ECOSYSTEM FISHERY MANAGEMENT PLAN

In September 2010, the Pacific Fishery Management Council (Pacific Council) heard a report from the Ecosystem Plan Development Team (EPDT) on the goals, purpose and need, and the regulatory and geographic scope of a proposed ecosystem fishery management plan (EFMP). In its discussion following the presentation, the Council remained supportive of moving forward with an EFMP, reduced the range of potential plan formats by opting not to pursue an omnibus FMP that would combine all of the existing FMPs into a single plan, and recommended the west coast Exclusive Economic Zone as the initial geographic range. The Council reserved the option for the EFMP to have regulatory authority and requested additional analyses before identifying specific goals, needs, and authorities under the plan. The Council asked the EPDT to review the Council's four FMPs to identify existing ecosystem-based principles and common management needs that could benefit from a coordinated, overarching EFMP framework and to provide background for a future discussion of the EFMP's regulatory authority. The Council also affirmed their guidance for regular informational updates on science in support of ecosystem-based management and the status of the California Current Ecosystem (CCE), as permitted by Council meeting agenda scheduling.

In November, the Council heard from Dr. Patricia Livingston, the Director of the Resource Ecology and Fisheries Management Division at the Alaska Fisheries Science Center and Chair of the North Pacific Fishery Management Council's (North Pacific Council) Scientific and Statistical Committee about initiatives to integrate ecosystem approaches within the Alaska fishery management process. Dr. Livingston provided an overview of North Pacific Council efforts to prevent overfishing, promote sustainable fisheries and communities, avoid impacts prohibited species, preserve the food web, and reduce habitat impacts through the incorporation of ecosystem-based management objectives. Trends in ecosystem indicators (i.e. population trends of apex predators and forage species) and fishing impacts on the ecosystem (i.e. total catch, effort, and discards) are reported in ecosystem considerations sections annual Stock Assessment and Fishery Evaluation documents.

The National Oceanic and Atmospheric Administration (NOAA) has been working on an initiative to incorporate incorporating ecosystem principles in ocean and coastal resource management. An integrated ecosystem assessment (IEA) is a synthesis and quantitative analysis of information on relevant natural and socioeconomic factors in relation to specified ecosystem management goals and is an important element in the implementation of ecosystem approaches to management. NOAA has been working on an IEA focused on the west coast and the CCE and has published an information report to, in part, initiate dialogue and solicit input on future developed and application of the IEA (Agenda Item J.1.b, Attachment 1). At this meeting, Dr. John Stein, Acting Director of the Northwest Fisheries Science Center, and Dr. Cisco Werner, Director of the Southwest Fisheries Science will provide a brief overview of the west coast IEA initiative.

In response to Council guidance in September 2010, the EPDT has developed and will present a report that reviews the Council's four FMPs to identify existing ecosystem-based principles, common needs and potential benefits, and ways the developing ecosystem science can be brought into the Council management process (Agenda Item J.1.c, Attachment 1). The Ecosystem Advisory Subpanel (EAS) met on February 16, 2011 to review the report and develop its recommendations.

Regarding the purpose and need, the goals and objectives, and the regulatory scope of an EFMP, the EPDT and EAS reports from the September 2010 Council meeting are still relevant and serve as a useful reference for March. Specific to the Council's guidance to further explore the EFMP's regulatory authority, Chapter 5 from the EPDTs' September 2010 report "*Ecosystem Fishery Management Planning for U.S. West Coast Fisheries*" (September 2010, Agenda Item H.1.b, Attachment 1) is included for reference and the entire report is included on the March 2011 Briefing Book CD (Agenda Item J.1.c, Attachment 2). All reference materials from the Council's September 2010 session on this topic are posted on the Council web page. At this meeting the Council is tasked with reviewing new reports and recommendations of its Advisory Bodies and providing additional guidance on continued development of an EFMP.

Council Task:

1. **Review and comment on the EPDT report, *Discussion Document: Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process.***
2. **Provide guidance on the needs, goals, and objectives of the EFMP.**
3. **Provide guidance on the format and regulatory scope of the initial EFMP.**
4. **Provide feedback to NOAA on the west coast IEA.**
5. **Provide guidance and tasks on the next steps, future work, and schedule on EFMP development.**

Reference Materials:

1. Agenda Item J.1.b, Attachment 1: February 10, 2011 Cover Letter and IEA Executive Summary from Dr. John Stein and Dr. Cisco Werner.
2. Agenda Item J.1.c, Attachment 1: *Discussion Document: Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process.*
3. Agenda Item J.1.c, Attachment 2: Chapter 5 Excerpt from the September 2010 EPDT Report: *Ecosystem Fishery Management Planning for U.S West Coast Fisheries* (**full document available on the Council web page and the March 2011 Briefing Book CD**).
4. Agenda Item J.1.c, Supplemental EPDT Report.
5. Agenda Item J.1.d, Supplemental EAS Report.
6. Agenda Item J.1.e, Public Comment.

Agenda Order:

a. Agenda Item Overview — Mike Burner
b. Integrated Ecosystem Assessments — John Stein, Cisco Werner
c. Report and Recommendations of the Ecosystem Plan Development Team (EPDT) — Yvonne deReynier
d. Reports and Comments of Advisory Bodies and Management Entities
e. Public Comment
f. Council Discussion

PFMC
02/14/11

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112-2097

February 10, 2011

Council Members,

Attached are the initial results of the first California Current Integrated Ecosystem Assessment (CCIEA) and an overview of the IEA process and products. The goals of presenting this information to the Council are to familiarize members with NOAA's work to date on IEAs, further the dialogue with the Council and EPDT on the utility and application of an IEA, seek your input on our initial products, and get your views on moving the CCIEA forward so that is a valuable strategic tool for the Council and other natural resource managers on the coast.

To inform our discussion, we have provided two documents describing the 2010 CCIEA process and research accomplishments during its first year:

1) A pre-release draft of the executive summary glossy document (attached)
2) A 2010 status report on the health of the California Current (400 pgs, available here: www.nwfsc.noaa.gov/publications/iea.pdf)

This year's effort focused primarily on developing the structural framework for the CCIEA, compiling key data sets for assessing the status of the California Current, and identifying useful status indicators for three CCIEA components that would inform current policy and management processes: Ecosystem Health, Fisheries, and Protected Species. Considerable effort was made in the selection of appropriate status indicators, which were then applied to ecosystem models to evaluate the status and recent trends of these components. Pilot management strategy evaluations (MSEs) were conducted to demonstrate how IEA ecosystem models can be used to evaluate management options of interest to managers.

The work accomplished by the NOAA IEA team this year, and presented in the attached documentation, integrates existing ecosystem datasets in a way that provides a richer understanding of how parts of the system will respond to various management approaches. The CCIEA is a work in progress as we continue to solidify the partnership, science, data, and modeling building blocks that will produce a robust IEA process and analysis. We look forward to working with the Council on this effort.

Proposed Council Engagement Timeline:
We would like to propose the following timeline for engagement with the Council:

March 2010 Meeting:	CCIEA team presents materials and presentation at the March PFMC meeting.
Late March 2010:	PFMC provides comments to the CCIEA team regarding IEA structure and a list of a few species to use as a pilot for a targeted IEA.
September 2010 Meeting:	CCIEA team presents status report for pilot species at September PFMC meeting.

Sincerely,

John Stein
Program Manager CCIEA
Acting Science & Research Director
Northwest Fisheries Science Center

and

Cisco Werner
Program Manager CCIEA
Science & Research Director
Southwest Fisheries Science Center

Preliminary
DRAFT 2 - For PFMC

Integrated Ecosystem Assessment

The Science Needed for a Healthy California Current

INTRODUCTION

The coastal areas of the United States are made up of diverse habitats and species that provide food, energy, recreation, aesthetic, spiritual, and economic benefits to coastal communities. Understanding marine systems and the processes that drive them is the first step to ensuring healthy oceans for the future. We need better scientific tools to accomplish this goal. The National Oceanic and Atmospheric Administration (NOAA) has developed a cutting edge new tool, Integrated Ecosystem Assessments (IEAs), to synthesize and analyze science knowledge and package it in a manner that informs management decisions. It will help managers understand the status and health of the oceans and how various management actions might influence its health. This document provides an overview of this new tool and the results of the pilot 2010 California Current IEA.

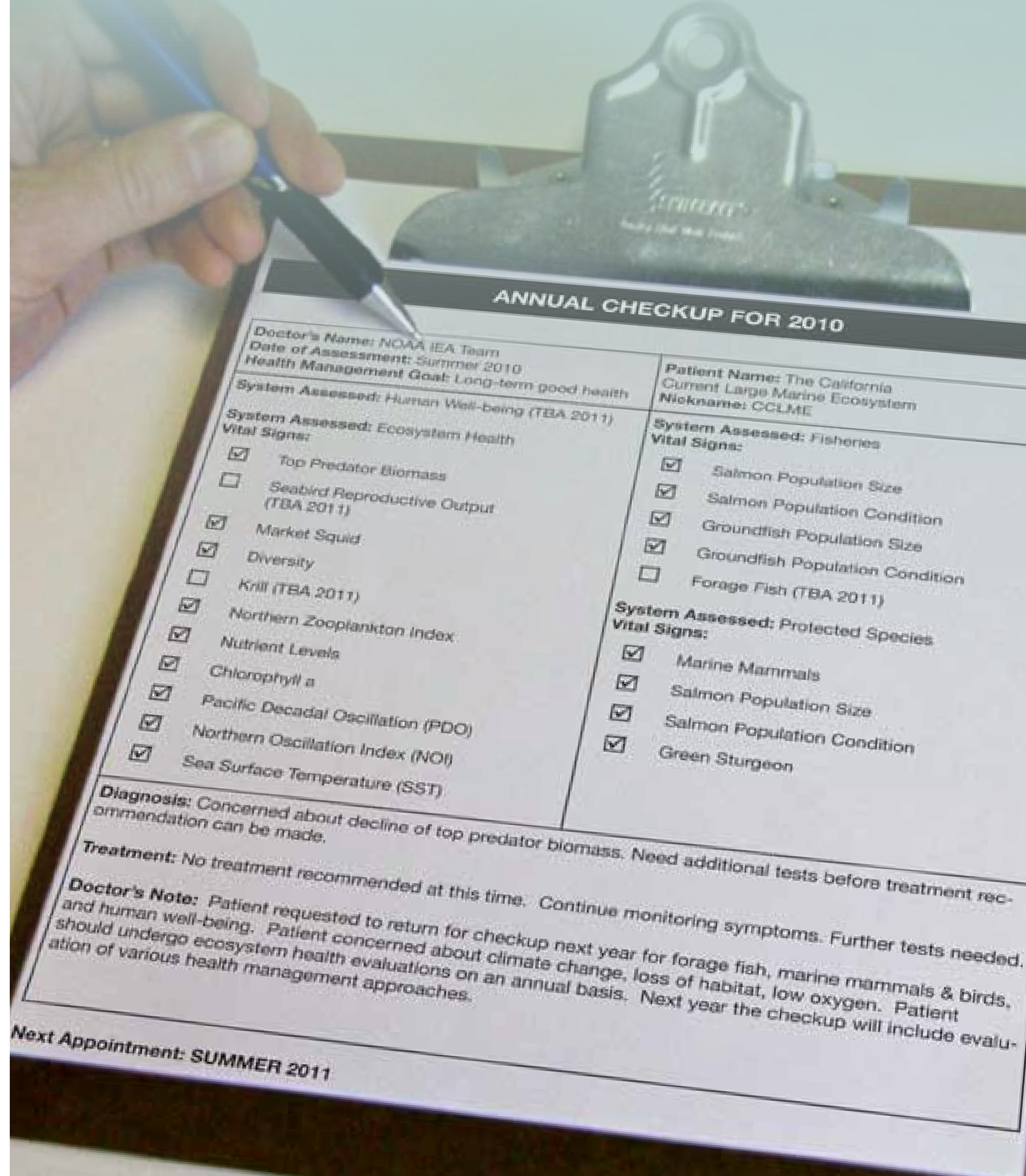
What is an ecosystem?

An ecosystem is a geographically specified system of organisms (including humans), the environment, and the physical processes that control its dynamics. The National Oceanic and Atmospheric Administration (NOAA) further defines the environment as “the biological, chemical, physical, and social conditions that surround organisms.”

Ecosystems come in many sizes, often with smaller distinct systems embedded within larger ones. For example, a kelp forest in Puget Sound, Washington can be thought of as a small ecosystem that is nested within a Puget Sound-wide ecosystem, which is in turn embedded within the larger ecosystem that includes the California Current.

At larger marine scales, ecosystems are often categorized as Large Marine Ecosystems (LMEs). Approximately 64 LMEs have been recognized globally, and 10 of these are located in U.S. waters. The boundaries of each LME are defined primarily by oceanographic and topographic features. All LMEs include multiple habitats such as sandy beaches, kelp forests, rocky shores, seagrass beds, or pelagic habitat. Individuals of a few marine species spend their entire life within a single habitat such as a kelp forest, but most species have larval or juvenile stages that are transported across habitats or ecosystems. Thus, even if the adult stage is sedentary, individuals may use multiple habitats within an LME over its lifespan.

In 2010 President Barack Obama announced the first-ever **National Ocean Policy.** NOAA’s contribution to implementing the new policy includes **developing science tools to support ocean resource management decisions. IEAs will be one of NOAA’s key tools** for informing the agency’s wide-ranging **responsibilities for conserving and managing the physical, biological, and human environment.**



What is the California Current ecosystem?

The California Current Large Marine Ecosystem (CCLME) is a large, dynamic and spatially heterogeneous marine environment in the eastern North Pacific Ocean along the west coast of North America from the continental shelf to associated upland watersheds. It spans nearly 3,000 km of latitude, from approximately the northern tip of Vancouver Island, British Columbia, Canada to Punta Eugenia, Baja California, Mexico.   Based on physical and biological attributes, the CCLME can be divided into three distinct “sub-ecosystems:

- southern British Columbia, Washington and Oregon to Cape Blanco;
- Cape Blanco, southern Oregon, to Point Conception, California; and
- southern California (south of Point Conception) and Baja California.

What is ecosystem-based management of the California Current?

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

Ecosystem-based management differs from management approaches that focus on a single species, sector, activity or concern by considering the cumulative impacts of different sectors on the whole ecosystem.

Specifically, ecosystem-based management:

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

INTEGRATED ECOSYSTEM ASSESSMENTS

What is an IEA?

Integrated ecosystem assessments (IEAs) are designed to fill a critical gap in achieving effective EBM. An IEA is a formal synthesis and quantitative analysis of all relevant scientific information – biological, geological, physical, economic, and social – in relation to ecosystem management objectives. The goal of an IEA is to fully understand the web of interactions in an ecosystem and forecast how changing environmental conditions and management actions affect the status of the ecosystem. It brings together citizens, industry representatives, scientists, and policy makers through formal processes to evaluate a range of policy and/or management actions on particularly difficult environmental problems.

IEAs are a tool, a product, and a process. IEAs are a **tool** that use statistical analysis and ecosystem modeling to integrate a range of social, economic, and natural science data and information. IEAs are a *product* for managers and stakeholders who rely on scientific support for policy and decision making, as well as for scientists who want to enhance their understanding of ecosystem dynamics. Finally, IEAs are a *process* that begins with involvement of stakeholders to address critical management and policy questions, moves to a quantitative assessment of ecosystem health, and concludes with an evaluation of management options. Through the tenets of adaptive management, the process reaches full circle to trigger an update of the assessment.

An IEA results in the following:

- Identification of a key management or policy question
- Assessment of status and trends of the ecosystem
- Assessment of the environmental, social, and economic causes and consequences of these trends
- Forecast of likely ecosystem status under a range of policy and/or management actions
- Forecast of ecosystem status under a different management strategies
- Identification of crucial gaps of knowledge of the ecosystem that will guide future research and data acquisition efforts.

Why IEAs?

Periodic evaluation of the health of ecosystems promotes the sustainable human use of those ecosystems. IEAs provide critical scientific information for a wide variety of stakeholders and agencies responsible for ecosystem management. IEAs serve as a forum for integration of knowledge and data collected by federal agencies, states, non-governmental organizations, and academic institutions. Importantly, IEAs take into account interactions among ecosystem components and management sectors, as well as cumulative impacts of a wide spectrum of ocean-use sectors. IEAs also identify critical data gaps, which, if filled, greatly reduce uncertainty and improve our ability to fully employ ecosystem approaches to management.

What is the process to conduct an IEA?

There is a five step process for conducting an IEA consisting of scoping, indicator identification and testing, risk analysis, risk analysis integration into the assessment process, and strategy evaluation.

Step 1: Scoping. Scoping initiates the process and begins with a review of existing documents and information. It also includes involvement of stakeholders, resource managers, and policy makers to identify the management objectives, articulate the ecosystem to be assessed, identify attributes of concern, and stressors. The goal of the scoping period is to move from broader goals to specific ecosystem objectives that management and policy makers need to consider.

Step 2: Develop and Test Indicators. Following the scoping process, researchers develop and test indicators that reflect chosen ecosystem attributes and stressors. Indicators are selected based on their relevance to management objectives, attributes of concern, and stressors.

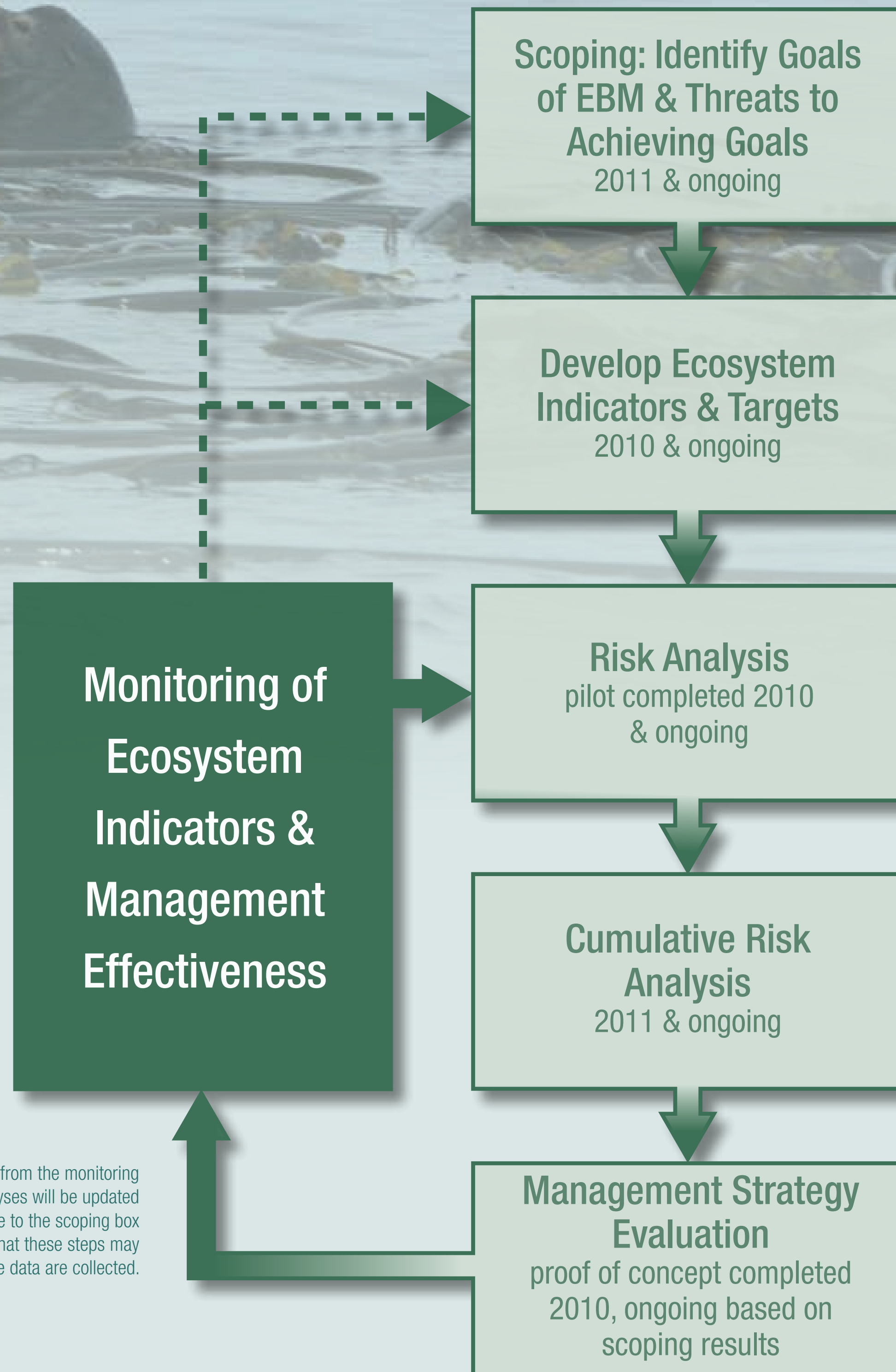
Step 3: Risk Analysis. Once indicators are chosen, an analysis is performed evaluating the risk to the indicators posed by human activities and natural processes. The goal of these risk analyses is to fully explore the susceptibility of an indicator to natural or human threats.

Step 4: Cumulative Risk Analysis. Results from the risk analysis for each ecosystem indicator are then integrated in the assessment phase of the IEA. The assessment quantifies the status of the ecosystem relative to historical status and prescribed targets. This step considers the status of a suite of indicators simultaneously.

Step 5: Strategy Evaluation. Based on results of the integrated risk analysis, researchers use conceptual and computer models to evaluate the potential of different management strategies to influence the status of natural and human systems. These assessment models serve as a formal Management Strategy Evaluation and estimate the predicted status of individual indicators and the ecosystem as a whole. Strategy evaluation serves to identify which policies and methods will meet management objectives and reveal the tradeoffs inherent in management options.

What are the outputs/products of an IEA?

The planned products of an IEA are peer-reviewed technical documents reporting the state of the ecosystem, an Executive Summary outreach document summarizing the results for partners and policy makers (this document), results of management strategy evaluations, and a dynamic web-based application that can be updated as new data becomes available.



A five step process for an IEA. The solid line from the monitoring box to the risk analysis box indicates that analyses will be updated as more data becomes available. The dotted line to the scoping box and the indicators and targets box indicate that these steps may need revisiting as more data are collected.

Real Application of an IEA: IEAs and Coastal and Marine Spatial Planning

Central to the new **National Ocean Policy** of the United States (Executive Order 13547) is a shift from single-sector/ single-species management toward comprehensive **Coastal and Marine Spatial Planning (CMSP).** CMSP provides an **objective, science-based,** and **transparent** way for society to determine how specific areas of the ocean are to be used and conserved on a region scale. IEAs are positioned to provide the **scientific synthesis** and **analysis** for CMSP.

Evaluation of Spatial Closures and Fisheries Gear Regulations in the Central California Coast

Scientists from the Northwest Fisheries Science Center worked collaboratively with resource managers at NOAA's regional offices and NOAA Sanctuaries to explore the potential influence of broad fisheries management options on both groundfish and ecosystem health. In addition to examining the status quo management, they explored the consequences of several gear switching and spatial management scenarios using the California Current Ecosystem model.

The results showed that no single scenario maximized all performance metrics. Any policy choice would involve trade offs between stakeholder groups and policy goals.

The scenarios also revealed strong trophic effects in the food web. For instance, 50% reductions in fishing led to declines in forage fish (sardines and anchovies) because as their predators increased in abundance they experienced greater predation. The decline in forage fish subsequently caused declines in marine mammals and birds.

These preliminary evaluations were not meant to evaluate specific policy options, but rather to illustrate a modeling technique that allows simultaneous consideration of multiple management alternatives that are relevant to numerous state, federal and private interests.

One of the important lessons learned from this application of IEAs to CMSP is that IEAs must explicitly consider both spatial extent and the temporal periods over which ecosystem dynamics and management issues occur. CMSP is, by definition, regional. However, a great deal of fisheries management occurs at the scale of the US EEZ but clearly influences what occurs at the regional scale of CMSP. IEAs provide the ability to forecast how large scale drivers (e.g. climate), and management (e.g. coast-wide fisheries regulations such as gear restrictions) interact with more regional spatial management or activities (e.g. MPAs, wave energy) to affect the status of key ecosystem components.

ELEMENTS OF THE CALIFORNIA CURRENT IEA

A comprehensive IEA of the California Current (CC IEA) is an enormous undertaking. NOAA's approach to complete this daunting task was to systematically decompose the California Current into a series of ecosystem components and ecosystem pressures that are of keen interest to resource managers, policy makers, researchers, and the public. Working with regional managers, we then selected a limited set of ecosystem-based management components and pressures to use in the initial phase of the CC IEA.

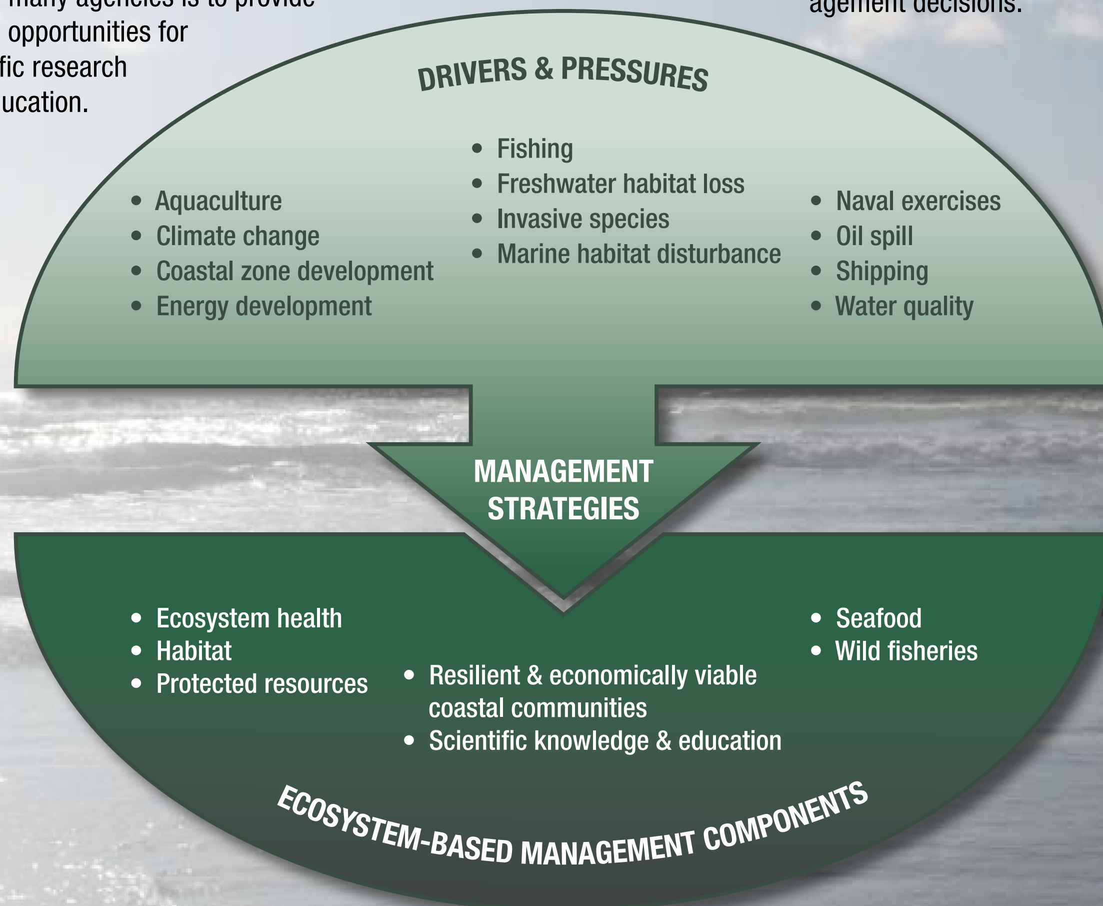
CC IEA Components

Any biological, physical, or human dimension that policy makers, managers, or citizens are trying to manage or conserve is considered a component of an IEA. For the purpose of the 2010 California Current IEA, researchers binned these into seven categories:

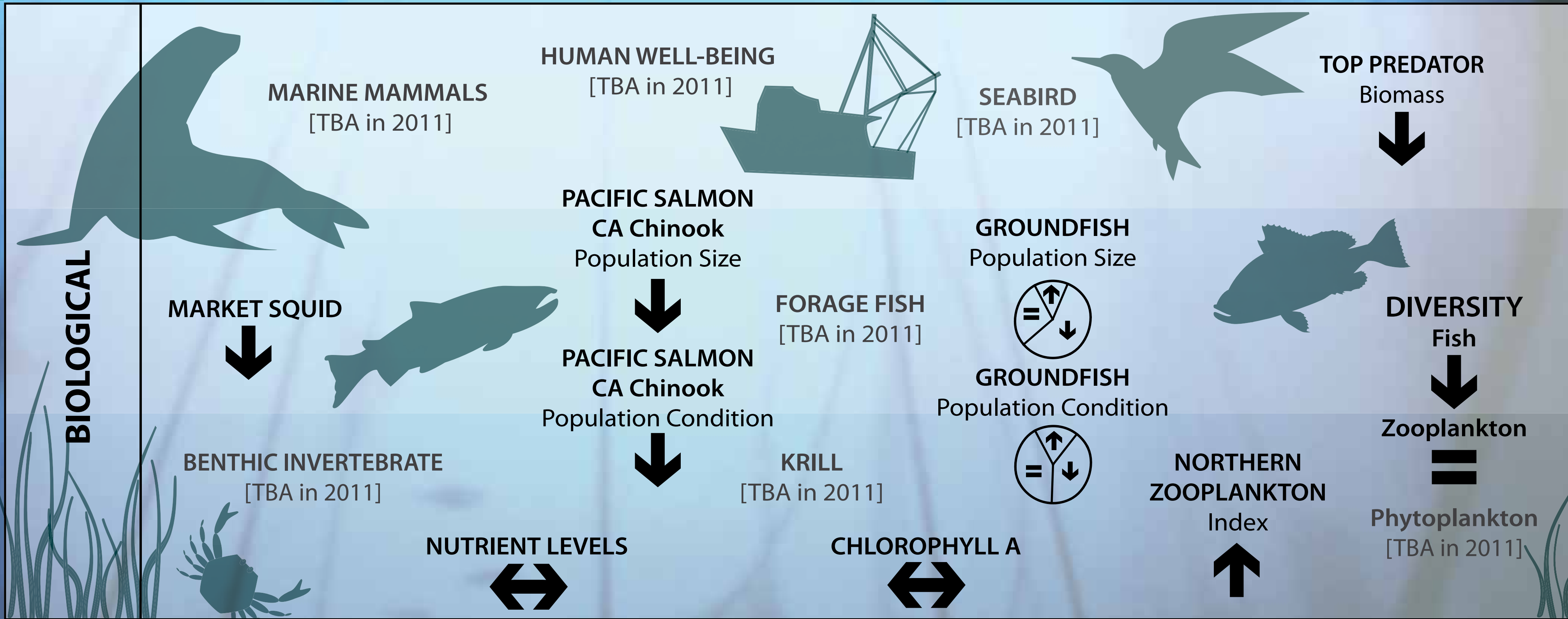
1. **Habitat –** including habitats both on the seafloor and in the water column
2. **Wild Fisheries –** centered on the condition of fishery stocks included in the Coastal Pelagic Species, Highly Migratory Species, Groundfish, and Salmon Fishery Management Plans
3. **Seafood –** distinct from fisheries, this component focuses on the consistent delivery of plentiful, safe seafood. Includes aquaculture and production hatcheries and focuses more on the provisioning of food for human consumption.
4. **Ecosystem Health –** refers to the structure and function of marine and coastal ecosystems and ecological communities.
5. **Resilient and Economically Viable Coastal Communities –** including social, economic, and cultural well-being and human health as it relates to the marine environment.
6. **Protected Resources –** species legally protected by such laws as US Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Act, among others.
7. **Scientific Knowledge and Education –** a distinct goal of many agencies is to provide unique opportunities for scientific research and education.

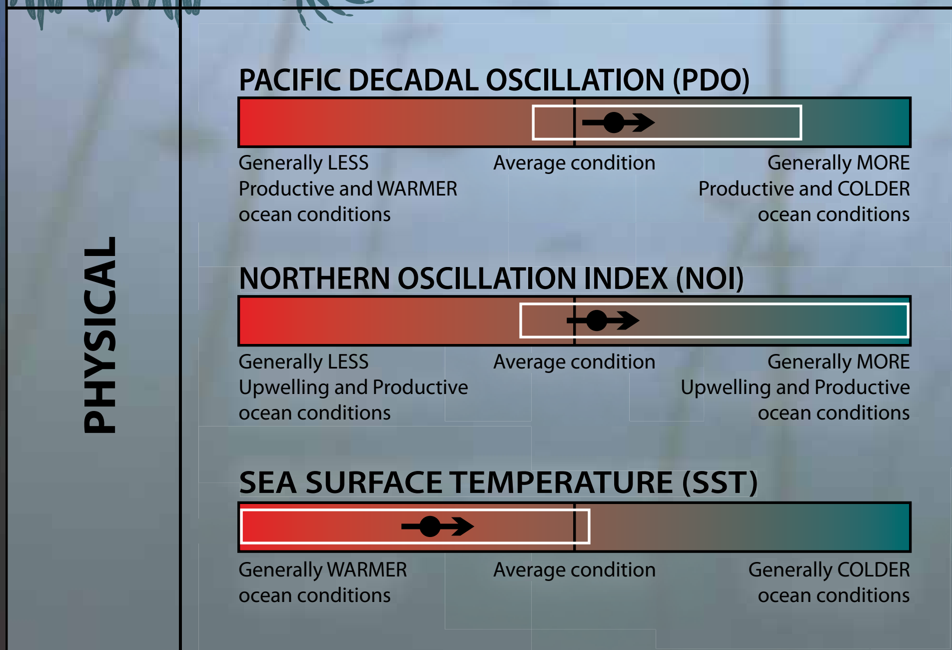
CC IEA Drivers and Pressures

Researchers also created a list of drivers and pressures, presented in the image nearby. Drivers are defined as factors that result in pressures that cause changes in the ecosystem. Both natural and anthropogenic factors such as climate variability and human population size were considered. While human driving forces can often be assessed and controlled, natural environmental changes cannot be controlled but must be accounted for in management decisions.



Status of the California Current Ecosystem at a Glance





This graphic provides a summary of the status of the California Current ecosystem 2005-2010 using key physical and biological indicators. The physical ocean indicators suggest that ocean productivity is better than average, with strong, seasonal upwelling bringing nutrients to surface waters to fuel the production of phytoplankton, captured here as chlorphyll A. Good ocean conditions are manifested in positive trends of northern (fat-rich) zooplankton. However, indicators of ecological processes higher in the food chain tend to show decreasing trends. This trend is true for population size and condition of pacific salmon, many groundfish, market squid, fish diversity, and top predator biomass. Additional biological indicators will be added in the 2011 CCLME IEA including marine mammals and birds, forage fish, and human well-being.

KEY

TBA = To Be Added

- Downward Trend
- Upward Trend
- No Trend
- Variable Coastwide
- 2010 Value & 5yr Trend
- Range from Last 5 Yrs

The ultimate aim of the California Current IEA is to fully understand the web of interactions that links drivers and pressures to EBM components and to forecast how changing environmental conditions and management actions affect the status of the ecosystem. For 2010, the IEA team chose four aspects of the suite of components: Ecosystem Health, Groundfish (representing Fisheries), Green Sturgeon and Salmon (representing Protected Resources). Given existing scientific tools and management needs, the team decided that addressing these components would have the greatest benefit to ongoing policy and management processes.

For the 2010 California Current IEA, the IEA team:

1. selected a limited set of scientifically credible indicators for each component listed below,
2. reported on status and trends of these indicators, and
3. explored how management options might affect the indicators through a management strategy evaluation process.

The following pages present the results of this work.

ECOSYSTEM HEALTH

What is Ecosystem Health?

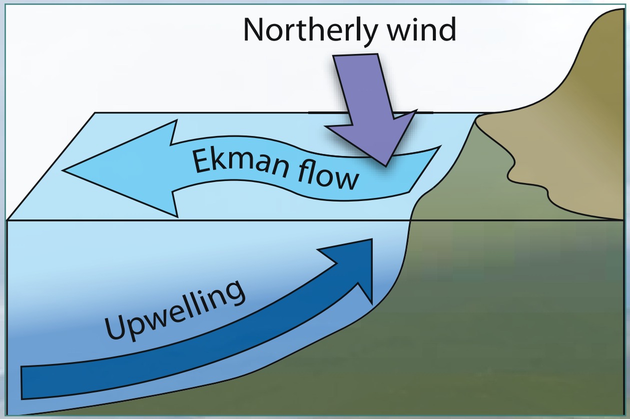
Just as the task of a physician is to assess and maintain the health of an individual, resource managers are charged with assessing and, when necessary, restoring 'ecosystem health'. However, defining 'ecosystem health' is more complex than this simple analogy because ecosystems are open and dynamic with loosely defined assemblages of species. Even so, this analogy has become part of the lexicon of Ecosystem-Based Management and resonates with stakeholders and the general public.

Key Attribute	Indicator	Status
Community composition	Top predator biomass	=
	Zooplankton species biomass anomaly	↑
	Taxonomic diversity	↓
Energetics & materialflows	Chlorophyll a concentration	*Varies spatially*
	Inorganic nutrient levels	=

Ecosystem Health Attributes and Indicators

To measure the health of the CCLME ecosystem for the 2010 CCLME IEA, the IEA team selected two key attributes representing the structure and function of the CCLME: Community Composition (structure) and Energetics and Material Flows (function).

The suite of indicators used to evaluate the status of each Ecosystem Health attribute are summarized in the table nearby. "Status" represents the trend in each indicator over the last five years of the dataset compared to the long-term trend of the entire dataset. Four of these indicators are described in further detail below.



Upwelling

Upwelling is directly related to productivity and ecosystem health in the CCLME. The strength and duration of upwelling in the CCLME is highly variable, and is driven by large-scale atmospheric pressure systems. The interaction between southerly winds and the water surface moves water offshore in the surface layer, and this water is replaced by cooler, saltier, nutrient-rich water upwelled from depths of greater than 50-100 m. The onset and duration of the upwelling season varies latitudinally, starting earlier and lasting longer in the southern CCLME.

The timing, duration and intensity of coastal upwelling in the CCLME have been highly variable the past five years. Upwelling was delayed in 2005, leading to disruptions in ecosystem productivity and structure. Relatively intense upwelling prevailed in 2006-08, but the onset of upwelling was again delayed in 2010.

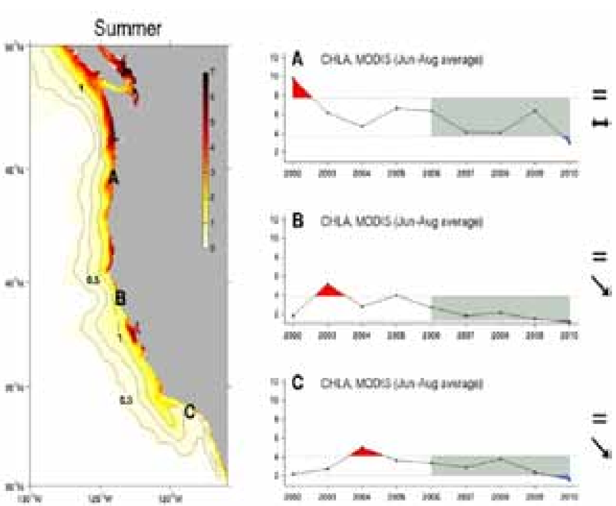
Ecosystem Health continued

Sea Surface Temperature and Pacific Decadal Oscillation

Since 2005, summer SST has declined in central California approximately 1°C, partly as a result of strong coastal upwelling. The Pacific Decadal Oscillation (PDO), a climate signal in North Pacific SST that affects biological productivity in the northeast Pacific, has remained negative for most of the past 11 years, indicating cool nearshore waters and high productivity. The recent development of a tropical La Niña suggests that cool, productive conditions will persist through mid-2011.

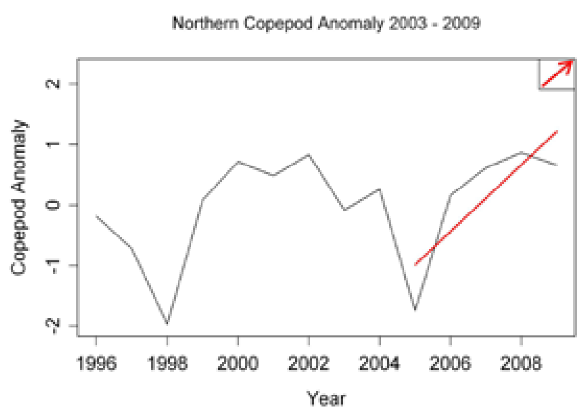
Chlorophyll a

The amount of primary productivity, measured as total chlorophyll-a per unit area (chl-a), is an important baseline metric of marine food webs. In the CCLME, there is a high degree of spatial variation in chl-a values. Spatial patterns show chl-a values are greater near the coast, particularly in estuaries such as San Francisco Bay, Puget Sound, and the mouth of the Columbia River. In 2010, several locations had low levels of chl-a during the summer, and some locations have showed a declining trend in chl-a during the summer over the past five years (locations B & C on the map).



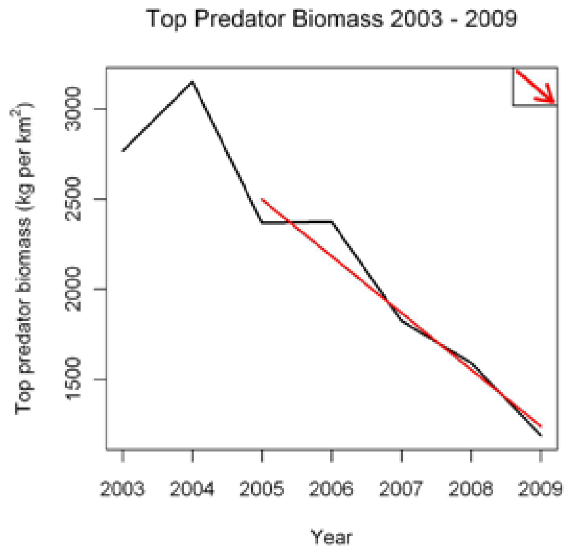
Northern Zooplankton Index

The Northern Zooplankton Index (also known as the northern copepod biomass anomaly) measures whether fat rich zooplankton species from northern waters are more or less common than normal off of the Oregon coast. It is responsive to climate effects such as El Niño or Pacific Decadal Oscillation and indicates change in the structure of the zooplankton community. Over the last five years, the index shows an increasing trend, suggesting positive conditions at the base of the food web because northern species are typically rich in fats and other nutrients.



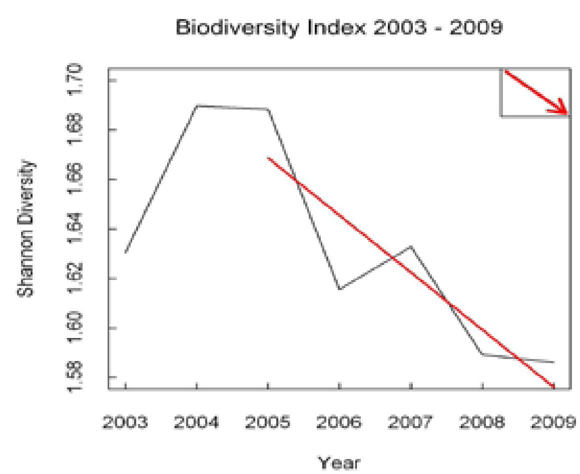
Biodiversity

The stability and resilience of an ecosystem can be correlated with measures of species or taxonomic diversity. Community-level processes may be more stable when there is higher species or taxonomic diversity in ecosystems perturbed by pressures such as climate change, disease, or fishing. In the CCLME, the diversity of groundfish within the West Coast Bottom Trawl Survey has declined substantially over the last five-year sampling period (2005 – 2009). This suggests a change in the community composition of groundfish across the CCLME.



Top Predator Biomass

The abundance of top predators in an ecosystem is often related to the structure and function of an ecological community. Removing top predators from an ecosystem may result in a trophic cascade in which prey species increase in numbers because they are released from predatory control. In some instances, this process cascades to the lowest of trophic levels. In addition to ecological functions, top predators are of great societal interest. Using data collected by the West Coast Bottom Trawl Survey, top predator biomass has declined sharply across the entire dataset from 2003 - 2009.



Groundfish are a significant component of the California Current ecosystem because of their ecological importance and high value as recreational and commercial fisheries. Data for monitoring groundfish trends comes from the U.S. Westcoast Bottom Trawl Survey of Groundfish Resources conducted by the Northwest Fisheries Science Center. Analyses examined a subset of fourteen species representing different functional groups of fishes from various habitats and trophic guilds.

Population Size

Population size (the number of individuals per km2 in a trawl survey) is a useful indicator of trends in the population and is also a metric of conservation importance that is easy to understand in the policy arena. Eight of the 14 species showed declines in population size from 2005-2009 relative to the longterm mean (functional group in parenthesis):

- Rex sole (small flatfishes)
- chilipepper (midwater rockfishes)
- spiny dogfish (small demersal sharks)
- shortbelly rockfish
- white croaker (miscellaeneous nearshore demersal fishes)
- stripetail rockfish (shallow small rockfish)
- canary rockfish
- longnose skate (skates and rays)

Four species had stable population trends:

- splitnose rockfish (deep small rockfishes)
- darkblotched rockfishes (deep large rockfish)
- red strip rockfish (shallow large rockfish)
- yelloweye rockfish.

Only lingcod (large demersal predators) and arrowtooth flounder (large flat fishes) increased in population.

Size Structure

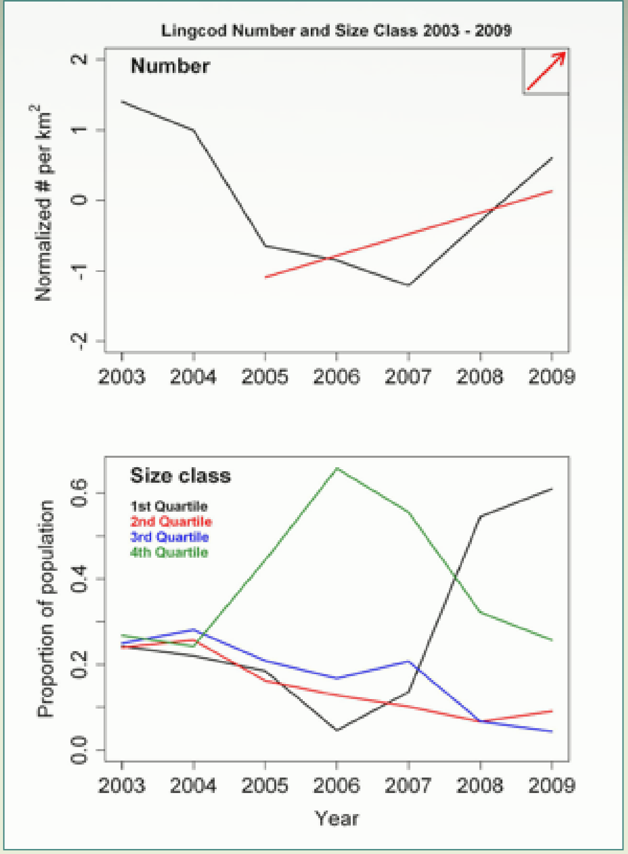
Size structure of a population is an indicator of population condition. The mean size of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a simple indicator to evaluate the overall effects of fishing on an ecosystem. Size-based metrics respond to fishing impacts because body size determines the vulnerability of individuals, populations, and communities.

All species except for shortbelly rockfish showed some variation in population size structure. Lingcod and arrowtooth flounder, which both showed increases in population size over the last five years, also showed increases in the proportion of the population of small fishes indicating growing populations with strong recent recruitment. Other species like species like stripetail rockfish and redstripe rockfish had decreasing population sizes with a increasing proportion of individuals in the larger size classes suggesting an aging and declining population.

Spatial Structure

The spatial structure of a population is a measure of a species' geographic range and distribution. Changes in spatial distribution can be caused by responses to climate or exploitation so further research is necessary to disentangle the causes.

Several species showed changes in spatial distribution in 2009 relative to the full time series. Arrow tooth flounder, splitnose rockfish, spiny dogfish and canary rockfish all showed substantial (>150 km) shifts to the south with the center of abundance for canary shifting over 1000 km and its biomass more than 500 m to the south. Rex sole, longnose skate and yelloweye showed smaller shifts to the north. For Canary rockfishes, the decline in population size, decline in the proportion of large individuals in the population and the strong southern shift suggest strong ecosystem impacts in more northerly areas.



(a) Number and (b) size trends for lingcod, Ophiodon elaongatus, in the California Current from 34-48o latitude and 50-350 m bottom depth. The trend for numbers has been normalized by subtracting the mean and dividing by the standard deviation (sd). Red line indicates the trend over the last five years of the data. The five year trend showed an increase in numbers greater than one sd of the full time series. For the size class data, size class limits were set based on quartiles 2003. The increase in total numbers and small size classes suggest a rebuilding population with a strong recruitment pulse.

Fisheries: Groundfish continued

			Size Structure - Body Size				Spatial Structure	
Functional Group	**Representative Species**	**number**	**sm**	**med**	**lg**	**xlg**	**number**	**biomass**
Large Flatfishes	Arrowtooth Flounder	+	+	-	-	=	S	=
Misc Nearshore Demersal Fish	White Croaker	-						
Small Flatfishes	Rex Sole	-	-	=	+	+	N	=
Large Demersal Predators	Lingcod	+	+	-	-	-	=	S
Skates and Rays	Longnose Skate	-	-	+	+	=	N	=
Deep Large Rockfishes	Darkblotched Rockfish	=	=	=	-	=	=	=
Deep Small Rockfishes	Splitnose Rockfish	=	=	=	-	+	S	S
Midwater Rockfishes	Chilipepper	-	=	=	-	=	=	=
Shortbelly	Shortbelly Rockfish	-	=	=	=	=		
Canary	Canary Rockfish	-	+	=	-	-	S	S
Shallow Large Rockfish	Redstripe Rockfish	=	=	-	+	=		
Yelloweye	Yelloweye Rockfish	=	-	-	=	+	N	N
Shallow Small Rockfishes	Stripetail Rockfish	-	=	-	=	+	=	=
Small Demersal Sharks	Spiny Dogfish	-					S	S

Changes in number, size, and spatial distribution trends for 14 species and 14 functional groups. Numbers were calculated as number per km2. Number and size structure trends were considered to show changes if change in the 5-year trend was greater than one standard deviation of the full time series. Changes in spatial distribution were quantified as the shift of species in 2009 relative to the full 2003-2009 time series.

Protected Species: Salmon

For the 2010 CCLME IEA the team emphasized two of the approximately 50 genetically distinct groups of West Coast salmon and steelhead. Roughly half of those groups have been listed as endangered or threatened under the Endangered Species Act. In future years the CCLME IEA will be expanded to include assessments of as many West Coast salmon groups as data allows.

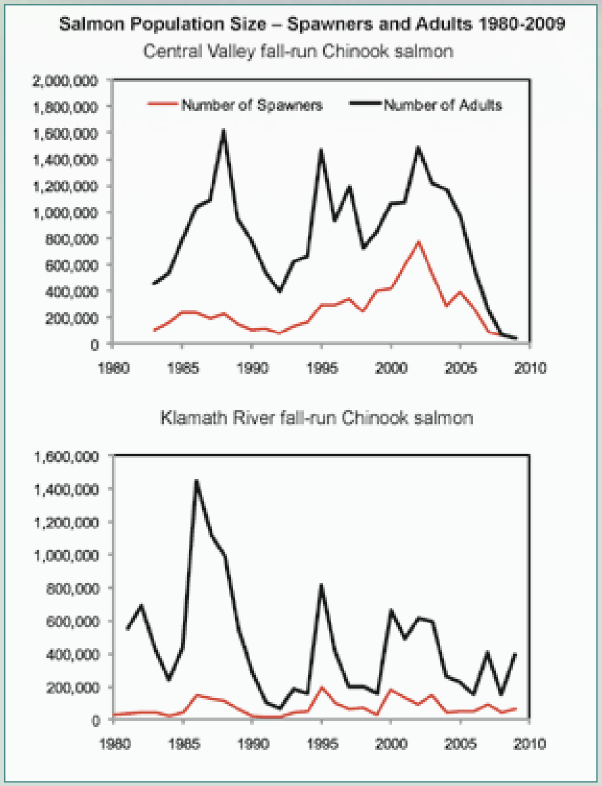
Chinook salmon and coho salmon make up the vast proportion of salmon abundance within the CCLME. Salmon spawn in freshwaters where their eggs and juveniles spend up to a year before migrating to sea. The ocean conditions at the time of sea entry are extremely important to the survival and ultimate abundance of fish to the fishery and later spawning population. Chinook salmon generally spend 2 to 5 years at sea before returning to their natal stream to spawn. Coho spend approximately 1.5 years at sea. Data for monitoring salmon trends comes from trawl surveys conducted by the NOAA's Northwest and Southwest Fisheries Science Centers and estimates of catch and spawning numbers from state and federal agencies.

The viability of a salmon population is dependent, in part, on maintaining behavioral diversity in the population. There are four Sacramento River, CA Chinook salmon runs (i.e. stocks) which express different behavioral patterns in their timing of return and spawning and spawning habitat selection. These runs are referred to by the season they return to freshwater to spawn: fall, late-fall, winter, spring. Such diversity acts to bet-hedge against environmental variability. Currently, the fall-runs make up the largest number of Chinook salmon in the California catch.

Key Attribute	Indicator	Status	
		Klamath River Chinook	Sacramento River Chinook
Population size	Number of spawners	=	↓
	Hatchery proportion	↓	=
	Population growth rate	=	↓
Population condition	Age structure	=	*Not enough data*

Population size: number of spawners

Sacramento River fall-run Chinook salmon abundance has varied over the years with greatest abundance in 1988, 1995, and 2002 (Figure X). As a result of decreased fishing pressures the spawning abundance has had an increasing trend, though the values have plummeted since 2002 (Figure X). This plummet has been attributed, in part, to poor ocean conditions. There was also a near complete reproductive failure for the 2004 and 2005 brood years (Figure X). As a result there were exceptionally low numbers of spawners for the fall-run California Chinook salmon in 2007-2009. By comparison, the Klamath River Chinook salmon fall-run population appears to have similarly variable abundance over the last thirty years with peak abundances occurring during 1986, 1995, and 2000-2003. Unlike Sacramento River fall-run Chinook salmon, the spawning abundance time series for the Klamath River fall-run Chinook salmon demonstrates no particular trend (Figure X).

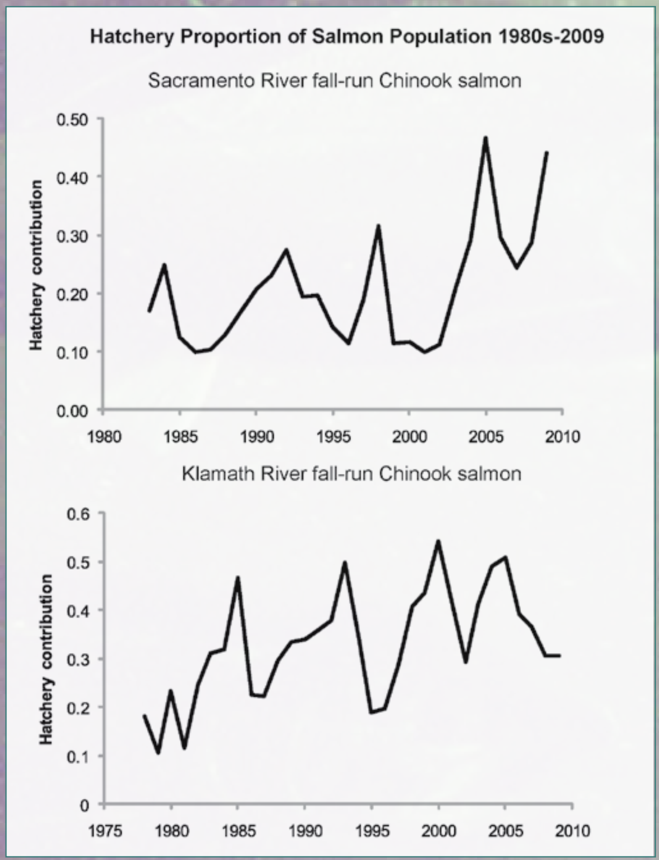


Total abundance of adults (black) and spawning escapement (red) for Central Valley populations and Klamath River fall run populations of Chinook salmon. Data represents total returns to spawning grounds (hatchery+natural).

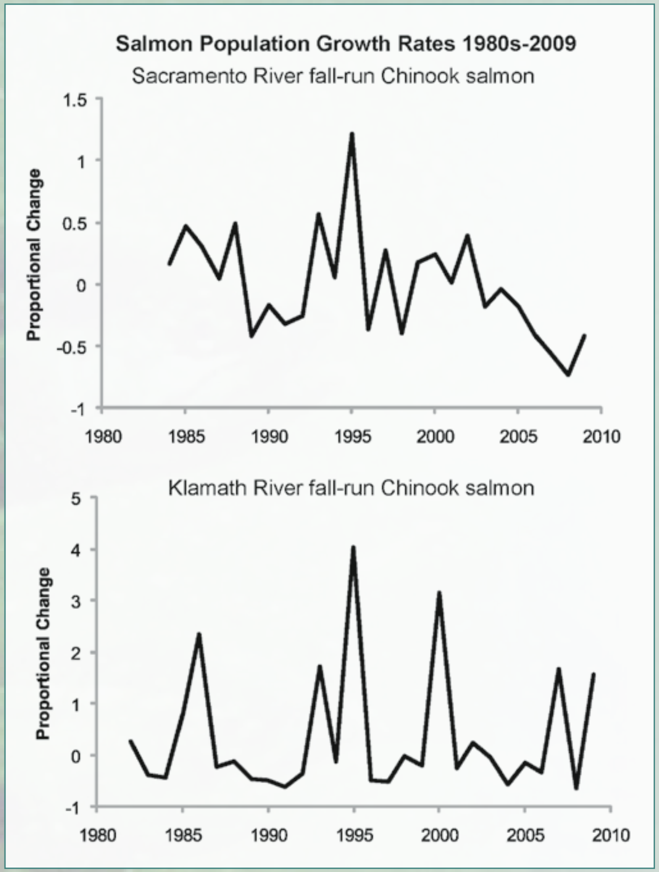
Protected Species: Salmon continued

Population size: hatchery proportion

The timing of certain behavioral characteristics, such as emigration to sea, migration along the coast, and return timing, may also vary within each run type and across years. For instance, fall-run Chinook salmon express a degree of behavioral variability within and between years. However, the behavioral characteristics of hatchery fall-run Chinook are relatively homogenized. Therefore, if hatchery production overwhelms natural production, we run the risk of stock collapse much like that observed for the Sacramento River fall-run Chinook salmon. The proportion of Sacramento River fall-run Chinook salmon spawning in hatcheries has increased to its greatest values during the last five years (Figure X; note: while estimates are substantially greater than previous years there is no observed trend 2005-2010). Fall-run Chinook salmon from the Klamath River did not experience any particular trend in hatchery contribution (Figure X).



Shown are the proportions of Chinook salmon from the Sacramento River, CA fall-run and Klamath River fall-run Chinook salmon stocks that spawned in hatcheries. This should be considered only an index of hatchery contribution as estimates of hatchery fish spawning in natural areas are not available.



Population growth rates for Sacramento River, Ca fall-run Chinook salmon (the largest component of the Central Valley Chinook fall runs) and Klamath River fall-run Chinook salmon. The growth rate for the Sacramento River fall run was calculated as the proportional change in the total adult abundance (= spawners + all harvested) between successive years. The growth rate of the Klamath River fall run was calculated based on the ocean abundance of Age 3 Klamath River fall-run fish.

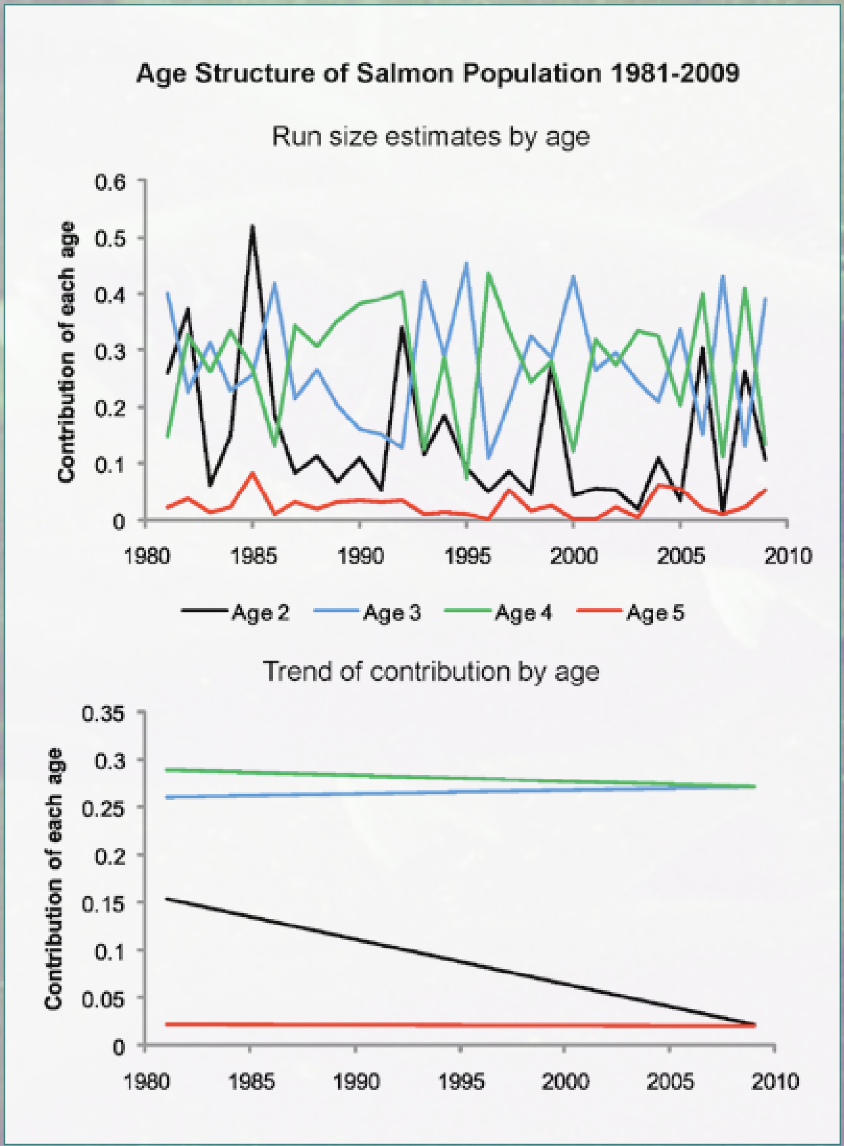
Population Size: growth rate

Sacramento River and Klamath River fall-run Chinook salmon population growth rates do not show the same trends. The Sacramento River fall-run Chinook salmon population has shown an average 15% decline in population growth rate over the last ten years with an exceptional 48% decline in the last five years (Figure X). Not shown in the figure, Sacramento winter-run and spring-run Chinook salmon have also experienced precipitous declines in growth rates over the last five years (38% and 61% respectively). Unlike the Sacramento River fall-run Chinook salmon, Klamath River fall-run Chinook salmon did not experience any particularly trend in growth rates over the last five to ten years (Figure X). Instead, growth rate was relatively stable but punctuated by extremely productive years.

Population Condition: age structure

Age structure of a population is a critical characteristic that allows Chinook salmon to naturally mitigate year-to-year environmental variability. Older, larger Chinook produce more and larger eggs. Therefore, they produce a brood which may contribute proportionally more offspring than broods from younger, smaller fish. However, diversity in age that also includes younger fish helps a population accommodate variability in the environment. If mortality on any given cohort is great, there is benefit to having more young spawners.

The Sacramento River Chinook salmon stocks lack age-specific data to evaluate age structure of the population. For Klamath River Chinook, examination of the proportional contribution of each age to spawning stock demonstrates that the largest fraction of the spawning population is Age 3 and 4 fish and there has been a declining fraction of Age 2 spawners (Figure X). However, the negative trend for Age 2 fish seems to be driven, in large part, by a few extraordinary years. Chinook salmon age structure appears relatively stable across the last thirty years; no trends are apparent in the age structure. However, this evaluation of Klamath River Chinook salmon should not be extrapolated to Sacramento River Chinook salmon. It is likely that Chinook salmon from the Sacramento River did demonstrate a change in age structure in recent years due to several consecutive years of poor early survival.



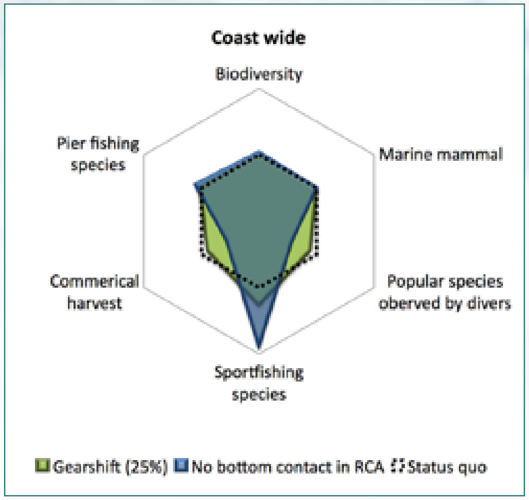
Shown are the time series of run size estimates for each age of returning Klamath River fall-run Chinook salmon in given years (upper plot). Specifically, this figure represents the age structure of the Klamath River fall-run population during any given year. As indicated by the lower plot, there was only a trend in the Age 2 group. Namely, the proportion of fish returning to spawn at Age 2 has declined. However, examination of the time series (upper plot) shows that the trend is likely derived from a few years (e.g. 1982 and 1985) that represented enormous numbers of Age 2 fish returns.

Management Strategy Evaluation

IEAs can be used to **test approaches to ecosystem management** by incorporating IEA-generated information into **ecosystem models,** such as the **Atlantis Model** for the California Current.

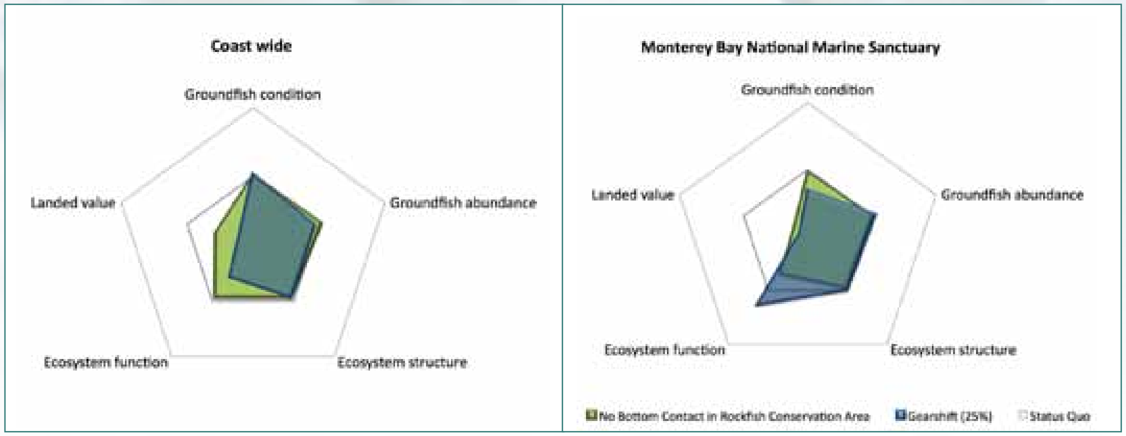
In 2010 the NOAA IEA team worked with fishery managers at NOAA's regional offices and staff at NOAA Sanctuaries to conduct a proof of concept test using IEA findings to evaluate management scenarios. They examined the influence of broad fishery management options on groundfish and ecosystem health. They explored status quo management as well as 20-year projections of several gear switching and spatial management scenarios, using the Atlantis ecosystem model (see side bar). These scenarios involved changes to Rockfish Conservation Areas, Essential Fish Habitat, the amount of trawling relative to other gears, and overall levels of fishing effort, both within Monterey Bay National Marine Sanctuary and coast-wide.

The team evaluated the scenarios based on ecological and economic performance. For groundfish, performance metrics included biomass, age structure, and population trends of both harvested groundfish and unharvested species. For ecosystem health, performance metrics included zooplankton abundance, primary production, top predators, and the number of juvenile seabirds.



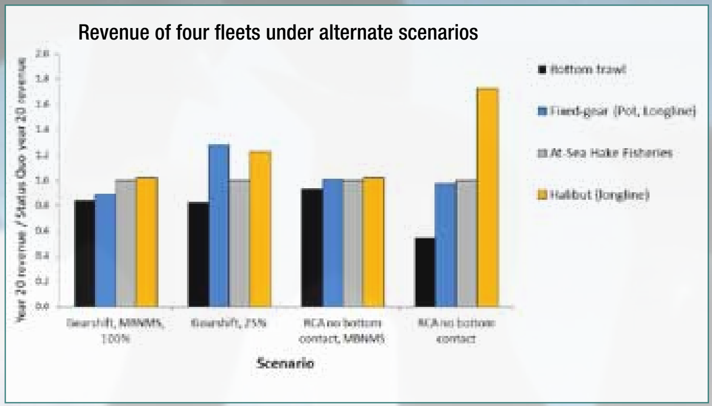
Preliminary outcomes of alternative management scenario evaluation proof of concept

Of the scenarios that involved large-scale management changes, no single scenario maximized all performance metrics. Any policy choice would involve trade offs between stakeholder groups and policy goals. When judged at a coast-wide scale, large management changes were needed to substantially change performance from status quo. When spatial management was imposed in specific areas, such as the Monterey Bay Sanctuary, any coast-wide impacts that did occur tended to involve local interactions that were difficult to predict based solely on fishing patterns. On the other hand, if we measured the performance of the scenarios at the local scale (i.e. only within the Sanctuary), local gear shift and spatial managements options did lead to increases in ecosystem function and health and landed value. Economic costs within the Sanctuary that were associated with some of the improvements in ecological performance were highest when the management actions only involved the sanctuary, and were minimal when the management action occurred at a coast-wide scale.



Comparison of the Atlantis model results when run coastwide and in a specific area, the Monterey Bay National Marine Sanctuary.

This exercise demonstrates the value of IEA information and management strategy evaluation in illuminating the tradeoffs in management options. In future years the IEA team will conduct additional strategy evaluations based on input collected through stakeholder and partner scoping.



The scenarios involved winners and losers among both fleets and species. For instance, there were direct impacts of the scenarios on fleets, such trawl and longline+pot fleets, as well as indirect effects such as the halibut longline fishery that gained revenue when trawl effort declined.

California Current Atlantis Model (CCAM): A decision support tool for integrated ecosystem assessment and marine spatial planning

IEA researchers use ecosystem models to assess the performance of management strategies. Ecosystem models allow them to predict how key aspects of the ecosystem will change under different management scenarios.

Background

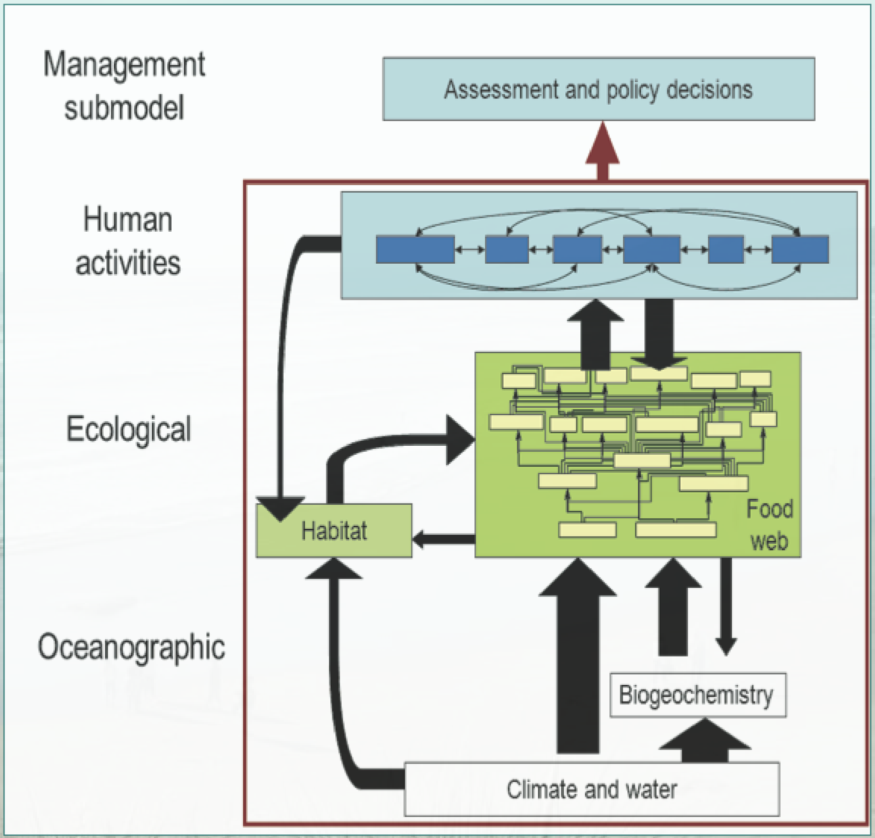
The California Current Atlantis Model (CCAM) is a decision support tool used in the California Current IEA that is built on the Atlantis ecosystem modeling framework. Worldwide, thirteen Atlantis models are in use, and several others are in development. The FAO recently named Atlantis the best ecosystem model available for marine resource management. CCAM simulates the ecosystem and allows researchers to forecast the ecosystem impacts of a wide range of human activities (e.g., fishing, pollution) or natural perturbations (e.g. climate variability). CCAM divides the coast into discrete spatial units so that evaluation of spatial management options is available.

Structure of the Model

Just like ecosystems are comprised of many smaller interrelated processes and nested ecosystems, the CCAM is made up of many sub-models representing ecosystem dynamics. These sub-models simulate oceanographic processes, biogeochemical factors driving primary production, and food web relations among species groups. The modular structure allows users to construct separate, site-specific models. The user can specify the level of complexity needed from few functional groups with simple foodweb interactions to complex models with multiple fishing fleets and management options. CCAM simulates an area from Point Conception, California north to the US-Canadian border, and from the shoreline west to a depth of 2400 meters. The area is divided into 82 regions, each consisting of up to 7 depth layers.

Elements of the Model

The core of CCAM is an ecological module which follows nutrients through 62 species groups in the system (5 bacteria/detritus, 8 plankton/algae, 14 invertebrate, 35 vertebrate). This module simulates feeding relationships and ecological processes including consumption, production, migration, predation, recruitment, habitat dependence and mortality. The ecological processes are repeated in each of the depth layers within each region. An oceanographic model simulates fluxes of water and nutrients driven by temperature and salinity. CCAM represents persistent oceanographic processes such as a latitudinal stratification of salinity and temperature, and ocean circulation. A human impacts submodel currently simulates multiple fishing fleets. Future work will address water quality and wave energy. This module considers both target and non-target species, bycatch, and habitat effects. The economic consequences of different management scenarios is evaluated at the port level using information about potential revenue, costs, as well as fishing effort dynamics.



CALIFORNIA CURRENT IEA: NEXT STEPS

As the California Current IEA matures it will be refined, expanded and improved over time as new information, analysis techniques, and management needs arise. In the near-term scientists and members of the IEA team plan to collect and incorporate additional data, identify and test new ecosystem indicators, develop new analytical methods, and enhance risk assessments. Future plans include expanding coverage of drivers and pressures to include analyses of the effects of fishing, wave energy, habitat alteration, water quality and climate. A brand new component, Resilient and Economically Viable Economically Coastal Communities, will be added to address socioeconomic attributes.

One important step for the CC IEA is to conduct scoping through public forums to incorporate stakeholder input into these analyses. In 2011 and 2012 a series of scoping workshops will be held in coastal communities in California, Oregon, and Washington to elicit stakeholder input for the IEA process. These workshops will allow the IEA team to gain insight about what kind of ecosystem information is important to stakeholders, understand how stakeholders use ecosystem information and why, and help define appropriate ecosystem targets and management scenarios for the IEA. In addition, expanding in-reach and outreach efforts is needed to communicate the progress and benefits of the IEA.

To learn more about IEAs, visit: http://www.st.nmfs.noaa.gov/st7/iea/

LIST OF PARTNERS

NOAA Offices Supporting the IEA Effort

- Office of Ocean and Atmospheric Research
- Northwest Fisheries Science Center
- Southwest Fisheries Science Center
- National Sea Grant Office
- National Ocean Service
- National Marine Fisheries Service Northwest Regional Office
- National Marine Fisheries Service Southwest Regional Office
- Office of National Marine Sanctuaries
- National Coastal Data Development Center

Members of the NOAA California Current IEA Action Team

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- Kathi Lefebvre, Northwest Fisheries Science Center
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- Rikki Dunsmore,Monterey Bay National Marine Sanctuary
- Churchill Grimes, Southwest Fisheries Science Center
- Joshua Lindsay, NMFS Southwest Regional Office
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- Elizabeth Petras, NMFS Southwest Regional Office
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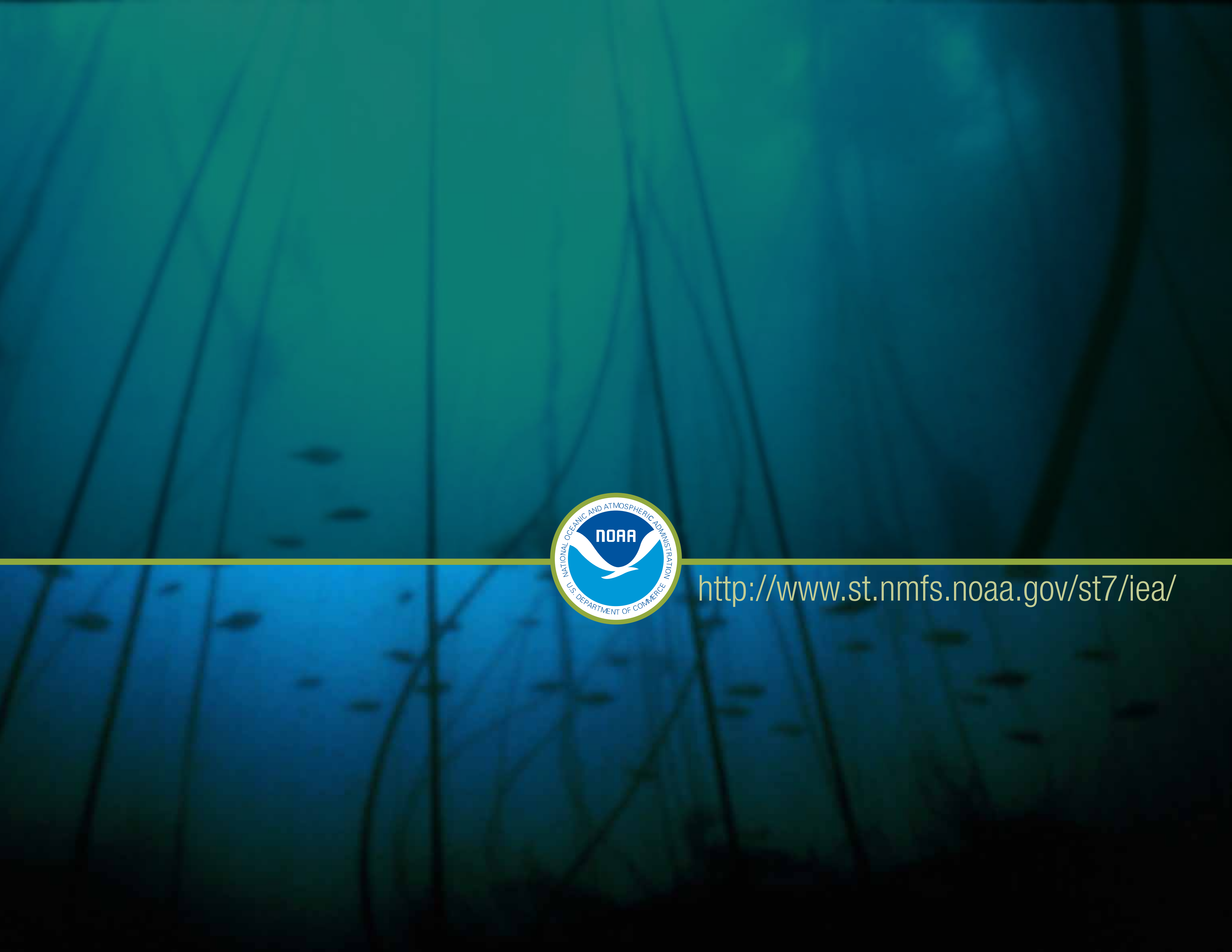
http://www.st.nmfs.noaa.gov/st7/iea/



http://www.st.nmfs.noaa.gov/st7/iea/

Agenda Item J.1.b
Supplemental IEA PowerPoint (Stein/Werner)
March 2011

Integrated Ecosystem Assessment

The Science Needed for a Healthy California Current

Outline

- Brief overview of IEA
- Status report on last year's work
- Plans for this year
- Working with the Council

What is an IEA?

- An IEA is a process and a product for organizing science to inform management decisions.
- IEAs scientifically assess the status of a whole ecosystem and measure it against established benchmarks.
- An IEA synthesizes the best-available science relative to specified management goals and provides strategic advice to managers on anticipated responses and tradeoffs of management options.

IEAs

- They are a ***process*** that identifies objectives, assesses ecosystem status and includes an evaluation of management options

- They are a ***product***
  - for those who rely on scientific support for decision making

Policy Question	IEA Action
What does a healthy ecosystem look like?	Identifies objectives, indicators / targets
What is the health of the ecosystem?	Assesses current status, conducts risk assessment
What action should be considered?	Generate alternative management options
Where should we start?	Conducts management strategy evaluation

How do IEAs build on what we are doing now?

- Advance our ability to understand cumulative risks to species, habitats, and ecosystem services.
- IEAs will build on, not replace, existing management tools.

What have we accomplished to date?

- Selected an initial suite of ecosystem indicators
- Completed an *initial* California Current IEA and published a technical document
- Assessed status and trends of the California Current ecosystem
- Developed new methods for ecological risk assessment
- Completed proof of concept for Management Strategy Evaluations
- Drafting an Executive Summary outreach document

NOAA Technical Memorandum NMFS-NWFSC-XX

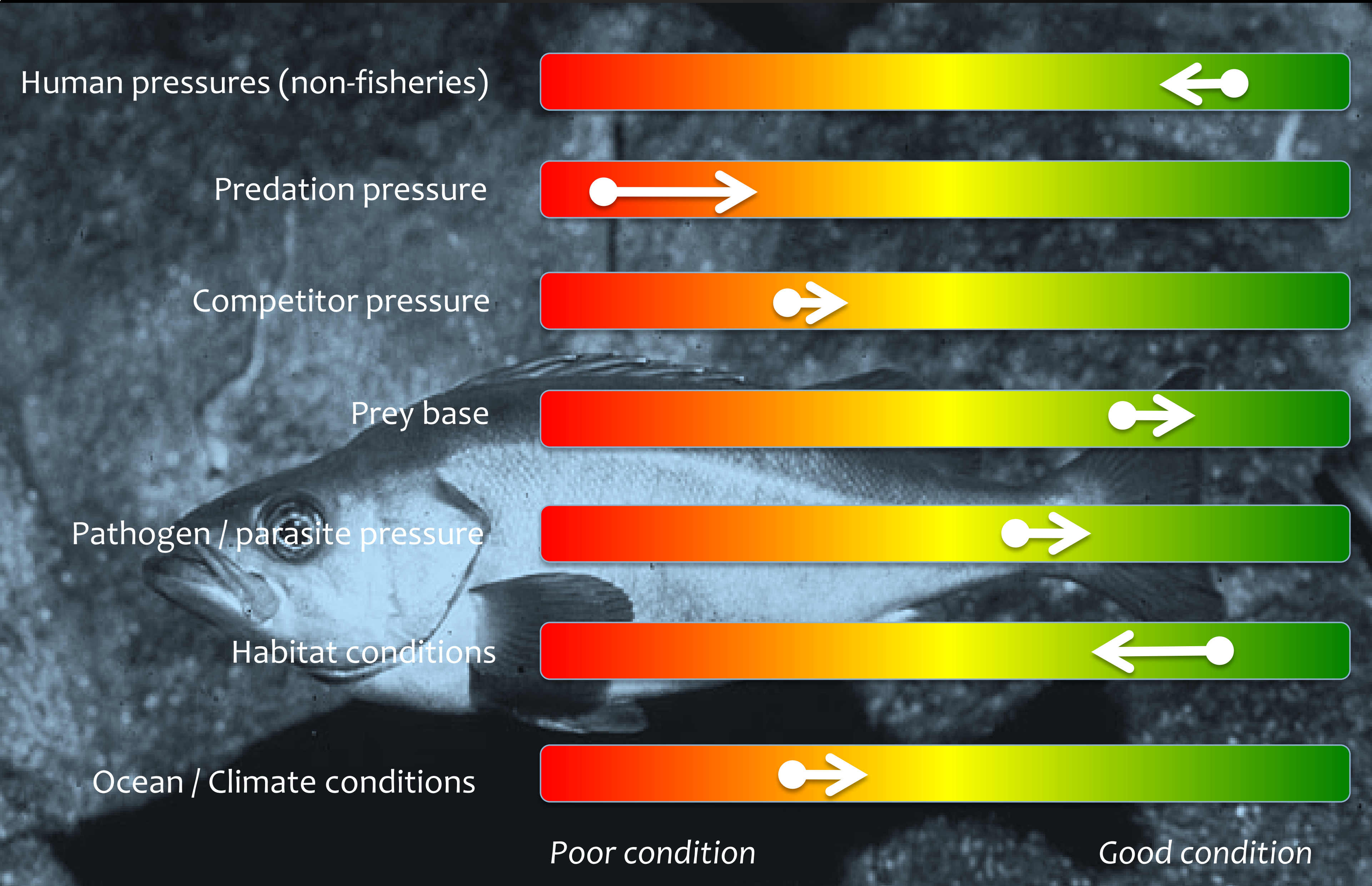
Technical background for an IEA of the California Current:

Ecosystem Health, Salmon, Groundfish, and Green Sturgeon

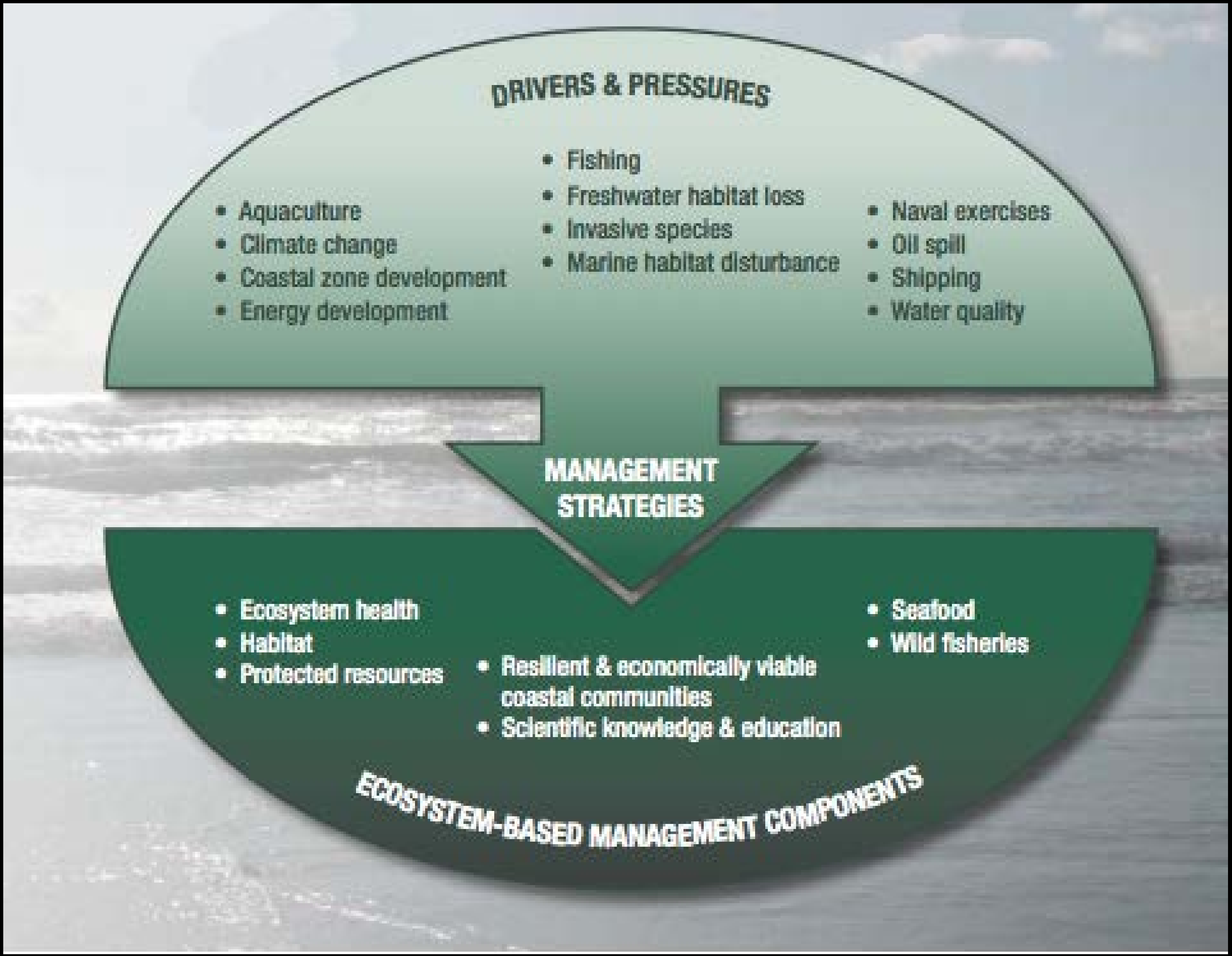
Edited by Phillip S. Levin and Franklin Schwing[1]

From contributions by Cameron Ainsworth, Kelly Andrews, Steven J. Bograd,[1] Merrick Burden,[2] Shallin Busch, John Dunne,[3] Tessa Francis, Elizabeth Fulton,[4] Churchill Grimes,[1] Elliott L. Hazen,[1] Peter Horne, Issac Kaplan, Phillip Levin, Steve Lindley,[1] Thomas Okey,[5] Jameal Samhouri, Isaac Schroeder,[1] Franklin Schwing,[1] William J. Sydeman,[1] Sarah A. Thompson,[1] Nick Tolimieri, Brian Wells,[1] and Greg Williams

http://www.nwfsc.noaa.gov/publications/iea.pdf



Hypothetical status and trend results of for species X in the California Current based on the 2010 IEA analysis (new product?).


DRIVERS & PRESSURES
• Aquaculture
• Climate change
• Coastal zone development
• Energy development
• Fishing
• Freshwater habitat loss
• Invasive species
• Marine habitat disturbance
• Naval exercises
• Oil spill
• Shipping
• Water quality
MANAGEMENT STRATEGIES
• Ecosystem health
• Habitat
• Protected resources
• Resilient & economically viable coastal communities
• Scientific knowledge & education
• Seafood
• Wild fisheries
ECOSYSTEM-BASED MANAGEMENT COMPONENTS

The California Current IEA
G1 → G2

2010

Focused on state indicators

Limited ecosystem components

Developed and tested risk assessment methods

Pilot management strategy evaluations

2011

Increase stakeholder involvement

Develop pressure indicators

Expand taxonomic coverage
mammals, birds, invertebrates

Add Human dimensions

Conduct risk assessments

Continue management strategy evaluations

Key "customers" / partners

- National Marine Sanctuary Program
- NOAA Managers
- **Pacific Fisheries Management Council**
  - **Ecosystem Fisheries Management Plan**
  - **Ecosystem considerations in single-species management**
- Puget Sound Partnership
- West Coast Governor Agreement

To Close

- Engaging the Council early in the process
- Want to stay engaged
- Present a 2011 Status and Trends report for the CA Current in September
- Provide the PFMC with ecosystem consideration information on selected stocks

Thank you

Questions?

Discussion Document: Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process

February 2011

Prepared By:

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Table of Contents

1.0 Introduction

The Pacific Fishery Management Council (Council or Pacific Council) received its first report from its Ecosystem Plan Development Team (EPDT) at its September 2010 meeting. That report, the September 2010 Agenda Item H.1.b., Attachment 1, discussed ecosystem fishery management planning generally, draft goals and objectives for a potential ecosystem fishery management plan (EFMP,) issues to consider for developing the regulatory scope of management unit species for a potential EFMP, the geographic range and scale of an EFMP, and the state of ecosystem science. At that meeting, the Council decided to move forward with an ecosystem fishery management planning process, although the Council reserved the decision on whether to proceed with an EFMP with regulatory authority for some future time. To begin the planning process, the Council tasked its EPDT with reviewing the Council's four fishery management plans (FMPs) to identify existing ecosystem-based management principles, and to scope common management needs that may benefit from a coordinated overarching ecosystem-based fishery management planning framework. This document provides those reviews in Section 2, *Existing Ecosystem-Based Principles and Management Measures*, and Section 3, *Cross-FMP Review of Common Management Needs and Challenges*.

Based on the comments the Council received from its Scientific and Statistical Committee (SSC) and other advisory bodies, Section 4 of this document, *Cross-FMP and Ecosystem Science*, proposes an initial science product development process for the Council arena, discusses science questions for future considerations, and highlights some current science tools that could inform Council decision-making. And, based on Council discussions in September 2010, Section 5 of this document, *Understanding the Cumulative Effects of Fisheries Action*, discusses ways that the scientific information and products described in Section 4 could support analyses of the effects of Council actions taken under its four FMPs.

The EPDT has deliberately called this report a *Discussion Document* because we hope that it will generate discussion within and between the Council, its advisory bodies, and the public. While EPDT members have experience in a diverse array of Council-related science and management programs, our knowledge of Council activities and needs is far from comprehensive. If the issues below continue to be of interest to the Council and the public, we hope that many others join in the discussion to refine and develop an approach for ecosystem-based fishery management in the California Current.

2.0 Ecosystem-Based Principles and Management Measures

Fishery managers need the best possible understanding of the interactions among physical, ecological, socioeconomic, and management issues in the California Current Ecosystem (CCE) for a more integrated approach to decision making. Both long and short term changes in distribution and abundance of individual species, subsequent changes in fishing grounds, shifts in fishing effort among species and changes in market demand, can all have major ecosystem effects. Many FMP species have may have experienced historic stock declines or may have highly variable population levels, most likely due to the cumulative interactions among life history and habitat factors (Levin et al. 2006,) the impact of changing environmental conditions on productivity within the CCE (Brodeur et al. 2008,) and harvest rates. Variability in the biophysical components of the ecosystem must be considered in the context of variability and change in social components of the system (Lester et al. 2010, White and Costello 2011). An ecosystem fishery management planning process can help integrate knowledge and data in the CCE to: 1) promote sustainable human uses of the CCE, 2) allow for a coordinated evaluation of ecosystem health, 3) aid in identifying critical data gaps and common ground within and between current FMPs, and 4) allow for evaluation of ecosystem tradeoffs (e.g. predator/prey interactions). Ecological and economic considerations are of notable importance in providing comprehensive optimum yield estimates; the choice of yields depends on the relative net benefits provided society through ecosystem interactions (Hannesson et al. 2009; Hannesson and Herrick 2010).

In identifying existing ecosystem-based principles and management measures in place within current FMPs, the EPDT looked for management measures that were either taken to mitigate the impact of fishing on the environment or ecosystem, or measures that take into account the effects of the biophysical environment on managed species. For each measure listed under the species group FMPs, we indicate in brackets the FMP species groups or protected species that may benefit from the measure listed. The following lists, separated by FMP, may not be comprehensive and would benefit from review by species group management teams and advisory panels.

2.1 Coastal Pelagic Species FMP

1. Krill harvest prohibition: The coastal pelagic species (CPS) FMP prohibits harvest of all species of euphausiids (krill) that occur within the U.S. West Coast Exclusive Economic Zone (EEZ) to help maintain important predator-prey relationships and the long-term health and productivity of the West Coast ecosystem. These ecosystem conservation principal enhance fishery management by protecting, to the extent practicable, krill resources, which are an integral part the ecosystem. [highly migratory species (HMS), groundfish, salmon, CPS, marine mammals]
2. Conservative Management Strategy: The Council has demonstrated a consistently conservative approach to CPS harvest management and in response to Pacific sardine's ecological role as forage and its importance to west coast fisheries. The Council frequently reviews new science in support of stock assessments and management strategies. In the late-1990's, the Council chose the most conservative harvest control rule for Pacific sardine when presented a wide range of FMP harvest policies. The resulting and current control rule includes an environmental parameter linking temperature to estimated FMSY. [HMS, groundfish, salmon, CPS, marine mammals]
3. Environmental Indicators: The intent of the existing environmental parameter in the Pacific sardine harvest control rule is to explicitly adapt harvest levels in response to environmental variability. The existing environmental parameter is one of the Council's priority research needs and new science suggests a need to explore a broader range of ecological indicators of Pacific sardine productivity. [CPS]
4. Cutoff Parameters: CPS harvest control rules have long utilized "Cutoff" parameters to protect a core spawning population and avoid overfishing. The Cutoff is a biomass level below which directed harvest is not allowed. Cutoff values are set at or above the overfished threshold and have the effect of automatically reducing harvest rates as biomass levels approach an overfished status. This mechanism serves to preserve a spawning stock size. For Pacific sardine, the Cutoff value is 150,000 mt or three times the overfished threshold and is part of the Council's conservative management approach. [HMS, groundfish, salmon, CPS, marine mammals]
5. Monitored stock harvest strategy: The ABC control rule for monitored stocks consists of a 75 percent reduction from the species overfishing level. This precautionary approach is in response to relatively low harvest levels and/or greater scientific uncertainty about stock status or management. [HMS, groundfish, salmon, CPS, marine mammals]
6. Essential fish habitat (EFH): EFH for CPS finfish species is temperature-based: The east-west geographic boundary of EFH for CPS is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C to 26°C. The southern boundary is the United States-Mexico maritime boundary. The northern boundary is more dynamic, and is defined as the position of the 10°C isotherm, which varies seasonally and annually. [CPS]

2.2 Groundfish FMP

1. EFH Conservation Areas: extensive, coastwide, long-term closed areas to protect groundfish EFH from bottom contact gear, particularly in rocky reef areas; extensive, coastwide, long-term closed area to freeze the footprint of West Coast trawl gear use to inshore of 700 fm depth contour. [Groundfish, salmon (particularly Chinook), marine mammals, seabirds]
2. Rockfish Conservation Areas: coastwide, seasonally-variable closed areas to minimize bycatch in all groundfish fisheries of rebuilding groundfish species. For cowcod and yelloweye rockfish, species-specific closed areas off the southern (cowcod) and northern (yelloweye) U.S. West Coast. [Groundfish, salmon (particularly Chinook), marine mammals, seabirds]
3. Salmon Conservation Zones: mid-coast, estuary-plume-focused closed areas to minimize bycatch in whiting fisheries of endangered and threatened salmon stocks. [Salmon, CPS, green sturgeon, marine mammals, seabirds]
4. Commercial fishery vessel monitoring system (VMS) requirements to better enforce closed areas and other regulations. [Groundfish, salmon, marine mammals, seabirds]
5. Coastwide, mandatory observer program to gather total catch data from commercial fisheries. [All FMP species, all protected species taken as bycatch]
6. Weak stock management to curtail allowable harvest of more abundant species in order to reduce opportunities for incidental catch of less abundant, co-occurring species. Harvest levels for species managed via an overfished species rebuilding plan are usually set at a fraction of F_{MSY} harvest rate. [Groundfish, salmon]
7. For less abundant stocks and stocks with little scientific information, harvest policies become increasingly precautionary. [Groundfish]
8. Allowable harvest of shortbelly rockfish, an abundant species with high prey value to the CCE, is set extremely low to accommodate incidental catch while discouraging any fishery development, to ensure that it retains its role as prey for other (non-human) predator species. [Groundfish, HMS, salmon, marine mammals, seabirds]
9. Stock assessments include literature review and discussion of relevant ecological biological, social and economic factors and the interactions between them, to allow SSC and Council to weigh impacts of those factors under different potential harvest scenarios. [Groundfish]
10. Trawl gear regulations to constrain habitat damage through a small footrope requirement shoreward of the RCAs, and minimize catch of juveniles through a minimum mesh size requirement. Fixed gear regulations to prevent lost gear from ghost fishing through a gear attendance requirement and, for pots, a biodegradable escape panel requirement. [Groundfish, salmon (particularly Chinook), marine mammals, seabirds]
11. Regulations requiring fishery participants to sort their catch by species, ensuring better long-term data on the hugely varied groundfish species catch and landings. [Groundfish]
12. For whiting, participation in a U.S.-Canada bilateral treaty organization to jointly manage and conserve Pacific whiting to ensure that harvest of the cross-boundary resource remains within sustainable parameters. [Groundfish, marine mammals, seabirds]

2.3 Highly Migratory Species (HMS) FMP

1. FMP designates EFH for each species within the FMP, with sub-designations for the different life stages of those species. EFH designations for some HMS' life stages are temperature-based, recognizing those species' habits of associating with certain temperature ranges, regardless of where those temperatures may occur in any given season or year.
2. Sea turtle and marine mammal bycatch minimization and mitigation measures: swordfish longline fishery closure west of 150° W. long.; prohibition on light stick possession for longline vessels operating west of 150° W. long.; gear and operational modification requirements for HMS longline and drift gillnet vessels; seasonal area closures for longline and gillnet fisheries in times

and areas where there have been prior fishery interactions with sea turtles, with additional closures during El Niño events; equipment and handling requirements for bringing incidentally caught turtles onboard, and resuscitating and releasing when possible. [Sea turtles, marine mammals]

3. Seabird bycatch minimization and mitigation measures: gear configuration and setting requirements, offal discharge requirements, equipment and handling requirements for bringing incidentally caught short-tailed albatross onboard, and resuscitating and releasing when possible. [Seabirds]
4. Bycatch limitations for HMS taken with non-HMS gear. [HMS]
5. HMS permitting and record-keeping requirements for U.S. vessels operating in the EEZ and on the high seas and landing HMS in U.S. ports. [HMS]
6. Selected commercial fishery vessel monitoring system (VMS) requirements to better enforce closed areas and other regulations. [HMS]
7. Mandatory observer program to gather total catch data from commercial fisheries. [HMS, salmon, CPS, groundfish]
8. Nation-wide shark-finning prohibition. [Sharks]
9. Nation-wide dolphin-safe tuna import requirements. [Marine mammals]
10. Participation in international regional fishery management organizations to develop and implement multinational conservation measures, such as restricting fishing around fish aggregating devices (FADs) for tropical tunas, and area closures to minimize bycatch of mammals and turtles. [HMS, marine mammals, sea turtles]

2.4 Salmon FMP

1. FMP designates EFH from the ocean extent of the EEZ to the shore, and inland up to all freshwater bodies occupied or historically accessible to salmon in Washington, Oregon, Idaho, and California, with exceptions for dammed streams, recognizing the long-term potential for managed stocks to recover in historically-used areas. [Salmon, and in marine waters, groundfish and CPS where EFH for those species intersects with salmon EFH]
2. Yelloweye Rockfish Conservation Area off Washington state to minimize bycatch of an overfished rockfish species in the salmon troll fisheries. Regulations restricting groundfish and halibut retention, coupled with inseason management to adjust those as needed. [Groundfish, halibut]
3. Geographic control zones that may be opened or closed to fishing on an annual basis, depending on a particular year's management objectives and run forecasts, used to constrain the catch of salmon from less abundant runs caught in common with salmon from more abundant runs. [Salmon]
4. Adaptive management process that allows swift inseason regulations changes to respond as catch information becomes available. That same process also includes an annual retrospective analysis of the effectiveness of modeling and management, ensuring an ongoing refinement of predictive and monitoring methodologies. [Salmon]
5. Oregon coastal natural (OCN) and Columbia River coho harvest matrices that use juvenile salmon ocean survival as a predictor of ocean conditions, ultimately providing allowable total fishery impacts rates based on the return of jacks (sub-adults) to spawning streams. Also for OCN coho, the Council's SSC has recommended a new predictor methodology that blends multiple parameters, including sea surface temperature and copepod assemblage abundance. [Salmon]
6. Participation in international regional fishery management organizations to ensure cooperation on both North American and high-seas multinational conservation measures to prevent overharvest. [Salmon]

7. Prohibition on the use of nets to fish for salmon within the EEZ to allow for live release of undersized salmon and to prevent bycatch of non-target species. [Salmon, HMS, groundfish]

3.0 Cross-FMP Review of Common Management Needs and Challenges

The Council's four FMPs cover a broad array of species, with widely diverse life histories and trophic roles within the CCE. Management programs and fishing practices will necessarily differ for species that range from the short-lived and quickly-reproducing CPS, to the long-lived and slow-maturing groundfish species, to the fast-maturing and far-ranging salmon and HMS. The different FMP species fill different roles in the CCE, both in their interactions with each other and with non-FMP species. Figure 3.1, below, provides a simplified schematic of the interactions of our FMP species with each other and with non-Council species groups.

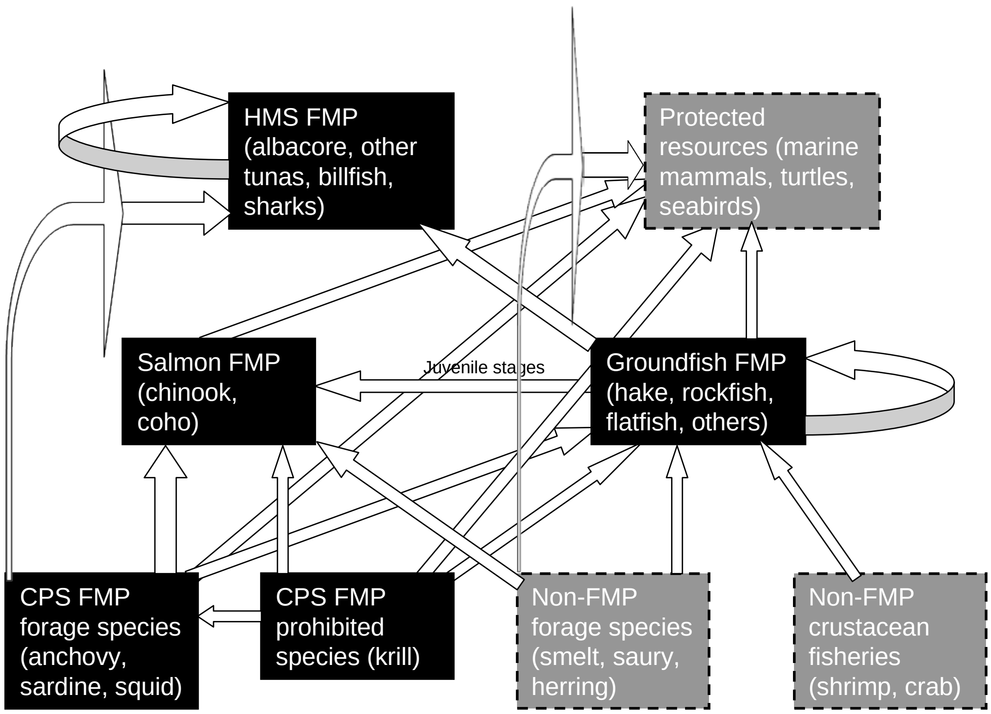

Figure 3.1: Simplified schematic of key trophic interactions between FMP species and others

Figure 3.1 provides a simplified schematic of generalized trophic interactions among the four FMP species groups and some of the major non-managed species groups in the CCE. This figure is not intended to represent the entire food web in any way, or to capture every potential interaction (trophic or otherwise) among the groups, rather the idea was simply to highlight where there are or may be major interactions among groups of FMP-managed and non-Council managed assemblages. For example, krill are an important part of the diets of many species in each of the FMPs, as well as many protected resource species. Similarly, salmon prey primarily on krill, coastal pelagic species (both FMP and non-FMP species, e.g., anchovy, sardine, herring and smelts), and groundfish (primarily young-of-year rockfish and other early life history stages). As such, there is presumably at least some level of connectivity between salmon productivity and the management of all of these other elements of the ecosystem, despite the fact that the functional relationships are poorly understood. Essentially, virtually all of the FMP assemblages have some level of direct trophic interactions with the other FMP assemblages, although the importance and strengths of such interactions vary. More accurate discussions of food webs interactions and food habits data can be found in the literature (Brand et al. 2007, Daly et al. 2009, Dufault et al. 2009, Field et al. 2006).

While Council process participants and the public are all aware that FMP species have varied life history characteristics and inter-species relationships, the traditional management process helps us to focus on immediate management challenges by separating managed species into the large FMP units. However, this tight species-group focus rarely provides an opportunity to step back and look at how the different FMPs approach similar fishery management challenges or the relationships between species. Below, we provide a series of tables with brief cross-FMP comparisons of how the Council addresses major fishery management issues in each of its four FMPs: harvest policies and overfished/overfishing, bycatch, essential fish habitat (EFH,) and community effects. We chose this particular set of issues as a starting point for discussion in order to highlight the Magnuson-Stevens Fishery Conservation and Management Act's (MSA's) national standard guidelines and EFH requirements.

3.1 FMP Harvest Level Policies and Overfished/Overfishing Issues (Appendix Tables A.1, A.2)

Setting harvest levels is at the heart of a fishery management council's responsibilities, as reflected in the MSA's National Standard 1: "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry." The policies that the Council uses to set its harvest levels and to address overfishing and rebuilding overfished stocks must be based in sound scientific advice under National Standard 2, "Conservation and management measures shall be based on the best scientific information available." The Council's harvest policies for the species in its four FMPs are notably different from each other, reflecting diversity of life history characteristics between FMPs. Harvest policies for the FMPs hew to the MSA's National Standard 3 that "To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination."

Beyond basic harvest policies, the MSA also requires ending overfishing where and when it occurs, and requires rebuilding overfished species in as short a time as possible, taking into account the status and biology of overfished stocks of fish, the needs of fishing communities, recommendations of international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem [§304(e)]. For the salmon FMP, the Council has the additional challenge of managing fisheries for a suite of evolutionarily significant units of salmon, some of which are listed as threatened or endangered under the Endangered Species Act (ESA). Among the many challenges of meeting the management requirements of both the MSA and the ESA, the Council has had to wrestle with the confusion of different terminology and standards in the two acts. Amendment 16 to the Salmon FMP is intended, in part, to resolve some of those differences in applying the two acts to the salmon management process.

In Appendix A, at Table A.1 we provide a snapshot of FMP harvest and overfished/overfishing policies. Table A.2 shows the Council's two-year schedule for setting harvest levels for its FMPs, two of which undergo an annual harvest specifications process (CPS and salmon,) and two of which undergo a biennial harvest specifications process (groundfish and HMS). The Council's HMS management work is significantly affected by the timing and management philosophies of the international regional fishery management organizations (RFMOs) that set stock-wide policies for many of the stocks within the HMS FMP.

The Council has a variety of policies and processes that account for both the trophic roles of its managed species and the relationships those species have with their environment. Despite such efforts, a more rigorous and quantitative analysis of these interactions and the possible trade-offs between managed species that might result from alternative harvest policies is lacking . A more organized ecosystem-based management effort could help the Council better address larger-scale harvest issues like: maintaining long-term age- and size-distribution in managed stock populations, assessing the evolutionary effects of fishing season timing and location; and climate shift effects on stock productivity and predator-prey relationships.

Cross-FMP Harvest Policy Issues

- In keeping with the MSA and the NS1 guidelines, Council harvest policies have been amended to better account for management and scientific uncertainty through the use of buffered harvest levels.
- Groundfish and CPS FMP amendments included Council direction to include ecological considerations in the setting of harvest specifications and in the development of management reference points. An ecosystem-based plan could provide valuable information within and between FMP and non-FMP species when developing harvest levels.
- The rebuilding of stocks declared overfished or listed under the ESA is a central responsibility and goal of Council fishery management. Improved understanding of ecological interactions between species of concern, healthy target stocks, and key predator and prey species could improve recovery efforts. The comprehensive prohibition on krill was, in part, based on an understanding that krill play a vital role in the ecology of many species of concern. Increased understanding of trophic interactions could help validate or improve forage species harvest policy while enhancing rebuilding efforts.
- Harvest policies commonly reduce allowable catch as stocks approach overfished thresholds. This is most notable in CPS harvest control rules where harvest is prohibited rather than restricted when MSST levels are approached for Pacific sardine or reached for Pacific mackerel. Reduction in allowable harvest is also built into groundfish harvest control rules and salmon harvest policies.

3.2 FMP Bycatch Issues (Appendix Table A.3)

Although the ESA and the Marine Mammal Protection Act (MMPA) have long supported bycatch minimization policies, Congress notably strengthened the MSA's approach to bycatch with the implementation of the 1996 Sustainable Fisheries Act. Among other things, the Act added National Standard 9, "Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch." The revised MSA also included a new requirement that FMPs "establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and include conservation and management measures that, to the extent practicable and in the following priority – (A) minimize bycatch; and (B) minimize the mortality of bycatch which cannot be avoided" [§303(a)(11)]. In addition to requiring the minimization of bycatch in domestic fisheries, the MSA also supports the minimization of bycatch in international fisheries.

The 2007 amendments to the MSA supported the Act's bycatch provisions from 1996 by formalizing and more fully funding a bycatch reduction engineering program designed to encourage innovative research into gear modifications for bycatch reduction. The Council has historically had greater concern with bycatch in the groundfish and HMS fisheries than in the salmon and CPS fisheries, although salmon fishery management itself is largely a complex effort to conduct fisheries that minimize the bycatch of threatened or endangered runs of salmon. As discussed in Table A.3, the groundfish and HMS fisheries have been the primary West Coast beneficiaries of bycatch reduction engineering funding. In addition to the programs discussed below, NMFS has conducted cross-fishery research into the effects of fishing on incidental take of marine mammals and seabirds.

FMP-based bycatch minimization policies necessarily focus on the bycatch within particular fisheries. Responding to the MSA by reducing the volume and rate of bycatch in individual Council-managed fisheries has most likely resulted in an overall reduction in the total volume of incidentally-caught and discarded CCE marine life. However, moving beyond the fishery-by-fishery approach could allow the Council to better assess issues like: the cumulative effects of the bycatch of non-Council species taken in Council-managed fisheries; whether gear innovation programs or products in one fishery could benefit other fisheries; and whether the timing and interactions of multiple Council-managed fisheries increase or decrease the likelihood of bycatch in these fisheries.

Cross-FMP Bycatch Issues:

- National Standard 9 has made bycatch a key focus of conservation and management in all four FMPs.
- Bycatch of both fish and non-fish marine vertebrate species (i.e., seabirds, marine mammals, and sea turtles) is of at least some concern in all four FMPs. Bycatch has been highly significant to the HMS, Groundfish, and Salmon FMPs with the latter two driven largely by "weak stock" management of rebuilding rockfish stocks and ESA listed salmon.
- The Council has employed closed areas, gear restrictions, and species handling rules to address bycatch in all four FMPs with some measures (e.g., yelloweye rockfish conservation areas) crossing FMPs.
- The many fishery sectors managed under each FMP are monitored to varying degrees and with different tools such as logbooks and at-sea observers. Monitoring resources are targeted at the sectors for which bycatch is of highest concern, yet there are gaps in monitoring for some fisheries.

3.3 FMP Essential Fish Habitat Issues (Appendix Tables A.4, A.5)

The 1996 Sustainable Fisheries Act brought the concept of essential fish habitat (EFH) into the MSA, and subsequently into FMPs throughout the U.S. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" [§3(10)]. For several fishery management councils, the requirement to identify EFH led to a new and greater understanding of how managed species interact with their physical environment. Although this new understanding has not been universally identified as a move toward ecosystem-based fishery management, some councils used their work on EFH to launch or support further work on ecosystem-based management.

The Act requires NMFS and fishery management councils to identify EFH for their FMPs, identify adverse impacts to that habitat, and ensure the conservation of EFH. Through their FMPs, fishery management councils develop, and NMFS implements, management measures to minimize the effect of fishing activities on EFH.

For non-fishing activities, fishery management councils are permitted to comment on and make recommendations to the Secretary of Commerce or any Federal or State agency "concerning any activity authorized, funded, or undertaken or proposed to be authorized funded or undertaken, by any Federal or State agency that, in view of the Council, may affect the habitat, including essential fish habitat, of a fishery resource under its authority" [§305(b)(3)(A).] The Pacific Council has an additional duty to consider the effects of non-fishing activities on salmon EFH, since fishery management councils are required to comment on and make recommendations regarding activities that are likely to substantially affect the habitat of anadromous species [§Section 305(b)(3)(B)]. NMFS has consulted on the effects of numerous non-fishing activities on EFH, with the bulk of those consultations designed initially to look at the effects of those activities on salmon EFH while also considering those activities in light of salmon critical habitat requirements under the ESA, but to also take into account effects on groundfish and CPS EFH. Federal regulations at 50 CFR 600.815(10) require that NMFS and fishery management councils conduct a complete review of all EFH information in each FMP as recommended by the Secretary of Commerce, but at least every five years.

Cross-FMP Habitat Issues:

As shown in Appendix A, Table A.4, EFH has been described for all four FMPs, with the groundfish FMP having the most detail, including Habitat Areas of Particular Concern (HAPC) designations and closed areas to protect EFH. Geographic maps of EFH have been developed for all FMPs, except CPS. Three of the four FMPs have also either recently finished a 5-year review of EFH (CPS) or recently initiated a review (Groundfish and Salmon), which suggests that the Council might consider if there could be efficiencies in integrating some of the work between FMPs in future 5-year EFH review processes. An integrated Council approach to EFH would provide a better understanding of complex overarching issues such as: research needs, common threats to habitat quality, protected species interactions, or ocean acidification. A first step could be to map all EFH data and boundaries in a common tool, like the Groundfish EFH Mapping Tool (http://sharpfin.nmfs.noaa.gov/website/EFH_Mapper/map.aspx or http://pacoos.coas.oregonstate.edu/.) CPS EFH, which has not yet been mapped, is in part defined by a sea surface temperature range between 10 °C to 26 °C, making it annually and seasonally variable; satellite data are available for mapping sea surface temperature changes. General mapping of oceanic events and seasons, such as El Niño/Southern Oscillation (ENSO,) is also possible. A cross-FMP mapping effort could better reveal those habitats important to all four FMPs simultaneously. These common habitats could serve as focal points for Council policy efforts to assess and mitigate for fishing and non-fishing effects on EFH, and for research to better understand the complex interactions between FMP species and their shared habitat.

Unfortunately, limited information about habitat preferences and habitat-specific demographic rates (e.g. survival or growth rates) has resulted in very broad EFH designations. By better understanding what habitats fish use, the demographic rates associated with these habitats, and the factors that make some habitats more valuable than others, it will be possible to make more efficient use of limited resources (Levin and Stunz 2005). When all habitats are considered EFH, prioritization is difficult. New scientific approaches suggest focusing on protecting the habitat-dependent ecological processes that allow populations of fished stocks to persist or expand (Mangel et al. 2006). To this end, the nationally-coordinated NMFS Habitat Assessment Improvement Plan (HAIP) focuses on the marine fisheries aspects of habitat science. The HAIP is intended in part to reduce uncertainty of stock assessments, increase the potential number of advanced stock assessments and contribute to assessments of ecosystem services. The nexus of HAIP, stock assessments and integrated ecosystem assessments has the potential to vastly improve our ability to indentify truly essential EFH.

3.4 FMP Community Effects Issues (Appendix Table A.6. and subsequent figures)

In addition to bringing new management requirements for fish and their habitat, the 1996 Sustainable Fisheries Act recognized the connection of fishing communities to fisheries and fish stocks, particularly through National Standards 8 and 10. National Standard 8 requires that "conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities." National Standard

8 recognized that, while the many new requirements in the Act were expected to end overfishing and ultimately result in healthier and rebuilt stocks, humans are also part of the environment and fishing communities particularly represent the place of humans within the ocean ecosystem.

National Standard 10 requires that "conservation and management measures shall, to the extent practicable, promote the safety of human life at sea." NMFS and fishery management councils have long worked with the U.S. Coast Guard, the states, and the public to address fishery safety issues, but fishing necessarily takes place in a harsh environment and remains a dangerous occupation. Table A.6 in Appendix A provides vessel incident data from the two U.S. Coast Guard West Coast offices, Districts 11 and 13, as well as information on how the Council addresses community effects in recommending fishery management actions. In providing the EPDT with U.S. Coast Guard safety data, Brian Corrigan of District 13 noted that the Dungeness crab fishery, which is not under Council purview, is usually considered the most dangerous fishery off the West Coast (Corrigan, pers. Comm. 2010).

One challenge of the Council's current process is that the Council regularly finds itself of having to make a management decision under one FMP without necessarily having a clear picture of how that decision might affect fishing opportunities under other FMPs. Analyses for the MSA, the National Environmental Policy Act (NEPA,) the Regulatory Flexibility Act (RFA,) and other laws do address some of these cross-FMP issues on a case-by-case basis. However, expanding our thinking about the socio-economic effects of the Council's decisions to an ecosystem context could provide the Council with more resources and information for assessing how their decisions on individual issues fit within the larger picture of all of the Council-generated management programs for fisheries within the CCE.

Cross-FMP Communities Effects Issues:

The importance of FMP fishery resources to fishing communities can be considered in terms of a community's dependence on, or engagement in, the harvesting or processing of commercially or recreationally targeted fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors and related entities that are based in such a community. One hundred and twenty three spatially defined communities in Washington, Oregon, California have been identified as being substantially dependent on or substantially engaged in the commercial harvest or processing of fishery resources (Norman et al. 2007). In addition to coastal tribal fisheries for FMP species, inland treaty tribes conduct commercial, and ceremonial and subsistence fisheries for salmon and steelhead. And, within Idaho, the sport fisheries for salmon and steelhead contribute to the economies of several river communities. From a holistic, ecosystem-based perspective it is important to understand how the structure and function of the CCE affects fishing activity (and vice versa), particularly spatial and temporal fishing patterns and the related impacts on fishing communities. This understanding will help the Council to assess how its specific management actions may affect the overall ecological-socioeconomic landscape.

Economists and other social scientists rely on economic impact, input-output models to gauge the impact of changes in fishing patterns on local and regional economic activity. These models can be coupled with models of the ecosystem to better understand the impact of changes in the ecosystem on fishing communities. The basic data for evaluating community dependence and interdependence on FMP fishery resources is the West Coast commercial fishing landings data found in the Pacific Fisheries Information Network (PacFIN) database. These data together with input from the Council's FMP advisory bodies can be used to assess the socio-economic impacts across fishing communities of a change in the CCE expressed through a change in the abundance and distribution of commercially targeted species.

4.0 Cross-FMP and Ecosystem Science

At the Council's September 2010 meeting, the EPDT received advice and questions from the Council, SSC, and others on the science process and science products that the Council and its advisory bodies might consider for ecosystem-based fishery management planning. In this section: we propose an initial science product development process (4.1), discuss science questions for future consideration, both for FMP species and for more broad ecosystem-wide issues (4.2), and some of the science tools and models that could inform the Council decision-making (4.3).

4.1 Bringing Ecosystem Science into the Council Process

Based in part on advice received from the SSC in September 2010, the EPDT views the incorporation of ecosystem science into the Council process as a two-part process. The first part is to identify and act on opportunities to improve the quantity and quality of ecosystem information used in the science that supports Council decision-making, particularly stock assessments. The second part is to bring a new whole-picture assessment of the CCE into the Council process.

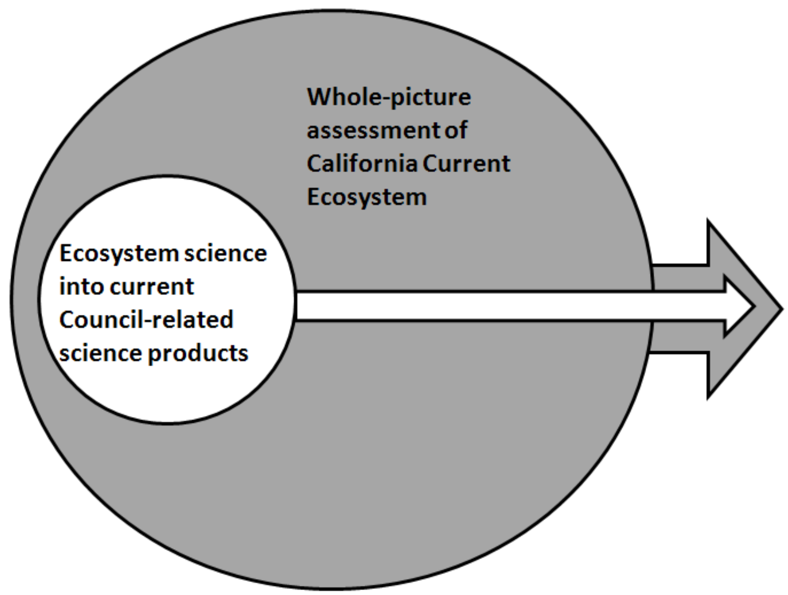

Figure 4.1: Two-part process to bring ecosystem science to the Council

4.1.1 Bringing More Ecosystem Information into Stock Assessments

While Council management decisions address a host of issues requiring wide-ranging science support and analysis, stock assessments and other harvest-level support science are the largest category of science products directly used in the Council process. Recognizing the status of stock assessments as both frequently conducted and heavily used Council-related science, the SSC recommended in September 2010:

> "*. . . that a subset of stock assessments be expanded to include ecosystem considerations. This would likely require the addition of an ecologist or ecosystem scientist to the Stock Assessment Teams (STATs) developing those assessments. The SSC's Ecosystem-Based Management subcommittee should develop guidelines for how ecosystem considerations can be included in stock assessments.*" (H.1.c., Supplemental SSC Report)

Based on this recommendation and on the management and activity cycles (Council Operating Procedure 9) for the Council's four FMPs, The first element of incorporating ecosystem science into the Council process could be addressed by a collaboration between NMFS's science centers and the SSC's Ecosystem-Based Management subcommittee to bring ecosystem considerations into some portion of near-future stock assessments.

There are three means by which ecosystem considerations could be incorporated into near-future stock assessments. First, assessments could include expanded ecosystem information in the overview text of the assessment document, as is currently included in PFMC stock assessments in a limited fashion and also in the North Pacific Fishery Management Council (NPFMC) stock assessments. Assessment documents typically summarize existing research on predator-prey interactions, as well as the impact of climate, habitat and/or predation on natural mortality, growth, fecundity, migrations, recruitment variability, and shifts in distribution that may impact availability to the fishery or survey. These topics could be expanded to more fully incorporate ecosystem considerations.

Second, stock assessment models and/or relevant model sensitivity runs that explicitly include ecosystem interactions, such as those described above, could be developed. The selection of specific stocks for which assessment models with ecosystem considerations are developed should be identified in collaboration with the SSC. There are at least three modeling approaches that might be considered for incorporating ecosystem interactions: 1) modifying relevant model parameters, 2) adding an environmental index of an ecosystem process (i.e. treating the ecosystem information as a data time series with a measure of variance), and 3) modifying the population dynamics equations using an index of an ecosystem process (treating the ecosystem information as known without error). Current stock assessment models have the technical capability to incorporate all of the above approaches given strong scientific evidence for including ecosystem considerations into stock assessment models. Research into improving stock assessments has been the focus of programs such as the NOAA Habitat Assessment Improvement Plan.

Finally, hypotheses on ecosystem considerations for or impacts on a specific stock could be investigated by using them to define alternative states of nature as the basis for the decision tables within current single species stock assessments, which are provided to managers as guidance for setting catches. Preferred methods for including ecosystem considerations into single species stock assessment should be addressed in the stock assessment terms of reference provided by the Council's SSC. Since the additional expertise necessary to include ecosystem considerations into stock assessment will likely extend beyond that of the current stock assessment teams single species stock assessments will require the commitment and active participation by agency ecologists and fisheries oceanographers. The following proposed schedule recognizes that stock assessment terms of reference and processes are generally prepared well in advance of the year in which they are ultimately used to support fishery management. HMS species are not included in this schedule because HMS stock assessments are conducted by international RFMOs.

Table 4.1: Bringing ecosystem considerations into stock assessment and harvest-setting processes	
CPS	November 2010 – Terms of reference were drafted for CPS stock assessment and methodology review panels that included revisions to begin to bring ecosystem considerations into the next full assessments (currently scheduled for 2014 per the CPS FMP) for Pacific mackerel and Pacific sardine, and for any other CPS species for which the SSC and Council deem such changes to be appropriate. June 2014 – Pacific mackerel full assessment with ecosystem considerations completed for first use in 2014-2015 fishery. November 2014 – Pacific sardine full assessment with ecosystem considerations completed for first use in 2015 fishery.
Groundfish	March 2012 – Proposed list of stock assessments, including recommendations on species assessments to be expanded to include ecosystem considerations, as part of *2013-2014 Terms of Reference for Groundfish Stock Assessment and Review Process*. June 2012 – Final list of stock assessments, including subset of species assessments to be expanded to include ecosystem considerations, as part of *2013-2014 Terms of Reference for Groundfish Stock Assessment and Review Process*. November 2013 – Groundfish stock assessments intended to inform 2015-2016 fishing years complete, including those that have been expanded with ecosystem considerations.
Salmon	April 2012 – As part of developing initial list of potential topics for salmon methodology review, Council and advisory bodies draft potential data and analysis requests for ecosystem information of potential benefit to salmon abundance and assessment models. September 2012 – Council and advisory bodies finalize data and analysis requests for ecosystem information of potential benefit to salmon abundance and assessment models for review by SSC Salmon Subcommittee and Salmon Technical Team. November 2012 – Council finalizes data an analysis requests for ecosystem information of potential benefit to salmon abundance and assessment models, using advice received through salmon-specific advisory bodies, the SSC, other advisory bodies, and the public. April 2013 – As part of developing initial list of potential topics for salmon methodology review, Council and advisory bodies review available ecosystem considerations data and analyses compiled in response to requests developed in 2012. September and November 2013 – Ecosystem considerations incorporated into salmon methodology for 2014 through regular methodology review process. March and April 2014 – 2014 salmon season management developed with methodologies that incorporate the ecosystem considerations developed over 2012-2013.

4.1.2 Bringing Ecosystem Information and Science into the Larger Council Process

At its September 2010 meeting, the SSC also provided advice on approaches to bring ecosystem information more broadly into the Council decision-making process by increasing and improving the ecosystem science information used within the Council process:

"…The Council should request NMFS to initiate development of an annual report on conditions in the California Current ecosystem. The SSC can provide guidance on the content, review and dissemination of this report…" (H.1.c., Supplemental SSC Report)

At its November 2010 meeting, the Council received a presentation from Patricia Livingston of NMFS's Alaska Fisheries Science Center (AFSC) that, among other things, discussed the AFSC's Ecosystem Considerations chapter of its Stock Assessment and Fishery Evaluation (SAFE) Report. The AFSC first published its Ecosystem Considerations report in 1995 and the ongoing dialogue that report has created between NMFS and the NPFMC has led to many refinements to the report's format and to the information it presents – see box at right. The AFSC's report provides an example of the type of annual ecosystem report that could address the second element of incorporating ecosystem science into the Council decision-making process. However, NMFS and its partner science entities will necessarily have different types of data and analyses for the CCE than those available for ecosystems of interest to the NPFMC. For example, there is currently an annual briefing and report available on physical and biological oceanographic trends and conditions throughout the CCE developed by the California Cooperative Oceanic and Fisheries Investigations (CalCOFI) consortium (McClatchie et al. 2009, Bjorkstedt et all 2010). While the CalCOFI report is technical in nature, it could provide the foundation for a summary of physical and biological trends of key interest to fisheries managers. NMFS and the Pacific Council have an opportunity to benefit from the experience of our colleagues in the North Pacific and in other parts of the country by evaluating lessons others have learned on ecosystem reporting to better design an initial report on conditions in the CCE.

History and Goals of the AFSC Ecosystem Considerations Report *[Adapted from: http://access.afsc.noaa.gov/reem/ecoweb/EcosystemIndex.cfm, as viewed on 12/27/10]*

Since 1995, the NPFMC Groundfish Plan Teams have prepared a separate Ecosystem Considerations section to the annual SAFE report. The first report in 1995 compiled information on Bering Sea, Aleutian Island, and Gulf of Alaska ecosystems, and discussed ecosystem-based management.

In 1996-1999, AFSC added information to the report on these and other areas of interest: biological features of the N. Pacific; effects of bycatch and discard on ecosystem; seabird and marine mammal research; precautionary approach in scientific literature; EFH and effects of fishing gear on habitat; collection of local knowledge; marine protected areas research, and oceanographic changes during 1995-1999.

From 2000 to the present, the AFSC has been adding to and refining the report to meet goals set in 1999, emphasizing indicators of ecosystem status and trends, and ecosystem-based management performance measures. These changes are intended to:

1) Track ecosystem-based management efforts and their efficacy;
2) Track the changes in the ecosystem that are not easily incorporated into single-species assessments;
3) Bring results from ecosystem research efforts to the attention of fishery scientists and managers;
4) Provide a stronger link between ecosystem research and fishery management; and
5) Assess the past, present, and future role of climate and humans in influencing ecosystem status and trends.

The report's ecosystem-based management indices are intended to track management performance in meeting stated ecosystem-based management goals of the NPFMC:

1) Maintain biodiversity consistent with natural evolutionary and ecological processes, including dynamic change and variability;
2) Maintain and restore habitats essential for fish and their prey;
3) Maintain system sustainability and sustainable yields for human consumption and non-extractive uses;
4) Maintain the concept that humans are components of the ecosystem.

In early 2011, NMFS's Northwest and Southwest Fisheries Science Centers will cooperatively release their first iteration of a California Current Integrated Ecosystem Assessment (CCIEA) (Levin and Schwing, in press.) The CCIEA will provide the Council, its advisory bodies, and the public with an illustration of the types of information and analyses that may be possible with data available on the CCE and its component species and physiological features. An annual report on ecosystem conditions and considerations of particular interest to the Pacific Council would be shaped by the Council and its advisory bodies, and could feature different issues than those explored in this first California Current IEA.

Both the AFSC Ecosystem Considerations report and the CCIEA provide scientific analyses rooted in ecosystem-based management issues for the geographic areas they address. These reports, and similar reports worldwide, use an analysis framework that assesses: the state of the environment; the driving forces that affect the environment, both human-induced and natural; the pressures those driving forces place on the environment; the impacts that the driving forces and resulting pressures have on the state of the environment; and the policy responses that humans may or may not make to address any of the other factors. This analysis framework is known as Driver-Pressure-State-Impact-Response (DPSIR). In simple terms, DPSIR represents a process that essentially asks, "What's going on in the environment, how are we affecting it, and what are our goals for how we might alter our future effects on it?"

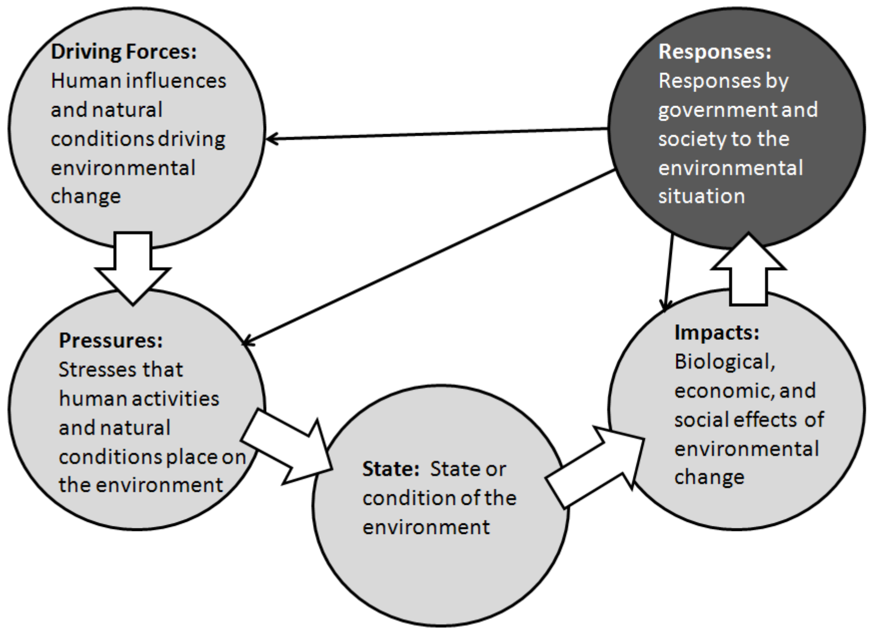

Figure 4.2: DPSIR Framework, illustration adapted from http://www.gulfofmaine.org/state-of-the-gulf/framework.html

As the DPSIR framework illustrates, a key task in assessing the state of the ecosystem is to ask management bodies to articulate their goals for the ecosystem and for their ecosystem-based management efforts. The Council has not yet articulated its ecosystem-based management goals, but this EPDT discussion document is an early step in the Council's ecosystem-based fishery management planning process. In our September 2010 report, we pointed out that the existing FMPs have suites of goals and objectives that have four common themes that are consistent with an ecosystem approach to fishery management: *avoid overfishing, maintain stability in landings, minimize impacts to habitat, and accommodate existing fisheries sectors*. The CPS FMP also explicitly recognizes the role of the target species in the food web, citing a need to *provide adequate forage for dependent species*.

The EPDT proposes an approach to develop an annual report format using existing capabilities at the NMFS Science Centers and leveraging the CCIEA. Currently, the CCIEA includes fisheries and "ecosystem health" among its primary foci. The initial iteration of the CCIEA examined trends in abundance, size structure and spatial distribution of target and non-target stocks (with a strong emphasis on groundfish). The ecosystem health component of the CCIEA examined attributes of ecosystem structure and function, including climate / ocean drivers, primary production, zooplankton and top predators.

For a more Council-focused CCIEA iteration, the EPDT would work with the Science Centers to select a pilot set of species, spread among the four FMPs and of potential interest to the Council. For each species, the next-round CCIEA would report the status of the following:

- Climate / ocean conditions affecting target species
- Juvenile and adult habitat (where data are available)
- Prey availability
- Predation risk
- Other ecological factors (e.g., disease, competitors, etc.)
- Other human activities that affect target species (e.g., water quality, activities affecting habitat, energy development, etc.

Thus, for each species, the report would provide a comprehensive picture of the ecosystem factors affecting stocks in a manner similar to the report in the North Pacific. By embedding this work within the IEA, the Council leverages other work performed within the IEA to get additional information such as:

- Influence of fisheries on protected species
- Effects of non-fishing activities on fish stocks and EFH
- Cumulative impact of fisheries

We envision this as an iterative process wherein the IEA team provides the Council with an initial ecosystem considerations report, for review and comment by the Council and its advisory bodies. Council feedback on the initial report would then lead to modifications to the topics or species considered, presentation, or other concerns, ultimately improving IEA products and reports over time.

Proposed Schedule:
March 2011 – IEA team begins assessment on [2 groundfish, some selected salmon ESUs, 1 CPS)
Sept 2011 – Draft product delivered.

In the North Pacific, NMFS and the NPFMC have had 15 years to develop and refine their Ecosystem Considerations report. NMFS could take a similar approach for the California Current – provide an initial report without first consulting with the Council on its items of interest for that report and rely on later iterations to bring in Council interests. However, ecosystem science and ideas about ecosystem-based management are much more advanced than they were when AFSC first led the way in designing an ecosystem considerations report. The EPDT believes that an initial investment of time to develop a format for and contents of a Council-focused California Current report through the Council process, accompanied by an iterative discussion of the Council's ecosystem-based management goals, will ultimately pay off with a more rapid coalescing of Council policies and science process.

4.2 Science Questions for Future Consideration

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. In this section, we review the science questions common across all four FMPs, follow with FMP-specific research issues, and conclude with a discussion of some broad-scale and long-term issues that could affect fisheries management, such as climate shifts and ocean acidification. 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). Given those recommendations, here are areas where ecosystem science might better inform Council decisions:

4.2.1 Cross-FMP – Needed Future Ecosystem Considerations

1. Evaluate the influence of climatic/oceanographic conditions on FMP species. Investigate the potential for incorporating environmental factors within the current stock assessment modeling framework (Stock Synthesis 3). Model effects of climate forcing 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 (Sibert et al. 2006). This is now done for many assessments in order to represent relative depletion from both a static and dynamic perspective (Maunder and Aires-da-Silva 2010).
2. 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). Link with socio-economic data and modeling to assess effects of changes in availability on West Coast fisheries. For example, during periods of low HMS availability, recreational fishermen who might prefer to harvest HMS species may increase harvest rates and activity for alternative species, such as rockfish and other groundfish.
3. Examine ecological interactions for influencing 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.
4. Develop quantitative information on the extent of the cumulative bycatch of all FMP fisheries.
5. Spatially-explicit management: What is the effect of marine spatial planning on FMP species and fisheries? To address this question, a review of marine spatial planning would include both fisheries and non-fisheries closures, traditional fishing grounds, the effects of potential future non-fishing ocean areas uses, and asking about the types of activities tend to generate EFH/ESA consultations.
6. Investigate how viability and resilience of coastal communities are affected by changes in ecosystem structure and function, including short- and long-term climate shifts.
7. 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).
8. Identify key indicators for recruitment, growth, spatial availability, and overall CCE productivity.
9. Review management reference points, including rebuilding reference points, in light of ecosystem interactions. For example, do reference points like Bzero account for ecosystem interactions of a given species, or do they just reference the life history information about that particular stock? (Brand et al, 2007)
10. Investigate how different habitat types contribute to species productivity rates (habitat-specific demographic rates). See Habitat Assessment Improvement Plan (NMFS 2010).
11. Better understand spatial structure (meta-population structure) of managed stocks and investigate what are the most appropriate spatial scales for management.
12. Assess the effects of different types of fishing gear on ecosystem structure and function, and investigate the effects of the ecosystem structure and function on gear performance.
13. 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.
14. Assess the evolutionary impacts of fishery management measures and fishing practices, and investigate whether those impacts affect yield or sustainability.
15. Develop an analytical framework to compile the information and evaluate the tradeoffs society is willing to make across the alternative ecological benefits fishery resources provide.

4.2.2 CPS FMP – Needed Future Ecosystem Considerations

1. 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.
2. Review and revise the climate-based factor in the harvest control rule 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. For sardine, the FRACTION term in the harvest control rule formula is a function of a three-year average of sea surface temperatures (SST) taken at the Scripps Institute of Oceanography pier located in La Jolla, California. Including this term reflects the positive relationship between sardine reproductive success and water temperature; at higher SSTs a greater fraction of the available biomass can be harvested. Recent work by McClatchie et al. (2010) finds that the Scripps Institute of Oceanography SST is no longer valid in terms of predicting sardine reproductive success. The Council has long identified the review of harvest control rules as a high priority research need and has tasked the CPSMT and the SSC with reviewing these findings. It is anticipated that the Council, the SWFSC, and the States will work toward the development of improved environmental indicators.
3. 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 come up with a comprehensive optimum yield in this situation, ecological and economic considerations come to the fore, since its resolution depends crucially on the relative net benefits provided society through these interactions (Hannesson et al. 2009; Hannesson and Herrick 2010).
4. NMFS's Southwest Region initiated a pilot observer program for California-based coastal purse seine fishing vessels targeting CPS in 2004 to augment and confirm bycatch rates derived from CDFG dockside sampling. The pilot observer program's primary intent was to gather data on total catch and bycatch, and on interactions between their fishing gear and protected species such as salmon, marine mammals, sea turtles, and sea birds. This program needs to be reviewed to determine whether it should be revived and fully implemented to include standardization of data fields, development of a fishery-specific Observer Field Manual, construction of a relational database for the observer data, and creation of a statistically reliable sampling plan.

4.2.2 Groundfish FMP – Needed Future Ecosystem Considerations

1. Many species show low frequency variability in recruitment due to lower biomass and/or a low productivity environmental regime. For example, the biomass of widow rockfish has decreased steadily since the early 1980s, and recruitment during early 1990s is estimated to have been considerably smaller than before the mid 1970s (He et al. 2007). However, there is evidence that recruitment of many rockfish species since 1999 has been higher than the average of the 1990s (He et al. 2007). Additionally, several data sources in the cabezon assessment indicate that there was potentially good recruitment after 1999 and before 1977, whereas these same sources indicate that recruitment was poor prior to 1999 in the Southern California Stock (Cope and Punt, 2006). The cabezon recruitment patterns of the California sub-stocks suggest a possible link between environmental forcing and population dynamics (Cope and Key 2009). Specifically, strong 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 (Cope and Key 2009). For example, declines in kelp

habitat caused by increasing ocean temperatures in southern California since the 1990s led assessors to suspect that the decline of blue rockfish in this area was in part due to environmental factors affecting habitat, rather than entirely a function of fishing (Key et al. 2008). Finally, correlations between spring sea surface height (Schirripa 2005), zooplankton indices (Schirripa 2007) and sablefish age-0 survival suggest environmental forcing of recruitment. Hamel et al. (2009) recommend investigating effects of PDO, ENSO and other climatic variables on recruitment. A better understanding of the relationship between the population dynamics and climate for such species could reduce the uncertainty of future assessments (Cope and Punt, 2006; He et al. 2007).

2. Provide research on relative density of rockfish in trawlable and untrawlable areas and differences in age and length compositions between these areas (e.g. shortspine thornyhead (Hamel 2005); darkblocked rockfish (Hamel 2008)).
3. Investigate predation impacts likely to affect abundance of assessed species (e.g. lingcod on gopher rockfish (Key et al. 2005); sablefish and shortspine thornyhead on longspine thornyhead (Fay 2005, Field et al. 2006); Humboldt squid on Pacific hake (Field et al. 2007, Homes et al. 2008).
4. Investigate hake spatial distributions across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years (Helser et al. 2006; Helser et al. 2008). Two primary issues are related to the changing spatial distribution of the survey as well as the environmental factors that may be responsible for changes in the spatial distribution of hake and their influences on survey catchability and selectivity (Agostini et al. 2006, Helser et al. 2006; Helser et al. 2008). Hamel et al (2009) also recommend investigating time-varying availability inshore for lingcod.
5. Review acoustic hake data to assess whether there are spatial trends in the acoustic survey indices that are not being captured by the model (Helser et al. 2006; Helser et al. 2008). Analysis should include investigation of stock migration (expansion/contraction) in relation to variation in environmental factors (Helser et al. 2006; Helser et al. 2008).
6. Investigate time-varying growth rates and maturity schedules as influenced by environmental factors because of apparent low frequency variability (e.g. Pacific hake (Hamel and Stewart 2009), bocaccio (MacCall 2008); chillipepper rockfish (Field 2007); english sole (Stewart 2008); lingcod (Hamel et al. 2009); splitnose rockfish (Gertseva et al. 2009), chilipepper (Harvey et al., in press).
7. Research consequences of poor environmental conditions on bioenergetic allocation patterns (bocaccio (Field et al. 2009)).

4.2.3 HMS FMP – Needed Future Ecosystem Considerations

1. Assess nearshore distribution of juvenile sharks for habitat needs and fishery vulnerability during nursery and pre-reproductive life stages (Hanan 1993, Cartamil 2010).
2. 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.
3. Evaluate utility of Pacific pelagic ecosystem models (e.g., Kitchell et al. 1999, Kitchell et al. 2002, Cox et al. 2002, Olson and Watters 2003, Watters et al. 2003, Hinke et al. 2004, Lehodey et al. 2008) for informing Council decisions. Polovina et al. (2009) recently found that with increasing fishing pressure, the catch rates of top predators such as marlin, spearfish, sharks, and large tunas (bigeye and yellowfin) declined, while the catch rates of mid-trophic level species such as mahimahi, pomfret and escolar increased – consistent with earlier models for this same area (Kitchell et al. 1999, Kitchell et al. 2002). Conversely, some later models did not predict as strong effects of fishing through the food web (e.g., Cox et al. 2002) or did not predict long term changes (e.g., Watters et al. 2003), the resulting release of predation mortality from mid-trophic level populations from declines in top trophic-level predators is consistent with the empirical results described in Sibert et al. (2006) and Polovina (2009).

4.2.4 Salmon FMP – Needed Future Ecosystem Considerations

1. 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 catch distributions.
2. Characterize and map the ocean habitats for anadromous species using data from satellites and electronic tags.
3. Characterize trends in hatchery salmon production and assess the potential for density-dependent effects in freshwater streams, estuaries, and coastal ocean environments. Assess the potential for increasing hatchery production throughout the Pacific Rim to impact body size, age-at-maturity and productivity of salmon in offshore ocean environments.
4. 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.
5. Research is needed on the effects of ecological interactions such as disease, predation and competition on the population dynamics of adult and juvenile salmon. In particular, research is needed on the unique impact of cultured salmon, both hatchery smolts and marine net pen reared fish, on disease and competition.
6. Characterize the influence of nearshore marine, estuarine and freshwater water quality on survival, growth, and reproduction of salmon.

4.2.5 Oceanographic Conditions, Broad-Scale and Long-Term Ecosystem Considerations

The California Current is an "Eastern Boundary Current," an upwelling-dominated ecosystem characterized by fluctuations in physical conditions and productivity over multiple time scales (Parrish et al. 1981, Mann and Lazier 1996). Food webs in these types of ecosystems tend to be structured around coastal pelagic species that exhibit boom-bust cycles over decadal time scales (Bakun 1996, Checkley et al. 2009). By contrast, the top trophic levels of such ecosystems are often dominated by highly migratory species such as salmon, tuna, billfish and marine mammals, whose dynamics may be partially or wholly driven by processes in entirely different ecosystems, even different hemispheres.

The CCE essentially begins where the west wind drift (or the North Pacific Current) reaches the North American continent. The North Pacific Current typically encounters land along the northern end of Vancouver Island, although this location varies latitudinally from year to year. This current then splits into the southward-flowing California Current heading south and the northward-flowing Alaska Current. The "current" part of the California Current is a massive southward flow of water ranging from 50 to 500 kilometers offshore (Mann and Lazier, 1996). Beneath this surface current, lies the California Undercurrent in the summer, which surfaces and is known as the Davidson current in winter. This current moves water poleward from the south in a deep yet more narrow band of water typically close to (but offshore of) the continental shelf break (Hickey 1998, Checkley and Barth 2009). The southward California current is typically considered distinct from the wind-driven coastal upwelling jet that develops over the continental shelf during the spring and summer, which tends to be driven by localized forcing and to vary on smaller spatial and temporal scales than offshore processes (Hickey, 1998). Jets result from intensive wind-driven coastal upwelling, and lead to higher nutrient input and productivity; they in turn are influenced by the coastal topography (capes, canyons and offshore banks), particularly the large capes such as Cape Blanco, Cape Mendocino and Point Conception. The flow from the coastal upwelling jets can be diverted offshore, creating eddies, fronts and other mesoscale changes in physical and biological conditions, and even often linking up to the offshore California Current (Hickey, 1998). One example is south of Point Conception, where part of the California Current swirls eastward and then northward to form the Southern California Eddy.

Superimposed on the effects of these shifting water masses that drive much of the interannual variability of the California Current, are substantive changes in productivity that often take place at slower rates, during multi-year and decadal periods of altering ocean condition and productivity regimes. Climatologists and oceanographers have identified and quantified both the high and low frequency variability in numerous ways. The El Niño/Southern Oscillation (ENSO) is the dominant mode of interannual variability in the equatorial Pacific, with impacts throughout the rest of the Pacific basin (including the California Current) and the globe (Mann and Lazier 1996). During the negative (El Niño) phase of the ENSO cycle, jet stream winds are typically diverted northward, often resulting in increased exposure of the West Coast of the U.S. to subtropical weather systems (Cayan 1989). Concurrently in the coastal ocean, the effects of these events include reduced upwelling winds, a deepening of the thermocline, intrusion of offshore (subtropical) waters, dramatic declines in primary and secondary production, poor recruitment, growth and survival of many resident species (particularly salmon and groundfish), and northward extensions in the range of many tropical species.

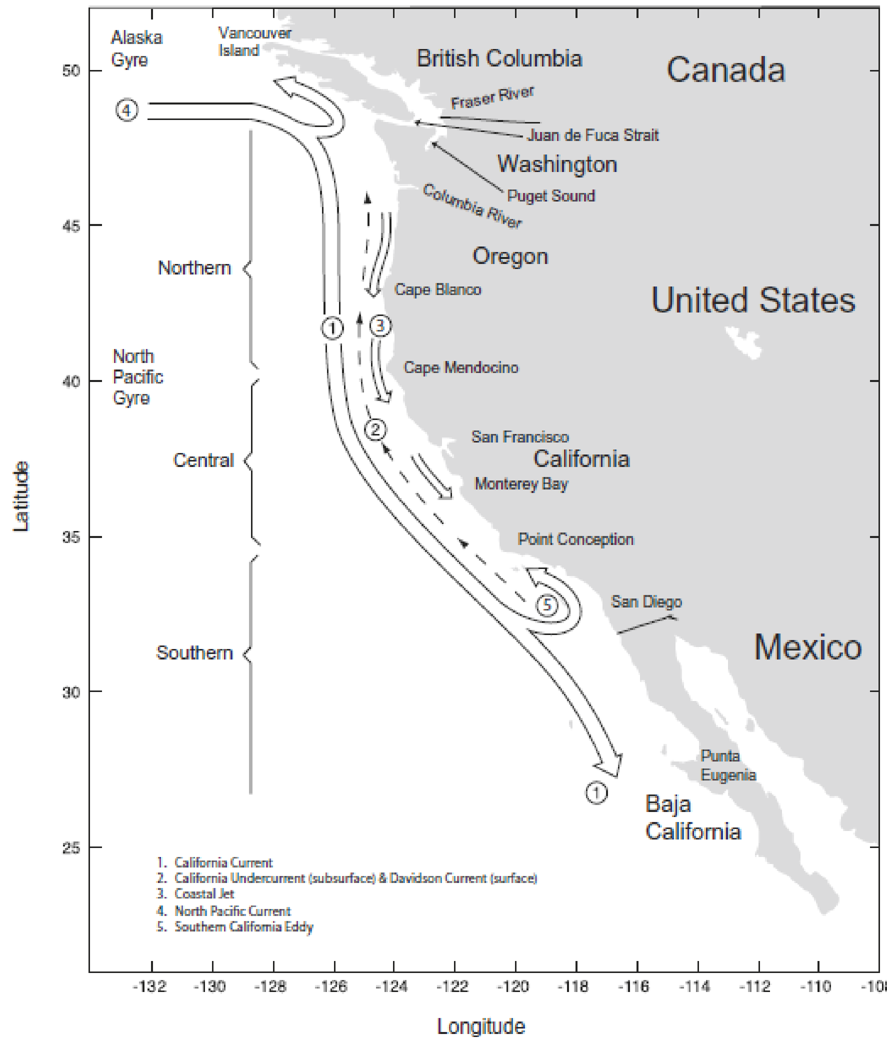

Figure 4.3: Dominant current systems off the U.S. West Coast

While the ENSO cycle is generally a high-frequency event (taking on the order of three to seven years to complete a cycle), lower frequency variability has been associated with what is now commonly referred to as the Pacific (inter)Decadal Oscillation, or PDO (Mantua et al. 1997). The PDO is the leading principal component of North Pacific sea surface temperatures (above 20° N. lat.), and superficially resembles ENSO over a decadal time scale. During positive regimes, coastal sea surface temperatures in both the Gulf of Alaska and the California Current tend to be higher, while those in the North Pacific Gyre tend to be lower; the converse is true in negative regimes. The effects of the PDO have been associated with low frequency variability in over 100 physical and biological time series throughout the Northeast Pacific, including time series of recruitment and abundance for commercially important coastal pelagics, groundfish and invertebrates (Mantua and Hare 2002).

Three major aspects of climate change that will have direct effects on the CCE are: ocean temperature, pH (acidity versus alkalinity) of ocean surface waters, and deep-water oxygen. Globally by 2050, ocean temperatures *on average* are expected to rise at least 1°C (by the most conservative estimates, ref: climate IPCC report), while at the same time, ocean pH in the upper 500m has steadily been decreasing (becoming more acidic, aka "ocean acidification") at a rate of approximately -0.0017 pH per year (Byrne et al., 2010). On a more regional basis within the CCE, deep-water oxygen levels have shown a steady and relatively rapid decrease since the mid 1980's (Bograd et al., 2008, McClatchie et al., 2010). There is linkage between these three factors: ocean temperature affects ocean pH, ocean temperature and deep water oxygen levels both can be controlled by large scale circulation patterns, primary production can affect both oxygen and pH, all three factors show long term trends and decadal scale variance similar to changes in the PDO (Mantua et al., 1997) and North Pacific Gyre Oscillation (DiLorenzo et al., 2008) climate signals.

Temperature

Increasing temperature will have both direct and indirect effects on all managed species within the CCE. For cold-blooded species, vital rates will change as a function of temperature, specifically growth and development rates, which could lead to changes in size-at-age relationships, and/or changes in egg production rates (Houde, 1989; Blaxter, 1992). Certain species with upper thermal limit tolerances, may become locally extirpated in some areas, or conversely expand into new territories that were once too cold. Other, more mobile species, may change their depth/and or spatial range in response to increasing temperature, typically through a northward shifting of population boundaries. Indirect effects on managed species include changes in both basic primary and secondary production rates, and/or community composition of the lower trophic levels which provide the food base for managed species. It is also likely that along with increased warming, there has been an increase in thermal stratification within the CCE (Palacios et al., 2004), which may lead to a decrease in overall primary production, through a reduction in the effectiveness of upwelling bringing nutrients to the surface layers. Thus we may expect system-wide changes in productivity, or changes in the centers of productivity over the next 50 years. Related to changes in temperature, there may also be associated changes in the timing of the onset of spring's seasonal upwelling, which could have widespread effects on total production, the match-mismatch of certain trophic interactions, and possible community shifts (Loggerwell et al., 2003; Holt and Mantua, 2009).

Temperature within the CCE is monitored reliably via several methods. Surface temperatures are sampled via satellite on relatively high temporal (daily) and spatial (several km) scales. In situ and some sub-surface temperatures are less frequently monitored by buoys and ship-based measurements. Gliders and shore-stations provide additional measurements at lower spatial coverage. CCE water temperature measurements have been taken for a longer span of time than any other measurements, providing excellent background data to evaluate current and historic trends (e.g. the CALCOFI program).

Ocean pH

Decreasing ocean pH ("ocean acidification") will have direct effects on certain species within the CCE. Primarily, decreasing pH makes it more difficult for shell-bearing species (such as corals, bivalves, gastropods, and crustaceans) to make their shells (Kleypas et al., 1999; Reibesell et al., 2000; Fabry et al., 2008). Decreased pH may possibly impact the larvae and young stages of fish, although studies documenting such effects on fish are sparse (see Fabry et al. 2008, and references therein). The most significant impact likely for the managed species within the CCE would be if decreasing pH caused changes in plankton productivity or community composition. Currently, the likeliness and extent of such effects are poorly known, but could be considerable. As changes in ocean pH roughly track changes in atmospheric pCO2 levels, it is expected that as pCO2 continues to rise, ocean pH will continue to steadily decrease, making changes in ocean plankton production and community structure more likely in the future. It is important to note that there is considerable daily, seasonal, and decadal scale variability in ocean pH, overlain on the overall long-term trend (reviewed in Fabry et al., 2008). Thus many oceanic species are already exposed to considerable variability in ocean pH compared to the rate of long-term change, and thus have some natural resilience to such changes.

Measurement of ocean pH requires in situ water sampling, and cannot currently be conducted via remote means. However, because of the relatively tight coupling of ocean pH with atmospheric forcing, biogeochemical models may be used in some cases to determine ocean pH at higher temporal and spatial frequency than in situ sampling would allow. In fact, historic ocean pH levels used for calculating long term trends have mostly been calculated used biogeochemical-atmospheric models (Fabry et al., 2008). There is much less data available, both temporally and spatially concerning ocean pH than nearly all other physical-chemical measurements, partly because up until recently, it was believed that the ocean was relatively “self-buffering” and would not undergo significant changes in pH. With the recent recognition that pH is indeed decreasing, and that this may be detrimental to many marine organisms, monitoring of pH has increased, particularly in coastal regions.

Oxygen

Within the CCE, there has been a notable decrease in deep-water oxygen levels since the mid 1980’s (Bograd et al., 2008, Chan et al., 2008). Effects of low oxygen levels on marine organisms are fairly well known: death in most cases if the organisms cannot avoid the area, or reduced growth for those species with some tolerance. Overlaid on this steady decrease, occasional periods of heightened primary production without concomitant surface grazing, have sometimes led to large hypoxic or even anoxic zones in deeper waters, resulting in mass fish kills (e.g. recent events off Oregon coast; Chan et al., 2008). The decrease in deep water oxygen levels is most likely a result of changes in oxygen content of the source waters of deeper parts of the CCE, more of a basin-wide phenomenon effecting large regions of the CCE (Bograd et al., 2008). On top of the long term, system-wide change in deeper water oxygen, are regional-scale events that may further decrease oxygen levels. Particularly, strong surface primary production may sink out before being remineralized in surface layers, leading to a higher respiratory demand in deeper waters. Coupling such events with the already depleted deeper waters, may thus lead to fish kills, the likelihood of which will probably increase as the deep water oxygen continues to decrease under the current trend.

Oxygen levels have been measured for many decades throughout the CCE (e.g.CALCOFI), traditionally via in situ sampling, followed by ship-board analysis. Oxygen cannot be measured remotely via satellites or other means. However, recent technological advances have enabled the development of in situ oxygen sensors that can provide fairly rapid subsurface measurements of oxygen (Tengberg et al., 2006). Modeling in situ oxygen levels is problematic in most cases, since it requires complex atmospheric-physical-biological coupled models with accurate mixing schemes, although such models do exist and can be applied in some areas with decent success (Najjar and Keeling, 2000). Thus, modeling may provide a limited ability to fill in data gaps, and make limited predictions of water oxygen content.

Future research considerations that would improve the Council's ability to incorporate temperature, pH, and Oxygen research and information into ecosystem-based fishery management are:

1. 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, reproductive rate
2. Current spatial and depth boundaries of all FMP, and non-FMP forage species in regards to Temperature, pH, and O.
3. Spatially-specific trend analysis of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species
4. Spatially-specific forecasts of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species
5. 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

5.0 Understanding the Cumulative Effects of Fisheries Actions

At its September 2010 meeting, the Council discussed the possibility of using information generated from the ecosystem fishery management planning process to support its work on its existing FMPs by broadening the scientific information available on the cumulative ecological effects of management actions taken for FMP species and their fisheries. The scientific questions, processes, and tools discussed in Section 4.0 are all intended to work towards this goal by ultimately improving the quality of ecological information available to inform Council decision-making. A suite of laws guide the issues NMFS and the Council must consider in making fisheries management decisions: MSA, NEPA, ESA, MMPA, the Regulatory Flexibility Act, Executive Order 12866, and others. Several of these mandates ask that we consider not just the particular action under consideration, but the larger management framework that governs that decision. NEPA particularly requires that we assess the cumulative effects of the proposed action, taken together with other "past, present, and reasonably foreseeable future actions" (40 CFR 1508.7.)

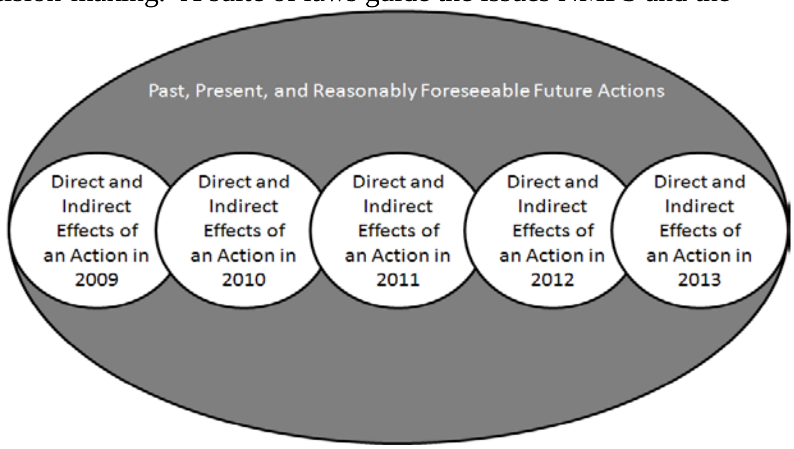

Figure 5.1: Cumulative Effects

Engaging in ecosystem-based management includes expanding our awareness of the range of human activities that affect the CCE. However, Council and NMFS authority is often constrained to considering fisheries actions, with some added authority and requirements to comment on how non-fisheries actions may affect CCE living marine resources and habitat. To assess whether ecosystem-based fishery management planning can aid in Council decision making, the field of effects of actions under Council consideration may be reduced to four broad categories:

1. *Removal of fish from a population*. Fishing activities result in some level of total (directed + incidental) fishing mortality. An action under Council consideration may specify the total permissible mortality level for certain species, for some defined time period – setting an annual catch limit, for example. The ultimate, or cumulative, effects of that action on the environment may be a series of actions, such as setting annual catch limits over successive years. The combined fishing mortality over time may have a broad range of effects, such as changes in age structure of target and non-target species populations, or availability of various species to other species as prey, predators, or competitors. Cumulative effects are likely to also be a product of various other non-fisheries actions, or even more ephemeral trends, such as climate forcing effects on primary productivity.
2. *Removal of other types of organisms from a population.* Our laws and regulations differentiate incidental mortality of protected, nonfish species (e.g., marine mammals) from fishing mortality. In terms of the overall effects, however, the same question applies – What are the ultimate effects of successive, human-caused mortality over time? We are asking ourselves, how multiple, individual regulatory actions affect population and trophic dynamics for these non-fish species.
3. *Destruction of biophysical habitat.* Fishing gear may have adverse effects on physical habitat, such as substrate, or on macrobenthos like corals and sponges. These effects represent the loss of physical habitat and its function in providing shelter and living space for other organisms. If habitat forming organisms may be killed as a result past, present, and

reasonably foreseeable future actions, then it may be appropriate to consider the types of population and trophic dynamic effects mentioned above for fish and non-fish species.

4. *Personal income and other socioeconomic effects.* Ex-vessel revenue is the proximate effect of selling fish (or, for recreational fisheries, revenue resulting from the sale of the fishing experience.) The movement of fish or the fishing experience as commodities within the economy, and resulting expenditures from revenues may be considered largely cumulative effects of an action or of the Council's activities as a whole. Other socioeconomic effects of past, present, and reasonably foreseeable future actions, such as the pleasure derived from private recreational fishing, diving, kayaking, or beachcombing, are less quantifiable but may also be considered in Council decision-making.

An ecosystem fishery management planning process may provide new information for or otherwise aid in Council decision-making in several ways. First, the scientific processes and research discussed in Section 4.0 would likely produce a detailed description of the affected environment at the ecosystem level. Second, these same scientific processes, research, and products could evaluate ecological linkages between the many Council-managed species at their varied trophic levels, and between the four categories of effects of fisheries actions discussed above. Finally, an evaluation of the effects of fishery management actions on the marine ecosystem could improve our understanding of both the role of fisheries within the ecosystem and the socio-economic role of the ecosystem for the U.S. and its citizens.

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Appendix A: FMP Summary Tables

Table A.1: FMP Harvest Level and Overfished/Overfishing Issues

	CPS	Groundfish	HMS	Salmon
What harvest policies are used for FMP species?	Actively managed stocks are assessed annually. Environmental indicators are used in Pacific sardine control rules and are a high research priority. "Cutoff" values (biomass levels below which harvest is prohibited) are used to protect spawning stock and avoid overfishing. Scientific uncertainty in assessments is used in combination with a risk-policy choice to reduce ABC relative to OFLs. A 75% reduction from MSY is used to set monitored species harvest levels.	The Council's harvest policies are intended to prevent overfishing and maintain stock abundance near the level that produces maximum sustainable yield (B_{MSY}: $B_{25\%}$ for flatfish and $B_{40\%}$ for all other stocks). Overfished stocks are managed with rebuilding plans to bring stock abundance back to B_{MSY} in as short a time as possible, within constraints. Harvest levels for more abundant species caught in common with overfished species are managed to constrain bycatch of overfished stocks within the rebuilding harvest levels of those overfished stocks.	The Council's harvest policies are intended to implement harvest strategies that achieve optimum yield for long-term sustainable harvests and which provide a foundation to support US positions in cooperative international management of HMS fisheries. Prevent overfishing and rebuild overfished stocks, working with international organizations as necessary.	To achieve optimum yield (OY,) prevent overfishing, and assure rebuilding of salmon stocks whose abundance has been depressed to an overfished level, the salmon FMP establishes, to the extent practicable, conservation objectives to perpetuate the coastwide aggregate of salmon stocks covered by the plan. Each stock has a specific objective, generally designed to achieve MSY, maximum sustained production (MSP), or in some cases, an exploitation rate to serve as an MSY proxy.
What is the minimum stock size threshold (MSST) for designating a stock *overfished*?	P. sardine = 50,000 mt P. mackerel = 18,200 mt *Stock levels at which recovery is assumed to be quickly possible. Although northern	For all flatfish species, the FMP's default proxy MSST is $B_{12.5\%}$, or 12.5% of the stock's unfished biomass level. For all groundfish species other than flatfish, the FMP's default proxy	The HMS FMP defines a default MSST as no less than half of B_{MSY} (when natural mortality exceeds 0.5). If natural mortality is equal to or greater than 0.5 then the MSST would vary between	The FMP does not define MSST or overfishing; instead the Council sets annual fishery escapement levels as conservation objectives, intended to produce MSY over the long-term while

Table A.1: FMP Harvest Level and Overfished/Overfishing Issues				
	CPS	Groundfish	HMS	Salmon
	anchovy does not have a formal MSST, it does have a mechanism to close the fishery if the stock falls below 300K tons.	MSST is $B_{25\%}$	$0.5B_{MSY}$ and $0.75B_{MSY}$ based on the calculation $(1-M)B_{MSY}$. For vulnerable species the HMS FMP currently suggests a precautionary adjustment from the default value used to calculate the MSST; it would be set generally closer to B_{MSY} than under the default calculation.	preventing overfishing. If a stock falls below its conservation objective (MSY proxy) for three consecutive years, this triggers an "overfishing concern" and the stock is designated overfished. Amendment 16 to the Salmon FMP would set MSST at 1/2 MSY spawning escapement (S_{MSY}) and would designate a stock as overfished if the recent three year geometric mean spawners is below MSST.
What is the *overfishing limit (OFL)* in the FMP?	The OFL is the harvest rate expected to produce MSY and is based on a species specific estimate or proxy of MSY. Actively managed stocks: OFL = Biomass*Fmsy*Distribution. Monitored stocks: OFL=Stocks specific MSY proxy.	The OFL is the harvest rate expected to produce MSY, F_{MSY}. For category 1 stocks (with data-rich, quantitative assessments,) F_{MSY} proxies are $F_{30\%}$ for flatfish, $F_{40\%}$ for whiting, $F_{50\%}$ for rockfish, and $F_{45\%}$ for all other species. For category 2 (data-poor quantitative, or nonquantitative assessments) and category 3 (less- to nonquantitative assessments) stocks, OFL is set based on historical landings levels (typically	The OFL is the harvest rate expected to produce MSY, F_{MSY}. For vulnerable species, a precautionary reduction from the default OY calculation is considered on a case-by-case basis, based on information about the vulnerability of the stock. The FMP has a precautionary threshold of $0.75\ F_{MSY}$. Amendment 2 to the FMP (passed by Council) emphasizes the case-by-case approach, with $0.75\ F_{MSY}$ as a starting point from	The Salmon FMP does not define overfishing. A *conservation alert* is triggered during the annual preseason process if a natural stock or stock complex is projected to fall short of its conservation objective. Conservation objectives are FMP measures intended to provide guidance during the annual preseason planning process. An *overfishing concern* is triggered if, in three consecutive years, the

Table A.1: FMP Harvest Level and Overfished/Overfishing Issues				
	CPS	Groundfish	HMS	Salmon
	The FMP framework includes ABC control rules that account for scientific uncertainty in assessed stock status and/or relatively scarce data and low landings.	reduced by approximately 50%.) For all three categories, ABC is reduced from OFL, with the percentage reduction from OFL based on the level of scientific uncertainty associated with each stock's OFL.	which to consider alternative values.	postseason estimates indicate that a natural stock has fallen short of its conservation objectives. Amendment 16 to the Salmon FMP proposed to establish an OFL equal to $F_{MSY.}$
Are any of the stocks within the FMP listed as *overfished*, or has *overfishing* occurred? Are any Council-managed stocks listed as threatened or endangered under the ESA?	Overfished species: none Undergoing overfishing: none	Overfished species: Bocaccio in the Monterey and Conception management areas; canary rockfish; cowcod south of Point Conception; darkblotched rockfish; Pacific ocean perch; widow rockfish; yelloweye rockfish, and; petrale sole. In addition to Council-managed species, three distinct groundfish population segments within Puget Sound (Washington) are listed as endangered (bocaccio) or threatened (canary and yelloweye rockfish). These stocks are not encountered in PFMC-managed fisheries.	Overfished species: none. Undergoing overfishing: yellowfin tuna, bigeye tuna, Pacific bluefin tuna	The Salmon FMP excepts three types of salmon stocks from overfishing criteria: hatchery stocks, stocks for which Council management actions have inconsequential impacts, and stocks listed under the ESA. Of the many evolutionarily significant units of West Coast salmon species, several populations are listed as either endangered or threatened under the ESA: Chinook, 2 endangered and 7 threatened; chum, 2 threatened; coho, 1 endangered and 3 threatened; sockeye, 1 endangered and 1 threatened; steelhead, 1 endangered and 10

Table A.1: FMP Harvest Level and Overfished/Overfishing Issues				
	CPS	Groundfish	HMS	Salmon
		Undergoing overfishing: none		threatened. Sacramento River fall Chinook triggered an overfishing concern in 2004 and are currently considered overfished.
Are additional economic, social, or ecological factors taken into account in setting annual harvests?	Pacific sardine landings tend to be the most constraining for the fishery. Socioeconomic impacts of sardine allocation were analyzed in support of the allocation formula adopted under FMP Amendment 11. This allocation scheme is applied to management annually. The CPSMT and the SSC are working to include additional ecological considerations in CPS management. For the 2011 management cycle the CPSMT reviewed PACOOS reports and trends in sea bird and	The Council's focus is on managing stocks for MSY based on the status and biology of each stock. Social, economic, and ecological factors are not typically taken into account in setting annual harvests for stocks above MSST, although overfished stocks are managed with rebuilding plans to bring stocks back to B_{MSY} in as short a time as possible, after taking those factors into account. The Council has reduced annual harvests based on other considerations for certain stocks (e.g., the 2011-12 ACLs for shortbelly rockfish were set based on the stock's ecological importance). In addition,	All HMS management unit species are managed under the auspices of regional fishery management organizations, to which the US is a party. The Council has not set annual harvests (quotas) for any HMS species. For common thresher shark and shortfin mako shark, the Council has set annual harvest guidelines. The guideline for mako shark is based on the stocks vulnerability and the possible importance of the West Coast EEZ as a nursery habitat.	The Council focuses on protecting weak or ESA-listed natural salmon stocks, while providing harvest opportunity on stronger natural and hatchery stocks. Achieving these objectives is complicated by natural variability in annual stock abundance, in ocean migratory routes and timing, and in the high degree of mixing of different salmon species and stocks in ocean fisheries. Socioeconomic objectives seek to: provide for Indian harvest opportunity as provided in treaties with the United States; maintain ocean salmon fishing seasons that continue established recreational and commercial

Table A.1: FMP Harvest Level and Overfished/Overfishing Issues				
	CPS	Groundfish	HMS	Salmon
	mammal populations when developing recommendations. This is an area of CPS management that would likely benefit greatly from an EFMP.	the Council does have social and economic objectives for utilization of the annual harvest (e.g., managing annual harvests to provide year-round fishing opportunity).		fisheries, while meeting fair and equitable salmon harvest allocation objectives among ocean and inside recreational and commercial fisheries.

Table A.2: PFMC Harvest Level and Management Measures Setting Process

	Odd-Numbered Years					Even Numbered Years				
	March	April	June	September	November	March	April	June	September	November
CPS			Stock assessment review for P. mack. and setting of annual specifications		Stock assessment review for P. sardine and setting of annual specifications			Stock assessment review for P. mack. and setting of annual specifications		Stock assessment review for P. sardine and setting of annual specifications
Groundfish	Final council action on whiting specifica-tions; inseason adjustments	Inseason adjustments	Stock assessment review for next odd-even biennium; inseason adjustments	Final stock assessment review for next odd-even biennium; inseason adjustments	Stock assessments and rebuilding analyses for next odd-even biennium; inseason adjustments	Final council action on whiting specifications; stock assessment planning for 2nd from next odd-even biennium; inseason adjustments	Interim discussion of biennial harvest specifications and mgmt. measures for next odd-even biennium; inseason adjustments	Final council action on biennial harvest specifications (and mgmt. measures) for next odd-even biennium; inseason adjustments	Inseason adjustments	Inseason adjustments
HMS								Preliminary consideration of potential biennial mgmt. measures	Council identification of preferred alternatives for biennial mgmt. measures	Final Council adoption of biennial mgmt. measures
		RFMO recommendations and potential RFMO stock assessment results					RFMO recommendations and potential RFMO stock assessment results			
Salmon	Review of prior year's fisheries and stock abundance forecasts for current fishing year	Final Council action on ocean salmon mgmt. measures for current fishing year. Preliminary list of new or revised methodologies proposed for use for next year.		Final list of topics chosen for salmon methodology review	Final Council approval of salmon methodology revisions for use in the next mgmt. cycle.	Review of prior year's fisheries and stock abundance forecasts for current fishing year	Final Council action on ocean salmon mgmt. measures for current fishing year. Preliminary list of new or revised methodologies proposed for use for next year.		Final list of topics chosen for salmon methodology review	Final Council approval of salmon methodology revisions for use in the next mgmt. cycle.

Table A.3: Bycatch Issues				
	CPS	Groundfish	HMS	Salmon
What standardized bycatch reporting methodologies are used in the FMP's fisheries?	Washington and Oregon state logbooks and California dockside monitoring. State and Federal observer programs are implemented dependent upon funding. Data from historic observations used in management.	Bycatch in commercial fisheries is monitored primarily by the West Coast Groundfish Observer Program. The rationalized trawl fisheries will be monitored with 100% observer coverage. Recreational bycatch is monitored with surveys in the three states (CA and OR also employ at sea observers in the for-hire/charter fleets).	Logbooks are required for all Council-authorized commercial HMS fisheries operating within and outside the West Coast EEZ and for West Coast recreational charter vessels. Observers are required on some HMS fisheries, primarily those with substantive potential for bycatch of ESA species or other species of concern (fish, birds, turtles, and mammals.) There is also dockside monitoring of commercial and recreational landings on the West Coast.	Bycatch estimation is based on observer data and release mortality studies. Bycatch does not include any fish that legally are retained in a fishery and kept for personal, tribal, or cultural use, or that enter commerce through sale, barter, or trade. In addition, under the provisions of the MSA, bycatch does not include targeted salmon released alive under a recreational catch-and-release fishery management program.
How often and in what format does the Council receive bycatch information for this FMP's fisheries?	Annually in CPS SAFE document	The NWFSC compiles information on landings and discards and reports total catch once per year (with roughly a one year lag). The Groundfish Management Team uses bycatch projection models that account for the time lags in discard data.	The SWFSC compiles bycatch information as it becomes available. Bycatch information is reported in the annual HMS SAFE documents. Specific, relevant bycatch information is also provided to the Council when it considers HMS fishery management actions (e.g., biennial management measures, EFPs or other fishery changes).	Annually in SAFE document, with focus on a review of the prior year's fisheries. In salmon preseason planning process, management options are assessed for the effects on the amount and type of salmon bycatch and bycatch mortality. Salmon bycatch and mortality estimates for salmon fisheries are reported throughout the preseason process.
Are any gear specifications or modifications required	When fishing for CPS, deploy a net if a southern sea otter is	Gear regulations to minimize bycatch include: selective flatfish trawl	Most HMS fisheries have some gear specifications to reduce or prevent bycatch (e.g., drift	Only hook-and-line gear is allowed in ocean salmon fisheries and many fisheries are

Table A.3: Bycatch Issues				
	CPS	Groundfish	HMS	Salmon
to reduce or prevent bycatch?	observed within the area that would be encircled by the purse seine net.	gear specifications; trawl gear footrope/bobbin size restrictions; pot gear must include "rotten cotton" escape panel; longline gear must be regularly tended.	gillnet fisheries, longline fisheries, purse seine fisheries).	limited to the harvest of fin-marked hatchery stocks (mark-selective fisheries). Gear modifications such as the mandatory use of barbless hooks/ Plugs, the prohibition of fish attractors or bait, and restrictions on the number of spreads per troll line are used to minimize bycatch and/or release mortality.
Are any area closures required to reduce or prevent bycatch?	Washington state waters closed to sardine fishing for salmon and forage reasons (not Council required).	There are coastwide Rockfish Conservation Areas (RCAs,) for which the precise depth closures may vary by season and latitude, since these closures are intended to minimize incidental catch of overfished rockfish in depth zones where they commonly co-occur with more abundant groundfish stocks while maintaining some fishing opportunities for healthier stocks. There are also several RCAs with static boundaries off California and Washington, with a focus	Bycatch has been identified as a concern in the HMS drift gillnet, longline, and large-vessel purse seine fisheries. Within the EEZ, leatherback turtle conservation area is seasonally closed to drift gillnet fishing to prevent bycatch of these turtles. There is also a summer closure area for drift gillnet fishing during El Niño years to prevent bycatch of loggerhead turtles, (The HMS FMP also accounts for state area closures for the drift gillnet fishery to reduce bycatch of thresher sharks and other species.) RFMOs may also adopt conservation measures with area closures for HMS fisheries. EEZ is closed to HMS harvest of great white, basking and	Conservation areas closed to salmon fishing are established around certain river mouths and ocean areas are closed seasonally or annually to avoid concentrations of salmon stocks of concern. Additionally, salmon fisheries are restricted by mandatory and voluntary conservation areas to aid in the rebuilding of yelloweye rockfish populations.

Table A.3: Bycatch Issues				
	CPS	Groundfish	HMS	Salmon
		on protecting overfished cowcod and yelloweye, respectively; and Salmon Conservation Zones intended to minimize salmon bycatch in the whiting fishery.	megamouth sharks for conservation purposes, and to Pacific halibut and Pacific salmon.	
Have any of the fisheries participated in the MSA bycatch reduction engineering program?	No.	*FY08:* conservation engineering funding for researching groundfish gear alterations to reduce bycatch (selective flatfish trawl) *FY09:* seabird bycatch avoidance research for groundfish fisheries; monitoring seabird distribution and abundance in the California Current; continuing of FY08 gear technology research *FY10*: Continued gear technology funding, with additional new focus on open escape window bycatch reduction device (BRD) for Chinook salmon and rockfish bycatch in whiting mid-water trawl fishery; for bycatch *of* groundfish, rather than in	*FY08:* collaborative research to reduce post-release mortality for common thresher sharks taken in the recreational fishery off California *FY09:* continuation of FY08 thresher shark research *FY10*: continuation of thresher shark research; incidental take a post-release mortality of blue shark research in drift gillnet and longline swordfish fisheries	No.

Table A.3: Bycatch Issues				
	CPS	Groundfish	HMS	Salmon
		the groundfish fisheries, FY10 also saw funding for BRD research in the Pacific shrimp trawl fishery to reduce juvenile rockfish bycatch		
Which **fish** species are of greatest concern as bycatch within the FMP's fisheries?	ESA-listed salmon	ESA-listed salmon; rockfish species managed under overfished species rebuilding plans	In addition to the prohibited shark and salmon species listed above, the fish species of greatest concern as bycatch are those proposed to be listed as EC species. Also, non-targeted HMS species taken incidentally in HMS fisheries, such as tuna species with overfishing occurring being taken in other tuna fisheries (e.g., purse seine).	Minimizing the bycatch of threatened and endangered salmonid ESUs is the primary concern in salmon fisheries, and bycatch of fish other than salmon is generally very limited. Regulations allow for retention of most groundfish species and limited numbers of Pacific halibut that are caught incidentally.
What are the known gaps in monitoring for bycatch of **fish** species within the FMP's fisheries?	Detailed information on the number, species and size of salmon bycatch. Oregon and Washington have state logbook programs but salmon must be immediately released if captured.	WCGOP coverage varies between sectors with the focus on the limited entry trawl and fixed gear fisheries. Some fisheries that catch rockfish are not observed at all (e.g., salmon troll and directed halibut fishery).	Drift gillnet fisheries and longline fisheries have mandated observer programs. These fisheries have declined in recent years in the EEZ and bycatch data are considered adequate at this time.	Observer data is either dated or nonexistent for some fisheries. The observed and forecast mortality associated with mark-selective fishing is an ongoing research priority. Genetic Stock Identification is a developing tool to better understand the mixing and migration of various natural salmon stocks.

Table A.3: Bycatch Issues				
	CPS	Groundfish	HMS	Salmon
Which **non-fish (mammals, turtles, birds)** species are of greatest concern as bycatch within the FMP's fisheries?	None. A Biological Opinion was prepared on the interaction of the sardine fishery with southern sea otters, but interaction rate is extremely small.	Bycatch of marine mammals, seabirds, and turtles is rare, occurring in fewer than 2% of observed trips in 2002-2008. Bycatch estimates for California sea lions were highest of the marine mammals taken in the groundfish fisheries, with these animals primarily taken in trawl nets. Bycatch estimates for black-footed albatross were highest of the seabirds taken in the groundfish fisheries, with these birds primarily caught by longline gear in the limited entry primary sablefish fishery.	Bycatch of several mammals, birds, and turtles are major concerns for HMS drift gillnet, longline and purse seine fisheries, both within and outside the EEZ. Biological opinions have been prepared to address some of these concerns. Many fishing gear requirements and fishing activity restrictions are implemented to prevent and reduce bycatches of these species.	The bycatch of non-fish species in salmon fisheries is negligible.
What are known gaps in monitoring for bycatch of **non-fish (mammals, turtles, birds)** species within the FMP's fisheries?	Currently no observer program for CPS vessels.	Bycatch is monitored using the same methods as for fish species, so although take of non-fish species is recorded, sampling design is focused on capturing the bycatch of fish in a statistically significant manner.	Bycatch is monitored using the same methods as for fish species, primarily observers and logbooks.	None.

Table A.4: EFH Issues				
EFH Issues	CPS	Groundfish	HMS	Salmon
Brief description of FMP's EFH	The east-west geographic boundary of CPS finfish and market squid EFH is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington to the limits of the exclusive economic zone (EEZ) and above the thermocline where sea surface temperatures range between 10°C to 26°C. The southern boundary is the US-Mexico maritime boundary, while the northern boundary varies both seasonally and annually with temperature.	All waters and substrate within areas with a depth less than or equal to 3,500 meters shoreward to the mean higher high water level or the upriver extent of saltwater intrusion, including seamounts in depths greater than 3,500 meters. (50 CFR 660.395)	In general, management unit species are found within temperate waters. The FMP does not provide a multi-species EFH designation. Instead, the FMP at 7.2 describes species- and life-state-specific EFH for: common thresher shark, pelagic thresher shark, bigeye thresher shark, shortfin mako shark, blue shark, albacore tuna, bigeye tuna, northern bluefin tuna, skipjack tuna, yellowfin tuna, striped marlin, swordfish, and dorado.	Water bodies occupied or historically accessible in WA, OR, ID, and CA in 4th field hydrologic units identified at 50 CFR 660, except for where certain identified dams represent the upstream extent of Pacific salmon access. EFH also includes marine and estuarine areas shoreward of the boundaries of the EEZ and shoreward of state marine boundaries off the coasts of California, Oregon, Washington, and Alaska. (50 CFR 660.412)
Brief description of FMP's Habitat Areas of Particular Concern	None.	Groundfish HAPCs include both mapped areas and described habitat types. In addition to the mapped area HAPCs, provided in the FMP at Section 7.3, groundfish HAPCs include the following habitat types: estuaries, canopy kelp, seagrass, and rocky reefs.	None.	None, although a list of potential HAPCs is under consideration as part of the Salmon FMP's 5-year review.
Does the FMP have any closed areas to protect EFH? Do	No.	Yes: large (>700 fm/>1280 m) coastwide closure, plus 51 enclosed areas. Yes:	No.	No.

Table A.4: EFH Issues				
EFH Issues	CPS	Groundfish	HMS	Salmon
those closed areas apply to fisheries not managed under the FMP?		prohibitions vary between areas, but apply to bottom trawl (including non-groundfish trawl) and bottom contact gear (including for spp. other than groundfish).		
Where is the FMP in its EFH 5-year review process?	Finished in 2010/	Review initiated in 2010. Council to affirm process schedule in 03/11 or 04/11	Not yet initiated	Review initiated over 2009-2010. Final Council action anticipated in April 2011
Is the EFH currently mapped? If not mapped, why not? How can the EFH be best described/communicated?	No, although there are maps of general locations of temperature boundary line.	Yes, see: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Groundfish-EFH/Index.cfm	Yes, but it is mapped for individual species, not aggregated for all FMP species. See: http://www.pcouncil.org/wp-content/uploads/HMS_AppF.pdf	Yes, see: http://www.nwr.noaa.gov/Salmon-Habitat/Salmon-EFH/Index.cfm
What consultations has NMFS done on the effects of non-fishing activity on the FMP's EFH?	Since the 1996 Sustainable Fisheries Act introduced the concept of EFH, NMFS's Northwest Region has completed >300 consultations on the effects of various non-fishing activities on CPS EFH, many of which were consultations combined with groundfish and salmon EFH consultations. Projects ranged from tidal and erosion area construction, military training, dredging, cable laying, and other activities.	Since the 1996 Sustainable Fisheries Act introduced the concept of EFH, NMFS's Northwest Region has completed >300 consultations on the effects of various non-fishing activities on groundfish EFH, many of which were consultations combined with CPS and salmon EFH consultations. Projects ranged from tidal and erosion area construction,	None.	Since the 1996 Sustainable Fisheries Act introduced the concept of EFH, NMFS's Northwest Region has completed >1800 consultations on the effects of various non-fishing activities on salmon EFH, ranging from construction projects in or near waterways, wastewater treatment, dredging, and other projects. Most of these

Table A.4: EFH Issues				
EFH Issues	CPS	Groundfish	HMS	Salmon
		military training, dredging, cable laying, and other activities.		consultations (>1700) were combined EFH and Endangered Species Act consultations on the habitat effects of the proposed action.

Table A.5: Critical habitat designations and proposed designations for ESA listed species on the West Coast	
Marine mammals Killer whale (*Orcinus orca*) – Southern Resident (Northwest U.S) Stellar sea lion (*Eumetopias jubatus*)	 Portions of Puget Sound (WA) Oregon and California rookeries
Marine and anadromous fish Chinook salmon (*Oncorhynchus tshawytscha) – 9 listed ESUs* Coho salmon (*Oncorhynchus kisutch) – 4 listed ESUs* *Chum salmon (Oncorhynchus keta*) – 2 listed ESUs Sockeye salmon (*Oncorhynchus nerka*) – 2 listed ESUs Steelhead trout *(Oncorhynchus mykiss) – 11 listed DPSs* *Green sturgeon (Acipenser medirostris) – southern DPS*	 CA, OR, WA streams and rivers CA, OR, WA streams and rivers OR and WA streams and rivers WA and ID streams and rivers CA, OR, WA, ID streams and rivers WA, OR, CA nearshore areas
Marine and anadromous fish *Pacific eulachon/smelt[1] (Thaelichthys pacificus) – southern DPS*	*Proposed freshwater creeks and associated estuaries of WA, OR, CA*
Sea turtles Leatherback sea turtle[2] (*Dermochelys coriacea*)	 *Proposed marine waters off WA, OR, CA*
Marine invertebrates and plants Black abalone[3] *(Haliotis cracherodii)*	 *Proposed nearshore waters off CA*

DPS – distinct population segment
ESU – evolutionary significant unit

[1] Critical habitat for Pacific eulachon was proposed on January 5, 2011. The proposed designation includes areas within the states of California, Oregon, and Washington. The proposed areas are a combination of freshwater creeks and rivers and their associated estuaries which comprise approximately 470 km (292 mi) of habitat. (76 FR 515).

[2] Critical habitat for Leatherback sea turtles was proposed on January 5, 2010. The proposed designation includes two adjacent marine areas totaling approximately 119,400 km² stretching along the California coast from Point Arena to Point Vincente; and one 63,455 square km²) marine area stretching from Cape Flattery, Washington to the Umpqua River (Winchester Bay), Oregon east of a line approximating the 2,000 meter depth contour. Proposed critical habitat extends from the surface down to a depth of 80 m (75 FR 319).

[2] Critical habitat for black abalone was proposed on September 28, 2010. The proposed designation includes approximately 390 square kilometers of critical habitat for the endangered black abalone, pursuant to section 4 of the Endangered Species Act (ESA). Specific areas proposed for designation include rocky habitats from the mean higher high water (MHHW) line to a depth of 6 meters (m) within the following areas on the California coast: Del Mar Landing Ecological Reserve to Point Bonita; from the southern point at the mouth of San Francisco Bay to Natural Bridges State Beach; from Pacific Grove to Cayucos; from Montan˜ a de Oro State Park to just south of Government Point; Palos Verdes Peninsula from the Palos Verdes/Torrance border to Los Angeles Harbor; the Farallon Islands; An˜ o Nuevo Island; San Miguel Island; Santa Rosa Island; Santa Cruz Island; Anacapa Island; San Nicolas Island; Santa Barbara Island; Catalina Island; and San Clemente Island. (75 FR 59900)

Sturgeon
http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/greensturgeon.pdf

proposed leatherback
http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/leatherback_proposed.pdf

stellar sea lion
http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/stellersealion_ca_or.pdf

killer whale
http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/killerwhale_sr.pdf

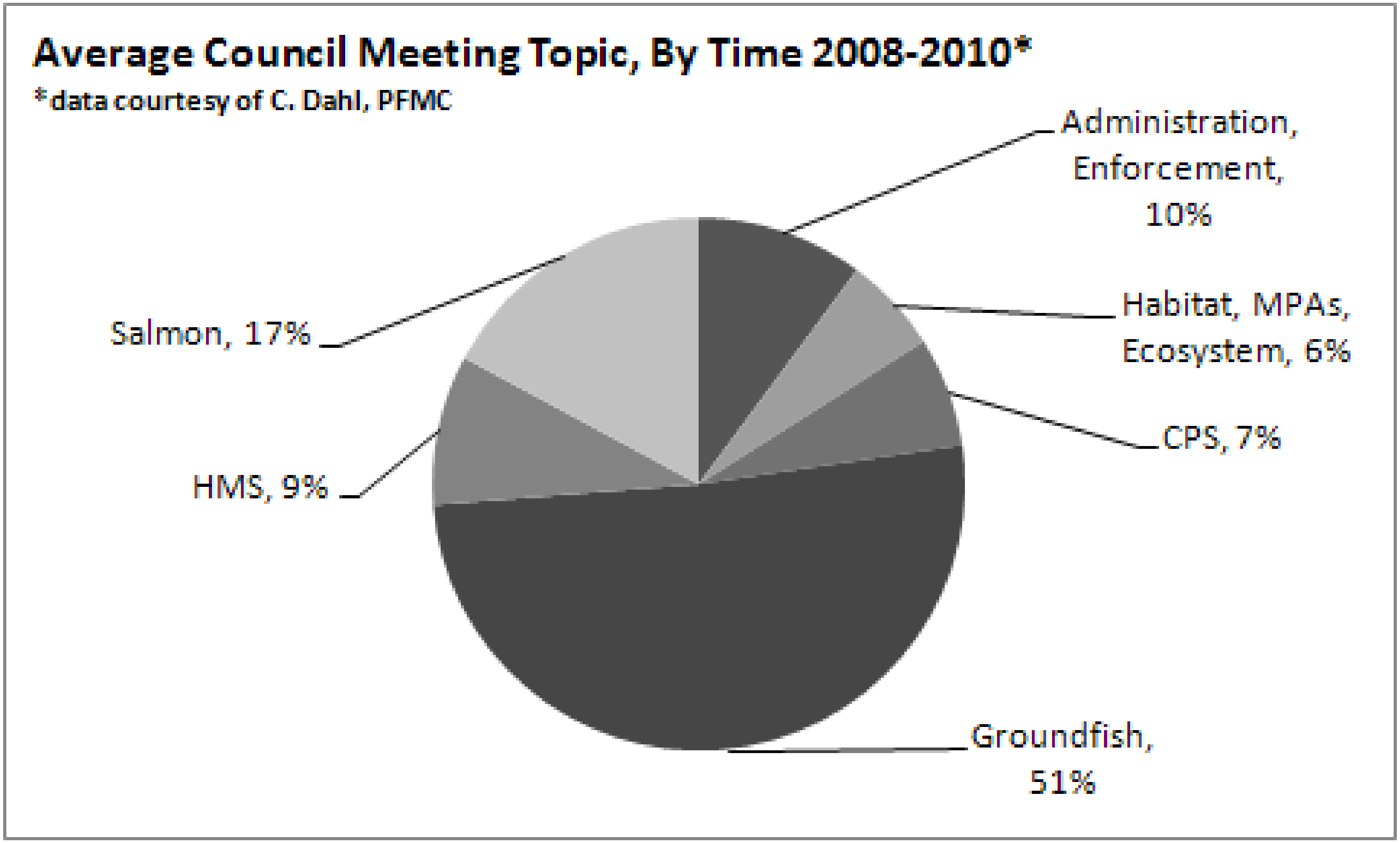
NW salmon
http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/upload/NWR-CH-map.pdf

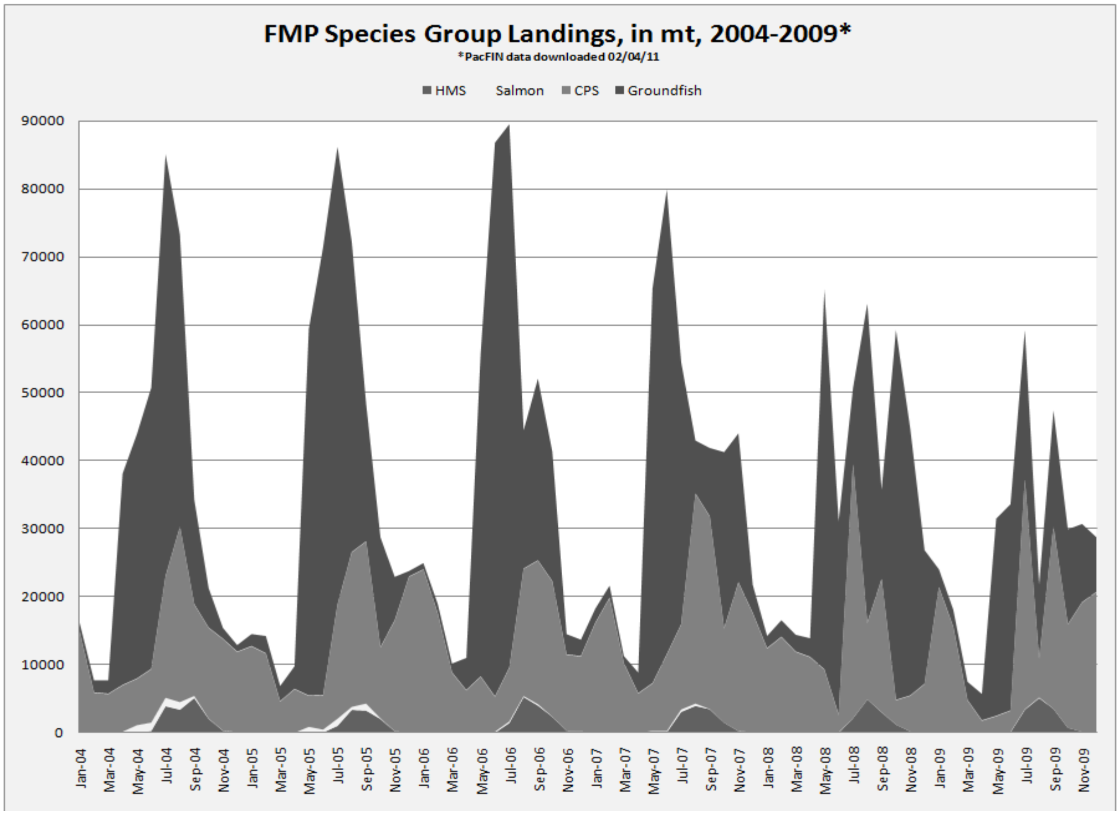
Cali. Salmon
http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/upload/SWR-CH-map.pdf

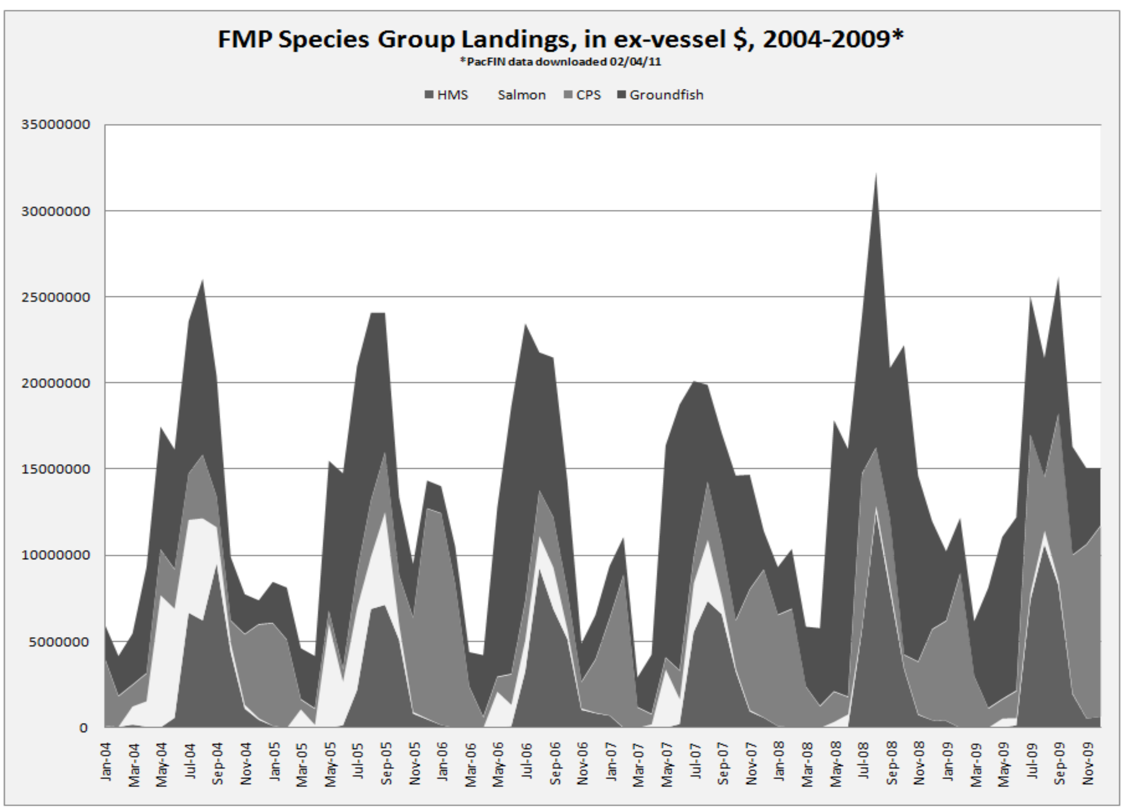
eluachon
http://www.nwr.noaa.gov/Other-Marine-Species/upload/eulachon-CH-maps.pdf

Table A.6: Community Effects Issues				
	CPS	Groundfish	HMS	Salmon
Recorded safety issues, vessel incidents, mortalities for fisheries under this FMP?	USCG District 11 2006-2010 data: 10 squid fishery vessel incidents, from which one life was lost and seven vessels were lost. USCG District 13 2000-2008 data: 4 sardine fishery vessel incidents, from which two lives were lost and four vessels were lost.	USCG District 11 2006-2010 data: 9 vessel groundfish fishery vessel incidents, from which two lives were lost and seven vessels were lost. USCG District 13 2000-2008 data: 10 groundfish fishery vessel incidents, from which six lives were lost and five vessels were lost.	USCG District 11 2006-2010 data: 1 tuna fishery vessel incident, no lives nor vessels lost. USCG District 13 2000-2008 data: 8 tuna fishery vessel incidents, from which two lives were lost and seven vessels were lost.	USCG District 11 2006-2010 data: 7 salmon fishery vessel incidents (3 of which were combination crab/salmon trips,) from which three lives were lost and five vessels were lost. USCG District 13 2000-2008 data: 17 salmon fishery vessel incidents, from which eleven lives were lost and sixteen vessels were lost.
Has fishing community dependence on FMP resource and resilience to changes in resource availability been assessed?	Socioeconomic and community impacts from Pacific sardine harvest policy were assessed for Amendment 11 which established a long-term allocation scheme.	The Council assesses impacts to fishing communities during the biennial management measures process.	The Council assesses impacts to fishing communities during the biennial management measures process and when considering other management measures (such as possibly establishing a high seas shallow-set longline fishery), and at times, when providing recommendations to RFMOs.	Socioeconomic impacts are assessed by port area, both historically (see Amendment 14-App. B) and for the proposals under the preseason management cycle.
How does Council receive policy process input from	The Council receives community input primarily from the Coastal Pelagic Species Advisory	The Council process receives input from public comment and the	The Council process receives input from public comment and the	The Council process receives input from public comment and the Salmon

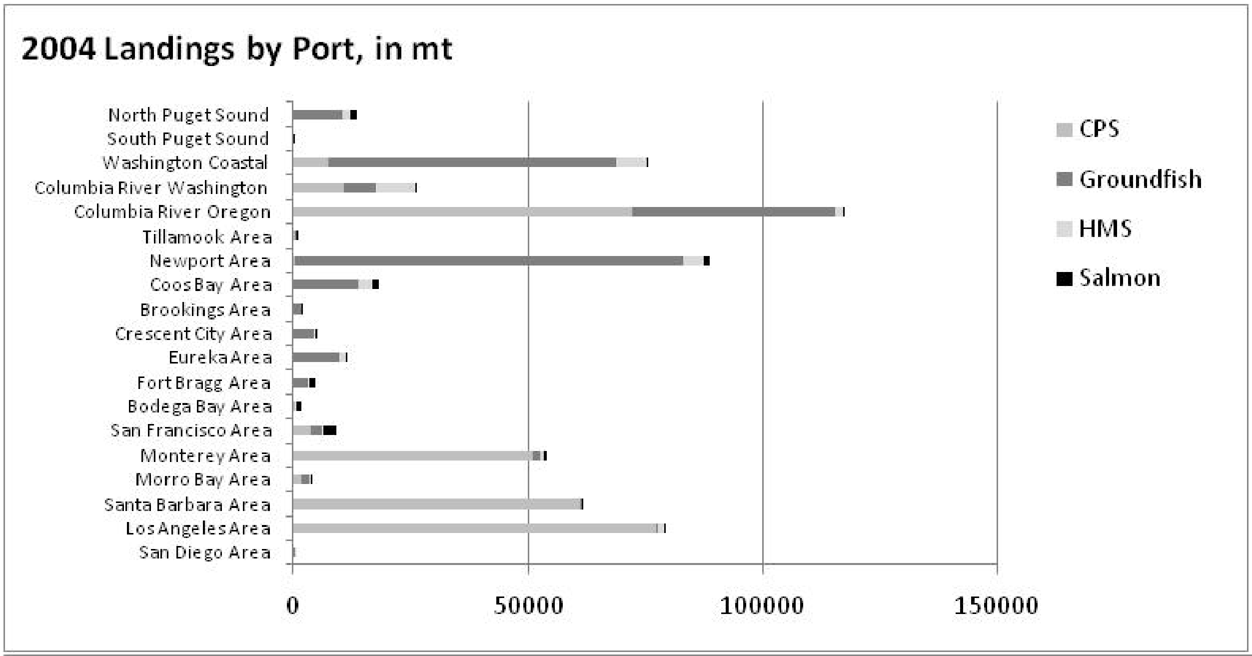
Table A.6: Community Effects Issues				
	CPS	Groundfish	HMS	Salmon
FMP's fishing communities?	Subpanel and the public.	Groundfish Advisory Panel each Council meeting.	HMS Advisory Panel each Council meeting. NMFS reports on RFMO processes and activities, which may involve community input via US advisory groups and delegations to RFMOs.	Advisory Panel each Council meeting and at annual public hearings.
How is economic and social information monitored and considered in the decision-making process?	The annual CPS SAFE contains information on fishery economics and socioeconomic impacts of harvest policies are considered through the Council and NEPA processes.	Economic and social information is monitored mainly by tracking landed catch and effort by port/area and is taken into account most prominently in the rebuilding plans as part of the assessment of the "needs of the fishing community." Regular monitoring of other socioeconomic information is limited. Information considered by the Council is compiled from existing sources (e.g., the U.S. Census) and a few voluntary surveys administered by NMFS. NMFS is implementing a mandatory economic data collection program for the trawl rationalization program.	Economic and social information is monitored mainly by tracking landed catch and effort by port/area and is reported in annual SAFE documents and considered during the biennial management cycle and when other management actions (e.g., EFPs) are being considered. It is also considered in the Council's formation of recommendations to RFMOs.	Economic and social information is monitored mainly by tracking landed catch and effort by port/area and is reported and considered during the preseason management cycle. Data for previous years as well as projections for each to the alternative management options are available to the public and the Council through a series of preseason documents.

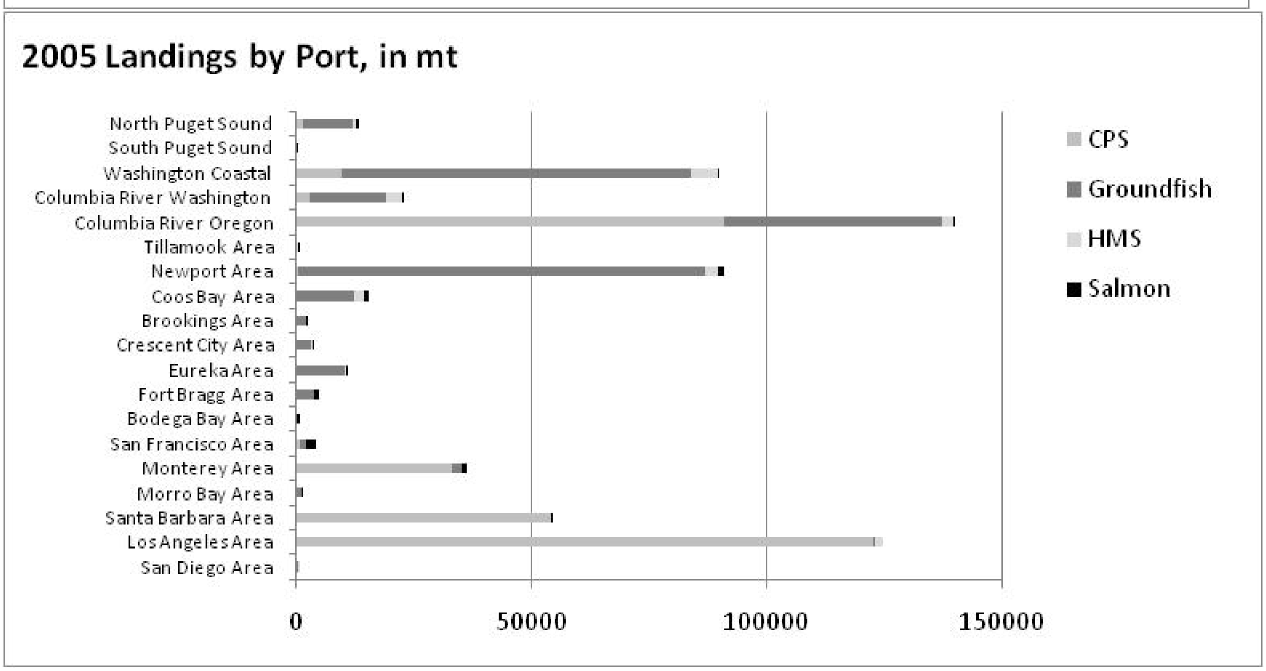

Average Council Meeting Topic, By Time 2008-2010*
*data courtesy of C. Dahl, PFMC
Administration, Enforcement, 10%
Habitat, MPAs, Ecosystem, 6%
CPS, 7%
Groundfish, 51%
HMS, 9%
Salmon, 17%

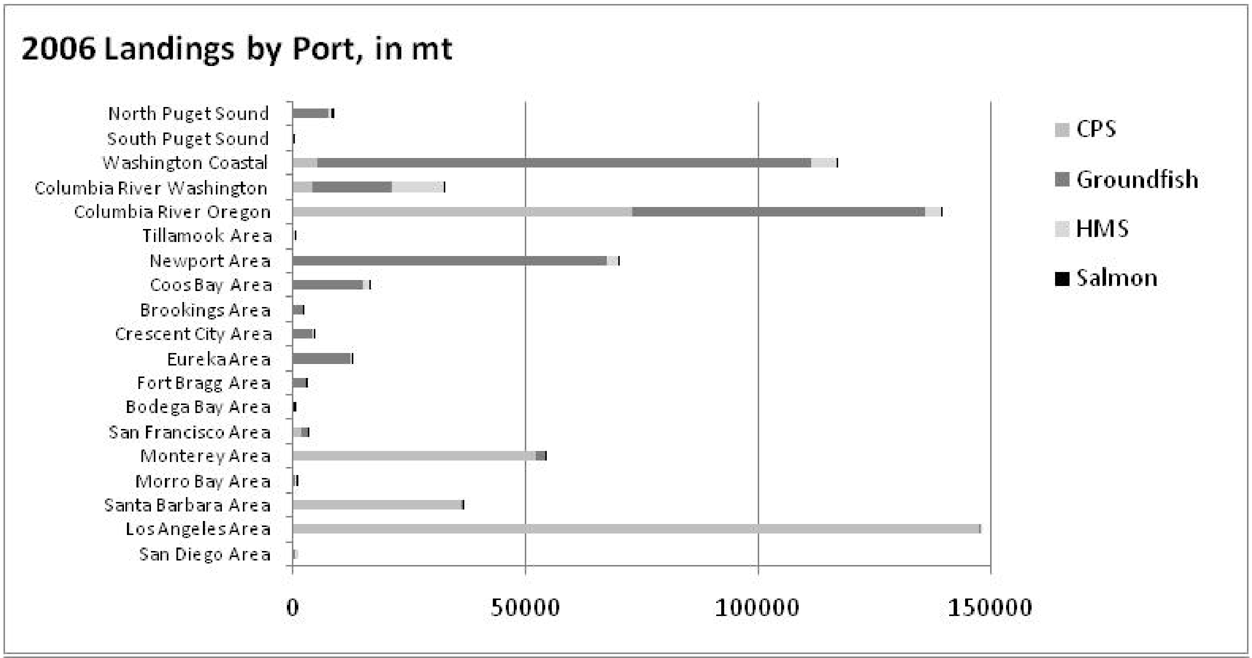

FMP Species Group Landings, in mt, 2004-2009*
*PacFIN data downloaded 02/04/11
HMS
Salmon
CPS
Groundfish


FMP Species Group Landings, in ex-vessel $, 2004-2009*
*PacFIN data downloaded 02/04/11
HMS
Salmon
CPS
Groundfish

The following charts illustrate 2004-2009 FMP species group landings in metric tons and in ex-vessel revenue, separated by Pacific Fisheries Information Network (PacFIN) Port Group Areas. A list of individual ports aggregated into each Port Group Area may be found online at: http://pacfin.psmfc.org/pacfin_pub/codes.php






2006 Landings by Port, in mt
North Puget Sound
South Puget Sound
Washington Coastal
Columbia River Washington
Columbia River Oregon
Tillamook Area
Newport Area
Coos Bay Area
Brookings Area
Crescent City Area
Eureka Area
Fort Bragg Area
Bodega Bay Area
San Francisco Area
Monterey Area
Morro Bay Area
Santa Barbara Area
Los Angeles Area
San Diego Area
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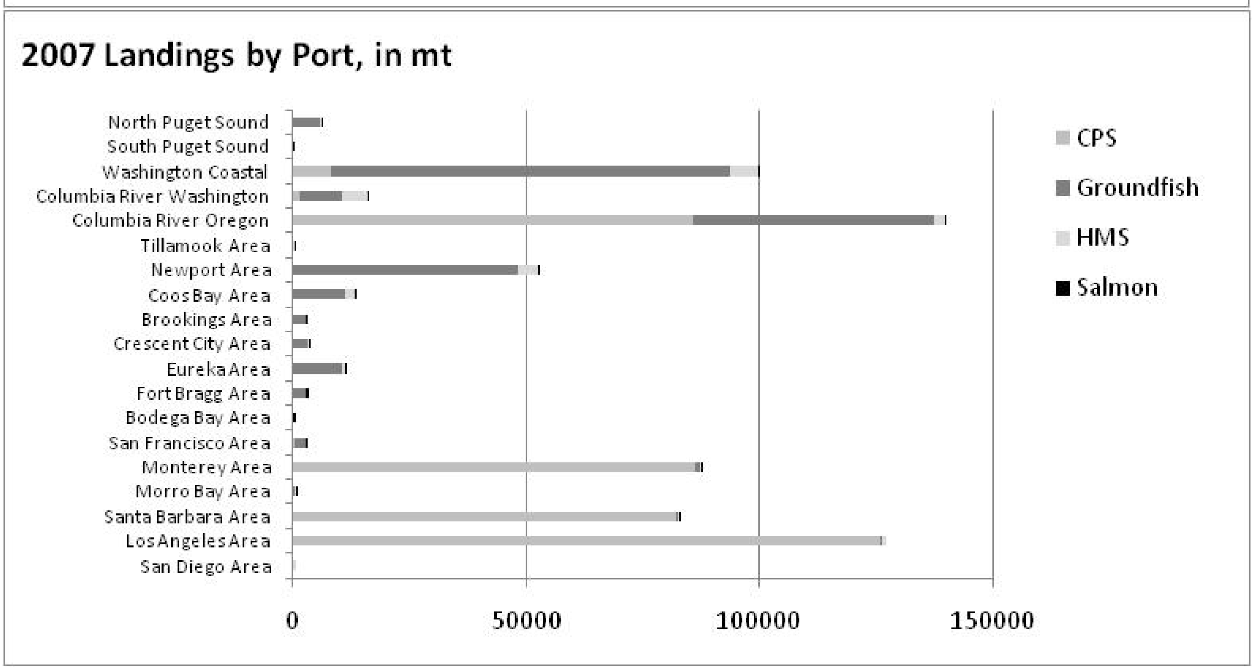
CPS
Groundfish
HMS
Salmon


2007 Landings by Port, in mt
North Puget Sound
South Puget Sound
Washington Coastal
Columbia River Washington
Columbia River Oregon
Tillamook Area
Newport Area
Coos Bay Area
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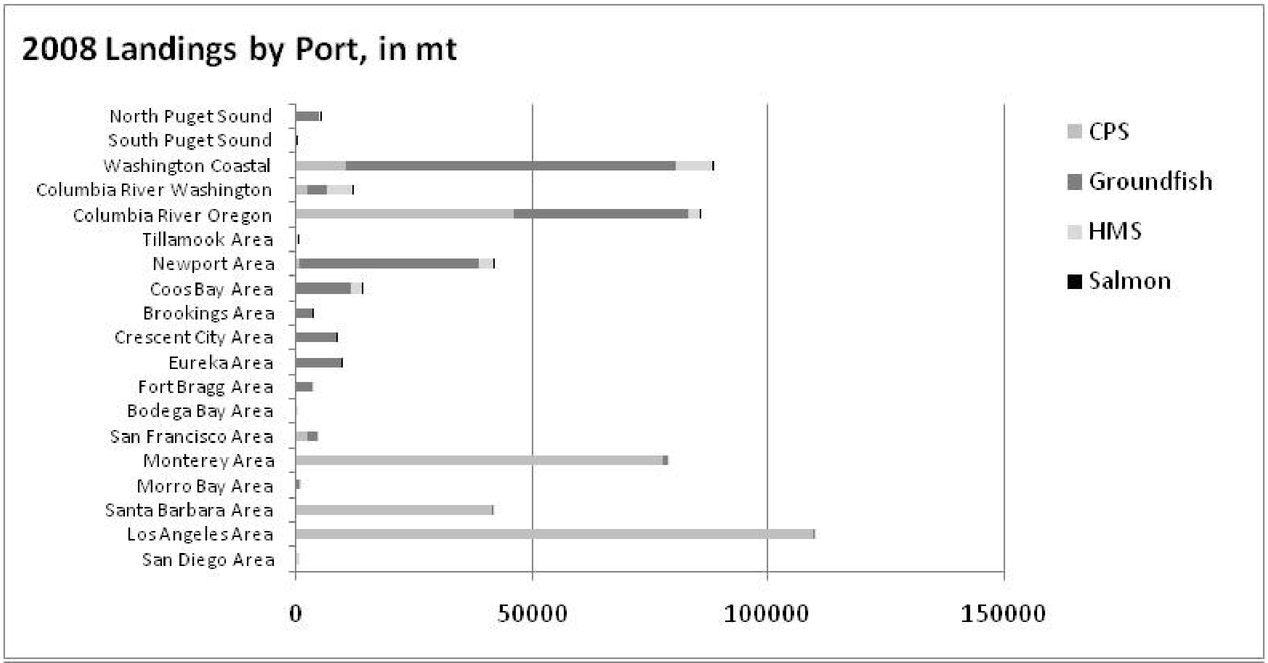
2008 Landings by Port, in mt
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South Puget Sound
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Coos Bay Area
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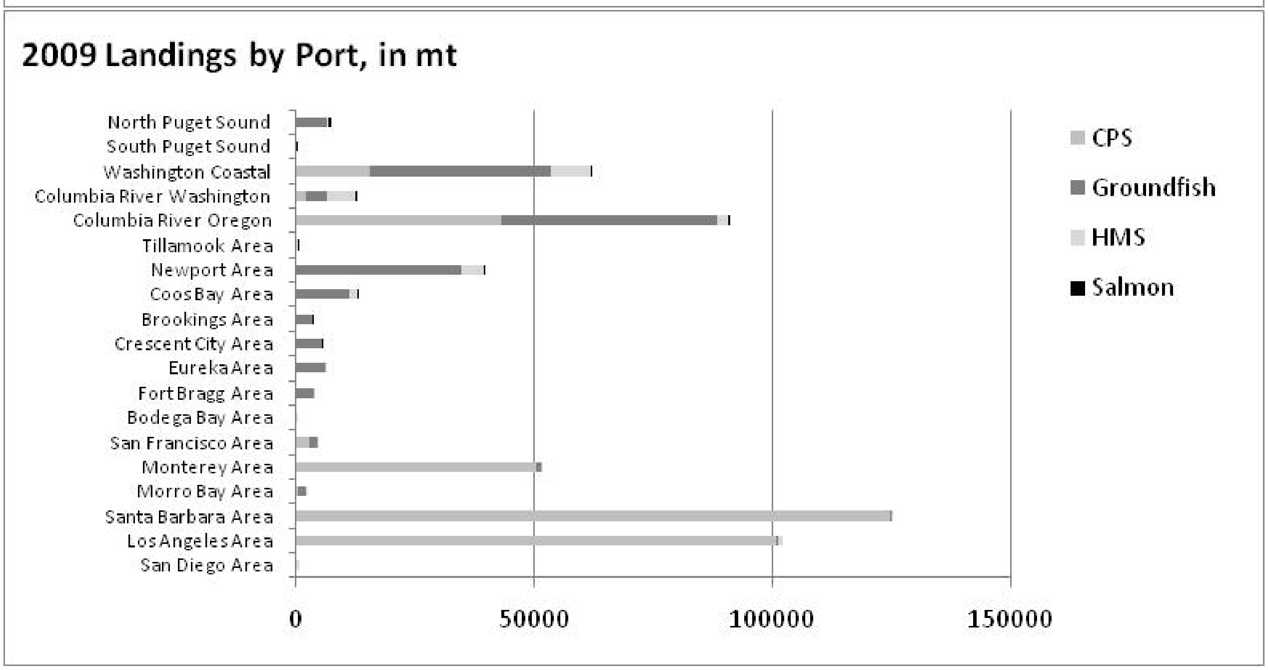
2009 Landings by Port, in mt
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South Puget Sound
Washington Coastal
Columbia River Washington
Columbia River Oregon
Tillamook Area
Newport Area
Coos Bay Area
Brookings Area
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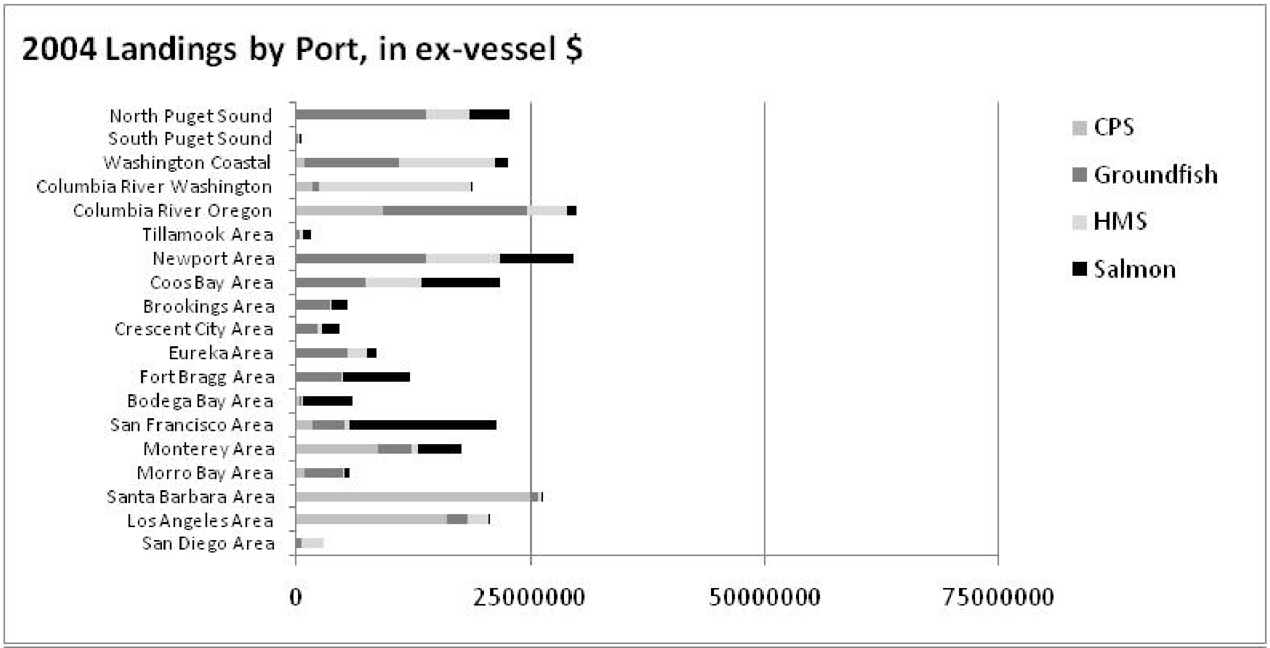
2004 Landings by Port, in ex-vessel $
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Columbia River Oregon
Tillamook Area
Newport Area
Coos Bay Area
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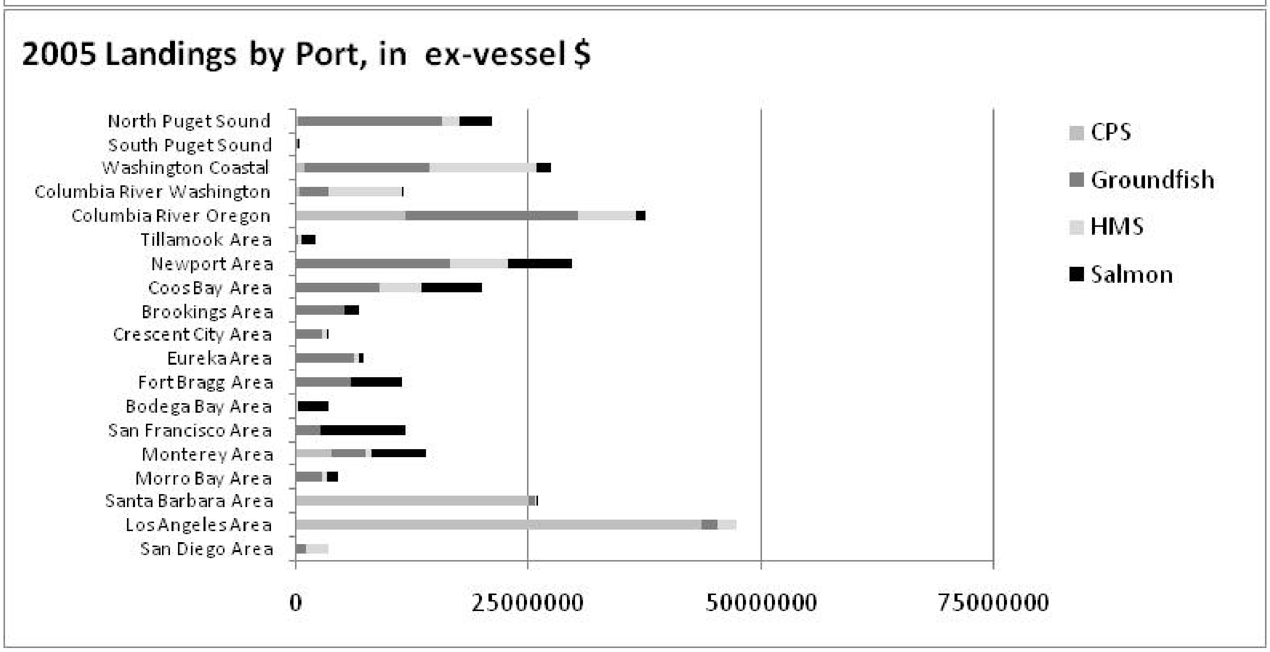
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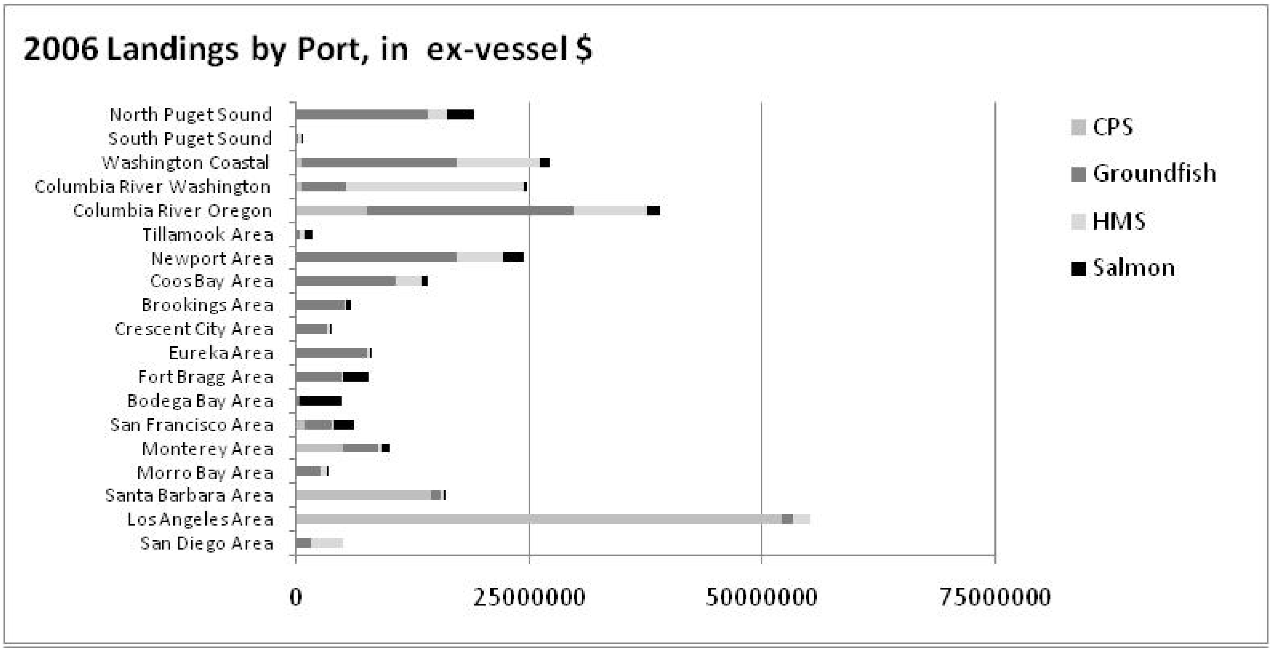
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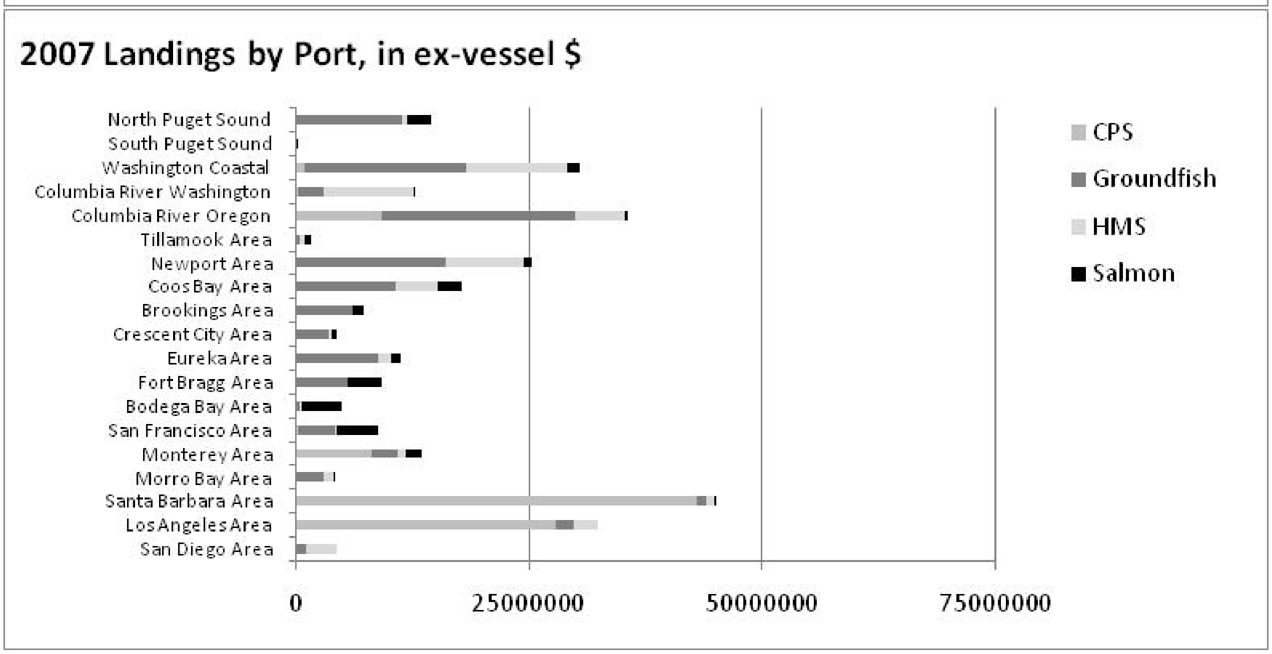
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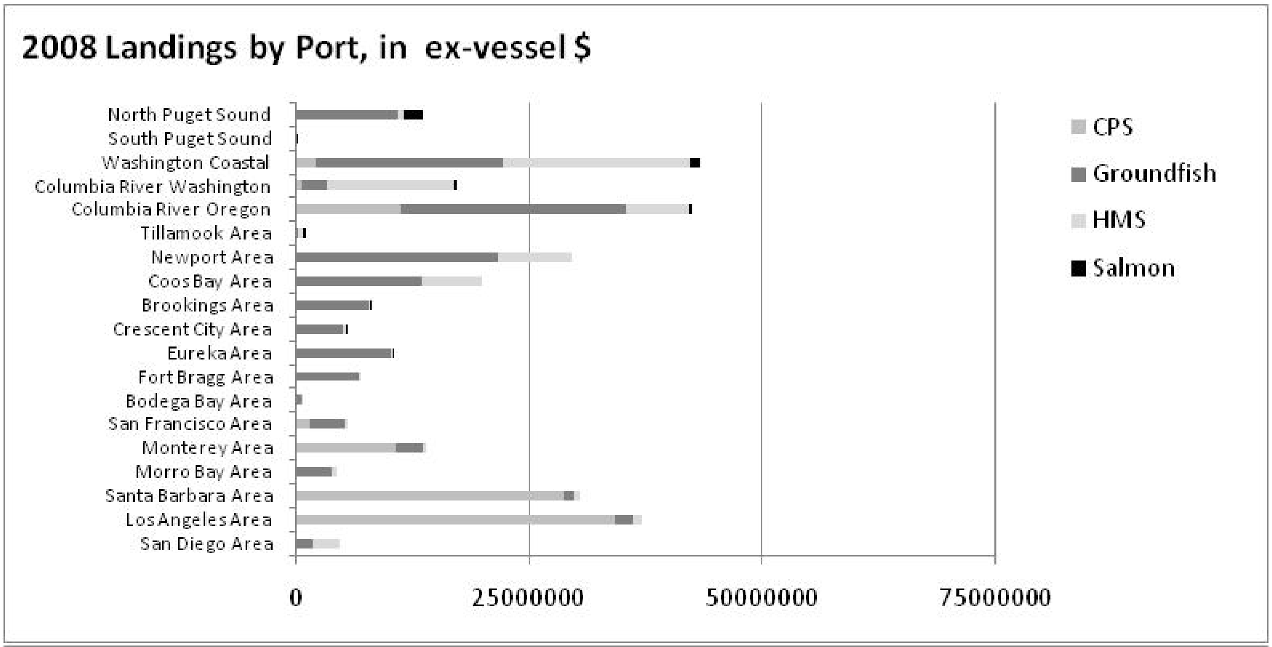
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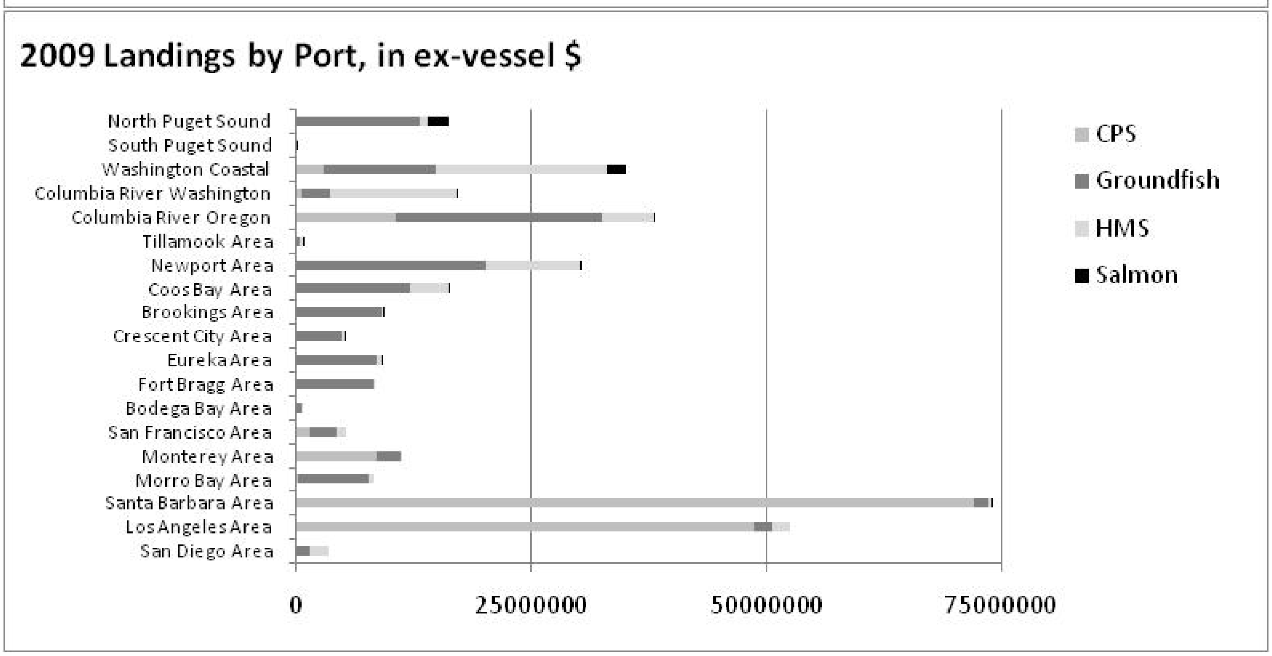
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02/10/11

ECOSYSTEM FISHERY MANAGEMENT PLANNING FOR U.S. WEST COAST FISHERIES

August 2010

PREPARED BY:

PACIFIC FISHERY MANAGEMENT COUNCIL
ECOSYSTEM PLAN DEVELOPMENT TEAM
7700 NE AMBASSADOR PLACE, SUITE 101
PORTLAND, OREGON 97220-1384
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Table of Contents

1 Introduction

At its November 2009 meeting, the Pacific Fishery Management Council (Council or Pacific Council) discussed ecosystem-based fishery management planning and assigned the following series of tasks to Council staff and to the Council's newly-formed Ecosystem Plan Development Team (EPDT) and Ecosystem Advisory Subpanel (EAS):

- Schedule presentations by scientists from the National Marine Fisheries Service (NMFS) Northwest and Southwest Fisheries Science Centers on the state of the science in support of ecosystem-based fishery management.
- Review the Council record of dialogue on ecosystem-based fishery management including statements by the Council, its advisory bodies, and the public.
- Review the existing Council fishery management plans (FMPs) to identify existing approaches and commonalities regarding ecosystem approaches to management.
- Inventory ecosystem-related management tools for their applicability to the ecosystem-based fishery management planning process.
- Review existing ecosystem-based fishery management efforts of other regional fishery management councils (FMCs).
- Prepare a report to the Council that includes statement of purpose and need; a list of initial goals and objectives; a range of options on the geographic range of an ecosystem-based fishery management planning document, the regulatory scope of the plan, and the management unit species within an Ecosystem FMP (EFMP); and list miscellaneous issues to be addressed by an EFMP.

This report is intended to be the EPDT's response to the final task on the Council's list, although it touches on some of the other tasks. The EPDT developed this report with substantial, and greatly appreciated, aid and comment from the EAS. This report is the EPDT's first product for Council and public review, and it concerns a subject that has a broad range of interpretations both within and beyond the Pacific Council process. The EPDT considers this report and any suggestions or recommendations herein as preliminary guidance intended to help and inform the Council as it initiates its discussions on ecosystem-based fishery management.

Note: Throughout this report, we use the term "EFMP" broadly, to include any kind of ecosystem planning document the Council might choose to develop. We recognize that the term "FMP" has a particular definition under the law, and that the Council has not yet chosen the format of the ecosystem planning document it wishes to develop. The Council may or may not choose to develop a document with the authorities and obligations of an FMP. The term "EFMP" is used herein for the sake of simplicity, because that is the term the Council process has used since it first began discussing these issues. No Council decision is implied in our use of the term.

2 Pacific Council Interests in Ecosystem Fishery Management Planning

In recent years, U.S. FMCs have expressed broad interest in ecosystem-based fishery management, with each council taking a different approach to incorporating ecosystem information into their fishery management processes. In keeping with published literature, the Pacific Council has discussed implementing ecosystem-based fishery management in a deliberative and iterative fashion, gradually adopting ecosystem goals, objectives and management actions, rather than a revolutionary upheaval to replace current management structures and objectives (EPAP 1999, Link *et al.* 2002, Pikitch *et al.* 2004, Field and Francis 2006, Francis *et al.* 2007, Murawski 2007, Marasco *et al.* 2007). The Council has implemented ecosystem-based fishery management principles through several existing actions, including a krill fishing ban, conservative harvest control rules for forage species, implementation of extensive area closures and marine protected areas, and the use of ocean survival indicators for determination of allowable fishery effects on coho salmon. The Council has also employed spatial management concepts for years and has recommended closed areas to rebuild overfished species, minimize bycatch, and preserve essential fish habitat.

In November 2006, the Council moved to begin development of an EFMP for waters off Washington, Oregon, and California. The Council saw an EFMP as providing the fishery management process with additional ecosystem information, and enabling comprehensive and coordinated fishery regulation in the exclusive economic zone (EEZ,) while also allowing more species-specific management to continue under the Council's four FMPs. The Council has expressed the intent to use an EFMP for long-term planning, particularly in improving and coordinating spatial management initiatives.

The Council maintains a detailed history of its EFMP considerations on its ecosystem-based management timeline website (http://www.pcouncil.org/ecosystem-based-management/ecosystem-management-timeline/). Since 2006, the Council has worked primarily through its Habitat Committee (HC) and with its Scientific and Statistical Committee (SSC) and that committee's Ecosystem Subcommittee to discuss bringing ecosystem science and ecosystem-based fishery management into the Council process. In the fall of 2009, the Council acquired funds to begin EFMP development and then appointed members of an EPDT and an EAS, providing initial tasks for these two new advisory groups.

The EPDT is a 13-member group of State, Federal, and Tribal scientists and policy analysts. The EAS is an 11-member multi-disciplinary group representing west coast industry, policy, and conservation interests. The EPDT and the EAS will apply their unique perspectives and broad expertise in close coordination to provide the Council with analyses and recommendations on science in support of ecosystem-based fishery management principles and to develop goals, objectives, and policy alternatives for Council consideration as the EFMP takes shape over the next few years.

The EPDT and the EAS held their first meeting as a joint session in Portland, Oregon on February 10-11, 2010. The meeting focused on the Council's initial tasks and ways the group could most effectively develop the requested report. The meeting also allowed some time to discuss the broad range of perspectives from members of the EAS and the EPDT on ecosystem-based fishery management planning and how it could be applied to the Council process. The EPDT developed its first draft of this report by April 2010, which was then reviewed and discussed by the EAS at its May 4, 2010 meeting in Portland, Oregon. The EPDT subsequently met, again in Portland, Oregon, on July 21, 2010 to review its report and EAS recommendations, and to make plans for revising the report in preparation for inclusion in the Council's September 2010 meeting's briefing book.

3 Consideration and Statement of Purpose and Need for Ecosystem-Based Fishery Management Planning and for a Planning Document

One of the Council-assigned tasks for the EPDT was a draft statement of purpose and need for an EFMP. Although purpose and need statements are required as part of National Environmental Policy Act (NEPA) analysis documents, the Council is not yet at a NEPA analysis stage in its process of considering EFMP development. Therefore, this section instead uses the discussion of purpose and need as an independent planning aid, not as it is more narrowly and formally used in NEPA analysis.

The purpose of and need for an ecosystem-based fishery management framework should come from the Council's mandates, authorities, and policy preferences and the general concepts and principles of ecosystem approaches to management. This section discusses the purpose of and need for ecosystem-based fishery management planning in general, and provides a potential draft statement on the purpose of and need for an ecosystem-based planning document within the Council process.

3.1 Ecosystem-Based Fishery Management Planning

In scientific literature, explorations of the purpose of and need for ecosystem-based fishery management often begin with a definition of what it is. Definitions of ecosystem-based fishery management use new terms —such as ecosystem services, biodiversity, resilience, etc.—yet these terms are just new labels on principles that have long been discussed as part of sustainable development or sustainability. In U.S. fisheries law, the 1976 Fishery Conservation and Management Act used these concepts to define conservation and management measures as assuring that: "a supply of food and other products may be taken and that recreational benefits may be obtained, on a continuing basis; irreversible or long-term adverse effects on fishery resources and the marine environment are avoided; and there will be a multiplicity of options available with respect to future uses of these resources" (FCMA 1976).

Ecosystem approaches to management are still about societal choice among competing objectives (Shepherd 2004). Fundamentally, ecosystem-based fishery management recognizes that fisheries both affect and are affected by the marine environment, and that what we do to address these effects via policy-making is a matter of societal choice. The purpose of the ecosystem approach is not to prescribe particular policy choices, but rather to promote better understanding of those policy choices. Ecosystem-based fishery management is meant to compliment current single-species approaches to fisheries management by providing additional information that may be used to expand the scope of these approaches into the future. Finally, ecosystem-based fishery management does not create additional mandates to protect the marine environment, but instead seeks to better understand fishery effects on the marine environment through improved information on ecosystem structure, processes and functions. As explained by Walters and Martell (2004), ecosystem-based fishery management aspires to:

> "provide a capability for fisheries scientists to respond to a broader set of policy questions and predictive demands than can single species analysis. These questions lead to a much broader set of options for future ecosystem management than might ever be imagined by thinking only of species populations one at a time."

With that broader set of policy options and the analytical tools to evaluate them, ecosystem-based fishery management should inform the policy process and provide for a transition from the setting of management targets only on individual components of the ecosystem to the setting of management targets on the ecosystem as a whole (NRC 2006). As explained in international guidance on ecosystem-based fishery management, it is intended:

> "to reflect the merging of two different but related and—it is hoped—converging paradigms. The first is that of ecosystem management, which aims to meet its goal of conserving the structure, diversity and functioning of ecosystems through management actions that focus on the biophysical components of ecosystems (e.g. introduction of protected areas). The second is that of fisheries management, which aims to meet the goals of satisfying societal and human needs for food and economic benefits through management actions that focus on the fishing activity and the target resource (FAO 2003)."

Ecosystem-based fishery management focuses both on "the impact of fisheries on the environment (including biodiversity, species interactions, and habitat), and the impact of the environment on fisheries (including natural variability and climate change)" (Garcia and Cochrane 2005). The end goal is to understand the linkages between ecosystem well-being and human well-being (FAO 2003; MEA 2005). Working toward this goal will involve difficult scientific and analytical challenges related to the measuring and monitoring of these linkages, the specification of ecosystem reference points for guiding management actions, and the identification and valuation on the full spectrum of policy choices associated with human well-being (Barbier 2010; Moore and Russell 2010; Quinn and Collie 2005; Link 2005; FAO 2003).

The widespread call for moving toward ecosystem-based fishery management arises out of a recognition that, when we do not explicitly weigh trade-offs, they will be resolved by default (Walters and Martell 2004). Our difficulty in quantifying and analyzing trade-offs and effects does not mean those trade-offs and effects are not occurring. Ecosystem-based fishery management can proceed without quantitative analysis and can be approached "more [as] an issue of context and mindset than of method." (Francis *et al.* 2007). At the same time, the call for ecosystem-based fishery management also recognizes that attempts to account for potential impacts and hidden tradeoffs without quantitative analysis can leave policy makers with uncertain choices and arbitrary bases for decisions (Hilborn 2009; Hilborn and Stokes 2010). The FMC process, where near- and long-term social goals and legal requirements are weighed through integrated scientific analyses, offers a unique venue for bringing together a large suite of interests and ideas for implementing ecosystem-based fishery management.

3.2 Ecosystem-Based Fishery Management Planning Within the Council Process

The purpose of an EFMP is to guide expansion of the Council process from species-specific management programs to include ecosystem science and broader ecosystem considerations and management policies that coordinate Council management across its FMPs and the California Current Ecosystem (CCE).

The needs for ecosystem-based fishery management within the Council process are: (1) to ensure that management of any one of the Council's fishery groups (coastal pelagic species, groundfish, halibut, highly migratory species, and salmon) does not negatively affect the management potential of the other species groups, non managed species, or their habitats; and (2) to keep the Council updated on current and potential effects on the CCE from human and natural causes (e.g., creation of dredge pile islands, industrial contamination, climate change, etc.). Council decisions on fisheries management throughout the CCE should benefit from more and better information on the biophysical and socio-economic systems that support West Coast fish and fisheries.

4 Consideration of Potential EFMP Goals and Objectives

Each of the Council's species group FMPs has a set of goals and objectives (see Appendix B). This section provides potential goals and objectives for a Council EFMP. As with the statement of purpose and need, the Council's ultimate goals and objectives will depend on the format that the document takes. In providing these potential goals and objectives, we are both responding to one of the Council's directions from November 2009, and providing a basis for public discussion on directions Council planning might take.

The overarching goal of this EFMP is to bring a greater understanding of the CCE to the Council participants and the public, so as to provide broad consideration and analysis of social, economic, and ecological policy options across the Council's areas of responsibility. The EFMP and its associated scientific products are intended to support Council decision-making by more fully addressing the goals and objectives shared by all FMPs for a healthy ecosystem with productive and sustainable fisheries, and vibrant fishing communities.

The Council's four existing FMPs each have suites of goals and objectives that differ in their precise language, but have four common themes that are consistent with an ecosystem approach to fishery management: avoid overfishing, maintain stability in landings, minimize impacts to habitat, and accommodate existing fisheries sectors. (See Appendix B for details.) The Coastal Pelagics FMP also explicitly recognizes the role of the target species in the food web; this is the only FMP that specifies a need to "provide adequate forage for dependent species." The following potential EFMP objectives, in keeping with the potential goal, are intended to be served by a plan or dedicated effort to integrate management across all the FMPs:

- Provide a vehicle to better inform Council decision-making by improving and integrating information that may affect species from multiple FMPs, such as trends in climate conditions or indicator species.
- Identify and address gaps in ecosystem knowledge, particularly with respect to the cumulative effects of fishing on marine ecosystems, and provide recommendations to address such gaps.
- Provide an ecosystem context for Council decisions that may involve common management concerns or trade-offs among species-specific FMPs.
- Provide administrative structure and procedures for coordinating conservation and management measures that address inter-species relationships across FMPs and with ecosystem components not included in the FMPs.
- Provide a nexus to regional and national ecosystem-related endeavors, particularly with respect to the consequences of non-fishing activities.
- Provide a framework for the consideration of cooperative management strategies that might facilitate management actions at appropriate spatial scales.

5 Regulatory Scope and Management Unit Species

At its November 2009 meeting, the Council's direction to the EPDT included a team report on the potential regulatory scope of an EFMP and on potential management unit species within an EFMP. These two questions are strongly connected and are dealt with together in this section.

The Council's and NMFS's regulatory authority over fisheries and marine resources is granted and bounded by the MSA. Under the MSA, FMCs exercise authority over fish and fisheries by the development and amendment of FMPs and the adoption of fishery conservation and management measures. The MSA and its implementing regulations formally define the regulatory authorities within an FMP and define the types of regulatory actions that may be possible for management unit species. In this early stage of the Council's ecosystem based fishery management planning process, the Council can help itself and the public better understand its intent for the future by assessing:

- The particular management actions the Council wishes to recommend for living marine resources and their habitats within the West Coast EEZ, and whether those authorities may be exercised under the MSA;
- Whether there are species the Council wishes to manage or monitor under an EFMP that are not currently managed under a Council FMP, or if any of the current Council FMP species would be more appropriately managed under an EFMP;
- Whether the Council wishes to use the EFMP as a vehicle for the MSA-sanctioned regulatory activities that are not required to be tied to specific species or FMP species groups.

The MSA requires the Council to prepare an FMP "for each fishery under its authority that requires conservation and management" (MSA Section 302(h)(1)). An FMP provides a FMC and NMFS with regulatory authority over fishing activities for the species listed in that FMP's fishery management unit (FMU). Any species of fish within a council's geographic area of authority may be named as part of an FMP's FMU. The Pacific Council's geographic area of authority is the fisheries in the Pacific Ocean EEZ seaward of Washington, Oregon, and California (MSA Section 302(a)(1)(F)).

Section 3(13) of the MSA defines "fishery" as: (A) one or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographic, scientific, technical, recreational, and economic characteristics; and (B) any fishing for such stocks." The term "fish" includes "finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds" (MSA Section 3(12).) National Standard 3 directs that: "To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination" (MSA Section 301(a)(3)). The National Standard Guidelines connect these terms by clarifying that, "A fishery management unit (FMU) means a fishery or that portion of a fishery identified in an FMP relevant to the FMP's management objectives. The choice of an FMP's FMU depends on the focus of the FMP's objectives, and may be organized around biological, geographic, economic, technical, social, or ecological perspectives." National Standard 3, taken together with the Council's fish and fishery conservation and management authority means that, if the Council wishes its EFMP to have regulatory authority, the EFMP must have FMU species. Potential Council authority or influence over the management of fish and other marine species in ocean ecosystems may be broadly separated as:

- Fishing activities for FMU species within a Council FMP;
- Fishing activities for species not within a Council FMP;
- Non-fishing activities that may affect the essential fish habitat (EFH) of FMU species within a Council FMP, and;

- Non-fishing activities that may affect the ecosystem(s) of which Council-managed species are a part.

We next discuss each of these types of activities, the manners in which they may be addressed in a FMC process, and how an ecosystem planning or regulatory document may or may not be useful in addressing these activities.

5.1 Fishing Activities for Fishery Management Unit Species

When a FMC chooses the species within an FMP's FMU, it is essentially choosing to manage any directed or non-directed fisheries for those species. Which species this Council includes in its potential EFMP's FMU will depend on how the Council wishes to use the EFMP. For example, if the EFMP were to be used as the primary authority for managing all the fisheries under the Council's jurisdiction, then all those species and their fisheries would be designated as the EFMP's FMU. This approach would be similar to that taken by the Western Pacific Fishery Management Council, which has converted its former species group FMPs into geography-based Fishery Ecosystem Plans (FEPs), which have all the required characteristics of FMPs, yet are arranged by geography rather than taxonomy. However, if the regulatory authority of the EFMP is intended to address either species for which there is neither a current nor future-desired fishery, or to address only issues that cross several of the Council's current species group FMPs, then the EFMP's FMU will be much more limited. We provide a range of potential EFMP formats that address these uses of FMUs in Table 5.1, below.

5.2 Fishing Activities for Species Not Within a Council FMP

Ecosystem-based fishery management for the CCE will bring new information into the Council process on a broad range of marine species, including species not defined as fish under the MSA, and species for which there is no fishery. Some species may be of interest to the Council for their roles as indicators of CCE health and productivity, even if those species are neither under Council management (e.g. state-managed fisheries or lower trophic level species), nor under potential Council jurisdiction except as bycatch to be avoided (like marine mammals, turtles, and seabirds). In describing alternative potential FMUs for the EFMP, this document assumes that the Council may request and discuss information on any species and its ecosystem relationships with other species (or even recommend action by other entities outside MSA authority to conserve and manage those species), regardless of whether it has the authority or inclination to name that species to an FMU in any of its FMPs.

The 2006 revisions to the MSA changed the authorization for Councils to "designate zones where, and periods when, fishing shall be limited, or shall not be permitted, or shall be permitted only by specified types of fishing vessels or with specified types and quantities of fishing gear," to require that such closure (Section 303(b)(2)(C):

> (i) is based on the best scientific information available;
> (ii) includes criteria to assess the conservation benefit of the closed area;
> (iii) establishes a timetable for review of the closed area's performance that is consistent with the purposes of the closed area; and
> (iv) is based on an assessment of the benefits and impacts of the closure, including its size, in relation to other management measures (either alone or in combination with such measures), including the benefits and impacts of limiting access to: users of the area, overall fishing activity, fishery science, and fishery and marine conservation."

The 2006 MSA revisions also added authority for FMCs to designate fishery closure zones to protect deep sea corals from physical damage by or interactions with fishing gear (MSA at Section 303(b)(2)(B)).

In support of this provision, the 2006 reauthorizing act also added Section 408 to the MSA, which requires NOAA Fisheries to establish a deep sea coral research and technology program. The agency's 2007 report, The State of Deep Coral Ecosystems of the United States, discusses current scientific information on deep sea corals and includes a chapter on west coast deep sea corals (NMFS 2007).

The MSA authorizes FMCs to exercise these general authorities without specifying how they are to be organized within FMPs. The South Atlantic Fishery Management Council (SAFMC) has an FEP that informs their actions taken under the authorities of their species group FMPs. The SAFMC has recently used its FEP to recommend establishing Coral Habitat Areas of Particular Concern, but is implementing those recommendations through linked amendments to each of its species group FMPs (SAFMC 2009). In other words, the SAFMC retains its authority within its species group FMPs, while using its FEP process to facilitate discussions on issues that affect all their FMPs.

5.3 Non-Fishing Activities that may Affect the EFH of Fishery Management Unit Species

Under the MSA, FMCs have the authority to use FMPs to identify EFH for managed species and to identify any adverse effects on EFH. Councils are permitted to comment on and make recommendations to the Secretary of Commerce or any Federal or State agency "concerning any activity authorized, funded, or undertaken or proposed to be authorized funded or undertaken, by any Federal or State agency that, in view of the Council, may affect the habitat, including essential fish habitat, of a fishery resource under its authority" (Section 305(b)(3)(A)). Councils are required to comment on and make recommendations regarding activities that are likely to substantially affect the habitat of anadromous species, such as Pacific Coast salmon (Section 305(b)(3)(B)). If the Council chooses to pursue an FEP intended primarily to inform its work across species group FMPs, rather than an EFMP with regulatory authority, it could use that FEP to organize comments on non-fishing activities that may affect EFH in several of its FMPs or that may affect non-Council species that interact with Council-managed species from several FMPs. Alternately, an EFMP with regulatory authority could serve the same cross-FMP organizing function, plus add EFH designations for any species included as part of that EFMP's FMU. Any ecosystem planning process the Council undertakes, whether it results in an FEP, EFMP, or other document, will have the significant benefit of serving as a coherent and comprehensive public statement of the Council's priorities for conservation and management of marine resources in the CCE.

5.4 Non-Fishing Activities that may Affect the Ecosystem(s) of which Council-Managed Species are a Part

Under NEPA, the Council has the opportunity to comment on any federally-managed or -permitted activities that it believes may affect Council-managed species or any portion of the ecosystem or ecosystems of which those species are a part. Similar state environmental review laws also provide comment opportunity on state-managed or –permitted activities. Unfortunately, ensuring that the Council has a voice in NEPA and other environmental review discussions relevant to the CCE can be logistically challenging when mandated review periods for actions affecting the environment do not fit within the Council's meeting schedule. As with non-fishing activities that may affect EFH of Council-managed species, a Council-generated EFMP will help guide analysis by agencies looking at non-fishing activities within the CCE and connected ecosystems. Instead of the Council finding itself in the position of having to alert agencies addressing non-fishing activities that the Council might wish to comment on those activities, it will be able to point to its EFMP at the beginning of the analysis process and request that analyses of non-fishing activities assess the effects of those actions on the species, inter-species relationships, and natural processes of the CCE.

Under the Regulatory Flexibility Act, the Council has an opportunity to comment on any draft regulations that may affect small businesses (such as fishing businesses), small entities (usually non-profit), or small government agencies (such as small coastal municipalities). The Council could use its EFMP as a basis for assembling more comprehensive information on the dependency of fishing communities on fishery resources, the vulnerability of those communities to changes in resource availability, and the resilience of those communities to economic change. Such an EFMP could help to strengthen the voices of fishing community members as they assess the potential future effects that non-fishing activities may have on the CCE and on their communities.

An EFMP could also have a role in national and West Coast governance of ocean resources. National and regional programs on coastal and marine spatial planning will require input from FMCs. An EFMP would articulate Council priorities for a healthy ocean ecosystem, and could improve the effectiveness of Council engagement with external entities that manage non-fishing activities that may affect the CCE.

5.5 Ecosystem Fishery Management Planning in Other Fishery Management Councils

Three FMCs (North Pacific, Western Pacific, and South Atlantic) have created FEPs for one or more of the ecosystems under their respective authorities. Each council has taken a different approach to the framing of and philosophy behind their FEPs. However, each FMC has also ensured that they have addressed their managed species under the MSA framework for FMP requirements.

North Pacific Fishery Management Council – Aleutian Islands FEP (2007)

> “The goal of this FEP is to provide enhanced scientific information and measurable indicators to evaluate and promote ecosystem health, sustainable fisheries, and vibrant communities in the Aleutian Islands region.”
>
> “…the FEP was developed to provide the Council with an understanding of important relationships among ecosystem components, which are not always considered together by managers. The FEP also identifies areas of uncertainty, describes how the Council may currently be addressing the associated risk, and provides suggestions for other tools the Council may wish to consider.”

The FEP provides background information and analyses on the Aleutian Islands ecosystem:

- describes and synthesizes the Aleutian Islands ecosystem processes and interactions,
- delineates the regulatory and bio-physical boundaries of the Aleutian Islands,
- conducts a qualitative risk assessment of Aleutian Islands interactions,
- uses management objectives of Aleutian Islands fisheries to identify Council priorities for the FEP,
- identifies ecological indicators appropriate to monitor key ecosystem interactions,
- identifies knowledge gaps and research needs,
- provides a framework by which ecosystem considerations identified herein could be implemented within the current Council structure and management practice.

The North Pacific Fishery Management Council (NPFMC) also completed an Arctic FMP in 2009 (NPFMC 2009), implemented at 50 CFR 679. Very little data or analyses are available on any fish species within the U.S. Arctic EEZ. The Arctic FMP provides an example of an FMP primarily intended to close a large geographic area to fishing for fish stocks about which little is known. The Arctic FMP has three so-called target species for its FMU, none of which are subject to targeting beyond subsistence fishing, and a suite of ecosystem component (EC) species.[1]

South Atlantic Fishery Management Council – Fishery Ecosystem Plan (2009)

> "The FEP will serve as a source document that will, over time, present more detailed information describing the South Atlantic ecosystem and the impact of the fisheries on the environment. As a living document, the FEP will provide a greater degree of guidance on incorporation of fishery, habitat, or ecosystem considerations into management actions, such as bycatch reduction, prey-predator interactions, maintenance of biodiversity, and identification of spatial management needs."

The SAFMC has a history of detailed and FMP-spanning work on EFH issues. In their EFH work, the SAFMC had considered the effects of fishing and non-fishing activities on both the EFH of individual species in their FMPs and on the collective EFH of all of their FMPs taken together. The South Atlantic FEP grew out of their work on EFH and their desire to have a cross-FMP source of information about biophysical ecosystem of their managed species, and about the effects of fisheries and non-fisheries activities on that ecosystem. The FEP is a multi-volume document that includes, but is not limited to:

- oceanographic and climate features of the South Atlantic Bight,
- locations of South Atlantic Fishery Management Council (SAFC) management areas,
- descriptions of the species and habitats (Council-managed and not) within the South Atlantic Bight,
- the South Atlantic human and institutional environment,
- spiny lobster economics and social environment,
- maps of commercial fisheries catch in the South Atlantic management area, by latitude/longitude blocks,
- perceived threats to the South Atlantic ecosystem and recommendations for addressing those threats, and
- description of research and data needs.

Western Pacific Fishery Management Council – Fishery Ecosystem Plans by Geographic Area (2009)

> "The Magnuson-Stevens Fishery Conservation and Management Act (MSA) authorizes FMCs to create fishery management plans (FMP). The Western Pacific Regional Fishery Management Council developed this Fishery Ecosystem Plan (FEP) as an FMP, consistent with the MSA and the national standards for fishery conservation and management. The FEP represents the first step in an incremental and collaborative approach to implement ecosystem approaches to fishery management in [*the FEP area – same language used across FEPs*]."

In December 2009, the Secretary of Commerce approved five new geography-based FEPs that had been drafted by the Western Pacific FMC for: American Samoa, Hawaii, Mariana Archipelago, Pacific remote island areas, and western Pacific pelagic fisheries. These FEPS all meet the MSA requirements for FMPs and FMP species. The FEPs explicitly do not establish any new fishery management regulations, but are

[1] 50 CFR 600.310(d)(5)(i): *To be considered for possible classification as an EC species, the species should: (A) Be a non-target species or non-target stock; (B) Not be determined to be subject to overfishing, approaching overfished, or overfished; (C) Not be likely to become subject to overfishing or overfished, according to the best available information, in the absence of conservation and management measures; and (D) Not generally be retained for sale or personal use.*

intended to provide a place from which FMCs may address ecosystem-based management principles in the future.

5.6 Beyond Council Documents

As discussed throughout this report, ecosystem-based fishery management planning is not simply about adding a new document to the suite of FMPs that bound the Council's regulatory authority. Beyond an EFMP, there are numerous actions the Council can take to help itself and the public think more about how Council-managed species interact with each other and their environment, including:

- Review the Council's 2008 Research and Data Needs (PFMC 2008) Section 2.0, Ecosystem-Based Fisheries Management, to determine whether the highest priorities set in this document are being met and if not, whether they can be met.
- Through the SSC, develop recommendations on a desired suite of natural and socio-economic ecosystem science products that could be useful to the Council process.
- As new appointments to Council advisory bodies become available, consider whether those bodies have adequate representation from persons with cross-species or ecology expertise.
- During the Council's EFH review process for its four FMPs, ensure that the EFH, habitat areas of particular concern (HAPCs), and any EFH closed areas designated for all Council species or species groups can be mapped in compatible fashions so that the Council and the public can review EFH designations and other areas across all the Council's FMPs.
- Early in each Council meeting week, preferably on the first meeting day, schedule a presentation on science in support of ecosystem-based fishery management (11/09 Council recommendation). If the Council opens a tradition of scheduling ecosystem issues early in its meeting weeks, then ecosystem concerns can better frame subsequent Council discussions throughout each meeting week.

<table>
<tr><th colspan="5">Table 5.1: Alternative Fishery Ecosystem Plan (FEP) and Ecosystem Fishery Management Plan Formats</th></tr>
<tr><th></th><th>Advisory FEP</th><th>Umbrella EFMP with Selected FMU and EC Species</th><th>Regional Omnibus EFMP</th><th>Coastwide Omnibus EFMP</th></tr>
<tr><td rowspan="2">Plan Format Summary</td><td rowspan="2">Similar to the NPFMC's Aleutian Islands FEP and the SAFMC's FEP, this FEP would provide information on the biophysical processes of and West Coast community ties to the CCE. The FEP would not be a framework for regulations, but would provide information that could be used to support regulations under the Council's species group FMPs.</td><td>Fishing activities for Council-managed species would continue to be managed under species group FMPs. Select species that are important to the CCE as a whole would be within the EFMP's FMU, and could be targeted (or not) according to Council management recommendations. Unless designated as an EFMP FMU species, all targeted and non-target bycatch species would continue to be managed under appropriate species group FMPs.</td><td>Similar to the WPFMC's FEPs, the West Coast EEZ would be split into several biogeographic provinces, with management frameworks for all the current Council-managed species merge into region-specific FMPs.

Existing EC species and management frameworks for those species could be added to the appropriate FMPs under this EFMP format.</td><td>This omnibus EFMP would merge all the current FMPs to provide regulatory authority for all Council-managed species within the CCE within the same document.

Existing EC species and management frameworks for those species could be added to the FMP under this EFMP format.</td></tr>
<tr><td colspan="3">All the ecosystem information available under the Advisory FEP would also be available under any of these EFMP formats. In addition, the existing FMPs could incorporate ecosystem information available under the Advisory FEP through FMP or regulatory amendment.</td></tr>
<tr><td>Fishery Management Unit (FMU) Species</td><td>None. Because this format is informational, no species would be subject to management under this FMP.</td><td>FMU would include any species that does not now easily fit within one of the Council's species group FMPs, or is currently beyond any of those FMPs but in need of Council management. EC species, as a component of the fishery, may be included in the EFMP for any of the following reasons: For data collection purposes; for ecosystem considerations related to specification of OY for the Council-managed fisheries; as</td><td>All species from current Council FMPs for a given geographic region, plus any additional predators or prey species the Council may wish to add and that fall within the definition of "fish" under the MSA, including EC species.</td><td>All species from current Council FMPs, plus any additional predators or prey the Council may wish to add that fall within the definition of "fish" under the MSA, including EC species.</td></tr>
</table>

		considerations in the development of conservation and management measures for the Council-managed fisheries; or to address other ecosystem issues. Species that are vulnerable to Council-managed fisheries would continue to be included in the appropriate species group FMP.		
Potential activities regulated and range of authorities	No fishing activity would be regulated under the FEP format.	All fishing activity currently authorized for management under the MSA would continue to be authorized for FMU species.	All fishing activity currently authorized for management under the MSA would continue to be authorized for these regional omnibus EFMPs. EC species could be added to the appropriate EFMPs.	All fishing activity currently authorized for management under the MSA would continue to be authorized for this omnibus FMP. EC species could be added to the EFMP.

6 Geographic Range and Scale

In keeping with the Council's November 2009 direction, this section addresses the potential geographic range and scale of a Council EFMP.

The geographic range of an EFMP for U.S. West Coast fisheries may be evaluated using by three major concepts: management authority, physical and ecological characteristics, and socio- economic or political jurisdictions. The Council has management authority over fisheries within the U.S. West Coast EEZ, which ranges from the Canadian border to the Mexican border and from state marine boundaries (3 nautical miles) seaward to 200 nautical miles offshore. Council authority also includes U.S. vessels fishing for FMP-managed species, when those vessels fish within or seaward of the EEZ and land their fish in California, Oregon, or Washington. Landward of the EEZ, Council authority is seated in EFH designation, and in its responsibility to comment on and make recommendations regarding activities that may affect habitats of fishery resources under its authority.

The U.S. defines the biophysical realm of the CCE using the Large Marine Ecosystem (LME) concept, based on four linked ecological criteria: bathymetry, hydrography, productivity, and tropic relationships. Globally, the California Current LME is one of 64 distinct LMEs (UNEP 2008.) Like most ecosystems, the boundaries of the California Current LME are not strictly delineated, but it can be generally defined as extending from north-central Vancouver Island southward to southern tip of the Baja California. Physically, the California Current is one of four major global "eastern boundary currents," consisting of strong southward flow in the offshore region, and dominated by strong upwelling in the nearshore coastal areas. The ecosystem is characterized by its high productivity, due primarily to nutrient enrichment via upwelling. The system is heavily influenced by basin-scale climate signals, such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation, resulting in highly variable inter-annual and inter-decadal ecosystem productivity. Thus, oceanographic forces play a large role in regulating the CCE's biological populations and communities, and its energy flow and ecological dynamics.

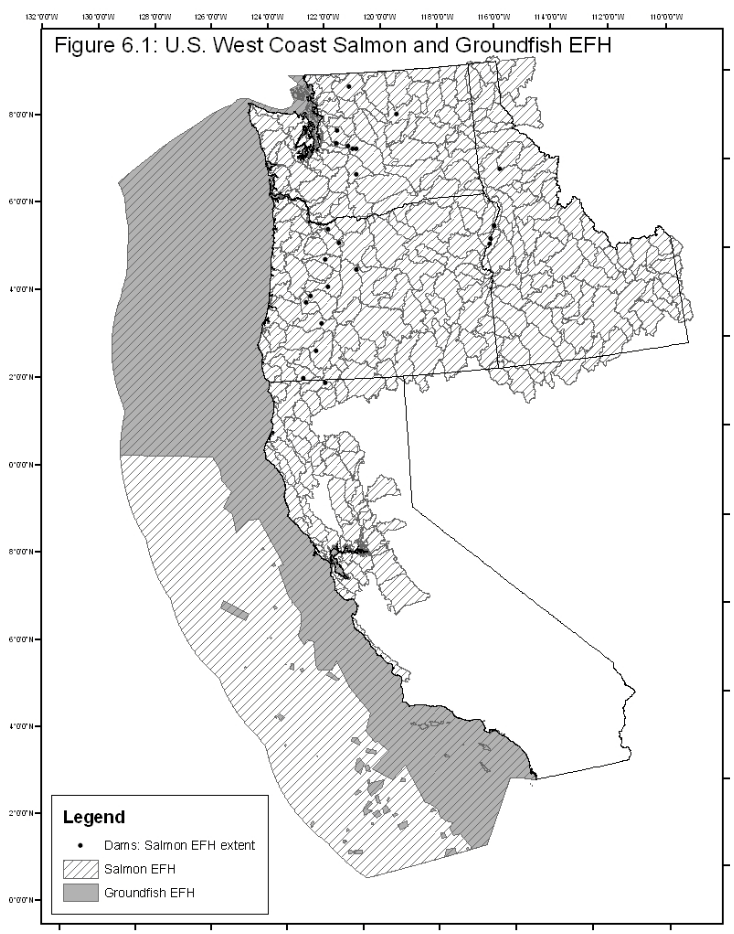

Figure 6.1: U.S. West Coast Salmon and Groundfish EFH

The socioeconomic boundaries of interest to the Council are shaped by the large and small coastal communities and fisheries of California, Oregon, Washington and Idaho. These include the economies of major estuaries, such as the San Francisco Bay, the Columbia River and the Puget Sound, but also those of smaller ports and economies of the four states.

In developing the geographic range of an

EFMP, the Council should consider the dynamic relationship between the three major interacting elements of the ecosystem: the geographic scope and spatial scale of management, biophysical processes, and socioeconomic regions. As with the EFMP's potential management unit species, there are geographic areas that are not under Council authority or influence, but which are of interest to the Council for informational purposes. Two examples are the biophysical boundaries of the ecosystem, including the EEZ itself, plus upland watersheds for Council-managed salmon stocks, and marine waters beyond the U.S. EEZ for highly migratory species. If the EFMP is to be an evolutionary and living document, the Council might limit the initial geographic scope of the EFMP to the U.S. EEZ, with the intent that later EFMP iterations include marine and terrestrial systems beyond the EEZ. As shown in Figure 6.1, the Council's salmon and groundfish EFH together cover the entire West Coast EEZ plus significant upland territory.

In addition to beginning with the EEZ and anticipating later expansion outward, the Council might also consider subdividing the EEZ into smaller biogeographic regions. Based on overall air-sea climate and rainfall patterns, the CCE can be divided into three major regions from north to south: the Pacific Northwest (including northern California), central California, and the Southern California Bight (Lester et al, 2010). Hydrographically, these regions can be further subdivided in the onshore-offshore direction into three major zones: the nearshore zone characterized by strong upwelling, the offshore zone characterized by the strongly southward flowing core of the California Current, and the furthest offshore zone characterized by either downwelling or weak curl-driven upwelling (Rykaczewski and Checkley, 2008). The CCE can also be further divided, based on the Cape to Cape concept (Francis *et al.*, 2008); due to topography, several major (and several more minor) capes along the coast exert substantial influence on both upwelling and the path of the California Current, leading to more localized regions of enhanced upwelling, "upwelling shadow" areas, areas of enhanced retention, and spawning points for meanders, eddies, and jets of the California Current itself. A nested approach to defining smaller, cohesive, segments of the CCE may help the Council to best match the spatial scales of biological populations, ecological communities and human communities for particular management issues.

7 The State of Ecosystem Science

Comprehensive reviews of ecosystem philosophies, principles, modeling approaches and other strategies abound in the scientific literature, as well as in the grey literature of management documents and records. This short review of the state of science for ecosystem-based management is not comprehensive, but is intended to briefly illustrate the general scope of ecosystem science by discussing: (1) philosophical guidelines or principles for implementing an ecosystem approach to fishery management, (2) the role and availability of multispecies and ecosystem models to provide strategic management advice with respect to ecosystem issues and trade-offs among policy objectives, (3) the development and role of ecosystem indicators, including reports on ocean and climate conditions and integrated ecosystem assessments, (4) the potential role of integrated ecosystem assessments, and (5) ecosystem-based management in practice. There is overlap among these broad and general types of tools, but they are distinct enough to frame a short review of how such tools have evolved and could be used by managers.

7.1 Philosophical guidelines or principles for implementing Ecosystem based management

Throughout the published literature it is commonly stated that ecosystem-based fisheries management will require a suite of research efforts and products before it can be successfully implemented. However, many of the more philosophical research efforts and associated publications on ecosystem-based management have addressed management more broadly, rather than on a laundry list of data sources, methodologies and models. This literature argues that broad principles could be adopted to guide management decisions regardless of the quantity and quality of data available to managers. In principle, an ecosystem-based approach to management could be adopted without abundant information, data and precise knowledge of ecosystem interactions, by simply making management decisions in the context of those principles.

One guiding principle addresses the issue of poor knowledge of ecosystem interactions directly, by recommending that management "be cognizant of the levels of ignorance in which it is working" (Mangel *et al.* 1996). This comment recognizes the common criticism that it would be folly to adopt an ecosystem based approach to management because of the presumed immaturity of the science. All management actions involve making decisions in the face of uncertainty, ecosystem-based management simply expands the scope of the uncertainty and trade-offs to a broader scale. Thus, successful implementation of ecosystem-based fishery management may be seen as management within the existing legal and institutional structure, but with additional guiding principles for decision-making.

Examples of Ecosystem Principles and Guidelines for Management (paraphrased) from Scientific Literature

Grumbine's (1994) five goals for sustaining ecological integrity:

- Maintain viable populations of all native species in situ.
- Represent, within protected areas, all native ecosystem types across their natural range of variation.
- Maintain evolutionary and ecological processes (disturbance regimes, hydrological processes, nutrient cycles, etc.).
- Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystem.
- Accommodate human use and occupancy within these constraints.

The Ecosystem Principles Advisory Panel's (EPAP 1999) eight guiding principles for marine ecosystem management:

- The ability to predict ecosystem behavior is limited.
- Ecosystems have real thresholds and limits that, when exceeded, can affect major system restructuring.
- Once thresholds and limits have been exceeded, changes can be irreversible.
- Diversity is important to ecosystem functioning.
- Multiple scales interact within and among ecosystems.
- Components of ecosystems are linked.
- Ecosystem boundaries are open.
- Ecosystems change with time.

Pikitch *et al.* (2004) propose that the overarching objective of ecosystem-based fishery management is to sustain healthy marine ecosystems and the fisheries they support, under these guidelines:

- Avoid degradation of ecosystems, as measured by indicators of environmental quality and system status.
- Minimize the risk of irreversible change to natural assemblages of species and ecosystem processes.
- Obtain and maintain long-term socioeconomic benefits without compromising the ecosystem.
- Generate knowledge of ecosystem processes sufficient to understand the likely consequences of human actions.

Francis *et al.* (2007) ten "commandments" for implementing ecosystem-based fishery management:

- Keep a perspective that is holistic, risk-averse, and adaptive.
- Question key assumptions, no matter how basic.
- Maintain old-growth age structure in fish populations.
- Characterize and maintain the natural spatial structure of fish stocks.
- Characterize and maintain viable fish habitats.
- Characterize and maintain ecosystem resilience.
- Identify and maintain critical food web connections.
- Account for ecosystem change through time.
- Account for evolutionary change caused by fishing.
- Implement an approach that is integrated, interdisciplinary, and inclusive.

These guiding principles provide a holistic approach to fisheries management by emphasizing the relationships between the parts of ecosystem and the whole, informed by data, models and formal quantitative evaluation of tradeoffs and uncertainty that are a part of most management decisions.

While the literature on ecosystem principles is voluminous, key themes emerge. Grumbine (1994) highlighted the need to maintain viable populations and ecosystem types, and evolutionary and ecological processes. Similarly, the Ecosystem Principles Advisory Panel (EPAP 1999) highlighted the importance of diversity to ecosystem function and recognized that exceeding ecosystem thresholds or limits can lead to ecosystem reorganization. Pikitch *et al.* (2004) and Francis *et al.* (2007) list sets of guiding principles, and also recommend the use of indicators to evaluate environmental quality and status. Indicators are recommended so that scientists and managers may use them to consider ecosystem changes through time and evolutionary changes caused by fishing, and to constantly question key assumptions, no matter how basic they might seem. See accompanying text box for details.

Lists of ecosystem principles can provide meaningful guidance and insight for managing with an ecosystem context. These principles might also be reduced into a key overarching principle, for example Holling and Meffe (1996) described the "golden rule" of ecosystem management as "management should strive to retain critical types and ranges of natural variation in resource systems in order to maintain ecosystem resiliency." That golden rule is based on the observation that ecosystems have thresholds and can flip between alternative states when thresholds are breached – such states may or may not be reversible. Given a more socioeconomic perspective, McEvoy (1996) contends that the most important target for achieving sustainability is the "long-term health of the interaction between nature, the economy, and the legal system," recognizing the importance of evaluating the social and economic needs while maintaining ecological structure and dynamics.

7.2 Multispecies and ecosystem models

Typically, the role of all fisheries models, whether single or multispecies, is to understand and inform decision-makers of the consequences of fishing or other human activities to living resources and the ecosystem in which they exist (Hollowed *et al.* 2000). While there have been attempts to model the inter-specific and community dynamics of ecosystems, the complexity of these interactions, coupled with the data requirements needed for model validation and the computing power needed to run complex models, have historically been limiting factors in the development of models for use by managers. However, in recent decades, the science of modeling ecosystem interactions has advanced tremendously and monitoring efforts have assembled data appropriate for developing relatively data rich single and multispecies models for many ecosystems.

A wide range of multispecies and ecosystem models have been developed and published in peer-reviewed literature, and a limited, but growing, number have been used to help inform marine resource management decisions. Comprehensive reviews of the multispecies and ecosystem modeling tools available to marine researchers, with detailed consideration of their strengths, drawbacks, and best practices for developing such models, are available from both NMFS (Townsend *et al.* 2007, Link *et al.* 2009) and the United Nations Food and Agriculture Organization (Plagyani 2007). In short, ecosystem models are complex, predictability is limited, and formally addressing uncertainty poses a unique set of challenges. Yet the science behind such models has significantly improved in recent years, and many regions now have sufficient data to begin applying these models in resource management. Given the increasing number of ecosystem modeling approaches, clearly defined management goals and questions are important. As Hill *et al.* (2007) state, "Predictive models, especially in ecology, are rarely intended to provide an all-encompassing description of how a system actually works, but they are intended to forecast how certain characteristics of the system respond to a specific set of conditions." Models can also serve as a stimulus and focus for initiating dialogues and discussions on future ecosystem trade-offs among management decisions.

Several published models are available for resources managed by the Pacific Council; an Ecopath with Ecosim model of the Northern California Current (north of Cape Mendocino) developed by Field *et al.* (2006), a seasonal model of the Oregon shelf ecosystem to evaluate the role of jellyfish (Ruzicka *et al.* 2007), and an Atlantis model of the California Current north of Point Conception documented in Brand *et al.* (2007). Some recent model applications include informing decisions such as the krill harvest ban (PFMC 2008), exploration of the role of Humboldt (jumbo) squid in the California Current (Field *et al.* 2007), analyses of potential ecosystem indicators (Samhouri *et al.* 2009), and comparative evaluations of ecosystem status from both single and multispecies perspectives (Worm *et al.* 2009). The Atlantis model in particular is likely to play a central role in quantifying trade-offs in future efforts to develop Integrated Ecosystem Assessments (IEAs) for the California Current (Levin *et al.* 2009).

Ecosystem models have also been used to formally evaluate tradeoffs between Pacific sardine as a directed fishery target and as forage for other commercially and ecologically important species (Hannesson et al 2009; Hannesson and Herrick, 2010). The sardine example represents a growing body of efforts to develop models that account for ecological and economic interactions (Finnoff and Tschirhart, 2003, 2004; Eichner and Tschirhart 2007). Such models consider the benefits and costs related to the use of fishery resources: (1) consumptive use; (2) non-consumptive use; and (3) indirect use of the resource in its natural state, and explore the consequences of alternative management actions to facilitate comparisons and trade-offs among management decisions. Extending this framework to more complex situations (e.g. multiple ecosystem functions, uncertainty, and dynamics) will require a great deal of detailed economic and ecological data, a commonality among all ecological and socioeconomic modeling approaches.

7.3 Ecosystem indicators, status reports, and integrated ecosystem assessments

The third type of ecosystem information for potential Council consideration includes ecosystem status reports, ecosystem indicators, and the results of IEAs. There are several products that could be adopted or otherwise incorporated into the Council ecosystem-based fishery management framework to inform decision making on the significance of environmental conditions to productivity and possible risk, as well as possible trade-offs among competing management objectives.

The State of the California Current (e.g., McClatchie *et al.* 2009) report is a comprehensive summary of physical climate and oceanographic trends (e.g. ocean temperatures, upwelling, basin scale indices such as El Nino) and biological productivity (zooplankton abundance, forage fish abundance, seabird and marine mammal productivity) taken from a wide range of monitoring and research efforts throughout the CCE. While the report is technical in nature, it provides an example of a publication that distills trends in ocean conditions and productivity in a way that may be informative for decision-makers. Similar documents are prepared for the North Pacific Fishery Management Council (The NPFMC Ecosystem Considerations Chapter, Boldt and Zador 2010), for the Department of Fisheries and Oceans in Canada (DFO 2009), and for the entire suite of ecosystems that constitute the North Pacific Ocean (PICES 2005). The Council has already begun to consider a summary of indicators for Pacific salmon management, based on work by Peterson *et al.* (2008) linking a suite of productivity metrics (ocean temperatures, timing of the spring transition, species composition and abundance of zooplankton communities). While these indicators are qualitative, they provide general guidance on the relative degree of productivity to be expected by salmon in the coastal ocean. Similarly, Wells *et al.* (2008) developed a statistical model that relates physical ocean and climate conditions with the productivity of lower, middle and higher trophic level species off of Central California, which could be used as an indicator of ecosystem productivity.

In addition to empirical indices or indicators of ocean conditions and productivity, both single and multispecies models provide estimates of resource productivity and status. The Council is familiar with single species reference points for stock status and trends. Ecosystem models are increasingly being used to develop indicators of ecosystem status, state or health, with one of the most cited criteria for useful indicators being that they can characterize the effects of fishing relative to standing biomass and productivity in an unambiguous and quantifiable manner (Murawski 2000). While the development of meaningful indicators remains a focal area of research, particularly through the use of simulation testing, suites of indicators may provide the most robust results. In general, it seems that indicators of key functional groups or at the level of community organization, such as zooplankton, forage fish and jellyfish, are most likely to characterize ecosystem state most reliably, possibly due to their rapid response to both direct and indirect changes in fishing pressure (Fulton *et al.* 2005; Samhouri *et al.* 2009). By contrast, indicators such as seabird biomass, or trophic level of the (fisheries) catch and total catch perform relatively poorly in simulation studies, although it remains necessary to validate these indicators with empirical data. Socio-economic indicators could represent the varied benefits that society derives from ecosystem services. Evaluating stakeholder interests will define these benefits, which in ecosystem-based fisheries management can be broadly categorized as: commercial fishing, recreation, and the environment. Each group benefits from better commercial fishing, better recreational fishing, bird watching, and other activities, and better stewardship, respectively. These indicators can provide practical and defensible measures of relative ecosystem value that can then be used to evaluate ecosystem-based fishery management planning alternatives.

7.4 Integrated Ecosystem Assessments

In recent years, the concept of IEAs has been promoted as a means to provide an appropriate interface between ecosystem science and the management community. The IEA approach builds upon risk analysis methods, and is best described as “A formal synthesis and quantitative analysis of information on relevant natural and socioeconomic factors, in relation to specified ecosystem management objectives” (Levin *et al.* 2008, Levin *et al.* 2009, deReynier *et al.* 2010). IEAs are not meant to replace current management approaches, but rather to highlight the tradeoffs and conflicts among competing objectives that are associated with management decisions. IEAs would likely draw upon both ecosystem models and model-based or empirical ecosystem indicators, by using risk analysis approaches to determine the probability that a given indicator may shift to, or stay in, an undesirable state in response to human activities and/or natural processes. IEAs could also use a management strategy evaluation approach to simulate ecosystem behavior and allow the ability to forecast changes in ecosystem state in response to management scenarios or decision rules, simultaneous with assessment of the empirical indicators based on in-situ ecosystem monitoring efforts. Recently, the Northwest Fisheries Science Center (NWFSC) and the Southwest Fisheries Science Center (SWFSC) have together secured funding to support preliminary development of IEA products for west coast marine resources, which should provide opportunities for the Council and its advisory bodies to become exposed to and provide feedback upon such initiatives.

7.5 Ecosystem based management in practice

While the science and the literature regarding ecosystem-based management are broad, examples of these products being applied in practice are limited (Tallis *et al.* 2010, Lester *et al.* 2010). The Alaska Fishery Science Center (AFSC) is a world leader in both compiling the necessary data and in developing quantitative food web models using those data (e.g., Aydin and Mueter 2007, Gaichas *et al.* 2009, Kinsey and Punt 2009). Results from AFSC ecosystem research are regularly brought before the NPFMC, and have been used to qualitatively guide decisions in conjunction with the results of traditional single species assessments. For example, in 2006 the NPFMC SSC recognized that while the Eastern Bering Sea Pollock stock was above the target (MSY) level, the stock had been declining due to poor recruitment, and ecosystem indicators suggested declines in zooplankton (prey), while an ecosystem model indicated an increase in juvenile predation by arrowtooth flounder (predators). The NPFMC SSC consequently recommended adopting a reduction in the maximum permissible ABC to account for these concerns.

Ecosystem advice has also been developed to inform management of Antarctic krill, by the Commission for the Conservation of Antarctic Marine Living Resources. Key management questions for Antarctic krill revolve around how to spatially allocate the allowable catch in a manner that minimizes the potential effects on krill-dependent predators. As the key uncertainties in this question relate to krill movement and advection rates, and the functional relationships between krill and their predators, several biophysical models have been developed to address these questions, and with which to explore competing hypotheses regarding krill movement and advection. As resource managers continue to be confronted with complex issues and trade-offs related to managed species and their complex interactions with climate conditions, other elements of the food web, and direct and indirect human activities, there is clearly a role for greater application of ecosystem principles, models, indicators and assessments of many flavors. Among the greatest challenges now is how to incorporate such guidance into the existing and continually evolving management framework to better understand the tradeoffs associated with management decisions.

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9 Appendix A: Example Practical Considerations for EFMP Alternatives

Need	Status Quo + (Do we need an EFMP?)	Advisory FEP	Umbrella EFMP with Selected FMUs	Regional Omnibus EFMP	Coastwide Omnibus EFMP
Meet PFMC Mission for Sustainable Fisheries Mgmt. **<u>Some Potential Benefits:</u>** 1) Improve information and decision-making 2) Identify information gaps 3) Integrate across species-specific FMPs 4) Provide a nexus with other ecosystem efforts 5) Establish a framework that enables mgmt. at the appropriate ecosystem scale for a species or species complex 6) Create incentives for improved stewardship 7) Encourage innovation by offering alternatives to achieve a more robust portfolio of fishing opportunities	Information and PFMC process improvements are limited and made on a case-by-case basis: Qualify some effects of management decisions and risks for one species on other ecosystem species, habitat, fisheries, communities, etc. Monitor and report other (non-PFMC) ecosystem efforts and provide input, as determined necessary and useful.	Non-regulatory plan provides a cohesive framework: Quantify effects of management decisions and risks for one species on another ecosystem species, habitat, fisheries, community, etc. Coordinated, organized and prioritized focus with identifiable goals for input to other ecosystem efforts.	Adds some regulatory authority/responsibility while maintaining current basic PFMC and FMP organization, structure and decision-making processes.	Revises PFMC and FMP organization, structure and decision-making processes to correspond to relevant ecological relationships. Adopt FMPs with specific FMUS for ecoregions. Some spp. may be included in a single FMP (e.g. cowcod), others in multiple FMPs (e.g. arrowtooth flounder, or northern lingcod) and some in all FMPs (e.g. thresher shark)	Consolidates all existing FMPs into a single FMP. Provides for simultaneous decision-making appropriate for the suite of ecosystem impacts. Provides greater consistency in goals, objectives, & processes across all current FMPs. Flexible FMP structure allows for changes in ecosystem understanding and information without requiring development of new FMPs. Allows for maintenance or revisions to PFMC and advisory group structure, as necessary.

Need	Status Quo + (Do we need an EFMP?)	Advisory FEP	Umbrella EFMP with Selected FMUs	Regional Omnibus EFMP	Coastwide Omnibus EFMP
Some PFMC Examples:					
Species, such as forage species	Qualitatively address forage fish issues: identify suite of spp. affected by anchovy harvests and nature of impacts on FMP species and fisheries, and non-FMP species. Will the salmon resource be affected (harmed) by the proposed anchovy harvest?	Explicitly address forage fish issues: Quantitatively assess sardine harvests on other FMP spp. and fisheries, and non-FMP spp. What are the effects on the salmon resource (and fisheries & communities) of the proposed anchovy harvest? How certain is it that these effects will occur (probabilities)?	Regulatory management for species like krill May selectively add new non-FMP managed species to an FMP	What are the impacts of the harvest of anchovies on other relevant resources, fisheries, habitats, and communities within Region X? What are the probabilities that these impacts will occur?	What are the impacts of the harvest of forage species on all other relevant resources, fisheries, habitats and communities on the West Coast? Make simultaneous management decisions for salmon, whiting, anchovy, sardine, smelt, albacore, etc. based on integrated ecosystem information.
Fisheries	Identify potential effort shifts among fisheries due to harvest opportunities for several target species: Will fishers for albacore tuna switch to fish more for salmon at the proposed salmon harvest level?	Quantify effort shifts among fisheries: To what degree will albacore fishers switch to/from salmon fishing as a result of the proposed salmon harvest level?	Explicitly account for harvest opportunities for FMU species in different FMPs, when setting management measures for these FMU species: Adjust salmon management measures and albacore management measures, as needed, to account for potential	When setting management measures in Region X, explicitly account for harvest opportunities for multiple FMU species within the regional FMP: Within Region X, account for potential efforts shifts between	Simultaneously set management measures that explicitly account for potential effort shifts among fisheries due to harvest opportunities for all FMU species.

Need	Status Quo + (Do we need an EFMP?)	Advisory FEP	Umbrella EFMP with Selected FMUs	Regional Omnibus EFMP	Coastwide Omnibus EFMP
			effort shifts between these fisheries.	salmon and albacore fisheries.	
Habitats	Identify how oceanographic processes may affect FMP fisheries: How does ocean acidification affect the food chain, and ultimately, the abundance of target FMU species?	Update and integrate information on EFH for all FMP species: Assemble available information to quantify areal extent and locations of habitat types important to each FMP species.	When setting harvest levels and management measures, assess and consider the effects of site development (e.g., energy facility), if any, on each FMP species and fishery.	Provide effective input to non-PFMC regarding activities potentially affecting PFMC mission: Within an FMP region, what are the kinds and level of impacts a proposed energy facility may have on the FMP species and fisheries?	For all FMU species, include oceanographic conditions in stock assessments and decision-making processes: Incorporate oceanographic information on the CCE into all stock assessments for FMU species on the West Coast.
Socio-Economic	For various fishing portfolio strategies, identify the annual revenue effects of proposed harvest levels and management measures for multiple FMU species: For small trollers, will they likely to receive more revenue if they switch to a different portfolio, e.g., target lingcod and salmon rather than other nearshore species?	For various fishing portfolio strategies, quantify the effects of proposed harvest levels and management measures for multiple FMU species on annual revenue: How much (more/less) annual income will large trollers receive if they primarily target albacore rather than salmon or groundfish ?	Evaluate socio-economic trade-offs among fishing portfolio strategies, and explicitly consider these when setting harvest levels and management measures for FMU species in different FMPs.	For a regional FMP, evaluate socio-economic trade-offs among fishing portfolio strategies, and explicitly consider these when setting harvest levels and management measures for all FMU species in the FMP.	For the West Coast, evaluate socio-economic trade-offs among fishing portfolio strategies, and explicitly consider these when simultaneously setting harvest levels and management measures for all FMU species and FMP fisheries.

Need	Status Quo + (Do we need an EFMP?)	Advisory FEP	Umbrella EFMP with Selected FMUs	Regional Omnibus EFMP	Coastwide Omnibus EFMP
Some PFMC Implementation Considerations	Within existing PFMC structure, focus more resources to: Acquire, organize, analyze and disseminate relevant ecological information (e.g., multi-species biology, oceanography, habitat, fisheries, socio-economics and their interrelationships) Improve utilization of relevant efforts (summaries, information, analyses) by non-PFMC entities Identify key non-PFMC ecosystem efforts to monitor or engage in. Implements priority revisions to PFMC structure and function (e.g., recommendations from EPDT and other advisory bodies)	Develop Terms of Reference for the delivery and review of ecosystem science to the PFMC PFMC adopt FEP (developed by EPDT)	If non FMP-managed species are included in the EFMP, then PFMC must set ACLs, OFLs, etc. for these new FMU species.	Reorganize information and decision-making from coastwide (generally fishery-related) to a regional basis (ecologically related). Set ACLs, OFL,s etc. for FMU species on a regional basis (e.g., like for fishery sectors in NS1 guidelines). Reorganize and potentially broaden advisory groups to correspond to regional FMPs. May need to revise existing rebuilding plans to account for different geographic scopes and FMU species in regional FMPs.	Provide significant resources and revise PFMC structure and operations to support very complex analytical and decision-making processes Provide for broad and timely communication among all relevant parties for information acquisition, analysis, and decision-making.

Need	Status Quo + (Do we need an EFMP?)	Advisory FEP	Umbrella EFMP with Selected FMUs	Regional Omnibus EFMP	Coastwide Omnibus EFMP
Some Potential Costs and Consequences: a) Resource costs for personnel, meetings, etc. b) Additional technical expertise c) Changes to Council organization or decision-making processes d) More complex decision-making e) Consultation with additional affected constituencies f) Effects on other entities (time, decisions and actions): governments, industry, NGOs, constituents, public g) Evaluation of EFMP performance h) Workload and time commitment from Council family to develop and implement EFMP while continuing current PFMC activities. Others?	Resources to assemble, organize, analyze and disseminate key information. Increase coordination among current advisory bodies.	Add resources and expertise to assemble, organize, analyze and disseminate all relevant information EPDT activities to draft plan PFMC and advisory bodies to review and approve plan SSC develop Terms of Reference for the delivery and review of ecosystem science to the PFMC	Add expertise and stakeholders to advisory panels. May inadvertently affect state-managed fisheries and resources.	Re-form and add advisory panels: likely broaden the range of scientific expertise needed and stakeholders affected. May take much more time to fully transition to new regional approach, for PFMC process adjustments and for developing new regional FMPs.	Timing of decision-making may be disadvantageous for some actions and advantageous for others. Evaluation of the outcomes of PFMC decisions could be more challenging and less timely.

10 Appendix B: Pacific Fishery Management Council Goals and Objectives from Each of its Four Species Group FMPs

This appendix provides the assembled goals and objectives from the Council's four species group FMPs: coastal pelagic species, groundfish, highly migratory species, and salmon. The goals and objectives of the four FMPs share four common themes that are consistent with an ecosystem approach to fishery management: avoid overfishing, maintain stability in landings, minimize impacts to habitat, and accommodate existing fisheries sectors. Those four larger themes emerge in a variety of ideas that are common across the FMPs, divided roughly in this table:

Pacific Council FMP Shared Goals and Objectives, by FMP Objective/Goal Number

Ecological	CPS	Gr. Fish	Salmon	HMS
Prevent overfishing and rebuild depleted stocks.	7	3	1	10
Provide adequate forage for dependent species.	6			
Describe, identify and minimize adverse impacts on essential fish habitat		5		14
Minimize bycatch (incl. protected species) and encourage full utilization of resources	5	9, 11	4	9, 17
Economic				
Achieve greatest possible net benefit (economic or OY) from resource	2	6	5	5
Promote efficiency and profitability in the fishery, including stability of catch	1	2, 7, 14	6	2
Accommodate existing fishery sectors	4	12	2, 3	4, 18
Minimize gear conflicts.	11	13		13
Minimize adverse impacts on fishing communities and other entities		15, 16	2, 3	3
Use gear restrictions to minimize need for other management measures wherever practicable		8		
Management				
Acquire biological information and develop long term research	8			11
Foster effective monitoring and enforcement.	9	1		12
Establish management measures to control fisheries impacts, use management resources effectively	10	4, 10		3, 15
Encourage cooperative international and interstate management	3		8	1, 6, 7, 8
Promote the safety of human life at sea		17	9	
Support enhancement of stock abundance			7	
Promote outreach and education efforts				16

All four FMPS are currently being amended to meet the new requirements of the MSA and its National Standard 1 guidelines and for other purposes, and are subject to change. The following list of FMP goals and objectives is a snapshot of those goals and objectives that were in place as of August 2010, and is provided herein to help the Council and the public consider the Council's management philosophy across its four FMPs and how that philosophy might be translated into goals and objectives for an EFMP.

10.1 Coastal Pelagic Species

Goals and objectives for the CPS FMP (not listed in order of priority):

1. Promote efficiency and profitability in the fishery, including stability of catch.
2. Achieve OY.
3. Encourage cooperative international and interstate management of CPS.
4. Accommodate existing fishery segments.
5. Avoid discard.
6. Provide adequate forage for dependent species.
7. Prevent overfishing.
8. Acquire biological information and develop long term research program.
9. Foster effective monitoring and enforcement.
10. Use resources spent on management of CPS efficiently.
11. Minimize gear conflicts.

10.2 Groundfish

The Council is committed to developing long-range plans for managing the Washington, Oregon, and California groundfish fisheries that will promote a stable planning environment for the seafood industry, including marine recreation interests, and will maintain the health of the resource and environment. In developing allocation and harvesting systems, the Council will give consideration to maximizing economic benefits to the United States, consistent with resource stewardship responsibilities for the continuing welfare of the living marine resources. Thus, management must be flexible enough to meet changing social and economic needs of the fishery as well as to address fluctuations in the marine resources supporting the fishery. The following goals have been established in order of priority for managing the West Coast groundfish fisheries, to be considered in conjunction with the national standards of the Magnuson-Stevens Act.

<u>Management Goals</u>

Goal 1 - Conservation. Prevent overfishing and rebuild overfished stocks by managing for appropriate harvest levels and prevent, to the extent practicable, any net loss of the habitat of living marine resources.
Goal 2 - Economics. Maximize the value of the groundfish resource as a whole.
Goal 3 - Utilization. Within the constraints of overfished species rebuilding requirements, achieve the maximum biological yield of the overall groundfish fishery, promote year-round availability of quality seafood to the consumer, and promote recreational fishing opportunities.

<u>Objectives.</u> To accomplish these management goals, a number of objectives will be considered and followed as closely as practicable:

Conservation

Objective 1. Maintain an information flow on the status of the fishery and the fishery resource which allows for informed management decisions as the fishery occurs.

Objective 2. Adopt harvest specifications and management measures consistent with resource stewardship responsibilities for each groundfish species or species group. Achieve a level of harvest capacity in the fishery that is appropriate for a sustainable harvest and low discard rates, and which results in a fishery that is diverse, stable, and profitable. This reduced capacity should lead to more effective management for many other fishery problems.

Objective 3. For species or species groups that are overfished, develop a plan to rebuild the stock as soon as possible, taking into account the status and biology of the stock, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem.

Objective 4. Where conservation problems have been identified for non-groundfish species and the best scientific information shows that the groundfish fishery has a direct impact on the ability of that species to maintain its long-term reproductive health, the Council may consider establishing management measures to control the impacts of groundfish fishing on those species. Management measures may be imposed on the groundfish fishery to reduce fishing mortality of a non-groundfish species for documented conservation reasons. The action will be designed to minimize disruption of the groundfish fishery, in so far as consistent with the goal to minimize the bycatch of non-groundfish species, and will not preclude achievement of a quota, harvest guideline, or allocation of groundfish, if any, unless such action is required by other applicable law.

Objective 5. Describe and identify essential fish habitat (EFH), adverse impacts on EFH, and other actions to conserve and enhance EFH, and adopt management measures that minimize, to the extent practicable, adverse impacts from fishing on EFH.

Economics

Objective 6. Within the constraints of the conservation goals and objectives of the FMP, attempt to achieve the greatest possible net economic benefit to the nation from the managed fisheries.

Objective 7. Identify those sectors of the groundfish fishery for which it is beneficial to promote year-round marketing opportunities and establish management policies that extend those sectors fishing and marketing opportunities as long as practicable during the fishing year.

Objective 8. Gear restrictions to minimize the necessity for other management measures will be used whenever practicable. Encourage development of practicable gear restrictions intended to reduce regulatory and/or economic discards through gear research regulated by EFP.

Utilization

Objective 9. Develop management measures and policies that foster and encourage full utilization (harvesting and processing), in accordance with conservation goals, of the Pacific Coast groundfish resources by domestic fisheries.

Objective 10. Recognizing the multispecies nature of the fishery and establish a concept of managing by species and gear or by groups of interrelated species.

Objective 11. Develop management programs that reduce regulations-induced discard and/or which reduce economic incentives to discard fish. Develop management measures that minimize bycatch to the extent practicable and, to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch. Promote and support monitoring programs to improve estimates of total fishing related mortality and bycatch, as well as those to improve other information necessary to determine the extent to which it is practicable to reduce bycatch and bycatch mortality.

Social Factors.

Objective 12. When conservation actions are necessary to protect a stock or stock assemblage, attempt to develop management measures that will affect users equitably.

Objective 13. Minimize gear conflicts among resource users.

Objective 14. When considering alternative management measures to resolve an issue, choose the measure that best accomplishes the change with the least disruption of current domestic fishing practices, marketing procedures, and the environment.

Objective 15. Avoid unnecessary adverse impacts on small entities.

Objective 16. Consider the importance of groundfish resources to fishing communities, provide for the sustained participation of fishing communities, and minimize adverse economic impacts on fishing communities to the extent practicable.

Objective 17. Promote the safety of human life at sea.

10.3 Highly Migratory Species

The general goals and objectives of this FMP are listed below to provide context for [management] actions. They are not listed in order of priority:

1. Promote and actively contribute to international efforts for the long-term conservation and sustainable use of highly migratory species fisheries that are utilized by West Coast-based fishers, while recognizing these fishery resources contribute to the food supply, economy, and health of the nation.
2. Provide a long-term, stable supply of high-quality, locally caught fish to the public.
3. Minimize economic waste and adverse impacts on fishing communities to the extent practicable when adopting conservation and management measures.
4. Provide viable and diverse commercial fisheries and recreational fishing opportunity for highly migratory species based in ports in the area of the Pacific Council's jurisdiction, and give due consideration for traditional participants in the fisheries.
5. Implement harvest strategies which achieve optimum yield for long-term sustainable harvest levels.
6. Provide foundation to support the State Department in cooperative international management of highly migratory species fisheries.
7. Promote inter-regional collaboration in management of fisheries for species which occur in the Pacific Council's managed area and other Councils' areas.
8. Minimize inconsistencies among federal and state regulations for highly migratory species fisheries.
9. Minimize bycatch and avoid discard and implement measures to adequately account for total bycatch and discard mortalities.
10. Prevent overfishing and rebuild overfished stocks, working with international organizations as necessary.
11. Acquire biological information and develop a long-term research program.
12. Promote effective monitoring and enforcement.
13. Minimize gear conflicts.
14. Maintain, restore, or enhance the current quantity and productive capacity of habitats to increase fishery productivity for the benefit of the resource and commercial and recreational fisheries for highly migratory species.
15. Establish procedures to facilitate rapid implementation of future management actions, as necessary.
16. Promote outreach and education efforts to inform the general public about how West Coast HMS fisheries are managed and the importance of these fisheries to fishers, local fishing communities, and consumers.
17. Manage the fisheries to prevent adverse effects on any protected species covered by MMPA and MBTA and promote the recovery of any species listed under the ESA to the extent practicable.
18. Allocate harvest fairly and equitably among commercial, recreational and charter fisheries for HMS, if allocation becomes necessary.

10.4 Salmon

The following objectives guide the Council in establishing fisheries against a framework of ecological, social, and economic considerations.

1. Establish ocean exploitation rates for commercial and recreational salmon fisheries that are consistent with requirements for stock conservation objectives within Section 3.1, specified ESA consultation or recovery standards, or Council adopted rebuilding plans.
2. Fulfill obligations to provide for Indian harvest opportunity as provided in treaties with the United States, as mandated by applicable decisions of the Federal courts, and as specified in the October 4, 1993 opinion of the Solicitor, Department of Interior, with regard to federally recognized Indian fishing rights of Klamath River Tribes.
3. Seek to maintain ocean salmon fishing seasons which support the continuance of established recreational and commercial fisheries while meeting salmon harvest allocation objectives among ocean and inside recreational and commercial fisheries that are fair and equitable, and in which fishing interests shall equitably share the obligations of fulfilling any treaty or other legal requirements for harvest opportunities.
4. Minimize fishery mortalities for those fish not landed from all ocean salmon fisheries as consistent with optimum yield and the bycatch management specifications of Section 3.4.
5. Manage and regulate fisheries so that the optimum yield encompasses the quantity and value of food produced, the recreational value, and the social and economic values of the fisheries.
6. Develop fair and creative approaches to managing fishing effort and evaluate and apply effort management systems as appropriate to achieve these management objectives.
7. Support the enhancement of salmon stock abundance in conjunction with fishing effort management programs to facilitate economically viable and socially acceptable commercial, recreational, and tribal seasons.
8. Achieve long-term coordination with the member states of the Council, Indian tribes with federally recognized fishing rights, Canada, the NPFMC, Alaska, and other management entities which are responsible for salmon habitat or production. Manage consistent with the Pacific Salmon Treaty and other international treaty obligations.
9. In recommending seasons, to the extent practicable, promote the safety of human life at sea.

11 Appendix C: Acronyms Used

Acronym	Term
CCE	California Current Ecosystem
EAS	Ecosystem Advisory Subpanel
EC Species	Ecosystem Component Species
EFH	Essential Fish Habitat
EFMP	Ecosystem Fishery Management Plan
EPAP	Ecosystem Principles Advisory Panel
EPDT	Ecosystem Plan Development Team
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
HAPC	Habitat Area of Particular Concern
HC	Habitat Committee
IEA	Integrated Ecosystem Assessment
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
SSC	Scientific and Statistical Committee

ECOSYSTEM PLAN DEVELOPMENT TEAM REPORT ON RECOMMENDATIONS FOR FUTURE ACTION

At its September 2010 meeting, the Pacific Fishery Management Council (Council) received its first report from its Ecosystem Plan Development Team (EPDT,) *Ecosystem Fishery Management Planning for U.S. West Coast Fisheries* (September 2010 Agenda Item H.1.b, Attachment 1). That report discussed ecosystem fishery management planning generally, draft goals and objectives for a potential ecosystem fishery management plan (EFMP,) issues to consider for developing the regulatory scope of and management unit species for a potential EFMP, the geographic range and scale of an EFMP, and the state of ecosystem science. For March 2011, the Council tasked its EPDT with reviewing the Council's four fishery management plans (FMPs) to identify existing ecosystem-based management principles, and to scope common management needs that may benefit from a coordinated overarching Ecosystem Fishery Management Plan framework. The EPDT's March 2011 report, *Discussion Document Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process* (Discussion Document, Agenda Item J.1.c, Attachment 1), addresses those Council tasks as well as September 2010 comments received from the Council's Scientific and Statistical Committee. This report complements the discussion document and focuses on potential next steps for Council action on ecosystem fishery management planning.

The discussion document provides EPDT suggestions on a variety of avenues for bringing ecosystem science information and research into the Council process. Because that report touches on the work of all of the Council's FMPs, the EPDT believes that review and comment from the Council's advisory bodies on the discussion document is essential to moving the Council's ecosystem fishery management planning process forward. Depending on Council direction, the EPDT anticipates working on its next Council assignments over spring and summer 2011, with its next face-to-face meeting to be held following the Council's June meeting. The EPDT provides detailed recommendations, below, but tentatively plans to:

- Receive comments on its March 2011 Discussion Document from Council advisory bodies, and document or process revision directions from the Council at the Council's June 2011 meeting.
- Report to the Council and its advisory bodies in September 2011 on developing ecosystem fishery management planning priority statements that the EPDT anticipates will both aid the development of an annual California Current Ecosystem report and in moving forward the Council's ecosystem policy priorities.

<u>EPDT Recommendations for Council Action</u>

- Assign Council advisory bodies, including FMP management teams and advisory panels, to review the EPDT's March 2011 Discussion Document, as well as the September 2010 EPDT report and associated comments from Council advisory bodies, and provide comment to the Council by its June 2011 meeting. Comments should consider: 1) whether the EPDT's discussions of current ecosystem-based management measures within FMPs are complete and, if not, detail missing measures or concepts; 2) whether the EPDT's proposed schedule (Table 4.1 in Discussion Document) for incorporating ecosystem considerations into stock assessments for selected species is feasible and, if not, suggest alternative schedules; 3) whether the EPDT's recommendations for research and information needed to bring additional ecosystem considerations into the Council process (Section 4.2 of Discussion Document) are comprehensive and, if not, provide additional suggestions.

- Request that the SSC particularly review Table 4.1 in the Discussion Document and comment on the appropriateness of revising stock assessment Terms of Reference, in consultation with management teams, to facilitate the participation of ecologists or other relevant experts on stock assessment teams to aid in ecosystem considerations development for stock assessments.
- Plan for Council input to NOAA's California Current Integrated Ecosystem Assessment, to help craft science products that will better inform Council conservation and management decision-making
- Request that the SSC begin planning for review of models in support of ecosystem-based management. The SSC typically reviews models and other science inputs to the Council process in the context of Council decisions. However, ecosystem models are new to the Council process and the initial model review process will require time for dialogue between the SSC and modelers.
- Provide discussion and guidance on the desired direction for ecosystem fishery management policy and assign EPDT policy and science analyses that could aid the Council in achieving that direction.

PFMC
03/02/2011

Agenda Item J.1.c
Supplemental EPDT PowerPoint
March 2011

Ecosystem Plan Development Team Report and Discussion Document

Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process

Council Assignments from September 2010

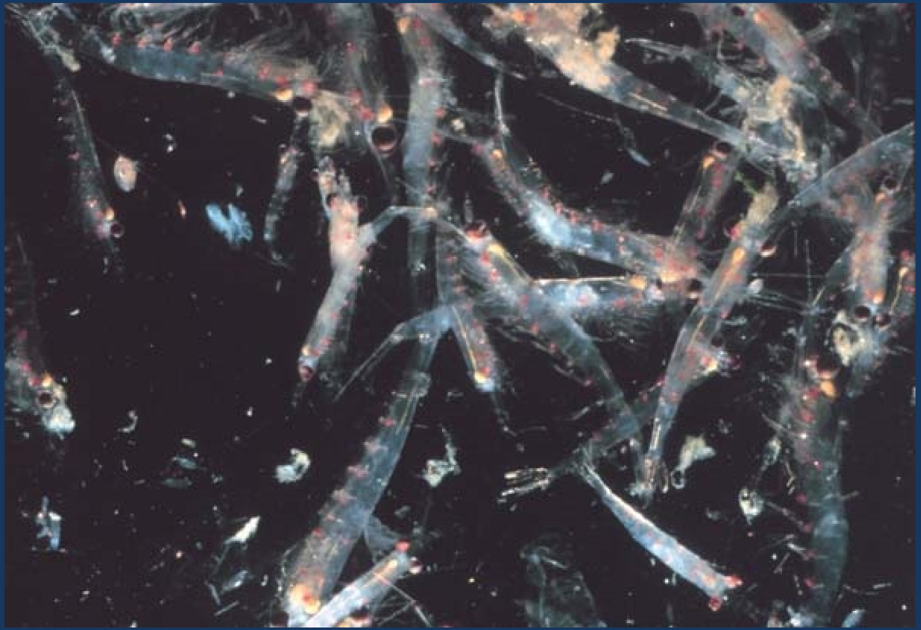
Identify existing EBM principles

Section 2, Discussion Document

Scope common management needs that may benefit from a coordinated overarching EBM framework

Section 3 & Appendix Tables, Discussion Document



SSC Recommendations from September 2010

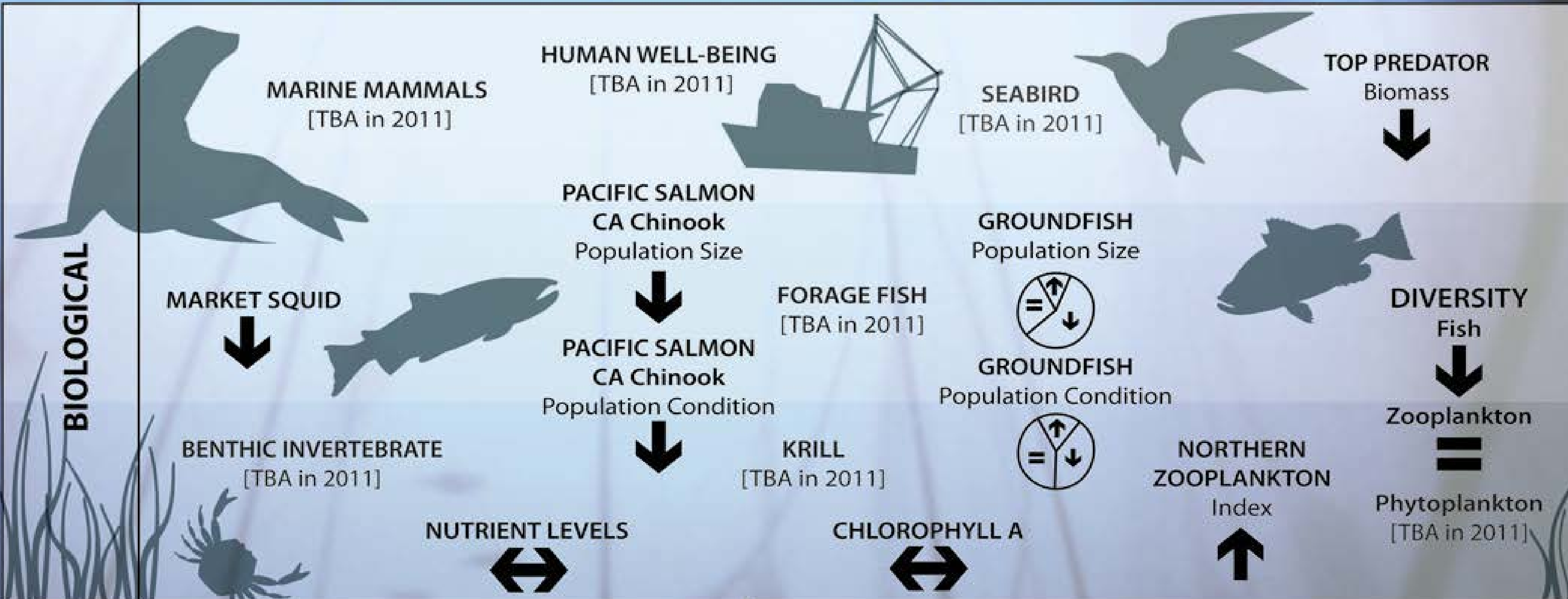
Expand stock assessments to include ecosystem considerations

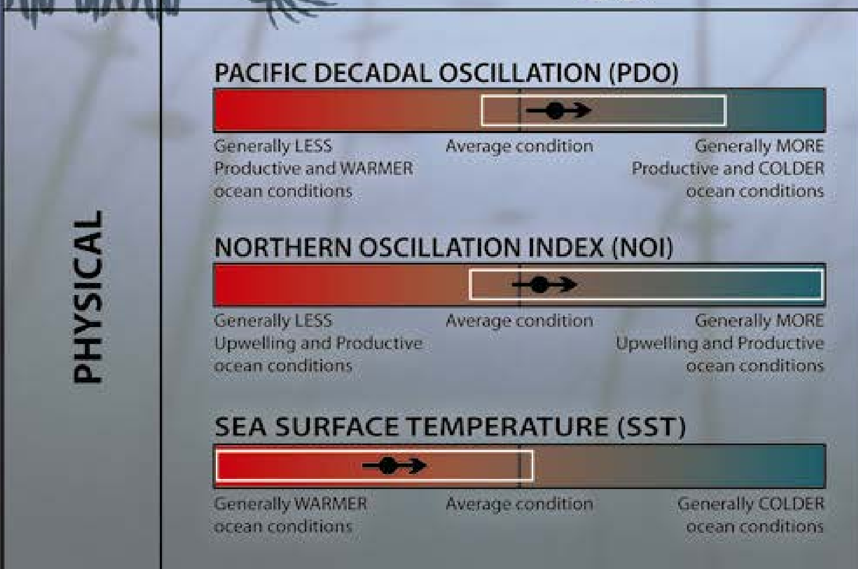
Section 4.1, Discussion Document

Begin annual reporting on conditions in California Current Ecosystem

Section 4.1, Discussion Document

Status of the California Current Ecosystem at a Glance





This graphic provides a summary of the status of the California Current ecosystem 2005-2010 using key physical and biological indicators. The physical ocean indicators suggest that ocean productivity is better than average, with strong, seasonal upwelling bringing nutrients to surface waters to fuel the production of phytoplankton, captured here as chlorphyll A. Good ocean conditions are manifested in positive trends of northern (fat-rich) zooplankton. However, indicators of ecological processes higher in the food chain tend to show decreasing trends. This trend is true for population size and condition of pacific salmon, many groundfish, market squid, fish diversity, and top predator biomass. Additional biological indicators will be added in the 2011 CCLME IEA including marine mammals and birds, forage fish, and human well-being.

KEY

TBA = To Be Added

↓ Downward Trend

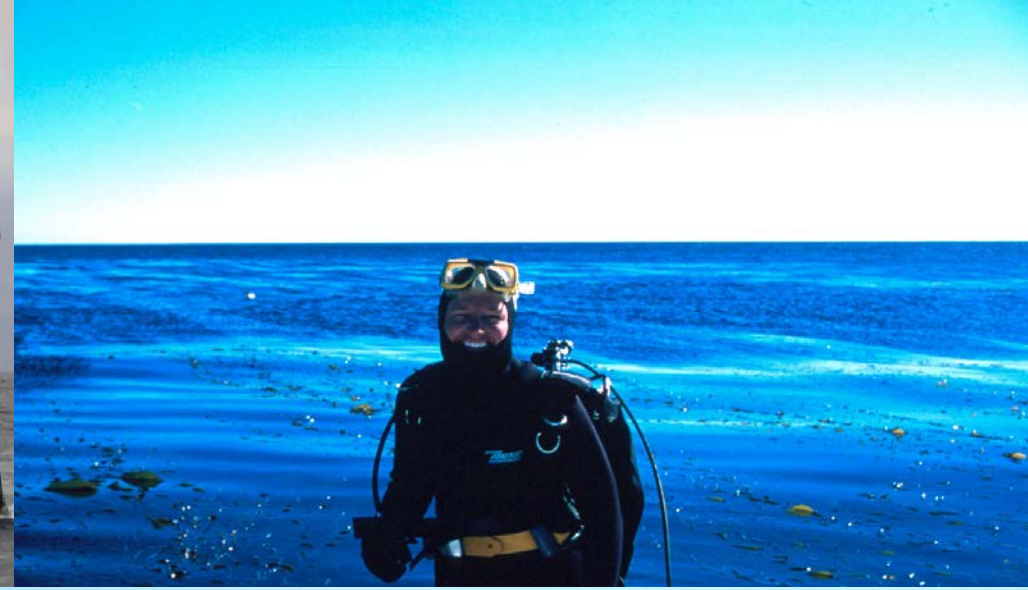
↑ Upward Trend

= No Trend

↔ Variable Coastwide

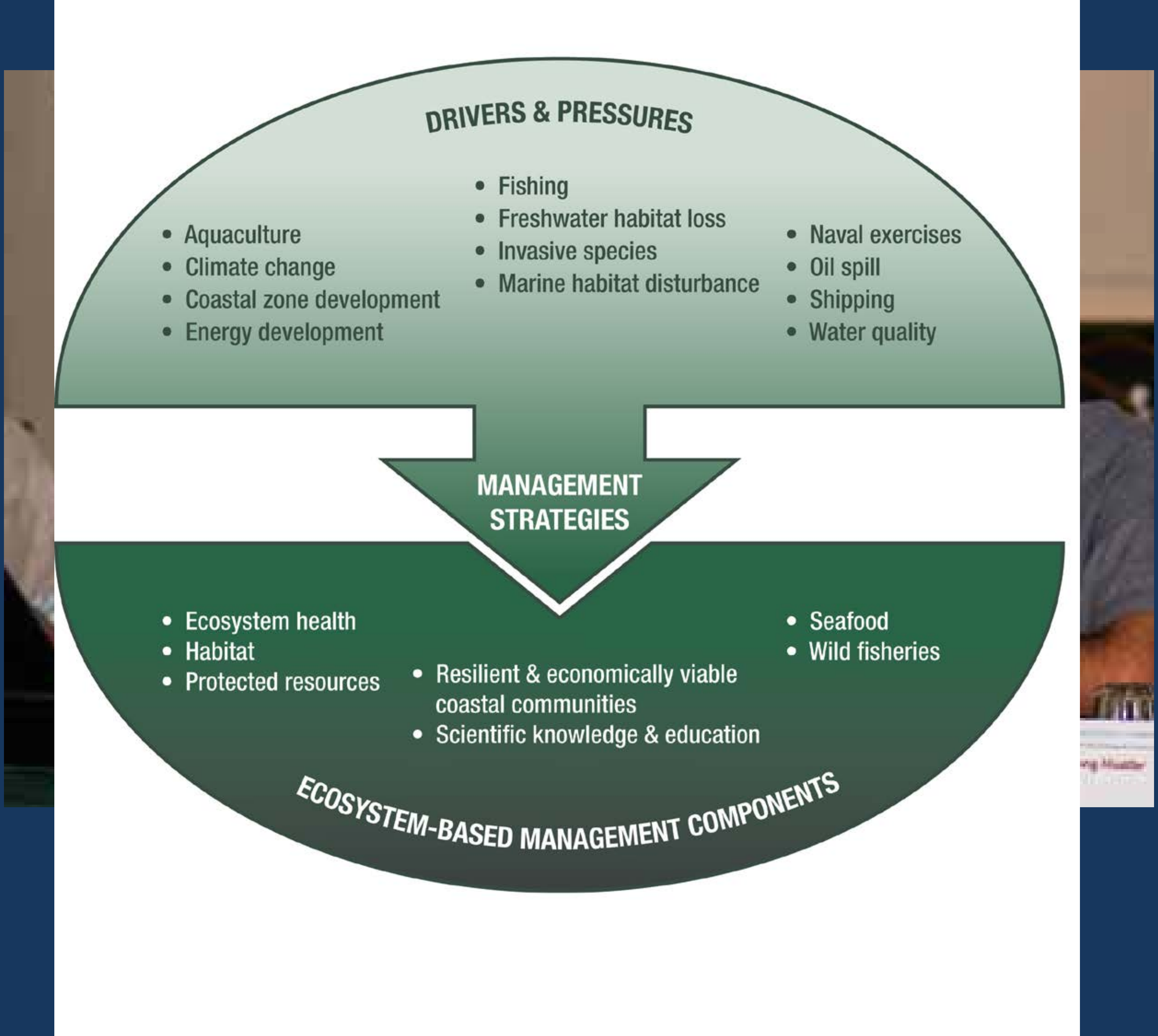
2010 Value & 5yr Trend

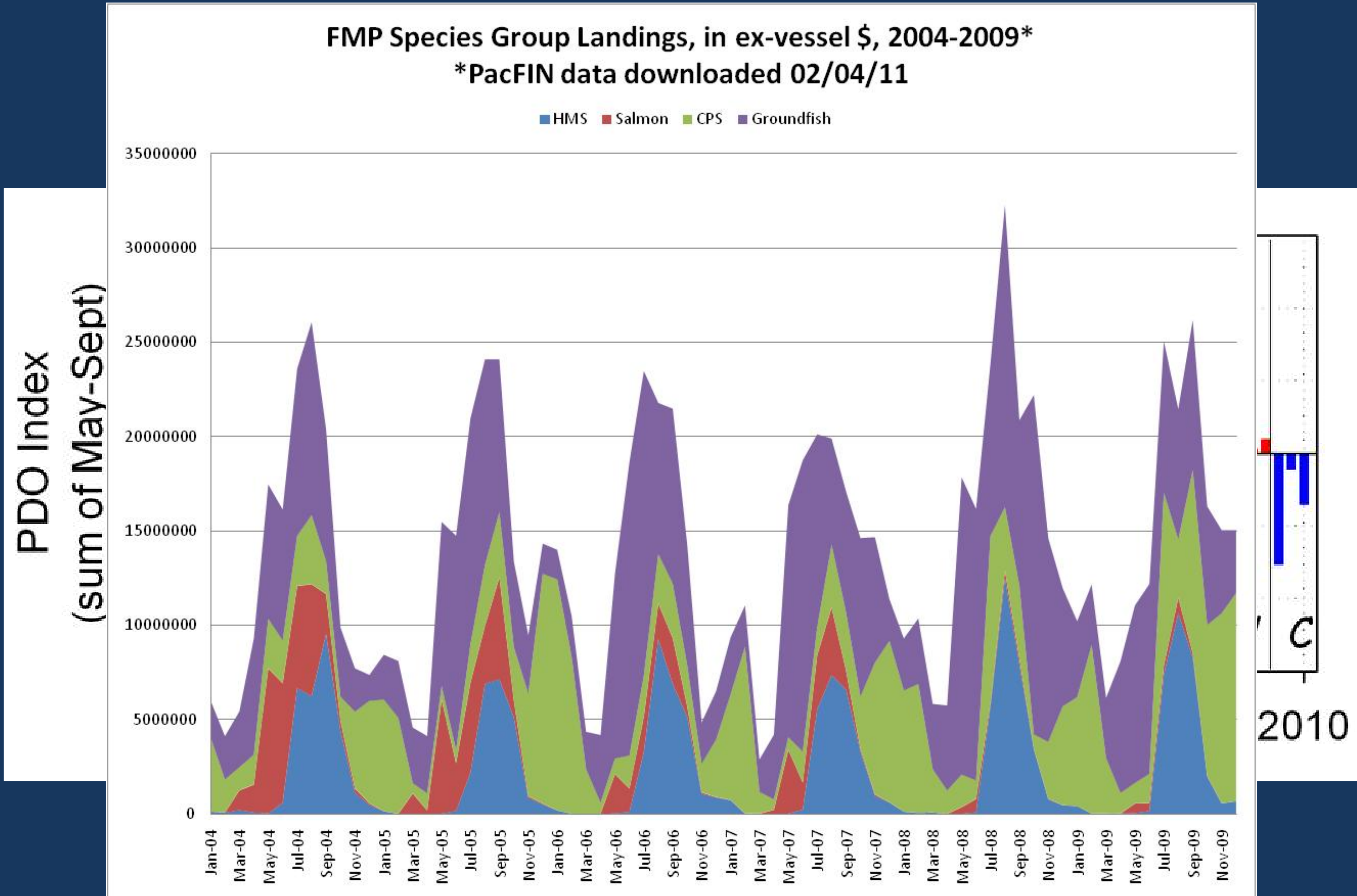
Range from Last 5 Yrs


578930
FISHERY RESEARCH
EXCALIBUR


EPDT Supplemental Report, J.1.c.

- Request feedback from Council advisory bodies on EPDT March 2011 and September 2010 reports
- Request SSC review of Table 4.1 in the Discussion Document and comment on a potential schedule for bringing ecosystem considerations into stock assessments
- Request SSC review of models in support of ecosystem-based management.
- Request Council input to NOAA's California Current Integrated Ecosystem Assessment
- Request Council discussion and guidance on the desired direction for ecosystem fishery management policy


DRIVERS & PRESSURES
• Aquaculture
• Climate change
• Coastal zone development
• Energy development
• Fishing
• Freshwater habitat loss
• Invasive species
• Marine habitat disturbance
• Naval exercises
• Oil spill
• Shipping
• Water quality
MANAGEMENT STRATEGIES
• Ecosystem health
• Habitat
• Protected resources
• Resilient & economically viable coastal communities
• Scientific knowledge & education
• Seafood
• Wild fisheries
ECOSYSTEM-BASED MANAGEMENT COMPONENTS



FMP Species Group Landings, in ex-vessel $, 2004-2009*
*PacFIN data downloaded 02/04/11
HMS
Salmon
CPS
Groundfish
35000000
30000000
25000000
20000000
15000000
10000000
5000000
0
Jan-04
Mar-04
May-04
Jul-04
Sep-04
Nov-04
Jan-05
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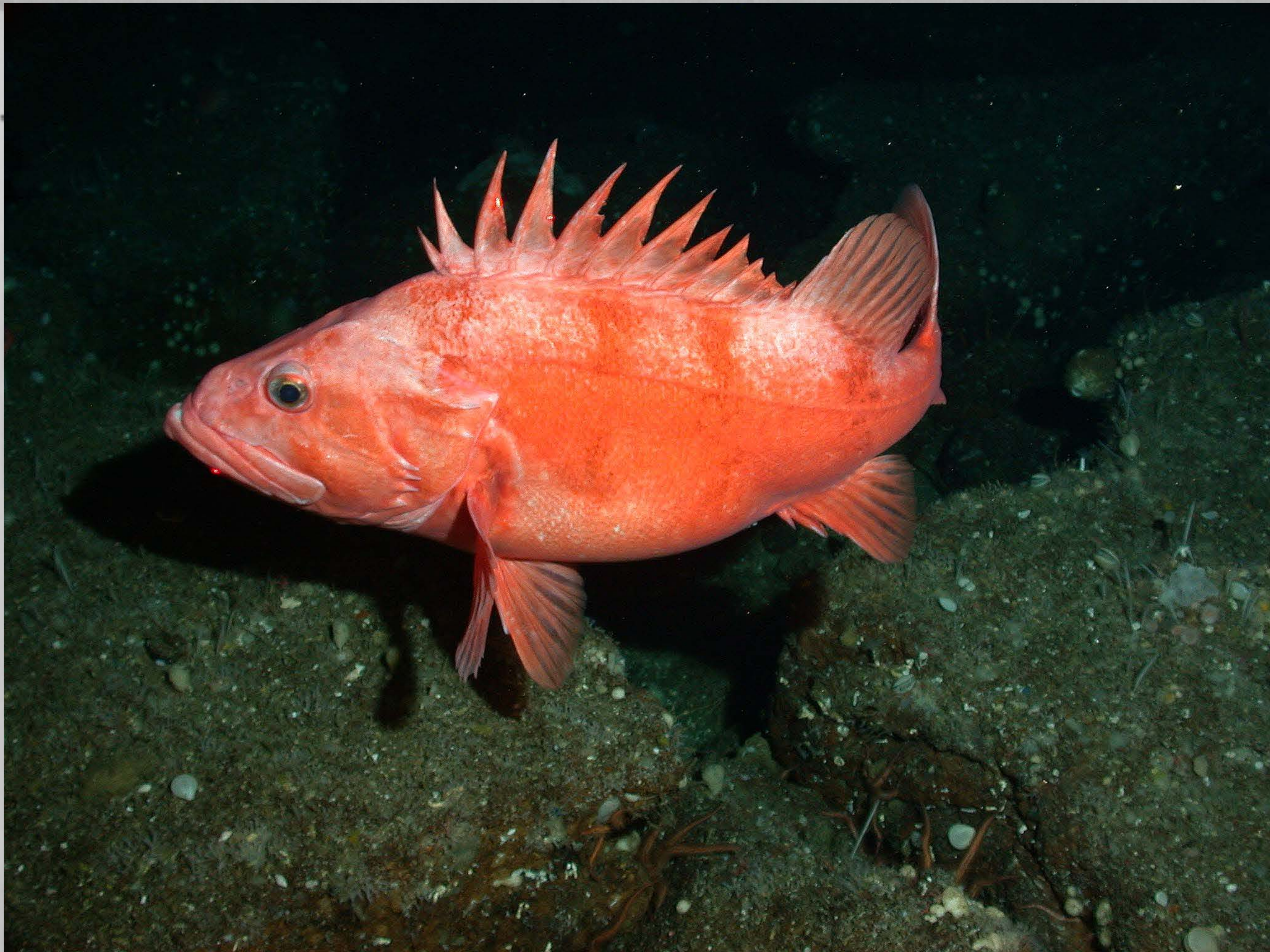
(sum of May-Sept)
C
2010



Unless otherwise indicated, all images courtesy of NOAA Photo Library, except:

Slide 2: *Bigeye thresher shark stomach contents, including bocaccio,* Antonella Previ
Slide 3: *Taimen Lee with canary rockfish and lingcod off B.C.*, Anne Salomon; *albacore angler*, WDFW; *salmon eggs at Quinault National Hatchery,* USFWS; *salmon eggs,* Bonneville Power Administration
Slide 4: *Severin Field with anchovies at Monterey Bay Aquarium*, John Field
Slide 7: *puffin,* USFWS
Slide 10: *canoe launching from Swinomish,* USGS; salmon *seining*, WDFW
Slide 14: *Makah tribe members at Neah Bay, 1890,* National Archives
Slide 15: *angler and Chinook*, and *South Fork of Salmon River, Idaho* Richard Scully
Slide 16: *Malcolm Dalton on beach*, Michael Dalton

ECOSYSTEM ADVISORY SUBPANEL REPORT ON AN ECOSYSTEM FISHERY MANAGEMENT PLAN

The Ecosystem Advisory Subpanel (EAS) met on February 16, 2011 to review an Ecosystem Plan Development Team (EPDT) draft report that was prepared in response to Pacific Fishery Management Council (Council) requested tasks on the initiation of an Ecosystem Fishery Management Plan (EFMP). The EAS reviewed the EPDT report and found it to be a very helpful review of information relevant to ecosystems work on the west coast.

Thus far, the EFMP development process has focused on gathering information and developing a foundation of shared understanding about ecosystem management concepts and learning from experiences elsewhere. In order to facilitate efficient and effective next steps in the EFMP process, we recommend that the Council schedule formal action at the June 2011 Council meeting to adopt the purpose and need of the EFMP.

In addition to recommending that the Council adopt the purpose and need, the EAS requests a primary role in developing information to aid the Council in the plan development process. The EAS has tentative plans to meet in April 2011 to prepare information for the June Council meeting about alternative approaches to incorporating ecosystem management into the Council process, the pros and cons of those alternatives, and guidance on a recommended approach.

Our efforts would seek to build upon the solid foundation laid by the EPDT and our prior recommendations because the development of an EFMP effort will benefit from creative collaboration.

For example, in May 2010 the EAS developed the following working definition of EBFM to facilitate our discussions:

> *EBFM is a systems approach that looks at interactions of habitats and species to optimize ecosystem services in ways that encourage sustainability of the broader marine ecosystem and the health and resilience of fisheries, fish stocks, and fishing communities.*

At the February 2011 meeting, the EAS discussed the following principles and goals for the Ecosystem Plan:

> *The EAS believes that an EBFM framework should provide tools for the Council to improve the precision, accuracy, and an improved understanding of the effect of fishery management decisions; to provide for a flexible and adaptive system able to be tuned to prevailing or forecasted environmental conditions; and an awareness of how these conditions drive fisheries.*

Specific to the purpose of and need for an EFMP, the EAS identified several specific items to be considered by the EPDT in developing the purpose and need statement, specifically: the EBFM document should provide a vehicle to (1) improve information and improve decision making; (2)

identify gaps in information; (3) integrate across species-specific FMPs; (4) provide a nexus to regional and national ecosystem-related endeavors; (5) establish a platform or framework that enables management at the appropriate ecosystem scale for a species or complex of species, (6) create incentives for improved stewardship and (7) encourage innovation by offering an alternative pathway for management of a complex of species that might yield a more robust portfolio of fishing opportunities.

As noted above, the EAS reviewed the current EPDT report and found it to be a very helpful. We highlight several key points from their document, which we believe warrant greater emphasis, including:

> Section 3.1 (page 9) – A more organized ecosystem-based management effort could help better address larger scale harvest issues like: maintaining long-term age- and size-distribution in managed stock populations, assessing the evolutionary effects of fishing season timing and location; and climate shift effects on stock productivity and predator-prey relationships.
>
> Section 3.4 (page 12) – One challenge of the Council's current process is that the Council regularly finds itself having to make a management decision under one FMP without necessarily having a clear picture of how that decision might affect fishing opportunities under other FMPs. Expanding our thinking about the socio-economic effects of the Council's decisions to an ecosystem context could provide the Council with more resources and information for assessing how their decisions on individual issues fit within the larger picture of Council-managed fisheries.
>
> Section 4.1.1 (page 14) – Hypotheses on ecosystem considerations for or impacts on a specific stock could be used to define alternative states of nature within current single species stock assessments. The SSC could include methods for incorporating ecosystem considerations into single species stock assessments in the terms of reference. Agency ecologists and fisheries oceanographers should be included on stock assessment teams to facilitate inclusion of ecosystem considerations into stock assessments.
>
> Section 4.1.2 (page 18) – Develop a Council-focused California Current report (based, for example, on the annual CalCOFI Report about the State of the California Current Ecosystem) because this would facilitate incorporation of this information into the Council policy and science processes.
>
> Section 4.2.1 (page 19) – The EPDT provided a useful and comprehensive list of considerations. The EAS suggests there is a need to develop criteria to prioritize the 15 listed items. The EAS also suggests 1, 3, and 7 as potentially high priority items:
>
>> 1. Evaluate the influence of climatic/oceanographic conditions on FMP species. Investigate the potential for incorporating environmental factors within the current stock assessment modeling framework (Stock Synthesis 3). Model effects of climate forcing 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 (Sibert et al. 2006). This is now done for

many assessments in order to represent relative depletion from both a static and dynamic perspective (Maunder and Aires-da-Silva 2010).

3. Examine ecological interactions for influencing 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.

7. 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).

In summary, the EAS believes that important progress has occurred in developing an understanding of ecosystem management concepts and applications. We believe that ecosystem understandings have value for the Council's policies. We recommend that the focus turn to development of the purpose and need of ecosystem fisheries management planning so that there is a shared foundation for further development efforts. The EAS offers its collaboration to help frame and evaluate options on this topic for the Council's consideration.

PFMC
02/28/2011

HABITAT COMMITTEE COMMENTS ON ECOSYSTEM MANAGEMENT

The Habitat Committee (HC) noted the work to date regarding the development of an ecosystem-based fishery management plan. The HC appreciated the progress made by, and the responsiveness of, the Ecosystem Plan Development Team (EPDT) to questions and suggestions made at the last Council meeting. The timeframe seems appropriate for more extensive input into the Discussion Document (J.1.c., Attachment 1) at the Council's June 2011 meeting. The HC developed a work plan to develop draft comments for discussion at the April, 2011 meeting, with final comments from the HC to be submitted to the June 2011 briefing book.

The HC also discussed the California Current Integrated Ecosystem Assessment (CCIEA) document (J.1.b. Attachment 1). The HC noted that the CCIEA team requested input from the Council on the appropriateness of the indicators included in the assessment. The HC discussed the indicators for ecosystem health and energetic and material flow, considering them most pertinent to HC concerns. The CCIEA team suggested focusing first on four indicators (selected out of 18 top indicators potentially available) for community composition, and two of the three top potential indicators for energetic and material flow. These indicators were chosen in part based on data availability, availability of long-term data sets, and coast-wide coverage.

Ecosystem health
1. Zooplankton species biomass anomalies
2. Taxonomic distinctness (average and variation)
3. Top predator biomass
4. Seabird annual reproductive output

Energetics and material flows
1. Chlorophyll-a (as an indicator of primary productivity)
2. Inorganic nutrient levels (phosphate, nitrate, silicate)

The HC commends National Marine Fisheries Service and their Integrated Ecosystem Assessment (IEA) team on their extensive work, documentation, and insights, and believes these indicators are appropriate. We support developing an indicator for forage fish for 2011, as forage fish are key ecosystem component species and are an essential fish habitat (EFH) component (as prey). The indicator chosen for forage or coastal pelagic species should include data from the entire California Current Large Marine Ecosystem (including data from south of Point Conception).

The HC recommends that the CCIEA team consider habitat indicators in its near-term pilot work. Areas of live corals and kelp are key habitat indicators as they are tied to EFH and habitat areas of particular concern (HAPC) and they also respond to risks from numerous threats (e.g. ocean acidification or ocean sea surface temperature) to the ecosystem. Indicators for water quality also merit near term attention, especially for assessing ecosystem health. The HC is also very interested in having indicators to assess the extent and duration of hypoxia zones, toxic algal blooms, proximity of acidic waters to shore, and freshwater inflow into nearshore and estuarine waters. The appropriate sampling and reporting timeframe for these indicators would be determined by the IEA team.

We (and others) have recommended that the Council receive an annual report on the status of the California Current ecosystem. The CCIEA can provide input to this report, helping to better inform the impacts of fishery management decisions for one Fishery Management Plan (FMP) on other FMPs, non-FMP species, and ecosystem health and how ecosystem status and function potentially inform fishery management decisions. A status report on the California Current ecosystem may introduce more explicit ecosystem considerations into stock assessment models and management decisions.

PFMC
3/4/11

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON ECOSYSTEM FISHERY MANAGEMENT PLAN

The Scientific and Statistical Committee (SSC) was briefed by Dr. John Field regarding the Ecosystem Plan Development Team's (EPDT) "Discussion Document: Assessing Ecosystem Policy Principles and Bringing Ecosystem Science into the Pacific Fishery Management Council Process" (Agenda Item J.1.c, Attachment 1). The SSC commends the EPDT for its thorough documentation of ecosystem-based management measures and research needs associated with each of the Council's four fishery management plans (FMPs), and for considering needs and challenges common to all FMPs and cross-FMP effects.

Section 4 of the discussion document includes a lengthy list of ecosystem science topics relevant to each FMP, as well as topics common across FMPs. It would be helpful if these topics were categorized according to whether they can be addressed in the short term or will require intermediate to long-term research to accomplish.

The SSC notes the following regarding ecosystem-based management:

- Procedures need to be established to identify the types of ecosystem information relevant to Council deliberations and when and how such information should be used in the Council process.

- Building upon existing population models already used by the Council is a constructive and practical way to make progress on incorporating ecosystem considerations into management.

- Incorporation of ecosystem considerations into stock assessments should be considered judiciously. While ecosystem data may be informative, integration of such data directly into assessments also introduces additional sources of uncertainty. Ecosystem data should be considered in terms of whether they provide practical benefits such as improving forecasts. Complexity for its own sake does not generally lead to better assessments or better management.

- Incorporation of ecosystem considerations into management is not limited to quantitative models. Information on biophysical variables, predator/prey relationships and the like may provide insights into stock assessment results or potential risks associated with management decisions.

- Some ecosystem variables may not be immediately relevant to management but may provide longer-term insights into the effects of dynamic factors such as climate change on Council-managed species. Processes for identifying and monitoring such information and tracking related research – perhaps as part of the California Current Integrated Ecosystem Assessment (CCIEA) – need to be developed.

- While stock assessment models currently used by the Council will continue to be relevant as the Council moves toward ecosystem-based management, additional tools (e.g., Atlantis, CCIEA) will also need to be evaluated. Atlantis is a complex model that includes many different modules (e.g., species interactions, stock assessment, fleet dynamics). Reviewing models such as Atlantis will require an interdisciplinary team of reviewers, adequate model documentation, and considerable review time. Procedures for reviewing such models need to be established.

- Socioeconomic factors are an important consideration in ecosystem-based management. For instance, the EPDT notes that FMP fisheries can have cumulative effects that are reflected in spatial and temporal patterns of fishing behavior, effort shifts among fisheries, and the viability and resilience of coastal communities. The SSC notes that community 'viability' and 'resilience' are often cited but ill defined concepts. It is important that socioeconomic changes be captured in a broad range of indicators that are measurable.

Orderly processes need to be established for identifying and incorporating relevant ecosystem considerations into management. The SSC proposes a two-day meeting of its Ecosystem-Based Management Subcommittee in mid-April to help address this need, as follows:

- The Subcommittee will draft terms of reference for identifying ecosystem information relevant to stock assessments and incorporating ecosystem considerations into assessments. Among other things, this will help bring clarity to what would be needed to meet the EPDT's proposed schedule for "bringing ecosystem considerations into stock assessment and harvest-setting processes" (Agenda Item J.1.c, Attachment 1, EPDT Discussion Document, Table 4.1).

- The Council has a longstanding practice of reviewing new models before they are considered for use in management. The Subcommittee will examine current terms of reference for methodology reviews to determine their applicability to review of ecosystem tools that are new to the Council, such as Atlantis.

- Information sources such as the CCIEA provide extensive technical information regarding the California Current Ecosystem. The Subcommittee will discuss the CCIEA in terms of its content and how that content can be organized in ways that enhance its utility to the Council. This is intended to complement efforts initiated by the EPDT to "work with the Science Centers to select a pilot set of species, spread among the four FMPs and of potential interest to the Council" (Agenda Item J.1.c, Attachment 1, EPDT Discussion Document, p. 17).

PFMC
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February 10, 2011

Mr. Mark Cedergreen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384

RE: **Agenda Item J.1: Ecosystem Fishery Management Plan**

Dear Mr. Cedergreen and Council members:

Oceana commends and supports the continued development of the Pacific Fishery Management Council's Ecosystem Fishery Management Plan (EFMP). If actively implemented, this effort provides the PFMC the opportunity to take a leadership role in ecosystem-based management, build on the success of the precautionary prohibition on krill harvest, and ultimately provide long-term protections for the vibrant coastal fishing communities and marine ecosystems off the U.S. West Coast. In particular, the plan should include additional protections for West Coast forage species, whose populations are critical to supporting the recovery of depleted fish species and maintaining healthy populations of fish and wildlife in the California Current Large Marine Ecosystem.

We are concerned, however, about both ongoing delay and the general lack of focus thus far in the development of the EFMP. The PFMC must make critical decisions and provide solid guidance by adopting a purpose and need statement and listing the specific management goals and objectives of the plan. In addition, the PFMC should formally initiate a National Environmental Policy Act (NEPA) process to accompany the EFMP. That NEPA process should result in a Programmatic Environmental Impact Statement (PEIS) evaluating the impacts, at an FMP level, of the fisheries authorized by the PFMC, including the synergistic and cumulative environmental impacts from fishing in the California Current ecosystem. In previous communications, Oceana has provided the Council with recommended language which we hope you will consider and adopt.[1]

The EFMP process will also allow the Council to address several outstanding legal obligations, such as issues that are not being addressed during the National Standard 1 process. Specifically, the PFMC is neither listing relevant ecological factors in its FMPs nor reducing harvest levels for each species to account for these factors, as is required by the Magnuson-Stevens Fishery Management and Conservation Act.[2] For example, it does not appear that any movement has been made to follow Council direction in June 2010 to include lists of relevant ecological factors in Amendment 13 to the CPS FMP and in Amendment 23 to the Groundfish FMP.

[1] Please refer to September 2010 PFMC Meeting Agenda Item H.1.d, Supplemental Public Comment, September 2, 2010 letter from Oceana to PFMC.
[2] 16 U.S.C. 1802 § 3(33)(A) & (B).

Further, the EFMP and PEIS can serve as an appropriate venue to take a hard look at the ecological effects of alternative harvest rules that determine Annual Catch Limits and management measures. The EFMP process also should incorporate the guidance of the EFH Final Rule, which includes prey as a component of EFH and requires Councils to implement management measures that minimize adverse effects of fishing on prey availability. Fishing impacts to prey components of EFH, however, have not been analyzed or minimized. Indeed, there are forage species that currently are subject to no management by the PFMC.

Oceana greatly appreciates the opportunity to participate in and support the EFMP process and has dedicated our limited resources to working with the PFMC ecosystem committee process. Without attention to these issues and specific direction from the Council, we are concerned that the process will lose its momentum and fall short of its potential.

Specifically, the Council needs to ensure that the following items are accomplished through the EFMP process:

- Initiate a NEPA process to accompany the EFMP that begins preparation of the PEIS evaluating the impacts of fishing under the existing FMPs and the cumulative impacts of West Coast fisheries and examining alternative harvest strategies.

- Ensure that Optimum Yield calculations explicitly account for ecological factors (e.g., role as prey), beginning with species which are key forage species in the California Current Ecosystem and that alternative harvest control rules are considered for all FMP species.

- Designate all key forage species in the California Current for which there currently are not management measures as Ecosystem Component species and establish regulations prohibiting the development of directed fisheries for these species (as was done for krill).

- Provide analysis of predator-prey interactions to inform the designation of key prey species as Essential Fish Habitat for species managed in the Council's other four FMPs, and to help identify adverse impacts to those prey.

Thank you for considering these comments. We look forward to continuing to work with you on the development of this ecosystem plan.

Sincerely,

Ben Enticknap
Pacific Project Manager

March 8, 2011
B. Enticknap, Oceana
Pacific Fishery Management Council
Agenda Item J.1. Ecosystem Fishery Management Plan

Draft Purpose and Need Statement

Within the California Current Large Marine Ecosystem, the Pacific Fishery Management Council (Council) and National Marine Fisheries Service (NMFS), in coordination with tribal co-managers and the four states, manage approximately 112 species and 18[1] recreational and commercial fisheries combined in four Fishery Management Plans (FMPs); Coastal Pelagic Species, Highly Migratory Species, Groundfish, and Salmon, plus Pacific halibut. These fisheries all take place within a complex and dynamic large marine ecosystem, including species that interact with each other in the marine food web, changing oceanographic conditions, protected species, and a variety of non-fishing human uses and activities outside of the Council's management responsibility and authority (e.g. shipping, hydrokinetic energy development, pollution discharge).

In order to advance the conservation and management of long-term sustainable fisheries that provide the greatest overall benefit to the Nation, including the protection afforded to the marine ecosystem, the Council and NMFS are proposing to develop an Ecosystem Fishery Management Plan (EFMP) for the California Current Ecosystem (CCE). The EFMP will provide analytical tools and structure necessary for accounting for ecosystem needs when setting Optimum Yield catch levels and managing fisheries. The EFMP will help ensure that management of any one of the Council's fishery groups (Coastal Pelagic Species, Groundfish, Highly Migratory Species, and Salmon) does not negatively affect the management potential of the other species groups, non managed species, or their habitats. The EFMP will identify key forage species in the CCE, will identify the value of the ecological services that such species provide, and will consider, and if appropriate implement, conservation and management measures that maintain their functional role as prey for managed species and all other components of the CCE. The EFMP will help keep the Council updated on current and potential effects on the CCE from human and natural causes (e.g. creation of dredge pile islands, industrial contamination, climate change, etc.). The EFMP will allow the Council and NMFS to improve decision making and advance precautionary, coordinated, and innovative approaches to ecosystem-based fisheries management.

This federal action would establish an EFMP to compliment the ongoing conservation and management of federally managed fisheries in the U.S. Exclusive Economic Zone off Washington, Oregon and California, as authorized by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and pursuant to NEPA and other applicable statutes and executive orders.

[1] Groundfish FMP – 89 species, 3 primary fisheries (groundfish trawl, non-trawl and recreational). Salmon FMP – three species, 5 fisheries (commercial and recreational ocean chinook and coho, pink salmon). HMS FMP – 13 species, 5 fisheries (commercial albacore, coastal purse seine, harpoon swordfish, drift gillnet, West Coast recreational). CPS – 6 species, 4 fisheries (commercial sardine, jack mackerel, Pacific mackerel, anchovy). Pacific halibut – managed by the International Pacific Halibut Commission, along with NMFS, and catch sharing by the PFMC (tribal, non-tribal, commercial and recreational).

"The overall objective of ecosystem based fishery management is to sustain healthy marine ecosystems and the fisheries they support"

Pikitch … 5: 346-347.