Agendum E.1.b
Attachment 1
September 2004

DRAFT FINAL WHITE PAPER

MARINE RESERVES: OBJECTIVES, RATIONALES, FISHERY MANAGEMENT IMPLICATIONS AND REGULATORY REQUIREMENTS

September 2004

Marine Reserves Subcommittee
Scientific and Statistical Committee
Pacific Fishery Management Council

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I. Background

The Pacific Fishery Management Council defines a marine reserve as "an area where some or all fishing is prohibited for a lengthy period of time" (http://www.pcouncil.org/reserves/reservesback.html). This definition reflects the Council's area of regulatory authority (fishing) and encompasses but is not limited to permanent, no-take closures. Other definitions of a marine reserve exist that vary in terms of the nature of activities restricted, the degree of allowable use and the duration of closure.[1] This paper is concerned with marine reserves as they relate to fishery management. It provides some scientific background, outlines potential uses of reserves, and provides guidelines for preparing and evaluating marine reserve proposals. These guidelines are intended to be applicable to no-take reserves as well as less restrictive types of area closures, to facilitate the Council's ability to consider various types of closures as they relate to particular management needs.

The Council has a long history of using area closures as a management tool. For instance, the Northern Anchovy Fishery Management Plan (FMP), as implemented in 1978, prohibited reduction fishing in nearshore waters to protect pre-recruits and reduce the possibility of social conflict between the reduction fishery and the live bait and recreational fisheries. The Groundfish FMP, as implemented in 1982, included area closures for foreign and joint venture operations. The Salmon FMP, implemented in 1984, closed designated areas around river mouths to fishing, and also specified the use of flexible time/area closures as a tool for setting annual specifications for the fishery. The Highly Migratory Species FMP, adopted in 2004, relies on area closures as a means of reducing bycatch of sea turtles.

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[1] For instance, the National Research Council describes a marine reserve as "a zone in which some or all of the biological resources are protected from removal or disturbance" (NRC 2001, p. 12). California's Marine Life Protection Act refers to a "marine life reserve" as "a marine protected area in which all extractive activities, including the taking of marine species and, at the discretion of the commission and within the authority of the commission, other activities that upset the natural ecological functions of the area, are prohibited" (California Fish and Game Code, Section 2852(d)). The Oregon Ocean Policy Advisory Council defines a reserve as "a highly regulated ocean or estuarine area designated to meet specific goals and to protect resources or uses from activities that may conflict with these goals" (OPAC 2002). A related but broader concept of area closures is a marine protected area (MPA). For instance, Executive Order 13158 defines an MPA as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (Presidential Documents 2000, p. 34909).

Since adoption of these FMPs, the Council has periodically used area closures to address new management needs. The most notable examples in recent years have occurred in the groundfish fishery. In 2001, the Council closed designated areas south of Point Conception to groundfish fishing to reduce bycatch of overfished cowcod. During September-December 2002, the Council implemented depth-based closures on the continental shelf to reduce bycatch of darkblotched rockfish, and subsequently expanded those closures in 2003 to protect overfished bocaccio and canary as well as darkblotched rockfish.

In response to a court order, the Council (as of September 2004) is in the process of preparing a Programmatic Environmental Impact Statement (PEIS) for the groundfish fishery to address essential fish habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, Section 303(a)(7)). The PEIS includes consideration of area closures as a management tool. Unlike the rationales previously used by the Council to justify such closures, the EFH mandate requires a more systematic consideration of habitat requirements than previously undertaken by the Council and a change in focus from protecting habitat to benefit fish stocks and fisheries to protecting habitat from potentially adverse effects of fishing operations.

In recent years there has been growing attention to the use of area closures as a means of protecting and managing not only target species but marine resources in general. While closures initiated by the Council have been intended to improve management of particular fisheries, proposals are being made to close areas of the ocean to most, if not all, fishing activity. While the time frame for closures customarily used by the Council ranges from short-term (e.g., salmon closures as part of annual specifications) to longer-term (e.g., groundfish closures to facilitate recovery of overfished stocks) to permanent (e.g., anchovy closures to protect pre-recruits and reduce social conflict), the new proposals focus more exclusively on permanent closures.

Expanding interest in marine reserves is evident at both Federal and State levels. For instance, Executive Order 13158 (Marine Protected Areas) mandates that, "To the extent permitted by law and subject to the availability of appropriations, the Department of Commerce and the Department of the Interior ... shall develop a national system of MPAs" (Presidential Documents 2000, pp. 34909-34910). The five National Marine Sanctuaries on the West coast (four in California, one in Washington) are in varying stages of revising their own management plans, with marine reserves being one area of consideration. One of these sanctuaries (Channel Islands) has already implemented reserves in the State portion of Sanctuary waters and is in the process of extending these reserves into the Federal portion. California's Marine Life Protection Act (MLPA) requires the California Department of Fish and Game to develop a Master Plan that includes "recommended alternative networks of MPAs" (California Fish and Game Code, Section 2856) in State waters. Oregon's Ocean Policy

Advisory Council has recommended that "Oregon test and evaluate the effectiveness of marine reserves in meeting marine resource conservation objectives through a system of marine reserves ..." (Oregon Ocean Policy Advisory Council 2002, p. 1).

II. Introduction

Marine reserves are advocated for a variety of reasons: (1) as an insurance policy against uncertainty and errors in fishery management, (2) as a source of fishery benefits, (3) as a source of ecosystem benefits, including habitat protection, (4) as a means of addressing social issues, and (5) as an opportunity to advance scientific knowledge.

The scientific literature pertaining to marine reserves has proliferated in recent years. Much of the discussion in the literature has focused on the development of theoretical models and guiding principles. Experiments have been conducted that relate larval fitness to maternal age in black rockfish (Berkeley *et al.* 2004a, Berkeley *et al.* 2004b). In addition, some empirical research has been conducted on the effects of West coast reserves (e.g., Martell *et al.* 2000, Paddack and Estes 2000, Palsson and Pacunski 1995, Schroeter *et al.* 2001, Tuya *et al.* 2000). The literature provides useful insights into changes in fish populations, ecosystems and habitat that may occur as a result of implementing reserves, how these changes may affect areas outside reserves, and information useful in reserve design, as well as suggestions for how to improve existing research on reserves.

Studies from the literature that address fishery management implications of marine reserves are limited (but see Hastings and Botsford 1999, Neubert 2003). A challenge for the Council and for other management agencies involved in considering marine reserves is to interpret the existing literature in a management context, to identify information gaps, and to encourage applied research in support of management. While good science is essential for good management, managers must be selective in focusing on scientific results that are not only technically sound but also applicable to the issue at hand. Management requires that concepts and objectives be translated into operational requirements. It is in the course of defining such requirements that the biological, socioeconomic, environmental and enforcement implications of an action become apparent.

The objective of this White Paper is to facilitate Council deliberations on marine reserves by:

- describing the rationale underlying various marine reserve objectives and providing an SSC perspective on the scientific basis for applying reserves to address these objectives;

- discussing the implications of reserves for fishery management, taking into consideration the objectives of the reserves; and

- establishing SSC guidelines and standards regarding the technical content of proposals initiated by the Council (or submitted for Council consideration by other entities) that involve changes in fishery regulations associated with establishment of marine reserves in Federal waters.[2]

Given the SSC's responsibility as a scientific advisory body to the Council, this White Paper distinguishes between reserve issues that are scientific in nature and therefore amenable to SSC input and review, and policy issues that are outside the SSC's purview. The SSC is responsible for reviewing the scientific basis of regulatory proposals considered by the Council. This White Paper includes SSC guidelines and standards regarding the analytical content of such proposals as they relate to reserves. The SSC makes recommendations to the Council to facilitate consideration of science in the management process. This White Paper provides suggestions regarding procedure and coordination that are intended to encourage systematic evaluation of the technical aspects of reserve proposals. SSC recommendations are guided by the Council's mandate to rely on the best available science and adhere to Federal regulatory requirements as specified in the National Environmental Policy Act, the Regulatory Flexibility Act, Executive Order 12866 and other applicable law.

The science related to fishery management is limited by an incomplete understanding of marine populations and ecosystems. Where theoretical understanding is well developed, data are often insufficient or uninformative. In addition, the physical ocean environment is highly variable, so biological responses to fishing may vary over time in ways that cannot be predicted. As a result, the science supporting all aspects of fishery management is not exact. Knowledge of marine reserves and their implications for fishery management is less well developed than is the case for traditional output- and effort-based management tools. Uncertainty regarding reserve effects on effort and yield should diminish over time, as experience accumulates in integrating marine reserves with fishery management. At the same time, the current state of knowledge is adequate to conclude that marine reserves are uniquely suited to habitat protection, ecosystem management applications, and maintenance of population age structure. Marine reserves, serving as relatively undisturbed reference sites, may help to improve understanding of population responses to harvest pressure and other aspects of fishery management science.

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[2] Reserves in State waters are subject to different regulatory requirements than those indicated in this document. To the extent that the Council is involved in deliberations regarding reserves in State waters, the SSC will rely on the Council for specific guidance regarding its role (if any) in reviewing State proposals and the criteria to be used in such review.

Section III elaborates on the five reserve objectives mentioned above and the potential management implications of each objective. Section IV provides guidance on the preparation of regulatory analyses of reserve alternatives as they relate to each objective. Section V summarizes SSC recommendations to the Council, and Section VI identifies research and data needs. Appendix A includes excerpts from the Environmental Impact Statement (EIS)[3] prepared by the Council for the 2003 groundfish specifications (PFMC 2003) that illustrate some of the points made in Section IV. This EIS is informative as an analytical example of how area closures are integrated with fishery management. Appendix B discusses implications for the Council if fishery-independent surveys are restricted inside reserves.

This White Paper should be considered a living document that may be modified over time as additional issues become apparent to the SSC in the course of reviewing marine reserve proposals, or as significant new research becomes available on marine reserves. References to government documents and the marine reserve literature cited in this paper are intended to be illustrative rather than comprehensive.

III. Reserve Objectives and Rationales

The following five objectives are commonly included among the reasons to implement marine reserves: (1) to provide insurance against management uncertainty and error; (2) to provide fishery benefits (including increased recruitment that may result from maintaining old fish in the population); (3) to provide ecosystem benefits (including habitat protection); (4) to address social issues; and (5) to provide opportunities to advance scientific knowledge (including establishing scientific reference sites). Each objective is discussed here in terms of its underlying rationale. Guidance is provided for reserve proposals in terms of the need for specificity in defining objectives, careful interpretation of the literature, and conceptualization of reserve issues in a manner that is useful for management. The separate treatment given to each objective in this section is intended to facilitate discussion of issues specific to that objective. Reserve proposals may have multiple objectives.

Evaluating the scientific basis of particular reserve rationales requires careful consideration of what the reserves literature does and does not demonstrate with regard to reserve effects. The SSC offers the following advice in interpreting that literature:

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[3] Throughout this document, the term "Environmental Impact Statement" is intended to refer to all of the analytical requirements (including Regulatory Impact Review and Regulatory Flexibility Analysis) for Federal regulations specified by law and executive order.

- Existing reserves (at least in the U.S.) have not been sited on the basis of statistical design considerations (see Section III.E). As a result, empirical studies of the effects of such reserves have been conducted primarily and by necessity under less than ideal conditions (e.g., lack of replicate reserves, non-random placement of reserves, lack of baseline information prior to reserve establishment). Lack of replicates makes it difficult to isolate reserve effects from other influences. Non-random placement of reserves makes it difficult to extrapolate results to other settings and complicates the placement and interpretation of control areas. Lack of baseline information limits the empirical analysis to comparisons of reserve and control areas after reserve establishment. In many of these empirical studies, technical difficulties are discussed and appropriate caveats are placed on study results. Reserve proposals that rely on results of empirical studies to justify projected benefits must be cognizant of the strengths and limitations of relevant studies and scale their claims accordingly.

- An issue that merits further study is the possibility that the reserve itself contributes to the differences observed between the reserve and areas open to fishing. Reserves may be a source of animals (adults, juveniles and larvae) for the open areas. They may also displace effort, thereby increasing pressure on populations and habitats in the open areas. In other words, the very establishment of a reserve modifies the context within which its effects are evaluated. Differences between reserve and open areas detected in empirical studies should consider these two counteracting processes. Both effects would generally be expected to diminish with distance from the reserve boundary and could potentially be assessed from transects running across the boundary. Interpretation of the ***status quo*** in empirical comparisons is complicated by the effect of the reserve on the surrounding open area. The effects of a reserve are best evaluated by what occurs both inside and outside the reserve after reserve establishment; the ***status quo*** is what would have occurred in the same two areas had no reserve been established.

- It is easiest to think about marine reserves as no-take areas, that is, areas totally closed to harvest and other human activities (except perhaps research and monitoring). Most, though not all, reserve studies discussed in the literature are based on such complete closures. Reserves closed to certain gear types or closed for certain time periods will be affected differently from no-take reserves. Projecting the effects of partial closures for fishery management will be a challenge. Effects of partial closures are likely to be intermediate between the extremes of total closure and open fishing.

- Reserves in the literature are typically established on a permanent or semi-permanent basis. Ecosystem changes within the reserves occur over time periods of a decade or more. Establishing reserves requires thinking and planning on decadal time frames.

III.A. Reserves as "Insurance Policy"

Reserves are sometimes advocated as an "insurance policy", that is, as a means of protecting fish stocks against environmental variability and errors and uncertainty in management (e.g., Guenette *et al.* 1998, Lauck *et al.* 1998). Uncertainty in fishery management arises from three general sources: getting the science wrong, getting the management wrong, and environmental variability. Potential sources of scientific error include (1) biological process error (variability in demographic parameters), (2) observation error (survey, laboratory and database error), (3) model choice error (e.g., Ricker versus Beverton-Holt), and (4) error structure error (e.g., gamma vs. lognormal). Potential sources of management error include (5) judgment error (e.g., not paying adequate attention to the science) and (6) implementation error (e.g., implementing regulations that result in catches over or under the intended target). This characterization of management uncertainty pertains to stocks that are assessed. For unassessed stocks, uncertainty is more fundamental, since the level of uncertainty is unknown without an assessment. Environmental variability in the Northeast Pacific Ocean results in highly contrasting conditions from year to year, decade to decade, and over longer time frames. Effects of short- to mid-term environmental variability are reasonably well understood for some species (e.g., salmon, lingcod, sablefish), but little is known for the vast majority of species. It is reasonable to assume that the life histories and population structures of marine organisms have evolved in response to this environmental variability. Reserves can allow many species to return to more natural age structures and species associations, decreasing the likelihood of stock failures due to environmental variability.

Reserve proposals intended to achieve an insurance objective should be specific regarding what the insurance is intended to achieve. For instance:

- The concept of overfishing has a particular technical meaning in the context of Council-managed fisheries. Reserve proposals that are intended to "protect against overfishing" must similarly include a clear definition of what the proposal defines as overfishing and how reserves can protect against it. A certain amount of risk aversion is currently reflected in Council harvest policy

- and regulations.[4] It is important that reserve proposals explicitly contrast their suggestions with existing policy and regulations in terms of reducing the risk of overfishing.

- Persistence implies that it is better to have a complete age structure in one area (i.e., the reserve) than an exploited age structure everywhere. Reserves, because of their potential to extend the age structure of target species in ways that cannot be accomplished with other fishery management tools, may be uniquely qualified to achieve this. With a full age structure, target species are more likely to be persistent in the face of environmental and human-induced adversity. In this sense, reserves may be suited as a tool for mitigating the uncertainty in stock assessments and managing unassessed stocks, irrespective of any judgment regarding whether they are over- or under-exploited but simply to increase the likelihood of long-term persistence.

The potential for reserves to serve as insurance for persistence varies among species. For sessile species with small dispersal distances (e.g., abalone), a network of small reserves can be quite effective. For groundfishes, information regarding distribution and movement is limited, with available information indicating significant behavioral differences among species. Given these differences, it is unlikely that any single system of reserve can be tailored to achieve a complete age structure for all species. However, the number of species protected and the degree of protection will scale with the size of the reserve. In some reserves, it has been observed that large predators increase while prey species decrease. It would be helpful if reserve proposals identified, to the extent possible, the species or species complexes likely to be affected by the reserve.

III.B. Reserves as Source of Fishery Benefits

The reserve literature includes a number of theoretical models that demonstrate benefits to fisheries associated with the export of adults and eggs/larvae from reserve areas (e.g., Rowley 1994, Russ 2002). Fishery benefits are typically defined in such models as an increase in yield. Underlying these models are assumptions regarding species mobility, the extent of density dependence at different life-history stages, the amount of exploitation prior to creation of the reserve, and the nature and extent of effort redistribution after the reserve is established.

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[4] Precautionary measures employed in the groundfish fishery include the 40-10 harvest rate policy for assessed stocks. For stocks for which data are not adequate to conduct assessments, the Council sets levels of allowable biological catch (i.e., 75% of average annual historical landings for rudimentarily assessed stocks and 50% for unassessed stocks) that are consistent with NMFS guidelines for data-poor situations (Restrepo *et al.* 1998).

The basic scenario is as follows: Fishery exploitation causes reductions in numbers, ages and sizes of the species caught by fishing gear. Conversely, increases in numbers, ages and sizes can be expected to occur when species are protected in reserves. These structural changes in fish populations within the reserve cause yield to increase outside the reserve, via several possible mechanisms.

Adult export hypothesis — According to this hypothesis, increases in the biomass/density of fish within the reserve result in net emigration of adult fish from the reserve to the area open to fishing. This adult "spillover" is precipitated by density-dependent processes, i.e., fish leave the reserve as density, and thus competition for resources, increases within the reserve (e.g., DeMartini 1993, Polacheck 1990).

The degree to which fish move has an important bearing on the extent of adult spillover from the reserve. If mobility is low relative to reserve size, substantial biomass may accumulate in the reserve, but export will be low because animals will not migrate to the area open to fishing in appreciable numbers. Conversely, if mobility is high relative to reserve size, fish will not remain in the reserve long enough to avoid the impact of fishing. Mobility must therefore be in an "intermediate" range in order to achieve both the accumulation of biomass within the reserve and the level of spillover that may lead to enhanced yields.

Egg/larval export hypothesis — The change in age structure that occurs in the absence of fishing causes total egg production per recruit to increase in the reserve. This increase is largely due to the higher fecundity of older females; for some species at least, older fish may also produce larvae that are more likely to survive (Berkeley *et al.* 2004b). In addition, the total number of fish in the reserve can be expected to increase due to the removal of some or all sources of fishing mortality, irrespective of any changes that may occur in the age structure. In concert, these effects act to boost total egg production within the reserve and may also increase the probability of larval survival. Dispersal of larvae from the reserve to the open area may increase yield to the fishery, particularly if it is presently overexploited (e.g., Holland and Brazee 1996, Sladek Nowlis and Roberts 1997, Botsford *et al.* 2001) or settlement limited (Halpern *et al.* In press).

In the traditional understanding of population dynamics, density dependence processes (e.g., competition for resources) imply an increase in the per capita production of fish populations as biomass/density decreases. Thus total surplus production (i.e., the product of per capita production and population size minus the production needed to sustain the population) tends to be highest at intermediate levels of biomass and/or density. Density dependent reductions in surplus production are expected as fishing mortality decreases and stocks rebuild within a reserve. The manner in which density dependence manifests itself has a significant bearing on the egg/larval export hypothesis. If density dependence occurs pre-dispersal (i.e., within the reserve), due for example to density-dependent growth, the per capita production of adult fishes in reserves will decrease as density increases, partially countering the increase in egg production per recruit and higher larval survival associated with the presence of older females in the reserve. If density dependence occurs post-dispersal (outside the reserve), the extent to which egg/larval production results in increased recruitment to the fishery will depend on factors such as dispersal distances, location and size of nearby reserves, availability of suitable habitat, and metapopulation dynamics (Botsford ***et al.*** 2001).

Conclusions drawn from theoretical models of adult or egg/larval export regarding the effect of reserves on fishery yield are sensitive to the assumptions underlying the models. The applicability of models to particular fish stocks is generally known only in a qualitative sense. For purposes of quantitative fishery management, detailed life stage modeling is less relevant than establishing an empirical relationship between reserves and yield outside the reserve. The body of empirical studies on West Coast reserves is limited and not definitive in terms of yield effects. Rather they focus on whether increases in fish abundance and size occur inside reserves. Increases in yield cannot be inferred solely on the basis of increased abundance inside the reserve.

The *status quo* in reserve proposals must pertain to the specific fishery for which reserves are being considered, as the details of that fishery matter a great deal to the conclusions that can be drawn. For instance, if the *status quo* is an overexploited fishery, reserves may enhance fisheries yield. However, if the *status quo* is a fishery that is being managed close to the level at which maximum sustainable yield (MSY) is achieved, it is not clear that reserves can enhance yield, given existing theoretical studies that demonstrate a general equivalence between the yield obtained through area-based and quota-based management schemes (e.g., Hastings and Botsford 1999, Mangel 2000).

Fishery benefits are typically characterized in reserve models in terms of increased yield in the area open to fishing. However, even in cases where potential yield increases in the open area, there is no guarantee that fishery benefits will increase. For fishery participants and fishing communities, economic and social effects (e.g., changes in producer and consumer surplus, income and employment impacts, community stability) often matter more than yield. Whether or not changes in yield imply such benefits depends on what happens outside the reserve with regard to displaced effort, harvesting costs, pressure on fishery resources, potential for social conflict and fishery regulation (e.g., Hannesson 1998, Smith and Wilen 2003).

Factors such as these will need to be considered in a full evaluation of fishery benefits.

III.C. Reserves as Source of Ecosystem Benefits

Ecosystems and the benefits they produce can be characterized in a variety of ways. Reserve proposals based on claims of ecosystem benefits must be clear in what is meant by this objective. It is important that measurable criteria be identified that can be used to indicate progress toward meeting the objective. Habitat protection can be considered an ecosystem benefit. Such ecosystem benefits will most likely be maximized through the use of no-take reserves.

The literature on ecosystem benefits of reserves provides a number of theories and guiding principles regarding what happens to ecosystems in the absence of fishing, and differences in ecosystem effects associated with larger versus smaller reserves. A number of empirical studies have been conducted (largely outside the U.S.) that evaluate the nature and extent of ecosystem effects associated with reserves (e.g., Shears and Babcock 2002). Depending on the study, the comparison is typically based on one or more indicators (e.g., density, numbers, biomass, size, diversity of organisms) classified in some particular way (e.g., trophic level, family, genus, species, rare or keystone species, target versus non-target species, all species). Habitat characteristics are occasionally also included in the comparison.

A number of reviews and meta-analyses have been conducted of ecosystem reserve studies (e.g., Cote *et al.* 2001, Halpern 2003, Mosquiera *et al.* 2000). Given the many ways in which ecosystem changes can be characterized, meta-analysis is necessarily constrained by the limited number of studies with common indicators that can be used as a basis for comparison. Comparison is further hampered by lack of documentation in some studies of additional factors that may also account for some of the observed ecosystem changes (e.g., extent of exploitation and habitat condition prior to reserve establishment, effectiveness of enforcement of reserve boundaries). Despite these limitations, one consistent result noted in many studies is that overall abundance/density of organisms tends to increase inside reserves. When analyses focus on effects at the individual species level, results tend to be more mixed, with a tendency for some species (e.g., larger fish, predators) to increase in abundance/size and for other species (e.g., smaller fish, prey) to do the opposite. Reserves that are intended to provide ecosystem benefits will not necessarily foster outcomes that are consistent with the objective of single species management. Trade-offs like this are inevitable, given the complexity of species interactions in the ecosystem. Similar trade-offs also occur at the single species level, e.g., when regulations that benefit one species adversely affect other species.

Ecosystem effects of reserves are typically characterized in the literature by contrasting what happens inside and outside the reserve. Depending on the nature and extent of fishing prior to establishment of the reserve, cessation of fishing may bring about significant ecosystem changes within the reserve. Under some circumstances there may be a considerable increase in effort outside the reserve, resulting in local depletion of stocks and habitat damage. Thus, reserve proposals intended to provide ecosystem benefits must balance the expected benefits within the reserve with potentially adverse effects of displaced effort on the ecosystem outside the reserve.

III.D. Reserves as Means of Achieving Social Objectives

Reserves may be intended to achieve objectives such as reducing social conflict among user groups, acknowledging and accommodating values held by various segments of the public regarding resource use, discouraging or encouraging particular types of resource use, or protecting areas deemed unique in terms of cultural or natural heritage (e.g., Bohnsack 1996). Clarifying the motivation is important, given its relevance to reserve design. For instance, if the intent is to reduce social conflict, then a design that focuses on achieving spatial segregation of conflicting uses may be appropriate. If accommodating different public values is the motivation, then a zoning approach that is tailored to finding a "balance" among various types of consumptive use, non-consumptive use and non-use areas may be appropriate. If the intent is to discourage or encourage particular types of use, then strategies such as spatial restrictions on use or spatial set-asides for use may be appropriate.

Generally speaking, regulatory analysis requires that a management objective be defined, that a problem be identified that is impeding achievement of the objective, that criteria be identified that measure progress toward addressing the problem, that regulatory alternatives be evaluated in terms of the criteria, and that a determination be made regarding which alternative best achieves the objective. Defining the objective and selecting a preferred alternative are ultimately policy decisions that reflect consideration of factors such as legal mandates and constraints, scientific evidence, and the magnitude and distribution of benefits and costs. In cases where an objective is expressed in terms that are subject to scientific evaluation, science can play a valuable role in terms of diagnosing the problem, identifying appropriate evaluative criteria and evaluating the relative merits of alternatives relative to the criteria. In cases where the objective pertains to social issues, the choice of criteria is a policy decision that is more appropriately based on notions such as equity, fairness and the public interest; the SSC's role in evaluating the suitability of any such criteria would be limited, at best. However, a technical analysis of some type may still be needed to evaluate the alternatives relative to the criteria. For instance, if economic value is considered a relevant criterion, economic methods may be used to analyze relative gains or losses in value associated with different alternatives. If "fairness" is a criterion, then methods of analyzing distributional effects may be useful. In such cases, the SSC could be of assistance to the Council in reviewing such analysis.

Some of the same approaches to reserve design that can be used to meet social objectives (e.g., zoning for multiple use, protection of unique areas) can also be used to address other objectives (e.g., ecosystem benefits). However, different objectives will not necessarily yield similar reserve outcomes. For instance, the attributes of an area that make it unique in terms of its role in the natural ecosystem may differ from attributes that are deemed unique and valuable to the public. It is important that reserve proposals clearly relate each management objective to criteria that are relevant to that objective.

The criteria used to evaluate achievement of a social objective are often themselves topics of intense public interest and advocacy, as these criteria typically have direct and obvious allocative implications.[5] One criterion sometimes advocated in the context of marine reserves is "existence value". Existence value is the value that people attach to an amenity independent of whether they use, consume, observe or otherwise directly experience it.[6] For example, existence value may be used to quantify the value of ecosystem benefits derived by the public from a marine reserve. Typically economists use "revealed preference" methods to infer the value of market goods. However, because existence value is not revealed or expressed in observable behavior, it must be measured by "stated preference" methods such as contingent valuation (CV).[7]

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[5] This situation is not unique to marine reserves. The Council has had similar experiences in its own deliberations on fishery allocation issues.

[6] Other concepts of value that are also disassociated from current use of an amenity include "quasi-option value" (the value of future information associated with retaining an option that would be otherwise be lost by irreversibly modifying an amenity) and "option value" (a risk premium that reflects the value of increasing the probability of future access to an amenity in the face of uncertainty in future supply or demand of the amenity).

[7] CV involves the use of survey methods to elicit the economic value attached by respondents to a particular good or service. CV surveys include a hypothetical scenario that is designed to be specific and plausible in terms of the nature of the amenity being valued, the context in which it is to be considered, and the payment vehicle. As a prelude to the valuation questions, respondents are reminded of their personal income constraint and the availability of substitutes for the amenity. The valuation questions are worded in terms of willingness to pay or willingness to accept compensation, depending on the assignment of property rights to the amenity (i.e., whether the respondent must pay in order to obtain access to the amenity or must be compensated for its loss). CV surveys typically include attitudinal and socioeconomic questions, as well as debriefing questions that facilitate determination of whether the valuations provided by respondents represent their "true" preferences. Strategies are

While broad consensus exists among economists regarding the legitimacy of the concept of existence value, disagreements exist regarding the reliability with which it can be estimated. In 1992, in the wake of controversy associated with the use of CV to estimate damages associated with the ***Exxon Valdez*** oil spill, the National Oceanic and Atmospheric Administration (NOAA) convened a panel of economic experts co-chaired by two Nobel laureates to evaluate the CV method. After hearing extensive testimony from CV proponents and opponents, the NOAA Panel concluded that "... CV studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values [existence values]". In elaborating on this conclusion, the Panel cautioned that "The phrase 'be the starting point' is meant to emphasize that the Panel does not suggest that CV estimates can be taken as automatically defining the range of compensable damages within narrow limits" (NOAA 1993, p. 4610). The Panel also provided guidelines for CV studies that NOAA subsequently adopted in developing standards for the use of CV in damage assessment.

While CV has been subject to extensive research and refinement since the NOAA Panel issued its findings, the methodology remains a topic of debate within the economics profession. While some argue that well-conducted CV surveys can reveal true economic preferences associated with the particular scenario depicted in the survey (e.g., Carson ***et al.*** 2001, Hanemann 1994), others argue that CV (at best) reveals only generalized attitudes regarding classes of amenities and (at worst) provides little meaningful information regarding public preferences (e.g., Diamond and Hausman 1994).

In addition to the issue of how well existence value can be estimated, its role in the policy arena is also subject to debate. Some of this debate reflects deeply held philosophical differences regarding the appropriateness of imputing a dollar value to environmental amenities.[8] Additionally, although the use of CV to estimate existence

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employed to ensure impartiality in the wording and administration of the survey and representativeness of the sample. Survey results are analyzed in ways to determine their plausibility and consistency with existing theories of consumer preference (e.g., Mitchell and Carson 1989). In addition to CV, stated preference methods that require respondents to rank alternative scenarios or identify a preferred scenario rather than attach a monetary value to particular scenarios may also be used to estimate existence value (e.g., Louviere ***et al.*** 2000).

[8] This debate is commonly framed in terms of anthropocentric versus biocentric views of the world. Utilitarianism, a particular form of anthropocentrism that attributes value to whatever brings satisfaction to human beings, is an underlying premise of cost-benefit analysis. As pointed out by Goulder and Kennedy, "...utilitarianism does not necessarily imply a ruthless exploitation of nature. On the contrary, it can be consistent with fervently protecting nonhuman things, both individually and as

value has occurred largely in the context of environmental damage assessment, existence value is a matter of public preferences and can conceivably exist for a broad range of goods and services. Just as gains in existence value may occur as a result of regulatory improvements, losses of existence value may occur as a result of regulatory costs.[9] Given the limited types of amenities to which CV has been applied, it is difficult to make generalizations regarding the relevance of existence value to the breadth of goods and services affected by regulation or to anticipate the particular circumstances in which a regulatory action is likely to trigger notable gains or losses in existence value.

All market and non-market values (including existence value) should rightfully be considered in cost-benefit analysis. Cost-benefit analysis, in turn, implies a decision criterion of economic efficiency (i.e., the desirability of allocating scarce resources to uses that yield highest economic value).[10] It is not clear to the SSC whether advocacy of existence value in the context of marine reserves is intended solely to highlight its importance in the decision process or (more broadly) to signal support of economic efficiency as a decision criterion. In either case, the policy

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collectivities" (Goulder and Kennedy 1997, p. 24) — thus the relevance of existence value to cost-benefit analysis. A more biocentric view is expressed by Ehrenfeld: "Assigning value to that which we do not own and whose purpose we can not understand except in the most superficial way is the ultimate in presumptuous folly" (Ehrenfeld 1988, p. 216).

[9] "...in considering rules that limit economic activity to protect the environment, it is as appropriate to include a contingent valuation of existence value for destroyed jobs as the one for protection of the environment" (Diamond and Hausman 1994, p. 59).

[10] The role of economic efficiency in Federal fishery management policy is prescribed in National Standard 5 of the MSFCMA: "Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose" (NOAA 1998, p. 24234). Policy makers are often at least as concerned with distributional effects as with economic efficiency. In this regard, it is relevant to note that the market and non-market valuation methods used in cost-benefit analysis reflect the prevailing distribution of wealth, with wealthier individuals generally mattering more both in terms of market influence and expressions of existence value. Distributional considerations are implicitly reflected in cost-benefit analysis in terms of the weights attached to the various costs and benefits and the discount rate used to weight current relative to future effects. Explicit consideration of distributional effects can be achieved by disaggregating the individual costs and benefits that comprise the cost-benefit ratio. Methods other than cost-benefit analysis can also be used to evaluate distributional effects in units other than economic value.

choice is not one of considering only quantified estimates of existence value or ignoring it altogether, as the public process allows for advocacy on behalf of all values (e.g., market values, non-market values attached to the existence of unfished areas and fishing fleets) whether they are quantified or not. The issue appears to be whether the public process yields a "better" policy outcome when values that are not normally quantified (e.g., existence value) are expressed monetarily. Generally speaking, data and analytical requirements make it difficult to estimate both market and non-market values of the type required for cost-benefit analysis. The Council typically relies on regulatory analysis using best available information (non-monetized and monetized), as well as public input, in evaluating benefits and costs.

In cases where CV estimates of existence value are included in reserve proposals, documentation of survey design, implementation, and analytical methods is important for determining whether the estimates meet standards for well-conducted CV surveys (e.g., Carson 2000, NOAA 1993). With regard to the CV requirement for a scenario that establishes context for the amenity being valued, completeness and accuracy of the scenario would be enhanced by a description of the trade-offs associated with provision of the amenity. Given existing uncertainty regarding the range of goods and services to which existence value can be reasonably attributed, a scenario that describes reserve benefits and associated short- and long-term gains and losses to the fishing industry would help ensure that whatever notions of existence value that respondents associate with both gain and loss aspects of the scenario can be reflected in their valuation responses. For proposals that include existence value estimates derived via benefit transfer methods (i.e., methods of transferring valuation estimates associated with a study site to a policy site), a rationale for why the study site results are relevant to the policy site is needed to determine whether the benefit transfer was conducted in a manner consistent with the literature (e.g., Kirchhoff *et al.* 1997, O'Doherty 1995, Smith *et al.* 2000). Finally, while CV can provide insights into public preferences, given the NOAA Panel's characterization of CV results as a useful "starting point" for discussion, it will also be important for proposals to avoid interpreting such results as highly precise estimates of such preferences.

III.E. Reserves as Opportunity to Advance Scientific Knowledge

Reserves are sometimes advocated as a way to advance scientific knowledge (e.g., Murray *et al.* 1999, Roberts 1997). For example, reserves can be used as reference sites against which areas not so protected can be compared to evaluate the impacts of fishing. Reserve proposals specifically intended to meet these objectives will need to meet the standards of a scientific research proposal. The established scientific paradigm for experimental research involves hypothesis testing based on replicated treatments (Hurlbert 1984). Hurlbert (1984) identified control, replication, randomization, and interspersion as essential elements in the design of ecological studies. These elements are required if the study is to produce data suitable for comparative statistical analysis. Reserve studies of this type are rare and occur largely outside the U.S. (e.g., Mapstone *et al.* 1996, Punt *et al.* 2001).

Reserve proposals based on a replicated study design will need to include a well-defined hypothesis, a rationale for why the hypothesis is worth exploring and a statistically valid experimental design (including a power analysis). In cases where some flexibility exists regarding the number, size, and location of reserves to be used in the experiment, it would be helpful if the proposal included a comparison of experimental design alternatives in terms of the nature and conclusiveness of results that can be expected from each alternative, as well as any other notable differences (e.g., budget) that may exist among alternatives.

A replicated study design, including hypothesis testing and statistical analysis, is probably best suited to systems of small nearshore reserves where replication and random or interspersed-random site selection is more likely to be feasible. However rigorous research of this type is often impractical or impossible, particularly with regard to offshore reserves. Access is limited, the physical and biological systems are dynamic, and reserves are open systems with import and export of water, nutrients, and organisms. Properly applying such an experimental design to marine reserves poses major challenges of cost, scale and logistics. In such cases, serious consideration should be given to alternative approaches, including before-after impact studies that can provide important scientific insights using primarily descriptive techniques.

An unreplicated treatment may provide useful information if a gross effect is expected or if the objective is to make only an approximate estimate of the effect. However, studies of this type require a different approach to data analysis. Hurlbert (1984) cautions strongly against applying standard statistical techniques — such as t-tests, ANOVA and their non-parametric analogues — to data from experiments that lack proper replication. For example, he points out the inappropriateness of applying inferential statistics to experiments involving a single treatment and control pair. One possible solution is to make graphs or tables showing mean values or trends, along with confidence intervals, allowing a reader to evaluate the likely importance of patterns. Effects on response variables can be related to treatments through measurements of factors related to known mechanisms of interaction. In this way a treatment effect can be convincingly described without the use of standard significance tests.

Successful unreplicated large-scale studies include artificial eutrophication of an experimental lake (Schindler *et al.* 1971) and clear-cut logging and herbicide treatment in an experimental forest (Likens *et al.* 1970). These studies tracked or mapped variables of interest such as temperature, nutrient concentrations, primary production, and phytoplankton species composition and distribution over time. Measurements were taken at intervals before and after treatment. Both studies demonstrated the effects of experimental manipulations without replicate experimental units and provide insights into design and analysis that may also be useful in marine reserve research.

Reserve proposals based on a non-replicated design will need a clear description of the system proposed for study and how the treatment is expected to affect this system, along with a rationale for the importance of the research. Especially important for this kind of proposal is a sampling program expected to illustrate the treatment effect in a meaningful way. Non-replicated designs are vulnerable to temporal changes that may be due to environmental and other influences being interpreted as treatment effects. Proposals should detail how they expect to be able to detect such confounding influences and distinguish them from treatment effects. Proposals should establish the current level of understanding of the system and describe the expected system response and mensuration techniques in sufficient detail to enable reviewers to evaluate the likelihood of success.

All scientific research proposals should include information on the time line for completion of the experiment, the methods of data collection and analysis that will be used, and the budget (including any assurances that can be provided regarding the adequacy of funding for the duration of the experiment). While pressures may arise to initiate experiments by taking immediate action to establish reserves, a well-designed experiment may require that sampling be conducted for a number of years prior to reserve establishment. Establishment of research reserves essentially requires that exclusive use of an area be given to a particular user group (scientists). Thus in weighing research benefits against costs, it is important to consider not only research costs but also the costs associated with displacement of other user groups from the area. Proposals for research reserves should provide reasonable assurance that they will yield conclusive and policy-relevant results if policy makers are to be receptive to the establishment of reserves solely on the basis of research.

In the U.S., research on reserves is more likely to be conducted opportunistically than at reserves established primarily for that purpose. While opportunistic research is necessarily conducted under less than ideal statistical design conditions (see Section III), it may provide valuable information that could not otherwise be obtained. Even research that is only capable of providing site-specific rather than generalizable insights into reserve effects may be useful, particularly to those with management responsibility for that site. In situations where reserve proposals do not include research as an objective but there is some flexibility in reserve design over and above what might be required to meet the objective of the proposal, it may be desirable to consider whether such flexibility is conducive to accommodating research needs in some way. The point is to encourage sound research methods and ensure that expectations and outcomes are conveyed to policy makers in ways that are commensurate with the technical merits and uncertainties associated with the particular research in question.

III.F. SSC Perspective on Scientific Basis for Achievement of Reserve Objectives

Reserves, like other types of management measures, must be considered in the context of the specific objectives that they are intended to achieve. Based on existing rationales and evidence regarding reserve effects, the SSC offers the following perspectives regarding the extent to which available scientific information indicates that reserves can be reasonably expected to achieve the objectives discussed in Sections III.A. to III.E. SSC comments should not be construed to imply any judgment about the relative merits of the objectives themselves, as the choice of objectives is a policy decision. Reserves may not be the only means of achieving some objectives and will usually require additionally regulations in the areas that remain open to fishing.

- *Reserves as insurance policy* — Reserves are uniquely qualified to provide a complete age structure for target species and thereby enhance persistence, i.e., the ability of fish stocks to withstand adverse effects associated with environmental variability and management uncertainty and error. In this sense, reserves have significant potential as a tool for mitigating uncertainty in stock assessments and managing unassessed stocks.

- *Reserves as source of fishery benefits* — Reserves can be effective in protecting population age structure, which, recent studies suggest, may increase recruitment and population resilience. On the other hand, theoretical models that are used to demonstrate increases in fishery yield outside the reserve are sensitive to underlying assumptions regarding the behavior of fish stocks, the extent of exploitation prior to the reserve and the extent of effort redistribution after the reserve is established. While such models provide insights into how particular circumstances and processes might affect yield, the practical question of how well model assumptions apply to particular fish stocks remains largely unanswered. For purposes of management, detailed life stage modeling is less relevant than whether an empirical relationship can be established between reserves and yield outside the reserve. Existing empirical studies focus largely on increases in fish abundance and size inside reserves; however, such effects do not necessarily imply increased recruitment to the fishery. The evidence for increased yield is not compelling, particularly in well-regulated fisheries. The SSC cautions against raising such expectations in Council-managed fisheries.

- *Reserves as source of ecosystem benefits* — Reserves provide the best opportunity to restore naturally functioning ecosystems and protect or restore habitat. However, in evaluating more general ecosystem effects of reserves, it is important to consider effects both inside and outside the reserve as the ecosystem itself extends to both areas. Depending on the nature and extent of fishing prior to reserve establishment, cessation of fishing may result in considerable ecosystem changes within the reserve. Reserves are a potentially useful tool for providing ecosystem benefits, provided that notable effects of effort displacement on the ecosystem outside the reserve are also effectively managed.

- *Reserves as means of achieving social objectives* — Reserves may be used to achieve objectives such as reducing social conflict among user groups, accommodating values held by various segments of the public regarding resource use, discouraging or encouraging particular types of resource use, and protecting areas that are deemed unique in terms of cultural or natural heritage. This objective differs fundamentally from the other reserve objectives in that the choice of criteria to evaluate achievement of this objective is a matter of policy rather than science. However science (most notably social science) can be useful for evaluating management alternatives relative to the policy criteria. Just as the Council has some discretion to address social issues such as allocation under the MSFCMA, reserve proposals may also employ social objectives to the extent that the objective is consistent with the specific legal mandates and constraints underlying the proposal.

- *Reserves as opportunities to advance scientific knowledge or establish reference sites* — Proposals for research reserves should be evaluated on the same basis as other types of research proposals. Technical requirements for such proposals would include a well-defined hypothesis, a rationale for why the research is worth pursuing, a description of experimental design, and sampling and analytical methods. Reserves can serve the function of enabling scientists to evaluate the impacts of fishing on marine communities by comparing fished areas to protected areas inside a reserve. However, the area inside a reserve and the area outside a reserve are not isolated from each other, nor are reserves normally placed with a view to testing scientific hypotheses, so caution must be used in drawing conclusions about reserve effects and the extent to which such effects can be generalized.

Marine reserves are one of many tools available to fishery managers. They are well suited to addressing objectives such as reducing management uncertainty and providing ecosystem benefits. The decision to implement reserves should be decided on a case-by-case basis, depending on the specific objective, the particular context in which reserves are being considered, and how management alternatives compare in terms of expected effects.

IV. Analytical Framework for Marine Reserve Proposals

As indicated in Section II, SSC expectations of all regulatory analyses are guided by the Council’s mandate to rely on the best available science and by Federal requirements as specified in the National Environmental Policy Act (NEPA), the Regulatory Flexibility Act (RFA), Executive Order (EO) 12866 and other applicable law. Comprehensive guidance to such regulatory requirements can be obtained by reference to the relevant literature (e.g., CEQ 1993, CEQ 1997, NMFS 2000, NMFS 1997, NOAA 1999, NOAA 1998, SBA 2003) and by consulting Council staff. There is no "cookbook" approach to evaluating reserve alternatives, as reserve proposals can vary widely in terms of their objectives and the particular context in which they are considered. The intent of this section is to make recommendations regarding how to address technical issues and analytical requirements that are specific (though not necessarily unique) to marine reserves.

This section focuses on topics that are customarily included in regulatory analysis: defining the objective, describing the management context and affected environment, identifying the problem that is impeding achievement of the objective, and devising and analyzing management alternatives intended to address the problem. In reviewing such analysis, the SSC considers a number of factors (e.g., the appropriateness of the data, the validity of data collection methods, the soundness of analytical methods, the manner in which the data and analysis are used to characterize the problem and evaluate potential solutions to the problem). The advice provided here is consistent with SSC expectations of all Federal regulatory analyses that it reviews for the Council.

For illustrative purposes, Appendix A discusses how the analytical guidelines provided in this section of the White Paper were addressed in the EIS prepared by the Council for the 2003 groundfish specifications (PFMC 2003). To facilitate consideration of the examples taken from the EIS, each subsection in Section IV includes a cross-reference to the relevant section of Appendix A. The reason for using this particular EIS as an illustration is that area closures were an integral component of the management alternatives considered in the EIS. Moreover, as a recently completed analysis, the EIS reflects current Federal regulatory requirements under the NEPA, the RFA and EO 12866.

While the Council's 2003 EIS provides examples of data and analytical approaches that can be used to evaluate potential effects of area closures, it may also differ in significant respects from an EIS that might be prepared for future marine reserve proposals prepared by the Council (or submitted for Council consideration by outside entities). For instance:

- The management objective addressed in the Council's 2003 EIS is to reduce the risk of overfishing. As indicated in Section III, other types of objectives are also possible.

- The area closures considered in the EIS are unprecedented in the Council's experience in terms of their size and the range of affected fishing operations. Other reserve proposals will differ in scope and size.

- The Council's 2003 EIS pertains to setting annual specifications for the groundfish fishery. These specifications are subject to reconsideration according to the Council's biennial management cycle. Proposals involving reserves will require a much lengthier temporal analysis than the EIS.

- The management objective addressed in the EIS is to ensure that optimum yields (OYs) for individual species — expressed as specific numeric values — are not exceeded. Marine reserve proposals may not be based on such strictly quantitative criteria.

Thus, the Council's 2003 EIS should not be viewed as a strict template for marine reserve proposals but rather as suggestive of the types of issues that may arise in considering reserves and the types of data and analytical approaches that may be useful for considering the impacts of reserves. Each topic heading in this section includes in parentheses the section of Appendix A that describes how that particular topic was addressed in the EIS.

IV.A. Specifying the Management Objective (see Appendix A-1)

The management objective addressed by the proposal should be described in specific terms and in the context of the relevant mandates. Some of the mandates that the Council is responsible for addressing (e.g., MSFCMA) may differ from mandates for reserve proposals initiated by outside entities (e.g., National Marine Sanctuaries Act).

IV.B. Describing the Management Context and Affected Environment (see Appendix A-2)

Background information should be provided that enhances understanding of the problem that the proposal is intended to address. Relevant areas of discussion include (1) the current management situation, (2) events leading up to the current situation, (3) ongoing or anticipated management issues or measures that may not be directly related to the proposal but may have a bearing on the larger context within which the proposal is considered, and (4) the environment (e.g., ecosystem, fish stocks, fishery participants, fishing communities) expected to be affected by the proposal.

IV.C. Identifying the Problem and Role of Reserves in Addressing the Problem (see Appendix A-3)

The proposal should describe the problem to be addressed, why the problem is significant and why the *status quo* is inadequate to address the problem. If reserves are deemed a unique solution to the problem, the proposal should explain what makes reserves unique. As indicated in Section III, the role of reserves should be explained in specific terms. For instance, if reserves are intended to address an ecosystem objective, the proposed objective should go beyond "provide a fully functioning ecosystem" to describe what aspects of ecosystem well-being are expected to be enhanced by reserves. If reserves are intended to reduce management uncertainty or provide fishery benefits, the proposal should specify the type of uncertainty that will be reduced or the type of benefits that will be provided.

IV.D. Defining the *Status Quo* (see Appendix A-4)

The proposal should include a description of the *status quo*, i.e., current and future conditions that can reasonably be expected to prevail if the proposal is not implemented. The time frame used to define the *status quo* (as well as alternatives to the *status quo*) should reflect the time period over which effects of the proposed regulatory change are expected to be realized. This is particularly important if benefits and costs are expected to change over time or to be realized over different time frames. Also, as discussed in Section III, all alternatives (including the *status quo*) should be evaluated on a common spatial scale, i.e., including areas both inside and outside the proposed reserve. Current (baseline) conditions may be a useful proxy for the *status quo*, but only if current conditions are expected to continue into the future.

IV.E. Defining Alternatives to the *Status Quo* (see Appendix A-5)

Reserve proposals should include a reasonable range of alternatives to the *status quo* and describe the rationale underlying them. If the problem identified in the proposal can be addressed only by reserves, the alternatives should take the form of different reserve configurations. The relevance of particular reserve features (e.g., location, size, configuration) should be discussed in relation to the management objective and other relevant considerations. Documentation of the data and assumptions underlying reserve design (e.g., habitat maps, species distributions, larval dispersal patterns, spatial distribution of fishing activity) should be provided, as well as any models or algorithms[11] that contributed to reserve design.

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[11] If a reserve siting algorithm is used to evaluate impacts of alternative siting schemes, it is important that use of the algorithm not be limited to a single reserve size. The algorithm should be rerun over a range of sizes to gain a better understanding of how achievement of the objective specified in the algorithm is affected by alternative sizes. It is also important to recognize that such algorithms

The marine reserves literature provides some insights into general principles for the design, size and location of reserves (e.g., larger reserves provide greater ecosystem benefits within their borders than smaller reserves; networks of reserves are needed to provide insurance against uncertainty). Specific recommendations in the literature regarding reserve size are based largely on theoretical models that focus on fishery benefits of reserves. As indicated in Section III.B., the results of such models are sensitive to underlying assumptions and have been subject to limited validation. Reserves are not "one size fits all." If reserve proposals intend to rely on size recommendations from the literature, it is important that such recommendations be consistent with model assumptions that are reasonably realistic in the context of the proposal.

The proposal should include a description of the operational requirements (i.e., the specific combination of regulations) associated with each alternative. If reserves are not a unique solution to the problem — that is, if the problem can also be addressed by non-reserve management measures or by combining reserves with other measures — the alternatives considered should reflect the broader range of feasible solutions. For instance, achieving an ecosystem objective may involve consideration of gear modifications or effort reduction, either separately or in conjunction with reserves. Achieving an insurance objective may involve considering more precautionary adjustments to existing harvest rate policies, either as a separate alternative or in conjunction with reserves. In designing management alternatives, it is important to consider not only regulatory features that promote achievement of the management objective but also features that may be needed to address effects of the reserve on areas that remain open to fishing.

IV.F. Analyzing Management Alternatives (see Appendix A-6)

In addition to specifying an objective (Section IV.A.) and the specific problem impeding achievement of the objective (Section IV.C.), the proposal should provide measurable, verifiable indicators of progress toward achieving the objective and thresholds for determining when the objective has been achieved. This requirement is not unique to marine reserves. For example, rebuilding plans require continued stock assessments to determine if plans are effective. It is, however, especially important for marine reserves because current understanding of the effects of reserves is rudimentary and each reserve is effectively an experiment. With proper monitoring and evaluation, the value of marine reserves to fishery management can be assessed and application improved.

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are analytical tools and that not all considerations relevant to selection of a preferred alternative can necessarily be quantified in a single algorithm.

Alternatives should be compared in terms of success in meeting the objective. Since the point of the analysis is to determine whether a change from the *status quo* is warranted, each alternative should be evaluated relative to the *status quo*.

Effects that may not be directly relevant to the objective should also be evaluated. For instance, if the objective of the reserve proposal is biological, management alternatives should also in terms of socioeconomic and ecosystem effects, both positive and negative. Documenting all consequences is important, as effects that may be unrelated to achievement of the objective may also have a bearing on the feasibility or desirability of an alternative.

One effect common to virtually all reserve proposals is effort displacement. If a reserve is placed in an area where few fish have traditionally been harvested, then few fishers will be affected by the presence of the reserve and there is likely to be little displacement of fishing effort. However, if a reserve includes historically productive fishing grounds, which seems the more likely scenario, the fishers who have previously been able to operate on those grounds will either have to cease fishing or shift their operations to other fishing grounds. This displaced effort could result in increased exploitation of the fishing grounds outside the reserve and increased competition and social conflict among the fishers operating there. The SSC is aware of the limited information and high degree of uncertainty inherent in addressing the effects of displacement. However, given the need for managers to consider whether closer monitoring and/or additional regulation are needed to address such effects, this issue cannot be ignored. The size of the closures considered in the Council's 2003 groundfish specifications warranted extensive consideration of this issue, including more restrictive regulation outside the closed area. Not all reserve proposals will necessarily warrant changes in monitoring or regulation outside the reserve. However, this cannot be determined without some evaluation of the potential extent of displacement.

In considering the potential effects of displacement, it is important to distinguish between effort foregone (effort that disappears from the fishery altogether) and effort that shifts to the area open to fishing. From an economic perspective, effort foregone implies economic losses, while effort shifted to the open area provides at least some opportunity to mitigate the short-term economic losses associated with the reserve. Effort shift may have implications not only for displaced vessels but also for vessels with whom they interact outside the reserve in terms of increased competition, congestion, harvesting costs and social conflict.

Whereas effort shift implies some ability to mitigate the short-term economic losses associated with the reserve, from a biological or environmental perspective, the less effort that moves to the area open to fishing the better. Determining the nature of such effects is not always straightforward. For instance, biological effects are not necessarily limited to stocks previously harvested in the reserve, as effort transferred to the area open for fishing may focus on different species than were targeted in the reserve. Bycatch patterns may also differ from what previously occurred in the reserve. Ecosystem effects may vary, depending on whether the transferred effort is associated with gear types or fishing strategies that are more or less likely to adversely affect habitat, and whether effort is transferred to habitats that are more or less vulnerable to gear effects.

To the extent possible, the analysis should be based on data and studies specific to the fish stocks, ecosystems, fishery participants and fishing communities that will be affected by the proposal. Assumptions underlying the analysis should be plausible in terms of reflecting the characteristics and behavior of the affected entities. To the extent that the analysis relies on data or results for other stocks, ecosystems, participants and communities, the appropriateness of relying on such outside information should be apparent in the analysis.

Regulatory analysis, whether it involves marine reserves or other types of management measures, is constrained by limited knowledge and data regarding the environment, fish stocks, and the social and economic behavior of fishery participants. A number of analytical approaches (e.g., risk assessment, sensitivity analysis) can be used to convey the extent of risk and uncertainty in an analysis. Careful interpretation and qualification of results are also useful for conveying the extent of uncertainty. In cases where effects cannot be quantified, a qualitative analysis may be useful for portraying the direction of change or relative differences among alternatives. A careful qualitative evaluation is preferable to a quantitative evaluation that conveys more certainty than is warranted. If an effect is unknown, it should be characterized as unknown.

IV.F.1. Biological (Species-Specific) Effects (see Appendix A-6a)

If the management objective pertains to protection or enhancement of particular species, analysis of biological benefits should focus on those species. Effects on species that are not directly relevant to the objective may also be of interest, particularly if such effects have implications for management of those species. While anticipating effects of reserves at the species level can be difficult, even information on the identity of affected species or species complexes and the direction of the effect may be helpful in identifying biological effects.

As discussed in Appendix B, the exclusion of fishery-independent surveys from reserve areas may complicate the Council's efforts to conduct the types of assessments needed to fulfill its management responsibilities. Reserve proposals should be clear regarding whether conventional research surveys — based, for example, on trawling — would be allowed in the reserve area and (if allowed) whether any constraints would be imposed on the conduct of such surveys.

IV.F.2. Social and Economic Effects (see Appendix A-6b)

Approaches for evaluating economic effects include economic impact analysis and cost-benefit analysis. Economic impact analysis focuses on income and employment impacts in local economies, while cost-benefit analysis focuses on societal-wide effects, as estimated using standard concepts of economic value (producer and consumer surplus, opportunity cost). Available data and models are rarely adequate for conducting a comprehensive cost-benefit analysis that addresses effects on all affected entities expressed in appropriate units of value (e.g., consumptive, non-consumptive, non-use values). A partial cost-benefit analysis (e.g., covering some affected entities) may be useful, although any such analysis should be accompanied by appropriate caveats regarding the types of effects that could not be addressed.

In cases where limitations in existing information preclude estimation of economic impacts or economic value, it may be necessary to rely on other monetary or non-monetary indicators of economic and social well-being. For instance, effects on fishery participants may be evaluated in terms of numbers of affected entities (e.g., boats, processors, other businesses, fishermen); amount of commercial and recreational effort displaced; changes in landings, revenues, costs, profits; extent of prior dependence on fisheries within the reserve area; nature and extent of fishing opportunities outside the reserve.

Socioeconomic effects expressed in a common monetary unit can have different meanings. Monetary effects that have disparate meanings should not be directly compared or added. For instance, measures of economic impact and economic value are not comparable. Even in cases where the same monetary variable is used to characterize effects on different entities, its meaning may depend on the context in which it is used. For instance, the ex-vessel value of landings is a source of revenue when applied to fishing vessels but a cost when applied to processors. While this particular component of processor cost may be correlated with processor revenue or differ from revenues only by a markup factor, it nevertheless has a different meaning to vessels and processors.

Reserve proposals should include a discussion of the allocational implications of each management alternative, i.e., who reaps the benefits and who bears the costs. For instance, effects may be categorized by fishery, gear type, geographic area (e.g., ports, counties, states, management areas), vessel size class. The types of categorization relevant to evaluating distributional effects will depend on the specifics of individual reserve proposals.

IV.F.3. Ecosystem Effects (see Appendix A-6c)

As indicated in Section IV.F., reserve proposals should provide some measurable, verifiable indicator of progress toward achieving the objective. In cases where the objective is ecosystem-related, identifying such an indicator is complicated by the many ways in which ecosystem effects can be portrayed. Given the limited information regarding density, numbers, biomass, size, and diversity of organisms, it may be more feasible to characterize alternatives in terms of the extent to which they protect relevant habitat types. Consideration should be given to impacts both within the reserve and in the area open to fishing. Given the difficulty of directly evaluating any adverse effects in the open area, it may be necessary to rely on indirect indicators: e.g., the amounts and types of effort shifted to the open area, the size of the fishing grounds over which this effort is likely to be dispersed, the habitat types likely to be occupied by this effort.

IV.F.4. Monitoring and Enforcement (see Appendix A-6d)

Reserve proposals should include a description of monitoring plans. These plans should be relevant to the objective of the proposal and the criteria identified in the proposal that measure progress toward meeting the objective. For instance, if a proposal is intended to achieve objectives such as reducing management uncertainty or providing ecosystem or fishery benefits, monitoring would provide the feedback needed to evaluate the effectiveness of the action taken and make adjustments as necessary to that action. If the objective is to advance scientific knowledge, monitoring would need to be consistent with the requirements of the experiment. If the objective is to establish reserves solely as an expression of public preferences, monitoring may not be needed to measure progress toward meeting the objective, as the objective may be met simply by the act of reserve creation. However, any reserves that are established should be considered as opportunities to advance knowledge, given the lack of information regarding the effects of marine reserves on the West Coast and their utility as a management tool.

Reserve proposals should include a description of the types of data that will be collected, the regularity with which they will be collected, data collection methods and costs, and whether there is any long-term commitment of resources for data collection.

The SSC appreciates the difficulties associated with designing and implementing monitoring programs. For instance, pilot studies may need to be conducted to address statistical design requirements of the program. Unanticipated issues may arise after the program is initiated that require reconsideration of data needs or sampling methods. It is important that data analysis and review of monitoring procedures be periodically conducted so that such issues can be revealed and resolved in a timely manner. If results of the monitoring program are intended to be relevant to future management decisions, it is important that the relevant data and analyses be available at appropriate points in the management cycle.

The proposal should indicate the extent to which existing data collection programs are expected to contribute to the monitoring effort. Monitoring costs (like other aspects of the management alternatives) should be evaluated relative to the *status quo*. If relevant monitoring efforts are already underway (and these efforts can be reasonably expected to continue into the future), then only the incremental cost over and above existing monitoring efforts should be considered in evaluating alternatives.

Reserve proposals should also specify enforcement requirements associated with each management alternative. Enforcement costs (like monitoring costs) should be evaluated relative to the *status quo*. If the management alternatives themselves include any features that are intended to facilitate monitoring or enforcement, these features should be identified.

IV.G. Documenting Public Process (see Appendix A-7)

Reserve proposals should include a description of the process by which the need for reserves was identified and management alternatives were developed and analyzed. The extent of public involvement in the process and the nature of public comment should be documented.

V. SSC Conclusions and Recommendations to the Council
V.A. Marine Reserves in the Larger Management Context

Marine reserves are a means of achieving management objectives such as reducing uncertainty in management and providing fishery and ecosystem benefits. In considering reserves as a management measure, it is important to remember that the appropriate starting point for discussion is the management objective. Management effectiveness is not achieved by focusing *a priori* on any particular regulatory measure but by determining which measure (or combinations of measures) would be most effective in addressing the objective. To accomplish this, it is important that the range of feasible solutions not be unduly restricted from the outset. The Council's EIS on the 2003 groundfish management specifications provides a good illustration of this point. While area closures were integral to achieving the Council's objective, the objective could not have been achieved without combining those closures with other types of management measures.

The SSC is keenly aware of deficiencies and gaps in existing data and scientific knowledge and the high degree of uncertainty that this brings to the management process. Just as uncertainty is an important and explicit topic of discussion in assessment models and regulatory analyses produced by the Council, marine reserve proposals are also expected to convey the extent of uncertainty in data, methods and results. The SSC supports the Council's commitment to fostering a management process in which technical issues can be aired openly and frankly; such dialogue is essential for improving data, methods and the scientific basis of management decisions. Similar transparency is expected in discussions of marine reserve proposals.

An EIS is much more than a paperwork requirement; it plays a substantive management role by providing a meaningful synthesis of information relevant to the issue at hand, conveying that information to the public and policy makers, and moving the process forward in a systematic and well-documented way. To serve the public process, several iterations of an EIS may need to be drafted and made available for public comment to ensure that a reasonable range of alternatives is identified and adequately evaluated. The public cannot be expected to provide constructive input and policy makers cannot be expected to make well-informed decisions unless they have access to a technically sound, informative and balanced EIS. Any policy preferences expressed in an EIS should be based on a rationale that reflects a careful weighing of alternatives and a recognition of positive and negative effects as well as uncertainties associated with all alternatives (including the recommended one).

The uncertainty and imprecision that are inherent in fishery data and assessment methods are also inherent in existing knowledge of marine reserves. In order to ensure that management is informed by the best available science, it is first important to distinguish between issues that can be addressed by science and those that cannot. While science (meaning both natural and social sciences) may inform many aspects of reserve design and facilitate systematic consideration of reserve effects, all relevant factors must ultimately be weighed in ways that are beyond the scope of science. Even with perfect knowledge, policy makers would be faced with difficult trade-offs in fishery management. Scientists can help policy makers understand likely effects of various management scenarios and the risks and uncertainties involved. Policy makers are responsible for weighing these risks and uncertainties in choosing appropriate management outcomes.

Regardless of the management objective, the choice of a preferred alternative is ultimately a policy decision. Potential effects within the reserve must be balanced against effects outside the reserve. The time frame for expected changes must be considered in terms of short- versus long-term effects. The distribution of costs and benefits among affected entities must be allocated to achieve an equitable outcome. Policy decisions are further complicated if the reserve is intended to achieve multiple objectives, as the same reserve outcome is not necessarily suited to all objectives and the importance of each objective will need to be weighed in making the decision.

The EIS for the Council's 2003 groundfish management specifications highlighted the role of OYs, depth-based closures, season closures, vessel landings limits and gear restrictions in enhancing the rate of recovery of overfished groundfish stocks. Rebuilding overfished stocks was an important objective for the Council.

However, by reducing the operational flexibility of fishing operations, such measures may also accentuate (however unintentionally) the incentive for vessel operators to seek additional avenues of investment that allow them to remain competitive in the race for the fish.[12] [13] The SSC supports the use of such measures (which are integral to achieving many of the Council's objectives) but points out that there is no panacea for fishery management problems. Reserves, like other types of management measures, are well suited for some purposes but not others. Reserves, like other measures, can aggravate as well as address problems, depending on the context in which they are applied and the manner in which they are used. The SSC encourages caution in making broad generalizations about reserve effects.

V.B. Process for Considering Marine Reserves

The Channel Islands National Marine Sanctuary has established reserves in California State waters and intends to extend these reserves into Federal waters; similar additional proposals from other entities may be forthcoming. To the extent that the Council becomes involved in implementation of such proposals, the SSC requests that the Council consider developing appropriate procedures for considering them. Council guidance could extend to a number of areas: e.g., procedures for keeping the Council informed and getting on the Council agenda; time constraints and deadlines for participating in the Council process (Council meeting schedules, briefing book deadlines, meeting notice requirements); types of information regarding the proposal that are needed at various stages of the process (initial discussion, development of alternatives, regulatory analysis, Council deliberation); advisory

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[12] The "race for the fish" - which is endemic in most West coast fisheries - creates an incentive for fishery participants to invest in boats and equipment in ways that increase their competitive advantage. Because all vessels share this incentive, the initial advantage gained from such investment eventually dissipates as more vessels engage in this strategy. The collective result is to encourage additional rounds of investment to stay competitive and more intensive fishing to pay off the debt burden associated with this wasteful type of investment. The economic pressures resulting from excess investment encourage the industry to take a short- rather than long-term view of resource stewardship, require increasingly restrictive measures that contribute to the continuing cycle of over-investment, and place untenable demands on fishery managers. This is the fundamental problem of fisheries management.

[13] The Council's EIS made several allusions to this issue as follows: "Proposed gear restrictions [finfish excluders, small footrope requirements] are likely to reduce gear efficiency, increasing cost per unit of harvest" (PFMC 2003, p. 4-29). Also, "As fishery revenue declines, absent new innovations that increase efficiency, and given the tendency of regulators to impose inefficiency as a means of fishery management, it is likely the fishery's ability to service debt declines" (PFMC 2003, p. 4-29). In an effort to change the incentive to race for the fish, the Council and the industry are now considering the use of individual transferable quotas in the groundfish trawl fishery.

committees that need to be consulted at each stage; relative responsibilities of the Council and the proposal sponsor in terms of developing management alternatives and preparing the regulatory analysis.

Proposal sponsors would logically have prime responsibility for justifying their own proposals and preparing the analyses needed to evaluate the effects of what is proposed. However, in cases where the objective of a reserve proposal could also be achieved by changes in existing fishery regulations (or by some combination of reserves and non-reserve management measures), the SSC expects the proposal to include alternatives that reflect such possibilities. Not all sponsors are likely to know enough about Council regulations to adequately address this expectation on their own, and may desire Council input in shaping or suggesting alternatives as they relate to fishery regulation. This may be desirable from the Council's perspective as well, to ensure that reserve proposals do not compromise the Council's ability to fulfill its own management responsibilities.

The SSC requests that the Council consider assuming a more proactive role in reserve discussions and plans as they relate to the Council's area of jurisdiction by developing an explicit policy with regard to marine reserves and working with other appropriate entities to develop a coordinated approach to reserves on the West Coast. Such coordination would facilitate communication, avoid duplication of effort and increase the likelihood of a productive outcome for all parties. Limited resources are clearly an issue. However, some commitment of resources will be required, regardless of whether the Council chooses to involve itself by reacting to individual reserve proposals on a case-by-case basis or by being more strategic in its involvement.

The SSC is concerned that the currently fragmented focus on marine reserves as a management strategy may result in outcomes that unduly complicate the Council's ability to carry out its management responsibilities. Given the stock assessment and fisheries expertise available within the Council family and the Council's experience with regulatory process and requirements, Council involvement in marine reserve planning processes would help ensure that such planning is grounded in the best available science and realistically reflects the complexities of management.

VI. Research and Data Needs

The data and models currently used by the Council provide limited consideration of the spatial distribution of habitat, fish and fishing activities. Recent developments (e.g., groundfish closures, EFH considerations) indicate a growing need for spatially explicit data and models. Such needs are directly relevant to Council management concerns and are not unique to marine reserves. Because reserves can affect a broad range of fisheries (depending on the types of fishing activity eliminated from the reserve and the alternative fisheries pursued by displaced vessels in the open area), spatial data are needed for a broad range of fisheries in terms of the distribution of fishing effort and social and economic characteristics of fishing activity. More and better information is needed on habitat and fish distributions. Research is needed on stock assessment models that include a spatial as well as temporal dimension, models that predict spatial shifts in fishing effort, and models that integrate stock and fleet dynamics in a spatially explicit way. Development of appropriate constrained optimization models based on explicit management objectives would be helpful for designing spatial management alternatives and evaluating the degree to which they meet the stated objective.

While more attention to spatial data and models is needed, data collection is costly and model development is not guaranteed to improve the science needed for management. Increased spatial resolution will require more complex models and thus estimation of more parameters. Model selection techniques will need to be applied to determine how differences in spatial resolution affect model performance and what approaches to data pooling might be appropriate. To the extent that data pooling occurs in non-spatial dimensions, the possibility exists that models will become less informative with regard to non-spatial dimensions of fish and fishery behavior.

Spatial closures are one of several methods that can be used in fishery management to reduce bycatch. The Council's groundfish closures are an example of this, albeit an extraordinary one due to the size of the closures. The groundfish closures provide a unique opportunity to analyze the effects of effort displacement on fishery participants, fishing communities and fish stocks in the open area. An important aspect of such research will be to distinguish the effects of effort displacement from other factors that may be going on concurrently with the displacement (e.g., regulatory changes).

Marine reserves are thought to benefit fisheries by exporting larvae and adults to open areas. The extent of this process, and species-specific responses, are unknown yet central if reserves that provide fishery benefits are to be integrated with fishery management. Achieving quantitative estimates of these reserve effects, and the scales of time and space on which they operate, would enhance the utility of marine reserves as a management tool.

If fishery-independent surveys are prohibited in reserve areas, the possibility of alternative data collection methods in the reserve may need to be considered to ensure the continuity of time series data used in stock assessments. This will require evaluating alternative non-lethal sampling methods in terms of feasibility, cost and whether they would provide the types of data needed for stock assessment. If non-lethal methods are deemed suitable, sampling procedures for reserve areas will need to be developed, as well as methods of calibrating results of such surveys with those from more traditional survey techniques used in the past. Consideration will also need to be given to whether possible changes in fish dynamics associated with reserve establishment may require changes in stock assessment models.

VII. List of Acronyms

CEQ - Council on Environmental Quality
CPUE - catch per unit effort
EFH - Essential fish habitat
EIS - Environmental Impact Statement
EO - Executive Order
ESA - Endangered Species Act
fm - fathom
FMP - Fishery Management Plan
GMT - Groundfish Management Team
HG - harvest guideline
IPHC - International Pacific Halibut Commission
LE - limited entry
MPA - marine protected area
MSFCMA - Magnuson-Stevens Fishery Conservation and Management Act
mt - metric tons
NEPA - National Environmental Policy Act
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
OA - open access
OY - optimum yield
PFMC - Pacific Fishery Management Council
RFA - Regulatory Flexibility Act
SBA - Small Business Administration
SSC - Scientific and Statistical Committee
VMS - vessel monitoring system

VIII. References

Berkeley, S.A., M.A. Hixon, R.J. Larson and M.S. Love. 2004a. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. *Fisheries*. 29(8): 23-32.

Berkeley, S.A., C. Chapman and S.M. Sogard. 2004b. Maternal age as a determinant of larval growth and survival in a marine fish, Sebastes melanops. *Ecology*. 85(5): 1258-1264.

Bohnsack, J.A. 1996. Marine reserves, zoning, and the future of fishery management. *Fisheries*. 21(9): 14-16.

Botsford, L.W., A. Hastings and S.D. Gaines. 2001. Dependence of sustainability on the configuration of marine reserves and larval dispersal distance. *Ecology Letters*. 4: 144-150.

California Department of Fish and Game. *Marine Life Protection Act*. Fish and Game Code, Section 2850-2863.

Carson, R.T. 2000. Contingent valuation: a user's guide. *Environmental Science and Technology.* 34:1413-1418.

Carson, R.T., N.E. Flores and N.F. Meade. 2001. Contingent valuation: controversies and evidence. *Environmental and Resource Economics*. 19: 173-210.

Cote, I.M., I. Mosqueira and J.D. Reynolds. 2001. Effects of marine reserve characteristics on the protection of fish populations: a meta-analysis. *Journal of Fish Biology*. 59 (Supplement A): 178-189.

Council on Environmental Quality. January 1993. *CEQ Guidance Regarding Biodiversity*. Council on Environmental Quality, Washington DC.

Council on Environmental Quality. January 1997. *CEQ Guidance Regarding Cumulative Effects*. Council on Environmental Quality, Washington DC.

DeMartini, E.E. 1993. Modeling the potential of fishery reserves for managing Pacific coral reef fishes. *Fishery Bulletin*. 91: 414-427.

Diamond, P.A. and J.A. Hausman. 1994. Contingent valuation: is some number better than no number? *Journal of Economic Perspectives*. 8(4): 45-64.

Ehrenfeld, D. 1988. Why Put a Value on Biodiversity? In: Wilson, E.O. (ed.). *Biodiversity.* Washington, D.C.: National Academy Press, pp. 212-216.

Freese, L., P.J. Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. *Marine Ecology Progress Series.* 182:119-126.

Friedlander, A.M., G.W. Boehlert, M.E. Field, J.E.Mason, J.V. Gardner, and P. Dartnell. 1999. Sidescan-sonar mapping of benthic trawl marks on the shelf and slope off Eureka, California. *Fishery Bulletin.* 97:786-801.

Goulder, L.H. and D. Kennedy. 1997. Valuing ecosystem services: philosophical bases and empirical methods. In: Daily, G.C. (ed.). *Nature's Services - Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press, pp. 23-47.
Guenette, S., T. Lauck and C. Clark. 1998. Marine reserves: from Beverton and Holt to the present. *Reviews in Fish Biology and Fisheries*, 8:251-272.

Guenette, S. and T.J. Pitcher. 1999. An age-structured model showing the benefits of marine reserves in controlling overexploitation. *Fisheries Research*. 39: 295-303.

Halpern, B.S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications*. 13(1) Supplement: S117-S137.

Halpern, B.S., S.D. Gaines and R.R. Warner. In press. Export of production and the displacement of effort from marine reserves: effects on fisheries and monitoring programs. *Ecological Applications*.

Hanemann, W.M. 1994. Valuing the environment through contingent valuation. *Journal of Economic Perspectives*. 8(4): 19-43.

Hannesson, R. 1998. Marine reserves: what would they accomplish? *Marine Resource Economics*. 13: 159-170.

Hastings, A. and L.W. Botsford. 1999. Equivalence in yield from marine reserves and traditional fishery management. *Science*. 284: 1537-1538.

Holland, D.S. and R.J. Brazee. 1996. Marine reserves for fishery management. *Marine Resource Economics*. 11: 157-171.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs*. 54(2): 187-211.

Kirchhoff, S., B.G. Colby and J.T. LaFrance. 1997. Evaluating the performance of benefit transfer: an empirical inquiry. *Journal of Environmental Economics and Management*. 33(1): 75-93.

Lauck, T., C.W. Clark, M. Mangel and G.R. Munro. 1998. Implementing the precautionary principle in fisheries management through marine reserves. *Ecological Applications*. 8(1) Supplement: Ecosystem Management for Sustainable Marine Fisheries. S72-S78.

Lawson, P.W. 1990. *Differential Selectivity of Three Gear Arrays Used in Commercial Trolling for Coho and Chinook Salmon*. Oregon Department of Fish and Wildlife, Ocean Salmon Management Program, Newport, Oregon.

Likens, G.E., F.H. Bormann, N.M. Johnson, D.W. Fisher and R.S. Pierce. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed ecosystem. *Ecological Monographs*. 40(1): 23-47.

Louviere, J.J., D.A. Hensher and J.D. Swait. 2000. *Stated Choice Methods*. New York: Cambridge University Press.

Mangel, M. 1998. No-take areas for sustainability of harvested species and a conservation invariant for marine reserves. *Ecology Letters*. 1: 87-90.

Mapstone, B.M., R.A. Campbell and A.D.M. Smith. 1996. *Design of Experimental Investigations Into the Effects of Line and Spear Fishing on the Great Barrier Reef*. CRC Reef Research Centre Technical Report No. 7, CRC Reef Research Centre, 86 pp.

Martell, S.J.D., C.J. Walters and S.S. Wallace. 2000. The use of marine protected areas for conservation of lingcod (*Ophiodon elongatus*). *Bulletin of Marine Science*, 66(3): 729-743.

Mitchell, R.C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington, D.C.: Resources for the Future.

Mosquera, I., I.M. Cote, S. Jennings and J.D. Reynolds. 2000. Conservation benefits of marine reserves for fish populations. *Animal Conservation*. 4: 321-332.

Murray, S.N., R.F. Ambrose, J.A. Bohnsack, L.W. Botsford, M.H. Carr, G.E. Davis, P.K. Dayton, D. Gotshall, D.R. Gunderson, M.A. Hixon, J. Lubchenco, M. Mangel, A. MacCall, D.A. McArdle, J.C. Ogden, J. Roughgarden, R.M. Starr, M.J. Tegner and M.M. Yoklavich. 1999. No-take reserve networks: sustaining fishery populations and marine ecosystems. ***Fisheries.*** 24(11): 11-25.

National Marine Fisheries Service, Office of Sustainable Fisheries. Revised August 16, 2000. *Guidelines for Economic Analysis of Fishery Management Actions*.

National Marine Fisheries Service. Revised May 1, 1997. *Operational Guidelines - Fishery Management Plan Process*. Silver Spring, Maryland.

National Oceanic and Atmospheric Administration. 1993. Natural Resource Damage Assessments Under the Oil Pollution Act of 1990. *Federal Register*, 15 CFR Chapter IX, 58(10): 4601-4614. Washington, D.C.: U.S. Government Printing Office.

National Oceanic and Atmospheric Administration. 1999. *Environmental Review Procedures for Implementing the National Environmental Policy Act*. NOAA Administrative Order 216-6.

National Oceanic and Atmospheric Administration. 1998. Magnuson-Stevens Act Provisions; National Standard Guidelines; Final Rule. *Federal Register*, 50 CFR Part 600, 63(84): 24212-24237. Washington, D.C.: U.S. Government Printing Office.

National Research Council, Ocean Studies Board, Committee on the Evaluation, Design and Monitoring of Marine Reserves and Protected Areas in the United States. 2001. *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*. Washington, D.C.: National Academy Press. 272 pp.

O'Doherty, R.K. 1995. A review of benefit transfer: why and how? *British Review of Economic Issues*. 17(43): 1-15.

Oregon Ocean Policy Advisory Council. 2002. *Recommendation to the Governor - Oregon and Marine Reserves*. Revised Working Group Draft for Discussion August 16, 2002.

Pacific Fishery Management Council. January 2003. *Final Environmental Impact Statement for the Proposed Groundfish Acceptable Biological Catch and Optimum Yield Specifications and Management Measures - 2003 Pacific Coast Groundfish Fishery.*

Paddack, M.J. and J.A. Estes. 2000. Kelp forest fish populations in marine reserves and adjacent exploited areas of central California. *Ecological Applications*. 10(3): 855-870.

Palsson, W.A. and R.E. Pacunski. 1995. The response of rocky reef fishes to harvest refugia in Puget Sound. In: *Puget Sound Research Proceedings '95*, Vol 1, pp. 224-234, Puget Sound Water Quality Authority, Olympia, WA.

Polacheck, T. 1990. Year around closed areas as a management tool. *Natural Resource Modeling*. 4(3): 327-354.

Presidential Documents. Executive Order 13158 of May 26, 2000 - Marine Protected Areas. *Federal Register*. May 31, 2000. 65(105): 34909-34911.

Punt, A.E., A.D.M. Smith, A.J. Davidson, B.D. Mapstone and C.R. Davies. 2001. Evaluating the scientific benefits of spatially explicit experimental manipulations of common coral trout *(Plectropomus leopardus*) populations on the Great Barrier Reef, Australia. *Spatial Processes and Management of Marine Populations*. Alaska Sea Grant College Program. AK-SG-01-02, pp. 67-103.

Restrepo, V.R. G.G. Thompson, P.M. Mace, W.L. Gabriel, L.L. Low, A.D. MacCall, R.D. Methot, J.E. Powers, B.L. Taylor, P.R. Wade and J.F. Witzig. 1998. *Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act*. NOAA Technical Memorandum NMFS-F/SPO. 54 pp.

Roberts, C.M. 1997. Ecological advice for the global fisheries crisis. *Trends in Ecology and Evolution.* 12(1): 35-38.

Rowley, R.J. 1994. Marine reserves in fisheries management. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 4: 233-254.

Russ, G.R. 2002. Yet Another Review of Marine Reserves as Reef Fishery Management Tools. In: Sale, P.F. (ed.). *Cora l Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*. London: Academic Press.

Schindler, D.W., F.A.J. Armstrong, S.K. Holmgren and G.J. Brunskill. 1971. Eutrophication of Lake 227, Experimental Lakes Area, Northwestern Ontario, by addition of phosphate and nitrate. *Journal of the Fisheries Research Board of Canada*. 28(11): 1763-1782.

Schroeter, S.C., D.C. Reed, D.J. Kushner, J.A. Estes and D.S. Ono. 2001. The use of marine reserves in evaluating the dive fishery for the warty sea cucumber (*Parastichopus parvimensis*) in California, U.S.A. *Canadian Journal of Fisheries and Aquatic Science*. 58: 1773-1781.

Shears, N.T. and R.C. Babcock. 2002. Marine reserves demonstrate top-down control of community structure on temperate reefs. *Oecologia*. 132: 131-142.

Sladek Nowlis, J. And C.M. Roberts. 1998. Fisheries benefits and optimal design of marine reserves. *Fishery Bulletin*. 97: 604-616.

Small Business Administration, Office of Advocacy. May 2003. *How to Comply with the Regulatory Flexibility Act - A Guide for Government Agencies.*

Smith, J.D. and J.E. Wilen. 2003. Economic impacts of marine reserves: the importance of spatial behavior. *Journal of Environmental Economics and Management*. 46: 183-206.

Smith, V.K., G.L. Van Houtven, S. Pattanayak and T.H. Bingham. 2000. *Improving the Practice of Benefit Transfer: A Preference Calibration Approach.* Prepared for U.S. Environmental Protection Agency, Office of Water, Office of Policy, Economics and Innovation. EPA Contract Number 68-C6-0021.

Tuya, F.C., M.L. Soboil and J. Kido. 2000. An assessment of the effectiveness of Marine Protected Areas in the San Juan Islands, Washington, USA. *ICES Journal of Marine Science*. 57: 1218-1226.

Appendix A. Relevant Examples from Pacific Council EIS on 2003 Groundfish Management Specifications.

A-1. Specifying the Management Objective

The management objective addressed in the EIS was "to ensure that Pacific Coast groundfish subject to federal management are harvested at OY during 2003 and in a manner consistent with the ... Groundfish FMP and National Standards Guidelines [of the MSFCMA](50 CFR 600 Subpart D)" (PFMC 2003, p. 1-1).

A-2. Describing the Management Context and Affected Environment

The EIS placed the 2003 groundfish specifications in their historical context. Extensive information on the history and current status of groundfish stocks and management was provided. The EIS described the criteria used by the Council to determine whether assessed stocks are overfished, in precautionary status, or healthy (PFMC 2003, p. 3-6); current harvest rate policies (PFMC 2003, Figure 3.2-1 for assessed stocks and Section 3.5.1 for unassessed stocks); life history, status and management history of individual groundfish stocks (PFMC 2003, Section 3.2.1); and rebuilding parameters for currently overfished stocks (PFMC 2003, Tables 3.2-2 and 3.2-3).

The OYs for overfished stocks associated with each management alternative were based largely on results of rebuilding analyses conducted as part of the Council's stock assessment and review process. The EIS placed these rebuilding analyses in their broader temporal context: "The management framework and rebuilding analyses for overfished species are based on long-term stock rebuilding targets; current year OYs are based both on estimates of how past fishing mortality has affected the population and an assumption that the current harvest will be used over the course of the rebuilding period. In this sense a rebuilding analysis is a cumulative effects analysis of 'past, present, and reasonable foreseeable future actions'" (PFMC 2003, p. 4-14).

The EIS identified a number of pending Groundfish FMP amendments that were relevant to the setting of annual specifications. These included amendments related to establishment of a biennial management cycle (PFMC 2003, p. 4-61) and a vessel monitoring system (VMS) for the limited entry (LE) trawl and fixed gear fleets (PFMC 2003, pp. 3-62, 4-60 and 4-61).

Because the 2003 management specifications were expected to affect fisheries coastwide that target groundfish or harvest groundfish as bycatch, the affected environment described in the EIS broadly encompassed all such fisheries. Thus the EIS described historical trends in coastwide commercial and recreational fisheries (PFMC 2003, Tables 3.3-1a to 3.3-1d, Tables 3.3-2a to 3.3-4c, Tables 3.3-5a to 3.3-5b, Tables 3.3-6a to 3.3-6b, Table 3.3-20) and provided detailed baseline descriptions of commercial harvesting activity (PFMC 2003, Tables 3-3.23a to 3.3-25, Table 3.3-7), commercial processing activity (PFMC 2003, Tables 3.3-26 to 3.3-33), recreational fishing (PFMC 2003, Tables 3.3-34 to 3.3-38) and fishing communities (PFMC 2003, Tables 3.3-39 to 3.3-47, Tables 3.3-49 to 3.3-50). Given the emphasis of the 2003 specifications on protecting overfished species, the EIS described landings and discard of overfished species in the recreational fishery (PFMC 2003, Table 3.4-3) and landings of overfished species in the commercial fishery (PFMC 2003, Table 3.4-2), and provided detailed documentation (as available) of bycatch in selected sectors of the commercial fishery (PFMC 2003, Tables 3.3-8 to 3.3-15, Tables 3.4-4 to 3.4-9, Table 3.4-11, Tables 3.4-13 to 3.4-14).

A-3. Identifying the Problem and Role of Reserves in Addressing the Problem

The EIS characterized the management problem as follows: "... groundfish fisheries are now largely managed for certain key constraining overfished species. The harvest limits placed on these species prevents the fisheries from approaching OYs for other overfished and healthy stocks" (PFMC 2003, p. 4-14).

With regard to the role of area closures in reducing the risk of overfishing, the EIS stated: "The centerpiece of the Council-preferred Alternative and for all considered alternatives other than the No Action Alternative and Allocation Committee Alternative (without depth restrictions) is depth-based restrictions that seasonally move fisheries that catch overfished stocks out of the depth zones they inhabit. This management strategy was considered critical for managing fisheries to stay within the OYs of the most constraining overfished groundfish stocks given the current uncertainty in monitoring total catch for most fishery sectors. Depth-based fishery restriction zones are therefore prescribed to reduce the risk of overfishing these stocks" (PFMC 2003, p. 2-1).

With regard to the role of area closures in providing continued opportunities to fish healthy stocks, the EIS noted that "While bycatch reduction is the primary goal of depth-based management, it also provides some economic benefits for some sectors of the fishery, especially those sectors operating in areas deeper than the outer bounds of Conservation Areas. In those circumstances, there is an ability to allow larger trip and cumulative landings limits that are not constrained by the need to limit harvest of otherwise co-occurring overfished species" (PFMC 2003, p. 2-1).

According to the EIS, fishing activities that did not contribute to the problem would be allowed in the closed area: "... fisheries without a significant bycatch of overfished groundfish species or those with mitigative gear modifications may be allowed to occur" (PFMC 2003, p. 2-1). The particular fisheries and gears that would be prohibited in the reserve varied among management alternatives, depending on the OYs associated with the alternative, and also by area, depending on which overfished species were present in the area and how susceptible those species were to particular gear types. For instance:

- With regard to the Council Preferred Alternative, the EIS noted: "All gears with a demonstrated significant bycatch of bocaccio, cowcod, and other constraining overfished groundfish species are excluded from the 20-150 fm [fathom] depth zone south of Cape Mendocino, California where these species reside" (PFMC 2003, p. 2-1).

- For the Low OY Alternative, which prohibited all bocaccio harvest, "it was assumed that any nongroundfish fishery with reasonably measurable amounts of bocaccio would be closed in order to achieve the zero OY". To justify the choice of fishery closures, the EIS documented the extent of bocaccio bycatch in a number of fisheries, including pink shrimp, ridgeback prawn, salmon troll, sea cucumber and spot prawn (PFMC 2003, Table 3.4-5). For other non-groundfish fisheries for which <u>bocaccio</u> bycatch data were not available (e.g., Dungeness crab, gillnet complex, Pacific halibut, coastal pelagics, highly migratory species), the likelihood of bocaccio bycatch was surmised on the basis of <u>groundfish</u> bycatch and whether the fishery occurred in areas where bocaccio were likely to be encountered (PFMC 2003, pp. 3-56 to 3-57, pp. 3-58 to 3-59). "Based on discussions of the Ad Hoc Allocation Committee and Council" (PFMC 2003, p. 4-26), the EIS identified the non-groundfish fisheries that would be closed under the Low OY Alternative to include California halibut, gillnet complex, shrimp and prawn trawl and coastal pelagics.

A-3. Defining the *Status Quo*

Because the EIS pertained to setting management specifications for a single year (2003), the time frame for the analysis was also one year. It should be noted that this time frame is shorter than would be required for marine reserve proposals. The ***status quo*** (as well as alternatives to the ***status quo***) was defined to include conditions both inside and outside the proposed reserve area.

For purposes of the EIS, the <u>regulatory</u> ***status quo*** consisted of the management measures implemented in 2002 (PFMC 2003, Table Tables 2.1-6 to 2.1-8). However, defining the <u>fishery</u> ***status quo*** was more complicated. Because Council deliberations on the 2003 management specifications began in 2002, the most recent year for which complete annual fishery information was available was 2001. The EIS, however, deemed November 2000-October 2001 to be a more plausible baseline period for the commercial fishery than calendar year 2001 on the basis that "in November and December of 2001 the fishery was under severe limits that are not typical of the usual fishing cycle" (PFMC 2003, pp. 4-23 to 4-24). A ***status quo*** estimate of the ex-vessel value of landings was then derived from the baseline by assuming (1) a 10% reduction in groundfish landings and revenues from the baseline, to account for more restrictive regulations in 2002, and (2) no change in non-groundfish landings and revenues relative to the baseline period (PFMC 2003, pp. 4-24 to 4-25). Thus the EIS provided an example of a situation in which adjustments to baseline had to be made to obtain a reasonable representation of the ***status quo***.

A-5. Defining Alternatives to the *Status Quo*

The EIS included five alternatives to the *status quo* (PFMC 2003, pp. 4-14 - 4-15). A regulatory package was specified for each alternative that included OYs, depth-based closures, seasonal closures, cumulative landings limits, and gear restrictions for individual commercial fishery sectors (including LE groundfish, directed OA groundfish, tribal groundfish and non-groundfish sectors), and bag/size/gear/depth/season restrictions for the recreational fishery (PFMC 2003, Table 2.1-3).

The OYs specified under each alternative for key constraining overfished stocks (PFMC 2003, Table 4.2-1) reflected varying degrees of risk with regard to the probability of rebuilding these stocks to BMSY. The EIS provided a rationale for the range of OYs as follows:

- The Low OY Alternative was consistent with bocaccio fishing mortality of 0 metric tons (mt) and rebuilding probabilities of 80%-100% for other overfished stocks. According to the EIS, this alternative "projects the lowest bycatch of all the overfished species and is the only alternative to meet the zero fishing mortality standard for bocaccio" (PFMC 2003, p. 4-41).

- The High OY Alternative was deemed "risk neutral" in the EIS in that it is "based on rebuilding trajectories with an estimated 50% probability of rebuilding by TMAX. This is the longest rebuilding duration and the highest harvest allowed for overfished groundfish species under the National Standards Guidelines" (PFMC 2003, p. 2-3).

- With regard to the remaining three alternatives, the EIS noted that "The OYs represent a mix of the harvest levels and management measures within the range specified under the Low OY Alternative and the High OY Alternative" (PFMC 2003, p. 2-3). The two Allocation Committee Alternatives (one with, the other without reserves) were consistent with rebuilding probabilities of 60%-70%. The Council Preferred Alternative was more conservative than the Allocation Committee Alternatives in terms of depth and gear restrictions but less conservative than the High OY Alternative in terms of OY levels.

The EIS elaborated on each alternative by describing the role of each management measure (OYs, depth-based closures, season closures, trip/cumulative landings limits, gear restrictions) in ensuring precautionary management of overfished stocks while providing (to the extent possible) continued fishing opportunities. For instance:

The EIS highlighted the role of area closures as a key feature of the alternatives: "The Council and its advisors recommend a depth-based management strategy that prohibits some fisheries and fishing gears in the depth zones these [overfished] species inhabit. This is considered a significant precautionary strategy and, in effect, establishes (if ultimately adopted) the largest marine reserve in U.S. territorial waters" (PFMC 2003, p. 4-39). The boundaries of the closure were based on the depth affinity of the harvestable component of key constraining overfished stocks - most notably bocaccio in areas south of 40°10' N. lat., and canary and yelloweye in areas north of 40°10' N. lat. To meet the needs of these species, reserve boundaries differed north and south of 40°10' N. lat., and also varied depending on the OYs and the other regulatory measures associated with each management alternative. Reserve boundaries specified in the EIS design were also influenced by enforcement considerations. "Upon the advice of the Council's Enforcement Consultants, these lines are specified to be as straight as possible for ease of enforcement" (PFMC 2003, p. 2-1).

- With regard to the effect of the OYs on the size of the spatial closures and duration of seasonal closures, the EIS noted: "The area and time fisheries are restricted varies among alternatives relative to the amount of harvest allowed under each alternative. More liberal harvest alternatives allow more fishing opportunities in those depth zones during a greater portion of the year in order to better access healthy co-occurring groundfish and non-groundfish stocks" (PFMC 2003, p. 2-1).

- The relationship of depth and time closures to landings limits was described as follows: "While bycatch reduction is the primary goal of depth-based management, it also provides some economic benefits for some sectors of the fishery, especially those sectors operating in areas deeper than the outer bounds of Conservation areas. In those circumstances, there is an ability to allow larger trip and cumulative landings limits that are not constrained by the need to limit harvest of otherwise co-occurring overfished species" (PFMC 2003, p. 2-1).

- Gear restrictions were also imposed that would provide continued fishing opportunities in the sanddab fishery by reducing the likelihood of groundfish bycatch in that fishery: "The Council OY exception of allowing commercial line gear with no more than five hooks (number 2 or smaller) and up to five lbs of eight if the gear is closely attended is designed to allow some risk-averse target opportunities to catch Pacific sanddabs. The smaller hooks and the horizontal groundlines used in the fishery significantly reduce bocaccio impacts" (PFMC 2003, p. 4–44).

In addition to protecting fish stocks within the closed area, the EIS also focused on the need to prevent bycatch of overfished species outside the closure from exceeding the OY levels specified in the management alternatives. Bycatch reduction regulations were customized to suit particular fisheries. For instance:

- Yelloweye rockfish catch is a particular concern given their high market value, sedentary life style, and vulnerability to baited longlines. The GMT [Groundfish Management Team] recommended prohibiting retention of yelloweye rockfish in 2003 fixed gear fisheries and restricting most of these fisheries to outside the 100 fm management line....The recommendation to prohibit fixed gears in waters shallower than 100 fm...was based on the results of the IPHC [International Pacific Halibut Commission] Halibut longline survey where 99.1% of the yelloweye rockfish was caught inside 100 fm (Table 4.2-3)" (PFMC 2003, p. 4-43).

- With regard to the need to protect nearshore fish stocks from the effects of displaced effort, the EIS noted: "One of the consequences of limiting shelf fishing opportunities south of Cape Mendocino in 2003 is a significant commercial and recreational effort shift to nearshore areas. The southern nearshore fishery therefore needs to be restructured in 2003 in order to prevent over-harvesting of 14 nearshore rockfish species (including California scorpionfish) that are found primarily inside 20 fm" (PFMC 2003, p. 4-49).

  One method of restructuring nearshore fisheries involved strategic use of season closures that took into consideration the migratory patterns of key species. For instance, "...it was determined necessary to concentrate fishing opportunities during summer and autumn months, when the deeper nearshore stocks typically undergo an inshore migration.... This approach matches fishing opportunities with the depth distribution of the resource, avoids over harvest of other deeper nearshore (i.e., non-permit) species that have a more shallow depth distribution (such as olive rockfish and treefish), and addresses concerns the proposed 20 fm restriction could increase the potential for localized depletion of those species with a preference for shallow habitat. These specifications form the basis for the Council-preferred Alternative harvest levels for the 2003 southern nearshore fishery" (PFMC 2003, p. 4-50).

- Gear restrictions were also used to reduce bycatch: "Gillnets were a gear with a demonstrated bycatch of groundfish. The gillnet complex fishery primarily occurs in waters off California where bocaccio bycatch is a major concern. One of the specifications of the Council-preferred Alternative was to prohibit set gill and trammel nets with mesh sizes less than six inches within the CRCA [California Rockfish Conservation Area]" (PFMC 2003, p. 4-40).

- The EIS utilized information on the participation of LE groundfish trawl, hook-and-line and pot vessels in non-groundfish fisheries during 1994-1998 (PFMC 2003, Figures 3.3-2a to 3.3-2c) to predict which non-groundfish fisheries would most likely be impacted by the transfer of groundfish effort from the reserve. The EIS noted that "It is clear...there is some degree of gear loyalty for groundfish vessels participating in groundfish fisheries. For example, a notable proportion of the nongroundfish fishery participation by groundfish trawl vessels occurs in the shrimp and prawn trawl fisheries" (PFMC 2003, p. 3–40). Based on this result, several State regulatory actions were included in the management alternatives (PFMC 2003, Table 2.1-5) to reduce the effect of displaced effort on groundfish bycatch in the shrimp and trawl fisheries. Specifically:

> (1) "Vessels targeting pink shrimp also land groundfish species.... Efforts are underway to reduce the incidence of groundfish bycatch, by requiring bycatch reduction devices (BRDs a.k.a. finfish excluders) and no-fishing buffer zones above the seafloor" (PFMC 2003, p. 3-56).
>
> (2) "Trap and trawl gears that target spot prawn exhibit differential bycatch rates; trawls are much more prone to catch overfished groundfish species (PFMC 2003, Table 3.4-9).... California revealed plans to either eliminate spot prawn trawls, convert the gear endorsements to trap only, or restrict spot prawn trawls to waters deeper than 150 fm. Despite the fact that spot prawn trawls are rare north of Cape Mendocino, Oregon plans to eliminate spot prawn trawls soon and Washington has already done so" (PFMC 2003, p. 4-46).

- Given the assumption that non-groundfish fisheries would absorb the extra costs associated with bycatch avoidance requirements and continue to operate unless otherwise constrained (PFMC 2003, p. 4-26), particularly severe action was expected to be required to implement the Low OY alternative. Specifically, "it was assumed that any nongroundfish fishery with reasonably measurable amounts of bocaccio would be closed in order to achieve the zero OY" (PFMC 2003, p. 4-26).

The EIS also documented features of the management alternatives that were intended to mitigate adverse ecosystem effects associated with effort shift to the open area. These included gear restrictions and closed area boundaries that encouraged movement of effort toward habitats where it would be less likely to have adverse effects on the ecosystem. Specifically:

- Footrope restrictions, already implemented but extended to all areas shoreward of the closed areas under the Council-preferred Alternative, also reduce habitat impacts" (PFMC 2003, p. 4-3).

- The Council-preferred OY alternative specified an offshore closed area boundary of 250 fm (compared with the 150-250 fm boundary specified in the Allocation Committee alternative), while also allowing some trawling with small footropes in the nearshore CRCA. As noted in the EIS, "Assuming that trawl impacts in mud and sand areas are moderate, these exemptions may counterbalance the deeper outer boundary of the closed area, when comparing these two alternatives" (PFMC 2003, p. 4-4).

The alternatives were crafted in ways that highlighted the significance of particular management measures. For instance:

- Two versions of the Allocation Committee Alternative (with and without area closures) were devised to illustrate what would happen if the closures were not included in the regulatory package. Specifically, the EIS notes that "The Allocation Committee Alternative with no depth restrictions has lower trip limits and would result in the lowest projected catch of target species, although it would result in the highest bycatch of overfished species" (PFMC 2003, p. 4-4).

- Two versions of the Council-preferred alternative were evaluated to illustrate the importance of the nearshore caps. "For the nearshore fisheries it was assumed that effort and harvest would increase during open periods, and any nearshore caps established to control harvest would be fully harvested.... In order to better depict the economic effects of the cap, the recommended Council-preferred Alternative was modeled with and without the nearshore caps" (PFMC 2003, p. 4-25).

The EIS also documented alternatives that were considered and rejected. For instance, alternatives that would allow the bocaccio OY to exceed 20 mt were rejected on the basis that "More liberal bocaccio harvest level alternatives could risk stock extinction or an Endangered Species Act (ESA) listing" (PFMC 2003, p. 2-6). Complete year-round closure of the commercial fishery was rejected on the basis that it "would have significant socioeconomic consequences" (PFMC 2003, p. 2-7). Complete closure at certain times of the year was rejected on the basis that it "could force some segments of the fishery into times of the year when bycatch rates for a particular overfished species are highest....there is not one optimal time when all mixed stock fisheries could be closed and achieve the lowest bycatch rates" (PFMC 2003, p. 2-7). Documentation of this type is advisable in situations where management alternatives that may have been of particular interest to a stakeholder group did not make the "final cut" in the regulatory analysis.

A-6. Analyzing Management Alternatives

The analysis in the EIS relied on landings receipt, port sampling, logbook and survey data that were specific to the fisheries and species potentially affected by the management alternatives. The EIS also relied on relevant results from previous studies. For instance, descriptions of the distribution, life history and status of individual groundfish stocks contained in the EIS (PFMC 2003, pp. 3-6 to 3-24, Table 3.2-1) included numerous references to previous research specific to these particular stocks. The stock assessment and rebuilding analyses that served as the basis for the OYs specified in the management alternatives — as well as the development and analysis of alternatives — were based on information directly relevant to the species and fisheries under consideration.

All alternatives were evaluated on a comparable spatial scale, i.e., including areas both inside and outside proposed closed areas. Alternatives were evaluated on a common temporal basis, i.e., single year effects. Given that the EIS pertained to annual fishery regulations, this time frame was appropriate for this particular analysis.

Table 4.3-1 of the EIS compared the management alternatives relative to the ***status quo***. However, in other tables (PFMC 2003, Tables 4.3-2a to 4.3-11), the comparison was made relative to the baseline rather the ***status quo***. The reason for this inconsistency is not clear. However, it appeared to make little difference to the conclusions of the EIS, as the relative differences in ex-vessel revenue among alternatives tended to be similar, regardless of whether the basis for comparison was the baseline or the ***status quo*** (PFMC 2003, Table 4.3-1).

Sections A-6a to A-6c describe some of the approaches used in the EIS to analyze biological, social, economic and ecosystem effects. Section A-6d addresses monitoring and enforcement requirements.

A-6a. Biological (Species-Specific) Effects

The EIS provided a verifiable and measurable way to evaluate each alternative in terms of achieving the biological objective. Specifically, "The alternatives are compared in terms of their efficacy in constraining total fishing mortality on overfished stocks and the probability of rebuilding stocks" (PFMC 2003, p. 4-14). Alternatives were compared relative to the objective as follows: "Table 4.4-1 presents estimates of bycatch of overfished species across all fisheries....These values can be compared to the OYs in Table 2.1-1, which shows that the projected total mortality is at or below the OYs for all of these species, in some cases by a substantial amount (e.g., widow rockfish) due to the need to manage for constraining overfished species such as bocaccio, canary rockfish and darkblotched rockfish" (PFMC 2003, p. 4-15).

In evaluating the accuracy of the bycatch projections (Table 2.1-1), the EIS noted that harvests above OY "will have significant biological impacts," while harvests below OY will result in "socioeconomic impacts because of foregone income and fishing opportunities....Harvests above OY are unlikely because management measures can be changed throughout the year in order to slow harvest rates. However, harvests below OY for a given species have occurred in past years because of difficulty in managing multi-species fisheries" (PFMC 2003, p. 4-14).

As indicated in Section A-4, the OYs specified under each alternative for key constraining overfished stocks (PFMC 2003, Table 4.2-1) reflected varying degrees of risk with regard to the probability of rebuilding those stocks to B_{MSY}. These probabilities were based on the results of formal risk assessments. The EIS offered the following caveat regarding the uncertainty in the assessment results: "The accuracy and reliability of various data used in assessments — and the scientific assumptions on which they are based — need to be further evaluated to improve the quality of forecasts. Uncertainty associated with fishery logbook data, calibration of surveys, and accuracy of aging techniques also need more evaluation when considering survey reliability. Finally, a better understanding of ecosystem change and its influence on groundfish abundance will also improve stock assessments" (PFMC 2003, p. 3-60).

The bycatch estimates for overfished species provided in the EIS were based on an analysis of the separate effects of each management alternative on each key overfished species and each fishery sector. Some examples of the methods used in the EIS (and associated caveats regarding outcomes) are as follows:

- The EIS relied on a formal quantitative bycatch model developed by the GMT (PFMC 2003, pp. 4-40 to 4-43) to project harvest of key overfished species in the limited entry (LE) non-whiting trawl fishery under each management alternative. The model used PacFIN and trawl logbook data to estimate historical participation patterns specific to each vessel, target fishery, two-month cumulative landing period, area and depth. Using historical fishing patterns as a baseline, the model predicted the amount of effort displaced from the reserve under each alternative and the percentage of displaced effort expected to move to the open area. Observer data were used to estimate bycatch rates of individual overfished species in the various target fisheries (PFMC 2003, Tables 4.2-3a to 4.2-3b).

- The EIS offered the following caveats regarding bycatch estimates for non-trawl fisheries: "Without a comparably informative bycatch model for the fixed gear fisheries (including both the limited entry and open access sectors), there is much greater uncertainty estimating bycatch in these fisheries" (PFMC 2003, p. 4-43). Also, "The distribution of groundfish catch and bycatch in incidental open access fisheries is far less certain than in the other sectors (Table 3.4-5)" (PFMC 2003, p. 3-56).

- The EIS relied on behavioral inferences drawn from historical data and results of prior empirical studies to project the effect of the recreational fishery on key overfished groundfish stocks. Specifically, "The potential impact of nearshore fishing on these species [bocaccio, canary, yelloweye] may be estimated by (1) examining catch by depth from the recent recreational fishery, (2) estimating potential effort shift based on the recent performance of the recreational rockfish fishery during those periods when only 0 to 20 fm fishing was allowed; and (3) applying hooking mortality estimates to the bycatch of overfished species that will be inadvertently caught and released in the 0 to 20 fm fishery" (PFMC 2003, p. 4-51).

- Another example of an inference drawn from prior studies was use of a study by Lawson (1990) to predict the extent of groundfish bycatch in the salmon troll fishery: "With four spreads (the current configuration in Oregon south of Cape Falcon), catch rate reductions associated with alternatives that require a 4 fm distance between the cannonball and the lower most spread would be: 95% for canary rockfish, 0% for yelloweye rockfish (only two were caught), and 89% for lingcod (Figure 4.2-4)" (PFMC 2003, p. 4-45).

- To deal with uncertainties regarding how the Council might choose to allocate OYs of nearshore species between commercial and recreational fisheries and the effects of effort displacement in the recreational fishery on overfished stocks, the EIS described the implications of alternative feasible commercial/recreational allocations (PFMC 2003, Table 4.5-1) and also included a sensitivity analysis that explored the implications of different recreational effort shift and hooking mortality assumptions (PFMC 2003, Tables 4.5-2 and 4.5-4).

Given the importance of not underestimating bycatch of overfished species, the EIS preferred to err on the side of caution in making such estimates. For instance:

- "Since the [GMT bycatch] model did not incorporate more recent logbook data than 1999, the effect of the small foot rope restrictions on bottom trawling on the shelf are not represented. Use of the model in 2003 may tend to overestimate the bycatch of overfished shelf rockfish species and, in effect, provides a conservative buffer against overfishing" (PFMC 2003, p. 4-40).

- "For the nearshore fisheries, it was assumed that effort and harvest would increase during open periods, and any nearshore caps established to control catch would be fully harvested" (PFMC 2003, p. 4-25).

- "For the whiting and sablefish fisheries, it was assumed OYs would be fully harvested" (PFMC 2003, p. 4-26).

The EIS described various types of surveys (trawl, hook-and-line and SCUBA) that provide data in support of groundfish management. The EIS noted the usefulness of these surveys in providing "fishery-independent data which — because it is gathered in a uniform, consistent manner — provide 'benchmarks' used to track natural and anthropogenic changes in fish abundance" (PFMC 2003, p. 3-61). The management alternatives considered in the EIS allowed for continued collection of research survey data and an explicit accounting of mortality of overfished species in NMFS trawl and shelf surveys in the 2003 management specifications (PFMC 2003, Table 4.4-1).

A-6b. Social and Economic Effects

The EIS described the management alternatives in terms of how they would affect economic opportunities in specific fisheries. For instance:

- "The Low OY alternative would effectively end the recreational groundfish fishery in the south since the harvest rate on bocaccio would be set to zero. While other recreational fishing activities may be supportable in southern waters, these may be limited by the fact that bocaccio are not exclusively caught on the bottom or over hard substrate" (PFMC 2003, p. 4-46).

- "The High OY, Allocation Committee (with depth restrictions) and Council-preferred alternatives all specify no fixed gear opportunities in the 27-100 fm zone north of Cape Mendocino in California and Oregon and restricts the fishery to outside of 100 fm in waters off Washington to minimize canary rockfish and yelloweye rockfish bycatch....Without the depth restrictions, as modeled in the Allocation Committee Alternative, the fishery would be restricted to the nearshore 0 fm to 27 fm zone in northern California and Oregon. Fixed gear fisheries would be eliminated in Washington without depth restrictions since Washington does not allow commercial groundfish fisheries in their coastal marine waters" (PFMC 2003, p. 4-44).

The monetary and non-monetary indicators used in the EIS to describe socioeconomic effects were driven largely by data availability. In using available data, no attempt was made to "over-interpret" the data or construe the analysis as a cost-benefit analysis. Thus, for instance, because effects of the alternatives could not be measured in a consistent way among fishery sectors, comparison of alternatives was done on a sector-by-sector basis. The EIS also demonstrated a clear understanding of the distinction between economic impacts and economic value and took care to provide an accurate interpretation of income impacts: "These effects [income impacts] should be thought of as those 'associated with' the fishery rather than 'generated by' the fishery, because in the absence of the fishing opportunity some of the income would still be generated in the community or elsewhere in the economy" (PFMC 2003, p. 3-44).

Effects of the management alternatives on fishery participants and fishing communities were characterized in a variety of ways. For instance, fishery effects were expressed in terms of ex-vessel value for commercial harvesters (PFMC 2003, Tables 4.3-1 to 4.3-9, Table 4.3-13) and buyers/processors (PFMC 2003, Tables 4.3-10 to 4.3-11), and in terms of fishing effort and personal income impacts for the recreational fishery (PFMC 2003, Table 4.3-12).

In considering the distributional implications of each alternative, the EIS went to great lengths to compare effects not only among fishing communities and among commercial, recreational and tribal fisheries but also within fisheries. For instance, effects on the commercial fishery were evaluated separately for LE trawl, LE entry fixed gear, targeted open access (OA), incidental OA and non-groundfish vessels. Additional analysis was done to demonstrate how effects within each of these categories varied, depending on vessel dependence on groundfish (measured as percent of revenue attributable to groundfish), vessel involvement in fishing (measured by total fishing revenue) and vessel length (PFMC 2003, pp. 4-30 to 4-31, Tables 4.3-2a to 4.3-3b, Tables 4.3-5a to 4.3-6b). Effects on buyers/processors were evaluated in terms of their fishery participation (measured by the ex-vessel value of their landings receipts) (PFMC 2003, Table 4.3-10). Effects on the recreational fishery were evaluated by area and fishing mode (PFMC 2003, Table 4.3-12). Tribal effects were evaluated by gear type (PFMC 2003, Table 4.3-13). Community effects were evaluated by categorizing coastal ports into 17 fishing communities (PFMC 2003, Table 4.3-14), and expressing effects in each community in terms of the ex-vessel value of landings and income and employment impacts (PFMC 2003, Tables 4.3-14 to 4.3-18).

In addition to providing quantitative measures of socioeconomic effects, the EIS also provided qualitative insights into other socioeconomic implications of the alternatives. For instance:

- "To the degree that vessels might possibly target the species covered in the preceding list [species for which fishing would be potentially affected by depth restrictions south of Cape Mendocino] by moving their effort in areas that remain open, it is likely that costs would be higher and/or CPUEs lower than in normal fishing areas, raising cost per unit of catch" (PFMC 2003, p. 4-28).

- "Recreational charter vessels are probably more dependent on their home port than commercial vessels, though recreational charter vessels are known to exhibit some mobility between ports....Charter vessel operators and crew which do attempt to move operations to a port in an open area will face obstacles in recruiting clientele or developing new relationships with booking agents. The operator and crew may experience social effects associated with distance from family and social networks" (PFMC 2003, p. 4-32).

- "Those [recreational groundfish anglers] that live in an area may respond to a time/area closure by (1) not going groundfish fishing at all and spending their time and money in the same community on an alternative activity; (2) going groundfish fishing at a different, less optimal time; or (3) traveling to a different area to go fishing or take part in an alternative recreational activity. All cases reflect a loss of value to the individual associated with a shift to second choice activities" (PFMC 2003, p. 4-32).

- "Total value placed on offsite nonconsumptive use of the stock or component of the ecosystem set aside will depend on 1. the size of the human population, 2. the level of income, 3. education levels, 4. environmental perceptions and preferences. The above relationships imply that as human populations and the welfare of these populations increase and as the fish stocks and their ecosystem remaining in good condition declines, the nonconsumptive values associated with maintaining ocean resources is likely to increase. Also implied is that once the basic integrity of ecosystem processes and marine fisheries components are preserved, the likely additional benefit from incremental increases will decrease (PFMC 2003, pp. 3-37 to 3-38).

A-6c. Ecosystem Effects

While the Council's management objective was largely biological (to protect overfished stocks), the management action was of sufficient magnitude to warrant careful consideration of potential (albeit unintended) effects of displaced effort on the ecosystem outside the reserve.

Citing several west coast studies on the effects of trawl gear on habitat (Freese *et al.* 1999, Friedlander *et al.* 1999), the EIS concluded that "Bottom trawling is known to modify seafloor habitats by altering benthic habitat complexity and by removing or damaging infauna and sessile organisms" (PFMC 2003, p. 4-1). With regard to other gear types, the EIS noted that "Limited qualitative observations of fish traps, longlines, and gillnets dragged across the seafloor during set and retrieval showed results similar to mobile gear, such that some types of organisms living on the seabed were dislodged. Quantitative studies of acute and chronic effects of fixed gear on habitat have not been conducted" (pp. 4-1 to 4-2). Given the limitations in existing knowledge regarding gear effects, the EIS concluded that "... there is insufficient information to quantitatively predict the effects of the Pacific Coast groundfish fishery on ecosystems and habitats because indirect and cumulative effects are poorly understood" (PFMC 2003, p. 4-3). The evaluation of ecosystem effects provided in the EIS was thus largely qualitative.

The EIS noted the beneficial effect of area closures on the ecosystem <u>inside</u> the reserve: "Depth-based restrictions, if used, would eliminate bottom trawl impacts to habitat in large areas of the continental shelf (depending on the alternative)" (PFMC 2003, p. 4-3). In addition, the EIS evaluated potentially adverse effects on the ecosystem <u>outside</u> the closed area in terms of the specific regulatory measures associated with each alternative. For instance, the EIS noted that alternatives associated with smaller closures and/or lower OYs for overfished species would necessarily be accompanied by lower trip limits on target species to ensure that total bycatch of overfished species remained within the bounds set by the OYs; because lower trip limits would discourage targeting of healthy stocks, they would also imply lower levels of fishing effort and thus lesser effects on the ecosystem outside the closed area. The EIS described existing gear restrictions intended to protect habitat against adverse effects of fishing gear: "Bottom trawl footrope restrictions implemented by the Council make it difficult for fishers to access rock piles and other areas of complex topography (due to the risk of gear damage)" (PFMC 2003, p. 4-1). As indicated in Section IV.E., the EIS also discussed specific features of the management alternatives (i.e., spatial expansion of footrope restrictions, boundary features of the closed area that encouraged movement of effort toward habitats where such effort would be less likely to adversely effect the ecosystem) to mitigate the effects of displaced effort on the ecosystem outside the closed area.

The EIS utilized fishing effort as a surrogate for evaluating relative ecosystem effects among alternatives. Effort displacement, however, could only be modeled for the LE trawl fleet. As noted in the EIS, "...in the absence of a comprehensive assessment that will enhance the ability to quantify the effects of different types and amounts of fishing, the relative effects [derived from the trawl effort model] are presumed to correlate with total fishing effort and its distribution among the alternatives, which must also be evaluated qualitatively since currently we do not model fishing effort across all fisheries. This makes it difficult to meaningfully distinguish between the alternatives with respect to effects on the ecosystem because, although we know that the alternatives would have differential effects on ecosystem and habitat, we cannot specify the nature or magnitude of those effects with any precision" (PFMC 2003, p. 4-3).

The EIS described each management alternative in terms of closed area boundaries and trip limits (PFMC 2003, Tables 2.1-9 to 2.1-12). Footrope restrictions were described in Table 2.1-2 for the LE trawl fishery and in Table 2.1-5 for non-groundfish trawl fisheries (California halibut, sea cucumber, ridgeback prawn). By comparing the alternatives in terms of presence or absence of these ecosystem-relevant features, the EIS was able to provide some qualitative insights into the ecosystem effects of particular alternatives. For instance:

- "The Low OY Alternative will have the least impact on ecosystem and habitat because it has the lowest projected catch and most extensive closed areas" (PFMC 2003, p. 4-3).

- "Trip limits under the High OY Alternative are generally higher and depth-based restrictions are not as extensive as under the Low OY and Council-preferred alternatives. Thus this alternative is likely to have the greatest relative effect on ecosystem and habitat because it would allow the highest level of fishing effort. It would, however, implement depth-based restrictions but not the depth-based footrope requirement" (PFMC 2003, p. 4-4).

Conclusions in the EIS regarding ecosystem effects were tailored to what could be surmised from available information: "All of the action alternatives will result in reduced fishing effort in comparison to baseline conditions because of lower trip limits. Depth-based restrictions, if used, will eliminate bottom trawl impacts to habitat in large areas of the continental shelf (depending on the alternative). Footrope restrictions, already implemented but extended to all areas shoreward of the closed areas under the Council-preferred Alternative, also reduce habitat impacts. Thus, although the alternatives will have some effect on ecosystems and habitat (including EFH), these effects will be reduced from historical levels" (PFMC 2003, p. 4-3).

It is important to note that the management objective specified in the EIS was to protect overfished species, not provide ecosystem benefits. Thus for purposes of the EIS, it was deemed sufficient merely to demonstrate that management action would not make the ecosystem worse off relative to the *status quo*. Reserve proposals for which ecosystem benefits are the objective will require more concerted efforts to rank alternatives in terms of ecosystem effects than demonstrated in the EIS.

A-6d. Monitoring and Enforcement

The EIS described the *status quo* in terms of existing monitoring and enforcement activities. These included vessel reporting requirements (e.g., fish tickets, logbooks, declaration programs[15]), as well as agency activities such as dockside sampling and shoreside and at-sea surveillance (PFMC 2003, p. 3-62). Achieving the objective specified in the EIS (i.e., ensuring that harvests do not exceed OYs) has been a long-standing Council responsibility: "In accordance with the Groundfish FMP, since 1990 the Council has annually set Pacific Coast groundfish harvest specifications (acceptable and sustainable harvest amounts) and management measures designed to achieve those harvest specifications" (PFMC 2003, p. 1-2). As indicated in the EIS, existing methods of harvest monitoring and making in-season regulatory adjustments would continue to be used. For instance, "The commercial fishery HGs [harvest guidelines] will be tracked inseason through the PacFIN 'Quota System Management' (QSM) system next season, and adjustments to the trip limits will be employed to align the cumulative landings with the available tonnage for the commercial sector" (PFMC 2003, p. 4-54).

The EIS described several ways in which monitoring and enforcement considerations shaped the management alternatives. For instance, with regard to alternatives that included area closures, the EIS noted that "Upon the advice of the Council's Enforcement Consultants, these lines [closed area boundaries] are specified to be as straight as possible for ease of enforcement" (PFMC 2003, p. 2-1). As another example, the EIS identified a provision of the High OY, Allocation Committee and Council-preferred alternatives that was intended to encourage full accounting of canary bycatch in the recreational fishery: "...a sublimit of one canary rockfish in the daily bag limit would be allowed in the north. This accommodates unavoidable bycatch and reduces the number of canary rockfish that are discarded dead. In the

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[15] According to the EIS, "Under declaration programs, legal incursions into closed areas must be reported to state enforcement authorities prior to fishing. This requirement is generally reserved for vessels that would otherwise appear to be fishing illegally when viewed from an at-sea patrol craft" (PFMC 2003, p. 3-62).

Council's judgment, this would not promote targeting of the species" (PFMC 2003, p. 4-47).

The EIS distinguished between management alternatives that included area closures and those that did not in terms of enforcement requirements: "Depth-based closed areas are proposed in four of the action alternatives as a way to reduce bycatch by keeping vessels out of areas where species of concern — overfished species — occur. However, this change in the management regime introduces a new set of enforcement issues because compliance must occur at sea, requiring different monitoring and enforcement requirements" (PFMC 2003, p. 4-48).

The EIS described the Council's plans to address enforcement requirements associated with the management action: "The existing methods of patrolling sea areas either by airplane or ship (carried out primarily by the Coast Guard, although state agencies have some capacity in this regard), and using fishery observers to monitor vessel position can be used to monitor and enforce closed areas. In fact, until VMS is implemented these will be the available methods. However, VMS is a superior enforcement technology because the position of vessels with transmitting units can be tracked at all times. Because violations can be relatively easily determined, VMS would also serve as an effective deterrent for participating vessels" (PFMC 2003, p. 4-49).

The EIS documented the cost of using VMS for enforcement: "The Council has recommended that VMS units be installed on the limited entry trawl and limited entry fixed gear fleets (over 400 vessels).... Currently, the estimated costs of a VMS transmitting unit ranges from $1,800 to $5,800 with transmission costs of $1.00 to $5.00 per day. In the absence of federal funding the costs may be bourne entirely by the vessel owners" (PFMC 2003, pp. 3-62 to 3-63). The EIS also noted the potential for VMS to enhance enforcement capabilities: "As a new monitoring tool for West Coast groundfish fisheries, VMS will dramatically enhance rather than replace traditional techniques" (PFMC 2003, p. 3-62).

A-7. Documenting Public Process

The EIS included a description of the annual specifications process, including scoping and public review processes. It also includes comments by the Ad Hoc Allocation Committee and a summary of written, email and oral comments provided by the public at Council meetings, State-sponsored public hearings and other public fora (PFMC 2003, pp. 1-5 to 1-13, Tables 1.5-1 to 1.5-2).

Appendix B. Implications of Restricting Fishery-Independent Surveys Inside Reserves

An important issue to consider in evaluating reserve proposals is whether or not fishery-independent surveys currently used for stock assessment would be prohibited (along with other types of fishing activity) inside the reserve. To the extent that the size and location of reserves do not significantly interfere with the customary spatial coverage of fishery-independent surveys, this will not be a problem. However, to the extent that such interference does occur, alternative non-lethal data collection methods (e.g., remotely operated vehicles [ROVs], submersibles [subs]) may need to be considered in the reserve.

Dead fish sampled in fishery-independent surveys provide valuable data on length, age, sex, stomach contents and stock structure, as well as an index of abundance. Non-lethal survey methods can provide data on observable characteristics of fish that are useful for stock assessment (length, index of abundance, also sex for species where this is visually obvious). In some cases, it may also be possible to collect genetic material without killing the animals. However, data on age and stomach contents cannot be obtained from non-lethal surveys (Table B-1). The loss of age structure information, which is critical to estimating year class strengths, is particularly significant in terms of limiting what can be done with stock assessment models.

In addition to issues regarding loss of data important for stock assessment, the use of non-lethal sampling methods also raises issues of cost and calibration. Non-lethal sampling is costly. Because sampling of this type provides an index of abundance for a limited time period, it must be repeated frequently to be useful for stock assessment. By contrast, a single trawl survey can provide a whole demographic sample from which inferences can be drawn regarding year class strengths.

This is not to say that trawl surveys are well suited for all purposes. For instance, trawls have limited access to rocky areas. Trawls are also incapable of providing observations of fish behavior (e.g., fish-habitat associations, fish-fish associations) in the context of the environment in which they occur. On the other hand, non-lethal methods also have their limitations. For instance, the ability of small ROVs to run transects in heavy currents is limited. Large ROVs and subs are costly to operate. Use of subs is limited by weather conditions. Video techniques used on ROVs and subs are not suitable for observing pelagic rockfish. No single data collection method is suitable for all ocean conditions or purposes.

Fishery-independent trawl survey data provide critical information for stock assessment. A lengthy time series has been constructed with such data. Combining trawl survey data collected outside the reserve with data from live sampling inside the reserve will require intercalibration of surveys. Achieving such calibration will likely require that both survey methods be used outside reserves for a number of years.

If at some point the Council is faced with the prospect of utilizing non-lethal survey methods in reserve areas for its own assessments, it will be important that the Council evaluate the desirability of relying on sponsors of reserve proposals to provide such data from their own monitoring programs. One issue that may arise is whether the proposal sponsor is willing to provide the Council not only with summaries of monitoring results but also the raw data collected in the monitoring program. This may be problematic, for instance, If the data are collected by individual researchers who may claim the data as intellectual property. Additional issues in this regard pertain to whether the Council can count on the data collection being sustained over the long term and whether the data will be made available to the Council in a sufficiently timely manner to allow the Council to meet its assessment schedules. Continuity and timeliness of data are issues that the Council already faces with the data that it routinely uses. These issues are potentially more difficult if the Council must rely on data being collected by entities who do not have an ongoing stake in Council decisions.

The development of alternative survey methods is an issue that the Council may need to address in the future, for reasons of its own. As indicated in the Council's EIS on the 2003 groundfish management specifications, "For overfished stocks with low OY values, the research take can represent a significant proportion of the harvest specification. At the same time, the reduction in fishery catches means less data are available from this source, making it even more difficult to determine abundance, measure stock recovery, and estimate potential yields....Because catches of overfished species has become a critical concern, survey methods that do not involve capture need to be developed" (PFMC 2003, p. 3-61).

Table B-1. Types of biological data that can be obtained using non-lethal and lethal sampling methods.

Data Type	Non-Lethal Sampling Methods (e.g., subs, ROVs)	Lethal Sampling Methods (e.g., trawling)
Index of abundance	Yes	Yes
Length	Yes	Yes
Age	No	Yes
Sex	Maybe	Yes
Stomach contents	No	Yes
Genetics	Maybe	Yes
Fish-habitat association	Yes	No
Fish-fish association	Yes	No