IMPROVING THE USE OF THE "BEST SCIENTIFIC INFORMATION AVAILABLE" STANDARD IN FISHERIES MANAGEMENT

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

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Committee on Defining Best Scientific Information Available for Fisheries Management

Ocean Studies Board

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

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Preface

Understanding what comprises the best available science for fisheries management is a subject of evolving interest to Congress, scientists, and stakeholders interested in effective management of the nation's living resources. The science used to support fisheries management is integral to providing sustainable fisheries.

To this end, the National Research Council Committee on Defining Best Available Science for Fisheries Management (Appendix A) was charged with the difficult task of examining the application of the term "best scientific information available" as the basis for fishery conservation and management measures required under National Standard 2 of the Magnuson-Stevens Act and recommending approaches for the more uniform application of the standard based on the "best scientific information available" for fisheries management. The committee gave careful consideration throughout this process to keeping its recommendations within the context of current and future fisheries management efforts.

Committee members were chosen for their expertise in fisheries science and management. The committee met on two separate occasions to discuss and plan this report. At the first meeting in Seattle, Washington, on July 16-17, 2003, the committee organized a workshop to draw upon additional expertise and points of view on the perceived need for further definition of "best scientific information available" and to explore approaches for improving the application of National Standard 2 in the preparation of fishery management plans. The workshop was convened in Washington, D.C., on September 8-9, 2003 (Appendix B). At the workshop, the committee and attendees heard keynote presentations and participated in panel discussions on perspectives from regional fisheries management councils, House and Senate subcommittees involved in reauthorization of the Magnuson-Stevens Act, and organizations involved in fisheries-related lawsuits. In breakout groups, participants were asked to comment on how "best scientific information available" should be defined, if a ranking or bar system should be employed to information submitted to councils, and whether it should be codified in law or in guidelines or regulations. Workshop participants, panels, and discussions helped set the stage for the fruitful committee discussions that followed. The committee also relied on written comments provided by the National Oceanic and Atmospheric Administration's (NOAA's) regional fisheries science centers and regional fishery management councils responding to an e-mail questionnaire on how they interpret best science to develop fishery management plans (Appendix C).

The committee hopes that the recommendations provided in this report can be used to guide NOAA Fisheries continued commitment to the effective management of the nation's fisheries resource for the benefit of all stakeholders.

Committee on Defining Best Available Science for Fisheries Management

Acknowledgments

This report was greatly enhanced by the participants of the workshop held as part of this study. The committee would first like to acknowledge the efforts of those who gave presentations at meetings: Dayton Lee Alverson, Carli Bertrand, Eric Bilsky, William Fox, David Fluharty, Daniel T. Furlong, Peter Huhtala, Andrew Minkiewicz, Graciela García-Moliner, Jake Rice, John Sibert, Margaret Spring, Patrick J. Sullivan, Usha Varanasi, Catherine Ware, and Pat White. These talks helped set the stage for fruitful discussions in the closed sessions that followed. In addition, the committee and staff would like to thank the following fisheries science center directors and the fishery management council executive directors for their prompt responses to the questionnaires; this was much appreciated, and the responses were extremely useful to the committee.

- <u>Regional Fisheries Science Center Directors</u>: Douglas P. DeMaster (Alaska), John Boreman (Northeast), Usha Varanasi (Northwest), Jeff Polovina (Pacific Islands), Nancy Thompson (Southeast), and Michael F. Tillman (Southwest)
- <u>Regional Fishery Management Council Executive Directors</u>: Paul J. Howard (New England), Chris Oliver (North Pacific), Daniel T. Furlong (Mid-Atlantic), Donald McIsaac (Pacific), Robert Mahood (South Atlantic), Kitty Simonds (Western Pacific), Wayne Swingle (Gulf of Mexico), and Miguel A. Rolon (Caribbean)

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in their review of this report:

DAVID FLUHARTY, University of Washington, Seattle
MARK LUNDSTEN, Queen Anne Fisheries, Inc., Seattle, Washington
GORDON H. ORIANS, University of Washington, Seattle
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ANDREW SOLOW, Woods Hole Oceanographic Institution, Massachusetts
PATRICK SULLIVAN, Cornell University, Ithaca, New York
VIDAR WESPESTAD, Resource Analysts, International, Lynnwood, Washington

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by **John Burris**, Beloit College, appointed by the Divison on Earth and Life Studies, and **May Berenbaum**, University of Illinois, appointed by NRC, who were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

Executive Summary

BACKGROUND

In the United States, the use of "best scientific information available" and related terms originated in legislation protecting marine mammals (Marine Mammal Protection Act of 1972), in amendments to the Endangered Species Act of 1973, and in establishing management standards for marine fisheries (Fishery Conservation and Management Act of 1976; reauthorized in 1996 as the Magnuson-Stevens Act). Under the Magnuson-Stevens Act, National Standard 2 specifies that "conservation and management measures shall be based upon the best scientific information available" (*Magnuson-Stevens Act*, sec. 301). Similar terminology has been included in subsequent federal and state environmental statutes.

Numerous lawsuits have challenged whether National Standard 2 has been met in fisheries management plans and other federal actions under legislation mandating the use of "best scientific information available." The federal courts have not defined "best scientific information available," but instead have examined the amount and quality of information available at a particular time in relation to the National Oceanic and Atmospheric Administration (NOAA) Fisheries' regulatory responsibilities to conserve and rebuild stocks.

National Standard 2 is currently under scrutiny as Congress develops legislation for reauthorizing the Magnuson-Stevens Act. Therefore, it is an opportune time to consider whether the phrase "best scientific information available" requires further explanation or definition in the new legislation or whether National Standard 2 can be implemented more effectively through agency-developed regulations or guidelines. The motivation behind these approaches lies in the desire to improve the application of scientific information in conservation and management decisions to reduce costly and time-consuming litigation.

A previous National Research Council (2002a) report also recognized this issue:

> …the National Standard 2 directive to use the best scientific information available has not provided sufficient guidance. Instead, it appears to have served as an invitation to challenge the validity of the scientific information used for stock assessments and for decisions on ecosystem aspects of management.

This study takes a more in-depth look at National Standard 2 and provides recommendations for more uniform application of "best scientific information available" in the preparation of fishery management plans.

STUDY SCOPE

NOAA Fisheries asked the National Research Council's Ocean Studies Board to examine the application of the term "best scientific information available" as the basis for fishery conservation and management measures required under National Standard 2 of the Magnuson-Stevens Act. In particular, the National Research Council was asked to consider the following questions:

- How should adherence to National Standard 2 be measured?
- How and when should it be employed?
- Should National Standard 2 be applied to exclude information deemed inadequate, or should information be ranked and applied in relation to relevance and rigor?

To gain perspectives on this issue from a broad spectrum of interested parties, the study committee convened a workshop in September 2003 to discuss the original rationale behind National Standard 2 and its subsequent application in developing fishery management plans. In addition to considering the above questions, workshop participants (Appendix B) explored the interpretation of National Standard 2 by the courts in response to legal challenges of the scientific basis of regulatory actions. The committee also requested information from each of the regional fisheries science centers and fishery management councils on their interpretation and application of National Standard 2 (Appendix C).

The committee recognized that the process of fisheries management is complex and includes issues beyond those addressed here. However, because of the short time frame provided to complete this report and address its charge, the committee concentrated the discussion and recommendations on those aspects that are most directly affected by application of the "best scientific information available" standard.

DEFINING THE PROBLEM

NOAA Fisheries is responsible for fisheries management within the exclusive economic zone of the United States. NOAA's regional fisheries science centers conduct stock assessments, gather scientific information, and provide social and economic analyses for fisheries on an annual basis. The scientific information they produce is provided to the eight regional fishery management councils and their advisory committees for the development of fishery management plans for stocks within each region. The Secretary of Commerce is invested with the authority to approve or remand the plans based on whether they are in compliance with the 10 national standards specified by the Magnuson-Stevens Act.

The interpretation and application of scientific information in fishery management plan development may have the potential to form the basis for contentious policy decisions. Council members generally have little or no expertise in stock assessment science, and they rely on advice received during council meetings from their expert panels as well as from NOAA scientists and interested members of the public. The role of the councils is to use scientific advice to manage and conserve resources while simultaneously balancing competing fishery interests. In some cases, controversy over the scientific information used in stock or other assessments has delayed management action or reduced the influence of the scientific advice in the development of a management plan. Without a clearer understanding of how scientific assessments are developed, validated, and applied under National Standard 2, more management decisions will be destined for costly and time-consuming litigation.

Although there are common elements in the application of "best scientific information available" among the councils, there are differences resulting from region-specific characteristics of the exploited stocks and the types of data available to evaluate fish populations, fish habitat, and the socioeconomic status of the fisheries. In addition, there are differences in data quality (data-rich versus data-poor regions) and the amount of research conducted independently of the science centers (for example, fishery-funded research or observer programs).

PRINCIPAL FINDINGS

The following findings address the concerns regarding the "best scientific information available" as outlined briefly above. The findings are discussed in greater detail in the body of the report, and additional findings are presented in Chapter 4.

- **National Standard 2 embodies the idea that decisions regarding management and conservation should be made in a timely and effective fashion with available information despite recognized data gaps.**
- **The Magnuson-Stevens Act provides specific guidelines for the development of fishery management plans; however, no guidelines exist for the uniform application of National Standard 2.**
- **Fisheries science centers and fishery management councils report a common *interpretation* of National Standard 2; however, there are both institutional and regional differences in the *application* of the standard.**
- **A statutory definition of what constitutes "best scientific information available" for fisheries management is inadvisable because it could impede the incorporation of new types of scientific information and would be difficult to amend if circumstances warranted change.**
- **Establishing procedural guidelines is the preferred alternative for creating accountability and enhancing the credibility of scientific information used in fisheries management.**

RECOMMENDATIONS

NOAA Fisheries should implement the guidelines presented below to govern the production and use of scientific information in the preparation of fishery management plans and supporting documents. Procedural consistency would provide NOAA with a stronger basis for defending controversial management decisions in court. More specifically, guidelines that address issues of relevance, inclusiveness, objectivity, transparency, timeliness, peer review, and the treatment of uncertainty are consistent with the procedural cues that have been sought by the courts. They will promote consistency in both the production and the use of scientific information without unduly constraining the ability of scientists to adopt new scientific protocols for data collection and analysis. Guidelines should remain sufficiently flexible to accommodate the strong regional differences in fisheries and the amount of scientific information available.

Guidelines

Relevance—Scientific information should be representative of the fish stock being managed, although the data need not be site specific or species specific. In some cases, analogous information from a different region or the biological characteristics of a related species or species with similar life-history strategies will be informative and relevant, and may constitute the best information available.

Inclusiveness—Scientific advice should be sought widely and should involve scientists from all relevant disciplines. The goal should be to capture the full range of scientific thought and opinion on the topic at hand. Critiques and alternative points of view should be acknowledged and addressed openly. Anecdotal (experiential, narrative, or local) information should be acknowledged and evaluated during the process of assembling scientific information. When no other information is available, anecdotal information may constitute the best information available. In addition, anecdotal information may be used to help validate other sources of information and identify topics for research.

Objectivity—Data collection and analysis should be unbiased and obtained from credible sources. Scientific processes should be free of undue nonscientific influences and considerations.

Transparency and Openness—Congress has enacted laws intended to give the public full and open access to the development of federal policies, including advisory meetings, background documents, and other sources of information. Accordingly, the public should have information about each phase of the process from data collection to data analysis to decision making. Decision makers should provide a clear rationale for the choice of the information that they use or exclude when making management decisions. The processes of collecting data and selecting research for use in support of management decision making should be open, broad-based, and carefully documented. All scientific findings and the analysis underlying management decisions should be readily accessible to the public. The limitations of research used in support of decision making should be identified and explained fully. Stock assessments and economic and social impact assessments should clearly describe the strengths and weaknesses of the data used in analyses.

Timeliness—There are at least two aspects to timeliness. First, timeliness refers to the acquisition of data in such a manner that sufficient time exists to analyze it adequately before it is used to make management decisions. Second, timeliness refers to whether the data are applicable to the current situation. Some types of information, such as the life-history characteristics of a species of fish, may not change over time, so they remain current. Other types of information, such as population survey data, have to be updated on a regular basis. Timeliness can also mean that in some cases, results of important studies and/or monitoring programs must be brought forward before the scientific team feels that the study is complete. Uncertainties and risks that arise from an incomplete study should be acknowledged, but interim results may be better than no new results at all. Management decisions should not be delayed indefinitely on the promise of future data collection or analysis. Fishery management plan implementation should not be delayed to capture and incorporate data and analyses that become available after plan development, except under extraordinary circumstances when a brief and clearly defined postponement is agreed upon by the management council and the Secretary of Commerce, and measures are already in place to ensure that overfishing will not occur during the delay.

Peer Review—Peer review is the most accepted and reliable process for assessing the quality of scientific information. Its use as a quality control measure enhances the confidence of the community (including scientists, managers, and stakeholders) in the findings presented in scientific reports. Peer review is not infallible, but it has proved valuable for uncovering errors and providing diverse perspectives on data collection, analysis, and interpretation. This includes cases in which documentation of the scientific information would be insufficient to validate or reproduce the results of an analysis of a given set of data. Reproducibility of data analysis is one important method for ensuring the validity of scientific information.

NOAA Fisheries should establish an explicit and standardized peer review process for all documents that contain scientific information used in the development of fishery management plans. Each region should have some flexibility to adapt peer reviews to individual circumstances; however, the following key elements should be included:

- the review should be conducted by experts who were not involved in the preparation of the documents or the analysis contained in them;
- the reviewers should not have conflicts of interest that would constrain their ability to provide honest, objective advice;
- all relevant information and supporting materials should be made available for review; and
- a peer review should not be used to delay implementation of measures when a fishery has been determined to be overfished.

Internal peer review of scientific information is often sufficient; however, an external review may be advisable when one or a combination of the following circumstances applies: questions exceed the expertise of the internal review team, there is substantial scientific uncertainty, the findings are controversial, or there are a range of scientific opinions regarding the proposed action.

Adherence to National Standard 2

NOAA Fisheries should require each fishery management council to provide explicit findings on how scientific information was used to develop or amend a fishery management plan. The use of the guidelines provided in this report will facilitate more uniform application of National Standard 2 and may help reduce the pressure on the councils to disregard scientific advice that would require difficult management decisions. Compelling the councils to explicitly document their interpretation and use of the scientific information would clarify their decision-making process and would provide the Secretary of Commerce with a clearer rationale for evaluating the merits of the fishery management plans in terms of National Standard 2.

The Secretary of Commerce should determine whether a plan adheres to National Standard 2 by the extent to which the guidelines

have been followed as part of the review for compliance with all 10 national standards specified by the Magnuson-Stevens Act. A rigorous secretarial review of the use of scientific information will result in a feedback process that will improve the compliance of fishery management plans with National Standard 2. The goal is to reduce the pressure on all parties to tailor the management plans to the interests of any one constituency, regardless of the scientific findings.

Scientific reports should explicitly identify the level of uncertainty in results, provide explanations of the sources of uncertainty, and assess the relative risks associated with a range of management options. Decision making in fisheries requires an accurate and understandable assessment of uncertainty and risk. Managers need to take into account both the short-term and the long-term effects of management actions. Scientists can help by estimating the risks to the fish population and to the fishery over different periods and in relationship to the uncertainties. Descriptions of uncertainty can also provide an index of the quality of available information that should then be used to help set research priorities.

NOAA Fisheries should develop and implement a plan to systematically improve the quality of the "best scientific information available" that includes regular assessments of the outcomes of management actions and evaluation of the predictive quality of the scientific information supporting those actions. After a management action has been passed by the council and approved by the Secretary of Commerce, a follow-up evaluation of the effects of that management action is rarely undertaken. Yet evaluation of the outcomes of management actions over time is necessary to ensure the continued use and refinement of scientific information. As the quality of scientific information improves, the basis for good management decision making will be stronger. Such an evaluation process requires explicit hypotheses (statements about relationships) regarding potential actions and their related system components. Properly designed studies will provide new knowledge that tests these hypotheses and leads to a more refined understanding of the consequences of management actions.

1

Introduction

The Fishery Conservation and Management Act of 1976 created eight regional fishery management councils (Figure 1.1) that oversee the management of fisheries in federal waters based on scientific advice provided primarily by the National Oceanic and Atmospheric Administration (NOAA) Fisheries. The primary responsibility of the regional councils is the development of fishery management plans (FMPs). The regional fishery management councils are responsible for preparing management plans for marine species under federal jurisdiction within the U.S. exclusive economic zone.

The process of FMP development consists of five phases: (1) development of draft documents; (2) public review and council adoption; (3) final plan review for compliance by NOAA Fisheries; (4) approval by the Secretary of Commerce; and (5) implementation. In general, members of the fishery management councils are not fishery scientists. For example, 83 percent of all appointed council members in 2002-2003 were either commercial or recreational fishers (NOAA Fisheries, 2004).

Therefore, to develop FMPs the councils depend upon the scientific and technical expertise of the NOAA Fisheries regional fisheries science centers that conduct stock assessments and social and economic impact analyses for the councils. The councils also have their own advisory committees in which NOAA Fisheries scientists, council staff, and independent scientists participate (e.g., scientific and statistical committee, plan development team, social science advisory committee). These committees provide data analysis, review, and advice about the information used in developing FMPs. In some instances, scientists outside of these committees are asked to provide additional advice and commentary. NOAA Fisheries is required to approve, disapprove, or partially approve FMPs developed by the councils. The Secretary of

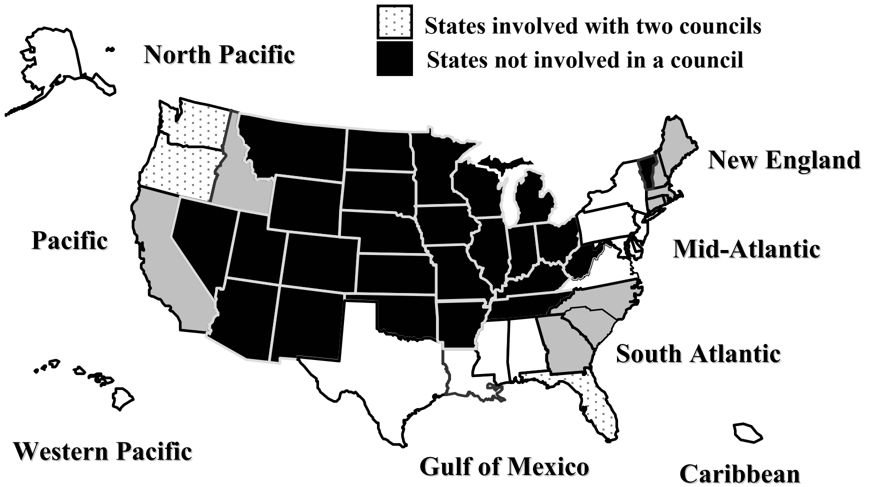

FIGURE 1.1 Map of the states and territories covered by the eight regional fishery management councils (used with permission from the National Oceanic and Atmospheric Administration).

Commerce, advised by NOAA Fisheries, must determine whether each FMP is in compliance with the 10 national standards contained in the Magnuson-Stevens Act as amended in 1996 (Box 1.1) prior to implementation.

These standards include the requirement to prevent overfishing and to rebuild overfished stocks. National Standard 2 specifies that "conservation and management shall be based upon the best scientific information available" (*Magnuson-Stevens Act*, sec. 301). Similar requirements appear in other environmental statutes such as the Marine Mammal Protection Act, the Endangered Species Act, and the Safe Drinking Water Act (Box 1.2).

BOX 1.1
National Standards in the Magnuson-Stevens Act
(*Magnuson-Stevens Act*, sec. 301)

(a) IN GENERAL—Any fishery management plan prepared, and any regulation promulgated to implement any such plan, pursuant to this title shall be consistent with the following national standards for fishery conservation and management.

1) Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the U.S. fishing industry.
2) Conservation and management measures shall be based on the best scientific information available.
3) To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4) Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5) Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
6) Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
7) Conservation and management measures shall, where practicable, minimize cost and avoid unnecessary duplication.
8) Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts in such communities. [Added in 1996]
9) Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize mortality of such bycatch. [Added in 1996]
10) Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea. [Added in 1996]

BOX 1.2
"Best Science" Clauses in Federal Legislation

The Marine Mammal Protection Act of 1972

> The Secretary, on the basis of the 'best scientific evidence available' and in consultation with the Marine Mammal Commission, is authorized and directed from time to time, having due regard to the distribution, abundance, breeding habits, and times and lines of migratory movements of such marine mammals, to determine when, to what extent, if at all, and by what means, it is compatible with this chapter to waive the requirements of this section so as to allow taking, or importing… (*Marine Mammal Protection Act*, sec. 1371).

The Endangered Species Act of 1973

- In determining whether to list a species as threatened or endangered, the Secretary shall make determinations based "solely on *the best scientific and commercial data* available to him" (*Endangered Species Act*, sec. 1533).
- In designating critical habitat, the Secretary shall make designations "on the basis of the *best scientific data available* and after taking into consideration the economic impact" (*Endangered Species Act*, sec. 1533).
- In taking actions that avoid jeopardy and protect critical habitat, the secretary "shall use the *best scientific and commercial data available*" (*Endangered Species Act*, sec. 1536).

The Magnuson Fishery Conservation and Management Act of 1976, National Standard 2

"Conservation and management measures shall be based upon the *best scientific information available*…" (*Magnuson Fishery Conservation and Management Act*, sec. 301).

Amendments to Safe Drinking Water Act of 1996

> In carrying out this section and, to the degree that an Agency action is based on science, the Administrator shall use—
>
> (i) the best available, peer-reviewed science and supporting studies conducted in accordance with sound and objective scientific practices; and
> (ii) data collected by accepted methods or best available methods (if the reliability of the method and the nature of the decision justifies use of the data.). (*Amendments to Safe Drinking Water Act*, sec. 300g-1)

The scientific information produced under the authority of the Magnuson-Stevens Act leads to policy decisions in the form of FMPs. FMPs come under close scrutiny by environmental, recreational, and commercial fisheries and seafood processor groups. In some cases, these groups have sued the Secretary of Commerce, in part, over whether management actions are based upon the "best scientific information available" as required under National Standard 2. The quality of the scientific information used in stock assessments has been a frequent target because these assessments form the basis for establishing fishing limits, which in turn affect the allocation of fish among user groups.

In these cases, the federal courts have not defined "best scientific information available" but have ruled that the standard does not require conclusive evidence. The courts have required that management measures be *based* on scientific information and not on political judgments. In part as a consequence of frequent litigation and complaints from constituents, current bills for reauthorization of the Magnuson-Stevens Act include detailed definitions of "best scientific information available."

The scientific information used in FMPs has become a target of lawsuits because the Magnuson-Stevens Act requires that fisheries be managed to prevent overfishing while achieving optimum yield (Box 1.1) based on the "best scientific information available." If the scientific information indicates that a stock is overfished, the act requires that regulations must be enacted to constrain fishing and allow the stock to recover. To avoid being subject to sometimes severe reductions in allowable catch, the industry has often challenged the scientific information underlying the finding that the stock is overfished.

PURPOSE AND GOALS OF THE STUDY

The National Research Council Committee on Defining Best Available Science for Fisheries Management was charged with examining the application of the term "best scientific information available" as the basis for fishery conservation and management measures required under National Standard 2 of the Magnuson-Stevens Act (Box 1.3). The committee focused on the application of National Standard 2 and the development of procedures to ensure that the "best scientific information available" is used consistently to support management decision making. In carrying out its charge, the committee considered related environmental legislation, such as the Marine

Mammal Protection Act and the Endangered Species Act, because they contain similar directives on the use of scientific information in formulating policies.

BOX 1.3
Statement of Task

This study will examine the application of the term "best scientific information available" as the basis for fishery conservation and management measures required under National Standard 2 of the Magnuson-Stevens Act. A workshop will be convened to discuss the original rationale behind this standard and its subsequent application in developing FMPs. Workshop attendees will also explore the interpretation of this standard by the courts in response to legal challenges of the scientific basis of regulatory actions. Questions to be considered include the following:

- How should adherence to the standard be measured?
- How and when should it be employed?
- Should the standard be applied to exclude information deemed inadequate, or should information be ranked and applied in relation to relevance and rigor?

A brief report will be produced with recommendations for more uniform application of "best scientific information available" in the preparation of FMPs.

This report refers to previous efforts to define "best scientific information available" or develop processes that will standardize the way in which the information is generated and applied. During the course of this study, the committee sought to identify procedures that could be adopted to standardize the application of the term "best scientific information available" as it is applied to fisheries management.

The committee recognized that the process of fisheries management is complex and includes issues beyond those addressed here. However, because of the short time frame provided to complete this report and address its charge, the committee concentrated the discussion and recommendations on those aspects that are most directly affected by application of the "best scientific information available" standard.

REPORT STRUCTURE

The report is organized to first present an overview of how "best scientific information available" has been formulated in legislation, implemented by management agencies, and interpreted by the courts. Chapter 2 presents the legislative history of the phrase "best scientific information available," the application of National Standard 2 to fisheries management, and the challenge of addressing uncertainty in the decision-making process. Chapter 2 also includes a summary of the court's interpretation of National Standard 2. Chapter 3 presents previous and ongoing efforts to define or delimit "best scientific information available." Chapter 4, the final chapter of this report, contains the committee's findings and recommendations, which include guidelines for standardizing the production and application of "best scientific information available" in the development of FMPs.

This report contains eight appendixes that provide additional background information. Appendix A presents the biographies of the National Research Council Committee on Defining Best Available Science for Fisheries Management. Appendix B lists attendees that participated in the Workshop on Defining Best Available Science for Fisheries Management in September of 2003. Appendix C contains questionnaires sent to the regional fisheries science centers and regional fishery management councils to help the committee determine how they use "best scientific information available" in their decision-making process. Appendix D provides federal regulations that support FMP development with regard to National Standard 2. Appendix E contains a list of acronyms used in this report. Appendix F is a compilation of regional fisheries science centers and the committees that conduct stock assessment and peer review and of the fishery management councils they support and the committees and panels that provide advice. Appendix G is a copy of the report of a fisheries workshop by the Consortium for Oceanographic Research and Education completed on February 18, 2000. Appendix H provides examples of recent case law supporting guidelines for "best scientific information available."

2

National Standard 2: From Origin to Application

LEGISLATIVE HISTORY: ORIGINS AND RATIONALE

Congress invoked the first "best available science" clause of the modern genre in the Marine Mammal Protection Act (MMPA) of 1972. It allowed the Secretary of Commerce to waive the general moratorium on mammal takes required elsewhere in MMPA "on the basis of the best scientific evidence available and in consultation with the Marine Mammal Commission"[1] (National Oceanic and Atmospheric Administration, 1998). Congress turned to a "best available science" clause again in the Endangered Species Act (ESA) of 1973, requiring that endangered species listing decisions proceed "on the basis of the best scientific and commercial data" (*Fishery Conservation and Management Act*, sec. 2) and after consultation with appropriate parties. Congress has used various "best available science" formulations repeatedly in amendments to these two laws: 12 similar "best available science" clauses are found in MMPA and 8 more appear in ESA. These and other environmental laws enacted in the 1970s provide context for Congress' use of the phrase "best scientific information available" in the Fishery

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[1] It is worthwhile to note that one of the original bills that ultimately became the Fisheries Conservation and Management Act provided for an independent body that would have served as a source of scientific expertise to ensure that the best scientific information available actually formed the basis for conservation and management. A similar structure is used in MMPA, which creates the independent Marine Mammal Commission to consult on all the determinations that are required under MMPA.

Conservation and Management Act (FCMA) of 1976 (later amended and renamed the Magnuson-Stevens Act).

Congress declared in its original statement of purpose in 1976 that its intent with passage of the Fishery Conservation and Management Act was to ensure "that the national fishery conservation and management program utilizes, and is based upon, the best scientific information available" (*Fishery Conservation and Management Act*, sec. 2). This purpose was embodied in National Standard 2, which has its origins in the draft Law of the Sea Treaty in circulation in the early 1970s. Neither the congressional statement of purpose nor National Standard 2 has changed since 1976. A report of the Senate Commerce Committee described National Standard 2 "as an important adjunct" of National Standard 1 and stated that it "must be recognized as one of the most important standards" (Senate Committee, *Fishery Conservation and Management Act*, 94).

There is little doubt, given the context of the times and the paucity of knowledge of fish populations, that the original intent of National Standard 2 was that management and conservation measures would proceed in a timely fashion despite recognized uncertainties in the scientific information. In its report, the Commerce Committee insisted that "there should be no uncertainty that the basic goal of management is to protect the productivity of fish stocks" (Senate Committee, *Fishery Conservation and Management Act*, 94).

The Commerce Committee recognized that if certainty were required before a management action could be taken in the inherently uncertain arena of natural resource ecology, policies already recognized as detrimental would be continued under the guise of doing no harm. Hence, the consequences of not taking action must be assessed with the same level of scrutiny as other management alternatives (Dayton, 1998). This idea was later included as part of the precautionary approach to fisheries management recommended by the United Nation's Food and Agriculture Organization (1995) in the code of conduct for responsible fishing and required by the United Nation's Agreement on Straddling and Highly Migratory Fish Stocks.

Nevertheless, the U.S. Senate Commerce Committee did not view decision making with limited information as a panacea for future fisheries management, as evidenced by these statements from its report:

> As just stated, a basic management objective is to harvest a stock of fish at the level of optimum utilization. If little is known about the size of the stock or environmental effects on other stocks or similar

> relationships, however, even the best management regime will fail. Therefore another primary goal must be to **achieve** [emphasis added] the best available scientific information about the stocks. The term "scientific information" is meant to include not only biological and ecological data but also economic and sociological information as well. (Senate Committee, *Fishery Conservation and Management Act*, 94)

The practical consequence of the congressional intent in using the phrase "achieve the best available scientific information" is that the National Oceanic and Atmospheric Administration (NOAA) Fisheries and the councils also have the responsibility to improve scientific information for decisions in future years. Thus, being able to make decisions with limited scientific information should not be used as an excuse for not doing research to improve scientific information. Because NOAA Fisheries has a limited capacity to support data collection and analysis to improve the scientific information used in stock assessments, "achieving" the best scientific information has not been possible for all fisheries. In fisheries that are managed with outdated or insufficient information, some stakeholders have therefore argued that scientific information should meet an independent standard before it is deemed worthy to be used as a basis for decision making.

DECISION MAKING UNDER UNCERTAINTY

Much of the dissatisfaction with the quality of science used in fishery management decisions arises from uncertainty in the scientific information available. An understanding of both the origins of this uncertainty and how it affects management decisions is necessary to completely understand the application of National Standard 2. First, it is important to realize that uncertainty is characteristic of scientific research, especially as it relates to natural resources. This uncertainty exists due to the complexity of natural systems, the length of time required to conduct experiments in the natural world, and in some cases, the limited availability of funds for research (Rice and Richards, 1996; Francis and Shotton, 1997). There is substantial uncertainty in the scientific knowledge of fish population dynamics and the effects of fishing because the measurements of populations are imprecise, and the interactions among human, biological, and physical systems are especially complex and usually unknown.

Given that uncertainty exists, it is important that the science underpinning management decisions assess the level of uncertainty by developing and testing alternative hypotheses and conducting sensitivity analyses to determine where uncertainties in parameter estimations are likely to have the greatest management consequences. Also, such analyses will identify important gaps in information where additional research is needed. Under an adaptive management framework, new information can be incorporated as it becomes available.

There are a number of ways of expressing uncertainty (National Research Council, 1998; Patterson et al., 2001). The simplest way is to determine the statistical imprecision of an estimate based on the standard error and/or the confidence interval. More complex methods are used by stock assessment scientists to determine the relative probability that a given catch level will result in population persistence or population collapse over time. This requires translating uncertainty into an expression of risk that is then available to decision makers charged with managing risk. When presented with an explicit description of risk, decision makers are better able to evaluate actions relative to the potential consequences of undesirable and irreversible outcomes.

Currently there is no standard for determining an acceptable level of risk. An example of a court decision in which the judge ruled that the probability of obtaining a desired result (e.g., rebuilding within some time frame) must be at least 50 percent is presented in Box 2.1.

Compliance with the objective to avoid undesirable outcomes should be considered along with the costs and benefits associated with other management objectives. In fisheries, the most common objective is to first consider maximum sustainable yield and use it as the basis for defining optimum yield, as stated in National Standard 1 in the Magnuson-Stevens Act. However, it is at least equally important to avoid population levels that are so low that they substantially increase the probability of collapse of the fish stock and, by extension, collapse of the fishery.

A management decision that allows a fishery to continue at a rate that ultimately forces its closure is undesirable for many biological, economic, and social reasons. Recognizing this situation, Congress added the mandate to avoid overfishing to the 1996 reauthorization of the Magnuson-Stevens Act. This objective is consistent with the precautionary approach of "acting before there is strong proof of harm, particularly if the harm may be delayed and irreversible" (Harremoës et al., 2002).

BOX 2.1
Natural Resources Defense Council v. Daley

Summer flounder (*Paralichthys dentatus*), a commercially valuable species harvested off the Atlantic coast, has been overfished since the early 1990s. When stocks are overfished, the fishery management plan (FMP) (or plan amendment) is required to specify a time period for rebuilding the fishery that is as short as possible (not to exceed 10 years) given the status and biology of the stock, the needs of fishing communities, and the interaction of the overfished stock within the marine ecosystem. The target fishing mortality rate for a stock maximizes the yield of a single year-class of fish over its entire life span. It represents the maximum mortality rate that will avoid overfishing while providing the optimum yield.

Despite the overfished condition, NOAA Fisheries recommended a quota for summer flounder in 1999 that afforded only an 18 percent likelihood of achieving the target fishing mortality rate. The National Resource Defense Council challenged NOAA Fisheries' quota on the grounds that it did not provide sufficient assurance that it would meet the conservation goals of the Magnuson-Stevens Act. The court decided that the 1999 quota was unreasonable because the proposed plan had at least an 82 percent chance of resulting in a mortality rate higher than the target rate. The court suggested that the management plan should have at least a 50 percent chance of achieving the target mortality rate, observing that "only in Superman Comics' Bizarro world, where reality is turned upside down, could [NOAA Fisheries] reasonably conclude that a measure that is at least four times as likely to fail as to succeed offers a 'fairly high level of confidence'" (*Natural Resources Defense Council v. Daley*, 209 F. Supp. 3d 747, 754 [D.C. Cir. 2000]).

The strategy for avoiding undesirable states has other implications for the decision-making process that raise a number of questions about the use of the "best scientific information available." Should there be a threshold level of uncertainty allowed in the scientific information used in fishery management decisions? It is unrealistic to require a specific level of certainty in scientific information in an inherently uncertain science such as fisheries. Such a goal would endlessly delay management decisions required to protect or utilize the resource effectively. Delay is in itself a decision with consequences that must be weighed. One way of dealing with this problem is to quantify the level of risk associated with a suite of management actions and possible states of nature to explicitly examine the trade-offs between action and inaction.

Should the same level of certainty be required in a decision that moves a system toward an undesirable state as in one that moves it away from an undesirable state? For example, to guard against overfishing, it seems reasonable to demand greater scientific certainty for a decision to increase fishing effort than is demanded for one to decrease it. This commonsense concept seems consistent with congressional intent and is a part of the precautionary approach. It is also relevant to court cases regarding the "best scientific information available," cases that predominantly pertain to economically important, heavily fished stocks whose status is in question (i.e., there is debate about their abundance).

When fisheries initially develop, landings are typically high. Although there is often little information about the underlying fish populations that support these fisheries, high catches lead to management decisions to allow higher catches and ultimately increased fishing capacity. Over time, catches may decline due to population depletion, resulting in a need to reduce fishing capacity. The immediate consequence of any decision to reduce capacity would be economic: loss of jobs and income for fishermen and processors and a difficult economic transition for the fishing community. These decisions naturally engender greater scrutiny, often leading to questions about the scientific information highlighting the uncertainty in fish population assessments and the unpredictable effects of proposals for reducing catch. Resource users may then focus on protecting their livelihoods for the short term rather than protecting the resource for the long term and, on that basis, advocate greater certainty in decisions that reduce fishing rather than in those that increase fishing. Choosing to err on the side of short-term economic security over long-term stock stability can lead to an undesirable state such as collapse of the fish stocks and consequent collapse of the fishery.

A major shift in thinking about uncertainty and decision making has surfaced in recent years. In the scientific arena, null and alternative hypotheses are proposed and tested, leading to either rejecting or accepting the null hypothesis. In fisheries management, the null hypothesis represents the situation in which there is no fisheries impact and, thus, management action is not needed. The alternative hypothesis is that the fisheries cause impacts and, thus, management action is needed.

The traditional approach in decision making has been to set a low probability for making a Type I error, that is, the error of incorrectly taking action when none is needed (e.g., harvest restrictions in excess of those needed for sustainability). The shift has been toward setting a low probability of making a Type II error, the error of incorrectly taking no action when action was needed (e.g., failing to regulate a fishery, resulting in overharvesting and stock collapse). Avoiding one type of error increases the probability of making the other type. This shift to emphasize Type II error, known as "reversal of the burden of proof" (Dayton, 1998), is changing the shape of scientific advice and the resulting natural resource policy. Yet formal guidance on how to balance Type I and Type II errors is not currently available.

NATIONAL STANDARD 2 IN APPLICATION

There are no federal guidelines that explicitly describe what constitutes "best scientific information available" as required by National Standard 2. However, NOAA Fisheries has published regulations that provide some specifics about the type of information to include in FMPs, and the importance of determining what type of new information is necessary to improve management (Appendix D). These regulations state explicitly that the "fact that scientific information concerning a fishery is *incomplete* does not prevent the preparation and implementation of an FMP" (*Fishery Conservation and Management Act*, sec. 2).

To understand how scientific reports and FMPs are produced in different management regions, the committee requested summaries of the process from each of the fisheries science centers and their associated fishery management councils (Table 2.1; Appendix C). Responses to the questionnaires were not complete or useful in all cases and therefore could not be used to conduct an in-depth analysis of the different procedures employed to evaluate scientific information among the regional management councils and science centers. Therefore, the guidelines recommended in Chapter 4 call for uniformity in the *application* of the "best scientific information available" rather than uniformity in the *process*. The council and science center responses, public input at the National Research Council workshop (Appendix B), NOAA web sites, and published literature provided an overview of the production and application of scientific information by the science centers and management councils.

Overall, there is broad overlap among regions in the *interpretation* of National Standard 2; however, there are both cultural differences among the science centers and the councils and region- and species-specific differences among the various centers and councils in its *application*. Regional differences result in large part from regional ecological conditions and socioeconomic standing. Indeed, the multiple fishery

TABLE 2.1 Regional Fisheries Science Centers and the Fishery Management Councils They Support

Regional Science Center	Fishery Management Council
Alaska Fisheries Science Center	North Pacific
Northwest Fisheries Science Center	Pacific
Southwest Fisheries Science Center	Pacific Western Pacific
Northeast Fisheries Science Center	New England Mid-Atlantic
Pacific Islands Fisheries Science Center	Western Pacific
Southeast Fisheries Science Center	South Atlantic Gulf of Mexico Caribbean

management councils were established to accommodate these differences. The councils have evolved as a result of regionalization to accomplish their required tasks. For example, “the eight councils take different approaches to decision making and management, as anticipated and intended by the act” (Hanna, 2002). This is evident in how the councils are structured as well as in how they address scientific questions. It is clear that the councils differ strongly in the ways they apply ecosystem principles to the fishery management process, respond to uncertainty (National Marine Fisheries Service, 1999), and organize and address problems (Miller, 1987). The quality of the data (e.g., data-rich versus data-poor regions), the value of the fishery, and the types of species being assessed may also vary from region to region, making it difficult in some cases to assess the differences in the way scientific information is used from council to council.

NATIONAL STANDARD 2 AS INTERPRETED BY NOAA FISHERIES SCIENCE CENTERS

NOAA Fisheries science centers consistently interpret "best scientific information available" as data systematically collected through established procedures and analytical products based on commonly accepted statistical techniques or models developed specifically for resource management.

Data sources and collection methodologies across science centers include both fishery-dependent and fishery-independent data gathered by numerous individuals, groups, and government agencies. Fishery-dependent data are collected by fishermen and processors through log books, trip tickets, and landing bills. They are also collected by state and federal agencies (or their contractors), through dockside intercepts (for both commercial and recreational fishers), through telephone surveys that relate to recreational fishing activities (e.g., Marine Recreational Fisheries Statistical Surveys), through telephone surveys that gather socioeconomic information, and through observer programs that provide detailed commercial catch, effort, and bycatch data.

Fishery-independent data are obtained through routine surveys conducted by NOAA Fisheries research vessels and chartered fishing vessels as well as through scientific research conducted by federal, state, and university scientists. New efforts at cooperative research between scientists and fishermen are also providing important sources of data (National Research Council, 2003). These cooperative projects engage fishers directly in the collection of data for stock assessments and management-related issues.

Typically, anecdotal or experiential information is not gathered in a systematic fashion (except as a part of specific sociological or anthropological studies) but is obtained and incorporated into the record through public comment from stakeholders (discussed below).

Not all data types are available for all fisheries. There are differences in the magnitude, frequency, and timeliness of data collection that characterize the various fisheries and regions. In addition, in some parts of the country, there is more trust and cooperation between the science center and the fishing fleet. Science benefits from that trust because of the flow of information in both directions. Alaskan fisheries tend to be data rich, with both fishery-dependent and independent surveys, while Caribbean fisheries suffer from a lack of data.

Science centers consider all of the data available to them, but do not necessarily incorporate all data in analyses. Data may be excluded *a* *priori* if they do not meet quality (precision and accuracy) or appropriate relevance standards, are dated, or appear to represent outliers due to equipment failures. In the North Pacific, all data may be included through weighting procedures incorporated into the stock assessment models. All relevant, high-quality data are included in the analyses using assessment models designed to account for different levels of uncertainty associated with specific data sources. The emphasis in the science centers is placed on ensuring that the analyses correctly communicate the risks and uncertainties involved with a variety of possible management decisions based on the information.

The regional fishery management councils, not the science centers or their advisory committees, are responsible for selecting among management options. This helps separate scientific from political issues. Science advisory committees are charged with advising the councils on the merits of natural and social scientific information presented, not with proposing policy. Doing so would have at least two undesirable effects: (1) the advisory committee would be perceived as advocating the policy options it proposes, and (2) its meetings would become politically charged with stakeholders attending with the intent of influencing the policies identified.

NATIONAL STANDARD 2 AS INTERPRETED BY FISHERY MANAGEMENT COUNCILS

The councils generally interpret "best scientific information available" as the most recent and relevant information available to them at the time of FMP development, typically as it appears in stock assessments and other reports generated through the science centers. Several councils, while lamenting the paucity of information on a number of stocks they are charged with managing, noted explicitly that in accordance with the mandate in the Magnuson-Stevens Act, limited information did not prevent them from making management decisions. The Western Pacific Fishery Management Council stated that "although comprehensive scientific information may be lacking in our fisheries, we do our best to provide [the public, council bodies, and council members] with the best information possible to aid the decision-making process" (Western Pacific Fishery Management Council, 2003).

Management councils typically do not collect scientific data. Rather, they rely on science centers to collect the bulk of the data used in the assessments and ultimately in FMPs. They also expect the science centers to ensure that those data meet data quality standards, as determined by stock assessment scientists.

However, the councils collect and record verbal and written anecdotal and experiential information, opinions, and recommendations from stakeholders and the interested public through responses to stock assessments and other reports, *Federal Register* publications, council meetings, and as part of the National Environmental Policy Act (NEPA) scoping process. This information is used in the preparation of FMPs, particularly in the development of possible management alternatives. Further, the councils often rely on the experiential information from fishermen as a means of corroborating scientific information, determining changes in stock distributions, and revealing data discrepancies. If the two types of information conflict, however, councils report that they more often than not defer to the scientific information.

NATIONAL STANDARD 2 IN PRACTICE: STOCK ASSESSMENTS AND FISHERY MANAGEMENT PLANS

The primary concern with the application of National Standard 2 for science centers is the stock assessments they conduct, and for councils it is FMPs they develop. Stock assessments contain all the available information (both published and through input from university and state agency scientists and stakeholders) on how stock demographics are collected, analyzed, and interpreted to determine the effects of fishing on fished populations (National Marine Fisheries Service, 2001). These assessments form the heart of FMPs, which in turn outline how the councils will achieve and maintain the optimum yield for each fishery.

Whereas data collection by the science centers occurs on an ongoing basis, stock assessments and other types of reports are produced primarily in response to requests from the councils and NOAA Fisheries regional offices. Each science center meets with the appropriate council(s), regional office, and relevant regional state fisheries commissions on a periodic basis to develop an operations plan for stock and economic assessments.

Stock assessments are generally performed by NOAA Fisheries scientists, although on occasion they may be conducted by paid consultants. The completed assessments undergo rigorous peer review (Box 2.2) both internally (within NOAA Fisheries) and, in many cases, externally before they are submitted to the councils for FMP development. This includes reviews from the Center for Independent

BOX 2.2
Peer Review

Peer review in science is one of the more important processes to which a body of scientific work is exposed. It is the process through which practitioners with technical expertise in a particular field provide objective, constructive criticism on the validity of a body of work to ensure its compliance with scientific methods. The review process uncovers scientific problems of method, interpretation, approach, or failure to provide sufficient detail to reproduce analytical results.

Although peer review is not perfect, it is an essential component in determining what constitutes the "best scientific information available" for use in policy decisions and ensures that managers focus on the science, free of economic, historical, and cultural factors (Meffe et al., 1998). It provides scientific advice on the quality of a body of work and therefore differs substantially in weight and substance from the opinions of those lacking similar scientific expertise.

Peer review of scientific information is applied extensively to the fishery management system, to manuscripts intended for publication in journals, and to the gray literature (stock assessments, dissertations, agency reports, white papers, and other types of scientific documents) that form the bulk of the science supporting management decisions. Gray literature may be subject to both internal and external peer review. The intent is to ensure that any questions about the science can be identified and, if need be, corrected.

In some cases, internal peer review—review conducted by scientists within the institution producing the report—is quite adequate. It reduces costs and allows decisions to be made in a timely manner. Problems may arise, however, when the issue is complex, is controversial, or has far-reaching implications for management. In this case, the internal review process used by NOAA Fisheries may be viewed as biased or insufficiently independent of the source of the report. An "inbred" review results if the relationship between the report authors and the report reviewers is too close to allow an independent assessment of the report. It is considered exclusionary if data sets—particularly those arising outside the agency—are categorically eliminated from consideration. It is therefore important that controversial reports be subject to independent, external peer review to avoid the perception of bias and conflict of interest.

Experts, which consists of a pool of scientists contracted to provide independent peer review for science conducted by NOAA Fisheries (Rosenstiel School of Marine and Atmospheric Science, 2003). Each regional science center has its own process for determining the "best scientific information available." The Northeast Science Center has for about the past 20 years used a two-part system consisting of stock assessment development conducted by the Stock Assessment Workshop and external peer review conducted by the Stock Assessment Review Committee.

In 2002, the Southeast Science Center developed a formal process, which is embodied in the Southeast Data Analysis and Review and involves three separate meetings that occur for the following purposes: (1) accumulation and review of the data by agency and academic scientists as well as fishermen and environmental stakeholders; (2) the conduct of stock assessments; and (3) the external peer review. Southeast Data Analysis and Review participants include agency and academic scientists, nongovernmental organizations, and recreational and commercial fishermen, as well as council members.

The Pacific region uses a combination of a stock assessment team and a review panel process called Stock Assessment Review (STAR). The different STAR panels are comprised of knowledgeable scientists who were not involved in the stock assessment and include members from outside the region. STAR panels hold working meetings, open to the public, in which they review draft stock assessment documents and any other pertinent information and then work with a stock assessment team to make necessary revisions to the stock assessment. A STAR panel report is written and used by the council to develop management recommendations. In the North Pacific, stock assessments are done primarily by the Alaska Fisheries Science Center and the Alaska Department of Fish and Game. Plan teams review the stock assessments at two meetings, and the scientific and statistical committee (SSC) performs subsequent reviews. In practice, the council treats SSC recommendations as upper limits for its catch recommendations. Outside reviews of stock assessments are sometimes conducted by either the Alaska Fisheries Science Center or the council when needs dictate.

The councils are the entities that initiate development of an FMP or an FMP amendment using scientific information provided by the centers. The Magnuson-Stevens Act specifies the contents of FMPs as described in 14 required and 12 discretionary provisions (*Magnuson-Stevens Act*, sec. 303). Relative to National Standard 2, this includes requirements that FMPs provide summaries of the information used to determine "the present and probable future condition of, and the maximum sustainable yield and optimum yield from, the fishery" (*Magnuson-Stevens Act*, sec. 303). Use of the "best scientific information available" as required by

National Standard 2 is inextricably linked with the uncertainties in biological systems and how that information is used in decision making. The role of science in this process is to quantify the risks involved in taking management actions by explicitly accounting for these uncertainties.

Also, FMPs must specify objective and measurable criteria for determining when stocks are overfished and provide an analysis of how the criteria were developed, including the relationship of the criteria to the reproductive potential of stocks in that fishery. The councils obtain advice (on FMP development, monitoring, and revision) from the states, the fishing industry, consumer and environmental organizations, and other interested parties through council membership and a number of advisory panels (Appendix F). Indeed, each council is required to "establish and maintain, and appoint the members of, a scientific and statistical committee to assist it in the development, collection, and evaluation of such statistical, biological, economic, social, and other scientific information as is relevant to such councils' development and amendment of any fishery management plan" (*Magnuson-Stevens Act*, sec. 302).

SSCs and other advisory bodies, which include members from a variety of disciplines, also help the councils establish FMP objectives and criteria for judging FMP effectiveness (*Magnuson-Stevens Act*, sec. 302) (Figure 2.1). They review stock assessment and fishery evaluation reports and ensure that the "best scientific information available" is being used by the science centers in developing FMPs. It is noted, however, that the councils have different structures for their advisory panels (Appendix F) and SSCs often serve different functions for different councils. Indeed, the Magnuson-Stevens Act does not specify how SSCs should operate. A number of councils underutilize the expertise of the advisory panels to help determine the most important research issues, according to some sources (e.g., Miller, 2002).

Typically, stock assessments appear in annual or semiannual stock assessment and fishery evaluation documents. An FMP requires an environmental assessment and regulatory impact review or an environmental impact statement for NEPA compliance. FMP development may involve stock assessment issues related to overfishing, but it also typically involves a variety of other issues related to access, seasons, and allocation, among others. As the Gulf of Mexico Fishery Management Council notes, "The quality control is inherent in the NOAA Fisheries entities providing the information and in the [stock assessment panels], [the socioeconomic panels], and SSCs using the

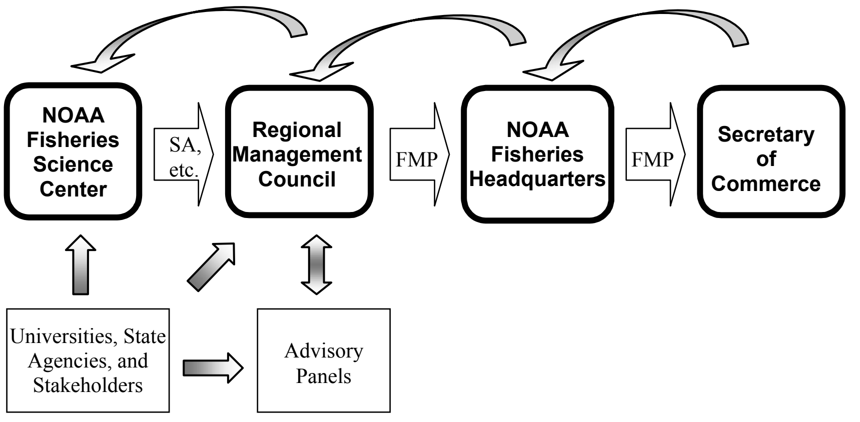

FIGURE 2.1 Flow of Scientific Information in the FMP development process (SA refers to a stock assessment).

information" (Gulf of Mexico Fishery Management Council, 2003). Where discrepancies occur, solutions are provided by the councils primarily with advice from NOAA Fisheries scientists, council advisory panels, and council staff. The scientific information is presented at council meetings, at advisory panel workshops, and at public meetings. The council staff (composed of scientists with expertise in population dynamics, sociology, and economics) then summarizes the assessments, the public input, and council deliberations to develop a draft FMP that contains alternative regulatory strategies, based on advice contained in the stock assessment. After further deliberation and public input, the council chooses among the alternatives, the council staff makes a final draft FMP and transmits it to the Secretary of Commerce for review, and the Secretary publishes a notification in the *Federal Register* that the plan is available for review and comment for 60 days. After that period, either the Secretary accepts or rejects the plan. If accepted, the final rule is published in the *Federal Register* and the plan is implemented. If the plan is not approved, the Secretary may either ask the council to change the plan or develop an alternative FMP, or the Secretary may submit an FMP amendment (Secretarial Plan), following the same format for review and input as the councils.

COMMUNICATING SCIENTIFIC RESULTS

Public participation in the management review process depends on the council's decision-making framework. In most cases, stakeholders may review assessments and help guide the decisions made by council members by submitting written or oral comments at open stock assessment workshops and public meetings publicized by the councils (except as noted in the Magnuson-Stevens Act).

The primary shortcoming of this format is that "open" and "accessible" cannot be construed as equivalent. Many fishermen do not attend the open meetings because they cannot afford the time away from work or the travel expenses associated with attending meetings. Further, even if they can attend, the information is not always accessible because of the form in which it is presented. Thus, the transfer of information is not always successful.

Scientists present their findings at public meetings to help council members, stakeholders, and the general public understand the scientific basis for the alternative management options being considered. Some scientists fail to do this effectively because their presentations are replete with complex terminology, methodologies, and theoretical concepts. Many fishermen lack this expertise, although nongovernmental organizations and fishing organizations often hire representatives who are conversant in the science and can interpret the information for their members.

Some council members may not be conversant in fishery science. Indeed, nearly all of the current 118 council members across the eight regional councils have no background in stock assessment science. The councils have expert scientists at their disposal on advisory panels and on review committees (Appendix F). Providing more training in scientific principles to council members is one means of making the translation of scientific information more effective. In addition, council members would benefit if those scientists who present information to the councils made a concerted effort to develop communication skills that effectively inform audiences with diverse, and often nontechnical, backgrounds.

FLAWS IN PRACTICE

Poor communication skills are not the only flaws in the application of National Standard 2. Data acquired by the science centers in a transparent fashion can ultimately contribute to flawed policy when the methods of data selection and analysis are not transparent or the limitations of the data are not acknowledged.

Good methodology is the bedrock of science. Without robust methods, the scientific information will be suspect. Further, the problem that looms largest in any regulatory milieu—whether fisheries management or environmental protection—comes at the point decisions are made about what scientific information to include and what scientific information to exclude from use in reaching important policy conclusions (Greer and Steinzor, 2002). The former is a problem for the science centers and the latter is typically a problem for the councils and ultimately NOAA Fisheries, the entities responsible for managing and conserving the fish stocks in federal waters.

The science centers have an incentive to apply "best scientific information available" correctly. They are scientific institutions with staff who apply scientific principles in their work and whose professional integrity is at stake. Councils, on the other hand, have a different mandate to use scientific advice to manage and conserve resources while balancing competing fishery interests (National Academy of Public Administration, 2002; Wilson and Degnbol, 2002). As outlined in this report, the generation of scientific information is itself a very complex problem. The interpretation and application of this information to fisheries management may be hindered by difficulties in communicating scientific conclusions, potentially leading to a disconnect between the two as management actions are developed.

The councils sometimes delay regulatory action concomitant with requests for additional information (Box 2.3), while disregarding peer review of stock assessments and the advice of the their own advisory bodies (Eagle and Thompson, 2003; U.S. Commission on Ocean Policy, 2004). NOAA Fisheries has the authority to approve, disapprove, or partially approve FMPs based on consistency with the conservation and management goals mandated by the Magnuson-Stevens Act. NOAA Fisheries also has the option to develop independent FMPs or amendments in the face of council inaction (Gulf of Mexico Fishery Management Council, 2002). However, both NOAA Fisheries and the councils are subject to political pressure that at times has moved management plans away from the recommendations of the scientific advisory bodies (Hanna, 2002; National Academy of Public Administration, 2002; U.S. Commission on Ocean Policy, 2004). Stakeholders, whether fishermen or environmentalists, have turned to the courts in disputes over the use of or disregard for scientific information.

BOX 2.3
Delayed Action: A Case Study on Vermilion Snapper in the Gulf of Mexico

NOAA Fisheries recognized that the vermilion snapper stock in the Gulf of Mexico was headed for trouble as early as 1991 when the first vermilion snapper stock assessment reported the species to be experiencing an exponential increase in fishing mortality. This forecast was followed by reports of stocks approaching an overfished condition (1998), experiencing overfishing (2000), and finally reaching an overfished condition (2001). NOAA Fisheries compiled a considerable body of scientific information—the "best scientific information available"—that consistently revealed the classic signs of overfishing. These included an overall decrease in landings, in mean size of fish in the commercial catch, in catch per unit effort, in recruitment of age-1 fish, and in the consolidation of the fishery into the most productive fishing areas.

The Gulf of Mexico Fishery Management Council failed to take any action, however, despite the requirements of the Magnuson-Stevens Act to end overfishing immediately once recognized; despite advice from NOAA Fisheries scientists, the Council's Reef Fish Stock Assessment and SSC advisory panels, and the NOAA General Counsel, and despite an explicit request from the Deputy Director of NOAA Fisheries. Rather, the council stated that it had little confidence in the status reported for vermilion snapper. Further, it declared that no action could be taken until additional data and follow-up analyses were available on age and growth, catch at age, fecundity rates, bycatch estimates, release mortality rates, and the effect of changes in fishing behavior on catch per unit effort—tasks that took several years to complete.

Currently, the council is working on proposed regulations to end vermilion snapper overfishing in the form of Draft Amendment 23 of the Reef Fish Fishery Management Plan, with a decision expected in 2004. However, the council is also asking for reevaluation of catch per unit effort and a new stock assessment. There are currently no regulations that would slow fishing mortality in this fishery.

INTERPRETATION OF BEST AVAILABLE SCIENCE BY THE COURTS

Courts are not immune from tactical forays in the use of "best science." They are the ultimate arbiters of agency decision making, and their rulings are based largely on what advocates present to them. Perhaps the best-known case of this type is the Supreme Court's *Daubert* decision

(Box 2.4). Disappointed stakeholders go to court to challenge agency decisions and must convince the court that some error was made in the decision-making process. This means that each link in the complex chain of administrative judgment is vulnerable to judicial review and can be tested after the fact by determined, informed, and highly interested critics.

The difficulties in defining the respective roles of science and law are revealed at the boundaries of environmental policy (Houck, 2003). "Good science" is often presented as that which supports the advocate's case. When scientific information is presented as the primary incentive for making a difficult or unpopular policy decision, the science will be attacked. This will bring added costs, inquiry, criticism of the scientists, and disruption of ongoing research and management activities. Scientific uncertainty will be used by those who object to the management action as a means to reject the conclusions of the scientific experts.

Congressional use of the term "best scientific information available" is one of several techniques commonly used to facilitate the preparation and influence of scientific information in the regulatory process along with mandates for scientific studies and the strengthening of scientific advisory apparatus. ESA contains "best science" clauses but also mandates *by law* that listing decisions be driven chiefly by the *biology* of the species, not subject to refutation for economic or social reasons (*Endangered Species Act*, sec. 1533). The "override" mechanism in ESA (commonly known as the "God squad") is so severely constrained by procedural hurdles that decisions to list are rarely appealed (*Endangered Species Act*, sec. 1536).

The rules for judicial review of science-based administrative choices are well known, but only in a general and frustratingly indeterminate fashion. Operative here is the so-called hard-look doctrine of judicial review that insists courts require agencies to explain, justify, and defend their decisions with a comfortable wrap of good sense, plausibility, and fair process. In several "best scientific information available" cases, the courts disapproved of the agency's treatment of science, condemning uses of poor analogy, stale data, end-run procedures, implausible assumptions, unexplained and erratic changes of course, failures to answer forceful objections, and fanciful guesswork (Appendix H).

A recent example of a court taking the agency to task over its failure to ground its actions in the "best scientific information available" is that involving essential fish habitat (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000]) (Box 2.5).

BOX 2.4
Daubert v. Merrell Dow Pharmaceuticals

In *Daubert v. Merrell Dow Pharmaceuticals* (509 U.S. 579 [S. U.S. 1993]), the U.S. Supreme Court prescribed the rules for the trial judge to follow in deciding whether expert testimony will be admitted to give guidance to the trier of fact (either the judge or the jury). This process is often described as the "evidentiary gatekeeper" function, and it obliges the trial judge to make a preliminary decision on the reliability of proffered scientific testimony. The Supreme Court explained:

> [The inquiry] entails a preliminary assessment of whether the reasoning or methodology is scientifically valid and of whether that reasoning or methodology properly can be applied to the facts in issue… The focus, of course, must be solely on principles and methodology, not on the conclusions that they generate.

Factors to be weighed include whether the theory or technique has been tested; whether it was subjected to peer review; the known or potential error rate; and whether it is generally accepted in the relevant scientific community.

In the course of its opinion, the Supreme Court adopted the so-called Popperian approach to science, asserting that "the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability" (Popper, 1989). Most state supreme courts have followed *Daubert* in defining exclusionary rules for expert testimony. Surveys of federal judges and attorneys confirm the belief that the *Daubert* rule has resulted in closer scrutiny of expert testimony and therefore more frequent exclusions of testimony.

Courts also afford agencies ample room to make predictions, order their own affairs, and experiment with process. However, NOAA Fisheries has recently begun to lose more cases under National Standard 2 (Figure 2.2). The losses may reflect poor advocacy, poor records, or simple mistakes. Also, cases may be lost because events move more rapidly than the judicial process or because understanding of the "best scientific information available" has undergone revision.

Still, NOAA Fisheries should not be indifferent to the instructions and lessons of judicial review. Policies and actions that win court approval enjoy stability, credibility, and longevity. Wins are better than losses, for many obvious reasons. Courts afford a continuing scrutiny of and commentary on agency performance on matters of scientific information that are not available from other entities. These judicial

BOX 2.5
American Oceans Campaign v. Daley

In 1996, Congress passed the Sustainable Fisheries Act amending the Magnuson-Stephens Act. One of its "main thrusts" was the long-term protection of essential fish habitat (EFH).

In August 1997, NOAA Fisheries contracted with the American Fisheries Society to undertake a comprehensive literature survey of scientific reports addressing fishing impacts on habitat. This survey, by Auster and Langton (1999), reviewed 90 studies from around the world "and concluded that 88 of them found some impacts resulting from fishing gear." Auster and Langton (1999) also concluded "that the overall impact of fishing-related activities in North American waters is unknown despite research efforts spanning 80 years."

On December 19, 1997, NOAA Fisheries promulgated EFH regulations, to become effective January 20, 1998 (*Fishery Conservation and Management Act*, sec. 2). It sent the Auster and Langton (1999) study to the regional councils and noted that it "was only a starting point, not a replacement for the EFH assessments for which the Fishery Management Councils were responsible" (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000]). The regional councils affected by the Magnuson-Stevens Act submitted draft EFH amendments to NOAA Fisheries for review and comments. In their final EFH amendments, "all Councils identified some EFHs within each of their jurisdictions, yet none adopted measures that restrict fishing gear in order to minimize adverse effects of fishing related activities on EFH" (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000]).

NOAA Fisheries partially approved these several amendments and wrote environmental assessments (EAs) for each of them. Each EA concluded that the council amendment would have no significant environmental impact. For the most part, consideration of alternatives was limited to continuing the status quo (which would violate the Magnuson-Stevens Act) and approving the amendment.

The court found that the administrative actions did not violate the Magnuson-Stevens Act, but the court found that each EA failed to comply with NEPA and implementing rules. The court said:

> It does not appear that [NOAA Fisheries] took a "hard look" at the problem with respect to any of the EAs. There is no substantive discussion of how fishing practices and gear may damage corals, disrupt fish habitat, and destroy benthic life that helps support healthy fish populations. Instead, a great deal of the discussion revolves around describing the limited number of proposed alternatives and what the agency's statutory obligations are under NEPA. There is only minimal or

> vague discussion of the actual environmental consequences and impacts on the designated EFHs. In several of the EAs, [NOAA Fisheries] simply states that no data is available, and therefore it cannot assess the environmental impact. Several EAs merely note that further action is deferred to future amendments. (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000])

The court enjoined enforcement of the amendments "until the Secretary performs a new, thorough, and legally adequate EA or Environmental Impact Statement for each EFH Amendment, in compliance with the requirements of NEPA" (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000]). The court was strongly critical of the agency's approval of five council decisions that had taken no action to address gear-related habitat damage.

> That outcome subverts the very purpose of NEPA, which is to ensure that agencies are fully aware of any adverse environmental effects of their actions, and of all feasible alternatives which may have lesser adverse effects on the environment, so that final decision-making will be informed by a full understanding of relevant environmental impacts. (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 5 [D. D.C. 2000])

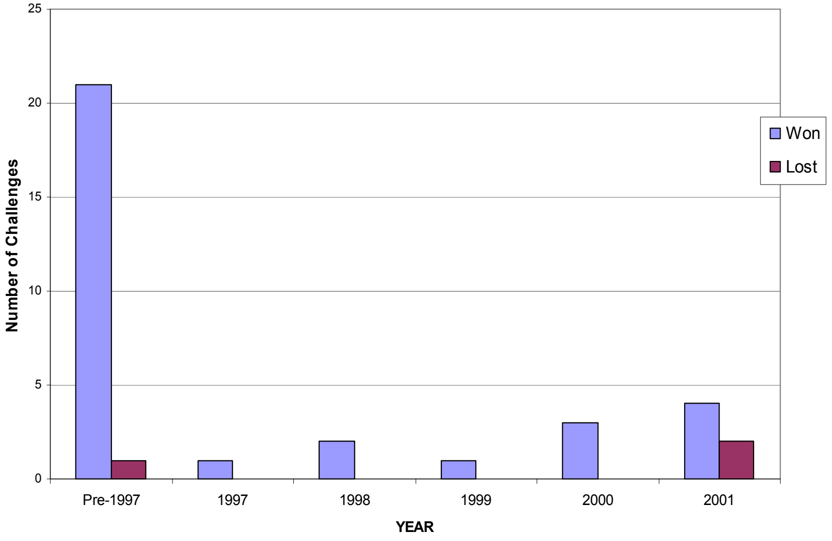

FIGURE 2.2 National Standard 2: win-loss record by challenges (National Academy of Public Administration, 2002; used with permission from the National Academy of Public Administration).

performance audits are usually easily accessed, thoroughly contested, and empirically rich. Judicial decisions discussing "best science" issues should be made readily available in summary or abbreviated form to all agency personnel. Court cases examining the reach and meaning of "best scientific information available" provide NOAA Fisheries with a hard-look doctrine of the courts. Procedural consistency would provide the agency with a stronger basis for defending decisions in court. More specifically, guidelines that address issues of relevance, objectivity, transparency, timeliness, peer review, and the treatment of uncertainty are consistent with the procedural cues that have been sought in the court cases documented in Appendix H. Courts have reversed and remanded agency decisions contrary to "best scientific information available" concepts that are intuitive, ad hoc, and derived from values articulated in individual judicial decisions. However, the "common law" of judicial review of "best scientific information available" is insufficiently mature, elaborate, and credible for day-to-day use within NOAA Fisheries.

3

Characterizing "Best Scientific Information Available"

PROBLEMS OF INTERPRETATION

The term "best scientific information available" as used in National Standard 2 of the Magnuson-Stevens Act has been interpreted in a number of ways, depending on whether the emphasis is on the quality (best) or timeliness (available) of the scientific information. This chapter reviews the reasoning, results, and conclusions of previous activities and publications addressing the issue of how to incorporate the "best scientific information available" into policy. In so doing, common themes and areas of disagreement have been examined to help develop the types of criteria that could be used to evaluate the scientific information provided to decision makers.

At its core, National Standard 2 affirms the role of scientific information in fisheries management. The basis for distinguishing scientific from other types of information has provided fertile ground for philosophical debate. It would be impractical to attempt to summarize and expand on this debate in a report of this limited scope and length. However, there are general attributes of scientific information that apply to the use of "best scientific information available" in fisheries management. The word science derives from the Latin word *scire* which means "to know." Scientific information has been described as knowledge that "emerges from a process of observation, identification, description, and testing of explanatory hypotheses about fundamental principles that govern cause-and-effect relationships" (Bisbal, 2002). The hallmark of the scientific approach is the generation of hypotheses based on observations and the testing of these hypotheses through the methodological collection and analysis of data. It is important to note in the context of this study that the U.S. Supreme Court upheld this view of science in the *Daubert* decision (Box 2.4).

The nature of scientific inquiry varies with the field of endeavor and the constraints imposed by the system under examination. For example, tightly controlled and replicated laboratory experiments form the basis of most research on the physiology and genetics of organisms. In contrast, this type of experimental approach often may be impractical for investigating the population biology, ecological relationships, and evolution of these same organisms because of the temporal and spatial scales and complexity of the systems. In these fields, much scientific information is derived from careful observation and analysis of empirical data. For each approach to scientific inquiry, potential sources of error or bias in either data collection or analysis may be identified through peer review. Ultimately, the quality of a given scientific analysis is revealed over time as additional information becomes available that either confirms or refutes earlier interpretations.

In practice, most disputes over scientific information used in management have arisen from the addition of the modifiers "best" and "available." The term best explicitly suggests that there is no better scientific information available and implicitly suggests the use of the most relevant and contemporary data and methods. Practically, best information will vary depending on the circumstances. The best information in a region where there is little scientific capacity or for a species about which little is known will differ in quality from the best information in a region with careful stock surveys and long-term monitoring by scientific experts. The term available suggests that management action is not contingent on the acquisition of new information. Hence, "best scientific information available" acknowledges the existence of scientific uncertainty, a feature of even the most robust biological population assessments, and dictates that prudent management be consistent with the scientific information that is available even though data gaps exist.

SCIENCE AND ITS ROLE IN THE NATIONAL MARINE FISHERIES SERVICE

A previous National Research Council report *Science and Its Role in the National Marine Fisheries Service* (National Research Council, 2002a) recognized that the governance structure has remained virtually unchanged since 1976, even though the laws governing the management of marine fisheries have been amended many times. That report recommended explicitly that "Congress should initiate a review of the fisheries governance system and the use of science in governance" (National Research Council, 2002a). Although recommendations on structural changes in governance are beyond the statement of task for this study, improving adherence to National Standard 2 cannot be considered fully without an awareness of the governance structure. Therefore, a review of some relevant findings from that earlier report will help put the issues of this effort in context.

The most relevant finding of the earlier report is that "the use of science in the marine fisheries management decision-making process is impeded by the governance system created by the [Magnuson-Stevens Act] and the resulting mismatch between institutional authorities and responsibilities" (National Research Council, 2002a).

It was recognized that breakdowns in the application of National Standard 2 can occur in the process of fishery management plan (FMP) development (National Research Council, 2002a):

> Regional [fishery management councils] sometimes disregard the scientific advice provided by [the National Oceanic and Atmospheric Administration (NOAA) Fisheries] and their science and statistical committees in setting total allowable catches (TACs) and in deciding other aspects of FMPs. [NOAA Fisheries] has the legal right to approve, disapprove, or partially approve FMPs; but when councils have disregarded the scientific findings of [NOAA Fisheries] and the advice of their science and statistical committees, [NOAA Fisheries] has sometimes sought compromises with the councils rather than upholding their original findings. The entire process is subject to intense political pressure, directly from stakeholders and indirectly through their representatives in Congress.
>
> A recommendation to require explanatory findings from the [fishery management councils] on their treatment of scientific information will help improve outside perceptions of how the agency conducts its scientific work.

CONSORTIUM FOR OCEANOGRAPHIC RESEARCH AND EDUCATION PANEL

Congressman Don Young (R-Alaska) asked the Consortium for Oceanographic Research and Education (CORE) to convene a panel of experts to provide advice on the clarification of “best scientific information available” as specified in National Standard 2 and the application of this standard to fisheries management. CORE held a workshop in Washington, D.C., on February 18, 2000, to address this question. The CORE panel concluded that it was not possible to elaborate a specific definition or standard for identifying scientific information (Appendix G). Instead, the panel recommended the development of procedural standards or principles and identified five criteria for establishing procedural standards (Box 3.1)

The CORE panel stated that a statutory definition was inadvisable because it would be written into law and therefore could not be adapted easily to different circumstances. Because science is continually evolving, any set of specific requirements may not be appropriate in all situations. A statutory requirement might specify exactly how and when the peer review must be conducted, whereas a variety of peer review mechanisms could produce a reasonable, perfectly acceptable result. For example, regulatory amendments or framework adjustments that simply represent part of an already-defined and approved rebuilding plan (e.g.,

BOX 3.1
CORE Report Procedural Criteria

- Relevance. Scientific information must be applicable to the management issue.
- Independent Scientific Review. Information must receive a positive review by independent experts.
- Timeliness. Information must be provided in advance of management decisions to allow meaningful review by interested parties.
- Reevaluation. Performance of management measures and underlying science should be reexamined and updated as new information and methodologies become available.
- Transparency and Inclusiveness. The process for developing scientific information should be open and broad-based; it should include all relevant information and a clear rationale in cases where information is excluded.

increasingly stringent quotas, increased size limits, decreased bag limits) might require only an internal review before being sent forward.

Similarly, with procedural guidelines there may be valid reasons for not following the guidelines precisely. It would be up to the Secretary of Commerce (or NOAA Fisheries), as part of FMP approval process, to determine whether the spirit of the guidelines has been followed. Under statutory guidelines, the process could not be completed until all guidelines were met fully. This could easily delay action necessary to protect living marine resources.

NOAA FISHERIES ORGANIZED DECISION PROCESS

NOAA Fisheries has published regulations for evaluating scientific information pursuant to its authority to define "dolphin-safe tuna" under the Marine Mammal Protection Act. NOAA Fisheries proposed an organized decision process to outline the types of information to be used by the agency to determine "whether the intentional deployment on or encirclement of dolphins with purse seine nets is having a 'significant adverse impact' on any depleted dolphin stock in the eastern tropical Pacific" (National Marine Fisheries Service, 2003). In the *Federal Register* notice, NOAA Fisheries provides guidelines for weighting information based on relevance, timeliness, independent peer review, and availability to NOAA Fisheries for verification. Scientific information is defined as "the results of properly designed scientific research" (National Marine Fisheries Service, 2003). Relevance and timeliness means that the information "is pertinent" to its use and is the "least degraded by the passage of time" (National Marine Fisheries Service, 2003). Independent peer review applies to information that

> …has been published in a refereed scientific journal in its field or independently read and criticized in writing by at least two peers; the criticism was disposed of either by acceptance or rebuttal, as appropriate, by the author(s); and the disposition of the criticism by the author(s) was independently determined to be appropriate and adequate. (National Marine Fisheries Service, 2003)

PEW FELLOWS PROGRAM IN MARINE CONSERVATION WORKSHOP

The "best scientific information available" was also the subject of a workshop sponsored by the Pew Fellows Program in Marine Conservation in 2001—*The Best Available Science: A Workshop on the Role of Science in Marine Conservation Law*. The purpose of the workshop was to consider ways in which policy makers identify and apply scientific information in conservation decisions. Participants examined recent litigation and related agency actions regarding the application of the Endangered Species Act and the National Environmental Policy Act to marine fisheries that are carried out in or near endangered wildlife habitat.

The workshop highlighted many of the difficulties in interpreting "best scientific information available." First, the goals of legislation (e.g., the Endangered Species Act, the Magnuson-Stevens Act, the Marine Mammal Protection Act) may be in conflict in some circumstances; hence, resolution will not depend on the quality of the scientific information but on which goal is considered the highest priority (e.g., to prevent overfishing or to minimize economic impacts). Second, different interpretations of the burden of proof in decision making among key players (the judiciary, scientists, politicians, industry, environmental groups, and the public) underlie many of the controversies in conservation and management issues. Should the resource or the resource user be subject to the greatest amount of risk when the scientific information is not definitive? Several themes raised in the Pew workshop were echoed in the committee's 2003 workshop, such as (1) when decisions are contentious, scientific information is likely to be subject to more scrutiny and the quality of the scientific information may be challenged; (2) incomplete information should not delay management action, but agencies should have incentives for information gathering to support future decision making; and (3) the scientific advisory process should be separate from management to ensure objectivity.

CANADIAN DEPARTMENT OF FISHERIES AND OCEANS

Canada has been developing guidelines for the provision of scientific advice on decision making and policy setting. The guidelines and overarching principles warrant direct mention (Box 3.2). In particular, the guidelines on "sound science and advice" are an attempt to produce explicit, operational guidelines for some of the same challenges that motivated this study (Rice, 2003). In 2001, the Canadian government adopted *A Framework for Science and Technology Advice: Principles and Guidelines for the Effective Use of Science and Advice in Government Decision Making* (Industry Canada, 2001) that embodies the six principles listed in Box 3.2.

The Canadian Department of Fisheries and Oceans (Industry Canada, 2001) has identified six goals that emerge from trying to synthesize the principles described above. These goals address the peer review and advisory process and the specific challenges of decision making in marine and fisheries science. They are similar to the criteria for best scientific information identified in the CORE report and the NOAA Fisheries guidelines for the Marine Mammal Protection Act. The Canadian Department of Fisheries and Oceans goals are relevance, quality, inclusiveness, consistency, timeliness, and cost-effectiveness.

BOX 3.2
Canada's Framework for Science and Technology Advice—Six Principles

- Early Issue Identification. The government has to anticipate, as early as possible, those issues for which science advice will be required, in order to facilitate timely and informed decision making.
- Inclusiveness. Advice should be drawn from a variety of scientific sources and from experts in relevant disciplines, in order to capture the full diversity of scientific schools of thought and opinion.
- Sound Science and Sound Advice. The government should employ measures to ensure the quality, integrity, and objectivity of the science and science advice it uses and to ensure that the science advice is used in decision making.
- Uncertainty and Risk. Science in public policy always contains uncertainty that must be assessed, communicated, and managed. Government should develop a risk management framework that includes guidance on when and how precautionary approaches should be applied.
- Transparency and Openness. The government is expected to employ decision-making processes that are open, as well as transparent, to stakeholders and the public.
- Review. Subsequent review of science-based decisions is required to determine whether recent advances in scientific knowledge have an impact on the science advice used to reach the decision.

The principles and goals adopted by Canada have many parallels with U.S. efforts to set standards for the scientific information used in conservation and management. For example, *early issue identification* necessitates improving communication among decision makers and the scientific community to ensure that the agency collects the appropriate information to address emerging issues. Although this principle is not discussed explicitly with regard to "best scientific information available" as used in the Magnuson-Stevens Act, it does embody the goal of *timeliness*. In the Canadian Department of Fisheries and Oceans draft guidelines, *inclusiveness* covers the consideration of disparate scientific opinion and scientific *quality* and involves experts from other, not necessarily scientific, disciplines. *Sound science and sound advice* embodies the application of rigor within the scientific process, from hypothesis formulation and data collection to internal and external review. *Uncertainty and risk* addresses the need for guidance on how to manage risk, especially when there is substantial scientific uncertainty, to determine when the precautionary approach should be applied. Scientists have the responsibility to explicitly identify uncertainty in scientific results and to communicate that uncertainty to decision makers. *Transparency and openness* raises issues similar to those identified in the CORE report. The development and application of scientific information should be conducted in a process that is open and accessible to stakeholders and other interested members of the public, including careful documentation of the decision-making process. *Review* is similar to the CORE report's reevaluation criterion; this principle ensures that the most current scientific methods and concepts are employed through the establishment of follow-up procedures. Criticism of data, data analysis, or interpretation in a peer review context permits in-course corrections, the opportunity to revise analyses, and thereby the opportunity to respond to or rebut comments. This self-correcting mechanism is what "best scientific information available" is intended to build into the process.

STATUTORY-BASED CRITERIA FOR "BEST SCIENTIFIC INFORMATION AVAILABLE"

A recent bill for reauthorization of the Magnuson-Stevens Act included a proposal to establish a statutory definition of "best scientific information available" (*Fisheries Science and Management Improvement Act of 2003*, 108th Cong., S.R. 482). The bill proposed by Senator Susan Collins (R-Maine) provides the following definition (*Fisheries Science and Management Improvement Act of 2003*, 108th Cong., S.R. 482):

> The term "best scientific information available", with respect to fishery conservation and management and stocks of fish, means information that—
> (A) is directly related to the specific issue under consideration;
> (B) is based on a statistically valid sample such that any conclusions drawn are reasonably supported and not speculative;
> (C) has been independently peer-reviewed;
> (D) has been collected within a period that is reasonably related to the specific issue under consideration;
> (E) is consistent with information that is available from other reliable sources; and
> (F) may include, but not consist solely of, anecdotal information collected from the harvesting and processing of fish. (*Fisheries Science and Management Improvement Act of 2003*, 108th Cong., S.R. 482)

There is a basis for concern that the term "best scientific information available" is too vague to provide sufficient guidance to NOAA Fisheries and the regional fishery management councils on the preparation and application of scientific information. The current disputes that end in litigation arise primarily over contesting the interpretation of the relative terms "best" and "available." The proposed definition introduces terms that could be considered just as relative and subject to interpretation (e.g., "*directly* related," "*reasonably* supported and not *speculative*," "*independently* peer-reviewed," "*reasonably* related," other "*reliable* sources") (*Fisheries Science and Management Improvement Act of 2003*, 108th Cong., S.R. 482). Adoption of the definition, therefore, would increase the number of relative terms and could result in more litigation, not less.

4

Findings and Recommendations

The fishery management councils and that National Oceanic and Atmospheric Administration (NOAA) Fisheries have the difficult task of making decisions that affect people's livelihoods and the health of the nation's fishery resources. Sometimes these decisions are based on scientific information that contains substantial uncertainty. In addition, significant regional differences exist in fisheries, in the social and economic constraints on the industries involved, and in the types and amounts of scientific information available to decision makers. It will not be possible to eliminate discontent with management decisions among some stakeholders; however, guidelines for the "best scientific information available" (National Standard 2) could improve the credibility of and the confidence and trust in scientific information used to manage the nation's fisheries.

This chapter has two objectives. First, it summarizes the findings that have been derived from examination of the application of the term "best scientific information available" in the preparation of federal fishery management plans (FMPs). Second, it provides recommendations for the uniform application of National Standard 2. The recommendations include proposed guidelines for the application of National Standard 2; how and when National Standard 2 should be employed; how adherence to the standard should be measured; and whether National Standard 2 should be applied to exclude information deemed inadequate or to rank information that would be used in relation to its relevance and rigor.

FINDINGS

The first set of findings is drawn from a previous National Research Council report titled *Science and Its Role in the National Marine Fisheries Service* (National Research Council, 2002a), which is relevant to this study:

- **The use of science in the marine fisheries management decision-making process is impeded by the governance system created by the [Magnuson-Stevens Act] and the resulting mismatch between institutional authorities and responsibilities.**
- **A better structure to conduct science in [NOAA Fisheries] would improve outsiders' perceptions of [NOAA Fisheries] scientists and science. A structure that allowed scientists to operate objectively and independently of the management body (but was responsive to requests for scientific investigations) could improve both the image and the performance of [NOAA Fisheries].**

Chapter 2 includes a review of the legislative history of the phrase "best scientific information available," describes the application of National Standard 2 by science centers and management councils, and analyzes the courts' interpretations of National Standard 2. Based on this information, the committee arrived at the following findings:

- **There is an implicit obligation in National Standard 2 to improve scientific information and reduce uncertainty over time.**
- **National Standard 2 embodies the idea that decisions regarding management and conservation should be made in a timely and effective fashion with available information despite recognized data gaps.**
- **It is not tenable to require a threshold of scientific certainty before making management decisions because National Standard 2 requires that managers make the best possible decisions based on the scientific information available.**
- **When presented with an explicit expression of the risks of management options, decision makers are better able to evaluate actions relative to the potential consequences of undesirable or irreversible outcomes.**

- **The Magnuson-Stevens Act provides specific guidelines for the development of FMPs; however, no guidelines exist for the uniform application of National Standard 2.**
- **Fisheries science centers and fishery management councils report a common *interpretation* of National Standard 2; however, there are both institutional and regional differences in the *application* of the standard.**
- **There are regional, as well as fishery-specific, differences in the quality and quantity of scientific information available; the means of ranking data quality; and the degree of transparency about data inclusion in the development of stock assessments and FMPs. This makes it difficult, in some cases, to assess the degree to which scientific information is used from council to council.**
- **The form and function of the regional fishery management councils' advisory panels in developing fishery regulations are poorly defined. Therefore the councils need guidelines to ensure accountability for their use of scientific information.**
- **Nearly all of the current 118 council members across the eight regional fishery management councils have no background in stock assessment science.**
- **Scientific information presented to fishery management councils sometimes is not clearly explained at open council meetings.**
- **One frequent consequence of the failure to convince stakeholders that a council has complied with National Standard 2 is litigation by stakeholders dissatisfied with the outcomes of fisheries management policies.**
- **Court decisions, through the hard-look doctrine, compel agencies to stay within the constraints of governing legislation, abide by fair procedures, explain and justify their decisions, and manifest a general commitment to reasoned decision making.**

Chapter 3 examined previous and ongoing efforts to define "best scientific information available." The examination of those efforts led to the following findings:

- **A statutory definition of what constitutes "best scientific information available" for fisheries management is inadvis-**

able because it could impede the incorporation of new types of scientific information and would be difficult to amend if circumstances warranted change.

- **Defining "best scientific information available" in legislation is unlikely to reduce the amount of controversy in the application of science to fisheries management.**
- **Establishing procedural guidelines is the preferred alternative for creating accountability and enhancing the credibility of scientific information used in fisheries management.**
- **There is widespread agreement in both scientific and policy communities on the criteria and procedures for determining the "best scientific information available."**

RECOMMENDATIONS

NOAA Fisheries should implement the guidelines presented below to govern the production and use of scientific information in the preparation of FMPs and supporting documents. The purpose of the guidelines is to promote consistency in both the production and the use of scientific information without unduly constraining the ability of scientists to adopt new scientific protocols for data collection and analysis. Procedural consistency would provide NOAA Fisheries with a stronger basis for defending controversial management decisions in court. More specifically, guidelines that address issues of relevance, inclusiveness, objectivity, transparency, timeliness, peer review, and the treatment of uncertainty are consistent with the procedural cues that have been sought in court cases.

The procedures used for producing and obtaining scientific information should be uniform. This would provide greater consistency across regions so that given the same information, each region would be expected to develop similar assessments of what is the "best scientific information available." The guidelines must be sufficiently flexible to accommodate the strong regional differences in fisheries and the scientific information available. The guidelines should be used by fisheries science centers, fishery management councils, and all other entities or parties that produce and/or use scientific information for fisheries management.

A statutory definition of "best scientific information available" is inadvisable, but there is a need for clear guidelines that create explicit and objective standards for deciding whether National Standard 2 has been met. A statutory definition would unduly restrict the incorporation of scientific advances into policy, thus increasing rather than decreasing the current gap between scientific information and the policy it is supposed to support. The most constructive alternative to such a definition is the development of agency guidelines that provide standards for ensuring consistency in the application of "best scientific information available," as required by National Standard 2. However, scientific information is not readily categorized by its quality because it is conditional on the current state of knowledge. What is best at one point may be obsolete in the next as new data and analyses become available.

The guidelines for ensuring the use of "best scientific information available" in fisheries management are based on the following widely accepted criteria (identified in Chapter 3):

- relevance,
- inclusiveness,
- objectivity,
- transparency and openness,
- timeliness, and
- peer review.

Guidelines

Relevance—Scientific information should be representative of the fish stock being managed, although the data need not be site specific or species specific. In some cases, analogous information from a different region or the biological characteristics of a related species or species with similar life-history strategies will be informative and relevant and may constitute the best information available. Stock assessments and economic and social impact assessments should clearly describe the strengths and weaknesses of the data used in analyses.

Inclusiveness—Scientific advice should be sought widely and should involve scientists from all relevant disciplines. The goal should be to capture the full range of scientific thought and opinion on the topic at hand.

- Critiques and alternative points of view should be acknowledged and addressed openly.

- Anecdotal (experiential, narrative or local) information should be acknowledged and evaluated during the process of assembling scientific information. When no other information is available, anecdotal information may constitute the best information that is available. In addition, anecdotal information can be used to help validate other sources of information and identify topics for research.

Objectivity—Data collection and analysis should be unbiased and obtained from credible sources. Scientific processes should be free of undue nonscientific influences and considerations.

Transparency and Openness—Congress has enacted laws intended to give the public full and open access to the development of federal policies, including advisory meetings, background documents, and other sources of information. Accordingly, the public should have information about each phase of the process from data collection to data analysis to decision making.

- Decision makers should provide a clear rationale for the choice of the information that they use or exclude when making management decisions.
- The processes of collecting data and selecting research for use in support of management decision making should be open, broad based, and carefully documented.
- All scientific findings and the analysis underlying management decisions should be readily accessible to the public.
- The limitations of research used in support of decision making should be identified and explained fully.

Timeliness—There are at least two aspects to timeliness. First, timeliness refers to the acquisition of data in such a manner that sufficient time exists to analyze it adequately before it is used to make management decisions. Second, timeliness refers to whether the data are applicable to the current situation. Management decisions should give greatest weight to the most recent, reliable data available. Some types of information, such as the life-history characteristics of a species of fish, may not change over time do they remain current. Other types of information, such as population survey data, have to be updated on a regular basis. Timeliness can also mean that in some cases, results of important studies and/or monitoring programs must be brought forward before the scientific team feels that the study is complete. Uncertainties and risks that arise from an incomplete study should be acknowledged, but interim results may be better than no new results at all.

- Management decisions should not be delayed indefinitely on the promise of future data collection or analysis.
- Except under extraordinary circumstances, FMP implementation need not be delayed to capture and incorporate data and analyses that become available after plan development.

Peer Review—Peer review is the most accepted and reliable process for assessing the quality of scientific information. Its use as a quality control measure enhances the confidence of the community (including scientists, managers, and stakeholders) in the findings presented in scientific reports. Peer review is not infallible, but it has proved valuable for uncovering errors in, and providing diverse perspectives on, data collection, analysis, and interpretation. This includes cases in which documentation of the scientific information would be insufficient to validate or reproduce the results of an analysis of a given set of data. Reproducibility of data analysis is one important method for ensuring the validity of scientific information.

NOAA Fisheries should establish an explicit and standardized peer review process for all documents that contain scientific information used in the development of FMPs. This is similar to a recommendation by the U.S. Commission on Ocean Policy (2004) that "[NOAA Fisheries], working with the Regional Fishery Management Councils and the interstate fisheries commissions, should develop a process for independent review of the scientific information generated by the Scientific and Statistical Committees in all regions." Each region should have some flexibility to adapt peer reviews to individual circumstances. However, the following key elements should be included:

- the review should be conducted by experts who were not involved in the preparation of the documents or the analysis contained in them;
- the reviewers should not have conflicts of interest that would constrain their ability to provide honest, objective advice;
- all relevant information and supporting materials should be made available for review; and

- a peer review should not be used to delay implementation of measures when a fishery has been determined to be overfished.

Internal peer review of scientific information may be sufficient; however, an external review is advisable (and more consistent with the purpose of the guidelines) when one or a combination of the following circumstances applies: questions exceed the expertise of the internal review team, there is substantial scientific uncertainty, the findings are controversial, or there are a range of scientific opinions regarding the proposed action.

Adherence to National Standard 2

NOAA Fisheries should require each fishery management council to provide explicit findings on how scientific information was used to develop or amend a FMP. It is important for the fishery management councils to explain how scientific information in each major component of an FMP was used and also to explain the reasoning when scientific information is presented to it and not used.

The guidelines provided in this report allow for more uniform application of National Standard 2 and, if applied, may prevent situations in which the councils disregard scientific advice provided by their scientific and statistical committees. In addition, requiring fishery management councils to be explicit in their handling of scientific information provided sharpens their responsibility. It also will help the Secretary of Commerce to intervene to correct situations where the scientific information has been disregarded or misapplied. It is important for NOAA Fisheries to defend its own scientific information after council decisions. The Secretary of Commerce should steadfastly reject plans that clearly ignore current laws or regulations.

Decision makers from the beginning to the end of the FMP process would benefit from clear articulation of and explicit findings on the use of their work products. NOAA science centers could incorporate feedback on how their work products are used to support the needs of the councils in future endeavors. Requirements for explicit findings are a way to assist fishery management councils and to moderate environments of raw politics with reasoned decision making. The findings of an earlier National Research Council (2002a) committee reiterated in this report will help NOAA Fisheries reviewers and the Secretary of Commerce to address their legal responsibilities for insisting on adherence to National Standard 2. They will also sharpen judicial review and allow courts to be more focused and discrete in their review functions. In addition, compelling the councils to document their interpretation and use of scientific information explicitly will clarify their decision-making processes and would provide the Secretary of Commerce with a clearer rationale for evaluating the merits of FMPs in terms of National Standard 2.

Examples, such as the vermilion snapper (Box 2.1) fisheries in the Gulf of Mexico, illustrate that the very structure of the Magnuson-Stevens Act sometimes impairs the goals of employing, adhering to, and applying the "best scientific information available." The reason for this is that the "best scientific information available" is only one goal among many in a set of national standards that include efficiency, cost minimization, bycatch avoidance, nondiscrimination, and protection of fishing communities. The "science" of the matter is thus in a constant "balancing" competition with other political and economic factors. This competition is ongoing in the review of all FMPs and is decided by fishery management councils having few members with scientific expertise (National Academy of Public Administration, 2002) based on information provided by scientists who often do not communicate risks effectively.

In many cases, this situation is a competition that "best science" cannot win. In this environment, the best science is vulnerable to being swamped repeatedly for reasons of economics, convenience, or preference. As currently applied, the science of the subject can be freely passed over, rejected, remanded, and trumped. Steps to protect the independence of the scientific information developed under National Standard 2 may require legislative change and almost certainly will require rule change. For example, the U.S. Commission on Ocean Policy (2004) recommends that "Congress should amend the [Magnuson-Stevens Act] and related statutes to require regional fishery management councils and interstate fisheries commissions to rely on their scientific and statistical committees, incorporating the scientific and statistical committees' findings and advice into the decision-making process." There is great value in separating hard-won, consensus science from the unpredictable changes of day-to-day politics.

The Secretary of Commerce should determine whether a plan adheres to National Standard 2 by the extent to which the guidelines have been followed as part of the review for compliance with all 10 national standards specified by the Magnuson-Stevens Act. The "best scientific information available” standard should apply to all stages in the process of producing and using scientific information in fisheries management: data collection, data analysis, dissemination of data and information, and development of FMPs. Documentation of how scientific information is produced, validated, and applied to management decisions will improve accountability at all stages of the plan development process.

A rigorous secretarial review of the use of scientific information will result in a feedback process that will improve the ability of fishery management councils to prepare FMPs that better meet National Standard 2 and minimize the need for intervention by the courts. The goal is to reduce the pressure on all parties to tailor the management plans to the interests of any one constituency, regardless of the scientific findings.

Effective Communication

The presentation of scientific information at regional fishery management council meetings should be concise and as free of scientific jargon as possible. Scientific information presented to fishery management councils often is not well understood by council members and stakeholders. In some regions, fishermen have a difficult time participating in reviews of stock assessments because they do not understand stock assessment methods. The scientific basis of management decisions may be challenged not only when the perceived quality of the scientific information is at issue, but also when the process of producing and validating the scientific information is neither transparent nor accessible to stakeholders. Data included or excluded from the analysis should be described, and a clear interpretation of the results should be given.

Scientific reports should explicitly identify the level of uncertainty in results, provide explanations of the sources of uncertainty, and assess the relative risks associated with a range of management options. Decision making in fisheries requires an accurate and comprehensible assessment of uncertainty. Managers have to take into account both the short-term and the long-term effects of management actions. Scientists can help by estimating the risks to the fish population and to the fishery over different time periods and in relationship to the uncertainties involved. Descriptions of uncertainty can also provide an index of the quality of available information that should be used to help set research priorities. Fishery management council members should receive an overview of scientific methodology that includes a discussion of the relationship between uncertainty and risk.

Improving the Quality of Scientific Information Used in Fisheries Management

NOAA Fisheries should develop and implement a plan to systematically improve the quality of the "best scientific information available" that includes regular assessments of the outcomes of management actions and evaluation of the predictive quality of the scientific information supporting those actions. NOAA Fisheries and the councils have attempted to improve the scientific information used in fishery management through a nationwide stock assessment improvement plan and an annual process of determining critical research priorities. Yet an additional process is necessary to improve accountability for use of the "best scientific information available" in the development of FMPs. Recently, the courts have acted as arbiters for determining whether National Standard 2 has been applied adequately in the preparation of contested FMPs. This default delegation of responsibility to the courts, however, results in additional costs, delays, and diversion of agency resources.

Legislative history shows that one of Congress' goals in establishing National Standard 2 "must be to *achieve* the best available scientific information" (Senate Committee, *Fishery Conservation and Management Act*, 94) for use in the preparation of FMPs. This suggests that the framers of the law intended NOAA Fisheries to acquire the scientific information necessary for effective fisheries management. Although use of the "best scientific information available" may involve applying incomplete information to determine management actions, it is not sufficient to rely on inadequate information over the longer term. NOAA Fisheries should formalize a system for establishing research priorities and funding levels across regions to gather the information needed to reduce uncertainty and improve understanding.

After a management action has been passed by the council and approved by the Department of Commerce through NOAA Fisheries, follow-up evaluation of the effects of that management action is rarely undertaken. Yet evaluation of outcomes of management actions over time is necessary to ensure the continued use and refinement of scientific information. As the quality of scientific information improves, the basis for good management decision making will be stronger. Such an evaluation process requires explicit hypotheses (statements about relationships) about potential actions and their related system components. Properly designed studies will provide new knowledge that tests these hypotheses and leads to a more refined understanding of the consequences of management actions.

Clearly, there is broad agreement that the "best scientific information available" should form the basis of management decisions. Although there is room for improvement in what constitutes the best scientific information, the problem lies more in the way the scientific information is applied to policy. Some of the legal challenges of scientific information could be prevented by uniform application of operational guidelines that ensure uniform provision, use, and documentation of the "best scientific information available" in the development of FMPs. Indeed, a key goal of this report has been to develop guidelines to ensure that management actions are based on the "best scientific information available" as required under the Magnuson-Stevens Act, starting with the premise that the scientific information has undergone sufficient peer review to ensure that the methods of data collection, scientific analysis, and scientific conclusions are explicit, transparent (includes the rationale used for the inclusion or exclusion of specific data sets), and accepted as the best available.

Legal challenges under National Standard 2 are not the only challenges to decision making for fisheries management. Other national standards also have been invoked in successful suits against the agency. Indeed, NOAA Fisheries has repeatedly and successfully been sued for ignoring the science in favor of more politically popular management decisions. This points to a problem with governance. Although it is not within the purview of this study to address governance, NOAA Fisheries is strongly urged to review recommendations made in previous National Research Council reports because governance speaks to the heart of the problem with the application of the "best scientific information available."

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Appendixes

Appendix A

Committee and Staff Biographies

COMMITTEE

Jon G. Sutinen (*Chair*) is currently a professor in the Department of Environmental and Natural Resource Economics at the University of Rhode Island. Dr. Sutinen earned his Ph.D. in economics in 1973 from the University of Washington. His research interests are concentrated on the implications of policies related to management of marine fisheries. His recent research projects have included interdisciplinary studies of the human dimensions of large marine ecosystems and the economic consequences of protecting and conserving fisheries habitat, in which the theoretical framework integrates economic models of human agents interacting with a dynamic natural system of fisheries populations. He has served on several fisheries advisory panels for the United States and other governments. Dr. Sutinen is currently president of the North American Association of Fisheries Economists and a former member of the Ocean Studies Board (OSB).

George Boehlert is professor and director of the Hatfield Marine Science Center of Oregon State University. He earned his Ph.D. in marine biology in 1977 from the Scripps Institution of Oceanography at the University of California, San Diego. His research interests include fisheries oceanography; the ecology of marine fishes, particularly early life-history stages; pelagic habitats; and seamount ecology. Dr. Boehlert was a member of the National Research Council (NRC) Committee on Biological Diversity in Marine Systems.

Louis W. Botsford is a professor of Wildlife, Fish and Conservation Biology at the University of California, Davis. Dr. Botsford received his Ph.D. in 1978 from the University of California, Davis. His research interests involve the dynamics of populations with age, size, and spatial structure, as applied to fisheries, marine reserves, endangered species, and the effects of environmental variability on populations.

Felicia C. Coleman is currently an associate scholar scientist in the Florida State University Department of Biological Science. Dr. Coleman earned her Ph.D. in biology in 1991 at Florida State University. Her research interests include the study of reef fish population ecology and the use of ecologically relevant information in the management of exploited species. Dr. Coleman was a member of the NRC Committee on Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States.

Robert B. Ditton is a professor of Wildlife and Fisheries Sciences at Texas A&M University with a joint appointment in the Department of Recreation, Park, and Tourism Sciences. He received his Ph.D. in recreation and park administration in 1969 from the University of Illinois. His research focuses on the sociology of natural resources with special attention to the human dimensions of fisheries. He has studied various state, federal, and international jurisdiction fisheries. Previously, Dr. Ditton served as a member of the Science and Statistical Committee of the Gulf of Mexico Fishery Management Council, an NRC Panel on Disposition of Offshore Platforms, and the Marine Fisheries Advisory Committee; he is currently a member of OSB.

Terrance J. Quinn is a professor at the Juneau Center of the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks, arriving there in 1985. Dr. Quinn earned his Ph.D. in biomathematics in 1980 at the University of Washington and worked at the International Pacific Halibut Commission. His research interests are fish and marine mammal population dynamics and stock assessment, and he is coauthor of the 1999 book *Quantitative Fish Dynamics*, published by Oxford University Press. Dr. Quinn is a former member of OSB. He also chaired the NRC Committee to Review Northeast Fishery Stock Assessments, co-chaired the NRC Committee on Fish Stock Assessment Methods, and has served on three other OSB committees.

William H. Rodgers is a professor of Environmental Law at the University of Washington. Dr. Rodgers received his LL.B. in 1961 from Columbia University. He specializes in natural resource law and now teaches environmental law, law and biology, public land law, resource management, and property. Dr. Rodgers was the chair of the NRC Committee on Scientific and Technical Criteria for Federal Acquisition.

Edella C. Schlager is an associate professor in the School of Public Administration and Policy and Political Science at the University of Arizona. Dr. Schlager earned her Ph.D. in political science in 1990 from Indiana University. Her research interests focus on coastal fisheries and water. She studies the emergence and evolution of institutional arrangements devised by communities to govern natural resources on which they are economically dependent. Dr. Schlager was a member of the NRC Committee to Review Individual Fishing Quotas.

STAFF

Susan Roberts became the director of OSB in April 2004 after six years of experience conducting studies for the board. Dr. Roberts received her Ph.D. in marine biology from the Scripps Institution of Oceanography. She worked as a research scientist at the University of California, Berkeley, and as a senior staff fellow at the National Institutes of Health. She has directed a number of studies for OSB including *Nonnative Oysters in the Chesapeake Bay* (2004); *Decline of the Steller Sea Lion in Alaskan Waters: Untangling Food Webs and Fishing Nets* (2003); *Effects of Trawling and Dredging on Seafloor Habitat* (2002); *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems* (2001); *Under the Weather: Climate, Ecosystems, and Infectious Disease* (2001); *Bridging Boundaries Through Regional Marine Research* (2000); and *From Monsoons to Microbes: Understanding the Ocean's Role in Human Health* (1999). Dr. Roberts specializes in the science and management of living marine resources.

Joanne C. Bintz was a program officer at OSB from June 2001 to August 2004. She received her Ph.D. in biological oceanography from the University of Rhode Island Graduate School of Oceanography. She has directed NRC studies on *A Review of the Florida Keys Carrying Capacity Study* (2002); *Chemical Reference Materials: Setting the Standard for Ocean Science* (2002); and *Implementation of a Seafloor*

Observatory Network for Oceanographic Science (2003). She is currently working on studies on *Restoration and Protection of Coastal Louisiana* and *A Review of the Activities Authorized Under the Methane Hydrates Research and Development Act of 2000*. She is developing studies on *Mitigating Erosion on Sheltered Coasts* and a *Review of Recreational Fisheries Survey Methods*. Her interests include coastal ecosystem ecology, marine technology, coastal restoration, oceanographic education, and coastal management and policy.

Jodi Bachim serves as a senior program assistant for OSB. She received a B.S. in zoology from the University of Wisconsin-Madison in 1998. Since starting with OSB in May 1999, Ms. Bachim has worked on several studies regarding fisheries, geology, nutrient over-enrichment, marine mammals, and ocean exploration. She is currently working toward an M.S. in environmental science at American University.

Denise Greene is currently an administrative coordinator with the Government-University-Industry Research Council and Federal Demonstration Partnership within the National Academies. While a senior project assistant at OSB, Mrs. Greene was involved with studies on marine biotechnology and environmental information for naval warfare.

Byron Mason serves as a senior program assistant for the Division on Earth and Life Studies where he assists with the work of the Coordinating Committee on Global Change, as well as the Committee on Disaster Research in the Social Sciences. During his tenure, he has assisted with the completion of four reports: *A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting* (2004); *Elements of a Science Plan for the North Pacific Research Board* (2004); *Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan* (2004); and *Nonnative Oysters in the Chesapeake Bay* (2004). Mr. Mason received a B.A. in anthropology from the University of Florida.

Appendix B

Participants at the Workshop on Defining Best Available Science for Fisheries Management

September 8-9, 2003
National Academy of Sciences
Washington, D.C.

NRC Committee on Defining the Best Available Science for Fisheries Management:
Jon Sutinen (*Chair*), University of Rhode Island
George Boehlert, Oregon State University
Louis Botsford, University of California, Davis
Felicia Coleman, Florida State University
Robert Ditton, Texas A&M University
Terrance Quinn, University of Alaska, Fairbanks
William Rodgers, University of Washington
Edella Schlager, University of Arizona

Ocean Studies Board Staff:
Susan Roberts, Study Director
Joanne Bintz, Study Director
Denise Greene, Senior Project Assistant

Speakers and Panel Members:
Carli Bertrand, Oceans, Fisheries and Coast Guard Subcommittee
Eric Bilsky, Oceana
David Fluharty, Former Member, North Pacific Council
Daniel Furlong, Mid-Atlantic Council
Graciela Garcia-Moliner, Caribbean Council

Justin LeBlanc, National Fisheries Institute
Andrew Minkiewicz, Oceans, Fisheries and Coast Guard Subcommittee
Jake Rice, Canadian Science Advisory Secretariat, Department of Fisheries and Ocean
John Sibert, The Pelagic Fisheries Research Program
Margaret Spring, Senate Subcommittee on Ocean, Fisheries and Coast Guard
Pat Sullivan, Cornell University
Catherine Ware, House Subcommittee on Fisheries Conservation, Wildlife and Oceans
Dave Whaley, House Subcommittee on Fisheries Conservation, Wildlife and Oceans
Pat White, Maine Lobstermen's Association and Pew Oceans Commission

Workshop Attendees:
Laurie Allen, National Marine Fisheries Service
Beth Bryant, University of Washington
Eugene Buck, Congressional Research Service
John DePersenaire, Recreational Fishing Alliance
Bridget Ferriss, Oceans, Fisheries and Coast Guard Subcommittee
F. Kelly Finn, National Marine Fisheries Service
Bill Fox, National Marine Fisheries Service
Rachel Gallant, Office of U.S. Representative Tom Allen
Jessica Geubtner, American Fisheries Society
Peter Huhtala, Pacific Marine Conservation Council
Jennifer Jeffries, National Marine Fisheries Service
Amanda Leland, Office of U.S. Representative Sam Farr
William Lindberg, University of Florida
Rick Marks, Robertson, Monagle & Eastaugh
Sunshine Menezes, Office of U.S. Representative Frank Pallone, Jr.
Mark Millikin, National Marine Fisheries Service
Jonathan Phinney, National Oceanic and Atmospheric Administration
Ellen Pikitch, Wildlife Conservation Society
Jim Preacher, U.S. Geological Survey
Tim Reagan, Marine Mammal Commission
Malia Rivera, Office of U.S. Representative Eni Faleomavaega
Robin Schrock, U.S. Geological Survey
Heather Silber, Office of U.S. Representative John Tierney
Edith Thompson, Office of U.S. Representative Wayne Gilcrest
Jim Uphoff, Maryland Fisheries Service

Appendix C

Questionnaires Sent to Fishery Management Councils and Fisheries Science Centers

FISHERY MANAGEMENT COUNCIL QUESTIONNAIRE

If possible, please submit a flow chart for the application of scientific information to the development of your fishery management plans (FMPs).

Questions

How does the council interpret the phrase "best scientific information available" as used in National Standard 2?

Are constituent observations, opinions, or recommendations considered in addressing Standard 2?

When there are discrepancies in information from different sources (e.g., NOAA Fisheries, council staff, state fishery scientists, academics, industry representatives) who determines which information to use in preparing the FMPs? What criteria are used to rank or reject information?

Who determines what information is contained in the Stock Assessment and Fishery Evaluation reports, what criteria are used to select the information included in those reports, and what quality control procedures are in place?

Please describe briefly the process by which the council (including the staff and committees) prepares FMPs and supporting documents (amendments, environmental impact statement, etc.)? How does the council ensure that Standard 2 is satisfied when preparing FMPs and supporting documents, and how does it determine what information to consider with respect to the folowing:

- Stock assessments
- Essential fish habitat
- Nontarget species impacts
- Socioeconomic assessments
- Other

What is the origin of the data used in these scientific reports? In other words, who collects the primary data and how is it collected?

Have any data been excluded from consideration in the aforementioned scientific reports? If so, what was the basis for such exclusion?

Have some data and/or information been ranked higher than others for scientific assessments? If so, please explain the basis for such ranking. If all data have been treated equally, please explain why.

Are there steps in process where the scientific data and findings are submitted for peer review? If so, is there a procedure for responding to critiques?

FISHERIES SCIENCE CENTER QUESTIONNAIRE

If possible, please submit a flow chart for the collection and analysis of data for the scientific assessments prepared for advising the fishery management councils.

Questions

How does the center interpret the phrase "best scientific information available" as used in National Standard 2?

Please describe briefly the process by which center prepares scientific reports for the Fishery Management Councils regarding the following:

- Stock assessments
- Essential fish habitat
- Nontarget species impacts
- Socioeconomic assessments
- Other

What is the origin of the data used in these scientific reports? In other words, who collects the primary data and how is it collected?

Who in the process makes the decision on what types of data and methods of analyses to use? Are there specific criteria?

Have any data been excluded from consideration in the aforementioned scientific reports? If so, what was the basis for such exclusion?

Have some data and/or information been ranked higher than others for scientific assessments? If so, please explain the basis for such ranking. If all data have been treated equally, please explain why.

Are there steps in process where the scientific data and findings are submitted for peer review? If so, is there a procedure for responding to critiques?

Appendix D

Regulations Supporting Fishery Management Plan Development and National Standard 2 of the Magnuson-Stevens Act

§§600.315. National Standard 2. 50 CFR Ch. VI (10-1-02). Scientific Information [from 61 FR 32540 June 24, 1996, as amended at 63 FR 24233 May 1, 1998.]

(a) *Standard 2*. Conservation and management measures shall be based upon the best scientific information available.

(b) *FMP [fishery management plan] development*. The fact that scientific information concerning a fishery is ***incomplete*** does not prevent the preparation and implementation of an FMP (see related §§600.320(d)(2) and 600.340(b).

(1) Scientific information includes, but is not limited to, information of a biological, ecological, economic, or social nature. Successful fishery management depends, in part, on the timely availability, quality, and quantity of scientific information, as well as on the thorough analysis of this information, and the extent to which the information is applied. If there are conflicting facts or opinions relevant to the particular point, a Council may choose among them, but should justify the choice.

(2) FMPs must take into account the best scientific information available at the time of preparation. Between the initial drafting of an FMP and its submission for final review, new information often becomes available. This new information should be incorporated into the final FMP where practicable, but it is unnecessary to start the FMP process over again, unless the information indicates that drastic changes have

occurred in the fishery that might require revision of the management objectives or measures.

(c) *FMP implementation.*

(1) An FMP must specify whatever information fishermen and processors will be required or requested to submit to the Secretary. Information about harvest within state boundaries, as well as in the [exclusive economic zone], may be collected if it is needed for proper implementation of the FMP and cannot be obtained otherwise. The FMP should explain the practical utility of the information specified in monitoring the fishery, in facilitating in-season management decisions, and in judging the performance of the management region; it should also consider the effort, cost or social impact of obtaining it.
(2) An FMP should identify scientific information needed from other sources to improve understanding and management of the resource, marine ecosystem, and the fishery (including fishing communities).
(3) The information submitted by various data supplies should be comparable and compatible to the maximum extent possible.

(d) *FMP amendment.* FMPs should be amended on a timely basis, as new information indicates the necessity for change in objectives or management measures.
(e) *SAFE [Stock Assessment and Fishery Evaluation] report.*

(1) The SAFE report is a document or set of documents that provides Councils with a summary of information concerning the most recent biological condition of stocks and the marine ecosystems in the FMU and the social and economic condition of the recreational and commercial fishing interests, fishing communities, and the fish processing industries. It summarizes, on a periodic basis, the best available scientific information concerning the past, present, and possible future condition of the stocks, marine ecosystems, and fisheries being managed under Federal regulation.

i. The secretary has the responsibility to assure that a SAFE report of or similar document is prepared, reviewed annually, and changes as necessary for teach FMOP. The Secretary or Councils may utilize any combination of talent from Council, state, federal, university, or other sources to acquire and analyze data and produce the SAFE report.

ii. The SAFE report provides information to the councils for determining annual harvest levels from each stock, documenting, significant trends or changes in the resource, marine ecosystems, and fishery over time, and assessing the relative success of existing programs. Information on bycatch and safety for each fishery should also be summarized. In addition, the SAFE report may be used to update or expand previous environmental and regulatory impact documents, and ecosystem and habitat descriptions.

iii. Each SAFE report must be scientifically based, and cite data sources and interpretations.

(2) Each SAFE report should contain information on which to base harvest specifications.

(3) Each SAFE report should contain a description of the maximum fishing mortality threshold and the minimum stock size threshold for each stock or stock complex, along with information by which the Council may determine:

i. Whether overfishing is occurring with respect to any stock or stock complex, whether any stock or stock complex is overfished, whether the rate or level of fishing mortality applied to any stock or stock complex is approaching the maximum fishing mortality threshold, and whether the size of any stock or stock complex is approaching the minimum stock size threshold.

ii. Any management measures necessary to provide for rebuilding an overfished stock or stock complex (if any) to a level consistent with producing the [maximum sustainable yield] in such fishery.

(4) Each SAFE report may contain additional economic, social, community, essential fish habitat, and ecological information pertinent to the success of management or the achievement of objectives of each FMP.

(5) Each SAFE report may contain additional economic, social, and ecological information pertinent to the success of management or the achievement of objectives of each FMP.

Appendix E

Acronyms

CORE	Consortium for Oceanographic Research and Education
EA	environmental assessment
EFH	essential fish habitat
ESA	Endangered Species Act
FMP	fishery management plan
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
OSB	Ocean Studies Board
SSC	scientific and statistical committee
STAR	Stock Assessment Review
TAC	total allowable catch

Appendix F

Compilation of Science Center and Management Council Reports and Committees

The following is a compilation of regional fisheries science centers and the committees that conduct stock assessment and peer review, and the fishery management councils they support and the committees and panels that provide advice. Stock assessment workshops are run primarily by the National Oceanic and Atmospheric Administration (NOAA) Fisheries scientists and staff with input from council staff and a variety of stakeholders in the particular fishery. NOAA scientists (or sometimes paid consultants) conduct the assessments. Peer review is first managed by NOAA Fisheries for internal and external review before assessments are submitted to the councils. After submission, the council's advisory bodies review assessments and other reports and provide input.

Regional Science Center	Stock Assessment and Peer Review Panels
Alaska Fishery Science Center	1. Crab Plan Team 2. Scallop Plan Team 3. Gulf of Alaska Plan Team 4. Bering Sea and Aleutian Islands Plan Team
Northwest Fishery Science Center Southwest Fishery Science Center	1. Stock Assessment Review 2. Independent Scientific Advisory Board 3. Biological Review Team 4. Recovery Science Review Panel 5. Technical Recovery Team 6. Program Review Panel for the Center-wide West Coast Groundfish, Hatchery, Salmon Ocean and Estuarine, and Watershed Ecology Programs

Fishery Management Council	Advisory Bodies
North Pacific Fishery Management Council	1. Scientific and statistical committee (SSC) 2. Advisory panel 3. Other North Pacific Fishery Management Council advisory bodies: • Ecosystem Committee • Essential Fish Habitat Committee • Fur Seal Committee • IFQ Implementation Committee • MSA Reauthorization Committee • Non-Target Other Species Committee • Observer Advisory Committee • Steller Sea Lion Mitigation Committee • U.S.-Russia International Committee • Vessel Monitoring System Committee
Pacific Fishery Management Council	1. SSC 2. Other advisory bodies: • Coastal Pelagic Species Advisory Subpanel • Coastal Pelagic Species Management Team • Enforcement Consultants • Groundfish Advisory Subpanel • Groundfish Management Team • Habitat Committee • Highly Migratory Species Advisory Subpanel • Highly Migratory Species Plan Development Team • Model Evaluation Workgroup • Salmon Advisory Subpanel • Salmon Technical Team

continued

Regional Science Center	Stock Assessment and Peer Review Panels
Northeast Fishery Science Center	1. Northeast Region Stock Assessment Workshop 2. Stock Assessment Review Committee

Fishery Management Council	Advisory Bodies
New England Fishery Management Council	1. SSC 2. Social Science Advisory Committee 3. Oversight committees: • Executive committee • Ad hoc aquaculture • Ad hoc capacity • Ad hoc gear conflict • Ad hoc large pelagics • Vessel monitoring system ad hoc • Dogfish • Enforcement • Habitat and marine protected areas • Herring • Mid-Atlantic Fishery Management Council Plans • Magnuson-Stevens Act • Marine protected areas • Monkfish • Protected species • Red crab and hagfish • Research steering • Groundfish • Scallops • Skates • Transboundary • Whiting • Trawl survey 4. Plan Development Team 5. Habitat Technical Team
Mid-Atlantic Fishery Management Council	1. SSC 2. Advisory panels: • Bluefish • Black sea bass • Scup • Summer flounder • Tilefish • Squid, mackerel, and butterfish • Surfclam and ocean quahog • Law enforcement • Dogfish • Monkfish

continued

Regional Science Center	Stock Assessment and Peer Review Panels
Pacific Islands Fishery Science Center	
Southeast Fishery Science Center	Southeast Data Assessment and Review: 1. Assimilate and review data 2. Perform stock assessment 3. Perform independent peer review

Fishery Management Council	Advisory Bodies
West Pacific Fishery Management Council	1. SSC 2. Sea Turtle Advisory Committee 3. Plan teams: • Bottomfish and seamount groundfish • Coral reef ecosystems • Crustaceans • Pelagics • Precious corals 4. Advisory panels: • Commercial • Recreational • Subsistence • Ecosystem and habitat • Demonstration projects
South Atlantic Fishery Management Council	1. Technical committees: • SSC • Snapper-Grouper Assessment Group • Shrimp Plan Development Team 2. Advisory panels: • Calico scallop • Coral • Dolphin and wahoo • Golden crab • Habitat and environmental protection • Information and education • King and Spanish mackerel • Law enforcement • Marine protected areas • Protected resources • Rock shrimp • Shrimp • Bycatch Reduction Device ad hoc • Snapper and grouper • Spiny lobster • Wreckfish

continued

Regional Science Center	Stock Assessment and Peer Review Panels
Southeast Fishery Science Center	Southeast Data Assessment and Review: 1. Assimilate and review data 2. Perform stock assessment 3. Perform independent peer review

Fishery Management Council	Advisory Bodies
Gulf of Mexico Fishery Management Council	1. SSC panels: • Standing SSC • Butterfish • Coral • Dolphin and wahoo • Mackerel • Oceanic migratory species • Red drum • Reef fish • Shark • Shrimp • Spiny lobster • Stone crab 2. Stock assessment panels: • Mackerel • Red drum • Reef fish • Shrimp 3. Socioeconomic panel 4. Advisory panels: • Billfish • Butterfish • Coastal migratory pelagics (mackerel-cobia) • Coral and coral reefs • Deep-water crabs • Dolphin and wahoo • Habitat protection (Texas, Mississippi, Louisiana, Florida, and Alabama) • Highly migratory (shark, swordfish, tuna) • Law enforcement • Red drum • Red snapper • Reef fish (except red snapper) • Shrimp • Spiny lobster • Stone crab • Bycatch reduction device • Essential fish habitat and environmental impact statement technical review • Essential fish habitat and environmental impact statement user review
Caribbean Fishery Management Council	1. SSC 2. Habitat advisory panel 3. Advisory panels: • Socioeconomic sector • Puerto Rico • St. Thomas • St. Croix • St. John

Appendix G

Scientific Information in Fisheries Management: The Report of a Consortium for Oceanographic Research and Education Fisheries Workshop

February 18, 2000

Dr. Andrew Solow, Director, Marine Policy Center, Woods Hole Oceanographic Institution, Massachusetts
Dr. Edward Houde, Professor, Chesapeake Biological Laboratory, University of Maryland, Solomons
Dr. Terrance Quinn, Professor, School of Fisheries and Ocean Sciences, University of Alaska, Juneau
Ms. Harriet Perry, Director, Center for Fisheries Research and Development, Gulf Coast Research Laboratory, University of Southern Mississippi, Ocean Springs
Dr. Lee Alverson, Chairman of the Board, Natural Resources Consultant, Inc., Seattle, Washington

BACKGROUND

Fisheries management in U.S. federal waters is governed by the Magnuson-Stevens Fishery Conservation and Management Act. Under the Act, regional fishery management councils are charged with preparing management plans within each of eight regions. Although responsibility for preparing management plans rests with the councils, the National Marine Fisheries Service (NMFS) must review the proposed plans for scientific and technical merit and for compliance with national standards set out in Section 301 of the Act. Thus, final management authority rests with the Secretary of Commerce upon advice from NMFS.

Standard 2 of Section 301 reads in its entirety: "Conservation and management measures shall be based upon the best scientific information available."

The Act provides no further elaboration of this standard and, in particular, provides no definition of the term "best scientific information available." In response to a request by Congressman Young, a small group of knowledgeable fisheries scientists was convened under the auspices of the Consortium for Oceanographic Research and Education to comment on the interpretation of this standard.

The group considered two broad, related issues. The first issue concerned the meaning of the term "best scientific information available." The group concluded that it is not possible to establish a specific definition or specific standards for identifying such information. However, it is both possible and desirable to establish procedural standards or principles to promote the quality of scientific information used in fisheries conservation and management.

The second issue considered by the group concerned specific problems with the process by which scientific information is currently incorporated into fisheries conservation and management. The group recognized that there is a lack of confidence by segments of the fishing industry and others in the way that scientific information is used in fisheries conservation and management. The group felt that this lack of confidence could be alleviated, at least to some extent, within the existing management structure.

STANDARDS FOR THE USE OF SCIENTIFIC INFORMATION

The first question considered by the group is whether it is possible to establish statutory standards for identifying the "best scientific information available." The group agreed that this is not possible. Science is by nature an evolutionary process. As the scientific enterprise proceeds, our understanding of the world changes. Results that are believed to be valid today may be modified or even overturned tomorrow. It is worth noting here that gains in scientific understanding tend to be incremental rather than revolutionary, so that fisheries conservation and management should not be overly sensitive to new results that may not withstand the test of time. In any case, it is difficult to imagine specific standards of scientific excellence that are flexible enough to accommodate the evolutionary nature of science.

While the possibility of establishing standards for "the best scientific information available" seems remote, the group agreed that it is both possible and desirable to establish procedural standards or principles for the use of scientific information in fisheries conservation and management. The group identified five broad criteria for this purpose. First, the information must be relevant. If scientific information, however high its quality, has no bearing on management issues, then it has no place in the management process. Second, scientific information must pass independent scientific review. It is important to emphasize that this criterion would not be satisfied by the mere occurrence of independent scientific review: it requires that this review be generally positive. Third, the information must be provided on a timely basis, leaving adequate opportunity for review by interested parties. The group noted that, in certain instances, a timeliness requirement would need to be relaxed: for example, when highly relevant, high quality scientific results come to light at the last minute. Fourth, the performance of management measures and the science upon which they are based should be re-evaluated in a regular and timely way. It is rare that detailed scientific issues are settled once and for all. For this reason, re-evaluation is a fundamental part of the scientific process. Fifth, the process by which information is brought into decision making should be open and broad-based. All relevant information should be considered, regardless of its source and, if particular information is not used in decision making, a clear rationale should be given.

The group believes that the five criteria listed above should be applied broadly to all scientific information used in the fisheries management process. However, it is possible to go further in establishing standards for specific activities within fisheries management. An excellent example is the checklist for fisheries stock assessment proposed in the National Research Council (1998) report *Improving Fish Stock Assessment*. It is noteworthy that, despite the specificity of the activity, this checklist provides ample flexibility for the adoption of new methods of data collection and analysis.

INCREASING PUBLIC CONFIDENCE IN FISHERIES SCIENCE

The second broad issue discussed by the group concerned ways in which industry and public confidence in the scientific basis for fisheries management can be restored within the existing management framework. It should be stressed that practices to obtain, review, and apply information vary across the eight management regions and, as a result, the level of industry and public confidence in NMFS and the management councils also varies.

In some cases, problems arise from conflicts between the mandate of NMFS under the Magnuson-Stevens Act and its mandate under the Marine Mammals Protection Act and the Endangered Species Act. As marine mammals share habitat and, in some cases, interact directly or indirectly with commercial fish species, it is difficult to separate the protection of the former from the management and conservation of the latter. Actions taken by NMFS under the Marine Mammals Protection Act or the Endangered Species Act can have serious implications for fisheries management. However, because such actions may be taken outside the Magnuson-Stevens Act, different provisions for the use of scientific information may apply. Consequently, a review of these Acts to identify conflicts and propose solutions may be in order. Another problem is the perception that scientific information not originating in NMFS may be held to a higher standard for review than scientific information produced within the agency. For example, internal NMFS review is often held to be sufficient for agency information, yet external information is required to meet the more stringent standards, such as publication in a peer-reviewed scientific journal. This problem could be alleviated by requiring that all scientific information that is provided in a timely manner be reviewed by the regional Scientific and Statistical Committee (SSC) provided for under the Magnuson-Stevens Act. SSC could make an initial judgment regarding relevance and could go on to review relevant material. This might place a standing burden on the regional SSC—the use of which has been irregular both within and between regions—but it seems to be a natural way to use the framework set out by the Magnuson-Stevens Act to strengthen the use of scientific information in fisheries conservation and management. Independent reviews by groups other than SSCs have been and should continue to be used to address specific scientific issues as they arise. In particular, the National Research Council regularly conducts studies relating to fisheries assessment and management. Finally, collaborative data collection and research efforts should be encouraged among agency scientists, independent scientists, and representatives of industry and public interest groups. Not only would this build confidence among the different groups, but it would provide access to valuable, non-traditional sources of information.

Appendix H

Recent Case Law Support for Guidelines on "Best Scientific Information Available"

The following provides several examples of recent case law that address the criteria on which the recommended guidelines are based: relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review.

RELEVANCE

Natural Resources Defense Council v. Daley—studies of mobile gear effects on other habitats "not sufficiently analogous" to prove effects on tilefish habitat; views of the preparers of the fishery management plan upheld by the court (*Natural Resources Defense Council v. Daley*, 254 F. Supp. 2d 434, 440 [S.D. NY 2003]; Magnuson-Stevens Act).

Midwater Trawlers Cooperative v. Department of Commerce—error to rely exclusively on political rather than scientific criteria in allocating the whiting fishery; "the best available politics does not equate to the best available science as required by the Act" (*Midwater Trawlers Cooperative v. Department of Commerce*, 282 F. 3d 710, 720 [9th Cir. 2002]; Magnuson-Stevens Act).

National Coalition for Marine Conservation v. Evans—rejecting claim that a pelagic longline closure was a product not of scientific data but of legal and lobbying pressure from environmental groups (*National Coalition for Marine Conservation v. Evans*, 231 F. Supp. 2d 119, 129 [D. D.C. 2002]; Magnuson-Stevens Act).

Maine v. Norton—rejecting allegations of improper motivation in the Endangered Species Act listing of Atlantic salmon (i.e., they did it to "settle a lawsuit") (*Maine v. Norton*, 257 F. Supp. 2d 357, 389-400 [D. ME 2003]; Endangered Species Act).

INCLUSIVENESS

Brower v. Evans—error to act in contradiction of all known evidence (including abundance studies, stress literature, and discounting of alternative explanations) that the tuna purse seine fishery was having a significant adverse impact on dolphin stocks (*Brower v. Evans*, 257 F. 3d 1058, 1071 [9th Cir. 2001]; Marine Mammal Protection Act).

American Oceans Campaign v. Daley—agency failed to prepare an impact statement taking a "hard look" at "how fishing practices and gear may damage corals, disrupt fish habitat, and destroy benthic life that helps support healthy fish populations" (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 21 [D. D.C. 2000]; Magnuson-Stevens Act; National Environmental Policy Act).

Parravano v. Evans—upholding secretarial emergency decision lowering ocean harvest rate to 14.5 percent; the fishery management plan had made conclusory assertions that a 22 percent ocean harvest rate for chinook salmon would ensure a sufficient escapement for the in-river Indian treaty fishery (*Parravano v. Evans*, 70 F. 3d 539 [9th Cir. 1995]; Magnuson-Stevens Act; Indian treaties).

Natural Resources Defense Council v. Evans—improper for U.S. Navy to withhold a "highly relevant" Defense Research Agency study on "The Effects on Fish and Other Marine Mammals of High-Level Underwater Sound" (Turnpenny et al., 1994) from the National Marine Fisheries Service during consultation on peacetime use of low-frequency sonar; the study is "directly relevant" and is not "'junk science'" (*Natural Resources Defense Council v. Evans*, 279 F. Supp. 2d 1129, 1179-80 [N.D. CA 2003]; Endangered Species Act; National Environmental Policy Act).

Greenpeace, American Oceans Campaign, and Sierra Club v. National Marine Fisheries Service, Evans, At-Sea Processors Association, United Catcher Boats, Aleutians East Borough, and Westward Seafoods, Inc., et al.—deferring to use of telemetry data as the "best available evidence" for evaluating Steller sea lion foraging (*Greenpeace, American Oceans Campaign, and Sierra Club v. National Marine Fisheries Service, Evans, At-Sea Processors Association, United Catcher Boats, Aleutians East Borough, and Westward Seafoods, Inc., et* *al.*, 237 F. Supp. 2d 1181, 1196-97 [W.D. WA 2002]; Marine Mammal Protection Act).

OBJECTIVITY

Natural Resources Defense Council v. Evans—tilefish; agency cannot use unsupported inference to override contradictory empirical evidence (*Natural Resources Defense Council v. Evans*, 254 F. Supp. 2d 434, 441-442 [S.D. NY 2003]; Magnuson-Stevens Act).

Greenpeace, American Oceans Campaign v. National Marine Fisheries Service—misuse of telemetry data on foraging Steller sea lions to develop a “zonal approach” to critical habitat not “rationally related” to the data (*Greenpeace, American Oceans Campaign v. National Marine Fisheries Service*, 237 F. Supp. 2d 1181, 1198 [W.D. WA 2002]; Marine Mammal Protection Act).

Hall v. Evans—also a violation of National Standards 4 and 5; error to resort to gear differentials (between trawl gear and gillnetters) for monkfish divorced from a scientific rationale; “there is no discernible, substantive scientific evidence” in the record that supports “gear differential regulations” (*Hall v. Evans*, 165 F. Supp. 2d 114, 134 [D. RI 2001]; Magnuson-Stevens Act).

TRANSPARENCY AND OPENNESS

Fishermen’s Dock Cooperative, Inc. v. Brown—summer flounder; “agency’s process of setting the 1994 quota was conducted in good faith, pursued with a proper understanding of the law, based on the best scientific information available, and adequately justified by the agency” (*Fishermen’s Dock Cooperative, Inc. v. Brown*, 75 F. 3d 164, 173 [4th Cir. 1996]; Magnuson-Stevens Act).

Natural Resources Defense Council v. National Marine Fisheries Service—groundfish rebuilding; court defers to agency: “Faced with a choice between an interpretation of the Sustainable Fisheries Act that requires a moratorium on harvesting of fish species that take more than ten years to regenerate naturally, and an interpretation that permits limited harvesting over the course of a longer rebuilding period, [the National Marine Fisheries Service] selected—after public notice and comment—the latter interpretation” (*Natural Resources Defense Council* *v. National Marine Fisheries Service*, 280 F. Supp. 2d 1007, 1014 [N.D. CA 2003]; Magnuson-Stevens Act).

TIMELINESS

Natural Resources Defense Council v. Evans—ordering defendants to prepare and adopt rebuilding amendments for darkblotched rockfish, canary rockfish, lingcod, and Pacific Ocean perch by January 31, 2004, and for bocaccio rockfish, cowcod, yelloweye rockfish, and widow rockfish by April 15, 2004; "there is evidence in the legislative history…that the Councils could be a source of delay and accordingly provided that where a council fails to prepare and complete a rebuilding plan in the statutorily mandated time period, the [National Marine Fisheries Service] itself should take over and complete the plan within the allotted time" (*Natural Resource Defense Council v. Evans*, 290 F. Supp. 2d 1051, 1056 [N.D. CA 2003]; Magnuson-Stevens Act).

Center for Biological Diversity v. Lohn—remanding for determination of whether "Southern Resident" orca whales should be listed as a "distinct population segment"; a violation of the "best scientific" standard to rely upon an "outdated and discredited global *Orsinus orca* taxon"; to rely upon "science it knows is inaccurate"; to heed a formal taxonomic process that lags behind current knowledge; and to defer to "changes to taxonomic classification that are time consuming, slow, and may be controversial"; "to deny listing of a species simply because one scientific field has not caught up with the knowledge in other fields does not give the benefit of the doubt to the species and fails to meet the best available science requirement" (*Center for Biological Diversity v. Lohn*, 296 F. Supp. 2d 1223, 1236-1241 [W.D. WA 2003]; Endangered Species Act).

Natural Resources Defense Council v. Evans—discredits use of 15-year-old "stale" data to set bycatch rates for bocaccio and lingcod that almost certainly are not operative now (*Natural Resources Defense Council v. Evans*, 168 F. Supp. 2d 1149, 1153-1155 [N.C. CA 2001]; Magnuson-Stevens Act).

Massachusetts ex rel. Division of Marine Fisheries v. Daley—improper to use historical data known to undercount seriously scup recoveries (*Massachusetts ex rel. Division of Marine Fisheries v. Daley*, 170 F. 3d 23, 27 [1st Cir. 1999]; Magnuson-Stevens Act).

Pacific Coast Federation of Fishermen's Associations, et al. v. U.S. Bureau of Reclamation, et al.—Klamath River dispute; report of a consultant is the "best science currently available," but a later decision (*Pacific Coast Federation of Fishermen's Associations, et al. v. U.S. Bureau of Reclamation, et al.*, 2003 U.S. Dist. LEXIS 13745 [N.D. CA 2003]) recognizes that "best science" changes over time and now includes a National Research Council (2002b) interim report (*Pacific Coast Federation of Fishermen's Associations v. U.S. Bureau of Reclamation and Klamath Water Users Association*, 138 F. Supp. 2d 1228, 1249-1250 [N.D. CA 2001]; Endangered Species Act).

Natural Resources Defense Council v. Evans—groundfish; rejecting a request that the court "light a fire" under the agency to move more aggressively to correct "overfishing"; "where is the science to support a shorter timeline than the agency proposes?" (*Natural Resources Defense Council v. Evans*, 243 F. Supp. 2d 1046, 1050, 1059 [N.D. CA 2003]; Magnuson-Stevens Act).

PEER REVIEW

Ocean Conservancy v. Evans—no violation of National Standard 2 to delegate stock assessment duties for sharks to an "independent scientific review panel" (*Ocean Conservancy v. Evans*, 260 F. Supp. 2d 1162, 1174 [M.D. FL 2003]; Magnuson-Stevens Act; National Environmental Policy Act).

ACCOUNTING FOR UNCERTAINTY

Natural Resources Defense Council v. Daley—questionable use of a methodology to fix a quota for summer flounder that has "at most an 18 [percent] likelihood" of achieving the targeted mortality ("Only in Superman Comics' Bizzaro World, where reality is turned upside down, could the Service reasonably conclude that a measure that is at least four times as likely to fail as to succeed offers a 'fairly high level of confidence'") (*Natural Resources Defense Council v. Daley* 209 F. 3d 747, 754 [D.C. Cir. 2000]; Magnuson-Stevens Act).

Natural Resources Defense Council v. Evans—tilefish; quoting final fishery management plan approvingly; it is improper to posit habitat damage when impacts are "completely unknown" and "unquantifiable" at this time (*Natural Resources Defense Council v. Evans* 254 F. Supp. 2d 434, 438 [S.D. NY 2003]; Magnuson-Stevens Act).

Fishermen's Dock Cooperative, Inc. v. Brown—summer flounder; rejecting selection of a methodology to fix a quota that has only a 59 percent probability of not exceeding the mortality goal (*Fishermen's Dock Cooperative, Inc. v. Brown*,75 F. 3d 164, 171-172 [4th Cir. 1996]; Magnuson-Stevens Act).

Greenpeace v. Mineta—error to open a lobster fishery without correcting a long-tolerated ignorance of its effects on the monk seal: "If, in the 1981 opinion [the National Marine Fisheries Service] was uncertain of the impact of the [fishery management plan] because it knew too little about the monk seal diet, by 1996 it was emboldened by its ignorance to draw definitive conclusions about the impact" (*Greenpeace v. Mineta*, 122 F. Supp. 2d 1123, 1132 [D. HI 2000]; National Environmental Policy Act).

Blue Water Fishermen's Association v. National Marine Fisheries Service—deferring to agency choice of "high" or "low" mortality data in assessing impact of longliners on leatherback turtles; the National Marine Fisheries Service chooses the "low" and thus more "fishing-friendly" figure (*Blue Water Fishermen's Association v. National Marine Fisheries Service*, 226 F. Supp. 2d 330, 339 [D. MA 2002]; Magnuson-Stevens Act; Endangered Species Act).

Blue Water Fishermen's Association v. National Marine Fisheries Service—upholding the use of scientific judgment to close 2.6 million square nautical miles of ocean to longliners to protect endangered loggerhead and leatherback sea turtles (conclusions need not be "airtight and indisputable") (*Blue Water Fishermen's Association v. National Marine Fisheries Service*, 226 F. Supp. 2d 330, 338 [D. MA 2002]; Magnuson-Stevens Act; Endangered Species Act).

American Oceans Campaign v. Daley—approving the establishment of essential fish habitat amendments that lacked site-specific scientific information; "review of the Secretary's action must be especially deferential, given the highly complicated scientific data that the agency must interpret" (*American Oceans Campaign v. Daley*, 183 F. Supp. 2d 1, 21 [D. D.C. 2000]; Magnuson-Stevens Act; National Environmental Policy Act).

Recreational Fishing Alliance v. Evans—deferring to the use of "aggregated" and "incomplete" data in setting retention limits for highly migratory species; courts can not "sidestep responsibility by imposing an obligation on the Secretary to find better data" (*Recreational Fishing*

Alliance v. Evans, 172 F. Supp. 2d 35, 43, 44 [D. D.C. 2001]; Magnuson-Stevens Act).

Blue Water Fishermen's Association v. Mineta—approving imposition of shark quotas over objections that they were unsupported by catch-rate data and insufficient for stock evaluation purposes; "regulation is permissible even if the agency lacks complete information" (*Blue Water Fishermen's Association v. Mineta*, 122 F. Supp. 2d 150, 166 [D. D.C. 2000]; Magnuson-Stevens Act).