

Appendix 2. Summary of the NMFS Science Quality Assurance Program

NMFS is charged with the stewardship of living marine resources for the benefit of the nation through science-based conservation and management. High quality science provides the foundation upon which NMFS operates to fulfill its stewardship mission. Fisheries management has become increasingly more complex through time, creating ever-growing, and increasingly sophisticated demands on the agency's science programs. Meanwhile, management decisions and the science upon which they are based have also come under increasing scrutiny from the fishing industry and environmental groups and, in extreme cases, have become the subject of law suits.

NMFS, throughout its history, has made consistent investments in conducting high-quality science. The Office of Science and Technology and each of the Fisheries Science Centers implement measures to ensure the quality of their science. The Science Quality Assurance Program (SQAP) was established to document, formalize and, where appropriate, standardize these collective efforts. The primary objective of this process is to ensure that NMFS' fisheries science is relevant, timely, objective and accurate. By combining several existing and some new programs into a coherent plan, the SQAP will provide a comprehensive examination of science quality issues within NMFS diverse scientific enterprise. Plan components include:

Strategic Plan for Fisheries Research (see the Introduction to this document for a summary of the goals and objectives)

This five-year plan outlines measures for meeting the requirements of the Sustainable Fisheries Act of 1996. Priorities and recent accomplishments on research areas stipulated by the Act are identified for each of the Fisheries Science Centers. A new edition of the plan will be released in early 2002.

Stock Assessment Improvement Plan (this document)

The SAIP is the report of the NMFS National Task Force for Improving Fish Stock Assessments. The Task Force consists of Headquarters and Science Center scientists. The plan also addresses recommendations made in the National Research Council study on Improving Fish Stock Assessments (NRC 1998).

NOAA Fisheries Data Acquisition Plan (Appendix 3)

This plan outlines a strategy for acquiring the at-sea data needed to manage the nation's living marine resources. Recommendations for the appropriate blend of research

platforms to ensure a consistent supply of high quality data into the stock assessment process are made.

NMFS Fisheries Science Center Accreditation

NMFS Fisheries Science Center Directors and the Office of Science and Technology will develop a set of standards designed to maintain and continually improve the high quality of NMFS science, including field activities, laboratory analyses, data handling and analyses, and reporting of results.

Fisheries Assessment Computational Toolbox (Appendix 4)

The purpose of FACT is to develop a set of standardized and verified software for conducting stock assessments. The toolbox allows analysts to use a variety of assessment models to select options and produce diagnostics appropriate to a particular resource assessment methodology. The suite of programs includes modules for data input, formatting and error checking, and exploratory data analyses for a series of assessment approaches.

Center for Independent Experts (Appendix 5)

NMFS maintains a pool of qualified scientists from outside the agency who can aid in the design and review of NMFS scientific endeavors and products. The core principle is that the CIE pool of experts be composed of independent (non-NMFS) members having the requisite technical and scientific expertise to provide impartial and comprehensive comments and advice.

External Independent Studies

Periodic studies by the National Research Council are commissioned by NMFS to provide an independent scientific examination and research recommendations on issues of national importance.

NMFS - Sea Grant Joint Graduate Fellowship Program in Population Dynamics and Marine Resource Economics (Appendix 6)

The program awards fellowships to Ph.D. students to encourage qualified applicants to pursue careers in population dynamics and stock assessment methodology or marine resource economics, to foster closer relationships between academic scientists and NMFS, and to provide real-world experience to graduate students and accelerate their career development.

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Appendix 3. Executive Summary from the NOAA Fisheries Data Acquisition Plan (NMFS 1998a)

NOAA Fisheries is charged with stewardship of the Nation's living marine resources through science-based conservation and management and promotion of the health of their environment. At-sea research and monitoring is the foundation upon which stewardship is based. This report responds to OMB's request for a data acquisition plan to outline how NOAA Fisheries' data requirements will be met over the next five years. The report deals with the interface of three highly dynamic systems: marine resources and their environment, the science and technology used to understand and manage them, and the policy arena that directs management and distributes fiscal resources. Linkages among these systems are robust; changes in one greatly influence the status of the others. Good planning is essential to the success of any mission, but planning for the future in this dynamic environment is particularly challenging. This Data Acquisition Plan (Plan) describes NOAA Fisheries' approach to provide the best possible information upon which to manage the Nation's living marine resources.

The Plan describes the evolution of NOAA Fisheries' mission, and its research fleet. Legislation which has influenced the stewardship process of marine resources, and its impact on data requirements is discussed. Changes on the horizon, such as management philosophies and impending technological advances, which will influence the way resources are researched, monitored and managed in the future are evaluated. All these factors were considered as the Plan was developed to achieve the flexibility required to properly manage a dynamic system in a dynamic environment.

A complex web of diverse data feeds into the resource management process. The critical importance of fisheries-independent data, requiring at-sea research is discussed. The Plan covers how decisions are made on what data are needed, how the criteria for data quality and quantity are established, and what tools are required to collect data that meet these criteria in the most cost effective manner. Available research platforms are evaluated, including NOAA or other fishery research vessels (FRVs), chartered fishing vessels and university ships.

The Plan discusses several options to meet the data requirements which were analyzed by a multi-disciplinary team from government agencies, academic institutions and private industry. They determined that a new generation of FRVs was needed. The central philosophy of the Plan is to construct a core fleet of purpose-built, dedicated FRVs, and integrate them with chartered vessels from the academic and private industry fleets. Acoustic quieting will

reduce behavioral responses of species targeted in surveys and minimize noise interference to hydroacoustic signals. The ships must have the speed, power and endurance to allow acoustic and trawl surveys at the shelf edge. The ships must have adequate berthing to support a full scientific complement, and be configured to support laboratories, computers and multi-gear (e.g., trawl, longline, oceanographic) capabilities. Further, the ships must be available for fisheries missions for at least a decade to protect the integrity of long-term resource surveys. Lastly, their design should accommodate technology development and mission changes over their service lives.

At-sea data are now collected by the existing NOAA fleet using 1,877 days at sea (DAS), supplemented by 1,227 DAS of chartered university and private industry vessels. NOAA Fisheries convened a workshop of stock assessment and vessel experts to review the requirements for DAS and how they were determined. The study concluded that 9.3 ship years of FRV time, supplemented with non-FRV (e.g. fishing vessel, research vessel) charters, are needed to meet at-sea data requirements. The Plan calls for the existing fisheries vessels in the NOAA Fleet to be phased out as four purpose-built FRVs are constructed, deployed and calibrated for service. NOAA will collaborate with UNOLS and the private sector to develop a means of meeting the remaining ship needs with chartered vessels.

An external review of the Plan was performed, and the report was provided to NOAA Fisheries in May 1998. The report concluded that construction of a core fleet of purpose-built vessels is a good approach, that the FRVs, as designed, will be outstanding, will serve the nation extremely well as the core of a dedicated fisheries fleet for their full projected lifetime, and that the vessels are not overspecified. Further study of vessel acquisition management, ownership, and operation was encouraged, and NOAA Fisheries is engaged in those studies now.

NOAA bears the stewardship responsibility for the largest EEZ in the world, and to perform that mission, it must have the proper tools. New legislation, management philosophies and scientific advancements have created new opportunities to improve fisheries management. Providing appropriate support will enable NOAA to capitalize on these opportunities, to the economic benefit of the Nation and integrity of our ecosystems.

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Appendix 4. Summary Description of the NMFS Stock Assessment Toolbox

A Windows-based desktop application, the Fisheries Assessment Computational Toolbox (FACT), has been designed to assist fisheries scientists conducting fisheries stock assessments. The software was developed at NMFS to facilitate the production of verifiable and repeatable results from various assessment models. It has been developed in such a way as to easily accept future enhancements and additional modeling capabilities. Individual stock assessment models have been compiled into dynamic link libraries (DLLs) and integrated with a Windows Interface. The application comes in a zip file that, once unzipped, will run a setup routine and install all necessary library files on a user's PC. At this time, the application is available for download from the FACT website: <http://www.wh.who.edu/fact> for authorized users.

FACT began as the Woods Hole Assessment Toolbox (WHAT) with a focus on enhancing the software being used in the population dynamics branch in Woods Hole. Since then there have been many contributors to FACT. In an effort not to redo work that has already been completed, much of the code comes from individuals or small teams using custom written programs. The modular approach allows researchers working on method development to quickly put together new analytical routines. Modules may consist of single relatively simple assessment methods or complex systems. FACT allows scientists to take advantage of a Windows-based interface to view and manipulate their data.

Currently the following assessment models have been incorporated into the Toolbox: Virtual Population Analysis, (VPA) with retrospective and bootstrapping capabilities, Age Projection, Yield Per Recruit and Spawning Biomass per Recruit, Aspic, A Stock Production Model Incorporating Covariates – a non-equilibrium stock production model, Aspic Projection, Precautionary Approach and Separable VPA Extended Survivors Analysis (XSA), and an Age-Structured Production Model (ASPM). A Delury model and several length-based methods are partially complete

and a VPA-2 Box is under construction at this time. Several additional models are currently under consideration for future inclusion into the Toolbox. The package also includes a comprehensive on-line Help and preliminary graphing capabilities.

FACT has been released to the Steering Committee, and the Population Dynamics branch in Woods Hole, MA. The site is password protected but anyone who would like to explore FACT (at his own risk) may obtain the password by contacting fact@whsun1.wh.who.edu. The FACT Steering Committee is currently developing testing procedures that will lead to a NMFS-approved set of standard assessment tools for use by NMFS and other scientists.

The FACT application has been designed with ease of use, computational power and speed in mind. Accordingly, a visual front-end has been developed using Visual Basic 6.0 forms. The majority of the mathematical and output routines have been written in Visual Fortran 6.0, with a few routines to accomplish particular tasks written in Visual C++ 6.0. The software design is one of a modular application within an object-oriented environment. This design allows for easy modification and simplified enhancement of the software. The front end consists of Visual Basic forms that facilitate the inputting of data and the subsequent processing and outputting of the data. Data may be input either by reading from a disk file or by user keyboard input. Once the data have been input, or read in from disk, they may be easily updated using fields on the various forms. Additionally, they may be viewed graphically via a built-in graphing utility. Then user then selects a command button to choose the type of assessment to be done. A series of windows, menus and options are used to lead the user in the processing of the data using the selected assessment model.

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Appendix 5. Summary of the Objectives and Scope of the Center for Independent Experts Program: An Independent System for Peer Review

As part of its Science Quality Assurance Plan, the National Marine Fisheries Service (NMFS) has established a formal system for independent peer review through a pilot program grant to the University of Miami, Cooperative Institute for Marine and Atmospheric Sciences (CIMAS). Within CIMAS, the Center of Independent Experts (CIE) administers the review process and a formal pool of qualified scientific experts recruited from outside the Agency. From its inception the pilot program has focused specifically on external peer review of NMFS' stock assessments and related management advice for selected stocks.

NMFS has a long tradition of involving outside experts in the design and review of scientific programs, stock assessments, and development of new assessment methodologies. These experts are typically internationally recognized academics in the United States and elsewhere, as well as leading government scientists from other countries. They are generally employed in public and private U.S. universities, with formal programs of teaching and research in fisheries science, as well as in government and academic institutions that deal with fisheries research outside the U.S.

At the core of the concept of a pool of external experts is that the reports they render be free from any manipulation by the Agency, which would steer the review in favor of one outcome over another. That is, expert reviews should be truly independent of any position NMFS may have. At the same time, it is important to NMFS that the selected experts will also be acting free from the influence of groups or organizations with vested interests in the review findings. That is, the expert's views should also be truly independent of any position taken by concerned constituent groups. Furthermore, it is important to NMFS that selected experts possess the depth of knowledge and experience that will maximize the likelihood of delivering a useful product, i.e., a product that is more relevant to the Agency's mission than is the typical academic peer criticism. The range of issues represented in the annual schedule of reviews have focused on cutting-edge science, applications of new or novel methods, or scientific advice given in controversial management actions and highly contentious litigation.

In order to accomplish the overarching goal of independent peer review, and to avoid perceptions of improper influence, it is necessary that a steering group outside NMFS administer the selection of individual reviewers with utmost transparency. As currently structured, the CIE Steering Committee is composed of tenured academics, or senior researchers, and charged with program oversight. The

potential pool of CIE experts is conceptually the universe of qualified scientists that may take on review tasks.

The guiding principle is that CIE's pool of experts be composed of independent (non-NMFS) members having the requisite technical and scientific expertise to provide impartial and comprehensive comments and advice on subject reviews. To further separate this review process from even the appearance of any influence from the affected parties, the CIE Steering Committee selects each reviewer and collects written assurances of no conflict of interest. For each contracted review, CIE program staff facilitates expert selection, travel arrangements, distribution of background materials, and provide intermediate status reports, including final written reviews, and a complete accounting of distributed funds.

Scope of Work

Reviews conducted by the Center of Independent Experts can vary in scope and duration. Some Members may be asked to carry out short-term assignments, such as proposal and stock assessment reviews, while others could be involved in long-term projects such as programmatic reviews and development, and review of new management methods. The following are some of the assignments—

- Review grant proposals.
- Conduct reviews of stock assessments.
- Conduct alternative stock assessments.
- Conduct reviews of scientific programs.
- Participate in the design of new scientific programs and management advice.

These assignments require special skills, knowledge and institutional granting and grant oversight capabilities generally found only in large U.S. academic research institutions with international reputations in the marine sciences. Additionally, CIE reviews focus on highly specialized scientific activities, including products of fishery resource assessments and research, and sometimes-controversial issues including court decisions to which the U.S. Government is a party. This has contributed to expanding the concept beyond a strict stock assessment focus into other issues of interest to the Agency. Recent reviews have included Pacific salmon-coastal watershed habitat requirements and endangered species listings.

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Appendix 6. Summary of the Joint NMFS/Sea Grant Graduate Fellowship Program

Introduction

The National Sea Grant College Program Office (NSGO) and the National Marine Fisheries Service (NMFS) established a new Graduate Fellowship Program in Population Dynamics and Marine Resource Economics (Program) in 1999.

Contingent upon the availability of Federal funds, the Program will award fellowships, to begin in the summer, to four students each year who are interested in careers related to 1) the population dynamics of living marine resources and the development and implementation of quantitative methods for assessing their status, and 2) the economics of the conservation and management of living marine resources. Two fellowships will be awarded each year in each of the above two disciplines resulting in an anticipated six students per discipline eventually supported annually by fellowships when the Program reaches its maximum level three years following its inception.

The fellowships will provide support for up to three years for highly qualified graduate students working towards a PhD in population dynamics or related fields of study and for up to two years for highly qualified graduate students working towards a PhD in marine resource economics, natural resource economics, or environmental economics. Continued support after the first year will be contingent upon the availability of Federal funds and satisfactory performance of the Fellow. In addition to his/her major professor, each Fellow will be required to work closely with an expert (mentor) from NMFS who will provide data for the Fellow's thesis, serve on the Fellow's committee, and host an annual summer internship at the participating NMFS facility.

The goals of the Program are to 1) encourage qualified applicants to pursue careers in a) population dynamics and stock assessment methodology or b) marine resource economics; 2) increase available expertise related to a) the population dynamics and assessment of stock status of living marine resources or b) economic analysis of living marine resource conservation and management decisions; 3) foster closer relationships between academic scientists and NMFS; and 4) provide real-world experience to graduate students and accelerate their career development.

Eligibility

Any student may apply who is a United States citizen. At the time of application, prospective Population Dynamics Fellows must be admitted to a PhD degree program in population dynamics or a related field such as applied mathematics, statistics, or quantitative ecology at a university in the United States, or submit a signed letter from the university indicating provisional acceptance to a PhD degree program conditional on obtaining financial support such as this fellowship. At the time of application, prospective Marine Resource Economics Fellows must be in the process of completing at least two years of course work in a PhD degree program in natural resource economics or a related field at a university in the United States.

Selection Criteria

Selection criteria will include 1) relevant academic ability and achievement, particularly quantitative skills (35%); 2) demonstrated research ability in the discipline and appropriateness/importance of proposed thesis topic (30%); 3) expertise of major professor (20%); and 4) additional relevant experience (15%).

Selection

Selection is competitive. A review panel consisting of experts in the two disciplines and representatives from the NSGO and NMFS will evaluate and rank the candidates in accordance with the above criteria. The panel members will provide individual evaluations on each candidate, but there will be no consensus advice. Two Fellows will be selected in each discipline by the Fellowship Program Manager based in part on the rankings provided by the review panel. In addition, the Program Manager will give priority to NMFS Fisheries Science Centers which do not currently have Fellows. Accordingly, awards may not necessarily be made to the two highest-scoring candidates in each discipline.

Participating NMFS Facilities

Mentors will be from participating NMFS Science Centers, Laboratories, or Regional Offices. Each Fellow will be required to work as a summer intern at the participating

NMFS facility either on his/her thesis or on appropriate related problems. Remuneration for the summer internship will be part of the annual award. Population Dynamics Fellows will also be expected to spend 10-20 days at sea per year learning about sampling techniques and problems, commercial fishing, fishery biology, and local and regional issues of importance to fisheries management. Fellows may also work, as necessary, at the participating NMFS facility during some or all of the academic year at the mutual discretion of mentor, major professor, and Fellow.

CONTACT: Information can be obtained from Dr. Emory D. Anderson, Program Director for Fisheries, National Sea Grant College Program, 1315 East-West Highway, Silver Spring, MD 20910, tel: (301) 713-2435 ext. 144, e-mail: emory.anderson@noaa.gov; from any state Sea Grant program, or from any participating NMFS facility.

Appendix 7. Extract from the Executive Summary of the NRC Report on Improving Fish Stock Assessments (NRC 1998a)

FINDINGS AND RECOMMENDATIONS

The committee focused its examination on the data that are used in assessments, model performance, use of harvest strategies, new assessment techniques, periodic review and quality control of assessments and assessment methods, and education and training of stock assessment scientists. The committee based its recommendations on the results of the simulations and on its collective experience. Caveats about how the analyses conducted for this study compare to actual stock assessments are given in Chapter 5. Accomplishing the recommendations of this report will require concerted and cooperative action by all interested parties (academic and government scientists, fishery managers, user groups, and environmental nongovernmental organizations) to improve the stock assessment process and products.

Data Collection and Assessment Methods

The committee concludes that stock assessments do not always provide enough information to evaluate data quality and to estimate model parameters, and it recommends a checklist that would promote more complete data collection for use in stock assessments. The results of the committee's simulations demonstrated that the availability of continuous sets of data collected by using standardized and calibrated methods is important for the use of existing stock assessment models. The best index of fish abundance is one for which extraneous influences (e.g., changes in gear and seasonal coverage, changes in fishers' behavior) can be controlled. The committee recommends that at least one reliable abundance index should be available for each significant stock. CPUE data from commercial fisheries, if not properly standardized, do not usually provide the most appropriate index. Likewise, CPUE data from recreational fisheries require standardization to serve as a good index of abundance.

Fishery-independent surveys offer the best opportunity for controlling sampling conditions over time and the best choice for achieving a reliable index if they are designed well with respect to location, timing, sampling gear, and other considerations of statistically valid survey design. NMFS should support the long-term collection of fishery-independent data, using either the NOAA fleet or calibrated independent vessels. Diminishing the quality of fishery-independent data by failing to modernize NOAA fishery research vessels or by changing sampling methods and

gear without proper calibration could reduce the usefulness of existing and future data sets.

The simulation study demonstrated that assessments are sensitive to underlying structural features of fish stocks and fishery practices, such as natural mortality, age selectivity, catch reporting, and variations in these or other quantities. Auxiliary information in the form of indices or survey estimates of abundance, population structure information, and accurate estimates of other population parameters (e.g., natural or fishing mortality, growth, catchability) improves the accuracy of assessments.

Formally reviewed sampling protocols for collection of commercial fisheries statistics have not been implemented in many geographic regions. The lack of formalized, peer-reviewed data collection methods in commercial fisheries is problematic because bias and improper survey conduct may exist, with unknown impact on data reliability. Greater attention should be devoted to sampling design based on an understanding of the statistical properties of the estimators for catch at age and other factors. Sampling and subsequent analysis should also consider the issue of systematic biases that emerge with factors such as mis-reporting. Formalized sampling protocols have been developed for recreational fisheries in the form of the Marine Recreational Fisheries Statistics Survey (MRFSS). MRFSS data and methods, albeit imperfect, have undergone independent peer review, are readily available, and could serve as a model for commercial fisheries. The committee recommends that a standardized and formalized data collection protocol be established for commercial fisheries nationwide.

Models

Both harvesting strategies and decision rules for regulatory actions have to be evaluated simultaneously to determine their combined ability to sustain stocks. Simulation models should be realistic and encompass a wide range of possible stock responses to management actions and natural fluctuations consistent with experience. The committee recommends that fish stock assessments present realistic measures of the uncertainty in model outputs whenever feasible. Although a simple model can be a useful management tool, more complex models are needed to better quantify the unknown aspects of the system and to address the long-term consequences of specific decision rules adequately. Retrospective analyses performed by the committee showed that persistent over- or underestimation can

occur over a number of years of assessment, regardless of which model is used. The committee recommends the use of Bayesian methods both for creating distributions of input variables and for evaluating alternative management policies. Other methods for including realistic levels of uncertainty in models also should be investigated.

In the simulations, model performance became erratic as more variability or errors were introduced to data sets. Newer modeling methods offer promise for reducing bias in key parameter estimates, although using mathematically sophisticated assessment models did not mitigate poor data quality. Different assessment models should be used to analyze the same data to help recognize poor data and to improve the quality of assessment results. Results from such comparisons can be used to direct survey programs to improve data quality and to assess the degree of improvement in data achieved over time. Greater attention should also be devoted to including independent estimates of natural mortality and its variability in assessment models. Further simulation work of this kind is also needed to determine whether the simulation results and the conclusions based on these results remain the same over multiple replications.

The committee believes that single-species assessments provide the best approach at present for assessing population parameters and providing short-term forecasting and management advice. Recent interest in bringing ecological and environmental considerations and multi-species interactions into stock assessments should be encouraged, but not at the expense of a reduction in the quality of stock assessments.

Harvest Strategies

Although the committee did not evaluate alternative harvest strategies, it believes that assessment methods and harvest strategies should be evaluated together because harvest strategies can affect stock assessments and the uncertainty inherent in stock assessments should be reflected in harvest strategies. Despite the uncertainty in stock assessments, fishery scientists may be able to identify robust management measures that can at least prevent overfishing, even if they cannot optimize performance. Conservative management procedures include management tools specific to the species managed, such as minimum biomass levels, size limits, gear restrictions, and area closures (for sedentary species). Management procedures by which the allowable catch is set as a constant fraction of biomass (used for many U.S. fisheries) generally perform better than many alternative procedures. However, errors in implementation due to assessment uncertainties

could result in substantial reductions in long-term average harvests in some years if biomass estimates are highly uncertain. Assessment methods and harvest strategies need to be evaluated simultaneously to determine their ability to achieve management goals. Application of risk-adjusted reference points (based on fishing mortality or biomass) would immediately lead to reduced total allowable catch and thus create an economic incentive for investment in improved data gathering and assessment procedures to reduce the coefficient of variation of biomass estimates.

There are at least four alternatives to harvesting a constant fraction of exploitable biomass that may result in levels of total mortality that are consistent with maintaining a fish stock. First, target fishing mortality can be reduced as a stock decreases in size to reduce risks. Second, a minimum biomass level can be established, below which fishing would be halted (this is done for some U.S. fisheries). Third, the size of fish captured can be increased by changing requirements for harvest gear. This restriction might allow smaller fish to escape and spawn, but could be ineffective if harvesters apply more effort to the larger fish. Finally, geographic areas can be closed to limit mortality for sedentary species if the distribution of organisms is well known and if the fishing mortality in other areas is not increased. Area closures have been implemented or proposed for many fisheries worldwide in the form of marine reserves and sanctuaries.

New Approaches

NMFS and other organizations responsible for fisheries management should support the development of new techniques that can better accommodate incomplete and variable data and can account for the effects of environmental fluctuations on fisheries. Such techniques should allow the specification of uncertainty in key parameters (rather than assuming constant, known values), should be robust to measurement error, and should include the ability to show the risks associated with estimated uncertainty.

A few prominent recommendations for new approaches emerged from the study. Scientists that conduct stock assessments and organizations that depend on assessments should:

- incorporate Bayesian methods and other techniques to include realistic uncertainty in stock assessment models;
- develop better assessment models for recreational fisheries and methods to evaluate the impacts of the quality of recreational data on stock assessments;

- account for effects of directional changes in environmental variables (e.g. those that would accompany climate change) in new models; and
- develop new means to estimate changes in average catchability, selectivity, and mortality over time, rather than assuming that these parameters remain constant.

The results from the simulation exercise should be sobering to scientists, managers, and the users of fishery resources. The majority of the estimates of exploitable biomass exceeded true values by more than 25%; assessments that used accurate abundance indices performed roughly twice as well as those that use faulty indices. A disturbing feature of the assessment methods is their tendency to lag in their detection of trends in the simulated population abundance over time. For example, some methods with some types of data consistently overestimate exploitable biomass during periods of decreasing simulated abundance and underestimate exploitable biomass during periods of increasing simulated abundance.

Although no stock assessment model was free from significant error in the simulations, it is also true that few of the models failed consistently. Hence, the message of this report is not that stock assessment models should not be used, but rather that data collection, stock assessment techniques, and management procedures need to be improved in terms of their ability to detect and respond to population declines. The simulation results and some actual fishery management examples suggest that overestimation of stock biomass and overfishing of a population can occur due to inaccurate stock assessments and that the overestimation can persist over time. The committee believes that the two most important management actions to mitigate this problem are: (1) to model and express uncertainty in stock assessments explicitly, and (2) to incorporate uncertainty explicitly into management actions such as harvesting strategies.

The absence of adequate data is the primary factor constraining accurate stock assessments. The differences between estimated and true values derived from the simulated data were most likely not introduced by any mistakes made by the analysts. Rather, the large differences that occurred under some scenarios were primarily the result of poor data and model mis-specification stemming from incomplete knowledge of the true situation by the analysts. The surplus production and delay difference models did not include the ability to account for changes over time in key parameters for the simulated populations. The simulated data sets were better structured for analysis by age-structured methods; hence, these kinds of models performed better. When they did not perform well, it was

generally because the models used biased information (e.g., the fishery CPUE index) or did not account for changes in selectivity and catchability over time. Had the analysts been told about these data features, it is likely that they could have compensated for them and obtained better assessments. Some of the newer models appear to be able to achieve such compensation through the introduction of process errors. Nevertheless, modeling will never be able to provide estimates that are as accurate as direct knowledge obtained by measurement and experimentation. Thus, if future stock assessments are to avoid some of the past problems, management agencies must devote the necessary resources to monitor and investigate fish populations in a stable research environment that fosters creative approaches.

Peer Review

It is imperative that stock assessment procedures and results be understood better and trusted more by all stakeholders. One means to achieve such trust is to conduct independent peer review of fishery management methods and results including (1) the survey sampling methods used in data collection, (2) stock assessment procedures, and (3) risk assessment and management strategies. When applied properly to stock assessments, peer review yields an impartial evaluation of the quality of assessments as well as constructive suggestions for improvement. Such reviews are most beneficial when conducted periodically, for example, every 5 to 10 years, as new information and practices develop. In addition, a complete review of methods for collection of data from commercial fisheries should be conducted in the near future by an independent panel of experts, which could lead to the adoption of formal protocols.

Education and Training

Reduction in the supply of stock assessment scientists would endanger the conduct of fishery assessments by the federal government, interstate commissions, and international management organizations and would hinder progress in the development and implementation of new stock assessment methods. NMFS and other bodies that conduct and depend on fish stock assessments should cooperate to ensure a steady supply of well-trained stock assessment scientists by using mechanisms such as personnel exchanges among universities, government laboratories, and industry and by funding stock assessment research activities. The training of stock assessment scientists should endow them with skills in applied mathematics, fisheries biology, and oceanography. Education of fisheries scientists should be organized and executed in such a way that it complements and augments the NMFS research mission and leads to improved management strategies for fisheries in the future.

Appendix 8. Executive Summary of the Report to Congress on a Proposed Implementation of a Fishing Vessel Registration and Fisheries Information Management System

The National Marine Fisheries Service (NMFS), fishery management councils, and states rely on fishery data to make decisions regarding the stewardship of the Nation's living marine resources. Citizens of the United States also rely on fishery statistics to make decisions regarding their participation, investment in, and use of commercial and recreational fisheries. In addition, fishery statistics can be used to measure how effectively governmental agencies are meeting stewardship goals and objectives. The quality of resource stewardship decisions and the predictability of the outcomes are strongly dependent on the quality of the data being used.

Given the increasing complexity of fisheries management, the current state of fisheries statistics needs to be greatly improved. Despite some regional successes, it is clear that the current overall approach to collecting and managing fisheries information needs to be rethought, revised, and reworked. The quality and completeness of fishery data are often inadequate. Data are often not accessible in an appropriate form or a timely manner. Methods for data collection and management are frequently burdensome and inefficient. These drawbacks result in the inability to answer some of the most basic questions regarding the state of the Nation's fisheries, such as: How many vessels and people participate in various fisheries? Do our policy decisions improve the economic and biological sustainability of our fisheries - by how much? How are different people (harvesters, consumers, coastal residents, non-consumptive users) affected by these stewardship decisions? An ability to answer these kinds of questions is essential to sound resource stewardship. Simply put, to manage fisheries at local, state, regional, or national levels requires a much better fisheries information system than the one in place.

To address these shortcomings, the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act required NMFS to "develop recommendations for implementation of a standardized fishing vessel registration and information management system" to improve the state of our fisheries statistics programs. This Report to Congress provides the recommendations for implementation of this "System."

The benefits of such a system would be seen on several levels. At the most basic level, answers to fishery perfor-

mance questions similar to those above would be immediately available. The ability to evaluate the status of all managed fish stocks would be enhanced. Scientists working with fishery data would be freed of the inordinate amount of time now spent on searching for, cleaning, checking, and reconciling data prior to use. Fishery participants would have an enhanced ability to make decisions on their participation and production. The entire system would be more efficient in the collection of data and the delivery of useful information to those who need it. Just as a business requires data on raw materials, inventory, cash flow, employees, product quality, and capital investments to be successful, this fisheries statistics system is designed to deliver the analogous decision-making information to those who manage and depend on the Nation's living marine resources for their livelihood, food or recreation.

The Magnuson-Stevens Act required that the system be implemented on a regional basis. Since several major regional information systems already exist or are being planned, NMFS recommends creating a system that improves, expands and integrates ongoing regional activities under a nationwide "umbrella."

As specified in the Magnuson-Stevens Act, the system will have two main components. The first component, the Vessel Registration System (VRS) will enable fisheries managers to uniquely identify every US vessel engaged in commercial and recreational for-hire fishing. To implement the VRS component of the system, NMFS recommends utilizing a system already being developed by the U.S. Coast Guard (Coast Guard). The Vessel Information System (VIS), includes nearly all of the information needed for the VRS and is based on combining data from the Coast Guard vessel documentation and state vessel numbering files into one Coast Guard database. A pilot implementation of the VIS, with data from two states and the Coast Guard, is now on-line and undergoing testing. State participation in the VIS is currently voluntary. However, an expansion of this system to require coastal states and territories to participate would fulfill the requirements for a VRS as set forth in the Magnuson-Stevens Act in the least costly and least burdensome manner. The modifications to the Coast Guard VIS that would allow it to serve as the VRS include:

- Requiring that coastal states and territories participate in the VIS
- The placement of a Hull Identification Number (HIN) on all undocumented vessels participating in commercial or charter fishing that did not have one upon manufacture
- Creation of a “charter fishing” endorsement and principal use category

A new separate system to include recreational vessels in the VRS is not recommended. However, since pleasure craft are already in the VIS, conditionally including them in the VRS is recommended. The recommendation is contingent on there being no additional costs or burdens to participants or the state numbering agencies to include VIS pleasure craft in the VRS. Otherwise, the net benefits of inclusion would no longer outweigh the costs.

The VRS design requirement includes obtaining the identity of the owner and operator of each fishing vessel at the time of registration, but vessel operator data changes frequently over time. Several resource management agencies, regional statistics planning groups and industry members suggested that tracking vessel performance over time without information regarding the operator, and in some cases the crew, was insufficient to meet their needs. During development of the VRS proposal, it became clear that better data on fishermen, in addition to fishing vessels, was an important design criterion for many stakeholders. While many federal and state permitting and licensing programs contain information on vessel operators, there is no universally accepted means to identify fishermen across fisheries or states. More frequently than not, fishery performance data are not linked to the operator. While various regional statistics planning efforts have identified this issue for resolution, there has yet to be a consensus on how to do this. NMFS proposes that the regional statistics bodies be asked to continue to investigate the development of a regional operator identifier that would be included as part of the catch information.

The second component, the Fisheries Information System (FIS), will be implemented by integrating and expanding on the current regional fisheries cooperative statistics activities. Some of these regional activities are well developed, while others are in the early stages of implementation. Present control and management of these regional programs will remain local. The FIS will simply link and harmonize the data from these programs to each other to form a virtual national system. FIS implementation details are addressed under three major areas: Data Collection; Information Management; and Institutional Arrangements.

Under the recommended FIS, regional detail data would continue to be collected locally with minor adjustments in content, coverage, and quality control as required to meet both the Act’s requirements and regional requirements. Access to data will be controlled regionally to ensure a balance in the need for access to data with the confidentiality constraints under which they were collected. Routine summaries of detailed data will be made available for the most frequent uses of data. Reciprocity agreements to satisfy multiple state and federal data submission and user access requirements are recommended. Adoption of common codes or creation of bridges between coding systems is recommended.

Using the unique vessel identifier from the VRS/VIS as a link, the FIS will associate with each vessel a record of its fishing activities, including landings, fishing location, gear used, time periods of fishing, and other data recorded in the regional data collection systems. In addition, data in the VRS/FIS system will be available as necessary to assist in the issuance of permits and for other systems requiring vessel and ownership data so that an applicant will not have to submit identifying information more than once.

Resolution of issues arising among the states, the marine fisheries commissions, and federal agencies (including NMFS) concerning the development of agreements, policies, regulations, and laws to collect and share information, or concerning budgets and planning for cooperative development of the System, will be jointly resolved by the System partners. Statistical committees and work groups, plus an annual statistics meeting of all System partners, are proposed for bringing together the relevant parties. These groups would:

- Facilitate coordination of data sharing among states, regions and NMFS, where such outcomes support fisheries stewardship; and
- Facilitate consensual formulation of regional and national policies concerning data collection and management.

The plan relies on existing regional statistics, industry advisory and marine fisheries policy groups to facilitate solutions rather than the creation of new entities.

Section 401(a)(5) of the Magnuson-Stevens Act requires that the Report to Congress provide for “funding (subject to appropriations) to assist appropriate state, regional or tribal entities and marine fisheries commissions” for implementing activities associated with this Report. The total cost for the nationwide VRS/FIS system is projected to be \$51.9 million. This is the total incremental cost of imple-

menting the system over and above current funding levels, and was derived through an extensive consultative process with the states, Regional Fishery Management Councils, and Marine Fisheries Commissions. Overall, \$43.1 million are for data collection, integration and harmonization, \$7.2 million for information technology and management and \$1.7 million for institutional infrastructure costs. Eighty percent of these costs are annually recurring, with full implementation phased in over a period of 5-7 years. The totals include \$23.7 million to fix or redesign data collection programs to fill gaps in current needs, including state-level commercial trip ticket systems, \$3.4 million for data quality and data integration improvements, \$6.8 million for economic and sociocultural data collection, and \$1.7 million for improvements in state/federal information management communication and computer technology.

Three legislative/regulatory considerations associated with VRS/FIS implementation are recommended: 1) implement a fisheries statistics confidentiality sunset provision of 10 years coincident with the next Magnuson-Stevens Act reauthorization; 2) create a temporary VRS/FIS System liaison office within the Office of Management and Budget to obtain any Paperwork Reduction Act approvals coincident with VRS/FIS implementation in a comprehensive and expedited manner; and 3) strike prohibitions on collecting economic and financial fisheries statistics data in the Magnuson-Stevens Act coincident with its next reauthorization.

CONTACT: Mark Holliday, Office of Science and Technology, National Marine Fisheries Service.

Appendix 9. Executive Summary of the NMFS Bycatch Plan

Bycatch--defined as fishery discards, retained incidental catch, and unobserved mortalities resulting from a direct encounter with fishing gear--has become a central concern of the commercial and recreational fishing industries, resource managers, scientists, and the public, both nationally and globally. Bycatch concerns stem from the apparent waste that discards represent when so many of the world's marine resources either are utilized to their full potential or are overexploited. These issues apply to fishery resources as well as to marine mammals, sea turtles, seabirds, and other components of marine ecosystems.

Congress has responded to these concerns by increasing requirements of the Marine Mammal Protection Act, the Endangered Species Act, and, most recently, the Sustainable Fisheries Act¹ to reduce or eliminate bycatch. The Magnuson-Stevens Fisheries Conservation and Management Act highlighted the need for bycatch management in fishery management plans by requiring that *conservation and management measures shall, to the extent practicable, minimize bycatch and to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch*. Globally, the United Nations Food and Agriculture Organization's Code of Conduct for Responsible Fisheries, to which the United States is a signatory, also emphasizes bycatch reduction.

The national goal of the National Marine Fisheries Service's bycatch plan activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided. Inherent in this goal is the need to avoid bycatch, rather than create new ways to utilize bycatch.

Responding to these issues and increasing regulatory requirements, in 1992 the U.S. commercial fishing industries initiated a series of workshops to develop strategies to reduce bycatch and to increase the industry's and the public's understanding of bycatch issues. Their recommendations, as well as those from recreational fishing and environmental groups and the public, have prompted the National Marine Fisheries Service to prepare this plan, clearly articulating the agency's objectives, priorities, and strategies regarding bycatch. This plan includes national and regional bycatch objectives; specific recommendations concerning data collection, evaluation, and management actions necessary to attain the objectives; and an assessment of the state of knowledge about bycatch in the nation's

marine fisheries. The last of these is intended to serve as a benchmark for measuring progress in bycatch reduction.

Because there are little data available on the retained incidental and unobserved mortality components of bycatch, the assessment of bycatch focuses on the availability of quantitative discard estimates from the nation's fisheries, the significance of those discards to the health of fishery and protected stocks, and progress in addressing bycatch issues associated with each of the fisheries evaluated. Some quantitative information on fish discards was available for about half of the species or species groups; the availability of such estimates is disproportionate among regions of the country and among fisheries within regions.

Review of bycatch reduction efforts completed or under way indicates that successful programs share common characteristics that form the basis for the following seven national objectives in this plan:

1. Determine the magnitude of bycatch and bycatch mortality.
2. Determine the population, ecosystem, and socioeconomic impacts of bycatch and bycatch mortality.
3. Determine whether current conservation and management measures minimize bycatch to the extent practicable and, if not, select measures that will.
4. Implement and monitor selected bycatch management measures.
5. Improve communications with all stakeholders on bycatch issues.
6. Improve the effectiveness of partnerships with groups and individuals external to the National Marine Fisheries Service.
7. Coordinate NMFS activities to effectively implement this plan.

To accomplish these objectives, recommendations are made in the following six areas:

1. bycatch monitoring and data collection programs;
2. research on the population, ecosystem, and socioeconomic effects of bycatch;
3. research to increase the selectivity of fishing gear and to increase the survival of fish and protected species that are inadvertently encountered by fishing gear;
4. incentive programs for fishermen to improve bycatch performance;
5. analysis of the implications of conservation and man

agement measures for bycatch; and
6. exchange of information and development of cooperative management approaches.

Recommended actions in the six areas range from developing strategies for a long-term integrated scientific approach to the collection of biological, economic, and social data to providing information that will help define the benefits and costs associated with managing bycatch. The plan does not attempt an intra-regional needs prioritization. Instead, it suggests a seven-step decision-making framework to evaluate national and regional bycatch research and management.

The development of this plan has brought into focus the fact that there is a multifaceted and complex set of problems associated with bycatch that affects nearly all aspects of fishing operations. Regionally, the causes and implications of bycatch share some characteristics, but often dif-

fer since the status of exploitations of resources and the way fisheries are prosecuted and managed can vary substantially. Bycatch management can be accomplished with a wide variety of measures, depending on the specific characteristics of fisheries. As a result, no single solution to the “bycatch problem” exists. Rather, fishermen, managers, scientists, conservationists, and other interest groups must work together to craft a balanced approach to addressing bycatch-one that will promote the sustainability of our nation’s living marine resources.

CONTACT: Mark Chandler, Office of Science and Technology, National Marine Fisheries Service.

¹*The Sustainable Fisheries Act amended the Magnuson Fishery Conservation and Management Act and renamed it the Magnuson Stevens Fishery Conservation and Management Act.*

Appendix 10. Summary of the National Observer Program

Program Goal: To build a national observer program for the collection of high quality fisheries, environmental, and socioeconomic data from commercial and recreational fishing vessels to assess impacts on marine resources and fishing communities and to monitor compliance with marine resource laws and regulations.

Summary of Problem

An expansion of NMFS observer programs is needed to meet the agency's immediate observer coverage requirements as mandated by existing laws, regulations, fishery management plans, ESA section 7 consultations, and court decisions. NMFS must also establish observer programs in fisheries that are being managed with inadequate data on total catch, have a significant bycatch and/or discard of finfish or shellfish, have suspected incidental takes of protected species, or have rebuilding plans in place. NMFS must ensure that all data are of high quality and collected according to a rigorous sampling design, and that observers are safe, adequately trained, fairly compensated, and supported.

This proposal outlines a plan for meeting the critical information needs of the agency for the management of US commercial and recreational fisheries over the next five years, by placing sufficient observers on fishing vessels to meet target observer coverage levels. Achieving the objectives of this proposal will provide the data to meet the **Build Sustainable Fisheries** goals to eliminate and prevent overfishing and overcapitalization by improving stock assessments and predictions, reduce interactions between fisheries and protected species, and ensure compliance with environmental laws and regulations. By monitoring bycatch of nontarget species, including marine mammals, sea turtles, and sea birds, it will also contribute to reducing the probability of extinction and depletion of these species, meeting the objectives of the **Recover Protected Species** initiative.

The Kammer Report recognizes that NMFS observer programs assist in contributing important data necessary to manage, adhering to regulatory requirements, and strengthening relationships with state partners, and recommends additional funding for observers.

Approach

NMFS has developed 40 Fishery Management Plans to manage domestic fishery stocks, under the authority of

the Magnuson-Stevens Fishery Conservation and Management Act. Another nine Plans are currently under development. Observers are currently deployed to collect fishery dependent data in only 11 of the fisheries identified within these plans. NMFS also has responsibility for monitoring an additional 25 Category I and II state and federal fisheries under the Marine Mammal Protection Act, yet currently has coverage in only 7 of these fisheries. For fisheries that do have observer coverage, but levels are generally not adequate to determine the full extent of fisheries impacts. Low coverage levels result in incomplete implementation of sampling methodologies and, hence, may result in sampling biases.

In some cases, limited observer data or lack of observer coverage has resulted in fishery closures or restrictions on fishing effort. In other cases, NOAA has adopted a precautionary management approach in the absence of complete data - an approach that may be underutilizing a fishery's full capacity.

Program Highlights

Expansion of the National Observer Program would:

- Initiate observer coverage in key fisheries to monitor catch, bycatch of protected species, such as sea turtles, marine mammals, prohibited finfish, and environmental parameters associated with commercial and recreational fishing - approximately 4,000 additional sea days are planned.
- Improve the quality of data collected by observers through better coordination and consistency of NMFS observer program policies and procedures.
- Modernize data collection and dissemination technologies, as recommended by the National Research Council's report, *Improving the Collection, Management, and Use of Fisheries Management Data*.
- Develop better outreach and communication programs to facilitate fishery cooperation and fishermen's involvement in observer program activities.
- Investigate and prosecute noncompliance with fishery regulations as verified by observers.

Partnerships

Regionally, NMFS observer programs work closely with marine resource agencies in all coastal states, federal agencies such as the U.S. Fish and Wildlife Service and the U.S. Coast Guard, state educational institutions and the National Sea Grant College Program, regional Fishery Management Councils and interstate fisheries commissions, state marine resource agencies, the fishing industry, observer service providers, and non-governmental organizations.

The partners currently work together to manage fishery resources and monitor impacts of commercial fisheries on marine resources. However, the partners are limited by both funding and employees to sufficiently monitor the vast number of commercial and recreational fishing vessels that operate in U.S. waters. Additional resources are required to build the partnerships that will promote the establishment of priorities for fisheries observer programs.

CONTACT: Vicki Cornish, Office of Science and Technology, National Marine Fisheries Service.

Appendix 11. Extract from the NMFS Social Sciences Plan and FY2001 Budget Initiative

Background

ST1 staff were asked by the Science Board to assess the staffing requirements for augmenting a social sciences capability within the Agency, and to develop alternatives for implementing the program. Based on Science Board guidance, site visits were made to each NMFS region to determine current versus minimum FTE needs within each region. "Minimum" was defined as the level needed to ensure that NMFS meets its legal responsibilities under Executive Order 12866, the Magnuson-Stevens Fishery Conservation and Management Act (including adherence to national standards), the Regulatory Flexibility Act, the Marine Mammal Protection Act, the Endangered Species Act and the National Environmental Policy Act. The assumption was that current staffing levels (and data collection activities) are not sufficient to keep pace with increasing responsibilities and intensified scrutiny of the Agency's sociocultural and economic analyses. FTE requirements are broken out between a) economists and b) sociologists and anthropologists. In some regions, requirements above the minimum were also identified, with an "ideal" or optimal program including staff to conduct long term sociocultural and economic research that goes above the minimum requirements to enhance the credibility of the resulting analyses.

Two broad functions for social science staff were identified: (1) management support (e.g. conduct and review of RIRs/RFAs/SIAs/National Standard 8 analyses) and (2) applied research (modeling efforts and related data collection planning and oversight). Models and analyses devel-

oped by the research component relate directly to analysis needed to evaluate and support management decisions. It was noted in each region that socio-cultural and economic analyses are needed on a variety of issues, and that social science staff can contribute to all aspects of the Agency's mandates, not just fishery management decisions. For example, all regions have significant responsibilities for protected and endangered species, and habitat-related issues are becoming more prominent. In identifying staff requirements, NMFS social scientists took into account the range of analyses that would be needed to adequately satisfy the Agency's ability to develop and evaluate policies associated with the commercial and recreational fisheries harvest sectors, the processing and wholesaling sector, the trade and retail sectors, endangered and protected species, habitat, and hatchery and aquaculture activities. In addition, all regions recognize that NMFS must now also consider the effect of any actions on impacted human communities.

Findings

Table 1 presents aggregate minimum social staff requirements by region. The specific requirements of both the minimum and ideal requirements from each of the five NMFS regions follow this summary; the individual descriptions are summarized in terms of the key needs and issues in each region, and contain more detail regarding the areas of specialty and the desired mix of FTEs by graduate degree (Ph.D.s, Master's). In each region, evaluation of minimum requirements indicated the need to more than double social science staff. In the Northwest, where there

Table 1. Assessment of minimal social science staff requirements.

	Current Staff	Additional Economists		Additional Sociologists/Anthropologists		Total Additional FTEs	Ratio of New/Current FTEs
		Mgt. Support	Research	Mgt. Support	Research		
NEFSC	8	7	5.5	3	3	18.5	2.3
SEFSC	6	3.5	8	1.5	1.5	14.5	2.42
SWFSC	7	4	8	3	3	18	2.57
NWFSC	1	7	15	2	5	29	29
AFSC	6	5	7	1	3	16	2.67
Total	28	26.5	43.5	10.5	15.5	96	

is currently only one economist, an even larger increase is needed.

The direct cost of hiring these FTEs is approximately \$9.6M. However, it was noted by all regional social science staff that it is unrealistic to expect that this number of staff could or should be hired all at once (i.e. in FY01). First, it is doubtful that qualified staff could be found to fill these positions all at once. Second, the FTEs are based on the assumption

that core data needs are fully met. The current quality and quantity of NMFS sociocultural and economic data cannot support an immediate full program development (data needs of approximately \$5.5M per year were identified). These FTE requirements should be considered a mid-term goal for program development.

CONTACT: Amy Buss-Gautam, Office of Science and Technology, National Marine Fisheries Service.

Appendix 12. Terms of Reference for the NMFS National Standing Working Group on Advanced Technologies (Approved January 11, 2001)

Agency Needs

With increasing demands for accurate, precise, and timely information upon which to base assessments of living marine resources, it is incumbent upon NMFS to encourage and play an active role in the development, evaluation, and implementation of promising technological innovations. By establishing the Advanced Technology Working Group (ATWG), the NMFS Science Board recognizes the need for the agency and its scientists to demonstrate leadership in the ongoing process of improving the quality of assessments of the abundance and dynamics of living marine resources through refinement of existing techniques and implementation of improved methods. This process should also focus on improved characterization and understanding of the environments in which our living marine resources exist and assessment of the impact of fishing activities on these environments, and address needs for sampling over a broad range of temporal and spatial scales.

Mission

Promote the Use of Advanced Technologies for Improved Characterization and Assessment of Living Marine Resources and their Environment by:

- Identifying potential new technologies, innovative uses of existing technologies, and approaches which involve combination of technologies, and facilitating and leading research and development leading to implementation of these technologies.
- Fostering communication and collaboration regarding development of new technologies and appropriate application of existing technologies within NMFS and between NMFS and its partners.

Composition

- One or more scientists from each of the five NMFS Science Centers
- One representative from NMFS Headquarters
- Other participants which may be nominated by the Science Board
- Experts from other government offices, universities, and the private sector to be invited on an ad hoc basis.

- Subcommittees will be established as necessary to address specific areas of interest and report back to the working group.

Responsibilities

1) Identify critical needs for advanced technology and provide research and development leadership by:

- Developing and prioritizing technological solutions by coordinating with scientists involved in stock assessment, ecosystem monitoring and other research activities.
- Tracking and examining related efforts outside the agency (e.g., other NOAA offices, NASA, DOD, NRO, FWS, EPA, ONR, industry, international organizations) to capitalize on and seek collaboration with these other efforts.
- Monitoring and evaluating NMFS research activities which involve technological innovation.
- Identifying requirements for technical assistance and training related to the greater application of advanced technologies.
- Investigating appropriate methods to mitigate the impediments associated with obtaining classified data and technology.
- Preparing recommendations on how advanced technologies can be modified, expanded, and/or improved to support agency stewardship responsibilities.
- Sponsoring, encouraging, and participating in research and development on advanced sampling methodology.

2) Identify costs and funding opportunities for technological innovation by:

- Evaluating the costs and benefits of proposed (applications of) technologies.
- Developing appropriate budget initiatives
- Assisting in the development of new funding opportunities in collaboration with other organizations.

3) Improve awareness of agency needs for advanced technologies and new advances in technology by:

- Preparing and delivering an annual briefing to the NMFS Science Board apprising it of cutting-edge survey techniques and opportunities for collaboration and/or budget initiative development.
- Preparing presentations, briefings, and talking points for agency management and Congress.

- Developing and maintaining a website for outreach, coordination of working group activities, and cataloging of germane research and development expertise and activities.

4) Provide consultative advice on technology issues

CONTACT: William Karp, Alaska Fisheries Science Center, National Marine Fisheries Service.

Appendix 13. Summary of the Fisheries and the Environment (FATE) Fisheries Oceanography Initiative

Knowledge of decadal and basin-scale climate variability and its impacts on fisheries productivity is essential to effective fisheries management. Sudden shifts in climate regime, as seen recently in the North Pacific, have immediate and major impacts on fisheries productivity. The Fisheries and the Environment (FATE) program will provide the information necessary to effectively adapt management to mitigate the ecological, social and economic impacts of major shifts in the productivity of natural resources in the North Pacific, Bering Sea and Hawaiian Islands. Through the implementation of common observing strategies in widespread regions, it will be possible to invoke comparative analyses to evaluate the response of marine fish to different types of climate forcing. Towards this goal, FATE will provide indicators of ecological and oceanographic change at the population and ecosystem level and local to ocean-basin scales. The indicators, computed on annual or shorter frequencies, will provide early warnings of major shifts in the productivity of key stocks as well as monitoring current year trends in ocean conditions, fish production and ecosystem dynamics. While the initiative is based on an ecosystem approach, it will target a suite of commercially important species including groundfish, coastal pelagics and highly migratory fishes.

The program has two essential elements. One is a broad-scale observational program based on ecological indicators - there can be no indicators without measurements, and no useful forecasts without the observations to confirm them. From an array of moored instruments, NOAA will develop fields of mixed layer depth (MLD) and tem-

perature (MLT), surface and subsurface currents, salinities and fronts to support fisheries predictions. Basin-scale habitats will be monitored for changes in atmospheric and oceanic conditions. Biophysical indicators will also be derived from existing measurement programs such as NMFS stock assessment surveys, NOAA and NASA satellites, NBDC buoys, coastal C-MAN and tide stations, and ships of opportunity. Measurements will be enhanced through additional shipboard surveys, moorings, and aerial surveys.

The other essential element is the development of coupled regional-to-basin scale biophysical models. The vision is to use these coupled models to simulate potential impacts of climate change and climate variability on marine resources. Contrasting model predictions with key ecological indicators will allow critical evaluation of model assumptions and parameterizations in a manner similar to most stock assessment models. The iterative process of prediction, comparison and evaluation will improve the capability of NMFS scientist to provide advice regarding ecosystem considerations in fisheries management.

FATE activities will be initiated in early 2002, with a phased approach depending on the level of funding received. Activities will be conducted through partnerships between NOAA and collaborating state, federal and academic institutions.

CONTACT: Ned Cyr, Office of Science and Technology, National Marine Fisheries Service.

Appendix 14. Protected Species Programs, Plans, and Initiatives

In 1998 F/PR attempted to develop a national marine mammal abundance survey plan as part of its annual allocation of funding for stock assessments. This had two parts: (1) coming up with a scientific rationale or process for deciding how often all the various surveys had to be done (survey interval), and (2) putting together a list of all recent surveys with their cost, assigning each a proposed interval, and a schedule looking out 5 years with the purpose of estimating annual costs, and facilitating scheduling (moving surveys from one year to the next when there wasn't enough money in a given year). The first part was completed and was published by Wade and DeMaster (1999). For various reasons, the second part was never completed. Much of the funding was subsequently transferred permanently but large shortfalls in the program remain. We currently allocate about \$2M for stock assessments on an annual or multi-year basis. Below are three recent budget initiatives to improve protected resources stock assessment capabilities.

A. FY 2002 Initiative: Sustainable Fisheries Requirements for Protected Species

1. Desired outcome: To gather reliable and precise estimates of protected species abundance and distribution, as well as fisheries-related mortality, to help ensure recovery of species listed under the ESA and implementation of Sections 117 and 118 of the MMPA. Recovery of species listed under the ESA and conservation marine mammals pursuant to the MMPA depends upon reliable, precise estimates of distribution and abundance. Imprecise estimates increase the probability that species will be misclassified under the ESA/MMPA resulting in potentially significant economic loss to fisheries (and the Nation) or alternatively, increasing the risk of extinction for protected species.

2. Summary Initiative Description: RPS Stock Assessments and Mortality Estimation or "Know Your Resources:" Currently the status of over 200 protected and at-risk marine species is unknown. This initiative would launch a comprehensive effort to conduct adequate stock assessments for these species to provide, for the first time, the information needed to determine the most effective conservation efforts. Additional observer coverage is included to estimate fishery-related injury and mortality. The initiative includes additional funding needed to operate and maintain current and new FRVs serving the RPS program.

3. Brief Description of Initiative:

Stock Assessment: The major objectives of the MMPA and ESA are to prevent the extinction and decline of species and to make sure populations remain healthy enough to be functioning elements of their ecosystem. One of the most significant impacts on marine mammal and sea turtle stocks is death from entanglement and drowning in fishing gear. This is a particular issue of concern in those cases where the marine mammal stocks are endangered or threatened or where little is known about their status. Wise management of protected resources depends on knowing the trends of animal populations. At present, population trends are based on surveys that count animals. The results of these surveys are essential to understand the impacts of human activities on marine mammal stocks and to the development of appropriate conservation measures for fisheries. Unfortunately, the level of assessment is inadequate for the majority of species.

Observer Program: Commercial fishing is exempt from the MMPA prohibitions on incidentally killing marine mammals if the fishery is properly monitored and observed to validate the level of take. This requires that NMFS implement a statistically valid monitoring program for all 30 fisheries of concern (i.e. Category I and II fisheries). The MMPA requires that plans be put in place (Take Reduction Plans) to reduce the mortality of marine mammals in those fisheries where the take exceeds a biologically acceptable level. Four plans are in place that affect 6 fisheries. This means we need to develop new fishing technologies to reduce gear impacts and we need to find ways to keep fishing gear and marine mammals away from each other. It also means that we must educate fishermen on ways they can avoid marine mammals while still allowing them to catch fish.

B. FY 2002 Strategic Theme: Improving Assessments through New Technologies

1. Desired Outcome: Gathering reliable and precise estimates of protected species abundance and distribution to help ensure recovery of species listed under the ESA and implementation of Sections 117 and 118 of the MMPA.

2. Brief Description of Theme: Recovery of species listed under the ESA and conservation marine mammals pursu-

ant to the MMPA depends upon reliable, precise estimates of distribution and abundance. Imprecise estimates increase the probability that species will be misclassified under the ESA/MMPA resulting in potentially significant economic loss to fisheries (and the Nation) or alternatively, increasing the risk of extinction for protected species.

Considerable progress has been made in the development of assessment techniques over the past decades; examples of current and potentially useful assessment methods by major taxon are shown in the attached Table. However, much remains to be done; because of ESA/MMPA mandates and limited funding, surveys receive higher priority for funding than do the development of techniques supporting the surveys. As a result, methods development receives virtually no direct funding.

Within this theme, we propose funding solely for the development of techniques to improve assessments for all Protected Species taxa (cetaceans, pinnipeds, turtles, and fish) under the NMFS mandate. With these funds, NOAA will be able to capitalize on recent advances in survey technologies based partly on investments made by the Departments of Defense, Energy, and others by developing and testing more accurate and/or less expensive methods for assessing populations of protected species.

C. FY2003 Initiative: Improve and Modernize Stock Assessment Techniques for the Recovery of Endangered Large Whales

There are currently 23 stocks of 8 species of large whales listed as Endangered or Threatened under the Endangered Species Act (ESA), or depleted under the Marine Mammal Protection Act (MMPA). During the past 30 years, only one stock, the Eastern North Pacific Gray Whale, has been removed from the ESA's List of Endangered and Threatened Wildlife because it was deemed recovered. A number of additional whale stocks may have also recovered, but stock assessment information to confirm this is lacking. This initiative will provide the information to scientifically

determine whether other populations have recovered. If this determination is true, it has significant ramifications. If these stocks have not yet recovered, the information collected and techniques implemented will improve the precision of our stock assessments and our understanding of population recovery needs. In either case we would continue to monitor and protect these stocks as required under the MMPA.

With the exception of North Atlantic Right Whales (\$2.1M), North Pacific Right Whales (\$200K), North Atlantic humpbacks (\$42K), and North Pacific humpbacks (\$45K), there are no NOAA base funds to assess the status of large whales relative to their recovery under the MMPA and ESA. Basic information necessary to make a prognosis of a population's recovery, such as abundance estimates and trends (*how many whales are there today and are their populations increasing or decreasing?*), population structure (*how many discrete stocks are there and how many males, females and juveniles in each stock?*), and knowledge of their habitat (*what are the environmental conditions essential for the population*) is lacking. This information can be acquired with relatively small, focused, investments in stock assessment. Specifically, we will improve stock assessment techniques through traditional survey methods (photo-identification, aerial photogrammetry, ship-based surveys) and innovative technologies such as acoustics, genetics, and satellite telemetry for 5 large whale species.

Reference

Wade, P.R. and DeMaster, D.P. 1999. Determining the optimum interval for abundance surveys for management. Pgs 53-66 in *Marine Mammal Survey and Assessment Methods*, Garner, G.W, Amstrup, S.C., Laake, J.L., Manly, B.F.J., McDonald, L.L., and Robertson, D.G. (eds.), Balkema, Rotterdam.

CONTACT: Phil Williams, Office of Protected Resources, National Marine Fisheries Service.

Appendix 15. Habitat Programs, Plans, and Initiatives

A. The Habitat Research Plan of the National Marine Fisheries Service, by Gordon W. Thayer, James P. Thomas, K.V. Koski (1996)

Abstract

A responsibility of the National Marine Fisheries Service (NMFS) is to develop the necessary understanding, using basic and applied research and literature syntheses, to help conserve, protect, and restore habitats of living marine resources. The NMFS National Habitat Program has developed a Habitat Research Plan to direct and conduct research and transfer results to management components within NMFS involved in permit reviews, development of the habitat sections of Fishery Management Plans and protected species Recovery Plans, and development of restoration options and plans as part of the Natural Resources Damage Assessment claims. The plan also is designed to develop the necessary expertise to accomplish or oversee the restoration, creation, or acquisition of habitat to benefit living marine resources. This plan provides guidance in four areas - ecosystem structure and function, effects of alterations, development of restoration methods, and development of indicators of impact and recovery. The plan emphasizes a fifth area — the need for syntheses and timely scientific information to managers.

The National Marine Fisheries Service (NMFS), an agency of the National Oceanic and Atmospheric Administration (NOAA), is the principal steward of living marine resources (LMRs) in the U.S. Resource viability depends in part on habitat protection, maintenance, and restoration. Habitat loss to pollution and development is among the greatest long-term threats to the future viability of U.S. fisheries. NMFS has established a National Habitat Program whose goal is to conserve, protect, and restore the valuable habitats needed to sustain marine and anadromous communities. In the past, the conservation, protection, and restoration of habitat has been accomplished by reviewing licensing, permitting, and legislative and administrative activities that affect LMR and habitats; coordinating with Regional Fishery Management Councils on Fishery Management Plans; and conducting habitat-related research.

NMFS is restructuring the National Habitat Program to meet current and evolving demands and responsibilities relative to managing habitats and fisheries and protecting threatened and endangered species in coastal and estua-

rine areas. NMFS has created a coordinated research guidance plan and approach to support its habitat-related mandates as part of the program. The Habitat Research Plan (HRP) was developed with input from scientific and management personnel at both headquarters and field levels. The plan (1) provides a framework to conduct coastal and estuarine research and transfer results to those management components involved in permit reviews, development of the habitat sections of Fishery Management Plans and protected species Recovery Plans, and development of restoration options and plans as part of the Natural Resources Damage Claims; and (2) develops the necessary expertise within NMFS to identify habitat impacts and accomplish and oversee the restoration, creation, or acquisition of habitat for the benefits of living marine resources. This paper briefly describes the agency's HRP.

B. Linking Fish Productivity to Habitat (1997)

Executive Summary

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended by the Sustainable Fisheries Act of 1996, contains essential fish habitat (EFH) provisions and mandates a supporting research effort. The provisions require a program of research that will provide information to describe and identify EFH, to identify and evaluate actual and potential adverse effects on EFH (including both fishing-related and non-fishing related impacts), and to develop methods and approaches to conserve and enhance EFH. The ultimate goal of the research described is to link fish productivity to habitat. In concept this not only provides for the management of marine habitat via its protection, restoration and maintenance, but also advances our objectives to provide sustainable fisheries.

Research will focus on: 1) enhanced biological sampling to complete life history distributions and abundances of fisheries species; 2) characterization and relating of benthic habitats to the distributions and abundances of fisheries species; 3) identification of habitat properties that contribute most to survival, growth, and productivity; 4) determination of habitat properties important in recruitment; 5) determination and evaluation of adverse effects on habitat from point and non-point sources, harmful algal blooms, hypoxia, endocrine disrupting chemicals, and pathogens; 6) identification of impacts of fishing gear on habitat of managed species; 7) testing of harvest refugia concept for selected areas and managed species; and 8) development

of new methods and approaches for restoration of degraded habitats. This research is to be collaborative with other elements of NOAA (e.g. OAR, NOS, NESDIS), other federal and state agencies, and academic institutions, particularly where those agencies and institutions have needed strengths complimentary to those of NMFS.

C. NOAA/USGS Joint Initiative on Effects of Fishing Activities on Benthic Habitat (1999)

Recommendations

A key issue facing the long-term sustainability of our coastal and marine living resources is the potential effect of fishing activities on benthic habitats. Field surveys indicate that certain fishing practices may cause significant changes to habitat structure and function. The National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS) are partnering in a national initiative to conserve marine fisheries by assessing the relationship between benthic habitats and sustainable fisheries and recommending appropriate management strategies. The partners have unique capabilities that are essential for assessing the effects of fishing activities on benthic habitat. NOAA's National Marine Fisheries Service (NMFS) is responsible for managing our Nation's marine fisheries, including the regulation of fishing practices and provides a national expertise in biological assessments. NOAA's National Undersea Research Program (NURP) has unique technologies, including submersibles and underwater robots that are necessary for direct observations of seabed habitat structure and biological assemblages. NOAA's National Ocean Service (NOS) is responsible for developing coastal charts and for the stewardship of coastal resources. NOS also conducts research and monitoring on, and promotes sustainable management of, the nation's coastal ecosystems. The U.S. Geological Survey's Geological Division has particular strength and responsibility for regional seabed morphologic mapping and for subsequent interpretation of geologic character and processes. This initiative focuses on relating the biological and physical effects of fishing (e.g., dredging scars, trawl door marks) to the geological characteristics of benthic habitats (e.g., morphology, geochemistry, bioturbation, sediment stability, history and prediction of change). The partnership addresses these issues by directing research towards the most critical problems through dedicated initiatives and effective leveraging of the partners' resources. Two recommendations follow:

1. IT IS RECOMMENDED that, within the next 6 months, NOAA and USGS develop an implementation plan to jointly plan and undertake activities under the following themes:

A. Determine the Effects of Fishing Gear on Seabed Habitats.

B. Identify and Map Benthic Habitat Characteristics and the Extent of Fishing Impacts.

To facilitate this initiative a program team will be established to develop priorities and implementation plans for the projects under this initiative. The program team will consist of representatives from both the USGS and NOAA, headquarters and field. This team will report to senior management in both agencies through the NOAA/USGS Coordination Group. Further, the programmatic framework of this initiative will be reviewed and revised via a series of workshops to be held within the next 6 months which will strengthen and refine the planned research elements by including appropriate additional elements of the two agencies. A specific approach and workplan with priorities for research tasks and products will be developed from these workshops. Lastly, a national meeting is planned every other year to communicate and review results of benthic habitat studies supported by the two agencies and their partners, and to reassess program direction. The second national meeting (the first developed the foundation of this initiative) is being planned for November 12-14, 2002, as a symposium on the Effects of Fishing Activities on Benthic Habitat to be held in Tampa, Florida."

2. IT IS RECOMMENDED that NOAA and USGS commit the necessary resources to meet the minimal priorities identified in this initiative. The body of this initiative identifies a number of key regional projects with preliminary estimates of needed resources. While the major priority needs in each region have been identified, a full programmatic review is needed to develop a fully integrated program. This is now being addressed based on the workshops identified above.

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Appendix 16. Extract from the Executive Summary of the NRC Report on Review of Northeast Fishery Stock Assessments (NRC 1998b)

RECOMMENDED ACTIONS

The committee recommends that the National Marine Fisheries Service take the following actions to improve the Northeast stock assessments:

1. Improve the collection, analysis, and modeling of stock assessment data as detailed in Chapter 3. Such improvements could include evaluations of sample size, design, and data collection in the fishery and the surveys; the use of alternative methods for data analysis; consideration of a wider variety of assessment models; and better treatment of uncertainty in forecasting;
2. Improve relationships and collaborations between NMFS and harvesters by providing, for example, an opportunity to involve harvesters in the stock assessment process and using harvesters to collect and assess disaggregated catch per unit effort data;
3. Continue to educate stock assessment scientists through short-term exchanges among NMFS centers so that each center can keep abreast of the latest improvements in stock assessment technologies being used at other NMFS fishery science centers and other organizations in the United States or elsewhere;
4. Ensure that a greater number of independent scientists from academia and elsewhere participate in the Stock Assessment Review Committee (SARC) process; where necessary, pay competitive rates for such outside participation to ensure that a sufficient number of the best people are involved in the review;
5. Increase the frequency of stock assessments. As the New England Fishery Management Council intensifies its management of the Northeast fishery, stock assessments may have to be performed more frequently than every three years (the current timing);
6. Consider a wider range of scenarios (e.g., recruitment, individual growth, survival, sub-stock structure, ecosystem, data quality, compliance with regulations, long-term industry response) in evaluating management strategies;
7. Investigate the effects of specific management actions, such as closed areas and days at sea limitations, on fishing mortalities and related parameters;

8. Work toward a comprehensive management model that links stock assessments with ecological, social and economic responses, and adaptation for given long-term management strategies. This involves input from the social sciences (economics, social and political science, operations research) and from a wider range of natural sciences (ecology, genetics, oceanography) than traditionally is the case in fisheries management.

The committee has not explicitly considered the costs of implementing these recommendations, which may require either additional resources or a reprogramming of existing resources.

The committee concludes that stock assessment science is not the real source of contention in the management of New England groundfish fisheries. Comments at a public hearing held by the committee support this conclusion. Many speakers suggested that the social and economic concerns created by strong management measures and lack of participation in the management process were the more important concerns. Traditional fishery science has a major role to play in fisheries management, but sound stock assessment clearly is not the only consideration.

The New England Fishery Management Council will be facing critical decisions, depending on the recovery or non-recovery of groundfish stocks. A long-term management strategy will be needed to decide the rate of rebuilding required to reach particular targets. Without sound stock assessment, targets and rebuilding rates cannot be set, nor can the effectiveness of the regulatory actions be measured. However, stock assessment in the narrow sense of estimating status and dynamics of fish populations is not sufficient for rational fisheries management.

What constitutes a good management approach will vary over time, location, and components of the fish stock. To obtain the information necessary to design effective institutional and regulatory frameworks, it is essential that management draws on stock assessment, oceanography, ecology, economics, social and political science and operations research. Only when a more comprehensive approach is taken, with long-term management strategies based on data and insight from the various fields, properly accounting for the uncertainties surrounding data and theory, can fishery management provide for high continuing yield of food and health of stocks, while considering the needs of people dependent upon the fisheries.

Appendix 17. Executive Summary from “Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act” (Restrepo et al. 1998)

The 1998 Guidelines for National Standard 1 (Optimum Yield) of the Magnuson-Stevens Fishery Conservation and Management Act, 50 CFR Part 600, state: “*In general, Councils should adopt a precautionary approach to specification of OY.*” Because of the technical nature of the task, NMFS convened a panel of scientists to provide technical guidance on specifying OY that is consistent with the Guidelines (NSGs). The technical guidance is contained in this document.

The precautionary approach implements conservation measures even in the absence of scientific certainty that fish stocks are being overexploited. In a fisheries context, the precautionary approach is receiving considerable attention throughout the world primarily because the collapse of many fishery resources is perceived to be due to the inability to implement timely conservation measures without scientific proof of overfishing. Thus, the precautionary approach is essentially a reversal of the “burden of proof.”

The precautionary approach in fisheries is multifaceted and broad in scope. The discussions in this document are not so broad in scope, and are limited to providing guidance to managers and scientists for specifying OY and for developing reference points to guide management decisions.

A common element in the application of the precautionary approach to fisheries management worldwide is the definition of “limits” intended to safeguard the long-term productivity of a stock. Several international agreements and documents that deal with the precautionary approach identify maximum sustainable yield (MSY) levels as a minimum standard for defining management limits. The Magnuson-Stevens Act encompasses this concept in that it constrains OY to be no greater than MSY.

The NSGs identify two limits for fishery management (referred to as “thresholds”) that are necessary to maintain a stock within safe levels, capable of producing MSY: A maximum fishing mortality threshold (MFMT) and a minimum stock size threshold (MSST). The MFMT and MSST are intended for use as benchmarks to decide if a stock or stock complex is being overfished or is in an overfished state. In the NSGs, these two limits are intrinsically linked through an “MSY Control Rule” that specifies how fishing mortality or catches could vary as a function of stock

biomass in order to achieve yields close to MSY. If the maximum fishing mortality limit is reduced as biomass decreases, then the minimum stock size limit decreases (although the MSST cannot become lower than 2 of the equilibrium biomass under a constant-fishing mortality MSY control rule). Thus, the shape of the MSY control rule is an important consideration for developing status determination criteria for overfishing.

A default MSY control rule is recommended in Section 2 of this document. Noting that Councils have considerable flexibility in defining the shape of the MSY control rule for each stock under their jurisdiction, and that different control rule shapes pertain to different management objectives, the recommended default could be used in the absence of more specific analyses. The default makes use of estimates of the constant fishing mortality rate resulting in MSY, F_{MSY} , and of the corresponding average spawning biomass, B_{MSY} . The limit F, MFMT, is set equal to F_{MSY} at higher stock sizes; if the stock decreases much below B_{MSY} , the limit F is reduced proportionately (the reduction starts at a fraction of B_{MSY} related to the level of natural mortality). It is anticipated that estimates of F_{MSY} and B_{MSY} will be either unavailable or unreliable for many stocks. For this reason, Section 2 also presents a discussion of useful proxies.

Another common element in the application of the precautionary approach to fisheries management worldwide is the specification of “targets” that are safely below limits. Setting OY at its limit (MSY in the Magnuson-Stevens Act) would not normally be precautionary because there could be a high probability of exceeding the limit year after year. Under the precautionary approach, the target should be set below the limit taking uncertainty and other management objectives into consideration. Development of control rules requires communication between fisheries managers, scientists, industry and the public. If performance criteria for target control rules can be defined, then a range of alternative control rules can be developed and evaluated in terms of precautionary behavior and other desirable economic or operational characteristics for management, once precautionary constraints have been met.

Control rules are pre-agreed plans for making management decisions based on stock size. The pre-agreed nature of the measures ensures that management actions are implemented without delay, and it is possible to respond rapidly

to changing conditions. As with MSY control rules, Councils have considerable flexibility in defining targets. Section 3 presents a recommended default target control rule that could be used in the absence of more specific analyses. The default sets the target fishing mortality rate 25% below the default limit proposed in Section 2. The 25% reduction constitutes a safety margin that may not perform well for all stocks in terms of preventing overfishing. The performance of the default target can only be evaluated on a case-by-case basis and will depend on (a) the accuracy and precision of stock size, B_{MSY} and F_{MSY} estimates, (b) natural variability in population dynamics, and (c) errors in the implementation of management regulations. Age-structured deterministic models suggest that, for a large combination of life history parameters, the recommended default can result in high stock sizes (around 130% of B_{MSY}) at the expense of relatively small foregone yields (achieving around 95% of MSY). It is recognized that no single policy can fully address all of the considerations to be encountered in the wide variety of fisheries subject to the Magnuson-Stevens Act. Nevertheless, the default target will be useful in a variety of situations and should at least serve to encourage development of more suitable policies for individual fisheries.

The default target control rule may not be applicable for many stocks that are already below the MSST (i.e. that are already overfished). In such cases, the NSGs require that special plans be implemented to rebuild the stocks up to the B_{MSY} level within a time period that is related to the stock's productivity. This document does not propose a default rebuilding plan, because the time to rebuilding may depend on each stock's current level of depletion. Instead, the document presents the four key elements that should

be considered in rebuilding plans: An estimate of B_{MSY} , a rebuilding time period, a rebuilding trajectory, and a transition from rebuilding to more optimal management. The default target control rule may be adapted into a rebuilding plan for each overfished stock, for example, by allowing only a very low fishing mortality when the stock is below the MSST in order to rebuild the stock within the rebuilding time period.

This document also discusses a number of special considerations, such as changes in the selectivity of fishing gear, mixed-stock situations, changes in productivity due to the environment, and the appropriateness of various proxies for MSY-related parameters. One consideration of particular importance relates to setting limits and targets for data-poor stocks, i.e. those having very limited information. While the document provides defaults for these cases as well, it is imperative to improve the ability to make informed decisions through enhanced data collection and analyses.

Specification of MSY control rules, status determination criteria, and precautionary target control rules is a challenging exercise. Key to this process is communication between managers, scientists, users and the public. In the face of conflicting objectives (avoiding overfishing while achieving high long-term yields), it is essential to understand the trade-offs associated with alternative control rules and the importance of the weights assigned to the different objectives or performance criteria. Simulation frameworks can facilitate the necessary interaction. In addition, simulation tools should be used to examine the performance of management systems as a whole, including data collection, assessments, control rules, and implementation of management tactics.

Appendix 18. Conclusions and Recommendations from the Executive Summary of the NRC Report on Sustaining Marine Fisheries (NRC 1999)

Conclusions

Many populations and some species of marine organisms have been severely overfished. There are widespread problems of overcapacity: there is much more fishing power than needed to fish sustainably. Fishing affects other parts of the ecosystem in addition to the targeted species, and those effects are only now beginning to be understood and appreciated. Other human activities, such as coastal development, have adverse effects on marine ecosystems as well. The effects of these human activities, combined with ecosystem effects of fishing, may well be more serious in the long term than the direct effects of fishing on targeted species. Although societies have been concerned about the effects of fishing on particular populations and species for centuries, recent recognition of the ecosystem effects of fishing has resulted in part from research on ecosystem approaches and has led to calls for the adoption of ecosystem approaches to fishery management to achieve sustainability at a high level of productivity of fish and of ecosystem goods and services.

The committee concludes that a significant overall reduction in fishing mortality is the most comprehensive and immediate ecosystem-based approach to rebuilding and sustaining fisheries and marine ecosystems. The committee's specific recommendations, if implemented, would contribute to an overall reduction in fishing mortality in addition to providing other protective measures.

The committee recommends the adoption of an ecosystem-based approach for fishery management whose goal is to rebuild and sustain populations, species, biological communities, and marine ecosystems at high levels of productivity and biological diversity, so as not to jeopardize a wide range of goods and services from marine ecosystems, while providing food, revenue, and recreation for humans. An ecosystem-based approach that addresses overall fishing mortality will reinforce other approaches to substantially reduce overall fishing intensity. It will help produce the will to manage conservatively, which is required to rebuild depleted populations, reduce bycatch and discards, and reduce known and as-yet-unknown ecosystem effects. Although this approach will cause some economic and social pain at first, it need not result in reduced yields in the long term because rebuilding fish populations should offset a reduction in fishing intensity and increase the potential sustainable yields. Reducing fishing effort in the short term is necessary to achieve sustainable fishing. The

options lie in deciding how and when to reduce effort so as to reduce economic and social disruption. The options, however, can be exercised only if decisions are made before the resources are depleted.

Adopting a successful ecosystem-based approach to managing fisheries is not easy, especially at a global or even continental scale. That is why the committee recommends incremental changes in various aspects of fishery management. The elements of this approach, many of which have been applied in single-species management, are outlined below. They include assignment of fishing rights or privileges to provide conservation incentives and reduce overcapacity, adoption of risk-averse precautionary approaches in the face of uncertainty, establishment of marine protected areas, and research.

When overfishing (including bycatch) has been effectively eliminated, other human activities will be the major threat to fisheries and marine ecosystems. Although those effects are not a major focus of this report, they cannot be totally separated from fishing, and mechanisms involving cross-sectoral institutional arrangements will be needed to protect fisheries and marine ecosystems.

Recommendations

The following are recommendations to achieve the broad goals and approach outlined above. Appropriate actions need careful consideration for each fishery and each ecosystem.

Conservative Single-Species Management

Managing single-species fisheries with an explicitly conservative, risk-averse approach should be a first step toward achieving sustainable marine fisheries. The precautionary approach should apply. A moderate level of exploitation, might be a better goal for fisheries than full exploitation, because fishing at levels believed to provide the maximum long-term yield tends to lead to over-exploitation. Many species are overfished and their productive potential is impaired, even without considering the ecosystem effects of fishing for them. Expanding fisheries to include previously unfished or lightly fished species, such as deep-sea species, is unlikely to lead to large, sustainable increases in marine capture fisheries. Therefore, the committee recommends that management agencies adopt regulations and policies that strongly favor conservative and precautionary management and that penalize overfishing,

as called for in the Magnuson-Stevens Fishery Conservation and Management Act of 1976 and the 1996 amendments to that act, often referred to as the Sustainable Fisheries Act of 1996.

As described in Chapter 5, the committee's recommendation for more conservative and precautionary management requires that the concept of maximum sustainable yield be interpreted in a broader ecosystem context to take account of species interactions, environmental changes, an array of ecosystem goods and services, and scientific uncertainty. This step, although important, will not by itself sustain marine fisheries and ecosystems at high levels of productivity.

Incorporating Ecosystem Considerations Into Management

Fishery management should take account of known and probable goods and services of marine ecosystems that are potentially jeopardized by fishing. The aim is to sustain the capacity of ecosystems to produce goods and services at local to global scales and to provide equitable consideration of the rights and needs of all beneficiaries and users of ecosystem goods and services.

Dealing with Uncertainty

Fisheries are managed in an arena of uncertainty that includes an incomplete understanding of and ability to predict fish population dynamics, interactions among species, effects of environmental factors on fish populations, and effects of human actions. Therefore, successful fishery management must incorporate and deal with uncertainties and errors. The committee recommends the adoption of a precautionary approach in cases of uncertainty. Management should be risk-averse. Although research and better information can reduce uncertainty to a degree, they can never eliminate it.

Many of the problems that fishery managers face are issues concerning long-term versus short-term goals and benefits. Uncertainty in stock assessments and in future allocations of those stocks has led to an emphasis on short-term benefits at the expense of long-term solutions. Uncertainties over shares when allocations allow open competition can compel individuals to adopt a short-term horizon for decisions related to fishing effort and investment. Management incentives and institutional structures must counteract these responses to uncertainty that jeopardize sustainability. This is especially true when stock assessments are uncertain, which makes it harder for managers to hold the line on conservation.

Reducing Excess Fishing Capacity and Assignment of Rights

Excess fishing capacity (fishing capacity is the ability to catch fish or fishing power) and overcapitalization (capitalization, related to capacity, is the amount of capital invested in fishing vessels and gear) reduce the economic efficiency of fisheries and usually are associated with overfishing. Substantial global reductions in fishing capacity are of the highest priority to help to reduce overfishing and to deal with uncertainty and unexpected events in fisheries. Overcapacity is difficult to manage directly, and usually evolves in management regimes that encourage unrestricted competition for limited fishery resources. Consequently, managers and policy makers should focus on developing or encouraging socioeconomic and other management incentives that discourage overcapacity and that reward conservative and efficient use of marine resources and their ecosystems.

At the core of today's overcapacity problem is the lack of, or ineffective, definition and assignment of rights in most fisheries. In addition, subsidies that circumvent market forces have contributed significantly to the overcapacity problem in many fisheries. Therefore, the committee recommends for many fisheries a management approach that includes the development and use of methods of allocation of exclusive shares of the fish resource or privileges and responsibilities (as opposed to open competition) and the elimination of subsidies that encourage overcapacity. A flexible and adaptive approach is essential, and careful attention must be given to equity issues associated with such approaches. The committee recommends experimental approaches to community-based fishery management, including the development of virtual communities. This would include research into the establishment of management groups in which participation is based on shared interests in a fishery and its associated ecosystem, with diminished emphasis on where participants live or their direct financial interests.

Marine Protected Areas

Where they have been used, marine protected areas—where fishing is prohibited—have often been effective in protecting and rebuilding ecosystems and populations of many (but not all) marine species. They often also lead to increases in the numbers of fish and other species in nearby waters. Importantly, they can provide a buffer against uncertainty, including management errors. Permanent marine protected areas should be established in appropriate locations adjacent to all the U.S. coasts. It will be important to include highly productive areas—that is, areas in which fishing is good or once was—if this management approach is to produce the greatest benefits.

Protected areas will make the most effective contribution to the management of species and ecosystems when they are integrated into management plans that cover the full life cycles and geographic ranges of the species involved. Smaller, fixed protected areas will be most effective for species with life stages that are spent in close association with fixed topography, such as reefs, banks, or canyons. For other species, the degree of effectiveness of protected areas will be related to the importance of fixed topography in various stages of their lives. Wholly or largely pelagic species move according to ocean currents or other factors that are not necessarily related to fixed topographic structures and are thus likely to benefit less from small protected areas.

The design and implementation of marine protected areas should involve fishers to ensure that they believe the resulting systems will protect their long-term interests and to improve operational integrity. Because attempts to develop marine protected areas in the United States have been strongly opposed by some fishers, the broad involvement of users is a key strategy. Current theory and experience make clear that marine protected areas must be established over a significant portion of the fishing grounds to have significant benefits. Recent calls for protecting 20 percent of potential fishing areas provide a worthwhile reference point for future consideration, and emphasize the importance of greatly expanding the areas currently protected.

Marine protected areas are not alternatives to other techniques of fishery management and to the other recommendations in this report. They should be considered as only one of a suite of important ecosystem approaches to achieve sustainable fisheries and protect marine ecosystems. For marine protected areas to be most successful as fishery-management tools, their intended purposes must be clearly defined.

Bycatch and Discards

Bycatch and discards add to fishing mortality and should be considered as part of fishing activities rather than only as side effects. Estimates of bycatch should be incorporated into fishery-management plans and should be taken into account in setting fishing quotas and in understanding and managing fishing to protect ecosystems and nonfished ecosystem components. Reducing fishing intensity on target species can reduce bycatch, often with no long-term reduction in sustainable yield. In some cases, technological developments and careful selection of fishing gear (e.g. bycatch-reduction devices) can be effective in reducing bycatch, and those options should be encouraged, developed, and required where appropriate. More information is needed on discards and on bycatch and

their fate (i.e. whether bycatch is retained or discarded and whether discards survive or die).

Institutions

Effective fishery management requires structures that incorporate diverse views without being compromised by endless negotiations or conflicts of interest. The committee recommends developing institutional structures that promote:

- effective and equitable reduction of excess capacity,
- sustainable catches of targeted species,
- expansion of the focus of fishery management to include all sources of environmental degradation that affect fisheries,
- consideration of the effects of fishing on ecosystems,
- development and implementation of effective monitoring and enforcement, and
- the collection and exchange of vital data.

To achieve these goals, the spatial and temporal scales at which the institutional structures operate should better match those of important processes that affect fisheries. Participation in management should be extended to all parties with significant interests in marine ecosystems that contain exploited marine organisms. Institutions should allocate shares in or rights to fisheries, rather than allowing openly competitive allocations. The clear explication of management goals and objectives is a prerequisite to achieving effective and equitable management.

Information Needs

Better understanding is needed of the structure and functioning of marine ecosystems, including the role of habitat and the factors affecting stability and resilience. This includes attempting to understand mechanisms at lower levels of organization (i.e. populations and communities), long-term research and monitoring programs, development of models that incorporate unobserved fishing mortality and environmental variability (e.g. El Niño events) into fishery models, multispecies models, and trophic models. More research is also needed on the biological effects of fishing, such as the alteration of gene pools and population structures as a consequence of fishing. More research is needed on the conditions under which marine protected areas are most effective, and marine protected areas themselves should be used as research tools as well as for conservation.

More information is needed on the effects and effectiveness of various forms of rights-based management approaches and other management regimes, on the way

people behave in response to different economic and social incentives, and on barriers to cooperation and sharing of information. The committee recommends research into the roles of communities in fisheries management, including the use of community-based quotas and other assignments of rights to communities, and explorations into the feasibility of granting management responsibilities to those

engaged in a particular fishery, regardless of their geographical community (“virtual communities”).

The need for more information should not be used as an excuse for inaction; that excuse has contributed significantly to current problems. Enough is known to begin taking action now.

Appendix 19. Extract from the Executive Summary of the Ecosystem Principles Advisory Panel Report (NRC 1999b)

Ecosystem-based management can be an important complement to existing fisheries management approaches. When fishery managers understand the complex ecological and socioeconomic environments in which fish and fisheries exist, they may be able to anticipate the effects that fishery management will have on the ecosystem and the effects that ecosystem change will have on fisheries. However, ecosystem-based management cannot resolve all of the underlying problems of the existing fisheries management regimes. Absent the political will to stop overfishing, protect habitat, and support expanded research and monitoring programs, an ecosystem-based approach cannot be effective.

A comprehensive ecosystem-based fisheries management approach would require managers to consider all interactions that a target fish stock has with predators, competitors, and prey species; the effects of weather and climate on fisheries biology and ecology; the complex interactions between fishes and their habitat; and the effects of fishing on fish stocks and their habitat. However, the approach need not be endlessly complicated. An initial step may require only that managers consider how the harvesting of one species might impact other species in the ecosystem. Fishery management decisions made at this level of understanding can prevent significant and potentially irreversible changes in marine ecosystems caused by fishing.

Recognizing the potential of an ecosystem-based management approach to improve fisheries management, Congress requested that the National Marine Fisheries Service (NMFS) convene a panel of experts to: 1) assess the extent to which ecosystem principles are currently applied in fisheries research and management; and 2) recommend how best to integrate ecosystem principles into future fisheries management and research. In response, NMFS created the National Marine Fisheries Service Ecosystem Principles Advisory Panel (Panel).

THE FUTURE OF ECOSYSTEM APPROACHES IN U.S. FISHERIES MANAGEMENT

Fisheries scientists and managers are beginning to grasp the potential of ecosystem-based fishery management to improve the sustainability of fisheries resources. Given the depressed state of many U.S. fisheries, this awareness must be expanded and actions taken to implement this approach. Our management recommendations and research actions provide a pragmatic framework within which to apply

the ecosystem Principles, Goals, and Policies. The success of this approach depends on full implementation of measures already underway as a result of the passage of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (NMFS 1996), particularly the essential fish habitat (EFH) requirements and strengthened national standards. The recommendations contained in this report provide the required next steps.

While some of the recommended actions can start immediately, we believe that legislation is required to implement measures like the FEP. Given that legislative processes may require three to five years to enact the proposed regulations, we recommend interim actions by the Secretary of Commerce to develop demonstration FEPs and to encourage voluntary adoption by management Councils of the Principles, Goals, and Policies proposed herein. We also are aware that these new tasks will require additional human and financial resources for full implementation.

The benefits of adopting ecosystem-based fishery management and research are more sustainable fisheries and marine ecosystems, as well as more economically-healthy coastal communities. We have identified the actions required to realize these benefits. We urge the Secretary and Congress to make those resources available.

SUMMARY OF RECOMMENDATIONS

Fisheries management and policy recommendations are directed toward Congress for implementation by NMFS and the Councils. Interim measures and research recommendations are directed toward the Secretary of Commerce for implementation by NMFS and other appropriate agencies.

Develop a Fisheries Ecosystem Plan (FEP)

Require each Council to develop an FEP for the ecosystem(s) under its jurisdiction. The FEP is an umbrella document containing information on the structure and function of the ecosystem in which fishing activities occur, so that managers can be aware of the effects their decisions have on the ecosystem, and the effects other components of the ecosystem may have on fisheries.

Each FEP should require the Councils to take, at least, the following eight actions:

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

Measures to Implement FEPs

The following are general recommendations to ensure effective development and implementation of FEPs:

1. Encourage the Councils to apply ecosystem Principles, Goals, and Policies to ongoing activities.
2. Provide training to Council members and staff.
3. Prepare guidelines for FEPs.
4. Develop demonstration FEPs.
5. Provide oversight to ensure development of and compliance with FEPs.
6. Enact legislation requiring FEPs.

Research Required to Support Management

Require and provide support for NMFS and other appropriate agencies to initiate or continue research on three critical research themes which will provide the information necessary to support ecosystem-based fisheries management. These themes are:

1. Determine the ecosystem effects of fishing.
2. Monitor trends and dynamics in marine ecosystems (ECOWATCH).
3. Explore ecosystem-based approaches to governance.

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Appendix 20. Extract from the Executive Summary of the NRC Study on Improving the Collection, Management, and Use of Marine Fisheries Data (NRC 2000)

FINDINGS AND RECOMMENDATIONS

Broader Data Collection, Use, and Management

The committee believes that all the participants in fisheries management should take actions to improve the collection, management, and use of fisheries data. The committee developed the following recommendations to Congress, NMFS, the regional councils, interstate commissions, and commercial and recreational fishermen with the objective of improving fisheries data and thereby fisheries management.

Recommendations to Congress

The U.S. Congress affects fisheries science and policy in two primary ways. First, Congress is the architect of the centerpiece of federal fisheries legislation, the Magnuson-Stevens Act. At present, Congress is formulating legislation to reauthorize the Magnuson-Stevens Act, whose funding authority expires on October 1, 2000. The committee recommends several ways in which the reauthorization could improve fisheries data collection, management, and use in the United States.

Second, Congress appropriates funding for NMFS, the regional councils, and interstate and international commissions to carry out their activities related to fisheries science and management. The committee highlights several items for which additional funding could improve fisheries data collection, management, and use and, consequently, fisheries management. Funding for more capable research vessels and for planning a Fisheries Information System are recent examples of positive congressional steps toward modernization of fisheries data.

Fisheries management is based on ad hoc methods of data collection developed over the past 25 years that may no longer lead to the best management. Congress should support and encourage NMFS to reevaluate its systems of data collection, management, and use, and to conduct research to increase the effectiveness of these activities. Another important need is for a fishery-by-fishery analysis of the costs and benefits associated with data collection and fisheries management.

In the most recent reauthorization of the Magnuson-Stevens Act, Congress requested that NMFS develop a preliminary design for a Fisheries Information System. The com-

mittee believes that such a system could improve and standardize the management of U.S. marine fisheries data and thereby help managers understand regional trends and how they fit into the national context. The committee believes that the Fisheries Information System should be funded on an experimental basis for a fixed term, perhaps 10 years, with quantifiable and measurable objectives that can be evaluated at the end of that period.

Congress should continue to support the acquisition and calibration of new NMFS fishery research vessels that are more effective in data collection and handling than the vessels currently available in the aging NMFS fleet. The so-called "fish for research" programs used by NMFS and regional fishery management councils have proven to be a useful means of involving commercial fishermen in research and sampling. Congress should continue to support such programs, with the details of implementation left to the discretion of regional councils.

Congress should amend the Magnuson-Stevens Act to limit the confidentiality of commercial data. By providing better access to commercial data, such a step would help managers and scientists better understand the biology, sociology, and economics of fisheries. Sunset periods on confidentiality are logical outcomes of the public ownership of marine fish resources and the public trust responsibilities of NMFS and the regional councils in fisheries management. The proprietary periods may vary by data type (e.g. they may be shorter for fishing locations than for economic data) and by specific fishery, and these periods should be determined cooperatively between fishery managers and stakeholders. As part of the effort to gather and disseminate needed data, Congress should lift the prohibitions in the Magnuson-Stevens Act on collection of economic data (Sec. 303[b][7] and 402[a]).

Recommendations to NMFS

NMFS has many, in some cases conflicting, responsibilities. NMFS and the regional fishery management councils often suffer from a credibility problem and are more or less continuously engaged in conflicts with commercial and recreational fishermen and environmental advocates who disagree with fishery management plans or other aspects of fisheries management. These conflicts range from criticism voiced in regional council meetings and other public meetings to legal challenges to fishery management plans approved by the councils and NMFS. Some of these

conflicts are probably unavoidable results of the dynamics of the regulator-regulated relationship between NMFS and fishermen and their different perceived objectives—such conflict is to be expected. Nevertheless, NMFS and fishermen do share a fundamental objective: the long-term sustainable use of marine living resources and the acquisition of whatever data are necessary to achieve this objective. NMFS and fishery stakeholders should work together to resolve their conflicts to achieve “win-win” solutions. Conflicts might be reduced by greater cooperation between NMFS and fishermen in data collection, so that NMFS develops trust in data from commercial and recreational fisheries and fishermen become confident that NMFS provides accurate data and assessments.

NMFS should continue to explore more cost-effective ways of obtaining the fisheries data it needs, including implementing new remote sensing techniques (e.g. hydro-acoustics); implementing electronic logbooks and vessel monitoring systems; increasing observer coverage where needed; developing adaptive sampling in appropriate fisheries; and, especially, finding ways to improve commercial data to make it more useful for stock assessments and finding ways to estimate recreational catch more quickly to allow in-season management of recreational fisheries. NMFS also should consider creating mechanisms to obtain advice from commercial and recreational fishermen related to specific data collection policies and procedures. This could be accomplished through a combination of national meetings to discuss national-level policies and regional meetings to discuss data collection in specific fisheries, possibly through each regional council’s scientific and statistical committee.

The Marine Recreational Fisheries Statistics Survey (MRFSS) should be fully funded and include all coastal states and territories that request inclusion. NMFS should invest in research related to MRFSS and investigate new ways to enlist recreational fishermen in data collection for routine monitoring and special studies, but only if the agency intends also to fund implementation of the results of the research. It appears that MRFSS funding and staffing levels are adequate only to maintain the existing survey and conduct a minimal amount of research, the results of which are not always implemented in a timely manner. Some recommendations have been implemented (e.g., changes in variance estimates), whereas others remain to be implemented (e.g. retention of previously contacted anglers in subsequent surveys).

NMFS should standardize the data sets and protocols included in the proposed Fisheries Information System, using the standards for spatial and other data established by

the Federal Geographic Data Committee. The agency should consider moving away from proprietary data management software to software that is available from many vendors and for which data access and analysis routines can be written easily.

NMFS should evaluate the success of commercial data management firms in providing real-time value-added data products for specific operational purposes, and should determine ways to encourage such entrepreneurial activities. At the same time, NMFS should endeavor to obtain useful data from such sources.

The committee identified a number of data collection activities that merit special attention from fishery scientists within both NMFS and the academic community:

- Developing methods for evaluating the ecological benefits of fish stocks and their role in marine ecosystems.
- Determining how to minimize changes in the relationship of actual abundance to indices of abundance (e.g., survey, commercial, or recreational catch per unit effort) and misreporting when management systems are changed.
- Testing adaptive sampling for data collection for both NMFS and industry.
- Testing electronic logbooks and vessel monitoring systems that offer value-added features to fishermen.
- Linking environmental, economic, and social data, as well as climate forecasts, to stock assessments.
- Improving understanding of the functioning of the marine ecosystems affected by fishing activities by studying important non-target species to determine their feeding habits, their distribution, and their prey and predators.
- Gaining a greater understanding of the economic and social motivations of fishermen so that data from commercial and recreational fisheries can be interpreted correctly.
- Validating procedures for determining fish ages and identifying stocks.

Recommendations to Regional Fishery Management Councils

Regional councils should be more proactive and innovative in developing mechanisms within fishery management plans that encourage NMFS to work more effectively with commercial and recreational fishermen in data collection. Councils should play a major role in promoting greater use of data from commercial and recreational fisheries by including programs for collecting and using such data in fishery management plans, and working with NMFS to design appropriate mixtures of data collection approaches (e.g. vessel monitoring systems, observers, logbooks). The design and implementation of fishery management plans should include consideration of how data quality might be

enhanced and whether data of the required accuracy and precision are available or could be collected in a cost-effective manner. If sufficient data quality is unlikely to be achievable at a reasonable cost for a particular type of management, councils should consider alternative, less data-intensive management systems. Councils should give serious consideration to new “fish for research” programs that could engage fishermen in data collection and research. Councils should obtain the data needed to conduct in-season management of recreational fisheries or, conversely, manage recreational fisheries conservatively enough so that in-season data are not necessary. They should work with NMFS to improve outreach to commercial and recreational fishermen, and should encourage independent review of data collection and stock assessments on a regular basis.

Recommendations to Interstate Commissions

Interstate commissions should find ways to increase the standardization of state survey data used in federal stock assessments, consistent with important state uses of the data. Commissions should work with NMFS and the states to create and maintain regional databases, and coordinate them through the proposed Fisheries Information System.

Recommendations to Commercial Fishermen

Commercial fishermen are a critical source of data about the fish stocks they depend on, and more generally, about marine ecosystems. Under most existing management systems, however, commercial fishermen have many incentives to misreport catch data and few incentives to provide accurate and complete data. Although the extent of misreporting is hard to quantify, anecdotal evidence suggests that it does occur. Many improvements in fisheries management will require active participation of commercial fishermen in data collection, including more extensive cooperation in sampling and a reduction in misreporting of commercial data. Commercial fishermen should work with NMFS to obtain accurate and precise measures of the relative abundance of fish stocks, both through commer-

cial data and research surveys. Commercial fishermen could help improve both and it would be to their benefit to do so—the fish stocks on which they depend are more likely to be sustained if both fishermen and managers share the same accurate view of the abundance of fish stocks.

Recommendations to Recreational Fishermen

Recreational fishermen presently play a relatively small and passive role in data collection, although the interest of anglers in participating in fish-tagging studies have been well demonstrated through the efforts of the American Littoral Society and others to tag sportfish. Angler organizations should increase their cooperation with NMFS and academic scientists to assist in routine data collection and scientifically designed, targeted studies, in order to improve the recreational catch data that are needed in stock assessments. Although scientifically designed tagging studies demand careful implementation, they are crucial to the accurate assessment of fish mortality and movement. Angler assistance is particularly important in fisheries that have a significant recreational component, such as the summer flounder fishery.

CONCLUSION

The future of fisheries management will be based on complementary data from fishery-independent surveys, commercial fishermen, and recreational fishermen. A particular need is to improve the quality of data from commercial and recreational fisheries, so that stock assessment scientists can be justifiably confident about using such data in their models. Commercial and recreational sources could provide large quantities of data important for stock assessments and for understanding the social and economic aspects of marine fisheries, but these data are not always useful in their present form. The sustainable use of marine fish resources, and concomitant protection of marine environments, will require new levels of commitment by the public and their representatives in Congress and federal and state governments to fund and carry out appropriate data collection and management.

Appendix 21. List of Relevant National Marine Fisheries Service Partnerships

Academic Institutions

- Auburn University
- Albion College
- Bethune-Cookman College
- Boston University
- Bridgeport Aquaculture High School
- California State University (Chico, Humboldt, Long Beach, Monterey Bay, San Diego, San Francisco, San Jose)
- Cape Fear Community College
- Central Connecticut University
- College of the Atlantic
- College of Charleston
- Colorado State University
- Columbia University
- Cornell University
- Coastal Carolina University
- Dartmouth University
- Dillard University
- Duke University
- East Carolina University
- East Tennessee State University
- Eckerd College
- Fairfield University
- Florida A&M University
- Florida Atlantic University
- Florida Institute of Technology
- Florida International University
- Florida Marine Research Institute
- Florida Memorial College
- Florida State University
- Hampton University
- Harvard University
- Hawaii Preparatory Academy
- Iona College
- Iowa State University
- Jackson State University
- Kutztown University
- Louisiana State University
- Marine Biological Laboratory (Woods Hole)
- Massachusetts Institute of Technology
- McNeese State University
- Monmouth University
- Montana State University
- North Carolina State University
- Nova Southeastern University
- Old Dominion University
- Oregon Health & Science University
- Oregon State University
- Rutgers University
- St. Georges School, RI
- St. Mary's College, CA
- Savannah State University
- Sonoma State University
- State University of New York (Stony Brook)
- Texas A&M University
- Texas Tech University
- The Sound School, CT
- Universidad Metropolitana, Puerto Rico
- University of Alaska
- University of California (Berkeley, Davis, Irvine, San Diego, Santa Barbara, Santa Cruz)
- University of Charleston
- University of Colorado
- University of Connecticut
- University of Delaware
- University of Florida
- University of Hawaii
- University of Idaho
- University of Kansas
- University of Maine
- University of Maryland
- University of Massachusetts
- University of Miami
- University of Minnesota
- University of New Hampshire
- University of North Carolina
- University of Puerto Rico
- University of Rhode Island
- University of South Alabama
- University of South Florida
- University of Southern Mississippi
- University of Tennessee
- University of Texas
- University of Virginia
- University of West Florida
- University of Washington
- University of Western Carolina
- Virginia Institute of Marine Sciences
- Virginia Polytechnic Institute and State University
- William and Mary (College of)
- Worcester Polytechnic Institute
- Yale University

Federal Agencies

- Bonneville Power Administration
- National Aeronautical and Space Administration
- National Research Council
- National Science Foundation
- Regional Fishery Management Councils (8)
- Smithsonian Institute
 - American Museum of Natural History
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture
- U.S. Department of Commerce
 - National Oceanic and Atmospheric Administration
- U.S. Department of Defense
 - Civil Applications Committee
 - Navy
 - Naval Research Laboratory
 - Fleet Numerical Meteorology and Oceanography Center
 - Naval Postgraduate School
 - Office of Naval Research
- U.S. Department of Energy
 - Brookhaven National Laboratory
 - Oak Ridge National Laboratory
- U.S. Department of the Interior
 - Bureau of Reclamation
 - Fish and Wildlife Service
 - Geological Survey
 - Minerals Management Service
 - National Park Service
- U.S. Department of State
- U.S. Department of Transportation
 - Coast Guard
 - Maritime Administration
- U.S. Environmental Protection Agency
- U.S. Marine Mammal Commission

State Agencies

- Alabama Department of Natural Resources
- Alaska Beluga Whale Committee
- Alaska Department of Fish and Game
- Alaska Department of Environmental Conservation
- Alaska North Slope Borough
- Atlantic States Marine Fisheries Commission
- California Dept. of Water Resources
 - Interagency Ecological Program
- California Dept. of Fish and Game Commission
- California Health Department
- Connecticut Department of Environmental Protection
- Connecticut-New York Long Island Sound Habitat Restoration Committee

- Delaware Department of Fish and Game
- Exxon Valdez Oil Spill Trustee Council
- Florida Department of Environmental Protection
- Florida Department of Natural Resources
- Florida Fish and Wildlife Resources Commission
- Georgia Department of Natural Resources
- Gulf States Marine Fisheries Commission
- Hawaii Coastal Zone Management Program
- Hawaii Department of Business, Economic Development and Tourism
- Long Island Sound Lobster Mortality Working Group
- Hawaii Department of Land and Natural Resources
- Idaho Department of Fish and Game
- Louisiana Department of Wildlife and Fisheries
- Maine Department of Marine Resources
- Maine Water Resources Authority
- Maryland Department of Natural Resources
- Massachusetts Department of Natural Resources
- Mississippi Bureau of Marine Resources
- New Hampshire Fish and Game Department
- New Jersey Department of Environmental Protection
- New Jersey Fish, Game and Wildlife
- New York Department of Environmental Protection
- North Carolina Department of Environmental and Natural Resources
- North Carolina Department of Transportation
- North Carolina Maritime Museum
- North Carolina Sea Grant
- North Carolina Shellfish Sanitation
- North Carolina Wildlife Resources Commission
- Oregon Department of Fish and Wildlife
- Pacific States Marine Fisheries Commission
- Puerto Rico Department of Natural Resources
- Puget Sound Water Quality Action Team
- Rhode Island Department of Environmental Management
- South Carolina Department of Natural Resources
- South Carolina Marine Resources Department
- South Florida Water Management District
- Texas Parks and Wildlife Department
- Virgin Islands Department of Planning and Natural Resources
- Virginia Marine Resources Commission
- Virginia Marine Science Museum
- Virginia Sea Grant Consortium
- Washington Department of Fish and Wildlife
- Washington State Board of Technical & Community Colleges
- Waterford East Lyme Shellfish Commission

Fishing Vessels

- Alaska Dragger Association, Al Burch, F/V Hazel

- Lorraine, Hickory Wind
- At-Sea Processors Association, Trevor McCabe, F/V Katie Ann
- Einar Peterson, Tim Cosgrove, F/V Vesteraalen
- Groundfish Forum Inc., John Gauvin, F/V American No. 1
- Fishermen’s Marketing Association (Fishing vessels determined by bid)
- Ocean Prowler Partnership, F/V Ocean Prowler
- Morning Star LP, David Stanchfield, F/V Morning Star
- Trident Seafoods, Jim McManus, F/V Aldebaran, Arcturus, Dominator

Industry

- AIRSTAR Communications
- American Bureau of Shipping
- Aquaseed, Inc.
- Aquatic Farms, Hawaii
- ARIS Corporation
- Atlantic Offshore Lobster Association
- Bandon Pacific Seafoods
- Beaufort Fisheries, Inc.
- Bornstein’s Seafoods
- Browning-Ferris Industries Inc.
- Cedar Island Marina, CT
- C&C Technologies
- Coastal Biomarine
- Daybrook Fisheries Inc.
- Downeast Lobster Association
- Destron-Fearing
- Fisherman’s Marketing Association
- Fishing Family Assistance Centers (New Bedford & Gloucester)
- Florida Power and Light (St. Lucie Power Plant)
- Garden State Seafood Association
- Gloucester Fishermen’s Wives Association
- Gulf and South Atlantic Fishery Development Foundation
- Hallmark Seafoods
- International Gamefish Association
- Jersey Coast Anglers Association
- Johnson Controls
- Kaman Aerospace Corp.
- Lotek Marine Technologies Inc.
- Makai Animal Clinic
- Maine Lobster Association
- Massachusetts Lobster Association
- Midwater Trawlers Association
- Monroe County Commercial Fisherman’s Association
- National Geographic Ocean Futures
- Natural Resources Consultants Inc.
- NET Systems Inc.

- North Carolina Power Company
- North Carolina Coastal Federation, Inc
- Ocean Imaging Co.
- Ocean Technology Foundation
- Omega Protein Inc
- Pacific Coast Seafoods
- Pacific Shrimp, Inc.
- Pacific Whiting Conservation Cooperative
- Pyrcon, Inc.
- Reed Mariculture
- Rhode Island Saltwater Anglers Association
- Science Applications International Corporation
- Scientific Fisheries Systems, Inc.
- Sea World of Texas
- Seafood Processor’s Association
- Simrad Inc.
- Sunbeam Sport Fishing Fleet
- Virginia Power Company
- Washington Fish Growers Association
- World Services, Inc.

Private & Non-Profit Organizations

- American Fisheries Society
- American Institute of Fishery Research Biologists
- Audubon Society
- Baldhead Island Conservation
- Center for Marine Conservation
- Chelonia, Inc
- Children’s Hospital
- Coastal Conservation Association
- COMPASS - COMMunication PARTnership for Science and the Sea
- Consortium for Oceanographic Research and Education
- Dolphin Ecology Project, Florida Keys
- Environmental Defense Fund
- Gulf of Maine Council on the Marine Environment
- Harbor Branch Oceanographic Institute
- Heinz Center
- Hubbs-Sea World Research Institute
- Jekyll Island Authority
- Karen Beasley Sea Turtle Rescue & Rehabilitation Center
- Marine Fish Conservation Network
- Monterey Bay Aquarium
- Monterey Bay Aquarium Research Institute
- Mote Marine Laboratory
- Nags Head Dolphin Watch
- National Fish and Wildlife Foundation
- National Aquarium in Baltimore
- National Geographic Society
- National Fisheries Institute

- Natural Resources Defense Council
- Nature Conservancy
- New England Aquarium
- Pacific Aquaculture Caucus
- Pacific Ocean Conservation Network
- Reef Environmental Education Foundation
- Regional Association for Research on the Gulf of Maine
- Savannah Science Museum
- Sierra Club–National Marine Fisheries & Habitat Commission
- The Dolphin Project
- Whale Acoustics, WY
- Woods Hole Oceanographic Institute
- World Wildlife Fund

Indian Nations & Groups

- Quilleute Tribe
- Nez Perce Tribe
- Northwest Indian Fish Commission
- Suquamish Tribe
- Yakama Indian Nation
- Northwest Indian College

International Agencies & Academic Institutions

- Asian-Pacific Economic Cooperation Forum (APEC)
- Australia
 - Commonwealth Scientific and Industrial Research Organization (CSIRO)
 - James Cook University
 - Murdoch University
 - South Australia Fisheries Department
 - University of New England
 - University of Queensland
- Brazil
 - National Institute for Research on the Amazon
- Canada
 - British Columbia Ministry of Environment Lands and Parks
 - Dalhousie University
 - Department of Fisheries and Oceans
 - McGill University
 - Queens University
 - University of New Brunswick
- Chile
 - Instituto de Fomento Pesquero
 - Universidad de Concepcion
- China
 - Overseas Fisheries Development Council
 - Chinese Academy of Sciences
- Denmark

- Danish Institute of Marine Fisheries
- France
 - IFREMER
- Ghana
 - Fisheries Laboratory
- Grand Cayman Island
 - Cayman Turtle Farm
- Greece
 - National Centre for Marine Research
- Ireland
 - Marine Institute of Ireland
 - University College Cork
- Israel
 - Limnological and Oceanographic Society
- Italy
 - University of Padua
- Japan
 - Fisheries Agency of Japan
 - Hokkaido University
- Mexico
 - Centro de Investigacion Cientifica y de Educacion Superior de Ensenada (CICESE)
 - Instituto Nacional de la Pesca (INP)
 - Investigaciones Mexicanas de la Corriente de California (IMECOCAL)
 - Universidad Nacional Autonoma de Mexico (UNAM)
- Morocco
 - Fisheries Research Institute
- Mozambique
 - Fisheries Research Institute
- New Zealand
 - National Institute of Water and Atmospheric Research
 - University of Otago
- Nigeria
 - Institute for Oceanography & Marine Research
- Norway
 - Akvaforsk
 - Institute of Marine Research (Bergen)
 - University of Bergen
- Portugal
 - Universidade da Madeira
- Russia
 - Pacific Research Institute of Fisheries and Oceanography (TINRO) Laboratory
- Senegal
 - Center for Research in Oceanography
- South Africa
 - Sea Fisheries Institute of South Africa
 - Natal Sharks Board
- Spain
 - Instituto Espanol de Oceanografia
 - Ministerio de Agricultura, Pesca y Alimentacion
- Taiwan

- National Taiwan University
- United Kingdom
 - Medical Research Center (Edinburg)
 - Natural Environment Research Council
 - Southampton University
 - University of Cambridge
 - University of Durham
 - University of Oxford
- Ukraine
 - Ukraine Southern Scientific Research Institute of Marine Fisheries and Oceanography (YUGNIRO)

International - Commissions

- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- Inter-American Tropical Tuna Commission (IATTC)
- Intergovernmental Oceanographic Commission (IOC)
- International Council for the Conservation of Atlantic Tunas (ICCAT)
- International Council for the Exploration of the Sea (ICES)

- International Institute for Fisheries Economics and Trade (IIFET)
- International Pacific Halibut Commission (IPHC)
- International Whaling Commission (IWC)
- North Pacific Anadromous Fish Commission (NPAFC)
- North Pacific Marine Science Organization (PICES)
- Northwest Atlantic Fisheries Organization (NAFO)
- Secretariat of the Pacific Community, Oceanic Fisheries Program (SPC)
- South Pacific Forum Fisheries Agency
- The World Bank
- United Nations
 - Food and Agriculture Organization (FAO)
 - Development Program
 - Development Organization
 - Educational, Scientific and Cultural Organization
- United States – South African Bilateral Commission

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Appendix 22. Cooperative Research Programs with the Fishing Industry

Increasingly, there is interest among fishers to participate more directly in the collection of information relevant to the status of exploited fishery resources. Traditionally, information collected from fishing operations has been utilized to characterize catches, discards and fishery-dependent abundance indices based on CPUE. However, improvements in technology to monitor fishing gear performance and to collect and transmit near real-time information on ship location and other positional and catch data present new opportunities to reevaluated fishers' roles in this process. Several pilot cooperative research projects have already been successfully completed and a number of new regionally-based projects are currently in progress, particularly in the northeastern U.S. A National Cooperative Research Program is currently under development.

Fishery-Dependent Data

Fishery catch data are a key component of stock assessments because these data document minimum mortalities attributable to fishing, biological characteristics of the harvested species and, if taken in time series, trends in relative catch rates and representation of strong and weak year classes. When combined with indices of abundance, they represent a critical element of stock assessments. Collection and analysis of fishery-dependent data remain problematic since it requires a distributed data collection system that must take census and sample data representing numerous fleets, gear types, ports, and target species. Millions of dollars are expended by federal, state and private entities to document fishery catches. Additional data on the discard patterns of fisheries need to be collected from fishing operations to document these mortalities. Traditional methods of paper logbooks, port samplers and hierarchical data systems are problematic because of the time-delays inherent in assembling these data and in the inevitable problems of data accuracy and completeness. Increasingly, managers require more timely information on patterns of catch and relative abundance on a stock-by-stock basis, at increasingly finer scales in time and space (e.g. in support of time/area restrictions on fisheries). Given

this need, there is growing consensus to utilize electronic data collection and transmission systems aboard fishing vessels to improve the accuracy and timeliness of such data for fishery stock assessment and management purposes, where feasible. Programs are underway in all regions to test the feasibility of electronic data collection and data transfer systems and, where tested, there seems to be broad-based support by fishers and fishing groups.

Fishery-Independent Surveys

Most fishery independent survey data are currently collected using either government research vessels or those chartered to the government to collect data in survey mode. The key consideration in developing time series of fisheries independent survey data is to assure that changes in survey catches are not the result of changes in gear efficiency or other operational concerns. There is a substantial unmet need, particularly in some regions, to survey stocks not covered by existing programs. Additionally, improvements in the precision of surveys and increases in spatial coverage may be necessary to support some management needs. Fishers are interested in assuming some of these responsibilities, particularly if the issues of survey comparability can be addressed. New technologies offer the ability to document the spatial coverage, bottom contact and other characteristics of towed and fixed gears, thereby offering the potential of addressing some of the gear standardization issues. Increasing fisher involvement in standardized surveys can improve the comprehensiveness of information available for stock assessment, and narrow the basis for disputes regarding stock status. Given the increasing availability of technology to monitor gear performance, and the increasing willingness of fishers to be involved in surveying activities, there appears to be a role for utilizing fishing vessels to improve fishery-independent indices in certain prescribed situations.

CONTACT: Steve Murawski, Northeast Fisheries Science Center, National Marine Fisheries Service.

Appendix 23. Summary of NOAA's Ocean Exploration Program

Purpose:

Specifically designed to involve the diverse research community beyond NOAA as well as participants from many NOAA Line Offices, the Ocean Exploration program endeavors to address a growing national interest in exploring unknown regions, processes, and life within the global ocean as well as an increasing awareness of the oceans' importance to our environment and quality of life.

Ocean Exploration is the search and systematic investigation of the oceans for the purpose of discovery. NOAA's Ocean Exploration Program seeks to bring the best of our nation's ocean scientists to our ocean frontiers to discover new species, ocean processes, cultural antiquities and artifacts, and biological and mineral resources. The Program is about discovery-based science which promotes the collaboration of multi-partners and multi-disciplines and endorses an ethic of ocean stewardship and educational outreach.

In June 2000, a U.S. panel of ocean scientists, explorers, and educators convened to create history's first National Strategy of Ocean Exploration. Their report, "Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration," is a responsible plan to undertake new activities in ocean exploration. NOAA is embarking on this new strategy through its Ocean Exploration Program, and desires to partner with public, private, and academic ocean exploration programs outside of NOAA.

The discovery of living and nonliving ocean resources has the potential to provide great benefit to people the world over. New antiinflammatory drugs are already being produced from deep-sea organisms. The relatively recent discovery of hydrothermal vent communities within the oceans has resulted in key knowledge about geological processes and plate tectonics.

Developments in biotechnology, telemetry, microcomputers and materials science now permit ocean scientists to aspire to the achievements of astronauts and the space program in our ability to go where we've not gone before. Like true explorers, we can now immerse ourselves in new places with new technologies to study and benefit from the undersea frontier.

Objectives:

By developing coordinated field campaigns aboard NOAA and other partner vessels, NOAA will embark upon several oceanic expeditions. By employing a full array of modern ocean technology, these explorations will survey, characterize, and define diverse marine environments. These innovative expeditions have the potential to rewrite oceanography and marine biology textbooks. Ocean Exploration presents possibilities for new solutions to problems we may face as we move into the 21st century.

In 2002, the regions of exploration include:

- Gulf of Mexico
- North Pacific off of CA, OR, WA and AK
- Northwestern Hawaiian Islands
- South Atlantic Bight
- Gulf of Maine
- Polar regions

The expeditions will weave together five science themes integral to ocean research, which were developed by NOAA scientists and reflect the core science requirements articulated by the U.S. Panel on Ocean Exploration, as follows:

- Finding New Ocean Resources
- Exploring Ocean Acoustics
- Documenting America's Maritime Heritage
- The Census of Marine Life
- Exploring New Frontiers

Also a vital program component is educational outreach. Ten percent of all funds dedicated to the Ocean Exploration Program will go to education and outreach products. This financial commitment builds on the investments already made via NOAA's existing education programs and partnerships, and it provides the vehicle for bringing ocean discovery to the forefront of the public's imagination.

CONTACT: Margot Bohan, Office of Ocean Exploration, NOAA.

Appendix 24. Summary of the Census of Marine Life Program

The Census of Marine Life (CoML) initiative, formalized in 1997, is an international research program aiming at assessing and explaining the diversity, distribution, and abundance of marine organisms throughout the world's oceans. This ambitious goal is to be reached by stimulating well-coordinated dedicated regional research efforts that together provide significant new information on patterns and processes of marine life on a global scale.

The decade-long global program of research was begun with developmental funding largely from private foundations and input from a variety of international workshops resulting in a scientific plan that addresses three questions: What lived in the oceans? What lives in the oceans? What will live in the oceans? NMFS researchers collaborating in CoML pilot projects are expected to deliver new information having direct relevance to SAIP objectives.

The first CoML objective is to focus on the historical composition of the oceans by attempting to identify and reconstruct species complexes. The intent is to develop baseline time series of population abundance and decline before human influences. This is consistent with NMFS' efforts to improve fisheries-independent data and to examine historical population trends.

The second question addresses what presently lives in the ocean and is the focus of new "pilot projects." These will demonstrate the feasibility of achieving a worldwide census of marine life based on new technologies to gather synoptic and synchronous measurements over large ocean areas.

The forward-looking question focuses on modeling ecosystem dynamics and comports well with SAIP's Tier 3 (Next Generation Assessments). In out-years, NOAA's mandate to begin managing ecosystems, rather than single species, has potential for strong synergies with the CoML.

In FY 2001, first-time external (non-NOAA) funding supports three pilot projects:

- *Pilot Census of Marine Life in the Gulf of Maine* will describe the distribution and abundance of individual taxa, relationships of these to each other and to the physical environment, and diversity of organisms [NEFSC].
- *Tagging of Pacific Pelagics (TOPP)* project will employ electronic tags to quantify and improve knowledge of how key ecological species in the North Pacific utilize the pelagic environment [SWFSC and NWFSC].
- *Pacific Ocean Salmon Tracking (POST)* program shares the objectives of TOPP, but for all marine life stages of Pacific salmon in the North Pacific [SWFSC].

NMFS/CoML researchers are expected to receive dedicated funding from the NOAA Office of Ocean Exploration, beginning in FY 2002. Dedicated field activities are scheduled to begin in FY 2003.

Additionally NMFS scientists will participate in the international program:

Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic. This effort contributes to the description and understanding of patterns of distribution, abundance, and trophic relationships of marine life inhabiting the deep waters of the mid-oceanic North Atlantic, and attempts to elucidate and model ecological processes causing variability in these patterns by employing advanced technology and new systematic studies [NEFSC].

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Appendix 25. A Non-Exhaustive List of Other Programs and Activities that Could Provide Data and Other Inputs to Help Launch Stock Assessments Towards Tier 3

- The Oceans Commission, which was set up by the Oceans Act of 2000 (S.2327; Public Law 106-256) and is charged with assessing existing and planned ocean-related facilities and technologies, reviewing existing and planned ocean and coastal activities and opportunities, and recommending changes to U.S. law to improve management, conservation, and use of ocean resources.
- The GLOBal ocean ECosystems dynamics program (GLOBEC). Contact: Michael.Fogarty@noaa.gov
- Various Global Climate Change Initiatives. Contact: Suzanne.Bolton@noaa.gov
- Report of the National Task Force for Defining and Measuring Fishing Capacity, by J.M. Ward, T. Brainerd, S. Freese, P. Mace, M. Milazzo, D. Squires, J. Terry, E. Thunberg, M. Travis, J. Walden. Study currently under review. Contact: John M. Ward, Office of Science and Technology, NMFS; John.M.Ward@noaa.gov
- Identifying harvest capacity and overcapacity in federally managed fisheries: a preliminary and qualitative report. Office of Science and Technology and Office of Sustainable Fisheries, National Oceanic and Atmospheric Administration, Department of Commerce. March 2001. Contact: John.M.Ward@noaa.gov
- United States National Plan of Action for the Conservation and Management of Sharks. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce. February 2001. URL <http://www.nmfs.noaa.gov/sfa/Final%20NPOA.February.2001.pdf>
- The FWS/NOAA Aquatic Nuisances Program. URL <http://anstaskforce.gov/ansrpt-exec.htm>