

Strengthening Scientific Input and Ecosystem-Based Fishery Management
for the Pacific and North Pacific Fishery Management Councils

Suggestions from a panel discussion
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Abstract

A panel of scientists was convened by the Pacific States Marine Fisheries Commission for an intensive two day meeting to examine practical ways that the Pacific and North Pacific Fishery Management Councils (FMCs) could address two of the recommendations recently made by the U.S. Commission on Ocean Policy. One theme addressed ways to move towards an ecosystem-based approach to fisheries management. The other theme addressed the role of science in fishery management Council decisions, how to strengthen that role, and whether to separate conservation issues (how many fish are appropriate to catch) from allocation issues (who gets to catch them).

Recognizing that the process of incorporating ecosystem considerations into fishery management council decisions is an evolutionary one, the panel crafted a definition of ecosystem-based fishery management (EBFM), identified characteristics that were specific to an EBFM approach, and identified a process that would help the FMCs move forward in incremental ways, from the existing management approaches that generally consider ecosystem interactions in an implicit and often peripheral way, to a management system that, over time, would incorporate explicit EBFM considerations into the fishery assessments themselves.

The EBFM approach recognizes the broader uses and users of the marine environment (including fishing). There is a need to consult with, accommodate and, to the extent possible, reconcile the many societal goals and objectives of these users, so that future generations can also benefit from the full range of goods and services provided by the ecosystem. The development and testing of models that incorporate ecosystem considerations explicitly will focus attention on the research and monitoring needed to improve the models and reduce uncertainty. There also will be a need for a more rigorous setting of operational objectives and decision rules, and for the evaluation of management performance.

The panel noted that both FMCs, and particularly the North Pacific FMC, are already working to manage fisheries conservatively, to protect habitat, establish marine protected areas, protect forage fish, and to reduce bycatch--all tactics that are consistent with an EBFM approach. Additionally, the North Pacific FMC has established indicators of ecosystem health (and a monitoring plan for them). Further progress could be made with an approach that (1) recognizes, upfront, an expanded list of societal goals, (2) develops, tests, and uses new models for management that explicitly incorporate these goals (3) include factors such as oceanography, habitat productivity, food-web interactions, life- history, spatial variability, environmental trends, and uncertainty considerations, and (4) evaluates these measures to assure that specific goals are being met. Progress is critically dependent upon obtaining additional resources and funding to bridge the gap between current fishery management practices and EBFM.

The panel thought the existing mechanisms for scientific input into fishery management decisions worked well in the North Pacific and Pacific FMCs. In moving forward towards EBFM, the role of the FMC's Scientific and Statistical Committees (SSCs) will continue, however their workload will be greater and may require the addition of scientists with expertise in specialties that are not yet represented on the committees. The panel emphasized that important roles for SSCs include the specification of the acceptable biological catch (ABC), including reviews of the stock assessments and harvest formulas that are used to calculate ABC, and analysis describing relevant effects (including the extent of risk and uncertainty) of harvest alternatives and other management measures (Witherell, 2005).

The Panel noted that, while computation of an ABC is a scientific process, some of the key constraints in the calculation may be set by policy. In the future, as decision rules become more sophisticated, the quantification of uncertainty will become more formalized. That is, the stipulation of risk-related policy, namely the specification of how risk-averse or risk-tolerant the decision process should be, will become increasingly important. The formulation of such policy is not the role of scientific advisory bodies such as SSCs, but it should not be left to ad hoc decisions of the moment either. The goal of such formalized policy is to achieve consistency and stability across time and across districts, serving the best interest of society as a whole, in the long run, and putting more distance between the decision process and narrower considerations of expediency. For this reason, such policy should be the subject to national debate and independent scientific peer review. Regional differences must be recognized. Within such a framework, with its heavy technical demands, the role of scientific advisory bodies, such as SSCs, is to provide scientific quality control and quality assurance.

The panel concluded that SSCs should not be separated and insulated from the FMCs. Fisheries are not managed by science alone, but good fishery management cannot afford to ignore good science, and needs ready access to it. There will always be policy choices and tradeoffs that may be within the scope of the discretionary authority of the FMC, but the FMC will be in a position to better use that latitude if the SSC informs the FMC of the probable consequences of their choices. A close working relationship of a FMC with its SSC, which can be fostered by having both bodies meet at the same time, will facilitate such communication.

The Panel also suggested that the role of science and, thus, the SSCs would be strengthened if NOAA Fisheries and the Secretary of Commerce would ask for a rigorous justification from the FMC if decisions were contrary to scientific advice. It should be made clear that SSC members are to act independently as scientists (and at times may disagree with their agency positions). Additionally, there may be value in having periodic national or regional meetings of the SSCs to develop common operating procedures and to compare approaches to providing scientific advice.

Background

Echoing concerns of other reports and studies regarding the sustainability of marine ecosystems and the depletion of many fish species, the U.S. Commission on Ocean Policy (USCOP) recently recommended that the United States move towards an ecosystem based approach to management, including fisheries management. While this idea is good, there are substantial outstanding issues with defining what an ecosystem-based approach to management is and how it might be implemented.

Additionally, the USCOP recommended severing the Scientific and Statistical Committees (SSCs) from the Fishery Management Councils (FMCs), and separating “conservation issues” from “allocation issues”, because of concerns that political and fishing industry pressure may have resulted in some FMCs setting catches higher than was prudent¹. While some see this

¹ The U.S. COP notes that: “Although fishery data collection and stock assessment models can always be improved, a lack of adequate scientific information has not been the main culprit in most instances of overfishing. The Mid-Atlantic and New England FMCs [Regional Fishery Management Councils], which managed fourteen of the thirty-three stocks that experienced overfishing in 2001, have some of the best scientific support in the world. A 2002 National Research Council report concluded that the problem in most cases of overfishing was that the RFMCs

recommended separation as a way to promote the role of science in the fishery management decision making process, others see the potential for establishing conflicting bureaucracies and allowing political bodies more freedom to be subject to constituent influence.

There have been other reviews, workshops, and conferences that have addressed these topics and made recommendations (for example NMFS 1999, NRC 1999, Pew Oceans Commission, 2003, Busch 2003, FAO 2003, Witherell 2004, U.S. Commission on Ocean Policy 2004), most recently the Managing our Nation's Fisheries II conference in Washington, D.C. in March of this year (Witherell, 2005). However, there was interest in looking more specifically at these topics, considering the work that the North Pacific and Pacific FMCs² have already undertaken, in order to explore opportunities and mechanisms for additional progress towards Ecosystem-based Fishery Management (EBFM) and strengthening scientific input.

The Pacific States Marine Fisheries Commission (PSMFC) convened a panel of scientists to draft recommendations on these two topics, with a view toward specific applicability and utility to the FMCs. Panelists were chosen by PSMFC based on their technical qualifications, their familiarity with the operation of the North Pacific and Pacific FMCs, and their knowledge of the workings of their scientific and statistical committees. The list of panelists and short biographies are presented in Appendix 1. The panel was provided a briefing book of background materials and some additional documents at the meeting (see references). The panel discussion was held July 19th and 20th in Seattle, Washington at the SeaTac Marriott hotel. The discussion was chaired by Dr. Rich Marasco, and was organized around the specific questions stated by PSMFC in the charge to the panel (the questions are listed in Appendix 2).

The Marine Conservation Alliance (MCA) of Juneau, Alaska provided funding for this project. MCA has not been involved with developing or reviewing report contents. It is strictly a project of the PSMFC.

Discussion

Ecosystem-based Fishery Management

The first topic addressed by the Panel related to EBFM. Three questions were posed by the PSMFC. The first one was:

1. What is a practical definition of an ecosystem-based approach to fisheries management that could be used by fishery management councils?

Many definitions of an ecosystem-based approach to management and fisheries management have been suggested. Some are noted in Table 1. There are recurring themes in all of these definitions. For example, there is recognition that ecosystem-based approaches recognize broader uses and users of the marine environment (including fishing) and the need to accommodate and reconcile the many objectives of these users so that future generations can also benefit from the full range of goods and

disregarded or downplayed valid scientific information when setting harvest guidelines. Neither NMFS nor the Secretary of Commerce used their authority to prevent the RMFCs from taking such actions.

² These FMCs manage fish off Alaska and Washington, Oregon, and California, respectively.

services provided by the ecosystem. The approach also recognizes that humans are an essential component of the ecosystem in which fishing takes place, and it focuses on the interactions within the system. This is in contrast to current fishery management practices which focus on individual species, and do not deal with ecosystem issues in a comprehensive way.

Therefore the purpose of an EBFM approach is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystem.

Finding

The panel noted that there was no lack of good definitions. However, there was a desire to craft one that would help indicate to the FMCs what is needed above and beyond what is already being done. Simplicity was considered an important characteristic of a good definition. There also was interest in constructing a definition that would recognize interactions among various parts of the system, as well as the need to consider a broader set of societal goals and values. In addition, there should be recognition of the importance of defining goals and recognizing that there would be trade-offs between potentially competing societal goals. Finally, the definition should be value-free, steer clear of narrowly specifying matters where the substance of the science is evolving, and be applicable to the whole spectrum of management approaches from the current single species focus to a more explicit approach to ecosystem-based management. The following definition was considered to satisfy these concerns:

“Ecosystem-based fishery management recognizes the physical, biological, economic and social interactions among the affected components of the ecosystem and attempts to manage fisheries to achieve a stipulated spectrum of societal goals, some of which may be in competition.”

Table 1—Definitions Used By Others

Ecosystem-based Approach to Management (or Fisheries Management)

The North Pacific Fishery Management Council :

“Ecosystem-based approach to fisheries management is defined as the regulation of human activity towards maintaining long-term system sustainability (within the range of natural variability as we understand it) of the North Pacific covering the Gulf of Alaska, the Eastern and Western Bering Sea and the Aleutian Islands region.”

The Food and Agricultural Organization of the United Nations (FAO 2003):

“An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.”

The Scientific Consensus Statement on Marine Ecosystem-Based Management (McLeod et. al. 2005):

“Ecosystem-based Management is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need.

Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers cumulative impacts of different sectors. Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning and key processes;*
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;*
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;*
- acknowledge interconnectedness among systems, such as between air, land and sea; and*
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.”*

The National Research Council (NRC 1999):

“Ecosystem-based management is an approach that takes major ecosystem components and services—both structural and functional—into account in managing fisheries. It values habitat, embraces a multispecies perspective, and is committed to understanding ecosystem processes. Its goal is to achieve sustainability by appropriate fishery management.” (NRC 1999)

The second question addressed by the panel was:

2. What are the characteristics or management elements of an ecosystem based approach to fisheries management? Are the elements identified by the National Research Council (NRC 1999) and the Ecosystem Principles Advisory Council (NMFS 1999) still appropriate? Are there other elements or characteristics that should be included?

In considering this question, the panel reviewed a number of background documents regarding the characteristics of an EBFM approach. Table 2 is a sampling of some suggestions made by various panels and committees.

The Panel stressed that it is important to recognize that EBFM is neither inconsistent with, nor a replacement for, current fisheries management approaches. This means that EBFM is likely to be adopted as an incremental extension of current fisheries management approaches. The challenge will be to find ways to move forward given the high degree of uncertainty involved in employing new approaches, and not allowing this uncertainty to be a license to maintain the *status quo*. Rather, the uncertainty should be taken as a mandate to improve current understanding.

The single species assessment and management approach has a long empirical record. The approach has well defined models (Quinn and Deriso 1999), with research being conducted to fill data gaps to improve models (Quinn 2003, Quinn and Collie 2005). Properly used, it has been effective. Failures almost exclusively have not been due to the science and management approach, but rather due to political will and data limitations (Fogarty and Murawski 1998, Sissenwine and Mace 2001). The single species approach does incorporate ecosystem considerations. However, the ecosystem in these models is generally treated as a single collapsed background factor. The following are examples where ecosystem features have been included: a) a stock recruitment curve with density dependence for a given species may originate from predation by another species, b) time-varying natural mortality in a model may also be due to predation or disease effects, and c) the set of years used to define reference points may take account of perceived regime shifts (Quinn and Collie 2005).

It has been suggested that perhaps the most significant changes required for an EBFM would be an adjustment in thinking about goals to reflect a broader set of societal values than those involving the targeted fish species, and different (additional) scientific inputs that would be needed to help inform models to achieve those goals and the management strategies employed.

The panel agrees with the perspective expressed in a study conducted for the North Pacific FMC (Goodman et. al 2002) that:

“...moving from the conventional assessment view towards an ecosystem view involves a shift in the components of fundamental underlying ecological science that is relied upon. In essence, for current fishery management, population ecology is the fundamental ecological science, but for an approach that takes ecological and ecosystem considerations into account, community ecology is the fundamental ecological science. For example, when one thinks about single species, there can be “excess production” from a stock, but when one thinks about the “needs” of all the other species in an ecosystem, the notion of excess production from a single member of the community becomes far more complicated.”

Table 2—Suggestions from Others
Characteristics of an Ecosystem-based Fishery Management Approach

Ecosystem Principles Advisory Panel (EPAP) (NMFS 1999):

“A comprehensive ecosystem-based fisheries management approach would require managers to:

- consider all interactions that a target fish stock has with predators, competitors, and prey species;
- the effects of weather and climate on fisheries biology and ecology;
- the complex interactions between fisheries and their habitat;
- And the effects of fishing on fish stocks and their habitat.”

Scientific Consensus Statement on Marine Ecosystem-based Management (McLeod 2005)

(from those suggested by the U.S. COP and Pew Commission reports):

- Make protecting and restoring marine ecosystems and all their services the primary focus, even above short-term economic or social goals for single services.
- Consider cumulative effects of different activities on the diversity and interactions of species.
- Facilitate connectivity among and within marine ecosystems by accounting for the import and export of larvae, nutrients and food.
- Incorporate measures that acknowledge the inherent uncertainties in ecosystem-based management and account for dynamic changes in ecosystems. In general, levels of precaution should be proportional to the amount of information available; the less that is known about a system, the more precautionary management decisions should be.
- Create complementary and coordinated policies at global, international, national, regional, and local scales, including between coasts and watersheds. (Appropriate scales for management will be goal-specific.)
- Maintain historical levels of native biodiversity in ecosystems to provide resilience to both natural and human-induced changes.
- Require evidence that an action will not cause undue harm to ecosystem functioning before allowing that action to proceed.
- Develop multiple indicators to measure the status of ecosystem functioning, service provision and effectiveness of management efforts.
- Involve all stakeholders through participatory governance that accounts for both local interests and those of the wider public.

The Marine Fisheries Advisory Committee’s (MAFAC) Ecosystem Approach Task Force
(Busch 2003) suggested these elements:

- Enhancing intra-and inter agency cooperation and communication
- Delineating geographic area(s) of the ecosystem
- Preparation of quantified natural resource goals and objectives
- Identify and apply specific indicators
- Socio-Economic data to evaluate management tradeoffs

In moving to EBFM, the challenge will be isolating the influence of individual ecological factors (e.g. climate and oceanographic conditions) and developing an understanding of important interactions. High levels of uncertainty will be associated with efforts focused on characterizing these relationships. The uncertainty results from the limitations of currently available data for estimating parameters for ecosystem models and for validating these models. A critical danger is that without any track record for such models, the assumptions could be completely wrong. There is little such danger with the current single-species approaches. For this reason, it is likely that when scientists and managers select management procedures based on a likelihood of achieving the management objectives, there will be a tendency to avoid this uncertainty and choose procedures similar to the present procedures which are based primarily on conservative single-species management. However, selection of new management system features that are robust to uncertainty is possible when there is consistency across a number of different models. In other words, there are technical means for filtering out the most risky aspects of new, unproven models, while still giving a fair trial for innovation.

Additionally, though the management systems may look similar during the transition to EBFM, the increased importance and use of ecosystem models will assist in the identification of approaches to consider when designing management procedures, defining decision rules, and planning investments in research and monitoring. The design and employment of new models will also assure that there is at least qualitative consideration of interactions before management decisions are made.

Until necessary research is done, it is not possible currently to know what the optimal model configuration and corresponding data requirements will be for an ecosystem-based management approach. It could be that a set of single-species models combined with collection of ecosystem indicators and prudent management strategies could suffice for many systems. For others, it may be necessary to develop complex ecosystem models with links among fish species, oceanography, climate, habitat, and human elements. It is also possible that the lofty goals of understanding the ecosystem and managing human uses sustainably are not achievable with finite resources and modeling capabilities. In that case, the goal may have to be limited to an achievable one, in which the risks of ecosystem harm are minimized through robust procedures that account for errors due to incomplete understanding.

Regardless, it is to be expected that substantial attainment of the goals of EBFM will require more and better data than are routinely available at present, and will involve more complicated scientific models than are routinely used for current management advice. To get this work done, funding and resources will be needed.

The panel considered various management methodologies (e.g. conservative single-species management, bycatch reduction, marine reserve establishment) as suggested by the NRC and EPAP (see Appendix 3). The panel noted that the items in these lists could be considered to be primarily tactical (how goals are achieved) rather than strategic elements of an EBFM approach (which set out the goals). Many of the suggestions include items that go well beyond those specific to EBFM approaches. The Panel noted that there was an absence of quantitative specificity associated with the lists. That is, though these tactical approaches may fit into an EBFM approach (i.e. a reduction of fishing capacity is desired), they don't answer the question of effectiveness at meeting EBFM objectives.

Finding Question 2

The panel came up with a list of eight “key elements” that are believed to be particular to an EBFM approach. In the construction of this list, emphasis was placed on identifying elements that are either new or in need of elevated attention. It is recognized that it will take time and a significant commitment to fully address these eight elements. Additional resources and funding will be required. How this information can be used and integrated is addressed in the findings for Question 3, below.

Elements of an ecosystem-based fishery management approach

1. Employs spatial representation
2. Recognizes the significance of climate/ocean conditions
3. Emphasizes food web interactions
4. Ensures broader societal goals are taken into account (possibly by incorporating broader stakeholder representation)
5. Utilizes an expanded scope of monitoring (total removals, cumulative effects, non-target species, environmental covariates)
6. Acknowledges and responds to higher levels of uncertainty
7. Pursues ecosystem modeling/research
8. Seeks improved habitat information (target and non-target species)

The rationale for these elements is as follows:

Spatial representation: Accounting more explicitly for space (“spatial thinking”) is a practical way of moving forward with EBFM. Currently, management focuses on temporal and age-structured considerations. Spatial thinking can help define how and where human activity (both fishing and non-fishing) affects the ecosystem (fishing as well as non-fishing impacts), and delineate the management needed to deal with different user groups (e.g. zoning and marine protected areas). It is at the heart of understanding spatially explicit population dynamics (e.g. fish movements over time and space) and stock structure. Without finer scale spatial subdivisions, species would all be managed as one homogeneous population, which functionally negates the rationale for good management measures such as spreading out catch over different areas and times to protect life-history characteristics and biodiversity, as has been done with the Bering Sea and Gulf of Alaska pollock fisheries (in consideration of localized availability of prey to Steller sea lion, for example).³

³ To date, a wide variety of spatial models and approaches for fish and terrestrial populations have been used (Quinn and Deriso 1999). There has been limited application of these models due to the absence of necessary data on fish movement and population variables by spatial designation. Even when movement data are available (such as with Pacific halibut and Gulf of Alaska sablefish), spatial models are rarely used for stock assessment, because of the greater complexity and the lack of a substantial difference compared with the non-spatial assessment. However, in many cases, reasonable spatial distributions of harvest recommendations can be made from the whole area (non-spatial) assessment by partitioning with spatial survey biomass and catch information, as is done for many NPFMC stocks (e.g., GOA pollock, cod, sablefish).

Climate/ocean conditions: There is ample evidence of the importance of climate regime shifts and inter-annual variations in oceanographic conditions to the reproduction and survival of fish and other species. For example, it is known on the west coast that salmon, sardines, marine mammals, Alaska crab, pollock and other west coast groundfish are sensitive to regime changes (Beamish, ed. 1995, McGinn, ed. 2002). Some regimes favor some species over others, and this depends on life history characteristics, their position in the food chain, and other factors. Since the North Pacific and Pacific FMC's maximum sustainable yield calculations for groundfish are based on productivity, it would be prudent for management to change when the climate regime changes, and to anticipate changes if that proves possible. Much of the information on how climate/ocean patterns might impact species has been generated from retrospective analyses of oceanographic conditions. While predictive ability is still low, consideration of different strategies for management relative to climatic factors and species life histories is important in an EBFM approach. Further, research will help make these strategies more robust.

The North Pacific (the Gulf of Alaska and the Bering Sea), has experienced good environmental conditions for fish productivity since about 1976 due to a regime shift. There is speculation about other regime shifts (in 1989 and after), which could affect future productivity. It will be interesting to see how robust management strategies currently in place will perform. In contrast, the U.S. West Coast (Washington, Oregon, and California) has experienced poor environmental conditions over the same period. Alternative management strategies had to be put into place to deal with low productivity of many stocks (especially rockfish). It will be interesting to see if these strategies allow west coast stocks to fully recover.

Food Web Interactions: Food web considerations are important in EBFM because there have long been indications that harvesting low down on the food chain (lower trophic levels) has disproportionately larger impacts on species at the top of the food chain (higher trophic levels). For example, sensitive top predators such as sea birds may not be able to switch prey as quickly as their prey species are fished down, and impacts of forage fish depletion shows up as increased seabird mortality. Additionally, the present ability of the science to quantify the variable natural mortality of fish and other organisms at lower trophic levels is very limited, leading to a high degree of uncertainty and the need for precautionary management.

The National Marine Fisheries Service's Alaska Fisheries Science Center has maintained a food consumption database for fishes in the Gulf of Alaska and Bering Sea for over twenty years. As models become refined and better understanding of species interactions is obtained (through data analysis and field research programs), the implications of these changes for fisheries management may be better understood.

There is also some limited information of this type available for the west coast.

Broader goal specification and recognition: EBFM encompasses consideration of broader use and users of the ecosystem. Since fisheries goals are only a subset of societal goals, EBFM will involve consideration of a broader set of impacts. This may also require expanded participation and representation in the FMC process.

Moving from high-level policy goals to operational objectives is a major challenge in areas where the goals deal with concepts such as ecosystem integrity, ecosystem health and biodiversity. Given the broader stakeholder base under EBFM, there frequently will be a need for institutions to coordinate consultations. Joint decision making will be needed between

fisheries that operate in the same geographic area and other non-fishery related user groups that interact with them.

Pertinent societal goals would include national, regional and fishery specific goals, but would also extend beyond fisheries goals to accommodate constraints imposed by legislation and regulatory “goals”. These would include the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act)⁴, the Endangered Species Act, and the Marine Mammal Protection Act. Within an EBFM approach, these broader goals will need to be reflected and accommodated more explicitly in management models and actions.

Expanded Scope of Monitoring and Research: Monitoring and research for EBFM will be qualitatively different than the current work (i.e. will involve new and different work and the use of that work in management decisions) but probably will not replace the need for continuing the current monitoring. Monitoring and research for EBFM will involve understanding interactions. It should include the amount of total removals of species associated with fishing (e.g. total removals of target species as well as non-target species including other fish, invertebrates, birds, etc.). There is also need to understand cumulative effects, including those from non-fishing activities (e.g. point and non-point pollution, habitat alteration, etc.) Additionally, monitoring is essential to determine the magnitude and timing of climatic variations and to understand how these patterns affect various target and non-target species.

Uncertainty (acknowledge and respond to higher levels of): High levels of uncertainty are associated with the current understanding of ecosystem functions, interactions and feedback loops. Additionally, present ecosystem models are rudimentary for marine systems. However, even if the interactions are poorly quantified, models can be used to help focus attention on ecosystem thinking, which is part of the attitude shift needed for an EBFM approach. It is important to note that while there will never be complete information, there needs to be a focus on what information can be collected to improve estimates of the level of uncertainty so that management can take realistic account of it.

Ecosystem modeling/research: On-going review of ecosystem models, from the perspective of quantifying uncertainty and identifying critical data needs to reduce uncertainty, should receive high priority. Ecosystem modeling will also require development of ways to quantify trade-offs among objectives. It could be helpful to identify the data types that are cheap or easy to collect (e.g. remote sensing data collected by others), as well as to set priorities for the most important information that is more expensive to collect but that would help separate out the “noise” from the “signal”. For example, among other things, there is a need to collect ecosystem data that are not associated with data collected during fishing activities (i.e., “fishery-independent data”). Further, there is a need to continue research that is focused on how climate/ocean patterns impact different fish species.

Habitat: An increased and expanded focus on habitat considerations is needed for an EBFM approach. While the Magnuson-Stevens Act calls for the protection of essential fish habitat from fishing impacts, to the extent practical, current understanding of physical habitat for spawning, rearing, feeding, etc. of fishery resources is limited, and existing knowledge of ephemeral pelagic habitat, e.g. oceanographic features like fronts, eddies and other current patterns, is even

⁴ The Magnuson-Stevens Act requires, among other things, the protection of Essential Fish Habitat, reduction of bycatch, the rebuilding of over-fished stocks and consideration of social and economic considerations.

more rudimentary. Similarly, it is known that habitat is an important consideration for marine mammals and presumably for many non-managed species, but habitat needs are understood only for a minority of these species. There is also a need to focus more attention on understanding the cumulative effects on habitat and how it affects both the target and non-target species.

The third question addressed by the panel was:

3. Are there practical ways for the North Pacific and Pacific Fishery Management Councils to incorporate these elements or characteristics further into their respective fishery management programs? How can these Councils improve their incorporation of ecosystem factors in their decision making in the near term? What longer-term changes are needed?

The panel saw the process of incorporating EBFM elements in FMC decisions as an evolutionary one that will build on existing fishery management programs. Practical approaches are facilitated by considering the following continuum that describes adjustments that are needed in the fishery management process to reach the goal of EBFM (Goodman, et al, 2002).

Single species focus → Implicit treatment of ecosystem effects → Explicit treatment of ecosystem effects

In the first stage, consideration is focused on the status of the target species and its predators and prey. In the second stage attention is broadened to take into account environmental effects in a more direct fashion in determining the status of the target species and incorporates measures for the direct effects of fishing activities other than those on the target species, such as bycatch, incidental mortality and some direct effects on habitat. In stage three, the environment, target stock, and its predators and prey are integrated in the assessment before the management procedure is used to determine catch limits and other management measures.

An implicit ecosystem approach, stage two, recognizes the existence of ecosystem interactions, but doesn't make any specific attempts to quantify the surplus production that must be reserved to satisfy ecosystem needs, nor does it attempt to modify fishing behavior to specifically mitigate adverse impacts other than those on the target species. The focus of this approach is on the determination of the status of target and non-target species and the evaluation of measures for tractable problems (EFH and technical interactions).

An explicit ecosystem approach, stage three, differs from the implicit approach in that less tractable problems are added, such as, food web dynamics, predator requirements and regime shifts.

For fisheries under Federal management, the various FMCs are at different points on the continuum, but there has been movement towards EBFM, stage three. In the case of the North Pacific FMC, for example, an ecosystem considerations chapter has been included in its annual SAFE report since 1995. Currently, attention is being focused on methods that can be used to more fully integrate information contained in this chapter into the decision making process. For example, ways to inform the North Pacific FMC of climatic and oceanographic conditions and their importance in the decision making process are being developed. Information for use in the stock assessment processes is being provided to assessment scientists. Results of ecosystem model activities also are being refined to provide the FMC with information on important

interactions. The FMC has also been active in implementing habitat protection and bycatch measures.

The Pacific FMC has instituted weak-stock management for groundfish (that is, managing for the “weakest link”), because it is not feasible to selectively harvest particular species. Further it has begun to consider prey interactions by protecting krill as a forage species. It has additionally protected extensive areas of habitat from trawling impacts via the EFH process. The Pacific FMC also has supported requests from the Monterey Bay National Marine Sanctuary, Cordell Bank National Marine Sanctuary and Channel Islands National Marine Sanctuary to prohibit or restrict fishing within parts of the sanctuaries for ecosystem protection.

The Pacific FMC could improve their progress towards EBFM by estimating total removals (this will involve additional observers) and adding ecosystem considerations and information into Stock Assessment and Fishery Evaluation (SAFE reports). It will also mean defining ecological goals, coming up with alternative tactical options to be considered to achieve these goals, and evaluating these alternatives. It would also involve a process to bring outside stakeholders into the process. As noted above, additional progress towards EBFM will be made at the North Pacific FMC as climate and oceanographic information and other information contained in the ecosystem considerations chapter of the SAFE report becomes integrated into the decision making process.

Clearly the task of progressing from the left side of the continuum to the right side becomes progressively harder and more costly. Management that takes ecological and ecosystem effects into account will require expanded monitoring, improvement in the understanding of behavioral relationships among fishers, the fish they catch and the prey of the harvested species. In return for this increased management complexity and expense, the FMCs can expect to see greater stability and predictability in fisheries, and possibly even greater productivity of managed stocks.

In considering actions that could be taken, the panel considered the eight recommendations that the Ecosystems Principles Advisory Panel provided in its report (EPAP, NMFS 1999). The Panel concluded that these action items could be considered a practical check list of ways for the FMCs to incorporate ecosystem considerations into their management programs:

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

Finding Question 3

The panel thought that the information associated with the eight items in the EPAP was practical and relevant, but didn't contain information about how the items would be used. The Panel offered the following suggestions that might be useful as additional steps that would further help the Councils incorporate EBFM considerations into their management process. Though the level of detail and data available will change over time, the considerations identified would apply in both the short term and long term. The numbers shown below refer to the original numbering of the EPAP report. Additional steps are indicated by bullets. The Panel again emphasized that the process of incorporating EBFM elements in FMC decisions will be an evolutionary one and build on existing fishery management programs.

Actions for achieving an ecosystem-based fishery management approach

1. & 8. Delineate and characterize *the ecosystem including* the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries.
 - *Define the management goals to reflect the societal objectives*
2. Develop a conceptual model of the food web
 - *Develop a conceptual model of the influence of oceanographic and climatic factors*
3. Describe habitat needs of different life history stages of significant food web plants and animals and how they are considered in conservation and management measures
 - *Expand/modify the conceptual model of the ecosystem to include life history characteristics and spatial variation*
5. Assess how uncertainty is characterized and what kind of buffers against uncertainty are included in conservation and management actions
 - *Identify alternative management procedures. A management procedure would include specifications for the data required as well as how those data are analyzed to determine management actions: e.g., how uncertainty is quantified statistically and how the extent of uncertainty is used in the decision rules (control rules).*
4. Calculate total removals, including incidental mortality and show how they relate to standing biomass, production, optimum yields, natural mortality, and trophic structure
 - *Develop a numerical representation combining the food web model (which would include dynamic models of managed species), the oceanographic model, and explicit representation of management measures and quantities that have been identified as metrics of attainment of the management goals.*
6. Develop indices of ecosystem health as targets for management
 - *Use models to identify indices that are relevant to the stated goals. Identify which indices*

can be used as the basis for decision making. ‘Traffic light’⁵ approaches may be useful.

7. Describe available long-term monitoring data and how they are used *to estimate parameters for the model and to quantify the reliability of the model.*
 - *Use the model to identify critical data gaps, and put plans in place to address them.*
 - *Conduct evaluations of management procedures (Management Strategy Evaluations)⁶ :
Use the model to evaluate the costs and benefits of management procedures in terms of their probability of achieving as many of the management goals as possible, calculated over a realistic range of uncertainty.*
 - *The Fishery Management Council would select from among these management procedures in light of their calculated performance.*
 - *Implement the management procedure accordingly.*
 - *Monitor to verify success of the management procedure and validity of the model.*
 - *Revise the model and the management procedure wherever the monitoring data indicates that the initial approach was mistaken .*

It is recommended that this modified EPAP list of actions be used at least annually to determine progress being made in the implementation of EBFM. Discussing these items when setting catch levels and when considering management measures, will provide information to determine if any of the conditions contained in the following list exists (Murawski, 2000):

- Biomasses of one or more important species assemblages or components fall below minimum biologically acceptable limits, such that (1) recruitment prospects are significantly impaired, (2) rebuilding times to levels allowing catches near maximum sustainable yield⁷ are extended, (3) prospects for recovery are jeopardized because of species interactions, or (4) any species is threatened with local or biological extinction;

⁵ Traffic light approaches turn ecosystem health indicators into “stop” or “go” recommendations for management. For example, if forage fish density falls below a set level, then fishing mortality would be reduced.

⁶ Management Strategy Evaluation (MSE) is an approach that assesses the performance of a range of management strategies (for example how much harvest is appropriate) against a set of management objectives (for example maintaining biomass or a certain fishing rate), and allows the evaluation of the tradeoffs among different management strategies. They evaluate how sensitive these strategies are to uncertainty (for example, uncertainty about climate regime, how stocks are distributed spatially, and sampling effectiveness) and are also used to evaluate an implemented strategy against the predictions of the MSE.

⁷ There are various definitions of maximum sustainable yield (MSY). The Pacific FMC uses the following: MSY is an estimate of the largest average annual catch or yield that can be continuously taken over a long period from a stock under prevailing ecological and environmental conditions. Since MSY is a long-term average, it need not be specified annually, but may be reassessed periodically based on the best scientific information available.

- Diversity of communities or populations declines significantly as a result of sequential “fishing-down” of stocks, selective harvesting of ecosystem components, or other factors associated with harvest rates or species selection;
- The pattern of species selection and harvest rates leads to greater year-to-year variation in populations or catches than would result from lower cumulative harvest rates;
- Changes in species composition or population demographics as a result of fishing significantly decrease the resilience or resistance of the ecosystem to perturbations arising from non-biological factors;
- The pattern of harvest rates among interacting species results in lower cumulative net economic or social benefits than would result from a less intense overall fishing pattern;
- Harvests of prey species or direct mortalities resulting from fishing operations impair the long-term viability of ecologically important, non-resource species (e.g. marine mammals, turtles and seabirds).

Goodman et al. (2002) suggest that the conditions listed above could be regarded as metrics for ecosystem status. These could provide the basis for thresholds that should be avoided in an attempt to prevent ecosystems from becoming “unhealthy”.

It should be noted that the Councils and NOAA have the existing statutory and regulatory authority to move forward in these directions. In fact, as mentioned above, both the North Pacific and Pacific Fishery Management Councils have initiated actions identified in the modified EPAP list, although attention has been uneven among the items. Using these action items as a check list will serve to focus attention on important issues and facilitate the identification of critical management issues.

The panel noted that, as a practical matter, the Councils already have “full agendas,” and adding new items, especially those with high levels of uncertainty, will be difficult. One fear is that new approaches and analyses will be rejected because of their uncertainties or demands for institutional resources unless things are done in small steps. Another concern is if the Council moves forward on new things, other things will need to be pushed aside. For example, when the North Pacific FMC did their Groundfish Programmatic Supplementary Environmental Impact Statement, some stock assessments didn’t get done. Managing the increased workload will definitely be an issue, but shouldn’t be an excuse to shy away from making progress.

To avoid a false sense of security, it should be understood that these aren’t simple matters, and it is estimated that multiple-years will be required for implementation, testing, and adaptation.

However, there are ways of moving forward with all the elements outlined above. As a start, it will be important for the Councils to create and implement a process and institutional structure that will facilitate the identification of a broader set of goals and operational objectives that deal with concerns beyond the targeted fish species. Once the goals and objectives are clearly identified, the Councils can start by choosing the actions that can be done where the outcome reasonably can be assumed, i.e. ‘if we do this, that will probably happen’. There are also activities in the Panel’s list that could be implemented immediately, but there are limitations due to the unknown quality of the models. An important application of these models is to identify areas of high uncertainty and guide research or data collection to fill in these gaps. Therefore,

despite the limitations, it is still important to generate these conceptual models. If a model is inaccurate and/or imprecise, its high uncertainty level will be noted, and will indicate where work is needed to improve its performance.

These models will evolve over time from population models (single species) to community models (taking into account food web considerations) and ecosystem models (taking into account environmental considerations such as habitat and climate). Additionally, as research progresses, the fishery management approach will evolve from implicit and non-quantitative consideration of the ecosystem to a more specific and explicit quantification of these features. It will also progress from consideration of these factors “outside” the fishery assessment itself to a system where these factors are fully integrated into the assessment and management process (Goodman et. al 2002). (Also see Appendix 4 for more information.)

The Role of Science in Fisheries Management

The panel also addressed a second and related topic: the role of science in fisheries management. To do so, they commented on four questions.

The first question was:

4. What is the appropriate role of science in fisheries management? How will this change as management programs move increasingly towards ecosystem based approaches?

The role of science is to inform the management decision process. The Science and Statistical Committees provide the Fishery Management Councils with reviews of documents, identify research issues and needs, and provide advice on conservation and management issues. The role of science with the implementation of ecosystem-based management will be the same. However, the breadth of information supplied by science will expand. The ability to use ecosystem approaches to sustain marine fisheries will depend on better information.

As management programs move towards ecosystem-based approaches, the role of science is to: facilitate the implementation of a decision analysis framework, to provide advice on drafting management procedures, use management strategy evaluations for contrasting and evaluating management procedures, and to provide data driven inputs (e.g. stock assessments with uncertainty quantification).

The second question regarding the role of science in fishery management was:

5. How do the scientists and the Councils interact now at the North Pacific and Pacific Fishery Management Councils ? What are the current institutional arrangements?

A detailed description of how the Pacific and North Pacific FMCs SSCs operate was prepared for the Managing Our Nation's Fisheries II Conference held in Washington, DC. (Witherell, 2005) is found in Appendix 5. The panel emphasized the following characteristics:

The institutional setting of the management process that both the North Pacific and Pacific Fishery Management Councils (FMCs) use is characterized by consideration of science as an integral part of the process. A tier approach best characterizes the way these FMCs receive scientific advice. The Plan Teams (PT), called Technical Teams in the Pacific FMC, represent the first layer. These groups are made up of academic, federal and state agency scientists. Each fishery management plan has a PT. They provide the FMC with reviews and allowable biological catch (ABC) information, and other information upon the request of the FMC.

The Scientific and Statistical Committee (SSC) is the second tier. As with the PTs, the SSCs are made up of academic, federal and state agency scientists. The North Pacific SSC has an equal split of agency and academic representatives. An effort is made in the North Pacific FMC to have all relevant disciplines represented on the SSC so that the Council is informed of how management might impact the various marine resources in the Bering Sea and Gulf of Alaska. The Pacific Council's SSC has more non-academic (agency) representatives. At the request of the Councils, the SSCs provide critical review of documents, advice on research issues and advice on conservation and management issues. They also review the models and methods used by the PTs. On occasion, the SSCs have taken the initiative to provide advice on issues considered to be of importance to decision making⁸. However, the usual approach is for the Councils to seek information from the SSCs⁹. Meetings of the SSCs are scheduled to occur concurrently with each FMC meeting to promote dialogue which will foster science based management.

Outside scientists make up the third tier. The North Pacific FMC has used outside scientists and the Center for Independent Experts (CIE) to review scientific documents, stock assessments, and its groundfish harvesting strategy. The Pacific FMC has used outside scientists, including scientists selected by the CIE, during the FMC-sponsored stock assessment review process (STAR panels) and in the harvest policy review workshop.

⁸ The North Pacific FMC's SSC for example provided a recommendation to implement an observer program for groundfish, held a workshop on multispecies management, and conducted a socio-economic study for the crab fishery limited entry plan. The Pacific FMC's SSC prepared a white paper on overcapitalization and conducted a harvest policy workshop.

⁹ For example, at the request of the Pacific FMC, the SSC provided an evaluation of Marine Protected Area (MPA) objectives, rationales, fishery management implications and regulatory requirements.

The third question regarding the role of science in fisheries management was:

6. Are current institutional arrangements adequate to address the challenges of ecosystem based approaches to management? Should SSCs be separated and insulated from the Fishery Management Councils? Or should the working relationship be strengthened through closer ties between the SSCs and the Councils? What practical steps can be taken to strengthen the role of science in fisheries management? Are there steps that the Councils or the Secretary can take now? What about the longer term?

The structure, process and use of Science and Statistical Committees (SSCs) by regional fishery management councils (FMCs) vary. In the case of the North Pacific and Pacific FMCs, the panel believes that the institutional process used to deal with scientific information is working. The decision making process is science-based and their scientific review bodies (SSCs, Plan Teams) are active, visible, and important in the management process. Nevertheless, ecosystem-based fishery management will require the development of a more formal process governing trade-offs between competing objectives, and methods for explicitly dealing with high levels of uncertainty. Estimates of uncertainties will also be required, as these are inputs into the decision rules, and the SSCs will be involved in identification of methods that can be used to address uncertainty. Further, there will be a need to conduct and review Management Strategy Evaluations (MSEs). None of these steps are easy, and they will all require a lot of additional technical work. Though the institutional structure of the SSC is adequate, additional staffing will be needed, especially to conduct these MSEs. The existing disciplinary expertise may need to be examined to assure the presence of appropriate representation for the broader EBFM goals.

The panel believes that SSCs should not be separated and insulated from the FMCs. Fisheries are not managed by science alone, but good fishery management cannot afford to ignore good science, and needs ready access to it. There will always be policy choices and tradeoffs that may be within the scope of the discretionary authority of the FMC, but the FMC will be in a position to better use that latitude if the SSC informs the FMC of the probable consequences of their choices. A close working relationship of a FMC with its SSC, which can be fostered by having both bodies meet at the same time, will facilitate such communication.

The Panel also suggested that the role of science and, thus, the SSCs, would be strengthened if NOAA Fisheries and the Secretary of Commerce would ask for a rigorous justification from the FMC if decisions were contrary to scientific advice. It should be made clear that SSC members are to act independently as scientists (and at times may disagree with their agency positions). Additionally, there may be value in having periodic national or regional meetings of the SSCs to develop common operating procedures and to compare approaches to providing scientific advice

The last question regarding the role of science in fisheries management was:

7. The issue of the role of scientists in setting overall harvest levels is a fundamental question facing all fishery management councils nationwide. The North Pacific Fishery Management Council (FMC) has a long policy of having the SSC set the allowable biological catch (ABC) and the Council then setting catch levels (total allowable catch, TAC) at or below ABC¹⁰. Under what conditions (if any) should a FMC set catch levels (TAC) higher than the levels (ABC) recommended by the scientists? What institutional checks and balances (if any) or review procedures (e.g. peer review) should be in place prior to allowing any Council to exceed the scientifically recommended harvest levels?

In many parts of the United States, there has been long-standing concern with how science is used in the Council process. The 1986 Calio Report found that “fishery management will be markedly improved by a clear separation between conservation and allocation decisions.” It recommended further that NOAA should determine ABCs using the best available science along with local and regional expertise, and Councils should make allocations that could not exceed the ABCs. Similar proposals have occurred almost continuously since then. Recently, the U.S. Commission on Ocean Policy (USCOP 2004) stated that, “...a lack of adequate scientific information has not been the main culprit in most instances of overfishing” and suggested that the SSCs set the allowable biological catch level and require the Councils to set harvest limits for the various fishing interests at or below this amount.

In a paper submitted for a Regional Fishery Management Council workshop, the executive director of the New England FMC (Howard, 2004) argued that decisions on such technical issues as annual catch limits and status determination criteria require an evaluation of risk to both stocks and fisheries. Further, he stated that risk evaluation is the responsibility of managers, not agency scientists. He commented that with its varied expertise, the Council considers the scientific recommendations, discusses the level of risk associated with various alternatives, and makes a management decision.

At the Fishery Management Conference held this past March in Washington, D.C. the Conference science panel (Conference’s SSC) commented that important roles for SSCs in the specification of ABCs include peer review of the stock assessments and harvest formulas that are used to calculate ABC, and review of regulatory analysis describing relevant effects (including the extent of risk and uncertainty) of harvest alternatives (Witherell, 2005). That Committee noted that while computation of an ABC is a scientific process, how it is derived is based on formulations that already reflect policy choices. The Main Conference Panel stated that the FMCs should adopt the ABC determined by their SSCs and set the total allowable catch (TACs) at or below the ABC (Witherell, 2005).

At the same Conference, the Conference’s science panel noted that defining and using the best scientific information available is an important goal in conducting fisheries science and

¹⁰ There are various definitions of TAC and ABC. The Pacific FMC uses the following: TAC (Total allowable catch). The total regulated catch from a stock in a given time period, usually a year. ABC (Acceptable biological catch). The ABC is a scientific calculation of the sustainable harvest level of a fishery and is used to set the upper limit of the annual total allowable catch. It is calculated by applying the estimated (or proxy) harvest rate that produces maximum sustainable yield to the estimated exploitable stock biomass (the portion of the fish population that can be harvested).

implementing fishery management objectives. It was stated also that having the best available science doesn't necessarily mean that it will be used. It was suggested that existing institutional mechanisms should be strengthened, for example, by having the Secretary of Commerce examine if management is consistent with scientific advice. This could be done, for example, as part of the Environmental Impact Statement (EIS) review. For instance, EISs prepared by the FMCs in setting their annual specifications could be required to include an explicit discussion of whether FMC recommendations deviated from SSC advice and why.

To assure that the best available scientific information is used, the National Research Council (2004) recommended that NOAA Fisheries should develop and implement guidelines on the production and use of scientific information in the fishery management process. It suggested that the guidelines be based on criteria of relevance, inclusiveness, objectivity, transparency and openness, timeliness and peer review. The panel agreed that such guidance would be helpful.

The Panel also agreed that, while computation of an ABC is a scientific process, some of the key constraints in the calculation may be set by policy. In the future, as decision rules become more sophisticated, the quantification of uncertainty will become more formalized. That is the stipulation of risk-related policy, namely the specification of how risk averse or risk tolerant the decision process should be, will become increasingly important. The formulation of such policy is not the role of scientific advisory bodies such as SSCs, but it should not be left to ad hoc decisions of the moment either (e.g. where within the range of values provided by the Pacific Council's SSC is the appropriate ABC). The goal of such formalized policy is to achieve consistency and stability across time and across districts, serving the best interest of society as a whole, in the long run, and putting more distance between the decision process and narrower considerations of expediency. For this reason, such policy should be the subject to national debate and independent scientific peer review. Regional differences must be recognized. Within such a framework, with its heavy technical demands, the role of scientific advisory bodies, such as SSCs, is to provide scientific quality control and quality assurance to the implementation. This role will include assuring that policy-determined constraints with respect to risk are met.

The Panel believes that important roles for the Scientific and Statistical Committees (SSC) in the specification of acceptable biological catch (ABC) include peer review of the stock assessments and harvest formulas that are used to calculate ABCs, and review analyses describing effects (including the extent of risk and uncertainty) of harvest alternatives and other management measures.

Both the Pacific and North Pacific Fishery Management Councils (FMCs) have attempted to be precautionary in their selection of harvest strategies. They have consistently set the total allowable catch (TAC) below ABC, thereby showing that they incorporate scientific advice into their harvest strategies. An interesting distinction is that the North Pacific SSC provides their FMC with a point estimate of ABC for a given stock, while the PFMC SSC provides a range of values for ABC. Further, the Pacific FMC reduces ABC linearly as fish biomass drops. In contrast, the North Pacific FMC reduces fishing mortality linearly as fish biomass drops, which results in a quadratic decrease in ABC. Ample scientific evidence exists to show that these biomass-based reductions serve to reduce the risk of over-harvesting and the time to rebuild to the target level of biomass. Management strategy evaluations should be conducted by the Councils to ensure that the use of either approach (point estimates or ranges of values) is suitably precautionary.

When a FMC selects a TAC from a range of ABC values, there should be sufficient justification and documentation for the choice. The Panel believes that TACs should be set above the value recommended by the SSC only when independent and credible peer review reveals fundamental flaws in a stock assessment analysis. The panel believes NOAA Fisheries and the Secretary of Commerce should be more diligent in their review of the actions taken by the FMCs.

Conclusion

The Panel addressed a series of questions that were designed to obtain advice on two questions related to the work of Fishery Management Councils (FMCs), and particular the North Pacific and Pacific FMCs. One set of questions related to the means by which FMCs could move further forward with an ecosystem-based fishery management (EBFM) approach; the other set of questions related to the role of science in fishery management in general and how this might change to meet the challenges of EBFM.

The Panel was able to provide practical suggestions regarding the elements and steps that can be taken to transition from a predominantly single-species approach, with some limited consideration of ecosystem factors, to a fully specified and integrated EBFM approach. This will not involve starting anew, but will move incrementally forward. This will involve recognition of a broader set of societal goals so that the desires of a larger group of users are addressed. It will also involve considering food web interactions, various spatial scales, climatic and oceanographic variations, the role of habitat, and the higher degree of uncertainty involved in these factors. It will also require new monitoring work to provide information on non-target species and other environmental factors. Similarly, there will be a need for new modeling and research to provide data and reduce the uncertainty involved in employing new management strategies. This will take commitment of additional resources and funding. The Panel also suggested a checklist of steps that could be followed to further EBFM considerations, including steps such as developing an integrated ecosystem model, developing indicators of ecosystem health and a program to monitor these indicators, developing decision rules based on the indicators, and defining, evaluating, and revising various management strategies to better meet goals. Though the level of detail and data available will change over time, the considerations identified can be applied in both the short term and long term.

The Panel commented on the role of scientific input in the FMC process. They noted that the existing process was working well in the North Pacific and Pacific. With EBFM there will be a need for additional resources and expertise to develop expanded decision rules, evaluate risk, and conduct management strategy evaluations to determine the basis for the eventual policy choices. The Panel believes that maintaining and strengthening ties between the Scientific and Statistical Committees (SSCs) and their respective FMCs, rather than severing them, as has been suggested, was important in assuring a scientific basis for fishery management, provided clarity about their respective roles is maintained and the scientific independence of the SSCs is upheld. Membership on the SSCs will need to be expanded to include individuals with expertise necessary for implementing EBFM.

References

- Beamish, R.J., ed. 1995. Climate Change and Northern Fish Populations. Canadian Special Publication of Fisheries and Aquatic Sciences 121: 1-739.
- Busch, W.-D.N., B.L. Brown, and G.F. Mayer (Eds). 2003. Strategic guidance for implementing an ecosystem-based approach to fisheries management. United States Dept. of Commerce, NOAA, National Marine Fisheries Service, Silver Spring, MD. May 2003.
- Caddy, J.F. 2002. "Limit Reference Point, Traffic Lights, and Holistic Approaches to Fisheries Management with Minimal Stock Assessment Input." *Fisheries Research* 56: 133-137.
- Dayton, P., S. Thrush, S. and C. Coleman. 2003. Ecological Effects of Fishing in Marine Ecosystems of the United States. Pew Oceans Commission. May 2003.
- FAO Fisheries Department. 2003. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries*. No. 4, Suppl. 2. Rome, FAO. 2003. 112 p.
- Field, J and R. Francis. 2005. Considering ecosystem-based fisheries management in the California Current. In review : *Progress in Oceanography*.
- Field, J.C., R. Francis, and K. Aydin. 2005. Top down modeling and bottom up dynamics: lining a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. In review: *Marine Policy*.
- Fogarty, M.J., and Murawski, S.A. 1998. Large-scale disturbance and the structure of marine systems: fishery impacts on Georges Bank. *Ecol. Appl.* 8 (Suppl.): S6-S22.
- Goodman, D., M. Mangel, G. Parkes, T. Quinn, V. Restrepo, T. Smith, K. Stokes. 2002. Scientific review of the harvest strategy currently used in the BSAI and GOA groundfish fishery management plans. Prepared for North Pacific Fishery Management Council. November 2002.
- Holliday, Mark. 2004. Guidelines for Regional Marine Ecosystem Approaches to Management. Current Issues in Implementing the Magnuson-Stevens Fishery Conservation and Management Act; A workshop for members of the Regional Fishery Management Councils, Baltimore, MD, October 2004
- Howard, Paul. 2004. Governance Role of Fishery Management Councils under Regional Ecosystem Management. Current Issues in Implementing the Magnuson-Stevens Fishery Conservation and Management Act; A workshop for members of the Regional Fishery Management Councils, Baltimore, MD, October 2004.
- Lent, Rebecca. 2004. Ecosystem Approaches to Fisheries. Current Issues in Implementing the Magnuson-Stevens Fishery Conservation and Management Act; A workshop for members of the Regional Fishery Management Councils, Baltimore, MD, October 2004
- McGinn, N.A., ed. 2002. Fisheries in a Changing Climate. American Fisheries Society, Symposium 32: 1-295.

- McLeod, K.L., J. Lubchenco, S.R. Palumbi, and A.A. Rosenburg. 2005. Scientific Consensus Statement on Marine Ecosystem-Based Management. Signed by 217 academic scientists and policy experts with relevant expertise. Communication Partnership for Science and the the Sea (COMPASS).
- Mueter, F.J. and B. Megrey. 2005. Using aggregate surplus production models to estimate ecosystem-level maximum sustainable yields. FOCI-0545 NOAA's Fishery-Oceanography Coordinated Investigations.
- Murawski, Steve. 2004. Fishery Management and the Best Scientific Information Available (BSIA). Current Issues in Implementing the Magnuson-Stevens Fishery Conservation and Management Act; A workshop for members of the Regional Fishery Management Councils, Baltimore, MD, October 2004
- National Marine Fisheries Service (NMFS). 1999. Ecosystem-based Fishery Management: A Report to Congress by the Ecosystems Principles Advisory Panel.
- National Research Council (NRC). 1999. Sustaining Marine Fisheries. National Academy Press, Washington, D.C.
- National Research Council (NRC). 2004. Improving the Use of the "Best Scientific Information Available" Standard in Fishery Management, National Academy Press, Washington, D.C.
- NOAA 1986 (the Calio Report). U.S. Dept. of Commerce. *NOAA Fishery Management Study*. Washington, DC: June 30, 1986.
- Pew Oceans Commission. May 2003. Managing Marine Fisheries in the United States. Proceedings of the Pew Ocean Commission Workshop on Marine Fishery Management.
- Quinn, T.J., II. 2003. Ruminations on the development and future of population dynamics models in fisheries. *Natural Resource Modeling* 16: 341-392.
- Quinn, T.J., II, and Deriso, R.B. 1999. *Quantitative Fish Dynamics*. Oxford University Press, New York.
- Quinn, T.J., II, and Collie, J.S. 2005. Sustainability in single-species population models. *Philosophical Transactions of the Royal Society B* 360: 147-162.
- Sissenwine, M.P., and Mace, P.M. 2001. Governance for responsible fisheries: an ecosystem approach. In *Responsible Fisheries in the Marine Ecosystem* (M.Sinclair and G. Valdimarsson, eds.), CABI Publishing, Wallingford, England: 363-390.
- South Atlantic Fishery Management Council. 2004. Action plan. Ecosystem-based management: evolution from the habitat plan to a fishery ecosystem plan. Charleston, South Carolina. December 2004.
- U.S. Commission on Ocean Policy Report. 2004. An Ocean Blueprint for the 21st Century. Final Report. Washington, D.C.

Witherell, D., editor 2005. *Focusing on the Future; Managing Our Nation's Fisheries II*, Washington, D.C. Summary of findings from a conference held in Washington, D.C., March 2005.

Witherell, D., editor. 2004. *Managing our nation's fisheries: past, present and future*. Proceedings of a conference on fisheries management in the United States held in Washington, D.C., November 2003.

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

Appendix 1

Biographies of the Panel Members

Dr. Daniel Goodman: Dr. Goodman received his PhD from Ohio State University in 1972 and did post-doc work at Cornell University 1972-74. He worked as an Assistant Professor of Population Biology at Scripps Institution of Oceanography 1975-1983 and as an Assistant Professor of Biology at Montana State University 1981-1987. Since 1987 he has been a Professor of Biology at Montana State University. His research includes work on population modeling, environmental statistics, Bayesian decision theory, population viability analysis, marine mammal conservation, and salmon fisheries management. He has published over 80 reports on this work.

He has served on numerous national and international science panels. Among other work, he served, between 1987 and 1994, on various Science Advisory Boards of the US Environmental Protection Agency including the research strategies subcommittee, long-term ecological research subcommittee, a global climate research subcommittee, and an ecological processes and effects committee. He has served on the Independent Science Advisory Board for Salmon Recovery and the Independent Scientific Review Panel of the Northwest Power Planning Council since 1996 and 1997, respectively. Since 2002 he has also served on National Marine Fisheries Service's (NMFS) Hawaiian Monk Seal Recovery Team.

He served as chairperson for the Review Panel for the Groundfish Fishery Control Rule for the North Pacific Fishery Management Council in 2002. Since 2002 he has also been a member of the Science Panel for the North Pacific Research Board.

Dr. Churchill Grimes: Dr. Grimes is the Director of the NMFS Southwest Fishery Science Center, Fishery Ecology Division in Santa Cruz, CA, where he directs the research program to provide the scientific basis for conservation and management of demersal fishery resources and the recovery and restoration of ESA listed anadromous species in California. Prior to assuming his present position Dr. Grimes served as Director and as Leader of Fishery Ecology Investigations of the NMFS, Southeast Fishery Science Center, Panama City Laboratory and was Associate Professor of Marine Fisheries at Rutgers University in New Brunswick, NJ.

He has published over 100 papers, on his research on life history and population dynamics (in particular habitat ecology, recruitment processes and fishery oceanography) of various fishery resources in the Southern New England-Mid Atlantic Bight, U.S. South Atlantic Bight, Gulf of Mexico and Pacific Ocean off California.

He has served on numerous international, national and regional scientific advisory bodies. In 1987 he participated in developing the NMFS Ecosystem Initiative, throughout the 1990's he served on the Gulf of Mexico Fishery Management Council Scientific and Statistical Committee (SSC) and the Special Mackerel SSC, published papers on the utility of the Experimental Oculina Research Reserve off southeast Florida for managing reef fish stocks and on the use of marine reserves for fishery management. He also served on the steering committee of the American Fishery Society Symposium on Aquatic Protected Areas as Fishery Management Tools, organized and participated in the National Fisheries Conservation Center MPA Science Integration Workshop, and was the principal organizer of the NOAA MPA Science Integration Working Group process.

Dr. Peter Lawson: Dr. Lawson is currently a research fishery biologist at the NMFS Northwest Fisheries Science Center. He received an M.S. in 1984 and Ph.D. in stream ecology from Idaho State University in 1986. He then took a position as biometrician and modeler for the ocean salmon harvest team of the Oregon Department of Fish and Wildlife. In 1997, after ten years with ODFW, Pete joined NMFS.

He has served on technical advisory committees to the Pacific Fishery Management Council (PFMC) and the Pacific Salmon Commission since 1987. He served a two-year term as chair of the PFMC's SSC and several terms as vice-chair. He is currently chair of the SSC's salmon subcommittee.

Pete's models have been used to predict salmon runs, estimate harvest impacts, elucidate the non-landed mortality in selective fisheries, and explore coho salmon population dynamics with a fine-grained, habitat-based life-cycle model. Recent publications have treated climate effects on coho salmon survival in both freshwater and marine environments, with the goal of building a model that integrates across freshwater and marine phases of the life cycle.

Dr. Richard Marasco: Dr. Marasco received his bachelor's degree in 1965 from Utah State University in Applied Statistics and Computer Science. He received his doctor's degree from the University of California Berkeley in Agriculture and Natural Resource Economics in 1969. He served on the staff of the Agriculture and Natural Resource Economics of the University of Maryland from 1969 to 1977.

From 1977 to 2005, he served on the staff of the NMFS Alaska Fisheries Science Center, in Seattle, Washington. From 1981 to 2004 he was the Director of their Resource Ecology and Fisheries Management Division.

He was the U.S. delegate to PICES (North Pacific Marine Science Organization) from 1999-2004 and the chairman of its finance and administration committee from 1998 to 2004.

He also served on the North Pacific Fishery Management Council's Science and Statistical Committee from 1979 to 2004. He served several terms as Chairman of that body. Since 2002 he has also been Chairman of the Science Panel for the North Pacific Research Board.

Dr. André Punt: Dr. André Punt is an Associate Professor with the School of Aquatic and Fisheries Sciences, University of Washington, Seattle and a Research Scientist with CSIRO Marine and Atmospheric Research in Hobart, Australia. He holds an M.S. and a Ph.D. in Applied Mathematics from the University of Cape Town, South Africa. André has been involved in research on marine population dynamics, stock assessment methods, and harvesting theory since 1986, and has published over 100 papers in the peer-reviewed literature along with over 300 technical reports. His current research focuses on the performance of stock assessment methods, application of Bayesian approaches in fisheries assessment and decision analysis, and management strategies for fish and marine mammal populations.

Until early 2001, when he left Australia to join the University of Washington, André was chair of Australia's Southern Shark Fishery Assessment Group and a member of the Shark Fishery Management Advisory Committee. He has been a member of several other stock assessment teams and is currently an at-large member of the Scientific and Statistical Committee of the Pacific Fisheries Management Council. He is also a member of the IUCN Shark Specialist

Group, participated in the review of the IUCN criteria for listing species at risk of extinction, and is currently a member of the IUCN Red List Standards and Petitions Committee.

André has participated in the Scientific Committees of the International Commission for the South East Atlantic Fisheries (ICSEAF) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). He has been an invited participant to the International Whaling Commission (IWC) since 1990.

Dr. Terry Quinn II: Dr. Quinn received a BA in Mathematics from the University of Colorado in 1973, and an MS in Fisheries in 1977 and a PhD in Biomathematics in 1980 from the University of Washington. From 1977 to 1985 he was Biometrician at the International Pacific Halibut Commission. Since 1985, Dr. Quinn has served as a professor of Fish Population Dynamics at the University of Alaska Fairbanks.

He is the co-author or co-editor of 4 books, including the key reference for fishery models: Quantitative Fish Dynamics, with co-author Richard B. Deriso, published by Oxford University Press. He has also written about 100 peer-reviewed scientific publications. He has shepherded about 25 students through their post-graduate careers at either the M.S. or PhD levels.

He has been a member of the Statistical and Scientific Committee of the North Pacific Fishery Management Council since 1986 and is a former chairperson of that body. He is a former member of the Ocean Studies Board of the National Academy of Sciences and served on five of their committees, and has served as the chairperson or co-chairperson of two of these. He is an Associate Editor of the prestigious Canadian Journal of Fisheries and Aquatic Sciences.

Support Staff

Dave Hanson is the deputy director of Pacific States Marine Fisheries Commission (PSFMC). He is a non-voting member of both the Pacific and North Pacific Fishery Management Councils, and is currently chairman of the Pacific Council's Legislative Committee and Parliamentarian. He has been involved in the development of inter-jurisdictional fishery management plans for West Coast fisheries and has been involved in many international fishery issues for PSMFC.

Fran Recht is the habitat program manager for the PSMFC. She serves on the habitat committee of the Pacific Fishery Management Council, is involved with watershed restoration, protection, and education efforts, and was recently involved in helping prepare sections of the groundfish essential fish habitat document.

Jodie Little is a graduate student at the University of Washington's School of Aquatic and Fishery Sciences, working under the direction of Dr. Robert Francis. Her doctoral studies focus on modeling and evaluating interactions between the U.S. West Coast coastal marine ecosystem, economies and coastal communities.

Appendix 2: Questions for Panel

1. Ecosystem based Management

The United States Commission on Ocean Policy (USCOP) recommends moving towards an ecosystem-based approach to management but recognized that our limited knowledge of the marine environment and ecosystem relationships is a major hurdle. The National Research Council (NRC), also recognizing these limits, proposed eight specific elements of an ecosystem-based approach to fisheries management which could be used as guidelines in sustainable fishery management by regional management councils.

Questions for Panel consideration include:

- **What is a practical definition of an ecosystem-based approach to fisheries management that could be used by fishery management councils?**
- **What are the characteristics or management elements of an ecosystem based approach to fisheries management? Are the elements identified by the NRC/EPAP still appropriate? Are there other elements or characteristics that should be included?**
- **Are there practical ways for the North Pacific and Pacific Fishery Management Councils to incorporate these elements or characteristics further into their respective fishery management programs? How can these Councils improve their incorporation of ecosystem factors in their decision making in the near term? What longer term changes are needed?**

2. Role of Science in Fisheries Management

With the emphasis of moving more and more towards an ecosystem based approach to fisheries management, the role of science will be increasingly important. The USCOP called for separating the scientists (SSC) from the managers (Councils) to separate “conservation” decisions from “allocation” decisions. Others have called for strengthening the interactive role of science and management, arguing that a stronger institutional tie between science and management provides for better informed decision making. At the recent Managing Our Fisheries II Conference, the panel on Science and Management called for the scientists to set the overall harvest level and limiting the Council decisions to setting final harvest levels at or below the level recommended by the scientists. This was modified by the final Panel to allow for exceeding the ABC only with appropriate justification. Questions for consideration by the Panel include:

- **What is the appropriate role of science in fisheries management? How will this change as management programs move increasingly towards ecosystem based approaches?**
- **How do the scientists and the Councils interact now at the NPFMC and PFMC? What are the current institutional arrangements?**
- **Are current institutional arrangements adequate to address the challenges of ecosystem based approaches to management? Should the SSCs be separated and insulated from the Councils? Or should the working relationship be strengthened through closer ties between the SSCs and the Councils?**
- **What practical steps can be taken to strengthen the role of science in fisheries management? Are there steps that the Councils or the Secretary can take now? What about the longer term?**
- **The issue of the role of scientists in setting overall harvest levels is a fundamental question facing all fishery management councils nationwide. The NPFMC has a long policy of having the SSC set the ABC, and the Council then setting the TAC at or below ABC. Under what conditions (if any) should a Council set catch levels (TAC) higher than the levels (ABC) recommended by the scientists? What institutional checks and balances (if any) or review procedures (e.g. peer review, others) should be in place prior to allowing any Council to exceed the scientifically recommended harvest levels?**

Appendix 3: Management Elements Suggested by EPAP/NRC

Both the Ecosystem Principles Advisory Panel (NRC 1999) and the National Research Council (NRC 1999) have suggested various methods to achieve ecosystem-based management (see below). Some of the mechanisms suggested include accounting for the total amounts and kinds of species caught (bycatch), managing single species conservatively, reducing excess fishing capacity, establishing marine protected areas, and employing alternative fishing gears and using various management areas to reduce impacts. The panel considered many of these suggestions to be useful tactical approaches, rather than strategic elements, and ones that could help meet EBFM objectives, but that were not necessarily confined to an EBFM approach. They also noted an absence of quantitative specificity in these approaches.

For example, the North Pacific and Pacific FMCs have already adopted or are considering tactics to manage conservatively, reduce capacity, protect habitat and forage fish. The North Pacific in particular has employed most of these methods. However one doesn't know if these methods are enough to achieve the strategic goals; i.e. it doesn't necessarily answer the question "are we doing enough"?

ECOSYSTEM-BASED FISHERY MANAGEMENT APPROACH RECOMMENDATIONS (summarized)

<i>National Research Council report—Sustaining Marine Fisheries (NRC 1999)</i>	<i>Ecosystems Principal Advisory Panel (NMFS 1999)</i>
Incorporate ecosystem goals into management	Develop an overall Fisheries Ecosystem Plan (FEP) that involve Councils taking 8 actions ¹¹
conservative single species management	Estimate MSY and set OY conservatively
account for uncertainty to favor long-term goals	Make risk adverse decisions, err toward conservation (apply precautionary approach)
	change the burden of proof when effects are poorly known (no expansion fisheries/catch levels, no development/promotion of fisheries for under species)
reduce excess fishing capacity	
establish marine protected areas	marine protected areas/reserves as insurance
	develop system to detect & respond to adverse impacts at early stage
Incorporate bycatch and discards in setting catch (TAC)	consider total bycatch removals, understand by gear type, temporal and spatial distribution;
Management/incentives to favor gears and technology that promote conservation	id existing or potential alternative gear types or fishing patterns such as area closures to alleviate habitat impacts; reduce bycatch
develop institutions to achieve goals; provide appropriate socioeconomic incentives	local incentives through share-based allocations (IQs, units of fishing effort, rights to fish specific areas etc.)
conduct research/get info on marine ecosystems, models, socioeconomics	support on-going comprehensive ecosystem research and expand it to include research to determine the ecosystem effects of fishing, monitor trends and dynamics of marine ecosystems, and ecosystem-based approaches to governance.
	Promote maximum involvement of stakeholders in fishery management, including the interests of future generations, and maximum appropriate delegation of responsibility to the lowest levels of the management system (i.e. local or regional level)
Provide ecological principles training to Council members/staff	

¹¹ The actions include: delineating and characterizing each ecosystem; developing a conceptual model of the food web; etc. (see full listing under question 3 of this document).

Appendix 4
Excerpts From Scientific Review Of The Harvest Strategy Currently Used In The BSAI
And GOA Groundfish Fishery Management Plans (Goodman et. al 2002)

Summary of the information on moving from conventional fisheries assessments to
assessments that explicitly incorporate ecosystem considerations

Given sufficient investment in carefully designed experiments and monitoring to improve the predictive power of the models, they will evolve over time from population models (single species) to community models (taking into account food web considerations and environmental considerations such as habitat and climate).

Additionally, as research progresses, the fishery management approach will progress from implicit and non-quantitative consideration of ecosystem considerations to more specific and explicit quantification of these considerations. It will also progress from consideration of these factors “outside” the fishery assessment itself to a system where these factors are fully integrated into the assessment and management process.

This process is conceptualized as occurring in stages. In the first stages (a single species focus), consideration is focused on the status of the target species and its predators and prey (as well as the socio-economic world of the fishing community which takes the stock) in an implicit way. “Safety margins” or buffers are built in to account for non-target species. This then progresses to more specific and explicit accounting for the environmental effects on the status of target species, with measures incorporate to account for the direct effects of fishing on the other non-target species (e.g. bycatch and incidental mortality). That is, the status of prey and predators are considered in setting the catch limit in the management procedure, but the analyses are not integrated with the analyses that focus on the target species.

In the second stages of explicit consideration of ecological and ecosystem effects, management procedures take into account the status of the target stock, predator and prey species, and some environmental information such as direct effects of fishing for the target species on EFH and bycatch. The mitigation of the direct effects of the fishery is addressed through such things as bycatch reduction devices, habitat protection measures, and taking into account the prey needs of other species. At this stage too, the analysis of these factors are also separate from the analytical process for the target species (that is there is no direct link made between the fishery and its effects on ecosystem properties or the effects of the environment on the ecosystem other than the direct effects on the target population). The North Pacific FMC, for example, has produced an annual report on ecosystem considerations to be incorporated into each year’s Stock Assessment and Fishery Evaluation (SAFE) reports. This provides the FMC with information about the oceanographic conditions in the Bering Sea and Gulf of Alaska and the effects of environmental change on fish stocks, information on predator/prey interactions, and forecasts the ecosystem impacts of fishery management decisions. This information may limit the catch of target species, based on the ecosystem goals that Council has adopted, but the stock assessment and estimation of yield of the target species is still undertaken essentially in isolation of ecosystem considerations.

In the third stage, community ecology is directly incorporated into the analytical process for management of the target species, with information from the environment, including information about non-target species, integrated directly into the assessment process so that it directly

influences the scientific advice provided to the Council. At this state there is a higher level of uncertainty in some factors (such as climatic regimes and inter-annual variation) and where indirect effects of fishing are more broadly considered (e.g. where cause and effect may be several steps removed from each other). Recognizing the high level of uncertainty and predictive power of these integrated models, there will also be a need to use additional techniques such as risk analysis and adaptive management to allow action in light of this uncertainty and the possibility of errors.

The following figures are from the Goodman et al. 2001 report:

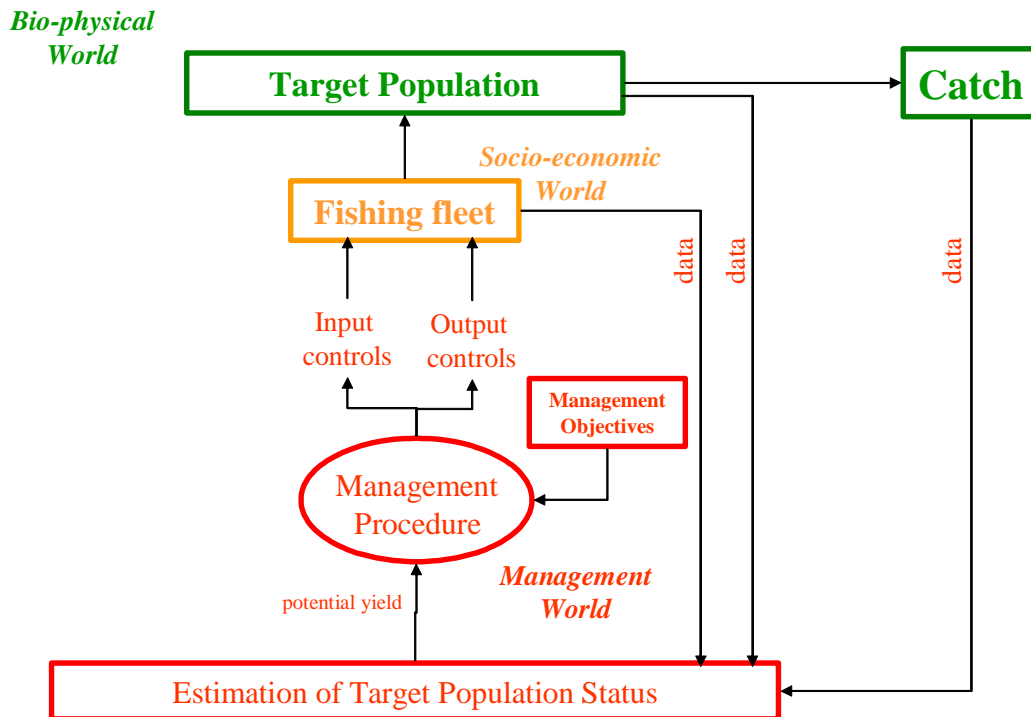


Figure 4.1. The conventional assessment world view, in which nearly all fishery management is currently done, recognizes the biophysical world in which the stock exists, the socio-economic world of the fishing community that takes the stock, and the management world in which catch limits are determined.

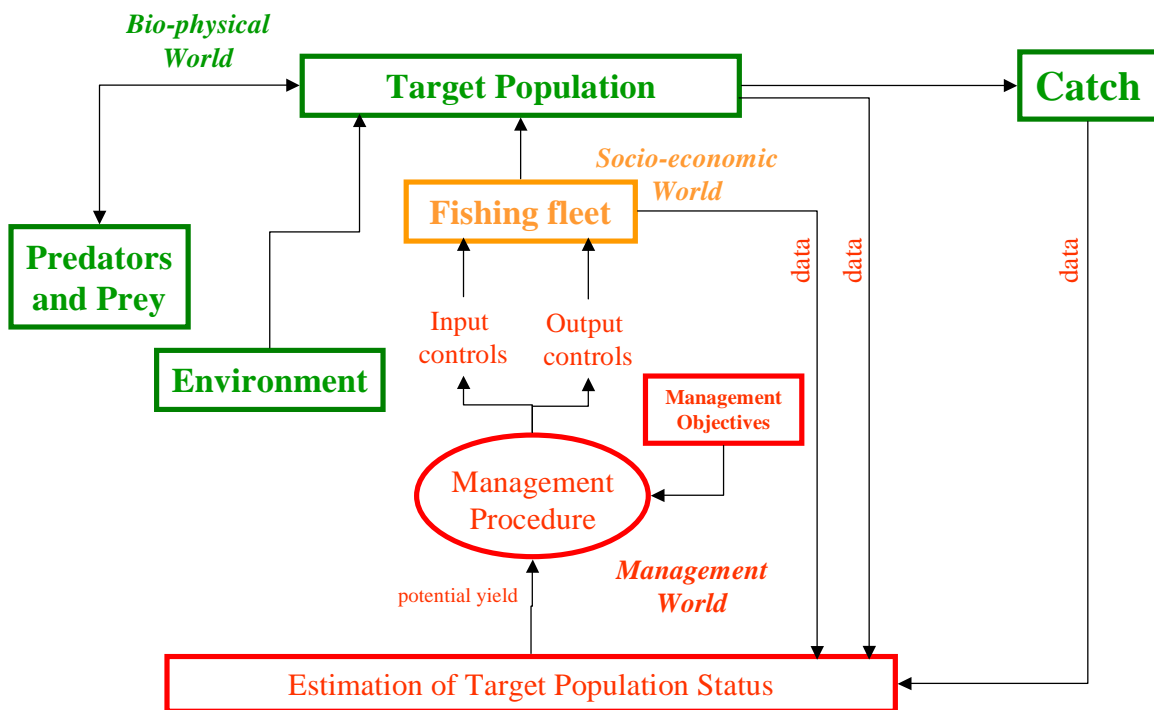


Figure 4.2. In the implicit ecosystem effects world view, we recognize that target species in fisheries are generally prey for other components of the ecosystem. While management objectives only take such predator needs into account in a very general way, the implicit view is cognizant of those needs.

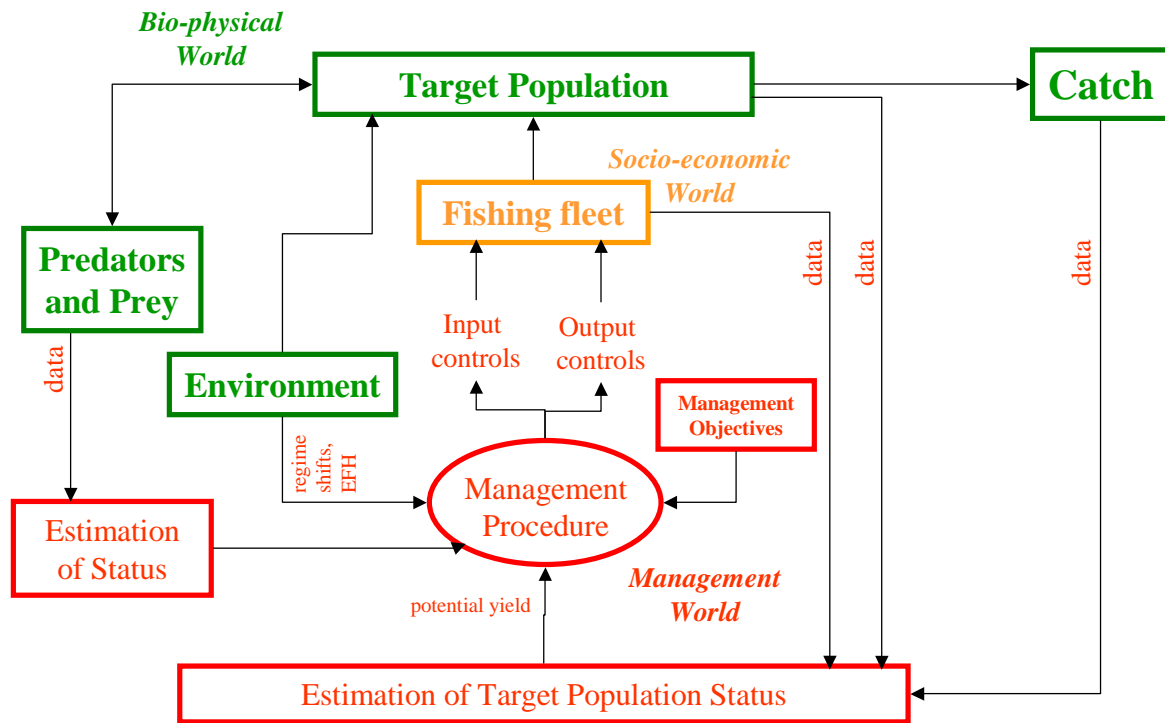


Figure 4.3. In the first stage of management that takes ecological and ecosystem considerations into account in an explicit manner, both the status of the target stock and its predators and prey are considered, but these are not integrated in a holistic management play. In some sense, then status of prey and predators thus constrain the catch limit from the management procedure.

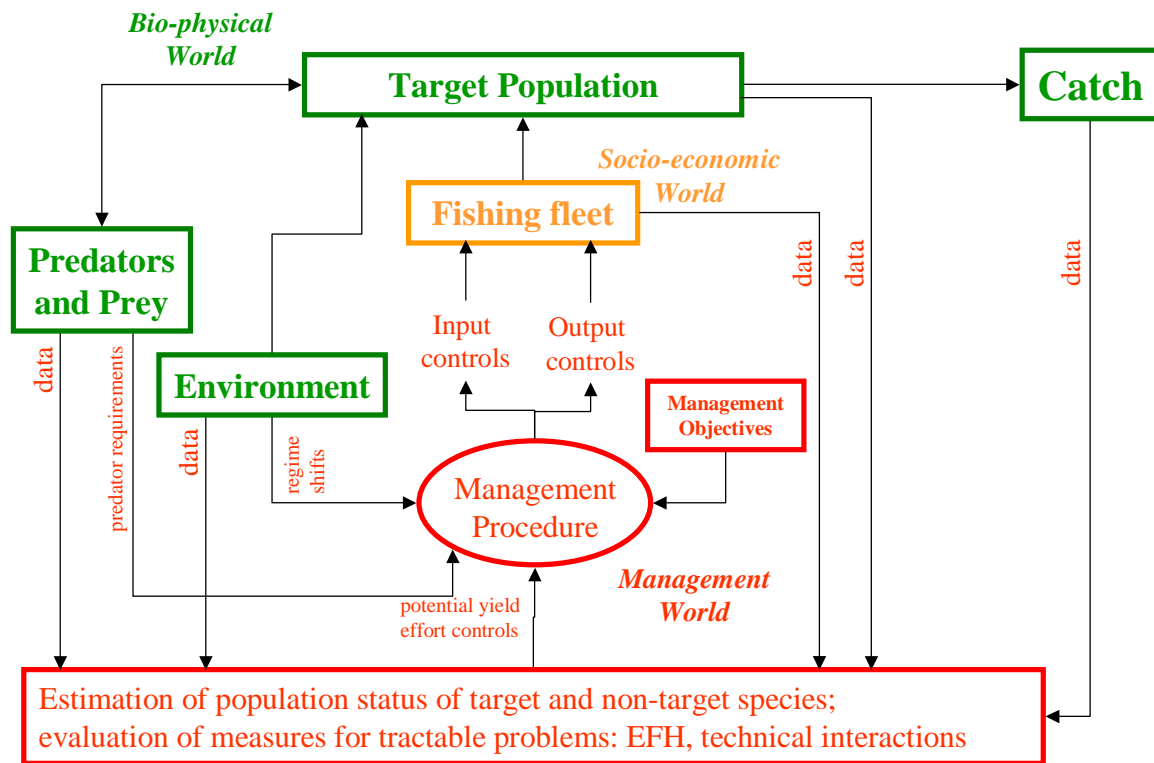


Figure 4.4. In the second stage of explicit consideration of ecological and ecosystem effects, one takes into account environmental effects in a more direct fashion in consideration of the status of the target stock and incorporates measures for the tractable problems described in Section 4.2.2.1.

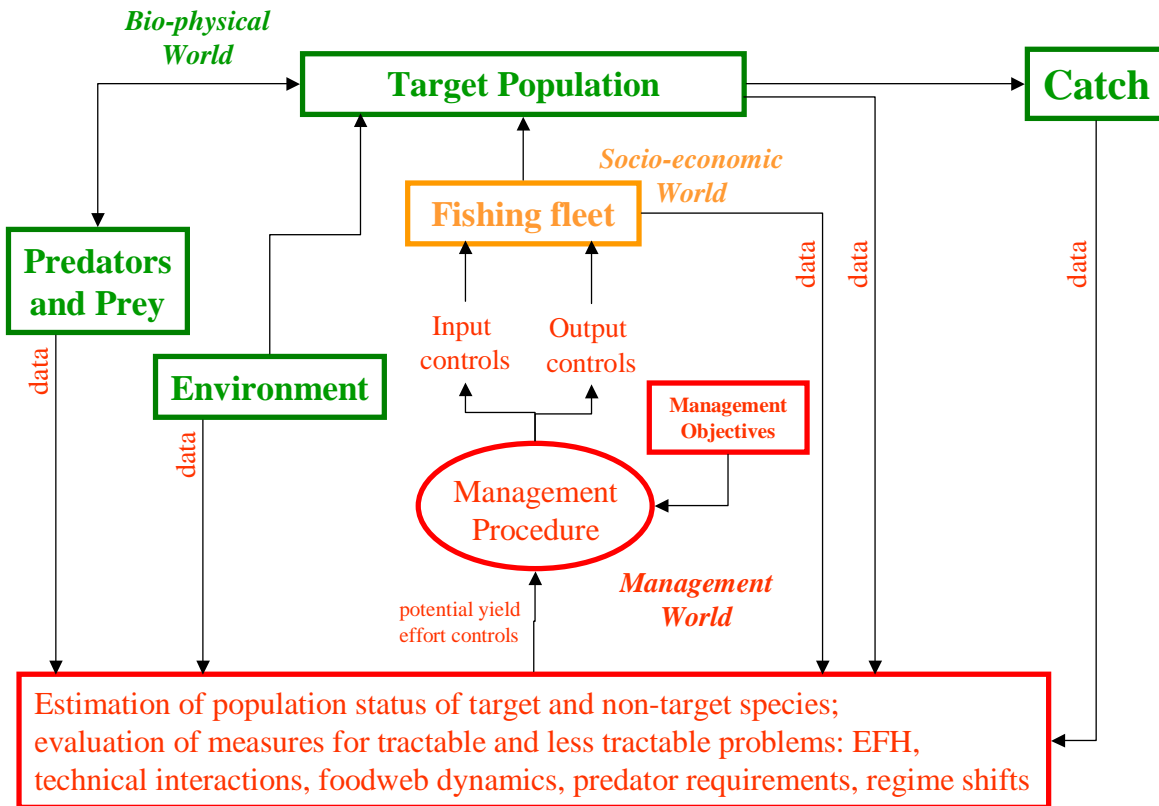


Figure 4.5. In the third stage, the environment, target stock, and its predators and prey are integrated in the assessment before the management procedure is used to determine catch limits. At the same time, the less tractable problems identified in Section 4.2.2.2 are included

Appendix 5

The following descriptions of the operations of the Science and Statistical Committees (SSCs) of the North Pacific and Pacific Fishery Management Councils (FMCs) was extracted from a larger document entitled “The Use of Scientific Review by the Regional Fishery Management Councils: The Existing Process and Recommendations for Improvement”, which described the operations of the other FMCs in the country as well. It was prepared by David Witherell, deputy director of the North Pacific Fishery Management Council for the March 2005, Managing Our Nation’s Fisheries II Conference held in Washington, D.C.

North Pacific Fishery Management Council

The North Pacific Council’s SSC currently has 15 members, consisting of population dynamics biologists, ecologists, economists, and social scientists from academia and federal and state agencies, appointed on an annual basis. There are no SSC members from private businesses or other organizations.

While most members are drawn from the Pacific Northwest, the SSC includes members from California, Utah, and Rhode Island. In practice, the SSC is a self-appointing body that recruits new members as they see fit, although in practice there are members who serve in “agency” seats for Oregon, Washington, Alaska, and NOAA Fisheries. Although the Council has final approval authority regarding SSC membership, recommendations of the SSC regarding its membership have always been approved by the Council. Each year, SSC members elect a chair and vice-chair from among their membership. While most chairs serve for several years, few serve for more than 3-4 years. The current SSC includes two former chairs, who serve with the current chair as an informal chairman’s council regarding the structure and operation of the SSC.

The SSC meets for 2 to 3 days, 5 times per year (or more frequently if the Council schedules additional public meetings). The SSC chair or vice-chair remain available to the Council for 2-3 days following the completion of the SSC meeting, to be able to present the minutes to the Council as each agenda item is reviewed by the Council and to respond to questions that Council members may have about the meaning and intent of those minutes. The SSC meetings occur at the same locale and begin just prior to each Council meeting to facilitate public participation and input. In addition, the SSC holds occasional workshops with agency analysts and researchers to explore analytic innovations or to encourage the development of new research programs.

The SSC reviews the scientific information for most actions that come before the Council¹². The process for changing regulations begins with a proposal that may originate from the fishing

¹² Before each meeting, the Executive Director (or Deputy Director) and the SSC chair discuss Council agenda items and identify those items that are most likely to require scientific review. The SSC generally does not review housekeeping items or items that are in final review. If however, the SSC requested that draft analytic documents be released after revision, the SSC is often asked to review the final draft document for compliance with SSC requests. The SSC may also be asked to review final review documents if there have been substantive changes in the documents or information included in the documents.

industry, environmental groups, NOAA Fisheries, the Council, or other advisory groups including the SSC itself.

The proposal is evaluated in subsequent meetings through discussion papers, environmental assessments, and socio-economic analyses. At each stage, the SSC provides scientific input to improve the analysis, and also makes a recommendation as to whether the analytical document is ready for public review, meaning that it meets their standard of best scientific information available.

The process for SSC review is similar in most instances. First, the SSC receives the first draft of an environmental assessment or impact statement, regulatory impact review, or other analytical document, by mail about 1-4 weeks prior to a meeting. At the SSC meeting, the lead analytical staff for a particular agenda item presents a summary of the analysis, and answers questions from SSC members. The public is given an opportunity to testify, and frequently several fishery participants or environmental representatives may testify on the scientific and technical details of a given analysis. Following the staff reports and public testimony, SSC members deliberate the scientific content of a given analysis. Generally, the SSC focuses their deliberations to determine best available scientific information by examining the appropriateness of input data, the methodology applied, and the conclusions drawn from the analysis. To ease the workload for individual SSC members, the SSC chair generally assigns 2-3 members to be discussion leaders for each agenda item topic. These individuals also summarize the SSC discussion and deliberation, and then prepare the first draft minutes for that particular analysis or issue.

All SSC members have an opportunity to review the draft minutes before they are presented to the Council by the SSC chair. The turn around time for preparing written minutes is short; in some cases the issue may have been discussed by the SSC less than one day prior to reporting to the Council. SSC members, particularly the chair and vice-chair, often work long hours to complete their minutes for distribution at the Council meeting. The minutes of the NPFMC SSC are not a formal record of deliberation, but represent a consensus opinion regarding the scientific merit of the documents under consideration. These minutes are not adopted by formal vote. The minutes also provide recommendations to improve the scientific analysis to meet SSC approval.

Should analysis be deficient and major revisions be required, the SSC will recommend to the Council that it not be released for public review. With the exception of a few very technical scientific issues (e.g., establishing overfishing definitions and setting acceptable biological catch limits), the SSC does not generally provide the Council with an explicit recommendation on which alternative should be chosen, but rather provides guidance on relative strength of the scientific information available (i.e., uncertainty). For example, in February 2005, the SSC reviewed the revised analysis and evaluation of fishing effects on essential fish habitat, and commented that “The analysis found no evidence that Council-managed fishing activities have more than minimal and temporary effects on essential fish habitat for any FMP species. Yet, a significant proportion of the ratings for fishing effects were classified as unknown. Given this result, application of the precautionary approach is warranted.” Citing the SSC’s recommendation in their deliberations, the Council voted unanimously to prohibit bottom trawling over vast areas, and establish ‘marine reserves’ in the areas shown to have dense deep water coral aggregations.

There are several levels of scientific review for stock assessments of North Pacific groundfish stocks (Figure 1). Nearly all of the stock assessments are conducted by highly competent and respected NOAA Fisheries scientists from the Alaska Fisheries Science Center. These

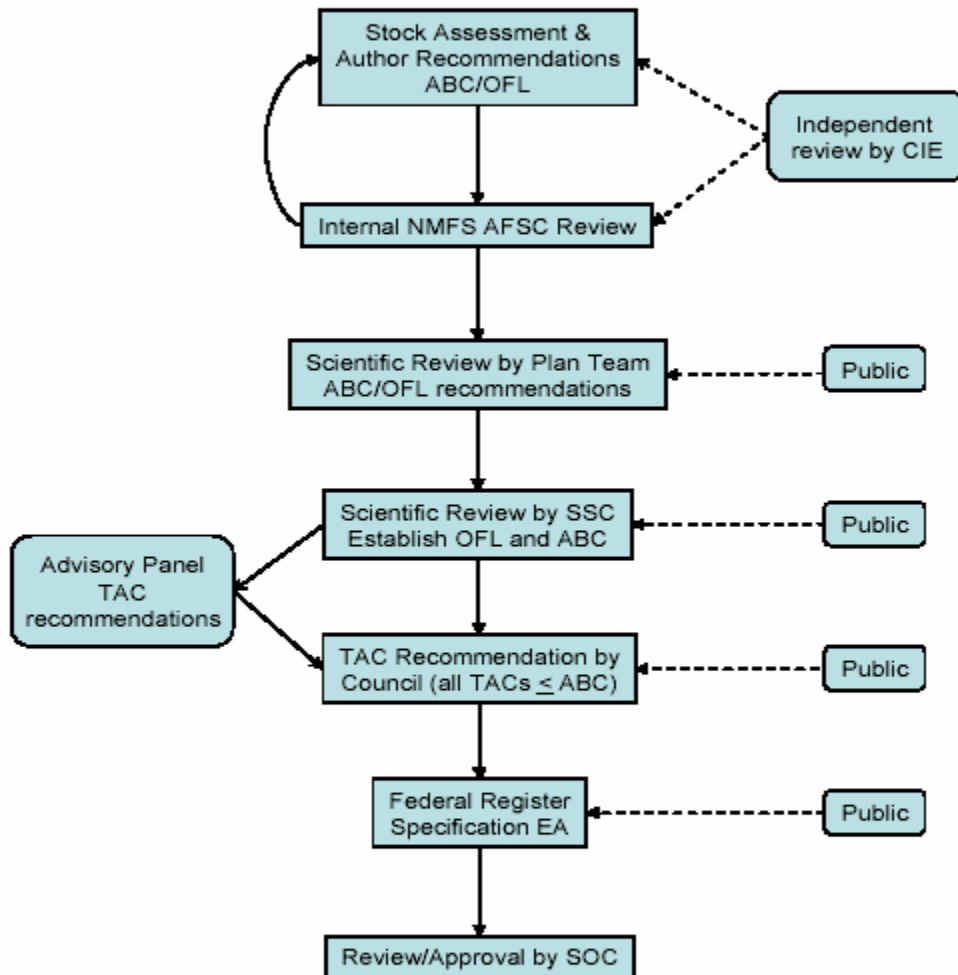
assessments are subject to internal review process at the Science Center. As a further quality control measure, one or two assessments are sent each year to the Center for Independent Experts for further peer review. Following these review processes, the stock assessments are further vetted by the Council's Plan Teams established for each FMP. The plan teams consist of state and federal scientists and managers that meet twice annually to review the assessments, prepare stock assessment and fishery evaluation reports, and, for groundfish stocks, recommend acceptable biological catch limits. The SSC makes a final review of the stock assessments and acceptable biological catch limits (ABCs). The Council has had a long standing practice of adopting all of the SSC's ABC recommendations, and this process was formally incorporated into the groundfish FMPs by amendments 83/75.

On occasion, an independent review by scientists outside of the SSC has been requested to get additional insights into scientific information on particularly controversial scientific issues. Recent examples of independent review include an evaluation of the harvest rate strategies used for North Pacific groundfish (Goodman et al. 2002), reviews on potential competition of fisheries with Steller sea lions (Bowen et al., 2001, NRC 2003), and a review of the evaluation of fishing activities that affect essential fish habitat (Drinkwater et al. 2004). These reviews came at a cost of time and money (approximately \$110,000 for the harvest rate review, \$140,000 for the Steller sea lion Biological Opinion review, \$500,000 for the NRC review of Steller sea lions and fisheries, and \$130,000 for the review of fishing effects on benthic habitat). Although none of the conclusions of these peer reviews were contrary to earlier findings by the SSC on these same issues, they did provide other perspectives regarding scientific content and analytical procedures.

From this standpoint, the reviews were beneficial in that they provided additional scientific guidance for analysts and the Council, and increased confidence that the best scientific information was made available.

Council use of SSC recommendations (from Table 1 of full report): The Council follows the SSC advice wherever possible or feasible. Council always follows SSC catch limit recommendations (always a single number for each stock or complex)

Figure 1. Flow chart depicting the scientific review process for stock assessments and establishment of catch specifications in the North Pacific region. Catch specifications include the overfishing level (OFL), the acceptable biological catch level (ABC), and total allowable catch limits (TAC), where $TAC \leq ABC \leq OFL$.



Pacific Fishery Management Council

The Pacific Council has a single SSC, with a 16 member composition set by a representation formula established in the Council's operational procedures. There are four state representatives (ID, WA, OR, CA), five federal representatives (2 Southwest Fishery Science Center, 2 Northwest Fishery Science Center, 1 Alaska Fishery Science Center), and 1 representative from the Treaty Indian Tribes. These members have indefinite terms and are nominated by their home agencies. In addition, there are six "at large" members that serve 3-year terms. Current composition of the "at-large" seats is: 2 Southwest Fishery Science Center, Fisheries Research Biologists, 1 University of Washington faculty, 1 University of California, Santa Cruz faculty, 1 California State Monterey faculty, and 1 private sector (an economist not associated with an agency or academia). The SSC operating procedures further requires that the committee consist of three social scientists, of which at least two shall have economic expertise. Currently, there are 3 economists; other expertise includes fishery biology, population dynamics, biostatistics. In addition to the standing SSC, there are six SSC subcommittees, one for each of the four FMPs (salmon, groundfish, highly migratory species, coastal pelagic species), one for MPAs, and one for economics.

Nominations for at-large seats are sought through an open nomination process. Vacancies are announced and candidates are solicited via the Pacific Council's website and via mailings to the public, agencies, and universities. The nomination period opens at least one month (and often longer) before consideration at a Council meeting and nominations are due along with Council meeting briefing materials, approximately two weeks before the meeting. Anyone can nominate an individual and individuals can self-nominate. Nominations must include a cover letter and CV. The SSC reviews nominations and evaluates qualifications of candidates in closed session and presents review results to the Council. The SSC review results are provided during Council closed session before the Council makes the appointments. The SSC chair and vice-chair serve two-year terms. Officers are elected by the SSC and approved by the Council chairman.

The SSC meets at each of the five Council meetings in a year, usually for the first two days of the meeting, but sometimes longer. The subcommittees meet as needed at the direction of the Council chair or the Executive Director. In recent years, the SSC subcommittees have met frequently, on the order of a half-dozen meetings in addition to the five Council meetings. Meetings of the SSC and SSC subcommittees are open to the public, and public comment is taken during SSC agenda topics (at the discretion of the SSC chair). There is also a public comment period for items not on the SSC agenda on the Monday of each SSC meeting. The SSC produces written reports at the Council meeting, and the SSC chair (or other SSC member) provides an oral report of their findings and responds to Council questions. Public testimony on SSC recommendations to the Council are taken after each SSC statement. SSC minutes are made available in the subsequent Council meeting briefing materials and are available on the Pacific Council's website.

The Pacific Council's SSC provides scientific review of all science and technical matters that are a component of Council decision making including harvest levels, fishery and economic models used by Technical Teams, population prediction models, harvest guidelines, Terms of Reference for stock assessment processes, and technical portions of Fishery Management Plan amendments and National Environmental Protection Act documents. Examples of special projects by category include: the SSC's marine reserves subcommittee has completed a white paper, *Marine Reserves:*

Objectives, Rationale, Fishery Management Implications, and Regulatory Requirements, the groundfish subcommittee is working on terms of reference for reviewing rebuilding plans, the groundfish subcommittee and economics subcommittee jointly reviewed Groundfish Essential Fish Habitat analyses, completed an economic capacity report for the *Groundfish Strategic Plan*, and reviewed commercial fishery bycatch modeling methods, and the highly migratory species subcommittee reviewed methods for assessing sea turtle impacts in the high seas longline fishery. Additionally, each year, the salmon subcommittee reviews salmon fishery modeling, run size prediction, and harvest policy methodologies.

For specific recommendations, like harvest levels, if a single value is provided by the SSC the Council generally adopts the recommended harvest level. The SSC may provide a range of possible harvest levels derived from the stock assessment process to advise to the Council on inherent uncertainties and risk. The SSC reports to the Council the range of values, the uncertainty, and level of risk (e.g., risk prone, risk-neutral, risk-averse).

Outside review of scientific and technical matters for the Pacific Council occurs during the Council sponsored stock assessment review process (which has been used for coastal pelagic species and groundfish) included participation by Center for Independent Expert reviewers from outside the Pacific Council family. The SSC then reviews the results of the stock assessment process and reports to the Council. SSC statements to the Council are not subject to outside review.

In addition to the SSC, each FMP has both a technical (or management) team. Technical teams are composed of fishery managers, biologists, and statisticians from the federal, tribal, and state agencies. Technical teams monitor catch rates, recommend harvest levels, and analyze the impacts of various management measures. Models and methods used by Technical Teams are reviewed by the SSC.

Council use of SSC recommendations (from Table 1 of the full report): The Council follows the SSC advice wherever possible or feasible. Council always follows SSC catch limit recommendations for single catch limit value, and within SSCs ranges of values for ABC and OY (Council generally selects midpoint).