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<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC - acceptable biological catch</td>
<td>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).</td>
</tr>
<tr>
<td>barotrauma</td>
<td>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.</td>
</tr>
<tr>
<td>CalCOFI</td>
<td>California Cooperative Oceanic Fisheries Investigations</td>
</tr>
<tr>
<td>catch per unit of effort</td>
<td>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.</td>
</tr>
<tr>
<td>CCA</td>
<td>Cowcod Conservation Area</td>
</tr>
<tr>
<td>CCE</td>
<td>California Current Ecosystem</td>
</tr>
<tr>
<td>CCLME</td>
<td>California Current Large Marine Ecosystem</td>
</tr>
<tr>
<td>CCS</td>
<td>California Current System</td>
</tr>
<tr>
<td>CDFW</td>
<td>California Department of Fish and Wildlife</td>
</tr>
<tr>
<td>coastal pelagic species</td>
<td>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.</td>
</tr>
<tr>
<td>coded-wire tag</td>
<td>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.</td>
</tr>
<tr>
<td>cohort</td>
<td>In a stock, a group of fish born during the same time period.</td>
</tr>
<tr>
<td>COP</td>
<td>Council Operating Procedures</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Council</td>
<td>Pacific Fishery Management Council</td>
</tr>
<tr>
<td>CPFV</td>
<td>Commercial passenger fishing vessel (charter boat)</td>
</tr>
<tr>
<td>CPS</td>
<td>Coastal pelagic species. See above.</td>
</tr>
<tr>
<td>CPUE</td>
<td>Catch per unit of effort.</td>
</tr>
<tr>
<td>CWT</td>
<td>Coded-wire tag. See above.</td>
</tr>
<tr>
<td>DIT</td>
<td>Double index tagging</td>
</tr>
<tr>
<td>EBFM</td>
<td>Ecosystem-Based Fishery Management</td>
</tr>
<tr>
<td>EEZ</td>
<td>Exclusive Economic Zone. See below.</td>
</tr>
<tr>
<td>EFH</td>
<td>Essential fish habitat. See below.</td>
</tr>
<tr>
<td>EIS</td>
<td>Environmental impact statement. See below.</td>
</tr>
<tr>
<td>El Niño Southern Oscillation</td>
<td>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 <em>El Niño</em>.</td>
</tr>
<tr>
<td>EMS</td>
<td>Electronic monitoring system</td>
</tr>
<tr>
<td>Endangered Species Act</td>
<td>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.</td>
</tr>
<tr>
<td>ENSO</td>
<td>El Niño Southern Oscillation</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>Environmental impact statement</td>
<td>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.</td>
</tr>
<tr>
<td>EPO</td>
<td>Eastern Pacific Ocean</td>
</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act. See above.</td>
</tr>
<tr>
<td>essential fish habitat</td>
<td>Those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.</td>
</tr>
<tr>
<td>Exclusive Economic Zone</td>
<td>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.</td>
</tr>
<tr>
<td>exempted fishing permit</td>
<td>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.”</td>
</tr>
<tr>
<td>Fathom</td>
<td>Used chiefly in measuring marine depth. A fathom equals 6 feet.</td>
</tr>
<tr>
<td>FEIS</td>
<td>Final Environmental Impact Statement (see EIS, NEPA).</td>
</tr>
<tr>
<td>FEP</td>
<td>Fishery Ecosystem Plan</td>
</tr>
<tr>
<td>Fm</td>
<td>Fathom (6 feet)</td>
</tr>
<tr>
<td>FMP</td>
<td>Fishery management plan. See above.</td>
</tr>
<tr>
<td>FRAM</td>
<td>Fishery Regulation Assessment Model. Typically used for salmon.</td>
</tr>
<tr>
<td>FWS</td>
<td>U.S. Fish and Wildlife Service</td>
</tr>
<tr>
<td>GSI</td>
<td>Genetic stock identification</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>Habitat areas of particular concern</td>
<td>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.</td>
</tr>
<tr>
<td>HAPC</td>
<td>Habitat areas of particular concern. See above.</td>
</tr>
<tr>
<td>Harvest guideline(s)</td>
<td>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.</td>
</tr>
<tr>
<td>HCR</td>
<td>Harvest control rule</td>
</tr>
<tr>
<td>Highly migratory species</td>
<td>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.</td>
</tr>
<tr>
<td>HMS</td>
<td>Highly migratory species. See above.</td>
</tr>
<tr>
<td>HMS FMP</td>
<td>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 Council and approved by the Secretary of Commerce.</td>
</tr>
<tr>
<td>IATTC</td>
<td>Inter-American Tropical Tuna Commission</td>
</tr>
<tr>
<td>IFQ</td>
<td>Individual fishing quota. See below.</td>
</tr>
<tr>
<td>IMECOCAL</td>
<td>A program in Baja California concerning small pelagics and climate change.</td>
</tr>
<tr>
<td>Incidental catch or incidental species</td>
<td>Species caught when fishing for the primary purpose of catching a different species.</td>
</tr>
<tr>
<td>Incidental take</td>
<td>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.</td>
</tr>
<tr>
<td>Individual transferable (or tradable) quota</td>
<td>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.</td>
</tr>
<tr>
<td>IO-PAC</td>
<td>A regional input-output model</td>
</tr>
<tr>
<td>ISC</td>
<td>International Scientific Committee</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ITQ</td>
<td>Individual Transferable (or Tradable) Quota. See above.</td>
</tr>
<tr>
<td>KRFC</td>
<td>Klamath River fall Chinook</td>
</tr>
<tr>
<td>Magnuson-Stevens Act</td>
<td>Magnuson-Stevens Fishery Conservation and Management Act. See below.</td>
</tr>
<tr>
<td>Magnuson-Stevens Fishery Conservation and Management Act</td>
<td>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.</td>
</tr>
<tr>
<td>Marine Mammal Protection Act</td>
<td>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”.)</td>
</tr>
<tr>
<td>Maximum sustainable yield</td>
<td>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.</td>
</tr>
<tr>
<td>MMPA</td>
<td>Marine Mammal Protection Act. See above.</td>
</tr>
<tr>
<td>MPA</td>
<td>Marine protected areas</td>
</tr>
<tr>
<td>MSA</td>
<td>Magnuson-Stevens Fishery Conservation and Management Act. See above.</td>
</tr>
<tr>
<td>MSFCMA</td>
<td>Magnuson-Stevens Fishery Conservation and Management Act. See above.</td>
</tr>
<tr>
<td>MSY</td>
<td>Maximum sustainable yield. See above.</td>
</tr>
<tr>
<td>National Marine Fisheries Service</td>
<td>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.</td>
</tr>
<tr>
<td>NGO</td>
<td>Nongovernmental organization</td>
</tr>
<tr>
<td>NMFS</td>
<td>National Marine Fisheries Service. See above.</td>
</tr>
<tr>
<td>NMFS NWFSC</td>
<td>National Marine Fisheries Service Northwest Fisheries Science Center</td>
</tr>
<tr>
<td>NMFS NWR</td>
<td>National Marine Fisheries Service Northwest Region</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>NMFS SWFSC</td>
<td>National Marine Fisheries Service Southwest Fisheries Science Center</td>
</tr>
<tr>
<td>NMFS SWR</td>
<td>National Marine Fisheries Service Southwest Region</td>
</tr>
<tr>
<td>ODFW</td>
<td>Oregon Department of Fish and Wildlife</td>
</tr>
<tr>
<td>ONMS</td>
<td>Office of National Marine Sanctuaries</td>
</tr>
<tr>
<td>Optimum yield</td>
<td>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.</td>
</tr>
<tr>
<td>OY</td>
<td>Optimum yield. See above.</td>
</tr>
<tr>
<td>PacFIN</td>
<td>Pacific Fisheries Information Network</td>
</tr>
<tr>
<td>Pacific States Marine Fisheries Commission</td>
<td>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.</td>
</tr>
<tr>
<td>PaCOOS</td>
<td>Pacific Coast Ocean Observing System</td>
</tr>
<tr>
<td>PBT</td>
<td>Parentage-based-tagging</td>
</tr>
<tr>
<td>PFMC</td>
<td>Pacific Fishery Management Council</td>
</tr>
<tr>
<td>PNW</td>
<td>Pacific Northwest</td>
</tr>
<tr>
<td>PSMFC</td>
<td>Pacific States Marine Fisheries Commission. See above.</td>
</tr>
<tr>
<td>Quota</td>
<td>A specified numerical harvest objective, the attainment (or expected attainment) of which causes closure of the fishery for that species or species group.</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
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</tr>
<tr>
<td>RFMO</td>
<td>Regional Fishery Management Organization</td>
</tr>
<tr>
<td>SAFE</td>
<td>Stock assessment and fishery evaluation. See below.</td>
</tr>
<tr>
<td>Scientific and Statistical Committee</td>
<td>An advisory committee of the Council 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.</td>
</tr>
<tr>
<td>SI</td>
<td>Sacramento Index</td>
</tr>
<tr>
<td>SS2</td>
<td>Stock Synthesis 2 – Population assessment program.</td>
</tr>
<tr>
<td>SS3</td>
<td>Stock Synthesis 3</td>
</tr>
<tr>
<td>SSC</td>
<td>Scientific and Statistical Committee. See above.</td>
</tr>
<tr>
<td>STAR</td>
<td>Stock assessment review</td>
</tr>
<tr>
<td>STAR Panel</td>
<td>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.</td>
</tr>
<tr>
<td>Stock Assessment and Fishery Evaluation</td>
<td>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.</td>
</tr>
<tr>
<td>TIQ</td>
<td>Trawl Individual Quota</td>
</tr>
<tr>
<td>Vessel Monitoring System</td>
<td>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 onboard vessels. These devices automatically send data to shore-based “satellite” monitoring system.</td>
</tr>
<tr>
<td>WCGOP</td>
<td>West Coast Groundfish Observer Program</td>
</tr>
<tr>
<td>WCPFC</td>
<td>Western and Central Pacific Fisheries Commission</td>
</tr>
<tr>
<td>WG</td>
<td>Working Group</td>
</tr>
</tbody>
</table>
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 Pacific Fishery Management Council (Council) management of West Coast fisheries.

Section 302(h)(7) of the MSA requires Regional Fishery Management Councils to:

“(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 report is intended to document and communicate the Council’s research and data needs through 2018, thereby fulfilling the Council’s responsibilities under MSA Section 302(h)(7).

1.1 Schedule of Document Development and Review

For 2012-2013 revisions, the Council rescheduled and streamlined the process listed under Council Operating Procedure 12 in response to the anticipated heavy Council and Scientific and Statistical Committee (SSC) workload associated with the Groundfish stock assessment cycle in 2013. Council staff and the SSC reviewed the Stock Assessment and Fishery Evaluation (SAFE) and other documents from recent years to develop this document with a 5-year outlook. At the September 2012 Council meeting in Boise, Idaho, the Council and available advisory bodies reviewed the initial draft document and the Council approved a revised draft for public review. At the November 2012 Council meeting, the Council reviewed a draft Fishery Ecosystem Plan (FEP) that included its own set of ecosystem-related research initiatives and the Council recommended moving those initiatives from the FEP to this document. At the March 2013 Council meeting in Tacoma, Washington, the Council approved this final document which records and communicates the Council’s research and data needs through 2018 to ensure continued well-informed Council decision-making into the future and to fulfill the Council’s responsibilities under the MSA.
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 around overarching fishery management topics such as economic and social science components, ecosystem-based fishery management (EBFM), marine protected areas (MPA), and EFH issues. Following these overarching topics, the document includes detailed sections that focus on each of the Council’s four fishery management plans (FMPs). 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 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.

1.3 Communication and Coordination

This document has been posted to Council web page and transmitted to many West Coast organizations and agencies to broadly communicate Council needs and to solicit research support. Groups to be included in the distribution include the other seven Regional Fishery Management Councils, Headquarters as well as west coast Regional Offices and Science Centers of National Marine Fisheries Service (NMFS), west coast states, the Pacific States Marine Fisheries Commission (PSMFC), tribal management agencies, the National Ocean Service’s Office of National Marine Sanctuaries (ONMS), West Coast National Marine Sanctuaries, and Sea Grant.

Following completion and distribution, as time and workload allow, the Council Chair and staff may meet with representatives from NMFS West Coast regions and centers, ONMS and PSMFC to develop a consensus on high priority initiatives needed to respond to Council needs that would be conveyed to NMFS.
2.0 ECOSYSTEM-BASED FISHERIES MANAGEMENT

2.1 Introduction

Ecosystem science can be useful both in its application to FMP species-group management, and to aid in long-term Council planning on ecosystem-wide concerns. Francis et al. (2007) recommend making scientific progress towards ecosystem-based fisheries management with these principles: 1. Keep a perspective that is holistic, risk-averse, and adaptive. 2. Question key assumptions, no matter how basic. 3. Maintain old-growth age structure in fish populations. 4. Characterize and maintain the natural spatial structure of fish stocks. 5. Characterize and maintain viable fish habitats. 6. Characterize and maintain ecosystem resilience. 7. Identify and maintain critical food web connections. 8. Account for ecosystem change through time. 9. Account for evolutionary change caused by fishing. 10. Implement an approach that is integrated, interdisciplinary, and inclusive (Francis et al. 2007).

The Council has nearly completed its initial FEP which is intended to serve as an informative rather than prescriptive document to expand the application of ecosystem-based management principles into fishery management decisions under the Council’s four FMPs. The Council has adopted the following purpose and need statement for the FEP.

The purpose of the FEP is to enhance the Council’s species-specific management programs with more ecosystem science, broader ecosystem considerations, and management policies that coordinate Council management across its Fishery Management Plans (FMPs) and the California Current Ecosystem (CCE). An FEP should provide a framework for considering policy choices and trade-offs as they affect FMP species and the broader CCE.

The needs for ecosystem-based fishery management within the Council process are:

1. Improve management decisions and the administrative process by providing biophysical and socio-economic information on CCE climate conditions, climate change, habitat conditions, and ecosystem interactions.
2. Provide adequate buffers against the uncertainties of environmental and human-induced impacts to the marine environment by developing safeguards in fisheries management measures.
3. Develop new and inform existing fishery management measures that take into account the ecosystem effects of those measures on CCE species and habitat, and that take into account the effects of the CCE on fishery management.
4. Coordinate information across FMPs for decision-making within the Council process and for consultations with other regional, national, or international entities on actions affecting the CCE or FMP species.
5. Identify and prioritize research needs and provide recommendations to address gaps in ecosystem knowledge and FMP policies, particularly with respect to the cumulative effects of fisheries management on marine ecosystems and fishing communities.

Given the broad applicability of ecosystem-based management principles, many of the research priorities identified in this chapter are reiterative or closely related to FMP-specific recommendations in later chapters. As funding becomes scarcer, it is important to identify these linkages or cross-FMP initiatives to see where research in one FMP can have multiple benefits.
for informing management in others. 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:

2.2 Highest priority Issues:

- Identify ecosystem-related objectives at all levels of assessment and management. This includes stock assessments, habitat analyses, and coastwide and regional ecosystem status reports.

- Identify an approach for evaluating the benefits of various management tools in relation to achieving EBFM management objectives.

- Provide a status of the ecosystem report to the Council annually that includes, but is not limited to, evaluation of current and future oceanographic condition, analysis of ecosystem responses to management measures and these conditions, updated habitat mapping or evaluation, observations of recruitment patterns across species, shifts in species distribution and community composition, and changes in trophic dynamics.

- Identify key physical and biological indicators for prediction of salmon early ocean survival and groundfish recruitment, as well as other conditions that are directly applicable to management.

- In the longer term, identify how the climate might be changing on long time scales in a way that will affect fisheries (i.e., climate change).

- Identify indices of ecosystem state (on appropriate temporal and spatial scales, e.g. demarcation points might be Point Conception, Point Año Nuevo, San Francisco Bay, Point Reyes, Cape Mendocino, Cape Blanco, Columbia River, Cape Flattery):
  - upwelling, El Niño, Pacific Decadal Oscillation, Sea Surface Temperature, etc.
  - abundance of key ecosystem process indicators, such as zooplankton and forage fishes
  - larval and juvenile fish abundance
  - total annual production and surplus production
  - species diversity and other measures of ecological health and integrity; describe rationale underlying each
  - a measure of ocean acidification and its associated impacts on marine resources and ecosystem structure and function.

- Estimate total catch for target and nontarget species and their prey and predators.

- Evaluate the effect of fishing on habitat and response of habitat to spatial closures.

- Encourage development of probabilistic/stochastic ecosystem-based models that incorporate environmental variation and anthropogenic disturbances to guide harvest policies and enable risk assessment for fishing strategies.
• Provide report on trophic interactions among exploited species and model consequences of fishing at various levels on predators or prey and/or the changes in biomass that may be expected due to major shifts in climate, oceanographic parameters such as acidification, and temperature, as well as anticipated effects on productivity.

• Prioritize these issues according to immediate need and relevance to management, and develop a comprehensive plan to integrate ecosystem-based processes and information into all aspects of assessment, monitoring, and evaluation.

• Estimate total population size (or collect existing time series) 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).

The following items arose during the development of the Council’s development of an FEP. These concepts reflect the general prioritization provided by the Council’s Ecosystem Advisory Subpanel based on consideration of the relative benefit of the information. ¹

High Benefit:

• Identify key indicators for recruitment, growth, spatial availability, and overall California Current Ecosystem (CCE) productivity.

• Examine ecological interactions for influence on managed and non-managed species, including predator-prey relationships, competition, and disease. Investigate the role of FMP species in the food web, including analysis of behavioral interactions (e.g. functional response) between predators and prey.

• Better understand spatial structure and geographic range (meta-population structure) of managed stocks and investigate what are the most appropriate spatial scales for management.

• Assess high and low frequency changes in the availability of target stocks, and the vulnerability of bycatch species, in response to dynamic changes in climate and oceanographic conditions (such as seasonal changes in water masses, changes in temperature fronts or other boundary conditions, and changes in prey abundance).

• Assess near-shore distribution of FMP species for habitat needs and fishery vulnerability during nursery and pre-reproductive life stages. Characterize the influence of nearshore marine, estuarine, and freshwater water quality on survival, growth, and productivity.

• Evaluate the influence of climatic/oceanographic conditions on the population dynamics of FMP species. Develop indicators to track that influence, such as for upwelling, sea surface temperatures, Pacific Decadal Oscillation, chl-a, and zooplankton index. Evaluate the efficacy of incorporating environmental factors within the current stock assessment modeling framework (Stock Synthesis 3). Model effects of climate forcing and other ecosystem interactions (e.g., trophic interactions) on productivity and assess utility of simulated estimates of the unexploited biomass over time (a “dynamic B0”) rather than the static estimate of long-term, mean, unfished abundance.

Moderate Benefit:

• Investigate how fishing activity affects ecosystem structure and function, particularly spatial and temporal fishing patterns and their relation to changing patterns in the ecosystem (cumulative impacts of all FMP fisheries).

• Spatially-explicit management: What is the effect of marine spatial planning on FMP species and fisheries? A review of marine spatial planning should include consideration of both fisheries and non-fisheries closures and the effects of spatially explicit management, not only on fisheries, but also on fisheries research, monitoring, and modeling (e.g. stock assessments).

• Evaluate effectiveness of standardized bycatch reporting methodologies in all FMP fisheries and develop quantitative information on the extent of the cumulative bycatch of all FMP fisheries.

• Develop an analytical framework to compile information and evaluate the tradeoffs society is willing to make across the alternative ecological benefits fishery resources provide.

• Investigate how viability and resilience of coastal communities are affected by changes in ecosystem structure and function, including short- and long-term climate shifts.

• Non-market valuation techniques need to be developed in order to estimate existence or other non-use values that are applicable to FMP target species, as well as the non-target species that interact with FMP target species.

• Develop methods and linkages to socio-economic data and modeling to assess effects of changes in resource availability, climate, and regulations on West Coast fisheries.

2.3 Emerging Issues:

• Develop an approach for interpreting the values for indicators, including the development of thresholds, where appropriate.

• Collect data on distribution, diet, and abundance for target and non-target species and their prey and predators on finer spatial scales, following a prioritization exercise that identifies target species in greatest need of finer-scale assessment and non-target or
target species that may function as indicators of trophic interactions and ecosystem condition.

- Conduct comprehensive stomach analysis to determine trophic interactions among and within target and non-target species. This information would be essential for assessments of the California Current Large Marine Ecosystem (CCLME) and represents the cross-FMP linkages that are sought under the developing EBM FMP.

- Use of hydrodynamic modeling, otolith elemental analysis or genetic fingerprinting and parental analysis to determine origin of benthic juvenile groundfish and formulate hypotheses for larval dispersal and stock structure.

2.4. Broad-Scale and Long-Term Oceanographic Conditions

Changes in temperature, oxygen saturation, and ocean pH are key oceanographic features that help to define both habitability and productivity for much of the CCE, have both direct and indirect impacts on fisheries species, and are expected to change with future climate variability. Future research considerations that would improve the Council’s ability to incorporate oceanographic conditions into EBFM are:

- Direct physiological effects of temperature, pH, and O changes on managed and non-FMP forage species, including, but not limited to: tolerance limits, growth rate, and reproductive rate,

- Current spatial and depth boundaries of all FMP and non-FMP forage species in regards to temperature, pH, and O,

- Spatially-specific trend analysis of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species,

- Spatially-specific forecasts of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species, and

- Spatially-specific trend and forecast of temperature, pH, and O effects on food chain base (1° and 2° production) for all FMP and non-FMP forage species.
3.0 MARINE PROTECTED AREAS AND ESSENTIAL FISH HABITAT

3.1 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 and our understanding of impacts on EFH from fishing.

The analysis also noted that these types of small marine 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. Use as a reference presumes independence, which needs to be justified.

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.

As MPAs and marine reserves are added to state waters and National Marine Sanctuaries, an evaluation of the likely benefits of these actions in the context of current management strategies


should be required. Cumulative impacts of closures on fishing effort distribution should be examined, as well as social and economic costs and benefits.

3.2 Priority Research and Data Needs Related to Marine Protected Areas

- 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. Use of Before/After/Control/Impact research design methods improves the inference of harvest and habitat relations in marine reserves. Over the past couple decades this has been the approach of choice for scientifically rigorous and defensible studies for determining differences in a control vs. treatment area and has been applied to marine reserves monitoring elsewhere in the world.

- Research is needed to understand the biological and socioeconomic effects of marine reserves and determine the extent to which acceptable biological catches 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 from marine reserves would help answer whether an individual marine reserve or network of marine reserves serve as either sources, sinks, or both of future fish populations. In other words, are the marine reserves providing offspring to the areas outside the marine reserve (a source) or is the outside area providing offspring to the marine reserve that may function as a nursery area and protection for the growing larva and juveniles (a sink)? Research emphasizing the differences between areas upstream and downstream of major geographical features may enhance our understanding of dispersal patterns of eggs and larva and therefore the optimal placement of marine reserves.

- 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 that might be extrapolated to evaluate the creation of additional reserves on the west coast.

- Biological and physical indicators should be developed and monitored over long time scales to assess the effectiveness of reserves.

- Information is needed on movement patterns of species (e.g., fish home ranges, residence times, distance for foraging forays) in different habitats (rocky and soft bottom), in different locales, and throughout the year to determine the appropriate sizing, spacing and scale of MPAs.
3.3 Essential Fish Habitat Issues

The Council has developed documents that describe and map EFH for Coastal Pelagic Species (CPS), salmon, groundfish, and Highly Migratory Species (HMS) 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 habitat areas of particular concern (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. This should include a spatially explicit description of ocean habitat, and include how those may change with shifting climate.

- Specifically identify HAPCs: 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 (such as the use of resource areas) to assess the effects of various fishing gears on specific habitats, including habitat recovery rates, 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 to the extent practicable.

- 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, including measuring the effectiveness of these restoration methods in pilot/demonstration projects.
4.0 ECONOMICS AND SOCIAL SCIENCE COMPONENTS

4.1 Introduction

This section focuses on research and data needed to (1) support and expand the use of socioeconomic information in Council deliberations and regulatory analyses, (2) improve understanding of the socioeconomic, biological and ecological tradeoffs involved when applying an existing policy or considering alternative policies to achieve a given objective (e.g., capacity management, stock rebuilding), (3) improve the Council’s ability to monitor the socioeconomic status of fisheries and fishing communities, (4) provide retrospective evaluations of past policies that could help inform future policies, and (5) advance National Standard 8, “Consider fishing communities to provide for their sustained participation and to minimize adverse economic impacts.”

Methods of economic analysis include benefit-cost analysis and regional economic impact analysis. Benefit-cost analysis provides estimates of net economic benefits (positive and negative) to businesses and consumers directly affected by a regulatory action. Regional impact analysis focuses on employment and income impacts in industries directly affected by a regulatory action, as well as secondary (“multiplier”) effects on the suppliers of those industries and households that derive income from the affected industries. Perhaps due to data limitations, benefit-cost analysis tends to be a less common component of regulatory analysis than regional impact analysis. It is important that the data and models needed to conduct benefit-cost analysis and regional economic analysis be developed for every FMP fishery.

4.2 Highest Priority Issues

Highest priority items were identified on the basis of whether they have broad potential for improving the socioeconomic content of Council deliberations and analyses, or address an important management issue that would benefit from advanced modeling or analysis to facilitate understanding of its socioeconomic implications. Further discussion of these items is provided in Sections 7.3 and 7.4.

The Council notes that socioeconomic data and analyses tend to be more robust for commercial than recreational fisheries. The Council recommends a research emphasis on socioeconomic impacts associated with recreational fisheries because they are of increasing interest to the Council and are an important aspect of community impact estimation.

Data priorities:

- Commercial cost-earnings surveys, including the Groundfish Economic Data Collection (EDC) Program
- Periodic recreational angler and charter boat (commercial passenger fishing vessels, or CPFV)\(^4\) surveys

\(^4\) Charter boats are known as CPFVs in California.
• Spatial data on location of catch for commercial and recreational fisheries

**Modeling and analysis priorities:**

• Expansion of the Council’s regional input-output model IO-PAC to cover all FMP fisheries and fishery sectors

• Recreational valuation models, particularly for salmon and groundfish

• Models of fleet dynamics for commercial harvesters and recreational charter boats, including spatial and fishery choice behavior

• Indicators of community dependence on fisheries and community well-being and resilience that can be linked to regulations, economic conditions, and other relevant factors

• Improved integration of socioeconomics into bycatch models used by the Groundfish Management Team to develop management alternatives for the Council

• Management strategy evaluation of alternative groundfish rebuilding strategies and alternative sardine harvest control rules (HCR) to help clarify the socioeconomic, biological and ecological trade-offs

• Analysis of socioeconomic effects of the groundfish catch share program on fishery participants and fishing communities

### 4.3 Ongoing Issues

Ongoing issues are categorized into two types of activities: data collection/augmentation and model development/analysis. Some of the data and modeling needs identified in this section are relevant to social as well as economic issues. The Council report *Social Science in the Pacific Fishery Management Council Process* provides additional information on social science needs and ways of increasing social science considerations in the Council process and can be found on the Council’s website at [http://www.pcouncil.org/resources/research-and-data-needs/](http://www.pcouncil.org/resources/research-and-data-needs/).
4.3.1 Data Collection and Augmentation

Economic data needs, as described in the Council’s *West Coast Fisheries Economic Data Plan 2000-2002*, are summarized in the following table and augmented to include communities as well as specific fishery sectors. Core data needs pertain to fundamental information relevant to understanding economic behavior and estimating the economic value and impact of fisheries. An emphasis should be placed on collaborative research efforts with stakeholders.

<table>
<thead>
<tr>
<th>Hardesters</th>
<th>Processors</th>
<th>Charter Vessels</th>
<th>Recreational Fishers</th>
<th>Communities*</th>
</tr>
</thead>
<tbody>
<tr>
<td># harvesters, effort by fishery (including AK)</td>
<td># companies, associated plants and buying stations</td>
<td># vessels, effort by trip type</td>
<td># anglers, effort by mode/trip type</td>
<td>Fishery-related businesses in harbor and larger community</td>
</tr>
<tr>
<td>Revenue by fishery (incl AK)</td>
<td>Volume of raw product by source (fishery deliveries, imports), revenue and value added</td>
<td>Revenue by trip type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable (trip) and fixed costs</td>
<td>Variable and fixed costs</td>
<td>Variable (trip) and fixed costs</td>
<td>Variable (trip) and fixed costs</td>
<td>Expenditures by fishery-related businesses</td>
</tr>
<tr>
<td>Employment and income (crew as well as vessel owners)</td>
<td>Employment and income (plant labor as well as plant owners)</td>
<td>Employment and income (crew as well as vessel owners)</td>
<td></td>
<td>Fishery-related employment and income</td>
</tr>
<tr>
<td>Vessel characteristics (including harvest capacity)</td>
<td>Processor characteristics (including processing capacity), location of markets and product flows</td>
<td>Vessel characteristics</td>
<td>Angler demographics and socioeconomic characteristics</td>
<td>Community demographics and socioeconomic characteristics</td>
</tr>
</tbody>
</table>

* Data elements listed under this heading may require updating as improved community analysis methods become available.

Data are needed to enumerate and quantify the spatial distribution of commercial and recreational fishing trips, processors and buying stations, charter (CPFV) activity, and other fishery-dependent businesses. Spatial data on fishing trips should include both landing sites and areas fished. Such data are needed to evaluate a range of spatial management issues, including,
but not limited to, marine reserves.

Processor files and vessel characteristic files available from the Pacific Fisheries Information Network (PacFIN) are probably in need of updating, or at least a thorough check for consistency and accuracy. The processor list, in particular, has typographical errors and non-standardized spelling that lead to ambiguities regarding the identity of processors. To facilitate analysis, each processor should be assigned a unique identification code that is standardized across states and that allows each processor to be linked with its associated plants and buying stations.

Currently, landings receipt data provide fairly coarse measures of fishing effort (numbers of vessels and landings). Analysts must rely on these measures or use logbooks, which are not available for most fisheries. Adding finer measures of effort, such as number of days fished or days at sea associated with each landing, would make the fish tickets more useful for economic analysis.

Inclusion of crewmember IDs on landings receipts would greatly facilitate understanding of the economic effects of regulations on crew participation, and provide routine information on this data-poor segment of the commercial fishery.

Bycatch has become a central issue in west coast fisheries management. Groundfish trawl logbooks have been an important tool for analyzing bycatch, and logbook programs have been implemented in fisheries such as that for market squid. Logbooks are a primary source of information on the spatial distribution of catch and fishing effort and should be considered for other fisheries. Vessel monitoring system data are being collected for commercial groundfish vessels, and should be investigated as a potential basis for analyzing spatial dynamics of fleet behavior.

Commercial fishery cost/earnings data should be collected and routinely updated to ensure that they reflect changing regulatory and market conditions. Groundfish catcher vessels, processors and catcher-processors involved in the groundfish catch share program are subject to a mandatory EDC Program. Voluntary cost-earnings surveys are conducted on a three-year rotating basis that cover other fisheries in which groundfish vessels participate (shrimp, crab), as well as the salmon troll fishery. Results of cost/earnings surveys and associated metadata for all FMP fisheries should be made available to the Council in formats that protect confidentiality and are useful for SAFE documents and regulatory analysis.

Angler surveys are needed to estimate the economic value and regional economic impacts of recreational fisheries. Such surveys are conducted fairly routinely on the Pacific coast and have been facilitated in recent years by improved electronic coverage of recreational license holders, including addresses/phone numbers. When supplemented by intercept interviews or other means of contacting anglers who are not in the license frame, such dual frame approaches are effective for collection of representative economic data. In order to expand economic survey results from the sample to the population, estimates of aggregate fishing effort (number of participants as well as number of trips by mode and trip type) are also needed for all states.

4.3.2 Model Development and Analysis

A regional input-output model (IO-PAC) developed by the Northwest Fisheries Science Center
(NWFSC) was reviewed by the SSC and has been used to analyze alternatives for the groundfish harvest specification process. IO-PAC should be expanded to include all FMP fisheries and fishery sectors as the required fishery-specific economic data becomes available. This would allow routine use of IO-PAC whenever estimates of regional economic impacts are needed (e.g., for SAFE documents and regulatory analysis).

Models of commercial fleet dynamics (e.g., spatial behavior, fishery choices) are needed to better understand fishing behavior and anticipate the effects of regulations.

Comprehensive models of charter (CPFV) fleet dynamics are needed that reflect the multi-species nature of the fishery, economic incentives of charter operators to provide not just fish but a “fishing experience,” and adaptations of charter vessels to regulatory, market and environmental conditions. Such models could be used to determine whether charter fleet dynamics yield single-species catches per unit of effort (CPUE) that can reasonably be used as an index of relative abundance for that species.

Angler participation models and net economic value estimates are needed for recreational salmon and groundfish fisheries. Recent modeling and valuation estimates are available for the Pacific Northwest.

The maintenance of fisheries socioeconomic baseline data at the community level is critical to effective socioeconomic analysis. Socioeconomic profiles of coastal communities significantly involved in west coast fisheries were compiled several years ago. Information that could enhance the utility of these profiles for management include the following:

• community-specific 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, and
• indicators of community dependence on fisheries and community well-being and resilience that can be linked to changes in regulations, economic conditions, and other relevant factors.

Over the past decade or so, the Council has taken a number of major actions – including Rockfish Conservation Areas in the late 1990s, the groundfish trawl vessel buyback in 2003, salmon fishery closures in the late 2000s, and the groundfish catch share program in 2011. Retrospective analysis of these actions is needed to determine their actual socioeconomic effects on fisheries and fishing communities, and the extent to which the Council’s goals for each action were achieved. Retrospective analysis would also help determine whether and how each measure might be effective in addressing similar issues in the future. Research is underway to evaluate the effects of some of these actions, with thorough evaluation being most likely for the catch share program (due to the mandatory EDC Program and a currently-funded project that focuses on qualitative social effects of catch shares in west coast fishing communities).

Periodic assessments of current fishery status are contained in SAFE documents produced for each FMP. Quantitative descriptions of economic status are generally limited to basic information such as landings, ex-vessel revenues and fishing effort. Cost-earnings surveys, the Groundfish EDC Program, recreational angler surveys, charter boat (CPFV) surveys, the IO-PAC model, and recreational valuation models provide the means to enhance the utility of SAFE documents. Information on profitability of commercial operations, economic value of
recreational fisheries, employment and income impacts, and other community effects should be included in SAFE documents as such information becomes available. For groundfish catch share fisheries, quota share prices are good indicators of economic status for those fisheries.

Harvest projection models are used to craft regulatory alternatives for the salmon and groundfish fisheries. Due to concerns regarding weaker (e.g., overfished, ESA-listed) stocks and the constraining influence of those stocks on the harvest of healthier stocks, a major focus of such models is to identify regulatory alternatives that keep the bycatch of weak stocks at acceptable levels. Methods of linking such harvest projection models (including the Groundfish Management Team’s bycatch models) to associated socioeconomic effects should be considered and periodically re-evaluated to ensure that they reflect best available socioeconomic information.

Management strategy evaluation should be conducted to evaluate the effects of alternative groundfish rebuilding strategies and alternative sardine HCRs – both of which have socioeconomic as well as biological and ecological consequences.

Information is needed regarding the socioeconomic effects of alternative capacity management programs - including limited entry and catch shares - on fishery participants and fishing communities. Important non-trawl fisheries to consider are open access groundfish and coastal pelagics. Models are needed to analyze the transition from open access to limited entry or limited entry to catch shares in terms of regional economic impacts, effects on costs, earnings and harvest capacity of the fleet, and community effects.

Bycatch is an important issue for many Council-managed fisheries. Alternative approaches to managing and reducing bycatch, bycatch mortality, and effects of gear on habitat should be evaluated – with cost-effectiveness and incentive compatibility included among the evaluation criteria.

Fisheries and communities benefit not only from the size of harvest opportunities but also the stability of such opportunities and the flexibility afforded by a diversity of such opportunities. Management approaches that enhance fishery stability and flexibility should be identified and evaluated.

4.4 Emerging Issues

Growing attention is being paid to more holistic approaches to management that focus on the relationship of fisheries to habitat, bycatch, and environmental and domestic/global market conditions, and that consider non-fishery activities and values that may be enhanced by ecosystem approaches to management. As above, these needs are divided into two activities: data collection/augmentation, and model development/analysis.

4.4.1 Data Collection and Augmentation

Many of the data needs previously identified in Section 4.3.1 are relevant to emerging as well as continuing issues.

To achieve some of the more holistic modeling discussed in Section 4.4, fishery data will need to be integrated with data on habitat, environment, market conditions and other human activities. Such integration will likely pose challenges in terms of data availability and lack of standardization in the measurement and temporal/spatial scale of individual data elements.
Cooperative data collections that pool resources and expertise of agencies, fishermen, and research entities may prove beneficial to all involved.

Spatial socioeconomic information by fishery type is needed at a scale that is also useful for ecosystem and habitat-based management activities. Spatial information is useful, for example, for determining economic effects of EFH and other protected habitat areas, and for anticipating the effects of other activities (e.g., wave energy development, aquaculture projects) on both fish habitat and fisheries.

Collaboration and cooperation among local (county), state, and Federal agencies to collect, analyze and share socioeconomic information is paramount. Developing a clearinghouse for socioeconomic data and research methods would be valuable for agencies and the public.

### 4.4.2 Model Development and Analysis

A more holistic perspective is being promoted 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 CCE, 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 comparison of costs and benefits among management alternatives. A systematic and critical evaluation of alternative economic models and analytical frameworks should be conducted, perhaps in the context of a workshop.

Computable bioeconomic models of fishing effort that are spatial and include effects of economic and environmental factors (e.g. prices, sea surface temperatures) are needed to predict effects of changes in regulatory, habitat, environmental, and market constraints on participation and harvest in the ocean commercial, ocean sport, tribal, and in-river sport salmon fisheries.

Models are needed to estimate and manage bycatch in non-trawl fisheries, for different species of concern including marine mammals, birds, sea turtles, and others.

Models are needed 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.

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. Studies are needed that (1) evaluate the robustness of stated preference responses to the types of information provided in the valuation scenario, (2) evaluate how the “extent of the market” varies according to the nature/scope/location of the good being valued, (3) address aggregation issues that may arise when summations of valuations across multiple goods yield implausible results, and (4) consider the extent to which non-use values are applicable to fisheries as well as environmental goods.
5.0 GROUNDFISH FISHERY MANAGEMENT PLAN

5.1 Introduction

The focus of this section is on research and data needs to support quantitative stock assessments and management of groundfish stocks in the FMP. Identification of research and data needs is a routine part of the groundfish Stock Assessment Review (STAR) process, and the needs summarized below were developed based on recommendations made by stock assessment authors and STAR panels. An emphasis is made on 1) continuation of on-going data collection programs that support assessments of groundfish stocks, 2) improving the quality and representativeness of these data collection programs, 3) developing new survey and sampling techniques to monitor stocks that cannot be surveyed effectively using current methods, and 4) further advancing modeling techniques and methods to analyze the data.

5.2 Data Needs

5.2.1 Fishery-Independent Data

Continue to conduct annual comprehensive shelf and slope bottom trawl survey

An annual slope survey in the U.S. Vancouver, Columbia, Eureka, Monterey, and a portion of the Conception International North Pacific Fisheries Commission areas was initiated by NMFS NWFSC in 1998. In 2003, the range of the slope survey was extended in depth onto the shelf and in latitude to the entire coast from the Mexican to Canadian border. The data from this survey have been used in almost every groundfish assessment on the U.S. West Coast. It is essential to continue this comprehensive annual survey, since a consistent long-term survey index informs estimates of abundance and productivity of groundfish stocks.

Continue to explore additional survey methods

Although informative for many groundfish species, the current NWFSC shelf and slope survey cannot access rocky areas, where a number of rockfish species occur. Also, trawl survey efforts are currently closed in the Cowcod Conservation Area (CCA), which is likely to include habitat for a number of rockfish (based on fishermen’s knowledge and the observation of catch rates at similar habitats along the boundaries of the CCA). There is, therefore, a need to develop alternative methods to assess abundance of fish in these untrawlable areas as well as other areas not well-surveyed by the current bottom trawl survey. Also, low yield and long rebuilding times of some rockfish, including yelloweye and canary rockfish, highlight a need to develop alternative methods of estimating abundance and biomass trends that have a lesser impact on resources than trawl surveys. All new survey methods should be thoroughly evaluated before being used in stock assessments. Specific recommendations regarding some of the alternative methods include:

- Continue exploring survey methods to survey untrawlable areas, including those that employ Autonomous Underwater Vehicles, submersibles, drop cameras, acoustics, towed cameras, light detection and ranging, etc. In recent years, small-scale surveys have been conducted using these non-invasive methods. Studies should be conducted to evaluate the comparative costs of these alternative survey methods for groundfish assessment.
• Continuation of whiting midwater acoustic surveys on a frequent basis and potential expansion to include rockfish surveys for species that spend the majority of their life history in the midwater portion of the water column. Acoustic survey frequency is under study by the Joint Management Committee of the Agreement Between the Government of Canada and the Government of the United States of America on Pacific Hake/Whiting. Issues that could be addressed include – acoustic survey frequency, the use of acoustic surveys for other midwater groundfish (e.g., widow rockfish and yellowtail rockfish), acoustic survey design (including target strength), and development of an age-1 hake index. This exploration should examine the trade-offs of increased survey frequency versus time off the water for researchers to do other important projects. Research should be conducted on survey design and acoustic methods to make the survey as accurate and informative as possible. Trade-offs associated with continuing to combine the surveys for sardine and whiting should be explored. Additionally, validate acoustic surveys using non-extractive CamTrawl methods in West Coast fishery surveys.

• Maintain California Cooperative Oceanic Fisheries Investigations (CalCOFI) egg and larval production surveys. Abundance indices based on data from these surveys have been used in a number of groundfish assessments, including bocaccio, chilipepper and shortbelly rockfish. It has been recommended to expand processing of biological samples collected, and improve survey data on canary and widow rockfish. It is also important to further explore the use of genetic methods to accurately identify larval fish species in plankton samples.

• Research should be conducted using automated image recognition (computer vision) over a variety of resource management applications. Incorporation of computer vision image recognition concepts into West Coast research and management objectives offers promise in advanced electronic monitoring strategies, aerial surveys of forage fish, marine mammal surveys, recreational vessel effort estimates, vessel-based automated bird-cam surveys, as well as other applications.

• Continue exploring the use of hook-and-line or longline gear for surveying rockfish populations, since this gear is inexpensive and can be deployable on a variety of bottom types. Since 2004, the hook and line survey has been conducted by NMFS NWFSC in collaboration with the PSMFC and the CPFV industry. This survey has been collecting data to generate abundance indices for several key species of shelf rockfish in the Southern California Bight, including bocaccio, the vermillion rockfish complex and greenspotted rockfish. The International Pacific Halibut Commission has conducted annual hook-and-line survey since 1998; this survey provides data on a number of groundfish species, including yelloweye rockfish. Explore conducting hook-and-line surveys with new barotrauma mitigation techniques within the CCA to provide data in this untrawlable area.

• Explore tagging programs as a potentially useful source of information on trends for nearshore species, such as black rockfish. When the tagging program is smaller in scale than the range of the stock assessed, quantitative prior probability distribution on tagging catchability should be developed.
• Evaluate the usefulness of current seafloor maps off the Pacific coast to better interpret survey abundance indices.

• Explore utility of genetic tags in estimation of population size.

5.2.2 Fisheries -Dependent Data

*Improve on fishery monitoring and data collection*

Collection of high quality fishery-dependent data continues to be one of the highest priorities for groundfish assessment and management. Fish ticket data are needed to census the landed catch, logbooks to document areas of capture, port sampling to estimate species composition of aggregated landings and biological characteristics of target and bycatch species, and observer program to document catch discarded at sea.

• Continue research on barotrauma and the use of recompression, or descending devices, for released rockfish, particularly for deeper waters (> 30 fm), over a broader suite of species, including overfished species. Estimates of discard mortality rates in recreational fisheries should be re-evaluated because the ability to survive barotrauma or hooking or trapping injuries may vary by depth and among species. Progress has been made in understanding short-term effects of barotrauma on some groundfish species. Additional work is needed to examine long-term physiological effects of capture and release on reproductive output of groundfish species, which could have implications for stock productivity and, therefore, management. Alternative release methods (e.g. post-capture release at depth) have been shown to be effective in reducing short-term mortality, but additional work is needed to accurately quantify the effects of real world implementation of these methods on discard mortality, for use in assessment and management.

• Research designed to evaluate mortality of discarded groundfish under various conditions (e.g., gear types, depths, water and air temperatures, etc.) is needed for stock assessments and management. Currently, discard-mortality assumptions (some < 100 percent mortality) are applied to selected species in recreational, commercial non-trawl, and trawl fisheries. These estimates may have been derived by research conducted in other regions (e.g., Alaska), or during narrow environmental or operational conditions (e.g., only during shallow-water sets or low-water temperature condition). Much research has shown that discard mortality may vary considerably (and predictably) over a range of conditions. The need for these types of experiments may be prioritized based on the level of discard relative to stock status (e.g., the assumed discard mortality proportion for some stocks may have no meaningful impact on the stock).

• Continue to monitor catch and discard in commercial fisheries at-sea. Currently there are two observer programs operated by the NMFS NWFSC on the U.S. West Coast. These programs include the At-Sea Hake Observer Program, which monitors the at-sea hake processing vessels, and the West Coast Groundfish Observer Program (WCGOP), which monitors catcher vessels that deliver their catch to a shore-based processor or a mothership. The At-Sea Hake Observer Program dates back to the 1970s, while WCGOP was implemented in 2001. The WCGOP began with gathering data for the limited entry
trawl and fixed gear fleets. Observer coverage has expanded to include the California halibut trawl fishery, the nearshore fixed gear, and pink shrimp trawl fishery. Since 2011, the U.S. West Coast groundfish trawl fishery has been managed under a new groundfish catch share program. The WCGOP provides 100 percent at-sea observer monitoring of catch for the new, catch share based Individual Fishing Quota (IFQ) fishery, including both retained and discarded catch. The WCGOP also provides estimates of discard and total groundfish removals from commercial, recreational, and research sources (including incidental catch from non-groundfish fisheries) for use in stock assessment and management. The methods used by WCGOP to estimate discard and total groundfish removals should be well-documented and reviewed by the SSC to ensure that the most reliable estimates are generated. Additionally, a method should be developed to evaluate observer coverage levels, and how that might influence management, stock assessments, and fleet behavior.

- Review the process for determining the species viability and the resulting discard mortality estimates for Pacific halibut and possibly other species in the commercial fisheries. The current mortality rates applied to the viability of released Pacific halibut is based on work conducted in Alaska in the 1970s, and updating this research may provide additional insight. Additionally, explore a method that would apply a formula consisting of variables such as tow/set time, temperature, and time on deck, etc. to determine viability, rather than the current visual estimate. This method might have the added benefit of easing some of the workload on the observers, since they would no longer have to conduct Pacific halibut viability estimates.

- The limited entry trawl fishery now operates under a catch-share program that requires full observer coverage and full sorting to species. The system for monitoring the landed catch should be evaluated to determine the levels of species contamination that may be occurring.

- Further explore use of electronic monitoring system (EMS) in commercial fisheries to monitor catch, estimate discard and identify species composition of the discarded portion of the catch. Studies should be designed and conducted to test reliability of EMS in collecting the data. Also, efforts should be devoted to evaluate costs of EMS data collection and processing, compared to observers’ costs.

- Continue to collect information on the size composition of the discarded portion of the commercial catch, because it is unlikely that discards have the same size composition as retained catch. In some cases, the size composition of discard can also provide information about the magnitude of recruiting year classes.

- Protocols and priorities for biological sampling (lengths and age structures) should be evaluated to ensure that sufficient data are being collected to support existing and new stock assessments. Significant gaps in the age and growth information have been identified for a number of stock assessments, including sablefish (for which age sampling from the commercial fishery has generally been sparse compared to other groundfish) and petrale sole, among others. There is a need to optimize the use of available resources (i.e., port samplers) in a way that provides maximum benefit to stock assessments.
• 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 further investigated and improved.

• Discard estimates in the recreational groundfish fishery, particularly for non-retention species, should be improved. Additional data should be collected on size composition of recreational discard.

• Recreational data (catch and biological samples) are currently available from several sources, including the state agencies and RecFIN. Total mortality estimates between these sources do not always match. A single database that holds all recreational data in a consistent format would reduce time spent by assessment scientists obtaining and processing these data, and ensure that the best available information is utilized by the assessments.

• Cooperative research programs are required under the recently reauthorized MSA and are playing an increasing role in west coast fishery science and management and could be utilized to expand data collection as fishing opportunities have decreased and research needs increased. 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.

• Improve the spatial coverage of logbook haul location information with additional ‘location’ fields added to trawl logbooks and WCGOP forms for interval or periodic recordings of GPS coordinates by fishers and observers. The haul information currently recorded in trawl logbooks does not provide accurate coverage of the area fished because only set and end locations are required. Interpolation methods provide only a course estimate of spatial coverage.

• Continue to conduct size and species-selectivity research for groundfish trawl and non-trawl fisheries. Size and species selectivity is important for stock assessments, establishing and understanding potential impacts of management measures, fisheries monitoring, and for fisherman (e.g., to maximize catches of marketable species and sizes while reducing catches of unmarketable, overfished, or threatened/endangered species). Individual accountability due to the IFQ program provides greater incentives for IFQ fishermen to utilize the most selective fishing practices available. Unfortunately, most selectivity studies available for fisherman, managers, and researchers are dated and were conducted during a period where the fisheries, assemblages, and gears were much different than presently seen. Other potentially needed selectivity studies (e.g., on non-trawl West Coast groundfish fisheries) have not been conducted at all. Note that recently selectivity studies have been undertaken or are currently underway to evaluate the selectivity of sorting grids and various trawl-codend mesh size and mesh shapes for various groundfish species caught in the trawl fishery.

*Develop a coastwide system for electronic fish ticket and fishery logbook data*
Development of an integrated system for reporting of electronic fish ticket data and logbook information on the U.S. West Coast would provide real-time and near real-time information needed to address a variety of stock assessment and inseason management needs.

Fish ticket data and logbook information, along with data from the WCGOP, are used to reconcile the total catch by area, and determine bycatch rates associated with target species. Currently, logbook data can lag by as much as a year, which delays the entire process of catch reconciliation. An electronic fish ticket and logbook system would substantially increase the timeliness of landings and discard estimates produced.

Electronic data are now available for the new IFQ fishery through the NMFS Vessel Accounts Database. Currently, the IFQ fishery is the only one which is completely covered by electronic tickets. Washington and Oregon are exploring expansion of their electronic fish ticket systems to other fisheries, but the potential range of coverage or possible timing of any expansion is not yet clear.

**Continue to improve historical catch time series**

Historical catch information is essential for fisheries stock assessment; without knowing the catch history it is difficult to understand how a stock responds to exploitation. Recent catch data (from 1981 on) are available from the PacFIN, a regional fisheries database that manages fishery-dependent information in cooperation with NMFS and West Coast state agencies. Catch information prior to 1981 is sparse and there is no database analogous to PacFIN to handle those data. In the recent past, historical reconstruction of catches prior to 1981 has been conducted by assessment authors for each assessment individually, and authors have often approached the problem differently, using different data sources and a variety of methods.

A coordinated effort to reconstruct West Coast groundfish historical catches has been recommended, to provide a comprehensive species-specific time-series for use in stock assessments to help improve the reliability of historical catches by identifying and drawing on preferred data sources, as well as applying a standardized method across all species. Such a coordinated effort should also facilitate review of stock assessments in the future.

Progress has been made in reconstructing California commercial and recreational, and Oregon commercial landings. However, historical time-series of Oregon recreational and Washington commercial and recreational landings are not yet complete.

In addition to providing the best reconstructed catch histories by species, alternative catch streams should be developed to reflect differences in data quantity and quality for different time periods. Such alternative catch streams would be very useful for exploring assessment models’ sensitivity to uncertainty in catch history, rather than applying a simple multiplier to entire catch time-series, which is currently the case for most groundfish assessments. An evaluation of time-series of historical discard is also needed, although it is recognized that historical discard data are extremely limited.

A database for historical (pre-PacFIN) time series of groundfish landings should be established. Ideally, in addition to providing the best reconstructed catch histories by species, this database
would also include estimates of uncertainty in these catch time-series. Also, process for updating and revising this database should be well-established.

**Investigate impact of fishing gear on habitats**

A major effort was made to prepare a comprehensive Environmental Impact Statement (EIS) analysis for the EFH amendment to the FMP. The EIS was based on Geographic Information System analysis that included integration of substrate maps of the Northeast Pacific Ocean off the Pacific coast, habitat suitability maps for groundfish species, and maps of fishing impacts and habitat sensitivity. The analysis discovered a complete lack of information on fishing impacts specific to Pacific coast habitats, and estimates of habitat sensitivity to fishing gear and habitat recovery were borrowed from studies in other areas.

It is, therefore, recommended to conduct studies to evaluate the effects of fishing on Pacific coast benthic habitats. These studies should be conducted on a variety of bottom habitat types and using different gear types. They should focus on both short- and long-term fishing effects on benthic communities and bio-geological processes.

The Council is currently engaged in reviewing groundfish EFH and has tentatively identified research and data needs through the EFH Review Committee. The higher priority items are included in Appendix II of this document.

**5.2.3 Life History Data**

Life history parameters determine the productivity of a stock, and therefore affect estimates of stock status and management quantities related to spawning stock biomass. There have been a number of data and research needs related to life history parameters identified during Council deliberations and in the most recent stock assessments, including:

-  Refine the estimates of maturity and fecundity for a number of species, including sablefish, yelloweye rockfish, and petrale sole. Assessment results for these species were found to be sensitive to changes in maturity and fecundity parameters, yet the available information is outdated, in addition to being variable among sources, years, and regions.

-  Improve quality of age data. Prioritize age reading of groundfish otoliths. Accurate, timely, and comprehensive age data is critical to the stock assessment process. If age data were more accurate, cohorts could be better tracked to older ages, and estimates of historical year-class strengths may be improved. Quality of age data could be improved through validation studies and exchange of age structures among labs. Also, ageing methods that could provide more precise age estimates should be explored. Studies to investigate the potential for bias in ageing methods should be conducted, as the results of these studies may have a strong effect on natural mortality estimates used in stock assessments.

-  It has been shown that a number of species exhibit spatial variability in life history traits. It is therefore recommended to continue to collect data to capture habitat-related and climate-driven variability in life history traits, and explore methods to integrate this information into stock assessments.
• A number of unassessed species lack basic life history information, such as growth, length-weight relationships, maturity, and fecundity. These species should be identified and studies should be designed to estimate parameters for these life history traits.

• Recent genetic research indicates that such species as vermillion and blue rockfish may each represent two morphologically similar, but genetically distinct species. Further genetic studies are needed to confirm these findings. These studies should be designed to investigate differences in spatial distribution between potentially different species, the extent of intermixing, differences in growth, maturity, and longevity.

• Conduct comprehensive stomach analysis to determine trophic interactions of groundfish. This information would be essential for assessments of the CCLME.

5.3 Stock Assessment Issues

**Improve on methods to assess data-poor and data-moderate stocks**

A substantial progress has been made in developing and implementing methods to assess data-poor and data-moderate stocks. The Depletion-Based Stock Reduction Analysis (DB-SRA) and Depletion-Corrected Average Catch (DCAC) method have been adopted by the Council to estimate OFLs and set harvest specifications for data-poor stocks. XDB-SRA and exSSS have recently been developed to assess data-moderate stocks. Further work is recommended to refine data-poor and data-moderate methods, which includes:

• Improve inputs used by the data-poor and data-moderate methods, including natural mortality (M), a ratio of $B_{MSY}$ to $B_0$, a ratio of $F_{MSY}$ to M, and reduction in abundance, or delta parameter (which represents stock depletion).

• Catch time series in data-poor and data-moderate methods are currently assumed to be known, and tools for incorporating catch uncertainty into these methods should be developed.

• Performance of data-poor and data-moderate stock assessments has been evaluated through comparing data-limited and data-moderate assessment results with outputs from full assessments. Simulation studies are needed to further evaluate utility of these data-poor and data-moderate methods in real applications.

• Data-moderate assessments are likely to have greater uncertainty in their results than full assessments since much fewer data are used in data-moderate assessments. Further work is needed to determine how to best describe uncertainty in data-moderate assessments.

**Further advance modeling approaches and data analyses**

• Current models used to assess groundfish stocks are complex, with many parameters being estimated, yet often the data used to fit these models are sparse. Also, complex models make it difficult to understand how specific data elements affect model outcomes. The benefits of adopting the complex model should be evaluated relative to simpler assumptions and models.

• In a number of recent stock assessments, Bayesian prior probability distributions for natural mortality (M) and stock-recruitment steepness (h) derived from meta-analyses of
different species and different methods were utilized. Guidance should be provided on
how to best use these (and other) priors in stock assessment models to account for
uncertainty in parameter estimates and propagate this uncertainty to the assessment
results.

- Continue to develop and evaluate standard methods to process biological data for
assessment model input files, including those related to input sample sizes and data
weighting procedures. Explore alternative error distribution assumptions used for
compositional data.

- Conduct studies to help determine which selectivity assumptions (dome shape vs.
asymptotic) are most appropriate for the various groundfish stocks, including lingcod and
other species with age-structured assessment models.

- Further explore models that account for spatial structure of the stock, with spatial
differences in life history parameters (multi-area assessments). It is also recommended to
further explore models that account for migration patterns (via incorporating tagging
data) as this feature is currently available within the Stock Synthesis modeling
framework.

- Continue to explore methods to include environment variables in stock assessment.
Previous work has illustrated methods to relate recruitment to environmental factors
using Stock Synthesis, but environmental forcing applied to other population parameters
has not been fully explored. When selecting environmental variables to include in an
assessment model, cross-validation should be used to ensure a derived relationship
between climate forcing and a parameter is robust.

- A number of stock assessments utilize international boundaries to delineate stocks even
though stocks’ ranges are not limited always to the area managed by the Council. These
stocks include sablefish, spiny dogfish, blackgill, canary, widow, yelloweye rockfish,
Pacific ocean perch, and others. It is therefore recommended to further investigate the
structure of transboundary stocks and evaluate implications of stocks’ connectivity with
Canada on the north, and Mexico on the south, and, in some cases, explore the possibility
of joint stock assessments in future years.

- Continue to evaluate biological reference points, HCRs and policies used for groundfish,
to ensure the best available scientific information is utilized for management decision-
making. Harvest policies should be tested to determine whether they are robust to
decadal-scale environmental variation and directional climate change.

- Further explore how best to account for (and report) uncertainty in stock assessments.
Explore alternative approaches to evaluate scientific uncertainty associated with OFL
estimates, as the method that is currently in place does not include all sources of scientific
uncertainty.

- 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 to understand the properties of recreational CPUE data (e.g., method evaluation with simulation data or cross-validation studies). In particular, the effect of management changes and alternative fishing opportunities should be evaluated.

**Improve on stock assessment data and methods reporting**

- Establish a database for all the data relevant to groundfish stock assessments, with a current point of contact identified for each source. This database should be accessible online and include details about the nature and quality of the data in each source. Such a database would help stock assessors make informed decisions on which sources could be useful in their assessment as well as expedite the process of requesting the data.

- Develop a concise set of documents (and update them when needed) that describe current best practices in treating data from sources commonly used in stock assessments and in deriving assessment model inputs. These documents would include, for instance, a description of methods to calculate survey abundance indices via Generalized Linear Mixed Model, and an approach used to develop prior probability distributions for natural mortality (M) and stock-recruitment steepness (h). Ideally, these documents would be reviewed by the SSC prior to the assessment cycle.

- The current best practices (item above) should be well-communicated among stock assessment scientists and the SSC.

**5.4 Ecosystem Issues**

Ecosystem-based research needs arose as the Council developed its FEP. Some of these research needs are similar and complementary to needs identified elsewhere in the document. The following ecosystem considerations specific to HMS are included here for emphasis:

- West Coast groundfish species show low frequency variability in recruitment (i.e. prolonged periods of high and low recruitment) due to lower biomass and/or a low productivity environmental regime. This variability can increase the level of uncertainty in assessment results. Specifically, strong El Niño Southern Oscillation (ENSO) conditions (especially in Southern California) may be a pre-cursor to significant recruitment events and should be explored further to help increase the understanding of spatially-explicit recruitment responses and inform future recruitment events. Historical reports of large year classes (e.g., the 1947 year class of canary rockfish reported by sport fishermen in central California) could be investigated to better inform recruitment drivers. Finally, periods of low and high recruitment may correlate with the environmental conditions that could help predict future biomass levels. Investigate the effects of Pacific Decadal Oscillation, ENSO, and other climatic variables on recruitment and develop a better understanding of the relationship between the population dynamics

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5 For additional information, see the November 2012 FEP Draft, November 2012 Briefing Book, Agenda Item K.1.a, Attachment 1 (http://www.pcouncil.org/wp-content/uploads/K1a_ATT1_DRAFT_FEP_NOV2012BB.pdf)
and climate using tools such as meta-analysis as a means of reducing the uncertainty of future assessments.

- Research is needed on relative density of rockfish in trawlable and untrawlable areas and differences in age and length compositions between these areas. Understanding groundfish distribution and habitat features can provide more precise estimates of abundance from the surveys, and can guide survey augmentations that could better track changes in stock size through targeted application of newly developed survey technologies (e.g. for untrawlable habitats). Such studies could also assist in determining selectivity and in aiding the evaluation of spatial structure and the use of fleets to capture geographically-based patterns in stock characteristics, such as different exploitation histories, growth, or fecundity in different areas.

- Investigate predation impacts likely to affect abundance of assessed species.

- Time-varying catchability and availability of fish to surveys may affect our fishery-independent index of abundance for some groundfish species. A review of the survey data and stock migration to assess whether there are spatial trends in the indices that are not being captured by assessment models.

- Investigate how growth rates, maturity schedules, and fecundity have varied over time and between areas, as influenced by environmental factors and changes in population density because of apparent low-frequency variability in environmental conditions and/or population density. Regional differences in exploitation history and biological traits can result in demographic independence of local stocks, even in the absence of clear genetic differentiation, with important implications for management.

- Standard modeling approaches that take into account changes in target fisheries to estimate historical discards (bycatch) should be developed that can be used across stock assessments.

- There are high densities of many groundfish stocks near the U.S.-Canada or U.S.-Mexico borders. Given the high likelihood that many groundfish stocks are transboundary, combined with potential seasonal or directed movement patterns for some species, suggests that U.S. and Canada/Mexico should explore the possibility of joint groundfish stock assessments. At a minimum transboundary stock effects—in particular the consequences of having spawning contributions from external stock components, catches in transboundary waters, and common life history traits—should be evaluated. While resolution of conducting bi-national assessments is beyond the scope of what can be reasonably expected from the U.S. stock assessment teams alone, a formal framework for completing such assessments should be established.
6.0 SALMON FISHERY MANAGEMENT PLAN

6.1 Introduction

In the previous Research and Data Needs report, two highest priority issues were identified separately for Research Issues and Data Issues. The issues, and the progress on them, are summarized below:

Research Issues:

- **Further development and application of stock identification methods such as Genetic Stock Identification (GSI), Parentage-based (intergenerational genetic) tagging (PBT), and otolith marking to augment the fishery-specific stock information supplied by the current coded-wire tag (CWT) system.** GSI, in combination with at-sea sampling by fishermen, is providing detailed information regarding migration patterns and stock contributions to ocean fisheries for Chinook salmon. There have been three years of reasonably comprehensive sampling in Washington, Oregon, and California. Development of applications to fisheries management depends on continuing coast-wide annual data collection. PBT is now in place for many California and all Idaho Chinook salmon hatchery programs and allows identification of both the stock and exact age of individual fish. This technique can provide data for cohort reconstruction, migration and straying studies, survival-rate comparisons, and other fine-scale data needs.

- **The development of habitat-based models that incorporate environmental variation and anthropogenic disturbances to evaluate harvest policies and enable risk assessment for different fishing strategies is encouraged.** There has not been much progress on this issue since the 2008 Research and Data Needs Report.

Data Issues:

- **Escapement and fishery monitoring should be maintained and expanded where appropriate and data collection should include information on age and sex composition, mark rates, CWT recovery, and include spawning ground carcass enumeration and sampling.** Sampling programs in some systems have been expanded and new escapement estimation methods developed such as genetic mark-recapture techniques.

- **Related to mark-selective fisheries and their use as a management tool, a more accurate assessment of total fishing-related mortality for natural stocks of coho and Chinook is needed. The ability of existing management models to predict and assess non-catch mortalities needs to be evaluated and the models modified, as needed.** Theoretical development of unbiased methods for estimating non-catch mortalities has occurred and been evaluated through simulations. The incorporation of these methods into the management models and evaluation of their performance are the required next steps.

Research issues and data issues for salmon management are discussed and prioritized in the following two sections. Other high priority needs associated with hatchery fish and their
interactions with wild stocks are also identified. All research and data projects listed in this chapter are considered either “highest priority needs” or “high priority needs” according to their ability to meet the criteria listed in the introduction to this report.

6.2 Research Issues

6.2.1 Highest Priority Research Issues

Data and information issues are covered in the next section. Section 4.5 (which addresses emerging issues) contains additional information on the highest priority research and data needs.

6.2.1.1 Stock Identification

Advances in GSI, PBT, 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 CWT system alone does not provide the desired level of information. The Council encourages efforts to integrate a variety of techniques to address this issue.

Substantial progress has been made on this issue in the past eight years. Through the West Coast Salmon GSI Collaboration, three years of fine-scale GSI data have been collected for Chinook in Washington, Oregon, and California. Based on a coast-wide microsatellite database for Chinook and, more recently, a single-nucleotide polymorphism database for use in California, distributions and migration routes of Chinook in the commercial salmon fishery have been charted. 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 being used on an inseason basis in Canada to manage salmon fisheries off the west coast of Vancouver Island and in the Strait of Georgia. Studies are underway to evaluate the potential usefulness of real-time GSI samples in Chinook management.

6.2.1.2 Habitat-based Fisheries Models

The development of habitat-based models that incorporate environmental variation and anthropogenic disturbances to evaluate harvest policies and enable risk assessment for different fishing strategies is encouraged.

Overfishing definitions are required to relate to the MSY exploitation rate ($F_{MSY}$). $F_{MSY}$ is related to productivity, which varies annually in the freshwater and the marine environments. 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 goals and overfishing determinations.

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 these types of models 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 would be a valuable contribution to harvest management, but to become useful, substantial development efforts are needed.

### 6.2.2 High Priority Research Issues

**Alternatives to Time-Area Management.** The annual planning process for salmon 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 preseason 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, needs to be developed and evaluated.

**Stock Migration and Distribution.** 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. 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.

**Ocean Distribution of Natural Stocks.** Research is needed to improve our 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 the distribution and migration patterns of natural stocks; 2) GSI, 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.
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.

Coast-wide Models. Currently, at least five models are employed to evaluate impacts of proposed regulatory alternatives considered by the Council. A single coast-wide 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 the tasks of estimating mortalities in fisheries operated under retention restrictions (e.g., landing ratios or non-retention).

New Forecast and Harvest Models. Develop forecast and harvest models for numerous west coast salmon stocks including Klamath River spring Chinook, California coastal Chinook, Oregon coastal Chinook, and Central California coastal coho. This information could then be used to establish or reevaluate appropriate conservation objectives.

Forecast Precision and Accuracy. Investigate the precision and accuracy of existing and new abundance forecasts, including examination of forecast models incorporating environmental variables. Develop estimates of uncertainty for stock assessments and abundance and harvest models used in fishery management.

6.3 Data Issues

6.3.1 Highest Priority Data Issues

Research issues are covered in the previous section and Section 6.5 contains additional information on high priority research and data needs related to emerging issues.

6.3.1.1 Fisheries Data Collection and Modeling Improvements

Better information leads to better fishery management decisions and improved fishery performance relative to preseason expectations. These benefits have the potential to increase the effectiveness of conservation objectives and decrease the negative socioeconomic impacts of drastic stock fluctuations and fishery closures.

California Central Valley Fall Chinook Assessment and Management

A sharp decline in SRFC abundance led to widespread fishery closures in 2008-2010. A NMFS scientific work group was convened in 2008 to analyze the potential causes of the decline, and a report describing their findings was released in 2009 (Lindley et al. 2009). The report

concluded that poor ocean conditions were likely the proximate cause of the poor performance of the 2004 and 2005 broods. However, in addition to the effect of poor ocean conditions, the report concluded that degradation of freshwater and estuarine habitats as well as the heavy reliance on hatchery production likely also contributed to the decline.

As a result of the SRFC decline, increased attention has been directed at better understanding the dynamics of the SRFC stock. For instance, recent changes have been made to SRFC hatchery marking and tagging practices. Currently, 25 percent of SRFC production releases are marked and tagged with a CWT. This represents a large improvement on earlier marking and tagging practices that had been inconsistently applied. In addition, a recently-developed Central Valley Chinook escapement monitoring plan is in the process of being implemented, resulting in changes to data collection and methods used to estimate escapement. Such changes could allow for development of new models for use in assessment and management of SRFC. The research and data needs for this stock include a mixture of items related to the development of new models, as well as investigations aimed at improving the current assessment.

- Estimation of age-specific river harvest and escapement. Collection and analysis of CWTs and scales collected from river fishery and escapement surveys can allow for estimation of age-specific return information. Estimates of age-specific river harvest and escapement is a priority because it is necessary for cohort reconstructions.

- Development of a cohort reconstruction model for SRFC. Cohort reconstructions would allow for estimation of ocean abundance, exploitation rates, maturation rates, and other metrics that could be used to improve management.

- Continued evaluation of the contribution of hatchery-origin SRFC to ocean harvest, river harvest, and escapement.

- Evaluation of alternative forecast models for the Sacramento Index (SI). Current management of SRFC depends heavily on the SI forecast. In recent years, forecasts have been overly optimistic, and consideration of alternative forecast methodologies is warranted.

**Klamath and California Coastal Chinook Management**

Many research and data needs for Klamath River fall Chinook (KRFC) have been identified through the annual salmon management cycles and the methodology reviews. While some of the research needs identified in the past have been addressed, more exist. Furthermore, other stocks in the region such as Klamath River spring Chinook and California Coastal Chinook are relatively data-poor in comparison to KRFC, and many research and data needs exist for these stocks as well. Data needs and potential avenues for future research on these stocks include:

- Increased collection of basic escapement data for California Coastal Chinook. Current escapement data for populations in this Evolutionarily Significant Unit is sparse and

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generally confined to small portions of the available spawning habitat. More complete escapement survey coverage is needed.

- Estimation of the concordance of KRFC and California Coastal Chinook stock distributions. Such an investigation will allow for inference regarding how the cap on the forecast KRFC age-4 ocean harvest rate serves to limit ocean fishery impacts on California Coastal Chinook.

- Increased collection and reporting of Klamath River spring Chinook escapement and river harvest data.

- Investigation of the existence of trends in KRFC age-specific maturation rates, and the effect such trends may have on abundance forecasting.

- Examination of Klamath Chinook stock proportions in areas north and south of Point Reyes. GSI data has provided evidence that the proportion of the catch in the San Francisco management area north of Point Reyes commonly has a greater Klamath contribution rate than the areas south of Point Reyes. Investigation into the magnitude and consistency of this difference in stock proportions north and south of Point Reyes may allow for consideration of Point Reyes as a management line.

- Evaluation of the onshore versus offshore distribution of KRFC relative to other Chinook stocks.

**Fall Ocean Salmon Fishery Impact Estimation**

Model development should include an assessment of data needs to move to a 12-month fishery impact estimate to avoid the current accounting dilemma for fall salmon fisheries. Currently, salmon impacts associated with ocean fisheries in the fall are not estimated pre-season, but rather, are accounted for post-season with any resulting overages considered in the following year’s management cycle. This so called “credit card” mechanism can create considerable management challenges and a modeling change to improve our pre-season or inseason understanding of fall ocean fishery impacts would have substantial benefits for Council salmon management.

6.3.1.2 Mark-Selective Fisheries

*A more accurate assessment of total fishing-related mortality for natural stocks of coho and Chinook is needed. The ability of existing management models to predict and assess non-catch mortalities needs to be evaluated and the models modified, if needed.*

Fishery management regimes designed to reduce impacts through selective fishing, or non-retention, depend on the accuracy of estimates of non-catch 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 better 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.
Harvest models have been modified to incorporate non-catch mortality. The current Fishery Regulation Assessment Models (FRAM) used for coho and Chinook should work well when exploitation rates are relatively low, but, as selective fisheries become more intense, these models will tend to underestimate total mortality of the unmarked stocks. Theoretical development of unbiased methods for estimating non-catch mortalities has been conducted, evaluated using simulations, and reviewed for Coho FRAM. The incorporation of these methods into Coho FRAM and evaluation of their performance are the required next steps. These harvest models become more sensitive to estimates of non-catch fishing mortality as the selective fisheries modeled become more intense. Uncertainty and risk need to be explicitly incorporated into these models as they are developed.

**Continue double index tagging (DIT) of all exploitation rate indicator stocks and electronic sampling for them in all fisheries.**

With the advent of mark-selective fisheries that use the adipose fin clip as a mass mark, CWT and marked groups no longer represent unmarked groups and cannot be used to estimate exploitation of natural or unmarked stocks in the presence of mark-selective fisheries. DIT releases have been implemented to address this change in the CWT program. DIT releases consist of paired tag groups, one marked, and the other unmarked. The relationship between marked and unmarked groups in a DIT pair provides a means to estimate encounters of the unmarked group in mark-selective fisheries. The tagged and unmarked fish are released to provide a representative for natural production.

Evaluation of DIT as a means to monitor and assess mark-selective fisheries remains a high priority.

**6.3.2 High Priority Data Issues**

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

**Environmental Influences on Survival.** Estimates of 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.) are needed. Substantial predictive errors in forecasts based on previous year returns and apparent large-scale, multi-stock 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.

**Cohort Reconstruction.** Develop full cohort reconstruction for all Council-managed Chinook and coho salmon stock complexes. This would require additional escapement monitoring for some stocks, notably Rogue River Chinook stocks.
6.4 Interaction of Hatchery and Wild Salmon

In addition to the above high-priority items a number of issues related to hatchery/wild salmon 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 PBT. 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 effects (competition, predation, displacement) 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, otolith marking, CWTs, genetic marking, 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.

6.5 Emerging Issues

**Genetic Stock Identification**

Several emerging issues are related to the high priority 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 time-and-space 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 Council management.

• Evaluate whether PBT sampling and tag recovery programs can be practically and cost-effectively implemented to provide information for annual stock assessment needs.

**Essential Fish Habitat**

The Council is currently reviewing EFH for salmon and has developed the following data and mapping needs.

• Improve fine scale mapping of salmon distribution to inform future reviews of EFH for Pacific Coast salmon and aid in more precise and accurate designation of EFH and the consultation process. Potential approaches include, but are not limited to:
  
  o Develop distribution data at the 5th or 6th Hydrologic Unit level, across the geographic range of these species;
  
  o Develop habitat models that can be used to predict suitable habitat, both current and historical, across the geographic range of these species;
  
  o Develop seasonal distribution data at a 1:24,000 or finer scale.

**Ecosystem and Habitat Issues**

Long-term fluctuations in salmon abundance have 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.

Analyses are needed to which describe the impact of environmental variability in the CCE on seasonal to decadal time scales to the distribution and population structure of salmon. This effort is broadly relevant to other species in the Council’s FMPs and is closely related to ecosystem research needs identified in Chapter 1.

• 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 production.
Ecosystem-based research needs arose as the Council developed its FEP. Some of these research needs are similar and complementary to needs identified elsewhere in the document. The following ecosystem considerations specific to CPS are included here for emphasis:

- Develop tools that describe the environmental state and potential habitat utilization for near-shore anadromous fish, including coastwide sampling of juvenile distributions, monitoring and characterization of the forage based for juvenile and adult salmon, and fine-scale mapping of stock-specific ocean habitat and catch distributions.

- Examine temporal trends in regional salmon harvest rates and measure their covariation with temporal and spatial patterns of environmental variability. Characterize temporal changes in size, age, and migration timing of heavily exploited salmon stocks to evaluate correlations with harvest and environmental patterns. Assess the evolutionary effects of fishing season timing and location.

- Characterize the influence of nearshore marine, estuarine, and freshwater water quality on survival, growth, and reproduction of salmon.

- Determine influence of sea surface temperature anomalies to smolt-to-adult return predictions.

- Evaluate apparent increasing percentage of one-ocean jacks in salmon returns to freshwater.

- Develop targets and metrics for monitoring regional ecosystem and/or population-level effects of climate change on the distribution and survival of salmon.

- Acquire data and develop management tools to support regional, total-mortality management of salmon harvests.

- Evaluate the positive and negative effects of hatchery production, on a regional basis, on population dynamics of wild salmon stocks, in maintaining the role of salmon in the CCE, mitigating for loss of historic production, serving objectives of salmon restoration and recovery, sustaining local components of the fishing industry, sustaining treaty fisheries and meeting international agreements.

- Document the effects of ecological interactions such as disease, predation and competition on the population dynamics of adult and juvenile salmon.

- Develop cumulative risk assessment models and other tools to evaluate the cumulative effects of human activities (habitat reduction, hydropower generation, hatchery production, harvest) and ocean conditions (seasonal variations, interannual and inter-decadal climate shifts, long-term climate change) on West Coast salmon productivity, population status, and predator-prey relationships.
7.0 COASTAL PELAGIC SPECIES FISHERY MANAGEMENT PLAN

7.1 Highest Priority Research and Data Needs

- Establish a long-term index of abundance(s) for the CPS assemblage off the USA Pacific coast that is based on a sound and representative sampling design, which necessarily will require systematic/synoptic survey efforts, both temporally (annual) and spatially (Mexico to British Columbia).

- Coordinate more timely exchange of fishery catch and biological port samples for age structures for both Pacific sardine and Pacific mackerel in the northern and southern end of their respective ranges. In particular, efforts must be made to develop a systematic and long-term program of data exchange with Mexico.

- Re-evaluate the HCRs for Pacific sardine and Pacific mackerel, as well as other members of the broader assemblage, including northern anchovy (two substocks) and jack mackerel. Since the establishment of the current MSY-proxy control rule in the CPS FMP more than a decade ago, modeling tools have advanced and data on CPS have been accumulated. Moreover, recent research suggests that the relationship between $F_{MSY}$ and temperature, which is a formal part of the HCR for Pacific sardine, may no longer be meaningful for management purposes. Simulation modeling that addresses Pacific sardine and Pacific mackerel should be undertaken and potential management strategy evaluations should consider the broader CPS assemblage as well, given biology and fishery operations are generally similar across the individual species.

- Biological research studies should be developed for individual species based on a long-term program that allows stock parameters to be evaluated in an efficient and timely manner. In this context, age/growth, maturity/longevity, diet, natural mortality, etc. projects should be conducted on a systematic basis and consider the broader assemblage over the long-term. For example, presently, the ageing error time-series for Pacific mackerel used in an ongoing stock assessment is outdated, potentially biased, and would benefit from further age/growth analysis in the laboratory; such work was recently conducted for Pacific sardine. Finally, a life history studies program should be ongoing and include CPS in general.

- Federally-mandated ecosystem considerations are now critical requirements of most marine resource management frameworks and as such, dictate a broader research and stock assessment direction for CPS than currently in place. In this context, a general, more adaptive approach for conducting supportive research and formal assessments for CPS should be developed in accordance with the amount of information available, the uncertainty associated with the available data and time series, the fraction of the quota which is taken coastwide (domestic and international landings), and the (historical) frequency of formal assessments and review.
7.2 Continuing Issues

7.2.1 General CPS Research and Data Needs

- 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 acoustic-trawl survey now covers the bulk of the USA west coast, but does not yet cover waters off Baja Mexico and British Columbia, Canada. Development of a coastwide survey needs to account for the distribution of the CPS at various times of the year.

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

- Increase fishery sampling for age structures (Pacific sardine and Pacific mackerel) in the northern and southern end of the range. Establish a program of port sample data exchange with scientists from Mexico (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 and well-supported forum for discussion between the USA, Mexico, and Canada. Recent USA-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. Additionally, the annual Trinational Sardine Forum results in effective exchange of data and ideas on the science and economics of coastwide sardine management.

- Evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and predatory/prey relationships. Increase the use of fishery information to estimate seasonal reproductive output (e.g., fat/oil content). The CPS Management Team continues to encourage research projects related to the role of CPS in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and defining predator-prey relationships.

- Studies of krill concentrations and CalCOFI larval data in association with annual and intra-annual variations in environmental conditions may provide insights into predator-prey relationships, ocean productivity, and climate change (also see Section 2.3).

- More collaboration should be encouraged with the fishing industry, particularly, related to the overall data collection and analysis processes for CPS.

- Improve information on salmon and other bycatch in the CPS fishery. The 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 CDFW 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, creation of a statistically-reliable sampling plan, and increasing 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.

7.2.2 Pacific Sardine

- Growth data for Mexico, southern California, northern California, the Pacific Northwest (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 USA 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.

- Hypothesis of a single stock off the USA west coast should be examined using existing tagging data and additional tagging experiments, trace element analysis, and microsatellite DNA markers.

- Biological surveys should include regular systematic sampling of adult sardine for: 1) reproductive parameters for the daily egg production method; 2) population weight at age; and 3) maturity schedule. Specifically, adults collected during 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 USA west coast have the potential to provide such information as well as basic data.

- 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 USA. The long-term benefits of this forum will be greatly enhanced if it can be formalized through international arrangements.

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

7.2.3 Pacific Mackerel

- A large fraction of the catch can be landed by fisheries in Mexico given the range of the species. Efforts should continue to be made to obtain total catch, length, age, and biological data on a timely basis from these fisheries for inclusion in stock assessments. Survey data (Investigaciones Mexicanas de la Corriente de California [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.

- Applicability of the acoustic-trawl survey time series as an index of abundance in stock assessments of this species should be further evaluated, i.e., the current fishery-dependent
indices of abundance used in this species’ assessment are necessarily problematic, and highly uncertain. This effort would include reviewing/summarizing historical information from 2006 to the present, as well as consulting with survey staff regarding appropriate spatial extent of future surveys.

- Revisit biological parameters, such as maturity-at-age, ageing error, sex ratio, sex-specific parameters, and natural mortality rates ($M$), e.g., examine sex- and/or age-specific $M$.

### 7.2.4 Market Squid

- Additional work is required on reproductive biology, including the potential fecundity of newly mature females, the duration of spawning, egg output per spawning episode, the temporal patterns of spawning, and the growth of relatively large immature and adult squid. Also, further clarity regarding this species’ age/growth dynamics (via laboratory statolith studies), both spatially and temporally, would benefit management efforts directed towards this important commercial resource off California.

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

- Gain a better understanding of (and quantify, if possible) impacts to substrate used to attach eggs and to the egg masses themselves. Information about egg survival and paralarvae production per unit area in different types of spawning habitats is needed for understanding potential impacts from fishing and non-fishing activities in shallow water.

- Improve information on the distribution and depth of squid spawning grounds, as well as the dispersal of adults and paralarvae, along the West Coast (information north of Central California is particularly limited).

### 7.3 Emerging Issues

Standard data processing procedures should be developed for CPS species, similar to those developed for groundfish species.

#### 7.3.1 Pacific Sardine

The most recent full stock assessment for Pacific sardine was conducted in 2011 using the Stock Synthesis 3 (SS3) platform. Several of the recommendations below came directly from the 2007, 2009, and 2011 assessment review processes.

- The DAILY EGG PRODUCTION METHOD 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. In addition, aerial surveys should be extended to cover the PNW. Aerial surveys are not only useful for relative abundance estimates, but for studying pelagic habitat utilization. This survey has been in place since 2008 and it should be reviewed, taking into account the recommendations of the 2007 review panel and the review of the aerial survey during the 2009 STAR Panel.

• 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. Consider spatial models for Pacific sardine, which can be used to explore the implications of regional recruitment patterns and region-specific biological parameters. These models could be used to identify critical biological data gaps as well as better-represent the latitudinal variation in size-at-age.

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

• 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.

• Consider a model which explicitly models the sex-structure of the population and the catch, and models with variable natural mortality by age, location, and year.

• Fecundity-at-age is based on weight and does not account for the total number of batches of eggs produced during a season (annual fecundity). While the spawning frequency during the peak season does not appear to be age-dependent, the length of the spawning season may be longer in older fish. This may affect the stock-recruitment relationship. Whether visual estimates of activity (presence of developed gonads) from port-collected samples can be used to estimate length-specific timing and duration of spawning across the stock’s range should be explored.

7.3.2 Pacific Mackerel

The most recent full stock assessments for Pacific mackerel was conducted in 2011 using the SS3 platform. The recommendations below come directly from the most recent, as well as previous assessment reviews.

• Examine the disparity between the observed recruitment dynamics (boom-bust) and the underlying spawner-recruit model (uncorrelated recruitment deviations).
In addition to estimating ageing imprecision and bias for incorporation into assessment models, an age validation study should be conducted for Pacific mackerel. Such a study should compare age readings based on whole and/or sectioned otoliths and consider a marginal increment analysis.

The data on catches come from several sources, which are not well-documented. The catch history from 1926-27 to 2006-07 should be documented in a single report.

7.3.3. Market Squid

The use of target egg escapement levels as biological reference points for managing this resource is partly predicated on the assumption that the spawning that takes place prior to capture is not affected by the fishery and ultimately, fully contributes to future recruitment. However, it is possible that incubating eggs are disturbed by the fishing gear, since the fishery takes place directly over shallow spawning beds, 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. In this context, 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.

7.3.4. Northern Anchovy and Jack Mackerel

Population estimates of anchovy and jack mackerel are in need of an update. Reasonable estimates of their current biomass are needed for sound ecosystem management, particularly before ecosystem models can be used to accurately forecast dynamics of planktivorous organisms in the food web. One potential direction for these species is to use similar fishery-independent methods developed for species such as Pacific sardine and Pacific mackerel.

7.3.5. Habitat and Distribution

Address the southern vs. northern stock designations, and boundaries defined by sea surface temperature. Is sea surface temperature a robust indicator of north/south stock boundaries, and what additional ecosystem indicators provide better predictive power for determining sardine productivity than sea surface temperature?

Characterize and map the ocean spatial distribution patterns of abundance both seasonally and interannually. CPS may have aggregated distributions tied to spatially and temporally fixed areas of high productivity, which could be useful to fisheries that pursue them.

7.4 Ecosystem Issues

Ecosystem-based research needs arose as the Council developed its FEP. Some of these research needs are similar and complementary to needs identified elsewhere in the document. The following ecosystem considerations specific to CPS are included here for emphasis:
• Research related to the role of CPS in the ecosystem, the influence of climactic/oceanographic conditions on CPS, and defining predator-prey relationships.

• Climate or ecosystem indicators are not included in the annual stock assessments for Pacific sardine and Pacific mackerel, the FMP’s actively managed species. If significant climate-productivity relationships could be developed for Pacific sardine and Pacific mackerel, as well as for other CPS, assessments would benefit since CPS are known to be quite sensitive to long and short-term climate change in the CCLME.

• Review and revise the climate-based factor in the HCR for Pacific sardine. While not included directly in the assessment process, a climate-based factor is included in the process for determining the annual harvest level for Pacific sardine.

• A management concern of the Council under EBFM will be the evaluating trade-offs between increasing/decreasing the yield of CPS and the potential yield loss/gain of a predator that may be in another Council FMP or be of concern in terms of its ecological importance. In order to evaluate optimum yield in this situation, ecological and economic considerations come to the fore, since its resolution depends crucially on the relative net benefits provided to society through these interactions.

• Determine whether climate change and ocean acidification pose differential risk to invertebrates (squid) compared to fish in the CPS group.
8.0 HIGHLY MIGRATORY SPECIES FISHERY MANAGEMENT PLAN

8.1 Background

The Council’s FMP for 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 extends well beyond the U.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 RFMO. U.S. scientists (whose affiliations include NMFS, academia, nongovernmental organizations, 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 provides scientific advice on the status of North Pacific HMS stocks that straddle the 150° 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 and advice that the RFMOs use to base management decisions for the straddling stocks.

Research and data needs for the Council’s HMS FMP have been organized in this chapter by order of priority. These needs cover a range of HMS management issues, from stock assessments to protected species interactions, EFH, and fisheries economics.

For stock assessments, the overarching priority is to permit accurate and timely status determinations and monitoring of trends in population abundance and fishing mortality for all stocks, with priority given to stocks that are most important to and most affected by Council-managed fisheries. Stock assessments rely on three main categories of data: (1) indices of abundance, (2) accounting of total fishing mortality (“fisheries statistics”), and (3) biology and life history characteristics. Thus, in addition to prioritizing stocks in terms of management need, this chapter also identifies priority data gaps for each stock. A comprehensive prioritization would consider these data gaps across the full set of stocks and evaluate which data sources should be added, enhanced, or maintained to produce some optimal level of information. In some cases, it may be desirable to collect information on a stock with relatively lower management priority if higher priority stocks are already being adequately assessed. This balancing of the need to address data-poor stocks while also maintaining and improving timeliness and accuracy of assessments for stocks of highest management priority must also take into account the transboundary nature of HMS stocks—as mentioned above, NMFS cannot make status determinations or track catches for most HMS stocks without cooperation from other countries.
Stock assessment priorities will also have to factor in the new MSA requirements. All of the Council’s HMS stocks are managed under international treaty agreements and, as such, are exempted from annual catch limit and accountability measure requirements. However, all will still require an estimate of acceptable biological catch and status determination criteria. The HMS sharks include some of the most data-poor stocks in the FMP. In some cases, it may be necessary to give priority to sharks of lower management priority (e.g., thresher sharks) in order to obtain basic fisheries information (e.g., total annual catch), and meet the annual catch limit requirements.

8.2 Highest Priority Issues

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

8.2.1 North Pacific Albacore

Fisheries Statistics: Timely submission of national fishery data to the ISC Albacore Workgroup data manager is critical for producing timely and up-to-date stock assessments. Additional resources are needed to monitor the submission of these data, to provide adequate database management, and to adequately document the entire database system, including metadata catalogs. Electronic reporting systems increase data entry convenience for industry participants, reduce processing time and costs for data managers, and significantly improve the quality of data being collected through validation checks. Following examples set in Alaska and on the east coast, the implementation of an electronic fish ticket system on the West Coast would greatly improve the availability, timeliness, and accuracy of fishery landings data. The development of a coastwide, multi-fisheries electronic logbook system would provide similar results for logbook data.

Biological Studies: Biological information is a critical building block for stock assessments and should be reviewed and updated regularly to capture changes in population parameters as they occur. Unfortunately, these updates have not been accomplished for North Pacific albacore because of limited resources for biological studies. Consequently, the stock assessment models used by the ISC Albacore Workgroup still rely on some biological information that was developed largely in the 1950s and 1960s, although updated length-weight schedules have been applied and a recent age and growth study has provided new information.

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

- age and growth with the goal of updating growth rates and identifying regional differences in growth rates;
- reproductive biology with the goal of updating the maturity schedule and identifying regional differences;
- development of new indices of abundance particularly from fisheries that regularly catch recruitment-age albacore (age 1), e.g. the U.S. recreational fishery;
migration and habitat utilization, with the goal of determining migration and habitat use patterns, improving fishery catch-effort standardization and fishery selectivity/catchability estimates;
natural mortality with the goal of estimating natural mortality rates using well-designed tagging experiments;
influence of environmental conditions on albacore biological parameters, including recruitment, growth, migration, habitat use, and catchability of albacore; and
albacore age and length data through port and biological sampling.

Stock Assessment and Management Studies: Demand for more frequent and more precise information on the status of the stock and the sustainability of albacore fisheries is likely to increase. With this in mind, the albacore stock assessment needs improvement in several areas:

evaluate effects of changes to assessment model structure and assumptions, by testing the assessment model with data generated by a simulation model tuned to albacore biology;
investigate the drivers of biomass scaling in the SS3 model used for the most recent (2011) stock assessment;
develop simulations to assist fishery managers in selecting appropriate biological reference points for albacore;
development and improvement of abundance indices from commercial and recreational fisheries;
stock-recruitment relationship, with the goal of improving current assumptions of the stock-recruitment relationship;
evaluation of the utility of formally adding tagging data into the assessment; and
development of environmental indices that influence albacore population dynamics and evaluate effects of including these environmental indices in assessment models.

8.2.2 Swordfish

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

Biological Studies: All biological studies listed above for albacore are needed for swordfish as well. In addition, 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 swordfish. In particular, there is a need for additional work on effort standardization.

Economic Studies: Explore economic viability of harpoon and longline gear as an alternative to drift gillnet gear for swordfish. Research the best options to promote developing and testing novel gear (e.g., deep-set buoy gear or deep-set daytime longlining) to reduce protected species interactions and increase swordfish catch. Gauge the impact on global swordfish production and trade of unilateral measures to limit West Coast fishing effort.
8.2.3 Sharks

Most of the tunas covered in the HMS FMP are being assessed on a regular basis, with varying degrees of completeness and sophistication. 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. 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 HMS shark species are likely to be more vulnerable to overfishing than other HMS. The Pacific RFMOs have begun to prioritize shark stock assessments. The WCPFC, IATTC and ISC have each developed plans to assess some shark stocks over the next several years, but given the fact that many species are not targeted and fishery data are scant, there will be many challenges.

As with the other transboundary 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 and shortfin mako shark). Others are more coastal—with a substantial portion of their habitat shoreward of the U.S. EEZ—but exhibit north-south migrations with significant catches in Mexican waters (e.g., common thresher shark). The net effect is that accounting for the total catch of sharks over their entire period (several decades) and areas of exploitation 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, non-profit, 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, effort, and the corresponding size samples, stock assessment efforts and concomitant management by the Council will be problematic.

The following specific research priorities have been identified for the two sharks species of greatest priority to the Council with respect to their importance in U.S. West Coast commercial and recreational fisheries:

**Common thresher shark:**

- stock structure and boundaries of the species and relationships to other populations;
- estimate total annual stockwide catch;
- the pattern of seasonal migrations for feeding and reproduction, and where and when life stages may be vulnerable;
- improved recreational catch estimates which adaptively sample the pulse nature of fishing effort;
- improved commercial fishery monitoring in Mexican waters;
- age 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 the West Coast EEZ;
- estimate total annual stockwide catch;
- stock structure and boundaries of the species and relationships to other populations; and
- age and growth rates (current growth estimates differ widely).

### 8.2.4 Interactions with Protected Species and Prohibited Species

More complete catch information and data on interactions with protected and prohibited species are needed for most HMS fisheries. There is inadequate understanding of the fisheries on some HMS stocks that are shared with Mexico (e.g., species composition of shark catches in Mexican fisheries), and inadequate data exchange with Mexico. These fisheries are likely affecting both protected species and prohibited species of fish.

More work is needed to better understand possible impacts of the HMS fisheries on protected species of sea turtles, birds, and marine mammals. For example, there is a need to investigate the post-release survivorship of protected species, such as turtles and seabirds that are caught as bycatch in the HMS fisheries. In addition, fisheries-independent research is required to better understand distribution and habitat use by turtles and to determine the linkages to ecosystem parameters (oceanographic and biological). This includes data on turtle migration seasonality and routes, genetic stock composition of populations by species, and habitat use in order to better understand turtle life histories and likely periods of interaction with fisheries. Predictive models that integrate oceanography, ecosystem parameters (e.g., prey distribution), and habitat use of turtles are needed. More work on the sizes and structures of turtle populations by species would also enable improved application of the ESA and other laws and regulations to HMS fisheries. Continued research on the abundance and distribution of marine mammals is also critical, particularly for HMS fisheries operating within the West Coast EEZ.

Some specific research priorities include:

- Research habitat use of leatherback turtles and other species of concern, including target species, to better understand the potential for reducing bycatch;
- Explore whether hotspots or temperature bands can be identified in near-real-time in order to provide information to fishermen regarding places with potentially high interaction risks;
- Explore how regulating the U.S. West Coast Pacific swordfish fishery affects international trade in swordfish and the potential unintended consequences for protected species interactions in foreign fisheries;
- Compare bycatch rates of drift gillnet vs. shallow set longline gear for swordfish, both by mining observer data and conducting gear comparison studies in the fishery areas; and
- Develop probability-based estimates of unobserved bycatch for observer programs with less than 100 percent observer coverage.
8.3 High Priority Issues

8.3.1 Blue shark

As noted above, relatively little assessment and research activity is focused on shark species compared to the existing work being done on other HMS, such as tunas. Blue shark catch was relatively high in the California CPFV fishery of the late 1980s, but has steeply declined. Blue sharks are encountered in relatively small numbers coastwide in commercial and recreational fisheries. Three specific research needs identified for blue sharks are to: 1) monitor sex and size composition of catches; 2) determine the migratory movements of juvenile and maturing fish from the EEZ to high seas; and 3) examine the Pacific-wide stock structure and interactions among populations using genetics and other techniques.

8.3.2 Striped Marlin

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

Biological Studies: All biological studies listed above for albacore are also needed for striped marlin. 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. A synoptic, critical review of all available information (fisheries data, ichthyoplankton data, and genetic studies) is needed to either resolve the issue or at least to reduce the number of credible hypotheses; and
- Age and growth data from locally-caught fish should be examined.

Stock Assessment and Management Studies: All stock assessment and management studies listed above for albacore are also needed for striped marlin. Specific to striped marlin, there is a need for additional work on effort standardization.

8.3.3 Pacific Bluefin Tuna

Fisheries Statistics: The timeliness of data reporting, as outlined for albacore above, is equally important for bluefin tuna. Additionally, increased port sampling of commercial bluefin length frequencies is needed in the Eastern Pacific Ocean (EPO), particularly of the fish destined for the pens in farming operations.

Biological Studies: All biological studies listed above for albacore are also needed for bluefin tuna. Additionally, 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;
estimate natural mortality rates since previous assessment results were highly sensitive to
the assumed mortality rates; and
estimate age-specific migration rates of bluefin tuna from the Western and Central Pacific
Ocean to the Eastern Pacific Ocean and understand the factors that influences those rates,
since this in turn strongly influences the availability of bluefin in the EPO.

Stock Assessment and Management Studies:  All of the stock assessment and management
studies listed above for albacore are also needed for bluefin tuna.  In addition:

- there is a need for improvements to standardization of abundance indices;
- development of an abundance index from spotter plane data from the EPO; and
- incorporating tagging data and environmental indices into the assessment model.

8.4 Other Priority Stocks and Issues

8.4.1 Management Unit Species Catch Data

Total catch data are likely inaccurate for some HMS fisheries due to inadequate at-sea data
collection programs, logbook programs, and shoreside sampling programs for west coast
fisheries and unreported catch by international fisheries.  Catch data needs include:

- Total catch information (including incidental and bycatch) and protected species
  interactions for surface hook-and-line, purse seine, and recreational fisheries, and
  additional at-sea sampling of drift gillnet fisheries

- Catch composition data for harpoon gear

- Size composition of bycatch in drift gillnet fisheries

- Condition (e.g., live, dead, good, poor) of discarded catch in all HMS fisheries

Additional work needs to be done to develop ways to adequately sample recreational fisheries,
particularly shore-based anglers and private vessels.  There is a need to develop methods for
sampling private marinas and boat ramps to determine catch, and the level of bycatch and
protected species interactions, as well as sample the catch for length and weight of fish caught to
convert catches reported in numbers to catches by weight.  Better catch and effort estimates are
also needed for HMS recreational fishing tournaments, in particular those tournaments focusing
on common thresher and mako sharks.

8.4.2 Survivability of Released Fish

Little is known of the long-term survivorship of hooked fishes after release, the effectiveness of
recreational catch-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). Alternative gears and methods to increase survivability of recreationally-caught fish and to minimize unwanted bycatch in fisheries should be identified.

8.4.3 Essential Fish Habitat

There is very little specific information on the migratory corridors and habitat dependencies of these large mobile fish; 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 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.

8.4.4 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 STAR process. This may become an issue for the Council if international management regulations begin to affect U.S. 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.

8.4.5 Tropical Tuna Species and Dorado

The commercially-important tropical tuna species, namely yellowfin, bigeye, and skipjack tuna, are principally harvested in the EPO by vessels from the Central and Latin American fishing fleets. Although a small West Coast-based U.S. flag purse seine fishery opportunistically harvests these tunas, the U.S. does not have a fleet active in the main EPO fishery at present. The tropical yellowfin, bigeye, and skipjack tunas are no longer taken in large numbers by West Coast-based commercial fisheries.

The California CPFV fleet is the principal U.S. West Coast fishery for dorado, which are often taken in the Mexican EEZ. Dorado can be a significant portion of the total CPFV annual catch and has been the leading species in some years, followed by yellowfin tuna and albacore tuna. Specific recommendations on dorado research include:

- Determine the stock structure of dorado in the eastern Pacific, and
- Investigate the significance of floating objects and other-species associations relative to life history.
8.4.6 Pelagic and Bigeye thresher sharks,

These species occur in far lower frequency than common thresher sharks in U.S. West Coast fisheries. Nevertheless, they are taken in Council-managed fisheries and studies of their life history and ecology, and temporal and spatial catch monitoring will help inform management along the West Coast and in other areas.

8.4.7 Archival PacFIN Data Cleanup

Some progress has been made to address coding issues with the gear codes for drift gillnet records in the PacFIN data base. The results of the recoding are reflected in drift gillnet landings and revenue summaries provided in Chapters 2 and 4 of this HMS SAFE Report; however, issues remain for PacFIN archived longline records.

Review and subsequent revision of archival PacFIN data is needed to improve the accuracy of historical commercial landings and revenues for longline landings.

8.4.8 Ecosystem Issues

Ecosystem-based research needs arose as the Council developed its FEP. Some of these research needs are similar and complementary to needs identified elsewhere in the document. The following ecosystem considerations specific to HMS are included here for emphasis:

- Assess nearshore distribution of juvenile sharks for habitat needs and fishery vulnerability during nursery and pre-reproductive life stages.

- Research and modeling needed on the links between climate and the migration patterns of protected bycatch species to allow us to refine our closed area management programs, such as for leatherback and loggerhead sea turtles. For turtles in particular, fisheries-independent research is needed to better understand turtle distribution and habitat use, and to assess and model linkages to oceanographic and biological trends within the CCE.

- Evaluate utility of Pacific pelagic ecosystem models for informing Council or other management body decisions. Both models and empirical evidence suggest that with increasing fishing pressure, decline in top predators has or should contributed to increasing catch rates of mid-trophic level species such as mahimahi, pomfret, and escolar. An improved understanding of the impacts of fishing on pelagic food webs and the productivity on different trophic guilds in this ecosystem should be beneficial to both modeling and management efforts.

- More comprehensive data and modeling of real or potential interactions with protected and prohibited species are needed for most HMS fisheries. This is particularly the case with HMS stocks that are shared with Mexico, where there is inadequate understanding and data exchange for HMS fisheries that are likely affecting both protected species distribution patterns and migration routes of prohibited species of fish. Improved habitat data for target and prohibited species north of Point Conception, where there has similarly been very little research on habitat associations, could also reveal insights about
the potential differences in both geographic and vertical distribution of target and prohibited species.

- The long-term consequences of climate change are expected to drive large-scale changes in species-specific habitat availability as well as ecosystem-wide patterns of biodiversity, with up to 35 percent change in the core habitat for some species. An improved understanding of which species (including both target species and protected species that interact with fisheries) might benefit and which might become more vulnerable to fishing impacts would benefit long-term management efforts.
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).
APPENDIX I - 2011 GROUNDFISH STOCK ASSESSMENT REVIEW
PANEL RECOMMENDATIONS FOR FUTURE RESEARCH AND DATA COLLECTION

Pacific Ocean Perch

• Considering transboundary stock effects should be pursued. In particular, the consequences of having spawning contributions from external stock components should be evaluated relative to the steepness estimates obtained in the present assessment (see more complete discussion of this recommendation under the Unresolved Problems and Major Uncertainties section, above).

• The benefits of adopting the complex model used this year should be evaluated relative to simpler assumptions and models. While the transition from the simpler old model to Stock Synthesis was shown to be similar for the historical period, the depletion estimates in the most recent years were different enough to warrant further investigation.

• Discard estimates from observer programs should be presented, reviewed (similar to the catch reconstructions), and be made available to the assessment process.

• The quality of the age and length composition data, as presented, should be reevaluated, since they appear to affect model results.

• A survey that is better-suited to rockfish species would be beneficial for the assessment.

• The ability to allow different “plus groups” for specific data types should be evaluated (and implemented in Stock Synthesis). For example, this would provide the ability to use the biased surface-aged data in an appropriate way.

• Historical catch reconstruction estimates should be formally reviewed prior to being used in assessments and should be coordinated so that interactions between stocks are appropriately treated. The relative reliability of the catch estimates over time could provide an axis of uncertainty in future assessments.

Petrale sole

• Expand the stock assessment area to include Canadian waters to cover the entire biological range of petrale sole (see more complete discussion of this recommendation under the Unresolved Problems and Major Uncertainties section, above).

• Conduct a formal review of all historical catch reconstructions and, if possible, stratify by month and area. The mixing of U.S. and Canadian catches is of particular concern for the Washington fleet.

• Discard estimates from the WCGOP should be documented, presented, and reviewed (similar to catch reconstructions) outside of the STAR panel process. The reviewed WCGOP data should then be made available to the assessment process.

• Consider combining Washington and Oregon fleets in future assessments within a coastwide model.

• The petrale sole maturity and fecundity information is dated and should be updated.
• As noted by the previous STAR Panel, the current assessment platform (SS3) is structurally complex, making it difficult to understand how individual data elements are affecting outcomes.
• The Panel recommends, where possible, investigating simpler, less-structured models, including statistical catch/length models, to compare and contrast results as data and assumptions are changed.
• The length binning structure in the stock assessment should be evaluated, including tail compression fitting options.
• The residual patterns in the age-conditioned, length compositions from the surveys should be investigated and the potential for including time-varying growth, selectivity changes, or other possible solutions should be examined.
• Management strategy evaluation is recommended to examine the likely performance of new flatfish control rules.

Spiny dogfish (prioritized)

1. Improve age estimates and aging methods.
2. Examine the uncertainties regarding the catch data and discard mortalities. In particular, bycatch estimations are very important, given that they are larger than the recorded landings over recent years.
3. Research on dogfish movement. This would be informative not only in providing a better definition of the unit stock, but also aid addressing # 4 (below).
4. Linkage with fish on Canadian side of the border and exploration of a joint assessment process for this stock.
5. Continuation of the commercial catch and bycatch sampling.
6. Examination of catchability priors in the New Base model as well as a method for deriving future priors.
7. Examination of the Beverton-Holt derivation, as it relates to dogfish, and comparison with new stock-recruitment model used in this report.

Widow rockfish (not prioritized)

The Scientific and Statistical Committee Groundfish Subcommittee (SSCGS) reviewed widow rockfish assessment at the “mop-up” meeting. The SSCGS recommends devoting additional efforts to reconstructing historical landings. This recommendation also applies to most groundfish species on the U.S. West Coast (and not only widow rockfish). In addition to providing the best reconstructed catch histories by species, this effort should develop alternative catch streams that would reflect differences in data quantity and quality available for different time periods. Such (more realistic) alternative catch streams would be very useful while exploring model sensitivity to uncertainty in catch history (rather than applying a simple multiplier to the entire catch time series, which is currently the case for most groundfish assessments).
The SSCGS also recommends further exploration of historical discards, especially given that more detailed (trip limit specific) historical discard information (GMT discard rate estimates from the Pikitch study) has become available.

The SSCGS suggests revisiting the fleet structure used in the assessment, particularly exploring the option of splitting bottom and midwater trawl fisheries in Washington and California, and/or evaluating the need of treating bottom and midwater Oregon trawl fisheries separately. The assessment includes a number of “legacy” data sources (for example, Oregon bottom trawl logbook CPUE index); however, those sources lack proper documentation on how the data were collected and analyzed. The SSCGS recommends revisiting those “legacy” sources and considering whether these data sources still contribute to the assessment. If the “legacy” data sources are still considered valuable, detailed information should be provided for each.

The assessment utilizes age data from six different sources (for example, Oregon bottom trawl logbook CPUE index); however, those sources lack proper documentation on how the data were collected and analyzed. The SSCGS recommends revisiting those “legacy” sources and considering whether these data sources still contribute to the assessment. If the “legacy” data sources are still considered valuable, detailed information should be provided for each.

At the review meeting, efforts were devoted to exploring different assumptions regarding fishery selectivity patterns (dome-shaped and asymptotic). The SSCGS recommends further investigation of the theoretical basis for selecting particular patterns for different fisheries and evaluation of data (biological and fishery-related) which would provide information on this issue.

**Sablefish (prioritized)**

**General recommendations affecting more than one assessment.**

- Complete and review the Washington catch reconstruction and review the California and Oregon catch reconstructions. The accuracy and wide availability of consistent basic information is essential to the development of Pacific coast assessments. In addition to the raw data, the reliability and availability of more spatially dis-aggregated forms of the data should be investigated to determine if they could be used to develop more spatially- or temporally-explicit models without causing sacrifices in accuracy.

- Include in future versions of Stock Synthesis the capability to explore alternative error distribution assumptions for compositional data. Currently the multinomial distribution is the only type of error distribution available in Stock Synthesis for length or age information. It appears that this may have some impact with respect to underestimating strong year-classes. It would be helpful to be able to explore alternative error assumptions in order to analyze composition information, in particular where the effective sample size estimates (which control the variance in the composition data) may be related to perceived stock abundance.

- Develop guidelines for use of the Lorenzen model for age-dependent natural mortality. The panel investigated the use of age dependent M in both the Dover sole and sablefish
assessments. In each case one of the reasons for exploring different mortality schedules was the potential imbalance between the genders in the age- and length composition information, either in the sex ratio at older ages (Dover sole) or in the ratio of young to old fish (Sablefish). The use of the Lorenzen M model, which is based on a decline in M with age by the inverse of the growth rate, implies a link with size-based predation. However, with likely wider use of this model feature there should be development of some guidance on the appropriateness of the implementation in other stock assessments.

- Conduct new studies of maturity by length and age based on more comprehensive coastwide and depth-based sampling and using histological techniques for determining maturity stage. Given that there is uncertainty regarding the temporal stability of maturity schedules, there should be periodic monitoring to explore for changes in maturity.

- Modify the Stock Synthesis code to allow changes to the plus-group age. The Panel found it very helpful to be able to modify the plus-group in the age-composition data to investigate the influence of old versus young age composition data. This feature could also be used to explore the influence of ageing errors. The current version of SS requires restructuring of the input data if the plus-group is changed.

**Recommendations specific to sablefish.**

- Further investigate potential inaccuracy in using maximum likelihood estimates and the normal distribution to approximate confidence limits for estimates of spawning biomass. The current assessment’s measures of uncertainty in spawning biomass are based on the assumption that the errors can be adequately approximated by normal distributions. The current model for sablefish is sufficiently simple that it may be feasible to conduct a full Bayesian analysis of uncertainty. There is concern that asymmetries in the error distributions, which the normal distribution cannot account for, may be creating a biased view of stock status.

- Conduct new studies on maturity and age-reading error. A major uncertainty in the sablefish assessment relates to the maturity schedule and in age determination. Better maturity and age-at-length data could reduce uncertainty and help resolve issues of cohort size.

**Dover sole**

**General (affecting more than one assessment)**

1. Complete and review the Washington catch reconstruction and review the California and Oregon catch reconstructions. The accuracy and wide availability of consistent basic information is essential to the development of Pacific coast assessments. In addition to the raw data, the reliability and availability of more spatially dis-aggregated forms of the data should be investigated to determine if they could be used to develop more spatially-explicit models without causing sacrifices in accuracy.

2. The difficulties encountered in the Dover sole assessment and some other flatfish assessments with respect to the linkage between selectivities require addressing.
Although in many instances size-based selectivity may be appropriate, when sexes separate spatially there is a requirement for models to at least be able to investigate complete independence between genders. It is important that this be implemented in an updated version of SS3.

3. The panel investigated the use of age-specific natural mortality in both assessments presented during STAR 4. In each case, one of the reasons for exploring different mortality schedules was the difficulty in fitting the imbalanced abundance at age information (as seen through residuals to fits), either in the sex ratio at older ages (Dover sole) or the ratio of young to old fish (Sablefish). The use of Lorenzen M based on a decline in natural mortality by the inverse of the growth rate implies a link with predation; however, wider use and development of some guidance on the appropriateness of the implementation in other stock assessments should be investigated.

4. Currently, the only available error distribution for age information is the multinomial probability function. It appears that this may have some impact with respect to underestimating strong year-classes, and it would be desirable to explore the use of alternative error assumptions in order to analyze survey information, in particular where variance estimates in catches-at-age may be less than independent on abundance.

5. There should be new studies of maturity by length and age based on more comprehensive coastwide and depth-based sampling and using histological techniques for determining maturity stage. Given that there is uncertainty regarding the temporal stability of maturity schedules, there should be periodic monitoring to explore for changes in maturity.

6. Update the STAR Terms of Reference to ensure that assessment documents include standard plots (or tables) of likelihood profiles that include likelihood components by data source and fleet. Such plots are an important diagnostic tool for displaying tensions among data sources.

Specific to Dover sole

1. Researching ageing error, particularly aging bias, is important for Dover sole, given the current base model’s difficulty with reconciling some tensions between different data sources regarding the sex ratio at the oldest ages. In addition, the ability of the model to track cohorts accurately would be significantly disrupted if there were severe size-based bimodality in cohorts caused by vastly different times of settlement (Dover sole are thought to have a larval period of 6-18 months). Consequently, larval period should also be examined.

2. For the NWFSC combo survey, raw age and length information appeared to imply persistently different sex ratios when viewed in isolation. The concern is that there is some unrepresentative sampling occurring in the age distribution as ages are sub-sampled from length. The sampling procedure should be investigated more closely and potentially improved.

3. The conclusions of the NMFS workshop on developing priors on catchability were not available to the Panel. These should be made available and the information reconsidered.
specifically with respect to Dover sole, in an attempt to reconcile the relatively low
catchability estimates for the surveys, particularly the NWFSC combo survey, which is
thought to cover the majority of the stock distribution.

4. Having simplified the model compared to previous assessments, especially with respect
to uniform growth, it is important to continue investigating if this is likely to introduce
undesirable levels of bias into the assessment process as more information becomes
available. Spatial information on the distribution by age/size of females, particularly in
the southern part of the range, particularly across the stratification boundaries of the
survey as well as between stocks, should be the primary focus of this work.

**Blackgill rockfish** (not prioritized)

To address uncertainty regarding the portion of blackfish population residing in Mexico, the
Panel follows the suggestions of the 2005 STAR Panel to attempt to document catches in
Mexican waters by both U.S. and Mexican fishers and consider the implications of blackgill
being a shared stock. The Panel also suggests exploring alternative sources of information (i.e. to
investigate whether there are relevant studies conducted at Universities in Mexico), that could
yield information on biology, life history, and exploitation of the blackgill that could be used in
the next assessment.

The Panel recommends devoting additional efforts to reconstructing historical landings. This
recommendation applies to most groundfish species on the U.S. West Coast (and not only
blackgill rockfish). In addition to providing the best reconstructed catch histories by species, this
effort should develop alternative catch streams that would reflect differences in data quantity and
quality available for different time periods. Such (more realistic) alternative catch streams would
be very useful while exploring model sensitivity to uncertainty in catch history (rather than
applying a simple multiplier to entire catch time-series, which is currently the case for most
groundfish assessments). Also, taking into account a spatial shift in fishing efforts to deeper
waters would be a significant improvement to catch reconstruction of blackgill rockfish and
other species landed in mixed-species categories.

Both the STAR Panel and the Stock Assessment Team (STAT) agreed that alternative means of
exploring relative or absolute abundance in the CCA is a key research priority. Submersible or
other non-invasive survey methods could potentially provide additional information on habitat
and abundance for this species. Also, it is important to develop alternative methods to monitor
length and age compositions of fish inside the CCA.

The STAT emphasized that blackgill rockfish has proven to be very difficult to age, and age
estimates are highly uncertain. Improving age data quality (through validation studies, otolith
exchange between labs) and greater exploration of possible differences in age and growth
throughout the range of this stock using the data from otoliths that have not yet been processed is
desirable. The STAR Panel agreed, but noted that careful consideration should be devoted to
producing exactly the age data which would be of most direct benefit to the assessment, based on
representative sampling, since expertise, time, and funds are all limited.
**Greenspotted rockfish** (not prioritized)

To address uncertainty regarding the portion of the greenspotted rockfish population residing in Mexican waters, the Panel suggests an attempt should be made to document catches taken in Mexican waters by both U.S. and Mexican fishers, and to consider the implications of there being a single shared stock. The Panel also suggests exploring alternative sources of information (i.e. to investigate whether there are relevant studies conducted at Universities in Mexico), that could yield information on biology, life history, and exploitation of greenspotted rockfish that could be used in the next assessment.

The Panel recommends devoting additional efforts to reconstructing historical landings. This recommendation applies to most groundfish species on the U.S. West Coast (and not only greenspotted rockfish). In addition to providing the best reconstructed catch histories by species, this effort should develop alternative catch streams that would reflect differences in data quantity and quality available for different time periods. Such (more realistic) alternative catch streams would be very useful while exploring model sensitivity to uncertainty in catch history (rather than applying a simple multiplier to entire catch time-series, which is currently the case for most groundfish assessments). Taking into account a spatial shift in fishing efforts to deeper waters would be a significant improvement to catch reconstruction of greenspotted rockfish and other species landed in mixed-species categories. Also, existing reconstruction efforts focus entirely on historical landings, although discard has been a significant portion of removals for many species on the U.S. west coast. The Panel recommends devoting efforts to reconstruct historical discard as well.

Both the STAR Panel and the STAT agreed that alternative means of exploring relative or absolute abundance in the CCA is a key research priority. Submersible or other non-invasive survey methods could potentially provide additional information on habitat and abundance for this species. Also, it is important to develop alternative methods to monitor length and age compositions of fish inside CCA.

The available data were limited (especially for the southern region) to reliably estimate growth, therefore, consideration of ageing available otoliths should be a priority. The Panel noted that ageing of historic samples (and future samples) would only be useful if samples were representative of the population. This needs to be examined before undertaking time-consuming and costly ageing work.

It is important to further explore stock structure and spatial variability of life history parameters of greenspotted rockfish, since currently only limited (or not species-specific) information is available. The Panel also recommends exploring alternative model structures to account for spatial pattern in species biology, including the model with one stock assumption, model with two areas (with linkage between areas), several growth assumptions, and others. Given this recommendation, the Panel suggests conducting a full assessment next time the species is assessed to allow exploration of model structure (which would be impossible in the case of an update assessment).
APPENDIX II - ITEMS DESCRIBED AS “HIGH” PRIORITIES IN THE ADDENDUM TO THE PACIFIC COAST GROUNDFISH 5-YEAR REVIEW OF ESSENTIAL FISH HABITAT

For additional details, see the September 2012 Council Briefing Book, Agenda Item H.6.  

- (high) Evaluate the boundaries of the 2005 EFH closures, relevant to the distribution of seafloor habitats in the newly developed 2011 maps, to identify areas where habitat protection should be refined.
- (high) Evaluate changes in the distribution of fishing effort, using the new 2005 and 2011 maps of effort for the bottom-contact fisheries, and determine if changes to current area management measures and gear restrictions from 2006 groundfish EFH regulations may be warranted.
- (high) Update the table in Amendment 19 (Summary of mean sensitivity levels and recovery times for all combinations of major gear types (including new gear types and midwater trawl) and bottom habitat types: Appendix 10 of Appendix A, Table 3) that addresses relative ranking of gear types in terms of their habitat impacts.
- (high) Evaluate new information on EFH relative to Level 1-4 (as defined in the EFH guidance, EFHRC Phase I Report page 13) and compare to information level available in establishing the 2006 groundfish EFH regulations.
- (high) Evaluate corals and sponges as components of EFH for groundfishes (conduct studies to map the distribution and abundance of biogenic species) (high) Evaluate the 2005 mobile-fishing-gear risk assessment model relevant to new data.
- (high) Run the habitat suitability probability models for all west coast groundfish species, using the new maps of habitat distributions and other relevant data.
- (high) Conduct visual, no-take surveys of fishes and habitats inside and outside current EFH closures in order to evaluate the effectiveness of these conservation areas.
- Assess near-shore distribution of FMP species for habitat needs and vulnerability during nursery and pre-reproductive life stages.
- Describe and classify soft-sediment habitat types and fish-habitat relationships. Dynamic seafloor conditions, such as dunes, mobile sand sheets, sediment waves and ripples occur in soft, unconsolidated sediment. These features may be foraging habitat for groundfishes.

Habitat Impact Analyses and Baseline Data Gathering

- Conduct studies to understand the relationship between an individual trawl pass and the level of disturbance of benthic macro-invertebrates that results. Develop new models for estimating fishing impacts on biogenic and physical habitats, such as those used in the Alaska 2006 EFH process.

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Conduct long-term studies to understand how benthic environments (including sessile benthic macro-invertebrates) recover from the effects of fishing, including control areas that remain closed to trawling. Studies since 2005 found significant impacts of trawling on soft sediment habitats, and little is known about recovery of seafloor habitat.

Conduct studies to explain past and present trends in the bycatch of biogenic species, particularly in areas off Oregon, as emphasized in the EFH report.

Conduct studies to understand the cumulative impacts of fishing gear (including line, weights, traps and pots) including derelict fishing gear on important habitats such as rocky reefs and eelgrass beds. These gears can impact rocky and biogenic habitat. Evaluate adverse effects of hypoxic conditions on resident species in rocky habitats, and susceptible species (e.g., petrale sole) in soft-bottom habitats.

Conduct baseline studies of fisheries resources at the onset of newly funded offshore energy development projects, particularly off southern Oregon, where a BOEM-sponsored wind energy demonstration project has recently been funded.

**Improve seafloor maps (bathymetry, backscatter, and associated interpreted substrata types):**

- (high) Conduct high-resolution seafloor mapping, particularly on the shelf and slope associated with groundfish EFH conservation areas not previously mapped.
- (high) Develop maps of interpretative substrate from a backlog of sonar mapping data that was not examined or used to create substrate interpretations presented in the Groundfish EFH Review Report. Create an integrated data set from the “aggregate seabed habitat” data to produce a seamless substrate map suitable for regional scale analyses.

**Improve the Habitat Use Database (HUD):**

- (high) Develop tools and protocols to aid in data entry and to address specific architectural problems
- (high) Address potential biases associated with the recent inclusion of species from the Oregon Nearshore Strategy
- (high) Update associations and distribution of groundfish habitat (including prey), using new information reported in the EFHRC report. Add descriptions for other species groups similar to those provided for Flatfish group.
- (high) Update HUD definitions, documentation, and standards (e.g. clarify ‘preferred depth’; consider young of year (YOY); verify species range and habitat preference using fishery dependent and independent survey data; develop standards for recording database amendments and expert opinion).

**Improve groundfish prey information for under-sampled FMP species:**

- (high) Develop criteria for defining major prey species for groundfish species and lifestages.
- (high) Compile lists of major prey species for the all stocks and lifestages in the groundfish FMP.
- (high) Evaluate the habitat use and distribution of major prey species for groundfishes.
- (high) Evaluate potential adverse effects from fishing and non-fishing activities on the major prey species in the diets of groundfishes.
The following model-related research recommendations are excerpted from reports of the 2011 and 2012 assessment reviews.

- Explore use of Canada DFO’s mid-water trawl survey off Vancouver Island.
- Temperature-at-catch could provide insight into stock structure and the appropriate catch stream to use for assessments, because the southern subpopulation is thought to inhabit warmer water than the northern subpopulation. Conduct tests of sensitivity to alternative assumptions regarding the fraction of the MexCal (in particular, Ensenada and Southern California) catch that comes from the northern subpopulation.
- Explore models that consider a much longer time period (e.g., 1931 onwards) to determine whether it is possible to model the protracted period and determine whether this leads to a more informative assessment and provides a broader context for evaluating changes in productivity.
- Consider a scenario that explicitly models the sex-structure of the population and the catch.
- Reconsider a model that has separate fleets for Mexico, CA, OR-WA, and Canada.
- Develop a relationship between egg production and age that accounts for the duration of spawning and batch fecundity by age.
- Consider model configurations that use age compositions, rather than length compositions and conditional age-at-length data, given evidence for time- and spatially-varying growth.
- Explore reasons for the discrepancy between the observed and expected proportions of old animals in the length and age compositions. Possible factors to consider in this investigation include ageing error / ageing bias and the way dome-shaped selectivity has been parameterized.
- Consider a Beverton-Holt or other spawner-recruit relationship in place of the Ricker to see if such a change will stabilize the model relative to the number of recent years of recruitments estimated, while providing a biologically realistic relationship.
- Consider the changes within and between years regarding targeting in developing appropriate fishery selectivities, as well as proper blocking and/or weighting of these data.
- Conduct a methods review to consider how best to use data from the aerial survey. Consider incorporating the aerial survey as a minimum estimate of total abundance.