are not officially taking into account, like water quality and so on. Or we could make our assessments account for the key complex issues. You have identified a series of linkages that scientists have become more and more aware of over just the last 10 or 15 years. So we are in a position to take into account many of those factors that link landscape practices to fisheries production. So I think that on the science side, we can do a much better job than we are currently doing, taking into account ecosystem components. Obviously, we manage people, not ecosystems and not fisheries, so we have to figure out how one goes about altering the behavior of people to enhance these habitats so that they can produce the fish they currently produce.

One of the constraints on that is that the Magnuson Act deals with managing fisheries and works through NOAA. Many of those other factors that are having an impact on Chesapeake Bay and the Albemarle-Pamlico Sound are regulated through entirely different acts, through entirely different Government agencies. So how to achieve the sort of cooperation it will take to do ecosystem management will be a daunting task, both from a scientific perspective and from a governance perspective. But I think we have little choice, but to move in that direction.

Mr. GILCHREST. Now we want to replace the word "daunting" with challenging, and fascinating, and curious.

Dr. CROWDER. Well, for scientists, these are challenging, fascinating, fun tasks to get involved in, but it is also something that is not inexpensive to jump into. If we could manage these fisheries at the population level, that would simplify our tasks substantially. What we have discovered empirically is that we cannot successfully do that, so we at least have to take something of the ecosystem context into account when we develop Fisheries Management Plan.

Mr. GILCHREST. Thank you.

Dr. Fluharty?

Dr. FLUHARTY. Mr. Chairman, I think what you have said has very well-portrayed the set of issues we wrestled with in the panel. What you projected is what we would generally term "ecosystem management," and I think that that is the broad context under which a more limited approach which was our focus was how do you manage fisheries more ecologically. So that is a really a subtask of the broader task that you have put out before us. I think there may be—it may be useful to think of these in two related actions: one in terms of Magnuson-Stevens Act, in terms of the authorities that exist within the management councils; and, two, within the context of the Ocean Commission that is being established and getting started. I think that what you express is really the leading edge and would be a great organizing principle for that group is how do you bring the watersheds, the marine pollution, the various other kinds of activities, as well as the natural dynamics of the system into a common management framework. How do we start looking at that more holistically across Government? So I would suggest there might be two ways to do this, and two vehicles that would help us move along as quickly as we can.

Mr. GILCHREST. Thank you.

Mr. Hinman?

Mr. HINMAN. Using your Chesapeake Bay example, every description I have seen and heard of how a fishery ecosystem plan would operate in those kind of situations would begin with defining the structure and the composition of the ecosystem and mapping out the significant food web which, in this case, would include species such as striped bass, menhaden, blue crab, but also on the predator level the bluefish and weakfish, and at the prey level, the shad. And I think you would find that certain solutions would arise out of this. You can do certain things, such as be more conservative in the harvest of menhaden, do more to restore the runs of shad in the Bay, which are an important food source for striped bass, and it is the absence of those species and menhaden or the scarcity of menhaden that may be increasing the consumption of blue crabs. I think you would find that there are ways that you can work with that system and actually produce a variety of abundance of all of these species in the Bay and provide a lot of benefits for most of the users of the Bay. It is not a matter, I don't think, of one user over another.

I think we are in a situation right now where we have people saying, "Let us kill more striped bass so that we can kill more blue crabs or we can kill more menhaden or whatever," this kind of micromanaging the system to produce certain yields, levels of yields which is I think bound to fail. It is extremely risky, and it is a kind of a micromanipulation of an ecosystem that is the opposite of what we are talking about. Since this issue was raised by Steve earlier, of rebuilding all of these populations, I don't know that there is any scientific reason to believe that an ecosystem in balance cannot support a variety of species in abundance. I think they can, and I think by managing for abundance of both predator and prey species, we will have healthier populations that will provide those commercial and sport, as well as ecological benefits that we are trying to achieve.

Mr. GILCHREST. I guess when we talk about an ecosystem in balance, to some extent, each of the species in that ecosystem is dynamic and the population goes up and down, depending on who is eating who and whatever. So it is really, it is moving, and it is dynamic, and it is cyclical. So, when you incorporate humans in there, they are the, I would suspect, to a large extent, they are the only aspect, since humans are a part of the ecosystem, of that ecosystem that is not dynamic. It is just steady. You want to catch so many pollock, and so many crabs, and so many rockfish, and if your effort is much greater, you still need to come out with that certain number in order to be financially stable.

So what type of wrinkle does that pose to the ecosystem approach to a very dynamic, natural process?

Dr. Crowder?

Dr. CROWDER. At least in North Carolina, and I think this is true for many fisheries, historically, fishermen were also fishing those systems adaptively; that is, they didn't fish just in one fishery, they were able to move from one fishery to another. And I think, as our fisheries have expanded, we have ended up with fisheries that are highly specialized and require essentially a single resource, based

on the gear and the fishing technique, and they have a difficult time, as resources come and go, making a move from one to another. It is pretty typical for watermen in North Carolina to fish in five or six different fisheries. This, of course, requires them to have a lot of equipment of different kinds, and so on, to make those moves, but they respond to fluctuations in the abundance of prey, and that generates lots of problems with being permitted and licensed to fish in a variety of different fisheries.

So it could be that as we managed things toward specialization, we put fishermen in the position of requiring a stable resource when that is just not physically possible in the world that we live in. All of these stocks fluctuate up and down naturally, and we can seek to understand that, but if it is environmentally driven, we cannot control it. So we have economic processes that would like nice, stable yields in a world that does not produce nice, stable yields.

Mr. GILCHREST. Yes, sir?

Dr. MURAWSKI. Yes, it is certainly the case that fisheries can have a tremendously de-stabilizing effect in complex ecosystems. In the Northeast, we have seen the effect of fishing on the downside because natural fluctuations are perturbed even more as fisheries seek to maintain their catch rates. And so they tend to basically exert this negative feedback on these populations that drive them even farther down than they would normally be under sort of a natural cycling.

One of the things that we have discovered in looking at these kinds of systems, both in the real world and in computers, is that if the broad array of fish stocks are fished at reasonable levels, ecosystems tend to be very resilient. A lot of the species that we are talking about are relatively long lived, and so even if you have recruitment failure for a year or 2 years or 3 years in a row, because you have got a lot of older adults in the population, you have the potential to pick up the stocks relatively quickly. But if you have fisheries that are bouncing around from target to target in a system that we call sequential depletion, which is very well-understood now, that we can destabilize a whole ecosystem in a sequential basis, and that makes recovery in these systems much more difficult.

Mr. GILCHREST. Sequential depletion, could you explain that?

Dr. MURAWSKI. Yes. The term basically has been defined based on two interesting examples. First of all, back 30 years ago, we had large foreign factory fleets show up off the Northeast United States, and they bounced around from one target to the next because they needed to maintain very high catch rates for these large factory ships. And so as they depleted haddock, and then cod, and yellowtail and then started to move down the food chain, as Pat said, to herring and mackerel, we saw the catch rate stay stable, although there was a lot of target species shift.

We have also seen this in the Alaskan fisheries for shell fish, where things like shrimp, and crabs, and others, we had a mobile fleet that was capable of switching from fishery to fishery, and this whole concept is very well-understood now, and it argues for a comprehensive effort control across fisheries, rather than just simply managing one target species in an FMP over here and another one

over there, recognizing that that effort is very efficient. It can seek new targets very effectively.

Mr. GILCHREST. Unfortunately, we are going to have a series of votes, which means we will probably, rather than keep you here for a half-hour or 40 minutes doing nothing, and perhaps just myself coming back, I have just a couple other quick questions. I would like to stay in touch with all of you, whether I will come to Alaska the next time, North Carolina or whatever.

In an ecosystem approach, what impact do you suppose we might have with exotic species, invasive species? Has that been taken into consideration over the past several years with some of these projects?

Dr. Fluharty?

Dr. FLUHARTY. I am probably bolder than the scientists who really know this topic. But in these discussions with respect to marine protected areas and marine ecosystems, an ecosystem that is intact, is healthy, is thought, in simple terms, to be more resistant to invasion and thus less likely to be invaded—it doesn't mean it can't be, but it is less likely—you haven't created openings within the ecological niches by depleting, say, a stock that would allow something to come in.

I will stop there because that is the limit of my knowledge.

Mr. GILCHREST. There is another comment?

Dr. CROWDER. I would add to that. I think that there is increasing evidence from experimental systems, that conservationists have worked on in both terrestrial freshwater aquatic systems that systems that maintain a high level of biodiversity, a broad cross-section of species, are more resistant to invasion by nonnative species. And as we modify these systems with pollutants, with losses of species or severe depletions of species stocks, we actually make them open to increasing opportunities for invaders.

Many of the invasive species that we have causing problems now have had many, many opportunities to invade, and didn't seem to invade until just recently. So it causes at least some concern that its alterations to the systems that we have made that, in fact, make them more vulnerable.

Mr. GILCHREST. It sounds like an ecosystem approach is going to be beneficial in a number of ways, including a healthy ecosystem which is more resistant and resilient to exotic species.

One other quick question. With all of the complexities that we see, that you have mentioned in your testimony, that you have seen over the last number of years, Dr. Fluharty, in your ecosystem-based fishery management proposal, research document, you laid out some specific steps that could be taken by the Congress in the authorization of the Magnuson to put in place an implementation plan to the councils for an ecosystem approach.

Now, if anybody on the panel has read those steps, would you comment on them because they seem to be positive things for us to do to put in the Magnuson Act, and do you have any reservations about that? I guess we can just lift the language right out of the report then.

Mr. HINMAN. Well, I was a member of that panel, and I can also point out that a lot of those recommendations were the basis for the Marine Fish Conservation Network's recommendations to Con-

gress for the Magnuson Act changes, and they have also been very influential in everything from the Chesapeake Bay Program's approach to multispecies management and some of the councils that have undertaken this task. So I think there is a broad understanding and support for those recommendations as the way to go.

Mr. GILCHREST. I am sorry. We are a typical Congress day. We have a vote. What I would like to do is just turn the chair over to Mr. Underwood. Unless somebody has to catch a plane, I will be back as fast as I can, and Mr. Underwood can continue the line of questioning.

Thank you.

Mr. UNDERWOOD. [Presiding] Thank you, Mr. Chairman. Since I am a little out of the flow of the questions, let me just, as a general question, Dr. Fluharty, you mentioned in your testimony or you made the analogy that Congress could be the coach for ecosystems management. How directive do you want this "coach" to be? Do you want them to be more a manager?

Dr. FLUHARTY. Mr. Underwood, I think that this follows directly along the line that we were pursuing with the Chairman concerning just what steps could Congress do. I think that the steps we outlined might be seen as timid by some people who would like to see us move much more quickly, but the Committee or the panel talked about this quite a bit and felt like this was pretty much a sure-fire way, that these are things we could actually get moving on over a period of years.

The key element of that, as I tried to emphasize, is the National Marine Fisheries Service, the councils, the environmental groups that work with us and the industry groups that work with us all are very much overloaded with implementation of the issues that have been brought before us by the Sustainable Fisheries Act. This is rightly so. I am not whining. I think that we are headed in the right direction and doing the right kinds of things. But I think, as we add more tasks, as the coach might say we are going to raise the bar higher, we need to recognize the need to really either get some new recruits in to help with the effort or to provide more resources so that we can actually, have the energy to be innovative and to get on with the task.

Mr. UNDERWOOD. Well, Dr. Hogarth, do you have a response to that?

Dr. HOGARTH. I think I just would echo what Dr. Fluharty said. The 1996 amendments to the Magnuson-Stevens Act put great expectations on the Agency. The manpower and dollars to get the work done were not there. I think that is one of the reasons we are paying the price today with many lawsuits, and the other thing we have is that we have a tremendous increase in what we should be doing and really not have the means to get it done.

Looking here at what is recommended, I do not think the Agency has any reservation of undertaking ecosystem-based management. If you look at some of the requirements, with 900 species or so to deal with and 540 of those whose status is unknown, implementing this system into law would create, I think, a tremendous backlash from industry, in terms of additional lawsuits, questions about having a lot more vessels, or the need to have a lot more people to really gather necessary data.

I don't think any of us are fighting ecosystem-based management. I think it depends on how much you would put into law that has to be an impact on the Agency.

Mr. UNDERWOOD. So has the Agency considered costing out what some of these recommendations might entail?

Dr. HOGARTH. We are in the process of that now. I don't know if you heard me say we are going to have a workshop this fall to try to outline more of the system requirements, what would it take the Agency to implement the system, what would be the cost, and what would be the best way to go.

For example, the coral reef ecosystem plan that we are developing in Hawaii right now, costs us about $1 million, with consultants and others just to write the plan. That dollar figure for the number of ecosystem plans we would be doing, in that district, includes writing the plan. It doesn't include having all of the data or filling in all of the holes that you have.

The Groundfish Ecosystem Plan that Alaska prepared is about a 3,600-page document that still has holes in it. People are getting answers about now, and developing more definite alternatives, especially alternatives for management.

I don't want to sound negative because I am not negative. What I am trying to say is it is a tremendous amount of work. It is going to take a lot of additional data to do these plans and do them properly so that you do not have the Agency back in court trying to defend the plan. My concern is that we have got to have the resources if we want to go to this process.

We are going to try to work on this in the Agency. We are trying to do it now. We have several plans that we are working on to see how it works, but it has not been an easy process. It has not been a cheap process, and we have lots of holes that we need to fill.

Mr. UNDERWOOD. I think the appropriate response to that, Dr. Hogarth, would be to see some resource statements about what the costs would entail, what the costs would be to implement some of these recommendations.

Yes, sir, you had a comment? I am sorry. I cannot see your nameplate.

Okay. Mr. Hinman?

Mr. HINMAN. In answer to your question of how directive Congress should be on this issue, I have a couple of comments.

First of all, I think Congress clearly has to do a lot more than just say to fishery managers, "Consider ecological relationships, consider the effects on ecosystems." I think those are the kind of soft mandates that our experience has shown really do not produce results. They are akin to saying, "Prevent overfishing. Minimize bycatch." And I think in both those cases, when there is an absence of some kind of directive of how to do that or some kind of goals or standards that are set attached to them or some kind of prescriptive measures, very little is done in either case. That was the case with preventing overfishing for 20 years. Now things are starting to change because some prescriptive things have been put in there, some ways of holding them accountable.

Minimize bycatch. I do not think a lot is happening, and I think it is because that is pretty much as far as the act has gone. So if you do that with the ecosystems approach, I think that will be the

result; (A) that very little will be done; or (B) things will be done, but it will be in an uncoordinated or piecemeal manner or, possibly, in an improper manner.

I think what Congress has to do is put some requirements in the act, and it has to require that the Councils look at these issues and go through a process to show, to demonstrate that they have looked at the issues of what information is available and give them some kind of guidance on how they are to consider these things, how they are to weigh them. And I think both those things can be done in the Magnuson Act and should be done.

I think that guidance is what people have talked about, in terms of putting together some kind of FEP, demonstration FEP, and I am glad to hear that the National Marine Fisheries Service is beginning to look at what kind of guidance they can give the managers. But if you do not give the managers that kind of guidance, I think we are going to continue on the path we are on right now, and I think decisions will not be very well-educated and well-informed.

And worse, I think, from Congress's standpoint and from a political standpoint, we have, as I said in my testimony, decisions being affected by these kinds of perceptions of what people think is going on, and they are demanding some kind of action. And if we do not have a very established process for dealing with that, where we show people what information was considered, the things that happen or the things that are done are not going to be very credible either to fishermen or the public, and those problems will continue, and people won't have much faith in the fisheries management system, as it gets into those issues, as it must.

And one last point. The Advisory Panel's report does recommend that we do this through an incremental strategy, and tries to stress that we should not be overwhelmed by the enormity of the task or the amount of information we need, but that there are certain things that can be done, and we should begin doing things where we have information available and where we can recognize what kind of relationships are going on and what the impacts are. And we can begin doing those things in some fisheries right now, rather than waiting until we have the resources to collect all of the information to cover every aspect of the ecosystem, which will not happen in our lifetime.

Mr. UNDERWOOD. Thank you for that.

Dr. Murawski?

Dr. MURAWSKI. Yes. To your question about developing resources in order to do the job, the Agency has developed a document called the "Stock Assessment Improvement Plan," and this is in reaction to a National Research Council study to improve stock assessment. The strategy that we have been pushing forward is a three-tier strategy to, one, fully analyze the data that we already have collected; two, improve the basic data collection that we do to support the FMPs, as they are currently constructed, and that would include better observer coverage, more fishery independent surveys, and better fisheries landings data; and a third tier is to extend these stock assessments into the ecosystem realm, where we start to better study the fishery interactions, et cetera.

Certainly this is an expensive proposition and one that we see as an incremental proposition. As was stated before, this kind of enterprise doesn't necessarily throw out the basic data that we need. It really just adds to it, and we see this as our vehicle to improve the ecosystem basis for management.

Mr. UNDERWOOD. Dr. Fluharty?

Dr. FLUHARTY. Mr. Underwood, as part of the incremental approach that Ken was mentioning that we, the panel, recommended, if we look at the thrust right now, in terms of both litigation and Agency effort, to become NEPA compliant, if we look at the implementation of essential fish habitat, and particularly the habitat areas of particular concern and the fishing effects components of that, these are all major activities that involve councils, and the National Marine Fisheries Service, and users, as well, and environmental organizations.

If we think of that in terms of providing the building blocks that we are going to need for ecosystem-based fishery management, basically, looking at sort of what we are doing, but recognizing the significance of those activities right now, I think that that is a really good start for the Fisheries Ecosystem Plan. Even just looking at what is being done as we go more consciously, in an ecosystem context, is the kind of thing that really provides some legs to this concept.

Mr. UNDERWOOD. I am getting the sense, and correct me if I am wrong, I am getting the sense that part of the difficulty in trying to perhaps ensure public confidence, and this is one we are constantly assessing, and that is a normal part of the process, and now we are positing, trying to implement this ecosystem management plan, and now we are talking about in terms of implementing it incrementally. What do we mean by incrementally? I mean, what is the time frame that we are hoping to give to this?

Dr. FLUHARTY. Mr. Underwood, I guess I would say that I would see a time frame, and this is my perspective alone, of 2 to 3 years, where we, through various workshops, programs, bringing ourselves up to speed on essential fish habitat, especially fishing effects, totally implementing the Sustainable Fisheries Act, and further refining the concept of ecosystem-based fishery management and building a better concept of the fishery ecosystem plan, we would be in a position where we would have the wherewithal to get moving.

This doesn't mean that I am suggesting we wait until then to start using the information we have, and I don't think that will happen. But it is, in terms of a process, I think we have got about 3 years of ramping up on this and then a year or two of finalizing the concept and getting it into regulations so that, people can know what to expect.

That would be my perspective. I expect others may have ideas.

Mr. UNDERWOOD. Yes, sir?

Dr. CROWDER. Thank you, Mr. Underwood.

I agree with Dr. Murawski that there is an awful lot of data that has been collected about these ecosystems and a lot of understanding with these ecosystems not only with Government agencies, but within oceanographic institutions and the academic institutions that have cooperated. Under GLOBEC and under the

NOAA Coastal Ocean Program, there have been very useful programs of collaboration across academic/Government boundaries—we are trying to make them bridges—so that we don't have to start over collecting a bunch of new information. We need to look at the information we have got and figure out what the critical holes are that need to be filled.

So I think that, in addition to the resources that are available through Government, there are ample resources in the U.S., through the oceanographic institutions, to contribute to these issues.

Mr. UNDERWOOD. Anyone else?

Mr. Hinman?

Mr. HINMAN. Yes. It is hard to say exactly how long it would take to put together a fishery ecosystem plan, whether it is a couple of years. I think, as soon as—as Larry just said—as soon as we start trying to put together these plans to gather and synthesize this information, I think people are going to discover that there is a lot more information, and we know a lot more than we may think we do, which I think would probably lead to being able to put it into implementation sooner, rather than later. But I think part of the incremental strategy, I firmly believe that a requirement of taking into consideration some of the significant predator-prey relationships is something that needs to be in the reauthorization, and I think they are things that can be done right now, that can be done even before a fishery ecosystem plan is completed. We do know of some very significant relationships among predators and prey that are being harvested, being caught at very significant levels, and that we have gathered tremendous amounts of information on over the years.

Some of the examples we have talked about today, we were talking about them because there is a tremendous amount of information. So I think those things don't have to wait at all. Fishery ecosystem plans will take probably a couple of years to put together, but again I think we will find, as we do that, that we know a lot more than we think we do and that we can do a lot more than some people think, sooner than we think.

Mr. UNDERWOOD. Dr. Hogarth?

Dr. HOGARTH. Just one last point, one of the other considerations is the human considerations in this effort. We are in a need for a lot of social economic-type data, and the impacts on communities and all, not only the biological impacts, but you are going to have to look at communities, the socioeconomic effects. That is the type of data that we, in the Agency need, but have had a lack of funding for a number of years, and I think it is one of the critical issues.

The second thing is that our workshop will look at the process for ecosystem management. If we can develop a process or a model, so to speak, that we will use for these type plans, then I think that you could focus more on the type of data needed, the assumptions necessary, and this type of thing. It will focus the discussion a little more once we can come to an agreement on the process or a model on how these plans will be done. That is what we want our workshop to focus on this fall.

Mr. UNDERWOOD. Explain what you mean by socioeconomic data.

Dr. HOGARTH. Well, you have to know what the fishery and the value of some of the ecosystems from a fishery standpoint; if it is whale watching or if it is, the whole ecosystem in terms of the economics, the social aspects of the ecosystem and what impacts of management would be. When you look at the ecosystem, you are looking at it, from a management standpoint, of all the uses, including fisheries, but also the other uses.

Mr. UNDERWOOD. Okay. Dr. Fluharty, under this ecosystem-based fishery management, when you prepared this report, what elements of it were perceived in the final recommendations you made as perhaps the most controversial or what elements did you leave out, as well, that people wanted?

Dr. FLUHARTY. I think that some of the discussion today reflects the sort of underlying concerns that we had. As scientists, as managers, and as economists who were involved in putting this report together, I think there was a real interest in moving this concept ahead. The question was how quickly could we do it and what were the best methods? And we gave our best shot at that.

And so I think that, clearly, there were people that wanted us to move to, as Ken has suggested, to a much more enforceable and action-oriented Fishery Ecosystem Plan. I mean, what would the plan be, what kinds of management actions would flow from that document? We adopted a somewhat more conservative incremental implementation approach, knowing that it is going to take some while to gather information together to get people up to speed, understanding there is a lot of education that needs to go on throughout the fishery management process.

I think, if there was any controversy, that might have been it. I think another area where we struggled quite a bit was on how to discuss marine protected areas and what were their roles in fishery management. Clearly, fishery management has a wide variety of what are generally termed "marine protected areas," but they are not fully protected areas or no take areas.

And so these were some of the dynamics that were here, and our approach emphasized the fact that fishery managers already are using, already are putting marine protected areas together in large areas like Georges Bank in the North Pacific where you have no trawl zones to protect habitat or to achieve different kinds of things. But other people looking at that say, well, you still allow some fisheries to take place in there. Therefore, they don't count. Well, scientifically, they mean a huge amount and really solve some of the major problems where we have threats.

So just about every debate I am sure you had been brought into on this Committee relative to fisheries was hashed out—

Mr. UNDERWOOD. Part of the discussion.

Dr. FLUHARTY. —in this discussion.

Mr. HINMAN. Even ITQs came up.

Mr. UNDERWOOD. Pardon me?

Mr. HINMAN. Even ITQs.

Can I add something to that?

Mr. UNDERWOOD. Sure, a couple of comments and then—go ahead.

Mr. HINMAN. Yes, I agree with Dave that we were trying to strike a balance between how action oriented the recommendation

should be and being a little bit more conservative on that and recognizing a lot of the information needs.

One area that was not necessarily controversial, but we really didn't get that far into because our mandate was to look for changes under the Magnuson-Stevens Act was this sort of interjurisdictional ecosystem of institutions that are under a lot of different Federal laws. For example, a lot of the species in the ecosystems that we are going to be mapping out in Fishery Ecosystem Plans are managed by other laws, such as the Marine Mammal Protection Act, the Endangered Species Act, interstate compacts and other things.

There was some discussion about eventually needing to somehow harmonize our ecosystem objectives and considerations among these various different Federal laws because they are all going to impact things. Once you get into the habitat issue, you get into a whole bunch of other laws and agencies, and it becomes pretty, the word "daunting" comes up again, but I think that was one thing that we did look at. And I think some of them are more compelling than others, some of the marine wildlife issues that we need to harmonize that because we have fisheries issues that are now bumping up against Endangered Species Act issues and the Marine Mammal Act issues, and I think those will become even more focused as we get into the ecosystem context, and that will have to be dealt with.

Mr. UNDERWOOD. Dr. Murawski?

Dr. MURAWSKI. You would think, from the witnesses' testimony here this morning, that this is rather noncontroversial in terms of implementing—

Mr. UNDERWOOD. I don't think so.

Dr. MURAWSKI. —Fishery Ecosystem Plans as a tier on the way we currently do business. If we look at the broader issue, there is a large dichotomy in people's approach to this issue. Some would have us scrap fishery management the way we do it now and go with a broad and ill-defined ecosystem basis for managing fisheries, recognizing or at least stipulating that what we are doing is a failed paradigm.

Most of us in the business feel that conservative single-species management is the foundation that would improve stocks, that would buffer against unanticipated changes in the ecosystem, and it is really far along the line. We feel that this approach gives us a foot in the door, with a lot of the mechanisms that we do know work, that can recover depleted species, in most cases, and move forward. But I wouldn't discount the controversy, particularly among some of the groups that are out there, that this is not the way to go.

Mr. UNDERWOOD. Thank you for those remarks.

We will stand in recess until the return of the chair.

Thank you.

[Recess.]

Mr. GILCHREST. [Presiding] The Subcommittee will come back to order.

We appreciate your patience, and I also want to thank Mr. Underwood for continuing the hearing. It seems as if the most productive time during any hearing is the recess time.

[Laughter.]

Mr. GILCHREST. But I guess it is not always that people have an opportunity to discuss these critical issues with other people from different parts of the country. And when they do so, it provides a great benefit.

I, also, want to thank all of you for waiting and being patient with us. I had just a few more questions to finish up with.

Dr. Hogarth, in this Chesapeake Bay NOAA ecosystem approach, could you tell me who the collaborative partners are in this.

Dr. HOGARTH. Judith Freeman is here.

Mr. GILCHREST. Judith just stepped out.

Dr. HOGARTH. We will get them right now; Peter Hill is here.

Mr. GILCHREST. That is fine, Dr. Hogarth.

Dr. HOGARTH. If not, we will get those to you. I don't know all of them, but, yes, I know EPA is involved, but we will get it to you.

Mr. GILCHREST. Thank you. The Chesapeake Bay NOAA Office is that a, the ongoing effort to gather data to an ecosystem approach then is contained within the Chesapeake Bay proper, the Chesapeake Bay fisheries itself, and not outside the Chesapeake Bay?

Dr. HOGARTH. There are some outside the Bay, yes, sir.

Mr. GILCHREST. And would that have an impact or could that have an impact, and is there any collaboration with the Mid-Atlantic Fisheries Council on that program?

Dr. HOGARTH. I am not sure at this point. I will have to take a look at that. I know we are looking at some of the species that migrate in and out of the Bay. I don't know what we are working with the Council itself or just the Mid-Atlantic States.

Mr. GILCHREST. We will wait until Judith comes back. Thank you.

Ms. Livingston, could you give us some idea of what you see—to me, and perhaps to all of you, as well, would you agree that we are at the very early stages of two things: understanding how to create a Fishery Ecosystem Plan and then, once you had the scientific data or ongoing understanding of how it all works, what would you say the difficulties of that would be for us to appropriately place language in the reauthorization bill so that a management council would then be required to proceed with those steps to implement this umbrella of a Fishery Ecosystem Plan that we are talking about, upon which information would be drawn for a Fisheries Management Plan?

Ms. LIVINGSTON. Mr. Chairman, I think we have somewhat of a grasp on what is involved in producing a Fishery Ecosystem Plan, as outlined by the Advisory Principles group.

As I mentioned in my testimony, we have struggled with that in the last year, although we didn't use the term "FEP." What we did with our last Groundfish SEIS is clear that we did a lot of the work that would be required under an FEP.

In listening to Mr. Hinman's recommendation that the Magnuson Act be amended to include consideration of predatory-prey interactions sounds very good, but when we look at what we have done so far in our work, trying to develop indicators that look at how we are performing in terms of protecting forage species, what we are doing with top-level predators, it is very difficult to say what

we should do with it in a quantitative way. I would say that is the biggest difficulty. How much is enough? And if there is some way to put it in a framework, that would be the most useful because I would say we still have a very big lack of scientific knowledge about how much is enough.

Mr. GILCHREST. You are saying if, when we reauthorize the Magnuson Act, we create a framework to move in a direction of ecosystem management, with each council having a clear direction to go in, but then enough flexibility to deal with all of the various variables, could you give us some idea, from your perspective, if and when we move in this direction to give some framework to ecosystem management approaches, to do it effectively, as some of you mentioned about the backlog of compliance with existing regulation, and part of that is not enough data, part of that is not enough people collecting that data and so forth, what would it take, you know, from being on the Council and you want to pursue this new adventure, what would it take?

Ms. LIVINGSTON. Well, we have heard two things of what it would take. It would take the manpower to come into compliance, to do the Environmental Impact Statements on EFH, to have the other regions do, as we did with our programmatic EISs, to look very comprehensively at that. That takes a lot of manpower. When I look at what we did last year, we nearly burned ourselves out trying to do that. So that is one aspect.

Mr. GILCHREST. On the North Pacific Management Council you need manpower to continue to pursue this.

Ms. LIVINGSTON. On the Council and at NMFS.

Mr. GILCHREST. What does that mean—five people with certain degrees, ten people with certain experiences?

Ms. LIVINGSTON. I would have to get back to you on the exact numbers. I haven't computed that. But given that we have the EFH EIS, and I know that on the Council itself a lot of action has been stopped, at the moment, on a lot of our habitat issues and other things because staff have been so busy with other things.

Mr. GILCHREST. So, besides manpower then, what was the next thing?

Dr. HOGARTH. One aspect is the manpower at NMFS and on the Councils to deal with doing these comprehensive assessments; and the next is, as Dr. Murawski talked about, the research aspects that are outlined in the NMFS Stock Assessment Improvement Plan. There are some dollar amounts and manpower associated with that in the plan itself.

Mr. GILCHREST. Dr. Hogarth, is that a quantifiable number that we could get from the councils—the manpower to pursue the process of an ecosystem approach, what is necessary to complete the implementation of the backlog of existing regulations, and then what each council would need in terms of scientific expertise? Is that something that we could actually see? When we implement this into our amendment, it would be helpful to us if we could say we need "X" number of dollars to do this appropriately, and here is where those "X" number of dollars are going to be spent?

Dr. HOGARTH. Yes, I think we can develop estimates of that. That is what we are planning to do internally. We have not dealt totally with the councils yet. We are dealing internally, but that

would then translate to the councils. But if you give us a time frame, we will try to get it done.

Mr. GILCHREST. Let us see, what is Monday's date?

[Laughter.]

Dr. HOGARTH. A little bit more realistic—

Mr. GILCHREST. A couple more weeks. We will meet down at Barrent Island and plant some more marsh grass.

Dr. HOGARTH. That would be great. That was fun.

We are in the process of doing this. We are looking at the existing problems we have in NEPA and trying to resolve that, and we are meeting with the councils at the end of July, so we are looking at existing problems.

Mr. GILCHREST. Dr. Fluharty, is that something you think can be—can you establish a number where you would have people doing ecosystem approach? What does it take to take care of the existing backlog? Because I would assume that that backlog of implementation of existing regulations has, I would guess, a negative impact on the whole picture of the council.

Dr. FLUHARTY. Mr. Chairman, that is correct. I think it has a number of effects. I have heard staff talking to us in the North Pacific about the Sustainable Fisheries Act essentially tripling the workload. If you look at numbers keying off that, and dollars keying off of that, that is pretty substantial, but I don't think that is entirely out of the question. In part, that is why we proposed a more incremental approach to this.

One of the things in the council and NMFS process we found to be extremely effective is the fact that, particularly where you are integrating across these things, you are using existing personnel who have specific expertise to contribute to a joint project. So it is not always just a new position here or there, although you could conceive of it: If each council had or each region had a Fishery Ecosystem Plan coordinator whose job it was to bring everyone together and work on this, that would be a big help.

This would be just bringing together the information that we do have available, not going out and doing additional research. I think that the additional research, we have some good understanding of what that needs to do, but again it is integrated across everything that the Agency and the councils are currently involved in. So I would certainly defer to Dr. Hogarth and the people here in terms of how you actually think of this, in terms of the management institutions. But I suspect that the number is daunting, as well, and I think that that is realistic, in terms of what we want to do in the marine environment.

And I think you, in your leadership role, have seen that we are far behind what is going on in the terrestrial environment, in terms of really understanding what it is that needs to be done and developing the institutions to accomplish that. So there is a tremendous opportunity and need for moving in these kinds of directions.

Mr. GILCHREST. Dr. Fluharty, you are suggesting that each council would have a possible designated position referred to as an ecosystem coordinator?

Dr. FLUHARTY. I could see it at the council level, but I am also concerned, and this is why, you know, I would benefit from discus-

sions with others. Since this is an ecosystem-based and scientifically-based concept, much of the work takes place in the science centers of the National Marine Fisheries Service, as well as with partner agencies, the various States who are members of council areas, and tribes and others that are involved. So there is a tremendous effort here, and I am not sure where I would necessarily think the best place to put such a coordinator would be, but I could see a regional coordinator position would be extremely valuable.

Mr. GILCHREST. On each council.

Dr. FLUHARTY. At a minimum, yes, and probably one for the highly migratory species billfish area as well. That is a much different type of ecosystem concern, but I could see that very easily, as necessary.

Mr. GILCHREST. Dr. Hogarth, does that look like something that is feasible?

Dr. HOGARTH. I would say I think we can make the estimate. They will be somewhat ballpark.

The other thing we have got to be concerned about is the State's involvement. For example, summer flounder, we need to look at the problems we have had with summer flounder. When you get into ecosystem management of summer flounder, you have a number of states involved. We would have to make sure they were brought into the fold to work with us.

I think we can give you an estimate of what it takes. And I think, as Dr. Fluharty said, we have already done some work internally. It is some large number of people and dollars. It is something we have discussed. We have not put it on paper yet, but we have discussed it and looked at estimates of the cost of the projects. Because we were trying to figure out how to implement a system, we may take it in stages that Steve was talking about earlier this morning, how we would implement it in stages on a trial basis and this type of thing.

Mr. GILCHREST. Well, we will do everything we can up here to inform our colleagues of the importance and, to some extent, the sense of relative urgency. Everything is urgent up here, but it would be useful for us to understand the picture of ecosystem management as clearly as possible, from all its varied aspects, so that if we were going to implement this in stages, we would make sure that that was done in a fashion that moved us in the right direction with reasonable appropriations as quickly as possible.

Dr. Hogarth, you mentioned the states, and if I could, since he is in the room, I am going to paraphrase something Jack Dunnigan said I think it was last week or the week before, and he certainly can stand up if I am missing the mark, but we did have a brief discussion about menhaden, and crabs, and rockfish at the previous hearing from the gentleman from North Carolina. And Jack, I thought, gave a pretty good answer in that he said that there were many more interested parties in menhaden than there used to be, and as a result of that, the regime for managing that species had changed, but it was not for some particular political purpose.

But then I think Jack Dunnigan made a comment, in reference to ecosystem management, that he said the Atlantic State Marine Fisheries Commission needs some clear direction as to which way we are going, and so what we are trying to do at this hearing is

to give people some idea as to the direction we would like to go in, and one of those directions will be to understand how to incorporate an ecosystem management approach to our fisheries.

I was handed a question here. Oh, okay.

Dr. Hogarth?

Dr. HOGARTH. I do have an answer for you on the people that are working on the FEP. There are representatives from the Maryland Department of Natural Resources, the Virginia Institute of Marine Science, University of Maryland, Chesapeake Biological Labs, and the Academy of Natural Sciences, Maryland Sea Grant, United States Marine Fishery Commission, the U.S. Geological Survey, the Mid-Atlantic Council and the South Atlantic Councils. And Judith Freeman just told me we have a lot of scientists who have given us time, devoting time to work with it that no one is paying for. It is just an undertaking they are doing, and NOAA is not paying them for it. They are just giving their time to help with the process.

Mr. GILCHREST. Thank you very much. We would like to come down and visit on a somewhat regular basis to see the progress.

Can you have an ecosystem management approach to highly migratory species?

Mr. Hinman?

Mr. HINMAN. Well, since that question sort of crosses over two issues I spend most of my time on, I hope I have an answer.

Yes. In our written testimony, we pointed out that two of the issues that are on the table right now in front of managers that are ecosystem issues, predator-prey issues, involve highly migratory species. We have to take a look at the fact that we have a whole tier at the top of the food chain, our large pelagic fish, that are some of our most overfished species. About a fifth of the species on our list of overfished species in the United States are highly migratory species—coastal sharks, big tunas, big-eye and bluefin, swordfish and both marlins, and this can have dire biological consequences on the ecosystem. We have taken out so many of those fish from that part of the food web.

As a number of studies have shown, and something that Dr. Peter Larkin and some others have published on, is the belief that actually removing the predator is going to cause more enduring damage to an ecosystem than removing some of the prey species because the predators are less responsive, because they are longer lived, slower growing. They are less quickly responsive to changes in the environment, openings of niches because of competitors being overfished or changes of availability of prey. So I think this is a big concern.

I am answering the question I guess that, yes, we definitely should consider and should be applying the ecosystem approach to highly migratory species. So should the related concern that so many of these species are now the object of rebuilding plans, both national and international plans, and that we have a lot of their forage species that we are increasing our harvest of—squid, herring, mackerel. And those catches have gone up tremendously in the 1990's, and we are still allowing them, as of decisions being made right now at the council level, allowing those catches to increase even more, but we are not considering whether that food

source is going to be out there on the shelf for the returning populations of pelagic species.

I guess you are getting into the question for highly migratory species, can we do ecosystem management on an international level? And that is the institutional question. We can't effect that, I don't think, through the Magnuson Act, except to the extent that we can require a Fishery Ecosystem Plan to be developed by the U.S., by the National Marine Fisheries Service, HMS Division, looking at all of these issues I have been talking about, and others, and trying to map out those significant relationships within the highly migratory species community, as well as their important forage species, and make recommendations on what kind of actions we should be taking, and then they could become the basis of both domestic actions, as well as U.S. positions when negotiating international treaties.

Mr. GILCHREST. I guess this sounds like something that would be, at least as far as the Magnuson Act was concerned, appropriate for an ecosystem manager at each council on a collaborative effort between the other councils and the State associations, and on an international arena would have to be obviously an international agreement for an international treaty.

But I guess if we moved in that direction, and the data was collected and the U.S. took a leadership role in it, it would be more easily understood and possibly accepted.

Dr. Murawski?

Dr. MURAWSKI. I think your question, in an ironic way, applies equally to the Chesapeake Bay. We had a scoping meeting that Judith and her colleagues put together several years ago, and we talked about the first question of what are the boundaries of the Chesapeake Bay? And we came to the conclusion, obviously, that you had to include the migratory predators in the system, and so that it rapidly extends its boundaries out.

Now, large marine predators like the top predators have wide boundaries. They cross across defined ecosystems. But as Ken Hinman said, the failure to include them as actors in the ecosystem leaves a big hole in what we are doing. So we obviously need to be flexible in those definitions of boundaries.

Mr. GILCHREST. Thank you.

I have just one more question. In some areas in the United States, where States or regions are trying to protect wildlife habitat, they have conservation corridors between one hub to another hub in which the ideal situation is the wildlife, when they are going from one acreage to another acreage, they will have a path to travel through.

Is there a mirrored concept, a similar concept in the oceans, where you can have corridors maybe connecting marine protected areas to another marine protected area, and is that something of a consideration now or down the road with ecosystem management?

Yes, sir?

Dr. CROWDER. Yes. Both the Marine Conservation Biology Institute and the National Resources Defense Council have sponsored workshops within the last year to look at corridors. And we have been talking about resource species, but many of the protected spe-

cies, the sea turtles, for example, undergo extremely wide migrations. And what we have been trying to do is put together what we know about the habitat they use at various stages in their life history, what their annual migration patterns look like, in an effort to string together that kind of protection.

We need to know where the organisms are at particular seasons and which fisheries they interact with as they are moving around those systems. So I think people in marine fisheries, marine conservation, are starting to think about those issues, and we do have some information on which to base some preliminary estimates. I think there is an NRDC report out just recently that deals with the Atlantic coast that involved the input of 20 or 30 experts on different taxon groups about which portions of the Atlantic coastline might be appropriate to consider for some sort of protection, and one of the issues was migratory species.

Mr. GILCHREST. Dr. Hogarth?

Dr. HOGARTH. Judith is back, but she just passed me a note, and she may want to follow up on this, but she said in the Chesapeake Bay they are using a corridor-type management for blue crabs to protect the females move from one area to the other.

Mr. GILCHREST. So the corridor for blue crabs is an area set aside—

Dr. HOGARTH. So that the females could, yes, move on—

Mr. GILCHREST. So that is an area that you can't fish in.

Dr. HOGARTH. Right.

Mr. GILCHREST. You can't catch the blue crabs in.

Dr. HOGARTH. Right.

Mr. GILCHREST. And that goes down through Virginia?

Ms. FREEMAN. It is in Virginia.

Mr. GILCHREST. It is in Virginia.

Ms. FREEMAN. Yes. It is in effect during certain times of the year, but the intention has been described as a protected corridor.

Mr. GILCHREST. That is great.

I have a few more. I think they are a little bit, they are ecological questions, El Nino, El Nina, climate change, that kind of thing, but I think, through conservations you have stated here, I think the obvious answer to a question about El Nino is that it is going to have a, depending on the size of the El Nino, a smaller, dramatic effect on a particular species or a number of species.

Yes, sir?

Dr. FLUHARTY. Excuse me, Mr. Chairman. I know you didn't ask that as a question, but I happen to be involved with some work in the North Pacific, and this whole concept of El Nino, La Nina, Pacific Decadal Oscillation (PDO), longer term fluctuations, are very relevant to understanding what is going on in the ecosystem, and it is an area where, for example, in the North Pacific, are we looking at a decline in Steller sea lion populations that it is mediated, to a large extent, as an alternative equilibrium state or Steller sea lions, because of change in the ecosystem, and a fair amount of study has been put into this, and it is a major contributor to what is actually going on. So you are right on, in terms of the kinds of things that would have to be taken into account in the ecosystem-based approach.

Salmon management in the North Pacific, you have a very strong North-South signal in Nino years and with the Pacific (Inter)Decadal Oscillation, where you have an inverse production regime between Washington State, and Oregon, and California versus Alaska. So, when things are really bad in Western Oregon and California, as they have been for the last 20 years, they have been extremely good, i.e., world record catches of salmon in Alaska.

This inverse regime may be breaking down now. We may be seeing some recoveries along the Pacific Coast, Columbia River stocks, that is related to this shift. So there is a lot to be understood, and it really does need to be brought into the fishery management context and is being brought in, in the Pacific setting.

Mr. GILCHREST. A reduction in the stock of salmon in Washington and Oregon, I know there are a lot of human factors there, but part of that is related to the warmer water?

Dr. FLUHARTY. Yes, sir.

Mr. GILCHREST. And then the warmer water is now beginning to move into the Alaskan waters, and so that is having some effect on Alaskan salmon stock?

Dr. FLUHARTY. Just the opposite. The warmer waters moving farther North give a productivity boost in the Northern areas. When it gets colder, that changes things. It helps us down in Western Oregon and California, where we get certain kinds of up-welling conditions that bring colder, more productive water, down off our shores, a bit more suitable for, thus, survival of some—

Mr. GILCHREST. You are saying the warmer water in Alaska?

Dr. FLUHARTY. It is relatively warmer.

Mr. GILCHREST. Relatively warmer.

Dr. FLUHARTY. A degree or two.

Mr. GILCHREST. Oh, I see.

Dr. FLUHARTY. A degree or two warmer water in Alaska seems to be associated with some pretty major regime shifts.

Mr. GILCHREST. Has El Nino affected or, I have heard a lot of different things about Steller sea lions, one of which is because of the change of temperature in the North Pacific in and around Alaska, the pollock population has been diminished, and therefore the Steller sea lions have not had enough to eat. In other words, the Steller sea lion food source has been diminished because of the change in water temperature.

Dr. FLUHARTY. Mr. Chairman, I am not sure where you got that information, but we have—

Mr. GILCHREST. Oh, herring and mackerel. I got my fish wrong.

Dr. FLUHARTY. Yes. So that the pollock is doing quite well. In fact, the population has more than doubled since the Steller sea lion population started to decline in the Bering Sea, so that we see, and Dr. Livingston can keep me straight here, so that in the Bering Sea we see a major increase in pollock as a food source, and that is one of those things that makes us scratch our head, looking at the small fatty fish, forage fish, for which we do not allow fisheries to take place, those have dropped out of the ecosystem, some of the shrimp and some of the other prey that are also eaten by Stellers as opportunistic feeders. So these are the kinds of questions that we are wrestling with, in terms of understanding what

is the role of the fishery with respect to Steller sea lion decline and/or recovery.

Mr. GILCHREST. Is this an example of the difficulty of trying to understand and implement an Ecosystem Fisheries Plan?

Dr. FLUHARTY. Yes, sir, and also why we need to do it.

Mr. GILCHREST. So we don't have any specific answer as to why the decline in Steller sea lion population.

Dr. FLUHARTY. Well, no, we do not have a definitive answer.

Mr. GILCHREST. Ms. Livingston, what were you going to say?

Ms. LIVINGSTON. Well, I was going to say that there are a whole host of factors that have contributed to the decline, and there is no one factor at this point that we can point to.

Mr. GILCHREST. Give me three factors.

Ms. LIVINGSTON. Previous harvest of sea lions, climate factors, and now the big discussion is localized depletion of sea lion prey.

Mr. GILCHREST. What are the sea lion prey?

Ms. LIVINGSTON. Walleyed pollock, Pacific cod, and mackerel are the primary ones.

Mr. GILCHREST. Is there any reason for their decline?

Ms. LIVINGSTON. Those prey had not necessarily declined in overall abundance. The factor that we are talking about is localized depletion, which is a fishery coming in, in a small time and space frame, and removing fish. Although it may be a very large population, the fishery may be locally reducing prey abundance during a critical feeding period of Steller sea lions, so that they may not be able to find adequate prey during that particular season or area.

Mr. GILCHREST. Is there little or sufficient science on that issue?

Ms. LIVINGSTON. That is one thing we are really working on right now, to get a better understanding of the seasonal distribution of these fish. As you might know, because we are up in an Arctic or boreal system, we usually only survey during the summer, and now we are trying to get a better handle on what these fish are doing in the winter, where they are, and how abundant they are.

Mr. GILCHREST. Where do the Steller sea lions go in the winter? Do they stay there?

Ms. LIVINGSTON. That is another question that we are trying to get a better handle on. We believe they stay there. We are not sure how much they move across the different rookeries.

Mr. GILCHREST. But they stay in Alaska.

Ms. LIVINGSTON. Yes.

Mr. GILCHREST. Well, we could probably go on, and have pizza brought in, for another couple of hours, but I do want to thank all of you for discussing this most fascinating mystery. We will continue to pursue this, and with your help, we hope we can reauthorize the Magnuson Act in a way that will be most beneficial to the ecosystem, which includes us.

I have to ask unanimous consent that the hearing record remain open for member statements and/or other material for an additional 10 days. The Subcommittee will have follow-up questions for each of you, if you don't mind. And if each of you, in your respective places, we are looking for places to travel to, if you want to invite us to your region of the world, we would be more than happy to go there.

Thank you all very much. The hearing is adjourned.

[Whereupon, at 11:58 a.m., the Subcommittee was adjourned.]

[Dr. Hogarth's response to questions submitted for the record follow:]

GENERAL QUESTIONS FOR THE RECORD

HOUSE RESOURCES COMMITTEE

SUBCOMMITTEE ON FISHERIES CONSERVATION, WILDLIFE AND OCEANS

HEARING ON ECOSYSTEM-BASED FISHERY MANAGEMENT

JUNE 14, 2001

Question 1: Describe the ecosystem-based fisheries management requirements.

Answer: To make wise use of public resources that contribute the maximum benefit to the Nation, NOAA needs to take a fresh approach to living marine resource stewardship and modernize its scientific and management practices. New data and well-designed processes that synthesize and communicate information into successful public policies are essential to achieving the mission of building sustainable fisheries, restoring healthy coastal ecosystems and enhancing recovery of protected species.

When NOAA was created 30 years ago, no one adequately predicted the human and environmental complexity of the task of living marine resource stewardship. Today, the concept of ecosystem-based fishery management is gaining momentum. Such an endeavor is an enormous challenge. NMFS and the eight regional fishery management Councils have already begun investigating how ecosystem considerations can be incorporated into the existing fisheries management structure. Generally, the approach is to conduct detailed single-species assessments and embed them in an ecosystem context. In other words, consideration of ecosystem effects tends to be qualitative or semi-quantitative, rather than fully quantitative. Multispecies and ecosystem models are being developed in all NMFS Science Centers and by a few academic institutions, but they are usually difficult to validate and frequently suffer from lack of adequate baseline biological and environmental data. Extensive monitoring programs for all Federally-managed species, associated and dependent species, oceanographic data, habitat mapping, and climate effects are needed to fulfill the data requirements of ecosystem models.

Ecosystem-based fishery management will require a multifaceted approach, including significantly expanded monitoring programs and new, adaptive governance systems, generally referred to as fishery ecosystem plans (FEPs). When fishery managers are better able to understand the complex ecological and socioeconomic environments in which fish and fisheries exist, they will be better able to anticipate the effects fishery management will have on the ecosystem and the effects that ecosystem change will have on fisheries. In developing an ecosystem approach to research and management, it is important to recognize that a great deal is already known about marine ecosystems, but that this information is not consistently applied in current management efforts. This is, in large part, because there is no agreed upon method or process for applying it. Therefore, emphasis must be placed not only on what new information is required, but also on how to apply existing information effectively. In addition, it must be recognized that both science and management are ongoing processes, and that mechanisms are required to incorporate new scientific, social, cultural, economic and institutional information into the management process as it becomes available.

To fully implement ecosystem-based approaches to fisheries management for all managed U.S. marine species, NMFS and the Councils will require a significant increase in funding and staffing in order to produce the necessary baseline monitoring data. This attests to the complexity of integrating data from many scientific disciplines into an ecosystem-based management approach. Development of fishery ecosystem plans will require a deliberate, incremental process. Public expectations of what NOAA can and should produce need to be aligned with the reality of what they are willing to spend and how wise use of natural marine resources comports with other national priorities. The primary enhancement elements and cost estimates required to develop FEPs and provide the necessary baseline monitoring data are outlined below. To reach this level of effort will require a phase-in period of five years or more.

Question 2: What is the estimated funding and Full Time Equivalent (FTE) employee requirements to implement ecosystem-based fisheries management and implementation costs?

Answer: A narrative accompanies each element in the chart in response to the question.

	Ramp-up Costs ($ in millions)	FTEs
Stock Assessment Improvement	91.2	608
Fisheries Oceanography	31	25
Socioeconomics	12	86
Fisheries Information System	44	50
Advanced Sampling Technology	22	19
National Observer Program	54	40
Fishery Research and Charter Vessels	34.7*	--
Essential Fish Habitat	10	TBD
Fisheries Ecosystem Plan Development	40**	TBD
TOTAL	**$339 million**	**828 FTEs**

*In addition to this annual cost, $158.1 M is needed for ship construction.

**$5 M per ecosystem; 8 ecosystems minimum (1 per Council)

IMPROVEMENTS IN ASSESSMENTS OF STOCKS ($91.2M; 608 FTEs)

NOAA is mandated to provide sound scientific advice, based on comprehensive, high quality data and state-of-the-art analysis techniques for all marine fisheries under national jurisdiction.

The National Marine Fisheries Service is committed to enhancing its program efforts through implementation of the Stock Assessment Improvement Plan (SAIP). This plan guides NOAA's out-year investments in fishery science program infrastructure and key staff resources to improve the comprehensiveness, timeliness, quality, and communication of state-of-the-art fishery assessments. The SAIP puts forth a multi-year framework for the improvement of NMFS stock assessments through new national standards of quality and scope. This framework provides new standards by which to evaluate all stock assessments performed (i.e., Tiers of Assessment Excellence):

- Tier 1 -- Improve Assessments using Existing Data -- Improve core species stock assessments using existing data, and mine existing databases to evaluate status determination criteria for fishery stocks of unknown status.
- Tier 2 -- Elevate all Assessments to a Nationally–Acceptable Level -- Conduct adequate baseline monitoring for all federally-managed species, upgrade assessment levels for heavily exploited stocks and ecologically significant species.
- Tier 3 -- Next Generation Assessments -- Develop next-generation assessment models that explicitly incorporate ecosystem considerations from multi-species interactions and environmental effects, applied fisheries oceanography, and spatial and seasonal analyses.

Increased funding and FTEs are needed to improve NMFS" ability to provide expert analysis that will allow the status of unknown stocks to be elevated to the known category (Tier 1 and 2). Elevation of the status of stocks from the currently unknown category would be accomplished by using existing databases of research vessel survey data and/or commercial and recreational statistics, and possibly performing data rescue operations, in order to decipher trends in stock size and productivity. The requested funds will allow more science staff time to be devoted to improving the review and communication of assessments in order to facilitate better

fishery management decisions. Tier 3 funding will facilitate development of next-generation models and methods to support ecosystem approaches to stock assessments and fisheries management (e.g., multi-species models, models that explicitly incorporate climate and oceanographic effects, spatial and seasonal analyses, and social and economic analyses).

TOTAL FTES AND BUDGET REQUIRED TO MEET THE THREE TIERS OF ASSESSMENT EXCELLENCE FOR ALL FIVE FISHERIES SCIENCE CENTERS

Stock Assessment Improvement Plan	Tier 1	Tier 2	Tier 3	Total
FTEs	103	305	200	**608**
Cost (FTE x $150 K)	$15,450 K	$45,750 K	$30,000 K	**$91,200 K**

FISHERIES OCEANOGRAPHY ($31M; 25 FTEs)

The goal of fisheries oceanography is to understand the effects of ocean and atmospheric processes at varied time and space scales on living marine resources, and thus is a critical component of any ecosystem-based management approach. Operational fisheries oceanography is largely interested in how physical mechanisms (e.g., temperature, enrichment, concentration, and transport) cause variations in fish distribution and movement, and thus how they impact commercial and recreational fishing success and resource management.

Current fisheries oceanography research is conducted at several spatial and temporal scales but is generally focused on small- to meso-scale projects, often referred to as "process-oriented studies." These studies have materially improved our understanding of the processes governing local physical variability and juvenile fish survival, and, to a certain extent, interannual variability in recruitment. It is becoming increasingly evident, however, that we must be concerned with not only climate change but also with decadal-scale changes (i.e., "regime shifts") that impact production throughout diverse ecosystems. These shifts occur rapidly as the components of the climate system realign themselves, moving from one state to another in a period of months to years. The goal of future fisheries oceanography investigation is to develop and improve bio-physical models that can predict these impending regime shifts and their associated impacts on marine ecosystems and fisheries resources.

SOCIOECONOMICS ($12M; 86 FTEs)

Human aspects of ecosystem management are an integral part of the NMFS mandate to manage the Nation's living marine resources. A strong NOAA social sciences program will improve the scientific and economic foundation of the Agency's policies, increase the confidence that we are dealing with fishery issues in a responsible way, and help decision makers weigh the ecological, social, and economic impacts of their decisions. A key feature of the federal regulatory process is that we cannot simply implement a regulation to achieve a conservation goal but instead must consider a suite of management alternatives. Social and economic analyses can identify the alternative that minimizes losses to stakeholders while still achieving conservation goals, allowing NOAA to be proactive, rather than reactive, in its resource management strategy. Current social science staff levels, data collection and research funds are insufficient to adequately handle increasing responsibilities and emerging issues. Shortcomings in the National Environmental Policy Act (NEPA), Regulatory Flexibility Act, and community impact analyses have led to lawsuits and regulatory challenges of fisheries policies in the last several years, resulting in overturned rebuilding objectives, biologically unsustainable Total Allowable Catches (TACs), and eroded confidence in NOAA Fisheries' social sciences capability. In addition to stock rebuilding, capacity reduction is a primary goal of NMFS, the Councils, and the fishing industry. However, the current capability to comply with international capacity reduction goals under the U.S. participation in the United Nations Food and Agriculture Organization (FAO) Plan of Action on overcapacity is extremely limited because of insufficient information on current fleets and their capitalization. As a result, NOAA's ability to determine and optimize the social and economic consequences to its stakeholders of various management actions is quite limited.

The NOAA Fisheries social sciences program is necessary to quantify achievement of the performance measures in the NMFS and Build Sustainable Fisheries (BSF) Strategic and Operating Plans and is critical to the BSF goal of managing living

marine resources for economic growth and achieving sustainability in marine fisheries. The program will contribute to all aspects of the Agency's mandates, including those covering the commercial and recreational fisheries harvest sectors, the processing and wholesaling sector, the trade and retail sectors, and ultimately, endangered and protected species, habitat, and hatchery and aquaculture activities. Significantly, the program encompasses the ability to assess and predict the effect of any management action on impacted human communities. In addition, the research, analysis and data collected under this initiative will help industry and local and state governments determine the effects of management actions on their current and future activities and allow them to adjust their planning accordingly.

NATIONAL FISHERIES INFORMATION SYSTEM ($44M; 50 FTEs)

Fishery dependent data is a key component in assessment of the status of stocks. To increase the accuracy and effectiveness of existing fishery dependent data collection programs, NMFS will implement a national fishing vessel registration and fisheries information system in cooperation with the Marine Fisheries Commissions, states, industry, and the Fishery Management Councils. The system will establish common data collection, information technology, and quality standards for regional programs, and integrate results into a unified WEB-enabled information system. The approach will also fill critical information gaps through initiation of new data collection programs that will subsequently reduce the risk and uncertainty of living marine resource policy decisions. Research and application of electronic data collection techniques will reduce the burden on those that submit data. By coordinating the techniques used to gather and disseminate data on a nationwide basis, the collaborative program will efficiently bring into balance the demands for timely and credible data with the need to thoroughly evaluate, choose and monitor state and federal public resource management policies.

ADVANCED SAMPLING TECHNOLOGIES ($22M; 19 FTEs)

The amount of fish stock abundance information needed for fishery management has increased precipitously over the last several years, because of declining stocks, official definitions of overfishing, increased exploitation of new fisheries, and extensive litigation. To address data collection and information needs for improved stock assessment products, including oceanographic observations and habitat characterization, NMFS will require the research and development of new technologies, improvements in and innovative uses of existing technologies, and development of new and advanced sampling systems and approaches. Examples include multi-frequency and multi-beam acoustics, optical systems (LIDAR and laser line scan systems), alternative sampling platforms (remotely-controlled and autonomous underwater vehicles), other technologies (electronic tags, direct sampling tools), development of satellite monitoring capabilities, and improvements in seagoing computer systems for collecting and managing real-time biological and oceanographic data. In addition, advanced technology can be used to improve fishery dependent data by developing systems for catch weight and composition monitoring systems and remote monitoring of fishing activities.

NATIONAL OBSERVER PROGRAM ($54M; 40 FTEs)

Understanding fisheries effects on the ecosystem requires accurate information on the total catch. The national observer program collects high quality fisheries, environmental and socioeconomic data from commercial and recreational fishing vessels to assess impacts on marine resources and fishing communities and monitors compliance with marine resource laws and regulations. Observers provide high quality data including many data elements that are not available to shoreside sampling after a trip is completed. Observer data taken in conjunction with fishing activities gives direct information on harvesting activities. At present, only 11 fisheries include observer deployment. In addition, NMFS has responsibility for monitoring 25 Category I and II state and federal fisheries covered under the Marine Mammal Protection Act, but only 7 presently include observers. Even for those fisheries that do have observer coverage, levels are generally not adequate to determine the full extent of fisheries' impacts. In some cases, limited observer coverage has resulted in closures or restrictions of fishing effort. In other cases, a precautionary approach has been adopted, which may be underutilizing a fishery's full production capacity.

FISHERY RESEARCH VESSELS (FRVs) AND CHARTERS ($158M ONE TIME COST; $34.7M ANNUAL COST)

Vessels are needed for collecting the data on the physical environment and sampling the biological components of the ecosystem. These data will improve our knowledge on the relationship of habitat, physical characteristics of the ocean, and the ecological relationships. The data are used in ecosystem models that will im-

prove analyses of population status and trends. In ecosystem-based management a complex web of diverse data feeds into the population assessments and ecosystem management processes. Of critical importance is the acquisition of fisheries-independent data, requiring at-sea research. NMFS convened a workshop of stock assessment ecosystem and vessel experts to review the requirements for days-at-sea (DAS) to meet these needs. A total of over 6,000 additional DAS are needed to fulfill NMFS mandated mission. Meeting this need requires building three additional new fisheries research vessels and funding for chartering commercial fishing and other vessels.

Budget:

Acquisition of three FRVs	$158.1 M - one time cost
Operating costs for FRVs	$7 M
Charter vessel costs	$27.7 M
Total	**$192.8 M ($34.7 M annual cost)**

ESSENTIAL FISH HABITAT STUDIES ($10M; FTEs TBD)

The Magnuson–Stevens Fisheries Conservation and Management Act (MSFCMA) requires NMFS to identify essential fish habitat (EFH) in all fishery management plans (FMPs), minimize the adverse effects of fishing on EFH to the extent practicable, and consult with other agencies to develop EFH conservation measures for actions funded or undertaken by a Federal agency. NMFS and the Councils have incorporated initial EFH information into existing FMPs, and NMFS has begun conducting the required consultations, but existing resources are not sufficient to implement the EFH requirements. NMFS has been criticized heavily by Congress, the fishing industry, non-fishing industries, environmental groups, and other stakeholders for not doing enough to focus its activities on the most valuable habitat areas and the most pressing threats to those habitats. NMFS has summarized available information to identify broad areas as EFH; identified a number of fishing activities that may have adverse effects on EFH; and reoriented longstanding environmental review functions to focus on the habitats needed by federally managed species. However, the agency has not made substantial efforts to fill recognized data gaps regarding the habitat needs of managed species; has not identified whether fishery management strategies should be adjusted to minimize impacts to EFH; and has not addressed the expectations of Federal action agencies or other stakeholders for NMFS to provide input on ways to reduce the impacts of Federal actions on EFH. Additional resources are necessary to refine the EFH designations, identify Habitat Areas of Particular Concern within EFH, improve our understanding of the effects of fishing on EFH, and ensure that EFH consultations are efficient and effective. Doing so would improve the conservation of the habitats that are essential for building and maintaining sustainable fisheries.

NATIONAL ENVIRONMENTAL POLICY ACT AND OTHER REGULATORY ISSUES ($15M)

NMFS is facing a major challenge in developing long term compliance with regulatory requirements, including the National Environmental Policy Act. It is currently estimated that over 25 of the 102 fisheries based lawsuits facing the Agency involve NEPA related issues. Findings against the agency in litigation over NEPA have the potential for significant economic loss to coastal communities; Federal courts have ruled that NMFS has failed to meet its obligations under NEPA and enjoined the pelagic longline fishery in the Western Pacific. By building a solid foundation of all regulatory requirements, especially NEPA, the agency will significantly reduce the risk of unsuccessful legal decisions.

To insure success in reducing the litigation against NMFS, all partners in the MSFCMA must be brought into the process. It is especially critical that the MSFCMA Councils, which FMPs and, in some cases also the Environmental Assessments and Impact Statements, be given additional support to meet all regulatory requirements.

FISHERY ECOSYSTEM PLAN DEVELOPMENT ($5M for each ecosystem within Council jurisdiction)

The development of fishery ecosystem plans (FEPs) will require considerable communication, education, and outreach efforts by NMFS and the Councils. To serve as a proxy for FEP development costs, NMFS has reviewed the programmatic costs (in-

ternal NMFS and external contract costs) for developing the Supplemental Environmental Impact Statement (SEIS) for the Alaska Groundfish fishery. It is anticipated that this SEIS will cost approximately $4.0M when completed. Over 8,000 comment letters have been received and reviewed. This document is still only in the draft stage. Development and refinement of FEPs is anticipated to be a significantly more complex task and will require greater resources.