RESEARCH AND DATA NEEDS

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PRELIMINARY DRAFT
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ACRONYMS AND DEFINITIONS

Acronym	Definition
ABC	Acceptable biological catch. See below.
acceptable biological catch	The ABC is a scientific calculation of the sustainable harvest level of a fishery and is used to set the upper limit of the annual total allowable catch. It is calculated by applying the estimated (or proxy) harvest rate that produces maximum sustainable yield to the estimated exploitable stock biomass (the portion of the fish population that can be harvested).
ASAP	Age-structured Assessment Program
ATCA	Atlantic Tunas Convention Act
AUV	Autonomous Underwater Vehicle
barotrauma	Physical trauma or injury to a fish due to pressure change. When a fish is rapidly brought from deep water to the surface, the drop in pressure can cause a variety of physical problems, such as severe expansion of the swim bladder and gas bubbles in the blood.
CalCOFI	California Cooperative Oceanic Fisheries Investigations
catch per unit of effort	The quantity of fish caught (in number or weight) with one standard unit of fishing effort. For example, the number of fish taken per 1,000 hooks per day, or the weight of fish, in tons, taken per hour of trawling. CPUE is often considered an index of fish biomass (or abundance). Sometimes referred to as catch rate. CPUE may be used as a measure of economic efficiency of fishing as well as an index of fish abundance.
CCS	California Current System
CDFG	California Department of Fish and Game
coastal pelagic species	Coastal pelagic species are schooling fish, not associated with the ocean bottom, that migrate in coastal waters. They usually eat plankton and are the main food source for higher level predators such as tuna, salmon, most groundfish, and humans. Examples are herring, squid, anchovy, sardine, and mackerel.
coded-wire tag	Coded-wire tags are small pieces of stainless steel wire that are injected into the snouts of juvenile salmon and steelhead. Each tag is etched with a binary code that identifies its release group.
cohort	In a stock, a group of fish born during the same time period.

Acronym	Definition
COP	Council Operating Procedures
Council	Pacific Fishery Management Council
CPFV	Commercial passenger fishing vessel (charter boat)
CPS	Coastal pelagic species. See above.
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CPUE	Catch per unit of effort. See above.
CUFES	Continuous Underwater Fish Egg Sampler
CWT	Coded-wire tag. See above.
DEPM	Daily egg production method
EBFM	Ecosystem-Based Fishery Management
EEZ	Exclusive Economic Zone. See below.
EFH	Essential fish habitat. See below.
EIS	Environmental impact statement. See below.
El Niño Southern Oscillation	Abnormally warm ocean climate conditions, which in some years affect the eastern coast of Latin America (centered on Peru) often around Christmas time. The anomaly is accompanied by dramatic changes in species abundance and distribution, higher local rainfall and flooding, and massive deaths of fish and their predators. Many other climactic anomalies around the world are attributed to consequences of *El Niño*.
Endangered Species Act	An act of federal law that provides for the conservation of endangered and threatened species of fish, wildlife, and plants. When preparing fishery management plans, councils are required to consult with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service to determine whether the fishing under a fishery management plan is likely to jeopardize the continued existence of an ESA-listed species or to result in harm to its critical habitat.

Acronym	Definition
Environmental impact statement	As part of the National Environmental Policy Act (NEPA) process, an EIS is an analysis of the expected impacts resulting from the implementation of a fisheries management or development plan (or some other proposed action) on the environment. EISs are required for all fishery management plans as well as significant amendments to existing plans. The purpose of an EIS is to ensure the fishery management plan gives appropriate consideration to environmental values in order to prevent harm to the environment.
ESA	Endangered Species Act. See above.
essential fish habitat	Those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.
Exclusive Economic Zone	A zone under national jurisdiction (up to 200 nautical miles wide) declared in line with the provisions of the 1982 United Nations Convention of the Law of the Sea, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources.
exempted fishing permit	A permit issued by National Marine Fisheries Service that allows exemptions from some regulations in order to study the effectiveness, bycatch rate, or other aspects of an experimental fishing gear. Previously known as an "experimental fishing permit."
Fathom	Used chiefly in measuring marine depth. A fathom equals six feet.
FEIS	Final Environmental Impact Statement (see EIS, NEPA).
Fm	Fathom (6 feet)
FMP	Fishery management plan. See above.
FRAM	Fishery Regulation Assessment Model. Typically used for salmon.
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
GSI	Genetic stock identification
Habitat areas of particular concern	Subsets of essential fish habitat (see EFH) containing particularly sensitive or vulnerable habitats that serve an important ecological function, are particularly sensitive to human-induced environmental degradation, are particularly stressed by human development activities, or comprise a rare habitat type.

Acronym	Definition
HAPC	Habitat areas of particular concern. See above.
Harvest guideline(s)	A numerical harvest level that is a general objective, but not a quota. Attainment of a harvest guideline does not require a management response, but it does prompt review of the fishery.
Highly migratory species	In the Council context, highly migratory species in the Pacific Ocean include species managed under the HMS Fishery Management Plan: tunas, sharks, billfish/swordfish, and dorado or dolphinfish.
HMS	Highly migratory species. See above.
HMS FMP	Highly Migratory Species Fishery Management Plan. This is the fishery management plan (and its subsequent revisions) for the Washington, Oregon, and California Highly Migratory Species Fisheries developed by the PFMC and approved by the Secretary of Commerce.
IATTC	Inter-American Tropical Tuna Commission
IFQ	Individual fishing quota. See below.
IMECOCAL	A program in Baja California concerning small pelagics and climate change.
Incidental catch or incidental species	Species caught when fishing for the primary purpose of catching a different species.
Incidental take	The "take" of protected species (such as listed salmon, marine mammals, sea turtles, or sea birds) during fishing. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct.
Individual transferable (or tradeable) quota	A type of quota (a part of a total allowable catch) allocated to individual fishermen or vessel owners and which can be transferred (sold, leased) to others.
ISC	International Scientific Committee
ITQ	Individual Transferable (or Tradable) Quota. See above.
KOHM	Klamath Ocean Harvest Model (for salmon)
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act. See below.

Acronym	Definition
Magnuson-Stevens Fishery Conservation and Management Act	The MSFCMA, sometimes known as the "Magnuson-Stevens Act," established the 200-mile fishery conservation zone, the regional fishery management council system, and other provisions of U.S. marine fishery law.
Marine Mammal Protection Act	The MMPA prohibits the harvest or harassment of marine mammals, although permits for incidental take of marine mammals while commercial fishing may be issued subject to regulation. (See "incidental take" for a definition of "take").
Maximum sustainable yield	An estimate of the largest average annual catch or yield that can be continuously taken over a long period from a stock under prevailing ecological and environmental conditions. Since MSY is a long-term average, it need not be specified annually, but may be reassessed periodically based on the best scientific information available.
MMPA	Marine Mammal Protection Act. See above.
MPA	Marine protected areas
MSA	Magnuson-Stevens Fishery Conservation and Management Act. See above.
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act. See above.
MSY	Maximum sustained yield. See above.
National Marine Fisheries Service	A division of the U.S. Department of Commerce, National Ocean and Atmospheric Administration (NOAA). NMFS is responsible for conservation and management of offshore fisheries (and inland salmon). The NMFS Regional Director is a voting member of the Council.
NGO	Nongovernmental organization
NMFS	National Marine Fisheries Service. See above.
NMFS NWFSC	National Marine Fisheries Service Northwest Fisheries Science Center
NMFS NWR	National Marine Fisheries Service Northwest Region
NMFS SWFSC	National Marine Fisheries Service Southwest Fisheries Science Center
NMFS SWR	National Marine Fisheries Service Southwest Region
NMSA	National Marine Sanctuaries Act

Acronym	Definition
NMSP	National Marine Sanctuaries Program
NOAA	National Oceanic & Atmospheric Administration. The parent agency of National Marine Fisheries Service.
ODFW	Oregon Department of Fish and Wildlife
Optimum yield	The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. The OY is developed on the basis of the Maximum Sustained Yield from the fishery, taking into account relevant economic, social, and ecological factors. In the case of overfished fisheries, the OY provides for rebuilding to a level that is consistent with producing the Maximum Sustained Yield for the fishery.
OY	Optimum yield. See above.
Pacific States Marine Fisheries Commission	The PSMFC is a non-regulatory agency that serves Alaska, California, Idaho, Oregon and Washington. PSMFC (headquartered in Portland) provides a communication exchange between the Pacific Fishery Management Council and the North Pacific Fishery Management Council, and a mechanism for federal funding of regional fishery projects. The PSMFC provides information in the form of data services for various fisheries.
PaCOOS	Pacific Coast Ocean Observing Program
PFMC	Pacific Fishery Management Council
PNW	Pacific Northwest
PSMFC	Pacific States Marine Fisheries Commission. See above.
Quota	A specified numerical harvest objective, the attainment (or expected attainment) of which causes closure of the fishery for that species or species group.
RCA	Rockfish Conservation Area (Depends on how it is used)
RFMO	Regional Fishery Management Organization

Acronym	Definition
RMP	Resource management plan. Covers impacts to listed species from activities of state and local governments, under section 4(d) of the Endangered Species Act.
SAFE	Stock assessment and fishery evaluation. See below.
SEM	Scanning Electron Microscopy
Scientific and Statistical Committee	An advisory committee of the PFMC made up of scientists and economists. The Magnuson-Stevens Act requires that each council maintain an SSC to assist in gathering and analyzing statistical, biological, ecological, economic, social, and other scientific information that is relevant to the management of Council fisheries.
SS2	Stock Synthesis 2 – Population assessment program.
SSC	Scientific and Statistical Committee. See above.
STAR	Stock assessment review
STAR Panel	Stock Assessment Review Panel. A panel set up to review stock assessments for particular fisheries. In the past there have been STAR panels for sablefish, rockfish, squid, and other species.
Stock Assessment and Fishery Evaluation	A SAFE document is a document prepared by the Council that provides a summary of the most recent biological condition of species in the fishery management unit, and the social and economic condition of the recreational and commercial fishing industries, including the fish processing sector. It summarizes, on a periodic basis, the best available information concerning the past, present, and possible future condition of the stocks and fisheries managed in the FMP.
TIQ	Trawl Individual Quota
Vessel Monitoring System	A satellite communications system used to monitor fishing activities—for example, to ensure that vessels stay out of prohibited areas. The system is based on electronic devices (transceivers), which are installed on board vessels. These devices automatically send data to shore-based "satellite" monitoring system.
WCGOP	West Coast Groundfish Observer Program
WCPFC	Western and Central Pacific Fisheries Commission
WDFW	Washington Department of Fish and Wildlife

WG	Working Group

1.0 INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) includes directives to 1) prevent overfishing, 2) rebuild depressed fish stocks to levels of abundance that produce maximum sustainable yield (MSY), 3) develop standardized reporting methodologies to assess the amount and type of bycatch, 4) adopt measures that minimize bycatch and bycatch mortality, to the extent practicable, 5) describe and identify essential fish habitat (EFH), and 6) assess the impact of human activities, including fishing impacts, on habitat. The MSA also encourages the participation of the fishing industry in fishery research. Additionally, Standard 8 mandates consideration of the effects of fishery management measures on communities. These directives require substantial data collection and research efforts to support Council management of West Coast fisheries.

In January 2007, the *Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006* reauthorized the MSA through fiscal year 2013. The MSA, as amended, retains key feature of the *Sustainable Fisheries Act of 1996* while strengthening the Regional Fishery Management Councils, improving fishery management decision making through improved processes and an increased role of science, and increasing U.S. leadership in international fishery management and conservation issues.

Specific to research, data collection, and reporting, the amended MSA added several new provisions and programs, including:

- A study on the state of science for the integration of ecosystem consideration in fishery management, MSA Section 406.
- Bycatch Reduction Engineering Program, MSA Section 316.
- Cooperative Research and Management Program, MSA Section 318.
- Deep Sea Coral Research and Technology Program, MSA Section 408.
- A requirement under Regional Fishery Management Council Functions, MSA Section 302(h)(7), that the Council shall,

  "(7) *develop, in conjunction with the scientific and statistical committee, multi-year research priorities for fisheries, fisheries interactions, habitats, and other areas of research that are necessary for management purposes, that shall—*

  (A) establish priorities for 5-year periods;

  (B) be updated as necessary; and

  (C) be submitted to the Secretary and the regional science centers of the National Marine Fisheries Service for their consideration in developing research priorities and budgets for the region of the Council."

This document, when adopted in its final form by the Council in the fall of 2008, is intended to document and communicate the Council's research and data needs through 2014 thereby fulfilling the Council's responsibilities under MSA Section 302(h)(7).

1.1 Schedule of Document Development and Review

The Council proposes to follow the schedule outlined in the recently approved Council Operating Procedure 12 (see excerpt below). Council staff is providing this preliminary draft in March to allow additional time for advisory bodies and the Council to review the document during this busy time of year and provide written comments to the SSC and Council staff by at the April Council meeting.

EXCERPT FROM COUNCIL OPERATING PROCEDURE 12

PROCEDURE

Contingent upon its overall workload priorities, the Council will strive to develop and maintain relevant documents which display and communicate the Council's research and data needs for 5-year periods using the following schedule of tasks as a standard guide.

Continuous

Year-Round — *Council staff keeps track of research and data needs as they arise in various forms throughout the year and, as appropriate, advocates for efforts to address Council (such advocacy shall not include the lobbying of Congress).*

Five-Year-Update Cycle

April — *Council staff presents updated research and data document to the Scientific and Statistical Committee (SSC) and other advisory bodies for review at the April Council meeting. Advisory bodies provide written comments to the SSC. (Item is not on Council agenda).*

June — *The SSC presents recommended revisions to the Council. Other advisory bodies provide comment to the Council. The Council approves draft documents for public review.*

September — *After reviewing comments from the public and Council advisory entities, the Council adopts its research and data needs. The document is submitted to NMFS West Coast regions and centers and the states. The final document is also transmitted to West Coast and National Sea Grant institutions and posted on the Council web page.*

Early December — *Council Chair and staff meet with representatives from NMFS West Coast regions and centers and Pacific States Marine Fisheries Commission (PSMFC) to develop a consensus on high priority initiatives needed to respond to Council needs. Council Chair writes a letter to NMFS to transmit the conclusions from the meeting.*

Out-of-Cycle Modifications to the Needs List

If a situation arises that would benefit from an out-of-cycle modification to the documents, the Council may announce its intent to modify the research and data needs document outside the 5-year process and make such a modification at its next meeting.

1.2 Document Organization

This document represents a summary of research and data needed by the Council to implement its responsibilities as defined by the MSA, the Regulatory Flexibility Act, and other pertinent legislation. The document is largely organized according the Council's four FMPs with additional sections for economic and social science components and ecosystem-based fishery management and marine protected area issues. Because each FMP or management component has a unique Council history and its own issues and data needs, each section is organized in a style best suited for its particular research and data needs. Where appropriate, these sections address continuing issues and identify important emerging issues.

The bulleted list below represents the set of general criteria used to identify the highest priority needs. These criteria were first identified in 2000 and were applied in this most recent exercise as guiding principles rather than explicitly defined rules for developing research and data needs.

- Projects address long-term fundamental needs of West Coast fisheries.
- Projects improve the quality of information, models, and analytical tools used for biological assessment and management.
- Projects increase the long-run market competitiveness and economic profitability of the industry.
- Projects contribute to the understanding by decision makers of social and economic implications in meeting biological and conservation objectives.
- Projects provide data and/or information to meet the requirements of the MSA, the Regulatory Flexibility Act, and other applicable laws.

2.0 GROUNDFISH FISHERY MANAGEMENT PLAN

2.1 General Issues

Further planning and coordination is needed with longer time horizons to address strategic objectives. A plan is needed for the development of research and data collection projects. The plan should include an evaluation of the availability of assessment data for each species in the FMP and the adequacy of existing surveys to monitor stock abundance trends. The plan should include specific projects as well as mechanisms for coordination and development of an ongoing interagency program for addressing West Coast groundfish research and data needs.

2.2 Continuing Issues

Develop and implement a coastwide multi-state system for electronic recording of fishticket information and fishery logbooks in consistent form.

An integrated electronic recording system for fishticket and logbook information for the Pacific coast is not yet in place. There has been some progress towards this goal. A pilot project was developed by NMFS NWFSC and tested by the California Department of Fish and Game (CDFG) and one processor in 2004, but this project received no additional funding. Funds for development of an electronic fishticket system for the Pacific coast have been allocated to the Northwest Regional Office for distribution to PSMFC as part of a nationwide NMFS initiative to promote electronic data recording. It is reasonable to anticipate that that this effort will bear fruit within several years.

This item remains a priority. The present need for real-time estimates of landings and discards is acute. The Groundfish Management Team and NMFS track groundfish catches inseason and attempt to produce close to real-time estimates of landings and discards. An electronic fishticket system would provide real-time landings data that are more precise with all the requisite information captured.

Logbooks are used with fishtickets and West Coast Groundfish Observer Program (WCGOP) data to reconcile the total catch by area and determine bycatch rates in association with target species. Logbook data availability can lag by as much as a year, which delays input data to bycatch models and the total catch reconciliation process. Electronic logbooks, like electronic fishtickets, increase accuracy of critical data needed for good management decision-making. Logbook programs should be developed for other commercial sectors beyond the limited entry trawl fishery.

Develop methods, programs, or analytical tools to quantify amount of groundfish discarded by the various fishing sectors.

WCGOP was established in 2001 to improve estimates of total catch and discard in West Coast fisheries. The program deploys over 40 observers, and collects at-sea data from limited-entry trawl and fixed gear fleets as well as from open access, nearshore, prawn, and shrimp fleets. Currently, the coverage objective is to maintain, at minimum, 20% coverage of the limited-entry trawl fleet and fixed gear fleets. WCGOP has made progress in quantifying discard in trawl fisheries and limited entry fixed gear fleets, however, observer coverage of open access fleets is

currently being expanded. Continued improvements in facilitating timely access to the information and data collected by WCGOP necessary to implement Council objectives remains a high priority. This would aid in analyses that help identify areas or fishing strategies in which available target species might be accessed with focused target fishing strategies, or within particular regions, with acceptable impacts on overfished species

Continue to work on a plan to conduct annual resource surveys.

An annual slope survey conducted by commercial trawlers was initiated by NMFS NWFSC in 1998. In 2003, the slope survey was extended onto the shelf and is now intended to be a comprehensive annual survey of both shelf and slope groundfish resources along the entire West Coast from the Mexican to Canadian border. This expanded survey supplants the Alaska Fisheries Science Center's triennial shelf survey, which was conducted for the final time in 2004.

Investigate impact of fishing gear on specific habitats and habitat productivity on the West Coast fishing grounds.

A major effort was made to prepare a comprehensive EIS analysis for the EFH amendment to the FMP. The EIS analysis was an integrated Geographic Information System (GIS) analysis that included the first complete substrate map of the Pacific coast, habitat suitability maps for groundfish species, and maps of fishing impact and habitat sensitivity. This analysis was a significant achievement, but a notable shortcoming was the lack of information on fishing impacts specific to Pacific coast habitats. In an extensive literature review, the EIS identified only two Pacific coast studies. One study was anecdotal; the other was an observational study funded by the Monterey Bay National Marine Sanctuary and published in 1998. Estimates of habitat sensitivity to fishing gear impact and habitat recovery were obtained from studies in other areas. There is no active research program to study fishing gear impacts on Pacific coast marine habitat. However there has been significant progress made consolidating existing information about the groundfish habitats as part of the EFH environmental impact statement (EIS) process.

Improve Fishery Monitoring and Data Collection

For reasons already noted, a fully integrated fishery statistics program, including fishtickets, logbooks, shoreside sampling, and observer program data is a priority for groundfish management.

- Estimating discards in the recreational groundfish fishery is increasingly important, particularly for non-retention species. Additional data is needed on the number and size of recreational discards.

- Bycatch model used to estimate total discards is an empirical model whose performance should be evaluated on an ongoing basis as data become available. Refinements to the bycatch model may be needed if model predictions of discard need improvement.

- Information on the size composition of discards was identified as data needed for the assessment of Dover sole, petrale sole, and English sole. Discards of these species can be significant and are unlikely to correspond to the default assumption that discards have the

same size composition as retained catch. In some cases, the size composition of discard provides information about the magnitude of recruiting year classes.

- Use of electronic monitoring of bycatch should be further explored.

- Electronic technologies and methods should be explored to improve the pace of data reporting of observer information as well as fish ticket information.

- There are significant information gaps in the age and growth information needed for assessments. Stock assessment review panel recommendations regarding additional age and growth information needs for stock assessments. In particular:
    - Uncertainty of length-at-age information for petrale sole and longspine thornyhead should be examined.
    - Sample sizes of age-collections for widow rockfish should be increased.
    - Production ageing should be conducted for blackgill rockfish.
    - Age information should be collected and used to resolve broad-scale questions regarding changes over time in growth in bocaccio.
    - Age and growth studies should be conducted for cabezon.

Resource Assessment Surveys

Given the low estimates of potential yield and the long rebuilding trajectories for many rockfish, particularly yelloweye rockfish and canary rockfish, there is a particular need to supplement existing surveys with means of estimating abundance and biomass trends that have a lesser impact on resources, and that survey habitat not traditionally indexed by trawl surveys.

- Evaluate feasibility of and develop as appropriate alternative survey methodologies for measuring abundance and distribution of groundfish. In recent years, feasibility studies or small-scale surveys have been conducted using Autonomous Underwater Vehicles (AUVs), submersibles, acoustics, towed cameras, LIDAR, hook and line gear, and egg and larval sampling. Research should be conducted to evaluate the comparative costs and utility of these alternative survey methods for groundfish assessment.

- Develop a coastwide survey of rockfish populations in untrawlable areas. Fairly low cost non-extractive advanced technologies (i.e., bottom mapping AUV's) are currently available. The use of comprehensive non-extractive methods to assess abundances in areas not well surveyed by the current bottom trawl survey should be developed and evaluated. Continue to explore an acoustical-optical survey as and index of groundfish abundance off southern and central California.

- The continuation and enhancement of the International Pacific Halibut Commission's annual hook-and-line survey as a means to collect yelloweye rockfish data for consideration in the yelloweye rockfish stock assessments is also a high research priority, given the truncation of catch per unit of effort (CPUE) time series from targeted longline and recreational fisheries.

- Maintain CalCOFI surveys and expand processing of collected samples.

- Improve survey information for canary and widow rockfish. Cooperative industry surveys for canary and widow rockfish hold promise.

- Additional attention should be given to evaluating hook and line or longline gear for surveying rockfish populations. The gear is inexpensive, can be standardized across survey platforms, is deployable on a variety of bottom types, and is suitable for cooperative research projects with the fishing fleet. Since most rockfish species are not common and have low productivity, sustainable yields are likely to be low even after overfished species are rebuilt. Only low cost or self-funding survey methods may be viable over the long term given the vagaries of state and Federal funding for fisheries research.

- Review research needs identified in recent *Joint Canadian and U.S. Pacific Hake/Whiting Stock Assessment Review Panel Reports* and conduct additional investigations to improve the Pacific whiting acoustic survey including:
    - Evaluating the current target strength for possible biases.
    - Exploring alternative methods for estimating target strength.
    - Continuing to compare spatial distributions of Pacific whiting across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years.

Biological Information Including Fishery and Productivity Parameters

- Expand research on basic life history of nearshore groundfish stocks that are targeted by hook and line fisheries and recreational fisheries. Studies should be specifically designed to estimate basic assessment information, including growth curves, length-weight relationships, age and length-maturity schedules, and longevity. Identify which species in the groundfish FMP are lacking this basic information and develop a timetable for generating this information.

- Recreational fishery impacts could be better estimated with improved understanding of discard mortality rates, particularly in nearshore waters where the ability to survive barotrauma or hooking or trapping injuries, may vary among species. There may also be long-term physiological effects on reproductive output due to capture and release, which could have stock productivity and management implications.

- Conduct comprehensive gut analysis of groundfish to determine basic trophic interactions. Only piecemeal information is currently available. Comprehensive information will be essential for developing ecosystem assessments for the California Current System (CCS).

Stock Assessment Modeling

- Evaluate the statistical properties (i.e., bias, estimability, variance, etc.) of current stock assessment models used for groundfish. Assessment models for groundfish are complex with many estimated parameters, yet often the data used to fit these models are sparse and

uncertain. The reliability of model estimates should be tested using simulation procedures.

- Conduct field projects and modeling studies to determine which selectivity assumptions (dome shape vs. asymptotic) are most appropriate for the various groundfish stocks including lingcod and numerous species of rockfish with age structured assessments.

- Continue the evaluation of optimum yield (OY) control rules, biological reference points, spawner-recruit relationships and harvest policies used to make decisions about acceptable biological catch and harvest guideline/OY for groundfish. Simulation methods should be used to evaluate the performance of harvest control rules used to determine OY, and to test alternative methods for determining B_{MSY} and F_{MSY} . Harvest policies should be tested to determine whether they are robust to decadal- scale environmental variation.

- Evaluate how best to account for and report uncertainty in stock assessments. Explore alternative approaches to present uncertainty in a way that facilitates informed decision-making.

2.3 Emerging Issues

Fishery Monitoring and Data Collection

- Several of the 2007 assessments have conducted historical commercial and recreational catch reconstructions. An effort needs to be made to develop a consistent approach to reconstructing catch histories. The ideal outcome would be a single document outlining the best reconstructed catch histories for each species (c.f. Rogers (2003) that lists foreign catches). Particular attention should be paid to constructing a coastwide catch history for rockfish.

- The accuracy and precision of recreational catch and effort estimates for minor fishing modes such as beach and bank anglers, private access sites, and night fishing needs to be investigated.

- The California landing receipts on microfilm back to 1950 should be incorporated into the landings database.

- Development of fishery independent time series using fixed sites and volunteer fisherman properly supervised using standard protocols.

- Cooperative research are playing an increasing role in West Coast fishery science and management as fishing opportunities have decreased and research needs increased. Ongoing cooperative research opportunities, such as those coordinated through a successful program in Oregon, could be utilized to expand data collection. However, it is critical to design programs and implement the necessary data evaluations and analyses to ensure that ongoing and future cooperative research work can be used in fishery management (i.e., fishery models, stock assessments, etc.) on a timely basis.

Resource Assessment Surveys

- Develop methods to integrate the NMFS NWFSC shelf-slope survey into groundfish assessments.

- Accurate bottom substrate maps, including trawlable and untrawlable habitat, are critical to interpretation of survey abundance indices. Efforts should continue to refine habitat maps of Pacific coast continental shelf and slope. Many commercial vessels are now using automated mapping software to augment digital navigation charts with improved bathymetry and bottom substrate information from echosounders. Cooperative research projects to access this information should be considered.

- Examine how best to use young-of-the-year groundfish surveys in stock assessment. Topics that need to be considered include 1) review and finalization of protocols for an integrated, coastwide pre-recruit survey, 2) evaluation of methods for including existing pre-recruit survey data in groundfish stock assessments and 3) evaluation of the usefulness of pre-recruit abundance indices in assessing the status of groundfish stocks.

- Develop genetic methods to identify larval fish in plankton samples for accurate species identification.

- Explore use of genetic tags in population size estimation.

Biological Information Including Fishery and Productivity Parameters

- Current harvest polices for rockfish use female spawning biomass or egg production as a metric of reproductive output. Recent laboratory research suggests that the larval survival of black rockfish increases with the age of the spawner, a result that calls into question the current working assumption. At present it is unclear if this is a general characteristic of rockfish reproductive biology. Both fieldwork and laboratory studies are needed to evaluate the importance of maternal age in rockfish reproductive biology. Analysis is needed to assess the effects on current harvest policies.

- Recent genetic research indicates vermillion rockfish and blue rockfish may each represent two distinct but morphologically similar species warranting additional research and evaluation and additional investigations of other rockfish species classification.

Stock Assessment Data Reporting Improvements

Identification of research and data needs is a routine part of the groundfish stock assessment review process. Stock Assessment Review (STAR) Panels frequently capture these needs in their final reports. The following general data reporting improvements were reiterated in several of the STAR Panel reports from the 2007 assessment reports. Species specific recommendations from 2007 reports are contained in Appendix I.

- Establish a meta database of all data relevant to rockfish stock assessments. The database should include enough detail about the nature and quality of the data that a stock assessment author can make a well informed decision on whether it could be useful for their stock assessment.
- Establish accessible online databases for all data relevant to groundfish stock assessments, so that assessment authors can expeditiously obtain the raw data if required.
- Establish a database for historical groundfish catch histories, "best" guesses and estimates of uncertainty (and processes for updating and revising the database).
- Develop a concise set of documents that provide details of common data sources and methods used for analyzing the data to derive assessment model inputs.
- Routinely produce and present supporting documentation for any derived indices which are included in a stock assessment model (e.g., GLMM derived trawl survey abundance indices).

Stock Assessment Modeling

- Current assessment models treat populations as a single unit. Often there are geographic differences in biological and fishery characteristics without compelling evidence that separate stocks exist. Population densities and temporal pattern of fishing mortality also show geographic differences. Meta-population assessment models should be developed for linked populations. Such models will be necessary to assess impacts of spatially-explicit management measures now being used by Council, and likely to be used to a greater degree in the future.

- The use of recreational fishery CPUE in stock assessments has increased, particularly for assessing nearshore species for which there are no other reliable indices of abundance. Although there have been some recent advances in the analytical methods used to derive abundance indices from CPUE data, further work is needed understand the properties of recreational CPUE data. In particular, the effect of management changes and alternative fishing opportunities should be evaluated.

- Develop guidance on use of Bayesian priors in stock assessment models.

- Develop methods to assess and manage stocks for which data are not adequate to fit age-structured assessment models. Develop procedures to calculate acceptable biological catches (ABCs) and OYs for these data-poor stocks.

- Many stock assessments utilize artificial boundaries to delineate stocks, in particular those associated with international boundaries. While such assumptions are difficult to avoid in many cases, investigations regarding the implications of stock structure and population connectivity of transboundary resources has been highlighted by review panels as a key research priority in 2005 assessments of blackgill, canary, widow, and yelloweye rockfish, as well as in past review panels for other species. Investigations such as genetic methods to provide insights on stock structure, and modeling scenarios that could consider the implications of transboundary stock structure, remain critically important research needs.

- Develop standard and appropriate methods for modeling age and length data, including choice of distribution, initial variance assumptions, and tuning methods (current methods can and should be improved).
- Develop standard and validated methods for producing recreational CPUE indices that adequately deal with the influence of regulation changes and the peculiarities of the recreational data collection systems.
- Continuation of joint U.S./Canada technical forums, workshops, and research programs is an important aspect of improving the assessment of transboundary rockfish stocks.

3.0 SALMON FISHERY MANAGEMENT PLAN

There is increased interest in some areas for further integration of selective fisheries for hatchery salmon stocks as a management tool to reduce fishery impacts on natural salmon stocks of concern. Successful implementation of selective fisheries will require accurate estimates of non-retention mortalities and new, more detailed information on fishery stock contributions and migration patterns. Techniques for Genetic Stock Identification (GSI) are now developed to the point that they are a potential management tool. With the establishment of the coastwide genetic baseline for Chinook, close to 200 stocks of can be identified from a tissue sample. There is currently intense interest in using these techniques for inseason management of weak stock impacts. Recent expansion of the listings under the Endangered Species Act (ESA), and the new definition of EFH, expand the Council's concerns with both freshwater and marine habitat in relation to harvest strategies and conservation.

In 2000, three highest priority research and data needs for salmon, along with numerous additional high priority needs were identified. This review briefly discusses the progress on the three highest priority needs. Continuing issues are the high priority needs from the 2000 document that form an essential basis for the highest priority needs. Other high priority needs associated with hatchery fish are also included. Emerging issues are concerned with the implementation of GSI in fishery management, improved forecasting and modeling of Klamath fall Chinook, and ecosystem and habitat interactions.

All research and data projects listed in this section are considered either "high priority" needs or "highest priority needs" according to their ability to meet the criteria listed above.

3.1 Highest Priority Issues

A more accurate assessment of total fishing related mortality of natural stocks of coho and Chinook.

Fishery management regimes designed to reduce impacts through non-retention or selective fishing depends on the success of unbiased estimates of non-catch mortality.

Harvest models have been modified to incorporate non-catch mortality. The selective coho Fishery Regulation Assessment Model (FRAM) has been approved for Council use, but the selective Chinook FRAM is still under review. There is interest in, and some progress in, the creation of coastwide models. The modified models should work well when exploitation rates on marked stocks are relatively low, but as selective fisheries become more intense, these models will tend to underestimate total mortality. This problem could be addressed by using continuous catch equations, which, in turn, would probably require a model of migration patterns. The harvest models become more sensitive to estimates of non-catch fishing mortality as modeled fisheries become more intense. Related to this issue is the need to incorporate explicit consideration of uncertainty and risk in these models as they are developed.

Advances in GSI, otolith marking, and other techniques may make it feasible to use a variety of stock identification technologies to assess fishery impacts and migration patterns.

The increasing necessity for weak-stock management puts a premium on the ability to identify naturally reproducing stocks and stocks that contribute to fisheries at low rates. In many instances, the coded-wire-tag (CWT) system alone does not provide the desired levels of information. The Council encourages efforts to integrate a variety of techniques for management.

Substantial progress has been made on this item in the past 6 years. A coastwide microsatellite database for Chinook has been developed. A similar database for coho salmon is under development, but needs resources to coordinate efforts for the entire coast. Genetic techniques have improved so that samples can potentially be analyzed within 24-48 hours of arrival at the laboratory. GSI is actively being used in Canada to manage coho salmon fisheries off the West Coast of Vancouver Island. Studies are under way to evaluate the potential usefulness of real time GSI samples in Chinook management, particularly in relationship to Klamath fall Chinook. There are proposals to develop operational alternatives to time-area management using these techniques, in combination with existing CWT marking, mass marking, otolith microchemistry, and other emerging stock identification techniques. These studies are now the highest priority for salmon management.

Encourage development of probabilistic habitat-based models that incorporate environmental variation and anthropogenic disturbances to establish harvest policies and enable risk assessment for fishing strategies.

Overfishing definitions are required to relate to a measure of MSY. MSY for salmon is related to productivity, which varies annually in freshwater and the marine environment. Techniques for evaluating productivity, or survival, in freshwater and marine habitats are needed to set appropriate harvest targets and associated conservation guidelines such as escapement floors and overfishing definitions.

Various habitat-based models have been developed, but in general they are not being applied to harvest management. One reason for this is that most of these models are developed to identify limiting factors and evaluate potential habitat restoration measures. Application to harvest management would require refined population dynamic components to these models. There is the potential for using this technique to evaluate recovery exploitation rates. Other possible contributions could be improved understanding of climate variability and environmental influences on survival and stock productivity. Once satisfactory habitat-based models of population dynamics have been developed, they can be used in management strategy evaluations to simulate alternate management scenarios. This could be a valuable contribution to harvest management, but to become useful substantial development efforts are needed.

3.2 High Priority Issues

The following high priority items are directly related to the highest priority items above.

Non-catch Fishing Mortality. In recent years, an increasing proportion of impacts of Council fisheries on naturally-spawning stocks have been caused by non-catch mortality as regulations

such as landing ratio restrictions and mark-selective retention have been employed. Research, using standardized methodologies (e.g., handling, holding, reporting, post-mortem autopsies, etc.), is needed to estimate release mortality, encounter, and drop-off rates associated with gears and techniques that are typically employed in different areas and fisheries. Special attention needs to be paid to mid-term and long-term mortality. Fleet profile data (i.e., fishing technique and gear compositions) are needed to estimate release mortality rates for individual fisheries.

Continuous Catch Equations. Because current planning models employed by the Council are constructed using simple linear, independent equations, interactions between stocks and fisheries within a given time step are ignored. This can result in biased estimates of impacts. Research is needed to investigate the feasibility of recasting the models from discrete to continuous forms. e.g., competing exponential risk catch equations.

Migration. The Council currently employs "single pool" type models (i.e., ocean fisheries operate simultaneously on the entire cohort) for evaluating alternative regulatory proposals. Under certain conditions, such models can produce results that are inconsistent with expectations of biological behavior. For example, if a fishery off Central California is closed to coho fishing for a given time period, the fish that were saved become available to fisheries off the Northwest Coast of Washington in the next time period. Research is needed to determine the feasibility of incorporating explicit migration mechanisms into planning models.

Coastwide Models. Currently, at least five models are employed to evaluate impacts of proposed regulatory alternatives considered by the Council. A single coastwide Chinook model would provide analytical consistency and eliminate the need to reconcile and integrate disparate results. Additionally, research is needed to determine the feasibility of combining Chinook and coho into a single model to simplify tasks of estimating mortalities in fisheries operated under retention restrictions (e.g., landing ratios or non-retention).

Alternatives to Time-Area Management. The annual planning process centers on the crafting of intricate time-area management measures by various groups. The feasibility of using alternative approaches (e.g., pre-defined decision rules to establish upper limits on fishery impacts, individual quotas, effort limitation) to reduce risk of error, decrease reliance on preseason abundance forecasts, improve fishery stability, simplify regulations, and reduce management costs needs to be investigated. For instance, the integration of Council planning processes with the abundance-based coho management frameworks under consideration by the Pacific Salmon Commission and by the State of Washington and Western Washington treaty tribes to streamline the preseason planning process needs to be developed and evaluated.

Selective Fisheries. The Council began to employ mark-selective retention restrictions for coho fisheries in 1998. Research is needed to investigate the utility of other types of selective fisheries. For example, GSI might be used to identify concentrations of stocks of conservation concern leading to time-area closures.

Mass Marking. Estimates of mark rates are essential for planning mark-selective fisheries. The accuracy of mark and release rates needs to be evaluated as well as the variability of mark-induced mortalities under operational conditions.

Stock Identification. In most cases it is not feasible to rely upon coded-wire-tagging of natural stocks, particularly those in depressed status, to obtain direct information on patterns of distribution and exploitation. Alternative stock identification technologies should be explored as a means to collect data necessary for stock assessment purposes. Research is needed to improve ability to estimate contributions of natural stocks in ocean fisheries and escapement. Potential research areas include 1) association studies to determine the degree to which hatchery stocks can be used to represent distribution and migration patterns of natural stocks; 2) genetic stock identification, DNA, otolith marking, and scale studies; 3) improved statistical methods and models; and 4) basic research on stock distribution and migration patterns.

Limiting Factors. Research is needed to identify and quantify those factors in the freshwater habitat which limit the productivity of salmon stocks. Research should focus on 1) quantifying relationships between habitat factors and salmon production; 2) measuring the quantity and quality of these habitat factors on a periodic basis; and 3) evaluating habitat restoration projects for both short-term and long-term effects. Activities such as water diversions, dams, logging, road building, agriculture, hydroelectric projects, and development have reduced production potential by adversely affecting freshwater conditions. Habitat quality and quantity are crucial for the continued survival of wild stocks.

Environmental Influences on Survival. Determine natural survival and stock distribution in the estuary and ocean, year-to-year, age-to-age, and life-history variability, and relationships to measurable parameters of the environment (i.e., temperature, upwelling, etc.). Substantial predictive errors in forecasts based on previous year returns and apparent large-scale multistock fluctuations in abundance suggest important large-scale environmental effects. Some work has been done for coho, but little is known for Chinook. Included in the information need are long-term and short-term relationships between environmental conditions and fluctuations in Chinook and coho salmon survival, abundance, and maturation rates.

Explicit Consideration of Uncertainty and Risk. Current planning models employed by the Council are deterministic. Most aspects of salmon management, such as abundance forecasts and effort response to regulations, are not known with certainty. Given the increased emphasis on stock-specific concerns and principles of precautionary management, the Council should receive information necessary to evaluate the degree of risk associated with the regulations under consideration. Research is needed to evaluate the accuracy of existing planning models, characterize the risk to stocks and fisheries of proposed harvest regimes, and to effectively communicate information on uncertainty for use in the Council's deliberations.

3.3 Interaction of Hatchery and Wild Salmon

In addition to the above high-priority items a number of issues related to hatchery/wild interactions are of ongoing interest:

Genetics. Determine the extent to which there may be gene flow between hatchery and wild stocks, and what the likely effect of that gene flow may be on the fitness of wild stocks. A new genetic technique that is being applied to this problem is Full Parental Genotyping. If all mating adults can be captured and genotyped then offspring can be linked to their specific parents. This has great power for identifying the relative success of various hatchery/wild matings, but is

limited in practice to relatively small systems and systems where all returning adults can be captured.

Freshwater Ecology. Investigate the ecological (competition, predation, displacement) effects of hatchery fish on natural production in freshwater. All life stages from spawner to egg to smolt may be affected.

Estuary Ecology. Migration timing, habitat utilization patterns, competition for food or space, and predator interactions are areas of interest. Differences between hatchery and natural smolts in these areas could help address the questions of the importance of density-dependent growth and survival and potential negative effects of hatchery releases on natural stock production.

Early Ocean Life-history. Points of comparison between hatchery and wild stocks could include: ocean distribution, migration paths and timing, size and growth, food habits, and survival rates.

Identification of Hatchery Fish. The presence of hatchery fish may interfere with the accurate assessment of the status of natural stocks. This problem may be alleviated by the use of mass-marking using otolith marking, CWTs, genetic marking, fin removal, or other technologies to estimate the contribution of hatchery fish to fisheries and natural spawning populations.

Supplementation. Research is needed to investigate the utility of using artificial propagation to supplement and rebuild natural stocks. Guidelines for the conduct of supplementation to preserve genetic diversity and legacy of populations are needed. Special care is needed to ensure that supplementation programs do not unintentionally jeopardize natural runs.

3.4 Emerging Issues

Genetic Stock Identification

Several emerging issues are related to the high priority recently assigned to the implementation of GSI technologies in weak stock fishery management. Research tasks and products necessary for this to be successful are:

- Identification of the error structure of GSI samples taken from operating fisheries.
- Development and application of technologies to collect high-resolution at-sea genetic data and associated information (time, location, and depth of capture, ocean conditions, scales, etc.).
- Collection of stock-specific distribution patterns on a coast-wide, multi-year basis analogous to the current CWT data base, but at a higher resolution.
- Identification of stock distribution patterns useful for fisheries management and appropriate management strategies to take advantage of these distribution patterns.
- Development of pre-season and in-season management models to implement these management strategies and integrate them with PFMC management.

Klamath River Fall Chinook Management

Many research and data needs have been identified through the annual salmon management cycles and the methodology reviews relative to Klamath River fall Chinook. Some of these research needs have been identified in the past and have recently reemerged due to current conservation concerns for Klamath River fall Chinook salmon.

- Review modeling methods for estimating Klamath River Chinook contact rates and catch projections.
- Examine the appropriateness of the September 1 "birth date" for Klamath River fall Chinook, and the sensitivity of the Klamath Ocean Harvest Model (KOHM) to changes in the birth date.
- An experimental design for a test fisheries to estimate the relative impacts to Klamath River fall Chinook in fisheries restricted to nearshore areas.
- Review methods for estimating fall fishery impacts in the KOHM in the annual preseason management process.

Ecosystem and Habitat Issues

Long-term fluctuations in salmon abundance has proven to be difficult to predict and can create significant instability in the conservation, management, and economics of salmon and salmon fisheries. A better understanding of marine and freshwater conditions and their impacts on salmon populations is needed. Recent declines in West Coast salmon populations, most notably Sacramento River fall Chinook, serve as a reminder of the volatility of salmon populations over time. Investigations into the recent salmon population decline may generate additional research and data needs in the spring of 2008.

- Describe environmental variability in the California Current ecosystem on seasonal to decadal time scales for use in understanding the impact of environmental variability on the distribution and population structure of salmon.
- Develop tools that describe the environmental state and potential habitat utilization for near-shore anadromous fish.
- Characterize and map the ocean habitats for anadromous species using data from satellites and electronic tags.
- Characterize climate variability in the northeast Pacific and its relation to salmon productions.

4.0 COASTAL PELAGIC SPECIES FISHERY MANAGEMENT PLAN

4.1 Continuing Issues

4.1.1 General CPS Research and Data Needs

Gain more information about the status of the CPS resource in the north using egg pumps during NMFS surveys, sonar surveys, and spotter planes.

To address these questions, biological information has been collected from NMFS research surveys off the Pacific Northwest (PNW). So far, the PNW research surveys have occurred in July 2003, March and July 2004, and winter 2005. These Southwest Fisheries Science Center-based surveys included sardine acoustic trawl and Continuous Underway Fish Egg Sampler surveys off the coast of Oregon and Washington. The surveys were designed to fill major gaps in knowledge of sardine populations, by measuring the age structure and reproductive rates, and assessing the extent the fishery is dependent on migration and on local production of sardine. The primary objective of the surveys is to accumulate additional biological data regarding the northern expansion of the population into waters off the PNW and ultimately, to include data directly (or indirectly) in ongoing stock assessments of both Pacific sardine and Pacific mackerel.

Develop a coastwide (Mexico to British Columbia, Canada) synoptic survey of sardine and Pacific mackerel biomass, i.e., coordinate a coastwide sampling effort (during a specified time period) to reduce "double-counting" caused by migration.

The first coast-wide, Baja California to British Columbia synoptic survey was completed in April 2006. Hopes are that this will be the first survey in a long time series, possibly within the Pacific Coast Ocean Observing System framework. The continuance of these synoptic research surveys on an annual basis is necessary to ensure survey results are representative of the entire range of this species (as well as other CPS of concern). Developing and conducting such a survey will necessarily require considerable additions to current budgets, staff, and equipment. Expanded coastwide surveys are planned for 2008. To address seasonal issues and to further explore the possibility of successful spawning in the PNW, the Southwest Fisheries Science Center is planning to conduct two cruises in 2008, one in April and a second in July.

Increase fishery sampling for age structure (Pacific sardine and Pacific mackerel) in the northern and southern end of the range. Establish a program of port sample data exchange with Mexican scientists (Instituto Nacional de la Pesca [INP], Ensenada).

There has been interest in coastwide management for the Pacific sardine fishery which would entail a more consistent forum for discussion between the U.S., Mexico, and Canada. Recent U.S.-Mexico bilateral meetings indicated willingness from Mexico to continue scientific data exchange and cooperation on research, and engage in discussions of coordinated management. Mexico suggested that the MEXUS-Pacifico Cooperation Program would be a good venue for starting that discussion.

In November 2007, the United States hosted the 8th annual Trinational Sardine Forum which resulted in effective exchange of data and ideas on the science and economics of coastwide

sardine management. The 9th annual forum is scheduled to occur in the fall of 2008 in Astoria, Oregon.

Evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS; predatory/prey relationships. Increase the use of fishery information to estimate seasonal reproductive output of the stock (e.g., fat/oil content).

The Coastal Pelagic Species Management Team (CPSMT) continues to pursue research to evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and define predator-prey relationships. In 2004, the Council directed the CPSMT to initiate the development of a formal prohibition on directed fisheries for krill. This proposed action is in recognition of the importance of krill as a fundamental component of the ecosystem and a primary food source for much of the marine life along the West Coast. In March 2006, the Council adopted a complete ban on commercial fishing for all species of krill in West Coast Federal waters and made no provisions for future fisheries. They also specified EFH for krill, making it easier to work with other Federal agencies to protect krill.

The Council has also initiated the development of an Ecosystem Fishery Management Plan. The previously discussed ban on krill harvest and harvest set-asides that recognize the important role of CPS and buffer against overfishing have been sited as good starting points for such a plan (see Chapter 7).

Improve information on salmon and other bycatch in the CPS fishery.

NMFS Southwest Region initiated a pilot observer program for California-based commercial purse seine fishing vessels targeting CPS in July 2004 with hopes of augmenting and confirming bycatch rates derived from CDFG dockside sampling. Future needs of the CPS observer program include: standardization of data fields, development of a fishery-specific Observer Field Manual, construction of a relational database for the observer data, and creation of a statistically reliable sampling plan.

4.1.2 Pacific Sardine

- Growth data for Mexico, southern California, northern California, the PNW and the offshore areas should be collected and analyzed to quantitatively evaluate differences in growth among areas. This evaluation would need to account for differences between Mexico and the U.S. on how birthdates are assigned, and the impact of spawning on growth.

- The timing and magnitude of spawning off California and the PNW should be examined.

- The likelihood of various stock structure hypotheses should be examined using existing tagging data and additional tagging experiments or (preferably) techniques such as analyses of trace element composition.

- Biological surveys should include regular systematic sampling of adult sardine for: 1) reproductive parameters for daily egg production method (DEPM); 2) population weight

at age; and 3) maturity schedule. Specifically, adults collected from survey trawls must be collected and analyzed more routinely in the future than has been the case in the past.

- Information which could be used in an assessment of the PNW component of a single coastwide population or of a separate PNW stock should be obtained. Synoptic surveys of Pacific sardine on the entire West Coast have the potential to provide such information as well as the basic data.

- Alternative methods for indexing the population (e.g. acoustics) should continue to be evaluated. Acoustic methods are a qualitatively different approach to indexing relative abundance and are the primary fishery-independent method for obtaining abundance indices for many of the world's major pelagic fish stocks. Acoustic methods have been applied to northern anchovy off California. Acoustic data have the potential to provide information on the relative abundance of the populations off southern California and the PNW.

- The Tri-national Sardine Forum and MEXUS-Pacifico (i.e. the NMFS-Instituto Nacional de Pesca Forum) should be utilized to share fishery, survey and biological information among researchers in Mexico, Canada, and the U.S. The long-term benefits of this forum will be greatly enhanced if it can be formalized through international arrangements.

- There should be overall greater collaboration with industry in the collection and analysis process for CPS, including Pacific sardine.

- Continued support of the newly adopted CPS Observer Program and in particular, bolstering sample sizes (spatially and temporally) to ensure an adequate number of trips are 'observed' to produce statistics that are representative of the fishing fleets at large.

- Re-examination of the MSY control rule utilized in the Pacific sardine FMP. Given substantial amounts of additional sample data have accumulated since the initial research that was undertaken to formally establish this harvest strategy, it would be prudent to conduct further simulation modeling work to address particular parameters included in the overall control rule (including 'cutoff,' 'fraction,' and 'distribution' values).

- Develop and test microsatellite DNA markers for Pacific sardine to examine DNA variation throughout the range to test for stock structure.

- Assess changes in early life history information from CalCOFI samples to evaluate Pacific sardine response to climate change.

4.1.3 Pacific Mackerel

- Efforts should be made to obtain survey (IMECOCAL) larvae abundance and distribution data from Mexico and to incorporate such data into future assessments.

- There is a lack of biological sampling (and catch) data available from Mexico for inclusion in the assessment, which is more critical in recent years when the Mexican catch has been as large as or larger than that of California.

- A concerted approach to develop a coastwide synoptic survey, ideally on an annual basis, to estimate an index of mackerel biomass should be initiated because there is a lack of fishery independent survey data, in particular outside of the Southern California Bight.

- The maturity schedule was developed more than 20 years ago, and it should be re-examined, with new data.

- There should be overall greater collaboration with industry in the collection and analysis process for CPS, including Pacific mackerel.

- Continued support of the newly adopted CPS Observer Program and in particular, bolstering sample sizes (spatially and temporally) to ensure an adequate number of trips are 'observed' to produce statistics that are representative of the fishing fleets at large.

- Re-examination of the MSY control rule utilized in the Pacific mackerel FMP. Given substantial amounts of additional sample data have accumulated since the initial research that was undertaken to formally establish this harvest strategy, it would be prudent to conduct further simulation modeling work to address particular parameters included in the overall control rule (including 'cutoff,' 'fraction,' and 'distribution' values).

4.1.4 Market Squid

- Additional work is required on reproductive biology, including the potential fecundity of newly mature virgin females, the duration of spawning, egg output per spawning bout, the temporal pattern of spawning bouts, the growth of relatively large immature squid, and the growth of mature market squid. Important questions about growth might be addressed through Scanning Electron Microscopy (SEM) studies of statoliths.

- There should be overall greater collaboration with industry in the collection and analysis process for CPS, including market squid.

4.2 Emerging Issues

4.2.1 Pacific Sardine

Full stock assessments were conducted in 2007 following the three year cycle in the CPS FMP. A new modeling program, Stock Sythesis 2 (SS2) was utilized for Pacific sardine in 2008. Several of the recommendations below came directly from the 2007 assessment review process. Additionally, in response to a decline in forecasted Pacific sardine abundance in 2007 and a desire for more research in the PNW, industry representatives are currently drafting a survey design for an aerial survey or relative Pacific sardine abundance in Washington and Oregon.

- The DEPM method should be extended so that constraints are placed on the extent to which the estimates of P_0 vary over time.

- The data on maturity-at-age should be reviewed to assess whether there have been changes over time in maturity-at-age, specifically whether maturity may be density-dependent.

- The aerial surveys should be augmented to estimate schooling areas and distinguish schools, and the enhanced survey design should undergo rigorous review. Data (e.g. bearing and distance to schools) should be collected which could be used in line transect-type estimation methods. 'Sea-truthing' of the species identification of the aerial surveys will enhance the value of any resulting index of abundance.

- An aerial survey program should be started in the PNW. Such a survey program would provide data for a component of the population currently not surveyed. However, it would take several years before any index based on such a survey could be included in the assessments.

- The extent of ageing error should be quantified and included in future assessments.

- Explore the use of PNW surveys (i.e.: NMFS NWFSC; Bob Emmett) as an index of abundance.

- Standardize data processing procedures be developed for CPS species, similar to those developed for groundfish species.

- The 2007 STAR Panel sensitivity model runs that assumed no ageing error resulted in compression of the range of spawning biomass and recruitment estimates compared to those estimated assuming ageing error (i.e. strong year-classes were estimated to be lower and weak year-classes were estimated to be larger when ageing error is ignored). This highlights the importance of the precision of the age data on model outputs. It is recommended that ageing comparisons be continued to determine the most appropriate estimates of ageing precision.

- The results of Stock Synthesis 2 (SS2) model runs at which treated the egg survey data either as an index of egg production or as an index of spawning biomass did not affect the outcome of the assessment, although estimates of survey selectivity were, unexpectedly, markedly different. The Panel recommends that SS2 be adapted to enable indices of egg production and spawning biomass to be fitted simultaneously.

- Noting that there is potential for sardine from different stock subcomponents to recruit to adjacent stock areas, it would be desirable to account for this in the assessment model. To do so requires development of a new assessment model or modification of an existing one. If feasible, SS2 should be amended to include such an enhancement. Further, tagging experiments (or other means to facilitate the estimation of movement rates) should be considered.

- The catch history for the Mexico and southern California fisheries should be examined to estimate the catch from the southern subpopulation. For example, use temperature and/or seasonality to separate catches by subpopulation. Based on the results of this analysis, determine the biological data (length- and conditional age-at-length) by subpopulation. The analysis of subpopulation structure should ideally be conducted in conjunction with a re-evaluation of the current harvest control rule.

- The estimate of the catchability coefficient for the DEPM estimates was 0.4 (for the base model). Analyses should be conducted, for example, based on prior distributions for the factors leading to differences between DEPM estimates and spawning biomass to assess the plausibility of values for DEPM-q of this magnitude.

- Development of alternative (preferably coastwide) indices will enhance the ability to monitor changes in the abundance Pacific sardine. At present, the assessment relies on the indices of abundance from southern and central California, although these regions constitute the core of the distribution when the population is low, a substantial fraction of the catch is now taken from other areas.

- Develop an index of juvenile abundance. The indices used in the assessment pertain only to spawning fish. An index of juvenile abundance will enhance the ability to identify strong and weak year-classes earlier than is the case at present.

4.2.2 Pacific Mackerel

Full stock assessments were conducted in 2007 following the three year cycle in the CPS FMP. A new modeling program, Stock Sythesis 2 (SS2) was unsuccessfully applied to Pacific mackerel in 2008. Several of the recommendations below came directly from the 2007 assessment review process. Additional recommendation specific to modeling methodologies can be found in the November 2007 Pacific mackerel STAR Panel report.

- The survey design of the new aerial spotter index should incorporate rigorous protocols. Attempts should be made to estimate school surface area. Also, an aerial spotter survey should be initiated in the PNW in conjunction with industry.

- Examine the disparity between the observed recruitment dynamics (boom-bust) and the underlying spawner-recruit model (uncorrelated recruitment deviations).

- There are currently very few otoliths that have been read multiple times so additional readings need to be made. In the longer-term, an age validation study should be conducted for Pacific mackerel. Such a study should compare age readings based on whole and sectioned otoliths and consider a marginal increment analysis.

- The construction of the spotter plane index is based on the assumption that blocks are random within region (the data for each region is a "visit" by a spotter plane to a block in that region). The distribution of density-per-block should be plotted or a random effects model fitted in which block is nested within region to evaluate this assumption (e.g. examine whether certain blocks are consistently better or worse than the average).

- The data on catches come from several sources. The catch history from 1926-27 to 2006-07 should be documented in a single report.

- Conduct a study to update the information used to determine maturity-at-length (and maturity-at-age).

- A large fraction of the catch is taken off Mexico. In particular, catches of mackerel have been as large as those off California in recent years. Efforts should continue to be made to obtain length, age and biological data from the Mexican fisheries for inclusion in stock assessments. Survey data (IMECOCAL program) should be obtained and analyses conducted to determine whether these data could be combined with the CalCOFI data to construct a coastwide index of larval abundance.

- The CalCOFI data should be reviewed further to examine the extent to which CalCOFI indices for the "core" area can be used to provide information on the abundance of the coastwide stock.

4.2.3 Market Squid

- The potential use of target egg escapement levels is partly predicated on the assumption that the spawning which takes place prior to capture is not affected by the fishery and contributes to future recruitment. However, since the fishery takes place directly over shallow spawning beds, it is possible that incubating eggs are disturbed by the fishing gear, resulting in unaccounted egg mortality. It is also possible that the process of capturing ripe squid by purse seine might induce eggs to be aborted, which could also affect escapement assumptions.

- The CalCOFI ichthyoplankton collections contain approximately 20 years of unsorted market squid specimens that span at least two major El Niños. This untapped resource might be useful in addressing questions about population response to El Niño conditions.

5.0 HIGHLY MIGRATORY SPECIES FISHERY MANAGEMENT PLAN

5.1 Background

The Council's FMP for highly migratory species (HMS) covers a broad range of species including tunas, billfishes, and sharks. The spatial extent of the Pacific Ocean used as habitat for these species is much larger that the USA's Exclusive Economic Zone (EEZ). The HMS FMP recognizes that stock assessment and management of these species cannot be done unilaterally – rather it must be done in conjunction with other nations that exploit these species throughout their range.

In the Pacific Ocean, HMS are managed by two regional fishery management organizations (RFMO) – Inter-American Tropical Tuna Commission (IATTC) and Western and Central Pacific Fisheries Commission (WCPFC) – that together cover the breadth of the Pacific Ocean habitat for the species included in the Council's HMS FMP (Figures 1 and 2). Stock assessments and related research are conducted under the auspices of these RMFO. U.S.A. scientists (whose affiliations include NMFS, academia, nongovernmental organizations (NGOs), and the fishing industry) participate in both RFMO processes.

A third scientific organization – International Scientific Committee (ISC) on Tuna and Tuna-like Species in the North Pacific Ocean conducts stock assessments for the North Pacific HMS stocks that straddle the 150^{o} W longitude boundary between the RFMOs. Examples of these stocks include North Pacific albacore, Pacific bluefin tuna, swordfish, and striped marlin. The ISC is not an RFMO in that it does not manage HMS international fisheries. Rather, it provides the stock assessments that the RFMOs use to base management decisions for the straddling stocks.

Both of the RFMOs (IATTC and WCPFC) have scientific staff (either in-house or contracted) with responsibility and funding for data collection, biological studies, and stock assessment. The Council's role in specifying research and data needs for the tropical tunas (yellowfin, bigeye, and skipjack) that are the primary focus of the RFMOs is somewhat limited and may duplicate other ongoing efforts. Instead the focus for this first draft of the HMS Research and Data Plan needs focuses on the HMS that (1) are not the primary focus of the RFMOs and (2) have ongoing international stock assessment efforts.

Based on the above criteria, research and data needs for North Pacific albacore, Pacific bluefin tuna, swordfish**,** and striped marlin are delineated below. Much of the material was extracted from recent ISC assessment working group (WG) reports on these species. As such, the research and data needs reflect consensus of the respective WG members, i.e. international scientists (including U.S.A. representatives) who are closest to the data and analyses. It should be noted that the ISC WGs do not formally prioritize their research and data lists, and that these classifications were inferred from sections of the WG reports that discuss the strengths and weaknesses of the assessments. Furthermore, since the focus is on species for which assessments are ongoing, most of the items are categorized as "continuing issues". Those that are considered "high priority" are noted. This is not to imply that there are no emerging issues for the Council with respect to HMS. Rather, it acknowledges that the prediction of the key issues that will emerge is more speculative. A final section entitled "Emerging Issues" is provided to highlight some of the issues most likely to emerge in the near term – especially for HMS that are not currently being assessed.

5.2 Continuing Issues

Research and data needs are identified in this section for the major HMS species pertinent to the Council.

5.2.1 North Pacific Albacore

Fisheries Statistics: Timely annual submission of national fishery data to the ISC Albacore WG data manager is critical for producing timely and up-to-date stock assessments. Additional resources are needed to oversee the submission of these data, provide database management, and improve documentation of the entire database system including metadata catalogs. An electronic fish ticket system on the West Coast would greatly improve the availability and timeliness of fishery data.

Biological Studies: Biological information is a critical building block for stock assessments. It should be reviewed and updated regularly to capture changes in population parameters if they occur. Unfortunately, this process has not been followed for North Pacific albacore because of limited resources for routine biological studies. Consequently, the stock assessment models used by the ISC Albacore WG rely on a patchwork of biological information that was developed largely in the 1950s and 1960s.

There is a critical need to reassess the biological information and to conduct contemporary studies to update this information. More specifically, there is a critical need to conduct studies on:

- age and growth with the goal of updating growth rates and comparing with older studies *(high priority)*;
- reproductive biology with the goal of updating the maturity ogive *(high priority)*; and
- development of new indices of abundance particularly from fisheries that regularly catch recruitment age albacore (age 1), e.g. the USA recreational fishery *(high priority)*.

Less critical but still important for improving the stock assessments are studies on:

- migration and habitat utilization, with the goal of better informing fishery effort standardization and fishery selectivity/catchability assumptions;
- an examination of whether there are multiple sub-stocks with juveniles having different migratory behaviors (i.e., juveniles from different spawning localities with different migration routes and timetables)
- environmental factors, as they relate to recruitment, growth, maturity, and catchability of albacore; and
- albacore length data through port sampling.

Stock Assessment and Management Studies: Recent stock assessment results as well as fishery developments suggest that the North Pacific stock of albacore is at or fast approaching full exploitation. Demand for more frequent and more precise information on status of the stock and the sustainability of the fisheries is therefore likely to increase. With this in mind, the albacore stock assessment needs improvement in several of its facets:

- investigation of competing assessment models using simulation to ascertain each model's strength and weakness when faced with input data generated from a known albacore-like population *(high priority)*;
- simulation studies to assist fishery managers in selecting appropriate biological reference points for albacore *(high priority)*;
- investigation of CPUE standardization;
- refinement of the VPA-2Box model (the WG's current assessment model);
- investigation of the applicability of Stock Synthesis 2 as an alternative assessment model for albacore;
- evaluation of the utility of formally adding tagging data into the assessment; and
- deveop new indices of abundance from fisheries that regularly catch recruitment age albacore (age 1), such as the U.S. recreational fishery.

5.2.2 Pacific Bluefin Tuna

Fisheries Statistics: The timeliness of data reporting, as outlined for albacore above, is equally important for bluefin tuna. Additionally,

- the official bluefin catch statistics need further scrutiny, e.g. there are apparent discrepancies between some of the reported catches and the corresponding Japanese import records (*high priority*); and
- increased port sampling of commercial bluefin length frequencies is needed in the Eastern Pacific Ocean, particularly of the fish destined for the pens in farming operations *(high priority*).

Biological Studies: All of biological studies listed above for albacore are also needed for bluefin tuna. In addition,

- there is a need to develop seasonal and perhaps area-based weight-length relationships as the bluefin condition factor appears to vary both seasonally and regionally (*high priority*).

Stock Assessment and Management Studies: All of stock assessment and management studies listed above for albacore are also needed for bluefin tuna. In particular, there is a need for additional work on effort standardization if credible indices of abundance are to become available for bluefin tuna *(high priority)*.

5.2.3 Striped Marlin and Swordfish

Fisheries Statistics: The timeliness of data reporting, as outlined above for albacore, is equally important for striped marlin and swordfish. Additionally:

- the official striped marlin catch statistics are considerably less well developed than those for albacore, and significant effort is needed to ensure that the total catch from all nations is well estimated *(high priority)*.

Biological Studies: All biological studies listed above for albacore are also needed for striped marlin and swordfish as well. In addition,

- stock structure for striped marlin in the Pacific Ocean is more uncertain than for other HMS species and several stock structure hypotheses are credible. Further genetic work is unlikely to resolve the issue. A synoptic, critical review of all available information (fisheries data, icthyoplankton data, and genetic studies) is needed to either resolve the issue or at least to reduce the number of credible hypotheses,
- age and growth data from locally caught fish should be examined, and
- the distribution of swordfish by season and age within the outer portions of the EEZ and high seas should be evaluated.

Stock Assessment and Management Studies: All stock assessment and management studies listed above for albacore are also needed for striped marlin and swordfish. In particular,

- there is a need for additional work on effort standardization *(high priority)*.

5.2.4 Dorado

The stock structure of dorado in the eastern Pacific should be examined.

5.3 Emerging Issues

5.3.1 Sharks

Most of the tunas covered in the HMS FMP are being assessed – with varying degrees of completeness and sophistication – on a regular basis (Table 1). Some of the billfishes – particularly striped marlin and swordfish – are either being assessed or have assessments planned in the near future. On the other hand, stock assessments for sharks have been preliminary at best, and few and far between. Furthermore, comprehensive shark assessments do not appear to be on the near-term planning horizon for the RFMOs or for the ISC. This situation should not be taken to imply that sharks are unimportant. Nor should it be inferred that sharks are less vulnerable to the effects of fishing than are the tunas and billfishes. In fact, because of the key vital rates of most sharks (especially reproductive rates that are lower than those for tunas and billfishes), many shark species are likely to be more vulnerable to overfishing than other HMS.

To understand this *prima fascia* inconsistency (i.e., perhaps more vulnerable but not assessed), it is necessary to understand the nature of the fisheries responsible for most of the catch of sharks over the past several decades. Internationally, these fisheries tend to be either (1) tuna-targeting fisheries that caught sharks as bycatch in their tuna fishing operations and discarded them (without recording numbers or mass) over most of their fishing history; or (2) smaller scale directed shark fisheries that tend not to report shark catches in a manner suitable for stock assessment, e.g. catch reports that aggregate the catch of multiple shark species into a single 'shark' category or do not report the catches at all.

As with the other species covered by the HMS FMP, most shark species cannot be assessed or managed unilaterally by the Council. Some species are highly oceanic with ranges similar to that of tunas (e.g., blue shark). Others are more coastal – with perhaps most of their habitat shoreward of the USA EEZ – but exhibit north-south migrations with significant catches in Mexican waters (e.g., thresher sharks). The net effect is that accounting for the total catch of sharks over their entire period of exploitation (several decades) is not possible. Furthermore,

there is a paucity of the biological samples needed to characterize the size of animals taken from the fisheries that account for most of the catch. Active biological studies (age, growth, maturity, food habits, etc.) are ongoing (NMFS, State, and academic researchers) and understanding of the biological characteristics for at least some shark species is probably sufficient for stock assessment purposes. However, without an accurate history of total catch and the corresponding size samples, stock assessment efforts and concomitant management by the Council will be problematic.

The following species-specific research priorities have been identified for sharks:

Thresher sharks:

- stock structure and boundaries of the species and relationships to other populations;
- the pattern of seasonal migrations for feeding and reproduction, and where and when life stages may be vulnerable;
- aging and growth rates, including comparisons of growth rates in other areas; and
- maturity and reproductive schedules.

Shortfin mako shark:

- distribution, abundance, and size in areas to the south and west of West Coast EEZ; and
- age and growth rates (current growth estimates differ widely).

Blue shark

- sex and size composition of catches; and
- migratory movements of maturing fish from the EEZ to high seas.

5.3.2 Survivability of Released Fish

Little is known of the long-term survivorship of hooked fishes after release, to assess the effectiveness of recreational tag-and-release methods on big game fishes (pelagic sharks, tunas, and billfishes) and of methods to reduce bycatch mortality in longline fishing. Controlled studies of the survivability of hooked and released pelagic sharks and billfishes are needed to determine the physiological responses to different fishing gears, and the effects of time on the line, handling, methods of release, and other factors. Appropriate discard mortality rates, by species, need to be identified in order to quantify total catch (including released catch).

5.3.3 Essential Fish Habitat

There is very little specific information on the migratory corridors and habitat dependencies of these large mobile fishes; how they are distributed by season and age throughout the Pacific and within the West Coast EEZ; and how oceanographic changes in habitat affect production, recruitment, and migration. Research is needed to better define EFH and to identify specific habitat areas of particular concern (HAPCs), such as pupping grounds, key migratory routes, feeding areas, and where adults aggregate for reproduction. A particularly important need is to identify the pupping areas of thresher and mako sharks, which are presumed to be within the southern portion of the West Coast EEZ, judging from the occurrence of post-partum and young

pups in the areas (e.g., NMFS driftnet observer data). Areas where pregnant females congregate may be sensitive to perturbation, and the aggregated females and pups there may be vulnerable to fishing.

5.3.4 Stock Assessment Review

Pacific HMS stock assessments are carried out by the RFMOs and by the ISC. The processes used to conduct the assessments and to have them critically reviewed varies considerably across the organizations and the species being assessed. In none of these cases, however, does the level of critical peer review approach that of the Council's Stock Assessment Review (STAR) process. This may become an issue for the Council if international management regulations begin to affect USA coastal fisheries to a greater extent than they do at present. The Council may want to consider having some member(s) of its SSC participate in these international processes. This will provide the Council with a better perspective on the stock assessments and the ensuing international management advice.

5.3.5 Interactions with Protected Species and Prohibited Species

More work is also needed to investigate the life history, stock structure, and hooking survivorship of protected species, such as turtles and seabirds that are caught as bycatch in the HMS fisheries. More work is also required on turtle migration seasonality and routes, and genetic structures of populations by species in order to better understand likely periods of interaction with fisheries and turtle life histories. More work on the size and structure of turtle populations by species would also enable improved application of the ESA and other laws and regulations to HMS fisheries.

Inter-American Tropical Tuna Commission (IATTC)

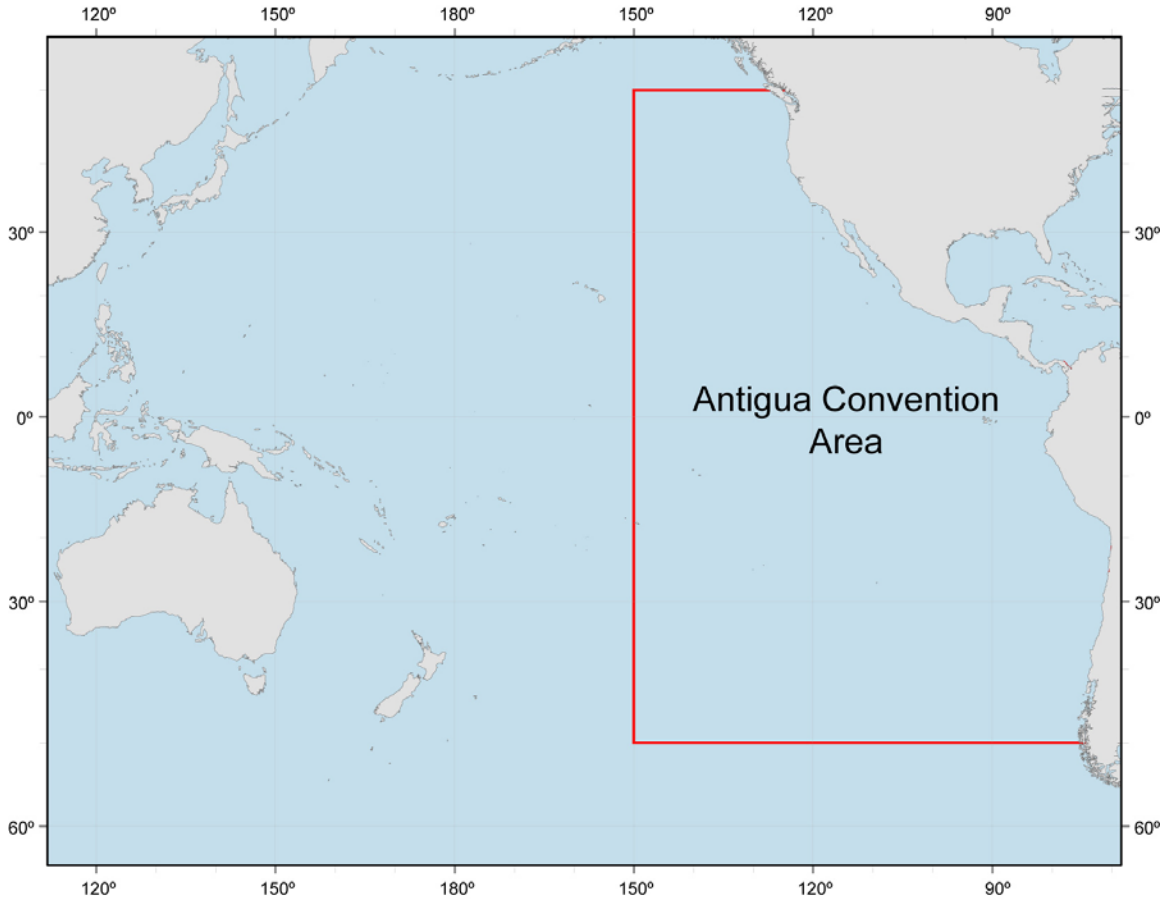

Figure 1. Area covered by the Inter-American Tropical Tuna Commission (IATTC). The Antigua Convention refers to the recent international treaty that revised the IATTC boundaries.

Western and Central Pacific Fisheries Commission (WCPFC)

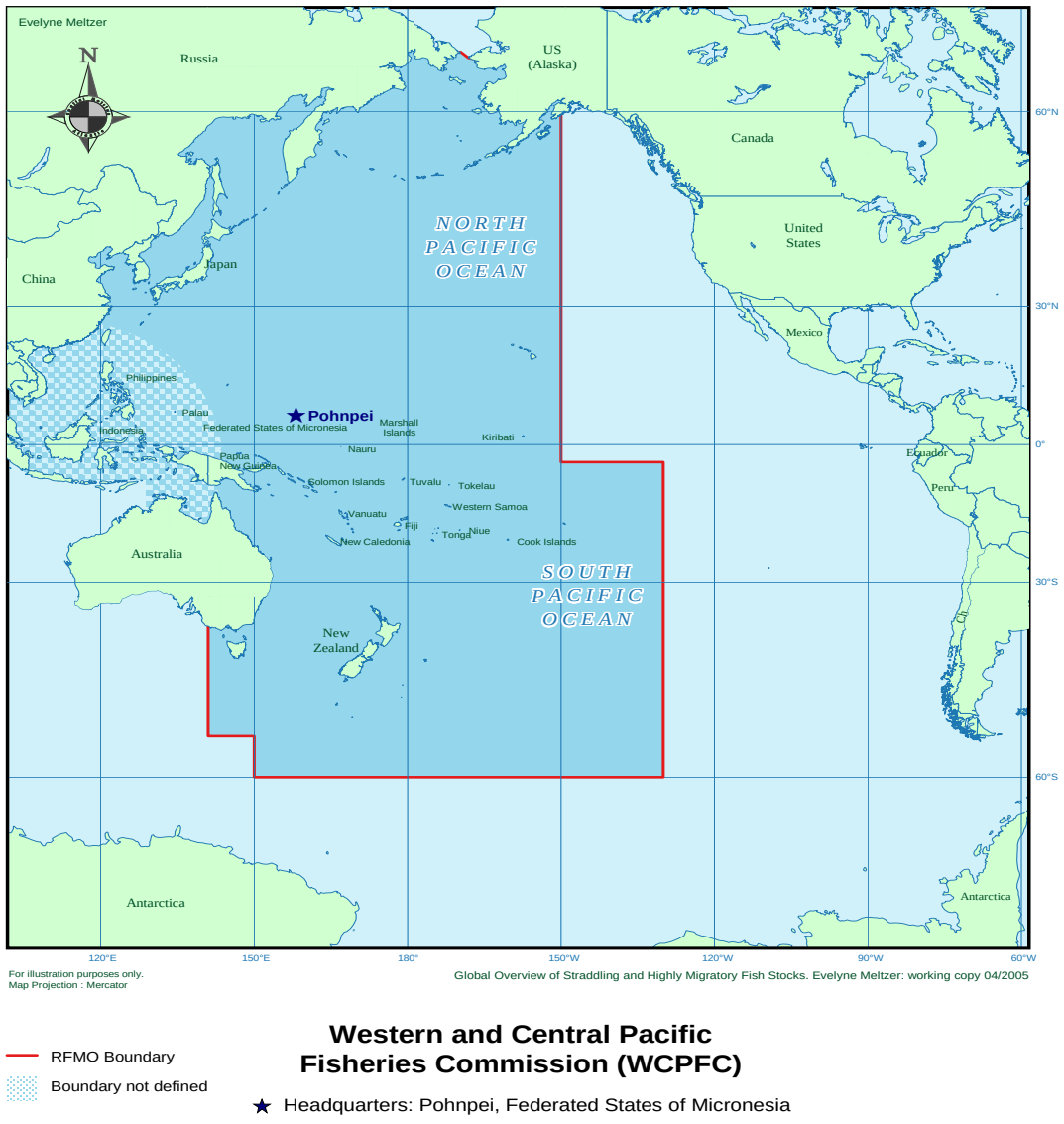

Figure 2. Area covered by the Western and Central Pacific Fisheries Commission (WCPFC).

Table 1. HMS Stock status and stock assessment history (adapted from the 2007 PFMC HMS SAFE document, will be updated with 2008 version when available).

Note that for most of these species, the scientific bodies developing the assessments do not have a consensus biological reference point for use in the context of managing the fisheries.

Species (stock)	F_{Recent}/F_{MSY}[1]	Overfishing? ($F/F_{MSY}>1.0$)	B_{Recent}/B_{MSY}[1]	B_{MSST}/B_{MSY}	Overfished? ($B_{Recent}<B_{MSST}$)	B_{FLAG}[2] ($1.25B_{MSST}/B_{MSY}$)	Assessment
TUNAS							
Albacore (NPO)	1.02–2.26[3]	Unknown[3]	0.67–1.07[3]	0.7	Unknown[3]		Nineteenth NPALBW, Stocker 2005
Bluefin (NPO)	>1.0[4]	Unknown[4]	Unknown	0.75	Unknown	0.94	ISC 2006a
Bigeye (EPO)	1.47[5]	Y	1.10[5]	0.6	N		IATTC, Maunder and Hoyle 2006
Bigeye (WCPO)	1.32[6]	Y	1.27[6]		N		WCPFC, Hampton, et al. 2006a
Skipjack (EPO)	Unknown[7]	Unlikely[7]	Unknown[7]	0.5	Unlikely[7]		IATTC, Maunder and Harley 2004
Skipjack (WCPO)	0.17[8]	N	3.01[8]		N		WCPFC, Langley, et al. 2005
Yellowfin (EPO)	0.98[5]	N	1.0[5]	0.5	N		IATTC, Hoyle and Maunder 2006
Yellowfin (WCPO)	1.11[6]	Y	1.17[6]		N		WCPFC, Hampton, et al. 2006b
BILLFISHES							
Striped Marlin (NPO)	Unknown[9]	Unknown	Unknown	0.5	Unknown		ISC 2006b
Striped Marlin (EPO)	<1.0[10]	N	≥1.0		N	0.63	IATTC, Hinton and Maunder 2003
Swordfish (NWPO)	Unknown[11]	Unlikely	Unknown	0.61-0.8	Unlikely		ISC 2004b
Swordfish (SEPO)	Unknown[12]	Unknown	>1.0		N		IATTC, Hinton and Maunder 2006
SHARKS							
C. Thresher (CA,OR,WA)	<1.0[13]	N	~1.10	0.77	N	0.96	NMFS, PFMC HMS plan development team 2002
Pelagic Thresher	Unknown[14]	Unknown	Unknown	0.85	Unknown	1.06	
Bigeye Thresher	Unknown[15]	Unknown	Unknown	0.78	Unknown	0.97	
Shortfin Mako	<1.0[16]	N	>1.0	0.71	N	0.89	NMFS, PFMC HMS plan development team 2002
Blue	<0.5[17]	N	>1.0	0.78	N	0.97	NMFS and NRIFSF Japan, Kleiber, et al. 2001
OTHER							
Dorado	Unknown[18]	Unknown	Unknown	0.5	Unknown		

Notes:

1 Measures of F_{MSY} and B_{MSY} are not available for all species. Various proxies for these values have been used in preparing this table. However, PFMC has not adopted the use of a particular proxy; hence the designation of Overfishing and Overfished should be considered preliminary.

2 For vulnerable species managed under the OY control rule only: bluefin tuna, striped marlin, and pelagic sharks.

3 Albacore results are based on a suite of F_{MSY} proxies ($F_{40\%}$, $F_{30\%}$ and $F_{0.1}$), two estimated levels of recent fishing pressure (F=0.43 and F=0.68), and two scenarios of productivity (high R = 31 million recruits and low R = 22.5 million recruits). However, "Unknown" is indicated because of the lack of a PFMC reference point for management.

4 Bluefin analyses indicated that F has exceeded F_{Max} 2-fold during the last 2 decades. However, "Unknown" is indicated because of the lack of a PFMC reference point for management.

5 EPO bigeye and EPO yellowfin results are based on base-case assessments assuming no stock-recruitment relationships.

6 WCPO bigeye and yellowfin results are based on the base-case assessments (LOWSAMP).

7 Because of uncertainties in the estimates of growth and natural mortality, MSY-proxy reference points could not be calculated for EPO skipjack; however, the IATTC does not consider there to be a need for management due to low fishing mortalities and high biomass estimates relative to historical levels.

8 CWPO skipjack results are from the base-case assessment.

9 Assessment results from three production models for NPO striped marlin are provisional, but F was shown to be slightly greater than F_{MSY} in one case and slightly lower than F_{MSY} in a second case. The ISC recommended that F not be increased.

10 Two production models demonstrate that the EPO striped marlin population is in good condition with fishing effort and landings in decline since the early 1990s.

11 Standardized CPUEs from swordfish fisheries indicate declining trends in the northwest Pacific; however, the fisheries are causing, at worst, modest declines in abundance.

12 Specific values for F/F_{AMSY} and B/B_{AMSY} are not available; however the assessment results indicate that stock biomass is well above the level which would support AMSY.

13 U.S. West Coast EEZ regional catch and CPUE demonstrated the population increasing from estimated low levels in the early 1990s. Recent (2000-03). West Coast commercial landings average 318 mt, which is less than 0.75 × MSY proxy (MSY proxy = LMSY from the Population Growth Rate method).

14 Status unknown, but catches are incidental and occur on the edge of the species' range, predominately during warm water years.

15 Status unknown, but catches are incidental and occur on the edge of the species' range.

16 Tentative results based on commercial landings and CPUE calculations. Recent (2000–03) West Coast commercial landings average 70 mt, which is less than 0.75 × MSY proxy (MSY proxy = average landings 1981–99).

17 Analyses demonstrated that for north Pacific blue shark, fishing pressure is 2 to 15 times below F_{MSY}. West Coast catch is poorly documented because the fish are not landed.

6.0 ECONOMICS AND SOCIAL SCIENCE COMPONENTS

6.1 Continuing Issues

Continuing needs are divided into three types of activities: Data Collection, Model Development, and Analysis. Data collection is a fundamental activity that is required for analysis, whether or not a particular model is used. Progress on these continuing needs is limited. However, the importance of economic data and the analysis of economic analysis was the subject of several revisions to the MSA in the 2007 reauthorization, most notably an emphasis on the importance of economic and social data under National Standard 8.

Comparative analysis of limited access and rights-based management programs.

An analysis of these programs is lacking, except for limited information from the Trawl Individual Quota (TIQ) program.

Baseline descriptions of fishing industry and communities and periodic assessment of fishery status.

Periodic assessment of fishery status is contained in Stock Assessment and Fishery Evaluation (SAFE) documents. Quantitative descriptions of baseline economic conditions for specific elements of the fishing industry (e.g. commercial harvesting sector, processors, etc.), or fishing communities, are lacking except for information that can be derived directly from fish tickets on landings and ex-vessel revenues.

Economic and social analysis of groundfish and salmon harvest and management strategies.

Analyses of harvest or management strategies are lacking in groundfish, salmon, and other fisheries. Bycatch models for selected components of groundfish fishery have been developed, and in some cases (i.e. limited entry trawl), reviewed. An economic analysis of strategies in the commercial salmon fishery was done in California cost-earnings survey is underway for the commercial groundfish fleet.

Recreational fishery net economic value and angler participation models.

Net economic value and angler participation models are under development for recreational fisheries in the PNW, and development of a similar set of models is planned for California.

Social Data and Socioeconomic baseline profiles of fishing industry and communities.

Brief qualitative overviews are available for 125 West Coast and North Pacific ports and other coastal communities have been developed and are posted on the NMFS NWFSC web page.

Annual port-specific profiles of all West Coast commercial fisheries are being developed for 1981-2005.

6.1.1 Data Collection

Economic data needs are described in the West Coast Fisheries Economic Data Plan 2000-2002, and are summarized again here in the following table, which has also been augmented to include a broader set of data on communities and information on non-consumptive uses: Core needs pertain to fundamental information relevant to understanding economic behavior or evaluation of economic behavior.

Harvesters	Processors	Charter Vessels	Recreational Fishers	Communities	Non-Consumptive
Revenue from all sources	Revenue and value added	Revenues	Effort and Catch of target species	Revenues from all marine resources	Nonconsumptive direct use (e.g. non-extractive recreation)
Expenditures and costs	Expenditures and costs	Expenditures and costs	Trip costs	Demographics and measures of dependence on fisheries	Indirect use (e.g. ecosystem function)
Employment and income	Employment and income	Employment and income	Angler demographics and socioeconomic characteristics	Demographics, employment and income from fishing, and other sources	Nonuse (e.g. non-market value of threatened or endangered species, ecosystem protection, stock rebuilding plans
Capacity	Location of customers and product flows				
	Infrastructure and capital		Site specific preferences and valuation	Harbor and fishery related infrastructure	

Data needed for the design and analysis of marine reserves are described in research and data 2000-2002. The perspective here is more general, and relates to all forms of spatial management. In particular, data is needed to enumerate and quantify the spatial distribution of commercial and recreational fishing trips, processors and buying stations, gear/bait/ice/fuel providers, commercial passenger fishing vessel (CPFV) operations and other fishery-dependent businesses. Spatial data on fishing trips should include both landing sites and areas fished.

6.1.2 Model Development

Data from recreational fisheries has become more prominent, for example the use of CPUE series in groundfish stock assessments. Consequently, there is an increased need for net economic value and angler participation models, including models of spatial movement, in recreational fisheries. Similarly, participation and response models are also needed for commercial harvesters, including models of spatial movement. Additional model development is recommended below, under new and emerging needs.

6.1.3 Analysis

Several types of analyses are needed to make progress on the highest priorities from 2000-2002:

- Periodic assessment of status of West Coast commercial and recreational fisheries - including participation, profitability, employment, income, and major management issues,
- Evaluation of alternative programs to document and reduce bycatch, bycatch mortality, and effects of gear on habitat – with cost-effectiveness and incentive compatibility included among evaluation criteria,
- Evaluation of alternative management approaches to increase harvest stability and enhance flexibility of fishery participants,
- Evaluation of alternative capacity management programs - including limited entry and dedicated access privileges - on fishery participants and fishing communities. Important non-trawl fisheries to consider are Open Access groundfish and salmon.

In addition, more specific and quantitative information is needed to augment existing socioeconomic profiles of fishing communities, including:

- Trends in major commercial and recreational fisheries, and factors affecting these trends,
- Infrastructure availability and needs (for commercial fisheries, recreational fisheries, other marine resource-related uses),
- Financial aspects of infrastructure development and maintenance,
- Development of indicators of community well-being and resilience that can be linked to changes in regulations, market conditions and other relevant factors.

6.2 Emerging Issues

Substantial changes have occurred in West Coast fisheries in the past five years, and recent events in Council managed fisheries should be evaluated. Prime examples include the implementation of RCAs, the groundfish trawl vessel buyback program in 2003, the current development of a groundfish trawl rationalization program, and the increasing use of marine protected areas. As above, these needs are divided into three types of activities: Data Collection

or Augmentation, Model Development, and Analysis. While some of the data and modeling needs identified in this section are relevant to social as well as economic issues, the Council's July 2005 report *Social Science in the Pacific Fishery Management Council Process*[1] provides more complete information on social science needs and can be found on the Council's website (www.pcouncil.org/research/resdocs.html).

6.2.1 Data Collection or Augmentation

Surveys or interviews are needed of individuals and entities that participated in the trawl vessel buyback program to determine whether individuals truly departed, or remained, in the groundfish fishery, or are now participating in other fisheries.

Better data on fish buyers and processors and fishing vessels would facilitate evaluation of economic impacts associated with changes in regulations and other factors. Processor files and vessel characteristic files available from the Pacific Coast Fisheries Information Network are probably in need of updating, or at least, a thorough check for consistency and accuracy. The processor list, in particular, has many typos that create ambiguities regarding the identity of processors. To facilitate analysis, each processor on the list should be assigned a unique identification code that is standardized across states.

Currently, landings data in fish tickets do not include a variable measure of fishing effort. Instead, researchers must rely on proxies such as number of vessels, or total catch, or use logbooks, which are not available for most fisheries. Adding a variable measure of fishing effort, such as days fished during a commercial fishing trip, would make the fish tickets much more useful for economic analysis.

Bycatch has become a central issue in West Coast fisheries management, and the groundfish trawl logbooks have been an important tool for analyzing bycatch. Logbook programs have been started in other fisheries (e.g. market squid, and non-trawl/nearshore groundfish in California). Logbooks are a primary source of information on the spatial distribution of catch and fishing effort.

6.2.2 Model Development

In addition to the valuation models for recreational fisheries that are described above, comprehensive models of CPFV fleet dynamics are needed that reflect multi-species nature of the fishery, economic incentives of CPFV operators to provide not just fish but a "fishing experience", and adaptations of CPFVs to regulatory, market and environmental conditions. Such models could be used to determine whether CPFV fleet dynamics yield single-species CPUEs that can reasonably be used as an index of relative abundance for that species.

Computable bioeconomic models of fishing effort that are spatial and include effects of ex-vessel prices and climate (e.g. sea surface temperatures, sea level pressure) are also needed to predict effects of changes in regulatory, habitat, environmental and market constraints on participation

[1] Pacific Council 2005. Social science in the Pacific Fishery Management Council process. Pacific Fishery Management Council, Portland, Oregon 97220-1384. July 2005.

and harvest in the ocean commercial, ocean sport, tribal and in river sport salmon fisheries. These models could also be used to aid bycatch estimation in non-trawl fisheries, for different species of concern including marine mammals, birds, sea turtles, and others.

A model and data are needed to analyze the transition from an open access fleet to a limited entry fleet. The model would be used to evaluate regional economic impacts, and effects on costs and earnings of the fleet.

An important area for research is to develop models and data to evaluate the economic dependency of coastal communities on fishery and marine resources and the linkages between these industries and the broader regional economy. This type of analysis should be developed to the point of incorporating general equilibrium effects, and linked to participation and bioeconomic factors.

6.2.3 Analysis

At least two retrospective analyses of recent events are needed to determine socioeconomic effects of:

- Rockfish Conservation Areas (RCAs) on commercial and recreational fisheries and fishing communities,
- The trawl vessel buyback program on related fisheries, and on fishing communities (including fishery infrastructure),
- The economic impact of marine protected areas, and
-

A holistic perspective has been emphasized recently in marine resource management (e.g. ecosystem-based management). In light of this perspective, a characterization is needed of all commercial and recreational fisheries within the California Current Ecosystem, including spatial distribution and identification of behavioral linkages among complementary and substitute fishing activities. In addition, an analytical framework that accounts for dynamic and inter-regional interactions among industries and households would improve estimates of economic impacts, and the analysis of costs and benefits among management alternatives. A workshop is needed to examine alternative economic models and analytical frameworks.

Finally, stated preference surveys and other non-market valuation techniques could be used to estimate existence or other non-use values associated with threatened and endangered species, ecosystem protection, and stock rebuilding plans.

7.0 ECOSYSTEM-BASED FISHERIES MANAGEMENT AND MARINE PROTECTED AREAS

7.1 Ecosystem-based Fisheries Management

These suggestions are based on the presumption that ecosystem-based fisheries management (EBFM) would be an evolutionary process rather than a revolutionary process. We also suggest that almost any movement towards EBFM will involve more spatially explicit management, whether through use of MPAs or in recognition of fine scale stock structure and spatial process affecting recruitment. Field and Francis suggest three key elements of an ecosystem-based approach:

- Increasing use of short and long term climate and ocean status, trends, and scenarios for the California Current ecosystem.

- Consideration of trophic interactions among all species, both fished and unfished, and the associated impacts on ecosystem structure and function.

- The increasing application of new management approaches, including spatial management measures to protect life history characteristics, biodiversity, and complex stock structure.

To begin moving towards these objectives and explicitly incorporating habitat and climatic factors in our fishery management models, the following data and research priorities are suggested:

7.1.1 Climate and ocean status and trends

- Provide indices of upwelling, El Niño, Pacific Decadal Oscillation, Sea Surface Temperature, etc. on spatial scales relevant to management.

- Provide indices of zooplankton abundance on the same spatial scales.

- Provide larval and juvenile fish abundance indices on the same spatial scales.

- Support research to evaluate fisheries and ecosystem responses to different climate conditions and both oceanographic and zooplankton indices (this would include groundfish, coastal pelagics, highly migratory species, and salmon).

- Assimilate the above into a status of the ecosystem report useful for management decisions.

7.1.2 Demographics, Trophic Interactions, Life History and Biocomplexity

- Provide total catch, abundance and status of both target and non target species and their prey and predators on finer spatial scales. Appropriate demarcation points might be Point Conception, Point Año Nuevo, Cape Mendocino, Cape Blanco, Columbia River, Cape Flattery.

- Encourage development of probabilistic ecosystem-based models that incorporate environmental variation and anthropogenic disturbances to establish harvest policies and enable risk assessment for fishing strategies.

- Estimate total annual production for the CCS.

- Provide total annual surplus production index for CCS.

- Estimate total population size of higher level carnivores, including sea birds and marine mammals and estimate forage needs and foraging efficiencies (to provide an estimate of not only their food requirements, but the prey density needed for them to acquire these food resources).

- Provide status of the habitat report.

- Provide indicators of species diversity and other measures of ecological health and integrity.

- Provide report on trophic interactions among exploited species and model consequences of fishing at various levels on either predators or prey.

- Use of otolith elemental analysis or genetic fingerprinting to determine origin of benthic juveniles and formulate hypotheses on larval dispersal and stock structure.

- Evaluate relationship between groundfish distribution and role of invertebrates in the structure of demersal habitats.

7.1.3 Highest Priority Issues

- Provide a status of the ecosystem report to the council annually and begin to develop methods for Integrated Ecosystem Assessments.

- Estimate total annual production and surplus production index for CCS.

- Provide total catch, abundance and status of both target and non target species and their prey and predators on finer spatial scales. Appropriate demarcation points might be Point Conception, Point Año Nuevo, Cape Mendocino, Cape Blanco, Columbia River, Cape Flattery.

- Provide population demographic and life history report on all exploited species (relative to estimated virgin biomass). Include overall trophic status of the ecosystem.

- Estimate total population size of higher level carnivores, including sea birds and marine mammals and estimate forage needs and foraging efficiencies (to provide an estimate of not only their food requirements, but the prey density needed for them to acquire these food resources).

7.2 Marine Protected Areas

In 1999, the Council began a two-stage process to consider marine reserves as a tool for managing groundfish. The first part was a "conceptual evaluation" and the second part was to develop alternatives for consideration. The second phase was to be started only if there was a positive result from the conceptual evaluation.

The first phase (Phase 1 Technical Analysis) ran from the spring of 1999 through September 2000. During this phase, a technical analysis[2] of marine reserves was prepared and an Ad-Hoc Marine Reserve Committee met to develop recommendations for the Council. Following these efforts, the Council adopted marine reserves as a tool for managing the groundfish fishery.

As part of the first phase, the technical analysis was designed to assist the Council in the conceptual evaluation of the role of marine reserves as a management tool. Four options were developed in considering the implementation of marine reserves. One option was the creation of "*heritage and research reserves*". The analysis concluded that these "heritage and research" types of marine reserves should be viewed as a supplementary management tool.

The types of research included evaluating the impacts of fishing on marine ecosystems relative to effects caused by natural changes and improving estimates of population parameters for harvested species, thereby directly improving management of the fisheries.

The analysis also noted that these types of small reserves may play a valuable role in fisheries management by serving as "*reference or benchmark sites*" which would provide necessary controls for monitoring local trends in populations and ecosystem processes and would be particularly effective as controls for evaluating the effects of fishing activities in nearby unprotected areas.

In 2004, the SSC completed a white paper entitled "Marine Reserves: Objectives, Rationales, Fishery Management Implications and Regulatory Requirements."[3] This document contains additional recommendations regarding research needs associated with marine reserves and MPAs.

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[2] Pacific Fishery Management Council. 2001. Marine reserves to supplement management of West Coast groundfish resources. Phase I Technical Analysis. Prepared by R. Parrish, J. Seger, and M. Yoklavich. 62 pp. Portland, Oregon.

[3] Pacific Fishery Management Council 2004. Marine Reserves: Objectives, Rationales, Fishery Management Implications and Regulatory Requirements. Pacific Fishery Management Council, Portland Oregon, 97220-1384.

7.2.1 Needs Identified in 2000

The top priority research and data needs related to marine reserves as identified in 2000:

- Identify type and scale of information needed to conduct stock assessments after establishment of marine reserves and evaluate the feasibility and cost of collecting such information.

- Information on the location and type of harvest and effort relative to a proposed marine reserve area is needed in order to begin to evaluate the degree of impact and effectiveness of the creation of marine reserves.

- Research is needed to understand the biological and socioeconomic effects of marine reserves and determine the extent to which ABCs would need to be modified when marine reserves are implemented, over the short-term and long-term.

- Information on advection of eggs and larva and pre-settlement juveniles. Particularly emphasis on differences between areas upstream and downstream of major geographical features.

- Knowledge of when in the life cycle density dependent effects occur is important in the assessment of the effects of marine reserves (as it is in assessing conventional catch management).

- Increased biological and socioeconomic monitoring of existing marine reserves and other areas of restricted fishing in order to gain information on current reserves that might be extrapolated to evaluate the creation of additional reserves on the West Coast.

7.2.2 Essential Fish Habitat Issues

The Council has developed documents that describe and map EFH for coastal pelagic species, salmon, groundfish, and highly migratory species and has suggested management measures to reduce impacts from fishing and non-fishing activities. The Council may use area closures and other measures to lessen adverse impacts on EFH. Given the Council's intention to review EFH descriptions, designations of HAPCs, and fishing impacts on EFH every five years, new data and the tools to analyze those data will be needed.

- Continue development of dynamic spatially-explicit models of habitat sensitivity, fishing impact, and habitat recovery.

- Specifically identify habitat areas of particular concern: those rare, sensitive, and vulnerable habitats (to adverse fishing and non-fishing effects). Identify associated life stages and their distributions, especially for species and life stages with limited information. Develop appropriate protection, restoration, and enhancement measures.

- Identify any existing areas that may function as "natural" reserves and protection measures for these areas.

- Map benthic habitats within Federal and State waters on spatial scales of the fisheries and with sufficient resolution to identify and quantify fish/habitat associations, fishery effects on habitat, and the spatial structure of populations. Mapping of the rocky areas of the continental shelf is critical for the identification of the rocky shelf and non-rocky shelf composite EFHs.

- Conduct experiments to assess the effects of various fishing gears on specific habitats on the West Coast and to develop methods to minimize those impacts, as appropriate. From existing and new sources, gather sufficient information on fishing activities for each gear type to prioritize gear research by gear, species, and habitat type.

- Explore and better define the relationships between habitat, especially EFH, and stock productivity. Improved understanding of the mechanisms that influence larval dispersal and recruitment is especially important.

- Evaluate the potential for incentives as a management tool to minimize adverse effects of fishing and non-fishing activities on EFH.

- Standardize methods, classification systems, and calibrate equipment and vessels to provide comparable results in research studies and enhance collaborative efforts.

- Develop methods, as necessary, and monitor effectiveness of recommended conservation measures for non-fishing effects. Develop and demonstrate methods to restore habitat function for degraded habitats.

APPENDIX I - 2007 AND 2008 GROUNDFISH STOCK ASSESSMENT REVIEW PANEL RECOMMENDATIONS FOR FUTURE RESEARCH AND DATA COLLECTION

Arrowtooth Flounder

- The arrowtooth flounder catch history should be reconstructed using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. As has been recommended previously by a variety of STAR Panels, the reconstruction of historical landings needs to be done comprehensively (i.e., with other species) to ensure efficiency and consistency.
- Evaluate the feasibility of a bi-lateral assessment with Canadian scientists, perhaps through the TSC (Technical Subcommittee of US Canada groundfish working group).
- Investigate the importance of calendar date on catch rates from the triennial survey and propose an adjustment, if needed.

Black Rockfish

Northern stock recommendations

- Development of informed priors for tagging and recreational CPUE *q*s.
- Age validation study
- Reader to reader comparisons are needed between States (Oregon and Washington).

Northern stock recommendations

- Additional work is needed to develop a quantitative prior for tagging catchability. Tagging catchability should be based on analysis of potential black rockfish habitat and the relative abundance of black rockfish throughout the geographic range of the assessment (see Appendix IV to the 2005 cowcod assessment). Continuation and/or expansion of tagging programs should consider the scope of project the relative to the area being assessed. If the area covered by the project is small relative to assessed area, the potential to provide useful information for stock assessment is limited. Development of priors for tag catchability should consider uncertainty as well as point estimates.
- Development of a fishery independent time series using fixed sites and volunteer fishers properly supervised using standard protocols. The CPFV dataset consisting of reef-specific CPUE data has been repeatedly identified as most valuable index for monitoring stock trends of nearshore species.
- The STAT excluded a large amount of ageing data because of inconsistencies that made it unsuitable for use in the assessment model. This raises concerns about age reading protocols. Age reader comparisons, both between readers within the same agency and between readers from different agencies, should be a routine part of age reading procedures.
- This assessment was limited by inadequate biological sampling of California component of the recreational and commercial fishery for black rockfish. Recreational fishery length data

could not be expanded to landings because strata with large landings were not sufficiently sampled. Age data were unavailable for California, which made it impossible to compare geographic differences in growth. There have been positive steps towards sustainable management of nearshore species off California at the policy level, but the lack of investment in long-term sampling programs for biological data may make it difficult to achieve policy objectives.

- For stocks whose primary assessment index is derived from recreational fishery CPUE, greater consideration should be given to the potential impact of management changes on the ability to assess the stock. Management tools such as bag limit and season closures may have different impacts on CPUE trend data. Each management change, e.g., a bag limit change, potentially reduces the value of fishery-dependent data.

Blue Rockfish

- Further genetic studies are needed to confirm that blue rockfish is two species. The sampling for genetic samples should be designed to address management issues, such as differences in spatial distribution, the extent of intermixing, differences in growth, longevity, and maturation schedules between the two species.
- Development of a fishery independent time series using fixed sites and volunteer fishers properly supervised using standard protocols. The CPFV dataset consisting of reef-specific CPUE data has been repeatedly identified as most valuable index for monitoring stock trends of nearshore species.
- The next assessment should provide documentation of historical blue rockfish catches off Oregon and south of Point Conception. A comprehensive assessment of blue rockfish throughout its West Coast range should be considered.
- This assessment was limited by inadequate biological sampling of the California recreational and commercial fishery for blue rockfish. Recreational fishery length data could not be expanded to landings because strata with large landings were not sufficiently sampled. Reliable age data are unavailable for past 20 years, which made it impossible to evaluate temporal changes in growth or to compare geographic differences in growth. There have been positive steps towards sustainable management of nearshore species off California at the policy level, but the lack of investment in long-term sampling programs for biological data may make it difficult to achieve policy objectives.
- Given the availability of biological samples, studies are needed on spatial and temporal growth patterns of blue rockfish.
- Given the availability of biological samples, studies are needed on reproductive biology of blue rockfish. The apparent higher mortality of male blue rockfish, which is unique among assessed rockfish (female mortality is higher for several shelf and nearshore rockfish species), may also be linked to reproductive biology or behavior.
- The next assessment should provide a detailed justification for the use of fishery CPUE indices as indices of abundance. A detailed descriptive analysis of the data should be provided, with particular attention to annual changes that affect fundamental assumptions. Further, evaluate the robustness of the method to trip selection criteria and regulatory changes in the fishery.

- GLM diagnostics for both binomial and non-zero catch rate regressions should be provided routinely in all assessments that use this technique.
- For stocks whose primary assessment index is derived from recreational fishery CPUE, greater consideration should be given to the potential impact of management changes on the ability to assess the stock. Management tools such as bag limit and season closures may have different impacts on CPUE trend data. Each management change, e.g., a bag limit change, potentially reduces the value of fishery-dependent data.

Bocaccio

- The next assessment of bocaccio rockfish should be a full assessment and should use SS2 or some comparable modeling platform.
- All the bocaccio rockfish data need a critical review and potential revision before being included in the next assessment. Of particular concern are adjustments for bag-limit and other management-induced changes, the derivation of length-composition data, and the basis and selection of data sources to include in the assessment. The next assessment document should provide thorough and comprehensive documentation of the data sources and statistical models used in processing the data.
- Assumptions about stock structure and boundaries should be reviewed in light of information on catches of bocaccio rockfish taken off Mexico, Oregon, and Washington.
- The bocaccio rockfish catch history should be reconstructed using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. The STAR Panel notes that the SWFSC has made significant progress in retrieving detailed historical landings data, which will facilitate catch reconstructions. As has been recommended previously by a variety of STAR Panels, the reconstruction of historical rockfish landings needs to be done comprehensively across all rockfish species to ensure efficiency and consistency.
- Length frequency data, which are collected seasonally, should be modeled accordingly. This could be accomplished within the stock assessment model or externally by converting length-compositions to age-compositions, as has been done in New Zealand (Hicks et al. 2002).
- The new assessment model and data should be configured to explore cohort- and/or year-specific growth. Again, this could be done within the stock assessment model or externally by converting length-compositions to age-compositions.
- Age-reading of bocaccio otoliths should be pursued.
- Establish a meta-database that provides a comprehensive overview of all relevant data sources and sufficient information to correctly interpret the data.
- Establish an accessible database for rockfish catch histories by species, including envelopes of high and low values for each species to set bounds for exploration of alternative catch histories.
- Relevant raw data, updated in a timely manner, should be readily accessible to assessment authors in on-line databases that are user-friendly.

- Develop comprehensive descriptive analyses of recreational fisheries and fleets to assist in interpretation of recreational CPUE and length-composition data.
- Develop a concise set of documents that provide details of common data sources and methods used for analyzing the data to derive assessment model inputs.

Canary Rockfish

- Assumptions about stock structure and distributional boundaries should be reviewed in light of information on Canadian/Alaskan catches.
- A catch history should be reconstructed using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. As has been previously recommended, the reconstruction needs to be done comprehensively across all rockfish species to ensure efficiency and consistency.
- Evaluate the feasibility of a bi-lateral assessment with Canadian scientists, perhaps through the TSC (Technical Subcommittee of US Canada groundfish working group).
- Investigate the importance of calendar date and other covariates on catch rates from the triennial survey and propose adjustments to account for seasonal and other variation in selectivity/availability.

Chilipepper Rockfish

- Reconstruct the chilipepper rockfish catch history using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. The Panel notes that the SWFSC has made significant progress in retrieving detailed historical landings data, which will facilitate catch reconstructions. As has been recommended previously by a variety of STAR Panels, the reconstruction of historical rockfish landings needs to be done comprehensively across all rockfish species to ensure efficiency and consistency.
- Read chilipepper rockfish otoliths from the triennial and combination bottom trawl surveys to provide better data on the early stages of growth and possible time-variations in growth.
- Explore use of conditional age-at-length data rather than coupled age- and length-composition data.
- Explore time-varying growth as influenced by environmental changes.
- Explore possible spatial structuring of the data and model.
- The next STAT should have full access to raw data from the NWFSC trawl survey.

Cowcod

- Present and consider all available data potentially relevant to abundance trends in recent and historical years (e.g., outfall surveys, CalCOFI data, NWFSC bottom trawl data, observer data, and hook and line survey data). Data for recent and current trends are important in tracking progress towards rebuilding. Historical data may be useful in corroborating trends in CPFV logbook data.

- Enhance modeling procedures for standardizing CPFV data, particularly in representing potential interactions between year and region.
- Provide reviewers with complete sets of model diagnostics for standardized abundance indices based on CPFV and other types of data.
- Conduct additional video surveys to provide direct measures of current cowcod biomass and to facilitate interpretation of the existing video survey data. Ideally, video sampling should be carried out both inside and outside the Cowcod Conservation Areas so that extrapolation to the entire stock is not required.
- Reconstruct the cowcod rockfish catch history using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. As has been recommended previously by a variety of STAR Panels, the reconstruction of historical rockfish landings needs to be done comprehensively across all rockfish species to ensure efficiency and consistency.
- A preliminary query of the RecFIN database showed a very small number of cowcod in the RecFIN sample data. The Panel recommended that a thorough investigation of these data be prepared for the next assessment of this stock.
- Re-examine the assumption that commercial selectivity at length is the same as maturity at length.
- Conduct a full Bayesian assessment if possible. Cowcod are an ideal potential case because of the simple model structure and uncertainties about key model parameters and data.
- Develop surveys that track trends in abundance of cowcod. The NWFSC bottom trawl shelf and slope surveys should, in particular, be evaluated for cowcod.
- For the historical and recent fisheries, evaluate the relative capacity of fishing fleets and markets for cowcod to determine how much catch might have reasonably been taken during historical periods and whether relatively high fishing mortality rates during the late 1980s are plausible.
- Evaluate the hypothesis that CPFV indices are nonlinear measures of stock biomass.
- Assessment and review work would have been enhanced if the STAT had consisted of more than one person and if more time had been available to carry out the assessment.

Darkblotched Rockfish

- GLMM survey index swept area biomass data for the NWFSC shelf and slope surveys were much higher than simple swept area biomass calculations. Although some differences might be expected, the magnitude and consistency of the differences was surprising. GLMM procedures and models used to standardize the survey data should be checked and differences should be explained.
- Assessment data and background information should be presented clearly and completely before dealing with assessment models and modeling results. Data tables should be distributed at the start of the review.

- Future assessments should include complete sets of model diagnostics for GLMM standardized abundance indices, and other types of model runs.
- Maps showing the spatial overlap of the darkblotched rockfish stock area, surveys, fishing grounds and prime habitat should be provided and considered in interpreting survey data.
- Continued work to characterize effective sample size for length composition and, particularly, conditional age composition data is needed. For example, the procedure used to assign effective sample size initially for darkblotched rockfish was questioned in this assessment.
- Conduct a full Bayesian assessment.
- It would be useful to routinely check model estimates of survey catchability to determine if they imply implausible biomass estimates. This can be done by comparing the prior and posterior for q in a fully Bayesian assessment. Other approaches involve calculating bounds for plausible q values, comparison of model and minimum swept-area biomass estimates from trawl surveys.
- Assessment and review work would have been enhanced if the STAT had consisted of more than one person and if more time had been available to carry out the assessment.

Longnose Skate

- Re-create catch history (best estimates plus uncertainty) based on fishing effort.
- Investigate anomalous 2004 AFSC triennial survey longnose skate (and possibly other flatfish) catches.
- Ageing (validation) studies and maturation rate studies.
- Continue skate species identification in the fishery.
- Continue discard monitoring.
- Studies to estimate discard rates and discard mortality.

Sablefish

- The sablefish assessment needs a full review (this is not possible during a STAR Panel meeting). Additional resources are required to do this. Personnel with specialist experience and skills should critically review each data source. Model complexity should be simplified to be compatible with the expected information content of the data. The starting point should probably be an age-only model with growth estimated outside the model.
- Age data, in general, and especially for sablefish, intrinsically contains more information on recruitment (and biomass) than length data. Of course, if ageing methods are unreliable, then age frequencies will be also. The existing age frequencies (and model fits) should be critically examined to see if cohorts (at relatively young ages) are being tracked reliably. If they are not, then ageing methods should perhaps be reviewed with consideration given to how representative the age samples are likely to be. If cohorts do track reliably, then priority should be given to ageing any remaining samples.
- The exercise for deriving the prior on q should be redone. All potentially relevant data sources should be made available to a selected group of participants with appropriate skills

and experience. Ideally, priors would be formed for all of the trawl surveys used in the assessment. The sablefish q-priors could be derived at a more general workshop covering several species.

- The use of environmental variables as recruitment indices is currently fashionable and results do look encouraging. However, the priority for this work is to conduct a full cross validation study on the existing candidates rather than to further refine the candidate environmental indices.
- Continuation of trawl time series is essential for future stock assessments. The NWFSC slope survey has been surveying the whole of the Conception stratum in recent years and this should probably continue. If the full survey results are used to construct a time series then the Conception stratum must be subdivided at Point Conception. A consistent time series, using the full area, could be constructed using a number of methods including a GLM or extrapolation using the ratio of average catch rates north and south of Point Conception. A GLM is probably preferable, especially if there are significant vessel effects.
- Continued sampling of the commercial fishery is necessary and priority should be given to obtaining representative samples (good spatial and temporal coverage for the main fleets).

Pacific Whiting

- The Panel recommends that a Management Strategy Evaluation approach be used to evaluate whether the current 40-10 harvest control rule is sufficient to produce the management advice necessary to ensure the sustainable use of the Pacific hake stock with its dramatically episodic recruitment. The 40-10 rule assumes that simply reducing catches in a linear fashion as stock biomass declines will be sufficient to guide the fishery back towards the target spawning biomass level. However, with the fishery being dependent upon a single declining cohort just reducing the catch may achieve the status quo but it rebuilding will not occur without new recruitment.
- Related to Recommendation 1, the operating model developed for the Management Strategy Evaluation should evaluate how well the different assessment models recapture true population dynamics. At issue is whether a simpler model such as ADAPT / VPA performs better or worse than a more complex model such as SS2.
- Female Pacific whiting grow differently than male Pacific whiting and many of the more influential dynamic processes that operate in the fishery are length-based but are currently considered from an age-based perspective (for example selectivity). The Panel recommends that future assessment models explore the need for including both gender- and length-based selection into the dynamics.
- The inclusion of ageing error was found to be influential on the model fit in the SS2 model. However, issues with ageing still remain. Further ageing error analyses are required, especially focused on estimating any bias in the ageing. It will be important to conduct a cross-validation of ageing error from the different laboratories conducting the ageing. It is especially important to include otoliths that were read by AFSC staff.
- In light of current acoustic survey information, re-evaluate treatment / adjustment of pre-1995 acoustic survey data and index values. For example, compare the biomass index implied by the area covered by the pre-1995 surveys with the total biomass from the full area

covered by the post-1995 surveys. The difference between these two indices has implications for the magnitude of the survey catchability coefficient prior to 1995.

- There should be further exploration of geographical variations in fish densities and relationships with average age and the different fisheries, possibly by including spatial structure into future assessment models.
- There should be exploration of possible environmental effects on recruitment and the acoustic survey.
- There should be further investigation and resolution of possible under-reporting of foreign catch.