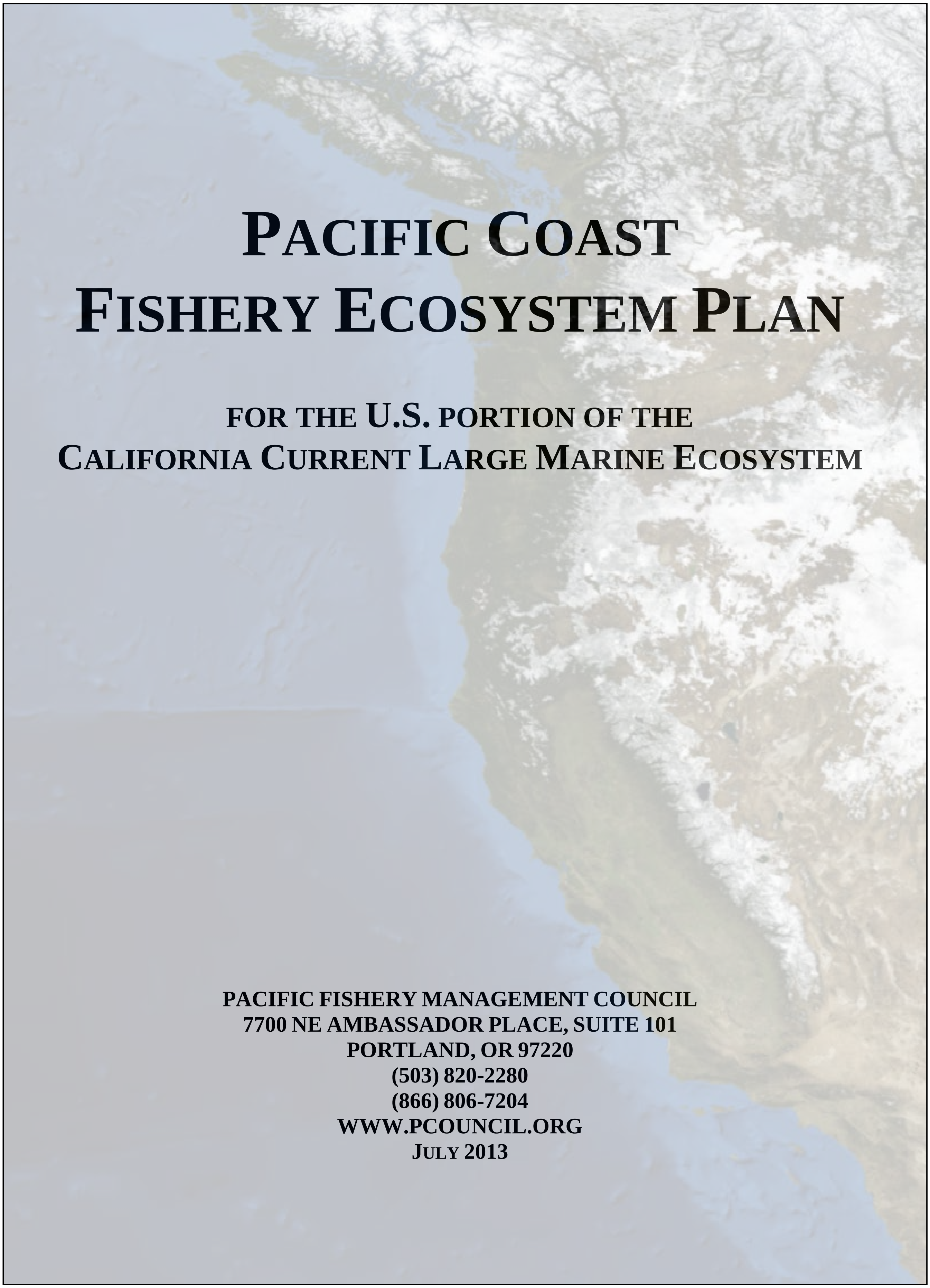

PACIFIC COAST
FISHERY ECOSYSTEM PLAN

FOR THE U.S. PORTION OF THE
CALIFORNIA CURRENT LARGE MARINE ECOSYSTEM

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ACKNOWLEDGMENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

ACL	annual catch limit
AM	accountability measure
AP	advisory panel
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCE	California Current Ecosystem, or California Current Large Marine Ecosystem
CDFW	California Department of Fish and Wildlife (formerly CDFG, for ". . . and Game"
CFGC	California Fish and Game Commission
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Council	Pacific Fishery Management Council
CPS	Coastal Pelagic Species
DLCD	Oregon Department of Land Conservation and Development
DPS	Distinct Population Segment (under the Endangered Species Act)
EAS	Ecosystem Advisory SubPanel
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
ENSO	El Niño/Southern Oscillation
EPDT	Ecosystem Plan Development Team
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit (under the Endangered Species Act)
FAO	Food and Agriculture Organization (of the United Nations)
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
HAB	Harmful algal bloom
HAPC	Habitat Area of Particular Concern
HCR	Harvest control rule
HMS	Highly Migratory Species
IEA	Integrated Ecosystem Assessment
ICES	International Council for the Exploration of the Sea
IATTC	Inter-American Tropical Tuna Commission
IPHC	International Pacific Halibut Commission
ISC	International Scientific Committee (of the WCPFC process)
JMC	Joint Management Committee (of the U.S./Canada Pacific Whiting Treaty process)
JTC	Joint Technical Committee (of the U.S./Canada Pacific Whiting Treaty process)
MLPA	Marine Life Protection Act
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	maximum sustainable yield
MTL	mean trophic level
nm	nautical miles
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Deparment of State Lands
OPRD	Oregon Parks and Recreation Department
PacFIN	Pacific Fisheries Information Network
PDO	Pacific Decadal Oscillation
PICES	Pacific ICES; formally, the North Pacific Marine Science Organization
PSMFC	Pacific States Marine Fisheries Commission
RCA	Rockfish Conservation Area
RecFIN	Recreational Fisheries Information Network
SAFE	Stock Assessment and Fishery Evaluation (Reports for Council FMPs)
SSC	Scientific and Statistical Committee
SST	Sea surface temperature
U&A	Usual and Accustomed (fishing areas, of Treaty tribes)
U.S.	United States of America
USFWS	United States Fish and Wildlife Service
WCPFC	Western and Central Pacific Fisheries Commission
WDFW	Washington Department of Fish and Wildlife
WFWC	Washington Fish and Wildlife Commission

Contents

1 Introduction

1.1 Purpose and Need

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

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

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

The FEP is meant to be an informational document. It is not meant to be prescriptive relative to Council fisheries management. Information in the FEP, results of the Integrated Ecosystem Assessment (IEA), and the Annual State of the California Ecosystem Report may be available for consideration during the routine management processes for fisheries managed in each FMP. How exactly these items will affect fishery management decisions is at the discretion of the Council.

1.2 How this Document is Organized

This FEP takes its organization from the Council's Purpose and Need statement, in Section 1.1. Chapter 2 provides the FEP's Objectives, a more detailed exploration of what the FEP would do to meet its Purpose and Need. Chapter 3 provides an overview of the CCE from a variety of physical, biological, and socio-economic perspectives and disciplines. Chapter 4 discusses the cumulative effects and uncertainties of environmental shifts and human activities on the marine environment. Chapter 5 discusses Council CCE policy priorities across its FMPs, so that ocean resource management and policy processes external to the Council (e.g. West Coast Governors' Alliance on Ocean Health, National Ocean Council, international fishery and ocean resource management bodies) may be made aware of and may better take into account those priorities. Chapter 6 broadly discusses processes for bringing ecosystem science into the Council process. In addition to this main FEP, there is an FEP Appendix A that provides an ecosystem-based fishery management initiative process for the FEP's use into the future.

1.3 Schedule and Process for Developing and Amending the FEP and the Ecosystem Initiatives

In November 2009, the Council appointed two new ad hoc advisory bodies, the Ecosystem Plan Development Team (EPDT) and the Ecosystem Advisory SubPanel (EAS). From 2010 through early 2013, these advisory bodies, with direction from the Council and in cooperation with its permanent committees, developed a draft FEP for public review, released in February 2013. At its April 2013 meeting in Portland, Oregon, the Council adopted a final FEP, providing instructions for the document's last revisions and for the Council's future discussions of ecosystem science and cross-FMP policy issues.

This document, the main body of the FEP, will not be amended until the Council determines that an FEP review and revision process is necessary. At that time, the Council may consider appointing new ad hoc advisory bodies to review and recommend revisions to the FEP. The Council does not anticipate initiating an FEP review process until at least 2018. In addition to the main body of the FEP, which consists of Chapters 1-6, the Council may choose to add one or more appendices to the FEP without opening the main body of the FEP to revision.

Appendix A to the FEP is an Ecosystem Initiatives appendix that: 1) provides the Council with a process by which it may consider ecosystem-based management initiatives to address issues of interest to the Council that may cross authorities of two or more of its FMPs; 2) provides a fleshed-out example FEP Initiative 1 that the Council has decided to consider in 2013 and beyond, to protect unfished lower trophic level (forage) fish species within the U.S. West Coast Exclusive Economic Zone (EEZ); and 3) provides additional potential cross-FMP initiatives for review and consideration by the Council and the public.

Each year at the Council's March meeting, the Council and its advisory bodies will:

- review progress to date on any ecosystem initiatives the Council already has underway;
- review the list of potential ecosystem initiatives provided in Appendix A to the FEP and determine whether any of those initiatives merit Council attention in the coming year;
- if initiatives are chosen for Council efforts, request background materials from the appropriate entities;
- in March 2015 and in each subsequent odd-numbered year, assess whether there are new ecosystem initiative proposals that could be added to the appendix; and
- in March 2018, assess whether to initiate a review and update of the FEP.

Each initiative in Appendix A includes suggestions for background information needed to support consideration of the initiative and suggestions for the expertise needed on an ad hoc team to develop the initiative. If the Council determines that it wishes to address a new ecosystem initiative, it would begin by requesting relevant background information from the appropriate agencies and other entities, which would then be made available to the Council and its advisory bodies at a subsequent Council meeting, scheduled at the Council's discretion. Upon review of the background informational materials, the Council will decide whether to further pursue that initiative, and may then request nominations for appointments to an ad hoc team to be tasked with developing the initiative. Any materials developed through the ad hoc team process would, as usual with Council advisory body materials, be made available for review and comment by all of the Council's advisory bodies and the public during the Council's policy assessment and development process.

1.4 State-of-the-Ecosystem Reporting

In support of its ecosystem-based management processes, the Council has requested that NMFS, in coordination with other interested agencies, provide it with an annual state-of-the-ecosystem report at each of its March meetings, beginning in March 2014. The Council asked that the report:

- be bounded in terms of its size and page range to about 20 pages in length, and
- not wait for the "perfect" science to become available, should there be scientific information that does not come with definitive answers and numbers, but which may be useful for the Council to consider.

At its November 2012 meeting, the Council received a draft Annual State of the California Current Ecosystem Report. That report briefly synthesized those results of the California Current IEA that might be most useful to the Council's major decisions on potential harvest levels for its managed species groups. The Council and its advisory bodies reviewed the draft report, provided suggestions for future reports by commenting on the information in the report that appeared to be most useful to the Council process, and asked if National Oceanic and Atmospheric Administration (NOAA) Fisheries Northwest and Southwest Fisheries Science Centers might collaborate on developing the report annually into the future. The Council re-iterated its guidance that the report not exceed 20 pages in length, and be tailored to providing information on indicators directly relevant to Council decision-making. Information in the report is intended to improve the Council and public's general understanding of the status and functions of the CCE and is not tied to any specific management measures or targets for Council-managed species. When the Council receives future annual ecosystem reports, it anticipates continuing to review the reports' contents so that they may be tailored to best meet management needs.

Oregon coast. Photo credit: NOAA

2 Objectives

The FEP objectives, listed below, are intended to address the purpose and need statement in Section 1.1. This FEP and related activities are together expected to further integrate management across all Council FMPs, while recognizing that the Council's authority is generally limited to managing fisheries and the effects of fisheries on the marine ecosystem, protected species, and to consultations on the effects of non-fishing activities on essential fish habitat (EFH). The Council's work often requires Council members to think about their larger goals for the CCE, including and beyond goals they may have for managing fisheries. Chapter 5 of this FEP, *PFMC Policy Priorities for Ocean Resource Management*, discusses the Council's CCE policy priorities as they apply to ocean resource management and policy processes external to the Council. Thus, Chapter 2 provides Council objectives for Council work, while Chapter 5 provides the Council's aspirations for the work of others within the CCE, given Council priorities for the fish stocks and fisheries it manages.

The Council's four existing FMPs each have suites of goals and objectives that differ in their precise language, but have five common themes consistent with an ecosystem approach to fishery management: avoid overfishing, minimize bycatch, maintain stability in landings, minimize impacts to habitat, and accommodate existing fisheries sectors. The Coastal Pelagic Species (CPS) FMP has an additional goal of providing adequate forage for dependent species. The following FEP objectives are intended to build upon the Council's four FMPs by recognizing that, through the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the United States (U.S.) supports the ongoing participation of its citizens in commercial and recreational fisheries off its coasts, while also requiring that fish stocks be conserved and managed for optimum yield.

1. Improve and integrate information used in Council decision-making across the existing FMPs by:

    a. Describing the key oceanographic, physical, biological, and socioeconomic features of the CCE and dependent fishing communities;
    b. Identifying measures and indicators, and informing reference points to monitor and understand trends and drivers in key ecosystem features;
    c. Identifying and addressing gaps in ecosystem knowledge, particularly with respect to the cumulative and longer-term effects of fishing on marine ecosystems;
    d. Examining the potential for a science and management framework that allows for managing fish stocks at spatial scales relevant to the structure of those stocks.

2. Build toward fuller assessment of the greatest long-term benefits from the conservation and management of marine fisheries, of optimum yield, and of the tradeoffs needed to achieve those benefits while maintaining the integrity of the CCE through:

    a. Assessing trophic energy flows and other ecological interactions within the CCE;
    b. Assessing the full range of cultural, social, and economic benefits that fish and other living marine organisms generate through their interactions in the ecosystem;
    c. Improving assessment of how fisheries affect and are affected by the present and potential future states of the marine ecosystem.

3. Provide administrative structure and procedures for coordinating conservation and management measures for the living marine resources of the U.S. West Coast EEZ:

a. Guiding annual and regular reporting of status and trends to the Council;
b. Providing a nexus to regional, national, and international ecosystem-based management endeavors, particularly to address the consequences of non-fishing activities on fisheries and fish habitat;
c. Identifying ecological relationships within the CCE to provide support for cross-FMP work to conserve non-target species essential to the flow of trophic energy within the CCE.

Kelp and sardines. Photo credit: CDFW

3 California Current Ecosystem Overview

3.1 Geography of the Ecosystem

The geographic range for this FEP is the entire U.S. West Coast EEZ, shown in Figure 3.1.1. The Council recognizes that the EEZ does not encompass all of the CCE, nor does it include all of the waters and habitat used by many of the Council's more far-ranging species. The Council also recognizes the importance of freshwater and estuarine ecosystems to the CCE and may expand this intitial effort to include these ecoregions in the future. The Council also does not believe that designating the EEZ as the FEP's geographic range in any way prevents it from receiving or considering information on areas of the CCE or other ecosystems beyond the EEZ.

3.1.1 General Description and Oceanographic Features of the CCE

The CCE is comprised of a major eastern boundary current, the California Current, which is dominated by strong coastal upwelling, and is 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 CPS that exhibit boom-bust cycles over decadal time scales (Bakun 1996, Checkley and Barth 2009, Fréon et al. 2009). By contrast, the top trophic levels of such ecosystems are often dominated by HMS 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. Ecosystems analogous to the CCE include other shelf and coastal systems, such as the currents off the western coasts of South America and Spain.

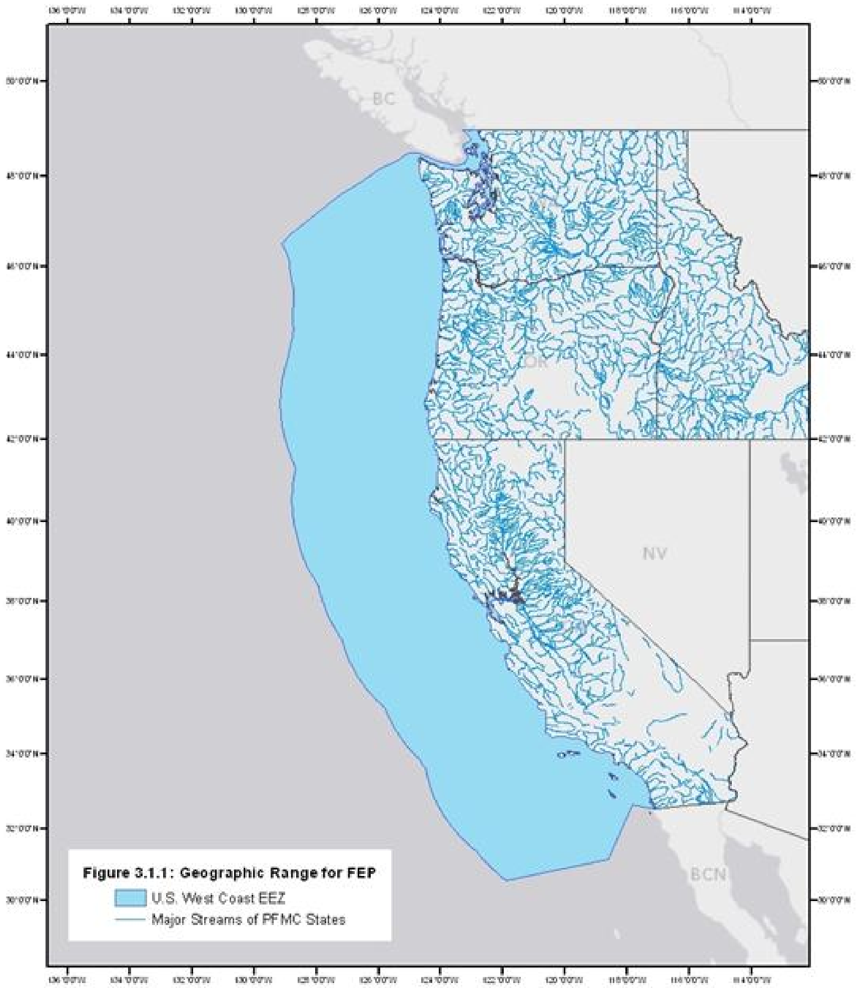


Figure 3.1.1: Geographic Range for FEP

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 (shown in Figure 3.1.2) and the northward-flowing Alaska Current. The "current" in 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, flows what is known as the California Undercurrent in the summer, which then 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 and offshore of the continental shelf break (Hickey 1998, Checkley and Barth 2009). The southward-flowing California Current is typically considered distinct from the wind-driven coastal upwelling jets that develop over the continental shelf during the spring and summer, which tend to be driven by localized forcing and to vary on smaller spatial and temporal scales more 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).

Superimposed on the effects of these shifting water masses that drive much of the interannual variability of the CCE, 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 and Peterson 1989). Concurrently in the coastal ocean, the effects of these events include reduced upwelling winds,

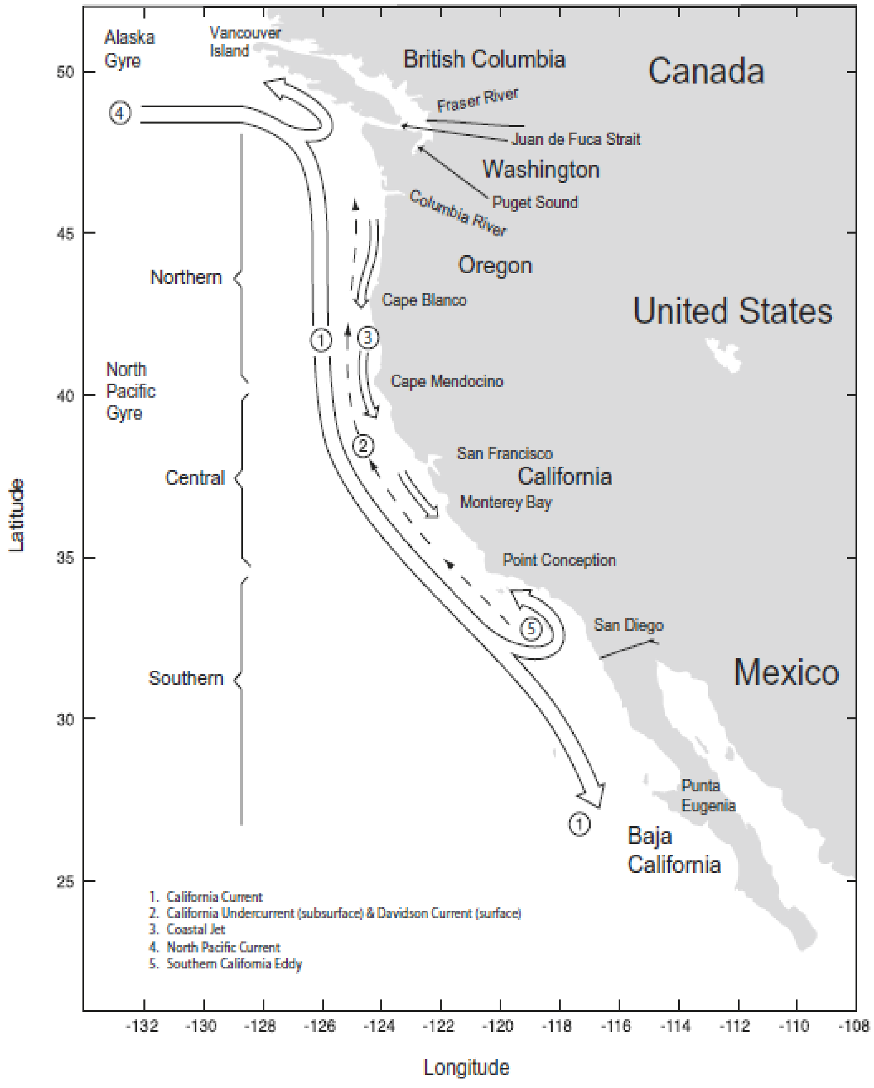


Figure 3.1.2: Dominant current systems off the U.S. West Coast

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.

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).

3.1.2 Major Bio-Geographic Sub-Regions of the CCE

Although there are many ways of thinking about dividing the CCE into sub-regions, Francis et al. (2009) have suggested three large-scale CCE sub-regions:

- Northern sub-region extending from the northern extent of the CCE off Vancouver Island to a southern border occurring in the transition zone between Cape Blanco, OR and Cape Mendocino, CA;
- Central sub-region extending southward from that transition zone to Point Conception, CA; and
- Southern sub-region from Point Conception to Punta Baja, on the central Baja Peninsula.

Francis and co-authors suggested these three sub-regions based on various oceanographic and ecological characteristics with a focus on the Council's Groundfish FMP. A different set of sub-regions may be more appropriate in the context of other issues and analyses, such as sub-regions tailored to reflect the population structures of various fish species and stocks.

Each of these three major CCE sub-regions experiences differences in physical and oceanographic features such as wind stress and freshwater input, the intensity of coastal upwelling and primary productivity, and in the width and depth of the continental shelf. Regional scale features like submarine ridges and canyons add to the distinct character of each sub-region. These physical and oceanographic differences then

Tazzi Sablan (Quileute Tribe) hauling coho near mouth of Quillayute River, WA. Photo credit: Debbie Ross-Preston, NWIFC

translate into differences in the ecosystem structure of each sub-region. The portions of the three CCE sub-regions lying within the U.S. EEZ are discussed in more detail, below.

3.1.2.1 Northern sub-region: Strait of Juan de Fuca, WA to Cape Blanco, OR

This sub-region is approximately 375 miles long, extending from its northernmost point at Cape Flattery, WA to Cape Blanco, OR. The upwelling winds for which the CCE is known are relatively weak in this sub-region, yet at the same time, some of the CCE's most productive areas are found within this region (Hickey and Banas 2008). The southward-flowing California Current is also relatively weak in this sub-region and the flow can even shift poleward off the Washington coast when the bifurcation of the North Pacific current shifts southward.

A key feature of this sub-region is the abundant freshwater input from the Straits of Juan de Fuca and the Columbia River, which provide a steady supply of terrestrial nutrients to the euphotic zone. In the absence of all other forces, a large freshwater discharge like that observed at the Columbia River mouth behaves as a "buoyancy flow," where a buoyant freshwater jet rides over the dense saline oceanic water and moves poleward (Wiseman and Garvine 1995). Two generalized flow regimes have been observed with the Columbia River freshwater plume: (1) southward upwelling-favorable wind stress causes the Columbia River plume to meander southward and offshore and (2) northward downwelling-favorable wind stress causes the plume to meander poleward and along the coastline.

The Columbia River Estuary and its seaward-extending plume is a zone of highly mixed river and ocean water and high primary productivity. Although most of the plume nitrate originates from coastally upwelled water, river-supplied nitrate can help maintain ecosystems during delayed upwelling (Hickey et al. 2010). Phytoplankton biomass concentrations are generally higher off the Washington coast than off the Oregon coast despite mean upwelling-favorable wind stress averaging three times stronger off the Oregon coast (Banas et al. 2008). Since phytoplankton flourish in the nutrient-rich environment of upwelled water, it would be expected that Oregon would have higher biomass concentrations. Banas et al. (2008) provides evidence that the high concentrations of biomass off Washington are due to the Columbia River plume.


Island within Olympic Coast NMS. Photo credit: NOAA

The U.S./Canada border divides this sub-region artificially. Based on biological and oceanographic features, the Northern sub-region extends northward to Brooks Peninsula on Vancouver Island. Brooks Peninsula is generally considered to mark the rough border between the CCE and the Gulf of Alaska marine ecosystems (Lucas et al. 2007). The continental shelf is relatively wide in this sub-region and broken up by numerous submarine canyons and oceanic banks. Hickey (1998) describes two major canyons, Astoria and Juan de Fuca, and one major bank, Heceta Bank, all of which are important both oceanographically and for fisheries productivity.

Features like the Juan de Fuca eddy and Heceta Bank also help retain nutrients and plankton in coastal areas. The many submarine canyons in this region can also intensify upwelling, adding to primary productivity. These and other factors combine to produce chlorophyll concentrations in this sub-region that can be five times higher than off Northern California, despite the weaker upwelling winds (Hickey and Banas 2008).

3.1.2.2 Central sub-region: Cape Blanco to Point Conception

In the region just north of Cape Blanco, the shelf begins to narrow, winds and upwelling intensify, and coastal waters move offshore. At or near Cape Blanco, what had been a simple, lazy southward current becomes a maze of swirling eddies and turbulent coastal flows that continue approximately 170 miles southward to Cape Mendocino (Botsford and Lawrence 2002). The area between Cape Blanco and Cape Mendocino experiences the strongest winds and upwelling in the CCE. This transition area also includes the southern boundary of oil-rich, subarctic zooplankton. This sub-region then continues southward for another approximately 465 miles to Point Conception.

The Mendocino Escarpment is another key geological feature of this region, the largest east-west submarine ridge within the U.S. West Coast EEZ, extending westward from Cape Mendocino to just beyond the 200 nautical mile (nm) EEZ boundary, as if pointing toward the Steel Vendor Seamount at 40°21.30’ N. lat., 129°27.00’ W. long. South of the Mendocino Escarpment, the continental shelf narrows, creating notably different habitat ranges for bottom-dwelling organisms (Williams and Ralston 2002). This area south of Cape Mendocino also features several submarine canyons (Vizcaino Canyon, Noyo Canyon, Bodega Canyon, Monterey Canyon, and Sur Canyon) that enhance the high relief shelf and slope structure and demersal fish habitats. Biogeographic barriers extend out to sea because of strong winds related to the high relief coastal mountains and the funneling of air at high speeds from the Klamath and Sacramento basins to the coast. There are several distinct upwelling zones in this sub-

**Juvenile rockfish (multiple spp.) over Cordell Bank.
Photo credit: Greg McFall, NOAA/CBNMS**

region near major points, such as Point Reyes, northern Monterey Bay, and Point Sur. Outflow from the Sacramento River system through the San Francisco Bay Delta region is a significant source for freshwater input into the CCE in this sub-region.

3.1.2.1 Southern sub-region: Point Conception to Mexico border

This approximately 236 mile long sub-region is substantially different from the north and central areas. The topography is complex, the shelf is typically more narrow and shallow than to the north, and the coastline suddenly changes from a north-south to an east-west orientation at Point Conception. This area of the coast is also sheltered from large-scale winds and is a transition point between large-scale wind-driven areas to the north and the milder conditions of the Southern California Bight. There is also a cyclonic gyre in the Bight area that mixes cooler CCE water with warmer waters from the southeast (Hickey and Banas 2008). To the east of a line running south of Point Conception, winds are weak, while further offshore, to the west, wind speeds are similar to those along the continental shelf of the central sub-region. The Santa Barbara Channel remains sheltered from strong winds throughout the year.

Santa Barbara Island. Photo credit: U.S. National Park Service

In contrast to the relatively contiguous continental shelf in the central sub-region, the offshore region from Port San Luis to the Mexican border encompasses some of the most diverse basin and ridge undersea topography along the U.S. West Coast. Islands top many marine ridges and some of the most southerly topographical irregularities are associated with the San Andreas Fault. This complex topography, in combination with the influence of sub-tropical waters from the south, results in a marine community very different from more northern sub-regions.

Like in the Northern sub-region, the international boundary divides what could be considered a common region. Based on ecology and oceanography, the Southern sub-region extends south to Punta Baja, Mexico (30° N. latitude). A fourth sub-region of the CCE exists in Mexican waters, reaching from Punta Baja to the tip of the Baja Peninsula at Cabo San Lucas (U.S. GLOBEC 1994).

3.1.3 Political Geographic and Large-Scale Human Demographic Features of the CCE

From north to south, the CCE includes waters offshore of Canada's province of British Columbia, the U.S. states of Washington, Oregon, and California and Mexico's states of Baja California and Baja California Sur. This FEP is a product of a U.S. fishery management process, which means that it focuses on the effects of U.S. citizens, government entities, businesses, and economies on the U.S. portion of the CCE.

The Council has 14 voting members and five non-voting members. The voting Council members include:

- The directors of state fish and wildlife departments from California, Oregon, Washington, and Idaho, or their designees.
- The Regional Director of the National Marine Fisheries Service (NMFS) or his or her designee.
- A representative of a federally-recognized West Coast Native American tribe.
- Eight private citizens who are familiar with the fishing industry, marine conservation, or both. These citizens are appointed by the Secretary of Commerce from lists submitted by the governors of the member states. These eight members include one obligatory member from each state and four at-large members who may come from any state.

There are also five non-voting members who assist Council decision-making. They represent: the Pacific States Marine Fisheries Commission (PSMFC), which coordinates data and research for the Pacific states; the United States Fish and Wildlife Service (USFWS), which serves in an advisory role; the State of Alaska, because both fish and the people who fish for them migrate to and from Alaskan waters; the U.S. Department of State, which is concerned with management decisions with international implications; and the U.S. Coast Guard, which is concerned with enforcement and safety issues.

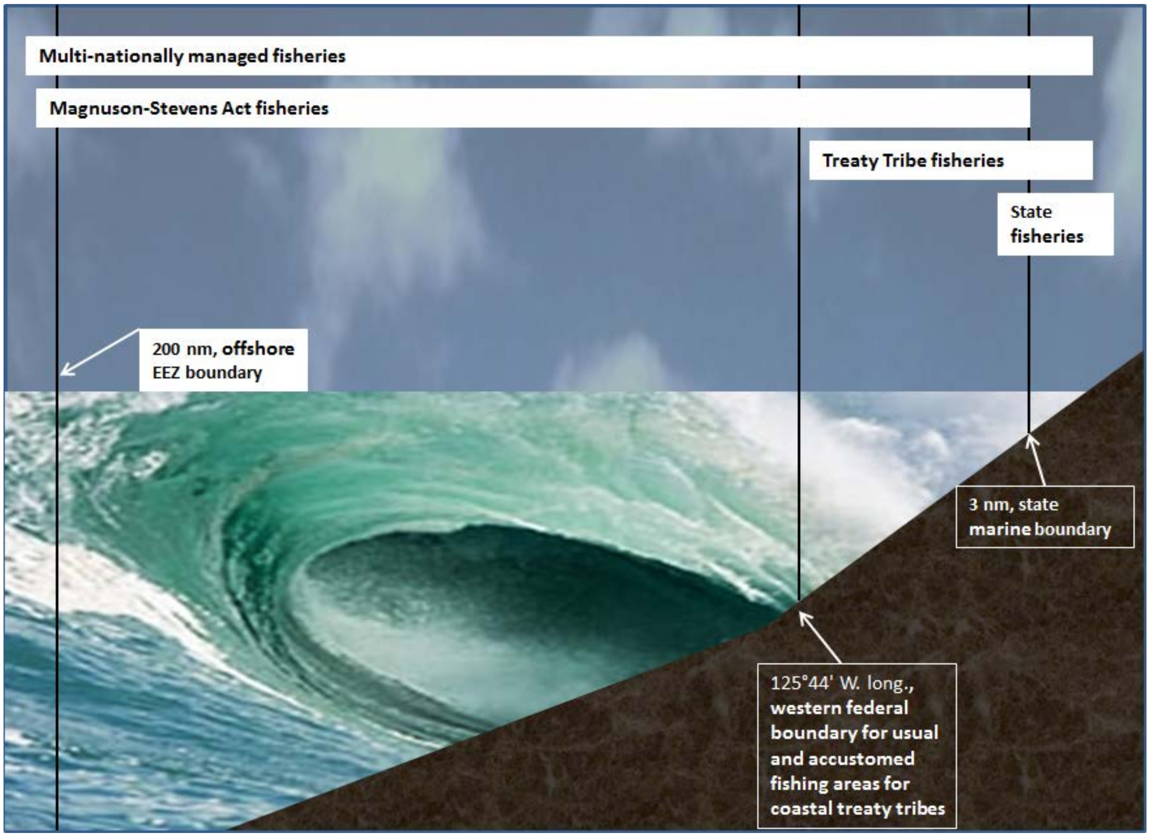


Figure 3.1.3: West Coast EEZ Fishery Management Authorities

Marine waters off the U.S. are divided into an array of jurisdictions (Figure 3.1.3) under a host of laws. West Coast states have management responsibility for those ocean fisheries targeting species that primarily occur inshore of the state marine boundary of 3 nm. Off the northern Washington coast, four treaty Indian tribes have Usual and Accustomed fishing areas that include marine waters out to 40 nm offshore. Domestically, inter-state coordination for state fisheries managed separately from the Council process is facilitated by PSMFC. The Federal government has explicitly extended non-tribal management authority over Dungeness crab (*Metacarcinus magister*) which occurs in both state and Federal waters, to the states of Washington, Oregon and California (16 U.S.C. §1856).

The Council is responsible for managing fisheries that primarily occur within Federal waters, 3-200 nm offshore, and separates management for those fisheries into four FMP: CPS, groundfish species, HMS, and salmon species. Tribes and states that participate in the Council process also participate in U.S.-Canada bi-national management processes for Pacific halibut (*Hippoglossus stenolepis*), Pacific whiting (*Merluccius productus*, also known as hake), Pacific salmon, and albacore (*Thunnus alalunga*). The Council shares management of HMS with the Western Pacific Fishery Management Council, and both councils and their member states and territories together participate in international management bodies for the central Pacific Ocean. More detailed information on Council, state, tribal, and international fisheries and management processes is available in Section 3.4.

Major West Coast commercial fishing ports over the 2000-2011 period, by volume, include: ports in the Southern California port area, mainly San Pedro, Terminal Island, Port Hueneme and Ventura; northern Oregon ports, mainly Newport and Astoria; and southern Washington ports of Chinook and Westport. Major West Coast recreational fishing areas over the 2004-2011 period include southern California, north-central California,

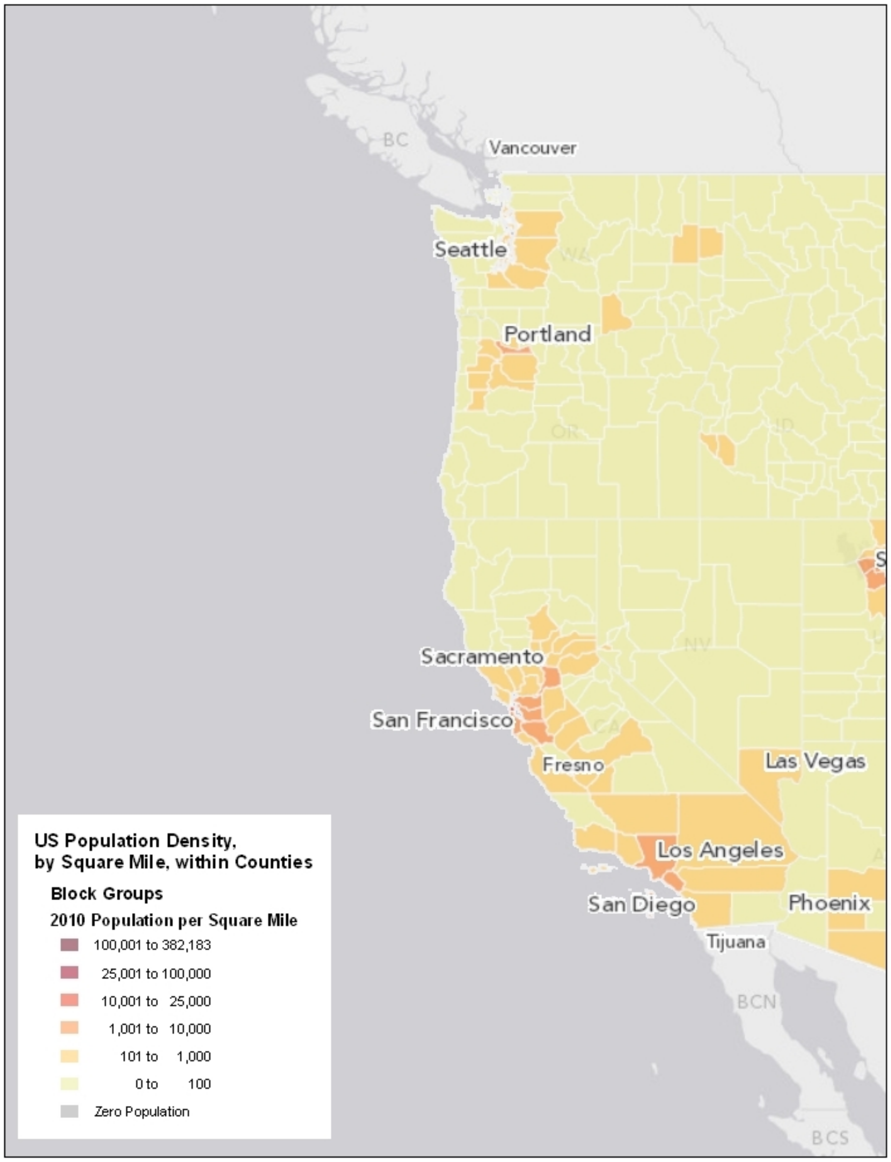


Figure 3.1.4: Human Population Density in the Western U.S.

central Oregon, and the Washington coast off Grays Harbor, although recreational fisheries are generally more active off California than off Washington or Oregon. For more detailed information, see Section 3.4.

West Coast urban areas, those with human populations greater than 1,000 people per square mile, include: the eastern and southern shore of Puget Sound, Washington; metropolitan areas of Oregon's Willamette Valley; California's capital in Sacramento, connecting into the counties surrounding San Francisco Bay; and the southern California metropolitan areas surrounding Los Angeles and San Diego. Figure 3.1.4 shows U.S. population density by square mile, from the 2010 U.S. census data.

Human activities that compete with fishing for ocean space include: non-consumptive recreation, dredging and dredge spoil disposal, military exercises, shipping, offshore energy installations, submarine telecommunications cables, mining for minerals, sand and gravel, and ocean dumping and pollution absorption. See Section 3.3.4 for additional discussion. In addition to human activities within the ocean, human institutions have created a host of different types of marine protected areas (MPAs) off the West Coast, many of which are closed to some or all fishing activities. The largest West Coast EEZ MPAs with fisheries restrictions or prohibitions are the Council's group of EFH Conservation Areas – also see Section 3.3.4. Also significant in size, and with varying types of protections, are the five West Coast National Marine Sanctuaries (NMS): Channel Islands NMS, Cordell Bank NMS, Gulf of the Farallones NMS, Monterey Bay NMS, and Olympic Coast NMS. The Council works with the West Coast NMSs to develop EFH conservation areas within sanctuary boundaries (Figure 3.1.5). There are numerous additional state MPAs, which are discussed in more detail in Section 3.3.4.

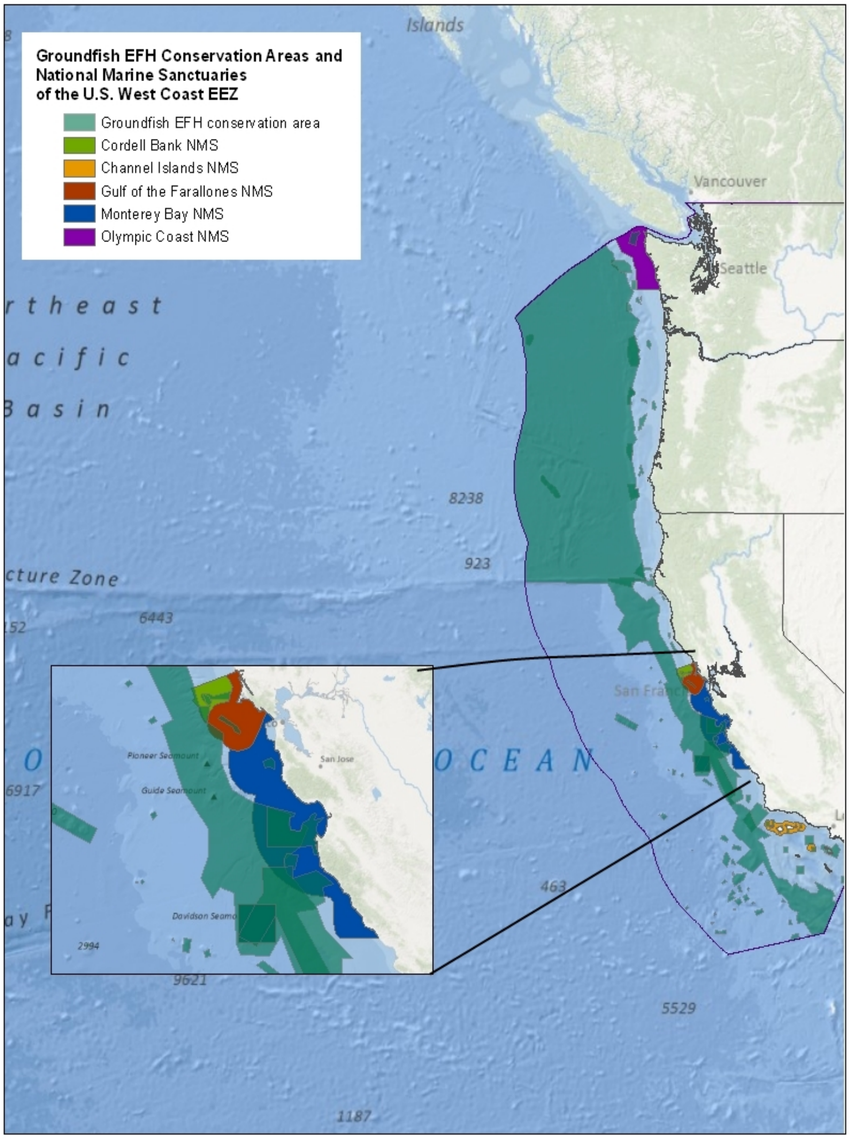


Figure 3.1.5: West Coast EFH Conservation Areas and National Marine Sanctuaries

3.2 Biological Components and Relationships of the CCE

3.2.1 Biological Components

This section defines the major biological components of the CCE in terms of trophic levels – a biological component's position within the larger food web. A biological component's trophic level is roughly defined by its position in the food chain. Lower trophic level species consist of, or feed predominantly on, primary producers (phytoplankton, etc). Higher trophic level species are largely top predators such as marine mammals, birds, sharks, and tunas.

As shown in Figure 3.2.1 from Field et al. (2006), the CCE contains a diverse array of species, most of which make a relatively modest contribution to the energy flow within the ecosystem. Because the flow of energy is more of a "food web" than a "food chain," the species of the CCE do not neatly divide into clearly delineated trophic levels (for example, an organism may eat a prey item and also eat items that its prey eats), except at the highest and lowest levels. This FEP, below, discusses CCE species within broad trophic level categories, while recognizing that most CCE species do not occupy a single trophic level and may occupy multiple trophic levels, particularly when considering changes that occur over the course of their life as they change both their size and feeding preferences.

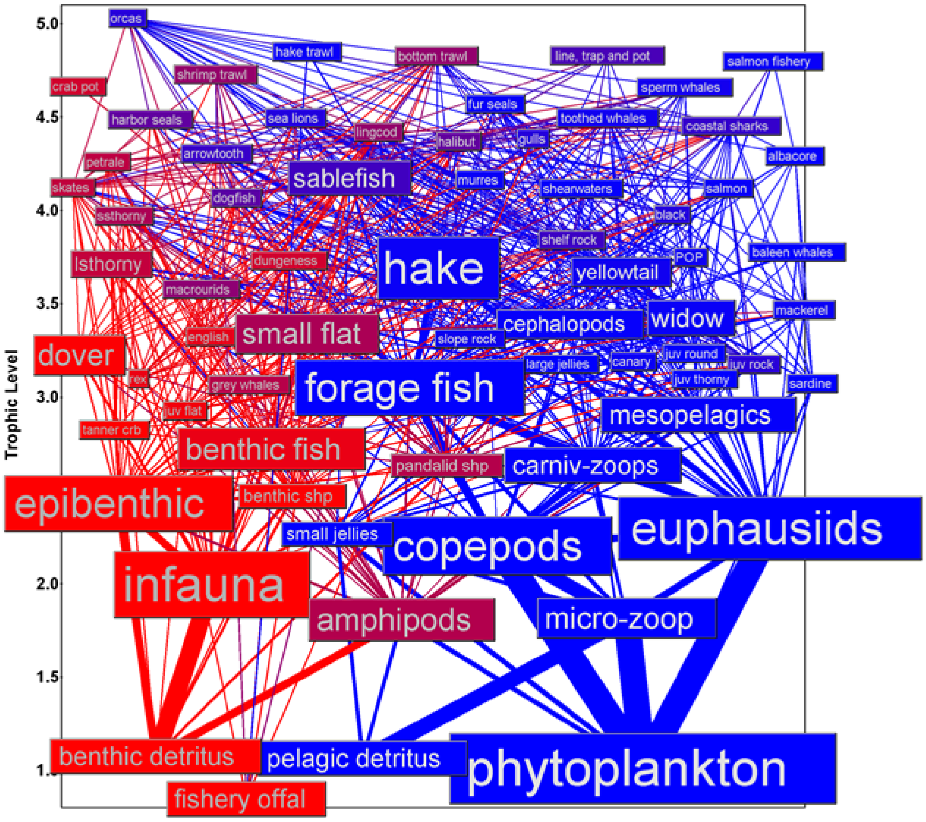


Figure 3.2.1: The significant food web of the Northern CCE. Height of boxes is scaled to standing biomass of species or groups names, width of lines between groups represents biomass flux of prey to predators. Benthic energy pathways are shown in red, while pelagic energy pathways are shown in blue. This "snapshot" represents the model values for the 1960 time period, as reported in Field et al. (2006).

3.2.1.1 High trophic non-fish species: mammals, birds, and reptiles of the CCE

Marine mammals, seabirds, and marine reptiles of the CCE tend to occupy the system's mid- to higher trophic levels, and are generally protected species, although many were also historically targeted for harvest. Many of the largest populations forage in the CCE seasonally, and breed elsewhere, such as fur seals (*Callorhinus ursinus*, breed in the Bering Sea), Humpback whales (*Megaptera novaeangliae*, breed off Mexico or central America) sooty shearwaters (*Puffinus griseus*, breed in New Zealand), and leatherback turtles (*Dermochelys coriacea*, breed in the western tropical Pacific). Similarly, top predators that do breed in the CCE, such as sea lions (*Otariinae* spp.) and elephant seals (*Mirounga angustirostris*), often migrate or forage elsewhere seasonally, although most of the larger seabird populations that breed within the CCE (such as common murres (*Uria aalge),* auklets (family *Alcidae),* and gulls (*Laridae* spp.) typically do not have extensive foraging ranges. The literature on movements and migrations for any given population is substantial, but Block et al. (2011) provide an excellent synthesis of the range of movements for many of these (and highly migratory fish) populations based on a concerted effort to tag top ocean predators over the past decade as part of the Tagging of Pacific Predators program. Additionally, Block et al. (2011) describe the seasonal patterns of productivity, thermal variability, and other ocean processes that drive many of these movements. Seasonal patterns appear to be the greatest drivers of migrations and variable distributions, although inter-annual and longer-term climate variability also shapes the distribution and abundance of many of these higher trophic level species. The response of populations that breed in the CCE to such variability is often difficult to determine, although high California sea lion (*Zalophus californianus*) pup mortalities have clearly been associated with El Niño events.


Sooty shearwater. Photo credit: NOAA

Both migrant (such as sooty shearwater and black-footed albatross, *Phoebastria nigripes*) and resident seabirds (such as common murres and rhinoceros auklets, *Cerorhinca monocerata*) have been described as having either warm or cool water affinities, and vary their distribution, abundance, productivity, and even diet accordingly (Sydeman et al. 2001; Sydeman et al. 2009). One of the most abundant migratory seabirds in the CCE, sooty shearwaters, declined by as much as 90 percent immediately following the 1977 regime shift (Veit et al. 1996), although numbers have been variable since that time and it remains unclear whether there was an actual decline in population or a shift in distribution (Bjorksted et al. 2010). Understanding such changes in the population dynamics of seabirds is increasingly essential for effective fisheries management, providing the means to minimize interactions between fisheries and threatened or endangered species (Crowder and Norse 2008, Howell et al. 2008). Large-scale seasonal area closures to West Coast large mesh drift gill-net fishery of the HMS FMP is an example of a measure implemented to minimize interactions with leatherback sea turtles that forage intensively on jellyfish (*Scyphozoa* spp.), particularly in Central California, from late spring through the fall (Benson et al. 2011). Since sea turtles (*Cheloniodea* spp.) likely represent one of the most vulnerable taxa in the CCE, and much of this vulnerability lies beyond the control of the Council and other U.S. management entities, Dutton


CDFW samplers Megan DuVernay and Chris Read measuring fin-clipped Chinook salmon at Eureka Marina, with brown pelican on-looker. Photo credit: Edgar Roberts, CDFW

and Squires (2011) assert that there is little potential for reversing long-term sea turtle population declines without a multinational, holistic strategy directed to that purpose. Within the U.S. portion of the CCE, turtle conservation efforts prioritize minimizing turtle-fisheries interactions.


California sea lion at Bonneville fish ladder. Photo credit: NOAA

Although the historical removals described earlier collectively kept most pinniped and whale populations at low to moderate levels until the middle to late 20th century, most populations have increased, many dramatically, over the last several decades. Humpback whales in the CCE are now thought to number over 2000, blue whales (*Balaenoptera musculus*) nearly 2500, elephant seals approximately 124,000, California sea lions on the order of 270,000, and short-beaked common dolphins (*Delphinus delphis*) over 400,000 animals (Carretta et al. 2012). Appreciation for the cumulative historical impacts of whaling and sealing, and the potential cascading impacts to marine ecosystems, has grown as many marine mammal populations have recovered (NRC 1996, Estes et al. 2006). Currently, many mammal populations appear to be approaching some level of carrying capacity, and there is no substantive evidence for indirect competition with fisheries for prey resources. Increasing mammal populations have direct impacts on many salmonid populations and have indirect impacts when combined with human alterations to habitat, such as dams, that serve to aggregate salmonids where they are easy prey for some marine mammals. Although most mammal populations experience some incidental mortality as a consequence of fishing operations, mortality sources generally do not exceed estimates of potential biological removals. One of the goals of the Marine Mammal Protection Act (MMPA) is that the incidental mortality or serious injury of marine mammals in fisheries should be reduced to insignificant levels approaching zero. All FMPs are managed to be consistent with this goal. One fishery, the HMS drift gillnet fishery, has specific management measures to reduce marine mammal interactions in accordance with the MMPA. In recent years there has been concern regarding high mortality rates for some cetaceans, particularly blue and humpback whales, caused by large ship strikes within and outside of fisheries (Berman-Kowalewski et al. 2010).


Humpback whales in Olympic Coast NMS. Photo credit: NOAA

Higher trophic level mammals, birds, and reptiles represent important sources of predation mortality and energy flow in the CCE. Estimates of the role of cetaceans in the CCE suggest that they annually consume on the order of 1.8 to 2.8 million tons of prey (primarily krill, but also coastal pelagic fishes, squids, groundfish, and other prey; Carretta et al. 2008), and simple bioenergetic estimates suggest that pinnipeds may consume as much as an additional million tons (Hunt et al. 2000), mostly fish and squid. Comparable estimates for seabirds are limited; Roth et al. (2008) estimated total annual consumption by common murres (the most abundant resident species in the CCE) at approximately 225,000 tons; however, Hunt et al. (2000) estimated summer consumption by all seabirds throughout the CCE at considerably lower levels. There have been few efforts to explicitly model interactions between fisheries and marine mammal population dynamics (although, see Yodzis et al. 2001 and Bundy et al. 2009). However, there is a rich body of literature linking seabird productivity to prey availability that helped guide the development of harvest control rules (HCRs) for some of the earliest CPS fisheries (e.g., Barlow et al. 2008).

Much of the literature is synthesized in a recent manuscript that indicates a commonality in the non-linear response of seabirds to empirical changes in prey abundance, in which seabird productivity declines gradually at low to moderate levels of reduced prey availability, but declines steeply when prey abundance is below approximately one-third of the maximum prey biomass observed in long-term studies (Cury et al. 2011). The Cury et al. (2011) results could be used to guide appropriate management limits or thresholds when managing high biomass forage species that seabirds depend upon. However, the question of what constitutes a baseline level was not explicitly addressed, and is a key factor for consideration in the management of stocks that undergo substantial low frequency variability such as CPS. Smith et al. (2011) evaluated a similar question, using ecosystem models and altering harvest rates (rather than using empirical data and evaluating functional relationships). Substantial impacts on food webs and higher trophic level predators were found when fishing at maximum sustainable yield (MSY) levels, but impacts on marine ecosystem indicators were relatively modest given reduced exploitation rates (despite catches remaining at close to 80 percent of the maximum achievable levels). Although additional empirical analyses and modeling efforts will improve our understanding of trade-offs between high trophic level predator population dynamics and fisheries, it is clear that such trade-offs exist, can be estimated for a multi-species system, and can be considered in the context of strategic decision making – as opposed to in tactical decision-making, such as setting harvest quotas, for which such models are generally considered inappropriate.

3.2.1.2 Mid to High Trophic Level Fishes and Invertebrates

High trophic level fishes typically represent highly valued fisheries targets, rather than protected resources subject to take restrictions. A generalized breakdown would suggest three major communities of mid to high trophic level fish assemblages; HMS, groundfish, and anadromous fishes (principally salmonids, but including sturgeon and other species as well). A large number of invertebrate species might be included at mid- to high trophic levels, however, in considering invertebrates it is important to recognize that in many complex or biologically diverse communities (such as intertidal, kelp forest ecosystems, planktonic communities), small and generally overlooked species often represent high trophic levels and key roles that are well beyond the scope of this evaluation (such as various species of predatory copepods or jellyfish in pelagic ecosystems, or the predatory sun star, *Pycnopodia* spp., in


Pacific shortfin mako shark. Photo credit: NOAA

intertidal ecosystems). Other mid- to high- trophic level invertebrates are more conspicuous elements of the ecosystem, such as predatory squids and various larger crab species (including Dungeness). The competitive and predatory impacts of nonindigenous crab species on juvenile Dungeness crab survival may negatively impact recruitment into the fishery (McDonald et al. 2001). Changes in physical forcing in the CCE have driven the recent poleward expansion of jumbo squid (*Dosidicus gigas*) into the CCE increasing the potential for high levels of squid predation for several fish species, many that are commercially important, and potentially resulting in changes across trophic levels (Field et al. 2007). Seasonal patterns appear to be the greatest drivers of migrations and variable distributions for most mid- to higher trophic level species, both pelagic and benthic, although interannual and longer-term climate variability also shapes the distribution and abundance of many of the pelagic species in particular. For example, warm years (and regimes) have long been known to bring desirable gamefish such as tunas and billfish farther north and inshore (MacCall 1996, Pearcy 2002).

HMS include swordfish (*Xiphias gladius*), albacore and other tunas, several species of sharks (thresher (*Alopias* spp.), mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), soupfin (*Galeorhinus galeus*) and salmon (*Lamna ditropis*) key among them; although great white (*Carcharodon carcharias*), basking (*Cetorhinus maximus*) and sleeper (*Squaliformes* spp.) sharks are also of high ecological and conservation concern) and a variety of (generally southern) large coastal piscivores such as black seabass (*Centropristis striata*), white seabass (*Atractoscion nobilis*), and yellowtail (*Seriola lalandi*) are all key targets for both commercial and recreational fisheries with long histories of exploitation. The Council's HMS FMP is unique in that the relative impact and role of fishing activities under the jurisdiction of the Council for most HMS are generally modest, since many HMS species spend limited time subject to fisheries within the EEZ. Exceptions where West Coast vessels harvest an appreciable fraction of North Pacific catches include north Pacific albacore, swordfish, common thresher sharks, and blue sharks. The principle challenges associated with HMS resources (and the HMS FMP) are collaborating between the broad assemblage of nations and regulatory entities that are involved in HMS exploitation and management (see Section 3.5.4.3).

Although generalized to the entire North Pacific, Sibert et al. (2006) summarizes the variability and differences in tuna population trajectories, with western Pacific yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) declining steadily to near target levels, skipjack (*Katsuwonus pelamis*) and blue shark populations increasing, and albacore fluctuating in both directions. Importantly, Sibert et al. noted that increases in the biomass of some species are consistent with predictions by simple ecosystem models (e.g., Kitchell 1999, Cox 2002) as a result of declines in predation mortality that is consistent with a recent comparison of empirical data from fisheries statistics in the Central North Pacific region (Polovina et al. 2009). Specifically, with increasing fishing pressure, catch rates (and presumably biomass) of top predators such as billfish, sharks, and large tunas (bigeye and yellowfin) declined, while the catch rates of mid-trophic level

Albacore tuna. Photo credit: NOAA

species such as mahi mahi (*Coryphaena hippurus*), pomfret (*Brama japonica*) and escolar (*Lepidocybium flavobrunneum*) increased. Polovina et al. (2009) suggested that the cumulative effect of fishing on high trophic levels and consistent response by mid trophic level predators indicates that the longline fishery may function as a keystone species in this system. The CCE portion of these stocks may have similar dynamics to those in the Eastern Tropical Pacific for some stocks, and those of the Central Northern Pacific for others. However, in the foreseeable future the key ecosystem issues associated with HMS population dynamics are primarily associated with high and low frequency changes in the availability of target stocks in response to changes in climate conditions, as manifested by seasonal changes in water masses, changes in temperature fronts or other boundary conditions, and changes in prey abundance. Management of the directed fishery also requires minimizing the bycatch of high profile species, such as sea turtles, seabirds, and marine mammals. A greater appreciation of the relationships among climate variables, gear selectivities, and the spatial distributions of both target and bycatch species will continue to improve management of HMS resources, and will be key to both “single species” and ecosystem-based management approaches.

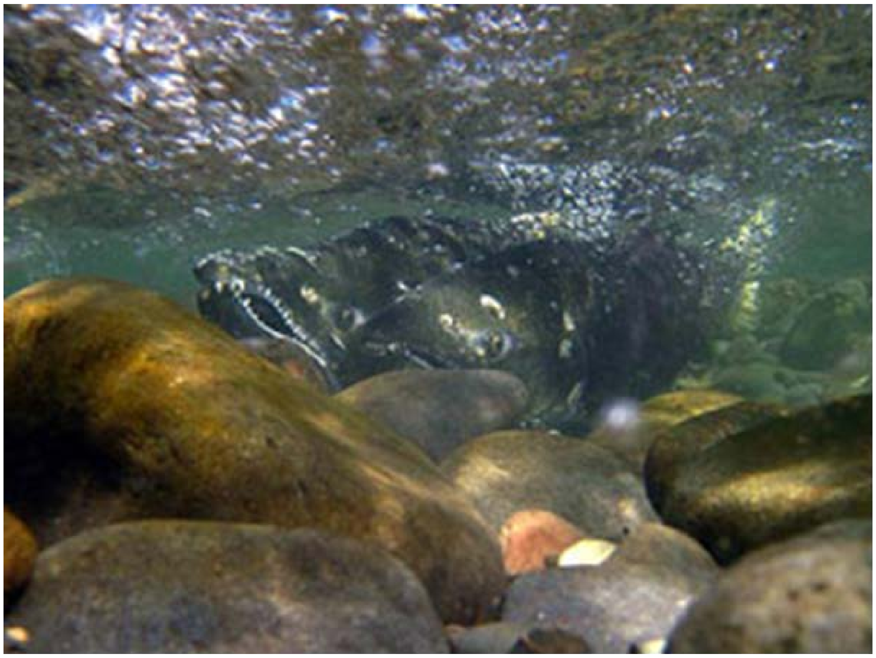
Groundfish and salmon occupy a range of trophic niches and habitats, but most species are considered to be at either middle or higher trophic levels. Large groundfish, such as cowcod (*Sebastes levis*), bocaccio (*S. paucispinis*), yelloweye (*S. ruberrimus*) and shortraker (*S. borealis*), as well as Pacific halibut, California halibut (*Paralichthys californicus*), arrowtooth flounder (*Atheresthes stomias*), Petrale sole (*Eopsetta jordani*), sablefish (*Anoplopoma fimbria*), lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), shortspine thornyheads (*Sebastolobus alascanus*), several of the skates (*Rajidae* spp.), and a handful of other species are almost exclusively piscivorous, and feed largely on juvenile and adult stages of other groundfish, as well as forage fishes, mesopelagic fishes, and squid. A broader range of species, including most rockfish, are ominovorous mid-trophic level predators that may be piscivorous at times but also feed on krill, gelatinous zooplankton, benthic invertebrates and other prey. Pacific hake, the most abundant groundfish in the CCE, shows strong ontogeny in food habits, since younger, smaller hake feed primarily on euphausiids and shrimps, switching to an increasing proportion of herring (*Clupea pallasii pallasii*), anchovies (*Engraulis mordax*), and other fishes (as well as other hake) as they reach 45-55 cm length, and are almost exclusively piscivorous by 70-80 cm.

Cowcod. Photo credit: NOAA

Higher trophic level predators have a potential to play a structuring role in the ecosystem, particularly over smaller spatial scales (e.g., individual reefs or habitat areas). Despite the rarity of piscivorous rockfish relative to more abundant omnivorous or planktivorous rockfish, visual surveys have shown that the piscivorous species can be relatively abundant in many isolated and presumably lightly-fished rocky reef habitats (Jagielo, et al. 2003; Yoklavich, et al. 2002; Yoklavich, et al. 2000). In rocky reefs, concentrations of smaller, fast-growing rockfish are considerably lower, while reefs thought to have undergone heavier fishing pressure tend to have greater numbers of smaller, fast-growing, and early-maturing species. Similar large-scale community changes are described by Levin et al. (2006), who found broad-scale changes in

CCE groundfish assemblages sampled by the triennial bottom trawl surveys on the continental shelf between 1977 and 2001. Levin et al. (2006) found declining rockfish catches, from over 60 percent of the catch in 1977 to less than 17 percent of the catch in 2001, with greater declines of larger species, while flatfish catches increased by a similar magnitude. The potential for intra-guild competition or top-down forcing, in both small-scale rocky reef systems and throughout the larger ecosystem, is also supported by theoretical considerations and simulation models. For example, Baskett et al. (2006) developed a community interactions model that incorporated life history characteristics of pygmy (*S. wilsoni*) and yelloweye rockfish to consider community dynamics within a marine reserve. Without interspecific interactions, the model predicted that larger piscivores would recover, given minimal levels of dispersal and reserve size. However, when community interactions were taken into account, initial conditions like the starting abundance of the piscivores and the size of the reserve became more important with respect to the ultimate stable state, such that under some circumstances (low piscivore biomass, or high planktivore biomass) recovery could be unlikely. Such results are consistent with similar simulations of the potential consequences of community interactions in marine systems (MacCall 2002, Walters and Kitchell 2001), and speak to the importance of considering such interactions in the design, implementation, and monitoring of recovery efforts for rebuilding species.

Anadromous species such as salmonids and sturgeon (*Acipenser* spp.), spend their early life stages in freshwater rivers and streams, then out-migrate to the ocean, where they mature before returning to their natal streams to spawn. Large variation in the abundance and life history characteristics of many anadromous fish populations have been attributed to climatic conditions (e.g. PDO or ENSO; Mantua et al. 1997, Finney et al. 2000, Peterson and Schwing 2003, Wells et al. 2006), although this relationship is not always strong for all salmonids populations (Botsford and Lawrence 2002). The fresh and saltwater ecosystems off central California are generally the southernmost marine habitat occupied by Chinook and coho salmon (*O. tshawytscha* and *O. kisutch*). Climate fluctuations may exacerbate stressors on low abundance stocks, or on stocks with reduced life-history or habitat diversity (Lindley et al. 2009, Carlson and Satterthwaite 2011). Salmonids prey upon an array of lower trophic level species including juvenile and adult stages of numerous fishes, squid, euphausiids, and various other invertebrates; in general, salmon tend to forage on larger prey items as they reach larger sizes (Daly et al. 2009).



Chinook salmon. Photo credit: NOAA

The effects of climate variability on the feeding ecology and trophic dynamics of adult Pacific salmon have shown that salmon are extremely adaptable to changes that occur in the ocean environment and their forage base (Kaeriyama et al. 2004). However, Pacific salmon populations can experience persistent changes in productivity, possibly due to climatic shifts, necessitating rapid and reliable detection of such changes by management agencies to avoid costly suboptimal harvests or depletion of stocks (Peterman et al. 2000, Dorner et al. 2008, Lindley et al. 2009). Changes in salmon productivity have been hypothesized to be a function of early natural mortality that is mostly related to predation, followed by a physiologically-based mortality when juvenile salmon fail to reach a critical size by the end of their first marine summer and do not survive the following winter (Beamish and Mahnken 2001). This growth-related mortality provides a link between total mortality and climate that could be operating via the availability of nutrients regulating the food supply and, hence, competition for food (i.e. bottom–up regulation) (Beamish and Mahnken 2001). Strong evidence of positive spatial covariation among salmon stocks within Washington, British Columbia, and Alaska and between certain adjacent regions, with no evidence of covariation between stocks of distant regions, suggests that environmental processes that affect temporal variation in survival rates operate at regional spatial scales (Pyper et al. 2001).

Some subpopulations of green sturgeon (*Acipenser medirostris*) are listed as threatened (71 FR 17757, April 7, 2006) under the Endangered Species Act (ESA). This determination was based on the reduction of potential spawning habitat, severe threats to the spawning population, the inability to alleviate these threats with the conservation measures in place, and the decrease in observed numbers of juvenile green sturgeon collected in the past two decades compared to those collected historically (NMFS 2005). Other subpopulations are listed as NMFS Species of Concern, since insufficient information is available to indicate a need to list the species under the ESA. Little is known about green sturgeon life history, particularly at sea. Adult green sturgeon inhabit estuaries during the summer (ODFW 2005), feeding upon amphipods (*Amphipoda* spp.), isopods (*Isopoda* spp.), shrimps (*Pandalus* spp.), clams (*Bivalvia* spp.), crabs (*Brachyura* spp.), and annelid worms (*Annelid* spp.) (Ganssle 1966, Radtke 1966). Temperature has been shown to affect both green sturgeon embryos (Van Eenennaam et al. 2005), as well as juvenile sturgeon (Allen et al. 2006) suggesting a possible sensitivity to climate change. Bycatch of green sturgeon in the California halibut fishery is of management concern.

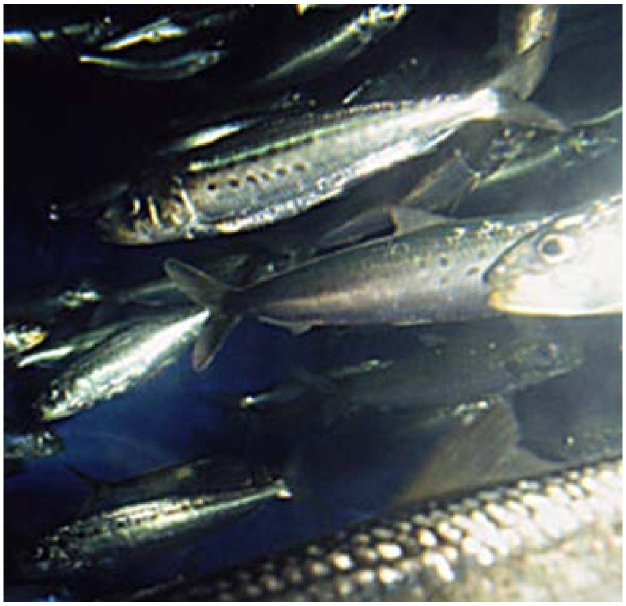
Oregon anglers and sturgeon. Photo credit: NOAA Historic Fisheries Collection

3.2.1.3 Low Trophic Level

Low trophic level species (secondary producers) are defined as species that feed either primarily or partially on the lowest trophic level, and includes the following groups ordered roughly from largest to smallest by individual body size:

- Small pelagic fish -- includes baitfish and other forage fish, such as sardine (*Sardinops sagax*), anchovy (*Engraulis mordax*), smelts (*Osmeridae* spp.), etc., which are relatively small as adults and feed on phytoplankton and/or zooplankton
- Ichthyoplankton – small larval stages of fish that feed on both phytoplankton and zooplankton, including the larvae of the small pelagics listed above, plus the larval stages of large pelagic fish and groundfish, such as Pacific whiting, jack mackerel (*Trachurus symmetricus*), and rockfish (*Sebastes* spp.)
- Euphausiids (*Euphausiacea* spp.) – krill, relatively large, often swarm- or school-forming crustacean zooplankton that feed on both phytoplankton and zooplankton
- Gelatinous zooplankton- soft-bodied zooplankton, such as jellyfish, pelagic gastropods (*Gastropod* spp., primarily pteropods), salps (*Salpidae* spp.), doliolids (*Doliolida* spp.), and apendicularians (*Appendicularia* spp.)
- Other crustacean zooplankton – this group includes shrimps, mysids (*Mysidae* spp.), and other less numerically dominant but important organisms that consume other zooplankton, phytoplankton, and microzooplankton
- Copepods (*Copepoda* spp.) – smaller crustacean zooplankton, often the numerically dominant multi-cellular organism in many areas of the CCE that feed on both phytoplankton, other zooplankton, and microzooplankton
- Microzooplankton – uni-cellular zooplankton that feed at high rates on phytoplankton, other microzooplankton, and bacteria

Small pelagic fish, such as sardine and anchovy, comprise an integral part of the CCE, feeding nearly exclusively on phytoplankton (typically diatoms), small pelagic crustaceans, and copepods (Emmett et al. 2005). A large portion of what are known as the "forage fish" of the CCE are comprised of small pelagic fish; this group functions as the main pathway of energy flow in the CCE from phytoplankton to larger fish and the young life stages of larger predators (Crawford, 1987; Cury et al. 2000). Thus, small pelagic fish form a critical link in the strong, upwelling-driven high production regions of the CCE. Ichthyoplankton, the larvae of larger fish, are also a key prey resource for larger fish and other marine organisms. A summary of over 50 years of the ichthyoplankton community gives some sense of the relative abundance of various ecologically important species in the CCE (Moser et al. 2001). Six of the top 10 most abundant species throughout this long time period are northern anchovy, Pacific hake, Pacific sardine, jack mackerel, and rockfish (shortbelly rockfish (*S. jordani*) and unidentified Sebastes, as most species are not identifiable to the species level). The



Sardines. Photo credit: NOAA

persistent dominance of the icthyoplankton of relatively few CCE species indicates that the relative abundance and importance, at least in the southern part of the CCE, of these key species is far greater than most other lower trophic level species. Notably, the remaining four species in the top 10 are mesopelagic species that further account for 12 of the top 20 most abundant species. There are considerably fewer ichthyoplankton data for central and northern California, although survey data suggest that anchovy, herring, sardine, and whitebait smelt (*Allosmerus elongatus*) have been the most abundant and important forage species in this region over the past 13 years (Orsi et al. 2007, Bjorkstedt et al. 2010). Ichthyoplankton data are more limited for the CCE north of Cape Mendocino, but existing studies suggest that off Washington and Oregon, smelts are often highly abundant in the nearshore shelf waters, and that tomcod (*Microgadus proximus*) and sandlance (*Ammodytes hexapterus*) are often fairly abundant (see Richardson and Pearcy 1977, Kendall and Clark 1982 and Brodeur et al. 2008).

Euphausiid. Photo credit: NOAA

Euphausiids, primarily the species *Euphausia pacifica* and *Thysanoessa trispinosa*, are another key link in the trophic web of the CCE (Brinton and Townsend, 2003). These species primarily eat phytoplankton (diatoms) and small zooplankton, and in turn are the food for many species of fish, birds, and marine mammals. Euphausiids can form large conspicuous schools and swarms that attract larger predators, including whales. Due to their high feeding rates, fast growth rates, and status as a key prey for many species, Euphausiids play a critical role in the overall flow of energy through the CCE.

When prevalent, gelatinous zooplankton provides an alternate pathway for energy flow that may or may not lead to production in higher trophic levels (Brodeur et al. 2011). Gelatinous zooplankton include a variety of forms, from free-floating jellyfish that passively ambush zooplankton and small larval fish prey, to appendicularians that build large gelatinous “houses” used to filter large quantities of the smallest phytoplankton classes from the water column. While gelatinous zooplankton grow at high rates, and have high feeding rates, their bodies are mostly composed of water; as a result, gelatinous zooplankton are not typically a good food source for larger organisms, with the exception of certain turtles that specialize in gelatinous prey. Thus, systems dominated by gelatinous zooplankton as the primary predators of phytoplankton tend to have limited production of fish species, and are generally considered “dead-end” ecosystems. Typically, gelatinous zooplankton blooms are found offshore in oligotrophic regions, although blooms occasionally predominate nearshore during warmer periods. An exception are pteropods, pelagic gastropods that form large gelatinous nets, much larger than their body size, used to capture falling detritus in the water column. Unlike the other taxa in this group, pteropods are known to be an important food source for at least salmon, and possibly other fish species (Brodeur, 1990).

Copepods and other small crustacean zooplankton have similar roles to krill within the CCE. However, copepods and small crustacean zooplankton do not tend to form large dense schools, although, at times, for brief periods (a few hours to a few days) they may be found at locally higher densities as they aggregate near physical (e.g. horizontally along physical fronts, or vertically near the main thermocline) or biological discontinuities (e.g. phytoplankton "thin layers"). Copepods eat phytoplankton, microzooplankton, and other smaller crustacean zooplankton, and in turn are food for krill, fish larvae, and small pelagic fish. An important feature of many of the larger crustacean zooplankton is that they undergo daily vertical migrations from depths as deep as several hundred meters during the day, up to near the surface at night, primarily as a means to avoid visual predators, such as fish. Other small crustaceans, such as shrimps and mysids, tend to be less abundant, but can be important in some areas. Mysids often form swarms in shallow nearshore waters, and may be an important food source for outmigrating smolts (Brodeur, 1990). Unlike many other zooplankton, several of the dominant species of copepods, those of the genus *Calanus* and *Neocalanus* in particular, undergo a wintertime dormant period, wherein they descend to great depths (~400-1000m) for anywhere from 4-8 months of the year (Dahms, 1995). These copepods then emerge in the springtime to reproduce. Thus, copepods have a marked seasonality in their availability to higher trophic levels, often leading to match-mismatch problems.

Unicellular microzooplankton include a diverse array of organisms, such as heterotrophic dinoflagellates, ciliates, and choanoflagellates. These organisms primarily eat other microzooplankton, phytoplankton, cyanobacteria, and bacteria. The CCE biomass of unicellular microzooplankton is not often high, however, their grazing rates are on par with the growth rates of phytoplankton (Li et al. 2011). Thus, contrary to common belief, it is these unicellular microzooplankton, not crustaceans or fish, which consume the majority of phytoplankton standing stock and production within many areas of the CCE (Calbet and Landry, 2004). A large portion of the energy that flows into microzooplankton does not reach higher trophic levels, but is returned to detrital pools, or recycled within the microzooplankton trophic level. This retention of energy within the unicellular microzooplankton trophic level is known as the "microbial loop" and, when prevalent, decreases the overall productivity of higher trophic levels. Unicellular microzooplankton are a key prey source for copepods, gelatinous zooplankton, and other small crustacean zooplankton due to their enriched nitrogen relative to carbon, in comparison to similarly-sized phytoplankton.

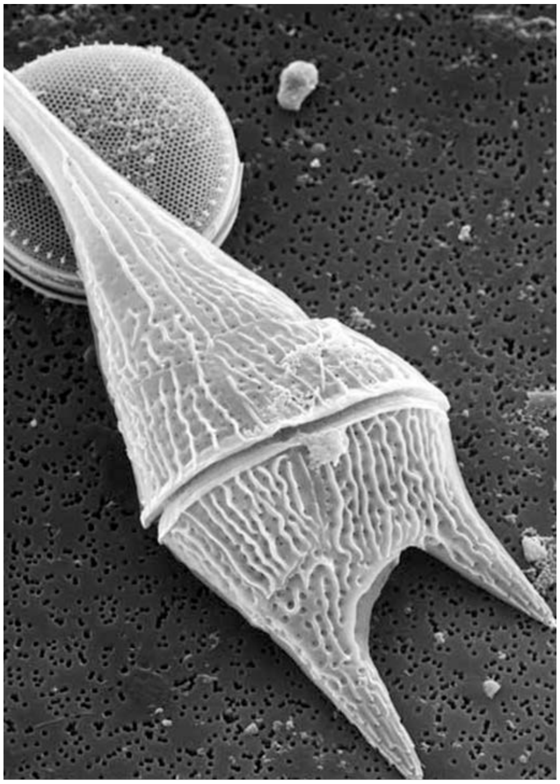
Julie Stewart, Hopkins Marine Station, sorting low trophic level species caught with micronekton net during juvenile rockfish survey. Photo credit: John Field, NOAA.

3.2.1.4 Lowest Trophic Level

Lowest Trophic Level species are those that carry out photosynthesis, i.e. phytoplankton (also known as primary producers). Large multicellular plants and vegetation are described in more detail in section 3.3.2. The most predominant phytoplankton groups within the California current include the single-celled phytoplankton classes:

- Diatoms (*Bacillariophyceae* spp.) – eukaryotic cells with hard silica-based shells, dominant in upwelling areas, occasionally harmful algal bloom (HAB) forming
- Dinoflagellates (*Dinoflagellata* spp.) – eukaryotic cells, many of which are slightly motile, often dominate in stratified regions, and more commonly form HABs than diatoms
- Cyanobacteria – prokaryotic cells, predominant in offshore regions, but still abundant in nearshore regions (~20 percent of phytoplankton productivity)

Diatoms are probably the most critical phytoplankton group in terms of overall productivity and importance as a food resource for higher trophic levels. Diatoms grow rapidly in nearshore regions where upwelling provides cool, nutrient-rich water. In turn, diatoms are grazed by most of the low trophic level species (described above). Occasionally, certain species of diatoms may constitute HABs. Specifically, the diatom *Pseudonitchia multiseries* produces a powerful neurotoxin known as Domoic Acid that can be bio-accumulated in the tissues of fish (described in more detail below in section 3.3.2). While diatoms are an important prey for copepods, their protective silica casing (known as a frustules) prevents them from being readily preyed upon by smaller microzooplankton. Dinoflagellates are an important resource in the CCE. Dinoflagellates may out-compete diatoms when silica is limiting, since dinoflagellates do not require silica for growth. Dinoflagellates are also typically preferred by other microzooplankton and small crustacean zooplankton as a food source as compared to diatoms, due to their relatively enriched nutrient content, and lack of a hard Si encasement (Kleppel, 1993; Leising et al. 2005). Because of this, when dinoflagellates predominate, there is a longer chain of organisms between phytoplankton and higher predators, hence a lower total transfer of energy to higher trophic levels (only about 30-35 percent of energy is transferred upwards from each trophic level, thus 65-70 percent of the energy is lost to recycling, Paffenhofer, 1976; Fenchel, 1988), as compared to diatom-dominated systems (nearshore upwelling) where the diatoms may be directly consumed by small fish and some fish larvae. Cyanobacteria are more important in offshore regions, where, although they do not have a high biomass, they may have high growth rates, providing for rapid nutrient turnover (Sherr et al. 2005). Cyanobacteria are primarily consumed by unicellular microzooplankton that may be prey for other microzooplankton. Hence, food webs dominated by cyanobacteria tend to have a low biomass at the higher trophic levels due to the relatively large number of trophic links.



Dinoflagellate under scanning electron microsope Photo credit: Carla Stehr, NOAA

3.2.2 Species Interactions

In addition to their own internal dynamics, fish populations interact with, and are influenced by, other species. Species interactions can take a variety of forms, summarized in Table 3.2.1.

Table 3.2.1: Species Interaction Types and Their General Effects

Nature of interaction	Species 1	Species 2
Mutualism	+	+
Commensalism	+	0
Predation / herbivory	+	-
Parasitism	+	-
Competition	-	-

+ positive effect; 0 no effect; - deleterious effect

Predation, parasitism, and herbivory all have the same general effects—a positive effect on one species and a negative effect on another. Competition is defined as a species interaction that has a negative effect on both species. Mutualism (two different species each derive benefits from the other) and commensalism (when two different species interact, one benefits while the other is unaffected) are less commonly discussed in the ecological (and especially fisheries) literature, but potentially play important roles for some species.

The vast majority of information we have on species interactions involving fisheries targets is on predation. As evidenced in the sections above, we have a strong general understanding of the trophic interactions among species in the CCE. In large part, this is because it is technically simple to obtain stomach contents—the founding basis for an understanding of predation. Additionally, diet observations can be complemented with stable isotope analyses that match predator diets to known carbon and nitrogen signatures in prey groups (Bosley et al. 2004). However, it is important to remember that diet composition alone is a poor indicator of the importance of predation on prey populations. That is, just because a predator's diet contains a small amount of a particular prey species, this does not mean that mortality from that predator is not important for prey dynamics. For example, harbor seals (*Phoca vitulina*) prefer herring and salmonids as prey; however, they also consume small numbers of rockfish. In some circumstances, this small level of predation by seals on rockfish could have important implications for rockfish population dynamics (Ruckelshaus et al. 2010).

In addition to understanding predation, diet information helps to inform analyses of potential competitive interactions. Interspecific competition may occur when individuals of two separate species share a limiting resource in the same area. If the resource cannot support both populations, then, by definition, both species will suffer fitness consequences in the form of reduced growth, survival, or reproduction. A first step in understanding competitive interactions is to document overlapping resource use. In the case of competition for food, this means

California sea lions carpeting the beach at Año Nuevo, CA. Photo credit: John Field, NOAA SWFSC

documenting the degree to which diets overlap. For example, Miller and Brodeur (2007) documented the diets of 20 nektonic species in the CCE and used cluster analysis to group species into trophic groups with similar prey. The strength of competition will be greater within trophic groups than among the groups, if food is a limiting resource. Dufault et al. (2009) similarly summarized diet overlap between both demersal and pelagic species, and other groups such as marine mammals and seabirds – see Figure 3.2.2.

Diet analyses such as those of Miller and Brodeur (2007) and Dufault et al. (2009) can be used to better understand the links between managed species and their prey and predators. Figure 3.2.2, below, illustrates links between Pacific whiting, referred to in the figure as Pacific hake, and its predators and prey, both of which classes include other Council-managed species. Diet links between species also connect FMPs, and imply that fishery management policies do not affect species in isolation. For instance, modeling studies suggest that when these linkages are included, simultaneous harvest of all groups at rates estimated to be

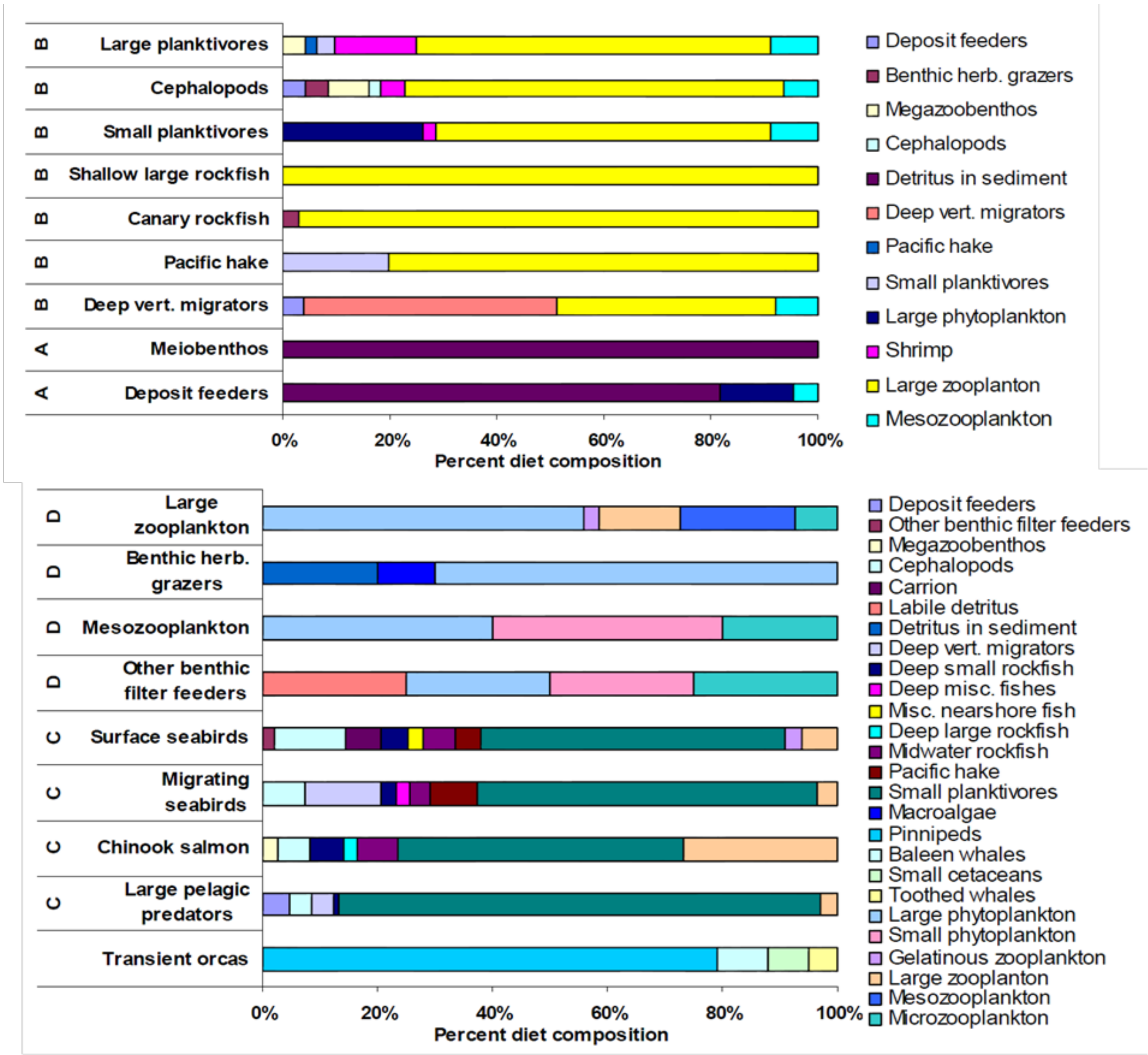


Figure 3.2.2: The prey composition of several feeding guilds of California Current predators, based on a functional group level hierarchical cluster analysis (Dufault et al. 2009; see full reference for other guilds, species, names, and data sources.)

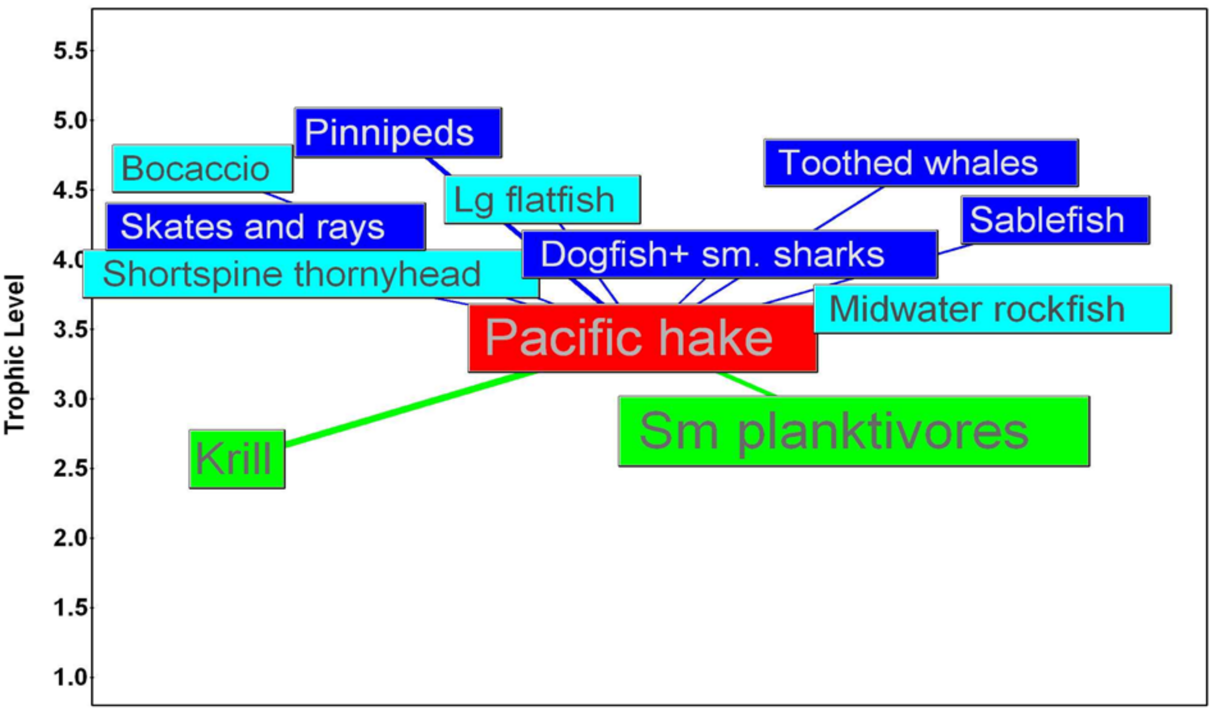


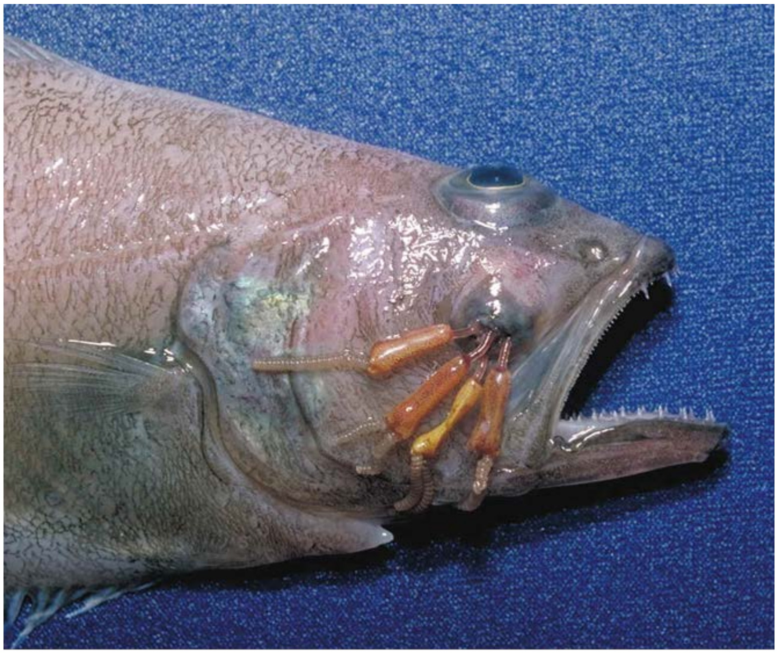
Figure 3.2.3: Primary food web of Pacific hake (also known as whiting). Pacific hake are red, major prey items are green, and major predators are dark blue. Turquoise groups are both prey and predators of hake at different life stages. Vertical position is approximately related to trophic level, with higher positions representing higher trophic levels. Size of the box is related to biomass size of the group. Links between boxes represent links in the food web, and most diet information shown here refers to adult predators. Diagram excludes minor prey items and predators that inflict small proporsions of predation mortality on Pacific hake. (Levin and Wells, 2011, Ecoviz 2.3.6 software provided by Aydin, NOAA AFSC)

sustainable based on single-species MSY may lead to an erosion of ecosystem structure and declines in top predator biomass and catch (Walters et al. 2005).

Competition for non-food resources may also occur. For instance, competition for space (e.g., refuges from predation) is common in a number of systems (Holbrook and Schmitt 2002, Hixon and Jones 2005). However, such competitive interactions are difficult to demonstrate, and ecologists often rely on manipulative experiments to demonstrate competition. Clearly, because their habitats make sustained observations difficult, such experiments or related observations are difficult for many if not most of the targeted fish species in the CCE. As a consequence, we know little about the role of competition for space or other non-food resources in offshore waters of the CCE.

Parasitism is another type of species interaction that we know little about in the California Current, but that is likely to be important based on the broader ecological literature (Washburn et al. 1991). Parasitism is the most common consumer strategy in food webs (Lafferty et al. 2008); however, parasites may affect hosts differently than predators affect prey. While a predator kills multiple prey individuals during its life, a parasite obtains nourishment from a single host during a life stage. Parasitism is often density-dependent, and thus fisheries can directly or indirectly influence the importance of parasites. For example, Lafferty (2004) showed that fisheries for spiny lobsters (*Panulirus interruptus*) resulted in an increase in densities of their prey, especially red sea urchins (*Strongylocentrotus franciscanus*). The increase in red sea urchin density, however, resulted in an increase in disease (aka micro-parasites), which ultimately resulted in a sea urchin population crash.

In the CCE, one common example of parasitism involves sanddabs (*Citharichthys sordidus*) that are parasitized by *Phrixocephalus cincinnatus*, a blood-feeding parasitic copepod that attaches to the eyes of flatfish hosts, generally blinding one eye but not causing immediate mortality. Prevalence in host populations varies by study year, ranging from 1-3 percent to 83 percent (Kabata 1969, Perkins and Gartman 1997). The effects of this dramatic example of parasitism on sanddab growth, reproduction, and population dynamics are currently unknown, as are the factors that determine prevalence of the parasite in host populations.



Arrowtooth flounder with eye parasites. Photo credit: NOAA

In addition to the direct species interactions described above, there are a number of important indirect effects of species interactions (Table 3.2.2). In general, we know that these indirect effects are important in a number of systems, but as with parasitism and competition, evidence of their importance in the dynamics of target species is sparse, at best. Nonetheless, based on the evidence in other systems (including shallow waters of the CCE), we can surmise that these indirect interactions may play some role in the population dynamics of target species.

Table 3.2.2: Indirect Species Interaction Types

Type of interaction	Description
Keystone predation	Predation that has a disproportionate effect on a marine community, relative to the abundance of the predator.
Trophic cascades	Changes in abundance at one trophic level (e.g. predator) result in a reciprocal change in abundance of prey, which then leads to reciprocal response in prey at a lower trophic level (e.g. increased predator abundance leads to decreased herbivore abundance and increased plant abundance).
Apparent competition	Reduction of species A that results from increases in species B, which shares prey or other resource with species A.
Habitat facilitation	One species indirectly improves the habitat of a second by altering the abundance of a third interactor.
Apparent predation	An indirect decrease in a nonprey produced by a predator or herbivore, e.g. when urchins reduce kelp cover, they eliminate shelter for some rockfish species.

3.3 CCE Abiotic Environment and Habitat

The CCE encompasses over 2 million square kilometers of ocean surface. This large area includes many diverse habitat types that can be described in a variety of ways and at a variety of scales—from individual features like kelp beds, submarine canyons, and seamounts, to broader scale regions, like the continental shelf break, that share certain features coastwide. The Council's efforts with habitat to date have been largely shaped by the MSA's EFH provisions. As discussed in section 3.3.4 below, the Council has described EFH in detail for the species managed in all four of the FMPs, and those details are not repeated here.

In general, ocean habitat can be thought of as extending from the transition between land and sea to the abyssal plain 4,000 meters below the surface and deeper. Key habitat for harvested species exists throughout the bulk of this range. The Council's EFH for groundfish, for example, includes all waters from the high tide line and parts of estuaries to 3,500 meters below the surface. When considering anadromous species like salmonids, the range of significant habitat then extends far into terrestrial watersheds. A wide range of marine and coastal habitat types can be found within relatively small areas of the coast (e.g. the Monterey Bay area) and within 100 or so nautical miles (nm) of shore in some places where the continental shelf is relatively narrow.

As described in this section 3.3, habitat can be defined by geologic sediments (e.g., rocky reefs, boulder fields, and sandy seafloors), or by organisms, including microbes, algae, plants, and even fallen whales (Lundsten et al. 2010) that form biogenic habitats by creating structure or providing resources for other organisms. Geochemical features—such as methane seeps —also create important habitat in deep sea environments, as can artificial structures like jetties, piers, and offshore oil platforms in more coastal waters.

Another important characteristic of marine habitats is that they can vary as much by the motion and physical and chemical properties of seawater (e.g., temperature, salinity, nutrient content) as by particular locations and geologic and biogenic structures. They can also be highly dynamic. For example, EFH for CPS is described by sea surface temperature and the thermocline/mixed layer. The location and extent of CPS EFH—in terms of both depth and latitude—will therefore differ between seasons and years. As described in section 3.3.2, features like oceanic fronts and eddies, upwelling zones and shadows, river plumes, and meandering jets all form key habitats throughout the CCE. These features may show regularity of pattern, yet are all marked by seasonal and annual variability in location and size, and in turn, in the type and quality of habitat that they provide.

Rosethorn rockfish in rocky slope habitat. Photo credit: NOAA

The CCE's spatial environment can be divided along three main dimensions: from north to south (latitude, and generally in the alongshore dimension), from east to west (longitude, and generally in the onshore-offshore dimension), and from the sea surface to the ocean floor. One key division is between coastal waters and the open ocean (the oceanic area), with the divide occurring roughly at the edge of the continental shelf break. Coastal waters can be further divided into the tidal or littoral zone—existing between the high and low tide marks—and the sublittoral, or neritic zone, which includes the waters from the low tide mark to the continental shelf break. Benthic- or demersally-associated species are often limited to one or more of these zones.

The third major division in the marine ecosystem is between the benthic habitats of the seafloor and the pelagic habitats of the water column. Each of these can be further subdivided based on depth and other features. The epipelagic (photic, e.g. where light can reach) zone is the shallowest of the pelagic zones and covers those waters where sunlight is strong enough for photosynthesis to drive primary production. The depth of this zone will vary as a function of water column structure and water clarity, varying in depth from a few meters to tens of meters in the neritic zone, to 200 m in the far offshore oceanic zone. The mesopelagic zone is the next deeper layer and the start of the aphotic zone—sunlight penetrates into this layer, yet not enough for photosynthesis to occur. The mesopelagic zone is also typically (but not always) the beginning of the main thermocline. Temperature changes drastically between the top and bottom of the layer. The bathypelagic zone begins at 1,000 m, and where the waters reach depths of 4,000 m and deeper, the abyssalpelagic zone follows. The relative divisions between these depth zones within the CCE change slightly in both the onshore-offshore dimension, and as a function on water column mixing and the east-west location of the major north-south currents. Hence, these zones are dynamic in space and time. Delineation of these zones is of importance in that certain species and fisheries are limited at times to particular zones, due to temperature, feeding, or reproductive requirements.

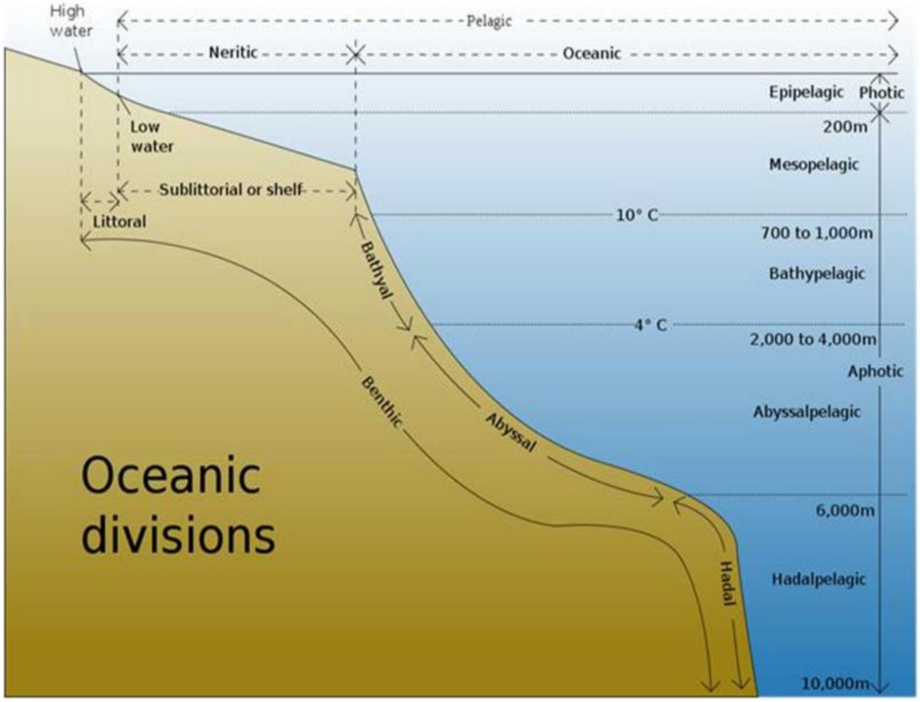


Figure 3.3.1: Divisions of coastal and oceanic zones, Wikimedia Commons

The benthic zone can be similarly divided (see Section 3.3.1). Discussions concerning the Council's Groundfish FMP—the most benthically-oriented of the four FMPs—tend to describe benthic habitats in relation to the continental shelf and slope. Habitats can be referred to as being in the nearshore, on the shelf (sometimes divided between the shallow and deeper shelf), or the slope. The continental shelf break, which describes the transition between the shelf and slope, provides key habitat for several managed species and is the main area covered by the Rockfish Conservation Area (RCA). The habitat of some commercially important species extends down the slope into the bathypelagic zone below 1,000 meters, e.g. sablefish and longspine thornyhead (*Sebastolobus altivelis*). The Council has closed bottom trawling in waters deeper than 700 fathoms (~1,300 meters). Detailed information on benthic habitat types, bathymetry, and other benthic zone features may be found in the Council's EFH Review Committee's September 2012 report to the Council (EFHRC 2012).

3.3.1 Geological Environment

Geologic features greatly influence current and wave patterns and provide habitats that influence species distributions and productivity within the CCE. The geology of benthic habitats is one among a variety of important ecological characteristics for managed fish species. The physical substrate or physiography of benthic habitats of the CCE can be described using a classification scheme developed by Greene et al. (1999) for deep seafloor habitats, which the Council used for describing groundfish EFH. This classification system organizes benthic habitat according to physical features in a hierarchical system of levels: megahabitat, seafloor induration, meso/microhabitats, and modifiers. Specific types of habitats in each level are:

- Level 1 megahabitat includes: continental rise/apron; basin floor; continental slope; ridge, bank or seamount; and continental shelf.

- Level 2 seafloor induration includes: hard or soft substrate.

- Level 3 meso/microhabitat includes: canyon wall; canyon floor; exposure and bedrock; gully; gully floor; ice-formed feature; and landslide.

- Level 4 modifier includes: bimodal pavement; outwash; and unconsolidated sediment.

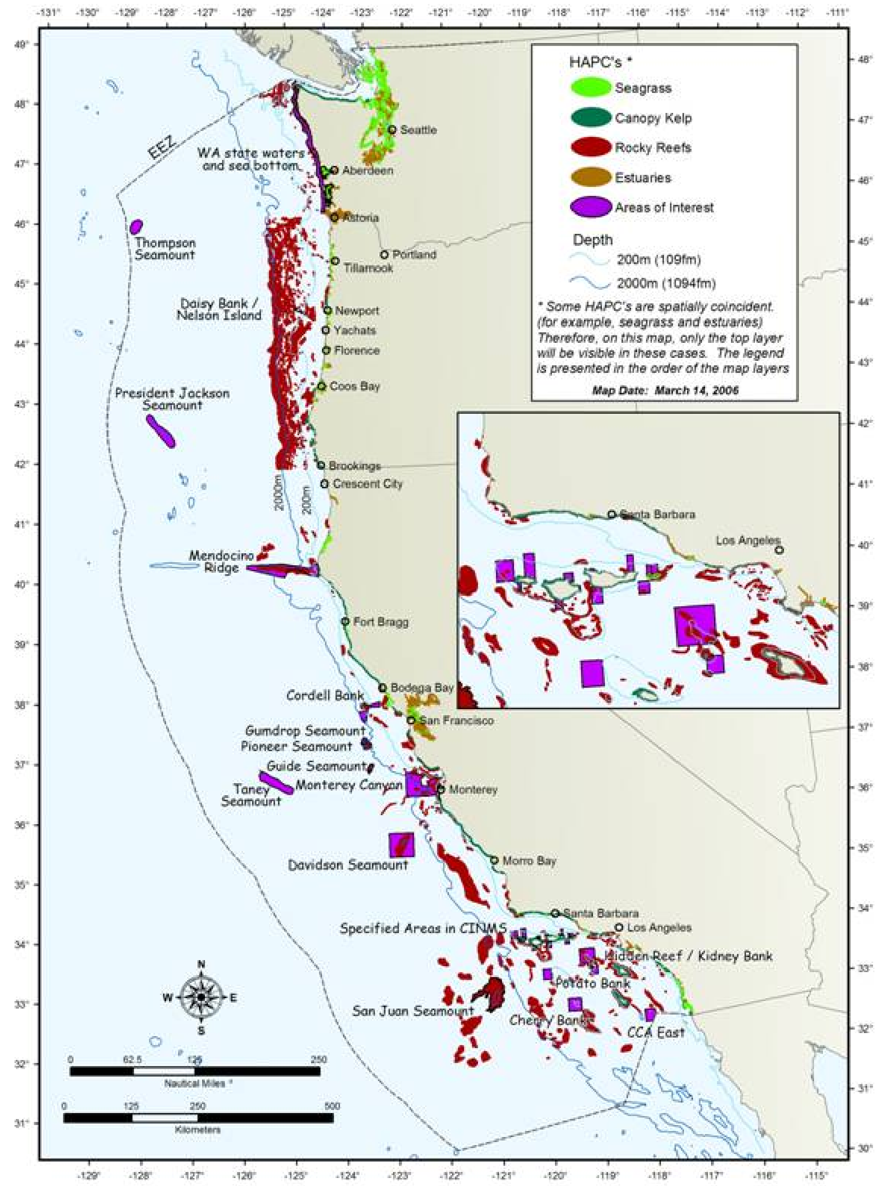


Figure 3.3.2: Groundfish HAPCs and Major Geological Structures [Figure 7-2 from Groundfish FMP].

The West Coast EEZ is geologically diverse and active. It includes all three types of global tectonic plate boundaries: 1) transform or strike-slip, 2) convergence or subduction, and 3) divergence or spreading. The Mendocino Triple Junction, where three plates meet, lies just south of the state boundary between California and Oregon, making the region geologically complex. Plate movements result in slipping, uplifting, landslides and other changes in the physiographic features off the West Coast.

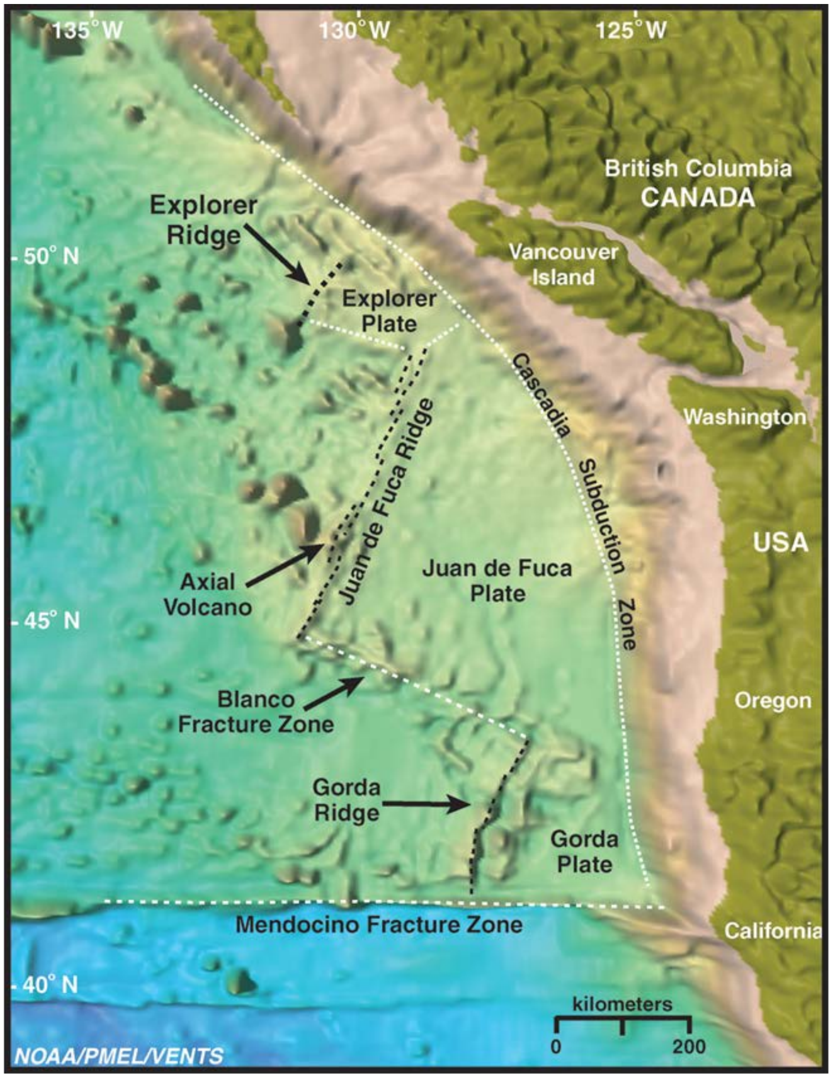


Figure 3.3.3: Satellite imagery of northeast Pacific Ocean tectonic plates. Image courtesy of Submarine Ring of Fire 2002, NOAA/OER.

In general, the West Coast EEZ has a relatively narrow shelf, steep slope, and wide abyssal plain. Some important geologic features are shown in Figure 3.3.2. The shelf, ranging from shore to depths of about 200 m, is generally less than 35 nm wide along most of the West Coast. Washington and Oregon have the broadest continental shelf anchoring a north-south trend of decreasing shelf width from Cape Flattery to Point Conception, CA. Most of the EEZ north of the California Bight also has a narrow slope with deep (abyssal depth) basins fringed on the west by volcanically active ridges. The Southern California Bight region is bathymetrically complex and differs dramatically from areas to the north. The shelf is generally very narrow, but widens in some areas of the Bight to include several islands that are an expression of the ridge and basin topography. Cape Blanco, Cape Mendocino and Point Conception are prominent features of the coastline and significantly influence oceanographic conditions offshore. They are often identified as boundaries separating biogeographic regions of the coast. Smaller capes are also dotted along the coastline and have more localized influences.

Major offshore physiographic features of Washington and Oregon include the continental shelf, slope, and Cascadia Basin. Low benches and hills characterize the upper slope. The lower slope intersects the deep sea floor of the Cascadia Basin at 2200 m depth off the north coast, and at about 3,000 m off the central and southern Oregon coast. Off northern California, the Eel River Basin, located on the continental shelf and stretching from the waters offshore of Oregon, has a high sedimentation rate, fed by the Eel, Mad, and Klamath Rivers. The offshore region of the southern California Bight encompasses some of the most diverse topography along West Coast. It is unique in that a complex series of northwest-southeast-oriented basins and ridges characterizes the continental border south of Point Conception with islands topping most of the ridges. Below, the FEP addresses major Level 1 megahabitat types off the U.S. West Coast.

3.3.1.1 Submarine Canyons

Submarine canyons are submerged steep-sided valleys that cut through the continental slope and occasionally extend close to shore. They have high bathymetric complexity, provide a variety of ecological functions, and affect local and regional circulation patterns. Submarine canyon habitats receive sediment and detritus from adjacent shallow areas, and act as conduits of nutrients and sediment to deeper offshore habitats. Canyons are complex habitats that may provide a variety of ecological functions.

Many submarine canyons cut through the continental shelf along the West Coast. The Rogue, Astoria, Quinault, Willapa, Guide, and Grays submarine canyons intersect the continental shelf of Oregon and Washington. Off northern California, five submarine canyons occur between Cape Mendocino and Point Delgada, including Mendocino Canyon, Mattole Canyon, Spanish Canyon, Delgada Canyon, and Eel Canyon. Off central California, Monterey Canyon is designated as a groundfish Habitat Area of Particular Concern (HAPC). Arguello and Conception Canyons occur south of Point Conception. Submarine canyons in the Southern California Bight generally connect to river mouths on land and include the Hueneme-Magu Canyon system, Dume Canyon, Santa Monica Canyon, Redondo Canyon, San Pedro Sea Valley, San Gabriel Canyon, Newport Canyon system, Oceanside Canyon, Carlsbad Canyon, La Jolla Canyon, and Loma Sea Valley.

3.3.1.2 Submarine Fans

Submarine fans often occur in association with submarine canyons when sediment is fed to the canyon head by seasonal flowing currents. For example, the Astoria Fan lies at the base of Astoria Canyon and is fed by sediments carried to the canyon head by seasonal flowing currents. Along with a portion of the Astoria Fan, the Willapa Fan occurs off Washington. Although rivers such as the Klamath possess gently sloping deltas, most of the rivers in Oregon and Washington have drowned mouths and estuaries.

In California, the Delgado Canyon, near Point Delgado, is particularly important because it transports considerable sediment to the Delgado Deep Sea Fan. The large Tufts Submarine Fan occurs in the deep basin off northern California, west of the Gorda Ridge. The Monterey Submarine Fan receives sediment from the Ascension Canyon, Lucia-Partington-Sur Canyons, and the Monterey–Carmel Submarine Canyons (Hamlin 1974). South of Point Conception, submarine fans in the Santa Monica Basin include the large Hueneme Fan and the small Magu and Dume Fans. In Hueneme Canyon, the Santa Clara River has produced a substantial delta that feeds the canyons of the Hueneme-Magu Canyon system. Turbidity currents traveling down Redondo Canyon and the San Pedro SeaValley have created moderate-sized fans in the San Pedro Basin. Turbidity currents in San Gabriel Canyon have constructed a submarine fan in the Catalina Basin.

3.3.1.3 Seamounts and Pinnacles

Seamounts rise steeply to heights of over 1,000 m from their base and are typically formed of hard volcanic substrate. They are unique in that they tend to create complex current patterns. Several unnamed seamounts exist along the mid- to lower-slope and on the abyssal plain in the Cascadia Basin. Within and adjacent to the Cascadia Margin, several major seamounts exist, including (from south to north) President Jackson, Vance, Cobb, Eickelberg and Union seamounts. Off California, significant seamounts include Gumdrop, Pioneer, Guide, Taney, and Davidson off the central coast and Rodriguez, San Juan, and San Marcos in the southern California Bight. Several of these seamounts have been identified in the Groundfish FMP as HAPCs, including Thompson Seamount and President Jackson Seamount off Oregon and Gumdrop Seamount, Pioneer Seamount, Guide Seamount, Taney Seamount, Davidson Seamount, and San Juan Seamount off California.

3.3.1.4 Ridges, Banks and Islands

A series of large ridges occur at the base of the continental slope offshore of Oregon and Washington with ridge crests elevated 400 m to 1000 m above the abyssal plain of the Cascadia Basin. The Gorda and Juan de Fuca ridges are major tectonic features that are volcanically active. The Gorda Ridge is a narrow shelf in the deep water offshore of northern California and southern Oregon. Near the coastline of Cape Mendocino, three active tectonic plate boundaries meet. These tectonic boundaries are the Cascadia Subduction Zone, the Mendocino Fracture Zone, and the San Andreas Fault. The Mendocino Ridge associated with this boundary zone is designated as a groundfish HAPC off California. In southern California, the Patton Ridge, which supports Sverdrup Bank, is a major bathymetric feature that separates the shelf from the abyssal plain.

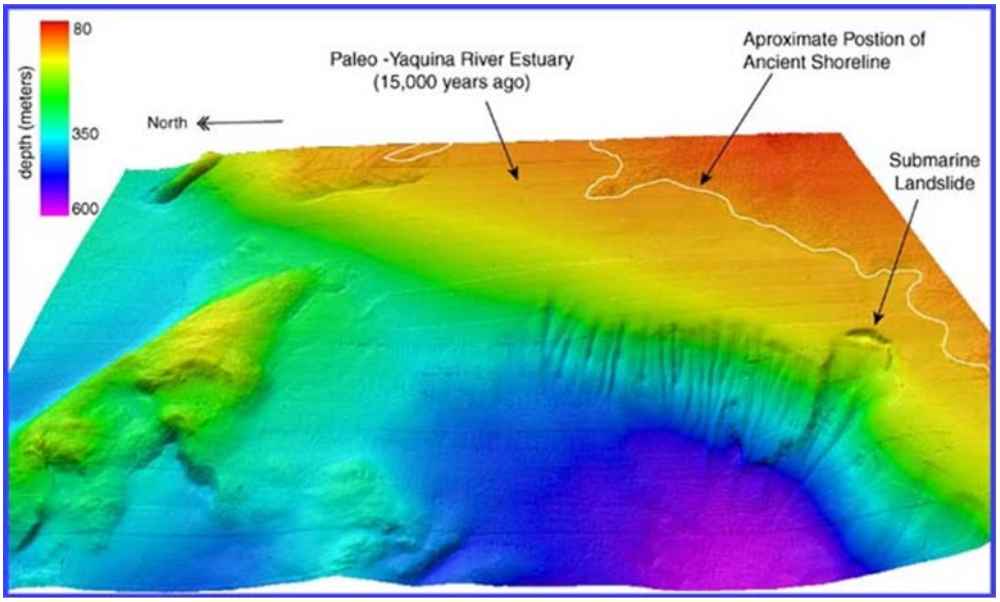


Figure 3.3.4: View of northeast Heceta Bank and the continual shelf break. Image courtesy of Lewis & Clark Legacy Expedition, NOAA/OER.

The continental shelf offshore of Oregon has several rocky submarine banks, creating shallow-water habitats within the deeper shelf waters. Four major banks include Nehalem Bank, Stonewall Bank, Heceta Bank, and Coquille Bank. In addition, Daisy Bank off Oregon and Cordell Bank off California have been designated as HAPCs for groundfish.

Islands and banks are more numerous in the southern California Bight than other areas along the West Coast. The major islands and banks include Richardson Rock, Wilson Rock, and San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands on the Santa Cruz Ridge that separates the offshore continental slope from the Santa Barbara Basin. The Catalina Ridge supports the Pilgrim Banks and Catalina Island; the San Clemente Ridge supports Santa Barbara Island, Osborn Bank, and San Clemente Island; the Santa Rosa-Cortes Ridge supports Begg Rock, San Nicholas Island, Nidever Bank, Dall Bank, Tanner Bank, and Cortes Bank.

3.3.1.5 Rocky Reefs and Pinnacles

Rocky habitat may be composed of bedrock, boulders, or smaller rocks, such as cobble and gravel. Hard substrates are one of the least abundant benthic habitats, yet they are among the most important habitats for groundfish. Pinnacles are vertical rocky features that are tens of meters in diameter and height, with a cone-shaped geometry. Pinnacles are generally a product of in-place erosional processes acting on rocky outcrops. Pinnacles can be important bathymetric features that attract fish and invertebrates.

3.3.1.6 Fjords (Washington's Inland Waters)

Puget Sound is a fjord formed during the last ice age when the region was repeatedly covered by a continental ice sheet advancing from the north. The main basin of Puget Sound is a partially-mixed estuary connecting through Admiralty Inlet to the Strait of Juan de Fuca and extending southward 100 km to Commencement Bay. The seafloor of Puget Sound is relatively deep (about 200m) and flat. The Sound has estuarine sills at both its seaward (Admiralty Inlet, 65 m depth) and landward (Narrows, 45 m depth) edges (Matsura and Cannon 1997). Four major basins (Main Basin, Whidbey Basin, Southern Basin, and Hood Canal) occur within Puget Sound. The bottom sediments of Puget Sound are composed primarily of compact, glacially formed clay layers and glacial tills. Major sources for sediments to Puget Sound are derived from shoreline erosion and river discharge. Sand and mud prevails in the eastern regions while the shores of Vancouver Island and the complex formation of the Gulf Islands have prominent slopes composed of bedrock and boulders.

The Strait of Juan de Fuca is a 160 km long channel ranging from 22 to 60 km in width with an average depth of less than 200 m. The mouth of the Straits extends to 250 m and, except for a sill south of Victoria, British Columbia that extends across the majority of the Strait, there are no distinctive bathymetric features.

3.3.2 Water Column Temperature and Chemical Regimes

Within the CCE there are roughly four common modes of water column structure:

- Well mixed nearshore waters
- Surface stratified nearshore waters
- Transition zones and fronts
- Deeply stratified offshore waters

Well-mixed (meaning that the water has only a very small change in density over depth) nearshore waters are typically the result of wind-driven mixing of upwelled water (Hickey, 1998). Such waters are often cold and nutrient-rich, and are the basis for the high productivity of the coastal portions of the CCE, making them one of the most critical environments within the CCE. Such waters are typically mixed to depths up to 50-75 m (or the bottom, whichever is shallower) depending on water column structure. Well-mixed waters may extend up to 10-20 km offshore in places, but are typically found within approximately 5 km of the coast. Seasonally, well-mixed waters tend to coincide with the spring-summer upwelling season, although wind-based mixing (and occasionally upwelling) can occur at any time of year (Hickey, 1998). Being well-mixed, and near the surface, these waters are typically well-saturated with oxygen.

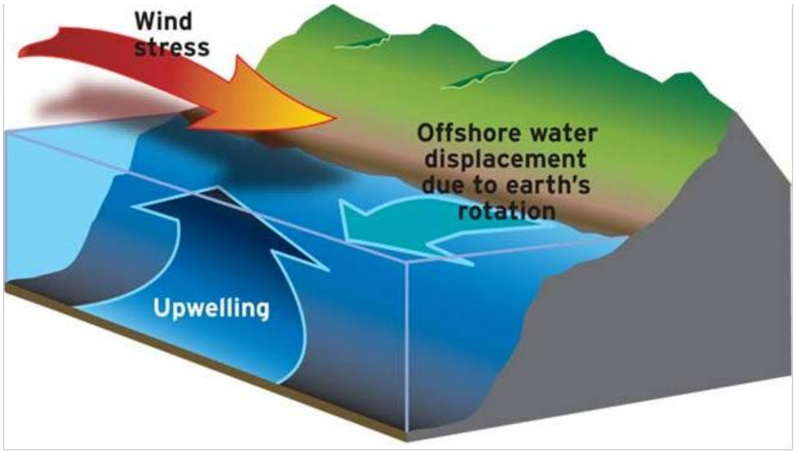
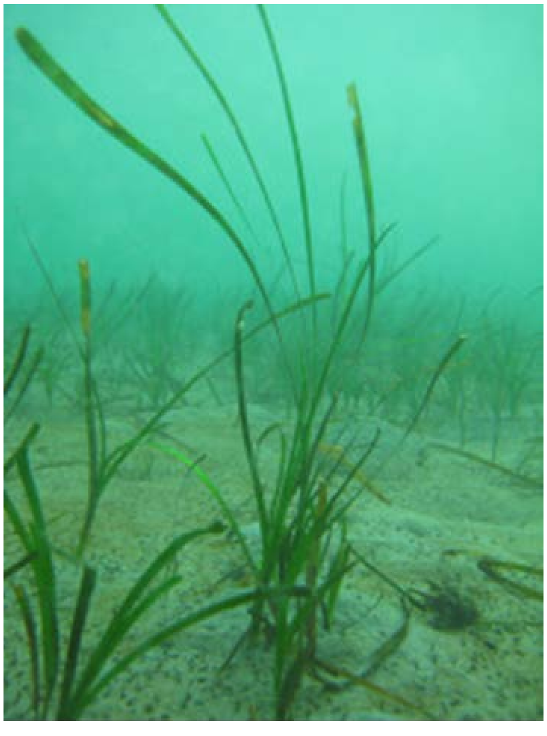


Figure 3.3.5: Forces affecting coastal upwelling in the CCE during the spring and summer. NOAA NWFSC.

When not well-mixed (e.g. when winds are low, or upwelling is not occurring), nearshore waters may often be strongly stratified (meaning there are large or abrupt changes of water density versus depth). In the nearshore region, e.g. east of the main core of the California current, such stratified waters are often characterized by a shallow weakly-stratified layer near the surface (often on the order of 10-20 m), with a stronger pycnocline below the weakly-stratified layer, below which lies waters that are also weakly-to-moderately stratified down to the bottom. Such stratified waters may also be an important habitat, since they often occur after upwelling has decreased; significant residual production may occur in these waters, often focused and intensified near the depth of the pycnocline. Where total water column productivity may be lower, it is often more concentrated within a particular depth stratum, forming a type of vertical "hot spot" for biological interactions. Weakly-stratified nearshore waters that form upon the cessation of upwelling are also typically the areas where HABs may form. Nitrate levels versus depth are usually the inverse of temperature, such that with increasing depth and decreasing temperature, nitrate levels increase. When strongly stratified, such waters may be lower in oxygen content, depending on the orginal source of the water, and the balance between oxygen production by plants, and oxygen use for organism respiration and bacterial decomposition. Oxygen levels typically decrease with depth, to the "oxygen minimum zone," which is typically just below to several hundred meters below the beginning of the main thermocline.

Between the nearshore upwelling region and the far offshore region lies the transition zone of the main core of the California Current, typically defined by relatively strong horizontal fronts. The front itself is partly what leads to the strong southward flow of the core of the CCE (Hickey, 1998). Beyond the transition zone lies a region of fairly well-stratified waters, with a deep pycnocline, often at a depth of 100-200 meters. Surface waters are warm, and this region is characterized by low, yet steady primary production.

These four major vertical water column types form four distinct habitats, differentiated primarily in terms of their temperature and primary productivity within the surface layers where fisheries occur. Complicating the geographic location of these different vertical water column structures is the dynamic nature of the California Current. Upwelling strength and location varies considerably due to multiple factors. Additionally, the location and strength of the core southward flow of the California Current is variable, both in strength and location, particularly through the formation of coastal "jets" and large "eddies" which may spin off from the main current.



Eelgrass in Dumas Bay, WA. Photo credit: WDNR

3.3.3 CCE Vegetation and Structure-Forming Invertebrates

Vegetation forms two major classes of large-scale habitats: large macro-algal attached benthic beds, and microalgal blooms. Seagrass (*Zosteraceae*) beds are also an important macro-algal habitat within the CCE, and are considered EFH for groundfish. Much of the scientific information on structure-forming invertebrates has been collected in recent years, both as a result of improvements in scientific observation technology and as a result of funding and direction expressly provided within the 2007 MSA reauthorization (see §408).

3.3.3.1 Seagrasses

Seagrass species found on the West Coast of the U.S. include eelgrass species (*Zostera* spp.), widgeongrass (*Ruppia maritima*), and surfgrass (*Phyllospadix* spp.). These grasses are vascular plants, not seaweeds, forming dense beds of leafy shoots year-round in the lower intertidal and subtidal areas. Eelgrass is found on soft-bottom substrates in intertidal and shallow subtidal areas of estuaries and occasionally in other nearshore areas, such as the Channel Islands and Santa Barbara littoral. Surfgrass is found on hard-bottom substrates along higher energy coasts. Studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993; Hoss and Thayer 1993). Despite their known ecological importance for many commercial species, seagrass beds have not been as comprehensively mapped as kelp beds. Wyllie-Echeverria and Ackerman (2003) published a coastwide assessment of seagrass that identifies sites known to support seagrass and estimates of seagrass bed areas; however, their report does not compile existing GIS data. GIS data for seagrass beds were located and compiled as part of the groundfish EFH assessment process.

Eelgrass mapping projects have been undertaken for many estuaries along the West Coast. These mapping projects are generally done for a particular estuary, and many different mapping methods and mapping scales have been used. Therefore, the data that have been compiled for eelgrass beds are an incomplete view of eelgrass distribution along the West Coast. Data depicting surfgrass distribution are very limited—the only GIS data showing surfgrass are for the San Diego area.

3.3.3.2 Macro-algal (kelp) beds

Along the Pacific coast, there are two major canopy-forming species of kelp, the giant kelp (*Macrocystis pyrifera*) and the bull kelp (*Nereocystis leutkeana*). These species can form kelp forests which provide habitat for a diverse mix of species including fishes, invertebrates, marine mammals, and sea birds. Kelp forests provide cover or nursery grounds for many adult, young of the year, or juvenile nearshore and shelf rocky reef fishes, such as bocaccio, lingcod, flatfish, other groundfish, and state-managed species including kelp bass (*Paralabrax clathratus*), white seabass, and Pacific bonito (*Sarda chiliensis lineolata*). Kelp is considered EFH for groundfish. Common invertebrates inhabiting kelp forests include abalone (*Haliotidae* spp.), sea urchins, spiny lobsters, and crabs. Sea otters (*Enhydra lutris*) are also found associated with kelp forests. Kelp plays an important role in the diet of some reef fishes and many invertebrates (e.g., urchins and abalone). In addition, when plants are ripped up after storms, the resulting kelp detritus functions as beach enrichment or contributes nutrients to the benthic environment when drifting plants sink.


Giant kelp. Photo credit: NOAA

Kelp forests are comprised of three main components—the holdfast that anchors the kelp to substrate, the stipes that grow upward from the holdfast toward the surface, and the canopy comprised of stipes and fronds that lay on the water surface, buoyed up by floats. Giant kelp forests are generally more dense, and three-dimensional, supporting more diverse communities than bull kelp forests. While the surface canopy of giant kelp is often removed in winter, it is considered a perennial because often the holdfasts remain over winter and new stipes and fronds grow up in the spring. Bull kelp is an annual, and the tangling of long stipes in winter storms rips up holdfasts, removing entire plants.

Along the coasts of Washington and Oregon, and southward to northern California, kelp forests are predominantly comprised of bull kelp in nearshore rocky reef areas, although these occur as far south as Point Conception. Giant kelp is distributed from Sitka, Alaska to central Baja California, forming dense beds from central California southward through the Southern California Bight and off the Baja Peninsula. Kelp forests are normally found in association with nearshore, rocky substrate – bull kelp occurs in water as deep as 75 feet, while giant kelp forests can occupy reefs at 120 feet in areas with excellent water clarity. In the Southern California Bight, kelp beds also occur on sandy surfaces, where they attach to worm tube reefs. Several other canopy-forming species are found in lesser abundance off southern California and the Channel Islands including *Macrocystis integrefolia*, the elk kelp—*Pelagophycus*, *Cystoseira*, and *Sargassum*.

Kelp distribution, productivity, growth, and persistence is dependent on a variety of factors including nutrient availability, severity of wave action, exposure, water quality, turbidity, sedimentation, water temperature, geology, pollution, and grazer abundance (e.g. sea urchins). Nitrogen and light are two of the most important parameters affecting kelp productivity. Under ideal environmental conditions, giant kelp grows up to two feet a day. It prefers nutrient-rich, cool water (50° to 60° F); in wave-exposed areas, fronds may reach a length of 150 feet. Hence, warmer conditions, or conditions that decrease coastal upwelling, decrease kelp growth (Dayton et al. 1999). Warm water events such as El Niño, in combination with severe storms, can wreak havoc on kelp beds—ripping out plants, reducing growth, and leaving only a minimal or no canopy. Seasonal effects are often more localized, and more large-scale, low-frequency episodic changes in nutrient availability seem to result in the most significant changes due to cascading community effects. For example, the status and success of understory kelps such as *Pterogophora*, *Eisenia*, and *Laminaria* can be affected through competition for light, effects on growth, reproduction, establishment, and survivorship.

Numerous studies explored the role of sea urchins in kelp forests and the dynamics of overgrazing by urchins on kelp resulting in loss of whole kelp forests or the creation of “urchin barrens” (Pearse and Hines 1979, Tegner and Dayton 2000). Urchin grazing can destroy kelp forests at a rate of 30 feet per year. In California, there is an active commercial fishery for urchins. Kelp has been commercially harvested since the early 1900s in California, and there was sporadic commercial harvesting in Oregon although it is currently prohibited. Pharmaceutical, food, industrial and forage uses of kelp include—herring-roe-on-kelp, algin, stabilizers, aquaculture food for abalone, and human food products (bull kelp pickles).

Extensive studies since the 1960s addressed concerns regarding the impact of giant kelp harvesting on the nearshore ecosystem. Overall, there was no evidence of long-term affects of harvesting (North and Hubbs 1968, Dayton et al. 1998). Potential impacts include temporary displacement of adult or young-of-the-year fishes to nearby unharvested reefs, predation on those young-of-the-year by larger displaced fishes (Houk and McCleneghan 1968), increased growth of sub-canopy species, increased harvesting of fishes and invertebrates by anglers or divers when harvesters create pathways through the beds, and delayed regrowth of kelp.

3.3.3.3 Microalgal blooms

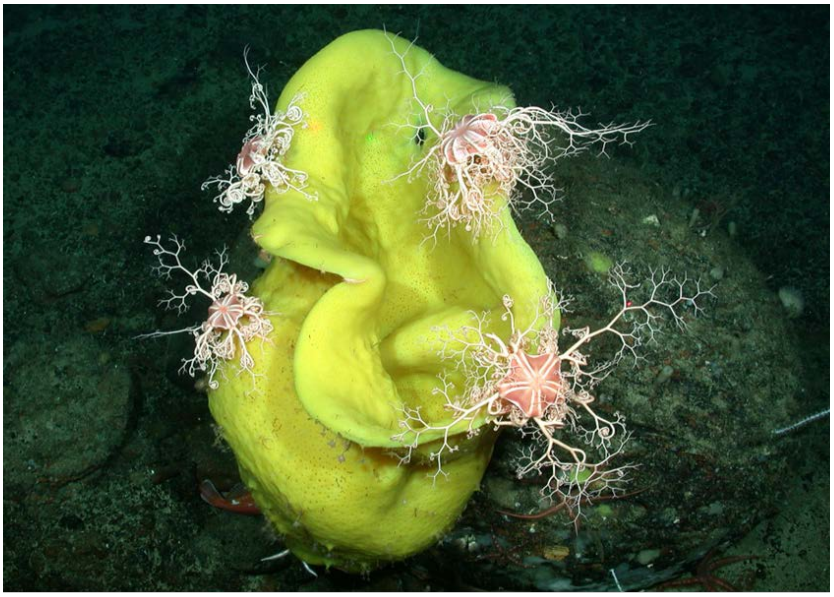
The major phytoplankton classes within the CCE include diatoms, dinoflagellates, small (often termed “pico”-) eukaryotes, and cyanobacteria. Diatoms are mainly responsible for large productive blooms in the nearshore upwelling regions. Thus they often form the basis of the productive food webs in those areas. Dinoflagellates also bloom in upwelling and other regions, and may provide an important food source for microzooplankton. Dinoflagellates have a dual role, since certain dinoflagellates may form HABs (although a few species of diatoms may also form HABs as well). Pico-eukaryotes and cyanobacteria are the smallest “phytoplankton” and form only a minor portion of phytoplankton biomass, although their productivity rates may be high in offshore regions. Thus, these pico-phytoplankton form an important link in offshore food webs, and may also fuel the growth of the smallest microzooplankton within nearshore regions as well (Sherr et al. 2005).

Seasonally, diatoms tend to bloom nearshore in the later winter or early spring, in a progression from south to north. The timing of this bloom tends to follow a change in upwelling strength, from the predominant downwelling condition during the fall and spring, to a net cumulative upwelling in the late winter early spring (Lynn et al. 2003). This change from downwelling to upwelling and the resulting phytoplankton blooms are termed the spring transition (Holt and Mantua, 2009). Year-to-year variability may occur in this timing, due to large-scale changes in wind patterns across the Pacific basin. Occasionally, there are brief periods of mixing or upwelling that occur prior to the main spring transition, which may also result in localized phytoplankton blooms of short duration, which may disappear before the main spring transition time. Blooms of dinoflagellates and other phytoplankton types tend to occur significantly after the main spring transition. In particular, dinoflagellates often bloom in the fall period, upon the cessation of upwelling, as the waters stratify.

3.3.3.4 CCE Structure-Forming Invertebrates

A host of invertebrate species of varying sizes and trophic levels inhabit the CCE. The trophic roles of invertebrates and vertebrates are discussed in Section 3.2. In this section, the FEP considers the scientific literature on invertebrates that serve as habitat for other CCE species. The delineation of benthic structure-forming invertebrates, in particular corals and sponges, is under more thorough discussion within the Groundfish EFH Review Committee for updates to Groundfish EFH designation (EFHRC 2012). The major challenge with observing bottom-dwelling invertebrates to assess and analyze their population structure, qualities as habitat (or not), and roles within the marine ecosystem is that they can only be observed alive in the places where they occur, e.g. from a human-occupied submersible, remotely operated vehicle, or autonomous underwater vehicle, or via shallow water diving operations, any of which require deploying equipment that is challenging to use even on small geographic scales (Krieger and Wing 2002, Etnoyer and Morgan 2005, Whitmire and Clarke 2007, Yoklavich and O'Connell 2008). However, laboratory studies can be also used to examine habitat preferences in fishes under controlled conditions and provide the opportunity to introduce predation as a factor influencing habitat preference (e.g., Ryer et al. 2004). Most of NOAA's scientific work on deep sea corals and other structure-forming invertebrates has been conducted in the last four years, coming out of a deep sea coral research program established in the 2007 reauthorization of the MSA [16 U.S.C. §1884].

Tissot and co-authors (2006) narrowed the question of which invertebrate taxa and associated morphologies should be viewed as having the potential to serve as habitat for other species by characterizing structure-forming invertebrates as those that, like some coral species, add functional structure to benthic habitats by nature of their large size (e.g. black corals (*Antipatharia* spp.), sponges (*Porifera* spp.), anenomes (*Metridium* spp.), and sea pens (*Subselliflorae* spp.) and through having complex morphologies



Basket stars on a deep sea glass sponge. Photo credit: NOAA SWFSC

(e.g., black corals, sea pens, and basket stars). Megafaunal invertebrates that aggregate in high numbers, such as sea urchins and sea pens, could also be considered structure-forming in areas where the physical environment is otherwise low-relief (Tissot et al. 2006).

Whitmire and Clarke (2007) listed 101 species of corals identified in the U.S. West Coast EEZ, within which four species were classified as having adequate individual or colony size and morphological complexity to be considered of high structural importance: *Lophelia pertusa*, *Antipathes dedrochristos*, *Paragorgia arborea*, and *Primnoa pacifica*. Several additional classes and individual species of coral were identified as being of medium structural importance: *Dendrophyllia oldroydae*, *Bathypathes* sp., *Isidella* sp., and *Keratoisis* sp. Corals of the West Coast EEZ are distributed over a variety of bottom habitats, with higher concentrations on hard-bottom (not sand) and medium-to-high relief rocky habitat. With their morphologically complex forms, corals can enhance the relief and complexity of physical habitat (Whitmire and Clarke 2007), although the literature remains divided on whether West Coast deep sea corals serve to aggregate fish (Etnoyer and Morgan 2005, Auster 2005, Tissot et al. 2006).

Marliave and co-authors (2009) found quillback rockfish (*S. maliger*) using colonies of cloud sponges (*Aphrocallistes vastus*) as nursery habitat in southern British Columbia's coastal waters, which are within the northern extent of the CCE. U.S. West Coast studies of the effects of trawling on benthic invertebrate populations and associated fish assemblages have found variations between trawled and untrawled areas (Engel and Kvitek 1998, Pirtle 2005, Hixon and Tissot 2007, Lindholm et al 2009). Interestingly, a recent California study found the greatest detrimental effects of trawl gear used in California flatfish fisheries came from the trawl doors, with more quickly recoverable effects from the small footropes pulled between those doors (Lindholm et al. 2013). Similarly, Hannah et al. (in press) found that technical modifications to shrimp trawl footropes used off Oregon could reduce trawl disturbance of benthic macroinvertebrates.

Mary Yoklavich, NMFS SWFSC entering Delta submersible for dive off San Nicholas Island, California. Photo credit: NOAA

3.3.4 Human Effects on Council-Managed Species' Habitat

The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Each of the Council's four FMPs has defined EFH for FMP species. Taken together, EFH of Council-managed species ranges from the salmon streams of Idaho to the outer boundary of the U.S. EEZ. Figure 3.3.3 shows salmon and groundfish EFH, which together encompass a wide variety of terrestrial, coastal, and marine habitats. EFH for Council-managed species also ranges from the near-surface waters used by CPS and HMS, through the mid-water domain of salmon and some groundfish species, down to the diverse bottom habitats used by many groundfish species. As discussed earlier, this FEP's designated geographic range is the West Coast EEZ. Therefore, this section will address the effects of human activities on CCE habitat within the EEZ. Extensive discussions of the effects of human activities on the freshwater habitat of Pacific salmon may be found in the habitat conservation plans for threatened and endangered salmon and steelhead (*O. mykiss*) managed under the ESA (http://www.nwr.noaa.gov/Salmon-Habitat/Habitat-Conservation-Plans/Index.cfm).

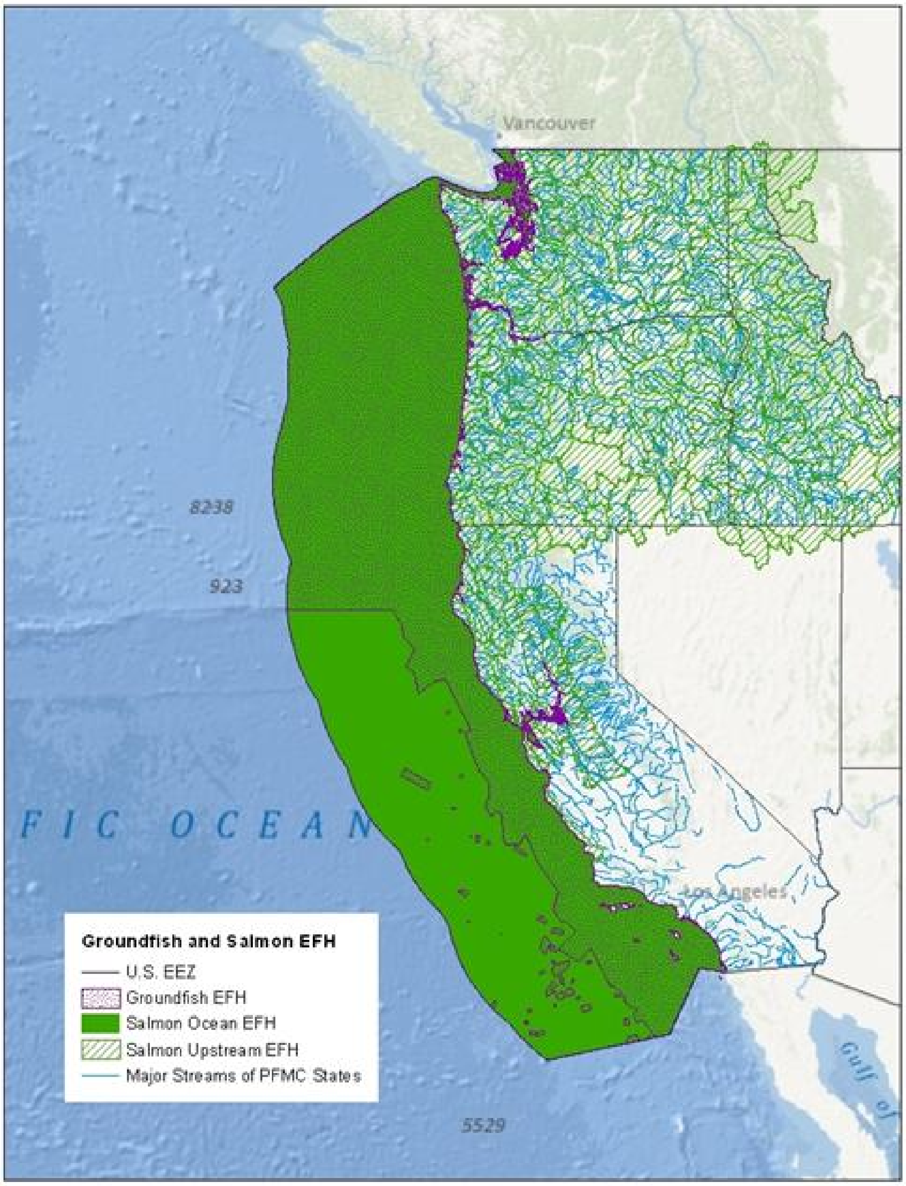


Figure 3.3.6: Groundfish and Salmon EFH of the West Coast

Humans have a variety of uses for the marine waters and substrate of the CCE, from direct uses like fishing, shipping, submarine cables, mining, recreation, or military maneuvers, to indirect uses like pollution and waste assimilation, oxygen-production, or nutrient cycling. The Council has direct responsibility for the effects of Council-managed fisheries on the EFH of FMP species. The Council is also required to comment upon and make recommendations on activities it views as likely to "substantially affect the habitat, including essential fish habitat" of anadromous species (salmon) under its authority. For all other species' EFH, the Council *may* make comments and recommendations. [16 U.S.C. §1855.] Federal regulations to implement the MSA's requirements for EFH at 50 CFR 600.815(a)(7) also regard human activities that may affect species that are the prey of FMP species as having potential effects on EFH functionality. While prey species are not considered habitat, the availability of prey species is considered a component of EFH, similar to temperature, water quality, or sediment type. The loss of prey species within EFH may affect the ability of a managed species to use that EFH as feeding habitat – just as, for example, significant shifts in water quality may affect the ability of a managed species to use an EFH area as feeding habitat.

Carcasses of coho salmon blocked by a barrier culvert.
Photo credit: WDFW

3.3.4.1 Fishing Activities that May Affect Habitat

In addition to describing and identifying EFH, FMPs must "minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage conservation and enhancement of such habitat" [16 U.S.C. §1853]. The review of fishing effects on bottom habitat generally focuses on occurrences of fishing gear coming into contact with the sea floor, or with rocks or living structures attached to the sea floor. The review of fishing effects on pelagic habitat generally focuses on occurrences when fishing gear is lost at sea, or when fishing activities, including the discarding of bycatch and offal at sea, affect where prey is available in the water column. For bottom habitat, the Groundfish FMP, which includes gear and fisheries that may come into contact with the sea bottom, has the most detailed and restrictive EFH protections of the Council's four FMPs. In large portions of the EEZ, the use of bottom trawl gear or other bottom tending gear (for any species or fishery) is prohibited – see Figure 3.1.5.

3.3.4.2 Non-Fishing Activities that May Affect Habitat

The Council has reviewed the non-fishing activities that may affect the EFH of its FMP species under each of its FMPs. These reviews are not limited to ocean habitat and often consider effects of non-fishing activities within state and freshwater habitats, particularly for species in the salmon FMP. Using information from the four FMPs, Table 3.3.1 aggregates non-fishing activities that may negatively affect CCE species' EFH.

Table 3.3.1 Non-Fishing Human Activities that May Negatively Affect EFH for One or More Council-Managed Species

Coastal or Marine Habitat Activities	Freshwater or Land-Based Habitat Activities
Alternative Offshore Energy Development Artificial Propagation of Fish and Shellfish Climate Change and Ocean Acidification Desalination Dredging and Dredged Spoil Disposal Estuarine Alteration Habitat Restoration Projects Introduction/Spread of Nonnative Species Military Exercises Offshore Mineral Mining Offshore Oil and Gas Drilling and Liquefied Natural Gas Projects Over-Water Structures Pile Driving Power Plant Intakes Sand and Gravel Mining Shipping Traffic and Ocean-based Pollution Vessel Operation Wastewater/Pollutant Discharge	Agriculture Artificial Propagation of Fish and Shellfish Bank Stabilization Beaver removal and Habitat Alteration Climate Change and Ocean Acidification Construction/Urbanization Culvert Construction Desalination Dam Construction/Operation Dredging and Dredged Spoil Disposal Estuarine Alteration Flood Control Maintenance Forestry Grazing Habitat Restoration Projects Irrigation/Water Management Military Exercises Mineral Mining Introduction/Spread of Nonnative Species Pesticide Use Road Building and Maintenance Sand and Gravel Mining Vessel Operation Wastewater/Pollutant Discharge Wetland and Floodplain Alteration Woody Debris/ Structure Removal

Federal agencies are required to consult with NOAA when undertaking or permitting activities that may have adverse effects on EFH. While the Council does not have the staff or committee capacity to comment on every action that may affect EFH, it often uses its Habitat Committee to provide initial reviews of large-scale non-fishing projects of particular interest or concern to the Council. Taken together, the projects that particularly attract the Council's notice tend to be large-scale energy projects that have the potential to result in the installation of man-made structures within areas designated as EFH, or any other land-based activities or planning processes that the Council believes may result in a significant loss of freshwater habitat or of the flow of freshwater itself within West Coast salmon streams. Some recent examples of non-fishing projects that have sparked Council review and comment have been:

- An Army Corps of Engineers policy on removing vegetation adjacent to its levees (2012)
- The U.S. Department of the Interior's management of water flow within the Klamath River and the adequacy of flow available for migrating Chinook salmon (2012)
- An Army Corps of Engineers policy on removing vegetation adjacent to its levees (2011)
- The Olympic Coast NMS' management plan review process (2011)
- The U.S. Bureau of Reclamation's draft Environmental Impact Statement on the potential removal of four dams on the Klamath River (2011)
- The U.S. Bureau of Reclamation's implementation of the Central Valley Project Improvement Act and the effects of that project on water flow within affected streams (2010)

- NOAA's engagement in Pacific salmon restoration within the Columba River Basin and the Biological Opinion for the Federal Columbia River Power System (2010)
- The potential effects of a Federal Energy Regulatory Commission permitting process for the Reedsport Ocean Power Technologies Wave Park on Council-managed species (2010)
- The U.S. Bureau of Reclamation's implementation of the Central Valley Project Improvement Act and the effects of that project on California's Central Valley salmon stocks (2010)
- The U.S. Bureau of Reclamation's consideration of the Council's EFH recommendations in its implementation of the Central Valley Project and State Water Project and the effects of those projects on Council-managed salmon stocks (2009)
- A U.S. Minerals Management Service proposal to lease areas off the outer continental shelf for alternative energy testing sites and the effects of that proposal on Council-managed species, fisheries, and EFH (2008)

In addition to and as partial mitigation for the various human activities that have the potential to negatively affect habitat, government agencies from small municipalities to the Federal government have implemented a variety of MPAs coastwide. NOAA and the Council's large-scale MPAs – the EFH conservation areas and the National Marine Sanctuaries – appeared earlier in the FEP at Figure 3.1.5. Below, Figures 3.3.7 through 3.3.11 illustrate some of the many nearshore West Coast MPAs under state, county, or local jurisdiction. More detailed maps and MPA information are available in the Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat Report to the Pacific Fishery Management Council (EFHRC 2012).

Washington State has a variety of MPAs with mixed levels of protection for marine habitats and species, managed under the authorities of its different natural resource agencies: Department of Fish and Wildlife, Department of Natural Resources, and Department of Ecology. Counties in Washington have county-specific MPAs, and the University of Washington works with the state and counties in several research reserves. Many of Washington's MPAs are concentrated in Puget Sound and on the southern portion of the outer Washington Coast, near Willapa Bay. Figure 3.3.7 shows some of Washington's nearshore MPAs, highlighting those in northern Puget Sound.

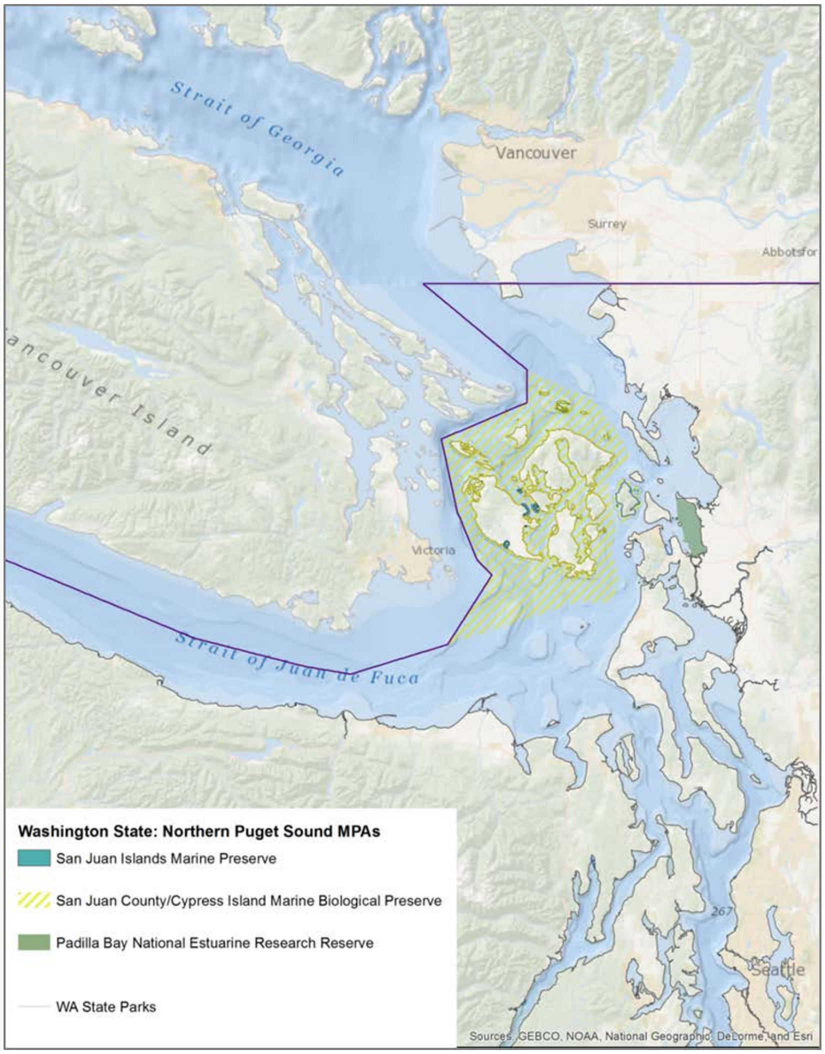


Figure 3.3.7: MPAs of Northern Puget Sound, WA

The largest MPAs in Oregon's state waters are two adjacent sites south of Port Orford, known together as the Redfish Rocks Marine Reserve and MPA – see Figure 3.3.8. No extractive activities are permitted within the marine reserve; within the MPA, the only permitted extractive activities are troll salmon fishing and crab fishing. These sites were proposed by the Port Orford Ocean Resource Team, a non-profit organization directed by fishermen and with a mission to support long-term sustainable fisheries in the Port Orford area. Developed locally, the Redfish Rocks sites were implemented through state legislation, first effective in 2009.

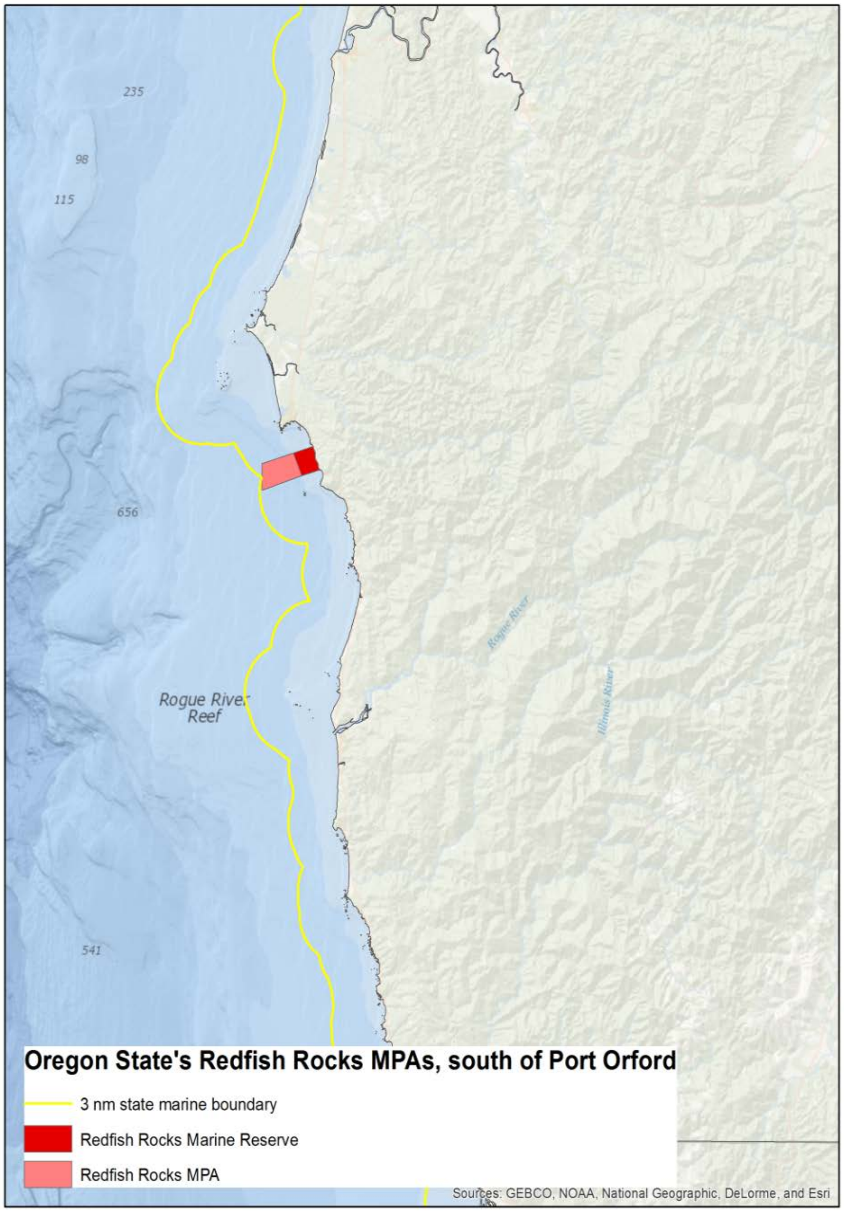


Figure 3.3.8: Redfish Rocks MPAs of southern Oregon

California has 124 MPAs along the entire length of the state's coast, from the Pyramid Point State Marine Conservation Area at the state border with Oregon to the Tijuana River Mouth State Marine Conservation Area at the U.S. border with Mexico. MPA designations in California include State Marine Reserves, State Marine Conservation Areas and State Marine Parks; the level of protection from extractive use varies by designation from full protection to allowance of limited commercial and/or recreational use. California's approach to fisheries management within state waters and integrated with its participation in the Council process is described, including the legislation behind its MPA designation process, in Section 3.5.2.5 of the FEP. As discussed in that section, 2013 marks the 15th anniversary of the state's Marine Life Protection Act (MLPA), which, among other things, directed the state to develop a coherent system of MPAs. Figures 3.3.9 through 3.3.11 show California's MPAs, from north to south. Figure 3.3.11 focuses on the Channel Islands in the Southern California Bight area, illustrating a complex combination of state and Federal MPAs designed to meet the Federal mandates under the NMSA and MSA, and state mandates under the MLPA.

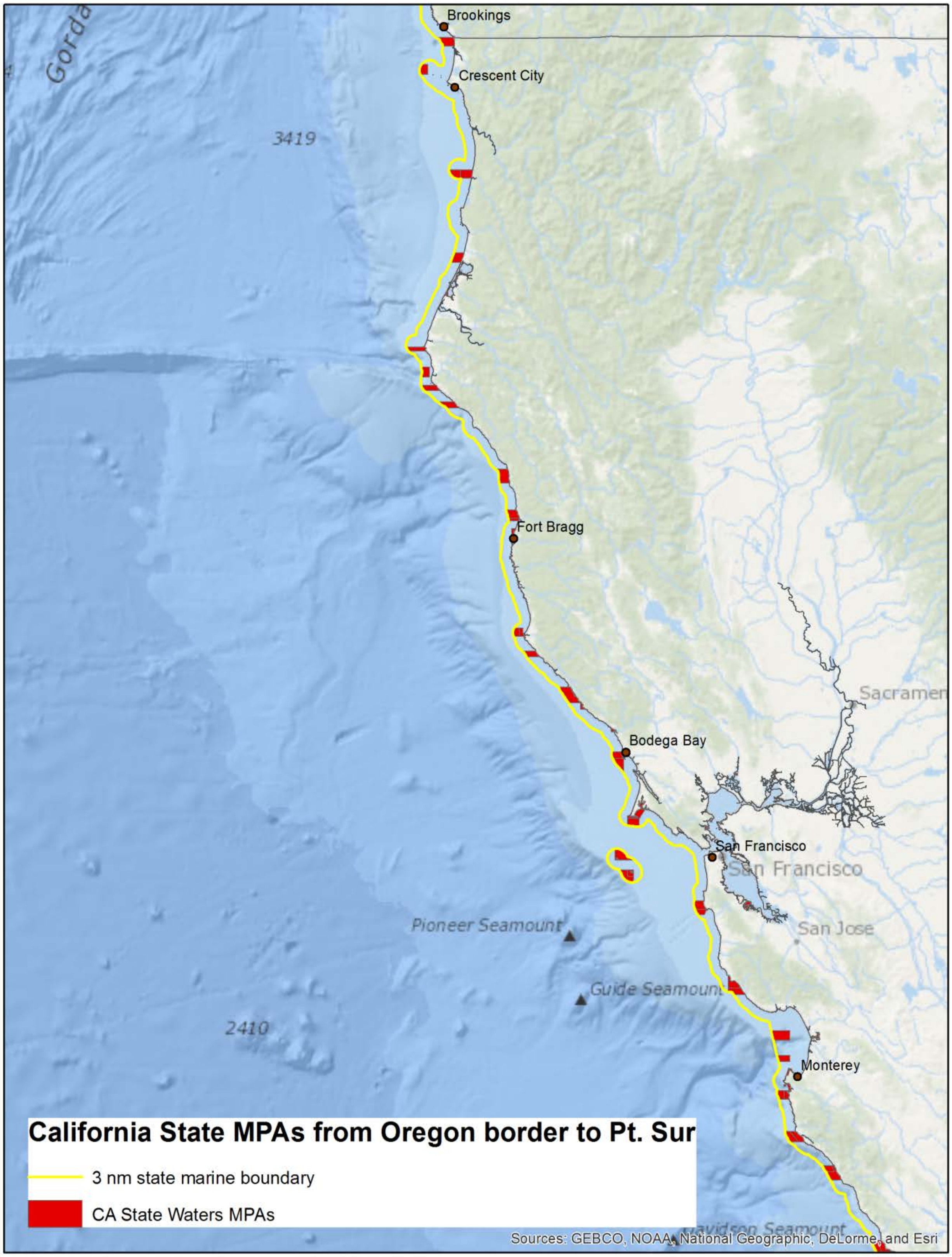
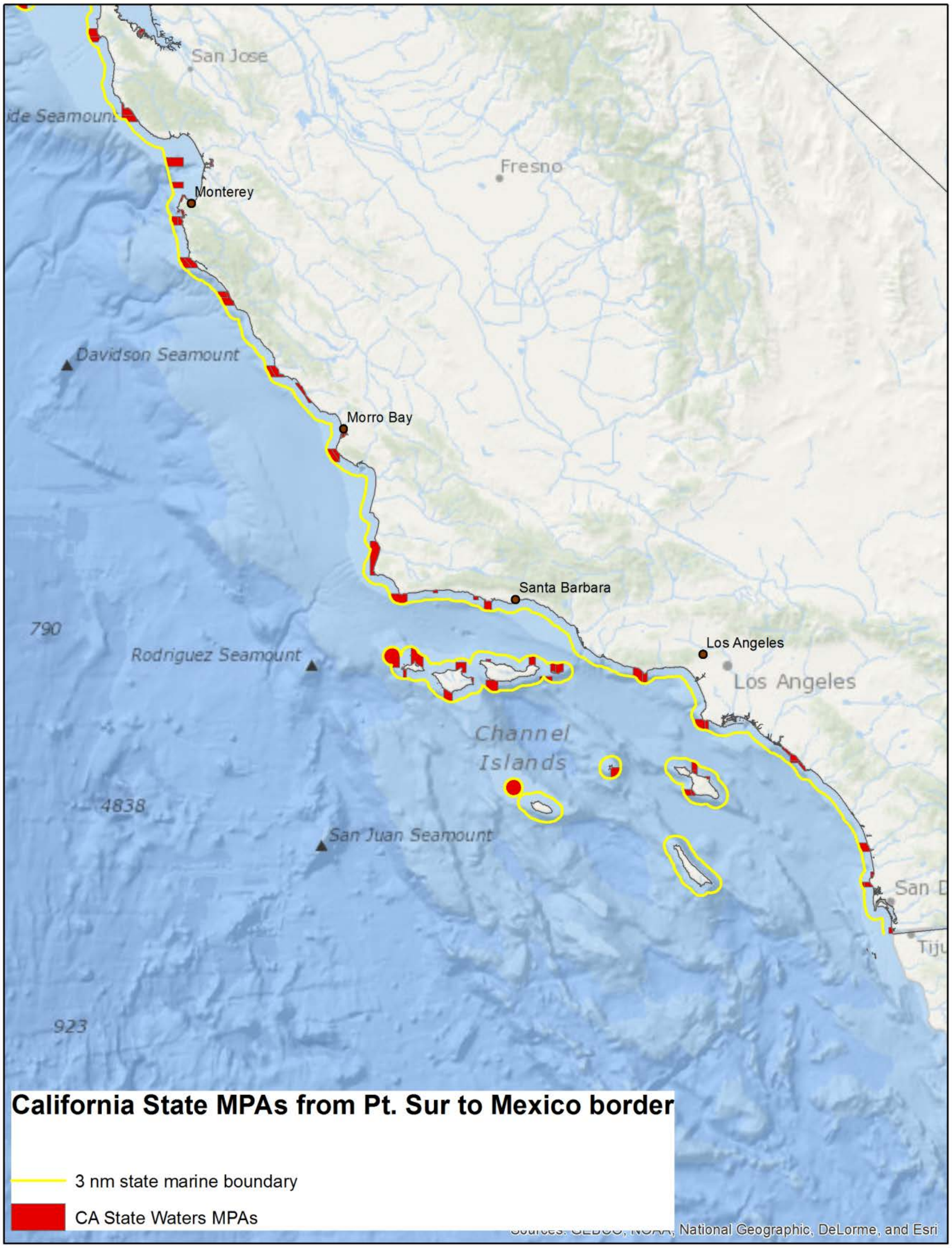


Figure 3.3.9: State MPAs of Northern California



Sources: GEBCO, NOAA, National Geographic, DeLorme, and Esri

Figure 3.3.10: State MPAs of Southern California

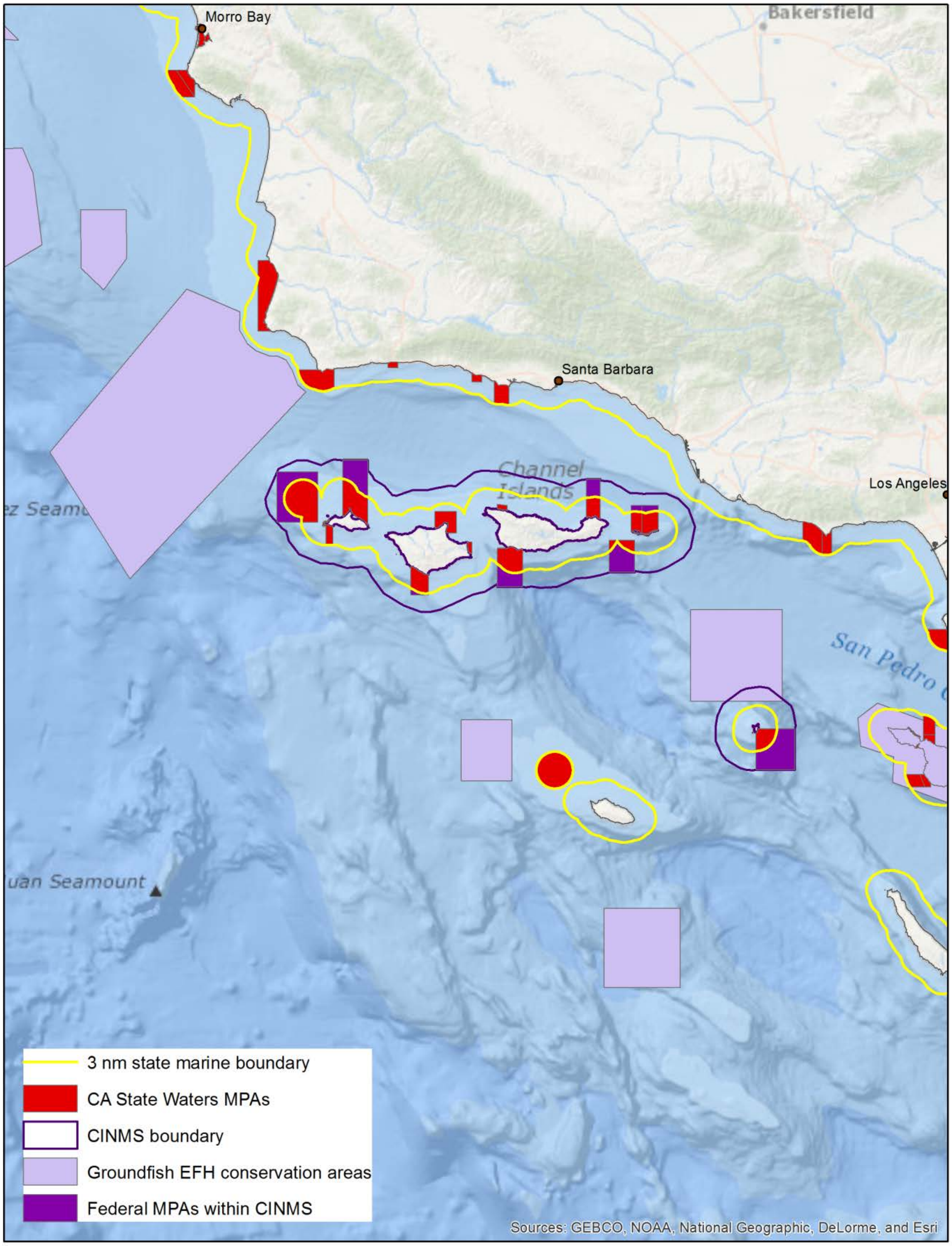


Figure 3.3.11: State and Federal marine management areas of the Southern California Bight

3.4 Fisheries of the CCE

Fisheries for a broad range of species occur within the CCE, and have since humans first inhabited North America's western coastal lands. The Council's four FMPs and analysis document for actions taken under those FMPs provide details on the fisheries for managed stocks, including: gear used, landings locations, season timing and duration, prohibitions, technical challenges, and communities that dominate landings. This section of the FEP is intended to look at all of the FMP fisheries together, minimizing duplication of descriptions in the Council's FMPs. This section provides a background on historic fishing in the EEZ and discusses cumulative CCE fisheries harvest, West Coast fisheries capacity levels, and the cumulative socio-economic effects of Council-generated fishery management measures on fishing communities.

3.4.1 Historical CCE Fisheries

The perception of the effects of fisheries exploitation on the environment has varied over time. Freon et al. (2005; see also MacCall et al. 2009) have defined a set of time periods that help frame the history of exploitation and the accompanying evolution of associated science. The period prior to the 20th century is best described as the "inexhaustible" period, when conventional wisdom held that fisheries could not have an appreciable impact on the resources that they exploited. Prior to the 1900s, global landings were minimal relative to contemporary catches. During the industrial exploitation period of 1900-1950, global landings for some species increased, and then often decreased dramatically. The rise and fall of the California sardine fishery is a classic example of such industrial fisheries, and the collapses that followed led to what might be considered the conventional management period of 1950-1975. That period saw the development of most of the basic foundations of contemporary fisheries science, including functional relationships addressing productivity, such as fisheries oceanography, spawner/recruit relationships, as well as population dynamics models such as surplus production models and virtual population analysis that allow hypothesis testing on the interactions of functional aspects and sustainability of populations to exploitation. The conventional management period also saw some of the greatest development of industrial fisheries, coupled with the application of the newly-developed science of fisheries management. However, the conventional management period also saw the world's largest fisheries failure, the crash of the Peruvian anchoveta (*Engraulis ringens*) fishery, which had been responsible for up to one quarter of global fisheries landings at the time. The anchoveta fishery collapse had tremendous ecosystem consequences (Jahncke et al. 1998) and led to what Freon described next as the "doubt" period from the mid-1970s through the mid-1990s. This period recognized the limitations and constraints of the sciences, and saw renewed emphasis on the role of climate as a driver of population and fishery dynamics. Based on the Freon et al. suggestion of major eras of

Makah Tribe members at Neah Bay, WA, 1890.
Photo credit: U.S. National Archives

fisheries management, the ecosystem-based management period has emerged from the mid-1990s to the present. This period is characterized by a gradual and wide recognition that ecosystem factors are important to marine resource science and management, but most management actions tend to be in an assemblage-based context that integrates single-species assessment model results. While a single-species focus in stock assessment still underpins U.S. fisheries population management, ecosystem-based assessment modeling frameworks are gaining influence (Lehody et al. 2008, Kaplan et al. 2012) providing the ability to quantify changes in ecosystems, particularly as they relate to fishery exploitation.

The marine and nearshore ecosystems of the CCE have been exploited at industrial levels for well over two centuries, and supported some of the most populous and culturally sophisticated Native American communities for millennia (McEvoy 1986, Trosper 2003). Figure 3.4.1 (from Field and Francis 2006) presents an accounting of the history of the most substantial marine resource removals over the past two centuries, illustrating both the magnitude of removals as well as the sequential nature of the development of the major fisheries in the region. European-era exploitation in this ecosystem began with the rapid conversion of the energy at the top of the food chain into commodities. The great whales, fur seals, elephant seals, sea lions, otters, and many seabird colonies were transformed into oil, pelts, and food. Exploitation continued with the depletion of many salmon populations due to fishing and the massive alteration or elimination of their freshwater habitat. Next arose the classic tale of the rise and fall of the California sardine fishery, and subsequent fisheries for anchovy, mackerel, herring, and squid (*Doryteuthis opalescens*). Throughout the past two centuries, some fisheries grew unsustainably fast, rapidly depleting resources (typically low turnover resources) in short pulses, including fisheries for: abalone, black and white seabass, and various elasmobranchs such as basking, soupfin, and dogfish (*Squalus acanthias*) sharks. Fisheries for many groundfish, including Pacific and California halibuts, sablefish, lingcod, Pacific ocean perch (*S. alutus*), and other rockfish seemed to be sustainable at low levels prior to the development of modern industrial fisheries during the 1950s, after which high fishing effort depleted many stocks below sustainable levels.

The large-scale removals of marine mammal populations began in the late 18th and early 19th century, at the scale of the entire North Pacific (Scammon 1874, Ogden 1933). Although New England whalers had been operating in the North Pacific since the late 1700s, they initially avoided coastal waters of the CCE due to the "savage disposition" of California gray whales (*Eschrischtius robustus*, Gordon 1987). However, whalers had been targeting CCE whale populations, and by the 1850s as many as a dozen shore-based whaling stations were spread out between Crescent City and San Diego, targeting a mix of gray, humpback, and other whales encountered in coastal waters. Gray whales were subsequently harvested to near extinction in the lagoons of Baja California by the 1870s, and the first pulse of coastal whaling ended shortly thereafter. Similarly, exploitation of sea otters, fur seals and elephant seals began during the late 19th century, with all of these animals taken for a mix of pelts, food, and oil. Many of these populations were commercially extinct by the late 1800s, during which time sea lions, harbor seals, and seabirds were also exploited. For example, the harvest of seabird eggs on the Farallon Islands and elsewhere was as great as 14 million eggs between the mid-1800s and 1900, with the result that

Puget Sound halibut schooner crew and catch, 1888.
Photo credit: NOAA Historic Fisheries Collection

the common murre population on the Farallons may have declined from nearly half a million birds to less than 5,000 by the 1920s (Ainley and Lewis 1974).

Both shoreside and at-sea whaling operations were widespread throughout the North Pacific during the second wave of whaling in the 1910s and 1920s, with catches of all species diminishing rapidly in the early 1920s (Tonnessen and Johnsen 1982, Estes et al. 2006). It is interesting to consider that these removals occurred in concert with the major expansion of the California sardine fishery, since stomach contents data from whales caught off California show humpback, as well as fin and sei whales, fed primarily on sardines, as well as euphausiids, anchovies, herring, and other prey (Clapham et al. 1997). If whales historically represented a substantial fraction of sardine (and other coastal pelagic) mortality, the decline of whale and other predator populations (e.g., fur seals, sea lions, tunas) might have led to a greater than average production or availability of sardines, contributing to that fishery's expansion throughout the early 1920s and the early 1930s. The observation that current abundance of sardines and other CPS is far lower than the historical abundance could be, in part, a function of the differences in predation mortality between these periods. Populations of most marine mammals in the CCE have recovered to, with some perhaps even exceeding, historical levels of abundance in recent decades. Appreciation for the historical impacts of whaling and sealing, and the potential cascading impacts to marine ecosystems, has grown as marine mammal populations have recovered (NRC 1996, Springer et al. 2003, Estes et al. 2006), and a basic understanding of the relative significance of both contemporary and historical trends and abundance of predators should be an integral component of an ecosystem approach to managing CCE fisheries.

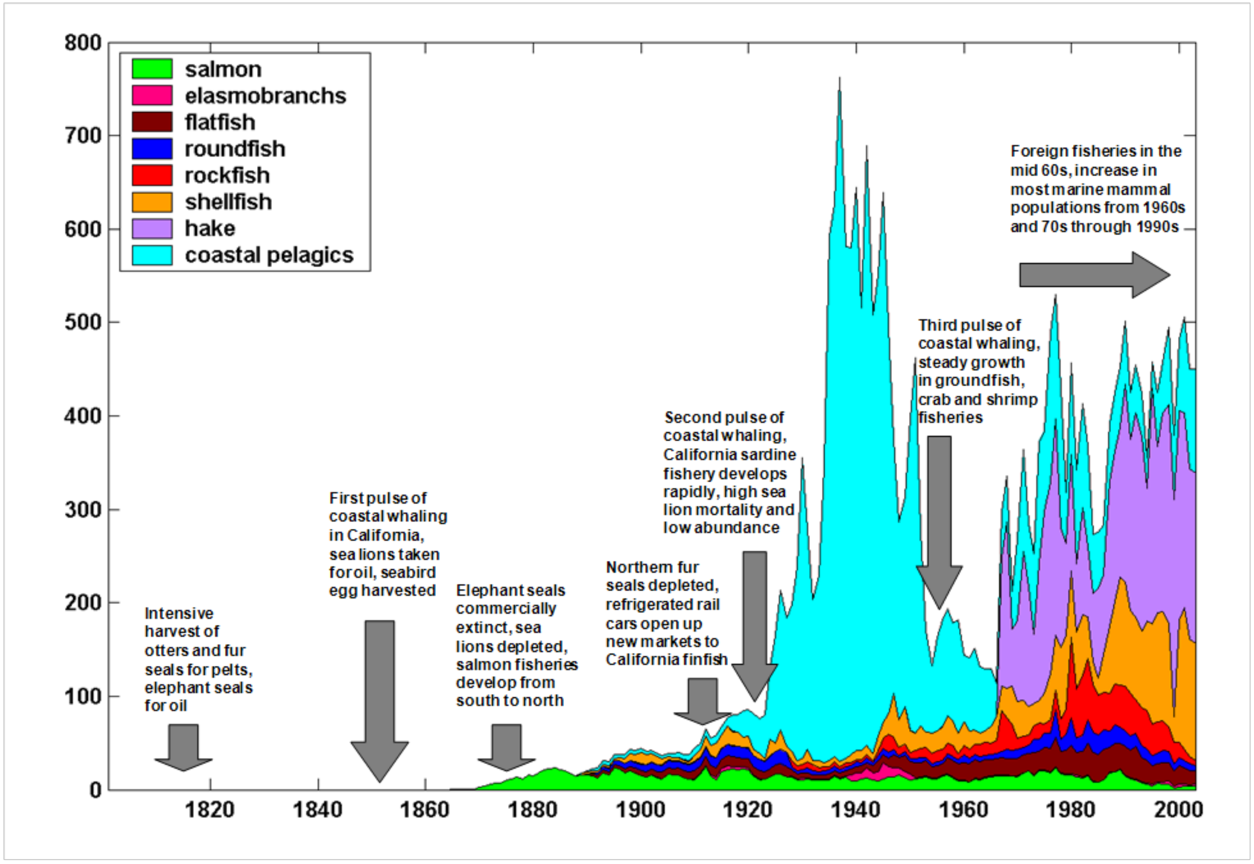


Figure 3.4.1: Major fisheries removals and developments within the U.S. portion of the CCE over the past two centuries

Salmon fishing represented the foundation of the livelihoods of native communities for thousands of years prior to West Coast settlement by Europeans, and salmon fishing preceded sardine fishing as the first major finfish to be exploited throughout CCE (both inland and offshore) waters (McEvoy 1986, Lyman 1988). Unsustainable salmon removals likely began with the rapid late 19th century development of the Sacramento river salmon fisheries, spreading rapidly northwards as Sacramento fisheries were overexploited (McEvoy 1986, 1996). Fishing and canning operations quickly developed on the Columbia River, where the salmon fishery grew from just tens of thousands of pounds in 1866 to over 20 million pounds by 1876 and over 40 million by 1885 (Cobb 1930). Salmon have continued to be among the most valued and vulnerable fisheries in the CCE with the associated fisheries management challenges and habitat issues remaining the subject of continual controversy. As the bridge between freshwater, estuarine, and marine environments, salmon have evolved complex population structures and life histories to cope with the variability in each of these environments. Prior to western contact, Pacific salmon had evolved complex meta-population structures, and the physical template provided by high quality freshwater habitat is thought to have provided the insurance needed for such population structures to persist under highly variable ocean conditions (Nickelson and Lawson 1998). Ongoing degradation of freshwater and estuarine habitats has contributed to a decline in the diversity of populations and life history types, increasing the vulnerability of both the remaining populations and the associated fisheries to climate variability (Lindley et al. 2009).

Of the major historical fisheries in the CCE, probably the most noteworthy is the Pacific sardine fishery, immortalized by John Steinbeck in *Cannery Row*. Although sardines had been fished in California waters since the mid-1800s, markets for canned sardines (and later highly lucrative markets for fishmeal and fertilizer) did not develop until World War I, largely in response to declining salmon canning opportunities in California. Sardine fishing rapidly expanded throughout the coast, from British Columbia to Southern California, and coastwide landings grew from roughly 70,000 metric tons per year in 1920 to a peak of over 700,000 metric tons in 1936. Both the sardine population and the fishery began to decline sharply shortly after World War II, with the sardines disappearing sequentially from north to south, leading to debates that continue to this day regarding the relative contributions of fishing and environment with respect to the interactions between fisheries and climate more generally. By the time the fishery was closed in 1968, the sardine population had declined by several orders of magnitude, and fluctuations were noted in other CPS

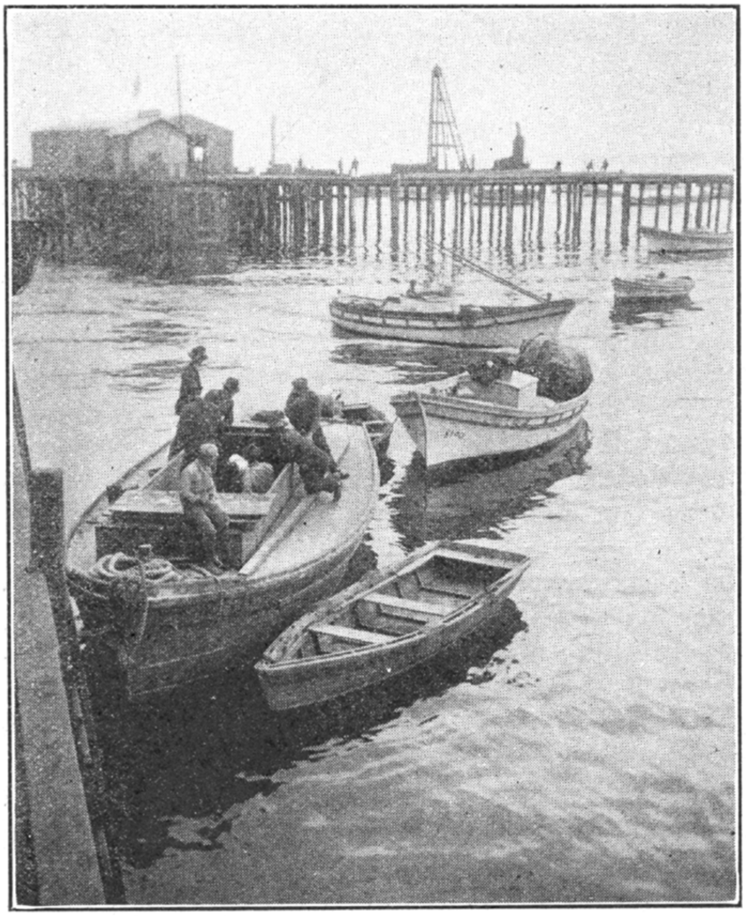


FIG. 7. Flat-bottomed lighter, skiff and launch with lampara piled in the stern. The second launch (center background) is a salmon troller with short mast and outrigger "poles." Photograph by W. L. Scofield, Monterey, July, 1919.

Image credit: Online archive of California, Division of Fish and Game California, Bulletin of Fish #19

fisheries as well. For example, the Pacific mackerel (*Scomber japonicus*) fishery was closed in 1972 as a result of declines in that population (which reversed in the late 1970s), while the anchovy fishery grew in the 1960s and 1970s, apparently in response to increases in abundance. Decades of studies devoted to understanding the proximate causes of the sardine decline, and comparable declines and dynamics in other ecosystems, have lead researchers to appreciate the role of climate in driving variability in the abundance and productivity of CPS, and it is now generally accepted that the sardine fishery exacerbated what would have likely been a natural decline in the abundance of sardine in the 1950s and 1960s (Baumgartner 1992, MacCall 1996, Chavez et al. 2003, Checkley et al. 2009). The recovery of Pacific sardines in the 1980s and 1990s was generally associated with changes in environmental conditions, resulting in a resurgent fishery as well as a more conservative management regime. However, uncertainties remain with respect to understanding the principle drivers of sardine productivity and the optimal management measures for balancing conservation needs with fisheries.

Pacific halibut and other groundfish were harvested by coastal native cultures throughout the CCE region, and soon became a staple of early explorers and traders throughout the Northeast Pacific. By 1892, coastwide catches of halibut and other flatfish, cod, rockfish, and sablefish combined were over 10 million pounds per year, with the majority taken from coastal inland waters of San Francisco Bay, the Columbia River estuary, and Puget Sound. Through the early 20th century, longline fisheries for Pacific halibut and sablefish expanded, as did paranzella (two-boat trawl) fisheries that had begun as early as 1876 in San Francisco. The introduction of otter trawls to West Coast fisheries following World War I was associated with a gradual expansion of the trawl fleet northwards, and by the late 1930s the center of West Coast trawling had shifted from San Francisco to Eureka (Scofield 1948). A sharp increase in effort and landings occurred during World War II, spurred on by both a need for inexpensive protein from flatfish and rockfish (much of which was ordered by the U.S. Army), and engine lubricant from the livers of dogfish, soupfin, and basking sharks. Demand for groundfish dipped slightly after the war, but trawlers kept busy as a market for mink food supplemented markets for fresh and frozen fish. The fishery grew steadily in the 1950s and 1960s following the postwar dip, and diversified as fisheries for Dungeness crab, pink shrimp (*Pandalus jordani*), and albacore tuna developed and expanded alongside existing fisheries for salmon and groundfish.

In the late 1960s through the 1980s massive fleets of Japanese, Russian, and Polish trawlers, many of them recent expatriates of declining whale fisheries, began intensively fishing the CCE's continental shelf and slope waters. The size and capacity of these trawlers stood in sharp contrast to the coastal fleets of trollers, draggers, and crab boats, and helped fuel

Southern California angler with 360 lb black sea bass
Photo credit: Phil Crawford family

the desire to nationalize marine resources and develop greater domestic fishing capacity. Senator Warren Magnuson captured the mood of the day, when he advised fishermen and scientists that “You have no time to form study committees. You have no time for biologically researching the animal. Your time must be spent going out there and catching fish… Let us not study our resources to death, let’s harvest them” (Magnuson 1968). As the growing conservation movement of that era drove passage of a plethora of environmental legislation in the early 1970s, environmental concerns soon matched the desire to nationalize marine resources. The Fishery Conservation and Management Act of 1976 (later reauthorized as the Magnuson-Stevens Fishery Conservation and Management Act, or MSA) ultimately included objectives that included both developing domestic fisheries as well as attaining sustainability as defined by the concept of MSY, although the latter was treated as a “target” in the 1976 Act, and has since evolved to represent a “limit” reference point.

3.4.2 Current Fisheries

3.4.2.1 Commercial Fisheries

West Coast commercial fisheries landings data from catches landed shoreside and at-sea are obtained from state fish tickets (landings receipts), contained within PSMFC’s Pacific Fisheries Information Network (PacFIN) database. Commercial landings do not include any fisheries’ biomass removals that may occur as bycatch in commercial fisheries, nor do they include recreational fisheries’ removals. Thus, while commercial landings data cannot tell us about the cumulative effects of West Coast fisheries on the CCE, they can tell us about how the fisheries function within the CCE: species groups targeted by fisheries, how the volume of landings compares with exvessel revenues from those landings, and levels of fishery participation by vessels operating off the U.S. West Coast. This section of the FEP considers 2000-2011 landings and ex-vessel revenues for U.S. West Coast commercial fisheries.

Commercial landings of all species for 2000-2011 ranged from a high near 546,000 mt in 2000 to a low of about 403,000 mt in 2003 to near (Fig. 3.4.2). Real exvessel revenues were generally increasing throughout the period (Fig. 3.4.2). Annual shoreside landings were dominated by CPS, mainly squid and sardine; by volume, CPS averaged 48 percent of total landings for the period. Groundfish followed CPS as a share of total landings, averaging 29 percent by volume for the period (Fig. 3.4.3). Dungeness crab accounted for the greatest share of shoreside exvessel revenues, an average of 31 percent for the period; groundfish had the next highest share at 17 percent (Fig. 3.4.4).

F/V Noah’s Ark. Photo credit: NOAA NWR

Pacific whiting dominated at-sea landings from 2000 through 2011, averaging about 99 percent of total volume and corresponding revenues. Of total whiting landings for the period, at-sea averaged about 60 percent by volume and revenue.

Figure 3.4.2: Total U.S. west coast landings (mt) and real exvessel revenues (2011$), 2000-2011

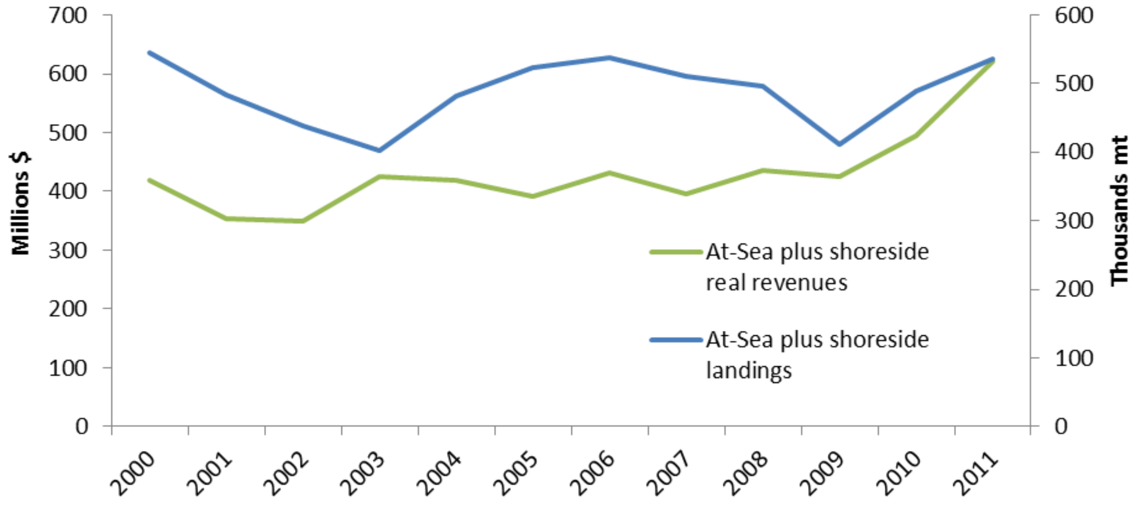
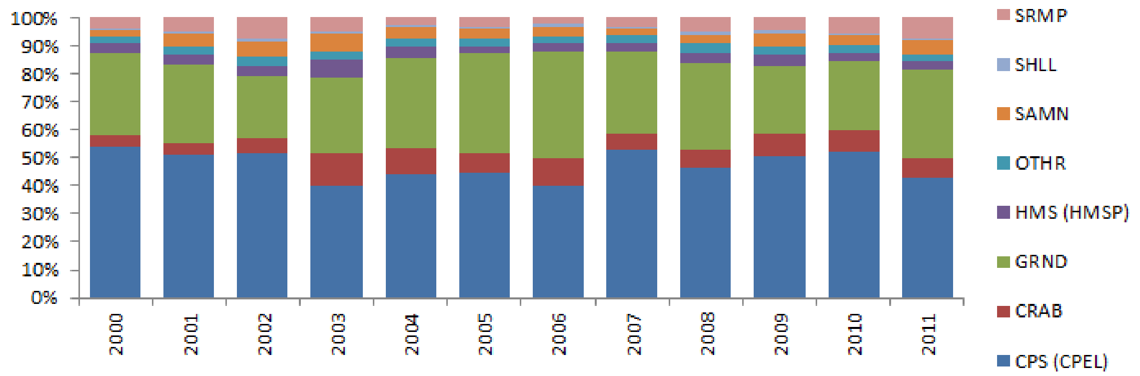


Figure 3.4.3: Percentage of total U.S. west coast commercial landings by PacFIN management group, 2000-2011.



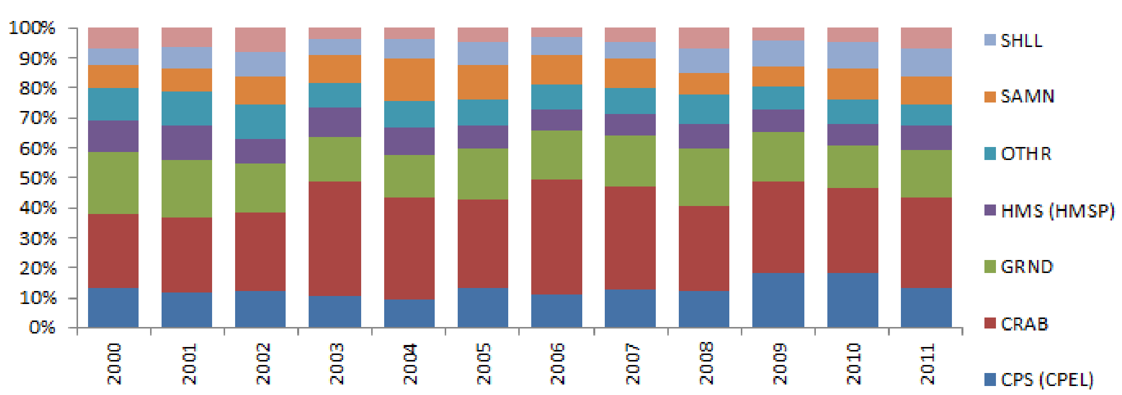


Figure 3.4.4: Percentage of total U.S. west coast exvessel revenues by PacFIN management group, 2000-2011.

U.S. West Coast commercial landings for 2000-2011 cover a wide range of species' trophic levels, ranging from 2.0 to 4.5 with an arithmetic mean and median of 3.6. Ranking the PacFIN management groups by their mean trophic levels (MTLs) from lowest to highest, shellfish are at the bottom, moving upward to shrimp, crab, CPS, other, groundfish, and salmon, with HMS at the top of the trophic scale. Based upon the species composition of the commercial landings, and trophic level measures for the individual species, the volume weighted MTL of the annual landings is shown in Figure 3.4.5. In 2001, the MTL was at its lowest level for the period, 3.27, and in 2006 it was at its highest level, 3.40. In the low MTL years, species from the lower half of the trophic scale, predominately CPS, are above average in quantities landed, while species in the upper half of the scale, mainly groundfish, salmon, and HMS are below average. For the high MTL years, the converse holds.

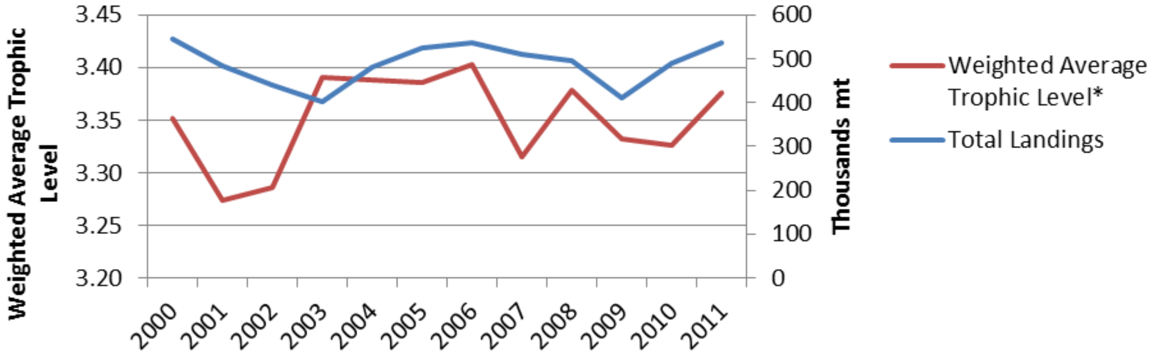


Figure 3.4.5: Total quantity (mt) and weighted average trophic level of U.S. west coast landings, 2000-2011.

In the Southern California port area, mainly San Pedro, Terminal Island, Port Hueneme, and Ventura accounted for the greatest share of landings volume by PacFIN port area over the 2000-2011 period. Ports along the northern Oregon coast, mainly Newport and Astoria, had the next highest share, followed by ports, primarily Chinook and Westport, in the Washington external marine port area (Fig. 3.4.6). CPS made up the significant bulk of the landings in Southern California while landings in the northern Oregon coast ports and in Washington external marine area consisted mainly of CPS, groundfish, and shrimp. Exvessel revenues were more evenly divided among port areas for the period, with Southern California (CPS and

HMS), the northern Oregon coast (crab, groundfish, and shrimp) and Washington internal and external marine areas (crab, groundfish, salmon and shellfish) being the major receivers of commercial fisheries revenue (Fig. 3.4.7).

Figure 3.4.6: Percent total of U.S. west coast landings by port area, 2000-2011

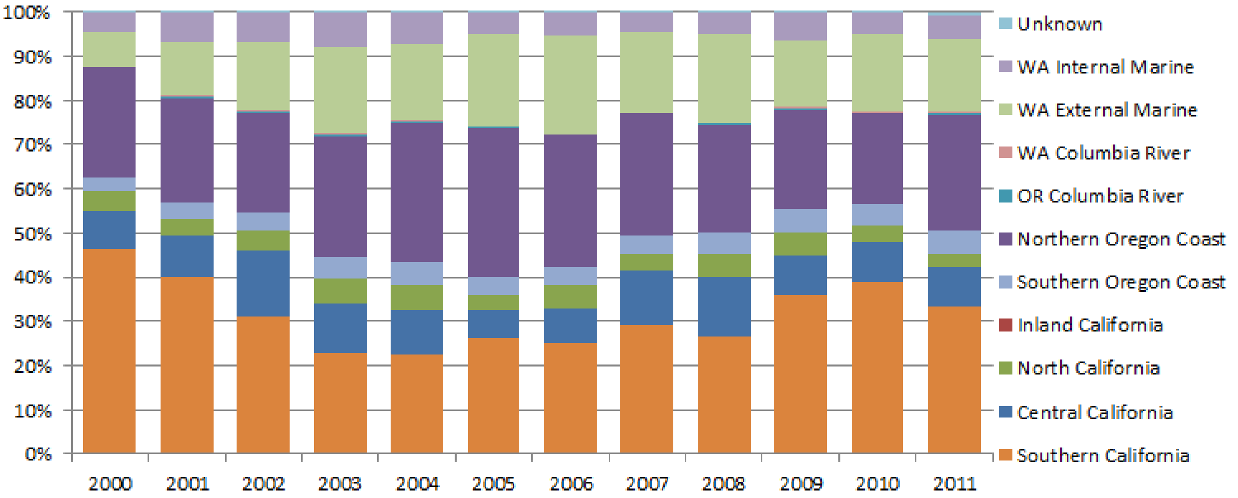
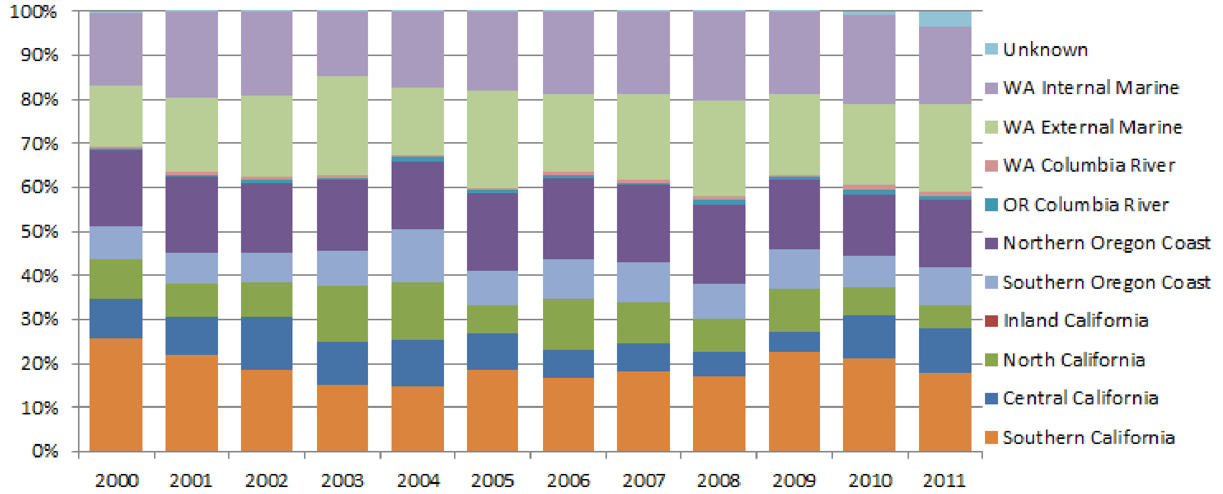


Figure 3.4.7: Percent total of U.S. west coast total exvessel revenue by port area



Based on the volume of shoreside landings, the greatest shares by PacFIN gear category were in the seine and midwater trawl categories (Fig. 3.4.8). Purse seine is the primary gear used in the high-volume CPS fisheries, while midwater trawl accounts for shoreside landings in the high-volume Pacific whiting fishery. The pot and trap gear category accounted for the greatest share of exvessel revenues over the period (Fig 3.4.9). Pots and traps are used to harvest relatively high-valued Dungeness crab, shrimp, prawns, lobster, and sablefish. Seine gear, based on the volume of CPS landings, also consistently accounted for a relatively high revenue share. The relatively high revenue share for the other known gear category can be mainly attributed to landings of high valued geoduck clams (*Panopea generosa*) harvested using dredge gear, which falls in the “other known gear” category.

Figure 3.4.8. Percent total U.S. west coast landings by gear category, 2000-2011.

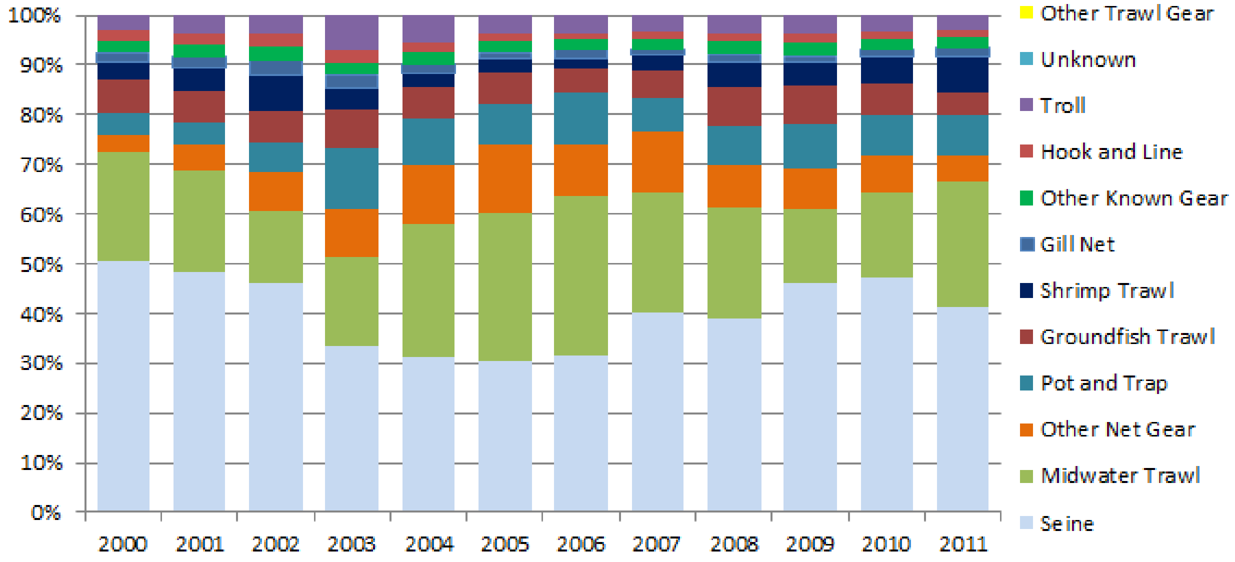


Figure 3.4.9: Percent total U.S. west coast exvessel revenues by gear category, 2000-2011.

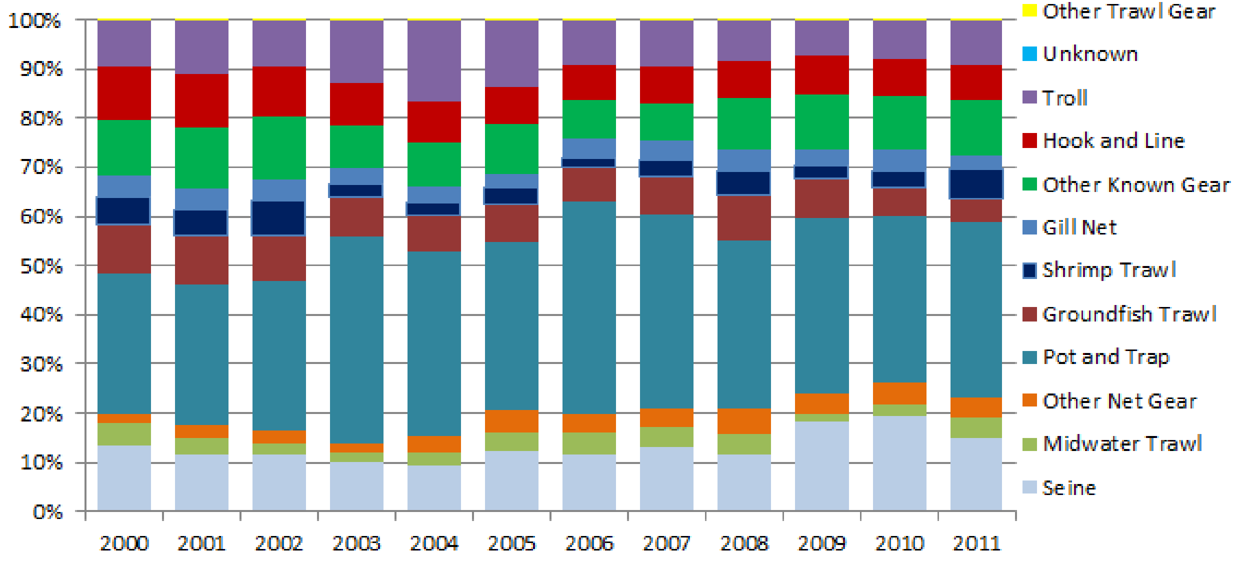
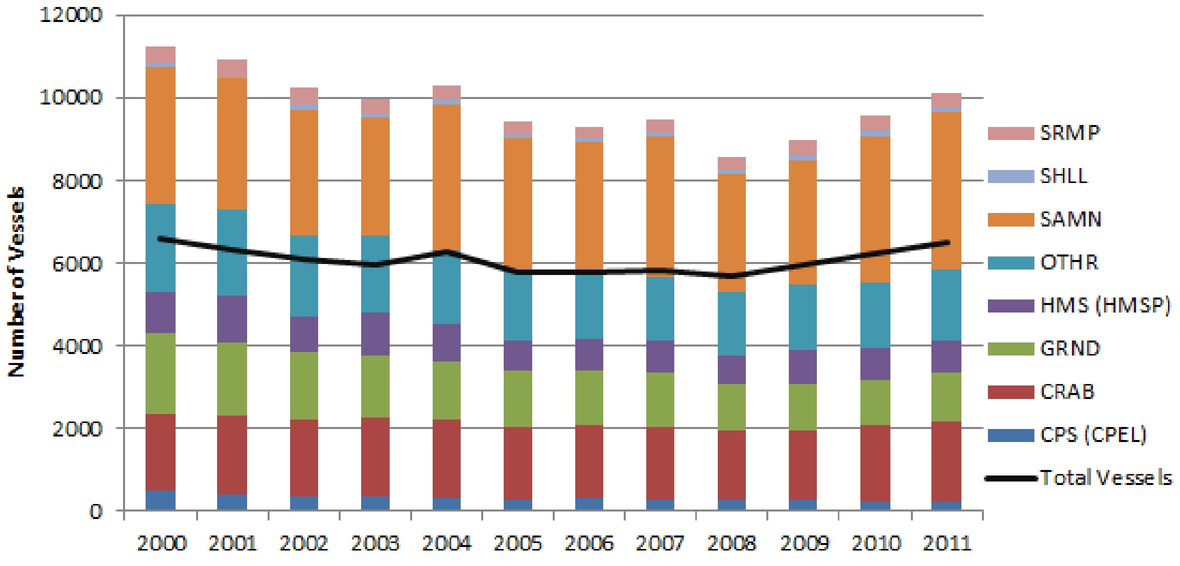


Figure 3.4.10: Total vessels with west coast landings and number with landings by management group, 2000-2011.



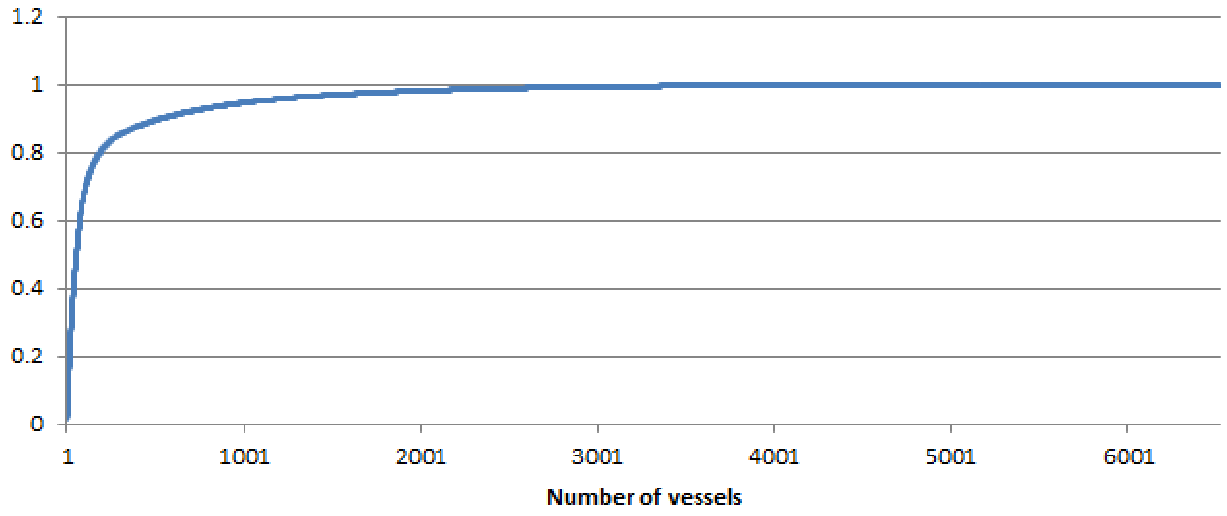
During the 2000-2011 period, the number of vessels that made shoreside landings in U.S. West Coast commercial fisheries remained fairly constant at around 6,000 annually (Fig. 3.4.10). Many of these vessels are capable of harvesting species in more than one management category, either using a single gear type (e.g. trawlers landing groundfish and shrimp) or multipurpose vessels that use different gear types (e.g. vessels landing: crab [pots] and groundfish [trawl]; crab [pots] and salmon [troll]). This multiplicity of fishing operations by vessels is indicated by the vessel totals in each management category shown in Figure 3.4.10. In all years, more vessels participated in salmon fisheries, which are comparatively unrestricted in terms of participation, than in any other management group. On the other hand, limited entry CPS fisheries with the highest annual landings over the period had relatively few participants.

In 2011, 6,523 vessels made at least one West Coast shoreside commercial landing of one pound or more. It is questionable how many of these vessels would be

F/V April. Photo credit: OCZMA

considered to be engaged in a significant business enterprise in the conventional sense. Assigning a reasonable criterion for distinguishing a significant fishing business enterprise is not within the scope of this FEP. Using a gross revenue criterion for example, of the 6,523 vessels only 5,128 had exvessel revenues in excess of $1,000. Nonetheless, Figure 3.4.11 presents the distribution of the 6,523 vessels according to their share of the total shoreside landings in 2011 and shows that 1,064 vessels, 16 percent of the total number of vessels with landings, accounted for more than 95 percent of the total harvest. This example, using the $1,000 exvessel revenue threshold, suggests that in 2011 there may have been far more vessels than necessary to harvest the total landings. This finding for 2011 must be tempered by the spatial-temporal scale and scope of West Coast commercial fisheries, which are subject to the vagaries of ecosystems and economic systems alike.

Figure 3.4.11: Cumulative vessel share of total shoreside landings, 2011.

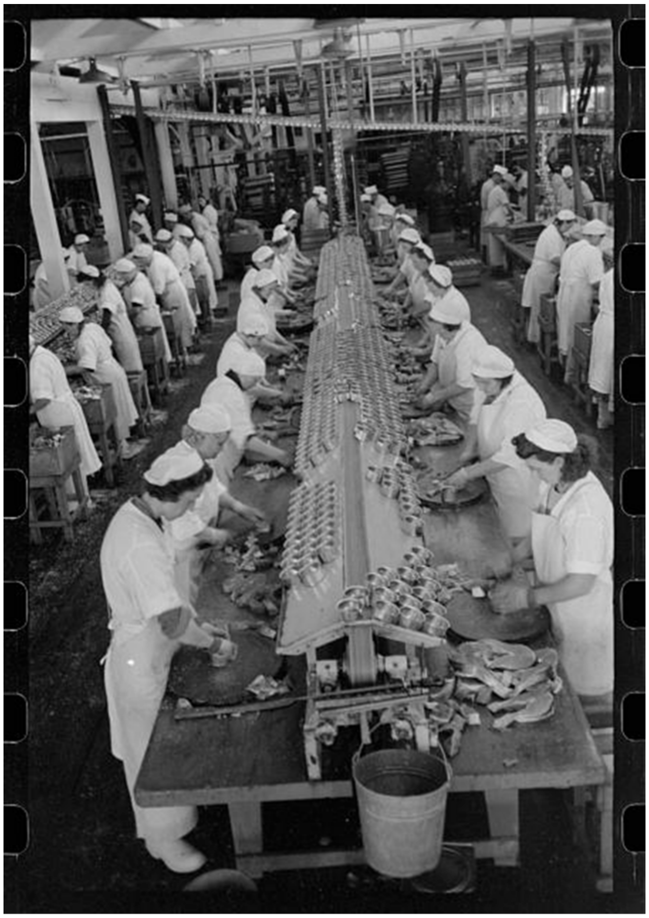


Hauling squid in Monterey Bay.
Photo credit: D.B. Pleschner & R. Price, California Wetfish Producers Association

3.4.2.2 Fish Receivers and Processors

West Coast fish processors and receivers process fish and shellfish in a wide variety of forms for sale in domestic and international markets. Most Council-managed species are processed on shore, although some species, such as Pacific whiting, may be processed at sea. Depending on the species and market preferences, fish may be sold live or processed into fresh, frozen, blast-frozen forms, canned or smoked, or converted to fish meal, oil, or surimi. Dungeness crab product, as an example, is sold live, or as fresh or frozen whole cooked crabs, as well as picked meat, legs and sections. Fish landed or otherwise caught in West Coast tribal fisheries for commercial sale are routed through similar processing chains to those used by the non-tribal fisheries. Tribal fisheries also land fish for personal and cultural uses, which are usually processed locally into fresh, frozen, smoked or canned products and are typically banned by tribal regulation from entering commercial markets.

Regulating the Buying, Processing, and Selling of Seafood


Packing salmon into cans at the Columbia River Packing Association, Astoria, Oregon, 1941.
Photo credit: Library of Congress

Delivery, purchase, and sale of fish are activities regulated primarily under state law, or when conducted on tribal lands, under tribal law. Federal rules can apply to certain activities as well. For example, those wishing to purchase fish harvested in the groundfish individual fishing quota program must be issued a first receiver site license from NMFS.

The first landing of fish from a vessel into a port or other place of delivery is the core activity regulated and monitored by the states and tribes. Each state and tribal government requires deliveries to be recorded on a marine fish receiving ticket, or "fish ticket," that records species landed, the amount landed in weight or numbers of fish, and the price paid for each species or market category. The fish tickets provide an official record of landings on the coast and can be used for other purposes such as the assessment of general and special taxes and fees on fish landings. Rules on the specific items needing to be reported and the timing of that reporting can differ by state and by fishery, but also show similarities. Contrasting Oregon and California, Oregon requires fish tickets to be forwarded to Oregon Department of Fish and Wildlife (ODFW) in paper form within five days or submitted electronically through the PSMFC West Coast E-Ticket system. In California, fish tickets are due at the local California Department of Fish and Wildlife (CDFW) office on the 16th and last day of the month, whichever is earlier, and electronic submission is not currently allowed.

Oregon and Washington regulate this system by licensing wholesale fish dealers to businesses that purchase fish directly from a vessel. A separate permit or license may be issued to fish buyers that represent a wholesale dealer or that purchase fish in a different location than the dealer's main operation. In

Washington, buyers on tribal lands are licensed by the tribal governments and may be dually licensed by the state. California has a similar system where the main license is referred to as a fish receiver's license. In all three states, it is possible for fishermen to be licensed as a wholesale dealer or fish receiver and, in essence, to deliver fish to themselves. Such deliveries must be recorded on a fish ticket in the same manner as if the transaction occurred between separate entities.

Processing and sales activities can fall under a variety of categories, which the states may regulate with one or more permit or license requirements. These categories range from the import and export of fish to direct sale to the public off the docks. The transport of fish is another activity that is regulated as a means of enforcing fish landings and importing rules. Regulations on sales, processing, and transport of fish differ by state, but also show many similarities. For example, Oregon requires a special permit for wholesale bait dealers. California has six major classes of commercial fish business licenses in addition to the fish receiver license and then a special permit for those businesses wanting to reduce anchovy for fish meal or other reduction purposes. All three states require special permits or licenses for fishing operations that sell directly from their vessel to a consumer or restaurant. The states and tribes can also differ in rules specifying how fish may be landed. For example, Washington does not allow fish to be landed and sold live whereas California, Oregon, and certain tribes do.

Seafood safety regulation, marketing and sustainability certification

Processors of fish and fishery products are required by the U.S. Food and Drug Administration to develop Hazard Analysis Critical Control Point plans to help identify potential hazards and develop control strategies and practices. Also for food safety purposes, state agencies like the Oregon Department of Agriculture require additional permits for shellfish distributors, shippers, and wholesalers; shuckers and packers; shellfish growers; and commercial harvesters from shellfish growing areas.

Seafood products are marketed in many ways, ranging from traditional methods such as local fishermen selling off their boat directly to consumers, to web-based marketing and sophisticated product coding that links an individual fish product to its harvester. For example, Pacific Fish Trax is an online information sharing system focused on West Coast fisheries. Its website provides viewers with tools to track seafood products, link customers and fishermen, and improve science, marketing, and management (Figure 3.4.12).[1]

Figure 3.4.12 Example of FishTrax bar code card

In Oregon, four seafood commodity commissions under the auspices of the Oregon Department of Agriculture, allow the fishing industry members to tax themselves and use the pooled funds to increase their commodity's recognition, value, and use. The Oregon Albacore Commission, Oregon Dungeness Crab Commission, Oregon Salmon Commission and Oregon Trawl Commission cooperate under the Seafood OREGON banner in marketing, promotion, and education. In 2009, California's Legislature passed the Sustainable Seafood Act – to develop and implement a voluntary sustainable seafood program to promote California fisheries. Actions to date include developing voluntary certification protocols for sustainable fisheries and recommendations for a marketing assistance program, as well as appointing an advisory committee.

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[1] Pacific Fish Trax website: http://www.pacificfishtrax.org/.

Ecolabeling and fishery sustainability certification by recognized organizations can improve marketability and profitability. For example, the Monterey Bay Aquarium Seafood Watch program makes recommendations to consumers and businesses on which seafood to buy or avoid. NOAA's FishWatch program provides similar advice to consumers.[2] Several West Coast fishery organizations and commodity commissions obtained Marine Stewardship Council certification for their fisheries, including North Pacific albacore, Oregon pink shrimp, Oregon Dungeness crab, and Pacific whiting.


Salmon processing at Pacific Seafoods, Clackamas, OR, 2008. Photo credit: Rod Moore, WCSPA

Coastwide and state level statistics

NMFS publishes descriptive statistics on the seafood processing industry in the *Fisheries Economics of the U.S.* series. This section describes statistics for the Pacific region and three West Coast states from the 2009 edition of that report (NMFS 2010) and an enhanced version of the economic model used to estimate the economic impact created by the seafood industry (NMFS 2012).

The fisheries under Council management are an important source of economic activity in the West Coast seafood processing industry. However, the West Coast seafood industry as a whole also depends on harvest from shellfish operations and other fisheries not managed by the Council. As discussed in Section 3.4.2.1, coastwide shellfish operations accounted for 62 percent of total landings revenue during the period 2006-2009. In addition, Dungeness crab fisheries, which are managed by the three states and several tribes individually, provide the most valuable source of landings in most years. As Table 3.4.1 indicates, seafood dealers and processors purchase shellfish and crab at the highest per pound prices with sablefish being the only species under Council management of similar per pound value. Foreign imports are another major source of economic activity in the West Coast seafood industry, as shown below.

Table 3.4.1. Total coastwide landings revenue ($ thous.) for the years 2006-2009 showing the relative contributions of finfish and shellfish harvesting

	2006	2007	2008	2009
Total revenue	471,788	459,772	500,447	488,155
Finfish & other	176,425	176,104	215,784	168,213
Shellfish	295,363	283,668	284,663	319,942

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[2] http://www.fishwatch.gov/

Table 3.4.2. Coastwide average annual price ($ per pound) of key species and species groups.

	2006	2007	2008	2009
Albacore Tuna	0.85	0.85	1.18	1.02
Crab	1.69	2.33	2.38	2.09
Flatfish	0.47	0.43	0.42	0.35
Pacific whiting	0.06	0.07	0.11	0.06
Shellfish	3.79	4.08	4.55	4.56
Rockfish	1.03	1.01	0.98	0.86
Sablefish	1.68	1.80	2.10	2.18
Salmon	1.18	1.38	1.42	0.74
Shrimp	0.61	0.65	0.70	0.50
Squid	0.25	0.27	0.31	0.28

The Fisheries Economics of the U.S. series also reports the number of seafood businesses active in the seafood product preparation and packaging, seafood retail sales, and seafood wholesale sales sectors in each of the states. These statistics are also categorized by whether the businesses hire employees or not. Figure 3.4.13 provides a view of the number of processing business from the PacFIN database plotted against landings of the major species management groups.

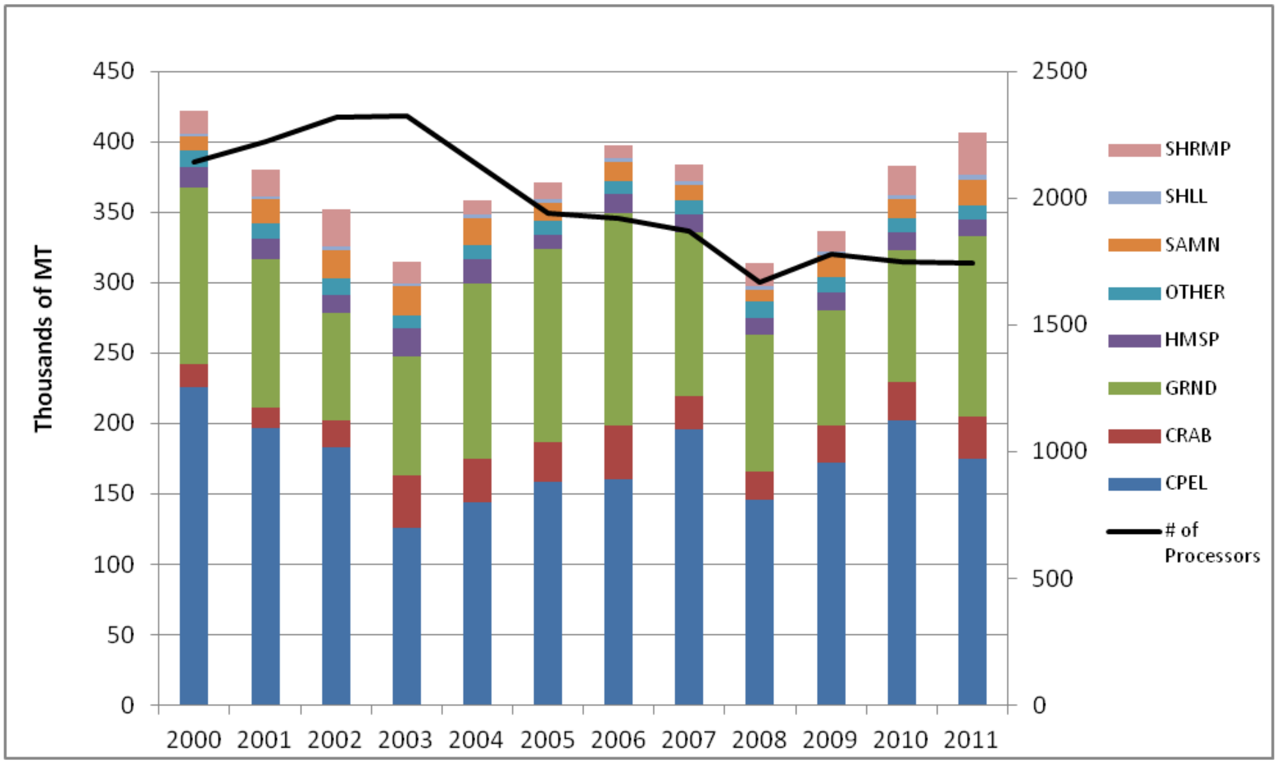


Figure 3.4.13 Coastwide processor count and major management species groups landings in mt. Unique primary processors only (secondary plants not counted), any processor that landed >100 lb in 2000-2011. Note: double-counting exists, since most processors land more than one type of species. Data source: PacFIN.

Table 3.4.3. Number of seafood businesses by state for 2006-2008 (NMFS 2010).

	2006	2007	2008
Seafood product prep. & packaging			
Washington			
Non-employer firms	53	63	44
Employer firms	96	98	96
Oregon			
Non-employer firms	7	0	19
Employer firms	21	22	23
California			
Non-employer firms	91	121	139
Employer firms	47	49	45
Seafood sales, retail			
Washington			
Non-employer firms	29	32	33
Employer firms	49	50	44
Oregon			
Non-employer firms	11	11	16
Employer firms	22	23	21
California			
Non-employer firms	163	222	210
Employer firms	184	182	161
Seafood sales, wholesale			
Washington			
Employer firms	115	127	108
Oregon			
Employer firms	16	18	18
California			
Employer firms	252	300	278

Broiled sablefish.
Photo credit: NOAA

NMFS also estimates the seafood industry's economic impact—nationally, regionally, and statewide for each of the 23 coastal states—using the National and Coastal State Input/Output Model (NMFS 2012). The estimates for the three West Coast states are reproduced in Tables 3.4.4 through 3.4.6.

These tables show direct economic impacts only. Direct impacts are those that express the economic effects (for sales, income or employment) in the sector directly affected by the activity under consideration." (NMFS 2012). The National and Coastal State Input/Output Model also estimates indirect and induced impacts. Indirect impacts are those that describe the economic effects created by seafood businesses purchasing from other industries (e.g. sales generated by the business providing goods and services to seafood business). Induced impacts are those arising from employees and owners spending the income they have earned from seafood businesses. These activities describe the bigger picture of how fish harvest can affect state, regional, and national economies. Indirect, induced, and total economic impacts can be queried with the NMFS Interactive Fisheries Economics Tool.

The National and Coastal State Input/Output Model is based on the same methods as used in the Fisheries Economics of the U.S. series, but certain enhancements have been made to the model and the values reported may differ between the two. For both, the primary inputs to the model are the fish and shellfish harvested and landed into each state and the foreign imports of seafood into each state. Various studies and surveys of the seafood industry are then used to translate those landings into the estimates of direct, indirect, and induced economic impacts.

Pike Place Market, Seattle, WA.
Photo credit: Smithsonian Institution

Of note, the model does not take into account interstate movements of fish products. NMFS identifies this as a shortcoming of the model, but one that washes out for the model's main purpose of describing national economic activity. The likely result of not accounting for interstate transfers of fish products is an underestimate of regional and state economic impacts where interstate movements of fish occur. On the West Coast, fish landed in one state are often trucked and processed or sold in another. For example, landings into Washington might be processed and sold in Oregon. The model also misses fish products that originate as landings into Alaska. Washington in particular has been a traditional processing and business hub for fish caught in Alaska. Some of the economic activities attributed to Alaska may actually occur in the West Coast states. At the same time, some of the activities attributed to the West Coast states might occur elsewhere, including Alaska.

The model outputs reported in Tables 3.4.4 through 3.4.6. include:

- The **employment impacts** estimate total full-time and part-time jobs produced in each sector.
- The **income impacts** that consist of wages and salaries and include self-employment income to business owners.
- The **sales impacts** that estimate the total sales revenues made by businesses within each sector category.
- The **value added impact** is an estimate of sales revenues minus the cost of the goods and services needed for production. It is the estimate of the industry or industry sector's overall contribution to the U.S. Gross Domestic Product (GDP).

NMFS advises that it is incorrect to add impacts across the income, sales, and employment impact categories (NMFS 2012). Fish imports contribute a substantial portion of the direct economic impacts in the region, especially in California and Washington. The *Fisheries Economics of the U.S.* identifies California as first in terms of overall seafood sales and value added impact in the nation, and Washington third, based largely on the size of the foreign imports of fish products into those states (NMFS 2010).

In Figure 3.4.14, regional landings are shown by weight and value, with 12 year trends and average proportions for major West Coast management species groups, 2000-2011. Differences between landings values and landings volumes are clearly visible for species that are either low-value/high-volume, or high-value/low-volume.

Table 3.4.4. Direct Seafood Industry Impacts for Washington, 2007-2009 (source: NMFS 2012)

	2007	2008	2009
Primary dealers/processors			
Employment Impacts (#)	12,118	10,901	10,714
Income Impacts ($ thous.)	346,260	312,211	307,311
Sales Impacts ($ thous.)	763,424	688,353	677,550
Total value added impacts ($ thous.)	369,096	332,801	327,578
Secondary wholesalers/distributors			
Employment Impacts (#)	1,557	1,412	1,373
Income Impacts ($ thous.)	63,979	59,281	58,342
Sales Impacts ($ thous.)	178,434	165,330	162,713
Total value added impacts ($ thous.)	68,199	63,190	62,190
Importers and brokers			
Employment Impacts (#)	545	479	473
Income Impacts ($ thous.)	21,815	19,194	18,919
Sales Impacts ($ thous.)	1,508,480	1,327,220	1,308,219
Total value added impacts ($ thous.)	62,321	54,833	54,048
Restaurants			
Employment Impacts (#)	15,016	14,433	13,941
Income Impacts ($ thous.)	196,398	192,817	188,453
Sales Impacts ($ thous.)	382,814	375,835	367,328
Total value added impacts ($ thous.)	209,350	205,533	200,882
Grocers			
Employment Impacts (#)	2,000	1,930	1,886
Income Impacts ($ thous.)	47,910	46,719	45,938
Sales Impacts ($ thous.)	81,883	79,848	78,511
Total value added impacts ($ thous.)	51,070	49,800	48,967
Total			
Employment impact (#)	31,236	29,155	28,387
Income impact ($ thous.)	654,547	611,028	600,044
Sales Impacts ($ thous.)	1,406,555	1,309,366	1,286,102
Total value added impacts ($ thous.)	697,715	651,324	639,617

Table 3.4.5. Direct Seafood Industry Impacts for Oregon, 2007-2009 (source: NMFS 2012)

	2007	2008	2009
Primary dealers/processors			
Employment Impacts (#)	827	854	805
Income Impacts ($ thous.)	21,257	22,355	21,283
Sales Impacts ($ thous.)	46,866	49,289	46,924
Total value added impacts ($ thous.)	22,659	23,830	22,686
Secondary wholesalers/distributors			
Employment Impacts (#)	366	342	332
Income Impacts ($ thous.)	14,825	14,136	13,909
Sales Impacts ($ thous.)	41,896	39,949	39,306
Total value added impacts ($ thous.)	15,803	15,068	14,826
Importers and brokers			
Employment Impacts (#)	65	58	55
Income Impacts ($ thous.)	2,620	2,314	2,191
Sales Impacts ($ thous.)	181,198	160,010	151,475
Total value added impacts ($ thous.)	7,486	6,611	6,258
Restaurants			
Employment Impacts (#)	5,258	5,336	5,002
Income Impacts ($ thous.)	63,371	65,688	62,299
Sales Impacts ($ thous.)	123,521	128,038	121,433
Total value added impacts ($ thous.)	67,550	70,020	66,408
Grocers			
Employment Impacts (#)	746	742	719
Income Impacts ($ thous.)	14,817	14,943	14,612
Sales Impacts ($ thous.)	25,324	25,540	24,973
Total value added impacts ($ thous.)	15,794	15,929	15,576
Total			
Employment impact (#)	7,262	7,332	6,913
Income impact ($ thous.)	114,270	117,122	112,103
Sales Impacts ($ thous.)	237,607	242,816	232,636
Total value added impacts ($ thous.)	121,806	124,847	119,496

Table 3.4.6. Direct Seafood Industry Impacts for California, 2007-2009 (source: NMFS 2012)

	2007	2008	2009
Primary dealers/processors			
Employment Impacts (#)	2,908	2,987	2,773
Income Impacts ($ thous.)	87,438	90,330	84,156
Sales Impacts ($ thous.)	192,781	199,156	185,546
Total value added impacts ($ thous.)	93,205	96,287	89,707
Secondary wholesalers/distributors			
Employment Impacts (#)	6,410	6,624	5,565
Income Impacts ($ thous.)	267,534	282,381	240,038
Sales Impacts ($ thous.)	789,282	833,084	708,165
Total value added impacts ($ thous.)	285,178	301,004	255,869
Importers and brokers			
Employment Impacts (#)	1,953	2,069	1,735
Income Impacts ($ thous.)	78,189	82,821	69,444
Sales Impacts ($ thous.)	5,406,612	5,726,911	4,801,942
Total value added impacts ($ thous.)	223,368	236,601	198,387
Restaurants			
Employment Impacts (#)	35,766	36,515	31,646
Income Impacts ($ thous.)	515,559	537,638	471,468
Sales Impacts ($ thous.)	1,004,879	1,047,914	918,942
Total value added impacts ($ thous.)	549,560	573,095	502,562
Grocers			
Employment Impacts (#)	7,534	7,929	6,854
Income Impacts ($ thous.)	193,435	203,858	176,421
Sales Impacts ($ thous.)	330,599	348,413	301,519
Total value added impacts ($ thous.)	206,192	217,303	188,056
Total			
Employment impact (#)	54,571	56,124	48,573
Income impact ($ thous.)	1,063,966	1,114,207	972,083
Sales Impacts ($ thous.)	2,317,541	2,428,567	2,114,172
Total value added impacts ($ thous.)	1,134,135	1,187,689	1,036,194

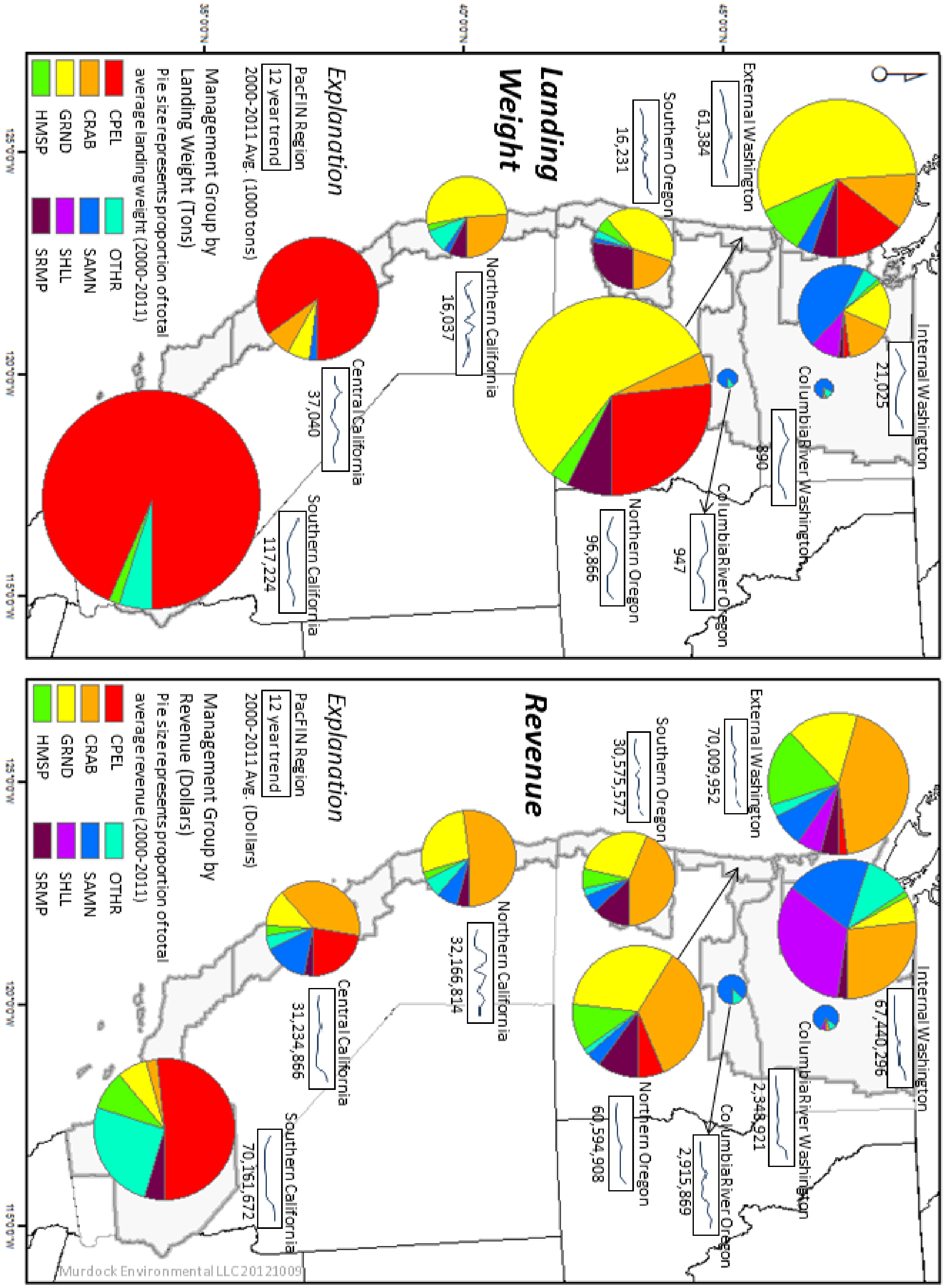


Figure 3.4.14. Regional landings by weight and value, with 12-year trends and average proportions for each major West Coast management group, 2000-2011. (Maps courtesy of Murdock Environmental, data source: PacFIN.

3.4.2.3 Recreational Fisheries

West Coast recreational marine fisheries catch data are compiled within PSMFC's Recreational Fishery Information Network (RecFIN) database. This database centralizes data collected from recreational fishing surveys from U.S. West Coast states since 1980. Each of the three states manages separate but compatible recreational fisheries data-gathering programs. For marine waters, each state conducts a combined survey and sampling program to provide a statewide, comprehensive approach to recreational fishery data collection intended to estimate total marine recreational catch and effort. The RecFIN network coordinates state sampling programs to provide a regional survey designed to gather information for all finfish species, from anglers in all modes of recreational fishing (i.e., shore, party/charter and private/rental, or skiff). Given the high cost of sampling, the states focus resources on the highest conservation needs, and some modes and times of year are not sampled. Oregon has annually conducted the Ocean Recreational Boat Survey since 1979, with some modifications as fishing patterns changed (Schindler, 2012). California conducts the California Recreational Fisheries Survey (CRFS). Washington conducts two survey programs, one to sample recreational catch from boats leaving coastal ports and the other for Puget Sound.

Client Randy Brown(r) and deckhand Seagra Carconnen (l) with Pacific halibut. Photo credit: Westport Charterboat Association

Components common to the three state data collection programs include: number, length, and weight (if possible) of fish observed in the catch, fishing effort, along with the angler's demographic and fishing activity information. Most of this information is collected by dockside samplers. Onboard observers are used in some cases to collect information on fish that are released. Phone surveys and catch record cards are used as well. Other information on anglers is collected through the sale of fishing licenses, which are required by the states with limited exemptions (e.g. juvenile anglers). The Council relies on both state data-gathering programs and on RecFIN to evaluate the effects of recreational fisheries on Council-managed species. All three states were granted a regional survey exemption from the Federal saltwater angler registry based on their coordination and participation in RecFIN.

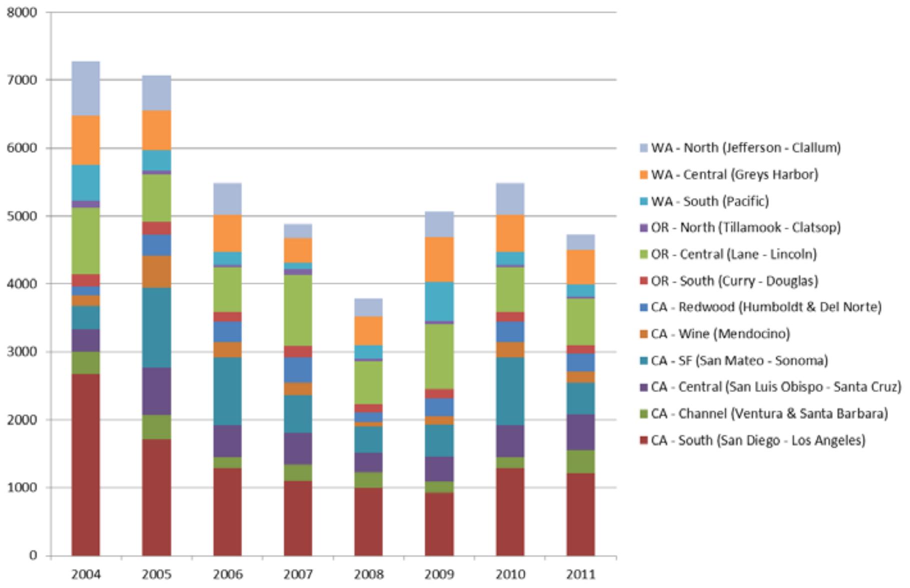
Recreational catch estimates are incorporated into stock assessments, particularly for salmon, Pacific halibut, and some groundfish and HMS species. In addition, some estimates are used as the season progresses, to track groundfish catches against low bycatch allowances for some rebuilding species or to track healthy species of interest, or to closely monitor daily or weekly catches of Pacific halibut and salmon. Inseason management is necessary because of variation in the number of participating anglers and the rate at which they encounter fish. Managers use catch and effort estimates to forecast and structure seasons that provide a target level of fishing opportunity. Yet the variation in catch and effort can result in actual opportunities varying from those forecasted.

Client Luis Mercado (r) and boat owner Robert Ingles (l) with lingcod. Photo credit: Half Moon Bay Sportsfishing

Recreational and commercial fisheries data are not strictly comparable, since the sampling programs for the different types of fisheries vary according to the operational practices of the various fisheries, the importance of the fishery, and the ability of the states to monitor them. For this FEP, however, recreational fisheries data offers a broad-scale perspective on fluctuations in catch volume from year to year and in different sections of the coast. This section of the FEP considers recent, 2004-2011, fisheries catches for U.S. West Coast recreational fisheries. Figures 3.4.14 and 3.4.15 show catch trends from 2004 through 2011, separated by RecFIN sampling area, and illustrates the often wide fluctuations in recreational catch totals. On average, about half of the catch comes from California.

The fluctuations seen each year can arise from variability in angler participation, differences in catch rates, or changes in the quotas made available to the recreational sectors. Cumulative recreational fisheries landings during the 2004-2011 period hit a low of about 3,800 mt in 2008, with a recent high in 2010 of about 5,500 mt. The ocean salmon fisheries in 2006 and 2008 were declared fishery disasters by the U.S. Department of Commerce. The absence of a salmon fishery in California and salmon fisheries at their lowest level in a decade in Oregon during 2008 contributed to the lower catch that year. Variations in catch can also result from how the catch is counted. Recreational catch numbers come from statistical estimates that will vary in precision and accuracy based on factors like the sampling design and the number of anglers that the state sampling program encounters. The states and PSMFC significantly revised West Coast recreational fisheries sampling and estimation methodologies after 2003, making comparisons between the periods before and after 2003 difficult.

Figure 3.4.15 Annual cumulative West Coast recreational fisheries catch, in mt, separated by RecFIN sampling area



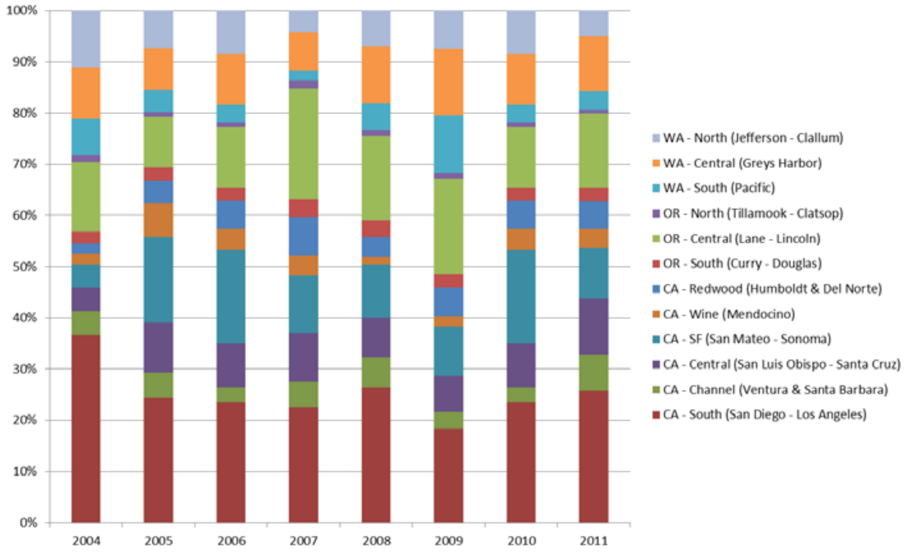


Figure 3.4.16 Annual cumulative West Coast recreational fisheries catch, by percent, separated by RecFIN sampling area

Recreational fisheries catches are strongly focused on a few particularly popular species. Table 3.4.7 shows the top twenty species taken in the marine recreational fisheries, by weight, for each year from 2004 through 2011. Of the Council-managed species, Chinook and coho salmon are consistently popular recreational targets, although recreational fishing for coho is prohibited in California. Other popular recreational targets are albacore tuna, several of the nearshore rockfish species, Pacific halibut, and Pacific mackerel. Many of the more popular recreational targets are state-managed species, particularly those taken in Southern California fisheries. All finfish species are overwhelmingly taken using hook-and-line gear, although some fish are caught by spear divers and other gear.

CDFW samplers Shannon Walkenhauer and Dan Troxel interviewing kayak angler at the Trinidad boat hoist during a rockfish tournament. Photo credit: Edgar Roberts, CDFW

Off the coasts of Washington, Oregon, and northern California the primary targets include salmon, lingcod, albacore, Pacific halibut, and nearshore rockfishes (primarily black or blue, *S. melanops* and *S. mystinus*). Chinook salmon can be taken in all three states and coho salmon can be taken in Oregon and Washington. The portion of the Northern Biogeographic Sub-Region [see 3.1.2] from Washington to north of Cape Mendocino is fairly similar from a recreational fisheries perspective, and the species diversity for rockfishes is much lower than areas further south. Primary targets along the central California coast include Chinook salmon, lingcod, albacore, nearshore and shelf rockfishes, Pacific sanddabs (*Citharichthys sordidus*), and California halibut. The diversity of rockfishes in catches of the Central Sub-Region includes 25 to 30 species, although, historically, it approached 40 species when anglers had more access to shelf waters. South of Point Conception, the diversity of primary recreational targets significantly increases for southern California anglers due to the added influence of warmer waters and year-round opportunities. Targets include albacore, yellowfin tuna, California scorpionfish (*Scorpaena guttata*), rockfishes (primarily vermilion (*Sebastes miniatus)*, bocaccio, and gopher (*S. carnatus*)), chub mackerel (*Scomber japonicas)*, Pacific bonito, California halibut, the basses, yellowtail, and barracuda (*Sphyraena argentea*). Albacore are an ephemeral target north of Point Conception due to their strong association with warmer waters and their tendency to school on the seaward side of upwelling fronts; they are encountered closer to shore during years when the warmer water moves shoreward—such as El Niño years.

In Washington, recreational fishing for Council-managed species is primarily boat-based, occurring aboard private and charter vessels that operate in ocean waters. Salmon angling is the main exception with fishing also occurring in the Strait of Juan de Fuca, Puget Sound, and in the state's rivers and estuaries. Although the discussion here is focused on Council-managed finfish, shellfish populations like Dungeness crab and razor clams (*Siliqua patula*) also provide popular and valuable recreational harvest opportunities in the state.

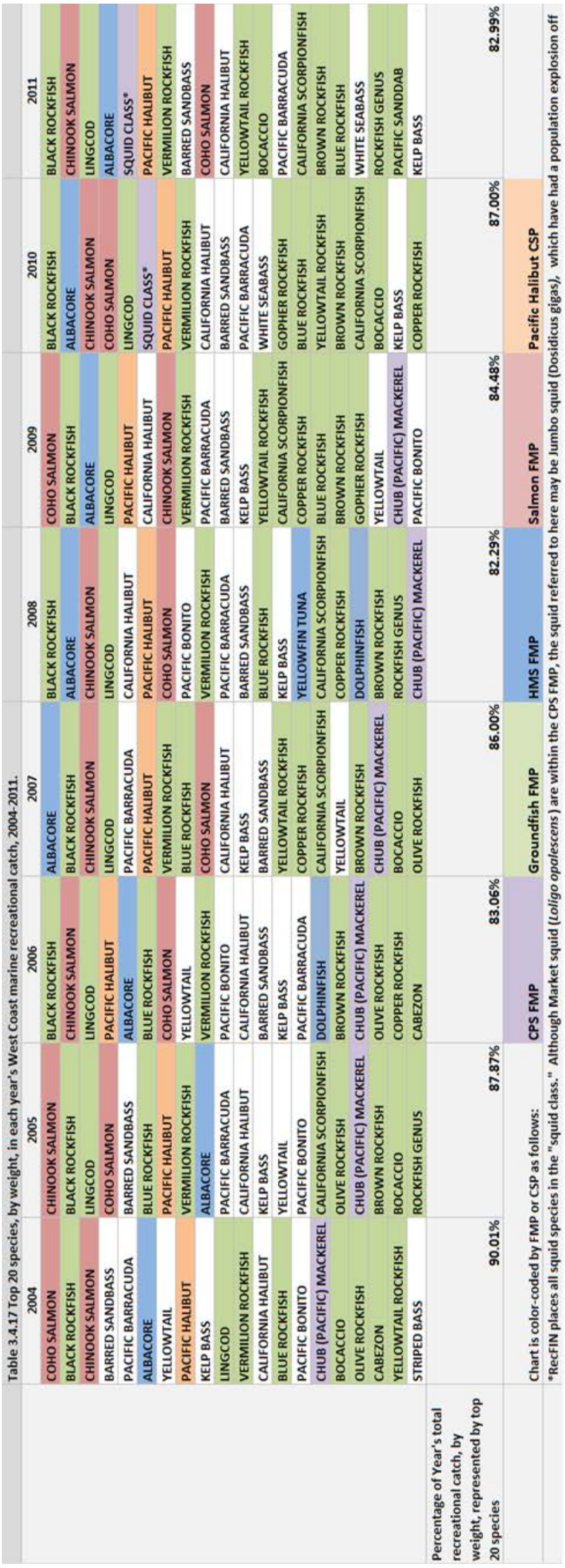


Table 3.4.17 Top 20 species, by weight, in each year's West Coast marine recreational catch, 2004-2011.

	2004	2005	2006	2007	2008	2009	2010	2011
	COHO SALMON	CHINOOK SALMON	BLACK ROCKFISH	ALBACORE	BLACK ROCKFISH	COHO SALMON	BLACK ROCKFISH	BLACK ROCKFISH
	BLACK ROCKFISH	BLACK ROCKFISH	CHINOOK SALMON	BLACK ROCKFISH	ALBACORE	BLACK ROCKFISH	ALBACORE	CHINOOK SALMON
	CHINOOK SALMON	LINGCOD	LINGCOD	CHINOOK SALMON	CHINOOK SALMON	ALBACORE	CHINOOK SALMON	LINGCOD
	BARRED SANDBASS	COHO SALMON	PACIFIC HALIBUT	LINGCOD	LINGCOD	LINGCOD	COHO SALMON	ALBACORE
	PACIFIC BARRACUDA	BARRED SANDBASS	ALBACORE	PACIFIC BARRACUDA	CALIFORNIA HALIBUT	PACIFIC HALIBUT	LINGCOD	SQUID CLASS*
	ALBACORE	BLUE ROCKFISH	BLUE ROCKFISH	PACIFIC HALIBUT	PACIFIC HALIBUT	CALIFORNIA HALIBUT	SQUID CLASS*	PACIFIC HALIBUT
	YELLOWTAIL	PACIFIC HALIBUT	COHO SALMON	VERMILION ROCKFISH	COHO SALMON	CHINOOK SALMON	PACIFIC HALIBUT	VERMILION ROCKFISH
	PACIFIC HALIBUT	VERMILION ROCKFISH	YELLOWTAIL	BLUE ROCKFISH	PACIFIC BONITO	VERMILION ROCKFISH	VERMILION ROCKFISH	BARRED SANDBASS
	KELP BASS	ALBACORE	VERMILION ROCKFISH	COHO SALMON	VERMILION ROCKFISH	PACIFIC BARRACUDA	CALIFORNIA HALIBUT	COHO SALMON
	LINGCOD	PACIFIC BARRACUDA	PACIFIC BONITO	CALIFORNIA HALIBUT	PACIFIC BARRACUDA	BARRED SANDBASS	BARRED SANDBASS	CALIFORNIA HALIBUT
	VERMILION ROCKFISH	CALIFORNIA HALIBUT	CALIFORNIA HALIBUT	KELP BASS	BARRED SANDBASS	KELP BASS	PACIFIC BARRACUDA	YELLOWTAIL ROCKFISH
	CALIFORNIA HALIBUT	KELP BASS	BARRED SANDBASS	BARRED SANDBASS	BLUE ROCKFISH	YELLOWTAIL ROCKFISH	WHITE SEABASS	BOCACCIO
	BLUE ROCKFISH	YELLOWTAIL	KELP BASS	YELLOWTAIL ROCKFISH	KELP BASS	CALIFORNIA SCORPIONFISH	GOPHER ROCKFISH	PACIFIC BARRACUDA
	PACIFIC BONITO	PACIFIC BONITO	PACIFIC BARRACUDA	COPPER ROCKFISH	YELLOWFIN TUNA	COPPER ROCKFISH	BLUE ROCKFISH	CALIFORNIA SCORPIONFISH
	CHUB (PACIFIC) MACKEREL	CALIFORNIA SCORPIONFISH	DOLPHINFISH	CALIFORNIA SCORPIONFISH	CALIFORNIA SCORPIONFISH	BLUE ROCKFISH	YELLOWTAIL ROCKFISH	BROWN ROCKFISH
	BOCACCIO	OLIVE ROCKFISH	BROWN ROCKFISH	YELLOWTAIL	COPPER ROCKFISH	BROWN ROCKFISH	BROWN ROCKFISH	BLUE ROCKFISH
	OLIVE ROCKFISH	CHUB (PACIFIC) MACKEREL	CHUB (PACIFIC) MACKEREL	BROWN ROCKFISH	DOLPHINFISH	GOPHER ROCKFISH	CALIFORNIA SCORPIONFISH	WHITE SEABASS
	CABEZON	BROWN ROCKFISH	OLIVE ROCKFISH	CHUB (PACIFIC) MACKEREL	BROWN ROCKFISH	YELLOWTAIL	BOCACCIO	ROCKFISH GENUS
	YELLOWTAIL ROCKFISH	BOCACCIO	COPPER ROCKFISH	BOCACCIO	ROCKFISH GENUS	CHUB (PACIFIC) MACKEREL	KELP BASS	PACIFIC SANDDAB
	STRIPED BASS	ROCKFISH GENUS	CABEZON	OLIVE ROCKFISH	CHUB (PACIFIC) MACKEREL	PACIFIC BONITO	COPPER ROCKFISH	KELP BASS
Percentage of Year's total recreational catch, by weight, represented by top 20 species	90.01%	87.87%	83.06%	86.00%	82.29%	84.48%	87.00%	82.99%
	Chart is color-coded by FMP or CSP as follows:		CPS FMP	Groundfish FMP	HMS FMP	Salmon FMP	Pacific Halibut CSP	

*RecFIN places all squid species in the "squid class." Although Market squid (*Loligo opalescens*) are within the CPS FMP, the squid referred to here may be Jumbo squid (Dosidicus gigas), which have had a population explosion off

Access to ocean waters is limited by the state's geography. Neah Bay, La Push, Westport, and Chinook/Ilwaco on the Columbia River are the state's major access points for recreational anglers. Access is also limited by weather and ocean conditions, with fishing occurring mostly during spring, summer, and early fall. May through September are the peak fishing months.

Brett Wolfe with Chinook salmon. Photo credit: Westport Charterboat Association

Of marine finfish, Pacific salmon are the most popular target for anglers in Washington. In the years 2008 to 2010, salmon trips accounted for 50 to 74 percent of all angler trips in the ocean with variations in that range attributable mainly to changes in salmon fishing opportunity. As discussed above, fishing opportunity for salmon can vary substantially from year to year based on fish abundance and quotas set by the Council, the state, or other management bodies. In 2008, there were fewer than 47,336 angler trips taken for salmon. In 2009, that number jumped to more than 120,409 because of the increased quota. That jump in salmon activity raised the total angler trips in the ocean by nearly 70,000, while activity targeting other species remained stable or slightly decreased, demonstrating the popularity of salmon angling within the state.

Bottomfish typically provided the most consistent recreational fishing opportunity off Washington's coast and fishing seasons have been typically open all year round, although tight quotas for some species have the potential to limit the length of the season. In 2012, Washington Department of Fish and Wildlife (WDFW) had to close bottomfish opportunities off the state's north coast after Labor Day weekend because of higher than expected catch of the rebuilding yelloweye rockfish stock. The state saw an average of 19,160 angler trips targeting bottomfish during 2008-2010.

Recreational fishing's contribution to Washington's economy was evaluated in a 2008 report commissioned by WDFW (TCW Economics 2008). That report estimated recreational angling to have contributed $393 million in total income and nearly 13,000 jobs to the state's economy in 2006. These figures included all recreational fishing activities, of which freshwater fishing typically makes up around 90 percent. Figures were also based on a USFWS (2008) survey that found anglers spent $900 million on fishing-related activities in 2006. This USFWS survey was conducted again for 2011 and found recreational fishing expenditures rose to above $1 billion (U.S. Fish and Wildlife 2012). The 2008 study of Washington's fishing economy also estimated that fishing for salmon and other marine finfish created $58 million in net economic value to anglers. Net economic value is intended as a measure of the value that people place on fishing opportunity and as a metric of the overall benefit that fishing provides anglers. The metric does not include the net economic value of economic activity generated by fishing-related business like charter fishing operations.

To provide a sense of who participates in the boat-based ocean fisheries off Washington, Figure 3.4.18 displays a county level look at anglers who caught Pacific halibut or salmon off the Washington coast in 2011. Over 90 percent of that catch was taken by state residents and residents of the most highly populated counties accounted for more than half of the catch. As shown in the bottom panel of Figure 3.4.18, counties near coastal ports contributed to the catch in much higher proportions than would be suggested by their share of the state's population.

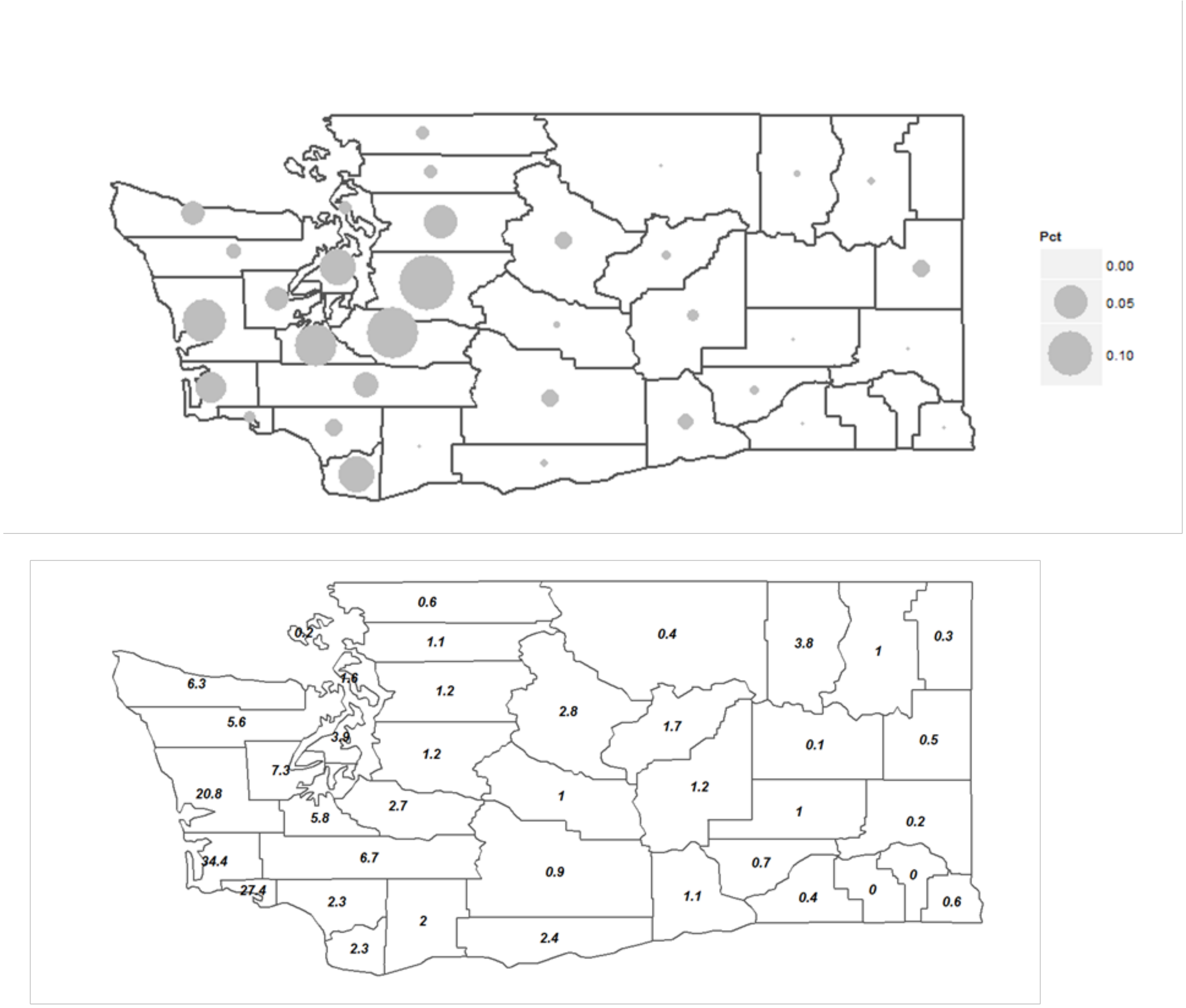


Figure 3.4.18 The distribution of the 2011 recreational catch of Pacific salmon and Pacific halibut off the Washington coast (WDFW Marine Areas 1-4) by county residence of anglers. In the *top panel*, the circles at the center of each county are scaled to the percentage ("Pct") of the total catch reported by anglers from that county. Anglers from other states accounted for 8.4 percent of the total reported catch. The *bottom panel* compares the catch to the county's population size with the numbering represents the ratio of the county's total catch percentage to its percentage of the statewide population. For example, the catch for Grays Harbor County's share of the catch is 20.8 times its share of the state's population. (Source: WDFW catch record card data and U.S. Census Bureau, Population Division).

In Oregon, recreational effort for marine fish and salmon species in the ocean, coastal estuaries and lower Columbia River totaled 802,000 angler trips during 2007 and 738,000 trips in 2008. Although the recreational salmon fishery was at a ten-year low, trips targeting salmon accounted for slightly more than half the total (55 percent) in 2008. The statewide estimated economic contribution (in personal income) from these trips totaled $33.5 million in 2007 and $29.8 million in 2008 (The Research Group, 2009). Recreational fishing is important to coastal residents, but also draws anglers from around the state and from other states. For example, many anglers tow boats long distances, generally from more populated towns and cities in central Oregon, to fish for marine species. Figure 3.4.19 shows the hometowns of boat owners who participated in the central Oregon coast halibut fishery and where they launched in 2011.

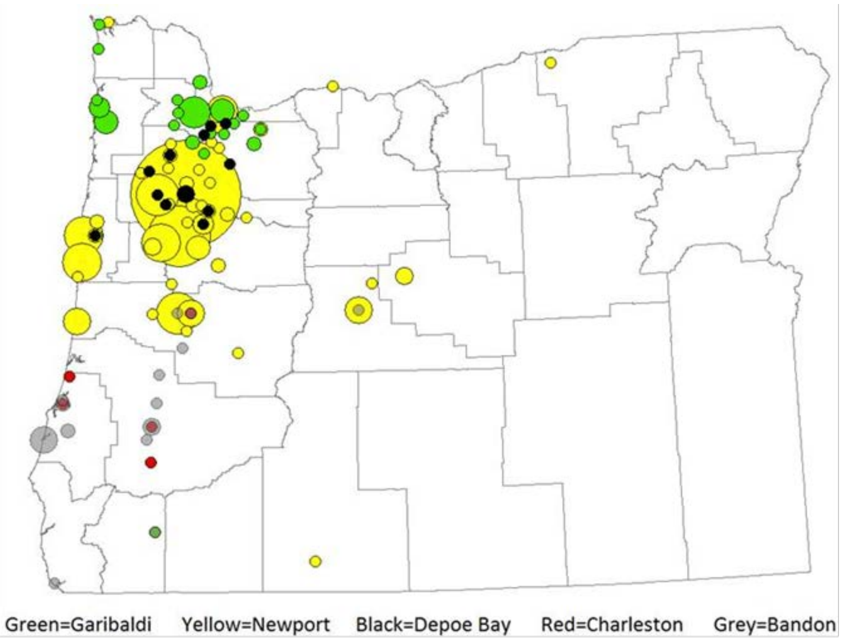
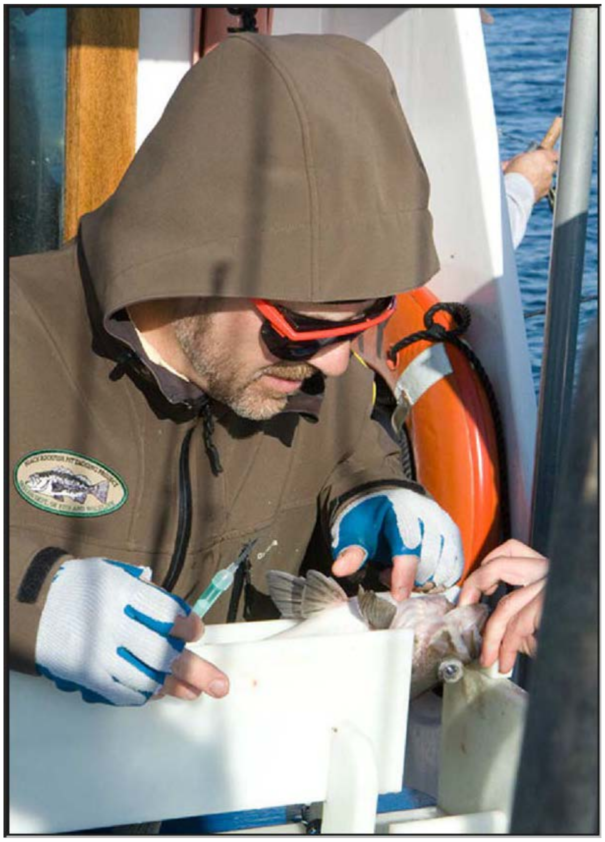


Figure 3.4.19 Hometowns of vessel owners and anglers who participated in the central Oregon coast halibut fishery. The colors and legend indicate the ports from which they launched. (Map courtesy of Patrick Myrick, ODFW).

In addition, significant recreational fisheries for shellfish occur along the Oregon coast, contributing an estimated $36 million in travel expenditures alone during 2008 (Runyon, 2009). Fisheries for razor clams on the north coast and for Dungeness crab are especially popular. Recreational catch and effort in the razor clam fishery on the Clatsop beaches is monitored annually. Clam diggers made an estimated 128,000 trips for razor clams, harvesting 1.8 million clams on the Clatsop beaches in 2006. Both catch and effort were higher than the previous 10-year average of 65,000 trips and 840,000 clams (Hunter, 2008). In 2011, recreational crabbers targeted Dungeness crab during an estimated 120,000 trips, including aboard private and charter boats, and from shore and piers along the Oregon coast. In total, they harvested 1,066,000 pounds of Dungeness crab in 2011 (Ainsworth et al. 2012).



David Wagman, ODFW, inserting black rockfish PIT tag. Photo credit: ODFW

Recreational fishing in ocean waters off the state of California includes boat-based modes (occurring aboard private and charter vessels) in addition to a significant shore-based component. Although the discussion here is focused on Council-managed finfish, Californians also participate in valuable recreational fisheries of state-managed species, such as California halibut and several basses, surfperches, Dungeness crab, California spiny lobster, and abalone. CDFW's Commercial Passenger Fishing Vessel database includes data collected for California recreational fisheries since 1936. However, information on catch and effort of many state-managed species is limited due to the emphasis on collecting information on the FMP species—this is particularly the case for invertebrates and species that are harvested from shore.

Recreational ocean fishing occurs year-round in California, especially in southern California where ocean and weather conditions are less extreme than in the northern portions of the state, permitting anglers greater access to the resource in winter months. Fishery regulations are often the constraining factor that determines when most recreational fishing occurs, and regulations have become increasingly restrictive over the last ten years. As in other West Coast states, peak fishing months are May through September.

NMFS estimated in its Fisheries Economics of the U.S. (FEUS 2011) report that recreational ocean fishing contributed $710 million and more than 13,000 jobs to California's economy in 2009. The NMFS report also estimated more than 1.4 million anglers made 4.6 million fishing trips for all modes of ocean fishing in 2009, which represents an 11 percent increase in number of fishing trips compared to 2008. The increase in number of fishing trips seen in 2009 is likely due to the low number of trips that occurred in 2008, a year when no salmon fishing was allowed in California's ocean waters. Under an average season, ocean salmon anglers contribute an estimated $121 million in direct revenues to the State's business sector, based on a USFWS national survey of fishing, hunting, and wildlife-associated recreation in 2006, and adjusted for inflation. Adding the indirect and induced effects of this initial revenue contribution, the total benefit of the recreational salmon fishery to California's economy is normally almost $184 million. The USFWS 2008 survey estimated $2.4 billion was spent in the state of California on all recreational fishing (ocean and freshwater fishing combined) in 2006. The USFWS survey was conducted again in 2011, and recreational fishing expenditures were estimated to have decreased to $2.3 billion in 2009 (USFWS 2012). In the most recent FEUS report (2012), added-value angler expenditures for ocean-related fishing activities were $1.4 billion in 2010.

Information is limited for the state's recreational invertebrate fisheries, although angler report cards provide some information on abalone and spiny lobster. An estimated 216,000 abalone were harvested by recreational divers in 2011, lower than the 2002-2011 annual average of 259,000. A study completed in 2010 indicated that the contribution of the abalone fishery to the North Coast's (Marin, Sonoma, Mendocino, Humboldt, and Del Norte counties) total economic output, wages, employment,

Bill Ernst with record-holding white seabass, Malibu. Photo credit: CDFW

and to local sales taxes as: $22 million (2009$), $9 million (2009$), 211 jobs, and $720,000, respectively, based on direct expenditures for abalone trips. Spiny lobster are the focus of a popular southern California recreational fishery. Based on available information, in 2010 an estimated 347,000 pounds of lobster were taken on 127,183 angler trips by divers or recreational anglers using hoop nets (D. Neilson pers. com).

To provide a sense of who participates in the state's boat-based ocean fisheries, Figure 3.4.20 displays the county of residence of anglers who caught salmon off the California coast in 2012 and their major port of fishing activity. Data are from CRFS interviews. At least eighty one percent of California anglers participating in the recreational salmon fishery resided in coastal counties – 2.5 percent declined to respond or were from out of state. Anglers from coastal counties in the central and northern portions of the state participated in the fishery at higher levels than anglers further south because the salmon resource is primarily located north of Point Conception (34°27' N. lat.). Overall in 2010, the most recent year available, 77 percent of angler trips in California were made by anglers living in coastal counties (NMFS 2011).

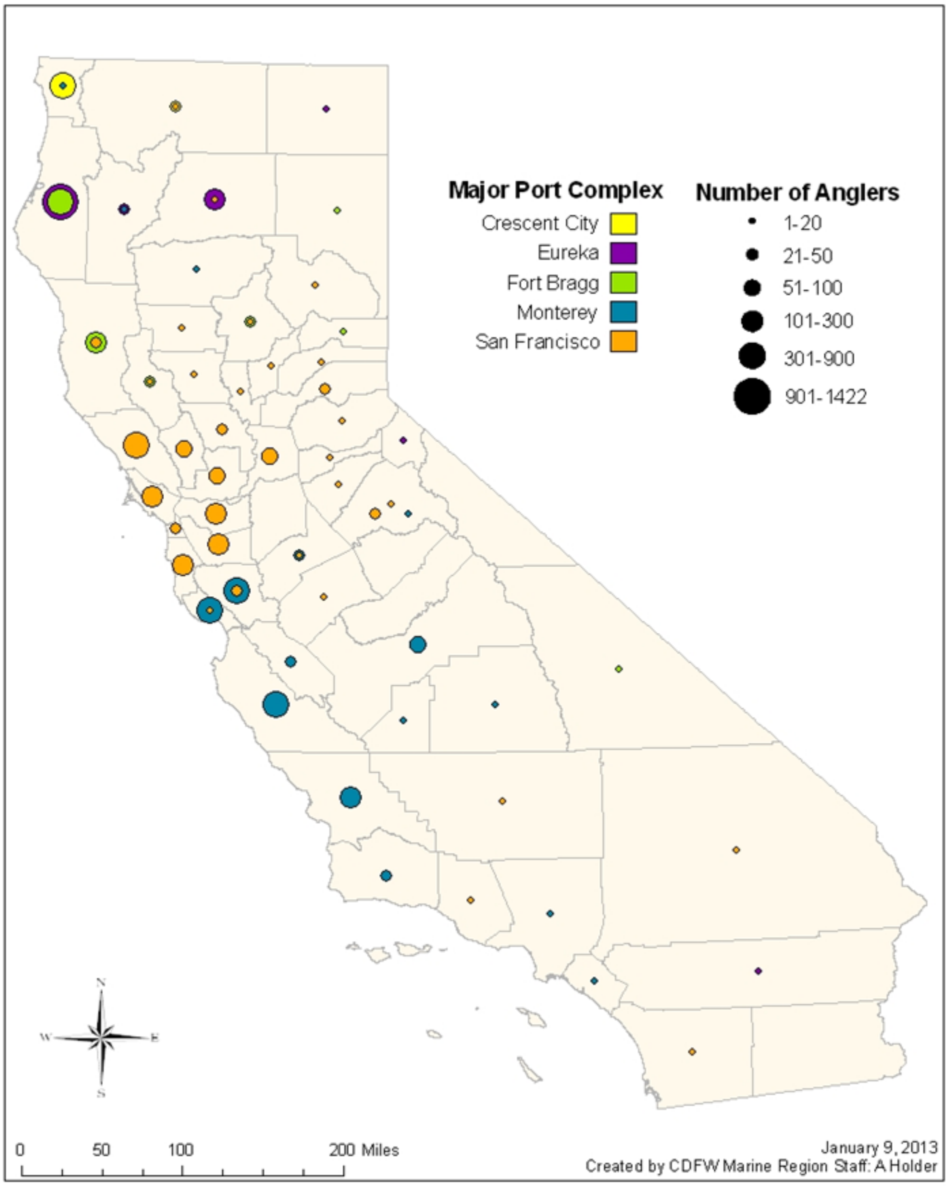


Figure 3.4.20 Distribution of 2012 California recreational salmon anglers based on fishing port of origin and angler county of residence from CRFS interviews. The colors and legend indicate the port area from which anglers launched. Some points overlap when multiple anglers residing in the same county fished out of different port complexes.

3.4.3 Fishing Communities

Morro Bay Fish Company. Photo credit: Steve Copps, NOAA NWR

The MSA places highest priority on conservation of fish stocks for the achievement of optimum yield. However, the MSA's National Standard 8 requires conservation objectives to be achieved in a manner that provides for the sustained participation of fishing communities in fisheries and minimizes adverse impacts on fishing communities to the extent practicable (16 U.S.C. 1851). National Standard 8 also requires the Council to use the best available scientific information when weighing impacts to fishing communities and fishing participation.

Under its Groundfish FMP, the Council has particularly addressed the MSA's direction to place highest emphasis on rebuilding overfished stocks, while still taking into account the needs of fishing communities, by also looking at the vulnerabilities of fishing communities to changes in availability of groundfish harvest (PFMC 2010). The Groundfish FMP at 4.6.3.2 characterizes fishing communities as needing "a sustainable fishery that: is safe, well-managed, and profitable; provides jobs and incomes; contributes to the local social fabric, culture, and image of the community; and helps market the community and its services and products." Although that language is found within the Groundfish FMP, it reflects priorities expressed in other FMPs to manage fisheries so that both harvest and community participation in fisheries is sustainable over the long term.

Under the MSA, a "fishing community" is a community that is "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and U.S. fish processors that are based in such community" (16 U.S.C. §1802). Social scientists have used that definition to develop profiles of West Coast fishing communities (Norman et al. 2007), and to define and quantify community involvement in commercial fisheries and their vulnerability to changes in fishery conservation and management measures (Sepez et al. 2007, Clay and Olson 2008, Alsharif and Miller 2012). NOAA's Technical Memorandum NMFS-NWFSC-85, Community Profiles for West Coast and North Pacific Fisheries: Washington, Oregon, California and other U.S. States (Norman et al. 2007) provides detailed social and demographic analyses of over 100 West Coast communities, which the FEP will not repeat here. However, that document provides a framework for thinking about coastal communities' vulnerability to changes in available commercial fishery harvest levels and available recreational fishing opportunities.

Teaching children about ocean creatures at the Port Orford, OR, Water Festival. Photo credit: POORT

The FEP Initiatives Appendix at A.2.6 suggests an initiative for the Council to look at human recruitment to the fisheries as a way to assess the long-term sustainability of the fishing communities themselves. In several West Coast fleets, the age distribution of fishery participants differs notably from the age distribution of West Coast residents. U.S. Census data of total populations includes children too young to be employed in fisheries, but even a simple comparison of workforce-aged persons shows that the age distribution of participants in several West Coast fleets is skewed to greater ages than the age distribution of the general population – see Figures 3.4.21 through 3.4.23.

Figure 3.4.21. Age Distribution of Oregon's Human Population -- 2010 U.S. Census

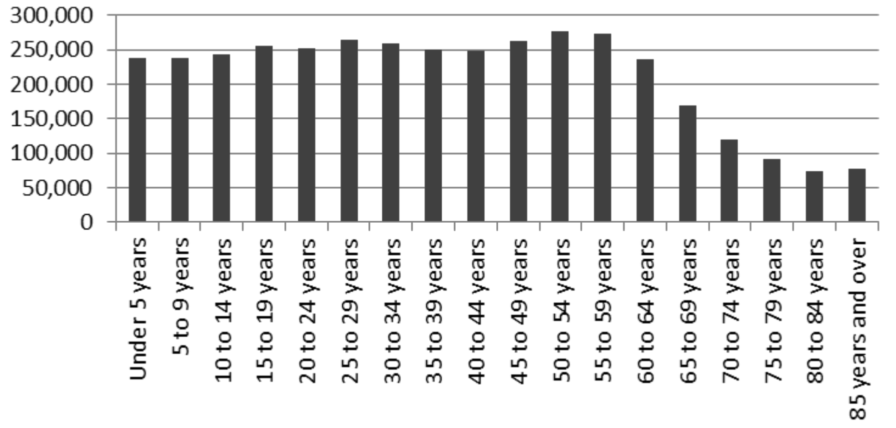


Figure 3.4.22 Age Distribution of Oregon's Salmon Troll Permit Owners

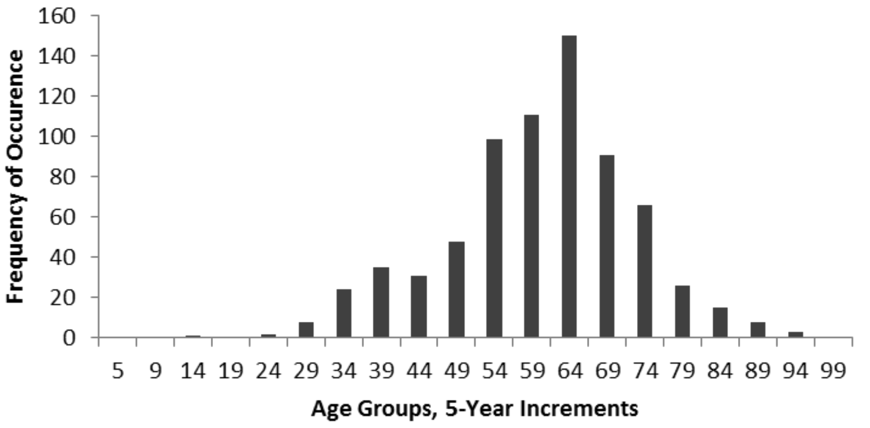
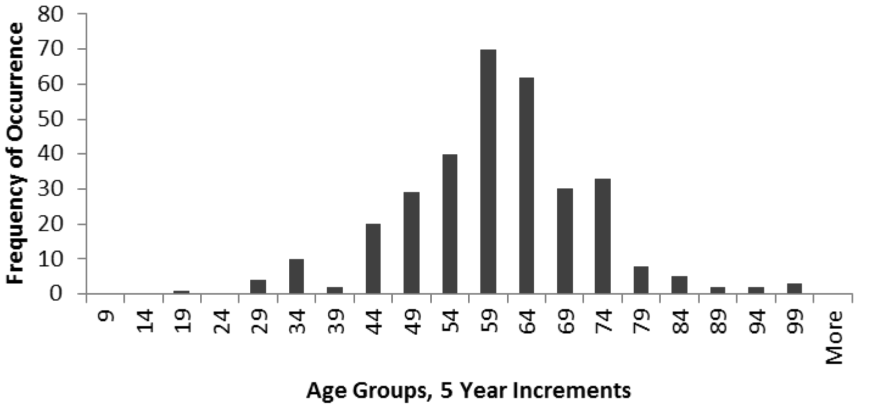


Figure 3.4.23 Age Distribution of Owners of Vessels Assigned to Groundfish Trawl Quota Shares

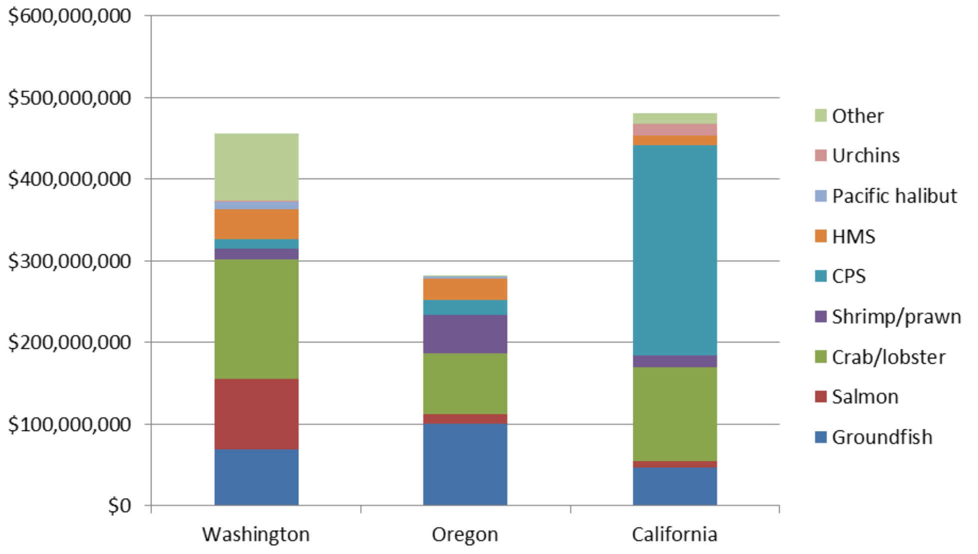


Within the Council process, economic analyses often separate fishing communities by geography or by sector (e.g., commercial or recreational, treaty or non-treaty, fishing or processing, trawl or fixed gear, purse seine or longline, etc). Regional economic models are employed to assess the amount of economic activity, in terms of sales, income, and employment, that is generated by the business operations of economic entities within a particular geographic region. The input-output model is one type of economic impact model that tracks the flow of dollars within a regional economy. With respect to ecosystem-based management, an input-output model can help to evaluate, predict, and assess goals and policies in an inter-connected system of sectors or industries comprising a regional economy. In this sense, it is akin to an ecological food web that characterizes predator-prey interactions within an ecosystem.

NOAA scientists sharing ocean creatures with the public at the Seattle, WA, Fall Fishing Festival. Photo credit: NOAA AFSC

To understand the socioeconomic effects of fishery management actions, the Council uses the Fishery Economic Assessment Model (FEAM), a production-oriented input-output model to estimate the contribution of West Coast commercial fishery sectors to the total income of the coastal communities of Washington, Oregon, and California (Seung and Waters 2005). The FEAM allows for geographic resolution from the state level down to port area within each state. It distinguishes fishery sectors within each geographic area by their corresponding FMP, and where appropriate, disaggregates harvests within a sector according to vessel or gear type and the condition in which they were landed (e.g. alive or dead). The FEAM[3] provides estimates of the income impacts stemming from the dollar value added to landings of West Coast commercial species as they make their way from the ocean, to the exvessel level, and through to the

Figure 3. 4.24 2011 fisheries income impacts for West Coast states, by species type



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[3] The Fishery Economic Assessment Model (FEAM) was developed by Dr. Hans Radtke and Dr. William Jensen to estimate local, state and regional marginal and average income impacts for West Coast fishery landings. The FEAM model is based on the U.S. Forest Service IMPLAN model enhanced with fishing sector coefficients specific to West Coast fisheries. In its current configuration the FEAM was calibrated using coefficients from the IMPLAN's 1998 input-output database, and PacFIN landings extractions for Year 2000.

exprocessor level of the fishery. It does this by deriving input-output multipliers, which are used to convert the revenues at each stage of the production process into either: (1) direct income - exvessel income generated in the region of interest by the harvesting sector of the fishing industry from landings by species, by port, and by gear; (2) indirect income - income generated in the region of interest by all industries, due to the iteration of industries purchasing from industries in response to landings of a particular species at the exvessel level; (3) induced income - the expenditures from new household income within the region of interest, generated by the direct and indirect income effects of landings of a particular species.


Darrin Seiji (l) and Erin Loury (r), with vermilion rockfish on research cruise for California Collaborative Fisheries Research Program. Photo credit: SLOSEA

Here, the FEAM was used to estimate the total income impact from each state's 2011 landings of species targeted by the major commercial fisheries occurring within the CCE (Figures 3.4.20 through 3.4.23). From the quantities landed and the corresponding exvessel revenues for a specific fishery sector shown Figures 3.4.20 through 3.4.23, and the related value added from processing that volume of raw fish, the direct, indirect, and induced incomes are calculated. These are then combined to estimate the total income impact generated by the fishery sector at the state and entire West Coast levels. For example, at the average exvessel price for each pound of Dungeness crab landed in Washington during 2011, the average total income impact was estimated to be $1.69 per dollar of exvessel revenue at the state level and $1.84 per dollar of exvessel revenue coastwide; for Oregon and California these total income impacts were $1.68 and $1.91 respectively at the state level, and $1.78 for Oregon and $2.13 for California coastwide.


Market squid boats in Monterey Bay, CA. Photo credit: Deb Wilson-Vandenberg CDFW

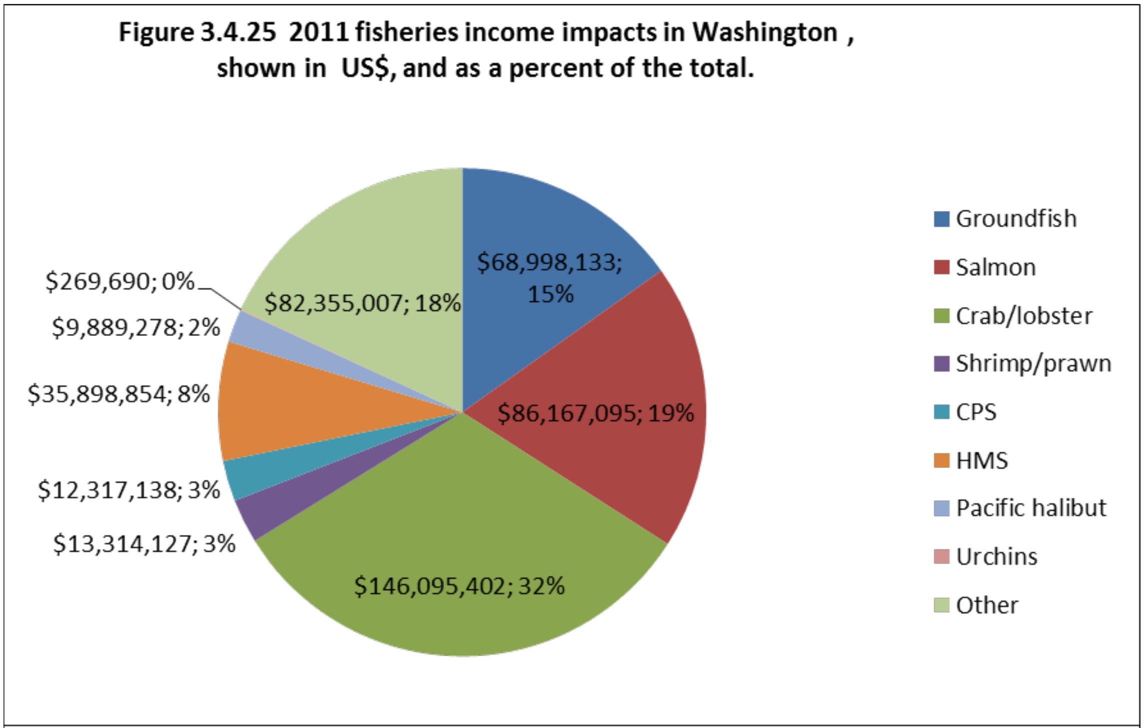


Figure 3.4.25 2011 fisheries income impacts in Washington , shown in US$, and as a percent of the total.

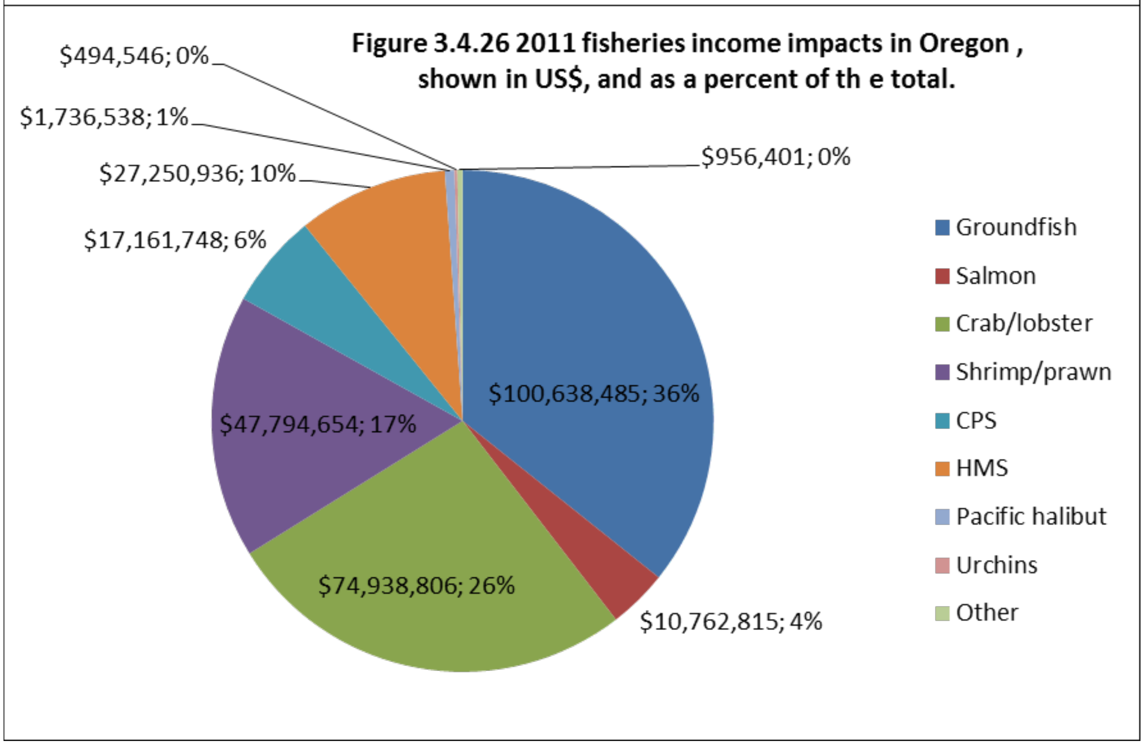
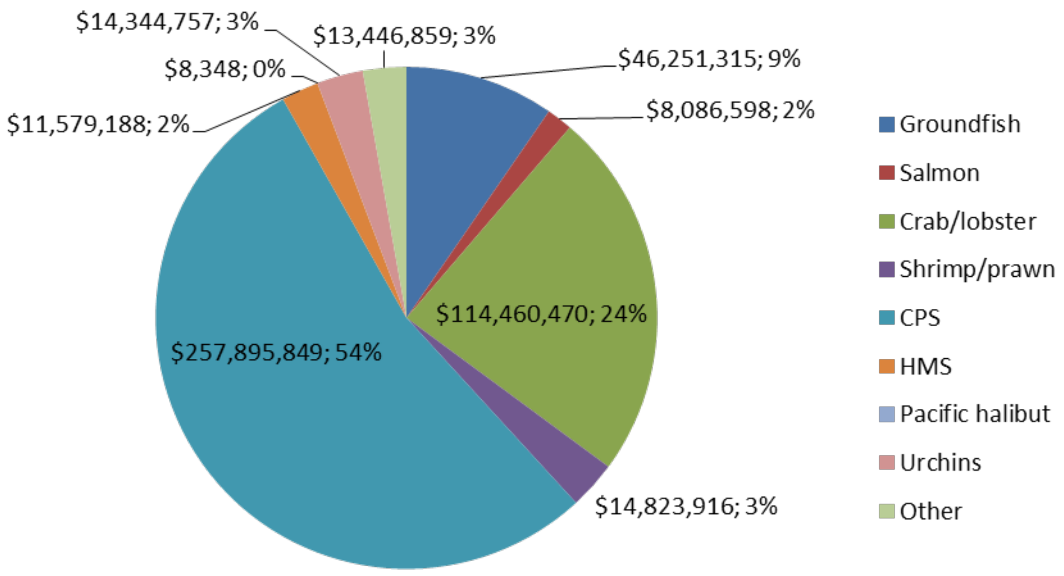


Figure 3.4.26 2011 fisheries income impacts in Oregon , shown in US$, and as a percent of th e total.

Figure 3.4.27 2011 fisheries income impacts in California, shown in US$, and as a percent of the total.

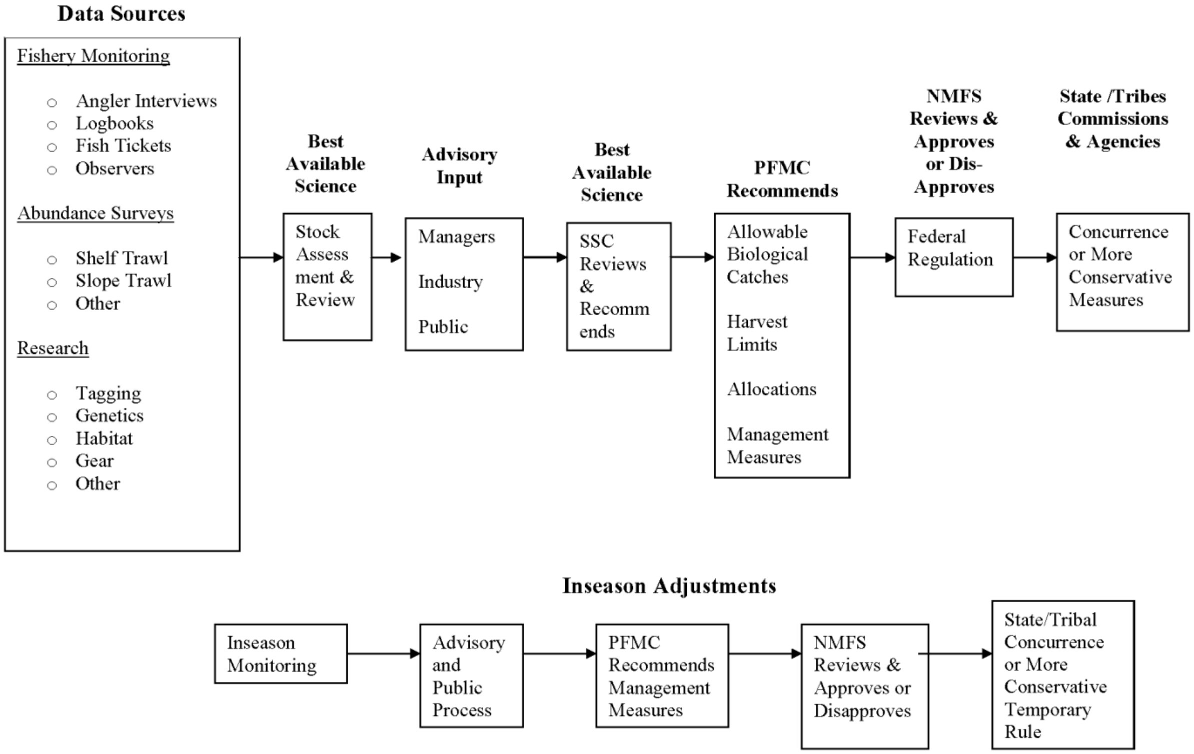


Half Moon Bay, CA, Pillar Point direct-to-public Dungeness crab market.
Photo credit: Pietro Parravano

3.5 Fisheries and Natural Resource Management in the CCE

Many CCE fisheries are under the Council's jurisdiction, but the Council also shares jurisdiction over or management responsibilities for the species it manages with other entities or institutions. While the states and tribes participate in the Council process, they also have separate management processes linked to and informing the Council's work. Beyond the EEZ, management processes for several Council species include multi-national processes with their own priorities and institutions. Figure 3.5.1 provides a general overview of the state/tribal/Federal management process: the states, tribal, and Federal government together organize and implement fisheries monitoring, data gathering, and research programs; scientific information is reviewed through the Council's Scientific and Statistical Committee (SSC); management measures and programs are developed through the Council's advisory bodies and associated public processes; scientific analyses are again reviewed through the SSC for their utility within the management process; the Council uses the SSC recommendations and advice from its advisory bodies and the public to recommend harvest levels and other management measures; Council recommendations are then reviewed and partially or wholly implemented through Federal, and then tribal and state, regulatory processes.

Figure 3.5.1: State/Tribal/Federal Management Process Overview



For species and fisheries under a Federal FMP, states and tribes may adopt regulations or management measures that concur with Federal regulations or which are more conservative than Federal regulations. Table 3.5.1 lists the major species within the CCE and the entity or entities responsible for managing fisheries for those species.

Table 3.5.1. Management authorities for CCE fisheries, by major species or species groups

SPECIES or SPECIES GROUP	STATE MANAGEMENT[1]	TRIBAL MANAGEMENT[2]	STATE-TRIBAL-FEDERAL MAMAGEMENT	INTERNATIONAL MANAGEMENT
All Salmon, except:	Concur/Conservative	Concur/Conservative	FMP	US/Canada Salmon Treaty
Nearshore & In-river	Regulation, SFMP	Regulation		US/Canada Salmon Treaty
All Groundfish, except:	Concur/Conservative	Concur/Conservative Intertribal Sharing Agreements	FMP	US/Canada Whiting Treaty
Cabezon	Regulation, SFMP			
California scorpionfish	Regulation, SFMP			
Some Greenlings	Regulation, SFMP			
Some Nearshore Rockfish	Regulation, SFMP	Regulation		
California Halibut	Regulation			
Miscellaneous spp.	Regulation	Regulation		
Pacific Halibut	Concur/Conservative	Concur Intertribal Sharing Agreement	Catch Sharing Plan	US/Canada Pacific Halibut Convention, IPHC
All Coastal Pelagic Species, except:	Concur/Conservative	Concur/Conservative	FMP	
Herring	Regulation or SFMP	Regulation		
Smelts	Regulation or SFMP	Regulation		
Squid, market	Regulation or SFMP			
Miscellaneous spp.	Regulation or SFMP	Regulation		
All Highly Migratory Species, except:	Concur/Conservative		FMP	WCPFC, IATTC, and US/Canada Albacore Treaty
Many sharks	Regulation			
Miscellaneous spp.	Regulation			
Other fish				
White seabass	Regulation, SFMP			
All Shellfish	Regulation or SFMP	Regulation		
Dungeness Crab	Regulation and Tri-State MOU	Regulation		
Other Crabs	Regulation			
Clams & Mussels	Regulation	Regulation		
Oysters	Regulation			
Scallops	Regulation			
Shrimp	Regulation			
Urchins	Regulation	Regulation		
Miscellaneous spp.	Regulation, SFMP (CA abalone)	Regulation		
All Other Marine Life	Regulation	Regulation		

[1] State Fishery Management Plan (SFMP)

[2] Several treaty tribes and Washington State have co-management responsibilities for many species

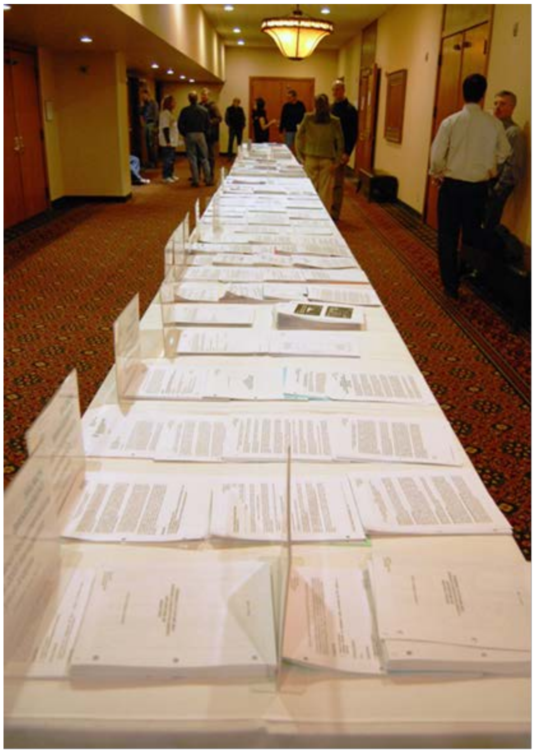
3.5.1 Council Fisheries Management

Fishery management councils were first authorized by the Fishery Conservation and Management Act of 1976 [Pub. L. 94-265]. That act also established an ocean fishery conservation zone [later, the EEZ] beyond state marine waters out to 200 nm offshore of U.S. coastlines, and gave councils areas of authority within the zone. The Pacific Council first met October 12-15, 1976, to begin discussions of shared state-Federal management priorities for the fisheries within U.S. waters offshore of the U.S. West Coast. Over the last 30+ years, the Council has developed four FMPs and a Catch Sharing Plan for Pacific Halibut, and has addressed a wide range of fisheries and environmental issues through amendments to those plans discussed in over 200 formal meetings and in countless public hearings. Major fishery management planning events in the Council's history are shown in Table 3.5.2, many of which were developed in response to the 1996 and 2007 reauthorizations of the MSA, the current-day iteration of the 1976 Fishery Conservation and Management Act.

PFMC meeting in the late-1970s. Photo credit: PFMC

Table 3.5.2: Major fishery management planning events in PFMC history by implementation date		
Federal Fisheries Legislation-Related Events	Year	Major Council Events
Fishery Conservation and Management Act first enacted, including assertion of 200 nm fishery conservation zone (later EEZ)	1976	
	1976	Council's first meeting
	1978	Northern Anchovy FMP final
	1978	Salmon FMP final
	1982	Groundfish FMP final
	1984	Amendment 6 to Salmon FMP – preseason and inseason management framework
First West Coast salmon ESA listing: Sacramento Winter-run Chinook, threatened	1989	
	1990	Amendment 4 to Groundfish FMP – specifications and management measures process
	1992	Amendment 6 to Groundfish FMP – limited entry program
	1995	Pacific Halibut Catch Sharing Plan adopted
Sustainable Fisheries Act (SFA)	1996	
	1997	Combined Amendment 12 to Salmon FMP & Amendment 10 to Groundfish FMP – setting parameters for salmon bycatch in whiting trawl fisheries
National Standard Guidelines revised	1998	

Table 3.5.2: Major fishery management planning events in PFMC history by implementation date		
Federal Fisheries Legislation-Related Events	Year	Major Council Events
	1999	Amendment 11 to Groundfish FMP – SFA provisions
	1999	Amendment 8 to Northern Anchovy FMP – expanded FMP scope to establish CPS FMP, SFA provisions
	2001	Amendment 14 to Salmon FMP – SFA provisions
	2001	Amendment 14 to Groundfish FMP –permit stacking program for limited entry fixed gear sablefish fishery
	2004	Amendments 16-1 & 16-2 to Groundfish FMP – established groundfish rebuilding plan framework, plus first four groundfish rebuilding plans (darkblotched rockfish, Pacific ocean perch, canary rockfish, lingcod)
	2004	HMS FMP final
	2006	Amendments 19 to Groundfish FMP – EFH identification and coastwide protection measures
MSA reauthorized	2007	
	2007	Amendment 1 to HMS FMP – bigeye tuna rebuilding plan and FMP reorganization
National Standard 1 guidelines revised	2009	
	2009	Amendment 12 to CPS FMP – prohibition on krill harvest
	2010	Amendment 20 to Groundfish FMP – trawl rationalization (catch share program)
	2011/ 2012	Amendment 13 to CPS FMP, Amendment 23 to Groundfish FMP, Amendment 2 to HMS FMP, and Amendment 16 to Salmon FMP – annual catch limits (ACLs) and accountability measures (AMs)



Contemporary PFMC meeting's reading material available to the public. Photo credit: PFMC

3.5.1.1 Cross-FMP Goals and Management Measures

While the Council develops and considers management programs for West Coast fisheries in four separate FMPs, the ideas about and priorities for management come from the MSA and from a regional ethos that collaboration and cooperation in management discussions can better-sustain fisheries now and into the future. The goals and objectives of the four FMPs share five common themes consistent with an ecosystem approach to fishery management: avoid overfishing, minimize bycatch, 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 Table 3.5.3:

Table 3.5.3 FMP Shared Goals and Objectives, by FMP Objective/Goal Number

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

Table 3.5.4 details the array of fishery conservation and management measures that the Council uses to implement its priorities for West Coast fish and fisheries.

Table 3.5.4 Conservation and Management Measures Across FMPs

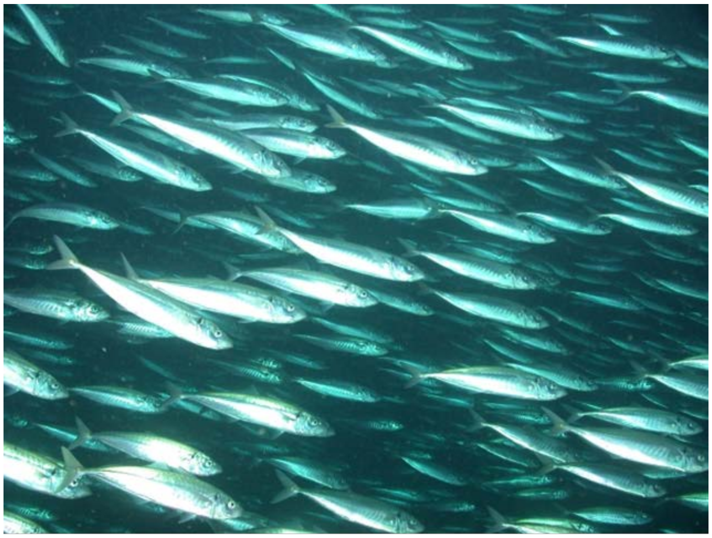
	CPS	Groundfish	Salmon	HMS
Annual harvest limits	✓	✓	✓	
Harvest restrictions to provide prey base for other spp.	✓	✓		
Season limits for all or some species	✓	✓	✓	
Fishing area restrictions to minimize bycatch		✓	✓	✓
Fishing area restrictions to minimize effects on EFH		✓		
Gear restrictions to minimize bycatch	✓	✓	✓	✓
Participation/access limitation program(s)	✓	✓		
Bycatch monitoring for all or some species/fisheries	✓	✓	✓	✓

3.5.1.2 Ecosystem-Based Management Measures within FMPs

This section identifies existing ecosystem-based principles and management measures within current FMPs, particularly 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. Additional protective management measures have also been promulgated under the ESA and MMPA. The fisheries are managed to include these protection measures. 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, are current through February 2013.

CPS FMP

1. Krill harvest prohibition: The CPS FMP prohibits harvest of all species of euphausiids (krill) that occur within the U.S. West Coast EEZ to help maintain important predator-prey relationships and the long-term health and productivity of the West Coast ecosystem. These ecosystem conservation principles enhance fishery management by protecting, to the extent practicable, krill resources, which are an integral part of the ecosystem [HMS, groundfish, salmon, CPS, marine mammals, birds]
2. Conservative Management Strategy: The Council has demonstrated a consistently conservative approach to CPS harvest management in response to their ecological role as forage and importance to West Coast fisheries. The Council frequently reviews new science in support of stock assessments and management strategies and conducts annual stock assessments for the actively-managed species because of the annual variability that can occur in the biomass of CPS. In the late-1990's, the Council chose the most conservative HCR for Pacific sardine when presented a wide range of FMP harvest policies. The rationale for this harvest policy, like the other harvest controls rules in the FMP, is oriented toward maximizing biomass versus maximizing catch. Because of this, the annual harvest levels that result from the rule never exceed 12 percent of the estimated biomass for that year. [HMS, groundfish, salmon, CPS, marine mammals, birds]
3. Environmental Indicators: The intent of the existing environmental parameter in the Pacific sardine HCR 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. Additionally the annual Stock Assessment and Fishery Evaluation (SAFE) document for CPS includes an 'Ecosystem Considerations' chapter that provides a summary of oceanographic trends and ecological indicators being tracked by NMFS in the CCE and potentially having an effect on CPS stocks. [CPS]
4. Cutoff Parameters: CPS HCRs have long utilized "Cutoff" parameters to protect a core spawning population and prevent stocks from becoming overfished. 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 decline. This mechanism



Anchovy school. Photo credit: NOAA SWFSC

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, birds]

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 greater scientific uncertainty about stock status or management. [HMS, groundfish, salmon, CPS, marine mammals, birds]
6. 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 U.S.-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]
7. Ecosystem Component (EC) Species: The CPS FMP contains two EC species, jacksmelt and Pacific herring. In recognition of their role as forage, bycatch and incidental catch of these species is specifically monitored, along with all other bycatch/incidental catch, annually in the CPS SAFE document.
8. Bycatch provisions: Incidental catch provisions are often included in annual management recommendations for CPS. These provisions are included to allow for small allowances of incidental catch of a specific CPS species, for which the directed fishery may be closed, in other CPS fisheries to prevent and reduce discard. [CPS]
9. ESA incidental take protections: CPS fishing boat operators and crew are prohibited from deploying their nets if a southern sea otter is observed within the area that would be encircled by the purse seine. [otters]

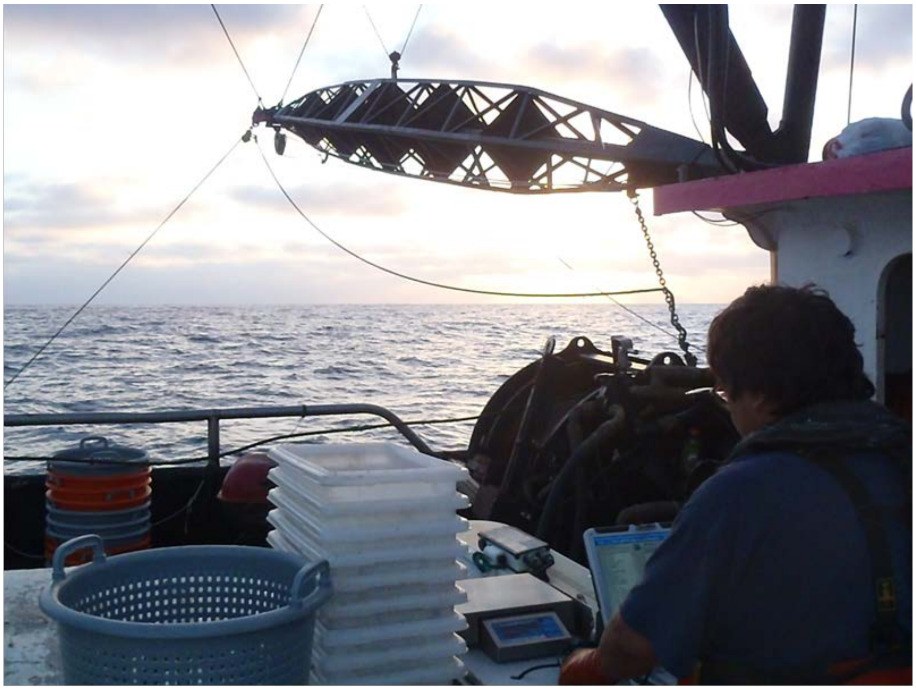
Groundfish FMP

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. RCAs: 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,


Tom Ghio at the helm of F/V Miss Alison.
Photo credit: John Field, NOAA SWFSC

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 FMSY 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 the 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]
13. Implementation of the Individual Fishing Quota trawl rationalization program, which has demonstrated reduced bycatch of non-target species such as halibut and overfished species of concern since its inception in January 2011. [Groundfish, Halibut]



Dan Kamikawa, NWFSC scientist, on groundfish trawl survey.
Photo credit: NOAA NWFSC

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: NMFS-trained observers on vessels. Sea turtle protections: swordfish longline fishery prohibited west of 150° W. long.; prohibition on light stick possession for longline vessels operating west of 150° W. long.; shallow set longline fishing prohibited east of 150° W. long; seasonal area closures for drift gillnet in times and areas where there have been prior fishery interactions with leatherback sea turtles (the Pacific Leatherback Conservation Area), regulations for drift gillnet closures during El Niño events; equipment and handling requirements for bringing incidentally-caught turtles onboard, and resuscitating and releasing when possible; mandatory sea turtle amd marine mammal training for skipper and crew participating in the drift gillnet fishery. Marine mammal protections: Pacific Cetacean Take Reduction Plan requires gear modifications on drift gillnet gear (pinger and gear depth requirements). State regulations to reduce marine mammal bycatch using time/area closures. [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]

F/V Diane Susan and 400 lb swordfish. Photo credit: Tom Roff, Central CA Joint Cable/Fisheries Liaison Committee

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 RCA 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 regulation 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 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 Oregon coastal natural 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]

Swinomish tribal members Mike Cladoosby (l), and Kevin Day (r) fish the Skagit River during a one-day spring Chinook fishery. Photo credit: Kari Neumeyer, NWIFC

3.5.1.3 CCE Species Managed Under the ESA or MMPA

Recovering ESA-listed endangered and threatened anadromous and marine species within the U.S. portion of the CCE is a joint effort between U.S. citizens and Federal, state, and tribal management agencies. NMFS has jurisdiction over recovery and protection of most marine and anadromous fish and mammal species of the U.S. CCE, including most marine mammals, sea turtles, marine fishes, invertebrates, and plants. Sea otter recovery is under the jurisdiction of the USFWS. The USFWS also has jurisdiction over recovery of CCE seabird species. The Council's FMPs include a variety of fishery management measures intended to minimize fisheries interactions with ESA-listed species. These measures are often the result of consultations on the FMPs required by the ESA. As the agency implementing FMPs, NMFS must ensure that all Federal fisheries comply with the ESA, and that actions authorized by the FMPs do not jeopardize listed species or adversely modify or destroy designated critical habitat. To meet this requirement, all FMPs have gone through ESA section 7 consultation with NMFS and with USFWS. Biological opinions, the outcomes of the consultations, have been completed for all Federal fisheries.

Southern sea otter. Photo credit: NOAA

In Section 3.2, the FEP briefly describes the contributions of different species to the trophic levels of the CCE's marine food web from a biological perspective. From a management perspective, the laws that are used to manage the different species of the EEZ do not necessarily reflect their trophic interactions, but instead often reflect their abundance levels as individual stocks, or as particular distinct population segments (DPS) or evolutionarily significant units (ESUs) of fish or other animals. Under the ESA, species considered for ESA protection include "any subspecies of fish or wildlife or plants, and any DPS of any species of vertebrate fish or wildlife which interbreeds when mature." For marine species with vast migratory ranges, a distinct population of a particular species may occur off the U.S. West Coast, while other distinct populations of that same species may occur elsewhere within the North Pacific or beyond. For example, Steller sea lions (*Eumetopias jubatus*) range across the entire North Pacific Ocean from coastal Japan and Korea to the U.S. West Coast. The portion of the Steller sea lion population off the U.S. West Coast is considered a DPS, known as the eastern DPS. The Steller sea lion's U.S. western DPS, generally found off Alaska and farther north, remains listed as endangered under the ESA. NOAA has proposed removing the eastern DPS from ESA listing, based on its recovery under the ESA (77 FR 23209, April 18, 2012).

Leatherback turtle. Photo credit: NOAA

Since 1991, NOAA has assessed ESA-listed salmonids for whether a particular population could be considered a DPS based on whether it could be considered an ESU of the particular population (56 FR 58612, November 20, 1991). Using the ESU designation allows NOAA to acknowledge under the ESA what salmon fishing people have known for centuries – that a single stream can host multiple runs of the same species of salmon arriving in their freshwater habitats at different times of year. A spring-run Chinook for a particular river may be genetically similar to a fall-run Chinook for that same river, but those fish cannot breed with each other because they are not in the same breeding place at the same time, thus they are distinct ESUs. The complex salmon-linked ecologies of North American rivers that drain to the Pacific Ocean require government agencies and the public to see salmon runs for their very particular roles in small geographic areas like individual streams, and for their ecosystem-wide roles linking the North American land mass to the Pacific Ocean. Salmon also serve as an important prey item for endangered southern resident killer whales (*Orcinus orca*), which are listed as endangered under the ESA.

As shown in Table 3.5.5, ESA-listed marine or anadromous species that, in some or at all times of the year, may occur within the U.S. West Coast EEZ include marine mammals, sea turtles, fish, and invertebrates.

Table 3.5.5: ESA-listed species that may occur in U.S. West Coast EEZ

Species		**Status**
Marine Mammals		
Blue whale *(Baleaenoptera musculus)*		Endangered
Fin whale *(Baleranoptera physalus)*		Endangered
Humpback whale (*Megaptera novaeangliae*)		Endangered
Sei whale (*Balaenoptera borealis*)		Endangered
Sperm whale (*Physeter macrocephalus*)		Endangered
Killer whales, southern resident DPS (*Orcinus orca*)		Endangered
North Pacific Right whale (*Eubalaena japonica*)		Endangered
Steller sea lion, eastern DPS (*Eumetopias jubatus*)		Threatened
Southern sea otter (*Enhydra lutris nereis*)		Threatened
Guadalupe fur seal (*Arctocephalus townsendi*)		Threatened
Birds		
Short-tailed albatross (*Phoebastria albatrus*)		Endangered
Marbled murrelet *(Brachyramphus marmoratus marmoratus)*		Threatened
California least-tern *(Sternum antillarum browni)*		Endangered
Xantus's murrelet *(Synthliboramphus hypoleucus)*		Candidate
Sea turtles		
Leatherback turtle (*Dermochelys coriacea*)		Endangered
Loggerhead turtle, North Pacific Ocean DPS (*Caretta caretta*)		Endangered
Olive Ridley (*Lepidochelys olivacea*)		Endangered/Threatened
Green Sea Turtle (*Chelonia mydas*)		Endangered/Threatened
Marine invertebrates		
White abalone (*Haliotis sorenseni*)		Endangered
Black abalone (*Haliotis crachereodii*)		Endangered
Fish		
Green Sturgeon, southern DPS (*Acipenser medirostris*)		Threatened
Pacific eulachon, southern DPS (*Thaleichthys pacificus*)		Threatened
Yelloweye Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes ruberrimus*)		Threatened
Bocaccio, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)		Endangered
Canary Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes pinniger*)		
Yelloweye Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes ruberrimus*)		
Salmonids		
Chinook (*Oncorhynchus tshawytscha*)	Sacramento River winter ESU	Endangered
	Central Valley Spring ESU	Threatened
	California Coastal ESU	Threatened

Table 3.5.5: ESA-listed species that may occur in U.S. West Coast EEZ

Species		Status
	Snake River Fall ESU	Threatened
	Snake River Spring/Summer ESU	Threatened
	Lower Columbia River ESU	Threatened
	Upper Willamette River ESU	Threatened
	Upper Columbia River Spring ESU	Endangered
	Puget Sound ESU	Threatened
Chum (*Oncorhynchus keta*)	Hood Canal Summer Run ESU	Threatened
	Columbia River ESU	Threatened
Coho (*Oncorhynchus kistuch*)	Central California Coastal ESU	Endangered
	S. Oregon/N. CA Coastal ESU	Threatened
	Oregon Coast ESU	Threatened
	Lower Columbia River ESU	Threatened
Sockeye (*Oncorhynchus nerka*)	Snake River ESU	Endangered
	Ozette Lake ESU	Threatened
Steelhead (*Oncorhynchus mykiss*)	Southern California DPS	Endangered
	South-Central California DPS	Threatened
	Central California Coast DPS	Threatened
	California Central Valley DPS	Threatened
	Northern California DPS	Threatened
	Upper Columbia River DPS	Endangered
	Snake River Basin DPS	Threatened
	Lower Columbia River DPS	Threatened
	Upper Willamette River DPS	Threatened
	Middle Columbia River DPS	Threatened
	Puget Sound	Threatened

Marine mammals are protected under the MMPA, regardless of whether their populations are depleted enough to warrant listing as threatened or endangered under the ESA. Marine mammals that may, during some or at all times of the year, occur within the CCE are shown in Table 3.5.6:

Orca whales, Monterey Bay. Photo credit: NOAA

Table 3.5.6: MMPA-protected species that may occur in U.S. West Coast EEZ

Species	**Stocks**
Cetaceans	
Harbor porpoise (*Phocoena phocoena*)	Various
Dall's porpoise (*Phocoenoides dalli*)	CA/OR/WA stock
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	North Pacific stock; CA/OR/WA stock
Risso's dolphin (*Grampus griseus*)	CA/OR/WA stock
Bottlenose dolphin (*Tursiops truncatus*)	California coastal stock
Bottlenose dolphin (*Tursiops truncatus*)	CA/OR/WA offshore stock
Short-beaked common dolphin(*Delphinus delphis)*	CA/OR/WA stock
Long-beaked common dolphin(*Delphinus capensis)*	California stock
Northern right whale dolphin (*Lissodelphis borealis*)	CA/OR/WA stock
Striped dolphin (*Stenella coeruleoalba*)	CA/OR/WA stock
Short-finned pilot whale (*Globicephala macrorhynchus*)	CA/OR/WA stock
Sperm whale (*Physeter macrocephalus*)	CA/OR/WA stock
Dwarf sperm whale (*Kogia sima*)	CA/OR/WA stock
Pygmy sperm whale (*Kogia breviceps*)	CA/OR/WA stock
Killer whale (*Orcinus orca*)	Eastern North Pacific southern resident stock
Killer whale (*Orcinus orca*)	Eastern North Pacific offshore stock
Killer whale (*Orcinus orca*)	west coast transient stock
Mesoplodont beaked whales (*Mesoplodon* spp.) - (Hubbs' beaked whales, Gingko -toothed whale, Stejneger's beaked whale, Blainville's beaked whale, Pygmy beaked whale or Lesser beaked whale, Perrin's beaked whale)	CA/OR/WA stocks
Cuvier's beaked whale (*Ziphius cavirostris*)	CA/OR/WA stock
Baird's beaked whale (*Berardius bairdii*)	CA/OR/WA stock
Blue whale (*Balaenoptera musculus)*	Eastern North Pacific stock
Fin whale (*Balaenoptera physalus)*	CA/OR/WA stock
Humpback whale (*Megaptera novaeangliae*)	CA/OR/WA stock
North Pacific right whale (*Eubalaena japonica*)	Eastern North Pacific stock
Sei whale (*Balaenoptera borealis)*	Eastern North Pacific stock
Minke whale (*Balaenoptera acutorostrata*)	CA/OR/WA stock
Gray whale (*Eschrichtius robustus*)	Eastern North Pacific stock
Pinnipeds	
California sea lion (*Zalophus californianus californianus*)	U.S. stock
Harbor seal (*Phoca vitulina richardsi*)	CA stock and OR & WA coastal stock
Northern elephant seal (*Mirounga angustirostris*)	CA Breeding Stock
Guadalupe fur seal (*Arctocephalus townsendi*)	
Northern fur seal (*Callorhinus ursinus*)	San Miguel Island stock
Steller sea lion (*Eumetopias jubatus*)	eastern Pacific stock (U.S.)

3.5.2 Tribe and State Fisheries

3.5.2.1 Northwest Tribes' Fisheries Management

Quinault Indian Nation Fisheries: Bruce Wagner (l) and Scott Mazzone (r), collecting otoliths and inspecting catch. Photo credit: Debbie Ross-Preston, NWIFC

The Treaty Tribes of Oregon and Washington (Tribes) have both exclusive and shared authority to manage a wide variety of fisheries and natural resources affected by both current and future actions of the Council and by biophysical conditions within the CCE. The Tribes manage and harvest marine species covered by the Council's FMPs as well as other species governed by the Tribes' own exclusive authorities or by co-management agreements with the states of Oregon and Washington. The Tribes also retain property interests in species they do not currently manage or harvest but may choose to do so at a future time.

Tribal fisheries have ancient roots and their harvests are used for commercial, personal use and cultural purposes. Authorities to plan, conduct and regulate fisheries, manage natural resources and enter into cooperative relationships with state and Federal entities are held independently by each of the Tribes based on their own codes of law, policies, and regulations. The independent sovereign authorities of each Tribe were federally recognized initially in a series of treaties negotiated and signed during 1854-1855 (Treaty with the Tribes of Middle Oregon (1855), Treaty with the Walla Walla, Cayuse, and Umatilla Tribes (1855), Treaty with the Yakama (1855), Treaty with the Nez Perce (1855), Treaty of Medicine Creek (1854), Treaty of Neah Bay (1855), Treaty of Olympia (1855), Treaty of Point Elliot (1855) and Treaty of Point No Point (1855) and have been reaffirmed by judicial review (e.g., U.S. v. Oregon (SoHappy v. Smith) 302 Supp.899 (D. Oregon, 1969) and U.S. v. Washington 384 F. Supp. 312 (W. Dist. Wash., 1974) and administrative policies (e.g., Executive Order 13175 and Secretarial Order 3206).

Each Treaty Tribe exercises its management authorities within specific areas usually referred to as Usual and Accustomed (U&A) fishing locations. These areas have been adjudicated within the Federal court system or confirmed by Federal administrative procedures. The restriction of treaty-right fisheries to specific geographic boundaries creates place-based reliance on local resource abundance and limits the Tribes' latitude for response to variations in ecosystem processes, species distributions, or fisheries management effects.

Each Tribe has established sets of laws and policies to achieve sustainable fisheries production through traditional and science-based management. Regulations to control the conduct of each fishery (time, place, gear, etc.) are set through governmental procedures, and performance is monitored to ensure objectives are met. The Tribes participate as full partners with Federal and state entities to ensure their criteria for resource conservation and sustainable fisheries are compatible. For example, the Tribes participate in the annual Pacific Salmon Commission process to preserve fishing opportunities on healthy salmon stocks and ensure conservation of depressed stocks of Chinook, chum (*O. keta)*, and coho salmon. They also participate in the North of Falcon process with the State of Washington to achieve an annual set of co-management plans for salmon fisheries within both the EEZ and terminal areas for Council action.

The Tribes' combined regions of management interest and authority include areas outside the EEZ and the physical boundaries of the California Current. However, many of the species managed and harvested in these areas are affected by Council management and by conditions within the CCE. For example, Treaty salmon fisheries in the Columbia River watershed and interior (Strait of Juan de Fuca, Puget Sound and their watersheds) and coastal waters of Washington are significantly affected by salmon harvest quotas and schedules in the EEZ and by general marine conditions for growth and survival. All of the Tribes hold a vested interest in, and participate in, the Council's processes because salmon, other anadromous fishes (e.g., sturgeon spp., lamprey spp., smelt spp., trout and char spp.), and many migratory species of interest (e.g., marine mammals, herring, halibut) traverse and/or are affected by actions and activities within the EEZ and the California Current.

The four coastal Treaty Tribes (Coastal Tribes) of Washington (Makah Nation, Quileute Indian Tribe, Hoh Indian Tribe and Quinault Indian Nation) have broad interests in the CCE and more complex relationships with Council processes and decisions. The U&A's of the Coastal Tribes overlap with the EEZ and they have active ocean fisheries operating under the Council's current FMP's (Table 3.5.5). Harvests in the Coastal Tribes commercial fisheries (Figures 3.5.2 – 3.5.4) provide important employment and entrepreneurial opportunities for their remote communities, and make significant contributions to the coastal economy of Washington.

Table 3.5.5: Coastal Treaty Tribes commercial fisheries

Fishery	**Species**	**FMP**	**Tribes**
Longline	Blackcod, Pacific halibut	Groundfish	Makah, Quileute, Hoh, Quinault
Bottom Trawl	Groundfish	Groundfish	Makah
Mid-Water Trawl	Whiting, Yellowtail Rockfish	Groundfish	Makah, Quileute
Troll	Salmon	Salmon	Makah, Quileute, Hoh, Quinault
Purse Seine	Sardine	CPS	Quinault
Pot	Dungeness Crab		Makah, Quileute, Hoh, Quinault
Manual Intertidal	Razor Clam		Quinault

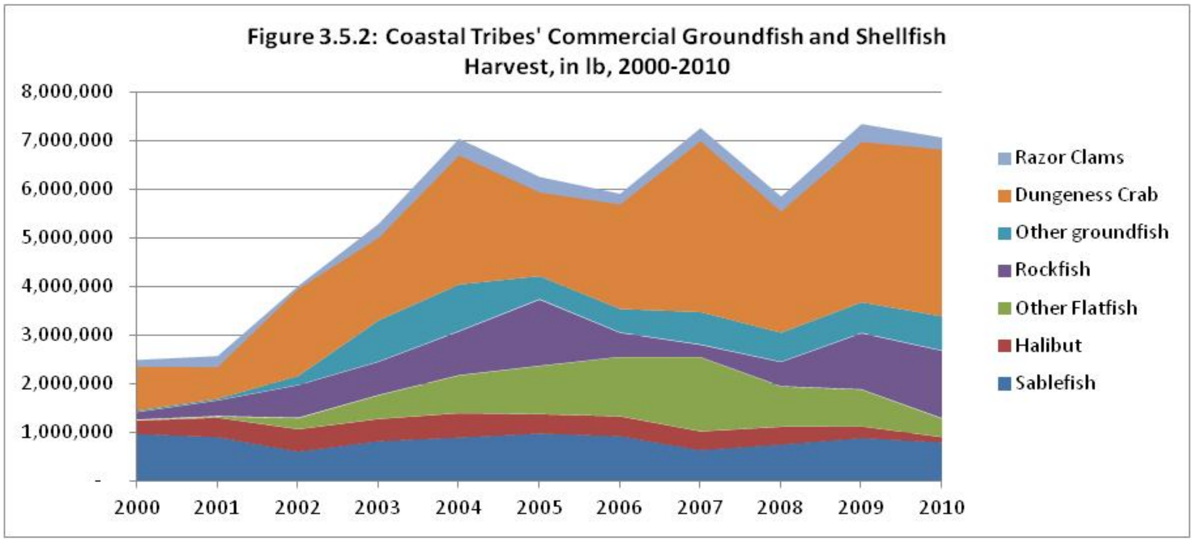


Figure 3.5.2: Coastal Tribes' Commercial Groundfish and Shellfish Harvest, in lb, 2000-2010

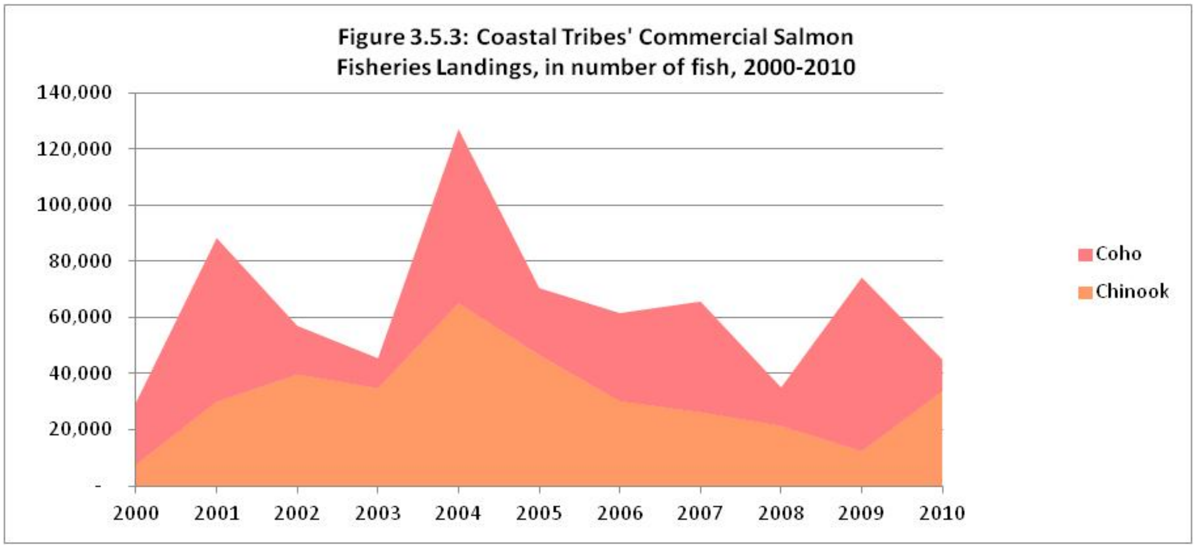


Figure 3.5.3: Coastal Tribes' Commercial Salmon Fisheries Landings, in number of fish, 2000-2010

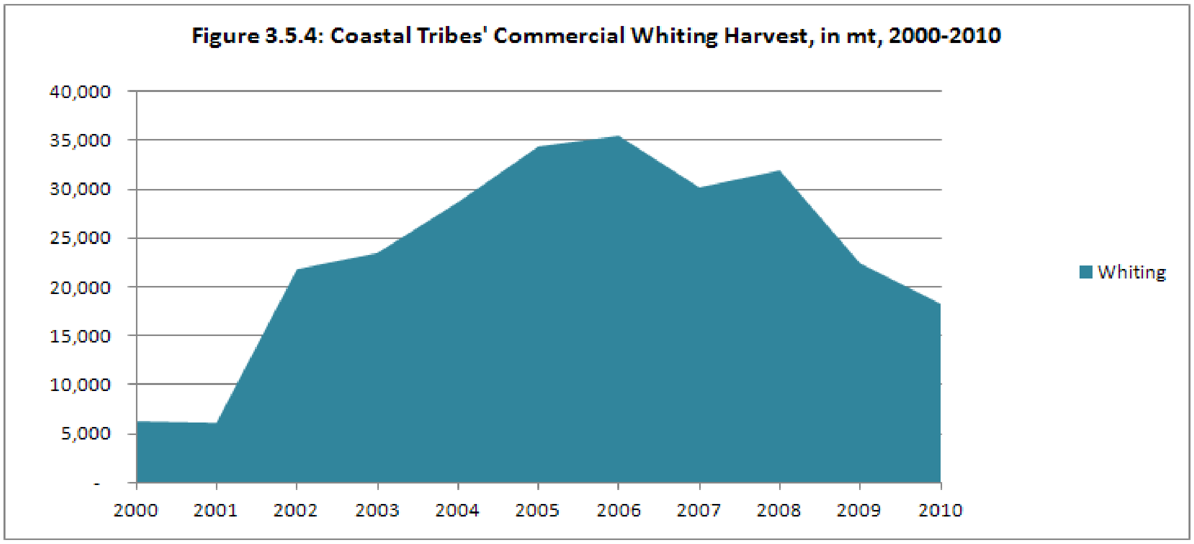


Figure 3.5.4: Coastal Tribes' Commercial Whiting Harvest, in mt, 2000-2010

3.5.2.2 California Tribes in the Council Process

Yurok Tribe members, Pete Thompson and Bob Ray, throwing drift net near the mouth of the Klamath River. Photo credit: Yurok Tribe

Fisheries have been important to California tribes since time immemorial for cultural purposes, subsistence, and commerce-related activities. The primary stock co-managed by the Council, California, and the Hoopa Valley and Yurok Tribes is fall Chinook of the Klamath and Trinity River basins, which is an indicator stock for the Southern Oregon and Northern California complex of the Salmon FMP. Klamath Basin spring Chinook are considered a component of the Southern Oregon and Northern California complex; however, co-managers have not yet identified conservation objectives or coordinated regional management for this stock.

The Yurok Tribal fishery occurs within the lower 44 miles of the Klamath River and within a portion of the Trinity River below the boundary of the Hoopa Valley Reservation. The Hoopa Tribal fishery occurs in the Trinity River from approximately one mile above the confluence with the Klamath River to the upstream boundary of the Hoopa Valley Indian Reservation, approximately 12 river miles. The primary gear type used is gillnets; however, a small portion of the Chinook harvest is taken by dip nets and hook-and-line. Fall Chinook are typically harvested from early August through mid-December, with peak harvest in the Klamath River estuary occurring during late-August through mid-September, and in the Trinity River during late-September to early-October.

In 1993, the Interior Department Solicitor issued a legal opinion that concluded that the Yurok and Hoopa Valley Tribes of the Klamath Basin have a federally-protected reserved right to 50 percent of the available harvest of Klamath Basin salmon. Under the Council's annual salmon management process, half of the annual allowable catch of Klamath River fall Chinook has been reserved for these tribal fisheries since 1994. Federal courts affirmed this decision in Parravano v. Masten, 70 F. 3d 539 (9th Cir. 1995), cert. denied, 116 S. Ct. 2546 (1996). Tribal fisheries with recognized Federal fishing rights occur on the Yurok and Hoopa Valley Indian reservations located on the Lower Klamath and Trinity Rivers, respectively. These fisheries are regulated by their respective governments.

The Yurok Tribal Council regulates the fall and spring Chinook fishery via annual Harvest Management Plans, which are based upon the tribal allocation and subsequent regulations regarding sub-area quotas, conservation measures, and potential commercial fisheries. When the Tribal Council allows a portion of the allocation to go to commercial fishing, then most harvest is taken in the estuary where commercial fisheries are held. Subsistence fisheries are spread throughout the reservation.

The Hoopa Tribal Fishery is conducted in accordance with the Hoopa Valley Tribe's Fishing Ordinance. Fishing by tribal members occurs within the exterior boundaries of the Hoopa Valley Indian Reservation. The Hoopa Valley Tribal Council is the sole authority responsible for the conduct of the tribe's fishery, enforces the fishing ordinance, and ensures collection of harvest statistics through its Fisheries Department.

The tribal fisheries normally set aside a small (unquantified) number of fish for ceremonial purposes. Subsistence needs are the next highest priority use of Klamath River fall Chinook by the Tribes. The subsistence catch has been as high as 32,000 fish since 1987, when separate tribal use accounting was implemented. Generally, commercial fishing has been allowed when the total allowable tribal catch was over 11,000 –16,000 adult Klamath River fall Chinook (PFMC, 2008).

Commercial sales from the Yurok and/or Hoopa Valley Reservation Indian fall gillnet fisheries occurred in 1987-1989, 1996, 1999-2004, and 2007-2011. Average commercial catch of fall Chinook was about 17,200 in those years, most of which occurred in the estuary of the Yurok Reservation. Commercial sales also occurred in spring gillnet fisheries in 1989, 1996, 2000-2004, and 2007-2011, with an annual average of about 1,200 fish sold; however, these were typically spring Chinook (as identified from Trinity River Hatchery coded wire tags) harvested in the estuary during the fall season (early August). Detailed Klamath Basin tribal fishery data can be found in the Council's annual SAFE Document: Review of Ocean Salmon Fisheries.

3.5.2.3 Washington Fisheries Management

Legislative Mandate and Management Areas

WDFW was created to "preserve, protect, perpetuate, and manage the wildlife and food fish, game fish, and shellfish in state waters and offshore waters" (Revised Code of Washington (RCW) 77.04.012). This legislative mandate also instructs WDFW to conserve fish and wildlife "in a manner that does not impair" the resources while also:

- seeking to "maintain the economic well-being and stability of the fishing industry in the state";
- promoting "orderly fisheries"; and
- enhancing and improving the recreational and commercial fishing in the state.

WDFW recognizes this conservation mission also requires the protection, preservation, management, and restoration of natural environments and ecological communities, as well as management of human uses for public benefit and sustainable social and economic needs (WDFW 2012[4]).

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[4] Washington Department of Fish and Wildlife. 2012.
—Mission and Goals: http://wdfw.wa.gov/about/mission_goals.html.
—Rules Information Center: http://wdfw.wa.gov/about/regulations.
—WFWC Policy Documents: http://wdfw.wa.gov/commission/policies.html.

WDFW divides management of coastal fisheries from those in inner waters. Inner waters begin at Cape Flattery and include the U.S. portions of the Strait of Juan de Fuca and Strait of Georgia, the San Juan Islands, Hood Canal, and Puget Sound. Marine areas on the coast and in inner waters include estuaries, with the transition to freshwater management areas occurring at the mouth of rivers and streams.

Westport, WA, commercial crab fleet. Photo credit: WDFW

WDFW’s Council-related activities focus mainly on the coastal region, although WDFW’s management activities for salmonids extend well into the inner marine and freshwater areas of the state. The Department’s legislative mandate covers “offshore waters” in addition to state waters, which the State Legislature defined as the “marine waters of the Pacific Ocean outside the territorial boundaries of the state, including the marine waters of other states and countries” (RCW 77.08.010(33)). The state has direct authority to manage the offshore activities of state residents and vessels that are registered or licensed with the state. WDFW also pursues its mission in offshore waters through collaboration and coordination with Federal, state, and tribal partners; formal engagement in intergovernmental forums, and interjurisdictional enforcement of state, Federal, and international laws. WDFW’s collaborative efforts also include the co-management relationship the state has with tribal governments that hold rights to fish and to manage the fishing activities of their members.

WDFW’s management is, on the whole, highly integrated with Council-managed fisheries. As in Oregon and California, the state is responsible for tracking commercial landings and recreational catch from vessels landing into state ports.

State Policy Process and Fisheries

WDFW consists of the Director, responsible for general operation and management of the agency, and the Washington Fish and Wildlife Commission (WFWC), which establishes policy and provides direction and oversight over the agency’s conservation and management activities. The WFWC consists of nine citizen members that are appointed by the Governor and subject to confirmation by the Washington State Senate.

The WFWC’s policy role includes rulemaking over the time, place, and manner of fishing activities, although the authority to issue some rules has been delegated to the Director (RCW 77.12.047). Regulations are issued through the process established by the states’ Administrative Procedure Act, Regulatory Fairness Act, and State Environmental Policy Act. The WFWC takes input and deliberates on proposed policies and regulations in formal meetings and informal hearings that are open to the public and held throughout the state. More information on the WFWC and the state’s rulemaking process can be found on the WFWC’s website (WDFW 2012).

The WFWC Policy C-3603 guides WDFW's involvement in the Council process. Preservation, protection, and perpetuation of the living marine resources through coordinated management of fisheries is WDFW's guiding principle. Among other things, this policy instructs WDFW's representatives to:

- Support harvest strategies that promote optimum long-term sustainable harvest levels;
- Seek the views of the public, including those who represent consumptive and non-consumptive interest groups;
- Support initiatives and existing programs that more closely align the harvest capacity with the long-term sustained harvest quantities of marine resources, including individual quota programs and license and effort limitations programs;
- Support tribal fisheries that are consistent with the applicable Federal court orders while recognizing the need for management flexibility to optimize fishing opportunity;
- Consider the social implications, impacts on fishing-dependent communities, net economic benefits to the state, and other factors when taking positions on resource allocation issues;
- Take a precautionary approach in the management of species where the supporting biological information is incomplete and/or the total fishery-related mortalities are unknown; and,
- Support consideration of the use of risk-averse management tools to protect the resources in the face of management uncertainty.

WDFW patrol boat at work. Photo credit: WDFW

To facilitate integration between state rules and Council management, the WFWC has delegated rulemaking authority to the Director over rules pertaining to the harvest of fish and wildlife in the EEZ. WDFW incorporates many Federal regulations issued through the Council process into state rules. Among other things, this allows for the enforcement of Council-recommended regulations in state courts.

Other WFWC policies that are of relevance to WDFW's engagement on the Council include:

- Policy C3012 – Forage Fish Management Policy, Goals and Plan
- Policy C3601 – Management Policy for Pacific Halibut
- Policy C3611 – Marine Fish Culture
- Policy C3613 – Marine Protected Areas
- Policy C3619 – Hatchery and Fishery Reform

The full set of policies can be viewed and tracked on the WFWC website (WDFW 2012).

The state has a few major commercial fisheries targeting species that are not included in Council's FMPs or for which Council management is limited. Dungeness crab is the highest value fishery, followed by pink shrimp and spot prawn. The state also allows limited harvest of anchovy for license-holders of the baitfish fishery. The state has only one emerging commercial fishery program in place, now targeted at hagfish. The state has closed state waters off the coast to commercial fishing for groundfish and Pacific sardines. The state does not have a commercial nearshore fishery and has also chosen to not allow the live fish fishery that has developed in Oregon and California. The major recreational fisheries on the coast are boat-based and target primarily salmon, halibut, groundfish (a.k.a. bottomfish), sturgeon, and albacore tuna.

3.5.2.4 Oregon Fisheries Management[5]

The major policies affecting Council FMP species include: the Oregon Food Fish Management Policy, the Oregon Conservation Strategy, the Nearshore Strategy, and the Oregon Native Fish Conservation Policy. Oregon's statutory Food Fish Management Policy (ORS §506.109) is intended to provide for the optimum economic, commercial, recreational, and aesthetic benefits for present and future generations of the citizens of the state. This policy includes the following broad goals:

- Maintain all species of food fish at optimum levels and prevent the extinction of any indigenous species.
- Develop and manage the lands and waters of this state to optimize the production, utilization, and public enjoyment of food fish.
- Permit an optimum and equitable utilization of available food fish.
- Develop and maintain access to the lands and waters and the food fish resources thereon.
- Regulate food fish populations and the utilization and public enjoyment of food fish in a compatible manner with other uses of the lands and waters and provide optimum commercial and public recreational benefits.
- Preserve the economic contribution of the sport and commercial fishing industries, consistent with sound food fish management practices.
- Develop and implement a program for optimizing the return of Oregon food fish for Oregon's recreational and commercial fisheries.

The seven Oregon Fish and Wildlife Commission members are appointed by the Governor and formulate general state programs and policies concerning management and conservation of fish and wildlife resources. Oregon's legislature has also granted the Oregon Fish and Wildlife Commission the authority to adopt regulations for seasons, methods, and limits for recreational and commercial take and sale as well as other restrictions and procedures for taking, possessing, or selling food fish, with the exception of oysters. Oyster production and commercial harvest is regulated by the Oregon Department of Agriculture.

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[5] ODFW Fishery and Fish Resource Information: http://www.dfw.state.or.us/fish/
ODFW Nearshore Strategy: http://www.dfw.state.or.us/MRP/nearshore/strategy.asp
ODFW Conservation Strategy: http://www.dfw.state.or.us/conservationstrategy/
Oregon Fish and Wildlife Commission: http://www.dfw.state.or.us/agency/commission/
Oregon Revised Statutes (Chapters 496-501 & 506-513): http://www.leg.state.or.us/ors/
Oregon Fisheries Rules: http://www.dfw.state.or.us/OARs/index.asp#Fish
Oregon State Ocean Planning Information: http://www.oregonocean.info/

ODFW biologist Steve Jones looks at the bycatch during testing of an excluder grate in a pink shrimp trawl off the Oregon coast. Photo credit: ODFW

In addition to Federal license limitation programs for some FMP species, Oregon limits participation in ten state waters fisheries: sardine, salmon troll, Dungeness crab, pink shrimp (trawl), black rockfish/blue rockfish/ nearshore fish, scallop (*Patinopecten caurinus*), sea urchin, bay clams (diving), roe-herring, and brine shrimp (*Artemia* spp.). Oregon fisheries are generally open, unless closed or otherwise restricted by regulation. Although fisheries currently fully utilize many food fish species in Oregon waters, some are underutilized. Under Oregon's Developmental Fisheries Program, underutilized species are identified and categorized according to whether they are actively managed and whether they have the potential to support an economically viable fishery. Currently, there are no species that have been identified as not currently actively managed off Oregon under another state or Federal management plan and that have the potential to be economically viable. Some underutilized species have been identified as underutilized yet have not shown the potential to be a viable fishery. Fishing for these species is open and is regulated indirectly through fishery regulations for other species, gears, seasons, and areas.

The Oregon Conservation Strategy is a blueprint, based on best available science, for conservation of the state's native fish and wildlife and their habitats. The Nearshore Strategy is a component of the Oregon Conservation Strategy for marine resources from shore to 55 meters water depth. Its purpose is to promote actions that will conserve ecological functions and nearshore marine resources to provide long-term ecological, economic and social benefits. The Nearshore Strategy is also intended to contribute to the larger domain of marine resource management processes, such as the Council, by guiding management, research and monitoring, and education and outreach actions toward priority nearshore issues and areas that have not received adequate attention, rather than duplicate efforts by other management processes. The purpose of the Oregon Native Fish Conservation Policy is to ensure the conservation and recovery of native fish in Oregon. This policy identifies three goals: prevent the serious depletion of native fish, maintain and restore naturally produced fish, and foster and sustain opportunities for fisheries consistent with the conservation of naturally produced fish and responsible use of hatcheries.

ODFW has authority to manage and set harvest restrictions for marine protected areas, including marine gardens, habitat refuges and research reserves. Marine gardens are areas targeted for educational programs that allow visitors to enjoy and learn about intertidal resources. Habitat refuges are specially protected areas needed to maintain the health of the rocky shore ecosystem and are closed to the take of marine fish, shellfish, and marine invertebrates. Research reserves are used for scientific study or research including baseline studies, monitoring, or applied research. In addition, ODFW has authority to manage shellfish preserves, which are closed to clam harvesting.

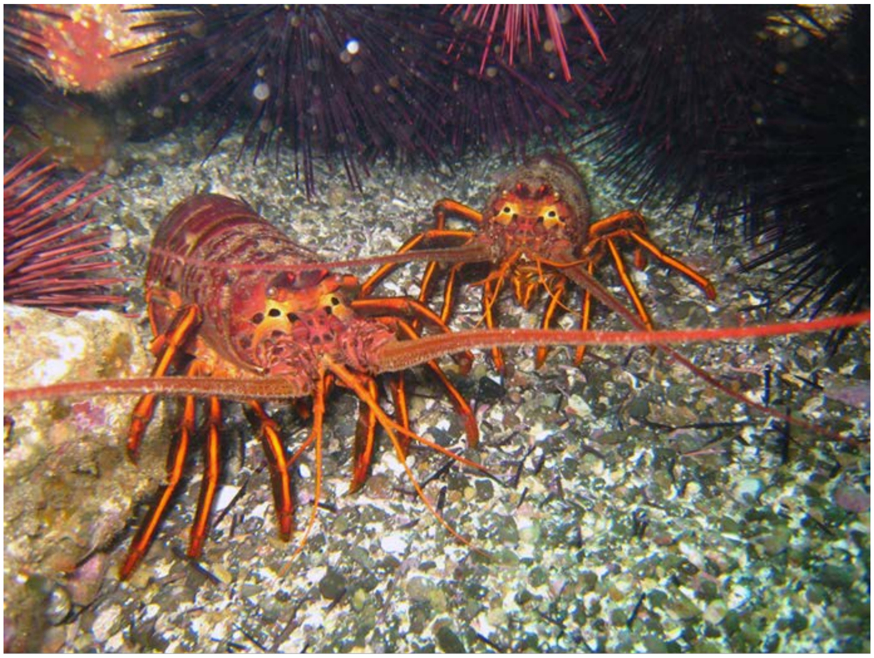
For marine reserves, the state Legislature has authorized the establishment of five reserves to date – see also Section 3.3.4. To implement these marine reserves, rule-making authorities of ODFW, Oregon Department of State Lands, and the Oregon Parks and Recreation Department must be coordinated. ODFW has authority to regulate fishing activities in the reserves. Oregon Department of State Lands has authority for managing submerged lands and Oregon Parks and Recreation Department has authority for managing Oregon's ocean shore, which includes public beaches, state parks, and intertidal areas along the entire coast.

The Federal Coastal Zone Management Act provides the Oregon Department of Land Conservation and Development (DLCD) with regulatory authority to review various Federal actions in or affecting the state's coastal zone for consistency with the Coastal Management Program. DLCD reviews various NMFS regulations, including those recommended by the Council, for consistency. Also under the Oregon DLCD's Coastal Management Program, the Oregon Territorial Sea Plan is designed to carry out Oregon's statewide planning goal for ocean resources: To conserve marine resources and ecological functions for the purpose of providing long-term ecological, economic, and social value and benefits to future generations. The Territorial Sea Plan provides an ocean management framework, identifies the process for making resource use decisions, provides a rocky shores management strategy, and identifies uses, including ocean energy, of the seafloor and the territorial sea.

Boats on Yaquina Bay, Newport, OR. Photo credit: ODFW

3.5.2.5 California Fisheries Management[6]

Within California's Natural Resources Agency there is the Fish and Game Commission (CFGC) and the CDFW administered by the Director. While the Director can exercise some regulatory authority, the majority is accomplished by the CFGC. The CFGC is comprised of five commissioners appointed by the governor and confirmed by the Senate, who have been granted increasing management authority for the state's marine resources by the Legislature. They regularly meet 11 times per year to address resource issues and adopt management measures, and they may schedule additional special meetings to gain information on specific issues or take emergency actions.


Spiny lobsters. Photo credit: CDFW

The Marine Life Management Act (MLMA) was passed in 1998 and effective in 1999, and introduced a new paradigm in the management and conservation of California's marine living resources. The MLMA was developed in part based on many of the tenets of the MSA. The MLMA's overriding goal is to ensure the conservation, sustainable use, and restoration of California's living marine resources, including the conservation of healthy and diverse marine ecosystems. Through the MLMA, the Legislature delegated greater management authority to the CFGC and the CDFW. Key features of the MLMA include:

- Application to entire ecosystems rather than only to exploited marine resources, with an overarching priority of resource sustainability.
- Recognizing the state's resources for their use benefits, aesthetic and recreational enjoyment, and value for scientific research and education.
- Shifting the burden of proof towards initially demonstrating that fisheries and other activities are sustainable, rather than requiring demonstration of harm to initiate action.
- Requiring an ecosystem-based approach to management rather than focusing on single fisheries, and the development of FMPs as the framework for management—initially specifying development of FMPs for the nearshore fishery and white seabass.

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[6] CDFW Nearshore Fishery Management Plan: http://www.dfg.ca.gov/marine/nfmp/
California Coastal Commission: http://www.coastal.ca.gov/whoweare.html
California Code of Regulations Title 14: http://ccr.oal.ca.gov/
California Fish and Game Code (Sections 2850-2863, 7050-7090, 8585-8589.7)
California Fish and Game Commission: http://www.fgc.ca.gov/public/information/
California Ocean Protection Council, http://www.opc.ca.gov/
Marine Life Protection Act: http://www.dfg.ca.gov/mlpa/
Public Resources Code (Sections:30000-30900, 35500-35515): http://www.leginfo.ca.gov/calaw.html

- Requiring development of a master plan that prioritizes fisheries according to the need for comprehensive management through FMPs.
- Recognizing the importance of habitat by mandating its protection, maintenance, and restoration.
- Minimizing bycatch and rebuilding depleted stocks.
- Emphasizing science-based management developed in collaboration with all interested parties so that stakeholders are more involved in decision-making and all aspects of management.
- Recognizing the long-term interests of people dependent on fishing; adverse impacts of management measures on fishing communities are to be minimized.
- Annual reporting on the status of the state's resources and their management.

With respect to regulating new or developing fisheries, the MLMA did not prohibit development of new fisheries. The MLMA recognized the need to be more precautionary in allowing existing fisheries to expand, or to encourage the initiation and growth of new fisheries that would be sustainable from the onset.

Developing FMPs was mandated by the MLMA—to date, fishery management and/or recovery plans are completed for the State's nearshore, white seabass, market squid and abalone fisheries. The state's FMPs are prepared by CDFW and adopted by the CFGC. A spiny lobster FMP is in progress, and completion of an FMP for California halibut is a priority.

Concurrent with implementation of the MLMA, the Legislature enacted the Nearshore Fisheries Management Act (NFMA) to address the need to protect nearshore finfish species due to limited biological data, lack of stock status information, and an expanding commercial live fishery. The NFMA recognized the importance of recreational and commercial fisheries for nearshore finfish species and provided management authority to the CFGC for those fisheries operating within state waters. The NFMA defined specific nearshore finfish species to be managed within one mile of the shoreline and established minimum size limits for nine species. All designated species, except for California sheephead (*Semicossyphus pulcher*), are also included in the Federal Groundfish FMP. A state commercial limited entry nearshore fishery permit was established and annual fees associated with the permit are deposited into a dedicated fund established under the NFMA. Funds may be used for research or management purposes, such as developing FMPs or stock assessments, or for enforcement involving education and outreach. Imperative to nearshore management under the NFMA, and mandated under the MLMA, is the state's nearshore FMP, which provides a framework for managing 19 nearshore species (16 of which are also federally managed), including fishery control rules more conservative than those in the Federal Groundfish FMP and incorporating marine protected areas into fishery management.

Herring eggs on eelgrass. Photo credit: CDFW

The MLPA was passed and made effective in 1999 and directs the state to reevaluate and redesign California's system of MPAs to: increase coherence and effectiveness in protecting the state's marine life and habitats, marine ecosystems, and marine natural heritage, as well as to improve recreational, educational, and research opportunities provided by marine ecosystems subject to minimal human disturbance. The MLPA also requires the best readily-available science be used in the redesign process, as well as the advice and assistance of scientists, resource managers, experts, stakeholders, and members of the public.

California has taken a regional approach to developing a network of integrated MPAs along its 1,100 mile coastline in accordance with the MLPA – see also Section 3.3.4. The statewide coastal network includes 124 MPAs and 16 special closures covering approximately 848 square miles of state waters and representing approximately 16 percent of all coastal state waters including those already adopted or proposed for the north coast (Point Arena north to the CA/OR border). Currently, almost 461 square miles of state waters have been set aside as no-take marine reserves to observe their transition to an unfished state and evaluate ecosystem impacts on marine resources. These MPAs are expected to benefit California’s marine resources including species under Federal FMPs.

The California Coastal Act (or the Coastal Act) commenced California's coastal zone management rules as the means to regulate projects with possible impacts on use of land and water in the coastal zone. The Coastal Act permanently established the California Coastal Commission as the reviewing or governing body over the coastal zone. Along with the [San Francisco] Bay Conservation and Development Commission, the Coastal Commission is one of California's two designated coastal management agencies for the purpose of administering the Federal Coastal Zone Management Act in California. The Coastal Commission mission is to: “…protect, conserve, restore, and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations.”

Spencer Gilbert, CDFW game warden. Photo credit: CDFW

The California Ocean Protection Act (COPA) was implemented in 2003 to better-integrate and coordinate regulations and agencies, both state and Federal, responsible for protecting and conserving the state's ocean resources. One objective of the COPA is to “...encourage cooperative management with Federal agencies, to protect and conserve representative coastal and ocean habitats and the ecological processes that support those habitats.” The COPA established the Ocean Protection Council (OPC), a cabinet-level oversight body, which actively works to facilitate coordination among various agencies on activities promoting ocean health and helps prioritize ocean resource needs. In addition, a Trust Fund overseen by the OPC was developed to insure best use of the state’s limited resources for ocean resource management.

Although the MLMA lays out policies for achieving sustainability, it does not provide a specific method for measuring sustainability of California’s vast marine resources. In 2009, California’s Legislature passed the Sustainable Seafood Act requiring the state’s OPC to develop and implement a voluntary sustainable seafood promotion program for California. The directives of the state program include development of protocols for guidance on certification of sustainable fisheries to internationally-recognized standards, a marketing and assistance program for fisheries ultimately certified, a competitive grant and loan program for assisting in certification, an eco labeling component, and an advisory committee. While the CDFW is not directly involved in the efforts to establish this program, it may provide biological data and expert consultation on the state’s fisheries for sustainability determinations.

California limits participation in the following commercial fisheries (some of which may also be restricted through Federal FMPs): nearshore live fishery, urchin (diving), lobster, herring, rock crab (*Cancer anntenarius, C. anthonyi* and *C. productus*), Dungeness crab, sea cucumber (*Parastichopus californicus*, diving and trawl), market squid, salmon, spot prawn (*Pandalus platyceros*, trap), California halibut (trawl), and northern pink shrimp (trawl). An additional limitation exists for the drift gillnet and set gillnet fisheries, which limits the number of participants specifically using each gear type (drift and set gillnet) rather than the species taken by the gear. Further species or fisheries in California that are monitored through the use of non-restrictive permits are: anchovy, golden prawn (*Penaeus californiensis*, trawl), ridgeback prawn (*Sicyonia ingentis*, trawl), swordfish (hook-and-line or harpoon only), bay shrimp (*Crangon* spp. and *Palaemon macrodactylus*), northern rock crab, southern pink shrimp (trawl), ghost shrimp (*Neotrypaea californiensis*), Tanner crab (*Chionoecetes tanneri*), marine aquaria collection, tidal invertebrates, and coonstripe shrimp (*Pandalus danae*, trawl). These non-restrictive permits do not limit the number of fishery participants, but are useful for indicating whether or not there is increased interest or potential development of market demand that would otherwise be unknown. Additional regulations may or may not be applicable to these non-restricted permits such as (but not limited to): size limits, trip limits, season closures, area closures, and gear restrictions. In recent years, California recognized developing fisheries, for Kellet's whelk (*Kelletia kelletii*) and hagfish (*Eptatretus stoutii*), which are not currently covered under existing FMPs or limited permits.

The major recreational fisheries in California are boat-based and target groundfish, salmon, tunas, and other HMS, California halibut, surf perches (*Embiotocidae* spp.), and seabasses. Retention of several sensitive species including white shark (*Carcharodon carcharias*). Garibaldi (*Hypsypops rubicundus*), giant (black) seabass, gulf and broomtail groupers (*Mycteroperca jordani* and *M. xenarcha*), and all species of abalone other than red abalone are prohibited in regulations.

3.5.2.6 Idaho Fisheries Management

Although Idaho is landlocked, it contains much of the Columbia River basin's salmon and steelhead spawning and rearing habitat in the middle and upper Snake River system (Waples et al 1991). The Snake River provides EFH for ESA-listed sockeye, spring, summer, and fall Chinook salmon, and summer steelhead (Ford et al 2010). Of these, only fall Chinook salmon are substantially affected by ocean fisheries. All are caught in fisheries in the lower Columbia and Snake Rivers.

The Idaho Department of Fish and Game manages sport fisheries for Chinook salmon and steelhead to minimize incidental take of ESA-listed wild fish and ensure adequate return of hatchery fish for brood stock needs (Hassemer, personal communication). The Nez Perce and Shoshone-Bannock tribes also pursue these anadromous fishes within Idaho. Historically, Idaho had an abundance of anadromous coho salmon, Pacific lamprey, and sturgeon. Snake River Coho were declared extinct in 1986. In the mid 1990s, the Nez Perce Tribe initiated a program to restore coho to the Clearwater River. Lamprey have dwindled to near extirpation in Idaho with only 48 crossing Lower Granite Dam in 2011 (Columbia River DART). White sturgeon (*A. transmontanus*) rarely use fish ladders but have maintained a landlocked population mostly in Hells Canyon of the Snake River.

Historically, the Snake River spring/summer Chinook run exceeded 1 million fish, but was reduced to near 100,000 fish by the mid 1950s (Mathews and Waples 1991). The Columbia's largest tributary, the Snake River and its tributaries lie mostly in Idaho and to a lesser extent in eastern Washington and Oregon. The Snake River fall Chinook run was about 72,000 in the 1940s and about 29,000 in the 1950s, but remained the most important natural production area for Columbia basin fall Chinook. Prior to the 1960s, the Snake River was considered the most important drainage in the Columbia River system for the production of anadromous fishes (Waples et al 1991). Dam construction on the upper Snake River substantially reduced the distribution and abundance of Snake River fall Chinook salmon (Irving and Bjornn 1981). Although considerable high quality spawning and rearing habitat remain in Idaho for spring and summer Chinook in the Salmon and Clearwater tributaries, their numbers have also declined in large part due to mortality during the outmigration through eight mainstem reservoirs and dams on the lower Snake River and Columbia.

Only limited Snake River fall Chinook spawning occurred downriver from Snake River km 439, the site of Oxbow Dam. The construction of Brownlee Dam in 1959 at Snake River km 459, Oxbow Dam (1961; RKm 439), and Hells Canyon Dam (1967; RKm 397) eliminated the primary production areas of Snake River fall Chinook salmon. Chinook were prevented from accessing 58 percent of prime spawning habitat as early as 1901 with the construction of Swan Falls Dam at RKm 734 (Parkhurst 1950). River habitat was further reduced with the construction of four fish-passable dams on the lower Snake River: Ice Harbor Dam (1961; RKm 16), Lower Monumental Dam (1969; RKm 67), Little Goose Dam (1970; RKm 113), and Lower Granite Dam (1975; RKm 173). Apart from the possibility of deep-water spawning in lower areas of the river, the main-stem Snake River from the upper limit of the Lower Granite Dam reservoir to Hells Canyon Dam (approximately 165 km) and the lower reaches of the Imnaha, Grande Ronde, Clearwater, and Tucannon Rivers are the only remaining areas available for fall Chinook salmon spawning in the Snake River Basin (Waples et al 1991). In 2009, state, Federal and tribal fisheries projects released 5.4 million fall Chinook smolts in the free-flowing reach of the Snake River and tributaries between Lower Granite Reservoir and Hells Canyon Dam[7]. In 2011, 25,541 adult fall Chinook salmon returned to this river reach (Columbia River DART), a smolt-to-adult return rate of 0.5 percent. Although most of these adults came from the smolt releases, Idaho Power's river flow management from Hells Canyon Dam since the early 1990s has benefited fall Chinook natural spawning and incubation in the Snake River. Additionally, cold-water releases from Dworshak Reservoir on the North Fork Clearwater River have improved migration conditions for juvenile fall Chinook. The main fisheries for Idaho-reared fall Chinook are in the ocean and lower Columbia River, with total exploitation rates of 40 percent to 50 percent (Ford et al. 2010). Of the 25,541 adult fall Chinook crossing Lower Granite Dam in 2011, only 952 (4 percent) were caught and only 210 (<1 percent) were harvested in Idaho sport fisheries (IDFG unpublished data 2012). Only 28 percent of the adults caught were adipose fin-clipped and legal to harvest. The 2011 Joint Staff Report prepared by the Oregon and Washington Departments of Fish and Wildlife estimate that 8,097 wild adult fall Chinook crossed Lower Granite Dam in 2011. This was the second largest run of naturally produced fall Chinook since their near collapse in 1975.


Anglers in the South Fork Salmon River, Idaho. Photo credit: Richard Scully

Habitat restoration, improved hatchery fish health, and improved

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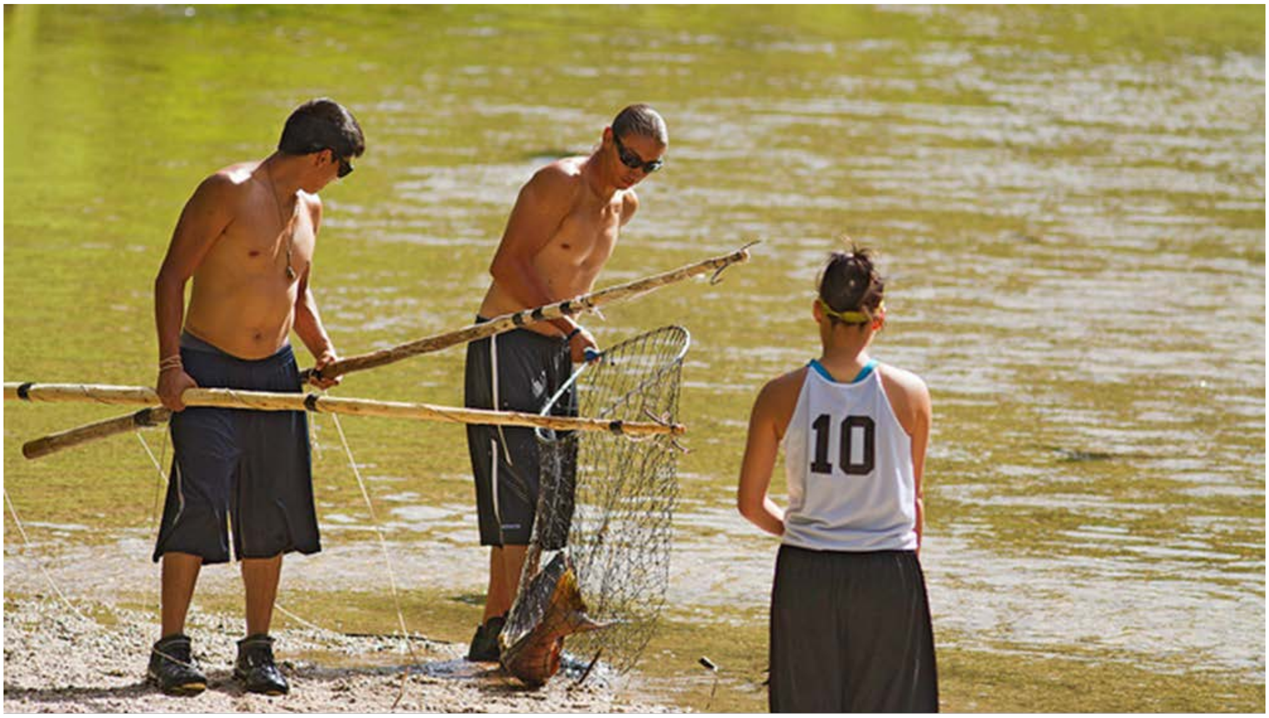
[7] Fish Passage Center: http://www.fpc.org/

juvenile fish passage technology at the lower Snake River dams have increased the return of spring and summer Chinook to an average of 56,000 from 1996 through 2004 (Columbia River DART), 40 percent (22,400) of which were wild fish (IDFG unpublished data). Although spring and summer Chinook are rarely harvested in the CCE, they are listed as threatened and managed under the ESA. When there is a harvestable surplus of hatchery spring and summer Chinook, and when there are sufficient natural spawners to allow for some incidental mortality, Idaho Department of Fish and Game opens state fisheries. After accounting for the number of spawners needed to fully seed hatcheries in the Snake River basin, the surplus production is allocated equally between sport and tribal fisheries. Sport allocation for spring/summer Chinook in Idaho was 17,300 in 2011 and is 29,490 in 2012 (IDFG unpublished data 2012). The lower value is closer to the average annual allocation for the recent decade.

Summer steelhead support the largest anadromous fishery in Idaho. Idaho's adult steelhead generally leave the ocean between June and October and are caught in state and tribal fisheries in the lower Columbia River. They are caught in fisheries in Idaho from mid-July through April. Spawning occurs in April and May. About 200,000 steelhead cross lower Granite Dam annually and about 76 percent are adipose fin clipped and available for harvest. In recent years, about 50 percent of the adipose-clipped steelhead are harvested (IDFG unpublished data).



Shoshone-Bannock tribal spear fishing in the South Fork Salmon River, Idaho.
Photo credit: Enrique Patiño, NOAA NWR

3.5.3 Multi-State, Multi-Tribe and State-Tribal Entities

In addition to the Council process, there are West Coast multi-state or state-tribal natural resource management processes that affect fisheries management within the CCE.

3.5.3.1 Pacific States Marine Fisheries Commission

Established in 1947, PSMFC is an interstate compact agency that helps resource agencies and the fishing industry sustainably manage Pacific Ocean resources in a five-state region. PSMFC's member states are California, Oregon, Washington, Idaho, and Alaska. Each state is represented by three Commissioners. PSMFC participates in both the PFMC and North Pacific Fishery Management Council processes as a non-voting member of each Council.

PSMFC has no regulatory or management authority. It serves as a neutral party, providing for collective participation by member states on topics of mutual concern and offering a forum for discussion and consensus-building. Its primary purpose is to promote and support policies and actions to conserve, develop, and manage these fishery resources. It coordinates research activities, monitors fishing activities, and facilitates a wide variety of projects. PSMFC staff collect data and maintain databases on salmon, steelhead, and other marine fish for fishery managers and the fishing industry. For example, PSMFC maintains the PacFIN and the Pacific RecFIN databases, which the Council and others rely on for timely and accurate data for management. Other major projects or programs relevant to Council management include the habitat program, the West Coast groundfish observer program, the passive integrated transponder (PIT) tag and coded wire tag programs, the aquatic habitat data project (StreamNet), the West Coast economics data program, an aquatic invasive species prevention program, and the Pacific ballast water group.

The PSMFC is also charged with convening the Tri-State Dungeness Crab Committee to discuss issues and with making reports to Congress on Dungeness Crab management. Under the MSA at Section 306, authority to manage the non-tribal ocean Dungeness crab fishery is delegated to the states of Washington, Oregon, and California. Each state may adopt and enforce State laws and regulations governing fishing and processing in the EEZ adjacent to that state in any Dungeness crab fishery for which there is no Federal FMP in effect. By memorandum of agreement, the state fishery directors have agreed to take mutually supportive actions to further the management and maximize the sound economic and biological utilization of the crab resource when appropriately requested by the Director of one of the other three cooperating state agencies. Decisions about West Coast openings of the commercial season based on crab soft shell condition are made under this agreement.

Dungeness crab. Photo credit: Scott Groth, ODFW

3.5.3.2 North of Falcon Process

The "North of Falcon" process is an annual salmon management planning process involving representatives from salmon treaty tribes, the states of Washington and Oregon, and the Federal government. Its name refers to the geographic area it addresses, salmon and fisheries management north of Cape Falcon, Oregon. The North of Falcon process is intended to support the Council's annual salmon management process by providing a series of advance public discussions of alternatives for the coming year's salmon seasons. Each November, the Council hears from its SSC and Salmon Technical Team on methodologies used to develop, support, and later assess the effects of that year's salmon season management parameters. In the winter months, salmon scientists update the models intended for use in the subsequent year's fisheries. Beginning in February, managers working within the North of Falcon process start their review of new science and management information for salmon fisheries. The North of Falcon process allows managers to both prepare for Council action in March and April to set the year's salmon season parameters, and to prepare for shifts in state- or tribe-specific regulations intended to keep the applicable fisheries within their allocations.

3.5.3.3 Intertribal Fisheries Commissions

The Northwest treaty tribes of Washington and Oregon formed two commissions in the mid-1970s to pursue common objectives and provide coordinated services to their memberships. The Columbia River Inter-Tribal Fish Commission (CRITFC) was formed by agreement among the Warm Springs, Yakama, Umatilla, and Nez Perce tribes in 1977. The Northwest Indian Fisheries Commission (NWIFC) was formed in 1976 by its 21 member tribes (Lummi, Nooksack, Swinomish, Upper Skagit, Sauk-Suiattle, Stillaguamish, Tulalip, Muckleshoot, Puyallup, Nisqually, Squaxin Island, Skokomish, Suquamish, Port Gamble S'Klallam, Jamestown S'Klallam, Lower Elwha Klallam, Makah, Quileute, Hoh and Quinault). The commissions are governed by their member tribes, which appoint commissioners to develop policy and guidance for their operations. All actions and policies created are by unanimous consent of the membership.

The commissions do not possess inherent, sovereign authority but, upon consent, can represent member tribes in local and regional fisheries management venues. The commissions provide mostly coordinating, advisory, and technical services to support tribal natural resources management efforts and provide mechanisms for unified actions to address joint issues and needs.

3.5.3.4 West Coast Governors' Alliance on Ocean Health

The West Coast Governors' Agreement (later "Alliance" on Ocean Health (WCGA) was created in 2006 as a unique regional partnership among Washington, Oregon and California to protect and manage coastal and ocean resources and the economies they support along the entire West Coast. The WCGA is intended to forward coastwide priorities on:

- Ensuring clean coastal waters and beaches;
- Protecting and restoring healthy ocean and coastal habitats;
- Promoting the effective implementation of ecosystem-based management of our ocean and coastal resources;
- Reducing adverse impacts of offshore development;
- Increasing ocean awareness and literacy among our citizens;
- Expanding ocean and coastal scientific information, research, and monitoring; and
- Fostering sustainable economic development throughout our diverse coastal communities.

Upon completing an action plan in 2008, ten Action Coordination teams, comprised of volunteers with expertise in priority areas, were created to develop and implement work plans to achieve high priority regional goals of addressing: climate change, IEAs, marine debris, ocean awareness and literacy, polluted runoff, renewable ocean energy, seafloor mapping, sediment management, *Spartina* eradication, and sustainable coastal communities. The recently-adopted Federal National Ocean Policy identifies the WCGA as the regional ocean governance partnership for the West Coast and one of nine such entities recognized throughout the U.S. For advancing functional, resilient estuarine and nearshore marine ecosystems along the West Coast, the WCGA has endorsed a working relationship with the newly-formed Pacific Marine Estuarine Fish Habitat Partnership, a group convened by the PSMFC.

3.5.4 International Science and Management Entities

For FMP species, the U.S. is a party with Canada in three treaties addressing fisheries for transboundary stocks: Pacific salmon, Pacific whiting, and North Pacific albacore. The U.S. is also a party with Canada on the Pacific Halibut Convention. Pacific Halibut is not an FMP species, but is taken as bycatch in some FMP fisheries and the Council has a Catch Sharing Plan for Pacific halibut taken off the U.S. West Coast. In addition, the U.S. is a party to several multi-lateral treaties addressing fisheries for HMS FMP species, and is a party to several agreements to conserve marine resources worldwide.

3.5.4.1 Pacific Halibut

The U.S./Canada Pacific Halibut convention established the *International Pacific Halibut Commission* (IPHC, originally called the International Fisheries Commission) in 1923 for the preservation of Pacific halibut in waters off Canada and the U.S. Its mandate is research on and management of the stocks, including monitoring the fishery, conducting research, assessing stock conditions and setting the allowable harvest for management areas. Halibut fisheries off Washington, Oregon, and California are within IPHC's management area 2A. The states, halibut treaty tribes, and NMFS together develop an annual Catch Sharing Plan for Pacific halibut fisheries off the U.S. West Coast, which the Council and IPHC review and adopt annually.

3.5.4.2 Salmon

The U.S./Canada Pacific Salmon Treaty was signed in 1985 and sets long-term goals for the benefit of the salmon and the two countries. The *Pacific Salmon Commission* is the body formed by the governments of Canada and the U.S. to implement the Pacific Salmon Treaty. The Commission itself does not regulate the salmon fisheries, but provides regulatory advice and recommendations to the two countries. It is responsible for all salmon originating in the waters of one country that are subject to interception by the other, that affect management of the other country's salmon or that biologically affect the stocks of the other country. The Pacific Salmon Commission must also take into account the conservation of steelhead trout while fulfilling its other functions. The role of the Pacific Salmon Commission is to: conserve Pacific Salmon in order to achieve optimum production, to divide harvests so that each country reaps the benefits of its investment in salmon management.

**Sockeye salmon in Olympic National Park.
Photo credit: National Park Service**

High seas salmon management in the North Pacific Ocean, for waters beyond the EEZs of any countries, is conducted under the multi-lateral Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean. That Convention authorized the *North Pacific Anadromous Fish Commission*, the parties to which are the U.S., Canada, Japan, South Korea, and Russia. The North Pacific Anadromous Fish Commission replaced the 1952-1992 International North Pacific Fisheries Commission the international high-seas salmon management commission that, among other things, first separated coastal waters around the North Pacific into scientific study areas. Off the U.S. West Coast, we still sometimes use and refer to International North Pacific Fisheries Commission science and management areas: Vancouver (north of 47°30' N. lat.), Columbia (between 47°30' and 43°00' N. lat.), Eureka (between 43°00' and 40°30' N. lat.), Monterey (between 40°30' and 36°00' N. lat.), and Conception (south of 36°00' N. lat.). The North Pacific Anadromous Fish Commission's Convention recognizes that its participant nations invest in conservation and salmon freshwater habitat protection in accordance with their national priorities, so takes the stance that fisheries for anadromous stocks should be conducted within EEZs to ensure that the benefits of those investments accrue to the nations making the investments. To that end, the Convention prohibits directed fishing for anadromous fish within North Pacific high seas waters, and the North Pacific Anadromous Fish Commission provides a forum for an international exchange of science, management, and enforcement information in support of its Convention.

3.5.4.3 Whiting

The U.S./Canada Pacific Whiting Treaty was signed in 2003 and establishes agreed percentage shares of the transboundary stock of Pacific whiting (also known as Pacific hake). It also creates a process through which U.S. and Canadian scientists and fisheries managers recommend the total catch of Pacific whiting each year. The agreement anticipates that stakeholders from both countries will have significant input into this process. The Agreement, implemented for the first time in 2012, created four bodies to assist in the assessment and sustainable management of the shared whiting resource:

- The Joint Management Committee (JMC) is charged with determining the total annual allowable whiting catch;
- An industry Advisory Panel (AP) is charged with reviewing the management of the fishery and making recommendations to the JMC regarding the overall total allowable catch;
- The Joint Technical Committee (JTC) is charged with annually providing the JMC with a stock assessment that includes scientific advice on the annual potential yield of the offshore whiting resource; and

Top photo: Pacific whiting being washed prior to processing. Bottom photo: Mothership Arctic Storm employees inspecting fillets. Photo credit: Arctic Storm, Inc.

- The Scientific Review Group is charged with providing an independent peer review of the work of the JTC.

Amendment 23 to the Groundfish FMP exempted the Pacific whiting stock from the FMP's annual catch limit (ACL) requirements based on the harvest policies of the Agreement. However, the Agreement's harvest policy is based on the Groundfish FMP's original 40-10 HCR, which involves a precautionary adjustment to the harvest rate when the stock drops below the 40 percent of its unfished stock size (i.e. $B_{40\%}$, the recommend abundance level for producing MSY from the stock). The main difference between this approach and the current harvest policies of the Groundfish FMP is that the Agreement does not require a scientific uncertainty buffer between the overfishing limit and the acceptable biological catch. Under the Agreement, the JMC may recommend a different harvest policy "if the scientific evidence demonstrates that a different rate is necessary to sustain the offshore hake/whiting resource."

3.5.4.4 HMS Species

Because of the wide-ranging movements of highly migratory stocks, all management unit species in the HMS FMP are covered under international agreements. Vessels from the U. S. and many other nations harvest HMS FMP species throughout the Pacific Ocean, and effective management of the stocks throughout their ranges requires international cooperation. The MSA requires adoption of ACLs and accountability measures (AMs) and other provisions to prevent and end overfishing and rebuild fisheries. However, a stock or stock complex may not require an ACL and AMs if it qualifies for a so-called "international exception" for stocks managed under an international agreement to which the U.S. is a party. However, if the Secretary of Commerce determines that an HMS FMP Management Unit Stock is overfished or approaching overfished due to excessive international fishing pressure, and for which there are no management measures to end overfishing under an international agreement, the Secretary and/or the Council must take action under MSA Section 304(i). This section requires the Secretary, with the Secretary of State, to take action at the international level to end overfishing. Further, within one year, the Secretary and/or Council shall recommend domestic regulations to address the relative impact of U.S. vessels on the stock and recommend to Congress international actions to end overfishing and rebuild, taking into account the relative impact of vessels of other nations and vessels of the U.S.

The U.S. and Canada manage cross-border albacore fisheries interactions through a bilateral treaty. The U.S. is a member of the multi-lateral Inter-American Tropical Tuna Commission (IATTC), which is responsible for the conservation and management of fisheries for tunas and other species taken by tuna-fishing vessels in the eastern Pacific Ocean. The U.S. is also a member of the Western and Central Pacific Fisheries Commission (WCPFC), which plays a parallel role in the western and central

Yellowfin tuna. Photo credit: NOAA

Pacific (generally, west of 150° W. longitude).

The U.S.-Canada Albacore Treaty took effect in 1982 and has been renegotiated several times to address limitations on access to North Pacific albacore tuna by fishing vessels of one country operating in the jurisdiction of the other. The Treaty is a framework that allows fishing in the host country beyond 12 nm during the fishing season. Until 2012, the two countries have agreed to a reciprocal fishing regime that specified conditions for vessels fishing in waters of the other country. Pursuant to the treaty, the U.S. and Canada annually exchange lists of fishing vessels that may fish for albacore tuna in each other's waters. The vessels agree to abide by the provisions of the Treaty, which include vessel marking, recordkeeping, and reporting. It also allows the fishing vessels of each country to enter designated fishing ports of the other country to conduct several types of business transactions including the landing of albacore without payment of duties; transshipment of catches to any port of the flag state; selling catches for export or locally; and obtaining fuel, supplies, repairs, and equipment on the same basis as albacore tuna vessels of the other country. The Treaty allows Canadian albacore vessels to land their catch in the U.S. ports of Bellingham and Westport, Washington; Astoria, Coos Bay, and Newport, Oregon; and Eureka, California.

The Inter-American Tropical Tuna Commission (IATTC) was established in 1949 for the conservation and management of fisheries for tunas, tuna-like species, and other species of fish taken incidentally by tuna fishing vessels in the eastern Pacific Ocean. Currently, there are 21 members of the IATTC: Belize, Canada, China, Colombia, Costa Rica, Ecuador, El Salvador, the European Union, France, Guatemala, Japan, Kiribati, Korea, Mexico, Nicaragua, Panama, Peru, Chinese Taipei, U.S., Vanuatu, and Venezuela. The Cook Islands is a Cooperating Non-Member.

The IATTC is responsible for the conservation and management of fisheries for tunas and other species taken by tuna-fishing vessels in the eastern Pacific Ocean. The Tuna Conventions Act of 1950 provides the U.S. with the Federal authority to implement the measures adopted by the IATTC. In 2003, the IATTC adopted a resolution that approved the Antigua Convention, a major revision of the original convention establishing the IATTC. It brings the convention current with respect to internationally-accepted laws on the conservation and management of oceanic resources, including a mandate to take a more ecosystem-based approach to management. The Antigua Convention entered into force in 2010.

The Western and Central Pacific Fisheries Commission (WCPFC) was created in 2004 under the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the western and central Pacific Ocean. The objective of the Convention is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks. The U.S. signed the Convention in 2000 and ratified it in 2007, thereby becoming a member of the WCPFC. The U.S. domestic procedures for ratification of the Convention were completed in June 2007. There are 25 Members of the Commission: Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Japan, Kiribati, Korea, Republic of

School of bluefin tuna. Photo credit: NOAA

Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, U.S., and Vanuatu. American Samoa, Guam, French Polynesia, New Caledonia, Tokelau, Wallis, Futuna, and the Commonwealth of the Northern Mariana Islands are Participating Territories, and Belize, Indonesia, Panama, Senegal, Mexico, El Salvador, Ecuador, Thailand, and Vietnam are Cooperating Non-members.

The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), is a separate scientific collaboration process to enhance scientific research and cooperation for conservation and rational utilization of the species of tuna and tuna-like fishes which inhabit the North Pacific Ocean during a part or all of their life cycle. The ISC conducts HMS stock assessments that, within the U.S., are used to develop harvest management measures within the Pacific and Western Pacific Fishery Management Councils. The ISC and IATTC also develop proposals for conduct of and coordinate international and national programs of research addressing such species. The ISC grew out of a Japan-U.S. initiative and present member countries include: Canada, China, Chinese Taipei, Japan, South Korea, and the U.S.

Other International Fisheries Agreements and Action Plans: The HMS FMP provides a framework for the U.S. to meet its obligations under other international agreements to which the U.S. is a party. United Nations Implementing Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks interprets the duties of nations to cooperate in conserving and managing fisheries resources, and dictates that coastal states (i.e., nations) may not adopt measures that undermine the effectiveness of regional measures to achieve conservation of the stocks. The U.S. is also a member of the Food and Agriculture Organization of the United Nations (FAO), which has implications for HMS management. In 1995, the FAO’s Committee on Fisheries developed a Code of Conduct for Responsible Fisheries, which more than 170 member countries, including the U.S., have adopted. Pursuant to this Code of Conduct, the U.S. has adopted the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas and four International Plans of Action: for Reducing Incidental Catch of Seabirds in Longline Fisheries, for the Conservation and Management of Sharks, for the Management of Fishing Capacity, and to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

3.5.4.4 Other International Forums

The *Tri-National Sardine Forum* began in 2000 and provides an annual opportunity for international coordination and collaboration among industry, scientists, and managers from Mexico, the U.S., and Canada for the sardine stock. The forum promotes coordinated coastwide data collection for sardine stock assessments, and promotes science and fishery management information-sharing. This forum is science-focused and there is no treaty governing the multi-national management of CCE sardines.

In 1902, northern Atlantic Ocean nations established the International Council for the Exploration of the Sea (ICES), an international partnership for the cooperative exploration of ocean and fisheries science. In 1992, northern Pacific Ocean nations, including those that had long been ICES members, established the *North Pacific Marine Science Organization,* known as PICES for “Pacific ICES.” PICES meets annually to promote and coordinate multi-national marine science within the North Pacific Ocean north of 30°00’ N. lat. Its member nations are the U.S., Canada, Japan, China, South Korea, and Russia.

The *North American Migratory Bird Treaty Act* of 1918 decreed that all migratory birds and their parts (including eggs, nests, and feathers) were fully protected. The Migratory Bird Treaty Act is the domestic law that affirms, or implements, the U.S. commitment to four international conventions (with Canada, Japan, Mexico, and Russia) for the protection of a shared migratory bird resource. Each of the conventions protect selected species of birds that are common to both countries (i.e., they occur in both countries at some point during their annual life cycle).

The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES, 27 U.S.T. 108) establishes a system of import/export regulations to prevent the over-exploitation of plants and animals listed in three appendices to the Convention. Different levels of trade regulations are provided depending on the status of the listed species and the contribution trade makes to decline of the species. Procedures are provided for periodic amendments to the appendices. CITES went into force worldwide in 1975. Within the U.S., the ESA is the implementing legislation for CITES. Executive Order 11911, signed April 13, 1976, designated Management and Scientific Authorities to grant or deny requests for import or export permits.

Western Hemisphere Convention (Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere; 56 Stat. 1354; TS 981). Under this 1940 treaty, the governments of the U.S. and 17 other American republics expressed their wish to "protect and preserve in their natural habitat representatives of all species and genera of their native flora and fauna, including migratory birds" and to protect regions and natural objects of scientific value. The nations agreed to take actions to achieve these objectives, including the adoption of "appropriate measures for the protection of migratory birds of economic or esthetic value or to prevent the threatened extinction of any given species." Within the U.S., the ESA is the implementing legislation for the Western Hemisphere Convention (16 U.S.C. 1531-1543; 87 Stat. 884).

Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean. Discussions to implement an agreement on limiting bottom fishing effort within the high seas waters of the North Pacific Ocean (FAO Statistical Area 61) have not yet resulted in a final international convention to regulate high seas bottom fisheries in accordance with United Nations General Assembly Resolution 61/105. The last multilateral meeting to discuss this convention occurred in 2011, with the following countries participating: Canada, China, Japan, South Korea, Russia, the U.S., and Chinese Taipei.

Laysan albatross mother and chick. Photo credit: Kevin Rolle, Smithsonian Institution

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4 Addressing the Effects and Uncertainties of Human Activities and Environmental Shifts on the Marine Environment

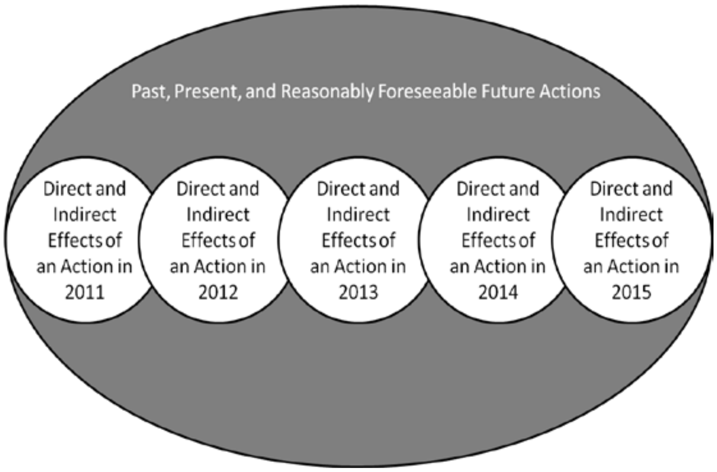


Figure 4.1: Cumulative Effects under NEPA

The purpose of this chapter is to consider the potential effects of human activities and environmental processes on the CCE. In Chapter 3, the FEP describes the CCE from a wide variety of disciplines and perspectives. Chapter 4 is intended to broadly look at how human and environmental forces may, singly or combined, have effects on Council-managed resources. For those effects that can be addressed by fishery management measures, the Council can improve and integrate the information that supports decision-making across its FMPs. Ultimately, the Council could use this FEP to inform fishery management measures to help buffer against uncertainties resulting from those effects, and to support greater long-term stability within the CCE and for its fishing communities.

Chapter 4 discusses five broad categories of effects, whether from human actions or environmental shifts, of changes within the marine environment. Because the Council's work is focused on fisheries management requirements and challenges, this chapter focuses on the types of effects that are most relevant to the Council work and which can be linked back to MSA guidance and direction. This chapter discusses potential changes in the following areas of Council interest or responsibility: fish abundance within the CCE (Section 4.1), the abundance of nonfish organisms within the CCE (Section 4.2), changes in biophysical habitat within the CCE (Section 4.3), changes in fishing community involvement in fisheries and dependence upon fishery resources (Section 4.4), and aspects of climate change expected to affect living marine resource populations within the CCE (Section 4.5).

A suite of laws guide the issues NOAA and the Council must consider in making fisheries management decisions: MSA, NEPA, ESA, MMPA, the Regulatory Flexibility Act, Executive Order 12866, and others. 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 – see Figure 4.1). This FEP's objectives, detailed in Chapter 2, call for the Council to use information generated from the ecosystem fishery management planning process to support its work within existing FMPs by broadening 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 Chapter 6 are all intended to work toward this goal by ultimately improving the quality of ecological information available to inform Council decision-making. In Chapter 5, the FEP provides guidance on the Council's priorities for how other management and private entities considering action within the CCE might best account for the nation's long-term needs for productive CCE fisheries. The FEP's Ecosystem Initiatives Appendix proposes several potential fisheries management initiatives that the Council could undertake to address some of the effects of human activities and environmental shifts on the marine environment.

4.1 Changes in Fish Abundance within the Ecosystem

Three major factors drive changes in the abundance and distribution of fished species in ecosystems: removals by fishing (and consequent changes in community structure and energy flow/predation within ecosystems), removals or habitat loss unrelated to fishing (typically such impacts are greater in freshwater, estuarine, and nearshore systems), and shifts in climate that lead to both direct and indirect changes in productivity (including indirect effects such as changes in the abundance of prey or predators). Any and all of these effects can have cascading and cumulative impacts on ecosystem structure and energy flow in marine ecosystems that could lead to unexpected changes or surprises with respect to marine resource and fisheries management activities.

4.1.1 Direct and Indirect Effects of Fishing on Fish Abundance

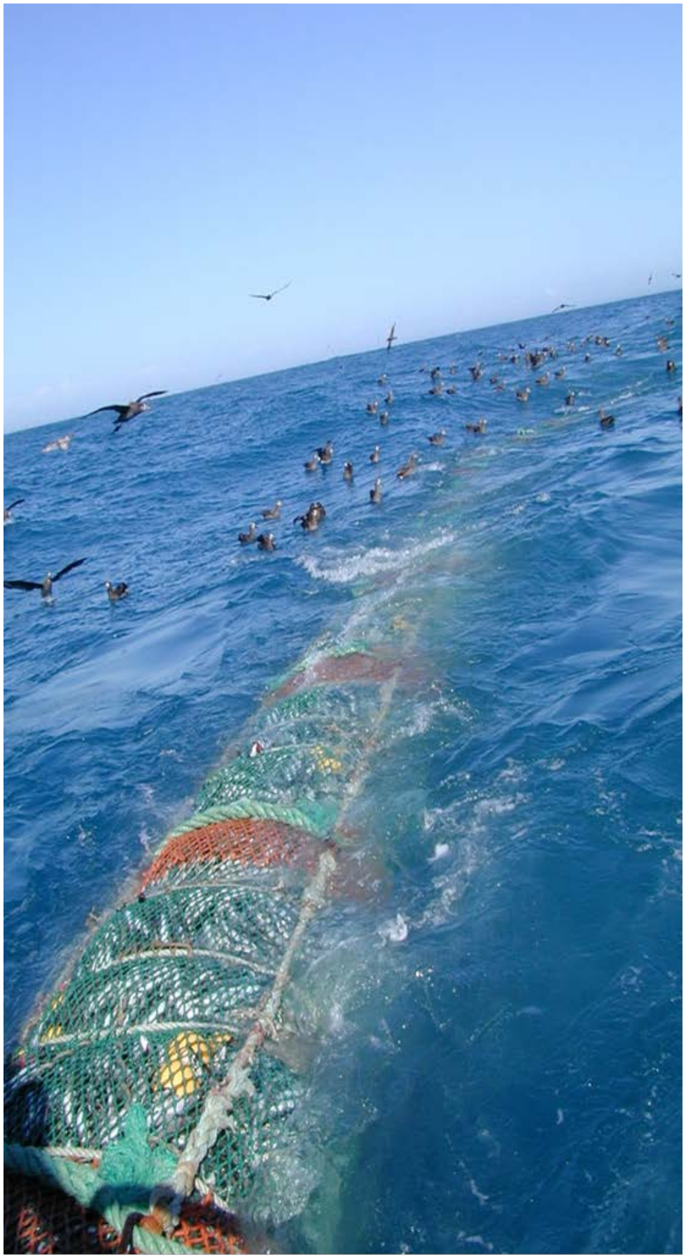
The consequence of fishing removals is typically predictable at the single species level, but less so at the community or ecosystem level. By both definition and design, fishing can result in substantial reductions in standing biomass of targeted populations and in moderate to severe shifts in the size and age structures of those populations. When adequate data exist, the consequences of fishing are easier to monitor and estimate; however, the subsequent realized or potential effects on predators, prey, or competitors within the ecosystem (and their predators, prey, competitors, etc.) are much less identifiable or quantifiable. Marine fisheries management in the U.S. and elsewhere is based on the idea that the reproductive strategies of harvested fish and shellfish populations will compensate for regular and sustained harvest of those populations. Compensatory processes are varied, complex, and often poorly understood (see Rose et al. 2001 for a thorough review). Both theory and observations indicate that populations that are below their theoretical carrying capacities are capable of growing at faster rates and producing more young than would be needed in an unharvested population. However, such processes may only be relevant over one to a few decades, and over longer time scales, management concerns will ultimately include consideration of how population dynamics and evolutionary processes may shift in response to longer-term ecosystem processes, including sustained fishing pressure and global climate change.

In U.S. fisheries management, the implicit assumption is that if single-species management approaches are able to successfully maintain the aggregate of fish stocks and populations close to target levels (usually by fishing at rates slightly lower than MSY or MSY proxies), then the ecosystems in which such stocks exist are likely to be "healthy." Limited evidence from food web models is consistent with the notion that the health of the whole of the ecosystem is equal to the status of the sum of its managed parts (Worm et al. 2009). However, the concept of a "healthy ecosystem" is subjective and not defined in objectively quantifiable terms. A "healthy" and fished or otherwise human-disturbed ecosystem is dramatically different from the ecosystem in its unfished state. We have yet to develop a clear and comprehensive understanding of

NOAA Research vessel Miller Freeman leaving Newport, OR. Photo credit: NOAA NWR

the possible long-term consequences of fishing activity to ecosystems. Assemblages and communities of fish and invertebrates maintained at certain abundance levels without regard to important population dynamics, such as movement, and age and sex structure, are likely notably different from where they would be in an undisturbed state (Jennings and Kaiser 1998, Hall 1999, Stokes and Law 2000, Longhurst 2006). From an ecosystem perspective, fisheries remove fish and other organisms from the sea that would have otherwise entered energy or nutrient pathways within their food web.

The 1996 Sustainable Fisheries Act commissioned a panel to develop "recommendations to expand the application of ecosystem principles in fishery conservation and management activities" (MSA at §406). Among other things, the panel suggested the rationale for surplus production is unclear if fishing is examined from an ecosystem context, since most production within an ecosystem prior to the advent of modern fisheries was simply recycled within that ecosystem (EPAP 1999). The consequences of various levels of fishing (or other impacts) include changes in the ecological relationships among competitors, prey and predators, and those consequences are rarely accounted for in single-species models. While any fishing activity will have some impact on an ecosystem, the levels of fishing that may trigger ecosystem-wide effects are unknown, and probably vary dramatically among ecosystems. Evidence for large-scale shifts in community and ecosystem structure as a consequence of intensive fishing has been documented in ecosystems ranging from polar to tropical waters, and temperate shelf communities have been observed to have undergone large-scale shifts as a result of intensive removals of target and non-target species (Hall 1999, Jennings and Kaiser 1999, Worm et al. 2009). There is general scientific consensus that overfishing is associated with large-scale ecosystem impacts. However, there is less consensus over how to develop a more holistic perspective on the trade-offs between harvest levels that can be modeled as sustainable for single-species and the cumulative effects of harvesting multiple species on ecosystem "health and integrity" (Francis 2003, Longhurst 2006, Gaichas 2008).



West Coast Pacific hake trawl net and interested seabirds. Photo credit: NOAA NWR

There are few examples of comprehensive efforts to evaluate the integrated and cumulative effects of fishing activities on marine ecosystems, since the scientific work needed to develop a comprehensive understanding of these effects is still under development. There has been one example of this type of evaluation, in which the cumulative consequences to the ecosystem of a range of fishing rates and harvest levels (from highly precautionary management to aggressive yield-maximizing harvest strategies) were evaluated for all groundfish fisheries in the EEZ off of Alaskan waters (NMFS 2004). The ultimate preferred alternative was associated with harvest strategies that adopted conservative harvest levels without explicitly embracing the transition to an ecosystem approach. There is also some empirical and model-based evidence of consequences to overall ecosystem productivity and yield when those are evaluated in multi-species models, rather than a suite of single-species models (May 1979, Walters et al. 2005, Steele et al. 2011), which indicates that exploiting lower trophic level species at maximum rates will lead to reduced productivity of higher trophic level species. More recently, both empirical and model-based research has demonstrated that dependent predators are likely to be notably affected when their prey populations are depleted to levels lower than the typical thresholds adopted by fisheries managers (Cury et al. 2011, Smith et al. 2011). Kaplan et al. (2013) looked more closely at the potential effects of depleting forage species in the CCE. Although most of the harvest scenarios assessed in that paper were more aggressive than West Coast harvest policies would allow, the paper concluded that current harvest policies for sardine are adequately precautionary to avoid disproportionate impacts from the fisheries to predator needs within the ecosystem.

Anglers and their halibut catch, Bandon, OR. Photo credit: Prowler Charters

For the CCE, both empirical evidence and simulation studies have suggested that there are likely to be impacts and interactions at broad-scale levels between the harvests of some assemblages on the productivity and abundance of others. Most of these have focused on interactions between lower trophic level species and their predators, or on very large-scale fisheries such as that for Pacific whiting. For example, Kaplan et al. (2012) evaluated the extent to which different fishing fleets (targeting different assemblages of species) acted in either an additive or combined (cumulative) manner using an Atlantis model of the CCE. They found a range of indirect effects of different fisheries on species other than those targeted. Their simulations indicated that increased fishing for Pacific whiting led to increases in the relative abundance of small planktivores, large flatfish, shortbelly rockfish, and pandalid shrimp. By contrast, changes in the effort of the purse seine fleet (targeting small planktivores) led to a range of responses; increases led to increased productivity of krill, salmon, and myctophids. With respect to cumulative effects, they found that the biomass of small planktivores (forage fishes) was lowest when all fishing was ceased, due to the increased abundance of higher trophic level piscivorous fishes.

While these simulations represent a major step forward in efforts to integrate the consequences of various fisheries on the food web, many of the models used in such approaches are not always capable of predicting or replicating trophic cascades or other “ecological surprises” (Sheffer et al. 2001, Folke et al. 2004, Baum and Worm 2009). A tremendous amount of research and effort has been invested in evaluating the extent to which sound single-species management may or may not be considered comparable to successful ecosystem-based management. Although the science needed to address such questions objectively and comprehensively is still in its relatively early stages (and is often limited by inadequate data), the Council's FEP development process resulted in the Council recommending a host of ecosystem-based revisions to its Research and Data Needs document (PFMC 2013) and in adding potential ecosystem initiatives to the FEP's Ecosystem Initiatives Appendix that could improve the scientific basis for addressing such issues in a management context.


Chad Leiferman (l), F/V Miss Yvonne crewman, Robert Hannah (c), ODFW biologist, and Jeff Boardman (r), F/V Miss Yvonne skipper, with experimental fish-excluding bycatch reduction device developed for Oregon's pink shrimp fishery through cooperative ODFW-industry experimentation. Photo credit: ODFW

Beyond the combined potential effects of managing suites of species to their estimated MSY levels, fishing often shifts or truncates the age- and size (length)- structure of fish populations, as older and larger individuals are typically subjected to higher cumulative mortality rates once they are fully selected by fisheries (Murawski et al. 2001). When well-understood or quantified, some of the consequences of changes to the age and size structure of a population can be explicitly addressed in population stock assessments. For example, more than half of the current stock assessments for West Coast rockfish explicitly considered size-dependent fecundity (in which larger, older fish produce proportionately greater numbers of eggs or larvae), in the estimation of the reproductive potential of the population (as opposed to the often-made assumption that spawning biomass is proportional to spawning output). Interestingly, while Spencer et al. (2007) and Spencer and Dorn (2013) found that accounting for such factors resulted in significant changes in management reference points, in some examples the consequences also included more optimistic perceptions of productivity, as estimated by the steepness of the spawner/recruit relationship. However, other indirect effects may be more subtle, or more difficult to formally quantify. For example, studies have shown larger, older mothers invest comparably more energetic resources into egg or larval quality (Marteinsdottir and Steinarsson 1998, Berkeley et al. 2004, Sogard et al 2008), and concerns have also been raised regarding the potential consequences to migratory behavior on populations for which younger fish "learn" migratory patterns from older, larger groups or individuals (Petigas et al. 2010, MacCall 2012).

In addition to the consequences of age or size truncation on the reproductive potential, there are likely consequences to population stability as well, such that truncation of size and age structure (and perhaps simply population reduction more generally) can lead to greater population variability and instability (Hsieh et al. 2006, Anderson et al. 2008, Shelton and Mangel 2011). The mechanisms may be varied, but have long been thought to relate to the significance of a broad age and/or size structure in buffering environmental variability (Leaman and Beamish 1984, Warner and Chesson 1985, Secor 2007). Shifts in age structure can increase the overall variance in recruitment (Lambert 1990; Marteinsdottir and Thorarinsson 1998; Worden, et al. 2010, Shelton and Mangel 2011), which has led to concerns over the effect of fishing on the response of populations to specific time scales of variability in the environment, as the dominant time scales of environmental variability are likely to change with climate change (Planque et al. 2010, Hollowed et al. 2011). The FEP's Ecosystem Initiatives Appendix proposes, in Section A.2.1, a potential initiative to investigate the long-term effects of both current and potential future Council harvest policies on age-and size- distribution in managed stocks. Current HCRs set a target level of female spawning biomass as an MSY proxy, while future HCRs may also explicitly consider the population age or length structure.

4.1.2 Direct and Indirect Effects of Non-Fishing Human Activities on Fish Abundance

Grand Coulee Dam. Photo credit: U.S. Department of the Interior

The consequence of removals or habitat loss not directly related to fishing, and exclusive of climate change, vary significantly depending on the species and habitat type in question. In freshwater systems (e.g. for salmonids and other anadromous species), the impacts are tremendous and severe, with indirect effects of habitat loss and alteration, and direct losses of smolts that suffer mortality as a result of being run through turbines (see Section 3.3.4). Direct mortalities or indirect impacts on carrying capacity can also result from dredging and dredge spoil disposal, offshore energy installations, saltwater intakes or other human activities and habitat alterations. Such effects are typically greatest on anadromous, estuarine, nearshore species, or offshore species with a nearshore juvenile stage, although future effects are likely to extend further offshore as a consequence of wave or wind energy structures, aquaculture operations, or other offshore development activities. Some indirect effects could be a consequence of past, present, and future human activities that influence the abundance and distribution of other predators of managed species as well. At the scale of most of the PFMC-managed resources of the CCE, few such activities have notable or major impacts on FMP stocks or complexes other than salmonids, although both catastrophic events (e.g., oil spills) and future human activities that could have larger footprints (e.g,. wave energy, offshore aquaculture) could be associated with broader-scale impacts on managed species.

As a key energy pathway and bridge between freshwater, estuarine, and marine environments, salmon have evolved complex population structures and life histories to cope with the variability in each of these environments (Nickelson and Lawson 1998, Mantua and Francis 2004, Lindley et al. 2009). However, this evolutionary strategy has been threatened by the combined impacts of habitat loss, hydropower, excessive harvest and hatcheries (NRC 1996a), problems that were exacerbated during generally poor environmental conditions throughout the 1980s and 1990s (Hare et al. 1999). Consequently, current salmon populations may lack the life history diversity and high-quality freshwater habitat that acts as a buffer against the intrinsic variability in their ocean habitat. For example, the marine waters off of central California are generally the southernmost habitat occupied by Chinook salmon, most of which are associated with the Sacramento River system and San Francisco Bay Estuary. These freshwater and estuarine ecosystems have been massively altered by dams, water diversion, flow alteration, pollution, nutrient loading and the introduction of non-native species. Simultaneously, these salmon are at the edge of the habitat range for this species, and consequently are likely to experience the strongest environmental impacts from regional and basin scale variability in ocean conditions. The combination of more extreme climate fluctuations and a reduction of life history and habitat diversity has led to additional strain on these populations, and represents a long-term threat to their sustainability and persistence (Lindley et al. 2009, Carlson and Satterthwaite 2011).

Indirect consequences of altered freshwater and estuarine environments also include the facilitation of predation pressure on managed species by other (native) components of the ecosystem, most frequently pinnipeds and seabirds, and often as a result of altered or expanded distribution and changes in behavior. There have been three eras of human relationships with pinnipeds and seabirds. The first involved subsistence and commercial hunting, harassment, and pesticide contamination (described in greater detail in Section 3.4.1). Subsequent declines in many marine mammals and seabirds ended in the early 1970s with the enactment of the MMPA and other environmental protection laws. This began the second era, in which killing or harassment of pinnipeds and sea birds was prohibited, which in turn facilitated the rapid population recovery of these species (e.g., Caretta et al 2011). As a result of localized interactions between populations and individuals of mammals and birds that threaten conservation efforts to protect or rebuild salmonid and other populations, we may now be entering into a third era. In this era, biologists will observe and quantify the risk associated with predator interactions with managed fish species, and respond with management actions when warranted.

For example, sea lions have posed substantial conservation problems to steelhead, Chinook, and other salmon populations throughout the California Current, with very high-profile management issues associated with reducing these impacts at both the Ballard Locks in Seattle and the base of Bonneville dam on the Columbia River (NMFS 1997, IMST 1998). Similarly, Caspian terns (*Hydroprogne caspia*) and double crested cormorants (*Phalacrocorax auritus*) have been estimated to consume millions of salmonid smolts per year in the lower Columbia River. In both instances, increased vulnerability of salmonids to predation was facilitated by human activities; the increased vulnerability of salmon to predation as they hold near dams and other structures, and the creation of nesting habitat for terns and cormorants as a result of man-made islands (the consequence of dredge spoils) on the lower Columbia (Collis et al. 2003). In the latter case, there are no historical records of terns

Caspian terns. Photo credit: USGS

nesting in the Columbia River estuary before 1984, when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island (NWP&CC 2004). However, by 2011, the East Sand Island tern colony was the largest in the world with 7,000 breeding pairs that consumed an estimated 4.8 million salmon smolts, and an additional 13,000 breeding pairs of double-crested cormorant colony (the largest colony in western North America) consuming an estimated 20.5 million salmon smolts. Piscivorous bird colonies have also increased on man-made islands further up the Columbia, including John Day and McNary pools (Evans et al 2012). Past and future management efforts include both non-lethal and lethal removals of problem sea lions to protect salmon, and relocation of colonies and reduction of available nesting habitat in order to better manage avian predation on salmon smolts (Roby 2011). It is highly likely that such activities will continue as threats to recovering or at-risk species arise.

4.1.3 Environmental and Climate Drivers of Fish Abundance

Although current management strategies and reference points for many stocks and species are often based on a reference “unfished” biomass level, the abundance of an unfished resource is rarely constant over time. Rather, species, communities, and ecosystems are in a constant state of flux and variation, responding to changes in the physical and biological environment and multiple temporal and spatial scales. The ocean-atmospheric climate system in the Pacific, and throughout the world, is characterized by large scale interannual (e.g., ENSO) and interdecadal (e.g., PDO) variability in physical properties that in turn lead to dramatic changes in both lower and higher trophic level productivity and dynamics. In the CCE, at least part of the mechanism for the impacts on productivity are the physical circulation patterns that often favor some source waters over others, which in turn contributes to large-scale variability in primary and secondary production in this ecosystem (Chelton et al. 1982, Peterson and Schwing 2003, Checkley and Barth 2009).

Numerous detailed studies of physical and biological time series indicate that there is coherence between various indicators of this physical forcing and biological indices of biomass, productivity, and recruitment of a wide range of stocks throughout the region (Mantua et al. 1997, McGowan et al. 1998, Hollowed et al. 2011, Mantua and Hare 2001, King et al. 2011). For high turnover species (such as market squid), abundance and productivity can change within months, and subsequent impacts on fisheries catches can be dramatic. From 1997 to 1999, market squid catches fluctuated from ~70,000 mt, to ~3,000 mt and back to 90,000 mt, thought to be almost exclusively a function of high-frequency variability in abundance in response to high-frequency environmental variability. Nearly all migratory stocks, including Pacific sardine, Pacific salmon, Pacific whiting, and virtually all HMS vary their movement

Anglers and Humboldt squid catch, HuliCat Sportfishing, Half Moon Bay, CA. Photo credit: John Field, NOAA SWFSC

patterns and distributions in relation to this variability. Typically, there are responses in recruitment, growth, and productivity as well, although these may only be observed over longer time scales.

Low-frequency variation in productivity is also an important factor; in general, there appear to have been shifts to lower values of zooplankton biomass, salmon smolt marine survival rates, and other indices of productivity for West Coast species following an apparent 1977~1999 regime shift, with higher values for similar time series in the North Pacific (Gulf of Alaska and Bering Sea). During this period, the West Coast observed higher productivity and abundance of Pacific sardine, particularly during warm years that were otherwise associated with lower productivity of many species (Jacobson and MacCall 1995, Rykaczewski and Checkley 2008, Song et al. 2012), demonstrating that there will be species and assemblages of species that do better or worse under different conditions. This information has been influential in fisheries management decisions, including the environmentally-driven control rule for sardine harvest policy, and the differential treatment of pre- and post-1976 ecosystem properties and abundance levels for the purposes of estimating groundfish reference points by the North Pacific Fishery Management Council. There is only one unfished groundfish stock that has been carefully evaluated, shortbelly rockfish, which indeed does demonstrate considerable variability (coupled with an apparent long-term decline) in abundance (Field et al. 2007). However, relative abundance time series of other unfished or lightly-exploited species indicate comparable patterns (Moser et al. 2000) and both simulations of groundfish model results and evaluation of the significance of climate factors indicate that there should be non-trivial changes in the abundance and productivity of many stocks (beyond the more noticeable higher-frequency variation observed in recruitment) for many species in the absence of fishing (Schirripa and Colbert 2006, Field et al. 2010, Zabel et al. 2011).

Although historical records of both climate conditions and the abundance of different stocks are difficult to come by, these patterns of long-term variability held in the early 1900s, and it seems increasingly clear that these patterns are typical of this ecosystem. As suggested by the high production of California salmon observed in the 1880s (McEvoy 1986), historical recognition of the massive changes in distribution and abundance of fishes and their prey associated with El Niño events (Hubbs 1948, Wooster and Fluharty 1985, MacCall 1996), a century's worth of massive changes in the abundance and distribution of coastal pelagics and tunas in the southern CCE (MacCall 1996), and a growing volume of paleological evidence that demonstrates that variability in the production of sardines, salmon and other species on such time scales has likely been occurring for thousands of years (Baumgartner et al. 1992, Finney et al. 2000, Field et al. 2006). However, it is becoming increasingly evident that recent patterns of variability are not necessarily consistent with historical patterns index (Di Lorenzo et al. 2008). With global climate change, variability patterns will likely deviate further from those of the past. This issue will be addressed more comprehensively in section 4.5. Despite uncertainties with respect to precise mechanisms of change, fisheries management decision-making should seek scientific tools that recognize that shifts in productivity exist and can matter to fish populations and the ecosystem. Further research should improve both our understanding of the processes that drive such variability, and the means by which such knowledge can and should be used in management decisions.

Canary rockfish school. Photo credit: NOAA.

4.2 Changes in the Abundance of NonFish Organisms within the Ecosystem

U.S. laws and regulations differentiate incidental mortality of protected, nonfish species (e.g., marine mammals, sea turtles) from directed 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? Many of the higher trophic order non-targeted species, particularly marine mammals, were historically targeted by human hunting and their populations may still be recovering from periods of intense targeting.

Elephant seals, Farallon Islands, CA. Photo credit: NOAA.

4.2.1 Direct and Indirect Effects of Fishing on Non-Fish Abundance

Although fisheries may affect non-target species in a variety of ways, impacts may be divided into two broad categories, direct and indirect effects. Direct effects are those directly related to the action, particularly those that occur at the same time and place as the action, such as non-target species being caught or taken during the prosecution of the fishery (incidental catch or bycatch) or habitat can be altered through direct contact with fishing gear. For indirect effects, there is some intermediate cause-and-effect between the action and the actual effect being evaluated; indirect effects may occur at a distance in time or place from the action, such as reductions in prey base that serve as forage. Although bycatch is often considered the most serious direct effect of fisheries on non-target species (Dayton et al. 1995), other potentially important fishing effects include: direct or indirect damage to habitat-forming organisms or benthic communities (Auster 1998), behavioral aggregation of scavengers from bycatch discards, and the indirect effects of target species reduction (Botsford et al. 1997).

Nonfish organisms in the CCE include everything from phytoplankton, zooplankton, and larger invertebrates within a size range typically smaller than fish, up to birds and marine mammals at sizes typically much larger than fish. Thus, nonfish organisms include both the major prey and the major predators of our managed fisheries species; these two groups are incredibly diverse. U.S. laws that require the monitoring and reduction of incidental catch and bycatch include: the MSA, 16 U.S.C. 1801 et seq.; the MMPA, 16 U.S.C. 1361 et seq.; and the ESA, 16 U.S.C. 1531 et seq. The MSA requires that FMPs establish standardized reporting methodologies to assess the amount and type of bycatch occurring within fisheries, and that conservation and management measures for fisheries minimize bycatch and bycatch mortality [16 U.S.C. 1853, 1851]. These protections extend to target and non-target species, with additional laws providing protections to species not managed under the MSA.

For example, pursuant to the MMPA, NOAA has promulgated specific regulations that govern the incidental take of marine mammals during fishing operations (50 CFR Part 229). Section 118 of the MMPA requires NMFS to place all U.S. commercial fisheries into one of three categories based on the level of incidental serious injury and mortality of marine mammals occurring in each fishery (16 U.S.C. 1387(c)(1)).

The regulations designate three categories of fisheries, based on relative frequency of incidental serious injuries and mortalities of marine mammals in each fishery:

I. **frequent** incidental mortality or serious injury of marine mammals
II. **occasional** incidental mortality or serious injury of marine mammals
III. **remote likelihood of/no known** incidental mortality or serious injury of marine mammals

Annually, NMFS publishes a List of Fisheries, which classifies each U.S. commercial fishery into one of these categories. The classification of a fishery in the List determines whether participants in that fishery are subject to certain provisions of the MMPA, such as registration, observer coverage, and Take Reduction Plan requirements. In the most recent List of Fisheries, out of the 53 classified fisheries that operate out of California, Oregon, and Washington, none were Category I fisheries, 9 were Category II fisheries, and the remaining 44 were Category III fisheries (76 FR 73912, November 29, 2011). The nine West Coast Category II fisheries, those that include occasional incidental mortality or serious injury of marine mammals, were:

- California halibut, white seabass, and other species set gillnet fishery
- California yellowtail, barracuda, and white seabass drift gillnet fishery
- California thresher shark and swordfish drift gillnet fishery
- Washington Puget Sound Region salmon drift gillnet fishery (including all non-tribal fishing in inland waters south of U.S. – Canada border and eastward of the Bonilla-Tatoosh line)
- California spot prawn pot fishery
- California Dungeness crab pot fishery
- Oregon Dungeness crab pot fishery
- Washington coastal Dungeness crab pot fishery
- Washington/Oregon/California sablefish pot fishery

Of these Category II fisheries, the California thresher shark and swordfish drift gillnet fishery of the HMS FMP (discussed below) and the sablefish pot fishery of the Groundfish FMP are Council-managed fisheries. The sablefish fishery has been classified as a Category II fishery based on a 2006 event when a humpback whale, became entangled with a sablefish pot vessel's gear. Because humpback whales are listed as endangered under the ESA, even a single encounter with or mortality from fishing gear can be notable as a percent of that species potential biological removal level.


White-sided dolphins off California. Photo credit: NOAA

Jannot et al. (2011) summarized the interactions of the West Coast groundfish fishery with marine mammals, seabirds, and turtles, based on observer data for that fishery. That report found that, over the 2002-2009 period, 22 marine mammal, seabird, and sea turtle species were caught incidentally, killed, or seriously injured through interactions with groundfish fishing vessels, gear, or vessel personnel. Incidental interactions noted by Jannot et al. (2011) included both lethal and non-lethal interactions. During that 2002-2009 period, a single leatherback turtle was taken, found entangled in sablefish pot fishing gear. Having only a single data point for sea turtle take over an eight-year period makes estimating turtle interactions for the fishery challenging, but turtle interactions are assumed to be rare. For marine mammals, direct cetacean interaction is rarely observed, although five cetacean species are known to have either interacted with the fishery through potentially injurious contact with a vessel or through lethal take as bycatch by fishing gear: Risso's dolphin, Pacific white-sided dolphin, bottlenose dolphin, harbor porpoise, and sperm whale. Unsurprisingly, the highly abundant California sea lion is the pinniped species that most commonly interacts with the groundfish fishery, with higher bycatch rates occurring south of Cape Mendocino, CA, where they are most abundant. The Jannot et al. (2011) analysis of groundfish fishery bycatch found that, of the seabird species incidentally taken in the groundfish fisheries, the most commonly taken species during the 2002-2008 period was black-footed albatross, with northern fulmar (*Fulmarus glacialis*) being the most commonly taken species in 2009.

The Northwest Fisheries Science Center (2011) summarized the potential impact of the CCE groundfish fisheries on species (mammals, birds, turtles, fish) listed as threatened or endangered under the ESA in its Risk Assessment of U.S. West Coast Groundfish Fisheries to Threatened and Endangered Marine Species. While there are limited data for some ESA-listed marine species, interactions between most ESA-listed marine species and the U.S. West Coast groundfish fisheries are infrequent enough to either not affect listed populations, or to not hinder the potential recovery of listed populations. However, there is low observer coverage for most fixed gear fleets, meaning that the potential for indirect or unobserved effects (Bearzi et al. 1999, DeMaster et al. 2001, DeMaster et al. 2006, Robbins et al. 2007) can cause considerable uncertainty in characterizing population level impacts from this gear type.

Of the Council-managed fisheries, only the groundfish fisheries use bottom-contacting gear, raising the potential for the fishery to have direct effects on benthic non-fish organisms. Benthic invertebrate communities are susceptible to damage from fishing gear, which can reduce habitat complexity by smoothing bedforms, damaging emergent epifauna, and removing invertebrate species that produce structures such as burrows (Auster 1998, Turner et al. 1999). Bottom trawling and other benthic fishing gear has been shown to damage corals and sponges that may be very slow to recover from such disturbance (Miller et al. 2012).

California sea lions off San Miguel Island, California. Photo credit: NOAA

Like the sablefish pot fishery, the classification of the California thresher shark and swordfish large mesh draft gillnet fishery as a Category II fishery is based on a participating vessel's recent encounter with a humpback whale. In 2009, a fisherman in this fishery reported an accidental entanglement of a humpback whale with his gear and, although he successfully cut the whale free, that the whale escaped with gear still entangling its fins. Based on the amount of gear still on the animal, this incident was considered a serious injury. As noted above, a single humpback whale serious injury or mortality from fishing gear can be notable as a percent of that species 'potential biological removal level. This sector of the HMS fisheries has management measures intended to monitor and reduce bycatch levels for marine mammals and sea turtles, including Protected Resource Area closures for leatherback and loggerhead sea turtles. The leatherback closure occurs annually from August 15 through November 15 along central California when leatherbacks are in the area foraging. The loggerhead Protected Resource Area off southern California is in place only during El Niño periods, when loggerhead sea turtles are more abundant within the U.S. EEZ.

HMS fisheries are subject to monitoring by NMFS-trained observers. NMFS' Southwest Region manages the observer program for HMS fisheries and tracks observed target and incidental catch in both the drift gillnet and deep-set longline fisheries. Both of these fisheries have been observed to cause entanglement and sometimes mortality of ESA-listed species. Recent levels of participation and effort in these fisheries have been below those of the 1990s, reducing incidents of entanglement and mortality from historic rates and numbers. NMFS has evaluated these fisheries and developed incidental take statements of ESA-listed marine mammals and sea turtles for the entanglements and mortality caused by the fisheries. These incidental take statement numbers are included in the Council's HMS SAFE documents. The 2012 SAFE Report for HMS fisheries through 2011 included the incidental take statement for the drift gillnet fishery for these species: fin whale, humpback whale, sperm whale, green turtle, leatherback turtle, loggerhead turtle, and olive ridley turtle. For the more recently developed deep-set longline HMS fishery, the 2012 SAFE Report included the incidental take statement for four turtle species: green turtle, leatherback turtle, olive ridley turtle, and loggerhead turtle. (PFMC 2012) The absolute number of animals anticipated and observed to be taken incidentally is low for all species, but historic data from these fisheries indicate that takes are possible. Green olive ridley and loggerhead turtles are particularly uncommon in these fisheries, except in El Niño years, or under other conditions when temperatures off the U.S. West Coast may increase to levels tolerable to these species.

Leatherback sea turtle. Photo credit: NOAA

CPS vessels fish with roundhaul gear (e.g. purse seine or lampara nets), which are encircling-type nets deployed around a school of fish or part of a school. Using purse seine gear and management directives like area and time closures, CPS fishery participants can usually target single-species schools and minimize bycatch of non-target species (CPS FMP). The most common incidental catch in the CPS fishery (99 percent of the time) is another CPS species (e.g., Pacific mackerel incidental to the Pacific sardine fishery). Within the CPS fishery, bycatch and interactions with protected species are and have been monitored through dockside sampling, logbooks, and occasional observer programs when funding has been available. Information from dockside monitoring and logbooks are reported annually in the CPS SAFE.

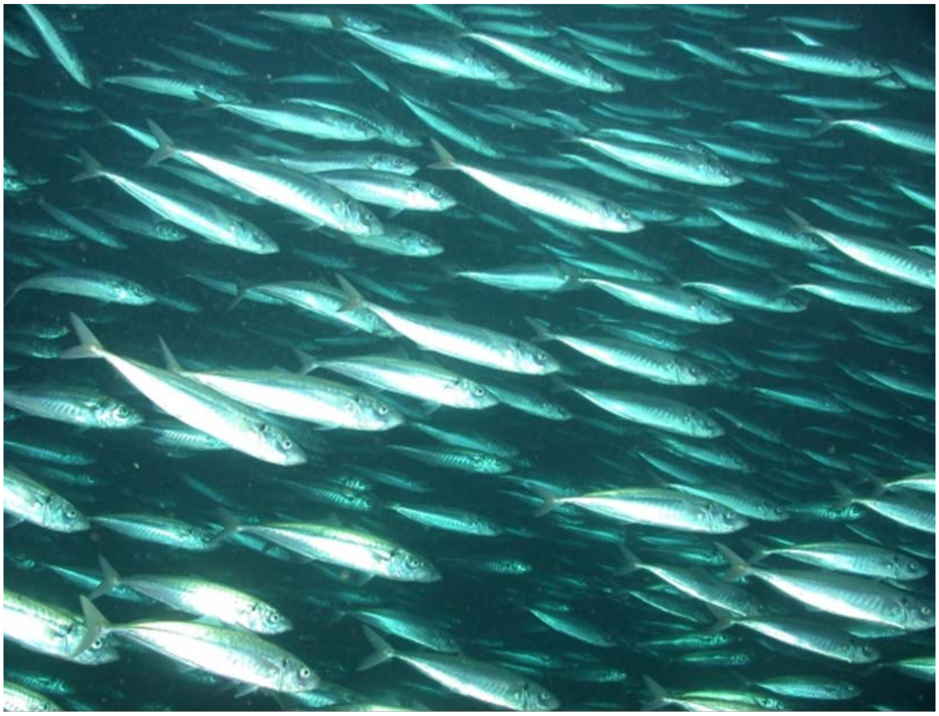
NMFS has conducted consultations related to the CPS fishery on ESA-listed sea birds, marine mammals, and fish stocks, and determined that fishing activities are not likely to jeopardize protected species. NMFS's most recent section 7 consultation on the operation and prosecution of the Pacific sardine fishery determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species, specifically including ESA-listed salmon. As a result of a consultation with the USFWS, and although interactions with sea otters and the CPS fishery are extremely rare, with only two known instances of otters jumping in and out of nets during fishing, reporting requirements and conservation measures are in place to avoid interactions with sea otters: CPS nets may not be deployed in an area where a sea otter is observed and can be encircled by the purse seine; any sea otter entanglements within CPS nets, regardless of whether the animal escapes without harm, must be reported to NMFS within 24 hours of the occurrence; and CPS vessel operators must record and report on all vessel or gear interactions with otters, (defined as otters within encircled nets or coming into contact with nets or vessels, including but not limited to entanglement) with their purse seine net(s) or vessel(s).


Southern sea otters.
Photo credit: California Coastal Commission

The salmon troll fisheries in Federal waters off the U.S. West Coast are Category III fisheries under the MMPA List of Fisheries, with no known encounters with marine mammals. Within Washington State's Puget Sound waters, the salmon gillnet fishery is a Category II fishery for its interactions with Dall's porpoise, harbor porpoise, and harbor seal. The Puget Sound salmon gillnet fishery is not a Council-managed fishery, although the salmon populations targeted in that fishery are either of interest to Council process participants or also occur within Federal waters for some portion of their lives. Like the CPS fisheries, the Federal waters salmon troll gear fisheries use a gear type that can more readily avoid direct interactions with non-fish species. West Coast salmon fishing is concentrated northward of central California, where most species of sea turtles rarely occur, although leatherback sea turtles have been observed throughout the CCE as far north as British Columbia. There are no known interactions between the salmon troll fishery and sea turtles. While the salmon fisheries have not been evaluated for their potential direct effects on seabirds, troll gear has not been the subject of international or national concern for its effects on seabirds (e.g. NMFS 2001).

While direct effects are relatively easy to indentify and quantify, at least to the extent that reliable data exists on the amount or type of bycatch or areas with potential contact with gear, indirect effects, although often as apparent, can be extremely difficult to quantify or determine the level of impact. For example, depletion of a prey stock may reduce the food supply of the predator and therefore may have a negative effect on the predator stock. However, given that most species feed on a variety of prey, it is very difficult to know how large the effect will be. Is the forage fish a vital prey item, or will the predator just shift to different prey? Additionally, interactions between species are seldom straightforward, and there can be several effects involved which can further complicate things.

For example, all species of the CPS FMP are critical members of the ecosystem, since they are the major grazers on phytoplankton, zooplankton, and in some cases fish larvae and small fish (in the case of market squid and mackerel). In turn, these species are preyed upon by a large variety of higher predators, such as fish, large marine invertebrates, marine mammals, and birds, and are generally thought of as part of a more general "forage" fish assemblage. Removal of these species through fishing therefore imparts a potential impact on the entire ecosystem, with krill in particular being noted as such an important resource that all harvest of them is prohibited. Of the remaining targeted CPS, if enough of them were removed from the system, it is possible that there could be two effects: 1) an increase in the abundance of their prey, as the prey are released from predation pressure, and 2) a decrease in the survival and/or reproductive success of their predators. However, what is unclear is whether enough of any of these particular species could be removed in such numbers as to have these effects, particularly since once one targeted species is removed, it is very possible that other similar species could fill their role in the ecosystem. Removal of sardines or anchovies from the system, for example, could potentially result in an increase in other small pelagic fishes (such as herring or smelts) that prey upon a similar prey base, such that large swings in plankton were unlikely.


Schooling sardines. Photo credit: NOAA

The extent to which different species and niches are interchangeable as predators is likely to be limited, at least to some extent, due to subtle differences in prey size spectrum and life histories that likely relate to the low-frequency variations that characterize these populations (e.g., Arthur 1976, Van der Lingen et al. 2006, Rykaczewski and Checkley 2008). The extent to which these species may be interchangeable as prey is less clear. Although there are some indications that some predators may tend to forage preferably on one species rather than another (for example, Glaser (2010) has suggested that albacore forage more exclusively on anchovies rather than sardines), most studies have shown most piscivorous predators to have more opportunistic diets, and many documented predators of sardines showed no signs of population duress or decline during periods of low sardine abundance in the CCE from the 1950s through the 1980s when their diets reflected an absence of this prey resource (Hannesson et al. 2009 and references therein). Although the CPS fishery targets, including sardine, anchovy, and mackerel, make up a significant fraction of the forage base, there are a wide range of other forage species, including the juvenile stages of many larger marine fish species, that provide alternative forage opportunities for predators. These types of indirect impacts of fishing have proven more difficult to quantify in anything but broad terms (Cury et al. 2011, Smith et al. 2011); however, attempts to quantify the effects typically suggest relatively modest impacts when exploitation rates are below single-species-based MSY levels. These results, combined with the observation that there have historically been no obvious declines of predators linked to historical declines or fluctuations in CPS populations, suggest that substantial impacts on predators in the CCE are unlikely under the existing management regime. Similarly, Kaplan et al. (2012) found that indirect trophic effects of groundfish fisheries on marine mammals in the CCE appear to be negligible.

Non-targeted species can also be inadvertently affected by activities associated with vessel operation (e.g., contaminant and noise pollution, introduction of invasive species, marine debris, and habitat modifications caused by vessel anchorings). Under normal operation of fishing vessels, discharges of lubricating petroleum products are inevitable (Lin et al. 2007, Rosenberg 2009). Petroleum products consist of thousands of chemical compounds that can be particularly damaging to marine biota because of their extreme toxicity, rapid uptake, and persistence in the environment (Johnson et al. 2008). Normal vessel operation also increases underwater noise. When background noise levels increase, many marine mammals amplify or modify their vocalizations, which may increase energetic costs or alter activity budgets when communication is disrupted among individuals (Holt et al. 2009, Dunlop et al. 2010). Fisheries may also contribute to the amount of marine debris encountered by non-target species in the form of lost fishing gear and trash disposed overboard (Keller et al. 2010, Watters et al. 2010). Marine debris, especially plastics, produces fragments that can be ingested by many marine organisms, resulting in mortality (Derraik 2002, Thompson et al. 2004, Browne et al. 2008). Marine debris in the form of lost fishing gear continues to “fish” by trapping fish, invertebrates, seabirds, and marine mammals (Kaiser et al. 1996, Good et al. 2010) and may affect populations behaviorally by concentrating individuals both at the water’s surface (FAD – floating aggregation devices; Aliani and Molcard 2003)) and on the bottom (artificial reefs; Stolk et al. 2007).

Retrieved derelict Dungenes crab gear. Photo credit: NOAA

4.2.2 Direct and Indirect Effects of Non-Fishing Activities on Non-Fish Abundance

The California Current IEA team has developed indicators for 23 anthropogenic pressures on the CCE. For many of the non-fisheries-related pressures, they found that pressures were relatively constant over the short term, and most were within historic long-term averages (Agenda Item K.3.a, Supplemental Attachment 1, November 2012 PFMC). However, inorganic and organic pollution and invasive species showed decreasing trends over the short term, but were still within historic levels. Conversely, dredging, shellfish aquaculture, coastal engineering, commercial shipping activity, and marine debris in the northern CCE have been increasing over the short term, but were still within historic levels. Seafood demand, sediment, and freshwater input have been constant over the short term, but are above historic levels, while offshore oil and gas activity and benthic structure construction are at historically low levels. Of particular note is that the indicator for disease was increasing over the short term, and was at historically high levels during the last five years of this dataset.

Importantly, none of these pressures act upon the ecosystem in a vacuum (i.e. many pressures are acting simultaneously on populations), and we have little understanding about whether the effects of multiple pressures will be additive, synergistic, or antagonistic on populations of interest. Moreover, these anthropogenic pressures will interact with the underlying effects of climatic and oceanographic pressures.

The extent to which these diverse threats influence non-target species will depend on exposure of species to these threats and their susceptibility to threats once exposed. To date, there are no comprehensive risk analyses of these non-fisheries threats to species of interest to the Council.

Port of Los Angeles, CA. Photo credit: Los Angeles County.

4.2.3 Environmental and Climate Drivers of Non-Target Species

As discussed in Section 4.1.3, a number of climatic and environmental factors can influence the population size and dynamics of marine species not targeted by fisheries. The same processes that influence targeted fish populations will also affect non-target species. Thus, large-scale interannual variability (e.g., ENSO) and interdecadal (e.g., PDO) variability can lead to dramatic changes in both lower and higher trophic-level productivity and dynamics. As discussed previously, in the CCE, the impacts on productivity are related to the physical circulation patterns that often favor some source waters over others, which in turn contribute to large-scale variability in primary and secondary production.

On average, smaller non-fish organisms grow faster, have shorter generation times, and have population production potential coupled more directly to environmental variables than higher trophic-level fish species. Large marine organisms, such as birds and mammals, are relatively slow growing, and live for longer periods, and thus may have less of a direct response to climate variability, although they still somewhat integrate the impacts of climate over their lifetimes, and may also have critical stages (e.g. egg production by birds) that can respond at shorter time scales to environmental drivers. In both cases, however, environmental variability may be expected to have some influences over these ecosystem components which might then have impacts upon managed fisheries species.

Plankton are well-known to be correlated in various ways with climate variability. For example, oceanic levels of chlorophyll-a (see Figure 4.2.1), which roughly tracks phytoplankton biomass, is correlated with trends in the North Pacific Gyre Oscillation (a.k.a. NPGO index (Di Lorenzo et al. 2008)). Thus the increased recent variability in this index may be indicating increased variability in phytoplankton biomass, which could then affect fisheries species through bottom-up impacts. Additional similar impacts through bottom-up processes driven by climate variability are further described in sections 4.5 and 3.2. Beyond correlations of abundance (and/or productivity) with these major climate signals, a potentially more critical aspect of the response to climate variability in plankton would be major community shifts. An example of how a plankton community may change as a function of environmental drivers can be seen in the coastal Oregon copepod community index (Hooff and Peterson 2006, Peterson et al. 2012). Roughly tracking the PDO, there are observed switches between a zooplankton community dominated by northern vs. southern copepod species. The key difference being that the northern group has more lipids in their bodies, and is thus a richer food source, likely promoting higher productivity in fish, versus the southern community, which has less lipid, and thus likely favors smaller fish or invertebrates. Currently, the system off of Oregon appears to oscillate between these two communities; however, it is possible that under long-term change, there might be a more permanent switch to one community over the other. It is also not clear if other portions of the community, such as phytoplankton, may undergo similar changes in species composition. Such changes in species and community composition driven by environmental factors might not lead to large changes in measured plankton abundance and/or biomass and productivity, but could still effect large changes in the trophic web if such changes lead to drastic changes in prey quality for higher tophic level organisms.

The impacts of climate variability on large non-fish organisms, such as birds and marine mammals within the CCE are harder to estimate, and are thus harder to assess than impacts on managed fisheries species. Long-lived marine mammals and birds tend to integrate the effects of climate variability over their lifespan; however, some species have particularly sensitive periods. For instance, marine birds have been

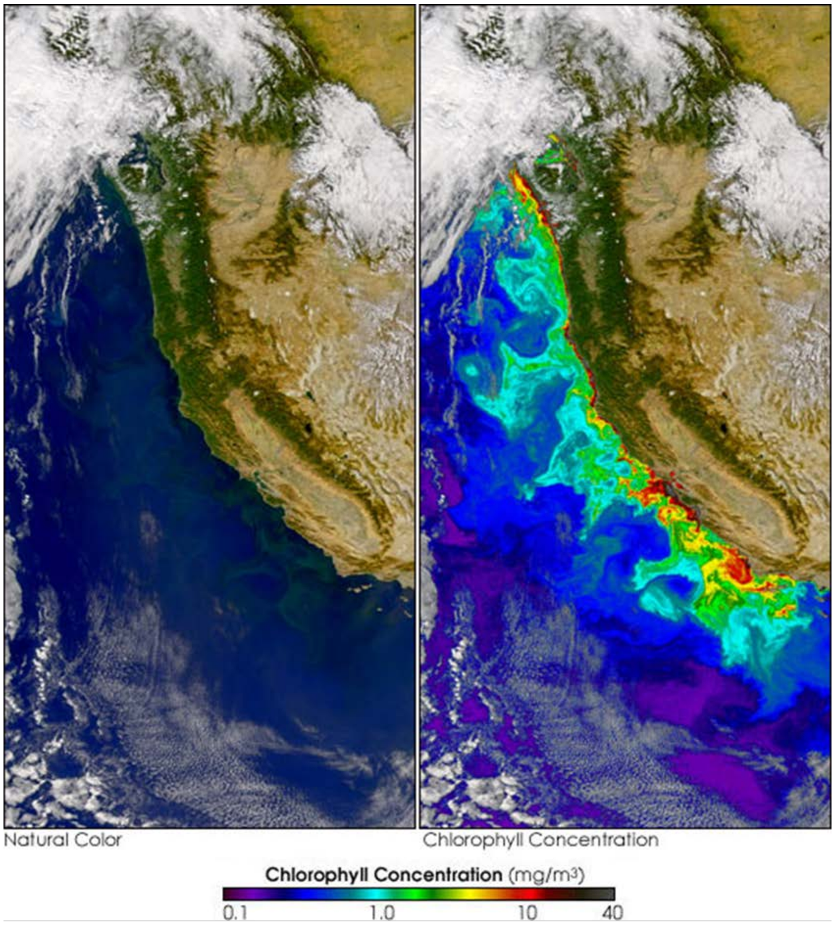
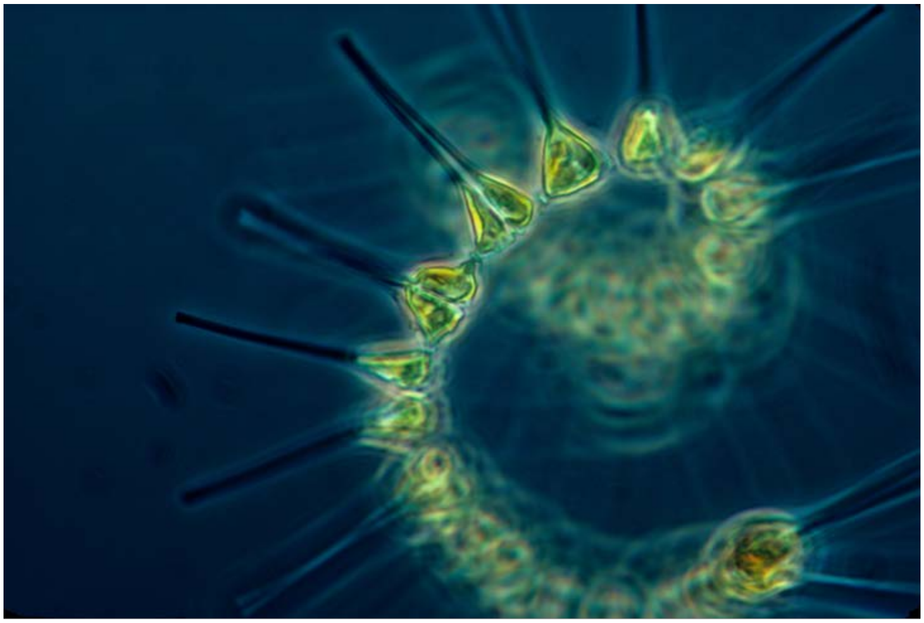


Figure 4.2.1: September 21, 2004 NASA image of the West Coast of North America during period of high phytoplankton bloom. In left-hand image, dark green waters indicate phytoplankton bloom. Right-hand image is colorized to indicate strongest concentrations of chlorophyll (red) to weakest (purple). (http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=14015)



Phytoplankton under magnification. Photo credit: NOAA.

shown to have connections between their reproduction in a particular year or season, and climate conditions or prey supply (Sydeman et al. 2006, Byrd et al. 2008). Similarly, whales and other marine mammals may not be as sensitive in their total growth over their lifetime to interannual variability, but their reproductive output during any particular season may be sensitive to more immediate climatic controls. Since both birds and marine mammals are important predators on both fishery-managed species, and the prey of fishery-managed species (particularly seabirds and whales feeding on krill), changes in the overall long-term abundance of these groups as a result in changes in demographic output through climate-related controls could have significant impacts on managed fisheries species. The extent of such impacts are currently unknown, and complicated to forecast.

4.3 Direct and Indirect Effects of Fishing on Biophysical Habitat

Aside from the direct consequences of mortality to the target populations themselves, the effects of fishing gear on marine habitat, particularly benthic marine habitat, is thought to be among the most significant impacts of fishing on the marine environment. Although virtually all fishing gear can affect the structure and biota of a given bottom habitat, the significance of the impact can be difficult to fully predict and quantify. There are natural background levels of disturbance to all types of benthic communities as a consequence of large-scale activities such as storms, wave action, tidal currents, and geological events, as well as smaller-scale actions such as bioturbation or predator feeding activities (Hall 1994, Kaiser et al. 2002). Consequently, shallow habitats are typically subject to greater natural disturbance than deeper habitats, such that the biota in such habitats may be more resilient to certain levels of disturbance than those in deeper or less-disturbed habitats. It is generally acknowledged that for fishing activities to have ecologically significant impacts, the disturbance must exceed the background levels and frequency of the natural disturbance regime (Kaiser et al. 2002). Where fishing does exceed background levels of disturbance, the impacts of fishing will also vary as a consequence of the magnitude and spatial extent of the disturbance, the complexity of the habitat substrate, the configuration and towing speed of the gear, and other factors (Collie 2000, NRC 2002). For example, depending upon the habitat type, intensive but spatially-localized disturbance may have relatively lower ecological impacts than more infrequent, but wide-spread, fishing disturbance (Kaiser et al. 2002). Another important consideration is the recovery rate for the return of the ecosystem to a state that existed before a disturbance. In some instances, altered habitat may not return to its pre-disturbance state.

Under the MSA, each FMP must contain an assessment of the potential adverse effects of fishing on EFH for management unit species. CPS fisheries have have little effect on physical substrates because the contact between pelagic round haul gears and the bottom is rare, and the opportunity for damage to benthos or the substrate is through lost gear (PFMC 1998). Similarly, HMS fisheries use pelagic fishing gears, and fishing effects on biophysical habitat are presumed to be negligible or unknown, and not described (PFMC 2007). At the time EFH was adopted in the Salmon FMP (PFMC 1999), there were no studies that indicated direct gear effects on salmon EFH from PFMC-managed fisheries.


Red gorgonian coral, basket star, shark egg cases. Photo credit: NOAA.

As described in the Groundfish FMP, Appendix 2C (2006), limited empirical data from the West Coast coupled with information from literature reviews showed that bottom trawl gear has effects on biophysical habitat. Information on the habitat effects of gears other than trawls was very limited, and empirical data were generally non-existent for West Coast habitats and fisheries. Based on this limited information, indices of sensitivity and recovery for the effects of fishing gears on bottom habitats were developed. The general results of the sensitivity analyses in the Groundfish FMP showed a nearly consistent ranking by substrate/macrohabitat type almost regardless of gear type from the most adversely impacted to least: biogenic > hard bottom > soft sediment. It also suggested the relative rankings of gear from highest to lowest impact: dredges > bottom trawls > pots & traps (no empirical data available for nets and hook-and-line gears). Although very little research exists, the various types of nets are generally considered to have much less impact on the seabed than dredges and trawls, and hook-and-line methods have the least impact (PFMC 2006). The Council’s Groundfish EFH designations are currently under review, and the EFH Review Committee is developing new sensitivity analysis methods for this review (EFHRC 2012). General impacts of the gear types with the potentially greatest effects on habitat are described below.

4.3.1 Commercial Fisheries with Mobile Fishing Gears

4.3.1.1 Groundfish Trawl Fishery

The Groundfish FMP is the only Council FMP managing fisheries that use gear that regularly contacts the ocean floor. As a result, the Council, its advisory bodies, and associated agencies have devoted considerable energy to identifying groundfish EFH even under data-poor conditions, and assessing and mitigating for the effects of bottom contacting gear on EFH. Impacts of bottom trawling to physical and biogenic habitats include: removal of vegetation, corals, and sponges that may provide structure for prey species; disturbance of sediments; and possible alteration of physical formations such as boulders and rocky reef formations

(National Research Council, 2002). Mid-water trawl gear is used to harvest Pacific whiting, shrimp, and other species. Mid-water trawl gear is not intended to be used as bottom-contacting gear, and effects are generally limited to the effects of: (1) removal of prey species, (2) direct removal of adult and juvenile groundfish, (3) occasional, usually unintentional, contact with the bottom, and (4) effects resulting from loss of trawl gear, potentially resulting in impacts to bottom habitats and ghost fishing.

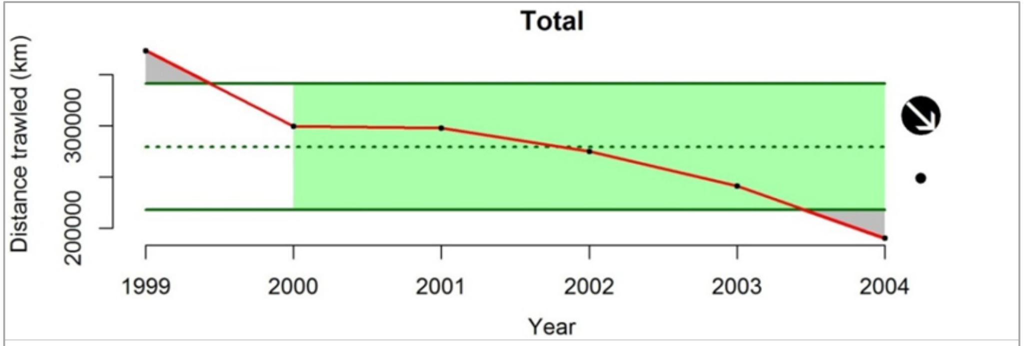


Figure 4.3.1. The time series of total distance trawled (km) along the coast of Washington, Oregon and California made by limited entry groundfish trawl fishery, with two relative statistics on the right hand side: the arrow at the top right indicates whether the trend of the last five-years is positive (arrow up), negative (arrow down) or unchanged (arrow sideways); the sign at the bottom right shows whether the mean of the last five years is greater than (a plus sign), less than (a negative sign) or within 1SD of the mean (a large dot) of the entire time series. Figure: CCIEA 2012. Data: Bellman and Heppell, 2007

Trawl effort for groundfish, measured in number of tows, dropped 60 percent between 1991 and 2001. Between the 1991–1993 and 1998–1999 periods, the number of annual tows for groundfish declined from 28,489 to 11,487. Based on distance trawled estimated from logbook data, limited-entry groundfish trawl effort continued to decline through 2004. Trawl effort (estimated distance trawled) over most habitat types is low and decreasing, compared to historical levels (Figure 4.3.1).

4.3.1.2 Pink Shrimp Trawl Fishery

The trawl fishery for pink shrimp off the coasts of Washington, Oregon, and Northern California operates in much the same way and has similar types of impacts to biophysical habitat as the trawl fishery for groundfish. Pink shrimp trawling, however, is concentrated in the muddy soft bottom areas pink shrimp inhabit. Soft mud habitat tends to recover more swiftly from the effects of trawling than rocky, hard bottom habitat. Shrimp trawl effort mainly occurs at 200m depth or shallower. In Oregon, 53 vessels participated in the fishery during 2010 and totaled 20,600 hours on the bottom, remaining in the low range seen in the fishery since 2003.

4.3.1.3 Geoduck Fishery

The commercial fishery for geoducks in Washington uses water jets to dislodge sediment from around the geoduck, which allows it to be removed from the substrate. A Habitat Conservation Plan (HCP) addresses fishing effects on habitat for commercial geoduck harvesting in Puget Sound, the Strait of Juan de Fuca, and San Juan Archipelago (Washington Department of Natural Resources, 2008). Commercial harvest occurs in specific leased areas called tracts, at subtidal water depths between 18 and 70 feet. Commercial geoduck tracts commonly encompass soft sand or sand and silt substrate. The topography of the tracts varies, but most are relatively flat or are gently sloping.

Harvest activities, particularly the use of water jets, and to a lesser degree vessel anchoring, diver movement, and the dragging of hoses and collection bags, temporarily disturb bottom sediments and unintentionally remove and damage organisms on and in the substrate in the vicinity of the harvest.

Harvesting geoducks temporarily leaves behind a series of holes where the clams are extracted, sediments displaced, and fine particles suspended. On average, harvest holes are about 15 inches wide, 3 inches deep, and the depth to which disturbance was measured is 18 inches. The time for them to refill can range from days to months. Disturbance is limited to the area that is harvested each year (1732 – 2380 acres). Soft-bodied animals may be inadvertently damaged and displaced from within the substrate by the water jets and those brought to the surface are exposed to predation by fish, crab, and other predators and scavengers. Tubeworms may be broken apart, while very small animals may be suspended and carried away by currents.

The HCP reports research results that indicate transport and deposition of sediment put into suspension by harvest activities has minimal impacts on the physical environment within the tract and adjacent areas. The amount of sediment re-suspended by harvest activities is negligible. Substrate disturbance, subsequent sediment suspension and eventual deposition, and impacts to fauna on the tracts cause temporary, local effects, confined to the track and immediate vicinity.

4.3.2 Commercial Fisheries with Fixed Fishing Gears

In general, the effects of fishing gear on habitat for non-Council fisheries, especially fisheries for shellfish, is less well-described. Saez, et al (2013) characterized eleven fixed gear fisheries on the West Coast, including longline, trap/pot and set gillnet anchored to the bottom. Fishing areas within operational depth ranges are described for each fishery (Table 4.1), and gives a general indication of habitats potentially affected. Saez et al (2013) graphically reported quarterly commercial landings aggregated by PacFIN port complex as a proxy for fishery effort for each fishery. Although many fixed gear fisheries operate in shallow depths close to the coast, fishing with sablefish pots and longlines occurs as deep as 450 fathoms and up to 80 kilometers offshore.

Table 4.1. Fishery operational depths (in fm) summarized by state (Table 2 from Saez, et al, 2013).

Fishery	CA depth (fm)	OR depth (fm)	WA depth (fm)
Coonstripe shrimp	20-30[1]	20-30[2]	X
California nearshore live fish	0-20[3]	X	X
California halibut/white seabass set gillnet	15-50[4]	X	X
Dungeness crab	10-40[1]	5-50[2]	5-60[5]
Hagfish	50-125[1]	80-120[2]	50-125[5]
Pacific halibut longline	X	30-150[6]	30-150[6]
Rock crab	10-35[1]	X	X
Sablefish longline	100-450[7]	100-450[7]	100-450[7]
Sablefish traps	100-375[7]	100-375[7]	100-375[7]
Spiny lobster	0-40[1]	X	X
Spot prawn	100-150[1]	60-175[2]	70-120[5]

Sources: 1. CDFW; 2. ODFW; 3. CDFW fishery regulations, Title 14 CCR § 1.90 (d);4. NMFS (2008); 5. WDFW; 6. IPHC; 7. NMFS West Coast Groundfish Observer Program

4.3.2.1 Dungeness Crab Fishery

The commercial Dungeness crab fishery off the West Coast is one of the largest of the fixed gear fisheries, in terms of the amount of fishing gear deployed. With the recent implementation of pot limits in all three states, approximately 400,000 pots are allowed to be fished annually, primarily on sandy substrates within ten miles of shore, from central California north to the Canadian border. Anecdotal information suggests that about 10 percent of pots may be lost each year as an unavoidable consequence of fishing largely during harsh winter conditions.

Limited information is available on the fishery's effects on habitat. Each pot is fished singly and may be deployed to the bottom, retrieved to unload catch, and re-deployed nearly on a daily basis through the peak months of the season. Effects on habitat may include crushing, burying, or exposing marine flora and fauna under the footprint of the pot or vicinity if its buoy line scrapes along the bottom with currents and tides. In the sandy areas typically fished, some local sediment disturbance can occur. Crab pots and lines may also add temporary habitat structure while fished on the bottom. Over the longer term, perhaps several years, a derelict pot can add structure to a variety of habitats, depending on where currents, tides, vessel traffic, or other factors may deposit it on the seafloor. Observations of recovered derelict gear shows a variety of algae and sessile marine invertebrates attach themselves to derelict pots and lines. Underwater observations also show that crabs and other marine life may take refuge in the derelict pots. All three states require that pots have escape mechanisms ("rotten cotton"), so that derelict pots do not continue to ghost fish.

Oregon fisherman collecting derelict crab pots through industry/government gear recovery program. Photo credit:ODFW

4.3.2.1 Sablefish and Halibut Longline Fisheries

As indicated in Table 4.1 above, the sablefish fishery operates in deeper waters than most West Coast fixed gear fisheries and farther from shore. The fishery for Pacific halibut is generally shallower than the sablefish fishery, but the fisheries do overlap in the 100-150m range. Empirical data are scant on the effects of longline gear on biophysical habitat on the West Coast. Movements of lines with currents along the bottom and as gear is being set and hauled may have the greatest impacts, perhaps increasing turbidity, severing or crushing sessile, structure-forming invertebrates, and altering sediments that may be in the path of lines.

4.3.3 Recreational Fisheries

Little is known about the effects of recreational gears on biophysical habitat. The primary recreational fishing gear on the West Coast is hook-and-line. As with other recreational gears, its effects on biophysical habitat are not well-studied on the West Coast, but are likely small and quite localized. Individual fishing lines may sever or tangle small amounts of kelp fronds if gear is fished in areas with kelp. Lost gear, such as sinkers, leaders, etc. also contributes to marine debris on the seafloor, shorelines, and structure-forming biota.

The recreational Dungeness crab fishery occurs in bays and nearshore coastal areas from central California northward. Fishing effort information is limited. Recreational pots are smaller and lighter than commercial pots, although they may have similar types of impacts on benthic habitats.


Sport fishing off Southern California. Photo credit: CDFW.

Effort in the razor clam fishery in large, sandy stretches of beaches on the Oregon and Washington coasts can be intense during low tides. Digging with shovels or clam guns occurs in the surf zone and vicinity. Sediments and infauna are disturbed in this high-energy environment, although holes are often filled in within minutes or by the next tidal cycle.

Harvesting of mussels, abalone, or other shellfish with some hand tools from rocks and rocky areas may have very minor localized, but longer-lasting effects on habitat.

4.4 Changes in Fishing Community Involvement in Fisheries and Dependence Upon Fisheries Resources

Like any community, fishing communities are affected by a variety of internal and external pressures, many of which are beyond the scope or control of Council fishery management programs. Fishing communities are necessarily located in coastal areas, which serve a wide variety of marine and other industries – from regional shipping hubs, to destination tourism locations, to submarine cable landing stations. Council decisions affect how much of which species of fish are taken within larger-scale geographic areas, but do not control whether and how coastal municipalities maintain harbor facilities, coastal community investments in attracting industries other than fishing, transportation infrastructure between fish landing facilities and major fish markets, or myriad other factors that affect income generated and quality of life within fishing communities.

Council decisions directly affect the amount of managed species available in any one year, but are less likely to affect the prices West Coast fishing operations receive for their catch. Ex-vessel revenues for West Coast species are often linked to the species' prices in the worldwide market and West Coast fisheries for most species tend to be exvessel price-taking, rather than price-setting. Ex-vessel revenue is the proximate effect of selling fish. Or, for recreational fisheries, the expenditures incurred can serve as a minimum measure of the benefits derived from the recreational fishing experience. The expenditures and revenues resulting from the commerce of fish or the fishing experience 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, may also be considered in Council decision-making.

Below, this section considers the direct and indirect effects of fishery resource availability on fishing communities, what may be known about the cost of participating in West Coast fisheries, and environmental and climate drivers for fishing communities.

4.4.1 Direct and Indirect Effects of Fishery Resource Availability on Fishing Communities

Section 3.4 provides an overview of West Coast fisheries, with figures showing the ports in which landings of managed species groups occur, and discusses factors affecting their timing. Here, the ports selected for each West Coast state were based on their hierarchical contribution to the state's total annual average landings over the 2000-2011 period. Figures 4.3 through 4.8 compare total landings in California, Oregon, and Washington with the corresponding overall revenues per pound (the weighted average exvessel price of all landings) to characterize fishery activity in each port in terms of the value to volume ratio. For example, the southern California ports of San Pedro and central California ports of Moss Landing, Port Hueneme, and Ventura, where landings are dominated by CPS, tend to be relatively low value per unit landed but high volume in nature. Conversely, fishery activity in Monterey and San Francisco, as well as the northern ports of Eureka and Crescent City, where relatively large amounts of crab, groundfish, and salmon are landed, tend to be more high value per unit landed but low volume. The Oregon ports of Astoria, Newport, and Coos Bay, where groundfish make up the bulk of the landings, can be portrayed as low value but high volume, whereas Brookings, Garibaldi, Columbia River and Port Orford, having relatively higher landings of crab, shrimp, and salmon, are more high value but low volume. In Washington, Westport fisheries appear to be low value per unit landed but high volume, while fisheries landings in the ports of Chinook, Bellingham Bay, Seattle, Neah Bay, Blaine, Shelton, Grayland, and LaConner, with relatively greater landings of salmon and crab, would be considered high value but low volume in type.

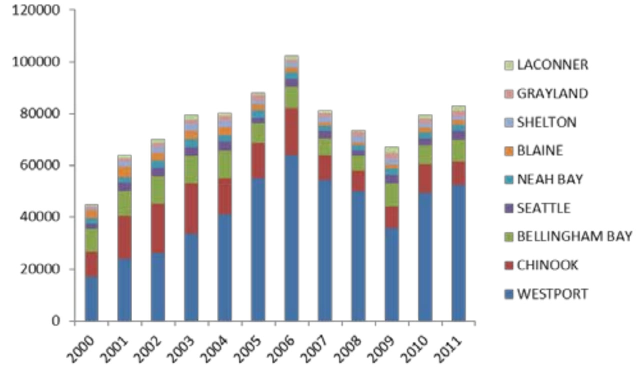


Figure 4.4.1. Annual total landings for the Washington ports accounting for 90% of the average annual commercial landings, 2000-2011.

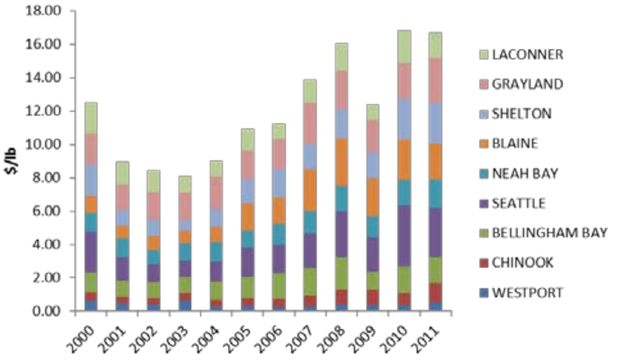


Figure 4.4.2. Revenue per pound for total landings in Washington ports that accounted for 90% of the average annual commercial landings, 2000-2011.

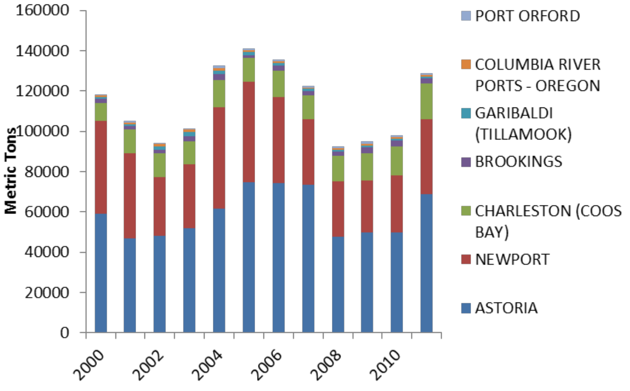


Figure 4.4.3. Annual total landings for the Oregon ports accounting for 99% of the average annual commercial landings, 2000-2011.

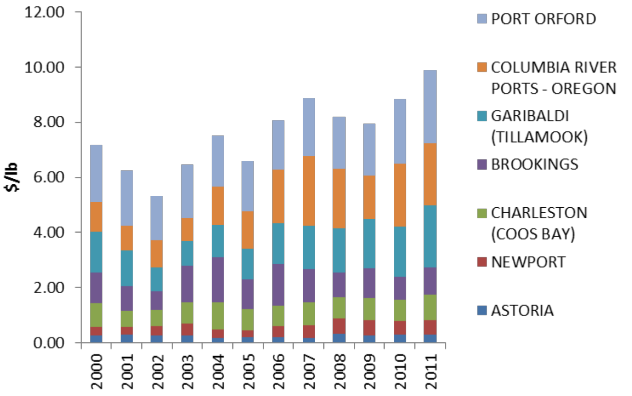


Figure 4.4.4. Revenue per pound for total landings in Oregon ports that accounted for 99% of the average annual commercial landings, 2000-2011.

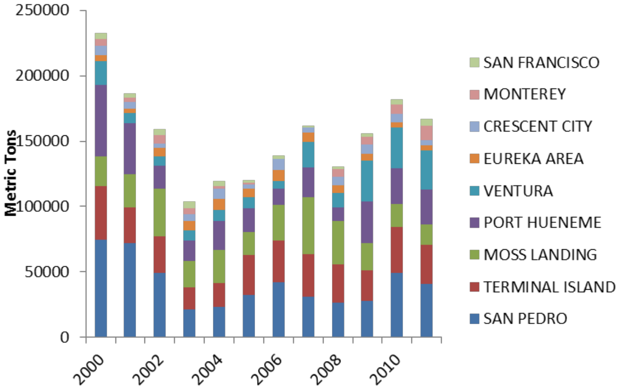


Figure 4.4.5. Annual total landings for the California ports accounting for 90% of the average annual commercial landings, 2000-2011.

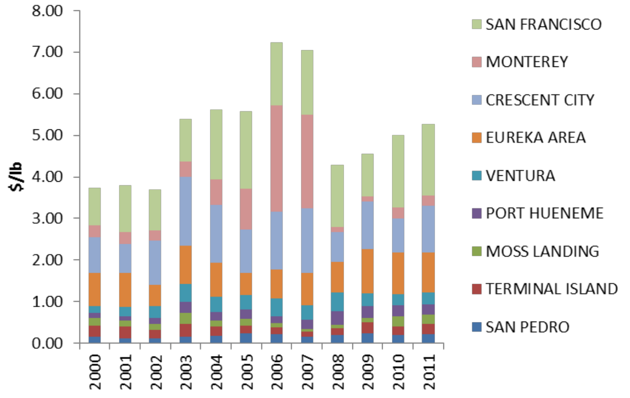
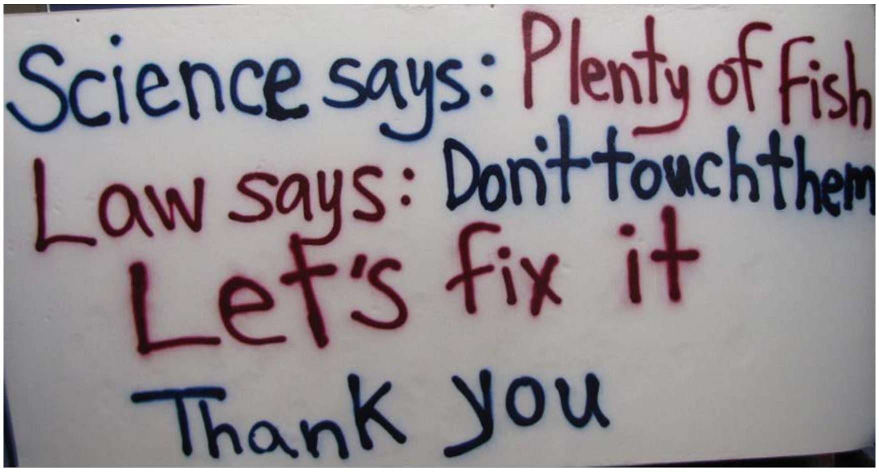


Figure 4.4.6. Revenue per pound for total landings in California ports that accounted for 90% of the average annual commercial landings, 2000-2011.

While Council decisions primarily affect landings volumes, fishery management programs can also affect the prices commercial vessels receive for their landings, the prices fish processors receive for their processed product, and the volume and prices recreational charterboat operations receive for the charter fishing experiences they offer. The goals and objectives of the Council's groundfish trawl rationalization program, for example, include creating "individual economic stability," and increasing "operational flexibility" (PFMC and NMFS 2010). These broadly-worded goals recognize that, when fishermen can plan ahead, and their management programs provide flexibility in when and where they land their fish, they can take better advantage of shifting seafood prices.

For some fisheries, like those for albacore, fishing must occur when the species in question is migrating through a particular region. For other species, like Dungeness crab, fishing must be timed for both biological (avoiding breeding season) and market (avoiding soft-shell season) reasons. Recreational fisheries, particularly those in the northern sections of the coast, are often constrained by seasonal weather. Washington's charterboat operators may be willing to take customers in January, but their customers are less willing to join a January charter than a July charter. The Council can improve stability for fishery participants and fishing communities by developing management programs that provide some level of predictability in available harvest levels, season timing, and duration.



Polite graffiti found at Monterey Bay (CA) area community fishing festival.

The WCGA's 2008 Action Plan identifies many of the indirect effects that losses of fishing opportunities have on fishing communities: aging or declining port facilities and infrastructure, losses of traditional waterfront businesses, increasing housing costs associated with coastal community economic shifts toward attracting tourism revenue and second home buyers, and lack of inland-to-waterfront transportation infrastructure (WCGA 2008). The WCGA's Sustainable Coastal Community Action Team elaborated further on these indirect effects of losses of fishing opportunity. That team's 2011 work plan identified multiple factors that threaten fisheries sustainability and the ongoing existence of coastal-dependent businesses and working waterfronts, including: a lack of a stable regulatory regime, which impedes business planning, lack of understanding from the general public about the land-sea connection, particularly about how degradations of terrestrial habitat may also affect marine species populations, reduced access to ports as a result of lack of funding for dredging and sediment management, insufficiently maintained port infrastructure, and a lack of opportunities to certify and sell locally-sourced seafoods (WCGA 2011).

The predominant fishery conservation and management issues facing the Council now and in the future deal with integrating physical, ecological, and economic systems into an analytical framework directed toward maximizing the benefits that the CCE is capable of providing society on a long-term sustainable basis. Society's interest in ecosystem-based fisheries management reflects the total economic value it derives from fishery resources, given the full range of goods and services they are capable of providing. Critical in this regard will be appropriate extraction levels for commercially and recreationally targeted species that take into account their interaction with other species having commercial, recreational, or charismatic value.

The Council's basic HCR for CPS exemplifies the ecosystem-based fisheries management approach when setting annual harvest quotas by accounting for the importance of CPS as forage for commercially important, recreationally important, and protected species predators (PFMC 1998). The challenge at this juncture is to incorporate the economic value of harvested and protected predators into the HCR to achieve optimal use of CPS resources from society's standpoint. For example, if fishery management explicitly considers the economic value of species being harvested or protected, then the ecosystem/economic modeling approach could indicate under what ecological-economic conditions a CPS harvest quota might be reduced to increase the harvest or populations of more valuable predators (Hannesson et al. 2009, Hannesson and Herrick 2010). The ecosystem/economic modeling approach may indicate that it is advisable to reduce harvest levels on low-value feed species (e.g. anchovy and sardine) to provide the potential for increases in the harvest volume and value of species that feed on these species. An ecosystem/economic modeling approach would allow us to include significant ecological and technological interactions among species in the calculation of their optimum yields and the extent to which these interactions affect their relative economic value.

There are numerous types of values ascribed to the organisms populating an ecosystem, and there will be tradeoffs between different ecosystem services or functions in order to achieve optimal use of the marine ecosystem. Recognition of these values and of ecosystem services has given rise to the current move in fisheries governance toward ecosystem-based management. Achievement of ecosystem-based fisheries management will be a lengthy, complicated process, one that engages diverse scientific methodologies in an interdisciplinary exercise to identify and describe all aspects of the linkages between complex natural and socioeconomic systems. The key here is to broaden the focus of traditional fisheries conservation and management science from a relationship between a target species and a commercial or recreational fishery, to a more comprehensive outlook that embraces all species in terms of their trophic, ecological, habitat, and fishery interactions, and most importantly their relationship to all of society. Only when the consequences of human actions and values are highlighted throughout the ecosystem can the entire range of tradeoffs be made apparent and considered in conservation and management decision-making.

4.4.2 Costs of Participating in Fisheries

The economic effects of fisheries management on fishing communities and on the nation as a whole are related to the costs of managing and participating in the fisheries and to the benefits derived not just by fishermen, but also by the larger fishing community, and by U.S. citizens. A thorough cost-benefit analysis requires detailed variable and fixed cost data. Variable costs typically include: labor (crew and hired captain expenses), fuel, trip provisions (food, groceries, etc), expendable gear and equipment, maintenance and repairs, and any other costs that vary with the amount of fishing effort expended. Fixed costs are incurred whether the vessel fishes or not, and typically include: vessel depreciation, interest payments, insurance, legal fees, office expenses, business licenses and fees, fishing permits, professional services, mooring/slip fees, drydock, routine vessel and gear maintenance and related purchases, supplies, salaries, and other. We routinely collect fisheries revenue and landings data, but in many instances, corresponding cost data is often only collected for specific research projects.

Food bank project poster for salmon collected from ODFW hatchery, canned by Tillamook Bay Boathouse, labeled by Neah-Kah-Nie High School students, and distributed to Tillamook-area food banks. Photo credit: Steve Albrechtsen, Neah-Kah-Nie High School

4.4.3 Environmental and Climate Drivers for Fishing Communities

Environmental and climate drivers that may affect fish abundance are discussed in Sections 4.1.3 and 4.5. Drivers that affect fish abundance also affect harvest levels available to human communities. Beyond the effects of fish abundance on fishing communities (Section 4.4.1) are the topographic and hydrological effects of climate change. Fishing communities are usually geographically located on or near the coast, and coastal communities face a variety of known and unknown challenges that may be associated with global climate change.

Documenting all of the potential effects of near-term climate variability and long-term climate change on West Coast fishing communities is beyond the scope of this FEP. However, some major potential concerns for the coastal communities of Washington, Oregon, and California are discussed in this section.

4.4.3.1 Near-term climate variability related to ENSO and PDO

California wildfire. Photo credit: U.S. BLM

As discussed earlier in this FEP, interannual climatic shifts like ENSO, and interdecadal shifts like PDO, can alter both the status of marine stocks and how humans experience climate on land. During El Niño periods, jet stream winds are often diverted northward, which can result in increased exposure of the U.S. West Coast to subtropical weather systems (Cayan et al. 1999). Along the coastline, this increase in southerly weather systems, coupled with elevated relative sea levels that are also associated with El Niño events, leads to increased storm damage and beach erosion in coastal areas (Storlazzi and Griggs 2000). While such events often cause dramatic shoreline impacts and property damage, we are not aware of studies that have evaluated the direct or indirect impacts to fisheries infrastructure or profitability, although the impacts on species catchability and the resulting profitability of different fishing strategies as a consequence of El Niño have been evaluated and shown to be substantial in case studies. For example, Dalton (2001) showed that El Niño events had positive impacts on the abundance and catch rates of albacore and negative impacts on the abundance of Chinook salmon, sablefish, and squid in Monterey Bay, with cascading impacts on both prices and profitability in all of those fisheries.

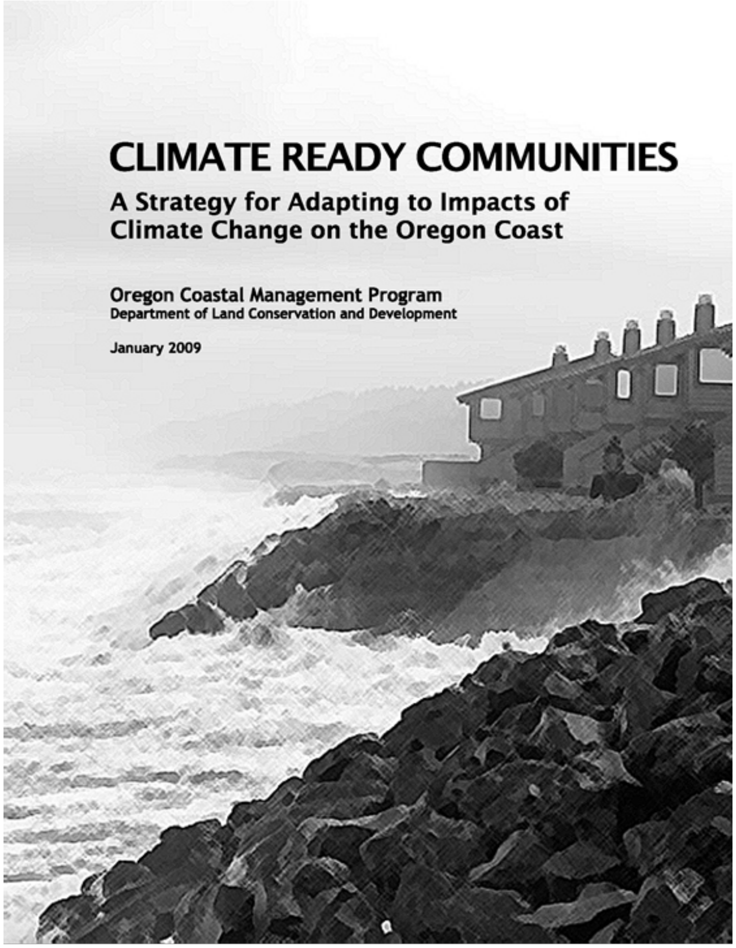
The changes in weather patterns more generally also leads to higher than normal rainfall in the southwestern U.S., with associated flooding and sediment dispersal more likely to occur from central California southward. By contrast, the northwestern U.S. experiences lower than normal precipitation during such events, often resulting in drought conditions both from lack of rainfall in the lowlands and from reduced snowpack in the mountains (Karl et al. 2009). During El Niño periods, the reduced precipitation in the northwestern U.S. has a direct effect on stream levels, reducing spawning and migration habitat for salmon. Drought conditions in the northwest also tend to result in more intense and more frequent forest fires, although northwestern forest fires most frequently occur east of the Cascade Mountain range, away from coastal communities. Conversely, La Niña periods bring unusually dry and hot conditions to the southwestern U.S., and wetter than normal conditions to the northwestern U.S. While the buildup of snowpack associated with La Niña years can be beneficial to salmon during spring snowmelt periods, increased northwest flooding can also move streamwater outside of streambed habitat into areas not hospitable to salmon spawning, such as agricultural fields or roadways. Reduced precipitation in the already dry southwestern U.S. often results in more frequent and more intense forest fires, which can occur in southwestern coastal communities. Reduced precipitation can also lead to more intense conflict over water rights in southwestern water systems that are already oversubscribed by multiple users.

4.4.3.2 Sea-Level Rise in Association with Climate Change

At the large-scale, the U.S. West Coast is relatively high-relief, meaning that the land often rises sharply from the ocean, making inundation from sea-level rise less of a concern for some undeveloped areas of the coast. However, several coastal areas, including San Francisco Bay and Puget Sound, are highly developed near low-lying shoreline, and are expected to be vulnerable to sea-level rise in the coming decades (Snover et al. 2007, Cloern et al. 2011). Even less-developed portions of the West Coast may be subject to accelerated erosion in association with sea-level rise, particularly where sandy dunes dominate the coastline.

In 2012, the U.S. National Research Council published a report evaluating sea-level rise for the U.S. West Coast in the years 2030, 2050, and 2100, in response to requests from the states of Washington, Oregon, and California for more information on where and how sea-level rise might affect the West Coast (NRC 2012). The report responds to the states' requests for information on the contributors to global sea-level rise, regional and local values for sea-level rise, climate-induced changes in storm-frequency and magnitude, the response of coastal habitats to sea-level rise and storminess, and the role of habitats and natural environments in providing protection from inundation and waves. In general, the report concludes that sea-level rise may have less of an effect north of Cape Mendocino, CA, where an upward-lifting tectonic plate will counteract the effects of melting polar ice, and more of an effect south of Cape Mendocino, where the coast's tectonic plate is sinking relative to surrounding plates. Storm frequency and intensity, however, is expected to increase coastwide, particularly in El Niño years, when Pacific Basin sea surface heights increase along the eastern Pacific Ocean (NRC 2012).

As with near-term climate shifts, fishing communities can start to prepare for sea-level rise by seeking out projections for their particular geographic regions. Projections may be less certain at smaller spatial scale, but can still help communities think about and plan for projected changes for their region. The three West Coast states, both individually and collectively through the WCGA, have been seeking state-level information and are organizing state-level planning on addressing the effects of climate change. Treaty tribes that participate in the Council process are also participants in regional and nation-wide efforts by native peoples to better prepare for sea-level rise and other effects of global climate change (e.g., FSS 2012).



CLIMATE READY COMMUNITIES

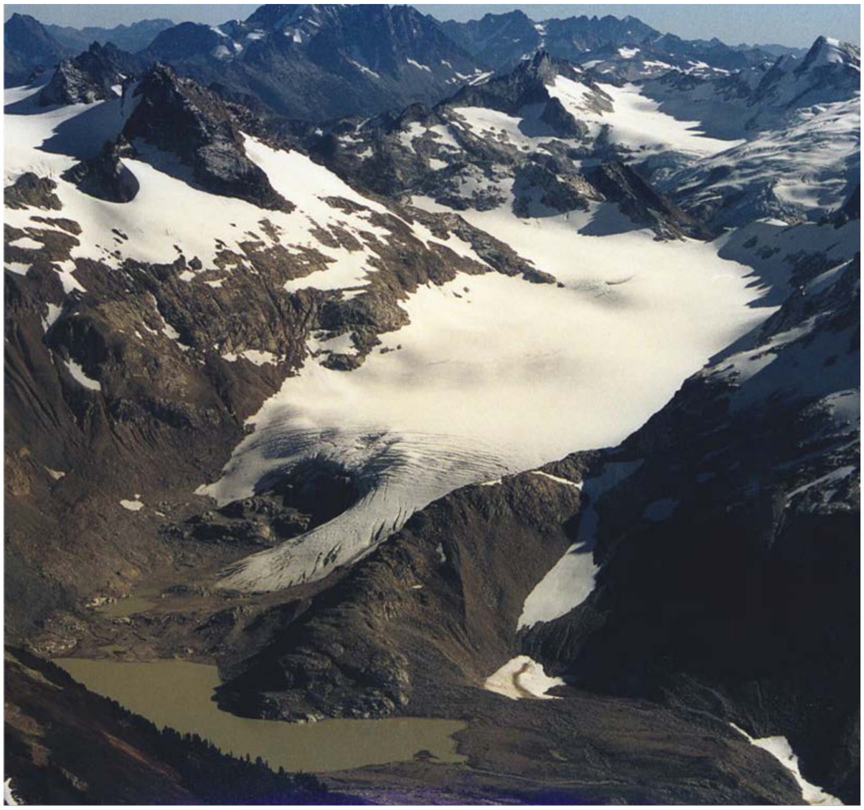
A Strategy for Adapting to Impacts of
Climate Change on the Oregon Coast

Oregon Coastal Management Program
Department of Land Conservation and Development

January 2009

Oregon Coastal Management Program's planning document for sea-level rise. Image credit: ODLCD

4.4.3.3 Hydrologic Cycle Shifts in Association with Climate Change



Glacial retreat in Washington's South Cascade mountains.
Photo credit: WA Dept. of Ecology

Climate change has already had measurable effects on the North American hydrologic cycle in the 20th century, and those effects are predicted to continue through the 21st century. For communities along the U.S. West Coast, hydrologic cycle shifts will differ along the length of the coast. Hot and dry sections of the southwestern U.S., particularly including coastal areas of the Southern California Bight, are predicted to become hotter and dryer, with longer droughts and more floods when rainfall occurs. The Northwest is also predicted to experience more droughts and floods, with less precipitation falling as snow, as well as earlier spring snowmelt periods, all of which will together exacerbate longer summertime droughts. Glaciers in U.S. western mountains, including those in Alaska, have been shrinking over the 20th century and are expected to continue to shrink through the 21st century. Freshwater supply conflicts already make water rights allocation difficult throughout the western U.S. As the U.S. population increases, particularly in drier regions, those conflicts are expected to increase (NRC 2012).

4.4.3.4 Shoreline Ecological Shifts in Association with Climate Change

With sea-level rise increasing coastal erosion and encroaching on wetlands, and with rainfall occurring in more brief and dramatic events, more sediment will likely be shifting to and around coastal areas. For some coastal communities, sediment shift may mean loss of beaches and connected tourism income, or loss of estuarine habitat. For other communities, more rapidly shifting sediment may mean increased needs for frequent dredging. More urbanized coastal communities with hardened shorelines may see more landslides and other dramatic erosion events. The western U.S. has been subject to a dramatic infilling and loss of wetlands habitat over the last 150 years, leaving less protection from coastal storms and erosion for humans, and less nursery habitat for fish. Although coastal development mitigation and environmental protection strategies now take better account of the need to retain the ecosystem services provided by wetlands, habitat restoration is unlikely to occur at a fast enough rate to counter the predicted sediment transport effects associated with climate change.

4.5 Aspects of Climate Change Expected to Affect Living Marine Resources within the CCE

Climate change is expected to lead to substantial changes in physical characteristics and dynamics within the marine environment, with complex and interacting impacts to marine populations, fisheries and other ecosystem services (Scavia et al. 2002, Harley et al. 2006, Doney et al. 2012). Three major aspects of future 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, IPCC 2007), 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-1980s (Bograd et al. 2008, McClatchie et al. 2010). These three factors are linked: ocean temperature affects ocean pH, ocean temperature and deep water oxygen levels both can be controlled by large scale circulation patterns, and primary production can affect both oxygen and pH (Gilly et al. 2013). 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. In addition to these three large-scale aspects of climate change, some more immediate and localized aspects of climate change observed in coastal marine ecosystem include: intensification of upwelling (Bakun, 1990, Schwing and Mendelssohn, 1997), changes in phenology (Bograd et al. 2009), and changes in the frequency and intensity of existing interannual and interdecadal climate patterns (Yeh et al. 2009, CCIEA 2012, and references therein). Substantial changes in weather and precipitation patterns will also affect snowpack, streamflow, river temperatures, and other aspects of freshwater habitat, with tremendous real and potential consequences to the future productivity and sustainability of anadromous resources such as salmon (Mantua and Francis 2004, Crozier et al. 2008).

Due to its expected significant impacts, the Council will eventually find it necessary to consider the effects of climate change on Council-managed species, whether those effects include a localized change in prey abundance for one species, or a large-scale shift in species composition within the CCE. The FEP's Ecosystem Initiatives Appendix, in Section A.2.8, suggests an initiative to help bring Council priorities for the information it needs about future predicted shifts in fish population abundance to the scientists and scientific programs assessing the vulnerability of natural resources and human communities to climate change.

4.5.1 Temperature

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 California Cooperative Oceanic Fisheries Investigations [CalCOFI] program).

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. Climate change has already been associated with poleward range expansions of marine species; animals with the highest turnover rates appear to show the most rapid distributional responses to warming (Perry et al. 2005; Burrows et al. 2011), suggesting that those with slower life histories could be more vulnerable to such impacts. Most recently, Hazen et al. (2012) evaluated likely changes in the distribution of available habitat to a suite of higher trophic-level predators (including many HMS species), and predicted that available habitat would change by up to 35 percent for some species, with corresponding northward shift in species ranges and biodiversity across the North Pacific.

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).

4.5.2 Ocean pH

Measurement of ocean pH requires in situ water sampling, and cannot currently be conducted via remote sensing. 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 using 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, monitoring of pH has increased, particularly in coastal regions.

One of the more significant direct consequences of increasing concentrations of carbon dioxide in the atmosphere is the alteration of ocean chemistry. The ocean has become a sink for approximately one quarter of the carbon dioxide emitted by human activities, which has led to a decrease in the pH of seawater, which is increasingly recognized as having potentially substantial consequences, particularly to organisms that build all or part of their structures (e.g., shells) out of calcium carbonate ($CaCO_3$). 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; Riebesell et al. 2000; Fabry et al. 2008). Decreased pH may possibly impact the larvae and young


Funnel of geoduck clam. Photo credit: WDFW

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 pCO_2 levels, it is expected that as pCO_2 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.

Although pH within the surface waters is highly related to atmospheric processes (e.g. the CO_2 content of the air), coastal upwelling may act to further decrease upper ocean pH. Waters at depths from 150-400 m are typically low in pH relative to the surface, since these waters are relatively "older," and hence have had more time for biological processes like respiration to occur, which naturally reduce pH (Feely et al. 2008). When water from these depths upwells towards the surface, as occurs seasonally within the CCE, the pH of the upper water column will decline. This results in a shoaling of the depth at which organisms can no longer make calcareous shells, thus restricting or possibly eliminating (when upwelling is strong enough to reach directly to the surface) their available depth habitat range (Feely et al. 2008). Such effects are temporally variable, since they are directly related to the strength and duration of seasonal coastal upwelling, with surface pH rapidly returning to its pre-upwelling, atmospherically-equilibrated state upon the cessation of upwelling. A recently-convened blue ribbon panel on ocean acidification in Washington State waters noted the potential for upwelling off the Washington coast to exacerbate the near-term effects of ocean acidification on northern CCE nearshore waters (Feely et al. 2012).

4.5.3 Oxygen

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.

Within the CCE, there has been a notable decrease in deep-water oxygen levels since the mid-1980s (Bograd et al. 2008, Chan et al. 2008). Much of this reflects a shoaling of the oxygen minimum zone throughout the Eastern Tropical Pacific, California Current, and North Pacific, in which the depth of the oxygen level thought to be constraining or lethal for most marine species becomes shallower (closer to the surface), compressing the available water column habitat for fishes with high oxygen demands. These low oxygen waters are a natural feature of the Eastern Pacific Rim and other regions characterized by high surface productivity and/or the upwelling of oxygen-poor source waters (Helly and Levin 2004). However, the ongoing 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 affecting large regions of the CCE (Bograd et al. 2008, Stramma et al. 2011), and one expected to continue or intensify with global change (Rykaczewski and Dunne. 2010). On top of the long-term, system-wide changes 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.


Oceanographic data buoy being deployed from R/V Miller Freeman. Photo credit: NOAA.

Within the oxygen minimization zone, species diversity declines to a smaller suite of species that have adapted to cope with low oxygen waters. In the CCE, the benthic inhabitants of the oxygen minimization zone are the well-known deepwater complex species (Dover sole, thornyheads and sablefish), which have evolved a range of adaptive strategies including metabolic suppression, slow growth rates, late ages at maturity, and ambush (rather than active searching) predation methods (Vetter and Lynn 1997, Koslow et al. 2000). However, the effects of low oxygen levels on marine organisms that are not tolerant of such conditions are fairly well-known: death in most cases if the organisms cannot avoid the area, or reduced growth for those species with moderate tolerance. Consequently, the combination of a steady decrease in baseline oxygen levels in deep water, with 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 massive fish kills (e.g. recent events off Oregon coast; Chan et al. 2008).

Over the longer term, the likelihood of oxygen decrease events may increase, as will a more gradual compression of available habitat for less-tolerant species. For example, McClatchie et al. (2010) evaluated potential scenarios for hypoxia to affect the habitat of cowcod, a rebuilding shelf species that is a key management species in the California Current. They found that as much as 37 percent of deep (240-350 m) cowcod habitat is currently affected by hypoxia, but that if the current trends of a shoaling oxygen minimization zone continue for 20 years, this could increase to 55 percent of deep habitat, as well as an additional 18 percent of habitat in the 180 to 240 m depth range. For deeper water species the impacts could be even greater; for example blackgill rockfish (*S. melanostomus*) have a much deeper depth distribution (among the deepest of the larger slope-dwelling Sebastes) and may be at considerably greater risk to the longer-term impacts of shoaling. Moreover, changes in the characteristics and dynamics of the oxygen minimization zone could lead to changes in the forage base for blackgill rockfish, which are described as foraging primarily on mesopelagic fishes that undergo diel migrations from the edge of the oxygen minimization zone to surface waters in order to feed. A comparison of the depth of the oxygen minimization zone and long-term records of fish communities suggests that oxygen minimization zone shoaling may be shifting the distribution of blackgill rockfish's mesopelagic prey species (Koslow et al. 2011). Such habitat compression is also likely to affect HMS, such as tunas and marlin, with the irony that such compression could increase the vulnerability of such predators to fishing (by concentrating their habitat), while decreasing their long-term carrying capacity and productivity (Prince and Goodyear 2006, Stramma et al. 2011).

4.5.4 Upwelling, Phenology, and Changes in Existing Climate Patterns

As described by Bakun (1990), global warming has led to an intensification of alongshore wind stress, which in turn has led to an intensification of coastal upwelling, as has been documented both around the globe, and specifically within the CCE (Schwing and Mendelssohn, 1997). Within the CCE, this long-term intensification is most notable during April to July, and is of greater magnitude than the typical seasonal variability. Such an increase in upwelling should lead to cooler surface waters and higher productivity; however, the long-term trend of increasing sea surface temperature (SST) has masked this effect, leading to overall net higher water temperatures (Schwing and Mendelssohn, 1997).

There have also been changes in the major existing climate patterns, e.g. the PDO, NPGO, and ENSO. The MEI (Multivariate ENSO Index), which is an indicator of occurrence and strength of El Niño conditions, has seen an increasing trend, with more positive values since 1977. Positive values are associated with warmer surface water and weaker upwelling. Hence, this climate indicator would suggest a relative decrease in productivity of the CCE since 1977. The NPGO index is a low-frequency signal of the sea surface heights over the NE Pacific, and has been linked to salinity and Chl-a within the CCE (Di Lorenzo et al. 2008). Since 1975, the NPGO has seen more extreme and/or longer duration events than previously (CCIEA 2012). Thus chl-a and salinity within the CCE may also be experiencing heightened extremes and durations of those extremes. The PDO is a low frequency signal of SST across the North Pacific that has been related to biological productivity (Mantua et al. 1997). The PDO has also seen a change since 1977, with generally more positive (indicative of warmer SSTs and hence likely lower productivity) values since that time (CCIEA 2012). However, over the past seven years, the PDO has declined (albeit with a sharp increase in 2010), thus possibly indicating higher productivity over this shorter time span.

These changes in upwelling and major climate patterns result in changes to the phenology of physical and biological events within the CCE. This is in addition to the above-described change in upwelling intensification. Recent trends over the past five years indicate an earlier timing to the start of upwelling in the south, and a later start to upwelling in the north (CCIEA 2012), with an earlier start of upwelling likely leading to higher integrated productivity. In any case, changes in the timing of upwelling may result in match-mismatch between predators and their prey, if those timings are somewhat uncoupled (e.g. salmon entering the ocean may have a different timing set by terrestrial forcing, as opposed to the timing of upwelling initiation). Changes in the timing of upwelling will also likely have impacts all the way up the food chain to the top-level predators and consumers, since it is the timing and strength of upwelling that primarily controls primary productivity of the CCE, and thereby overall productivity. However, the exact nature of how upwelling phenology may change is not clear, as it is affected by many factors, such as wind patterns, SST, mixing, stratification, circulation, etc., and may vary by region. These physical factors, SST, mixing, wind, etc., are in turn controlled by interrelated large-scale patterns – which are undergoing both long-term changes, and changes in their strength and variability as described above – therefore further complicating prediction of ecosystem response. An important secondary effect of changes in upwelling strength and phenology are potential changes in upper ocean pH. As described above, upwelled water may act to further decrease the surface ocean pH. Thus, changes in upwelling phenology are also likely to change seasonal and long-term patterns of ocean pH.

Point Reyes (CA) National Seashore. Photo credit: U.S. National Park Service

4.6 Sources for Chapter 4

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5 PFMC Policy Priorities for Ocean Resource Management

The purpose of this chapter is to provide non-Council entities with information on some of the Council's highest priority concerns for non-fishing activities within the West Coast EEZ. It is current as of April 2013, may be modified at any time after that, and must be considered within the larger suite of Council management programs and documents. This chapter discusses species, habitat types, fisheries, and ecological functions of particular concern to, or that may strongly drive, the Council's policies for CCE resources. Unlike Chapters 2 and 4, the purpose of Chapter 5 would not be to guide future Council work, but to provide external entities with guidance on Council priorities for the CCE's status and functions. External entities that may be interested in the Council's ecosystem-based management planning process and in the Council's cumulative management priorities may include Federal or state agencies conducting activities within the CCE, marine use planning bodies such as the National Ocean Council or West Coast Governors' Alliance on Ocean Health, and international fishery and ocean resource management bodies.

The Pacific Council is one of eight regional fishery management councils authorized by the MSA and is responsible for the management of fisheries of the living marine resources of the U.S. EEZ (3-200 nm) off the coasts of Washington, Oregon, and California. In addition to having management responsibility for 100+ species of fish and their associated fisheries of the U.S. West Coast EEZ, the Pacific Council is responsible for reviewing non-fishing activities that may affect EFH for Council-managed species. Cumulatively, EFH for Council-managed species extends throughout the U.S. West Coast EEZ, and inshore of the EEZ to encompass salmon rivers as far east as Idaho. Council priorities for its managed species may be found within its four FMPs. In general, the Council is interested in and may have concerns with any projects that have potential adverse effects on living marine resources, the biological diversity of marine life, the functional integrity of the marine ecosystem, or to important marine habitat or associated biological communities.

5.1 Species of Particular Interest to the Council

The Council has jurisdiction over fish, which the MSA defines as "finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds." NOAA and the USFWS administer recovery programs for all marine and anadromous species listed as threatened or endangered under the ESA, and administer protection programs for marine mammals under the MMPA. The USFWS manages protection programs for bird species, including seabirds, under the MBTA. The Council is concerned with the potential effects of non-fishing activities that could directly or indirectly harm or kill any of its managed species at any of their life stages, which are identified and discussed in detail in the FMPs. There are, however, some species and species groups that are likely to be more vulnerable to the effects of non-fishing activities on their life cycles and habitats.

5.1.1 Anadromous Species

Among species within Council FMPs, salmon are unique in that they are obligated to spend the spawning, incubation, juvenile, and a portion of both juvenile migration and adult-spawning migration stages of their lives in fresh water. Thus, the survival of individual populations and stocks of salmon are dependent on not only responsible fisheries management practices, but also on conservation of water quality and quantity for each spawning and rearing tributary, and on land-based activities taking into account the unique challenges and life cycles of salmonid species within each tributary.

Pink and chinook salmon in Elwha River. Photo credit: NOAA.

NOAA and the USFWS work with the states, tribes, municipalities, and private entities to develop recovery plans for salmon species listed under the ESA. Each of these recovery plans is intended to take into account the unique needs of particular runs of salmon within the geographic areas addressed by the plans. Recovery efforts for threatened and endangered West Coast salmon runs guide how and where non-fishing activities may affect salmon populations, and how those activities might be required to mitigate for their effects. For non-fishing activities that may take place within the West Coast EEZ, the Council would be particularly concerned with those activities that:

- May block, through physical, chemical, or other means, salmonid access to or from the entryways (mouths) of their tributary rivers;
- Physically harm or directly kill salmon through entrainment in man-made devices;
- Physically or otherwise alter EFH for anadomous species in a way that reduces the functionality of that habitat;
- Reduce the availability of salmon prey species through removal by physical, chemical, or other means;
- Serve to alter, through auditory herding or other means, migratory paths of either the anadromous species or their predators such that predators have increased access to wild salmonid populations;
- Introduce non-native species that would compete with, prey upon, have the potential to introduce diseases to, or which could alter the genetic composition of native salmonids; or
- Have the effect of concentrating wild stock parasites or diseases.

5.1.2 Species protected through an overfished species rebuilding program

The MSA requires that fishery management councils identify species that are overfished, prevent overfishing, and rebuild those stocks that have been identified as overfished. Since 1998, the Pacific Council has developed and implemented rebuilding plans for several of its managed species. Most of the species protected through overfished species rebuilding programs are long-lived, slow-to-mature rockfish species. Thus, although these species are successfully rebuilding, the life-history characteristics of several rebuilding species prevent swift recovery even when directed fishing for those species is prohibited. For example, target rebuilding years for cowcod and yelloweye rockfish under prohibitions on directed take are 2068 and 2074, respectively (50 CFR 660.40).

For species with solely marine lifecycles (i.e. not anadromous), the Council's rebuilding programs focus on minimizing or eliminating directed catch and minimizing opportunities for incidental catch. Therefore, the Council would be particularly concerned with non-fishing activities taking place within the West Coast

EEZ or within rebuilding species EFH that might jeopardize the ability of managed species to rebuild to their optimum population levels, such as activities that:

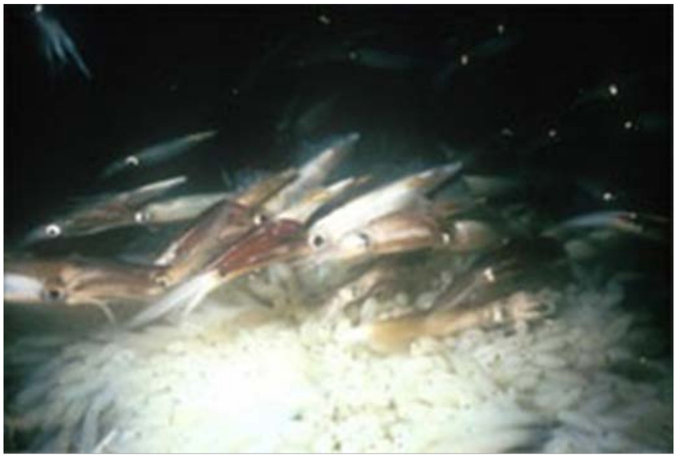
Yelloweye rockfish. Photo credit: NOAA.

- Physically harm or directly kill rebuilding species through entrainment in man-made devices;
- Physically or otherwise alter EFH for rebuilding species in a way that reduces the functionality of that habitat;
- Reduce the availability of the prey of rebuilding species through removal by physical, chemical, or other means;
- Serve to alter, through auditory herding or other means, migratory paths of rebuilding species' predators, such that predators have increased access to rebuilding species' populations;
- Disaggregate or otherwise disrupt rebuilding species during their spawning, parturition, or larval-settling seasons; or
- Introduce non-native species that would compete with, prey upon, have the potential to introduce diseases to, or which could alter the genetic composition of native species

5.1.3 Species dependent upon a fixed habitat type

The Council's FMPs define EFH for managed species. Some species have wide-ranging habitat, while others are dependent on fixed habitat types. Species dependent upon fixed habitat types may range in type from site-loyal rockfish species that, as adults, exist only in particular depth ranges on rocky habitats, to species that are pelagic as adults but which require fixed habitat for spawning, to species that can only exist within a particular seawater temperature range.

For species that are dependent upon a fixed habitat type, the Council would be particularly concerned with non-fishing activities taking place within the West Coast EEZ or within species-specific EFH that might jeopardize the ability of managed species to use that habitat for spawning, feeding, breeding, or growth to maturity. Discussions of non-fishing activities that may affect managed species' EFH may be found within the Council's FMPs, and the potential for those activities to affect EFH is not repeated here.



Market squid and their egg cases affixed to the ocean floor. Photo credit: NOAA.

5.1.4 Species and locations with tribal treaty rights to fishing

As discussed in Sections 3.5.2 and 3.5.3, there are numerous western Treaty Tribes that co-manage a variety of fish species and marine areas with the West Coast states and the U.S. government, and which participate in Council management processes. Fishing rights for Treaty Tribes are connected with the U&A fishing areas of those tribes, meaning that an action that affects the status of a managed species that occurs within a particular tribe's U&A fishing area must be assessed not just for its effects on the status of the species and its habitat as a whole, *but also for its effects on the availability of that resource to tribal fisheries within the particular U&A fishing area.* For example, a non-fishing activity that does not affect the overall status of the West Coast sablefish stock, but which could reduce the sablefish available for harvest off the northern Washington coast, would be subject to additional scrutiny for its effects on tribal treaty rights. Council-managed species that are also caught in tribal treaty fisheries include salmon, Pacific halibut, and groundfish occurring off the northern Washington coast. California tribal fishing rights are associated with Klamath basin salmonids. For tribal treaty species, the Council would have the same concerns as those discussed in Sections 5.1.1 and 5.1.2 under the types of non-fishing activities with the potential to affect salmon and species managed under rebuilding plans, but with particular focus on effects that might occur within tribal U&A fishing areas.

Makah tribal member Jongi Claplanhoo works on his family's boat at Neah Bay, WA. Photo credit: Debbie Ross-Preston, NWIFC

5.1.5 Internationally-managed species

As discussed in Section 3.5.4, several Council-managed species range across the U.S. EEZ boundaries into the EEZs of other nations, or into international waters. Non-fishing activities that may affect the status of internationally-managed stocks could disrupt the nation's participation within a variety of international forums. In addition to salmon, which is discussed as a species group of Council interest in Section 5.1.1, the Council would be particularly concerned with non-fishing activities taking place within the West Coast EEZ or within managed species EFH that might affect the status of Pacific halibut, Pacific whiting, and HMS. For internationally-managed species, the Council would have the same concerns as those discussed in Section 5.1.2 under the types of non-fishing activities with the potential to affect species managed under rebuilding plans.

5.2 Fish Habitat

Under the MSA, fishery management councils must describe and identify EFH for managed species. With regard to non-fishing activities that may affect EFH, the Council may comment on activities that may affect fishery resources under its authority, and shall comment on activities that may affect EFH of anadromous species, such as salmon. The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" 16 U.S.C. §1802. That definition, in combination with the diverse life histories of the 100+ species under Council management, has necessarily resulted in a large geographic area defined as EFH for the cumulative group of Council-managed species. As discussed in Section 5.1.3, the Council is concerned with non-fishing activities that may affect species with strong linkages to and dependency upon fixed or particular habitat. Similarly, the Council would be concerned with non-fishing activities that have the potential to affect managed species, habitat that is itself vulnerable to long-term alteration. Each of the Council's FMPs, their EFH appendices, and applicable NEPA analyses should be consulted for assessments of the types of human activities expected to have a potential negative effect on EFH for Council-managed species. While all fish habitat is of interest to the Council, some habitat types, the habitat needs of some species, and some types of habitat disturbance are of particular concern to the Council for their effects on the ecosystem as a whole, such as activities that:

Brownsville Dam Removal, Oregon. Photo credit: NOAA

- Disturb or kill structure-forming invertebrates or vegetation in a manner that either prevents those species from recovering within the affected area within their mean generation times, or which reduces the known distribution of those species;
- Alter the geological structure of the habitat such that the habitat cannot maintain or recover its functionality unaided;
- Alter the chemical composition, turbidity, or temperature of the seawater such that the habitat cannot recover to its pre-disturbance state – see also Section 4.5.

5.3 Fisheries

The Council manages the West Coast fisheries for species within its four FMPs: CPS, groundfish, HMS, and salmon. However, participants in the Council process also participate in state, tribal, and international management processes for West Coast species outside of the FMPs. Therefore, while the Council is particularly interested in non-fishing activities that may disturb or prevent fishing activities of Council-managed fisheries, Council process participants are also concerned with non-fishing activities that may

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affect all fishing opportunities for West Coast fishing communities. Some fishing communities and fishing types may be more vulnerable to disturbance by non-fishing activities than others, as detailed below.

5.3.1 Communities with a Dependency on Fishery Resources

Norman and colleagues (2007) provided summary descriptions of communities that, for West Coast and Alaska fisheries, meet the MSA's definition of a fishing community: "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and U.S. fish processors that are based in such community" (16 U.S.C. §1802). West Coast fishing communities vary in their levels of involvement in fisheries and dependency on fishery resources (Sepez et al. 2007). The Council is charged with not discriminating between residents of different States (16 USC §1851); therefore, it would be concerned with non-fishing activities that disproportionately affect fisheries access to fishery resources in a particular community or geographic area, and with activities that may have more broad-scale effects. Activities of potential concern to the Council include those that:

- Directly take or otherwise deplete local populations of marine species;
- Block or significantly revise (whether temporarily or permanently) physical access between a fishing community and the marine fishing grounds its vessels commonly use;
- Increase pollutant loads in the habitats of managed species such that those pollutants may bioaccumulate in the flesh of targeted species;
- Increase the hazards to navigation for vessels; or
- Have not undergone local consultation with the affected communities before implementation.

Port of Newport, OR. Photo credit: ODFW

5.3.2 Tribal Fishing Communities

As discussed in Section 5.1.4, the fisheries of western treaty tribes are geographically constrained to their U&A fishing areas. As a result, non-fishing activities under consideration for development within a U&A fishing area must be considered for their potential effects on local access to CCE marine resources. Changes in the accessibility of fishery resources to treaty tribes, whether due to ecosystem processes or management policy, have the potential to profoundly affect treaty Indian communities. Fishery resources not only fuel local economies, but also provide a significant portion of treaty tribal members' diets, and are deeply entwined in tribal culture and identity. If an activity affects local access to fishery resources, tribal fleets cannot follow fishery resources beyond U&A boundaries. If changes are extreme, such as with total loss of access to traditional tribal resources, tribal communities would be forced to make revolutionary changes in fishing strategies, dietary habits, and cultural ties. In recent years, treaty tribes that participate in the Council process have joined with U.S. Indian Tribes across the nation to strategize on tribal response and adaptation to climate change, including addressing shifts to or loss of fishery resources (e.g. ICCWG 2009, Swinomish 2010).

In addition to maintaining local access to fishery resources, treaty tribes are concerned with activities that may increase pollutant loads within the flesh (bioaccumulation) of species targeted by tribal fisheries (Kann et al. 2010). In 2011, the U.S. EPA approved new and stricter water quality standards for Oregon, influenced in part by fish consumption surveys of Oregon and Washington tribes. The State of Oregon found the fish consumption survey conducted by the Columbia River Inter-tribal Fish Commission (CRITFC 1994) to be particularly relevant to Oregon fish consumers generally, recognizing that both tribal and non-tribal Oregonians are likely to consume more fish annually than members of the U.S. population at large (ORDEQ 2008).

AJ Webster, Yurok Tribe/staff, surveying for instream restoration project, Lower Klamath River, CA.
Photo credit: Yurok Tribe

5.3.3 Brief Duration Fisheries

Brief duration or derby fisheries occur in situations where harvest levels are low relative to effort levels or fleet capacity. This situation is often exacerbated by reduced seasons, quotas, or harvest guidelines when the abundance of a particular stock declines, resulting in a limited harvestable surplus. Historically, commercial and recreational fisheries for Pacific halibut and salmon, as well as commercial fisheries for

Pacific sardine, have periodically experienced reduced harvest opportunities resulting in brief duration fisheries.

Brief duration fisheries often create an economic incentive to participate in a fishery during a narrow and inflexible period of time. The Council generally tries to minimize the occurrence of derby fisheries through license limitation and rationalization programs. Derby fisheries present several challenges, including the possibility that participants will need to fish during unfavorable weather conditions, fishing effort levels, and/or market conditions. However, brief duration fishing opportunities can represent a substantial portion of a fisherman's income, and additional challenges from poorly-timed non-fishing activities could be devastating if they limit or curtail a vessel's participation at a critical time. Non-fishing activities that could adversely affect a fishing vessel's participation in a fishery include, but are not limited to, port facility construction or improvement projects, interruptions to necessary supplies (fuel, ice, etc.), and dredging or jetty operations that impede bar crossings.

5.3.4 Location-Constrained Fisheries

Fisheries can be constrained to a limited geographic area due to regulatory restriction (fishery or non-fishery) or due to the biology and/or distribution of the target stock. West Coast groundfish fisheries are often limited to particular depth zones to avoid interactions with overfished species, which at times can force boats to concentrate in near-shore waters or require transit to waters of greater depth. Salmon fisheries often target a particular species or run by fishing in areas near river mouths or in specific depths. Fisheries for Pacific halibut and groundfish can tend to concentrate on areas with benthic structure, such as banks and reefs. Fisheries for CPS, particularly market squid and to a lesser extent Pacific sardine, often rely on aggregations of individuals in areas of favorable temperature, food sources, or spawning habitat.

Location-constrained fisheries can be particularly vulnerable to non-fishery ocean uses that also require specific locations (aquaculture facilities, marine protected areas, offshore energy development, military operations, undersea cable placement, etc.). The Council would be concerned with non-fishing activities that would restrict or displace fishing opportunities that are place-based and therefore difficult to relocate. The Council regularly engages in ocean zoning matters and participates in regional and national coordination efforts such as the WCGA and other coastal marine spatial planning initiatives. The Council is interested in coordinated spatial planning efforts as a means of considering non-fishing marine activities while preserving fishing opportunities and protecting areas that are critical to location-constrained fisheries.

Market squid boats in Monterey Bay, CA. Photo credit: Deb Wilson-Vandenberg CDFW

5.4 Ecosystem Structure and Function

Ecosystems are in a constant state of change, and an ecosystem's structure and function will change over time regardless of the level of human intervention with that ecosystem. However, there will be some human activities that have immediate and obvious effects on an ecosystem's structure and function, such as a large-scale oil spill. And, there will be some human activities that have had, and may continue to have, increasing effects on an ecosystem's structure and function over time, such as anthropogenic sound in the oceans.

Fishing, by its nature, alters the structure and function of the ecosystem. In the U.S., however, the MSA requires fishing to be managed so 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." (16 U.S.C. §1802). The MSA's forward-looking requirement that we manage fisheries so as to ensure their continuing use by future generations is in keeping with worldwide efforts to characterize sustainable human use of the environment.

The U.N.'s Convention on Biological Diversity specifies that a target of an ecosystem approach to managing human interactions with natural resources is "conservation of ecosystem structure and function should be conserved to maintain ecosystem services" (COP 5 2000). The ecosystem service that most concerns the Council is fishing – in other words, the ability of the CCE to support, on an ongoing basis, sustainable fisheries that provide food and recreation to the nation's human population. While the Council is charged with ensuring that fishing itself is sustainable, it is also concerned with non-fishing activities that may jeopardize the roles of fish, animals, and plants within the CCE, and their dynamic relationships to each other and to humans.

While the Council recognizes that not all human activities within the marine environment are governed by laws that require management to ensure use of the environment by future generations, this is the standard that the Council holds for non-fishing activities that may affect Council-managed species. Therefore, the Council would be concerned with any non-fishing activities that have the potential to jeopardize the Council's short- or long-term ability to manage West Coast fisheries so as to provide food and recreation to this and future generations of Americans.

Young Californians at Berkeley Pier. Photo credit: CDFW

5.5 Sources for Chapter 5

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Washington coast. Photo credit: NOAA

6 Bringing Cross-FMP and Ecosystem Science into the Council Process

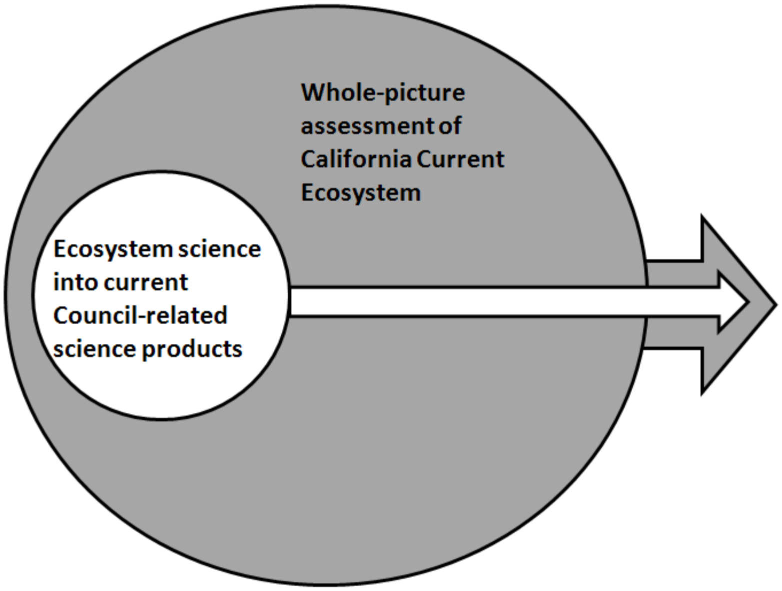

Figure 6.1: Two-part process to bring ecosystem science to the Council

Incorporating ecosystem science into the Council process will be 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. Throughout the development period for this FEP, the Council and its advisory bodies have discussed the type of scientific information and analyses needed to bring more ecosystem considerations into Council decision-making.

The November 2012 draft version of the FEP included recommendations for ecosystem science that could be conducted to support cross-FMP understanding of the CCE, and to improve ecosystem information available to decision-makers considering issues relevant to particular FMPs. At its November 2012 meeting, the Council moved the ecosystem science recommendations from the draft FEP into its draft 2013 Research and Data Needs document, which the Council finalized in March 2013. To address some of the major trends in scientific needs revealed during the FEP development process, the FEP appendix also includes several potential ecosystem initiatives directed at improving the ecosystem science available to Council decision-making.

As discussed in Chapter 1, the FEP's Ecosystem Initiatives Appendix proposes an ecosystem-based fishery management process through which the Council and its advisory bodies could analyze a variety of cross-FMP issues to bring a better understanding of the status and functions of the CCE into the Council's policy planning and decision-making processes. Each of the initiatives would require some background scientific work, although some of the initiatives are far more science-focused than policy-focused, including: an initiative on the potential long-term effects of Council harvest policies on age- and size-distribution in managed stocks, a bio-geographic region identification and assessment initiative, a cross-FMP socio-economic effects of fisheries management initiative, and an effects of climate shift initiative. With the exception of an initiative to prevent the future development of fisheries for currently unfished lower trophic level species, the Council has not yet determined whether it wishes to pursue any of the potential ecosystem-based management initiatives.

6.1 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. Simultaneous to the FEP development process, the Council's SSC has been considering a process to bring ecosystem considerations into stock assessments. 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' science centers and the SSC 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 Council stock assessments in a limited fashion and also in the North Pacific Fishery Management Council 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 affect 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.

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 assessments 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 assessments 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.

6.2 Annual Reports on Ecosystem Indicators

In November of 2012, the EPDT, in collaboration with the California Current IEA Team, provided the first iteration of a Report on the State of the CCE to the Council and its advisory bodies (Agenda Item K.3.a, Supplemental Attachment 1). This report was the result of an EPDT recommendation for bringing additional ecosystem information into the Council process, through the regular delivery of a synthesis of environmental, biological, and socio-economic conditions that may act as either drivers or indicators of impacts to the productivity, distribution, or socioeconomic conditions of managed fish populations and their associated fisheries. Based on the Council's recommendation, the report was limited to 20 pages in length, and recognized that several additional sources (many of which included greater technical details) on the state of the CCE are in existence, including: the CalCOFI State of the California Current report, PaCOOS quarterly summaries, and the emerging California Current IEA. The intent of the November 2012 Report was to focus on clear, straightforward explanations of the trends and indicators most relevant to Council-managed fisheries, particularly with respect to how and why such indicators were relevant to Council consideration.

The report included a relatively modest suite of some of the key physical and lower trophic level indicators commonly associated with changes in physical and biological conditions throughout the CCE over both broad (e.g., basin scale indices, such as the ENSO or the PDO) and more regional spatial scales (regional examples include upwelling indices, copepod biomass anomalies and relative abundance time series of CPS). Other indicators included status and trends for salmon and groundfish populations, trends in marine mammal populations, catch statistics for major West Coast fisheries, trends in fleet diversity, and a suite of additional indicators of human activities in the CCE (benthic structures, shipping activity, nutrient input to freshwater systems, offshore oil and gas activity). The overarching objective was to concisely synthesize a wide array of both natural and man-made processes that do or may have impacts (both positive and negative) on both the productivity of Council-managed resources and the socioeconomic well-being of the communities that depend upon them.

Although some of the selected indicators in the first report were more intuitive than others, and some that the EPDT or other advisory bodies had suggested for inclusion were not available for the first report, the report was generally well-received by advisory bodies and should serve as a template for future efforts. The Council and its advisory bodies also offered considerable advice for improving future reports, which should guide the development of and indicator choices for the March 2014 report called for in Section 1.4 of the FEP. As the SSC noted, “The report is an important first step in providing the Council family with an ecosystem perspective on West Coast fish stocks, fisheries, and coastal communities… The report will likely evolve over time, depending on which indicators are available and best suited to addressing ecosystem concerns identified by the Council” (Agenda Item K.3.c, Supplemental SSC Report). If the state of the ecosystem report becomes a routine product for informing the Council on CCE status and trends, it should help the Council improve its capabilities to bring ecosystem considerations into its decision-making processes.

Brian Wells, NOAA SWFSC, lowering CTD (Conductivity-Temperature-Depth) Sensor into Pacific Ocean.
Photo credit: NOAA/SWFSC