GUIDELINES FOR REVIEW OF MARINE RESERVES ISSUES

The Scientific and Statistical Committee (SSC) Marine Reserves Subcommittee has developed a white paper to facilitate Pacific Fishery Management Council (Council) consideration of marine reserve initiatives in relation to West Coast fishery management. The white paper evaluates the implications of marine reserves for contemporary fishery management on the West Coast, taking into consideration reserve objectives and uncertainties associated with both reserves and traditional fishery management. The goals of the SSC document are to:

- describe the rationale underlying various marine reserve objectives and provide an SSC perspective on the scientific basis for applying reserves to address these objectives;
- discuss the implications of reserves for fishery management, taking into consideration the objectives of the reserves; and
- establish 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.

The Council reviewed and considered a draft of the SSC white paper at the June 2004 Council meeting. At that meeting, the Council also reviewed several comments received from agencies and the public about the draft SSC document. Based on this input and the SSC's request to delay adoption of the document, the Council directed the SSC to thoroughly review comments received and finalize the document for Council consideration at the September 2004 meeting. The current draft of the report is included in the briefing book as Agendum E.1.b, Attachment 1.

Ms. Cindy Thomson, SSC Marine Reserves Subcommittee Chair, will summarize the contents of the report.

Council Action:

Consider adopting guideline recommendations.

Reference Materials:

1. Agendum E.1.b, Attachment 1: SSC white paper – *Marine Reserves: Objectives, Rationales, Fishery Management Implications and Regulatory Requirements.*

Agenda Order:

a. Agendum Overview — Dan Waldeck
b. Scientific and Statistical Committee (SSC) Report — Cindy Thomson
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. **Council Action:** Adopt Guideline Recommendations

PFMC
08/24/04

WHITE PAPER

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

September 2004

Scientific and Statistical Committee
Pacific Fishery Management Council

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ES. Executive Summary
ES.A. Introduction

The objective of this white paper is to facilitate Council deliberations on marine reserves by: (1) describing the rationale underlying various reserve objectives and providing an SSC perspective on the technical challenges of using reserves to achieve each of these objectives; (2) discussing the implications of reserves for fishery management, taking into consideration the objective of the reserve; and (3) describing SSC guidelines and standards regarding the technical content of proposals initiated by the Council (or submitted for Council consideration by outside entities) that involve change in fishery regulations associated with establishment of marine reserves primarily in Federal waters and, at times, in National Marine Sanctuaries.

SSC recommendations are guided by the Council's mandate to rely on 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. As such, evaluation of marine reserve proposals should be based on the same requirements as other types of management actions considered by the Council. SSC interest in this topic is prompted by the limited extent to which reserves have been evaluated in the context of Federal regulatory requirements and the likelihood of the Council's continued engagement in this topic.

ES.B. Reserve Objectives and Rationales

Based on existing rationales and evidence regarding reserve effects, the SSC offers the following perspective regarding the extent to which available scientific evidence indicates that reserves can be reasonably expected to achieve the following objectives:

- *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* – Recent studies suggest that the protection of age structure provided by reserves 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. Moreover, while the literature typically characterizes fishery benefits in terms of increases in yield, economic and social effects often matter more than yield to fishery participants and fishing communities.

- *Reserves as source of ecosystem benefits* – Cessation of fishing may yield ecosystem benefits (including protection or enhancement of habitat) within the reserve, depending on the nature and extent of fishing prior to reserve establishment. 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. Reserves are a potentially useful tool for providing ecosystem benefits, provided that effects of effort displacement on the ecosystem outside the reserve are also managed effectively.

- *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, discouraging or encouraging particular types of resource use, or 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, social science can be useful for evaluating management alternatives relative to the policy criteria.

- *Reserves as opportunities to advance scientific knowledge or to establish reference sites* – Reserves can allow scientists to evaluate the impacts of fishing on marine communities by comparing fished areas to protected areas inside a reserve. However, the SSC notes that fish populations inside and outside a reserve are not isolated from each other and are best studied as a system. In addition, most research reserves will not be designed primarily for research purposes. Caution must be used in generalizing from experimental observations to broad conclusions about reserve effects. Usefulness of study results depends largely on study design. Proposals for research reserves should be evaluated on the same basis as other types of research proposals. Sound research should be accommodated and encouraged even at reserves that are not established primarily for that purpose, to augment existing knowledge regarding biological, socioeconomic and ecological effects.

ES.C. Analytical Framework for Marine Reserve Proposals

SSC recommendations regarding the analytical content of reserve proposals prepared by the Council (or submitted for Council consideration by outside entities) are as follows. These recommendations are intended to be consistent with what the SSC generally expects to see in regulatory analyses.

- The management objectives addressed by the proposal should be described in specific terms and in the context of relevant mandates. 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.

- 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. Current (baseline) conditions may be a useful proxy for the *status quo*, but only if current conditions are expected to continue into the future.

- The proposal should include a reasonable range of alternatives to the *status quo*. If the problem identified in the proposal can be addressed only by reserves, the alternatives should take the form of different reserve configurations. 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. The proposal should include a description of the operational requirements (i.e., the specific combination of regulations) associated with each alternative, as these requirements are crucial for evaluating the biological, social, economic, environmental and enforcement implications of each alternative.

- Alternatives should be compared in terms of how well they achieve the management objectives. Biological, social, economic and ecosystem effects should be documented, as well as monitoring and enforcement requirements. To the extent possible, the analysis should be based on information specific to the fish stocks, ecosystems, fishery participants and fishing communities that will be affected by the proposal. All alternatives should be evaluated on a common spatial scale, in terms of effects inside and outside reserve areas. Regulatory analysis, whether it involves marine reserves or other types of management measures, is constrained by limited knowledge and data. It is important that reserve proposals be explicit about sources of risk and uncertainty in the analysis.

- 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.

ES.D. Conclusions and Recommendations

In considering reserves as a management measure, it is important that the management objectives be the starting point for discussion. 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 to address the objectives. To accomplish this, it is important that the range of feasible solutions not be restricted unduly from the outset.

Regulatory analysis plays a substantive role in the management process by providing a meaningful synthesis of the 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. 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 an analysis that is technically sound, informative and balanced.

Identifying a potential weakness in a management alternative does not, in and of itself, preclude adoption of that alternative. All alternatives have strengths and weaknesses, regardless of whether they involve marine reserves, more traditional management tools, or some combination of the two. An important role of regulatory analysis is to make these strengths and weaknesses apparent, so that policy makers have a sound basis for evaluating and weighing alternatives.

Regardless of the management objectives, the choice of a preferred management alternative is ultimately a policy decision. While science (meaning both natural and social sciences) may inform some 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. It is important to distinguish among issues that can be addressed by science and those that cannot. This distinction is important for ensuring that scientific issues receive the technical scrutiny they deserve and for clarifying the respective roles of scientists and policy makers in the management process.

The SSC recommends that the Council develop procedures for evaluating reserve proposals submitted to the Council by outside entities. The Council should assume a proactive role in reserve discussions and plans that pertain to its area of jurisdiction. This would include working with other appropriate entities to develop a coordinated approach to marine 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. Proactive 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.

Given the Council's increasing reliance on area closures as a management tool and the interest in reserves being conveyed to the Council by other entities, the SSC sees a growing need for spatially-explicit models and increased use of spatial data. However, data collection is costly and model development is not guaranteed to improve the science needed for management. Increased spatial resolution in models will lead to more complexity and hence the 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 pooling of data might be most appropriate.

An important issue for the Council in evaluating reserve proposals is the potential effect on stock assessments. Reserves may limit the use of fishery-independent surveys in reserve areas and constraints could be imposed on the conduct of such surveys. To the extent that reserves significantly interfere with the customary spatial coverage of surveys, the Council may be faced with loss of age structure information that is critical to estimating year class strengths in stock assessment models. Increased dependence on alternative non-lethal data collection methods may be needed in reserve areas to address management needs. The use of such methods also raises issues of cost and collaboration. Finally, possible changes in fish dynamics associated with reserve establishment may require changes in stock assessment models.

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

ES. Executive Summary - TO BE PROVIDED AS SUPPLEMENTAL MATERIAL AT THE SEPTEMBER 2004 COUNCIL MEETING

ES.A. Introduction

ES.B. Reserve Objectives and Rationales

ES.C. Analytical Framework for Marine Reserve Proposals

ES.D. Conclusions and Recommendations

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

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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

WHITE PAPER

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

September 2004

Scientific and Statistical Committee
Pacific Fishery Management Council

COMMONLY CITED
MARINE RESERVE BENEFITS

- Provide “insurance policy” against environmental variability and errors & uncertainty in fishery management
- Provide fishery benefits
- Provide ecosystem benefits (including habitat protection)
- Address social issues (e.g., reduce social conflict, protect unique cultural areas)
- Provide opportunities to advance scientific knowledge

PURPOSES OF WHITE PAPER

- Describe rationale & scientific basis for claims regarding marine reserve benefits
- Discuss implications of reserves for fishery management
- Establish SSC guidelines and standards for technical content of reserve proposals within Council's area of jurisdiction

ARE RESERVES POTENTIALLY USEFUL TOOLS FOR ACHIEVING THE FOLLOWING OBJECTIVES?

OBJECTIVE		RELEVANT ISSUES
Reduce uncertainty in fishery mgmt	+	Complete age structure ✡ enhance population persistence.
Provide fishery benefits (yield)	_	Theoretical models, empirical studies not sufficiently compelling. Yield not necessarily same as benefits.
Provide ecosystem benefits	+	Assuming effects of effort displacement effectively managed.
Address social issues (allocation)	+	Non-scientific criteria for evaluating achievement of objective.
Provide research opportunities	+	Expectations & conclusions commensurate with technical merits.

GUIDELINES FOR REGULATORY ANALYSIS

- Apply to no-take reserves as well as partial closures
- Based on Federal regulatory requirements (NEPA, RFA, EO 12866, other applicable law)
- Same standards as used for non-reserve proposals

ELEMENTS OF REGULATORY ANALYSIS

- Specify management objective.
- Describe management context and affected environment.
- Identify problem, role of reserves in addressing problem.
- Define status quo.
- Define reasonable range of alternatives to status quo.
- Analyze alternatives – biological, socioeconomic, ecological effects; monitoring, enforcement requirements.
- Document public process.

CONCLUSIONS & RECOMMENDATIONS

- Management objective is starting point.
- Ensure substantive role for regulatory analysis.
- Distinguish between science & policy.
- Recognize uncertainty, strengths & weaknesses of all management alternatives.
- Coordination & proactive Council involvement needed.

RESEARCH & DATA NEEDS

- Spatially explicit data and models
- Implications for stock assessments
- Fishery yield: spatial & temporal scale of species-specific effects

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON GUIDELINES FOR REVIEW FO MARINE RESERVES ISSUES

The Scientific and Statistical Committee (SSC) reviewed and discussed the September 2004 revision to the draft white paper *Marine Reserves: Objectives, Rationales, Fishery Management Implications and Regulatory Requirements*, prepared by the SSC Marine Reserves Subcommittee. The current version has been modified to address concerns and comments from advisory bodies and the public. Changes include:

- clarification of the difference between state and federal regulatory requirements and the scope of Council responsibility,
- elimination of the appearance of a dual standard in both science and regulatory requirements,
- expanded discussion of social objectives,
- clarification of the ecosystem objective to include habitat protection,
- inclusion of reference sites as a valid category of research reserves,
- inclusion of Appendix A, examples from the Council's Environmental Impact Statement for the 2003 groundfish specifications that illustrate appropriate approaches to conducting regulatory analysis, and
- a more balanced literature review.

The process for Council consideration of marine reserves is evolving as needs arise. The white paper would most appropriately be adopted as Terms of Reference to guide the Council and SSC in evaluating marine reserve issues.

The SSC endorses the current version, with minor edits, and recommends that the Council adopt the current draft document. The 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.

PFMC
09/15/04

HABITAT COMMITTEE COMMENTS ON GUIDELINES FOR REVIEW OF MARINE RESERVES ISSUES

The Habitat Committee (HC) appreciates the Scientific and Statistical Committee has addressed many of our concerns regarding the marine reserves white paper. In order to address persistent questions and issues regarding regulatory authority and policy considerations related to marine reserves, the HC recommends the Council encourage the writing of an additional paper dealing with policy and the Council's authority in addressing marine reserve issues. For example, there are questions about whether the Council can prohibit fishing for a species not under a fishery management plan. Other elements could include:

- an overview of organizations, interests, and authorities,
- how other authorities intersect with the Council (e.g., National Marine Sanctuaries, states),
- authority and limitations of Council under the Magnuson-Stevens Conservation and Management Act to implement marine reserves,
- implementation mechanisms (depending on goals)
- catalog of ongoing science efforts that relate to evaluating proposals in a management context, and
- establishment of common terminology.

PFMC
09/15/04

SALMON ADVISORY SUBPANEL REPORT ON GUIDELINES FOR REVIEW OF MARINE RESERVES ISSUES

The Salmon Advisory Subpanel urges the Council to move forward and adopt the Scientific and Statistical Committee white paper as a working document. The document appears to provide a thorough set of guidelines to evaluate marine reserve proposals, in particular, in terms of potential fishery effects.

PFMC
9/14/04

NRDC
THE EARTH'S BEST DEFENSE

NATURAL RESOURCES DEFENSE COUNCIL

September 13, 2004

Mr. Don Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, OR 97220

Dear Mr. Hansen and fellow Council members:

On behalf of the over 1 million members and activists of NRDC (Natural Resources Defense Council), we are writing to encourage the Council to take the direction of the SSC and begin implementing marine reserves[1] to complement existing management measures for west coast groundfish. As discussed in the white paper, marine reserves can offer many benefits when used in combination with effective fisheries management. The Council completed its Phase I technical analysis on marine reserves over four years ago and decided at that time to embark on Phase II, the designation phase. Unfortunately, little progress has been made on Phase II. Now is an opportune time for the Council to take up Phase II in earnest.

The Council is already considering area closures, such as no bottom-fishing zones, to protect essential fish habitat (EFH) through the EFH environmental impact statement. The boundaries of the large rockfish conservation area fluctuate each year. As part of Phase II, the Council should develop marine reserve network designs with the objectives of providing more stable, longer-term protection for vulnerable habitats and meeting bycatch-reduction goals. A network could also help simplify complex regulations. We believe the Council has the opportunity to meet the requirements of the Magnuson-Stevens Act and improve the sustainability of groundfish populations with a well designed marine reserve network.

The SSC has laid the groundwork for the Council to develop marine reserves. Much of the scientific information necessary to design marine reserves for groundfish is already available to the Council through its own documents, scientists, and advisors; in fact, Dr. Richard Parrish has already created a proposal for discussion. We ask the Council to produce a draft proposal by the fall of 2005.

Sincerely,

Kate Wing
Ocean Policy Analyst

Karen Garrison
Co-Director, Ocean Protection Initiative

[1] We are using the definition of marine reserve adopted by the SSC and the Council here: "an area where some or all fishing is prohibited for a lengthy period of time."

UPDATE ON MISCELLANEOUS MARINE PROTECTED AREAS ACTIVITIES

This update on ongoing marine protected area (MPA) activities includes information about:

1. National Fisheries Conservation Center (NFCC) Marine Reserves Science Conference.
2. Gulf of the Farallones and Cordell Bank National Marine Sanctuaries (NMS) Joint Management Plan Review.
3. National Oceanic and Atmospheric Administration (NOAA) MPA Science Institute – Integrating MPAs and Fishery Management Science Working Group.

NFCC Marine Reserves Consensus Conference

As described at previous Council meetings, NFCC organized a Consensus Conference to:

- Identify and prioritize key marine reserve scientific issues.
- Determine the present degree of uncertainty and related constraints on decision making.
- Reach agreement on the scientific studies needed to resolve these uncertainties.

This conference was held June 7-9, 2004 in Long Beach, California. A Consensus Statement from the Conference has been published. The abstract from this document is provided in the Briefing Book (Agendum E.2.a, Attachment 1). The complete document and more information about the Consensus Conference are available at the NFCC website – http://nfcc-fisheries.org/index.php.

Gulf of the Farallones and Cordell Bank NMS

At the June 2004 Council meeting, Sanctuary staff representing Gulf of the Farallones NMS (GFNMS) and Cordell Bank NMS (CBNMS) provided an overview of joint management plan review activities and several issues related to fishing within the Sanctuaries. GFNMS described potential proposed actions to address protection of submerged lands and impacts to seabirds from squid fishing lights. CBNMS described potential measures to address protection of benthic invertebrates and algae and to prevent disturbance of submerged lands.

Sanctuary staff will update the Council on their management plan review activities.

Two reports about seabirds and the effects of lights, which at the request of the Council were provided by GFNMS staff, are included in the briefing book (Agendum E.2.b, GFNMS – Information on Seabirds and Effects of Lights).

NOAA MPA Science Institute – Integrating MPAs and Fishery Management Science Working Group

At the June 2004 meeting, the Council was briefed on the NOAA MPA Science Institute's coordination of a working group to synthesize an approach for integration of MPAs with traditional fishery management. Further planning for the working group is ongoing. The working group has been established and is tentatively scheduled to meet during fall 2004. More information will be provided as it becomes available.

Council Task:

Council Discussion.

Reference Materials:

1. Agendum E.2.a, Attachment 1: NFCC Consensus Statement Abstract.
2. Agendum E.2.b, GFNMS – Information on Seabirds and Effects of Lights.
3. Agendum E.2.d, Public Comment.

Agenda Order:

a. Agendum Overview — Dan Waldeck
b. Gulf of Farallones and Cordell Bank National Marine Sanctuaries Staff Reports — Sanctuary Staffs
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. Council Discussion

PFMC
08/26/04

NFCC Consensus Statement

Integrating Marine Reserve Science and Fisheries Management

NFCC Consensus Conference

June 7-9, 2004
Long Beach, California

Consensus Statement
June 7-9, 2004

Integrating Marine Reserves Science and Fisheries Management

National Fisheries Conservation Center

Photo of Fuca Pillar, Cape Flattery, Olympic Coast National Marine Sanctuary courtesy of NOAA Photo Library

What is A Consensus Conference?

In late 2002, NFCC proposed a two-and-a-half-day consensus conference—modeled after the National Institutes of Health Consensus Development Conferences—to improve the integration of marine reserve science and fisheries management.

This style of consensus conference is designed to answer questions that require weighing scientific evidence in dispute. The consensus statement that emerges is intended to advance understanding of the scientific issues in question and to be useful to marine resource managers and the public.

As convenor, NFCC empanelled a planning committee to draft the questions and recommend review panelists. The non-advocate panel of experts based its findings on (1) presentations by investigators working in areas relevant to the consensus questions during a 2-day public session, (2) questions and statements from conference attendees during open discussion periods that were part of the public sessions, and (3) closed deliberations by the panel during the remainder of the second day and morning of the third.

This statement is an independent report of the consensus panel and is not a policy statement of NFCC or the organizations or institutions of the panelists.

Reference Information

For making bibliographic reference to this consensus statement, it is recommended that the following format be used, with or without source abbreviations, but without authorship attribution:

Integrating Marine Reserve Science and Fisheries Management. NFCC Consensus Statement, June 7-9, 2004, Long Beach, California.

Publication Information

The marine reserve science consensus statement, background materials prepared for the conference, and other NFCC publications are available by visiting our web site at http://nfcc-fisheries.org.

Disclosure Statement

All of the panelists who participated in this conference and contributed to the writing of this consensus statement were identified as having no financial or scientific conflict of interest, or any prior decision-making record on designation of marine reserves. Unlike the expert speakers who presented scientific data at the conference, the individuals invited to participate on the review panel were selected because they were not professionally identified with specific positions or research directions with respect to marine reserves science.

Abstract

Objective

The objective of this Consensus Statement is to inform the fishery management, ecological research, and marine protected area management communities of the results of the NFCC Consensus Conference on Integrating Marine Reserve Science and Fisheries Management. The statement provides an objective examination and assessment of the information regarding potential biological, social, and economic consequences of marine reserves, their potential effectiveness as a fishery management tool in the U.S., the methods for integrating their application with existing U.S. fisheries management and how marine reserves might be designed, monitored and evaluated. In addition, the statement addresses sources and magnitudes of uncertainty associated with marine reserves and conventional management approaches, and recommends areas for further study.

Participants

The conference included scientists and policy experts representing the fields of biological oceanography, marine ecology, fish biology, population dynamics, stock assessment, fishery management, fishery economics, and marine environmental law. The conference's seven-member review panel was made up of scientists and policy experts not currently engaged in research or advocacy in the field of marine reserves. The conference's ten-member presentation panel was made up of scientists and policy experts that are currently engaged in research or advocacy in the field of marine reserves. In addition to conference panelists, an audience of about 100 fishers, scientists, and policy makers was observed and contributed comments.

Evidence

The Communication Partnership for Science and the Sea (COMPASS) at Oregon State University conducted the literature search for the planning committee and the consensus conference and prepared an extensive bibliography for the panel and conference audience. COMPASS staff also prepared abstracts and topic syntheses for the panel with relevant citations from the literature.

Consensus Process

The panel, answering predefined questions, developed their conclusions based on the scientific evidence presented in open forum and the scientific literature. The panel composed a draft statement that was summarized and presented to the experts and the audience for comment. Thereafter, the panel resolved conflicting recommendations and released a summary of its revised statement at the end of the conference. The panel finalized the revisions after the conference. The draft statement was made available on the World Wide Web after panel revisions.

Conclusions

Marine reserves should be considered in the broader context of the development of ecosystem-based management in the U.S. From that perspective, marine reserves have clear application for meeting objectives for ecosystem conservation and protection of marine biodiversity in addition to whatever benefits they may have for achieving fishery management objectives. Furthermore, marine reserves are a category of area management options—including less restrictive and less permanent alternatives—that may be used in order to achieve ecosystem- or species-based management objectives.

With regard to fishery effects, studies of marine reserves and other area closures, most of which are from lower latitudes, have now shown that fishery target species have increased in abundance and expanded age structure within the closed area in a preponderance of cases (the so-called "reserve effect."). This is particularly the case where the resource species are significantly overfished. Evidence for effects outside closed areas, either by movement of adults across the reserve boundaries ("spillover") or larval "export" is more limited and effects on stocks within larger regions can only be deduced by models at this point. This is because of the limited size of existing reserves and inherent difficulties in measuring and interpreting such broader effects. In general, knowledge is sufficient to proceed with the design and evaluation of marine reserves and other marine protected areas and their incorporation into regional ecosystem-based management. More sophisticated modeling and analysis is required for better understanding of spatial movement rates, export of reproductive products, and adaptations by fishers.

Marine reserves clearly offer some advantages for simultaneously incorporating habitat protection and maintenance of ecosystem structure and function within the protected area. They may offer some advantages for multi-species management and as a hedge against environmental surprise or management failure.

Marine reserves are most likely to be an effective management tool for relatively sedentary species with broad larval dispersal, which are recruitment limited, and for mobile species with high site fidelity. They may also be effective for protecting rare habitats vulnerable to human disruption or in protecting aggregations of animals (e.g., when spawning), when exploited populations have been severely depleted, or where bycatch is high. Closed areas may also be useful in achieving broad demographic representation in spawning populations if large animals have limited movement potential relative to reserve boundaries, and when they can maintain populations of highly fecund, older females with strong reproductive potential. They may be more feasible to implement either when reduced yields have already restricted fishing activities and other management measures have been ineffective or when they address special needs within otherwise productive regions.

Marine reserves and other protected areas should be integrated with existing and emerging management measures as part of a coherent ecosystem-based approach to management of commercial and recreational fisheries and should not be simply layered over existing regulations. Careful consideration of the effects on allocation of resources among users, displacement of fishing activity, the requirements for surveys and stock assessment, and the costs of monitoring and enforcement should be made in considering protected area options and design.

The Panel found it difficult to limit its considerations to marine reserves as strictly defined, i.e. areas permanently protected from all extractive activities. We found that management actions need to be openly evaluated against stated goals and where goals are not being met changes in management must at least be considered. The design requirements for marine reserves depend heavily on the environmental context and specific management goals, including the overriding goal of sustainability and high yields of economically important species. Robust experimental design will be critical in order to determine the effects of displaced fishing pressures and enhancement effects on populations outside of reserves in before-after-control-impact assessments.

We have been hampered in evaluating the use of marine reserves as a tool for fishery management by the lack of experiments explicitly designed to address reserve effects on fisheries. These explicit experiments are urgently needed. There are numerous uncertainties associated with our understanding both of important biological and socioeconomic processes and with monitoring, analysis, prediction, and implementation. Some important uncertainties for marine reserves include the degree of effective dispersion and reproductive seeding and the ability to resolve spatial and temporal interactions in monitoring and modeling.

Further study is required on several key issues if closed areas are to assume a more important role in ecosystem approaches to fisheries management and biodiversity protection. These include high quality, synthetic bottom mapping with which to define vulnerable habitats that closed areas might best protect; study of dispersal rates; synthesis of effects of closures in northern temperate and boreal systems.

Many authors have speculated that marine reserves offer more precaution against management and scientific uncertainty than traditional measures. At this point, this is an assertion, and no studies using common definitions and metrics of precaution have been conducted. Given the importance of this issue, there is a need to conduct such work, applying biology and social science, particularly as it relates to findings from existing marine closures.

Introduction

The widespread degradation of coastal ocean ecosystems, attendant losses in biodiversity, and depleted status of many fishery stocks led the U.S. Commission on Ocean Policy to call for a new era of ecosystem-based management. Ecosystem-based management encompasses all ecosystem components, including human and non-human species and their environments. In its July, 2004 report, the Commission recommends such management be based on principles of sustainability, precaution, adaptation, and participatory governance and use the best available science.

Marine reserves, areas completely protected in perpetuity from all extractive and destructive activities, are being widely considered as a component of ecosystem-based management. While using marine reserves for biodiversity and ecosystem conservation is generally accepted, their potential role in fisheries management is controversial. Conservation advocates and some scientists have argued that marine reserves protect multiple stocks from over-exploitation in ways that conventional management methods that limit fishing effort or catches cannot or have not been able to do. Commercial and recreational fishing interests consider marine reserves as one more means to permanently limit their access to renewable resources. Some fishery scientists have argued that many fishery management objectives of marine reserves can be attained by effectively employing conventional measures and that marine reserves alone do not ensure sustainable fisheries management.

This two-and-a-half-day conference examined the current state of knowledge regarding the integration of marine reserve science and U.S. fisheries management. Experts presented the latest research findings to an independent Consensus Development Panel. After weighing this scientific evidence, the panel drafted a statement, addressing the following key questions:

1. What is the current state of knowledge of the potential biological, social, and economic consequences, both positive and negative, of marine reserves?
2. Under what circumstances could marine reserves be an effective fishery management tool in the U.S.?

3. How could marine reserves be integrated with existing fisheries management tools?

4. What general approaches to reserve design would meet fisheries objectives, taking into account social, economic, biological, and environmental factors?

5. What are the sources and magnitudes of uncertainty associated with marine reserves and conventional management approaches, and what are their implications for practical application of reserve design tools within the fishery management system?

6. What monitoring actions are needed to evaluate the results of marine reserves as a fishery management tool?

The Panel found it difficult to limit its considerations to marine reserves as strictly defined, i.e. areas permanently protected from all extractive activities, and found the issue of permanence the most highly contentious part of its overall charge.

(1) What is the current state of knowledge of the potential biological, social, and economic consequences of marine reserves?

Spatial closures have a long history as fishery management tools. They have been established to protect spawning aggregations, lower overall fishing mortality rates, minimize bycatch interactions, and reduce human impacts on vulnerable bottom habitat types. In the last decade, their use has expanded as fishery management objectives have widened, for example, to include essential fish habitat (EFH) protection. These closures range from narrowly focused prohibitions for particular gears to large-scale marine reserves prohibiting any removals from the three-dimensional reserve areas. Spatial closures by themselves are not marine reserves. However, since there are few studies examining the broad impacts of marine reserves explicitly, we also considered studies of closures. There have been many such closures and their results can inform us of the likely impacts of marine reserves on the species within them and the fisheries around them.

Knowledge about the biological and human-related consequences of marine reserves comes from two primary sources: (1) case studies of existing spatial closures, and (2) modeling studies evaluating the potential effects of reserves, either alone or in combination with other management measures. In general, these studies concentrate on impacts on yields and stock sizes of fishery target species, although some case studies have evaluated wider effects on associated species. Evidence presented to the panel indicates that available case studies for marine reserves are concentrated in the lower latitudes. Relatively few case studies exist from northern temperate and boreal waters. Many reserves and closures may not have existed for sufficient time to evaluate the potential consequences on long-lived component species.

Analysis of existing closures reveals that "reserve effects" (increased abundance and expanded age/size structures of resources and increased diversity in biological communities within the closed areas) commonly occur following spatial closures. Although this is not universal for all monitored species, in all regions, it is nonetheless surprisingly consistent. In many cases, significant, "reserve effects" have occurred where resource species were extensively overfished; thus the closure dramatically reduced fishing mortality on part or all of the stock. Such contrasts may not be observed with closures in areas where resource species are currently well managed. Other potential reserve effects include “spillover” (density-induced movement of adults across reserve boundaries into open areas) and larval “export” (movement of eggs and larvae to areas outside the reserve). Evidence for these latter effects is more limited than that for reserve effects; in particular, documenting export is a daunting technical challenge.

Spatial closures have been designed and established either to rebuild and maintain fishery populations, or to protect ecosystems and resources. In the case of closures for fishery enhancement, the federal fishery management process establishes target and threshold levels for stock size and fishing mortality as performance criteria, enabling evaluation of a closure’s (or a combination of measures) efficacy. Performance criteria for overall ecological effects of closures have no similar well-defined (statutory) targets and thresholds.

In general, we find that there currently is sufficient knowledge to proceed with the design and evaluation of reserves for the purposes of addressing primary fishery management goals (achievement of fishing mortality rate targets and stock biomass maintenance). In the United States (and in most of the developed world) detailed data exist on where target species are located, the spatial pattern of species abundance, general life history data (including longevity, maturity, dispersal of reproductive products, fecundity, and somatic growth rates), and some limited information on habitats in which the various life history stages occur. The design and evaluation of potential marine reserves requires these data in order to make first-order calculations of the biological impacts that alternative closed areas could have.

More sophisticated modeling and analysis of marine reserves require information on spatial movement rates, particularly across reserve boundaries; potential for export of reproductive products; and the likely behavioral adaptations by fishers (e.g., effort redistribution and its biological and socioeconomic impacts) to the establishment of marine reserves. Additionally, there are important, but unresolved, scientific questions regarding the functional value (relative productivity) of various habitat types, density-dependence at high levels of stock biomass (e.g., associated with reserve effects), and sub-stock structure within species. Few empirical studies exist with which to make generalizations regarding these effects. The Panel considers that studies of these factors represent a critical but heretofore-unmet research need. The lack of both a commonly agreed-to set of goals and clear performance measures regarding the effects of marine reserves on ecosystem function hampers the design and evaluation of closures for these purposes.

Below we briefly comment on the state of knowledge with respect to specific consequences of closures for the:

Population resilience of exploited species: Resilience measures are derived from life history information, stock-recruitment curves and similar knowledge. Such information exists for many species of fishery interest. Information regarding the relative efficacy of closures vs. alternative precautionary management measures to affect resiliency comes exclusively from modeling studies.

Variation in yield over time: Relatively low fishing mortality rates should result in less variability in annual yields, while high fishing mortality rates result in more dependency on variable incoming recruitment. Rotating open-closed areas can effectively buffer against yield variation where spatial patterns of recruitment may be variable, as in the management of some bivalve populations. There is little current information on the effects of reserves on yield variation (e.g., from adjacent open areas as a result of spillover and export), with the exception of some modeling studies.

Multispecies management: Bycatch avoidance has motivated the establishment of many existing closures, and such closures can be an effective strategy to reduce problematic bycatch in mixed species fisheries, and to avoid interactions with protected species. The consequences of closures on trophic dynamics have been evaluated in models, but few empirical case studies have produced information on this issue.

Habitat protection: Obviously spatial closures can afford high degrees of protection to benthic habitats, and some case studies document habitat changes following closures. However, the consequences of habitat protection to productivity of harvested species are generally poorly known. Some modeling studies have addressed the potential for fishing effects to reduce carrying capacity, and the effects that reserves might have on catch and biomass production under such conditions.

Protection of ecosystem services, structure, and function: Goals for ecosystem services, structure, and function have generally not been specified, nor have the effects of existing closures on these attributes been documented. In general, some modeling results indicate reserves should enhance these services and modifications of structure and function are more likely for reserves than other forms of spatial closures.

Insurance against environmental "surprise" or management failure: The concept of "insurance" in the context of resource management is ill-defined and thus a continuing source of ambiguity and contention. Overall, there is an open question regarding the proposition that marine reserves should, a priori, afford greater protection against perturbations or management failure than do precautionary management alternatives.

(2) Under what circumstances could marine reserves be an effective fisheries management tool?

Below, we outline the situations when marine reserves are likely to be ecologically beneficial and socio-economically feasible tools for fishery management. We assume that reserves will not be used alone for fisheries management but will be used in conjunction with other tools. Our discussion highlights the most critical and obvious circumstances; it is not intended to be an exhaustive list.

Biologically, the reserves may be most likely to be an effective tool for fishery management when:

- ♦ Species are sedentary or have high site fidelity (post-settlement) and have high larval dispersal. These species are the most likely to achieve long-term benefits (growth and survival) within reserves and to export these benefits through larval dispersal.
- ♦ Populations are recruitment limited.
- ♦ There are impacts to rare or key habitats. When the distributions of these habitats are limited, they are easier to manage with marine reserves.
- ♦ There are aggregations that can be managed within specific areas. The utility of reserves increases as more species occur in the aggregations and the aggregations occur at critical life history stages (e.g., nursery or spawning grounds).
- ♦ There is spatial consistency in the use of areas (e.g., in spawning grounds) by the population(s) to be managed. When there is less spatial overlap among populations, it will require a larger total area of reserves to protect the same amount of each population.

♦ When the protection of highly fecund (i.e., older and larger) individuals is desirable. These individuals have a disproportionately large contribution to larval supply in many populations and reserves can contribute to their development and/or protection. Traditional management measures (e.g., slot sizes) can also offer protection to these size classes but not if there are high post-release impacts (e.g., mortality) to released fishes.

♦ When stocks are depleted. Theoretical work indicates that the yield from reserves is most likely to be demonstrable when the MSY has been exceeded.

♦ Bycatch is high.

Socio-economically reserves are more likely to be an effective tool for fishery management when:

♦ Reserves meet multiple objectives (e.g., either for several stocks, fishery sustainability, habitat protection).

♦ Stocks are in sufficiently poor condition that limits on fishing have little added consequence.

♦ The economic condition of the fishery is good and reserves will have little direct economic impact.

♦ Spatial enforcement is feasible (e.g., there has been a history of spatial management).

♦ Their implementation does not add to a cumulative burden of regulations.

♦ Effort can be displaced with little economic impact.

♦ Fixed spatial management offers simplicity. In countries without complex fishery management systems, reserves are simpler to implement than stock-specific time, area, and gear regulations, which can be difficult to develop, communicate, and enforce.

♦ Information is limited and precaution is mandated.

♦ Other management measures have been ineffective.

♦ Fleet overcapacity is concurrently addressed.

(3) How could marine reserves be integrated with existing fishery management tools?

Several contextual elements underlie the integration of marine reserves with fishery management. The panel assumes that marine reserves would not be implemented as independent management tools in the absence of other management measures, but would be added to existing management. The panel finds, therefore, that they should be designed and implemented to integrate with existing management, create an internal coherence, and contribute to meeting the objectives of a fishery management plan. As with all fishery management tools, the cost and benefits of marine reserves should be evaluated in the context of their application within the specific fishery management plan.

Because they are layered over a set of regulations already in place, marine reserves will contribute to the cumulative effects of regulation. The economic condition of the fishery will be critical to the impact of these cumulative effects. The more economically healthy the fishery, the more likely that its participants will support marine reserve development and comply with its implementation. To this end, the panel finds the existence of ITQs or other forms of property rights will promote the economic conditions that encourage long-term investments in conservation.

(3A) Under what circumstances could marine reserves enhance or detract from conventional management approaches?

Marine reserves have the potential to enhance conventional fishery management in several ways. Setting aside areas from use can provide a buffer against management mistakes and scientific uncertainty. These areas can serve not only as hedges against risk, they can also be a means to provide direct protection for multiple species when this is required. In cases where weak stock protections limit harvest of other species, reserves could also provide the needed protection to these stocks so that outside-reserve harvest could continue. We note that an obvious area in which reserves can enhance conventional management is in cases where fishing disrupts or damages habitat in ways that diminish productivity of the resource. Finally, the panel finds that establishing marine reserves on a regional, rather than fishery-specific, basis could enhance management across several fishery management plans.

Marine reserves also have the potential to detract from conventional fishery management by increasing management costs without concomitant increases in benefits. The creation of additional costs may occur through the added complications resulting from poor design and a failure to integrate them into the fishery regulatory and economic context.

The panel finds that implementing marine reserves in fully utilized fisheries will have allocative effects that may detract from management effectiveness. Depending on their extent and location, reserves may alter the distribution of seafood landings in ways that diminish economic activity in fishing communities. The removal of areas from fishing may also create differential impacts on particular gear types or scales of operation. For example, marine reserves in nearshore areas can force small vessels to fish farther offshore under less safe conditions. Regulatory impacts on both communities and safety are addressed in National Standards 8 and 10, which fishery management plans must meet.

The displacement of fishing effort out of marine reserve areas and its concentration in outside-reserve areas is another potential detractor from fishery management effectiveness. The magnitude of this effect depends on the relative size of the area removed and the extent to which vessels have alternative areas to fish. In fully capitalized or overcapitalized fisheries, concentrating fishing effort could damage non-reserve areas. The potential for displacement to work against the management objectives requires attending to the potential for capacity management in conjunction with the development of reserves.

Finally, we note that marine reserves introduce additional requirements for monitoring and enforcement. Monitoring is necessary to assess the within-reserve response to protection and the progress toward meeting management objectives. Enforcement of reserves either through at-sea policing or vessel monitoring systems systems (VMS) on fishing vessels is necessary to ensure full protection. Both monitoring and enforcement introduce additional costs to management.

(3B) Would the use of marine reserves affect the application of conventional management and stock assessment?

The Magnuson-Stevens Fishery Conservation and Management Act requires that stocks be assessed individually. It is reasonable to expect that this requirement will continue, even with the multiple-species protections provided by marine reserves. Stock assessments make use of both fishery dependent (from landings) and fishery independent (from at-sea surveys) data. Depending on the size and extent of marine reserves, methods for collecting data from both sources may need to be changed to ensure adequate representation. Marine reserves, by setting aside areas from fishing, weaken the basic assumption under which fishery-dependent data are used—that the demographics of the fishery reflect the demographics of fish stocks. If reserve areas are large, stock-wide, rather than fishery-represented, abundance will need to be surveyed. This will increase the importance of fishery independent data and decrease the importance of fishery dependent data in stock assessment. The panel finds that new and restratified survey designs will need to be developed to reflect the new spatial patterns of the fishery. These changes will carry costs for redesign, new data collection, and analysis.

(4) What general approaches to reserve design would meet fisheries objectives?

Design of marine reserves, or any spatial management system, will be driven by specific goals. For fisheries management, sustainability is an overriding goal. We note, however, that more explicit, and occasionally non-fisheries, management goals may be sought. Consequently, the design process will be unique for each occasion; yet, for any management decision process, certain general guidelines will likely diminish confusion and maximize consensus among stakeholders. These include:

- Concisely articulating management goals
- Ensuring objectives are measurable and scientifically verifiable
- Allowing and planning for changes if objectives are not met
- Engaging all stakeholders in the process from the onset.

Inherent in these guiding principles is an adaptive management plan built on specific goals. As multiple spatial and conventional management actions may be applied to achieve objectives, there must be a view of the whole process that ensures separate management actions are coherent, and ideally, synergistic. Moreover, there should be an explicit plan for monitoring and assessing specific performance indicators (see Question 6 for more detail).

The panel recognized that many design criteria relevant to spatial management options (e.g., area, location, duration, etc.) are highly specific to explicit management goals. Therefore, it is only possible to make general recommendations concerning design criteria. First, because reserves will affect multiple species and multiple users, associated costs and benefits may introduce conflicts. Therefore, to minimize costs, efforts to reduce conflicts with and among users should be applied without compromising the management goals. Second, the concept of permanence with respect to reserves implies inflexibility when applied to fisheries management goals. Where possible, management planning should invoke the option for adaptive change in reserve design on a timeframe that allows for realistically assessing reserve effectiveness. However, it must be recognized that the multi-species and ecosystem nature of some management goals may require long time frames. Third, under circumstances of a given total area requirement, multiple, smaller reserves (i.e. networks) will generally better spread risks and costs than will a single large reserve. While ensuring individual reserves are large enough to be effective, placement of multiple reserves across the entire management region will reduce localized costs while simultaneously offering expanded benefits by spreading the risk of reduced reserve effectiveness that may result from localized perturbations.

Use of marine reserves and other spatial management options is likely to increase as management focus trends toward ecosystem-based options and processes. Expanded oversight of the management process should include efforts to minimize duplication by recognizing where different management goals may overlap and/or compete. The Panel finds that management processes that follow the above approaches including both planning and evaluation should facilitate realization of desired effects while minimizing negative impacts and conflict.

(5) What are the sources and magnitudes of uncertainty associated with marine reserves and conventional management approaches?

We recognize that the biological and socioeconomic processes related to the full range of fishery management approaches are all inherently knowable. All approaches, however, contain uncertainties that, if left unacknowledged or unaddressed, will lead us to misrepresent both our knowledge about these systems and our ability to manage them with reasonable confidence. It is important, therefore, to try to provide a framework for characterizing this uncertainty so that we might better understand and address it.

We also recognize that knowledge, and therefore uncertainty, in the context of fisheries management expresses itself at several levels.

Specifically, uncertainty exists in our fundamental understanding about the processes governing the ecosystem, the fishery that uses ecosystem resources, and the management methods used to govern the fishery. Uncertainty also exists in our ability to monitor these processes through data collection; analyze this information through estimation, modeling, and interpretation; make predictions given this analysis; and then implement and enforce management controls once the state of the system has been reasonably determined.

The panel proposes a means to contrast the various sources and magnitudes of uncertainty as illustrated in the table below. The descriptions in Table 1 (at right) are meant as a starting point for characterizing the uncertainty associated with these systems rather than an exhaustive presentation of the subject.

Uncertainty among several of the factors appears lower for use of marine reserves than for conventional methods. However, this perception may reflect our greater experience with conventional methods. More experience with marine reserves will better characterize both the sources and degree of uncertainty associated with their use.

Some suggest marine reserves will reduce the level of monitoring and evaluation needed for management. However, even areas closed to fishing require monitoring and evaluation to apprise managers of population and ecosystem trends. Given this continual need, the loss of information otherwise typically available from fishery dependent sources, and the higher dimensionality inherent in evaluating spatially referenced information, the effort and costs required to achieve reasonable information levels may prove higher than expected

Implementation uncertainty is not clearly identifiable at this time, but may be generally examined at various levels. We know that regulatory structures associated with conventional methods can become quite convoluted. Gear regulations, in particular, often prompt changes in fishing methods in response, resulting in a series of ad hoc modifications to existing policies. Regulations identifying no-fishing zones for marine reserves would seem inherently simpler and less subject to alteration through the evolution of fishing practices, and this may be so. Other aspects of implementation, such as the political will to site a marine reserve in contrast to imposition of stricter catch or effort control measures would also appear simpler. However, implementing reserves at the

Table 1. Comparison of Uncertainty

	Marine Reserves	Conventional
Ecological & socioeconomic processes		
Sources of uncertainty	Movement Dispersion Spillover Export Reserve size and location Home range Reproductive capacity	Natural mortality Fishing mortality Growth Selectivity Catchability Reproductive capacity
Magnitude of uncertainty	Low to moderate	Moderate to high
Monitoring		
Sources of uncertainty	Spatial and temporal Commercial and sport CPUE Survey indices Total harvest	Temporal Commercial and sport CPUE Survey indices Total harvest
Magnitude of uncertainty	Moderate	Moderate
Analysis		
Sources of uncertainty	Spatial-temporal modeling Production models Size or age structured models Stock recruitment Yield per recruit Growth	Temporal modeling Production models Size or age structured models Stock recruitment Yield per recruit Growth
Magnitude of uncertainty	High	High
Prediction		
Sources of uncertainty	Spatial-temporal modeling	Temporal modeling
Magnitude of uncertainty	High	High
Implementation		
Sources of uncertainty	Political will to initiate Regulation structure Enforcement	Political will to initiate Regulation structure Enforcement
Magnitude of uncertainty	High	High

locations and sizes needed to reduce fishing mortality to levels comparable to those currently sought through reductions in catch or effort may not be as easy to achieve.

In the end, the panel finds that identifying one of these approaches as being more precautionary than the other may be premature, strictly in terms of fishery management. Taking a broader set of factors into account, such as stabilizing trophic structure or preserving biodiversity, may tip the weighted risks and benefits in favor of utilizing a marine reserve. This forces us again to consider a broader set of goals and objectives with regard to managing these systems, and these must be clearly specified for each case prior to the debate over which mix of management procedures to consider.

(6) What monitoring actions are needed to evaluate the use of marine reserves as fishery management tools?

Monitoring and evaluating the ecological and socioeconomic impacts of marine reserves are essential aspects of the process of creating and implementing these spatial management tools. A monitoring plan should be developed during the design phase for the marine reserve and should clearly reflect its objectives.

The panel finds that any monitoring program should be based on clearly measurable and verifiable performance criteria or indicators that reflect reserve objectives and consider both socioeconomic and ecological aspects. Fishers and other interested groups should be involved in the selection of the performance indicators, as well as in the design and implementation of the monitoring program. We note that fishers can play a special role in data collection, assisting with the need for high resolution, spatially-oriented information.

The designers of the marine reserve must agree on the characteristics and timeframe of “success” as reflected by the measurable performance indicators. Management decisions and adaptations will follow from the monitoring plan and the evidence offered by the performance indicators. We note further, particularly in the context of federal legislation, that a variety of management alternatives to the proposed closures must be evaluated for their ability to meet biological objectives and all ten of the national standards under the Magnuson-Stevens Fishery Conservation and Management Act.

Performance indicators must embody the objectives of the marine reserve and should evaluate short- and long-term, positive and negative socioeconomic and ecological effects. They must consider the internal and external effects of the reserve. Economic indicators should attempt to quantify both market and non-market values and attempt to isolate benefits and costs to different users, e.g. displacement of effort; changes in fleet size, target species, and overall income. Ecological indicators must reflect both spatial and temporal changes in appropriate parameters, e.g. species and genetic diversity, abundance, biomass, and age structure. All indicators must be quantifiable and scientifically rigorous.

The monitoring plan should be linked to a broader research program that will address key uncertainties and causal linkages. The panel recommends that such a research program must embody careful experimental designs with control and replication experiments that recognize the limitations of "Before-After-Control-Impact" designs, as well as correct for potential effects due to displaced effort and export and or spillover to areas outside of the reserves.

We have been hampered in evaluating the use of marine reserves as a tool for fishery management by the lack of experiments explicitly designed to address reserve effects on fisheries. We have instead evaluated closures and marine reserves—often in ad hoc or crisis situations—the effects of which in these contexts is confounded and difficult to evaluate. Reserves show enough promise as fishery management tools to justify the explicit development of experiments to directly evaluate their effectiveness.

Conclusions

Marine reserves, areas of the ocean completely protected in perpetuity from all extractive and destructive activities, should be considered in the broader context of the development of ecosystem-based management for the Exclusive Economic Zone of the United States. From that perspective, marine reserves have clear application for meeting objectives for ecosystem conservation and protection of marine biodiversity in addition to whatever benefits they may have for achieving fishery management objectives. Furthermore, marine reserves are a category of area management options—including less restrictive and less permanent alternatives—that may be used in order to achieve ecosystem- or species-based management objectives.

With regard to fishery effects, many studies of marine reserves and other area closures, most of which are from lower latitudes, have now shown that fishery target species increased in abundance and their age structure expanded within the closed area in a preponderance of cases (the so-called “reserve effect.”). This is particularly the case where the resource species are significantly overfished. Evidence for effects outside closed areas, either by movement of adults across the reserve boundaries (“spillover”) or larval “export” is more limited and effects on stocks within larger regions can only be deduced by models at this point. This is because of the limited size and duration of existing reserves and inherent difficulties in measuring and interpreting such broader effects. Reserves show enough promise as fishery management tools to justify the explicit development of experiments to directly evaluate their effectiveness. More sophisticated modeling and analysis is required for better understanding of spatial movement rates, export of reproductive products, and adaptations by fishers.

Marine reserves clearly offer some advantages for simultaneously incorporating habitat protection and maintenance of ecosystem structure and function within the protected area. They may offer some advantages for multi-species management and as a hedge against environmental surprise or management failure in contrast to other precautionary fisheries management approaches, but these have not yet been empirically demonstrated and are likely to be context-specific.

Marine reserves are most likely to be an effective management tool for relatively sedentary species with broad larval dispersal, which are recruitment limited, and for mobile species with high site fidelity. They may also be effective for protecting rare habitats vulnerable to human disruption or in protecting aggregations of animals (e.g., when spawning), when exploited populations have been severely depleted, or where bycatch is high. Closed areas may also be useful in achieving broad demographic representation in spawning populations if large animals have limited movement potential relative to reserve boundaries, and when they can maintain populations of highly fecund, older females with strong reproductive potential. They may be more feasible to implement either when reduced yields have already restricted fishing activities and other management measures have been ineffective or when they address special needs within otherwise productive regions.

Marine reserves and other protected areas should be integrated with existing and emerging management measures as part of a coherent ecosystem-based approach to management of commercial and recreational fisheries and should not be simply layered over existing regulations. In general, the coupling of quotas or effort control with protected areas will likely produce more benefits to stocks and help foster the economic conditions that encourage such conservation approaches. Careful consideration of the effects on allocation of resources among users, displacement of fishing activity, the requirements for surveys and stock assessment, and the costs of monitoring and enforcement should be made in considering protected area options and design.

The Panel found it difficult to limit its considerations to marine reserves as strictly defined, i.e. areas permanently protected from all extractive activities. We found that management actions need to be openly evaluated against stated goals and where goals are not being met changes in management must at least be considered. The design requirements for marine reserves depend heavily on the environmental context and specific management goals, including the overriding goal of sustainability and high yields of economically important species. Management goals should be clear, objectives measurable and scientifically verifiable, and plans adaptable if objectives are not met. Development of the design should involve stakeholders at the outset, identify specific performance outcomes, and include sufficiently rigorous monitoring and assessment. Because most reserves would be intended to address multiple conservation, species-specific, and user goals, designs will require clear optimization procedures that do not unduly compromise key goals. Moreover, designs will have to take into account the regional network perspective in which the proposed specific reserve is included.

There are numerous uncertainties associated with our understanding both of important biological and socioeconomic processes and with monitoring, analysis, prediction, and implementation of all fishery management approaches. Although these uncertainties may be different between marine reserves and conventional management approaches, in general they are no greater for marine reserves and in some respects may be lower. Some important uncertainties for marine reserves include the degree of effective dispersion and reproductive seeding and the ability to resolve spatial and temporal interactions in monitoring and modeling.

Monitoring and evaluating the ecological and socioeconomic consequences of marine reserves is essential in this stage of their development as an ecosystem-based management tool. Monitoring should assess indicators of the performance outcomes included in the reserve design that support evaluations of “success” and subsequent adaptive management. Robust experimental design will be critical in order to determine the effects of displaced fishing pressures and enhancement effects on populations outside of reserves in before-after-control-impact assessments.

Research Recommendations

There are a number of specific and general areas requiring additional research if marine reserves are to assume a more important role in ecosystem approaches to fisheries management and biodiversity protection:

1. Throughout the U.S. there is limited information on bottom substrates and communities that structure fish habitats. There is a pressing need for high quality bottom mapping and assessment in order to define vulnerable habitats that might merit closure.

2. The fidelity of species to particular habitats is a major issue in designing effective areal closures. Spillover of harvestable animals requires that boundaries be established that allow some animals to range beyond the reserve, while building spawning populations within the closure area may depend on low dispersal rates. The use of modern technologies (chemical, molecular, etc.) to determine dispersal patterns and rates should be expanded.

3. While there are a number of well-documented studies of marine reserves and their effects in tropical or low latitudes, the amount of information for northern temperate and boreal systems is limited. Given that most of the high volume fisheries exist in these more poleward waters, there is a pressing need to develop a synthesis of the effects of area closures in such environments.

4. Few empirical studies, sophisticated modeling or analyses exist with which to make generalizations regarding the effects of marine reserves on spatial movement rates, particularly across reserve

boundaries; potential for export of reproductive products; and the likely behavioral adaptations by fishers (e.g., effort redistribution and its biological and socioeconomic impacts). Additionally, there are important, but unresolved, scientific questions regarding the functional value (relative productivity) of various habitat types, density-dependence at high levels of stock biomass (e.g., associated with reserve effects), and sub-stock structure within species. The Panel considers that studies of these factors represent a critical but heretofore-unmet research need.

5. Many authors have speculated that marine reserves offer more precaution (insurance) against management and scientific uncertainty than do traditional measures. At this point, this is an assertion and no studies using common definitions and metrics of precaution have been conducted. Given the importance of this issue, there is a need to conduct such work, applying biology and social science, particularly as it relates to findings from existing marine closures.

Review Panel

Don Boesch, Chair President, Center for Environmental Science, University of Maryland

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Dr. Boesch is an internationally known marine ecologist who has conducted extensive research in coastal and continental shelf environments. He has published two books and more than 60 papers on a wide range of scientific and science policy topics. He has been a member of the Marine Board and the Ocean Studies Board of the National Research Council, and he has chaired three prominent NRC committees. Dr. Boesch has also served on national advisory boards for the Department of the Interior, Environmental Protection Agency, National Science Foundation, the National Oceanic and Atmospheric Administration and the President's National Science and Technology Council.

Mike Beck, Senior Scientist, Marine Initiative, The Nature Conservancy

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Since 1998Mike has led several marine programs and initiatives atThe Nature Conservancy and isa research associate at the University of California Santa Cruz. Mike has trained and worked at the University of Virginia, Dauphin Island Sea Lab, Florida State University, and the University of Sydney. In his research, Mike examines factors that control the diversity and abundance of animals in seagrass, mangrove, rocky intertidal, and salt marsh habitats. He has served as a member of advisory committees for EPA, the Heinz Center, the European Union, NatureServe, and the Commission for Environmental Cooperation.

Bob Cowen, Professor and Maytag Chair of Ichthyology, University of Miami

His research has concentrated on ecology and early life history of fishes and the biological and physical oceanographic processes affecting the retention and transport of larval fishes, in terms of examining larval dynamics, population replenishment and connectivity. Dr. Cowan also worked on the reproductive and population biology of hermaphroditic (sex-changing) fishes, as well as community ecology of kelp bed systems. Recently he has focused on the role of juvenile habitat in the recruitment of fishes, population connectivity in marine fishes, and early life history dynamics of billfish.

Susan Hanna, Professor, Dept. of Agricultural and Resource Economics, Oregon State University

http://marineresearch.oregonstate.edu/assets/page_folders/faculty_page/hanna_hp.htm

Dr. Hanna teaches fishery economics, fishery management, history of fishery policy, and property rights. Her writing has focused on promoting the economic and ecological productivity of marine resources by improving management performance. She has served as a scientific advisor to the Pacific Fishery Management Council, Northwest Power Planning Council, National Marine Fisheries Service, Minerals Management Service, and National Oceanic and Atmospheric Administration. She is a member of the National Research Council's Ocean Studies Board and several NRC Committees, including the Committee to assess Pacific Northwest salmonids and the committee to Review Individual Quotas in Fisheries. She is president of the International Association for the Study of Common Property and a member of the Executive Committee of the International Institute of Fisheries Economics.

Steve Murawski, Chief, Population Dynamics Branch, Northeast Fisheries Science Center, NOAA Fisheries.

Dr. Murawski's areas of concentration are in fisheries science and management. He has led numerous stock assessment projects for the Northeast Fisheries Science Center in Woods Hole. He has direct experience with design and evaluation of large closed areas in New England.

Patrick J. Sullivan, Professor Dept. of Natural Resources, Cornell University

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The dynamics of natural populations and communities is the central focus of his teaching and research. Using statistical methods, such as survey sampling, nonlinear population modeling and assessment, and spatial statistics, to observe and model the dynamics of natural systems in a quantitative way, he is particularly interested in how variation can be used to characterize natural systems, address uncertainty and determine risk in order to improve environmental management. His research has focused mainly on fisheries problems in marine and freshwater environments. These include statistical methods for population assessment and modeling, methods for data acquisition and utilization, spatial modeling of habitat and abundance, and formulating mechanisms for making better use of information in the management arena.

Daniel Suman, Professor of Marine Affairs and Policy, University of Miami

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A member of the IUCN Commission on Environmental Law, Dr. Suman's research Interests include adaptability of the fishing sectors in Chile, Peru, and Ecuador to ENSO ("El Niño") climate variability, mangrove management in Latin American and Caribbean countries, and establishment of MPAs. His work places emphasis on integrating ecological, policy, economic, and legal aspects of complex resource management problems.

Presenters

Dick Allen is a New England fisherman with a 36-year commercial fishing career, in lobster, surf clam, groundfish, herring, and menhaden fisheries. He holds a BS in Natural Resource Development and MS in Marine Affairs from the University of Rhode Island. He served on the New England Fishery Management Council for 9 years, was a commissioner on Atlantic States Marine Fisheries Commission for 11 years, a member of the US Department of Commerce Marine Fisheries Advisory Committee. Most recently Allen was awarded a Pew Fellowship focusing on facilitating science-industry collaboration by introducing computer simulation models of the lobster fishery to the lobster fishing community. www.fisheryconservation.com

Jon Kurland is the Assistant Regional Administrator for Habitat Conservation with the National Marine Fisheries Service in Juneau. He oversees the Habitat Conservation Division, which carries out the agency's mandates to conserve habitats that support living marine resources. His group identifies and conserves Essential Fish Habitat (EFH) through fishery management, and provides technical advice to other agencies and the public on ways to minimize the effects of development activities on habitats that support commercially harvested fish as well as marine mammals. Before moving to Alaska in 2002, Jon was the national EFH Coordinator for NMFS in the headquarters office in Silver Spring, Maryland.

Loo Botsford is Professor of Wildlife, Fisheries and Conservation Biology at the University of California, Davis. His Research focus is the application of age, size and spatially structured population models to practical problems, usually problems in marine conservation of fisheries. Combines modeling approaches with field work to better understand critical aspects of dynamics. Retrospectiveanalyses of past data includes primarily calculations of the degree of covariability between environmental and biological variables. Has developed influential models that describe and predict the performance of marine reserves under different situations.http://wfcb.ucdavis.edu/www/faculty/Loo/BotsfordSiteFiles/BotsfordMain.html

Ken Frank is with Canada's Department of Fisheries and Oceans Bedford Institute of Oceanography. His Many years of management experience with DFO,include stock assessments of haddock fishery and evaluation of the large haddock closure in the North Atlantic. Current research focus on fisheries ecology, resource conservation, biogeographic theory, fisheries oceanography, and marine ecosystem assessment.

Arne Fuglvog is President of the Petersburg Vessel Owner's Association. A lifelong resident of Petersburg, Alaska, he has been fishing commercially since 1975, primarily longlining for halibut and sablefish, but has participated in salmon, herring and crab fisheries throughout the state of Alaska. He is a member of the North Pacific Fishery Management Council after serving 9 years on its advisory panel. Fuglevog also serves on the Research Advisory Board to the International Pacific Halibut Commission. He was named one of National Fisherman's "highliners of the year" for 2003.

Rod Fujita is a Senior Scientist at Environmental Defense. He has worked on acid rain, ozone depletion, global climate change, and protecting marine ecosystems. Fujita initiatedEnvironmental Defense's Coral Reef Project, and played a lead role in establishing the Florida Keys National Marine Sanctuary. He leads efforts to create sustainable fisheries along the Pacific coast of the U.S., in Hawaii, and in international waters. Fujita is currently working to stop overfishing and to create networks of marine reserves to increase fishery yields while protecting marine biodiversity and ecosystem health.

Mark Hixon is a Professor in the Department of Zoology at Oregon State University. He is a marine ecologist expert on coastal marine fishes, with research on mechanisms that naturally regulate populations and sustain biodiversity of marine fish. Collated research on potential fisheries benefits of existing West Coast marine reserves. Hixon serves on several advisory boards, including the MPA Federal Advisory Committee. http://oregonstate.edu/~hixonm/index.htm

Steve Palumbi is a Professor at Hopkins Marine Station of Stanford University. He has conducted research on genetics, evolution, population biology, and systematics of a diverse array of marine organisms. His major focus is genetics of marine populations in the context of marine protected areas for conservation and fisheries enhancement. Palumbi also investigates the use of molecular genetic techniques for the identification of whale and dolphin products available in commercial markets, and mechanisms of reproductive isolation and their influence on patterns of speciation and degree of genetic structure in marine systems. http://www-marine.stanford.edu/HMSweb/palumbi.html

Andy Rosenberg is a professor in the department of Life Sciences and Agriculture at the University of New Hampshire. His research focus is on marine science, marine policy, and marine fisheries. Former deputy director of the National Marine Fisheries Service, Rosenberg was a key agency policymaker and liaison to Congress, the administration, resource management partners, and the public. Implemented protection plans for marine mammals such as harbor porpoise and right whales, and endangered species like Atlantic salmon. Prior head of delegation to the North Atlantic Salmon Conservation Organization and the Northwest Atlantic Fisheries Organization, and is a member of the U.S. Commission on Ocean Policy.

Vidar Wespestad is President of Resource Analyst International. He consults in area of global marine resource assessment and serves as Chief Fisheries Scientist for the Pacific Whiting Conservation Cooperative. From 1977 to 1997 he was a fishery research biologist with the U.S. National Marine Fisheries Service and led. the Bering Sea stock assessment group at the Alaska Fishery Science Center. He is a recipient of the American Fisheries Society's Distinguished Service Award for organizing and co-chairing the First World Fishery Congress and has received fellowships from the Fishery Research Council, the Norwegian Marshall Fund, and the Rockefeller Foundation. He received his Ph.D. in fisheries from the University of Washington.

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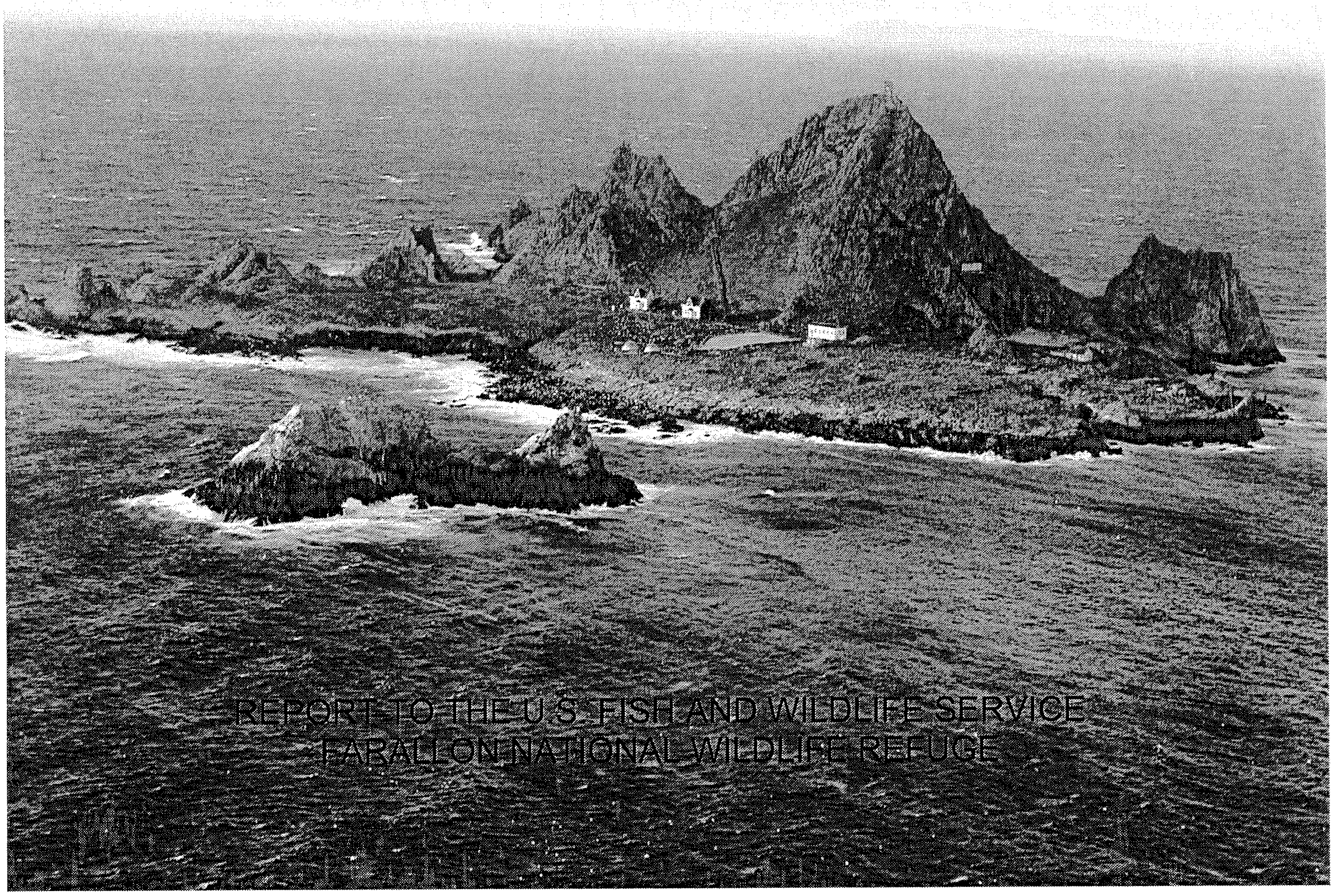
Agendum E.2.b
GFNMS - Information on Seabirds and Effects of Lights
September 2004

POPULATION SIZE AND REPRODUCTIVE PERFORMANCE OF SEABIRDS ON SOUTHEAST FARALLON ISLAND, 2003



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EXECUTIVE SUMMARY

(1) PRBO has been monitoring the population status, reproductive success, demography and chick provisioning of the seabird colonies on Southeast Farallon Island (SEFI) continuously, since 1971. El Niño conditions during the winter of 2002/2003 resulted in an unusual season for the seabirds on SEFI in 2003.

(2) The sea-surface temperature (SST) was anomalously warm in the early part of the breeding season, but cooled in June and July, during the peak of chick rearing. The mean seasonal SST for 2003 (12.07), though higher than the past few seasons, was considerably lower than in previous El Niño years.

(3) Population estimates were higher than last season for all species except double-crested cormorants and pigeon guillemots. This continues a trend of general population growth over the last four years, with murres, cormorants and Cassin's auklets growing at relatively high rates.

(4) All species experienced reduced reproductive success in 2003, although the effects on individual species varied.

(5) In addition 2003 was characterized by delayed breeding relative to the previous two seasons, a high rate of nest abandonment among Brandt's cormorants, and a reduction in the proportion of rockfish in chick diet.

(6) Large numbers of emaciated sea lions were observed around the island this season, probably due to a lack of sufficient food available during the winter and spring months. These individuals then had a direct impact on seabirds by crawling into the colonies, causing disturbance and actively preying upon murre chicks.

(7) The El Niño of 2003, the first in a "cold water regime" was much more moderate in its effects than previous events. Productivity, while reduced, was much higher than in 1998, 1992, or 1983, particularly among those species thought to be most sensitive (PECO, PIGU, and BRCO).

INTRODUCTION

This report contains information on the reproductive performance and population size of seabirds on Southeast Farallon Island (SEFI; Farallon National Wildlife Refuge) and West End Island (WEI), California, during 2003. We monitored eleven species: Ashy Storm-petrel (ASSP), Double-crested Cormorant (DCCO), Brandt's Cormorant (BRCO), Pelagic Cormorant (PECO), Western Gull (WEGU), Black Oystercatcher (BLOY), Common Murre (COMU), Pigeon Guillemot (PIGU), Tufted Puffin (TUPU), Rhinoceros Auklet (RHAU), and Cassin's Auklet (CAAU).

We are indebted to our research assistants, Aileen Miller, Michelle Schuiteman, Jessica Beaubier, Duncan Wright, Heather Darrow, Meghan Riley, Melinda Nakagawa, and Jennifer Greenwood for their invaluable assistance with data collection. Adam Brown oversaw data collection for the fall season. We are also very grateful for support provided by the skippers of the Farallon Patrol, our colleagues in the mainland PRBO office, and personnel at the San Francisco Bay National Wildlife Refuge. This report should not be cited without permission from W.J. Sydeman. This is PRBO contribution no. 1130.

METHODS AND RESULTS

Reproductive Performance

The reproductive performance of seabirds on SEFI is summarized in Table 1 and compared to previous years (Fig. 1a, b). All reproductive parameters reported in Table 1 are based on nests in which at least one egg was produced. Clutch size, brood size, hatching success, and fledging success were determined for first attempts only. Hatching success is calculated as the number of chicks hatched divided by the number of eggs laid. Fledging success is calculated as the number of chicks fledged divided by the number of chicks hatched, for clutches in which at least one egg hatched. Productivity (number of chicks fledged per pair) was determined for first attempts and for all attempts (including first attempts, relays, and second-broods). We compared productivity for all attempts to values from the past 32 years for each species. For a detailed description of the methods used to determine reproductive success and breeding population size see Sydeman et al. (1987, 2001). Due to inaccessibility of TUPU crevices and poor visibility of DCCO nesting areas, no reproductive data were collected for these species.

Brandt's Cormorant – BRCO productivity showed a decline in 2003. Cormorants nesting in the colony under the Cormorant Blind produced 1.01 fledglings per pair this season (approximately half of that observed in 2002, and 30% below the 32-year mean, Fig. 1a). If clutches that were initiated after 30 May are excluded from analysis, the productivity climbs slightly to 1.33. Banded birds that initiated egg-laying late in the season were primarily young breeders (banded in 2000 or 2001), and demonstrated reduced productivity. However, young breeders did not have as much influence on overall productivity as they have in the previous two seasons because there were few late breeding attempts and high rates of nest failure and abandonment amongst early nesters. The rate of nest abandonment this season was high, regardless of timing of egg-laying. Forty-four of 125 nesting attempts (35%) were abandoned. In most years, less than 5% of the nests are abandoned; less than 1% of nests were abandoned in 2002. The first eggs were observed on 25 April. Mean clutch size was 2.69 eggs per nest and hatching success (percentage of eggs that hatched) was low at 65%. Mean brood size was 1.71 chicks per nest. Fledging success was also low, with only 62% of the chicks that hatched surviving to fledging age.

Pelagic Cormorant – PECO produced 2.21 fledglings per pair. This is 14% lower than in 2002, approximately equal to the productivity observed in 2001, and still well above the long-term mean productivity for this species (Fig. 1a). The first eggs were observed on 20 May. The average clutch size was 3.07 eggs per nest and the average brood size was 2.44 chicks per nest. These numbers are approximate, based on the maximum number of eggs and/or chicks observed, and may be underestimates due to the fact that we did not always see the complete contents of each nest. Hatching success was 86%, and 92% of the chicks that hatched survived to fledge.

Western Gull – WEGU productivity has shown a steady decline through time (Fig. 1a). Productivity in 2003 was down approximately 14% compared to 2002, but still among the highest observed over the past ten seasons. The number of chicks fledged per pair was 0.81 (26% lower than the 32-year mean; Fig. 1a). The first eggs were observed on the island on 21 April, and in the study plots on 28 April. Out of 70% of eggs that hatched, 38% of those chicks survived to fledge. Mean clutch size was 2.91 eggs per nest. Brood size was 2.05 chicks per nest.

Black Oystercatcher – A total of 31 sites were monitored in 2003, of which 16 were active (up from 11 last season), defined as: (1) a territory occupied by a pair at least twice, (2) a territory in which a bird was seen at least once in incubation posture, or (3) a territory where an egg or chicks were seen. Eggs and/or chicks were documented at 12 of these sites (75%). Based on these 12 breeding sites, we estimate 1.1 fledglings were produced per pair. Although the mean productivity was equal to that observed in 2002, there was an increase in the total number of chicks produced. A total of 14 chicks were observed to have survived to fledging, whereas 10 were observed last season. The first eggs were observed on 5 May. BLOY nests are cryptic and difficult to observe; therefore clutch size, hatching success and fledging success were not determined.

Common Murre – During 2003, 195 Common Murre sites were monitored daily in the Upper Shubrick Point (USP) study plot. The number of breeding sites (where at least one egg was laid) was 158. Productivity at USP in 2003 was greatly affected by repeated disturbances of a juvenile California sea lion in the study plot. In order to document the effects of this disturbance, detailed notes were recorded on all egg and chick losses when the sea lion was present. For the purpose of estimating the overall productivity for the island, data from all sites for which the cause of egg or chick loss was directly attributable to the sea lion disturbance, were not used. For the 112 sites that were not affected, productivity was 0.72 chicks fledged per pair, approximately 6% lower than the value obtained last season. This value is slightly below the 32-year average of 0.75 (Fig. 1a). The first eggs were observed in this plot on 26 April.

Hatching success was low this season with only 80% of the eggs hatching. Fledging success, however, was high with 94% of the hatched chicks surviving to fledge.

The colony of Common Murres in the Upper Upper (UU) plot under the Cormorant Blind breeds later than the colony at USP. Birds did not regularly attend this sub-colony until 26 April, and the first egg was observed on 9 May. The number of sites monitored was 41, with 21 of those sites attended by a breeding pair (down from 29 breeding sites in 2002). Hatching success at UU was 0.86 this season, and 100% of these chicks survived to fledge (see Table 1). Productivity was 0.84 chicks fledged per pair, approximately 50% greater than last season. Although the productivity of the UU sub-colony was high this season, the continuing decline of the colony size is of concern. Peregrine Falcon predation is likely a factor in the decline in the number of breeding birds at UU over the years. At least one banded murre was predated by a falcon, and several other banded individuals relocated to new breeding sites within Corm Blind sub-colonies.

Pigeon Guillemot – A total of 141 sites were monitored on Lighthouse Hill, Garbage Gulch, and the Habitat Sculpture (a new site monitored since 2002), of which 96 were observed with at least one egg (68% of the total number of sites). One nest was located in the Habitat Sculpture, and two in Rhinoceros Auklet nest boxes by Russia house. Productivity fell considerably for PIGU this year compared to the previous four years. There were 0.92 fledglings produced per pair (Table 1), which was 44% lower than last season, but still 10% higher than the 32-year average productivity. The first eggs were observed on 7 May. The mean clutch size was 1.89 eggs per nest and 89% of chicks hatched successfully. Mean brood size was 1.73 chicks per nest, with 83% of the chicks surviving to fledge.

Rhinoceros Auklet – There were a total of 152 sites (boxes, crevices, and cave sites) monitored in 2003, 30% (n=46) of which were occupied by a breeding pair, down from 39% in 2002. Productivity was 0.45 fledglings per pair, which is 27% lower than last season and 20% below the 17-year average (Fig. 1a). The first eggs were observed on 17 April. Seventy percent of the chicks successfully hatched, but only 65% successfully fledged.

Cassin's Auklet – Occupancy of breeding birds in boxes was high again in 2003, with 91% (40 of 44) of the study boxes occupied. Productivity, while down from the previous two seasons, was still high in 2003, with 0.90 chicks fledged per pair (including second broods and relays). This is 24% lower than the record productivity observed in 2002, but still 24% above the long term mean. The initiation of breeding was later this season, with the first eggs being observed on 1 April. Seventy-three percent of the eggs hatched and 93% of these chicks successfully fledged (data for first attempts only). Sixteen pairs attempted to raise a second brood (down from 21 pairs in 2002), of which only 3 successfully fledged a second chick. This represents a 73% reduction in the success of second broods as compared to last season and is responsible for the difference in productivity observed between 2002 and 2003. The success of first attempts was higher than that for first attempts in 2002.

Ashy Storm-Petrel – ASSP pairs laid eggs in 33% of the 66 followed sites (n=22) in 2003. The first eggs were observed on 20 May. Eighty-three percent of the eggs hatched, but only 73% of the chicks successfully fledged. Productivity was low again this season, with 0.5 chicks fledged per pair. This is equal to the productivity observed in 2002 and 27% below the long-term mean. As of this report, however, three chicks had yet to fledge (all from relay attempts). If all of these chicks survive to fledge, the productivity estimate for this season would be 0.64 chicks per pair. This would represent a 23% increase over the 2002 productivity, but would still be 7% below the long-term mean.

<u>Population Estimates</u>

Population size and island-wide chick production was estimated for all species except ASSP, RHAU, and TUPU; breeding population size estimates (number of individuals) are presented in Table 2 and Fig. 7. All estimates include West End Island unless described otherwise.

Ashy and Leach's Storm-petrels –The mark/recapture study to estimate ASSP population size and survival continued in 2003. We operated two netting locations (Lighthouse Hill and Carp Shop) on 8 evenings between April and September. We banded a total of 334 and recaptured 46 (including a record capture night in which 108 birds were caught). There were 10 LESP banded this season, and one recaptured.

Double-crested Cormorant – The DCCO colony is located on Maintop on West End Island. Counts of this colony were conducted every five days from atop Lighthouse Hill on SEFI. A total of 26 counts were made in 2003, beginning on 17 March and ending on 20 July, when juveniles were indistinguishable from adults. On 21 May we counted a peak number of 196 "well-built" nests with birds in incubating posture. To estimate the minimum population size we multiplied the number of well-built nests by two, which yields a total of 392 breeding birds. This estimate is 20% lower than 2002, and approximately 11% lower than the 10-year average (Table 2).

Brandt's Cormorant – The BRCO breeding population was censused during ground-based surveys on 9 and 10 June. The boat portion of the census was completed on 5 June. A total of 5,611 "well-built" nests were counted (Fig. 2), yielding an overall estimate of 11,222 breeding birds (Table 2). We multiplied the number of nests by the number of chicks fledged per pair (Table 1) to estimate an island-wide production of 5,667 fledglings. Population size was 18% higher than the estimate for 2002, and 48% above the 10-year average (Table 2).

Pelagic Cormorant – The PECO breeding population was censused on 9 and 10 June during a land-based survey. The boat portion of the census was completed on 5 June. A total of 255 well-built nests were counted (Fig. 3). We therefore estimated a breeding population of 510 birds (Table 2) and an island-wide production of 564 fledglings. The population estimate for Pelagic Cormorants is 15% greater than in 2002, and 46% higher than the 10-year average.

Western Gull – The WEGU census was conducted on 2 and 3 June. To facilitate counting, the island was sub-divided into plots that were counted individually. Breeders and non-breeding, roosting, birds were counted separately. Counts of roosting birds were not included in the population estimate. The total number of birds counted was 11,354 (Fig. 4). Because not all breeding birds were present at the time of the census, we calculated a correction factor to convert counts of individuals into breeding pairs. The correction factor was derived by multiplying the number of nests in the three study plots by 2, then dividing the product by the number of adults present in the plots during the census. We then multiplied the average correction factor of these three plots by the total number of adults counted, to arrive at our population estimate (Appendix I). We estimated a breeding population size of 16,838 birds (Table 2) and overall production of 6,819 fledglings in 2003. The population size estimate for WEGU is 11% higher than in 2002, but still 15% lower than the 10-year average.

Black Oystercatcher - We estimated the population of BLOY by surveying all known breeding sites visible from Lighthouse Hill and the marine terrace. Of the 31 sites that were monitored this year, 12 were attended by a breeding pair that had eggs and/or chicks. Therefore, we estimated a breeding population size of 26 birds and a production of 14 fledglings. This estimate does not reflect birds on parts of West End Island not visible from the SEFI vantage points. Compared to previous years, this estimate is 18% higher than 2002 (Table 2), and 30% higher than the 10-year average.

Common Murre – The COMU breeding population was censused during land-based surveys conducted between 27, 28, 30 May and 1 June (Fig. 5). Individual birds were counted during these surveys. The boat portion of the survey was not conducted this year due to unfavorable weather conditions. The total number of individuals counted during the land-based survey was 37,131. As with WEGU, a correction factor was calculated using data from the USP, UU, and X study plots to account for breeding adults not present during the census (in previous years the correction factor was calculated using only data from the USP plot). The correction factor methodology was changed after the 2002 season in response to a report by Nur and Sydeman (2002), showing that correction factors for count data are best calculated using multiple counts on multiple plots. The correction factor used in 2003 was derived by multiplying the number of breeding sites in each plot by 2, and then dividing the product by the mean number of adults present on the survey dates (Appendix II). Multiplying the raw count by the correction factor yielded an estimate of 55,697 breeding birds. However, since a boat census could not be completed, we also added a second correction factor to account for the proportion of the population that would normally be censused from the boat. Based on the 2002 census data, 48% of the population breeds on West End Island and a few other SEFI locations not observable from land. Therefore, we multiplied the corrected count by 1.92 to arrive at an overall estimate of 107,105 breeding adults. We estimated island-wide production at 38,558 fledglings (Note: as with the calculation of the correction factor, productivity data from all three plots was pooled to estimate the overall number of fledglings produced, yielding an island-wide productivity of 0.72 chicks/pair). Population size in 2003 was 3% higher than in 2002 and also well above the 10-year average (Table 2). The population estimate would have been higher using just data from USP to calculate the correction factor, as has been done in earlier years, yielding an estimate of 115,492 birds.

Pigeon Guillemot – Our estimate of the breeding population of PIGU is derived by counting adults rafting on the water around SEFI at dusk throughout the month of April, before the birds begin regular attendance of sites. Our peak count was 500 birds on 19 April. This count was approximately equal to 2002, and 30% lower than the 10-year average (Table 2). However, over the last two seasons, we have noticed that the number of guillemots observed on the water around the island is much higher in the early morning than in the evening (when raft counts have traditionally been made). So, in 2002, we modified our protocols and initiated morning raft counts (0700-0830) to more accurately reflect the number of birds using the island. Our peak count during morning surveys in 2003 was 2,383, an increase of 21% compared to the peak count of 1,964 in 2002. On average, morning surveys were 90x higher than evening counts conducted on the same day. This number is similar to the peak numbers observed around the island in the late 70's and early 80's (Fig. 7), but based on a different methodology.

Tufted Puffin – There were no population estimates made for Tufted Puffin's this season. Birds were observed in their normal locations and seen carrying fish to their burrows later in the season, but no attempt was made to conduct a full census.

Rhinoceros Auklet – An island-wide estimate of breeding population size for RHAU is difficult to obtain because they nest underground and are crepuscular (active only at dawn or dusk). In 1987 we began a mark/recapture study of RHAU at four sites to monitor population trends. The results have yet to be analyzed. There were three netting sessions conducted at each of the four sites in 2003. A total of 18 new birds were banded and 36 were recaptured.

Cassin's Auklet – Similar to the RHAU, CAAU is another burrow/crevice-nesting nocturnal seabird that is difficult to census. Therefore, in 1991 we established twelve 10 x 10m index plots to monitor burrow density (Table 3). A complete census of nest sites on SEFI has not been conducted since 1989, at which time a breeding population size of 29,880 birds was estimated (Carter et al. 1992). To estimate the breeding population size for 2003, we applied the percent difference between the 1991 and 2003 counts in the index plots to the 1989 estimate. This calculation assumes that burrow counts in our index plots did not differ substantially between 1989 and 1991. Although index plot counts from 1989 are not available to test this assumption, this method currently provides our best estimate of population size. We counted a total of 291 burrows in the index plots this season (79% of the 1991 count). Therefore, we estimated a 2003 breeding population of roughly 23,692 birds ([291/367] x 29880), and total production of 10,661 fledglings on SEFI. The breeding population size estimate is 26% higher than that in 2002, and 18% higher than the 10-year average (Table 2).

DISCUSSION

Productivity of seabirds on SEFI during the 2003 breeding season was lower than in 2002 for all species, and lower than the long-term average for all species except Pigeon Guillemots, Cassin's Auklets, and Pelagic Cormorants. Mean monthly sea-surface temperatures (SST) at the Farallones from March to May were higher than or equal to the 32-year averages for each of those months (Fig. 6a, b). Sea-surface temperatures were then cooler than the average in June and July before rising again in August. The mean seasonal SST from March to August (12.07°C) was 0.5 degrees warmer than last season, but approximately equal to the 32-year average of 12.0°C for these months. Generally, relatively low SSTs are correlated with high ocean productivity in the California Current System (Barber et al. 1985). The increase in water temperature during 2003, a moderate El Niño, likely contributed to lower overall ocean productivity and corresponding reduced seabird reproductive success this season. Other indicators of reduced ocean productivity were a reduction in the number of Cassin's Auklets successfully raising second broods, the relative decline of juvenile rockfish (*Sebastes* sp.) in chick diet of COMU, PIGU, and RHAU (Fig. 8), and the occurrence of emaciated sea lions (*Zalophus californianus*) hauling out in the seabird colonies and feeding on or scavenging adults and chicks.

Productivity of Western Gulls was relatively high this season, though lower than 2002, and still below the long-term mean (Fig. 1). Productivity for this species has suffered a general decline over the past 15 years, hypothesized to relate to changes in prey availability combined with increased intraspecific predation (Sydeman et al., 2001). However, further studies are needed to test the mechanisms supporting the long-term reduction in WEGU productivity. The WEGU breeding population on SEFI has also exhibited a general downward trend over the past decades. While the population estimate for 2003 increased by 11% compared to last season, it is still 15% below the 10-year average (Fig. 7).

Breeding population sizes were higher than the 2002 estimates for all species with the exception of DCCO (19% lower) and PIGU (approximately equal to 2002), but were still lower than the 10-year average for PIGU, and WEGU. Population growth above 2002 estimates ranged from 3.4% (COMU) to 26% (CAAU).

Cassin's Auklets on the Farallones have declined considerably since 1971 (Ainley et. al. 1994, Fig. 7), and although the burrow counts for 2003 were 26% higher than in 2002 (and have increased each of the past four years), they are just now approaching the numbers observed prior to 1998 (Table 3). Productivity for this species has been high for the past 5 years and we expect this trend to continue as long as favorable oceanographic conditions and prey fields persist.

Sydeman et al. (1998) reported a 35% decline in ASSP numbers from 1972 to 1992. Future analyses of mark/recapture studies will examine if this decline has continued. Storm-petrel productivity has also declined in the past decade. Reasons for this decline are as yet unknown. Predation by Western Gulls, Burrowing Owls (*Athene cunicularia*), and possibly by the introduced House Mouse (*Mus musculus*) is suspected. Studies to determine the effects of mice on ASSP have been conducted over the past three years, but to date, no evidence of egg or chick predation has been documented.

Brandt's Cormorants and Pelagic Cormorants also have declined substantially over the past two decades (Nur and Sydeman 1999, Fig. 7), and although both populations have grown substantially over the past three seasons, the numbers remain well below those observed in the 70's and 80's. Much of the growth of the BRCO population is due to increased survival and recruitment of young into the colony over the past four seasons. Of the 99 monitored nests of known-age birds, 80 were attended by birds that hatched in 1999 or later. Decreased productivity in 2003 as well as potentially reduced survival of the 2002 cohort associated with the weak 2002/2003 El Niño may slow this recovery, but we anticipate continued population growth in general owing to strong cohort production in 1999-2001.

In summary, 2003 exhibited many classic signs of an El Niño year: reduced productivity, likely related to changes in prey availability, delayed breeding (not discussed), high rate of nest abandonment, lower chick growth rates (not discussed) and warmer sea surface temperatures (Fig. 6a, b). However, the impact of the first El Niño of the current "cold water" regime was much less severe than those of the past.

Relatively cool water temperatures in June and July may have positively affected prey availability during the chick-rearing period for many species. Positive signs such as the continued high productivity of Cassin's auklets, the continued presence of juvenile rockfish in the diet of piscivorous species, and continuing population growth for most species are very encouraging, especially if oceanic conditions in 2004 (and beyond) return to those observed between 1999-2002.

RESEARCH AND MANAGEMENT RECOMMENDATIONS

In addition to the continuation of research efforts, we recommend the following actions (listed in order of priority) for enhancing the protection, conservation and management of seabirds on SEFI:

1. To further our understanding of ASSP population trends and to determine if the population has further declined, the mark/recapture study should be continued in FY 2004. There is a need to determine the current state of the ASSP population on the island. However, in light of potential limitations of mark/recapture analysis to adequately determine population levels for this species, alternative methods to census the population should also be devised. Reproductive success is also continuing to decline, and is cause for concern. While we can accomplish fieldwork with available funds, costs for analysis and write-up cannot be met with present resources, and additional support is desirable.

2. Because Cassin's Auklets have declined dramatically on SEFI over the past three decades, we recommend detailed analysis of existing demographic data. The purpose of this analysis would be to: (1) estimate vital statistics (fecundity, recruitment and survival rates), (2) investigate long-term population viability and (3) determine if oceanographic and/or island-based factors are causes for the population declines. A population dynamics model and population viability assessment is currently being developed for SEFI CAAU. Additional funds are needed for the completion of this work.

3. In 2003 we established Rhinoceros Auklet burrow index plots at suitable locations around the island to aid in estimating breeding population size. We further recommend the use of an infrared camera to determine occupancy in natural burrows. On Año Nuevo Island, occupancy of breeding RHAU in natural burrows varies from approximately 70 to 90% (Thayer et al. 1998), indicating that breeding birds may dig more than one burrow or that non-breeding birds also dig burrows for shelter. Occupancy rates, in conjunction with burrow counts, quantification of habitat types, and mark/recapture analysis of current banding data, will provide the most accurate estimate of breeding population size.

4. A complete, island wide census of burrows has not been conducted since 1989 (see Carter et al, 1992). We recommend that this be done using the same methodology (preferably by the same researchers) in order to establish new, baseline population numbers for burrow/crevice nesting species.

5. To further our understanding of the foraging ecology of SEFI seabirds, we recommend the use of technology-based research techniques such as Time-depth recorders and radio telemetry. This newly available technology will greatly enhance our ability to examine marine habitat usage and foraging behavior, which will be important in the establishment of Marine Protected Areas around the Farallones and the future conservation and management of these seabird species.

6. Rhinoceros auklet productivity on SEFI has remained low despite improved oceanic conditions, and is usually between 10-15% lower than on Año Nuevo Island (Thayer and Sydeman, 2002). We recommend more detailed, proximate analysis of diet data in order to examine the causes of the chronically low productivity on SEFI.

7. Because Brandt's and Pelagic cormorants have declined significantly over the past three decades, we recommend more detailed analyses of data concerning breeding success and population trends to determine the causes of these decreases.

8. The Murre Blind has fallen into disrepair in the 30+ years since it was built and we recommend its replacement. This blind is one of the most important sites for our continued monitoring of Common Murres and Brandt's Cormorants. In addition, we recommend the establishment of an additional blind by "the Gap" that would allow us to monitor (without disturbance) the growing colonies of BRCO and COMU at Sea Lion Cove. Both of these projects are currently in the planning stage, but funds will be needed for their completion.

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Table 1. Mean (± 1 SD) productivity of eight species of seabirds at Southeast Farallon Island, California, 2003. Sample sizes in parentheses. All values based on first attempts only unless stated otherwise.

Species	Clutch Size (no. eggs laid)	Brood Size (no. chicks hatched)	Chicks Fledged/Pair	Chicks Fledged/Pair (includes relays)	Hatching Success	Fledging Success
BRCO	2.69 ± 0.68 *(84)*	1.71 ± 1.27 *(86)*	1.01 ± 1.09 *(91)*	1.01 ± 1.09 *(91)*	0.65 ± 0.45 *(74)*	0.62 ± 0.37 *(54)*
PECO	3.07 *(15)***	2.44 ± 0.74 *(49)***	2.21 ± 0.78 *(47)*	2.21 ± 0.78 *(47)*	0.86 ± 0.67 *(15)***	0.92 ± 0.15 *(47)*
WEGU	2.91 ± 0.32 *(148)*	2.05 ± 0.99 *(148)*	0.81 ± 1.04 *(147)*	0.81 ± 1.04 *(147)*	0.70 ± 0.33 *(148)*	0.38 ± 0.42 *(132)*
COMU* USP	1.00 *(172)*	0.68 ± 0.47 *(112)*	0.72 ± 0.45 *(127)*	0.72 ± 0.45 *(127)*	0.80 ± 0.40 *(138)*	0.94 ± 0.24 *(97)*
COMU* Upper Upper	1.00 *(21)*	0.86 ± 0.36 *(21)*	0.84 ± 0.37 *(19)*	0.84 ± 0.37 *(19)*	0.86 ± 0.36 *(21)*	1.00 *(16)*
PIGU	1.89 ± 0.32 *(90)*	1.56 ± 0.73 *(87)*	0.91 ± 0.63 *(77)*	0.92 ± 0.62 *(77)*	0.81 ± 0.36 *(86)*	0.62 ± 0.32 *(64)*
RHAU*	1.00 *(66)*	0.39 ± 0.47 *(67)*	0.45 ± 0.50 *(67)*	0.45 ± 0.50 *(67)*	0.70 ± 0.46 *(66)*	0.65 ± 0.48 *(46)*
CAAU*	1.00 (40)	0.75 ± 0.44 *(40)*	0.70 ± 0.46 *(40)*	0.90 ± 0.50 *(40)*	0.75 ± 0.44 *(40)*	0.93 ± 0.26 *(29)*
ASSP*	1.00 (22)	0.68 ± 0.48 *(22)*	0.50 ± 0.51 *(22)*★	**NA**	0.83 ± 0.38 *(18)*	0.73 ± 0.46 *(15)*

* COMU, RHAU, CAAU and ASSP lay only one egg per clutch
** PECO sites are difficult to see into. Numbers are based on the maximum number of eggs or chicks observed.
★ ASSP productivity estimates include only those chicks that fledged by mid-November

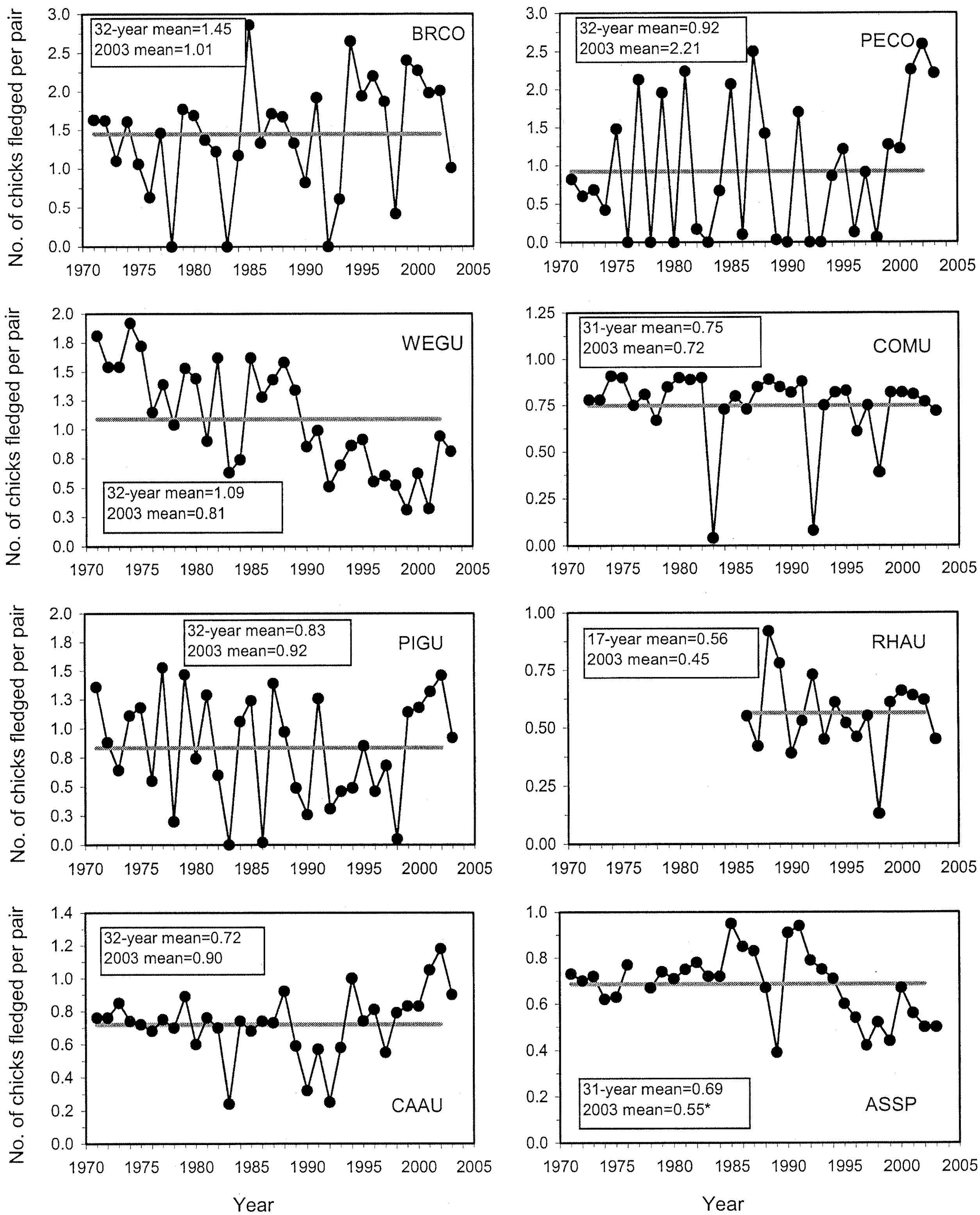
Table 2. Breeding population size estimates of seabird species on the South Farallon Islands, 1993-2003. Estimates include Southeast and West End Islands unless noted.

Species	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1993-2003 average
ASSP [m]	?	?	?	?	?	?	?	?	?	?	?	?
DCCO	392	486	402	402	468	330	188[c]	444	462	586	408	443
BRCO	11,222	9,466	6,570	5,896	6,345	5,092	7,490	8,074	10,630	11,740	4,648	7,595
PECO	510	442	416	260	222	164	316	374	374	570	?	349
WEGU	16,838	15,095	18,235	15,544	19,767	19,707	23,807	20,815	24,630	21,360	20,103	19,906
BLOY	26	22	30	26	30	18	22	12	6	12	20	20
COMU	107,105	103,588	68,194	53,301	58,878[b]	52,670	61,089	65,400	69,600[p]	?	44,400[p]	64,124
PIGU	500	499	502	568	468	294	1273	728	1650	944	260	719
TUPU	?	128	102	74	118	50	130	92	100	130	104	103
CAAU [m]	23,692	18,807	16,690	15,239	15,239	10,458	26,892	23,668	25,325	25,325	23,668	20,131
RHAU	?	?	?	?	?	?	?	?	?	?	?	?

[a] Estimate from Sydeman et al. (1998).
[b] Ammendment to the 1999 COMU population estimate.
[c] Low estimate due to counting of nests from Cormorant Blind Hill where visibility of sites was reduced.
* Estimate for 1989 from Carter et al. (1992).
[m] Estimates for Southeast Farallon Island only.
[p] Estimates from Sydeman et al. (1997).

Table 3. Cassin's Auklet burrow counts from 12 (10m x 10m) index plots on Southeast Farallon Island, 1991-2003.

Year	MT1	MT2	MT3	S4	S5	S6	S7	MT8	R9	N10	EA	EB	Total
1991	18	9	12	43	42	22	31	20	80	49	14	27	367
1992	18	11	14	24	33	14	25	26	80	43	15	24	327
1993	13	9	13	29	34	14	19	12	82	42	12	12	291
1994	19	13	15	20	28	10	13	21	89	47	15	22	312
1995	18	8	19	21	24	26	19	21	88	34	17	16	311
1996	9	10	13	18	19	19	7	14	97	45	14	24	289
1997	20	11	18	18	20	15	9	21	97	52	13	37	331
1998	9	6	5	8	8	7	6	7	36	17	5	13	127
1999	7	3	17	7	9	10	5	10	65	32	7	17	189
2000	11	2	4	9	11	4	10	14	61	32	9	20	187
2001	14	4	12	12	15	5	7	19	58	36	7	16	205
2002	20	9	20	14	20	14	8	13	47	45	6	15	231
2003	20	9	22	15	26	7	15	15	84	49	8	21	291
1991-2002 average	14	8	13	19	22	13	14	17	76	39	12	21	264



* Estimate only includes those chicks that fledged by mid November.

Fig. 1a. Productivity of 8 species of seabirds on Southeast Farallon Island, 1971-2003. Productivity is measured as number of chicks fledged per breeding pair (includes first attempts, relays and second broods). The bold horizontal line indicates mean productivity from all attempts between 1971 and 2002. Please note the different scales on the y-axis.

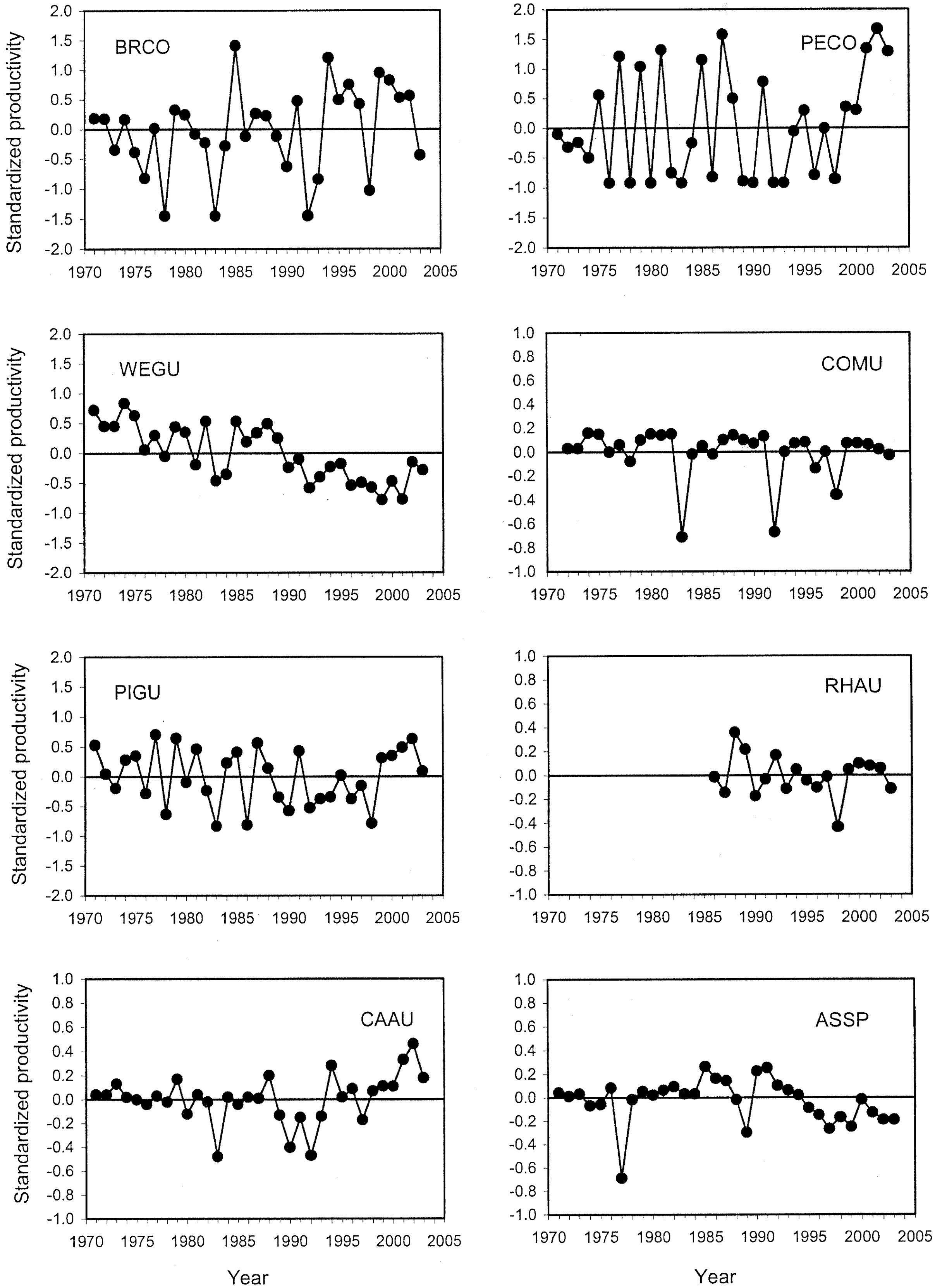


Fig 1b. Standardized productivity anomalies (annual productivity - long term mean) for 8 species of seabirds on SEFI, 1971-2003.

Brandt's Cormorant Census

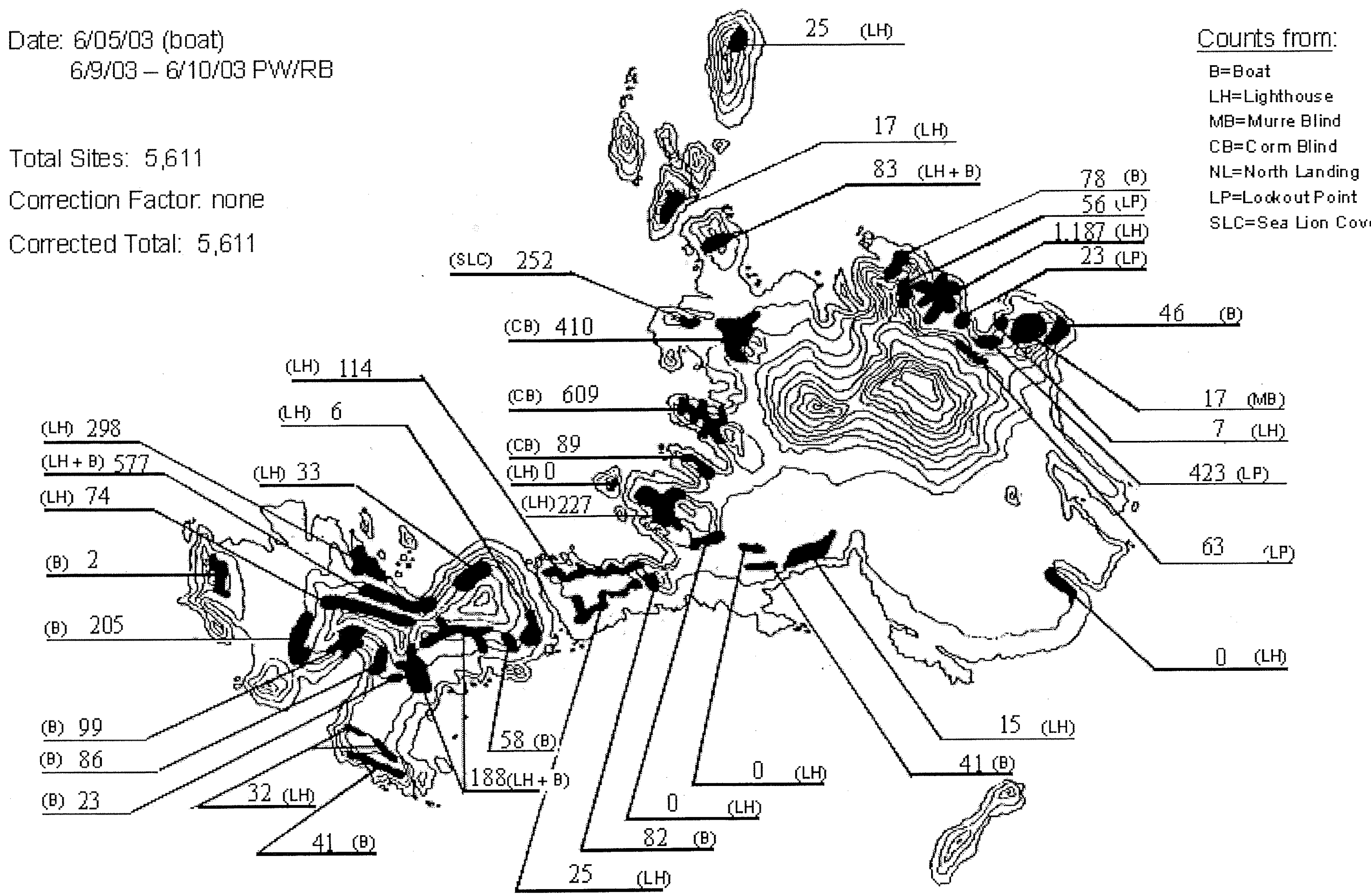


Figure 2: Counts of Brandt's Cormorants on Southeast Farallon Island during the 2003 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), and Boat (B).

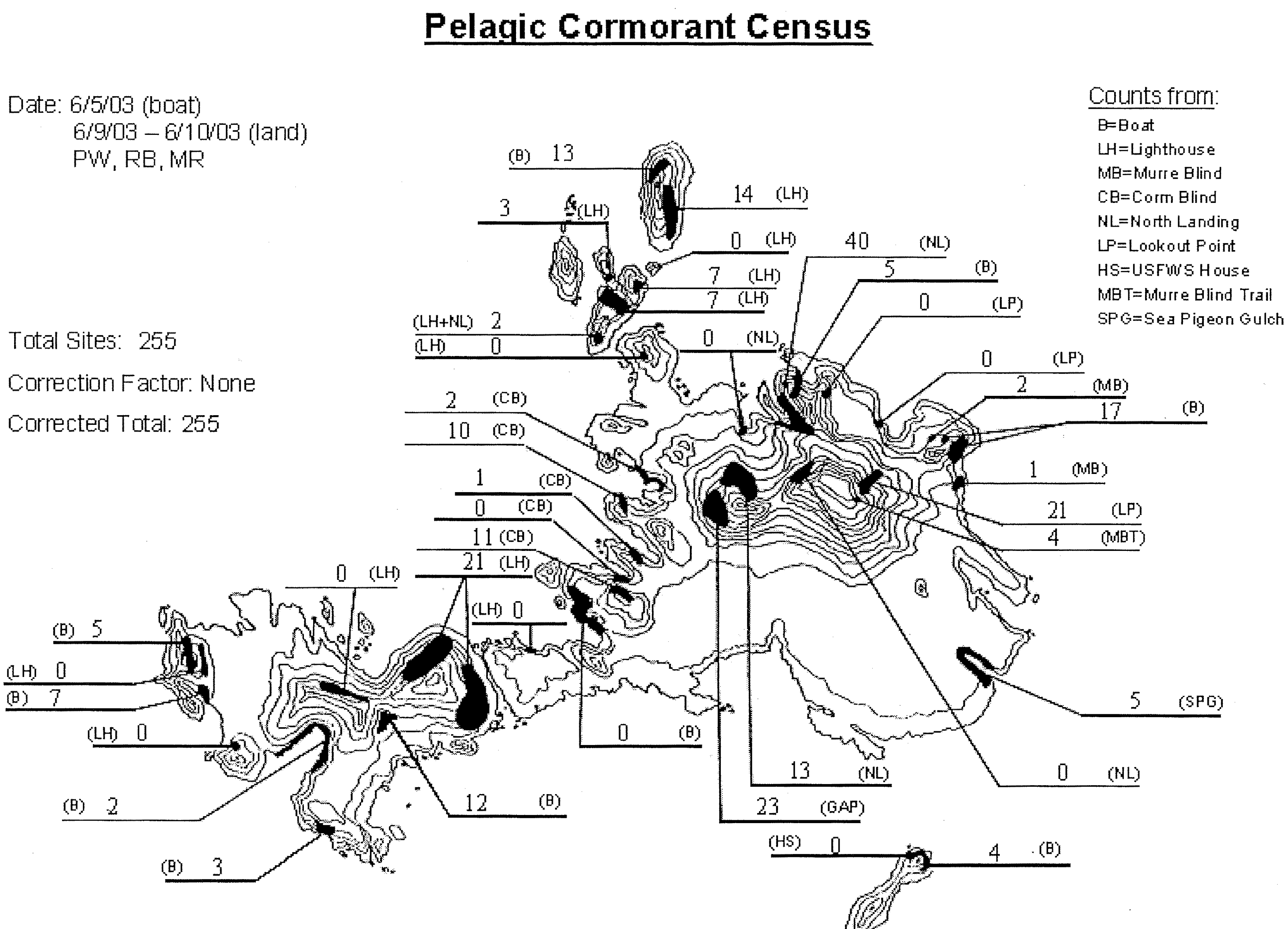


Figure 3: Counts of Pelagic Cormorants on Southeast Farallon Island during the 2003 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Lookout Point (LP), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), USFWS House (HS), Murre Blind Trail (MBT), Sea Pigeon Gulch (SPG), and Boat (B).

Western Gull Census

Date: 6/2/03 – 6/3/03

PW, RB

Total Counted: 11,354 (+7655 R)

Correction Factor: 1.483

Corrected Total: 16,838

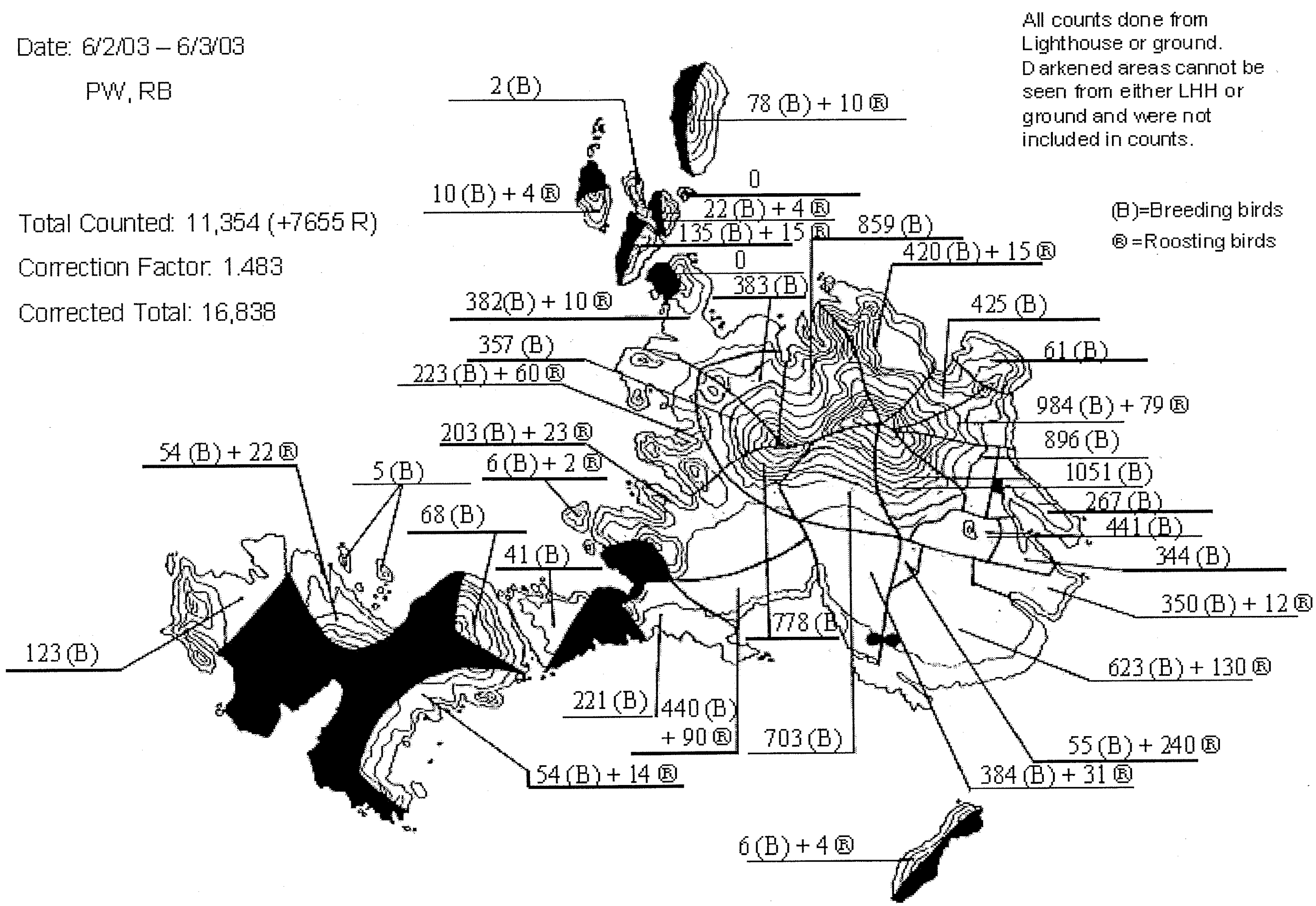


Figure 4: Counts of Western Gulls on Southeast Farallon Island during the 2003 census.

Common Murre Census

Date: 5/27/03 – 6/01/03
PW, RB, WS

Total Counted: 37,131
Correction Factor #1: 1.5
Corrected Total #1: 55,697
Correction Factor #2: 1.923 (boat)
Final Corrected Total: 107,105

Counts from:
B=Boat
LH=Lighthouse
MB=Murre Blind
CB=Corm Blind
NL=North Landing
LP=Lookout Point
HS=USFWS House

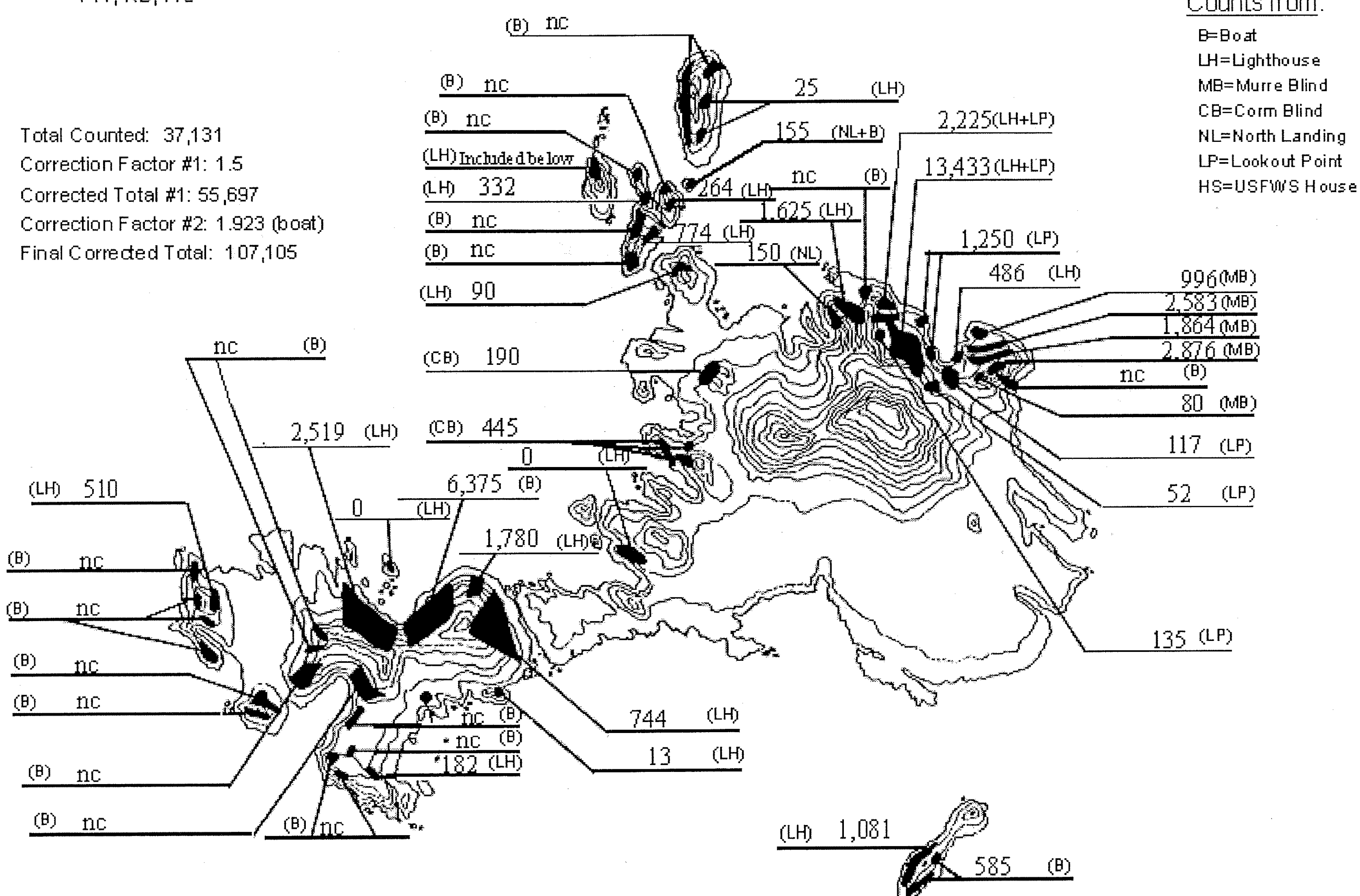


Figure 5: Counts of Common Murres on Southeast Farallon Island during the 2003 census. Surveys were conducted from the following locations: Lighthouse Hill (LH), Lookout Point (LP), Murre Blind (MB), Cormorant Blind (CB), North Landing (NL), USFWS House (HS). The boat survey (B) could not be done this year.

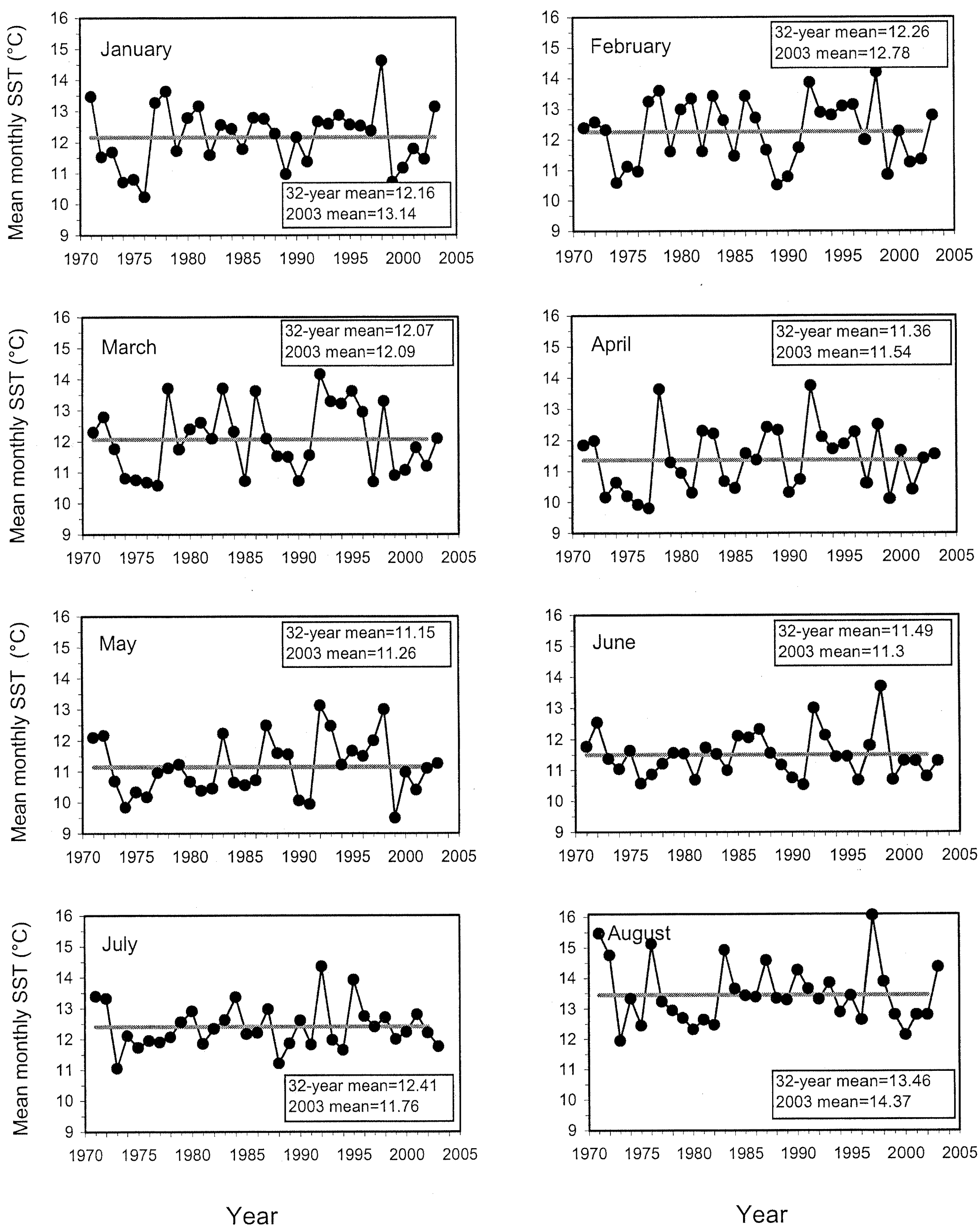


Fig. 6a. Monthly mean sea surface temperature (SST) at Southeast Farallon Island, 1971-2003. SST was measured daily from Water Sample Point near East Landing. The bold horizontal line indicates mean monthly SST from 1971 to 2002.

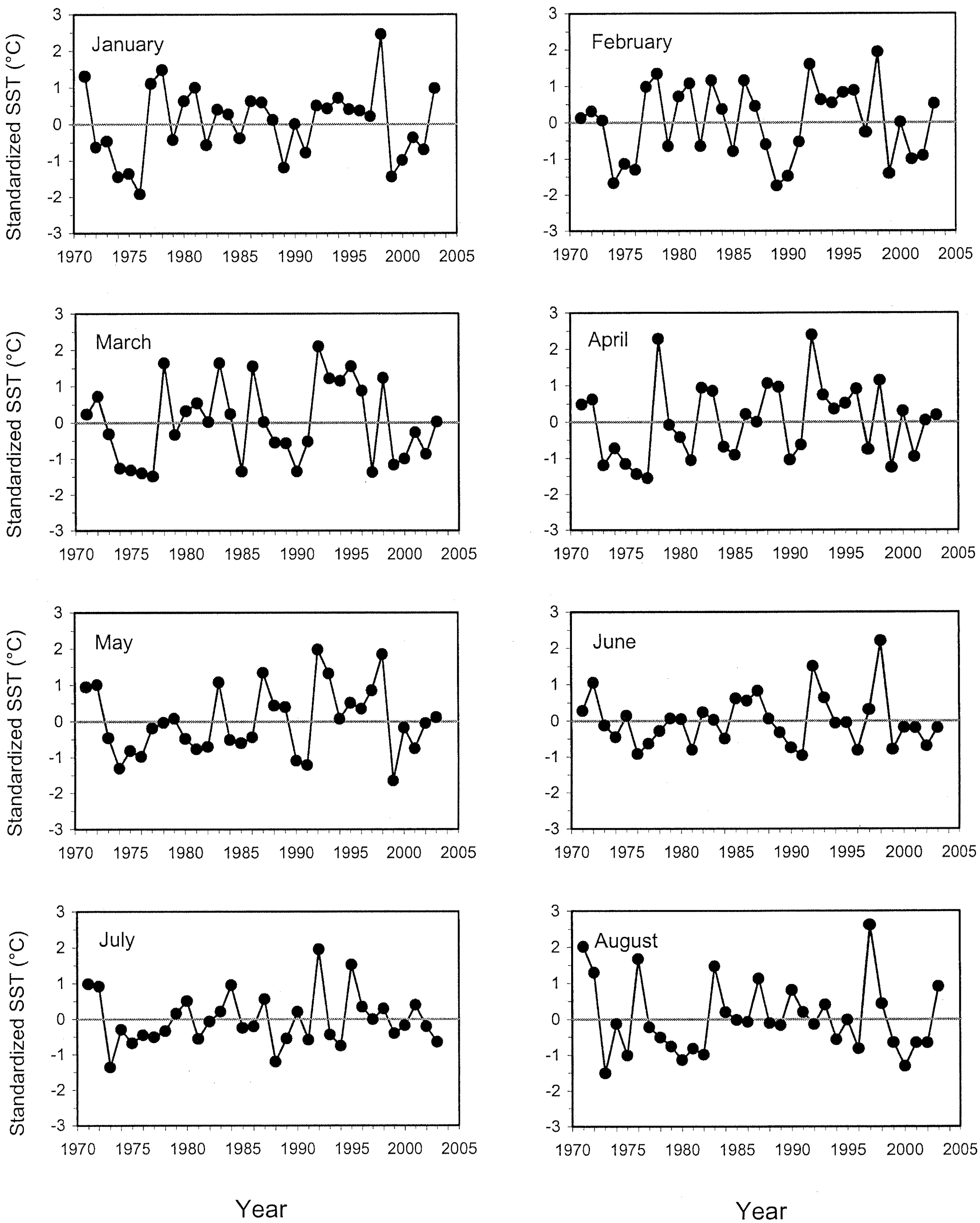


Fig. 6b Standardized Sea Surface Temperature (SST) anomalies (annual mean - long term mean) for SEFI, 1971-2003.

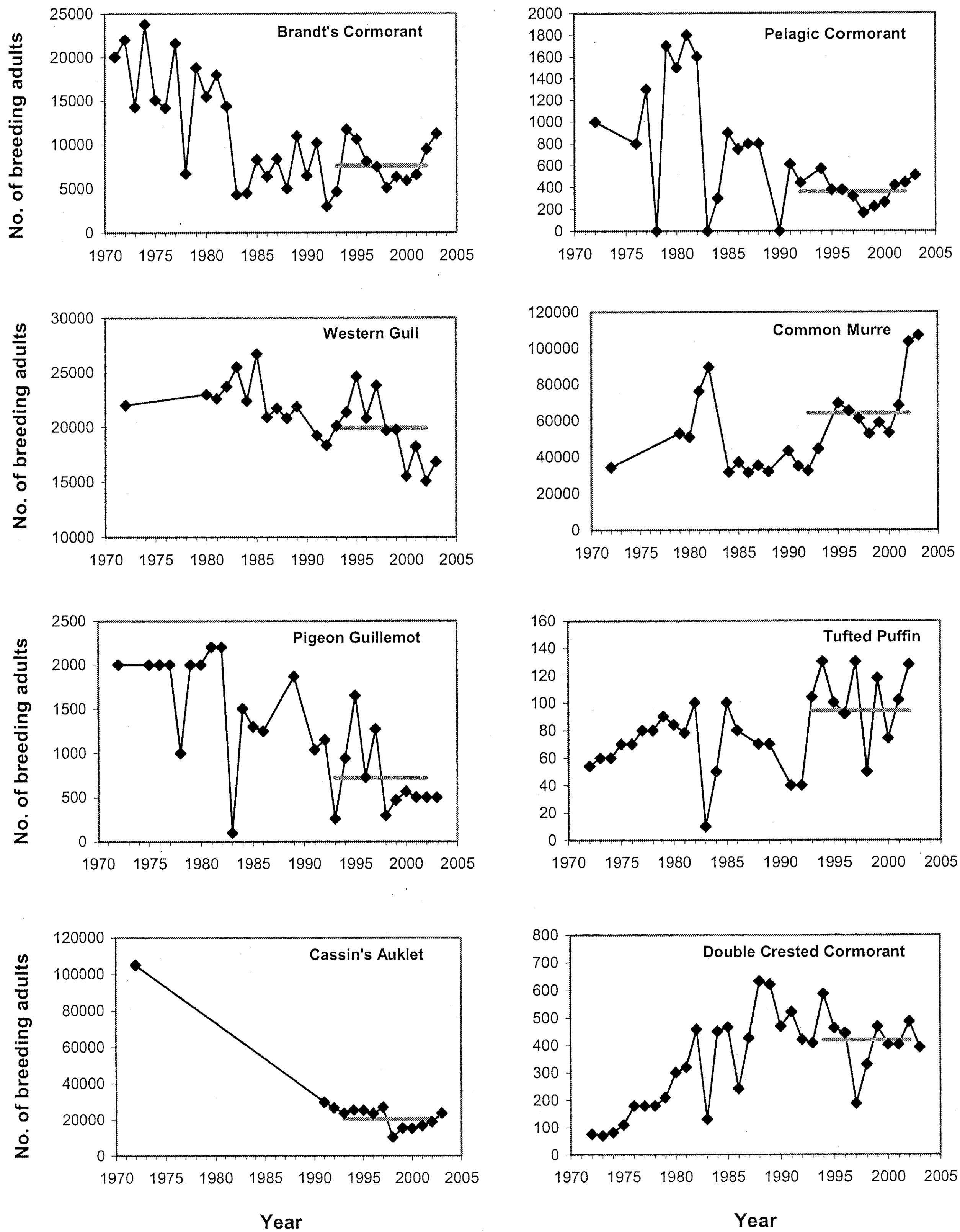


Fig. 7 Population trends for 8 species of seabirds on Southeast Farallon Island, 1972-2003 Populations were determined by counting either individuals or nests on all visible areas on SEFI and West End. Please note the different scales on the Y-axis. The bold horizontal line represents the 10-year average population.

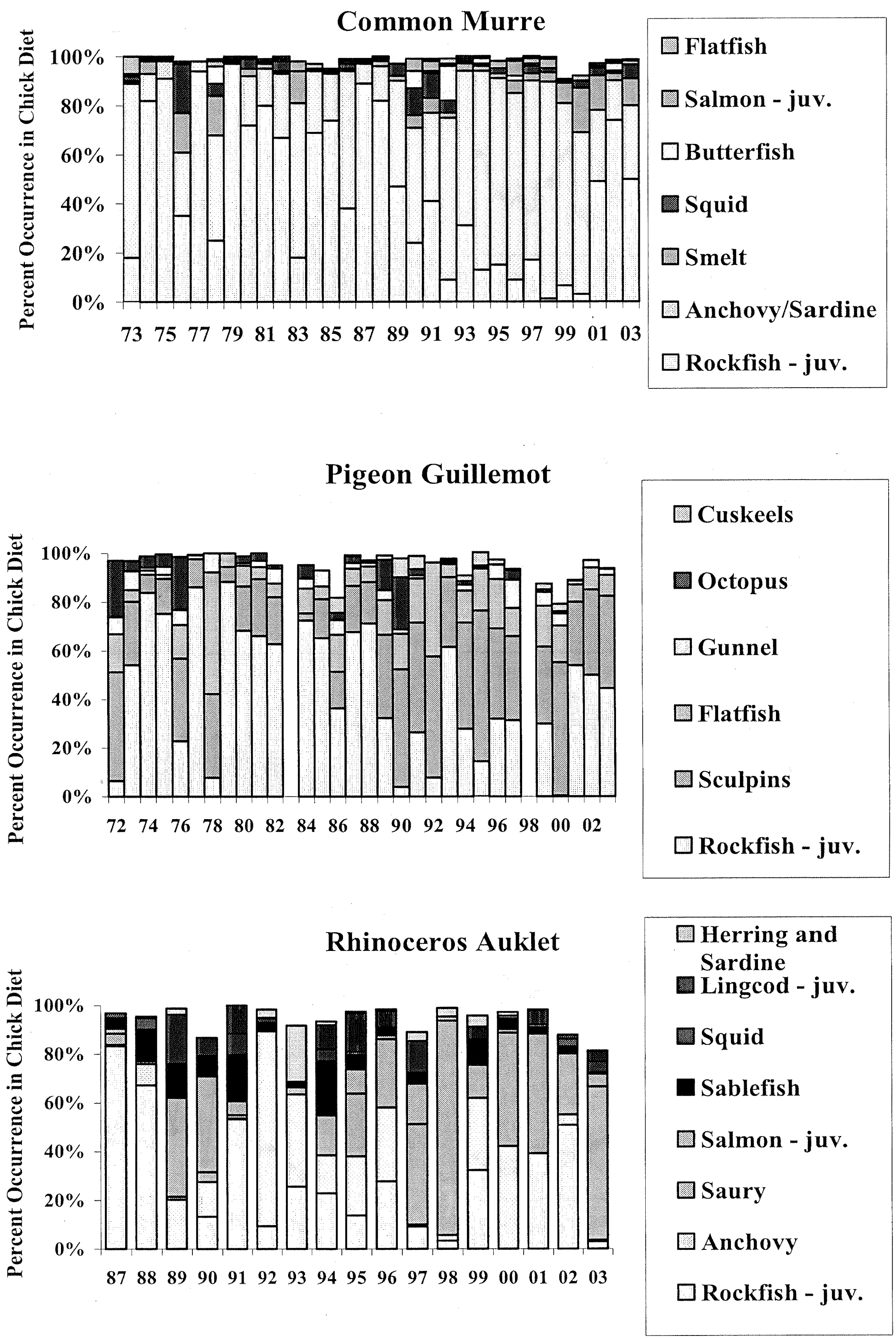


Fig. 8 Percent occurrence of common prey items in the diet of three species of seabirds on Southeast Farallon Island.

Appendix I. Calculation of correction factor for Western Gull population census, 2003.

Area	Nest Count	Bird Count	Correction Factor
C	100	178	1.124
K	150	169	1.775
H (H1 only)	238	307	1.550
Total			**1.483**

Appendix II. Calculation of correction factor for Common Murre population census, 2003. The correction factor was derived by multiplying the number of breeding sites in three study plots (USP, UU, and X) by 2, and then dividir product by the mean number of adults present in each plot on the census The correction factors generated for each plot were then averaged to derive a correction factor for the entire population.

USP

Date (Time)	Breeding Sites	No. of birds	Correction Factor
May 27 (1000)	158	197.00	1.60
May 28 (1015)	158	190.30	1.66
June 1 (1028)	158	196.60	1.61
Mean	158	194.63	**1.62**

UU

Date (Time)	Breeding Sites	No. of birds	Correction Factor
May 27 (1002)	21	29.00	1.45
May 28 (1045)	21	25.30	1.66
June 1 (1030)	21	28.00	1.50
Mean	21	27.43	**1.54**

X plot

Date (Time)	Breeding Sites	No. of birds	Correction Factor
May 27 (1038)	52	78.00	1.33
May 28 (1015)	52	72.60	1.43
June 1 (1028)	52	85.00	1.22
Mean	52	78.53	**1.33**

Mean correction factor for SEFI 2003: **1.50**

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Biological Rationale for Artificial Night-Lighting Concerns in the Channel Islands

22 July 2001

By Nora Rojek, Seabird Specialist, Marine Region

Evidence of detrimental effects of artificial light to birds:

There is a growing body of scientific evidence that birds of many different species are attracted to lighted man-made structures. Early accounts noted the attraction of birds to fires and lighthouses (Bretherton 1902, Verheijen 1958, Verheijen 1981, also see early literature accounts in Reed et al. 1985). Most of the recent literature documents the attraction of birds to the artificial lights of communication towers and other tall lighted structures, and documents that extinguishing lights stops or prevents birds' responses (Cochran and Graber 1958, Aldrich et al. 1966, Herbert 1970, Avery et al. 1976, Avise and Crawford 1981, Crawford 1981a, Crawford 1981b, Verheijen 1981, Larkin and Frase 1988, Fedun 1995, Bower 2000. See also reference lists on following web sites for multiple citations: reference list on light pollution, http://debora.pd.astro.it/cinzano/refer/node8.html; light effects on wildlife references, http://fwie.fw.vt.edu/jlw/light.html; bird kills at towers and other human-made structures, an annotated partial bibliography, http://migratorybirds.fws.gov/issues/tower.html).

Most of these studies and papers note that birds are spatially disoriented by lights, and usually flutter around the light until they fall down from exhaustion or actually hit the object, resulting in injury or immediate death. Most also note that fog or low cloud cover makes the attraction problem worse, because the moisture droplets associated with overcast conditions increase the area illuminated by refraction.

Seabird attraction to man-made lights, including ship lights, has been noted worldwide, particularly among the Procellariiformes, which include albatrosses, petrels, shearwaters, storm-petrels and diving-petrels, as well as, for the Alcidae (which include murrelets, murres, auklets, guillemots, and puffins) (Howell 1910, McLellan 1926, Miller 1936, Verheijen 1958, DeLong 1967, DeLong 1968a, DeLong 1968b, DeLong and Brownell 1968, Manuwal 1974, Jehl and Bond 1976, Byrd et al 1978, Dick and Donaldson 1978, Reed et al. 1985, Telfer 1987, Cherel et al. 1996, Carter et al. 1996, Whitworth et al. 1997, Chardine and Mendenhall 1998, Ryan and Watkins 1999, Carter et al. 2000, and Weimerskirch et al 2000). Literature as early as 1958 (Verheijen) note that the attraction of seabirds to lighthouses and lightships is a well-known phenomenon.

Breeding seabirds and their young of the year are attracted to lights, which can be disastrous for declining or endangered species. In Hawaii, the threatened Newell's shearwater (*Puffinus auricularis newelli*), the endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*) and very rare Band-rumped Storm-Petrel (*Oceanodroma castro cryptoleucura*) have been attracted to city lights since at least the 1950's (Byrd et al. 1978, Reed et al. 1985, Reed 1987, Telfer et al 1987, Harrison 1990). At least 1000 individuals (predominately Newell's shearwater fledglings on their first flights several km from mountainous nesting areas to the ocean) become disoriented and collide with city lights on Kauai. Birds may be killed on impact, injured, or preyed upon. An active education program has been in place on the island since 1978, including rehabilitation of injured birds and a light shielding and reduction program (Reed et al.1985). Shielding lights reduces attraction about 39%, but does not eliminate the problem. Despite these efforts, the Newell's shearwater numbers have been declining 13% each year since the 1993 hurricane and current population size is estimated at 20,000 birds (Tom Telfer, Wildlife Biologist, State of Hawaii, Department of Land and Natural Resources, pers. comm.).

Verheijen in 1958, noted that "birds can be captured with light." Since that time, the scientific community has actually used artificial lights as a technique for capturing birds for research purposes. This technique to disorient birds, allowing easy capture, as been used for a variety of species and reported in the literature, including several species of waterfowl (Cummings and Hewitt 1964, Bishop and Barratt 1969), Trumpeter Swans (Drewien 1999), Common Eiders (a sea duck) (Snow et al. 1990), Double-crested Cormorants (King et al. 1994), and Leach's and Fork-tailed Storm-petrels (Williams 2000). In the Channel Islands, this technique has been used to capture Xantus's Murrelets for radiotelemetry studies (Whitworth et al. 1997, Carter et al. 2000).

The attraction of seabirds to lights of commercial fishing vessels has been noted in observer programs for longline fisheries (see discussion below) (Cherel et al.1996, Ryan and Watkins 1999, and Weimerskirch et al. 2000). In addition, a few examples of large seabird wrecks have been noted in the literature. Dick and Donaldson (1978) documented over 6,000 crested auklets (*Aethia cristatella*) landing aboard a crab-fishing vessel near Kodiak Island, Alaska on 18 January 1977. The boat had bright fishing lights on and the crew feared they might capsize. After the crew finally realized that their outside lights attracted the birds and turned them off, the number landing on board decreased. Several hundred birds were still on the boat the following day.

While this is a dramatic example, the authors note that seabird wrecks are not uncommon on fishing vessels and floating processors in Alaskan waters, and that "almost every fisherman with two or more years of experience can relate instances where hundreds of seabirds flew onto his vessel, often during a storm, though the conditions of such occurrences seem to vary." Large breeding colonies of auks and storm-petrels are found in Alaskan waters (for example, crested auklet population estimated at 3 million, Gaston and Jones 1998), which would allow observations of such large wrecks to be possible. Breeding seabird populations in the Channel Islands are much lower: the estimated number of breeding Xantus's Murrelets is only about 3,350 individuals and the estimated number of breeding Ashy Storm-Petrels is only about 4,046 individuals (McChesney et al. 2000b, and Carter, Humboldt State University- U.S. Geological Survey, pers. comm.), thus squid fishing vessels in Channel Island will not be observing such occurrences. These examples from Alaska and other locations where larger seabird colonies exist (see also personnel communications below), however, demonstrate that seabirds do become disoriented and collide with vessel lights. The number that collide with vessels and the impact of those mortalities on a species' viability depends on population parameters such as reproductive output, natural mortality, size, and current trends.

Mitigation measures to decrease attraction of seabirds to artificial vessel lights in longline fisheries around the world:

No observer program has been established for the squid fishery or for general boat activity in the Channel Islands. Without such a program it is difficult to assess the numbers of seabirds that have collided, been injured or killed, or directly altered their behavior as a result of interactions with lights.

Many observer programs exist for longline fisheries in several countries and in international waters. These programs were established and have documented the bycatch of 1000s of seabirds, particularly albatrosses and petrels which are attracted to and dive after the baited hooks, and thus die. While most of the seabird species attracted to the longlines are diurnal (such as albatrosses), what is important to note is that through these observer programs, observations document seabird attraction to lighted vessels at night wherever the fisheries occur, even hundreds of miles from colonies (Cherel et al. 1996, Ryan and Watkins 1999, and Weimerskirch et al. 2000). In addition, seabirds such as storm-petrels (which are not diving after the bait) are documented on board such vessels. Mitigation measures for reducing seabird bycatch in the longline fisheries from several countries acknowledge that birds are attracted to lights and require minimal vessel light use at night for this reason. Organizations working on reducing seabird bycatch, such as BirdLife International - Seabird Conservation Programme, include in their general recommendations for avoiding seabird bycatch in longline fisheries to keep deck lighting to a minimum (without compromising safety) and all deck lights should be shaded and be directed towards the deck (see web site: www.uct.ac.za/depts/stats/adu/seabirds/bycatch.htm).

Examples of the type of observations and mitigation measures from these programs are described below:

1)The Patagonian toothfish longline fishery observer program, in the area of Prince Edward Islands (which is a Special Nature Reserve as of 1995, and has numerous seabird colonies) in sub-Antarctic, recorded 54 birds colliding with vessels fishing around the islands during 90 nights of fishing during 1998-1999 (Ryan and Watkins 1999, and Deon Nel, BirdLife International - Seabird Conservation Programme, pers. comm.). The vessels were a minimum of 5 km (3.1 miles) from the island and a maximum of 200 km (124.2 miles). Birds that collided with the vessels included Grey-backed and Black-bellied Storm-petrels, and Common and South Georgian Diving petrels. Deon Nel (Biologist, BirdLife International - Seabird Conservation Programme, South Africa) can confirm that it is a common occurrence for seabirds to collide with lighted vessels (both fishing and research vessels) near Prince Edward Islands in sub-Antarctic. **The regulations for this longline fishery prohibit the use of external lights on vessels fishing within 200 nautical miles of the islands**.

2) The Commission for the Conservation of Antarctic Marine Living Resources (the organization that regulates Antarctic fisheries) implemented conservation measures to decrease incidental seabird mortality in longline fisheries. Conservation Measure 29/XIX, includes adoption of the following measure: "Longlines shall be set at night only. **During longline fishing at night, only the minimum ship lights necessary for safety shall be used."** (From the Conservation Measures and Resolutions adopted at CCAMR-XIX, available on the web site, www.ccamlr@ccamlr.org).

3) A 1994 longliner observer program in the sub-Antarctic, in the vicinity of South Georgia and Kerguelen Islands (two internationally important breeding areas for albatross and petrel species), documented marked differences in the mortality rate of seabirds during night-time fishing depending on whether deck lights were on or off (0.59 versus 0.15 birds caught per 1000 hooks) (Cherel et al.1996).

4) During a four-year observer program of trawlers and long-liners in the Kerguelen Exclusive Economic Zone in the sub-Antarctic, all deck illumination was cut off during night setting. (Weimerskirch et al. 2000). Storm-petrels and petrels were the most abundant bycatch species in numbers around long-liners. The numbers of birds attracted to the boats increased as the breeding season progresses. The researchers concluded that during chick rearing, these species are performing shorter trips to increase chick provisioning, which in turn makes them more likely to encounter fishing vessels. Included in the mitigation measures tested during the program was night setting with no deck illumination. They concluded that **"Night setting with deck lights off seemed to be the most efficient measure in reducing seabird mortality when not associated with day setting."**

5) In the Australian long lining fishery, mitigation measures in the Threat Abatement Plan (management actions for threatened species or environments in Australia) for the incidental catch (or by-catch) of seabirds during oceanic longline fishing operations notes that **"deck lighting on vessels can attract birds during night setting and should be minimized while ensuring the safety of the crew."** (Web site: www.biodiversity.environment.gov.au/threaten/tap/longline/index.html).

Additional Personal Observations of Seabird Attraction to Lighted Vessels by Seabird Biologists:

I have been corresponding with seabird biologists from around the world, and most convened that this is little research that has been done to systematically assess the conditions under which seabirds are attracted to ship's lights, including distances from the breeding colonies. A few examples of known distances from colonies are explained below, as well as some personal observations from the Channel Islands.

1) Maura Naughton (Seabird Biologist, U.S. Fish and Wildlife Service, Migratory Birds and Habitats Program) worked on research vessels in the Channel Islands in 1976 and 1977. She related the following observations to me: "While working in the Channel Islands in 1976-1977, we frequently anchored the boat close to the islands. I remember one night in the landing cove at Santa Barbara Island during the late spring or early summer when young Xantus's murrelets (XAMU) were leaving the island. We had the deck lights on and a pair of murrelets and their downy young were soon swimming around the boat. Both adults and young appeared to be disoriented by the lights. California sea lions were also swimming around the boat and on at least one occasion a sea lion swam up under a XAMU chick and bumped it with its nose. Adult and young XAMU were becoming separated, so we turned out the lights. It is important to note that these were not particularly bright lights, just the typical deck lights on a 60' sport fisher. Unfortunately this was so long ago I do not remember the weather on this evening e.g. foggy or clear. Many times during our travels through the Channel Islands we would encounter Ashy Storm-Petrels on the deck at night, apparently attracted by the lights. On more than one occasion, as night fell, we heard Ashy Storm-Petrels calling and then saw them walking out from small dark crevices or cupboards on the boat where they had secreted themselves the night before." She does not remember what distances the vessel was at during these observations.

2) Paul Kelly (Environmental Specialist, CDFG, OSPR) recently related, by email, the following observations from the Channel Islands: "I want to relate to you observations I made last Friday evening (May 11, 2001) on the effects of light on Xantus's Murrelets at Anacapa Island. I was on the Channel Islands National Park Service vessel Ocean Ranger which was anchored about 500 yards offshore at East Fish Camp Cove on the south side of middle island from 1800 hours to 2400 hours. The trip was arranged for media representatives to view the American Trader - Anacapa Is. seabird restoration project. There were about 10 biologists and resource managers onboard in addition to the vessel crew and about 12 media representatives. Murrelets began calling and appeared about 2130 hours. They began to circle the vessel and land on the water illuminated by the vessel exterior work lights.

At about 2145 I participated in the capture of a murrelet. The capture was readily accomplished within about 60 seconds by shining a spotlight on the bird to disorient it. At 2200 moisture in the air caused some atmospheric reflection of the work lights. Disoriented murrelets began to circle the vessel and **land on** the vessel. Experienced seabird biologists were able to capture the birds without harm and release them. Disoriented murrelet chicks swam to the swim step of the vessel and were picked up by hand by Park Service biologists. Chicks became separated from the adults which could be heard calling to the chicks. In short, from the murrelet's perspective it was total chaos. At about 2230 the Captain, Dwight Willey recognizing the serious disturbance problem that we were causing (even though it was fascinating to witness), turned off the swim step and rear deck work lights. Subsequently the murrelets did not respond to the vessel lights. Gull activity seemed to be stimulated by our operations. Murrelet chicks would be extremely vulnerable to gulls.

These observations are essentially the same as similar observations I made at landing cove at Santa Barbara Island in 1977 when I was studying this species. These observations underscore for me the serious threat that lights from **any** vessel pose to these fragile seabird resources during the breeding season within the waters of the State Ecological Reserves."

3) Gerry McChesney (Seabird Biologist, Humboldt State University and U. S. Geological Survey) has spent many years studying seabirds in the Channel Islands. Between 1991 and 1996, he observed small numbers of Ashy Storm-Petrels, Xantus's Murrelets, and Cassin's Auklets come aboard anchored vessels at night off some of the Channel Islands (mostly San Miguel and Santa Barbara). Most were captured with only the anchor lights on, as they typically kept their lighting down to minimize birds coming on the boats. They usually discovered birds on the deck late at night, or early in the morning. Birds appeared very disoriented and they had to release the birds overboard (otherwise the birds continued to lie on the deck and did not try to depart on their own).

4) John Trapp (Biologist, U.S. Fish and Wildlife Service, Div. of Migratory Bird Management) spent several years working on a 65-ft motor vessel in the Aleutian Islands in the mid-1970s and personally witnessed the attraction of birds to ship's lights. As he recalls, storm-petrels, ancient murrelets, and auklets were the species most frequently attracted, and occasionally puffins. They rarely used the deck lights at night because of their attraction to birds.

5) Tim Reid (Seabird Biologist, Tasmanian Government) has regularly witnessed seabirds landing on vessels, generally on nights with misty conditions. He described one memorable occasion on a foggy night in January of 1992, while on the Australian Antarctic Division supply ship, *Aurora Australis*, which was anchored in Altas Cove on Heard Island. Many lights were on as the crew moved containers on the deck. He believes they were within one km of seabird breeding colonies. Many seabirds collided with the boat, and approximately 300 dead birds were collected. Many others were released but were oiled and it is unknown if they survived. Species collected included Antarctic and Fulmar Prions, Common and South Georgian Diving-petrels, Cape Petrels, Southern Fulmars, Kerguelen Petrels, and Wilson's Storm-petrels.

6) Jeff Williams (Seabird Biologist, U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit) has witnessed large numbers of storm-petrels attracted to the U.S. Fish and Wildlife Service Research Vessel, the *Tiglax*, in the Aleutian chain. He believes these events are usually related to bad weather, particularly foggy and misty conditions. On one foggy evening, in the summer of 1996, the *Tiglax* was anchored at Yoke Bay at Great Siskin Island. The anchor and a few other external flood lights were on. Hundreds of seabirds, mainly Fork-tailed storm-petrels and some Leach's storm-petrel were attracted and collided with the vessel. Birds continued to collide with the vessels until all external lights were shut off. It is important to note that the closest breeding colony for storm-petrels in this area of the Central Aleutians, on Ulak Island, is approximately five miles from Yoke Bay and this location was not directly on the flight path between the colony and the feeding grounds of these seabirds. It is his impression that the birds were disoriented and drawn to the lights, off their normal flight path. In the summer of 2000, a 60' long liner returned to Adak harbor from some point in the vicinity of

Ulak Island (exact location of fishing not known) and several hundred storm-petrels were on the boat and under the decks and remained there the following day. Adak harbor is located approximately 10 miles from Ulak Island. U.S. Fish and Wildlife Service personnel rescued about 150 birds. Jeff Williams estimated that an equal number were stuck in crevices under the deck where they could not be rescued and likely died. These types of observations have occurred commonly enough in Alaska, that service personnel actually occasionally use night lighting on the vessel close to breeding colonies for the purpose of collecting nocturnal seabirds for research purposes (Williams et al. 2000). I have personally observed the use of this technique at Ulak Island.

7) Dr. John Chardine (Biologist, Canadian Wildlife Service, Atlantic Region) related his experiences on vessels in Newfoundland and noted that in his experience, storm-petrels are the main species attracted to night lighting on boats and that around Newfoundland, vessels he has been on have attracted at least a few birds every night, at a distance from the breeding colony. He is not aware of any published reports of these observations. In one experience, 1000s of Leach's Storm-petrels were attracted to the lights of a ship he was on in the fall of 1997 as it steamed South about 20 km (12.4 miles) from Baccalieu Island, Newfoundland. Baccalieu Island is home to the largest Leach's Storm-petrel colony in the world with an estimated 3.5 million pairs. The trip coincided with the Leach's Storm-petrels fledging period and many of the birds collected off the deck were young of the year. Birds continued to collide with the boat throughout the night as they traveled south, from 20-120 km (12.4-74.5 miles) from the colony. He noted that attracted birds would typically flutter down to the lit deck and then find a dark corner or hide under machinery on deck. Birds would often contact oil on the deck and their plumage would become fouled and they became cold. While almost all the birds survived the impact with the ship in this case, crew members took care with the birds, drying and warming them, before releasing them from the bow, where is was dark.

8) Charla Sterne (Biologist, U.S. Fish and Wildlife Service, Alaska) related several observations from Alaskan fishing logs and observer programs of eiders (seaducks) strikes and mortality around lighted vessels. In one case, in December 1980(or 81), at least 150 dead eiders (species unidentified) were found on board the M/V *Northern Endeavor* which was anchored in the Bering Sea side of False Pass with its crab lights on all night.

9) Felix Canez (Fisheries Observer, National Marine Fisheries Service, and Alaska Department of Fish and Game) witnessed hundreds of birds landing on the deck of a light crab fishing boat during a storm near Adak, Alaska. He did not identify species at the time, but from photos, he had them identified as murrelets and storm-petrels.

Physics Calculations to Determine Artificial Illumination Levels and Distances Needed from Islands:

Dr. Joel Fajans, of the UC Berkeley Physics Department, stressed the only really accurate way to determine the light levels from the squid vessels is to take actual measurements from the boats themselves, including measurements close up to the vessels and at various known distances with proper equipment. He could provide assistance in a study design and even lend equipment for such a study. But considering the need for this information in a short time frame, that the squid fishing is done until next fall, and that we may not have funding and personnel time for such a study, it may not be feasible for us to pursue a field study at this time.

However, even without a field study, Dr. Fajans has related to me that it is possible to do calculations, based on the known wattage and type of light bulbs, to determine distances that such lights would need to be from an island to equal full moonlight, or less than full moonlight levels. I provided information to him regarding the current regulation for a maximum of 30,000 watts on a vessel and on the types of bulbs being used, and the possible numbers of bulbs being used based on information in the log books. Dr Fajans provided me with information on full moon [about 0.1 lux (lx); lux = lumens/m^2] and starlight (0.001 lx) illumination values and that the brightest bulbs emit approximately 100 lumins/watt. Some calculations were done, based on several assumptions: 1) the bulbs emit in all directions equally, 2) that the air is clear, and 3) that the bulbs are relatively new (bulbs dim with age). The calculations are attached as **Appendix A**. Dr. Fajans calculated that one boat burning 30,000 watts needs to be about a mile away to bring the light levels down to moonlight (the exact distance can be calculated, but at one mile, illumination is 0.092 lx, which is close to 0.1 lx for moonlight), and almost 10 miles away to bring the light levels down to starlight (0.001061 lx).

Further calculations would have to be done to consider other assumptions, such as shields, or different weather conditions (e.g., cloudy, foggy, rainy) etc... and could be done for different light bulb types and wattages (including types used on different vessels such as dive boats), different number of bulbs per boat, average wattage per light boat, etc... Other considerations include the cumulative illumination levels from several boats, and the addition of artificial illumination levels to moon illuminations.

Potential impacts from artificial light on seabirds and shorebirds in the Channel Islands:

Artificial lights in the Channel Islands could have the following impacts on seabirds nesting, foraging, or roosting on the islands and the surrounding waters:

1) Increased predation rates of nocturnal species at the colony as they leave/return to nests by increasing the visual abilities and activity levels of predators.

2) Decreased nest attendance, and as a result decreases in egg incubation, chick provisioning rates, and possible egg/chick mortality due to reluctance of parents to return to the colony under "moonlight" types of conditions (predator avoidance).

3) Direct collision of birds with vessels resulting in injury, oiling, or direct mortality. In addition, if breeding individuals, this will further result in egg/chick mortality.

4) Chick-adult separation at fledging state due to disorientation (particularly for Xantus's Murrelets).

5) Increased stress, altered hormone levels, altered diel patterns, and other altered behavior for diurnal species (e.g., Brown Pelicans; Brandt's, Pelagic and Double-crested cormorants; Black

Oystercatchers; Snowy Plover; Western Gulls; and Pigeon Guillemots) leading to nest abandonment, and as a result, egg/chick mortality.
6) Disruption of courtship activities due to disorientation and distraction in nearshore waters.
7) Colony-site abandonment.

The concern over the potential impacts of artificial lights on seabirds in the Channel Islands arose in 1999 when large increases in artificial light intensity levels associated with night-time squid fishery boat activity extended into the seabird breeding season. While no controlled studies occurred that year, or since that time, to examine the possible impact of the lights on the fauna of the islands, observations and data recorded by biologists conducting seabird monitoring studies in the islands indicate that lights may be negatively impacting listed species and species of concern by some of the factors listed above.

During the 1999 season, higher than average rates of nest abandonment and chick mortality were recorded for California Brown Pelicans (Frank Gress, unpublished data), which could not be explained by other environmental factors. If the pelicans were negatively impacted by increased light levels, it is likely that pelican behavior was altered by changes in their hormonal levels. The effects of altered light levels on circadian rhythms and on hormone levels, such as melatonin, are known in humans (Avery 2000, Bower 2000); and in animals, "photo-periodic" behavior, such as foraging and reproduction, can be affected by lighting (Bower 2000). Meredith West, a specialist in avian development, states in Bower (2000) that "lighting is a powerful stimulus on behavior. If there's enough of it, it can make them (animals) act in ways they wouldn't normally...Anything that alters the hormonal system will bring enormous changes. Hormones regulate growth and immune functions. But they're not produced all the time. If they don't shut down, you overload the body. It can't get rid of them. Hormones are toxic in the wrong amounts." In addition, birds are known to respond to stressful events (increased rates of disturbance and flushing from nesting sites would be considered stressful) by rapid increasing the secretion of the hormone corticosterone (Kitaysky et al. 1999). Studies of hormone levels in seabirds in Alaska indicates that increased levels of corticosterone are associated with colonies under stress (in this case, limited food supplies) and correlate with increases in reproductive failure (Kitaysky et al.1999, Kitaysky et al. 2000).

The California Brown Pelican is a Federal and State of California endangered species. Anacapa and Santa Barbara Islands are the only two areas where California Brown Pelicans nest in the United States. Between 5000 and 12,000 individuals nest on Anacapa and between 400 and 1200 individuals nest on Santa Barbara Island each year (total number varies each year).

In 1999, increased mortality rates of Xantus's Murrelets due to predation by Barn owls were recorded (Channel Island National Park, unpublished data). Park staff also noted that Western Gulls, which are normally diurnal, (another predator on Xantus's Murrelets and Ashy Storm-Petrels) were more active at night when squid lights were on, and predation rates likely increased over normal levels. Studies have shown that nocturnal seabird species display highly reduced activity levels on moonlit nights when they are apparently more susceptible to predation (Manuwal 1974, Story and Grimmer 1986, Watanuki 1986, Keitt 2001, in review). These studies also show that nocturnal species do not return to colonies, and to their nests, until the sun and moon set; thus on full moon nights, the amount of time of total darkness and access to their nests for incubation shift changes with mates or chick feeding, is very limited. Thus, successive nights of high artificial light levels off of breeding colonies would disrupt the normal nesting activities of these birds.

Nights with light levels at or above moonlight levels throughout the night would discourage birds from returning at all to their colony. The total number of nights in a lunar cycle with levels at or above moonlight would increase under such conditions, as well. For example, a 3-quarter moon with several lighted boats nearby may equal moonlight levels, increasing the expanse of consecutive days with full nightly moonlight levels. Even on a moonless night, several boats could be capable of increasing light levels up to moonlight levels. Brad Keitt (Island Conservation and Ecology Group, unpublished data, presented to the DFG Commission at the June 2001 meeting) measured light levels on Middle Anacapa from light boats on 2 April 2000 at full moonlight levels at an estimated 1 km distance. From his studies of Black-vented shearwaters in Mexico (which are also nocturnal and preyed on by Western Gulls), he concluded that increased predation of nocturnal birds in the Channel Islands likely occurs with artificial lighting (Keitt, pers. comm.). The only conclusion to draw from this is that birds would eventually abandon their nesting attempts, or return to the colony at increased risk of predation, or reduce the number of trips to their nests. All of these possibilities would increase mortality of eggs and chicks and decrease reproductive success.

Both the Ashy Storm-Petrel and Xantus's Murrelet are globally rare species (2 of 10 rarest seabird species in the North Pacific) and State of California and Federal Species of Concern, with extremely limited breeding ranges. They are nocturnal species, breeding in crevices on steep slopes, or in sea caves. In addition to the possible light impacts already mentioned, there are also possible impacts to fledging chicks of these nocturnal species. Xantus's Murrelet chicks depart to sea with their parents at night at 2 days of age and are dependent on their parents for an extended period of time (Gaston and Jones 1998). Chicks will die if separated from their parents at this time. Disorientation from lights can cause parent-chick separation and has been observed in the Channel Islands (Keitt, Kelly, Naughton, and McChesney, pers. comm.). Ashy Storm-Petrel fledglings depart the colony on their own. They may become attracted and disoriented by lights and collide with vessels, increasing the normal mortality rates of young-of-the year, as been documented for fledging petrels and storm-petrels in Hawaii and is a major concern for survival of these species (Byrd et al 1978, Reed et al. 1985, Reed 1987, Telfer et al. 1987, Harrison 1990).

Ashy Storm-Petrels breed only from Central California south to Los Coronados Islands, Mexico (just south of the U.S. border). About 41% of the world's breeding population, and 50% of the United States breeding population nest in the Channel Islands, primarily at San Miguel, Santa Barbara, and Santa Cruz islands.(see **Table 1**). The largest estimated breeding numbers in the Channel Islands occur at Santa Barbara (mainly at Sutil Island and along the West and North sides of the main island) and San Miguel islands (on Prince Island and Castle Rock). Population trends in the Channel Islands are not known, but the species is threatened by a variety of factors, including human disturbance, oil pollution, and predation. Also, USFWS studies in 1992 indicated elevated DDE levels and egg-shell thinning in Channel Islands Ashy Storm-Petrels (Fry 1994, Kiff 1994). Sydeman et al. (1998) documented declines in the breeding population at the Farallon Islands, the only other major nesting site.

Xantus's Murrelets breed from the Channel Islands south to Central Baja California, Mexico. Eighty percent of the United States breeding population and 33.5% of the world's breeding population nest in the Channel Islands (see **Table 2**). In the Channel Islands, the largest colony is at Santa Barbara Island (22.5% of the estimated world breeding population), with other important colonies at San Miguel, Santa Cruz, and Anacapa islands. A petition to list Xantus's Murrelet is almost ready for filing.

It should be noted that it is difficult to study and accurately document the breeding numbers of these species in the Channel Islands because they are nocturnal crevice-nesters, which nest in caves or on steep, inaccessible slopes. It is not possible to visually track birds entering and leaving nesting areas in the daytime and you can not visually assess their numbers by counting nests and birds on the surface (since they nest below ground) as use can for cliff nesters, like cormorants, and ground nesters, like gulls and pelicans. In addition, adult foraging offshore, up to 100 km from the islands, and only return to waters around the islands at night. Areas can be searched for nests and contents inspected, but much of this habitat is difficult and dangerous to access. Population estimates reported here are preliminary, and were primarily obtained by surveying the accessible areas (such as accessible caves), by counting night vocalizations, and by counting numbers seen at night with the use of radar (which indicates the presence of birds in areas not previously documented and not currently published) (Carter, pers. comm.).

Additional species which may be impacted by lights include the following. The Black Storm-Petrel is also a California Species of Special Concern (due to the small numbers that occur in the state) and in the U.S. only breeds at Santa Barbara Island (estimated at about 274 individuals, from Carter et al. 1992). The Snowy Plover is federally threatened, declining, and has important populations in Channel Islands (especially Santa Rosa and San Nicolas islands). Major plover nesting areas on found on beaches on the east side of Santa Rosa Island. Cassin's Auklets, while more widespread in distribution, are in decline in the Channel Islands, at the Farallones, and along the Pacific Coast in general (may be due to changes in oceanographic regimes caused by climate change) and are being considered for inclusion on the state species of concern list. Brandt's and Double-crested cormorants in Channel Islands have declined since 1991, probably mostly due to the El Niños in 1992-93 and 1998 (McChesney et al. 2000a.). Other species (e.g., Pelagic cormorants and Pigeon Guillemots) may have been similarly affected but there is little data (McChesney et al. 2000a.).

The Channel Islands are the most important breeding sites and habitats for several of these species, in California, and in the United States. Any impacts to the Channel Island populations of the declining species can have serious consequences for the survival of the species. Mortality of only a few birds can have serious, long-term implications for the survival of populations of long-lived seabirds that are already in decline or in jeopardy (Sydeman et al. 1998, Nur et al. 1999). A similar situation may be occurring or could occur as in Kauai, Hawaii, where measurements are in place to reduce illumination levels on the island, yet seabirds are still attracted to artificial lights each year, and the small populations of rare seabirds are declining each year (Tom Telfer, Wildlife Biologist, State of Hawaii, Department of Land and Natural Resources, pers. comm.).

Recommendations

Seabirds, by definition, spent the majority of their lives at sea. Their breeding habitats are limited to offshore islands, rocks, and coastline shores and cliffs. The colonial nesting species evolved to nest in large numbers (to reduce predation risk) and preferred habitat is on islands, because they are sensitive to disturbance. Island habitats have been highly altered by humans and the amount of this habitat availability to seabirds is continually declining. Island habitat is limited in California, and species highly disturbed at these sites have limited ability to move to new habitat. Mainland coastal sites are even more disturbed by human activity and not likely to be chosen as an alternative by these species. All or nearly all of southern California populations of most seabird species breed on the Channel Islands. Few (except terns and skimmers) breed on the mainland of southern California.

The Channel Islands National Park, the Channel Islands National Marine Sanctuary, and the State of California Ecological Reserves of the Channel Islands were created to protect the natural resources of these islands and their surrounding waters. However, neither the national park or marine sanctuary have jurisdiction over vessel activity. It is the Department's duty to assist these agencies in achieving these goals, particularly if we are permitting activities which are negatively impacting listed species and species of concern. In addition, the American Trader Trustee Council's (the Department is one of the trustees) is spending several million dollars on restoration efforts to restore seabird nesting habitat on Anacapa Island. If these projects are successful, the listed and species of concern would greatly benefit. For example, McChesney et al. (2000b) estimated that for Xantus's Murrelets, a total of 1,510 potential nesting sites are available if rats are removed.

In addition to the need for the Department to meet the Endangered Species Act and CEQA requirements for protection of listed species and species of concern, the Department is mandated by the Marine Life Management Act (MLMA) to take an "ecosystem approach" to management of the states fisheries. The underlying goals of the MLMA include the following (Weber and Heneman 2000):

1). Conserve entire ecosystems: It is not simply exploited populations of marine life that are to be conserved but the species and habitats that make up the ecosystem of which they are a part [CDFG Code §7050(b)(1)].
2). Non-consumptive values: Marine life need not be consumed to provide important benefits to people, including aesthetic and recreational enjoyment as well as scientific study and education [CDFG Code §7050(a)].

3). Habitat conservation : The habitat of marine wildlife is to be maintained, restored or enhanced, and any damage from fishing practices is to be minimized [CDFG Code §7055(b); 7056(b)].

To meet these goals, the MLMA calls for using several basic tools, one of which is Science. "Management is to be based on the best available scientific information as well as other relevant information. Lack of information should not greatly delay taking action. To help ensure the scientific soundness of decisions, key documents should be reviewed by experts [CDFG Code §7050 (b)(6); §7062; §7072(b)]" (Weber and Heneman 2000).

CDFG Code §7050(b)(6) states that the State of California must "manage marine living resources on the basis of the best available scientific information and other relevant information that the commission or department possesses or receives." "Marine living resources" are defined as "all wild mammals, birds, reptiles, fish, and plants that normally occur in or are associated with salt water, and the marine habitats upon which these animals and plants depend for their continued viability" [CDFG Code, §96].

Many of the threats to the seabird species in the Channel Islands (e.g., pollution, oil spills, altered food availability due to climate change, and exotic predators) can not be easily prevented or eliminated, but all cumulatively contribute to their declining numbers.

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Table 1. Preliminary estimates of the numbers of Ashy Storm-Petrel (ASSP) breeding individuals in the Channel Islands, percentage of total Channel Island breeding population by island, and percentage of total world breeding population by island. Carter, unpublished data (HSU-USGS), provided July 2001.

Channel Island	# ASSP Breeding Individuals (single point estimates)	% Channel Island Estimated Breeding Population (n = 4046)	% of Estimated World Breeding Population (n = 10,000)
Anacapa	100	2.5	1.0
Santa Barbara	1250	30.9	12.5
San Miguel	1850	45.7	18.5
Santa Cruz	814	20.1	8.14
Santa Catalina	20	0.5	0.2
San Clemente	12	0.3	0.12
San Nicolas	0	0	0
Santa Rosa	0	0	0
Total Channel Islands	4046	100	40.46

Table 2. Preliminary estimates of the numbers of Xantus's Murrelets (XAMU) breeding individuals in the Channel Islands, percentage of total Channel Island breeding population by island, and percentage of total world breeding population by island. Carter, unpublished data (HSU-USGS), provided July 2001.

Channel Island	# XAMU Breeding Individuals (single point estimates)	% Channel Island Estimated Breeding Population (n = 3350)	% of Estimated World Breeding Population (n = 10,000)
Anacapa	250 (but probably higher)	7.5	2.5
Santa Barbara	2250	67.2	22.5
San Miguel	200	6.0	2.0
Santa Cruz	400	11.9	4.0
Santa Catalina	125	3.7	1.25
San Clemente	125	3.7	1.25
San Nicolas	0	0	0
Santa Rosa	0	0	0
Total Channel Islands	3350	100	33.5

Appendix A. Calculations of illumination levels [in lux(lx); lux = lumens/m^2] at 1000 m, 1 mile (1.6 km), and 15 km from a vessel with 30kW. Bright moon light levels are about 0.1 lx, and starlight is about 0.001 lx. Assumptions are that the bulbs emit in all directions equally, that the air is clear, and that the bulbs are relatively new (bulbs dim with age). Provided by Dr. Joel Fajans, Physics Professor, U. C. Berkeley.

Calculate lux from 30kW at distance R

Light Power $P := 30000 \cdot W$

Luminous Efficiency $K := 100 \cdot \frac{lm}{W}$

Luminous Flux $\Phi := K \cdot P$ $\Phi = 3 \times 10^6\, lm$

Distance away $R := 1000 \cdot m$

Light Level $E := \frac{\Phi}{4 \cdot \pi \cdot R^2}$ $E = 0.239\, lx$

This is comparable (slightly brighter than full moon light.

Distance away $R := 1 \cdot mi$ $R = 1.609\, km$

Light Level $E := \frac{\Phi}{4 \cdot \pi \cdot R^2}$ $E = 0.092\, lx$

Somewhat less than moonlight

Distance away $R := 15 \cdot km$ $R = 9.321\, mi$

Light Level $E := \frac{\Phi}{4 \cdot \pi \cdot R^2}$ $E = 1.061 \times 10^{-3}\, lx$

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON UPDATE ON MISCELLANEOUS MARINE PROTECTED AREAS ACTIVITIES

The Groundfish Advisory Subpanel (GAP) received an update on marine protected area activities in California from Ms. Ann Walton. The GAP appreciates Ms. Walton taking the time to provide us with information.

The GAP is concerned the Cordell Banks National Marine Sanctuary (Sanctuary) is proposing a change in its designation document that would prohibit the use of certain fishing gear within the Sanctuary when that change is unnecessary. There is no evidence that fishing gear is harming Sanctuary resources, and in fact, some of the gear that would be prohibited is not currently used in the Sanctuary.

The GAP believes that this is yet another example of an attempt by the National Ocean Service and the Sanctuary program to regulate fishing, when such regulation is clearly under the authority of the Council and the National Marine Fisheries Service (NMFS). The GAP urges the Council and NMFS to make that position clear in contacts with the Sanctuary.

PFMC
09/15/04

MAKAH TRIBAL COUNCIL

P.O. BOX 115 • NEAH BAY, WA 98357 • 360-645-2201

IN REPLY REFER TO:

RECEIVED
JUL 0 2 2004
PFMC

June 16, 2004

Carol Bernthal, Sanctuary Superintendent
Olympic Coast National Marine Sanctuary
138 West First Street
Port Angeles, WA 98362

Re: Sanctuary Role in Fishery Management and Regulation

Dear Ms. Bernthal:

We write to support and amplify the views set forth in Billy Frank's May 3, 2004, letter to you regarding the role of the Olympic Coast National Marine Sanctuary ("Sanctuary") in the management and regulation of fisheries.

The National Marine Sanctuaries Act ("Act") requires the Secretary of Commerce ("Secretary") to provide the appropriate Regional Fishery Management Council with the opportunity to prepare draft regulations for fishing within the Exclusive Economic Zone as the Council may deem necessary to implement a proposed sanctuary designation. 16 U.S.C. § 1434(a)(5). Under the Act, "[d]raft regulations prepared by the Council, *or a Council determination that regulations are not necessary* pursuant to this paragraph, shall be accepted and issued as proposed regulations by the Secretary unless the Secretary finds that the Council's action fails to fulfill the purposes and policies of [the Act] and the goals and objectives of the proposed designation." *Id.* (emphasis added).

In accordance with this provision, the National Oceanic and Atmospheric Administration ("NOAA") consulted with the Pacific Fishery Management Council ("PFMC") during the designation process for the Sanctuary to determine if additional fishery regulations were necessary. "The PFMC responded that no additional regulations were necessary and that management responsibility regarding fishing activities should remain with existing authorities." Olympic Coast National Marine Sanctuary, Final Environmental Impact Statement/Management Plan, vol. 1 ("FEIS") at p. I-31.

The Secretary accepted this determination. The FEIS explained:

> NOAA evaluated the possibility of proposing some additional Sanctuary regulation of fishing. However, the existing management authorities, the [Washington Department of Fisheries], [the Washington Department of

> Natural Resources], [the National Marine Fisheries Service], PFMC, and the Tribes have comprehensive management authority of these resources. The management regime is highly complex and well coordinated with Canada and other west coast states through the International Pacific Halibut Convention and the Pacific Salmon Treaty. Sanctuary regulation of fishing *would undermine the existing international and regional regime*. The species are highly migratory and direct Sanctuary management of fishing *would have no foreseeable ecological benefits*.

FEIS at p. IV-89 (emphasis added). For these reasons, NOAA determined "fishing in the Sanctuary, including fishing for shellfish and invertebrates, *shall not be regulated as part of the Sanctuary management regime*." *Id.* at p. III-45 (emphasis added).

As Billy Frank pointed out in his letter, this determination was paramount in our tribe's support for designation of the Sanctuary. We would appreciate your assurance that the Sanctuary continues to adhere to this determination.

Sincerely,

Ben Johnson, Jr.
Chairman

Cc: Vice Admiral Conrad C. Lautenbacher, Jr., Assistant Secretary, Department of Commerce
Dan Basta, Director, National Marine Sanctuary Program
Bob Lohn, Regional Director, NOAA Fisheries
Jeff Koenings, Director, Washington Department of Fish & Wildlife
Donald K. Hansen, Chairman, Pacific Fishery Management Council
Billy Frank, Jr., Chairman, Northwest Indian Fisheries Commission

KRILL HARVEST BAN PROPOSAL

At the September 2004 meeting, the Pacific Fishery Management Council (Council), will consider initiating development of a formal prohibition on directed fisheries for krill (and, potentially, other forage fish species) in Council-managed waters. This would be in recognition of the importance of krill as a fundamental food source for much of the marine life along the West Coast. Moreover, state laws prohibit krill landings by state-licensed fishing vessels into California, Oregon, and Washington, respectively. Thus, the action could provide for consistent federal and state management.

There are currently no directed krill fisheries in Council-managed waters.

The Council requested staff work with National Marine Fisheries Service (NMFS) Southwest Region and NOAA-General Counsel to develop information about procedural mechanisms for prohibiting fishing for krill and other forage species within the West Coast U.S. Exclusive Economic Zone.

As discussed at the June 2004 meeting, the North Pacific Fishery Management Council (NPFMC) adopted a similar action to prohibit directed fisheries for several species of forage fish (including krill). The NPFMC took this action through a joint amendment of their *Bering Sea and Aleutian Islands Groundfish Fishery Management Plan* and *Gulf of Alaska Groundfish Fishery Management Plan*. Council staff has reviewed the joint fishery management plan (FMP) amendment and has annotated key elements in the document's Executive Summary (Agendum E.3.a, Attachment 1). The final rule (63*FR*13009) implementing the joint FMP amendment is also provided (Agendum E.3.a, Attachment 2).

Krill is an important prey item for numerous species managed under each of the Council's four FMPs. Thus, the Council should consider whether a joint FMP amendment is the preferred course of action. It would also be useful for the Council to receive guidance from NMFS on the amount of biological and socioeconomic information that could be necessary to analyze a suite of proposed alternatives. This would facilitate Council consideration of adding this item to the Council's workload.

Council Action:

Council discussion and guidance.

Reference Materials:

1. Agendum E.3.a, Attachment 1: Executive Summary (annotated) from *Environmental Assessment and Regulatory Impact Review for Amendment 36 to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area and Amendment 39 to the Fishery Management Plan for Groundfish of the Gulf of Alaska*–Council Review Draft, November 1996.

2. Agendum E.3.a, Attachment 2: Final Rule implementing Amendment 36 and Amendment 39.
3. Agendum E.3.a, Attachment 3: Southwest Fisheries Science Center report.

Agenda Order:

a. Agendum Overview — Dan Waldeck
b. Reports and Comments of Advisory Bodies
c. Public Comment
d. Council Discussion and Guidance

PFMC
08/24/04

Agendum E.3.a
Attachment 1
September 2004

Draft for North Pacific Fishery Management Council Review

Executive Summary

Environmental Assessment and Regulatory Impact Review
for

Amendment 36 to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea
and
Aleutian Islands Area
and
Amendment 39 to the Fishery Management Plan for Groundfish of the Gulf of Alaska

[*Annotated by Pacific Fishery Management Council staff – September 2004*]

To Create And Manage a Forage Fish Species Category

Prepared by

National Marine Fisheries Service
Juneau, AK
with contributions by
Alaska Fisheries Science Center
US Fish and Wildlife Service

November 1996

EXECUTIVE SUMMARY

Forage fish species (FFS) are abundant schooling fishes that are preyed upon by marine mammals, seabirds and other commercially important groundfish species. Forage fish perform a critical role in the complex ecosystem functions of the Bering Sea and Aleutian Islands management area (BSAI) and the Gulf of Alaska (GOA) by providing the transfer of energy from the primary or secondary producers to higher trophic levels.

Significant declines in marine mammals and seabirds in the GOA and the BSAI have raised concerns that changes in the FFS biomass may contribute to the further decline of marine mammal, seabird and commercially important fish populations. Members of the fishing industry have expressed concern that the current FMP structure with respect to FFS may allow unrestricted commercial harvest to occur on one or more of these species.

For purposes of this analysis forage fish species have been defined to include Osmeridae (which includes capelin and eulachon), Myctophidae, Bathylagidae, *Amodytes* spp. (sandlance), and Pacific sandfish. These species have been grouped together because they are considered to be primary food resources for other marine animals and they have the potential to be the targets of a commercial fishery. These forage fish species are currently managed under the BSAI and GOA FMPs under either the "other species" or "non-specified species" categories.

[*The final list of species included in the NPFMC forage fish category include: Osmeridae (eulachon, capelin, and other smelts); Myctophidae (lanternfishes); Bathylagidae (deep-sea smelts); Ammodytidae (Pacific sand lance); Trichodontidae (Pacific sandfish); Pholidae (gunnels); Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys); Gonostomatidae (bristlemouths, lightfishes, and anglemouths); and the Order Euphausiacea (krill). The Council would need to consider which species should be included under the proposed directed fishery ban. There are no directed fisheries for krill. However, eulachon and other smelts are actively fished along the West Coast. – Council staff*]

This analysis examines two alternatives:

[*The Council could develop similar alternatives to achieve the prohibition on directed fisheries. – Council staff*]

Alternative 1: Status quo. Catch of forage fish could be retained as groundfish under either the "other species" category TAC or as a "nonspecified species". Under this alternative a relatively unrestricted commercial fishery could develop for these species. Catch of those forage fish in the "other species" category are restrained by an overall TAC limit set for the whole category but any one of the forage fish species could be harvested in relatively large and unconstrained amounts within the "other species" TAC. The non-specified species would not be subject to any catch restrictions or reporting requirements.

[*Status quo for the Council would treat Euphausids (krill) as non-FMP species. In federal waters, these species would not be subject to any catch restrictions or reporting requirements. – Council staff*]

Alternative 2: A Forage Fish Species (FFS) category would be established for both the BSAI and GOA FMPs. Three options for management of the FFS category are presented.

> Option 1: Manage the FFS category as for other groundfish species with an ABC, TAC and overfishing limit.
>
> Option 2: Restrict the FFS category to a bycatch only fishery. A directed fishery for the FFS would not be allowed but these species could be harvested as bycatch in other directed fisheries. A suggested 1 percent maximum retainable bycatch amount could be established for the forage fish species category in aggregate.
>
> Option 3: Manage the FFS category as prohibited species. Under this option the incidental catch of these species would not be retained and any incidental catch would need to be returned to the sea with a minimum of injury, as is currently done with other prohibited species.

Under Alternative 2, Option 1 entails the setting of an ABC and TAC amount for the FFS category. This may be difficult given the lack of information on the abundance of the forage fish species and the limited catch history. In addition, an overfishing limit (OFL) would be established based on historical catch, which, when reached, could potentially result in the closure of other target species groups that incidentally harvest forage fishes. Option 2 would establish the FFS category as a bycatch only category with the harvest limited to 1 percent of the harvest of those species for which a directed fishery occurs. Option 2 would allow incidental harvest amounts of the FFS category while preventing a directed fishery from occurring and would not have the constraints of establishing an ABC, TAC or OFL. Management under Option 3 would treat the FFS category as prohibited species to be discarded at sea with a minimum of injury. This management strategy is typically reserved for economically important species other than federally managed groundfish. Option 3 could result in unnecessary discards and cause an unnecessary burden to catcher vessels that do not sort at sea and to processors who must handle these prohibited species. Option 2 would accomplish the objective of preventing the establishment of a directed fishery on forage fish, while minimizing any unnecessary discards and avoiding the problems associated with establishing an ABC, TAC and OFL amount.

Based on historical information, the total burden to the Alaska fishing industry resulting from restricting a fishery on the FFS species would be minimal because a total of only 6 vessels have reported targeting any species in this proposed category from 1984-1994, no annual commercial fishery has been established, and market availability for capelin varies.

[*If the proposed action focused on directed fisheries for krill, it is likely that similar conclusions could be drawn about the anticipated impacts of the proposed action. – Council staff*] permit for the same calendar year for the commercial halibut fishery in Area 2A.

(3) No person shall fish for halibut in the directed halibut fishery in Area 2A during the fishing periods established in Section 8 from a vessel that has been used during the same calendar year for the incidental catch fishery during the salmon troll fishery as authorized in Section 8.

(4) No person shall fish for halibut in the directed commercial halibut fishery in Area 2A from a vessel that, during the same calendar year, has been used in the sport halibut fishery in Area 2A or that is licensed for the sport halibut fishery in Area 2A.

(5) No person shall retain halibut in the salmon troll fishery in Area 2A as authorized under Section 8 taken on a vessel that, during the same calendar year, has been used in the sport halibut fishery in Area 2A, or that is licensed for the sport halibut fishery in Area 2A.

(6) No person shall retain halibut in the salmon troll fishery in Area 2A as authorized under Section 8 taken on a vessel that, during the same calendar year, has been used in the directed commercial fishery during the fishing periods established in Section 8 for Area 2A or that is licensed to participate in the directed commercial fishery during the fishing periods established in Section 8 in Area 2A.

26. Previous Regulations Superseded

These regulations shall supersede all previous regulations of the Commission, and these regulations shall be effective each succeeding year until superseded.

Classification

IPHC Regulations

Because approval by the Secretary of State of the IPHC regulations is a foreign affairs function, *Jensen* v. *National Marine Fisheries Service*, 512 F.2d 1189 (9th Cir. 1975), 5 U.S.C. 553 does not apply to this notice of the effectiveness and content of the IPHC regulations. Because prior notice and an opportunity for public comment are not required to be provided for this rule by 5 U.S.C. 553, or any other law, the analytical requirements of the Regulatory Flexibility Act, 5 U.S.C. 601 *et seq.*, are not applicable.

Catch Sharing Plan for Area 2A

An Environmental Assessment/ Regulatory Impact Review was prepared on the proposed changes to the Plan. NMFS has determined that the proposed changes to the plan and the implementing management measures contained in and implemented by the IPHS regulations will not significantly affect the quality of the human environment, and the preparation of an environmental impact statement on the final action is not required by section 102(2)(C) of the National Environmental Policy Act or its implementing regulations. At the proposed rule state, the Assistant General Counsel for Legislation and Regulation, Department of Commerce, certified to the Chief Counsel for Advocacy of the Small Business Administration that this action will not have a significant economic impact on a substantial number of small entities. No comments were received on this certification. Consequently, no regulatory flexibility analysis has been prepared. This action has been determined to be not significant for purposes of E.O. 12866.

Catch Sharing Plan for Areas 4C, 4D, and 4E

At the proposed rule stage, the Assistant General Counsel for Legislation and Regulation, Department of Commerce, certified to the Chief Counsel for Advocacy of the Small Business Administration that this revision of the CSP would not have a significant economic impact on a substantial number of small entities. No comments were received on this certification. Consequently, no regulatory flexibility analysis was prepared. This action has been determined to be not significant for purposes of E.O. 12866. The revision to CFR 300.63(b) made by this rule is not substantive in that it merely revises the description of the contents of the CSP to reflect that the Council no longer allocates for subareas 4A and 4B. Accordingly, it is not subject to a delay in effective date.

List of Subjects in 50 CFR Part 300

Fisheries, Fishing, Reporting and recordkeeping requirements, Treaties.

Authority: 16 U.S.C. 773–773k.

Dated: March 12, 1998.

David L. Evans,

Deputy Assistant Administrator for Fisheries, National Marine Fisheries Service.

For the reasons set out in the preamble, 50 CFR part 300 is amended as follows:

PART 300—INTERNATIONAL FISHERIES REGULATIONS

1. The authority citation for part 300, subpart E, continues to read as follows:

Authority: 16 U.S.C. 773–773k.

2. In § 300.63, paragraph (b) is revised to read as follows:

§ 300.63 Catch sharing plans and domestic management measures.

* * * * *

(b) The catch sharing plan for area 4 allocates the annual TAC among Areas 4C, 4D, and 4E, and will be implemented by the Commission in annual management measures published pursuant to § 300.62.

[FR Doc. 98–6854 Filed 3–12–98; 4:01 pm]

BILLING CODE 3510–22–P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 679

[Docket No. 971124274–8052–02; I.D. 110597A]

RIN 0648–AH67

Fisheries of the Exclusive Economic Zone Off Alaska; Forage Fish Species Category

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Final rule.

SUMMARY: NMFS issues regulations to implement Amendment 36 to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area and Amendment 39 to the Fishery Management Plan for Groundfish of the Gulf of Alaska (FMPs). This action creates a forage fish species category in both FMPs and implements associated management measures. The intended effect of this action is to prevent the development of a commercial directed fishery for forage fish, which are a critical food source for many marine mammal, seabird, and fish species. This action is necessary to conserve and manage the forage fish resource off Alaska and to further the goals and objectives of the FMPs. In addition, this action includes a technical amendment removing a date that is no longer applicable.

DATES: Effective April 16, 1998.

ADDRESSES: Copies of Amendments 36 and 39 and the Environmental Assessment/Regulatory Impact Review (EA/RIR) prepared for Amendments 36 and 39 are available from the Sustainable Fisheries Division, Alaska Region, NMFS, P.O. Box 21668, Juneau, AK 99802, Attn: Lori J. Gravel, or by calling the Alaska Region, NMFS, at 907–586–7228.

FOR FURTHER INFORMATION CONTACT: Kent Lind, 907–586–7228 or kent.lind@noaa.gov

SUPPLEMENTARY INFORMATION: The domestic groundfish fisheries in the exclusive economic zone of the Bering Sea and Aleutian Islands Management Area (BSAI) and of the Gulf of Alaska

(GOA) are managed by NMFS under the FMPs. The FMPs were prepared by the North Pacific Fishery Management Council (Council) under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). Regulations governing the groundfish fisheries of the BSAI and GOA appear at 50 CFR part 679, and general regulations governing U.S. fisheries appear at 50 CFR part 600.

A notice of availability of amendments 36 and 39 was published on November 12, 1997 (62 FR 60682), with comments on the FMP amendments invited through January 12, 1998. A proposed rule to implement amendments 36 and 39 was published in the **Federal Register** on December 12, 1997 (62 FR 65402), with comments invited through January 26, 1998. One letter of comment was received and is summarized and responded to in the Response to Comments section. Additional information on this action is contained in the preamble to the proposed rule and in the EA/RIR (See **ADDRESSES**). Upon reviewing amendments 36 and 39, the Administrator, Alaska Region, NMFS, has determined that amendments 36 and 39 are necessary for the conservation and management of the groundfish fisheries of the BSAI and GOA and are consistent with the Magnuson-Stevens Act and with other applicable laws.

Response to Comments

The following comment summarizes the one letter received on the FMP amendments and proposed rule:

Comment. The Department of Interior believes that managing forage fish, by establishing a separate category for these species, will benefit the marine ecosystems of the North Pacific. The Department of the Interior supports approval of the amendments as well as issuance of the implementing regulations which would prohibit directed fishing on forage fish species, and the sale, barter, trade, or processing of forage fish.

Response. NMFS agrees with the conclusions of the Department of Interior and has approved amendments 36 and 39.

Elements of the Final Rule

The following is a summary of the main elements of the final rule.

Forage Fish Species Category

The rule defines forage fish species to mean all species of the following families:

Osmeridae (eulachon, capelin, and other smelts),
Myctophidae (lanternfishes),
Bathylagidae (deep-sea smelts),
Ammodytidae (Pacific sand lance),
Trichodontidae (Pacific sandfish),
Pholidae (gunnels),
Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys),
Gonostomatidae (bristlemouths, lightfishes, and anglemouths), and the Order
Euphausiacea (krill).

These species have been grouped together because they are considered to be primary food resources for other marine animals and they have the potential to be the targets of a commercial fishery.

Affected Vessels and Processors

The requirements of the rule apply to all vessels fishing for groundfish in the Federal waters of the BSAI or GOA or processing groundfish harvested in the Federal waters of the BSAI or GOA. The rule does not apply to fishing for forage fish species within State waters.

Prohibition on Directed Fishing

The rule prohibits directed fishing for forage fish at all times in the Federal waters of the BSAI and GOA. The rule establishes maximum retainable bycatch (MRB) percentage of 2 percent for forage fish, meaning that vessels fishing for groundfish may retain a quantity of forage fish equal to no more than 2 percent of the round weight or round-weight equivalent of groundfish species open to directed fishing that are retained on board the vessel during a fishing trip. NMFS data indicate that the aggregate percentage of forage fish incidentally caught in current groundfish fisheries rarely exceeds 2 percent, and many vessels rarely or never encounter catch of forage fish species. Consequently, bycatch of forage fish species is not considered a problem in the groundfish fisheries off Alaska, and the 2-percent MRB is unlikely to result in increased discards of forage fish species.

Harvest Quotas

Insufficient information exists upon which to specify a total allowable catch amount (TAC) for forage fish species. Therefore, this action does not establish procedures for specifying an annual TAC for forage fish species. However, by establishing a new species category for forage fish, NMFS will be able to collect additional data on forage fish from vessel logbooks, weekly production reports, and observer reports. This information may be used to evaluate the need for and appropriateness of other management measures for forage fish species.

Limits on Sale, Barter, Trade or Processing

The rule prohibits the sale, barter, trade, or processing of forage fish species by vessels fishing for groundfish in the Federal waters of the BSAI or GOA or processing groundfish harvested in the BSAI or GOA, except that retained catch of forage fish species not exceeding the 2-percent MRB may be processed into fishmeal and sold. The rule allows fishmeal processing of forage fish retained under the 2-percent MRB amount to prevent undue burdens on operations that process unsorted processing waste into fishmeal. Industry representatives have indicated that separating small quantities of forage fish from the volumes of fish and fish waste that typically enter fishmeal plants would be nearly impossible. The small volumes of fishmeal production allowed under this rule are not expected to provide an incentive for vessels to target on forage fish through ‘‘topping off’’ activity.

This rule does not apply to onshore processors due to limitations of the authority of the Secretary of Commerce under the Magnuson-Stevens Act. At the June 1997 Council meeting, the State of Alaska indicated that it intends to proceed with parallel forage fish regulations to restrict the harvest of forage fish within State waters and the processing of forage fish by onshore processors.

Changes From the Proposed Rule

In the proposed change to Table 2 to 50 CFR Part 679, the order *Euphausiacea* was incorrectly identified as a family. This error has been corrected in the final rule. No other changes have been made in the final rule.

A technical amendment is made to § 679.20(c)(5) by deleting a date that is no longer applicable.

Classification

At the proposed rule stage, the Assistant General Counsel for Legislation and Regulation of the Department of Commerce certified to the Chief Counsel for Advocacy of the Small Business Administration that this rule would not have a significant economic impact on a substantial number of small entities. No comments were received regarding this certification. As a result, a regulatory flexibility analysis was not prepared.

An informal consultation under the Endangered Species Act was concluded for amendments 36 and 39 on July 11,

1997. As a result of the informal consultation, the Regional Administrator determined that fishing activities under this rule are not likely to adversely affect endangered or threatened species or critical habitat.

This final rule has been determined to be not significant for the purposes of E.O. 12866.

List of Subjects in 50 CFR Part 679

Alaska, Fisheries, Reporting and recordkeeping requirements.

Dated: March 10, 1998.

David L. Evans,

Deputy Assistant Administrator for Fisheries, National Marine Fisheries Service.

For the reasons set out in the preamble, 50 CFR part 679 is amended as follows:

PART 679—FISHERIES OF THE EXCLUSIVE ECONOMIC ZONE OFF ALASKA

1. The authority citation for 50 CFR part 679 continues to read as follows:

Authority: 16 U.S.C. 773 *et seq* ., 1801 *et seq.*, and 3631 *et seq.*

2. In § 679.2, the definition of ''forage fish'' is added in alphabetical order to read as follows:

§ 679.2 Definitions.

* * * * *

Forage fish means all species of the following families:

(1) *Osmeridae* (eulachon, capelin and other smelts),
(2) *Myctophidae* (lanternfishes),
(3) *Bathylagidae* (deep-sea smelts),
(4) *Ammodytidae* (Pacific sand lance),
(5) *Trichodontidae* (Pacific sandfish),
(6) *Pholidae* (gunnels),
(7) *Stichaeidae* (pricklebacks, warbonnets, eelblennys, cockscombs and shannys),
(8) *Gonostomatidae* (bristlemouths, lightfishes, and anglemouths), and
(9) The Order *Euphausiacea* (krill).

* * * * *

3. In § 679.20, paragraph (c)(5) is amended by removing the phrase ''(Applicable through December 31, 1996)'' and a new paragraph (i) is added as follows:

§ 679.20 General limitations.

* * * * *

(i) *Forage fish*—(1) *Definition.* See § 679.2.

(2) *Applicability.* The provisions of § 679.20(i) apply to all vessels fishing for groundfish in the BSAI or GOA, and to all vessels processing groundfish harvested in the BSAI or GOA.

(3) *Closure to directed fishing.* Directed fishing for forage fish is prohibited at all times in the BSAI and GOA.

(4) *Limits on sale, barter, trade, and processing.* The sale, barter, trade, or processing of forage fish is prohibited, except as provided in paragraph (i)(5) of this section.

(5) *Allowable fishmeal production.* Retained catch of forage fish not exceeding the maximum retainable bycatch amount may be processed into fishmeal for sale, barter, or trade.

4. In § 679.22, paragraph (c) is revised to read as follows:

§ 679.22 Closures.

* * * * *

(c) *Directed fishing closures.* See § 679.20(d) and § 679.20(i).

* * * * *

Table 2 to Part 679 [Amended]

5. Table 2 to 50 CFR part 679 is amended by adding species codes 207 Gunnels; 208 Pricklebacks, warbonnets, eelblennys, cockscombs and shannys (family *Stichaeidae*); 209 Bristlemouths, lightfishes, and anglemouths (family *Gonostomatidae*); 210 Pacific sandfish; 772 Lanternfishes; 773 Deep-sea smelts (family *Bathylagidae*); 774 Pacific sand lance; and 800 Krill (order *Euphausiacea*); in numerical order as follows:

TABLE 2 TO PART 679.—SPECIES CODES

Code	Species
* * *	* * * *
Group Codes:	
* * *	* * * *
207	Gunnels.
208	Pricklebacks, warbonnets, eelblennys, cockscombs and shannys (family *Stichaeidae*).
209	Bristlemouths, lightfishes, and anglemouths (family *Gonostomatidae*).
210	Pacific sandfish.
* * *	* * * *
772	Lanternfishes.
773	Deep-sea smelts (family *Bathylagidae*).
774	Pacific sand lance.
800	Krill (order *Euphausiacea*).
* * *	* * * *

Tables 10 and 11 to Part 679 [Amended]

6. Tables 10 and 11 to 50 CFR part 679 are amended by adding a column for aggregate forage fish as follows:

In Table 10 to 50 CFR part 679, a column for ''Aggregate Forage Fish'' is added between columns ''Atka mackerel'' and ''Other species,'' and footnote 5 is added to read ''Forage fish are defined at § 679.2.'' Table 10, as revised, reads as follows:

TABLE 10.—GULF OF ALASKA RETAINABLE PERCENTAGES

	Bycatch species [1]												
	Pollock	Pacific cod	Deep flatfish	Rex sole	Flathead sole	Shallow flatfish	Arrowtooth	Sablefish	Aggregated rockfish [2]	DSR SEEO [4]	Atka mackerel	Aggregate forage fish [5]	Other species
Basis Species													
Pollock	[3] na	20	20	20	20	20	35	1	5	10	20	2	20
Pacific cod	20	[3] na	20	20	20	20	35	1	5	10	20	2	20
Deep flatfish	20	20	[3] na	20	20	20	35	7	15	1	20	2	20
Rex sole	20	20	20	20	[3] na	20	35	7	15	1	20	2	20
Flathead sole	20	20	20	20	[3] na	20	35	7	15	1	20	2	20
Shallow flatfish	20	20	20	20	20	[3] na	35	1	5	10	20	2	20
Arrowtooth	5	5	0	0	0	0	[3] na	0	0	0	0	2	20
Sablefish	20	20	20	20	20	20	35	[3] na	15	1	20	2	20
Pacific Ocean perch	20	20	20	20	20	20	35	7	15	1	20	2	20
Shortraker/rougheye	20	20	20	20	20	20	35	7	15	1	20	2	20
Other rockfish	20	20	20	20	20	20	35	7	15	1	20	2	20
Northern rockfish	20	20	20	20	20	20	35	7	15	1	20	2	20
Pelagic rockfish	20	20	20	20	20	20	35	7	15	1	20	2	20
DSR–SEEO	20	20	20	20	20	20	35	7	15	[3] na	20	2	20
Thornyhead	20	20	20	20	20	20	35	7	15	1	20	2	20
Atka mackerel	20	20	20	20	20	20	35	1	5	10	[3] na	2	20
Other species	20	20	20	20	20	20	35	1	5	10	20	2	[3] na
Aggregated amount non-groundfish species	20	20	20	20	20	20	35	1	5	10	20	2	20

[1] For definition of species, see Table 1 of the Gulf of Alaska groundfish specifications.
[2] Aggregated Rockfish means any rockfish except in the Southeast Outside District where demersal shelf rockfish (DSR) is a separate category.
[3] na=not applicable.
[4] SEEO=Southeast Outside District.
[5] Forage fish are defined at § 679.2.

In Table 11 to 50 CFR part 679, a column for ''Aggregate Forage Fish'' is added between columns ''Squid'' and ''Other species,'' footnote 3 is redesignated as footnote 4, and a new footnote 3 is added to read ''Forage fish are defined at § 679.2.'' Table 11, as revised, reads as follows:

TABLE 11.—BERING SEA AND ALEUTIAN ISLANDS MANAGEMENT AREA RETAINABLE PERCENTAGES

	Bycatch species [1]													
	Pollock	Pacific cod	Atka mackerel	Arrowtooth	Yellowfin sole	Other flatfish	Rock sole	Flathead sole	Greenland turbot	Sablefish	Aggregated rockfish [2]	Squid	Aggregate forage fish [3]	Other species
Basis species[1]														
Pollock	[4] na	20	20	35	20	20	20	20	1	1	5	20	2	20
Pacific cod	20	na	20	35	20	20	20	20	1	1	5	20	2	20
Atka mackerel	20	20	na	35	20	20	20	20	1	1	5	20	2	20
Arrowtooth	0	0	0	na	0	0	0	0	0	0	0	0	2	0
Yellowfin sole	20	20	20	35	na	35	35	35	1	1	5	20	2	20
Other flatfish	20	20	20	35	35	na	35	35	1	1	5	20	2	20
Rock sole	20	20	20	35	35	35	na	35	1	1	5	20	2	20
Flathead sole	20	20	20	35	35	35	35	na	35	15	15	20	2	20
Greenland turbot	20	20	20	35	20	20	20	20	na	15	15	20	2	20
Sablefish	20	20	20	35	20	20	20	20	35	na	15	20	2	20
Other rockfish	20	20	20	35	20	20	20	20	35	15	15	20	2	20
Other red rockfish-BS	20	20	20	35	20	20	20	20	35	15	15	20	2	20
Pacific Ocean perch	20	20	20	35	20	20	20	20	35	15	15	20	2	20
Sharpchin/Northern-AI	20	20	20	35	20	20	20	20	35	15	15	20	2	20
Shortraker/Rougheye-AI	20	20	20	35	20	20	20	20	35	15	15	20	2	20
Squid	20	20	20	35	20	20	20	20	1	1	5	[4] na	2	20
Other species	20	20	20	35	20	20	20	20	1	1	5	20	2	[4] na
Aggregated amount non-groundfish species	20	20	20	35	20	20	20	20	1	1	5	20	2	20

[1] For definition of species, see Table 1 of the Bering Sea and Aleutian Islands groundfish specifications.
[2] Aggregated rockfish of the genera *Sebastes* and *Sebastolobus*.
[3] Forage fish are defined at § 679.2.
[4] na = not applicable.

[FR Doc. 98–6857 Filed 3–16–98; 8:45 am]

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A REVIEW OF U.S. PACIFIC COAST KRILL

Susan E. Smith
Southwest Fisheries Science Center
La Jolla, California

Principal stocks of interest

Eight species of euphausiid shrimp form the bulk of the euphausiid community in the Transition Zone of the California Current System (Brinton and Townsend 2003), but only two cold-water species, *Euphausia pacifica* and *Thysanoessa spinifera*, form large, dense surface aggregations and are likely to be potential fishery targets. They are also the most commonly reported euphausiids reported in the diets of a wide variety of California Current seabird, marine mammal and fish species (see Importance as Forage section below).

The daytime near-surface aggregating behavior of *E. pacifica* and *T. spinifera* is well known, and has been documented by Boden et al. (1955), Barham (1956), Pearcy and Hosie (1985), Smith and Adams (1988), and others. The sub-tropical and marginally tropical *Nyctiphanes simplex* also occurs in the California Current, and aggregates at the surface in large swarms, but is only abundant in U.S. West Coast waters during strong El Niño years, occurring predominantly to the south in Mexico waters (Brinton and Townsend 2003). Another euphausiid, *Nematocelis difficilis* is very abundant in the California Current, but not a vertical migrator, preferring the deeper layers of the thermocline where it is less accessible to harvest than *E. pacifica* and *T. spinifera*. The remaining species, *T. gregaria*, *E. recurva*, *E. gibboides*, *E. eximia*, are less abundant and not likely candidates for exploitation.

Biology

E. pacifica ranges throughout the subarctic Pacific, including the Gulf of Alaska as far south as 25 °N latitude (Brinton 1981). It performs extensive vertical migrations, usually over depths greater than 200 m, although it also occurs over the shelf. Off California, the adults live at a daytime depth of 200-400 m rising to near the surface at night (Brinton, 1976; Youngbluth 1976), sometimes amassing near the surface during the day (Endo et al. 1985; Brinton and Townsend 1991). *T. spinifera*, which commonly forms daytime surface swarms, is more coastal, occurring in neritic water mainly less than 100 m deep. It occurs from the southeastern Bering Sea south to northern Baja California, with regions of high density associated with centers of upwelling (Boden et al. 1955; Brinton 1962). Both are grazers on microscopic plants and animals. *E. pacifica* usually reaches its maximum length of 22 mm in about 12 or 13 months, have about a one-year life expectancy in our region, and individuals from 10 to 15 mm carapace length tend to predominate in the population. *E. pacifica* appears to have continuous recruitment year round with peaks associated with upwelling periods (Brinton 1976). Under ideal conditions a female, which carries 20-250 eggs which hatch into larvae, could spawn every two months.

The larger *T. spinifera* (to 30 mm) is thought to have a three-year life cycle, and a discrete spawning season that extends from May to July off California, coincident with the strongest upwelling (Brinton 1981). From May to July, it forms extensive inshore surface swarms as fully mature adults during the peak of the upwelling season (Brinton 1981, Smith and Adams 1988). These adults are thought to swarm, breed, then presumably die at the end of their three-year life cycle (Nemoto 1957). Maturing subadults are also know to swarm near the surface in late summer and fall (Schoenherr 1991; Kieckhefer 1992; Fiedler et al. 1998). Compared to other California Current euphausiids, adults and large juveniles of this species are thought to be more mobile and adept at avoiding towed nets, and thus likely to be underestimated when extrapolating abundance from net tows (Brinton 1965; Smith and Adams 1998; and Brinton and Townsend 2003).

Population dynamics

No comprehensive overall biomass estimates for any krill species have been made for the California Current area off the U.S. Pacific Coast, and MSY and OY are unknown. Brinton (1976) has described the population biology of *E. pacifica* off southern California with respect to reproduction, growth and development of cohorts, and successions in population structure and biomass over a four year period (1953-56). In a 1983 NMFS guide to underutilized fisheries resources off California, population size of *E. pacifica* was roughly estimated at ‘probably over 100 million tons in California,’ possibly based on Brinton’s (1976) work and known distribution off California, although no supporting data are provided.

Brinton and Townsend (2003), using the CalCOFI data series, recently published a time series analysis of fluctuations in abundance of the major California Current euphausiid species in relation to decadal oceanographic variability over the last 52 years. They found cold-water *E. pacifica* and *T. spinifera* declined dramatically during extreme warm water events, although they appear to be quite resilient in their ability to rebound from these periods of unfavorable oceanographic conditions. The two species abundances in southern and central California varied similarly over the five survey decades, both experiencing marked post-El Niño recoveries once cooler water periods returned. Periods of population depletion became increasingly frequent, though irregular, after a cool water regime shifted to a warm water regime in the 1970s. The more numerically abundant *E. pacifica* uniformly collapsed by as much as 90% during warm-water El Niño periods, but recovered to irregular but distinct bi-decadal peaks in abundance during six strong cold-water La Niña episodes, including the most recent cool-water episode from 1999 through at least spring 2002.

Importance as Forage

Diet studies over the last forty years indicate that krill are an integral part of the California Current System food web. *Euphausia pacifica* and/or *Thysanoessa spinifera* are preyed upon by market squid, *Lolling opalescen*s; Pacific hake, *Merluccius productus*; Pacific herring, *Clupea harengus*; dogfish, *Squalus acanthias*; blue shark, *Prionace glauca*; sablefish, *Anoplopoma fimbria*; myctophids (family: Myctophidae); jack mackerel, *Trachurus symmetricus*; various juvenile and adult rockfishes, *Sebastes* spp., which prey on eggs, larvae and adult krill; various flatfishes (e.g., Pacific sanddab, *Citharichthys sordidus*, slender sole, *Lyopsetta exilis*; Pacific halibut, *Hypoglossus stenolepis)*; Pacific salmon (*Oncorhynchus* spp.), albacore, *Thunnus alalunga*; humpback whale, *Megaptera novaeangliae*; blue whale, *Balaenoptera musculus*; Grey whale, *Eschrichtius robustus*; and various seabirds, especially Cassin’s auklets, *Ptychoramphus* *aleuticus*; sooty shearwater, *Puffinus griseus*; and common murre *Uria aalge* (Phillips 1964; Alversen and Larkins 1969; Alton and Nelson 1970; Pinkas et al. 1971; Cailliet 1972; Manuwal 1974; Tyler and Pearcy 1975; Baltz and Morejohn 1977; Karpov and Cailliet 1978; McCall et al. 1980; Vermeer 1981; Chu 1982; Peterson et al. 1982; Livingston 1983; Lorz et al. 1983; Brodeur and Pearcy 1984; Briggs et al. 1988; Chess et al. 1988; Smith and Adams 1988; Ainley and Boekelheide 1990; Ainley et al. 1990; Kiekeffer 1992; Reilley et al. 1992;Tanasichuk 1995; Ware and McFarlane 1995; Ainley et al. 1996; Robinson 2000; Benson et al. 2002; Hewitt and Lipsky 2002). Hake and Cassin's auklet appear so dependent on these species for food that the distributions of euphausiids determine those for hake and auklets (Vermeer 1981; Tanasichuk 1995; Ainley et al. 1996; Briggs et al. 1988). Krill are also especially important food of salmon, preparatory to their ascending tributaries to spawn. When the rust-colored swarms appear off central California, commercial sport fishing boats, guided by flocks of feeding seabirds, seek krill swarms out in search of salmon, which feed heavily on krill from April to July (Smith and Adams 1988). Blue and humpback whales also converge on krill-rich upwelling centers such as around the Farallon Islands, Monterey Bay, and the Point Conception/Channel Islands area to feed on *T. spinfera* and *E. pacifica* during summer and fall, since at least the mid-1980s and early 1990s (Smith and Adams 1988; Schoenherr 1991; Fiedler et al. 1998, Croll et al. 1998).

Commercial Importance

There is a market for krill as food for aquarium fish, in fish culture operations, and for pet food. It is also marketed for human consumption in non-domestic markets. It is most often frozen, and sometimes freeze-dried for ease in handling and distribution to retail markets (NMFS 1983). The British Columbia euphausiid fishery is market-limited with the majority of the product being frozen for export to the US where it is used in the production of fish feed or pet food (Nicol and Endo 1997).

EXISTING AND POTENTIAL KRILL FISHERIES—U.S.-CANADA PACIFIC COAST

California

California imposed a ban on krill fishing in state waters in 2000.

Oregon

Oregon imposed a ban on krill fishing in state waters in 2003. Fishing beyond state waters may not be feasible because of rough ocean fishing conditions which constrain krill fishing operations.

Washington

Currently, no krill fishery takes place in Washington, and there has been no interest expressed in harvesting krill in state waters. Washington law prohibits the landing and sale of commercial quantities of krill, which is designated an unclassified species with very limited take options. Given recent discussions relating to krill harvest in other Pacific coast areas, the state may consider additional modifications that might make future commercial harvest of krill in

Washington even more unlikely.

British Columbia

The only krill fishery along the U.S.-Canada Pacific Coast exists in the Strait of Georgia, British Columbia (Fulton and Le Brasseur 1984; Nicol and Endo 1997). A fishery for *E. pacifica* also exists in Japan in the western Pacific (Endo 1995; Nicol and Endo 1997).

Information on the British Columbia fishery has been summarized by Nicol and Endo (1997). It began on a experimental basis in 1972, confined to the Strait of Georgia and the east coast of Vancouver Island. Quotas were established in 1976 in response to concerns about harvesting such an important forage species upon which salmon and other commercially important finfish depend. The annual catch was set at 500 t with an open season from November to March to minimize the incidental catch of larval and juvenile fish and shellfish. This quota was derived from an estimate of the annual consumption of euphausiids by all predator species in the Strait of Georgia, and is 3% of this estimate. In 1983, participation in this fishery was restricted to those individuals who had applied for, and held, a certain category license, which was not subject to limited entry. Until 1985, annual landings were less than 200 t, with fishing concentrated initially in Saanich Inlet, then Howe Sound and most recently in Jervis Inlet. Due to continued concentration of fishing effort in Jervis Inlet rather than the adjacent waters in the Strait of Georgia, separate inlet quotas were introduced in 1989. The annual TAC increased to 785 t; 500 t for the Strait of Georgia and 20 to 75 t for each of the major mainland inlets.

In 1990, due to concerns of local stock overfishing, the overall annual quota was reduced again to 500 t; 285 t for the mainland inlets and 215 t for the Strait of Georgia. That year, 56 licenses were issued, of which 17 reported landings of 530 t for a landed value of Can $415,000. This was the first year since the beginning of this fishery that the annual quota had been reached. Only 53 t of euphausiids were reported landed in 1993 with a total landed value of Can $41,000. This decline in landings from 381 t reported in 1992 was a function of market conditions rather than any decline in krill stocks. Preliminary landings of euphausiids reported for 1994 were in excess of 300 t, with a value of Can$ 259,000, as markets stabilized somewhat from the previous year. The number of licenses issued for this fishery increased annually from 7 in 1983 to 56 in 1990, then declined to 45 in 1991. In 1993, licenses were limited to 25 vessels upon the advice of industry and because the annual quota was being taken by the current fleet. Only one vessel during 1993 and three vessels during 1994 reported euphausiid landings. Bycatch consists of larval and juvenile fish and myctophids (Lee 1995).

In late 1995 a workshop was held at the University of British Columbia on "Harvesting Krill: Ecological Impact, Assessment, Products and Markets " (Pitcher and Chuenpagdee 1995). The workshop dealt in some detail with the British Columbia euphausiid fishery, the importance of euphausiids to the coastal marine ecosystem, and improvements in assessments methods of the potential yield of British Columbia krill stocks. The Regional Executive Committee of the Canadian Department of Fisheries and Oceans has stated that as a matter of policy the region is not prepared to support additional developmental fisheries on forage species such as krill, and the 500 t quota for the Strait of Georgia and mainland inlets is expected to remain fixed for the foreseeable future (Morrison 1995).

Fishing methods-British Columbia

In the British Columbia fishery, two types of vessels participate — smaller freezer vessels whose catches are limited due to freezing capacity (5-6 t of krill a day) and larger vessels that land large quantities of euphausiids for onshore processing and freezing (Nicol and Endo 1997). The catch must be frozen within 24 hrs to avoid a significant deterioration of product quality. The fishing season can be as short as 20 days (actual fishing days) and individual vessels may land as little as 32 t in a season. Nets used have mouth areas of around 80 m^2, the trawl mouth is kept open by means of a beam and is buoyed to keep it from flipping when the ship turns. There are weights on the footline to maintain the net's shape. Fishing is carried out close to the surface - often less than 20 m deep and on moonless nights when the krill rise to the surface forming layers less than 10 m in vertical extent. The krill are located by echosounders. The larger vessels use a seine net and are usually out-of-season salmon fishing boats with no onboard freezing capacity. The presence of these vessels in the fishery is usually dependent on the success of the salmon fishery. If there has been a bad salmon catch, then krill are fished to increase revenues.

CALIFORNIA DATA SOURCES FOR CALIFORNIA CURRENT KRILL

NMFS SWFSC La Jolla Laboratory and University of California

SIO CalCOFI Euphausiid data sets: These consist of data generated from over 3,000 plankton samples collected in the California Current area (predominantly off southern and central California) since 1950 by California Cooperative Fisheries Investigations (NMFS and State of California, UCSD Scripps Institution of Oceanography). *Sampling period*: 1950-2002. *Associated publications*: Numerous reports and publications on California Current euphausiids published by Brinton and Brinton and Townsend are based on these data. The most recent publication, Brinton and Townsend 2003, describes a long time series of fluctuations in abundance of the major California Current species over the period 1950-2002, in relation to oceanographic regimes and La Niña and El Niño events. *Contacts:* Ed Brinton, Annie Townsend, UCSD SIO

NMFS/SWFSC Whale Habitat and Prey Studies (WHAPS) data sets: Acoustic, MOCNESS net, and whale scat data collected to determine krill distribution and abundance in relation to whales in the region of the southern California Channel Islands area. *Sampling times*: August 1995; July 1996. *Associated publications*: Croll et al. 1998; Fielder et al. 1998; Armstrong and Smith 1997. *Contacts:* Paul Fiedler, David Demer, Sue Smith, NMFS SWFSC La Jolla Laboratory.

1992-1993 FORAGE (Fishery Oceanography and Groundfish Ecology) cruises data set and samples: Acoustic, hydrographic and MOCNESS net data for stations sampled between Pt. Sur and Pt Arena, California 16-26 March 1992 and 26 June-7 July 1993 FORAGE cruises. *Associated publications:* Lynn et al. 1995. *Contacts* Bill Watson, Richard Charter, Ron Lynn, Sue Smith, SWFSC La Jolla Laboratory.

NMFS SWFSC Santa Cruz Laboratory and University of California

NMFS/SWFSC Santa Cruz Rockfish Recruitment Assessment Cruise Data: Acoustic, midwater and occasionally Tucker trawl data have been collected to determine the distribution and abundance of krill along the continental shelf break between Point Reyes and Monterey Bay. Concurrent surveys of birds and marine mammals are conducted on these cruises by Point Reyes Bird Observatory staff. *Sampling dates*: Acoustic information has been gathered during annual May/June juvenile rockfish surveys since 1999. Euphausiid catch information from midwater trawls has been collected since 1983. Krill identified to species in 1980s, and since 2002 by University of California Santa Cruz researchers. Intervening years' catches (1990-2001) not identified to species. *Associated publications*: Adams 2001; Laidig, et al. 1995; Brodeur, R. D., W. G. Pearcy, and S. Ralston 2003. *Contact:* Steve Ralston, NMFS SWFSC Santa Cruz Laboratory.

Shortbelly Rockfish Prey Study Data set: Day-night depth-stratified euphausiid collections made in the area of Ascension Canyon to determine temporal and spatial distribution of euphausiid species in relation to diel feeding patterns of shortbelly rockfish. *Sampling periods*: 74 sampling days between 1979 and 1982. *Associated publications*: Chess et al. 1988. Contact: Steve Ralston; Pete Adams, NMFS SWFSC Santa Cruz Laboratory.

Chinook Salmon Prey-switching Data Set: Day-night depth-stratified euphausiid collections made in the Gulf of the Farallones to determine temporal and spatial abundance of euphausiid species in relation to the feeding patterns of the chinook salmon. *Sampling period*: From about 1985 through 1998. *Associated publication*: Smith and Adams 1988; Adams 2001; Adams, Samiere, and Ryan in prep. Contact: Steve Ralston, Pete Adams, NMFS SWFSC Santa Cruz Laboratory.

University of California Santa Cruz: Acoustic data and whale tagging data in collaboration with NMFS/SWFSC Whale Habitat and Prey Studies (see above), and regular krill surveys in Monterey Bay. *Sampling Period:* WHAPS data sets, August 1995; July 1996. Monterey Bay data sets 1997-present. *Associated publications:* Croll et al. 1998; Fielder et al.1998. *Contacts:* D. Croll, B. Marinovic, M. Mangel

Data on krill is also gathered in Washington and Oregon by:

NWFSC-Newport Laboratory and Oregon State University, Newport, OR: Associated data bases relating to biology and ecology of krill populations off Oregon and the Pacific Northwest. *Contacts:* W. T. Peterson, R. Brodeur, W.G. Pearcy.

University of Washington: Data on Puget Sound euphausiid biology and habitat requirements. *Contacts:* A. Leising and A. Dignon

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Agendum E.3.b
Supplemental GAP Report
September 2004

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON KRILL HARVEST BAN PROPOSAL

The Groundfish Advisory Subpanel (GAP) discussed the issue of banning fishing for krill within all or part of the Council's area of jurisdiction, including the Monterey Bay National Marine Sanctuary.

The GAP encourages the Council to examine the issue, as it will re-emphasize the authority vested in the Council to regulate fishing activities within Sanctuaries. However, it is unclear whether the GAP should be involved in the development of an FMP amendment, as krill is not listed as a groundfish species. Given the many important issues in groundfish management, we are not convinced that development of a Pacific Groundfish FMP amendment to ban krill fishing is justified in terms of workload requirements for the Council's groundfish staff, the Groundfish Management Team, and the GAP.

PFMC
09/15/04

Agendum E.3.b
Supplemental HC Report
September 2004

HABITAT COMMITTEE COMMENTS ON KRILL HARVEST BAN PROPOSAL

The Habitat Committee (HC) applauds the Council for moving forward with a krill harvest ban because krill are prey for virtually all managed species. The HC recommends using whichever method is most effective and permanent to prevent the directed harvest of krill. However, the HC encourages the Council to select a method that does not require annual or biennial action - for example, setting an annual total allowable catch of zero.

We would like to see the Pacific Council follow the North Pacific Council's lead in protecting other forage species as well, and we would encourage consideration of banning harvest of an expanded list of forage species, not including currently managed or fished species.

PFMC
09/15/04

Agendum E.3.b
Supplemental NMFS PowerPoint Presentation
September 2004

U.S. Pacific Coast Krill (Euphausiids)

Prepared by:

Susan E. Smith
Roger Hewitt

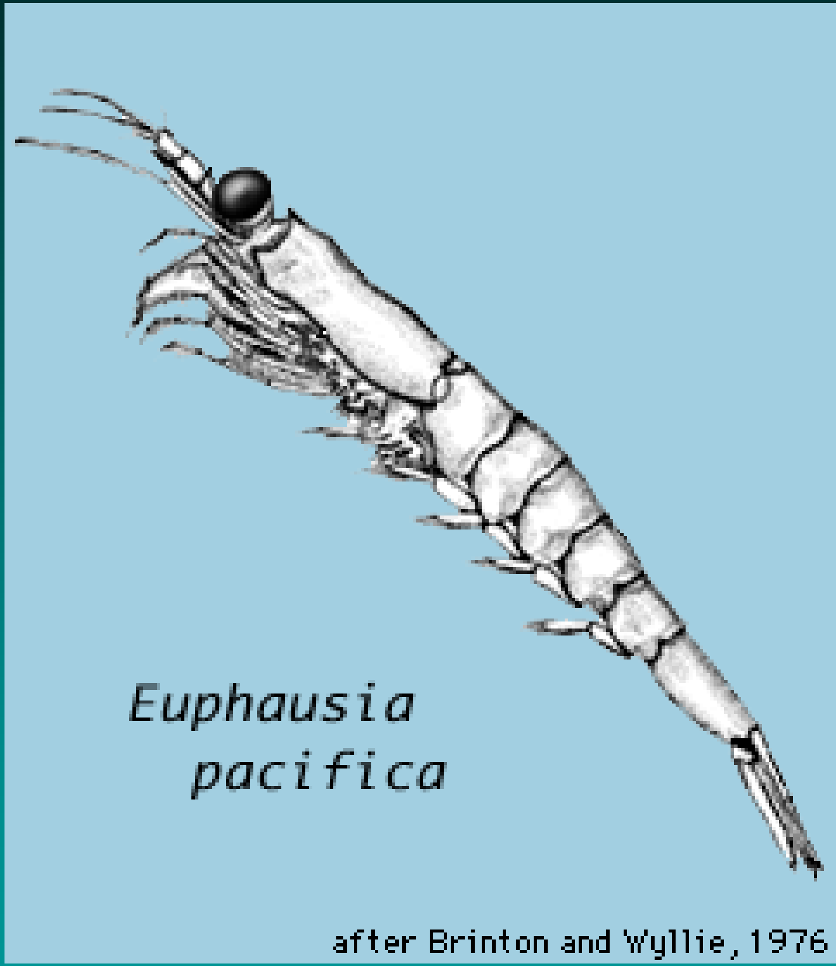
NMFS Southwest Fisheries Science Center, NOAA
8604 La Jolla Shores Drive, La Jolla, CA

Species of Concern

- Only two likely to be targeted by a fishery (because abundant and known to form dense surface swarms):
  - *Euphausia pacifica*
  - *Thysanoessa spinifera*
- Six others common but either do not swarm near the surface, or occur further to the south most years (e.g. *Nyctiphanes simplex*).

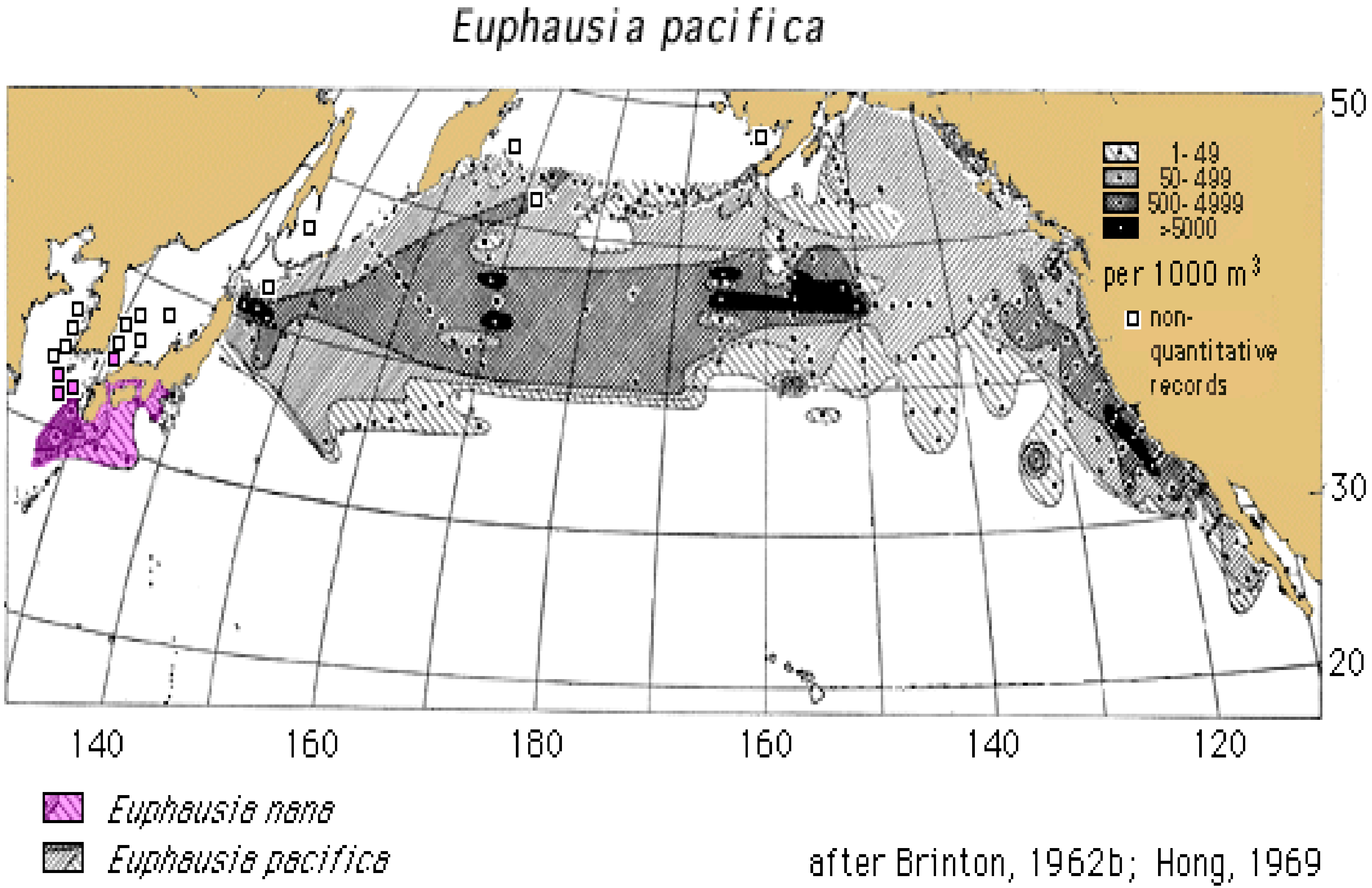
Euphausia pacifica

- Possibly the most abundant off our coast
- Strong vertical migrator-- surface at night descending to ~200-400m during day– but can also swarm at surface in day.



Adult size: to 11-25 mm (< 1”)

Distribution

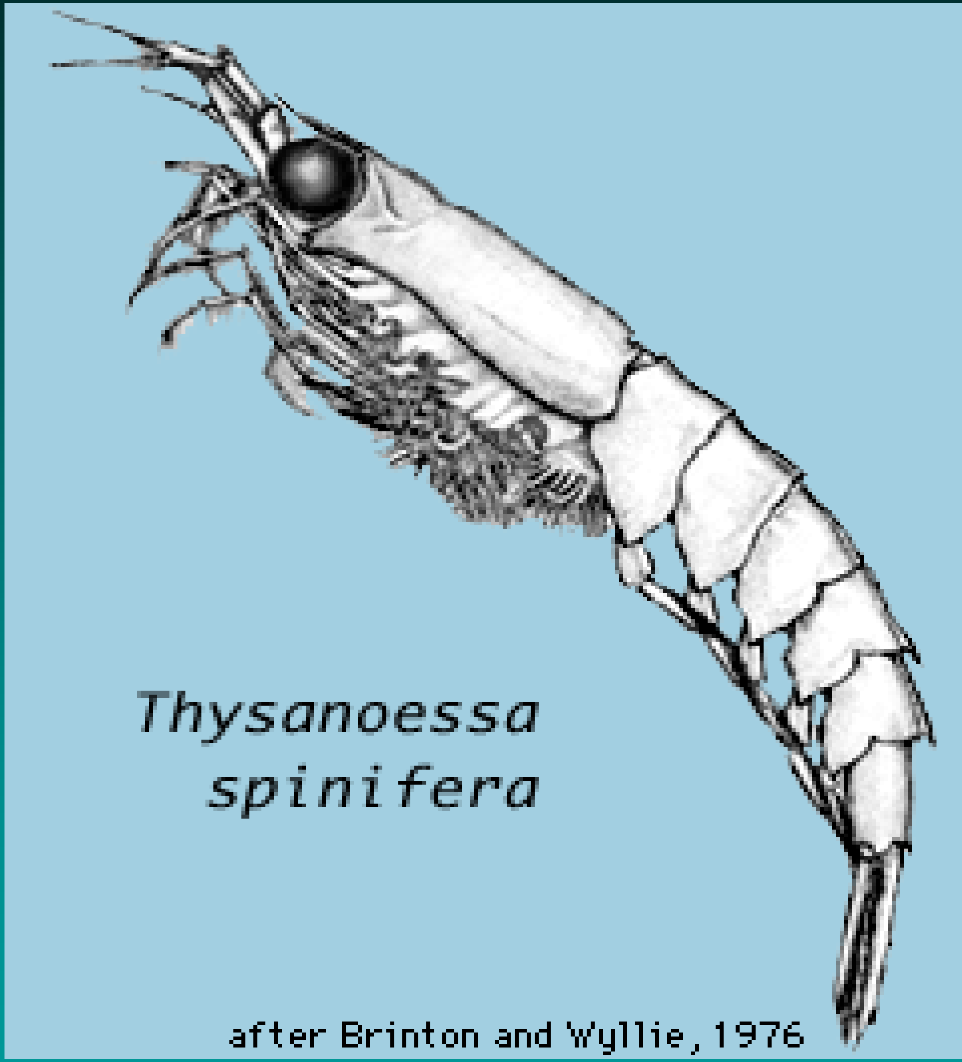


E. pacifica, continued

- I year life span off California (Brinton 1976)
- Continuous recruitment with peaks during upwelling periods. (Brinton 1976)
- Important prey of whales, fish, squid and birds.

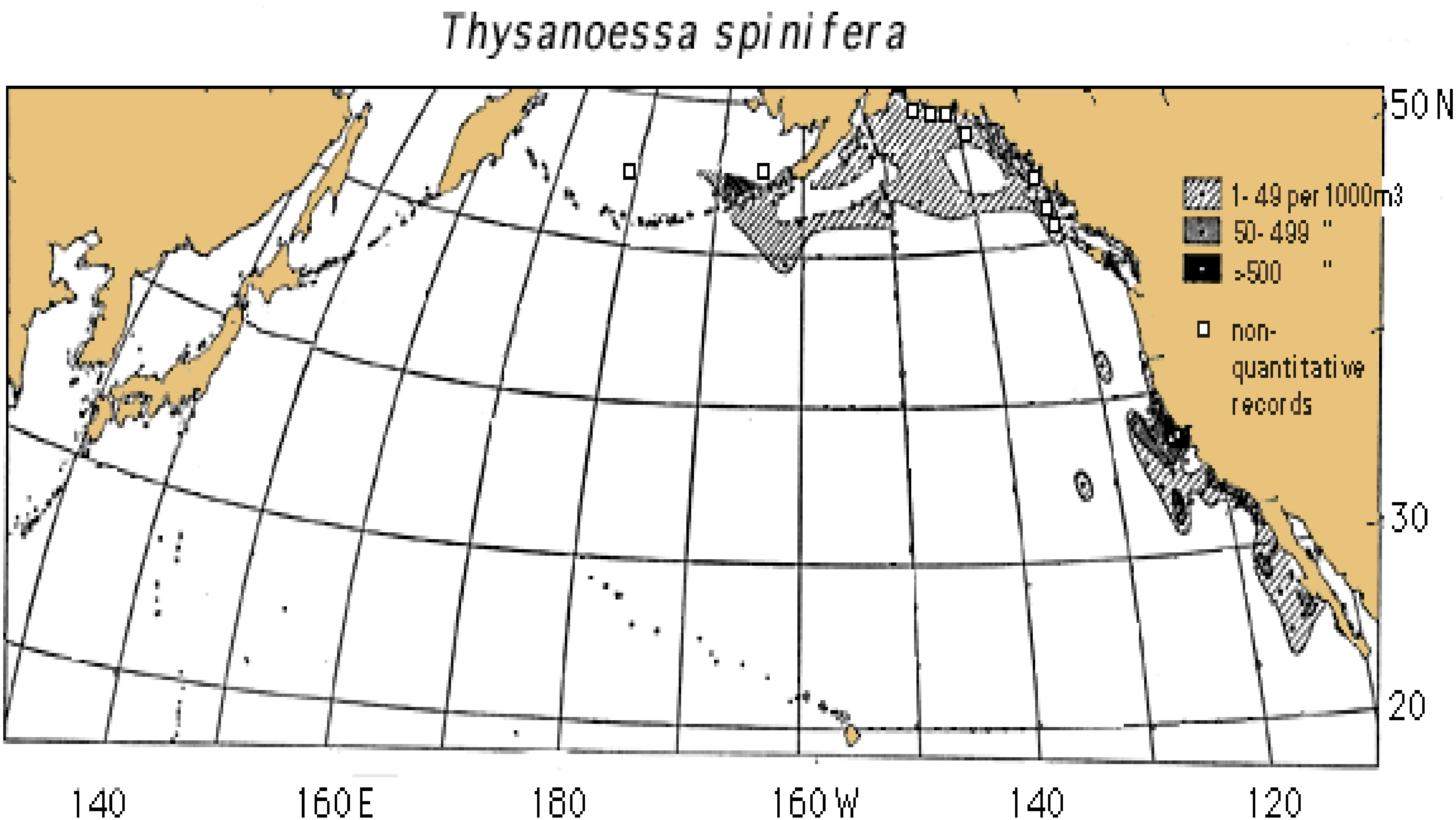
Thysanoessa spinifera

- Coastal/neritic; occurs in waters less than 100 m deep.
- Commonly forms dense daytime surface swarms.



- Size to 30 mm (1 ¼”)

Distribution



after Brinton, 1962b

T. spinifera, continued

- Longer life span; estimated three years.
- More discrete spawning season (May-July off California at upwelling peak).
- Biomass likely under-estimated — adults good at avoiding nets.
- Also important forage.

Both…

- Cool-water subarctic species.
- Biomass plummets extreme warm water years, but resilient, can rebound from El Niño lows.

BUT….

- No comprehensive coast-wide biomass, MSY or OY estimates available.
- No annual predator consumption estimates available, but lots on presence in diet of a great variety of California Current fishes, birds and whales.

Biomass Estimates

ESTIMATED BIOMASS/DENSITY

- Very rough *E pacifica* estimate from NMFS (1976) *of* "probably over 100 million tons off California." Thought to be based on Brinton's (1976) density estimates (i.e., avg. 10-1,000 mg wet weight of *E. pacifica* beneath 1m^2 of sea off California).

- Above avg. densities extrapolate to ~12,350 mt to 1.2 million mt for SCB alone. *BUT* from a cool-water (favorable) period, so represents *upper* range.

DECADAL BIOMASS TRENDS (1950-2002) **(Brinton and Townsend 2003)**

- *E. pacifica* and *T. spinifera* peak biomass collapsed as much as 90% during extreme El Niño periods, (less so in central vs. southern California), but populations rebounded quickly in succeeding cool years.

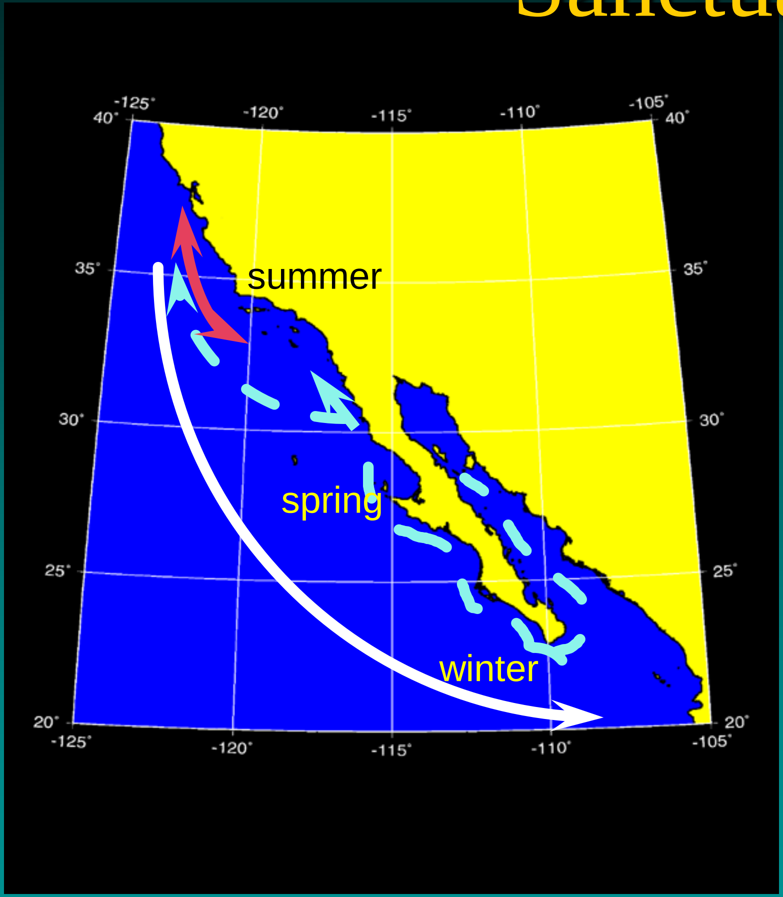
- Densities similar for *E. pacifica* in central and southern California; tho *T. spinifera* overall appears more abundant in north.

Partial List of Predators

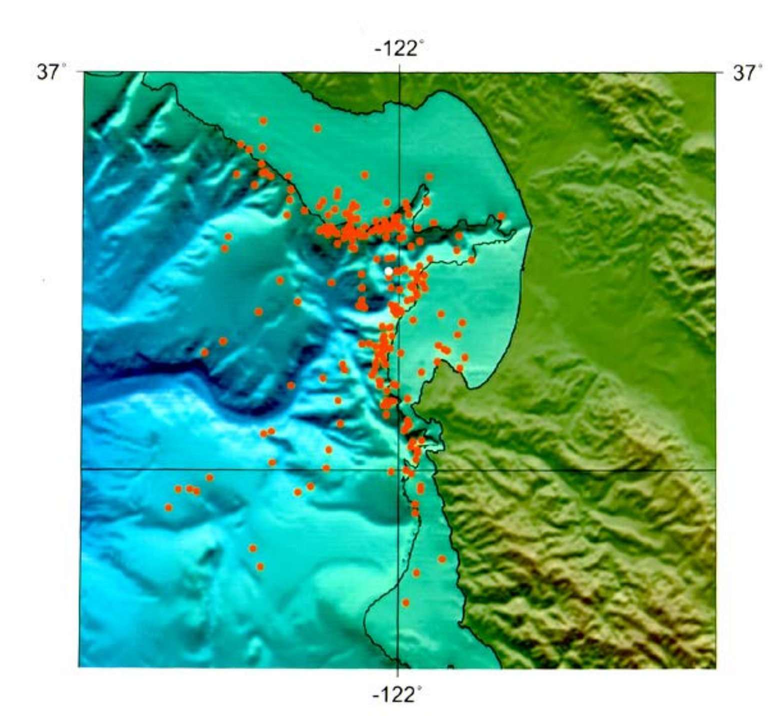
- Market squid
- Pacific hake
- Pacific herring
- Spiny dogfish
- Blue shark
- Sablefish
- Myctophids
- Jack mackerel
- Pacific mackerel
- Pacific sardine
- Numerous *Sebastes* species (e.g., boccacio, widow, yellowtail rockfishes)
- Pacific sanddab
- Slender sole
- Pacific halibut
- Chinook salmon
- Coho salmon
- Albacore
- Cassin's auklet
- Marbled murrelets
- Western gull
- Sooty shearwater
- Common murre
- Humpback whale
- Blue whale
- Grey whale

Krill Presence in NOAA Marine Sanctuary Waters

Blue and fin whales have been documented feeding on layers of krill in the vicinity of the Channel Islands, Monterey Bay, Gulf of Farallones and Cordell Bank Marine Sanctuaries.



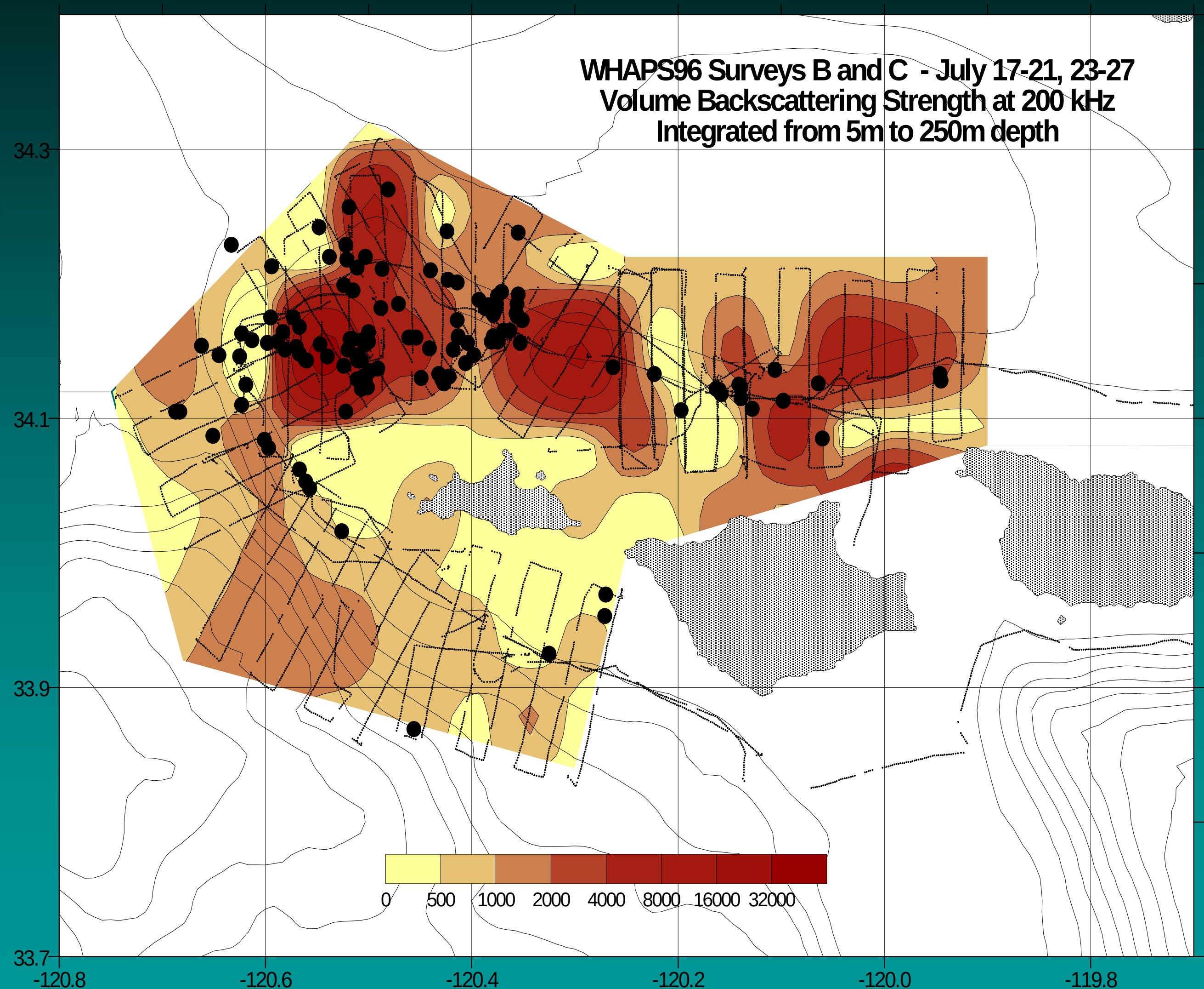
California Blue Whale Seasonal Movements
Calving: December - February
Weaning: June - August
(Calimbokidus, Gendron, Croll, Tershy)



Monterey Bay Blue Whale Sightings
N=411 sightings 1992-1996
(Black, Ternullo, Baldridge, Croll)

Presence in Marine Sanctuary Waters, Continued…

- High krill densities associated with bathymetric features that modify ocean currents (e.g., banks, continental shelves around islands, submarine canyons.

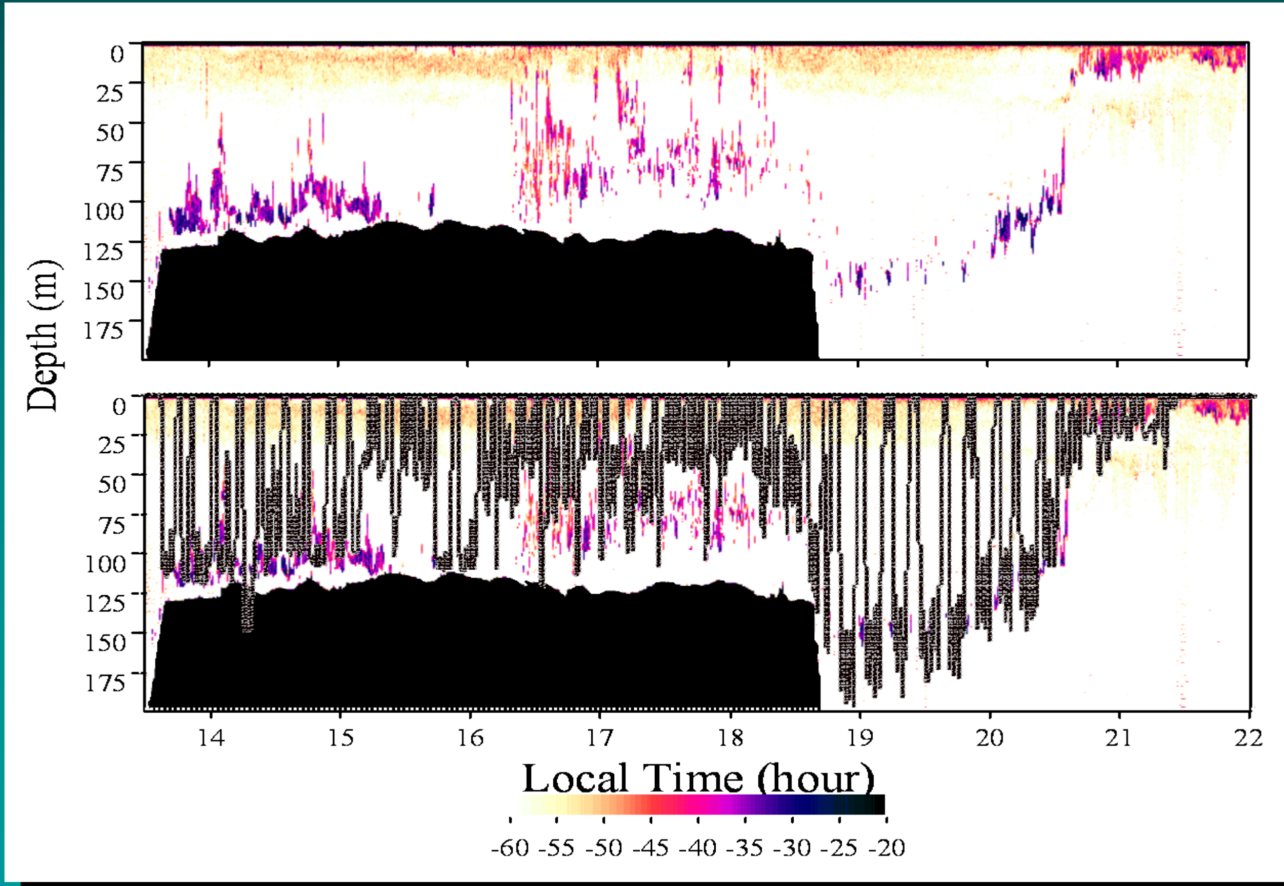


Integrated volume backscattering strength (m^2 nm^{-2}) of krill near the Santa Barbara Channel Islands, July 1996

Presence in NOAA Marine Sanctuary Waters, Continued…

- Whales and seabirds aggregate near these features to take advantage of high densities of krill.

Blue whale dive tracks (black) following day/night movements of krill (red) on shelf break near Channel Islands, California.



North Pacific Krill Fisheries

- Product used in fish culture; aquarium/ pet food; human consumption. Frozen; freeze-dried.
- California imposed ban on krill fishing in state waters in 2000; Oregon in 2003.
- Washington prohibits landing and sale of commercial quantities of krill.
- Fisheries for *E. pacifica* exist in Japan and British Columbia

British Columbia Fishery

- **Began as experimental fishery Strait of Georgia in 1972**
- **Quotas established 1976 in response to concerns about harvesting an important forage species, and bycatch of juvenile salmon.**
- **Annual catch set at 500 t (3% of estimated annual consumption of krill by all predators in the Strait). Seasonal closures enacted to limit bycatch.**
- **Limited entry in 1993 to 18 fisher licenses (< 10 vessels now active)**
- **1995 workshop held at U. of B.C. on "Harvesting Krill: Ecological Impact, Assessment, Products and Markets."**
- **Quota of 500 t remains fixed; Canada does not support further development of fisheries on forage species such as krill .**

Tentative Conclusions

- **Need estimates annual consumption by all predators**
- **Need annual regional biomass estimates of both species (with range covering different oceanic regimes).**
- **Possible that krill surplus off California (beyond predator needs) could support a small, quota-managed fishery in high production (cold-water) years, but not likely in warm-water years when forage is typically scarce for predators.**
- **Other factors, such as bycatch, should also be considered**
- **A background paper on krill has been prepared and is included in Council briefing materials.**

Acknowledgements

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- Michele Robinson Culver and Greg Bargmann, WA Dept Fish &Wildl.
- Jean McCrae, Oregon Dept. Fish & Wildlife
- Keith Sakuma, NMFS, Santa Cruz, CA

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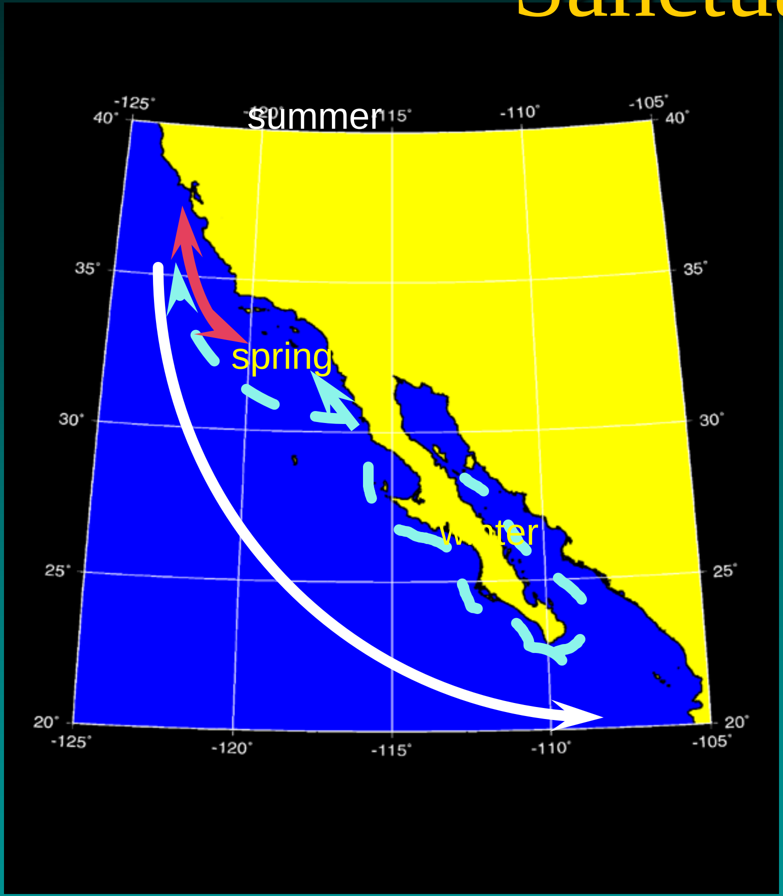

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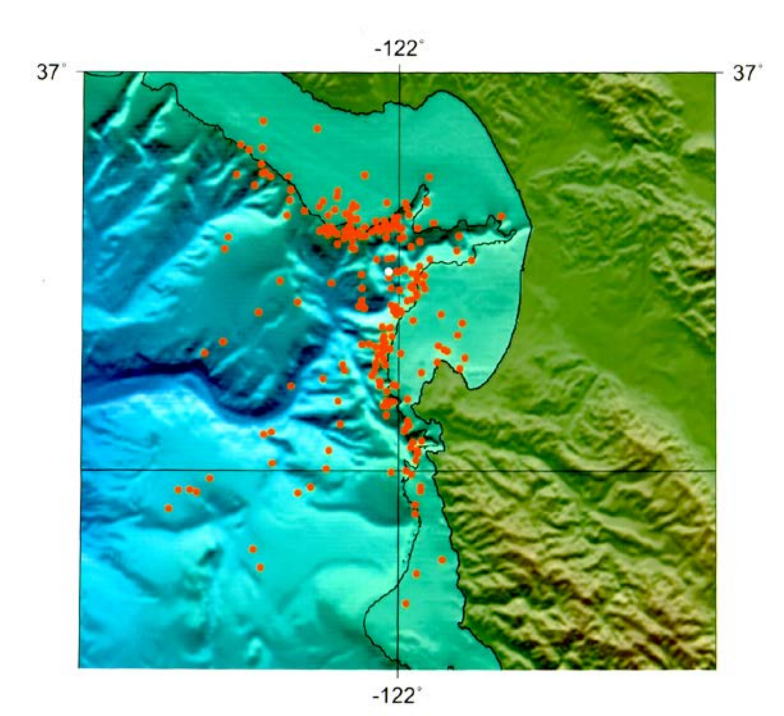

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N=411 sightings 1992-1996
(Black, Ternullo, Baldridge, Croll)

OPTIONS FOR CONTROLLING FISHING FOR KRILL

This paper is intended to provide information to the Pacific Council as it considers whether, and if so how, to control or prohibit fishing for krill in the EEZ off the West Coast.

1. Rely on List of Fisheries and State prohibitions

The List of Fisheries published at 50 CFR 600.725(v) was established under § 305(a) of the Magnuson-Stevens Act. The list identifies all fisheries under the authority of each regional council and all fishing gear used in such fisheries. It provides a means to prohibit the entry of new gears into U.S. fisheries until a council has had an opportunity to evaluate whether the entry would be consistent with the council's management programs. A person may not fish for and/or retain species except as taken with gear authorized for the listed fisheries. A person may not use a gear or participate in a fishery not already on the list unless that person has notified the appropriate council at least 90 days in advance. A council may request the Secretary to promulgate emergency regulations to prohibit any person or vessels from using an unlisted fishing gear or engaging in an unlisted fishery if the council determines that such unlisted gear or unlisted fishery would compromise the effectiveness of conservation and management efforts under the Magnuson-Stevens Act. This would provide the council with time to consider and adopt appropriate controls through regular processes. The list does not now include fishing for krill off the West Coast with any gear as a listed fishery. However, the list does include an entry for "Commercial (non-FMP)" with trawl as an authorized gear. Thus, it may not be useful in controlling krill fishing. A person who wants to engage in fishing for krill could to claim that trawl fishing for krill is eligible under the list. However, to be better prepared in the event of challenge, the person might be better off to advise the Pacific Council at least 90 days in advance of such fishing. At that point, the Council could decide whether to request emergency action under the M-SA. It should be noted (as in other materials) that the West Coast States already prohibit landings of krill, so there will continue to be control of krill fishing by coastal-based fishers for the time being except if they were able to find other locations at which landings would be permitted.

2. Incorporate krill as a management unit species in the CPS FMP

The CPS FMP provides a potentially useful model for explicitly incorporating the role that krill may serve as forage in the framework for managing fisheries for krill. For example, the FMP provides that the spawning biomass for Pacific sardine must be at a certain level before any fishing is permitted, and then only allows a portion of the spawning biomass above that minimal threshhold to be harvested. The FMP includes an objective or maintaining the biomass at levels that provide forage for other species. Conceptually, the same approach could be used with krill, with the distinction that, given the available information about krill and the nature and extent of dependence of other fish and non-fish species on krill, the available harvest would initially be zero. This would be a precautionary approach, recognizing the data poor situation and the risk that allowing directed harvest would have substantial adverse effects on other fish stocks and possibly other marine resources. Over time, through ecosystem research and monitoring, and possibly exempted fishing or cooperative research with industry, an information base could be developed that would demonstrate whether certain harvest levels, or harvests in certain times or places, would be acceptable. The amended FMP could establish a process for making such determinations through the Council process. This approach would preclude persons in other fisheries (whether under FMPs or not) from engaging in krill fishing until a Council decision allowing krill fishing.

By explicitly setting a stage for “management” of krill fishing, this alternative might increase the visibility of krill and thus enhance the ability to obtain resources dedicated to krill research and monitoring. This FMP amendment approach would be relatively straightforward, though it also would take dedication of some Council resources. The extent of Council resources needed would vary depending on the timetable in which the Council would seek to complete action and the extent to which NMFS would be able to take on some of the documentation requirements. In the interim, the controls associated with States’ prohibitions and the List of Fisheries (and the prospect of emergency action) could provide protection during the FMP amendment preparation and implementation period.

3. Designate krill as forage under one or more FMPs

Under this alternative, one or more fishery management plans would be amended to designate krill as forage for managed species and then prohibit fishing for krill. This approach was used by the North Pacific Council, which amended its fishery management plans for Gulf of Alaska groundfish and Bering Sea groundfish to prohibit krill fishing. Development of the amendments (both were necessary because of the geographic limits of the separate FMPs) was relatively simple and quick; there were no substantial objections from any sectors and thus the process went very smoothly. Given that there was no interest in fishing for krill and generally strong support for ensuring the continued abundance of krill for groundfish forage (as well as forage for some cetaceans and other species), this approach was very effective in Alaska. It is noteworthy that the Magnuson-Stevens Act has a special provision that allows the State of Alaska to assert management jurisdiction over non-State vessels in the EEZ off Alaska, and thus Council action with respect to groundfish fishers could be reinforced by State controls over non-groundfish fishers. In the Pacific Council, however, no such authority exists, though as noted all States currently prohibit landings of krill. This approach might be most effective if a “generic” FMP amendment were developed to establish krill as forage in all Council FMPs for species for which krill is known to be forage. It is not known, however, if there would be pressure to include other forage species (the Alaska approach identified several species as forage). This alternative would largely be a Council workload, and the workload might not be great if the amendment were kept very simple. NMFS would be able to provide substantial background information about krill and its forage role for fish and other living marine resources. The controls through State prohibitions and the List of Fisheries (and the prospect of emergency action) still could provide protection in the interim.

4. Designate krill as a component of essential fish habitat in follow-up to analysis of this action as an alternative in the EFH EIS and/or other FMPs

This in some respects is the same as the “forage” amendment as essential fish habitat (EFH) for managed fish species can include food sources for those species. Krill are known forage for a large number of groundfish species off the West Coast (as well as other fish species), and therefore, the Council could amend its Groundfish FMP (and possibly other FMPs) to designate krill as a component of the EFH for groundfish. This could be initiated by including in the EFH EIS an alternative in which krill is designated as an EFH component, with the harvest of krill to be prohibited. This could be followed by an FMP amendment to carry out this alternative. Because the EIS is driven by a court-mandated deadline, this step would be accomplished by May 2006. This approach would leave much of the preparation of background documentation in NMFS' hands as part of the EFH EIS process rather than taking Council staff resources. The ultimate FMP amendment(s), however, would be a Council responsibility. Because of the timetable for the EIS, however, this would likely not result in prompt action. The controls through State prohibitions and the List of Fisheries (and the prospect of emergency action) still could provide protection in the interim.

SALMON ADVISORY SUBPANEL REPORT ON KRILL HARVEST BAN PROPOSAL

The Salmon Advisory Subpanel encourages the Council to protect krill as a forage species.

PFMC
9/14/04