ECOSYSTEM WORKGROUP REPORT ON THE FISHERY ECOSYSTEM PLAN UPDATE

At the September 2020 meeting, the Pacific Fishery Management Council (Council) reviewed a first draft of the Fishery Ecosystem Plan's (FEP's) Chapter 3, an overview of the California Current Ecosystem (CCE). For this March 2021 meeting, the Council asked the Ecosystem Workgroup (EWG) to further update Chapter 3, and to provide a first draft of Chapter 4, *Environmental Change, Human Activities, and Social-Ecological Dynamics in the CCE*. The Council also asked the EWG to excerpt Chapter 5, *Council Policy Priorities for Ocean Resource Management*, from the FEP and submit it to this meeting as an outline for a stand-alone Council guidance document. An extended outline of that document is provided in EWG Report 2 for this agenda item.

The EWG held a public meeting on January 5, 2020, to discuss revisions to Chapters 3 and 4, and to receive public input on the revision process. In revising and updating Chapter 3 for this meeting, the EWG was not able to incorporate all of the September 2020 suggestions from the Council's advisory bodies, but we will continue to track and include those as we are able. To prevent potential confusion for readers of this report's draft Chapters 3 and 4, we note that:

- This version of Chapter 3 includes revisions suggested by the Groundfish Management Team (GMT) in September 2020, although we have largely re-drafted Section 3.4.2, *Current Fisheries*, including revising this section in keeping with suggestions from the GMT and the Coastal Pelagic Species Advisory Subpanel in September 2020. Chapter 3 also includes revisions provided by the Coastal Pelagic Species Management Team from their public meeting on February 2-4, 2021. Within the *Current Fisheries* section, we particularly anticipate having to revise the recreational fisheries section before the September 2021 meeting.
- Section 3.5, *Fishing Communities*, includes ideas suggested by the Ecosystem Advisory Subpanel, the Scientific and Statistical Committee, and by the suite of social scientists who consulted with the EWG at our September 2021 meeting.
- Chapter 4 was presented only in outline form in September 2020 and is entirely new for this meeting. While we continue to welcome comments on Chapter 3, we are now most in need of comments and guidance on the contents of Chapter 4.

For this March 2021 meeting, the EWG recommends that the Council:

- Review and provide guidance on the contents of Chapters 3 and 4;
- Review and provide guidance on the outline for the offshore activities guidance document provided as a draft in EWG Report 2 for this agenda item;
- Provide guidance on a final chapter for the FEP, tentatively titled, *Cross-FMP and Ecosystem Science in the Council Process*. The EWG will discuss this final chapter at its February 22-23, 2021 meeting, and intends to provide a supplemental briefing book report on an outline for that final chapter.

Pacific Coast Fishery Ecosystem Plan
Chapters 3 and 4
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Chapter 3 California Current Ecosystem Overview

While the CCE is considered one of the world's large marine ecosystems, it is also a social-ecological system that includes linkages and feedback between human and biophysical systems (Ostrom 2009; Duraiappah et al. 2014; Díaz et al. 2015; Levin et al. 2016, Figure 3-1). At its base, climate and ocean drivers such as ocean circulation, sea surface temperature, and upwelling patterns represent key influences in the CCE. Habitat occupies an intermediate tier where it translates effects of climate and ocean drivers on biota, and serves as the stage on which most ecosystem interactions occur. At the top level are specific focal components of ecological integrity such as seabirds, salmon, and diversity, which are either directly managed under Council FMPs, important indicators of the system (Foley et al. 2013), or both. Council-managed fisheries, and the human system more broadly, interact with and affect each of these tiers in different ways, not only as forces of change, but also as responsive members of a shared relationship that changes with the dynamics of the biophysical subsystem.

Like the biophysical environment, the human dimension of the CCE is comprised of multiple interrelated tiers (Figure 3-1). Human well-being (cf., Díaz et al. 2015) is mediated by broad social forces or drivers, local social systems, and human activities. Social drivers—such as population growth and settlement patterns, national and global economic and political systems, historical legacies, dominant cultural values, and class systems—constrain or enable local social systems and human activities in ways that directly or indirectly affect human well-being. Likewise, local social systems that vary geographically and across different social groups—such as state and local laws and policies, regional economies, local institutions and infrastructure, social networks and social hierarchies, diverse cultural values and knowledge, and more—affect human well-being directly or indirectly, and constrain or enable human activities related to the natural environment. These activities generate benefits for humans, and they are also ways by which humans affect the natural environment.

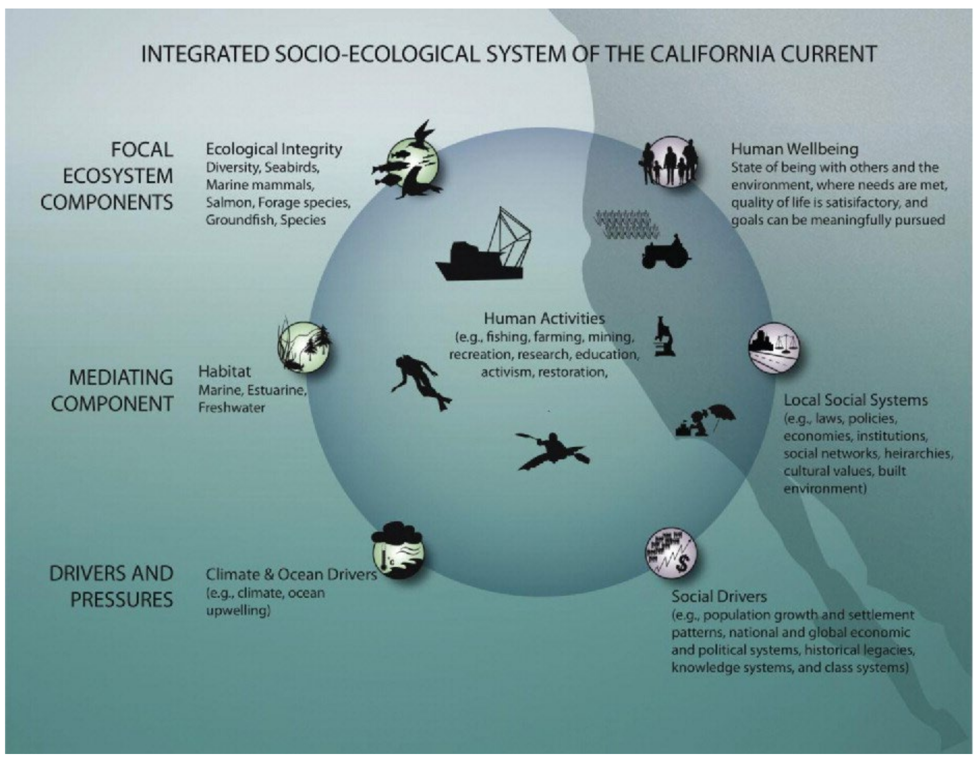

Figure 3-1. A conceptualization of the social-ecological system of the California Current showing broad biophysical and social drivers, the potential mediating effects of habitat and local social systems and the management endpoints of ecological integrity and human well-being. (From Levin et al. 2016).

In this chapter we describe the U.S. portion of the CCE as it relates to federally-managed fisheries, beginning with biogeographic subregions, associated oceanographic and geological features, biological components, and social and economic components of our particular social-ecological system.

3.1 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 California Peninsula.

Each of these three major CCE sub-regions experience 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 such as submarine ridges and canyons add to the distinct character of each sub-region. Similarly, in inland waters, physical forcing from the ocean drives biological processes in estuaries (Raimonet and Cloern 2016), and ocean conditions determine weather patterns that affect the hydrology of streams, rivers, and lakes far inland (DiLorenzo and Mantua 2016). Freshwater drivers also influence oceanographic processes, as river plumes transport sediment, nutrients, and pollutants onto the continental shelf (Hartwell 2008; Warrick and Farnsworth 2009; Checkley and Barth 2009, Kim et al. 2018). The complexities generated by interacting ocean and river currents concentrate resources, drawing pelagic predators (Brodeur and Morgan 2016; Phillips et al. 2017). These physical, hydrological, and oceanographic differences translate into differences in the ecosystem structure of each sub-region. 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 or to represent human communities-of-place (e.g., ports) and communities-of-practice (e.g., areas of the ocean used by fisheries) (St. Martin and Hall-Arber 2008, Zador et al. 2017). The portions of the three CCE sub-regions lying within the U.S. EEZ are discussed in more detail, below.

3.1.1 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. This area corresponds approximately to the "Northern California Current Ecosystem" sub-region reported in the annual Ecosystem Status Report to the Council (Harvey et al. 2020, Fig. 2.1c). 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 such as 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, Horner-Devine et al. 2009). 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 phytoplankton biomass concentrations. Banas et al. (2008) provides evidence that the high concentrations of phytoplankton biomass off Washington are due to the Columbia River plume.

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, at times contributing to harmful algal blooms (Giddings et al. 2014). 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).

The physical and biogeochemical dynamics of this sub-region are well-described by a Regional Ocean Modeling System (ROMS) framework developed by the University of Washington Coastal Modeling Group (UWCMG) (MacCready et al., 2009; Liu et al., 2009a, 2009b; Banas et al., 2009a, 2009b; Sutherland et al., 2011). Extensions of this model can provide seasonal forecasts of ocean conditions in this sub-region as well (Siedlecki et al. 2016). One of the most commonly used ROMS models for central California is a data-assimilative 10km x 10km historical model from 1980 - 2010 (Neveu et al. 2016). It has been paired with a real-time data-assimilative operational model for analyses since 2010 (Becker et al. 2016, Brodie et al. 2018) and for real-time nowcasts (Abrahms et al. 2019).

3.1.2 Central sub-region: Cape Blanco to Point Conception, CA

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, an area that corresponds approximately to the "Central California Current Ecosystem" sub-region reported in the annual Ecosystem Status Report to the Council (Harvey et al. 2020, Fig. 2.1c).

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-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.

3.1.3 Southern sub-region: Point Conception to U.S. - Mexico border

This approximately 236 mile long sub-region is substantially different from the north and central areas. The topography from Point Conception to the US-Mexico border 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, which corresponds approximately to the “Southern California Current Ecosystem” sub-region reported in the annual Ecosystem Status Report to the Council (Harvey et al. 2020, Fig. 2.1c), 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 seasonal 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 much of the year.

In contrast to the relatively contiguous continental shelf in the central sub-region, the offshore region from Port San Luis to the U.S. - Mexico border encompasses some of the most diverse basin and ridge undersea topography along the U.S. West Coast. Islands top many marine ridges (e.g., the Channel Islands) 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 that is very different from more northern sub-regions.

As 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 California Peninsula at Cabo San Lucas (U.S. GLOBEC 1994). In addition, a semi-permanent feature, the Ensenada Front spans the region near the U.S - Mexico border and can inhibit movement of marine organisms (Kahru et al. 2012, Moser and Smith 1993)

Like the northern sub-region, the Southern California Bight also has a highly functional 3-dimensional numerical hydrodynamic ROMS model (Shchepetkin & McWilliams 2005) that has been used to understand connectivity of populations along the coast to those offshore (e.g., Watson et al. 2010, 2011).

3.2 Oceanographic and Geological Features of the CCE

3.2.1 Oceanographic Features of the CCE

The CCE is comprised of a major eastern boundary current, the California Current which flows southward from approximately Vancouver Island to the Baja Peninsula (Checkley and Barth 2009, Bograd et al. 2016). The CCE is dominated by strong coastal upwelling particularly north of 36°N and is characterized by fluctuations in physical conditions and productivity over multiple time scales (Parrish et al. 1981, Mann and Lazier 1996, Checkley and Barth 2009, Bograd et al. 2009). Food webs in these types of ecosystems tend to be structured around coastal pelagic species that have historically exhibited 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 characterized by marine mammals and large bodied fish such as salmon, tuna, and billfish. Some of these predators are highly mobile, and thus their dynamics span multiple ecosystems and even ocean basins. Ecosystems analogous to the CCE include other eastern boundary current systems, such as the Humboldt Current off western coast of South America, the Benguela Current off sub-Saharan west Africa, and the Canary Current off Spain and northern west Africa (Freon et al. 2009).

The CCE is characterized by several distinct water masses including, but not limited to, the California Current (Figure 3-2). The California Current originates where the eastern-flowing west wind drift (or the North Pacific Current; NPC) collides with the North American continent. The NPC on average abuts land at the southern end of Vancouver Island (approximately 48.5°N), but the central point of contact ranges from southern Alaska to southern Oregon (Cummins and Freeland 2007). Upon colliding with the landmass, the NPC bifurcates into the southward-flowing California Current (shown in Figure 3-2) and the northward-flowing Alaska Current. The location of the bifurcation of the NPC is significant as there is a positive correlation between the latitude of bifurcation and nutrient load of the California Current (Sydeman et al. 2011). The California Current transports fresh, cold, oxygenated and nutrient rich water equatorward and ranges from 50 to 500 km offshore (Mann and Lazier, 1996).

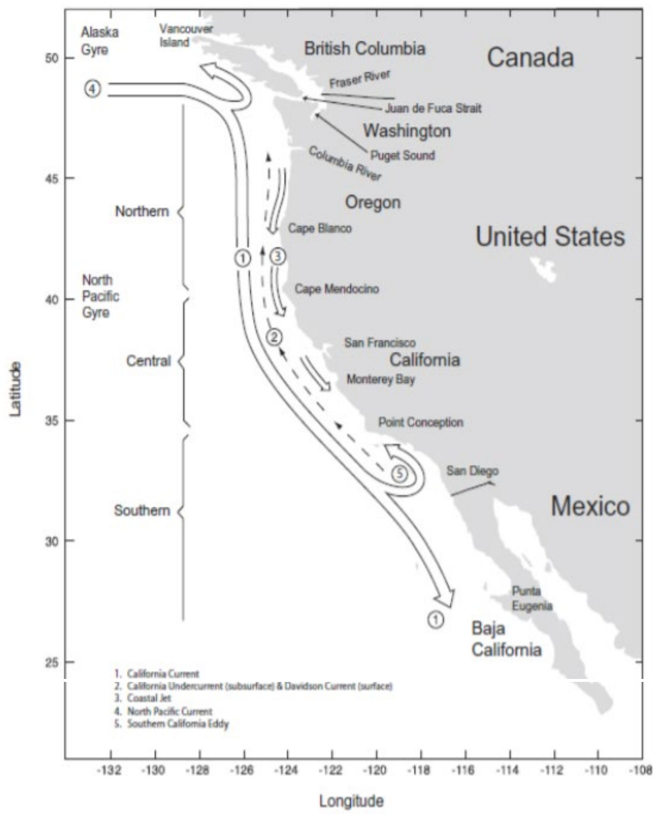

Figure 3-2. Current regime of the CCE.

The California Undercurrent (CUC) is another major water mass in the CCE. The CUC flows poleward over the continental shelf at depths of 150-300 m and is composed of Pacific Equatorial water, which is saline, warm, high in nutrients and low in oxygen (Checkley and Barth 2009). During the winter, the CUC merges with the seasonal, wind-driven, poleward-flowing, nearshore Davidson current such that the bulk of water over the continental shelf is moving north between fall and early spring. The CUC can transport Pacific Equatorial water as far north as southern Alaska (Thomson and Krassovski. 2010).

Wind-driven, coastal upwelled water is another important water mass in the CCE (Checkley and Barth 2009). Upwelling tends to be strongest in spring in the CCE and is fueled by northwesterly winds that cause Ekman transport of water offshore and upwelling nearshore. Upwelled water is typically cold, saline, nutrient-rich and deoxygenated. Upwelled waters in the CCE are highly productive, with upwelled nutrients driving the primary productivity that serves as the base of the food web. However, as this organic matter sinks into deeper water it is respired, consuming oxygen in the process, and in conjunction with climate change are leading to increasingly severe seasonal hypoxia in waters off OR and WA (Christian and Ono 2019 and references therein).

The degree of upwelling in the CCE is typically monitored through the use of an upwelling index - traditionally the Bakun upwelling index which estimates surface transport from pressure fields using the geostrophic wind approximation (Bakun 1973 and 1975, Mason and Bakun 1986, Schwing et al 1996. See also https://oceanview.pfeg.noaa.gov/products/upwelling/bakun). More recently the coastal upwelling transport index (CUTI) and the biologically effective upwelling transport index (BEUTI) have been used. These indexes use both ocean models, satellite and in situ data to improve upon the Bakun upwelling index, with CUTI providing an estimate of vertical transport near the coast and BEUTI providing an estimate of vertical nitrate flux, which is more relevant when considering biological responses (Jacox et al 2018. See also https://oceanview.pfeg.noaa.gov/products/upwelling/cutibeuti). These new upwelling indexes became part of the annual ecosystem status report for the CCE in 2019 (Harvey et al. 2019).

Coastal upwelling can also induce 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). Location of jets can be influenced by the coastal topography (capes, canyons, and offshore banks), particularly the large capes such as Cape Blanco, Cape Mendocino, Point Conception, and Punta Eugenia. 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). Central Pacific water, which is warm, moderately deoxygenated, moderately saline and nutrient poor, is located offshore of the California Current in the CCE. In the southern CCE, Central Pacific water regularly impinges upon the continental shelf during summer and fall and year-round in warm El Niño or Marine Heatwave years. For information on current MHWs in the CCE see https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker.

Freshwater input forms an important water mass in the northern CCE (Checkley and Barth 2009). The main sources of freshwater are the Columbia River and the Fraser River via the Strait of Juan de Fuca. Freshwater plumes are fresh, warm, and high in oxygen and nutrients that can be transported far from river mouths. In summer, freshwater typically moves south, while poleward transport tends to occur in winter. The nutrient-rich freshwater plumes provide important feeding grounds for marine organisms at multiple trophic levels. The spatial extent and temporal persistence of the various water masses in the CCE are highly dynamic. Changes in the size and duration of water masses affect marine organisms by redistributing populations that may reside exclusively within a particular water mass, and by fueling changes in overall population size. For example, upwelling of nutrient rich water can augment primary production, which then propagates up the food chain.

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 often include reduced upwelling winds, a deepening of the thermocline, intrusion of offshore (subtropical) waters, dramatic declines in primary and secondary production, poor recruitment, growth and survival of many resident species (particularly salmon and groundfish), and northward extensions in the range of many tropical species. In more recent years, ENSO events have been more variable with not every tropical ENSO having a CCE expression (Capotondi et al. 2015, Jacox et al. 2016) and recruitment of ecologically important species such as northern anchovy (Thompson et al. 2019) and rockfishes has been high (Schroeder et al. 2018).

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). An additional decadal scale driver of marine conditions within the CCE is the North Pacific Gyre Oscillation (NPGO) (Di Lorenzo et al. 2008). The NPGO is related to the sea surface height of the North Pacific Gyre and is driven by regional and basin scale variations in wind driven upwelling and horizontal advection. The NPGO has been found to be highly positively correlated with salinity, nitrate and chlorophyll-a and negatively correlated with oxygen variability. Occurring in less predictable cycles, marine heatwaves (MHWs) have emerged as a concern for resource managers. MHWs occur when ocean temperatures are much warmer than usual for an extended period of time (defined by NOAAs SWFSC as sea surface temperatures >1.29 standard deviations the norm), and the frequency of these conditions has increased in recent decades (Jacox et al. 2020).

3.2.2 Geological Features of the CCE

The CCE 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.

In general, the CCE has a relatively narrow shelf, steep slope, and wide abyssal plain. Some important geologic features are shown in Figure 3-3. 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 CCE north of the Southern 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, Point Conception and Punta Eugenia 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, submarine canyons, 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 the 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.

Figure 3-3. Induration in Northern CCE.

3.2.3 Habitat Classification

The oceanographic and geological features of the CCE greatly influence current and wave patterns and provide habitats that influence species distributions and productivity. Habitats are one of a variety of important ecological characteristics for managed fish species, and a common language by which to describe habitats and convey information about them is important for effective and efficient management. Previously, benthic habitats of the CCE were described using a classification scheme developed by Greene et al. (1999) for deep seafloor habitats, which organized them according to physical features in a hierarchical system of levels. In 2012, the Federal Geographic Data Committee (FGDC) endorsed the Coastal and Marine Ecological Classification Standard (CMECS), a structured catalog of ecological terms that provide a framework for interpreting, classifying, and inter-relating observational data with the goal of facilitating assessment, monitoring, protection, restoration, and management of biotic assemblages, harvested and protected species, vital habitats, and important ecosystem components (FGDC, 2012).

Figure 3-4. Benthic habitat in the CCE.

CMECS attempts to encompass all aspects of marine habitat, starting with the broadest and narrowing to the most specific using 6 elements – the biogeographic and aquatic settings, and the water column, biotic, substrate, and geoform components. The final product is a biotope that combines both biotic and abiotic features to create a unique combination of environmental variables that make up a particular habitat:

- Biogeographic setting – this setting identifies areas based on species aggregations and features influencing the distribution of organisms.
- Aquatic setting – CMECS classifies the coastal and marine environment in three systems: Marine, Estuarine, and Lacustrine (freshwater).
- The water column component describes the water column in terms of key features related to habitat, including features related vertical layering, temperature, salinity, and biogeochemistry.
- The geoform component describes the major geomorphic and structural characteristics of the coast and seafloor with descriptors for geologic, biogenic, and anthropogenic features.
- The substrate component describes the composition and size of sea floor materials.
- The biotic component classifies the composition of floating and suspended biota and the biological composition of the benthos.

The CMECS components can work independently or in combination with each other, as needed and available data permits.

At present, spatial high-resolution seafloor mapping is limited to particular areas of interest within the CCE, while much of the CCE is mapped or interpreted at relatively low resolution. Available data have been compiled into GIS maps to aid with management planning and essential fish habitat (EFH) designations/reviews, with some data available through online mapping tools. A basic CMECS habitat seabed induration map depicting hard, mixed and soft substrates (Figure 3.4, based on classification scheme by Green et al. 1999) was used during the most recent groundfish EFH review for the designation of EFH Conservation Areas (EFHCAs). This map (and source data) is available through the FRAM Data Warehouse (Figure 3-4; https://www.webapps.nwfsc.noaa.gov/data/map).

Subsequent to the recent groundfish EFHCA designations, and to better define future EFHCA designations, the treaty tribes of western Washington, in cooperation with NOAA (NMFS and the Olympic Coast National Marine Sanctuary) used CMECS as the first step towards developing a more comprehensive toolset for the analysis of marine habitats. They have compiled the geoform and substrate component data, and are in the process of developing the biotic and water column components (Figure 3-4; https://geo.nwifc.org/ocean/). This map illustrates some of the complexity of benthic habitats in the CCE from Cape Flattery, WA to Point Arena, CA.

3.3 Biological Components of the CCE

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.

3.3.1 Vegetation, Plants 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).

3.3.1.1 Phytoplankton and microalgal blooms

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. In addition, certain dinoflagellate species facilitate survival of first feeding larval anchovy, and may thus impact anchovy recruitment variability (Scura and Jerde 1977) 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.

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 and, depending on the dinoflagellate species, larval fish (Scura and Jerde 1977). 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.

3.3.1.2 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 of the United States. 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.

3.3.1.3 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 that 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*) also associate 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.

Kelp forests consist 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 by floats. In comparison with bull kelp forests, giant kelp forests are generally more dense, three-dimensionally structured and thus, support more diverse communities. 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 thrives in 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 and nutrient availability, 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 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.

In response to the cumulative impacts of environmental and ecological stressors, bull kelp forests along the Northern California and Southern Oregon coast have deteriorated dramatically since 2014. In 2013, mass mortalities of sea stars (many of which prey on urchins) were observed as a result of Sea Star

Wasting Syndrome (add citation). The following year began a period of warm water conditions as a result of a multi-year large scale marine heatwave (2014-2015) and a strong El Nino (2015-2016) (add citation). These conditions allowed for purple urchin populations to grow in numbers and outcompete other herbivores like abalone as they grazed aggressively on seaweeds. 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. These compounding factors have led to areas once dominated by productive kelp forests being lost.

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 effects 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.

3.3.1.4 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 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 also be 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 West Coast 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 et al. (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 (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.

3.3.2 Low Trophic Level Species

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
- Euphausiids (*Euphausiacea* spp.) – krill, relatively large, often swarm- or school-forming crustacean zooplankton that feed on both phytoplankton and 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.
-
- 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

A large portion of what are known as the "forage fish" of the CCE are small pelagic fish. 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).; 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, (larval fishes), 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 whiting, Pacific sardine, jack mackerel, and rockfish (shortbelly rockfish (*S. jordani*) and unidentified Sebastes, as most species are not identifiable to the species level). The 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).

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 augment 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 nutritious food source for larger organisms, with the exception of certain turtles that specialize on 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.

3.3.3 Mid- to High Trophic Level Fishes and Invertebrates [mostly FMP species]

Higher 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; groundfish, anadromous fishes (principally salmonids, but including sturgeon and other species as well), and highly migratory species (HMS). A large number of invertebrate species might also be included at mid- to high trophic levels. 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 intertidal ecosystems).

Other mid- to high- trophic level invertebrates are more conspicuous elements of the ecosystem, such as various large crab species (including Dungeness) and predatory squids. 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 and resultant prey communities in the CCE can drive poleward expansion of jumbo squid (*Dosidicus gigas*) into the CCE increasing the potential for high levels of squid predation on several fish species, potentially resulting in changes across trophic levels (Field et al. 2007, Stewart et al. 2012). 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) and the recent marine heatwave have brought desirable gamefish such as tunas and billfish farther north and inshore (MacCall 1996, Pearcy 2002, Sanford et al. 2019).

Groundfish 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*) and bocaccio (*S.*

paucispinis), 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. These fishes 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 omnivorous mid-trophic level predators that may be piscivorous at times but also feed on krill, gelatinous zooplankton, benthic invertebrates and other prey. Pacific whiting, the most abundant groundfish in the CCE, shows strong ontogeny in food habits, since younger, smaller whiting 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 whiting) as they reach 45-55 cm length, and are almost exclusively piscivorous by 70-80 cm.

Higher trophic level predators have the 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. Due to the adoption of rebuilding plans, many of the rockfish species have recovered in recent years.

The potential for intra-guild competition or top-down forcing, both in small-scale rocky reef systems and throughout the larger ecosystem, is also supported by theoretical considerations and simulation models. Baskett et al. (2006) developed a community interactions model that incorporated life history characteristics of pygmy (*S. wilsoni*) and yelloweye rockfish (*S. ruberrimus*) 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. 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. Under some circumstances (low piscivore biomass, or high planktivore biomass) recovery could be unlikely. Such results are consistent with similar simulations 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.

Ocean climate variability has an important influence on the recruitment, abundance, and distribution of groundfishes in the CCE (Tolimeri et al. 2018, Santora et al. 2017, Schroeder et al. 2018, Haltuch et al. 2019, Malick et al. 2020). Transport and source waters appear to be particularly important for the recruitment of young fishes to adult populations. For example, high abundances of pelagic juvenile rockfishes are associated with high transport of subarctic waters that are cool, fresh, and oxygen-rich. In contrast, low rockfish abundance is associated with higher transport of subtropical waters, which brings warmer, more saline, and more oxygen-deficient waters into the CCE (Schroeder et al. 2019).

Enhanced production of pelagic juvenile Pacific whiting and sanddabs is also related to high transport of subarctic waters and strong upwelling (Ralston et al. 2015, Sakuma et al. 2016), and variations in sablefish and petrale sole recruitment are strongly linked to oceanographic variables related to transport and temperature (Tolimeri et al 2018, Haltuch et al. 2020). In addition, ocean temperatures have been shown to affect the spatial distribution of groundfish in the CCE. For example, Malick et al. (2020) found that warmer than average subsurface temperatures are associated with higher biomass of adult Pacific whiting north of Vancouver Island, and lower biomass offshore of Washington and southern Vancouver Island. Cooler than average temperatures are associated with higher biomass of juvenile Pacific whiting coastwide.

Anadromous species 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. Over a dozen anadromous species are found in the CCE (Table 3-1). About half of these are protected under the Endangered Species Act. Salmon, eulachon, and sturgeon are of concern for Council-managed fisheries.

Table 3-1. Anadromous fish species found on the Pacific coast of the United States.

Scientific name	Common name
Entosphenus tridentatus	Pacific lamprey
*Acipenser medirostris**	Green sturgeon
Acipenser transmontanus	White sturgeon
Alosa sapidissima#	American shad
Oncorhynchus clarki clarki	Coastal cutthroat trout
Oncorhynchus gorbuscha	Pink salmon
*Oncorhynchus keta**	Chum salmon
*Oncorhynchus kisutch**	Coho salmon
*Oncorhynchus mykiss**	Steelhead trout
*Oncorhynchus nerka**	Sockeye salmon
*Oncorhynchus tshawytscha**	Chinook salmon
*Salvelinus confluentus**	Bull trout
*Hypomesus transpacificus**	Delta smelt
Spirinchus thaleichthys	Longfin smelt
*Thaleichthys pacificus**	Eulachon
Morone saxatilis#	Striped bass
Gasterosteus aculatus	Threespined stickleback

[*]At least some stocks listed under the Endangered Species Act – see Table 3-6.
[#]Introduced species

Bycatch in CCE fisheries is a concern for green sturgeon (*Acipenser medirostris*), white sturgeon (*A. transmontanus*), and eulachon (*Thaleichthys pacificus*). Green sturgeon are the most marine oriented of the West Coast sturgeons and disperse widely in estuarine and coastal waters (Moser et al. 2016). They are often found in non-natal estuaries in the CCE (Lindley et al. 2011; Schreier et al 2016) but spawn in the Rogue, Klamath, and Sacramento river systems, with a potential small spawning population in the Columbia River (Moser et al. 2016; Schreier et al. 2016; Schreier and Stevens 2020). The southern Distinct Population Segment of green sturgeon, which spawns in the Sacramento River, are listed as threatened (71 FR 17757, April 7, 2006) under the Endangered Species Act (ESA). Sturgeon from the Southern DPS may disperse to estuaries on the Washington and Oregon coasts (Lindley et al. 2011; Schreier et al. 2016). They are regularly reported as bycatch in coastal gillnet and trawl fisheries, including the California Halibut (*Paralichthys californicus*) fishery (Moser et al. 2016; Heublein et al. 2017). White sturgeon most often use rivers and estuaries but occasionally may make long-distance marine movements (Heublein et al. 2017) and hence be subject to similar hazards. Eulachon in the CCE were listed as Threatened in 2010 (Gustafson et al. 2012) and are distributed from northern California northward, with the largest spawning run in the Columbia River (Willson et al 2006). Eulachon often occur in mixed-species schools with herring and anchovy (Willson et al 2006) and are subject to by-catch in ocean shrimp trawl fisheries (Gustafson et al 2012; Hannah et al 2015).

Salmon have long been a mainstay of CCE fisheries. Chinook and coho salmon (*O. tshawytscha* and *O. kisutch*) are the most widely distributed in the CCE and are the commercially viable species in the CCE. The saltwater ecosystems off central California are generally the southernmost marine habitat occupied by these two species. Chinook and coho stocks from the West Coast tend to be distributed on the continental shelf with 200-400 km of their origin, although portions of any population may disperse farther (Beamish et al. 2018; Riddell et al. 2018). West Coast stocks of these two species tend to use certain portions of the ocean with consistent timing (e.g., Shelton et al 2019). Most Chinook caught in CCE fisheries are from ocean-type populations; stream-type Chinook from the Columbia River usually migrate northward on the continental shelf to the Gulf of Alaska (Riddell et al. 2018). Chum, sockeye, and pink salmon (*O. keta, O. nerka,* and *O. gorbuscha*) historically had spawning runs in rivers in California but regular spawning runs for these species currently occur north from the northern Oregon coast, Columbia River, and Olympic Peninsula, respectively. Several salmon stocks are listed under the ESA or considered overfished by the PFMC; consequently, many West Coast salmon fisheries are supported by hatcheries.

Marine survival in CCE salmon populations is typically determined during the first year at sea. Abundances of adjacent salmon stocks often fluctuate together, with no evidence of covariation between stocks of distant regions, suggesting regional environmental processes affect temporal variation in survival rates (Pyper et al. 2001). Correlative studies have established links to large-scale ocean conditions but havenot elucidated mechanisms (e.g., Logerwell et al. 2003; Scheuerell and Williams 2005; Dorner et al. 2018; Henderson et al 2019). Results of correlative studies like these have led to the concept of cool and warm phases in the CCE with associated ecosystem shifts that affect post-smolt survival (Mantua et al. 1997; Bi et al. 2011). In particular, the presence of lipid-rich northern copepods appears to be important to recruitment, although coho and Chinook do not feed on them directly (Beamish et al. 2018). Observations from studies like these have led to investigations seeking to mechanistically link oceanographic and biological metrics to salmon recruitment, with an eye toward improved forecasting and management of salmon fisheries especially in relation to environmental thresholds (e.g., Peterson et al. 2019; Satterthwaite et al. 2020).

Much recent work on salmon ocean ecology in the CCE has focused on predation, diet, and growth. Beamish and Mahnken (2001) proposed the ‘critical size, critical period’ hypothesis in which salmon productivity is a function of early natural marine mortality, 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. Support has been found for both parts of this hypothesis, although not always (e.g., Beacham et al. 2017). In some cases, predation soon after ocean entry was influential (e.g., Wells et al. 2017; Friedman et al. 2019). Interestingly, in some cases, predation at later stages had important effects (Chasco et al. 2017; Seitz et al. 2019). Diet composition during the first ocean year has also been related to eventual adult returns (Hertz et al. 2016; Dale et al. 2016). In other cases, growth was important (e.g., Tomaro et al. 2012; Miller et al. 2014) but the effects of growth on survival and recruitment are not always straightforward (e.g., Miller et al. 2013). For example, young salmon require more resources during warm years, which can lead to lower survival despite high consumption rates (Daly and Brodeur 2015). Studies such as these will be important to understand the effects that ecosystem changes have on CCE salmon stocks now and in the future.

HMS include billfish (such as sailfish, marlin, and swordfish), tunas, oceanic sharks, and a variety of (generally southern) large coastal piscivores (Table 3-2). HMS are 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 principal 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).

Table 3-2. Species in the HMS FMP.

Group	Common Name	Species	FMP Management Unit Species	FMP Ecosystem Component Species
Tunas	North Pacific albacore	*Thunnus alalunga*	X	
	Yellowfin tuna	*Thunnus albacares*	X	
	Bigeye tuna	*Thunnus obesus*		
	Skipjack tuna	*Katsuwonus pelamis*		
	Pacific bluefin tuna	*Thunnus orientalis*		
Sharks	Common thresher shark	*Alopias vulpinus*	X	
	Shortfin mako or bonito shark	*Isurus oxyrinchus*	X	
	Blue shark	*Prionace glauca*	X	
	Soupfin shark	*Galeorhinus galeus*		
	Salmon shark	*Lamna ditropis*		
	Great white shark	*Carcharodon carcharias*		
	Basking shark	*Cetorhinus maximus*		
	Sleeper shark	*Squaliformes spp.*		
	Bigeye thresher shark	*Alopias superciliosus*		X
	Pelagic thresher shark	*Alopias pelagicus*		X
	Mega mouth shark	*Megachasma pelagio*		
Billfish	Striped marlin	*Tetrapturus audax*	X	
	Swordfish	*Xiphias gladius*	X	
Other	black seabass	*Centropristis striata*		
	white seabass	*Atractoscion nobilis*		
	Yellowtail	*Seriola lalandi*		
	Dorado or dolphinfish	*Coryphaena hippurus*	X	
	Common mola	*Mola mola*		X
	Escolar	*Lepidocybium flavobrunneum*		X
	Lancetfishes	*Alepisauridae spp.*		X
	Louvar	*Luvarus imperialis*		X
	Pelagic sting ray	*Dasyetis violacea*		X
	Wahoo	*Acathocybium solandri*		X
	Opah	*Lampris sp.*		

CCE predators, including HMS, have been found to consume multiple forage fish and forage fish prey (Koehn et al. 2016). Variability in prey, has implications for how energy flows through the CCE food web, as well as the foraging costs and net energy gain of HMS which migrate long distances to reach the CCE (Childers et al. 2011; Fujioka et al. 2018). For example, by switching between coastal and offshore-associated prey species, albacore may exert spatiotemporally variable predation pressure on forage species, with implications for the CCE pelagic food web (Wade et al. 2007; Glaser 2010; 2011). These trophic links are likely to be highly dynamic especially for HMS. Therefore 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. As suggested by Muhling et al (2019), a better understanding of spatiotemporal overlap and trophodynamics of predators and prey is required in the CCE to achieve EBFM.

Although generalized to the entire North Pacific, Sibert et al. (2006) noted that increases in the biomass of some HMS 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 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. In addition, management of HMS directed fisheries 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.

3.3.4 High Trophic Non-fish Species: Mammals, Birds, and Reptiles of the CCE

Marine mammals, seabirds, and marine reptiles of the CCE serve as mid- to high trophic level predators in the California Current, some of which are protected species under the Marine Mammal Protection Act or Endangered Species Act. Many are recovering from past exploitation (e.g. sea lions) yet others still face cumulative threats that have limited their recovery or contributed to their decline (e.g. Southern Resident Killer Whales). Many 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). Top predators that do breed in the CCE, such as sea lions (*Otariinae* spp.) and elephant seals (*Mirounga angustirostris*), often migrate or forage far from their breeding grounds seasonally, although some 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 migration within, to and from the CCE.

Seasonal patterns in coastal upwelling and relaxation serve as one of the greatest drivers of migrations and variable distributions in the CCE, although inter-annual and decadal climate variability also shapes the distribution and abundance of many of these higher trophic level species. Recent anomalous events have led to increased presence of warm water species sighted in the California Current (Sanford et al. 2019, Becker et al. 2019?) but also unusual mortality events of California sea lions, Guadalupe fur seals, and large whales (16 U.S.C. §1421c). Modeling efforts have also explored the response of marine mammals and seabirds to warm water or upwelling anomalies (Sydeman et al. 2009 - common murres), predicted effects of climate change on TOPP species over the next century (Hazen et al. 2013), and the increased risk from changes in human activities and range shifts such as for humpback and blue whales (Abrahms et al. 2019, Santora et al. 2020). Many of these top predators may be able to provide insight on ecosystem status when oceanographic or forage measurements are unavailable, with a few CCE species suggested as climate and ecosystem sentinels (Hazen et al. 2019).

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 for generalists their 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, Maxwell et al. 2015). NMFS includes seabird indicators in the annual ESR, particularly noting large-scale wrecks (die-offs) of bird species that have been associated with the marine heat wave of 2014-15 and other warming anomalies in more recent years (e.g. Garfield and Harvey, eds. 2016).

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). This closure has shown to be in the right place and at the right time to minimize bycatch risk of Leatherback sea turtles (Eguchi et al. 2017), but changing such closed areas annually if not more frequently could increase opportunity while still maintaining conservation goals (Hazen et al. 2018). Similarly, a loggerhead closure has been enacted during "El Nino-like conditions" in the Southern California Bight with recent indicators developed to provide more explicit advice to management (50 CFR 660.713(c)(2), Welch et al. 2019 - https://coastwatch.pfeg.noaa.gov/loggerheads/). Within the U.S. portion of the CCE, turtle conservation efforts prioritize minimizing turtle-fisheries interactions. However multiple sea turtle species (*Cheloniodea* spp.) are critically endangered and much of this population vulnerability lies beyond the control of the Council and other U.S. management entities. Dutton and Squires (2011) assert that there is little potential for reversing long-term sea turtle population declines without a multinational, holistic strategy directed at international fisheries along with nesting beach threats (light, warming temperatures, poaching of eggs).

Although historical removals of marine mammals 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 2,700 individuals across multiple populations, blue whales (Balaenoptera musculus) over 1,500, elephant seals at minimum estimate of 84,000 , California sea lions on the order of 275,000, and short-beaked common dolphins (*Delphinus delphis*) over 830,000 animals (Carretta et al. 2018). 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, researchers have proposed that California sea lion (Laake et al. 2018) and blue whale (Monahan et al. 2017) 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. The HMS drift gillnet fishery has specific management measures to reduce marine mammal interactions in accordance with the MMPA (cite, cited in Mason et al. 2019). In recent years there has been concern regarding high mortality rates for some cetaceans, particularly blue and sub-populations of humpback whales, caused by large ship strikes within and outside of fisheries (Berman-Kowalewski et al. 2010, Rockwood et al. 2017, Abrahms et al. 2019).

3.3.5 Importance of Trophic Interactions in the CCE

Ecosystem-based fisheries management relies on understanding the role of forage fish in marine food webs (Koehn et al. 2016). Food-web-modelling studies have shown that none of the forage fish species in the CCE act as a keystone prey species, but instead most predators can switch among the various forage fish as their abundances vary (Koehn et al. 2016; but see krill-specialist predators - cite). These studies suggest total forage fish biomass, or biomass of species pairs (sardine v. anchovy & herring v. anchovy; Koehn et al. 2016) may be more important to predators than species-specific biomass as well. Krill specialists, however, have shown strong and specific responses to change in krill biomass / distribution such as complete breeding failure following a delayed start to the upwelling season (Sydeman et al. 2009). Recent extreme warm water events have resulted in novel trophic interactions by mixing forage species and predators with human uses of the oceans (Morgan et al. 2019). These changes have resulted in both prey and predator distribution shifts with new human-wildlife conflicts (Santora et al. 2020) and changes in bycatch patterns leading to the examination of adaptive management approaches (See GMT Report 1 for Agenda Item F.1.a., June 2020).

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, groundfishes, 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) of mostly fish and squid. Comparable estimates for seabirds are limited, but 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. Although 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), there is a rich body of literature linking seabird productivity to prey availability that helped guide the development of harvest control rules for some of the earliest CPS fisheries (e.g., Anderson et al. 1980).

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). Similarly, predator population trends along with the state of multiple forage species from the CCIEA have been proposed as an adjustment to the harvest control rule for California herring to account for predator needs for this small state-managed fishery (Thayer et al. 2020).

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, such trade-offs do exist, can be estimated for a multi-species system, and can be considered in the context of strategic decision making. Ecosystem indicators that include the effects from and needs of top predators could improve our efforts towards defining ecosystem thresholds and management strategies, recognizing that time series length may hamper our ability to detect nonlinear shifts in ecosystem response (Samhouri et al. 2017, Tam et al. 2017).

3.4 Fisheries of the CCE

Fisheries for a broad range of species have occurred within the CCE since humans first inhabited North America's west coast. The Council's four FMPs and analysis documents 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 examine all of the FMP fisheries together while 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) defined a set of time periods that help frame the history of exploitation and the accompanying evolution of associated science. The period before the 20^{th} century is best described as the "inexhaustible" period, when conventional European-centered wisdom held that fisheries could not have an appreciable impact on the resources. Prior to the 1900s, global fisheries 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 an industrial fishery, and the collapse that followed led to what might be considered the conventional management period of 1950-1975.

The mid-20^{th} century saw the development of most of the basic foundations of contemporary fisheries science, including functional relationships addressing productivity, such as fisheries oceanography, stock/recruit relationships, as well as population dynamics models such as surplus production models and virtual population analyses 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 coincided with the world's largest fisheries failure, the crash of the Peruvian anchoveta (*Engraulis ringens*) fishery in the early 1970s, 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.

The late-20^{th} century "doubt" 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 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 had long supported populous and culturally sophisticated Native American communities for millennia (McEvoy 1986, Trosper 2003). Figure 3.4.1 (from Field and Francis 2006 – working on updating for a future draft) 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 that affected recruitment. 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 rockfishes seemed to be sustainable at low levels prior to the 1950s development of modern industrial fisheries.

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 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 availability of sardines, contributing to that fishery's expansion throughout the early 1920s and the early 1930s. Populations of most marine mammals in the CCE have recovered too, 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.

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 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 fisheries as well. After remaining scarce for several decades, sardine populations began to rise in the mid-1980s. By the 1990's, sardine were once again targets of commercial landings, and sardine were once again caught as far north as Vancouver Island. In the mid-2000's, however, populations again began to decline and once again fell first in the north and then in the south. By 2015, sardine were at low enough levels that the PFMC closed the directed commercial sardine fishery. As of 2020, sardine population size was low throughout the CCE.

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 recruitment and ultimately population sizes of CPS, and it is now hypothesized 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,there is still limited understanding of the specific environmental mechanisms that induce recruitment fluctuation in CPS and the optimal management measures for balancing conservation needs with fisheries.

Pacific halibut and other groundfish have been harvested throughout the CCE region for millenia. 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 U.S. coastal fleets of trollers, draggers, and crab boats, and helped fuel 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

This section presents an overview of the CCE fisheries; descriptions of specific Council-managed fisheries are found in the FMPs and associated SAFE (Stock Assessment and Fishery Evaluation) documents. Most commonly, a "fishery" is defined in terms of the objective (profit, recreation, identity, the regulatory framework, the targeted species and the gear used to catch the fish. Thus, an example of a fishery is the commercial limited entry sablefish fixed gear fishery: the objective (profit), a regulatory component (a limited entry permit system), a target species (sablefish), and a gear type (fixed gear, covering bottom longlines and pots). Fisheries may be further categorized by other environmental characteristics such geography (north, south, nearshore, offshore), oceanographic domain (pelagic, benthic), habitat, and seasonality. A more fine-grained description may include social and demographic characteristics of fishery participants and the supporting communities (ports, processors, input suppliers). Looking at fisheries from the perspective of participants -- vessels and their operators -- inverts the characterization. Fishermen may participate in several fisheries per year; and there are long term shifts in participation measured by the number of vessels within a fishery and across fisheries. Technology, the status of targeted species, social values, and regulatory interventions can also change a fishery's essential characteristics over time. Within this section, commercial, recreational and tribal fisheries are addressed, although tribal commercial fisheries landings and revenue are included in the coastwide landings and revenues for all commercial fisheries in Section 3.4.2. In Section 3.4.3, Fishing Communities, we discuss West Coast communities for their social and economic characteristics, and for their participation in and dependency on fisheries resources

3.4.2.1 Commercial Fisheries

West Coast commercial fisheries can be identified by generally accepted definitions, as described above, although definitions may differ somewhat in their specifics across participants, managers, and researchers. Table 3-3 inventories and describes commercial fisheries accounting for 89% of coastwide landings and 69% of ex-vessel revenue during the past 10 years. These fisheries interact with an ecosystem with high biodiversity making the fisheries necessarily diverse in the species that they target, the gear used and fishing locations, and in where landings of different species are made. Table 3.X.2 is organized by whether they target species with gear that operates in the water column and off the ocean bottom (pelagic) or with gear that contacts the ocean bottom (benthic).

Among the fisheries described in Table 3-3, the Dungeness crab pot fishery is by far the most economically important, accounting for a third of total coastwide revenue over the past decade. Revenue in the Dungeness crab fishery is followed by market squid and pink shrimp trawl revenue, all three of which are largely state-managed fisheries. The Dungeness crab pot, albacore hook-and-line (pole/troll), salmon troll fisheries, and groundfish nearshore fixed gear fishery show the highest levels of participation in terms of vessel numbers, and vessels participating in these fisheries realize much of their landings and revenue in other fisheries. This suggests that these fisheries are important contributors to economic viability of many smaller fishing operations. In contrast, vessels in trawl fisheries for groundfish and pink shrimp tend to be much more specialized, deriving a large share of landings and revenue from these target fisheries.

Table 3-3. Major fisheries of the West Coast, by water column location, gear, and target species

Pelagic or Benthic?	Gear?	Target Species
Pelagic	Net: Round haul gear (purse seine, drum seine, lampara net).	Pacific sardine, northern anchovy, market squid, and tunas (skipjack, yellowfin and Pacific bluefin tuna). Vessels mainly fish off Central and Southern California; however, with the mid-2000s growth in the Pacific sardine stock, vessels also targeted sardine off the mouth of the Columbia River.
Pelagic	Net: scoop, brail, or purse seine gear to provide live bait for recreational fisheries targeting pelagic species.	Pacific sardine and northern anchovy. Incidental/bycatch includes "white croaker, queenfish, Pacific and jack mackerels, and various small fishes collectively known as "brown bait" that can include juvenile barracuda, Osmerids, Atherinids, and market squid" (CPS SAFE). (Commercial vessels, principally baitboats targeting albacore, also catch live bait for use in their fishing operations). Other species such as Pacific herring (Oregon) and market squid (Southern California) occasionally caught for the live bait market. Nearshore fishery, especially bays and estuaries.
Pelagic	Net: drift gillnet gear.	Swordfish and common thresher shark targeted off California (mostly in the Southern California Bight). Relatively high level of incidental/bycatch including tunas, other pelagic sharks, and ocean sunfish. Historically, the fishery also had relatively high take of sea turtles and marine mammals, but a large decline in participation and implementation of various mitigation measures has reduced this protected species take.
Pelagic	Hook-and-line: troll gear, or baitboats using hook-and-line gear.	North Pacific albacore. These gear types are selective and there is minimal bycatch in the fishery. Historically, the fishery occurred off California, although the fishery has shifted north in recent decades and now occurs

Pelagic or Benthic?	Gear?	Target Species
		mainly off Oregon and Washington. Fishing can occur far offshore, even outside the West Coast EEZ, depending on the distribution of albacore.
Pelagic	Hook-and-line: pelagic longline gear.	Tunas and swordfish. The HMS FMP prohibits pelagic longline fishing within the EEZ, prohibits the retention of striped marlin, and prohibits targeting swordfish with the shallow-set gear configuration. The Council has declined to adopt measures that would authorize an ESA-compliant fishery in the West Coast EEZ. However, vessels permitted to operate in the US EEZ off Hawai'i may target swordfish and land in West Coast ports. In the last decade, swordfish have accounted for 40% of landings by Hawai'i vessels, although tuna landings are increasing and account for slightly more than half of landings in 2019. Other frequently landed species include dorado (mahi mahi) and opah.
Pelagic	Hook-and-line: troll gear.	Chinook and coho salmon, various stocks with distinct spawning populations. Depending on the stock, salmon migration occurs at different times of year but in aggregate the fishery has a distinct seasonal pattern with catches picking up in May and peaking August to October.
Pelagic	Trawl: mid-water trawl.	Pacific whiting. This is a large volume fishery with a relatively low incidental/bycatch rate although bycatch of overfished rockfish species and Chinook salmon have led to management constraints. Vessels are divided between at-sea and shoreside fisheries, with the at-sea sector further subdivided between mothership processing vessels accepting fish from catcher boats and catcher-processor vessels. Most catcher-processor and mothership vessels also fish in Alaska waters for part of the year, as do many of the catcher vessels (slightly more than half the revenue earned by vessels in the at-sea fleet comes from fishing in Alaska). The fishery mainly occurs off of Washington and Oregon; it is prohibited south of 40°10' N latitude to minimize bycatch of more vulnerable salmon stocks.
Pelatic	Trawl: mid-water trawl.	Pelagic rockfish species, principally widow rockfish and yellowtail rockfish. These two species account for about two-thirds of catch; since they are using the same type of gear, Pacific whiting may be caught incidentally (Steiner, 2019). Landings of pelagic rockfish were a major component of the West Coast groundfish fishery in the 1980s and 1990s, but were effectively prohibited beginning around 2000 due to measures to rebuild overfished rockfish stocks. With successful rebuilding of these species, the fishery reemerged in the mid-2010s.
Pelagic	Harpoon: Swordfish.	Highly selective gear with no unintentional catch. Operates off the Southern California Bight, sometimes using spotter planes to locate swordfish schools.
Benthic	Trawl: bottom trawl gear.	Vessels tend to target Dover sole, thornyheads, and sablefish in deepwater on the continental slope (200-300 fathoms,) or flatfish (with petrale sole and Dover sole major sources of revenue), and other groundfish species on the continental shelf (<100 fathoms). Both strategies can be characterized as multispecies with relatively high levels of incidental yet retained catch. Fishery occurs primarily off Washington and Oregon with some activity in Northern California.

Pelagic or Benthic?	Gear?	Target Species
Benthic	Trawl: single and double-rigged shrimp trawl gear.	Pink shrimp, which occur on sandy and mud bottoms all along the West Coast, although the fishery is centered in Oregon. Pink shrimp vessels use bycatch reduction devices and light emitting diode (LED) lights to reduce bycatch including protected species such as eulachon.
Benthic	Trawl: bottom trawl.	California halibut, taken in nearshore areas in Central California, primarily off of San Francisco and around Point Conception (Richerson, et al. 2019). Bycatch includes the southern distinct population segment of green sturgeon, which is listed as threatened under the ESA.
Benthic	Fixed gear: bottom longline and pot/trap.	Sablefish, with allowable and incidental catch of other groundfish species such as thornyheads, rockfish, flatfish, spiny dogfish, and skates. Bycatch may also include Pacific halibut, which may be retained in some times and areas when taken with longline gear.
Benthic	Hook-and-line	Rockfish and other groundfish species. Varied catch is generally retained.
Benthic	Hook-and-line: longline	Pacific halibut. Bycatch includes rockfish and sablefish. Pacific halibut may be directly targeted, or may be retained (when permitted) in salmon and sablefish hook-and-line fisheries.
Benthic	Pot/trap: Dungeness crab.	Bycatch of other species unusual, although Dungeness crabs that do not meet regulatory requirements for size and sex are discarded with the expectation that they will survive to reproduce.
Benthic	Pot/trap: Spiny lobster.	Bycatch of other species is unusual, although cabezon, lingcod, and sublegal lobsters may occur as bycatch. Southern California Bight fishery.

The annual California Current Ecosystem Status Report (ESR, e.g. Harvey et al. 2019) provides trends in landings (mt) and revenue (millions of $) over time for the major West Coast fisheries. Over the 2015-2019 period, coastwide landings of all species, including at-sea from processing, have increased by more than a third, primarily due to Pacific whiting catches (Harvey et al. 2019). However, because of low catch and revenue in 2015 the recent five-year period is unrepresentative. Over 20 years of landings show substantial variability, with 2019 landings below the mean value for the period (Figure 3-5). Inflation-adjusted ex-vessel revenue increased to a peak in 2013, and after a large decline in 2015, has been fairly stable. These broad trends mask considerable variation across species groups; while CPS landings fell by almost 90% and salmon by close to half during this period, crab landings increased by almost 70% and groundfish by over 40%.

Figure 3-5. West Coast at-sea and shoreside landings and inflation-adjusted ex-vessel revenue, 2000-2019. Solid lines - one standard deviation above and below the mean (dotted line).

From the perspective of fishery participants, the degree to which they participate in different fisheries across time and space may be more socially, economically, and ecologically important. Participating in more than one fishery increases revenue diversification, which, all else being equal, should result in a more stable income stream, or, put another way, reduce financial risk for participants. The ESR includes a metric of revenue diversification for vessels making landings on the West Coast, based on the work of Holland and Kaperski (2016). Revenue diversification for West Coast vessels has generally declined over the time period examined (1981-2018), with a slight increase in the early 1990s and a significant decline thereafter. Fishery management interventions in the form of license limitation and catch shares are likely major contributors to fishery specialization, perhaps reflecting a broader trend of capital intensification that includes vessel and equipment costs. A slight increase in revenue diversification into the early 1990s may reflect unconstrained growth in participation across fisheries that prompted these management interventions.

The interconnectedness of fisheries can also be evaluated through network analyses. Fuller et al. (2017) conducted one such analysis, using West Coast landings data to define fisheries through a métier analysis which clusters trips (individual landings) based on gear used and species composition of landings. They evaluated fishery participation networks at a regional level using port groups defined in the PacFIN data set. They demonstrated significant diversity in network structure across these regions, evaluated the relative importance of different fisheries with these networks, and measured the resilience of the network, which can be related to social vulnerability. Figure 3-6 reproduces Figure 2 in Fuller et al (2017) presenting a coastwide representation of fishery connectivity and diversity across port regions. The analysis generally confirms the observation made above about the importance of the Dungeness crab pot, albacore tuna troll, and salmon (Chinook) troll fisheries with respect to cross participation. Frawley et al. (2020) also used network analysis focusing on the albacore troll fishery, supplemented by informant interviews, to incorporate fishery participant perceptions. They also used a métier analysis methodology to characterize fisheries based on gear and landings composition. Results in terms of network structure are similar, but they evaluated changes over time rather than space. Generally, the importance of Dungeness crab pot and albacore troll fisheries (measured by node size and edge weight) has increased over time.

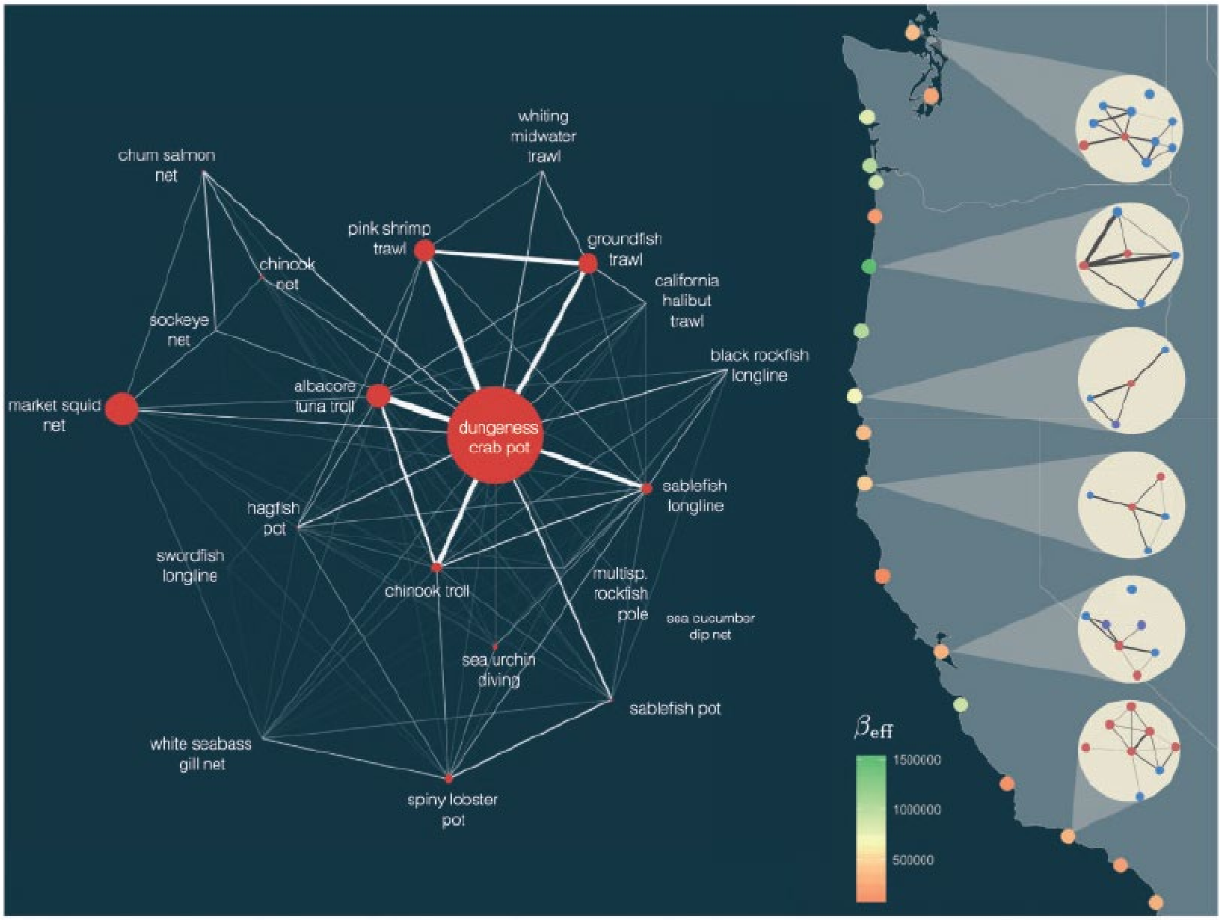

Figure 3-6.Summary of fisheries connectivity on the US west coast. The large network on the left is the fisheries connectivity network for the whole US CCLME. In scaling down, fisheries connectivity networks can be derived for each port or port-group. (Source: Fuller, et al., 2017)

Fisheries seasonality is another important factor driving participation. Seasonal variation in landings is primarily a function of species availability, but may be reinforced by regulations restricting when species may be targeted. Such restrictions may be motivated by either economic (e.g., product quality) or ecological considerations (e.g., protected species interactions). Figure 3-7 shows West Coast commercial fisheries landings and inflation-adjusted ex-vessel revenue by FMP in each month of the year, aggregated over 1999-2019 while Figure 3-8 shows a more detailed view at the species level. Clear patterns emerge showing when highest landings by weight occur in which fisheries, and when the most lucrative fisheries occur during the year. (As discussed above, Dungeness crab accounts for a large proportion of ex-vessel revenue but is not federally managed, as reflected in the high values for “None” in Figure 3-7.) The highest commercial landings by volume occur during the summer months, when Pacific whiting are available in the EEZ, and are targeted by vessels catching and processing at sea, or bringing their catch to shoreside processors.

Participants may follow an annual cycle, based on different species becoming available for harvest at different times of year. Both the Dungeness crab pot fishery and albacore troll fishery are very seasonal, and complementary in their seasonality, likely contributing to the high level of cross-participation in these fisheries. The Dungeness crab fishery is typically open during the winter months (late-December onward) when crab meat quality is at its best, while albacore landings mainly occur July through October. In contrast, shoreside landings of groundfish tend to be fairly steady throughout the year, but with higher landings levels in the summer months. Looking at other fisheries, squid landings are higher in winter months, peaking in November, while sardine landings are concentrated between July and September. Depending on the stock, salmon migration occurs at different times of year but in aggregate the fishery has a distinct seasonal pattern with catches picking up in May and peaking August to October.

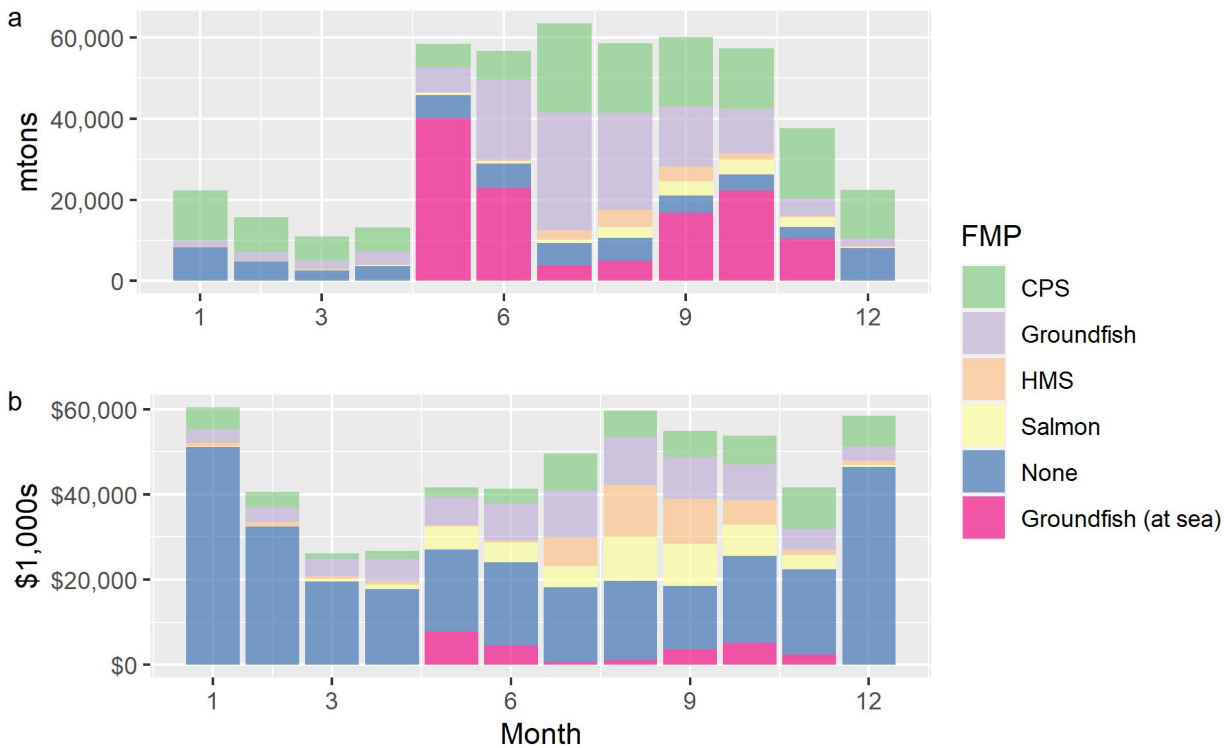

Figure 3-7. Average monthly landings and inflation-adjusted ex-vessel revenue ($1,000s) by FMP, 2000-2019.

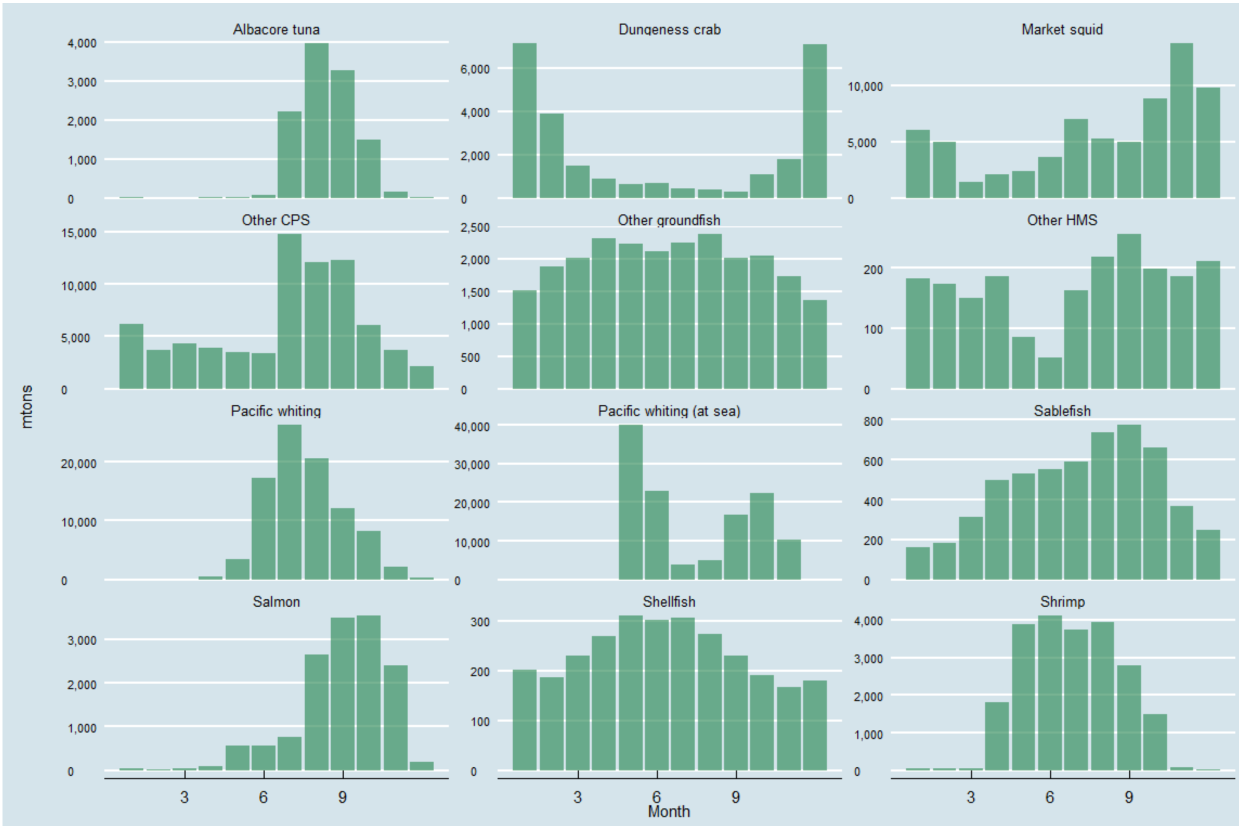

Figure 3-8. Average landings volume by month for selected species, 2000-2019.

3.4.2.2 Recreational Fisheries

Recreational fisheries catches are strongly focused on a few particularly popular species. 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 tunas (albacore in the Northern CCE and bluefin and yellowfin in the Southern CCE), 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.

[**March 2021 note: The EWG drafted this section on Recreational Fisheries with the intent of separating out fisheries by the bio-geographic regions discussed in Section 3.1. After further consideration, we are planning to re-organize this section using the 2013 FEP Section 3.4.2.1 as a model, where the FEP first presented aggregate coastwide recreational fisheries information, followed by more specific information on the recreational fisheries of each of the three coastal states.]

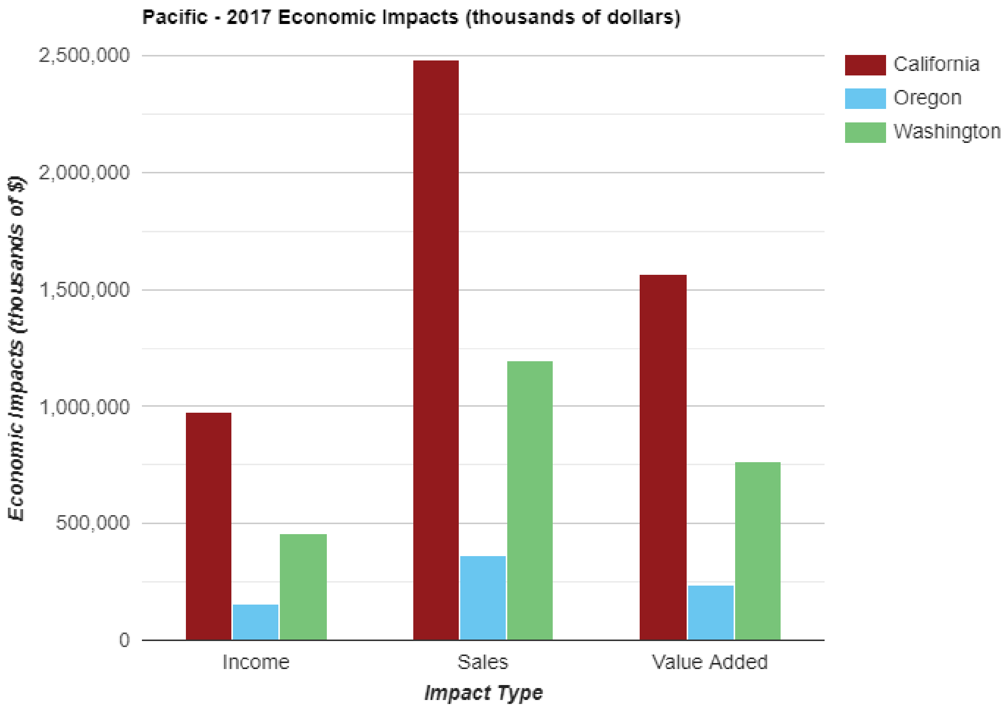

Figure 3-9. Economic impact of recreational fisheries (income, sales, value added) in West Coast states in 2017. (Source: [https://www.fisheries.noaa.gov/data-tools/fisheries-economics-united-states-interactive-tool)](https://www.fisheries.noaa.gov/data-tools/fisheries-economics-united-states-interactive-tool)

Recreational Fisheries in the Northern CCE

Catches in this region are fairly similar from a recreational fisheries perspective, and the species diversity for rockfishes is much lower than areas further south. Primary targets include salmon, lingcod, albacore, Pacific halibut, and nearshore rockfishes (primarily black , *S. melanops* and blue, *S. mystinus*), all of which are managed under Council FMPs. Chinook salmon can be taken in all three states and coho salmon can be taken in Oregon and Washington. All finfish species are overwhelmingly taken using hook-and-line gear, although some fish are caught by spear divers and other gear.

In this region, 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 not Council-managed, shellfish such as Dungeness crab and razor clams (*Siliqua patula*) also provide popular and valuable recreational harvest opportunities in the state.

In this region, while recreational fishing is important to coastal residents, anglers from more populated inland areas tow boats long distances to fish for marine species.

Recreational Fisheries in the Central CCE

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.

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 (*Paralabrax*), surfperches (family *Embiotocidae*), Dungeness crab, and California spiny lobster.

An estimated 216,000 abalone were harvested by recreational central California 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, 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.

Recreational Fisheries in the Southern CCE

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 Pacific bluefin tuna, yellowfin tuna, California scorpionfish (*Scorpaena guttata*), rockfishes (primarily vermilion (*Sebastes miniatus*), bocaccio, and gopher (*S. carnatus*)), Pacific chub mackerel (*Scomber japonicas*), Pacific bonito, California halibut, the basses, yellowtail, and barracuda (*Sphyraena argentea*). Although historically a recreational fishery target in the Southern California Bight, the distribution of albacore tuna has shifted north and this species has been a relatively minor component of recreational catch since the early 2000s. Cowcod rockfish were also historically an important recreational target but have not been fished since being declared overfished by the PFMC in the early 2000s.

Recreational ocean fishing occurs year-round in Southern California where ocean and weather conditions are less extreme than in the Central and Northern CCE, permitting anglers greater access to the resource in winter months. Clement weather and a large population combine to make Southern California Bight fisheries the largest component of angler effort and catch in the CCE.

Fishery regulations are often the constraining factor that determines when and where most recreational fishing occurs, and regulations have become increasingly restrictive over the last thirty years. As in other West Coast states, peak fishing months are May through September.

3.4.2.3 Tribal Fisheries Other Than Commercial

[**Placeholder text for March 2021: The marine ecosystems of the CCE support a wide variety of plant and animal species that tribes have always depended on for food, medicine, tools, culture, ceremony, and commercial endeavors. Shellfish (both mollusks and crustaceans) and various species of marine fishes are important for tribal cultural, social interactions, and health. Many types of near-shore species such as shore birds, dune grasses, seaweed, and kelp are used for food and cultural activities. Marine mammals such as otters, seals, and whales have great cultural importance and have been traditionally harvested.]

3.4.3 Fishing Communities

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 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).

To characterize West Coast fishing communities, the NWFSC Human Dimensions Team published a Community Profiles document in 2007 describing the history, geography, demography, infrastructure, and fisheries for 120 West Coast fishing communities. Subsequently, NMFS social scientists developed a composite Community Social Vulnerability Indicator (CSVI) based on metrics of social vulnerability, gentrification, and fisheries engagement and dependence (Jepson and Colburn 2013). These metrics may be accessed through the NOAA Fisheries Social Indicator Mapping Tool. In addition, the CSVI is plotted against a fishing reliance metric for selected West Coast fishing communities in section 6.1 of the Annual CCEIA Report.

This section summarizes the variation in West Coast fishing community characteristics across the three CCE regions described in Section 3.1, drawing on PacFIN data along with selected demographic characteristics derived from CSVI analyses to broadly describe regional variations in fisheries and community characteristics. For the discussions below, these metrics are only reported for fishing communities in each region, not the entire population of the region.

Figure 3-10 through Figure 3-12 provide a coastwide comparison of: (a) landings, (b) ex-vessel revenue, and (c) vessel participation across the CCE regions by fishery. Most landings and related ex-vessel revenue occur in the Northern CCE, where groundfish dominate landings volume. In terms of ex-vessel revenue, crab (primarily Dungeness crab) is the major contributor in both the Northern and Central CCE. Coastal pelagic species (primarily market squid) often account for the biggest proportion landings and revenue in the Southern CCE. State managed species, principally spiny lobster, also accounts for a large share of ex-vessel revenue in this region.

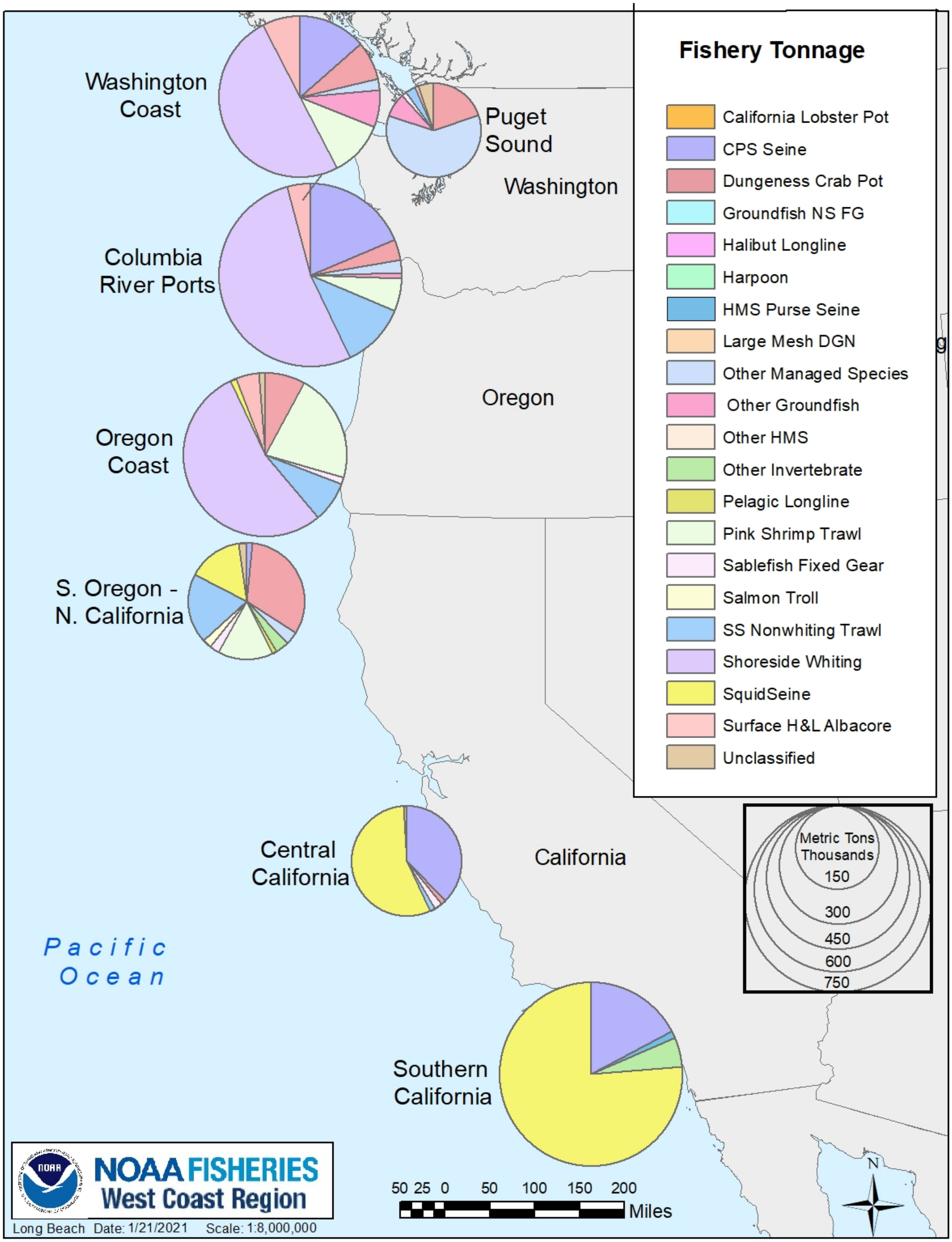

Figure 3-10. Proportion of landings (mt) by fishery and West Coast regions, pervious 10 years. (Source: PacFIN comprehensive_ft table.)

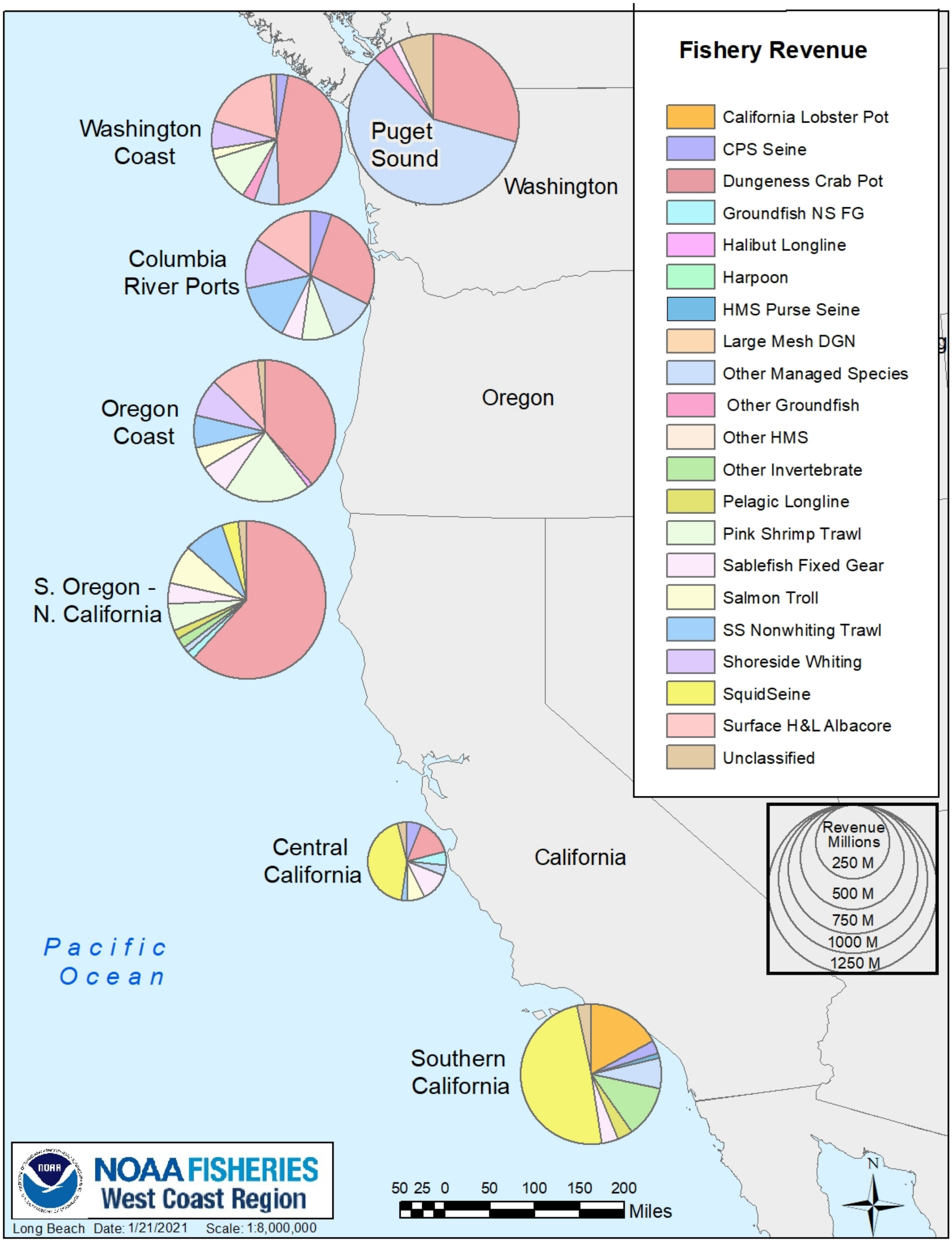

Figure 3-11. Proportion of inflation-adjusted ex-vessel revenue by fishery and West Coast regions, previous 10 years. (Source: PacFIN comprehensive_ft table.)

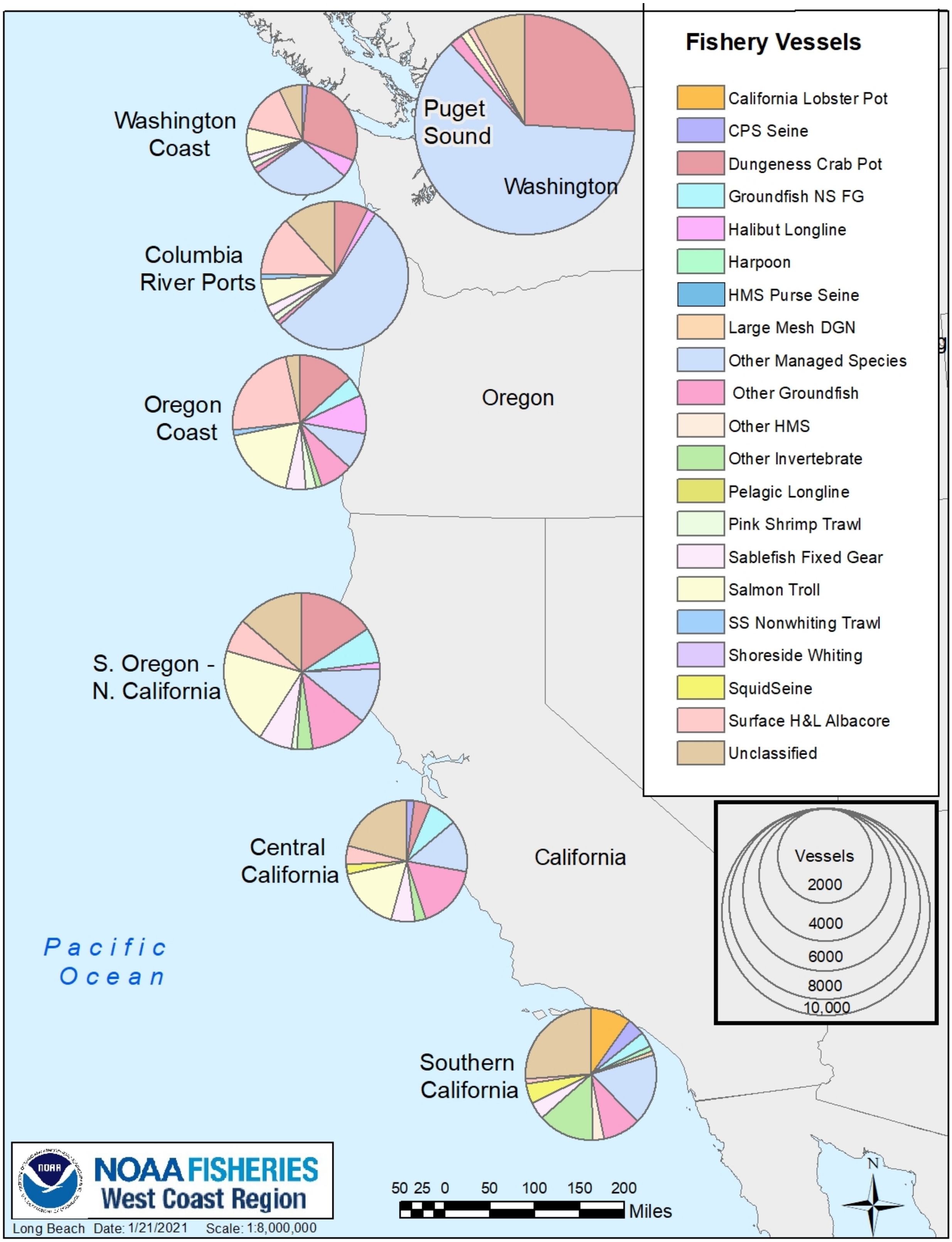

Figure 3-12. Proportion of vessels making landings by fishery and region, previous 10 years. (Source: PacFIN comprehensive_ft table.)

3.4.3.1 Communities in the Northern CCE

In the US EEZ, this region stretches from Cape Flattery in the north to a terminus at Cape Blanco in southern Oregon. This large region includes Puget Sound (also encompassing communities along the Strait of Juan de Fuca), the Washington Coast, the Columbia River area, and the Oregon Coast south of the Columbia River communities and extending to Cape Blanco.

Fishery Characteristics

There are 74 places where landings have been made in the Northern CCE during the past decade according to the PacFIN database. The largest commercial fishery ports by landings value are Westport, Washington (16% of total ex-vessel revenue in the region); Newport, Oregon (14%); Astoria, Oregon (12%); and Coos Bay, Oregon (9%).

Figure 3-13 shows ex-vessel revenue by fishery in the Northern CCE. As noted previously, the Dungeness crab, albacore troll, and pink shrimp fisheries are important contributors, accounting for just over half of ex-vessel revenue in the region. The highest value landings occur in the Puget Sound region; it accounts for the largest share of revenue (35%) but has the smallest landings volume (9%). Columbia River ports (principally Ilwaco, Washington and Astoria-Warrenton, Oregon) exhibit the opposite pattern: the largest share of landings volume (35%) and smallest revenue share (20%). This is because Ilwaco, Washington and Astoria, Oregon are major ports of landing for Pacific whiting, a high volume, low value species.

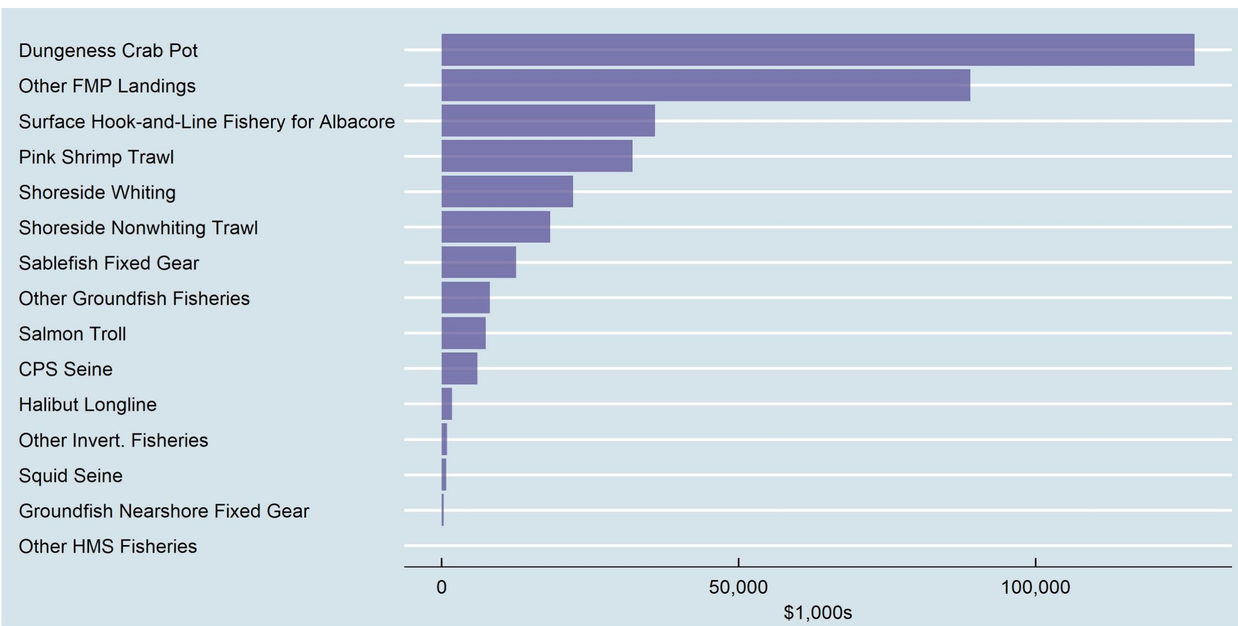

Figure 3-13. Annual average inflation-adjusted ex-vessel revenue by fishery in the Northern CCE, 2010-2019.

Demographic and Social Characteristics

Figure 3-14 plots the CSVI against the fishing reliance metric for fishing communities in the Northern CCE. (To improve the visualization, some communities with very high fishing reliance scores have been omitted.) Comparing the subregions in the Norther CCE, CSVI scores are generally higher on the Washington Coast and Oregon Coast subregions compared to the Puget Sound and Columbia River subregions. For example, nine-tenths of the CSVI scores in the Washington Coast subregion are greater than zero (indicating they are above the mean for all communities), as are three-quarters of the scores in the Oregon Coast subregion. Less than half the communities in the Puget Sound and Columbia River Ports subregions have positive values. Similarly, the two coastal regions have generally higher fishing reliance scores compared to the other two subregions. (The Oregon Coast region has the highest proportion of communities with fishing reliance scores greater than zero among all seven West Coast subregions.) Both these subregions are fairly isolated from major population centers, with their constituent communities generally having small populations. In comparison, Puget Sound and the Columbia River Ports regions both have more large population centers. This is reflected in Figure 3-19-a, a boxplot showing the distribution of the populations of each of the communities in the regions.[1] Note that the Washington Coast subregion has the smallest median value and is skewed towards smaller populations. On the other hand the Puget Sound subregion has the highest median value for the populations of its communities, followed by the Columbia River subregion.

Three other demographic metrics (in addition to total population), are displayed in Figure 3-19 panels b-d, intended to provide context in terms of social vulnerability and community wellbeing, and refer to demographic and vulnerability variables analyzed in the CSVI approach (Jepson and Colburn 2013). Table xx summarizes how each subregion ranks for these metrics with respect to the median value. The Washington Coast stands out across all the CCE subregions in terms of percent of families below the poverty line (highest median value) and median household income (lowest median value and within a fairly small range). The Oregon Coast subregion is also of note, ranking sixth in terms of household income and third in terms of families in poverty. Like the Washington Coast subregion, median household income values fall within a fairly narrow (low) range. Communities in the four Northern CCE subregions generally vary in terms of proportions of nonwhite populations (measured by the median value). Puget Sound and the Washington Coast rank third and fourth across all seven subregions (see Table 3-4), with a few high “outlier” values, while the Columbia River and Oregon Coast subregions rank sixth and seventh.

[1] Boxplots summarize the distribution of values. The box encloses the range from the 25th to 75th quartiles with the thick horizontal line indicating the median. The whiskers above and below the box represent an extension of the inter-quartile range with any values outside that represented by points.

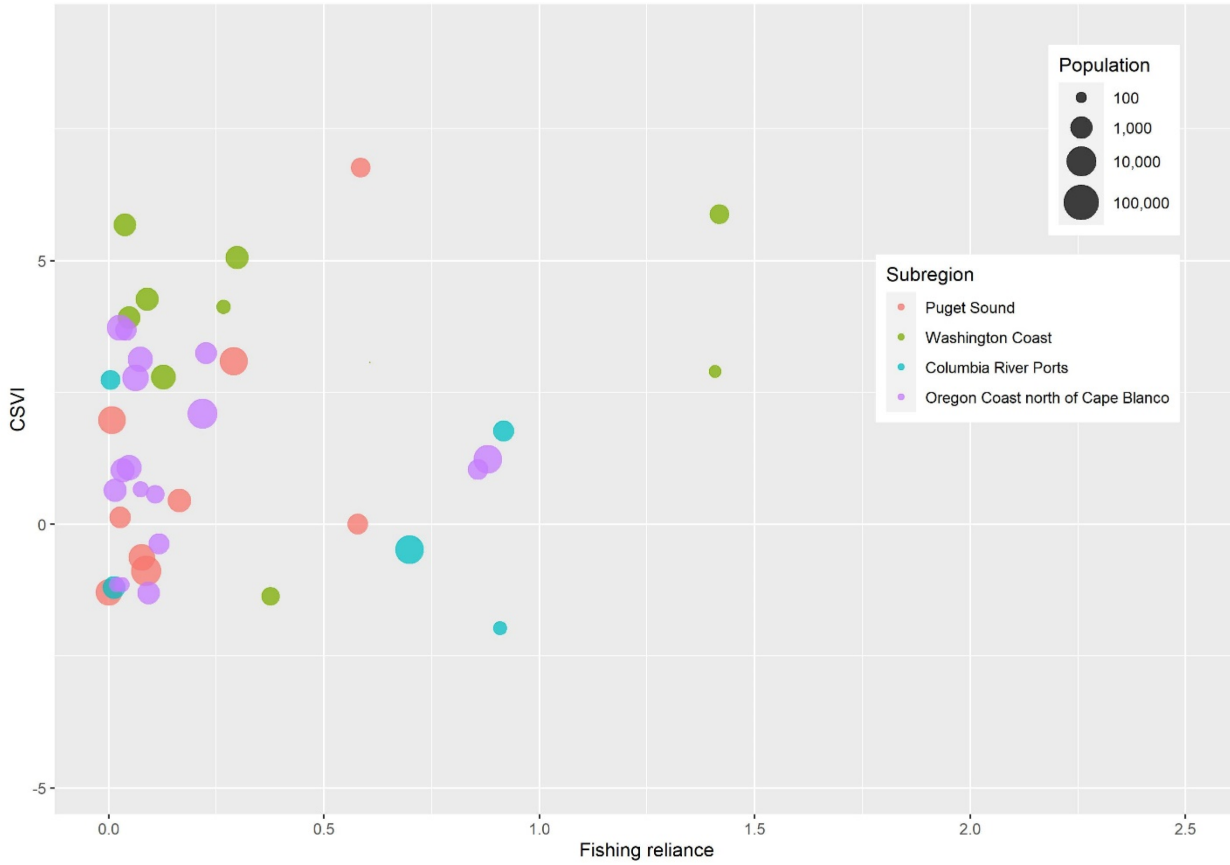

Figure 3-14. Community Social Vulnerability Index (CSVI) plotted against the Fishing Reliance Index for fishing communities in the Northern CCE region.

3.4.3.2 Fishing Communities in the Central CCE

The Central CCE extends from Cape Blanco in southern Oregon to Point Conception in California.

Fishery Characteristics

There are 73 places where landings have been made in the Central CCE during the past decade according to the PacFIN database. The largest commercial fishery ports by landings value are Crescent City (14% of total ex-vessel revenue in the region), San Francisco (13%), and Eureka (11%).

Figure 3-15 shows ex-vessel revenue by fishery in the Central CCE. Like the Northern CCE, the Dungeness crab fishery dominates in terms of ex-vessel revenue (52% of the region total) followed by the purse seine fishery for market squid (11%) and salmon troll fishery 8%). By value, ports between Cape Blanco and San Francisco dominate, accounting for 80% of ex-vessel revenue due primarily to the Dungeness crab fishery, while the market squid fishery is more important in the southern portion of the region.

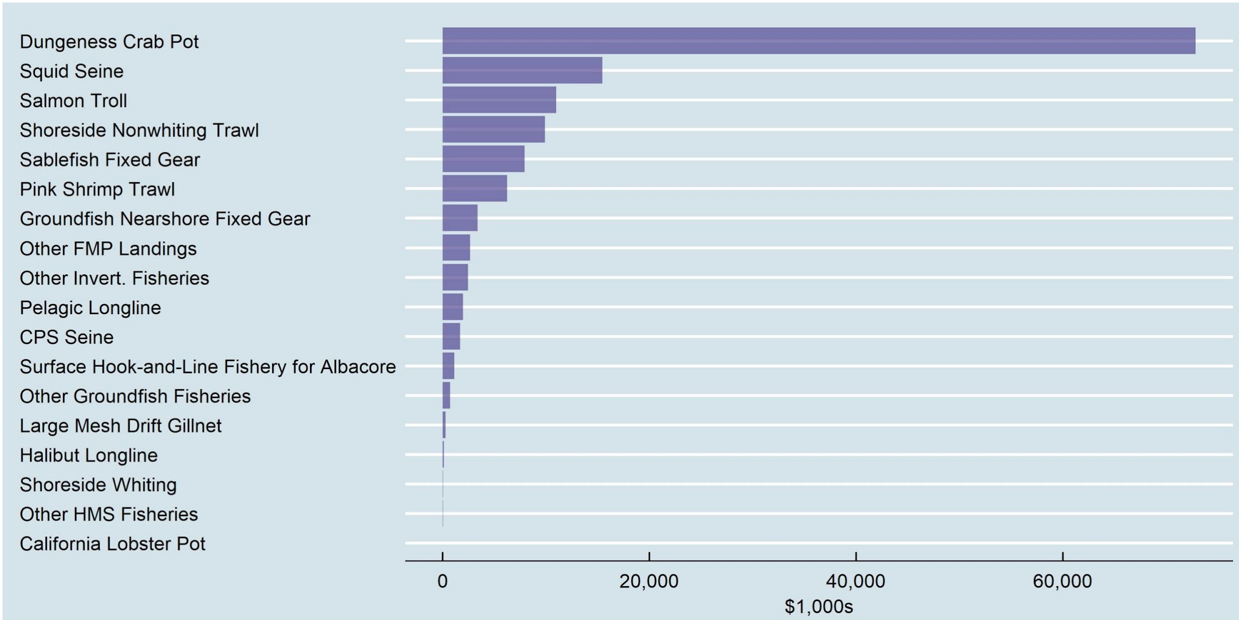

Figure 3-15. Annual average inflation-adjusted ex-vessel revenue by fishery in the Central CCE, 2010-2019.

Demographic and Social Characteristics

Figure 3-16 plots CSVI values against fishing reliance scores for the Central CCE broken out by its two constituent subregions (generally bisected by the San Francisco Bay Area). Overall, one third of the communities in the Central CCE have CSVI values greater than zero, with the Central California subregion having the lowest proportion (about one-fifth) of all seven West Coast subregions; both of the Central CCE subregions have lower proportions of communities with positive CSVI values compared to all of the four Northern CCE subregions. In both subregions fishing reliance scores are clustered slightly below zero, with a few communities in the Northern California subregion posting relatively high positive values.

Encompassing the San Francisco Bay area, Northern California subregion communities span a wide range of population sizes with the second highest median across all the subregions (see Figure 3-19-a). Central California subregion communities have a generally narrower distribution of population sizes with a few “outlier” values with a median value falling behind the subregions with major population centers: Southern California, Northern California, and Puget Sound.

Communities in the two Central CCE subregions have high median household income values (ranking first and second in terms of the median value for this metric). Communities in the Northern California region exhibit a very wide range in median household values with several high “outliers.” Likewise, these two subregions rank lowest in terms of the median value of family poverty rates although the Northern California subregion includes some communities with relatively high rates. The Northern California subregion ranks only behind Southern California in terms of the median value for the percent nonwhite population of its constituent communities. (See the display of these demographic metrics in Figure 3-19.)

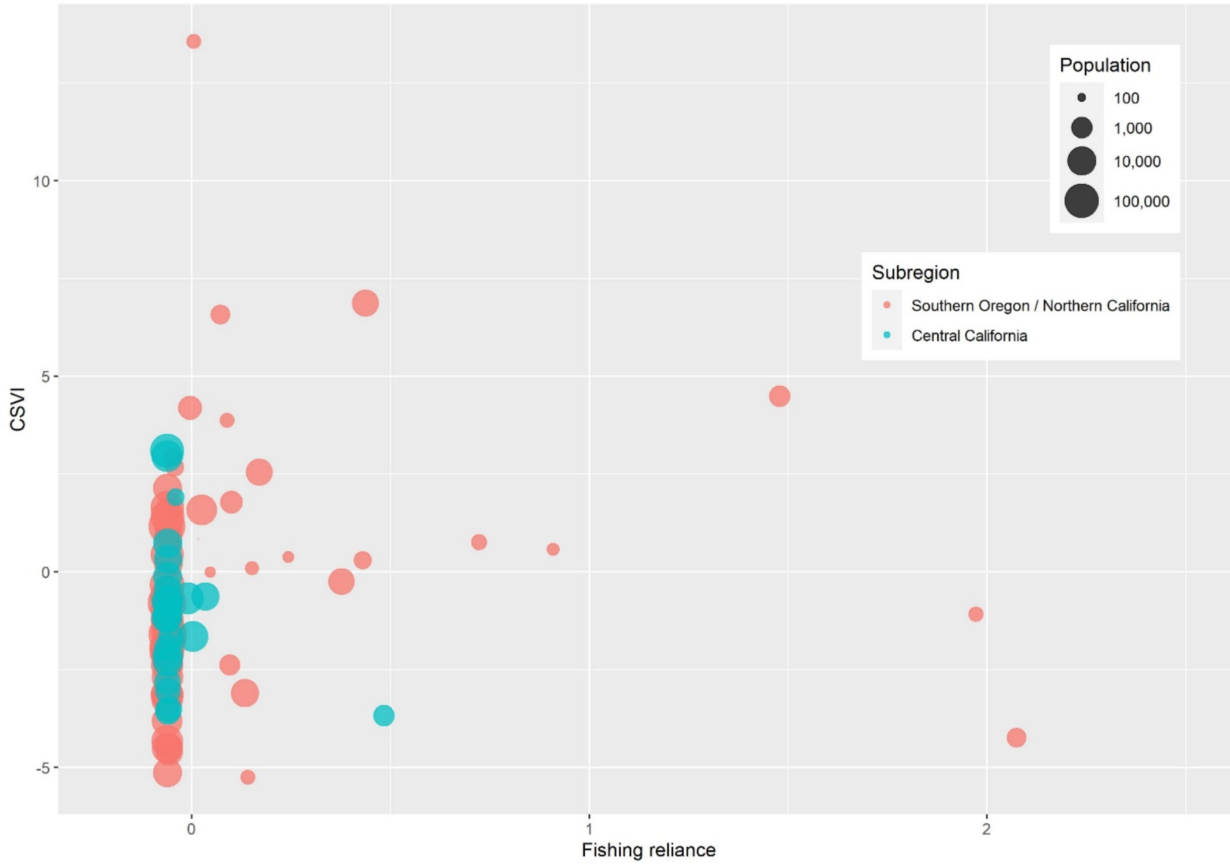

Figure 3-16. Community Social Vulnerability Index (CSVI) plotted against the Fishing Reliance Index for fishing communities in the Central CCE region.

3.4.3.3 Fishing Communities in the Southern CCE

The Southern CCE is coincident with the ecologically diverse Southern California Bight.

Fishery Characteristics

There are 48 places where landings have been made in the Southern CCE during the past decade according to the PacFIN database. The market squid purse seine fishery dominates in terms of ex-vessel revenue in this region (48% of the total for the region), followed by the pot fishery for California lobster (17%). The largest commercial fishery ports by landings value are Ventura (20% of the total), Terminal Island at the Port of Los Angeles/Long Beach (16%), and nearby San Pedro (15%).

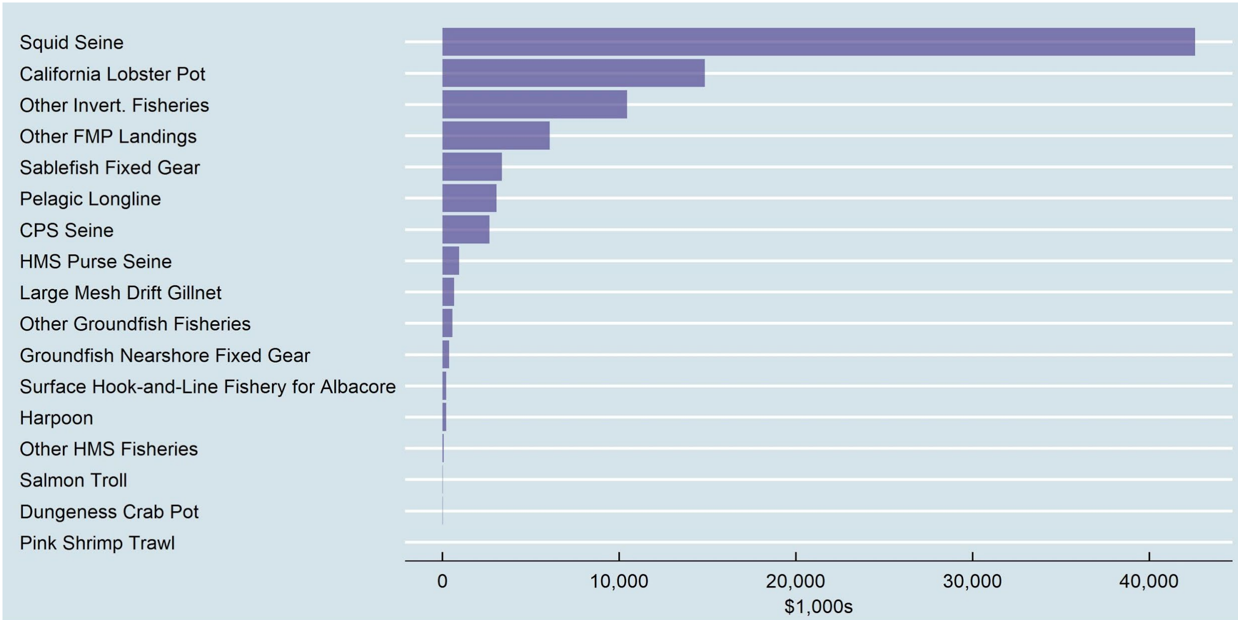

Figure 3-17. Annual average inflation-adjusted ex-vessel revenue by fishery in the Southern CCE, 2010-2019.

Demographic and Social Characteristics

For the purpose of this discussion, the Southern CCE is not further subdivided into subregions. Figure xx plots the CSVI against fishing reliance for communities in the region. Around 40% of the communities in this region have CSVI values greater than zero while there are no communities with a positive value for the fishing reliance score, and values tend to be clustered towards the lower end of the range.

Relative to the rest of the West Coast, the Southern California region is very urbanized. This urbanization is reflected in the range of total population levels in the constituent communities (see Figure 3-18). The median value for total population is higher than the seventy-fifth percentile of the range of other subregions except for Puget Sound and Northern California (as noted, influenced by the presence of the Bay Area).

The census metrics presented to provide context in terms of social vulnerability and wellbeing suggest the diversity of this region (Figure 3-19). Communities show a wide range in terms of percent nonwhite population, while the median value is the highest of the seven subregions presented here. Its ranking in terms of the median values for median household income and percent of families below the poverty level are intermediate compared to the other subregions.

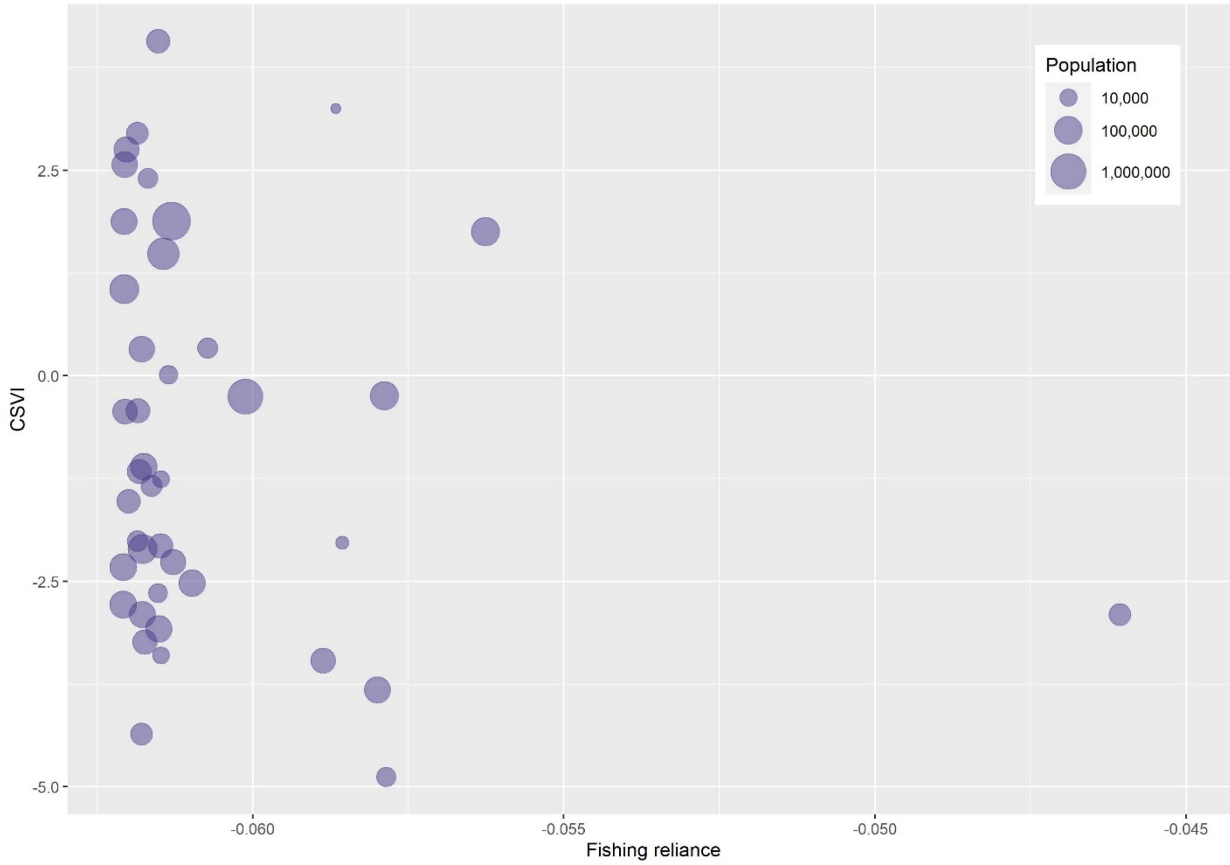

Figure 3-18. Community Social Vulnerability Index (CSVI) plotted against the Fishing Reliance Index for fishing communities in the Southern CCE region.

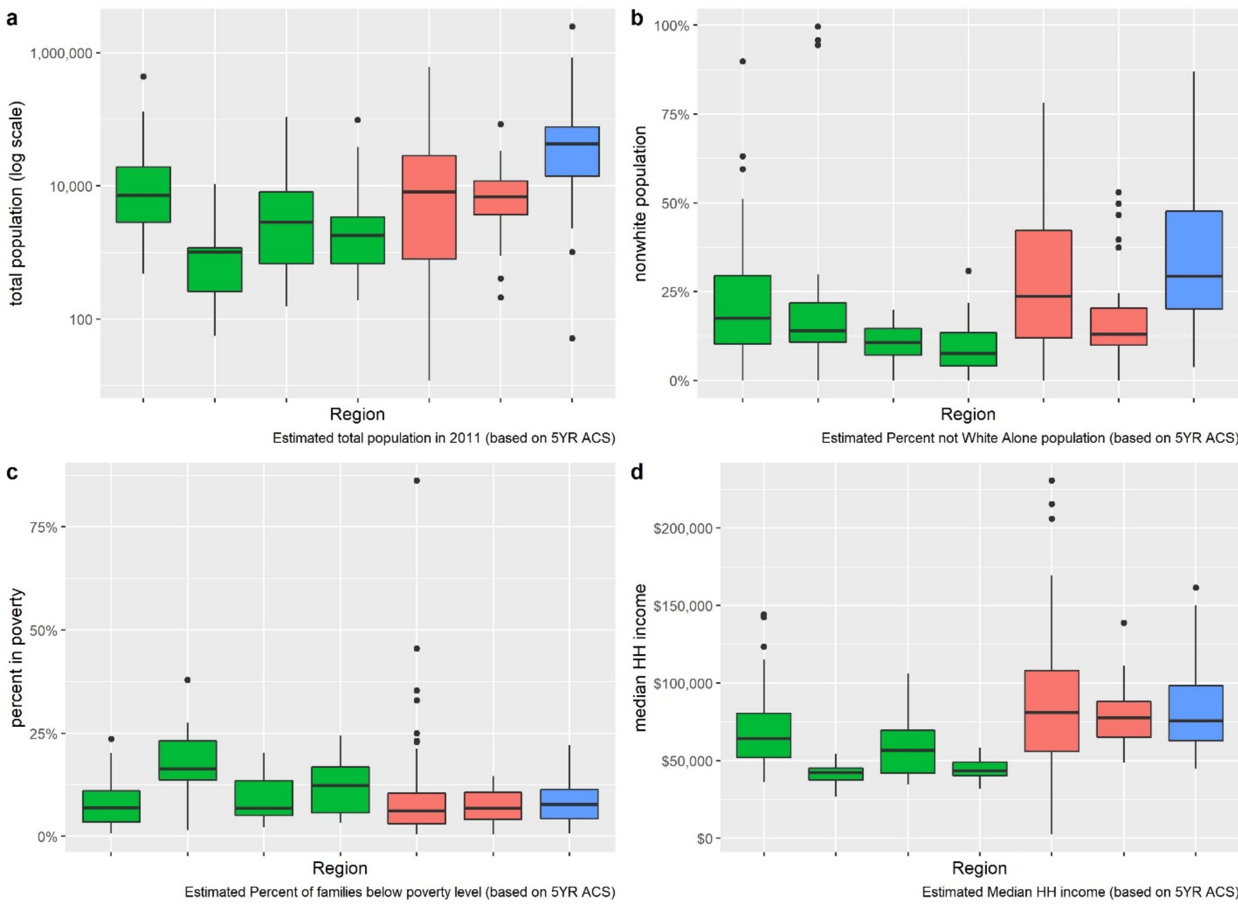

Figure 3-19. Demographic characteristics for CCE subregions: a) total population, b) percent nonwhite population, c) percent of families below the poverty line, d) median household income. Subregions from left to right are Puget Sound, Washington Coast, Columbia River Ports, Oregon Coast north of Cape Blanco, Southern Oregon/Northern California, Central California, Southern California. Fill colors indicate CCE regions: Northern CCE, green; Central CCE, red; Southern CCE, blue. (Data from U.S. Census American Community Survey 5-year estimates. Population, 2011 ACS; other demographic metrics, 2018 ACS.)

Table 3-4. Ranking of regions according to the median value of the community metrics displayed in Figure 3-19.

Region	Census Metric		
	Income	Poverty	Nonwhite
Puget Sound	4	5	3
Washington Coast	7	1	4
Columbia River Ports	5	6	6
Oregon Coast north of Cape Blanco	6	3	7
Southern Oregon / Northern California	1	8	2
Central California	2	7	5
Southern California	3	4	1

3.4.3.4 First 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.

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 and method 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 or submitted electronically through the PSMFC West Coast E-Ticket system within fishery specific timeframes. Electronic landings reporting became mandatory in California on July 1st, 2019.

NMFS publishes descriptive statistics on the seafood processing industry in the Fisheries Economics of the U.S. series. The most recent report along with an interactive data exploration tool may be found on the NOAA Fisheries website.

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. For example, according to PacFIN data, shellfish accounted for 23 percent of total inflation adjusted landings revenue during the period 2015-2019. Dungeness crab fisheries, which are managed by the three states and several tribes individually, provide the most valuable source of landings in most years and 30% of inflation adjusted ex-vessel revenue 2015-2019.

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.2

Table 3.X.X shows price per pound for the top 25 species ranked by total ex-vessel revenue in 2019 (out of a total of 252 species).3 Only four species in this list rank in the top 25 in terms of price per pound. Many of the most valuable species are landed in relatively small quantities and include a variety of rockfishes, likely destined for live fish markets.

Table 3-5. Top 25 species ranked by total ex-vessel revenue, 2019, showing average price per pound. (Source: PacFIN comprehensive_ft, 12/23/2020).

Management Group	Species	Price Per Pound	Total Ex-vessel Revnue ($1,000s)	Rank - Total Revenue	Rank - Price Per Pound
Crab	Dungeness Crab	$3.67	$204,822	1	44
Groundfish	Pacific Whiting	$0.09	$29,624	2	235
Salmon	Chinook Salmon	$4.91	$29,208	3	26
Shrimp	Pacific Pink Shrimp	$0.73	$28,337	4	160
HMS	Albacore	$1.66	$27,832	5	99
Groundfish	Sablefish	$1.94	$20,807	6	89
CPS	Market Squid	$0.50	$16,373	7	181
Other	California Spiny Lobster	$13.76	$11,334	8	1
Shrimp	Spotted Prawn	$11.96	$10,094	9	2

[2] Pacific Fish Trax website: https://marketplace.fishtrax.org/.

[3] Price per pound was obtained from the PacFIN database by dividing total ex-vessel revenue by total landed round weight in pounds. Species subject to confidentiality rules (less than three vessels or processors) are excluded.

Management Group	Species	Price Per Pound	Total Ex-vessel Revnue ($1,000s)	Rank - Total Revenue	Rank - Price Per Pound
Other	Pacific Halibut	$4.99	$7,387	10	24
Other	Red Sea Urchin	$2.12	$6,965	11	84
Groundfish	Petrale Sole	$1.20	$6,767	12	120
Groundfish	Widow Rockfish	$0.26	$5,399	13	214
Groundfish	Dover Sole	$0.42	$5,343	14	195
HMS	Bigeye Tuna	$3.44	$4,243	15	48
Other	Nom. Calif Halibut	$5.49	$3,933	16	18
Other	Unsp. Sea Cucumbers	$4.87	$2,945	17	27
Crab	Rock Crab	$1.79	$2,570	18	96
Salmon	Coho Salmon	$2.15	$2,563	19	83
HMS	Swordfish	$3.95	$2,530	20	42
Other	Unsp. Hagfish	$1.16	$2,374	21	123
Groundfish	Yellowtail Rockfish	$0.31	$2,221	22	209
Salmon	Chum Salmon	$0.84	$2,169	23	153
Groundfish	Lingcod	$1.30	$1,919	24	112
Groundfish	Nom. Shortspine Thornyhead	$5.12	$1,773	25	23

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 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.

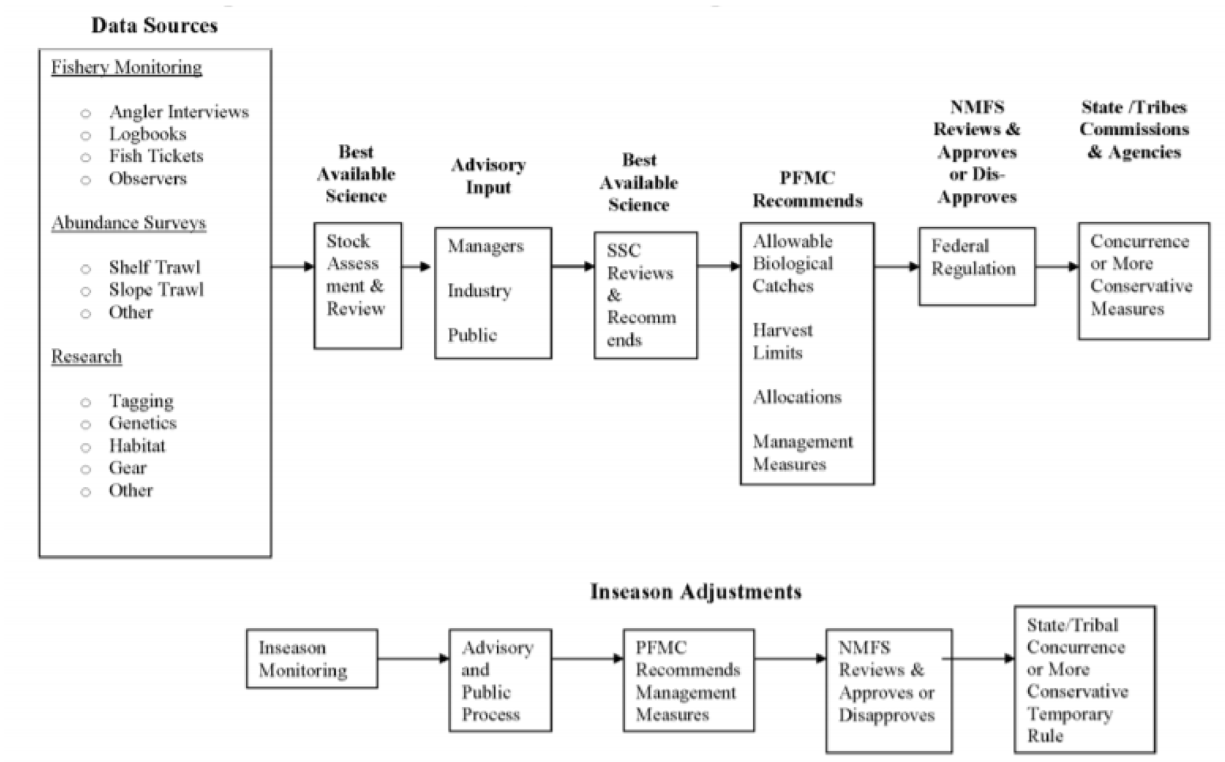

Figure 3-20. State/Tribal/Federal management process overview.

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 first 20 years of council management was a period of development and maturation of management frameworks, particularly including efforts to "Americanize" the fisheries occurring within the EEZ. The Council adopted fishery management plans for salmon (1978), groundfish (1982), and northern anchovy (1978). The Council also assumed a role in allocating the West Coast catch limit for Pacific halibut, established through an international body, the International Pacific Halibut Commission. Procedures to periodically adjust catch levels in relation to stock status were established under both the Salmon and Groundfish FMPs during this period. One of the objectives of the 1976 Act was to shift harvests in the EEZ from foreign to domestic vessels. Off the West Coast, this meant domestication of the large trawl fishery for Pacific whiting and other groundfish species, with all foreign fishing ending in the early 1990s. Full domestic management fostered a realization that many stocks were fully utilized, or had been overexploited by the offshore foreign fisheries of the mid-century. For groundfish fisheries, full utilization sparked a call in the late 1980s for a federal limited access permit program, ultimately adopted in 1992. Beginning in the late 1980s, the listing of salmon stocks under the ESA also necessitated increasingly precautionary management, accompanied by a steady long-term decline in catch.

The 1996 Sustainable Fisheries Act, one of a series of amendments and reauthorizations to the original MSA, ushered in an era of more precautionary management. The SFA triggered a more robust framework for determining stock status, ending overfishing, rebuilding overfished stocks, minimizing bycatch, and taking into account the effects of fisheries management on fishing communities. Another new provision directed Councils to identify essential fish habitat for federally managed stocks and to consider measures to reduce the effects of fishing on such habitat. Playing out over the subsequent decade, these provisions ushered in substantial changes in management to deal with newly declared overfished stocks and consideration of a broader range of environmental concerns.

In 1998, the Council expanded its northern anchovy FMP to become the more broad Coastal Pelagic Species FMP, which includes Pacific sardine, market squid, and other, similar species. This expansion of federal authority over new coastal species marked a steady increase in Council interest in a variety of species and issues. The Council developed a highly migratory species (HMS) FMP to address West Coast EEZ harvest of a suite of internationally-managed tuna and shark species, adopting that FMP in 2004. The Council's groundfish management efforts have increased significantly since the turn of the 21st century to include strict new overfished species rebuilding and bycatch minimization measures and a variety of catch share programs and related requirements.

In the most recent decade, the Council has implemented a prohibition on krill harvest through the CPS FMP (2009), a rationalization and full retention program for the groundfish fisheries (2010 and beyond), and has grappled with multiple salmon fisheries disasters resulting from climate variability and change (2010 and each year in 2013-present). Conservation restrictions implemented by the Council, NMFS, the states and tribes over 1999-2019 have resulted in the successful rebuilding of West Coast groundfish species. The breadth of issues considered by the Council has continued to expand along with the desire to take a more holistic view of fishery management signaled by the adoption of this FEP in 2013. While the FEP does not directly trigger management actions, the regular status reporting and topic specific initiatives resulting from it encourage the Council to widen its view of the effects of its fishery management actions. The FEP also served as a platform for developing ecosystem based management measures implemented in the FMPs, including the coastwide prohibition on the development of fisheries for unfished forage species implemented in 2016 (see Section 2.2).

3.5.2 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 2021.

3.5.2.1 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 CCE. These ecosystem conservation principles ensure that fisheries will not develop that could put krill stocks and the other living marine resources that depend on krill at risk. [HMS, groundfish, salmon, CPS, marine mammals, birds]
2. Conservative and Ecologically Driven 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, as well as the inherent variability in their population levels resulting from prevalent ocean conditions. The CPS FMP specifically included ecosystem considerations as part of the OY considerations built into the harvest control rules, stating that further ecosystem needs can be considered when setting annual catch limits, targets or guidelines. 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 control rules in the FMP, favors maximizing biomass over maximizing catch. Because of this, the harvest levels that result from the rule and which are used for annual management never exceed 12 percent of the estimated biomass for that year.

The Council frequently reviews new science in support of stock assessments and management strategies, and conducts stock assessments annually or biennially for Pacific sardine and Pacific mackerel, respectively, due to fishery interest and harvest and the annual variability that can occur in the biomass of CPS. For other CPS finfish stocks that are not subject to intense fishery interest or harvest and therefore not assessed frequently, the ABC control rule consists of a 75 percent reduction from the stock's overfishing limit. This precautionary management approach for these stocks accounts for variability in population biomass for these stocks over time. [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 conditions. The existing environmental parameter is one of the Council's priority research needs. 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 the ongoing work examining their potential effects on CPS stocks. [CPS]

4. Cutoff Parameters: HCRs for Pacific sardine and Pacific mackerel have long used "Cutoff" parameters to protect a core spawning population and to 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 serves to preserve a spawning stock size and is part of the Council's conservative management approach. For Pacific sardine, the Cutoff value is 150,000 mt or three times the overfished threshold and for Pacific mackerel, the Cutoff value set at the overfished threshold is 18,200 mt. [HMS, groundfish, salmon, CPS, marine mammals, birds]
5. 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. Defining EFH in this dynamic way, based on changes in the ecosystem itself over time, is by definition a form of ecosystem-based management. [CPS] Although the CPS FMP does not identify or apply management measures to mitigate fishing gear impacts to CPS EFH, NMFS is required to conduct consultations on any Federal activities that may adversely affect CPS EFH, as well as any other Pacific Coast EFH.
6. Ecosystem Component (EC) Species: The CPS FMP incorporates Pacific herring, jacksmelt, and a suite of lower trophic level species shared across all FMPs (Shared EC Species). Of these shared EC species, bycatch and incidental catch of jacksmelt in addition to Pacific herring in CPS fisheries is specifically monitored and reported along with all other non-EC species bycatch/incidental catch annually in the CPS SAFE document.
7. Bycatch provisions: Incidental catch provisions are often included in annual management recommendations. These provisions include small allowances of incidental catch of specific CPS species for which the directed fishery may be closed, and in other CPS and non-CPS fisheries to prevent and reduce discard. Salmon species may not be retained in non-tribal CPS directed fisheries and to the extent practicable must be released immediately with a minimum of injury.

Pacific halibut may not be retained in non-tribal CPS directed fisheries. [CPS, salmon, Pacific halibut]

8. 8. 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]

3.5.2.2 Groundfish FMP

1) EFH Conservation Areas: extensive, coastwide, long-term closed areas to protect groundfish EFH from bottom contact gear, particularly in rocky reef areas; extensive, coastwide, long-term closed area to freeze the footprint of West Coast trawl gear use to inshore of 700 fm depth contour. [Groundfish, salmon (particularly Chinook), marine mammals, seabirds]
2) 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, 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, had been set to 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. In 2017 incidental catches of shortbelly reached unprecedented levels beginning in 2017 based on a boom and shift north in the population. In June 2020, the Council recommended designating the stock as an EC species while identifying a clear trigger for revisiting the need for active bycatch management [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 require fishery participants in non-maximized retention fisheries to sort catch, both at-sea discard and landings, by FMP species or grouping as appropriate, ensuring continued high quality, long-term data on the hugely varied groundfish species catch, discards at sea, 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]

3.5.2.3 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]

3.5.2.4 Salmon FMP

1) FMP designates EFH from the ocean extent of the EEZ to the shore, and inland up to all freshwater bodies occupied or historically accessible to salmon in Washington, Oregon, Idaho, and California, with exceptions for dammed streams, recognizing the long-term potential for managed stocks to recover in historically-used areas. [Salmon, and in marine waters, groundfish and CPS where EFH for those species intersects with salmon EFH]
2) Yelloweye 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]

3.5.3 CCE Species Managed Under the ESA, MMPA, and MBTA

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, states' and tribes' science and 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.

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, while the eastern DPS has been recovered and removed from ESA listing (78 FR 66140, November 3, 2013).

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 3-6, 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 3-6. 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

Species		Status
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
	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 3-7:

Table 3-7. 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

Species	Stocks
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.)

Add table for MBTA species – see environmental assessment for Comprehensive Ecosystem-Based Amendment 1.

3.5.4 Tribal and State Fisheries Management

Suggestion for updated Tribal section:

- 3.5.x.1 Overview of Tribal Fisheries and Management - intro paragraph and a map
- 3.5.x.2 Oregon and Washington Treaty Tribes
- Keep the existing text, update catch and gear data

- 3.5.x.3 Non-Treaty Tribes - expand on this to cover all non-treaty tribes who are affected by Council decisions
- Currently only covers CA tribes (currently just the two Klamath tribes) - keep this information and update
- Add in information on OR and WA nontreaty tribes

3.5.4.1 Northwest Tribes' Fisheries Management (**2013 FEP**)

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 3-8). 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 3-8. 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

3.5.4.2 California Tribes in the Council Process (**2013 FEP**)

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.

3.5.4.3 Washington Fisheries Management

Legislative Mandate and Management Areas

WDFW was created in 1994 when the Washington State Legislature merged the Department of Wildlife wand the Department of Fisheries. WDFW's mandate is 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:

- 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.

In furtherance of this mission, WDFW identifies a set of Conservation Principles intended to advance ecosystem-based management through cross-disciplinary and collaborative work that embraces science, adaptive management, and integrates ecological, social, economic, and institutional perspectives into agency decision making (WDFW 2019). The goal of the Conservation Principles is "conservation by managing, protecting, and restoring ecosystems for the long term benefit of people, and for fish wildlife, and their habitat." WDFW is also currently crafting a 25-Year Strategic Plan to address the challenge of achieve its mission under a growing population, a changing climate, and changing public values and expectations in the state (WDFW 2020a).

WDFW divides management of coastal fisheries from those occurring 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.

WDFW's Council-related activities focus mainly on the coastal region, although 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 2020b).

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.

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 C-3012 – Forage Fish Management Policy, Goals and Plan
- Policy C-3601 – Management Policy for Pacific Halibut
- Policy C-3611 – Marine Fish Culture
- Policy C-3613 – Marine Protected Areas
- Policy C-3619 – Hatchery and Fishery Reform

The full set of policies can be viewed and tracked on the WFWC website (WDFW 2020b). The Hatchery and Fishery Reform policy (C-3619) is one of note that is currently under review and considered for revision by the WFWC.

3.5.4.4 Oregon Fisheries Management

Oregon fisheries management is guided by policies established by the Oregon Legislature (Oregon Revised Statutes, ORS), as well as codes and regulations established by the Oregon Fish and Wildlife Commission (Oregon Administrative Rules, OARs). In addition to ORS and OARs, there are several other policies that guide Oregon's fisheries management.

Under the Oregon Wildlife Policy (1973) (ORS §496.012) wildlife shall be managed to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of Oregon. This policy designates the State Fish and Wildlife Commission to represent the public interest of the State of Oregon. The seven 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, as is biotoxin monitoring and related public health regulations. The Commission adopts federal fishery regulations by reference to be consistent with federal guidelines.

Oregon's statutory Food Fish Management Policy (1975) (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 in all suitable waters of the state and prevent the extinction of any indigenous species.

- Develop and manage the lands and waters of this state in a manner that will 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 of the state and the food fish resources thereon.
- Regulate food fish populations and the utilization and public enjoyment of food fish in a manner that is compatible with other uses of the lands and waters of the state and provides optimum commercial and public recreational benefits.
- Preserve the economic contribution of the sport and commercial fishing industries, in a manner 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 Native Fish Conservation Policy (2003) (OAR 635-007-0502 through 635-007-0509) aims to provide a basis for managing hatcheries, fisheries, habitat, predators, competitors, and pathogens in balance with sustainable production of naturally produced native fish. The policy has three areas of emphasis. The first is defensive to ensure the avoidance of serious depletion of native fish. The second is more proactive to restore and maintain native fish at levels providing ecological and societal benefits. The third ensures that, consistent with native fish conservation, opportunities for fisheries and other societal resource uses are not unnecessarily constrained. This approach allows Oregon to play a vital role in the recovery of ESA-listed species and the prevention of future listings. Under the umbrella of the Native Fish Conservation Policy is the Marine Fisheries Management Plan Framework (Framework) (2015). The Framework is intended to provide resource managers with a consistent approach for evaluating the marine component of our resources. The Framework guides the development of balanced Marine Fisheries Management Plans (MFMPs) intended to optimize commercial fisheries, recreational fisheries, new fisheries, and other harvest of marine resources while maintaining ecosystem integrity. The Framework establishes the goals and the scope of marine fishery resources for which state MFMPs should be developed. It articulates the policies and guidelines applied by the Oregon Department of Fish and Wildlife (ODFW) in the management of marine fisheries. Lastly, the Framework places MFMPs into the context of existing international, federal and state fisheries management and summarizes the entities, principles, and processes involved. Current completed MFMPs include the Forage Fish and Pink Shrimp Fishery Management Plans. The Forage Fish MFMP specifically, complements federal management efforts by incorporating policies to protect specific assemblages of forage fish identified in Pacific Fishery Management Council's Comprehensive Ecosystem-Based Amendment 1.

The Oregon Conservation Strategy represents Oregon's first overarching state strategy for conserving fish and wildlife. It uses the best available science to create a broad vision and conceptual framework for long-term conservation of Oregon's native fish and wildlife, as well as various invertebrates, plants, and algae. The Conservation Strategy emphasizes proactively conserving declining species and habitats to reduce the possibility of future federal or state listings. This strategy builds on regulatory efforts to provide a framework for a cohesive, statewide, nonregulatory approach to habitat and species conservation. Implementation requires coordination among the state and federal agencies that implement existing regulations, and among a variety of groups that implement plans. The Nearshore Strategy, is a component of the Oregon Conservation Strategy and focuses on nearshore marine fish and wildlife for Oregon's territorial sea (0-3 nm offshore). Its purpose is to promote actions that will conserve ecological functions and nearshore marine resources to provide long-term ecological, economic and social benefits for current and future generations of Oregonians. 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.

Under the ODFW purview is the 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.

Through the Oregon Legislative process, came the authorized establishment of Oregon's five no-take marine reserves and associated marine protected areas (ORS §196.540 through §196.555 and Oregon Senate Bill 1510 (2012)). To implement these marine reserves, rule-making authorities of ODFW, Oregon Department of State Lands, and the Oregon Parks and Recreation Department coordinated regulatory and management efforts. 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. Not only does ODFW have the authority to regulate fishing activities in the reserves, but ODFW's Marine Reserves Program is responsible for overseeing the management and scientific monitoring of Oregon's system of marine reserves.

The Federal Coastal Zone Management Act provides the Oregon Department of Land Conservation and Development (DLCD) with authority to review various Federal actions in or affecting the state's coastal zone for consistency with enforceable state policies. Oregon has a networked coastal zone program; enforceable coastal zone policies are drawn from the statutes and regulations of Oregon state agencies with jurisdiction over activities in the coastal zone. ODFW's Wildlife Policy and Food Fish Management Policy, among others, are part of the state's enforceable policies under the Coastal Zone Management Act. DLCD reviews various NMFS regulations, including those recommended by the Council, for federal consistency. DLCD also manages the Oregon Territorial Sea Plan (1994), designed to guide how Oregon implements its statewide planning goals 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. State agencies with jurisdiction over ocean activities implement policies in the Plan under their own regulatory and management programs.

Lastly, the Climate and Ocean Change Policy (2020) (635–900–0001) is the framework under which ODFW will evaluate the impacts of climate change on the resources under its stewardship, adopt management practices to safeguard those resources, and minimize the impacts to communities that depend on these resources. Oregon is already experiencing changes that are consistent with changes observed and projected globally, such as increased average air and water temperatures, disrupted precipitation patterns, and increased ocean acidification and hypoxia. The purpose of this policy is to ensure that ODFW prepares for and responds appropriately to the impacts of a changing climate and ocean on fish, wildlife, their habitats, and their use and enjoyment by current and future Oregonians.

3.5.4.5 California Fisheries Management

California fisheries management is guided by laws established by the California Legislature in the Fish and Game Code as well as Public Resources Code. The Legislature also delegates some authority to the Fish and Game Commission (FGC,) which establishes regulations in Title 14, California Code of Regulations. Established in 1870, The FGC is the oldest conservation agency in the United States, predating even the U.S. Commission of Fish and Fisheries. The FGC is comprised of five commissioners appointed by the governor and confirmed by the Senate. The full FGC regularly meets six 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. Within the California Natural Resources Agency, the California Department of Fish and Wildlife (CDFW) is the lead agency charged with implementing laws and regulations and ensuring sustainable use of fish and wildlife.

The California Marine Life Management Act (MLMA) of 1998 is California's primary fisheries management law. It introduced a new paradigm in the management and conservation of California's living marine 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 FGC and 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 for needed action towards initially demonstrating that fisheries and other activities are sustainable, rather than requiring demonstration of harm to initiate action.
- Encouraging an ecosystem-based approach to management rather than focusing on single fisheries, and the development of Fishery Management Plans (FMPs) as the framework for management—initially specifying development of FMPs for the nearshore fishery and white seabass.
- 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.

The MLMA directs CDFW to develop a Master Plan to guide its implementation. The original Master Plan, adopted in 2001, was updated in 2018 to reflect new priorities and emerging management strategies for achieving the MLMA's goals, and to better describe CDFW's inclusion of MLMA principles in management decisions (CDFW 2018). The 2018 Master Plan is both a roadmap and a toolbox for implementation, providing guidance and direction in the following areas:

- Prioritization of management efforts - The Master Plan includes an interim list of prioritized species for management action and describes a more comprehensive approach to prioritization within a framework for MLMA-based management.
- Meeting stock sustainability objectives – The Master Plan identifies tools and approaches available to help consider and identify the most appropriate management strategies for achieving sustainability.
- Meeting ecosystem objectives - The Master Plan provides a stepwise approach to consider and address these issues.
- Integrating marine protected areas (MPAs) into fisheries management – Consistent with California's Marine Life Protection Act of 1999, the Master Plan provides information to consider to account for MPAs when attempting to meet stock and ecosystem-related objectives.

- Adapting to climate change – The Master Plan identifies that climate change needs to be factored into species prioritization, scaled management, identification of appropriate management strategies, adaptive management structures, and understanding the effects of management on fishery economics and communities.
- Engaging stakeholders and collaborating with partners - The Master Plan provides guidance on considering and crafting potential public engagement and identifies a range of areas where collaboration may be beneficial and the conditions necessary to ensure collaborations are effective.
- Advancing socioeconomic and community objectives - The Master Plan describes key socioeconomic questions and identifies strategies for obtaining related information as part of Master Plan implementation.
- Making management adaptive - The Master Plan identifies a range of structures, strategies, and recommendations for meeting the MLMA's adaptive management policy.
- Using the best available scientific information - The Master Plan identifies tiers of potential scientific review and considerations for identifying when each may be appropriate.
- Enhancing and scaling MLMA-based management - While FMPs remain an important tool for achieving the objectives of the MLMA, other tools such as Enhanced Status Reports (ESRs), targeted rulemakings, and more streamlined FMPs can also be used. The Master Plan describes a continuum of management to make more efficient and effective use of available tools and resources to implement the MLMA across a wider range of California's fisheries.

Ensuring the Master Plan is an effective resource and guide - The Master Plan describes the use of a new, online, publicly-accessible and user-friendly "living" library for California's state-managed fisheries information and the policies and tools of the Master Plan called the California Marine Species Portal. The goal is to organize and share the considerable research and management efforts of the Department and its partners, provide management resources and tools, and implement the new strategies described in the Master Plan.

3.5.4.6 Idaho Fisheries Management

Idaho formerly contained some of the Columbia River basin's most productive habitats for anadromous fishes, although it is landlocked (Mallet 1974; Waples et al 1991). Most of the watershed of the Snake River, the Columbia River's largest tributary, lies in Idaho. Anadromous fishes found in Idaho include Chinook Salmon (spring, summer, and fall runs), steelhead, sockeye salmon, coho salmon, Pacific lamprey, and white sturgeon. Dam building, overfishing, and habitat destruction have taken their toll on these fish populations. The Snake River fall Chinook run was about 72,000 in the 1940s and about 29,000 in the 1950s. 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). Further declines followed construction of hydroelectric dams in the Snake and Columbia rivers, although considerable high quality spawning and rearing habitat remains in Idaho. Coho salmon were declared extirpated in 1986. Sockeye salmon were listed as endangered under the Endangered Species Act in 1991, followed by listings of threatened for Chinook salmon (1992) and steelhead (1997). These listings have prompted a number of management initiatives that affect Idaho and Columbia River fisheries.

Current anadromous fish management programs in Idaho (IDFG 2019) include hatchery programs intended to mitigate for dam construction, habitat restoration, and management of fisheries to minimize risk to ESA-listed fish. Idaho also works collaboratively with federal regulatory agencies, tribes, and other states to seek management of rivers to improve migratory conditions. Idaho hatcheries support fisheries within Idaho and downstream to the mouth of the Columbia River. The Nez Perce Tribe reintroduced coho salmon to Idaho in 1995, accompanied more recently by translocated adult lamprey into selected Idaho streams. Over 50% of Idaho's streams inhabited by salmon and steelhead are located within roadless areas, designated wilderness, or Wild and Scenic Rivers; therefore, habitat restoration has focused on selected areas impacted by agricultural or forestry practices.

Annual abundance of anadromous fishes in Idaho during recent years varies widely due to a combination of ocean and migratory conditions. Runs of naturally reproducing salmon and steelhead in Idaho have generally improved since historic low abundances experienced in the mid-1990s, but they are still much lower than the 1960s and early 1970s. In the last 20 years, most hatchery programs in Idaho have matured in terms of their smolt releases. However, programs for fall Chinook, coho, and sockeye have begun producing larger returns. For all species, abundance has been dominated by returns of hatchery fish, which typically compose >75% of the run.

Anadromous fisheries in Idaho have similarly fluctuated in recent years. 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. The Nez Perce and Shoshone-Bannock tribes also pursue these anadromous fishes within Idaho. With the exceptions of fall Chinook and coho salmon, sport fisheries are mark-selective; only fish without adipose fish may be harvested in Idaho sport fisheries. Tribal fisheries are not mark-selective. After accounting for the number of spawners needed to fully seed hatcheries, the surplus production is allocated equally between sport and tribal fisheries. Steelhead are typically the most abundant anadromous fish and are usually more stable in their abundance. There have been peaks in the 2001-2002, 2009-2010, and 2014-2015 run years. 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. Reaches open to fishing include the Snake River downstream of Hells Canyon Dam, the main stems of the Clearwater and Salmon Rivers and a few selected tributaries. Statewide harvest has been >40,000 fish during 2001-2016. Beginning in 2017, harvest opportunities have been curtailed as run sizes have dropped precipitously.

Spring/summer Chinook are the next most abundant but are more variable than steelhead. There have been peaks in 2001, 2010, and 2015. Spring and summer Chinook from Idaho are rarely harvested in the CCE but are the focus of extensive fisheries from the Columbia River mouth and upstream. In Idaho, continuous reaches are open to fishing in the Snake River downstream of Hells Canyon, the Clearwater River, and its major tributaries, the South Fork Clearwater, North Fork Clearwater, Middle Fork Clearwater and Lochsa Rivers, because of the absence of ESA-listed fish. In the Salmon River drainage, fisheries are more restrictive to minimize impacts to ESA-listed fish. Portions of the Little Salmon and South Fork Salmon Rivers have been open to fishing. As abundances increased after 2001, portions of the lower and upper Salmon River have opened as well. Peak statewide harvest was >40,000 fish in 2001; however, in some recent years harvest has been less than 1,000 fish.

Fall Chinook in the Snake River have increased after 2006. There have been peaks in 2010 and 2014. 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). In Idaho, fisheries targeting fall Chinook salmon have occurred annually since 2013. Fisheries have been held in the mainstem Clearwater, Snake, and lower Salmon rivers with a total of 176 km of river open to fishing from September 1 through October 31 each year. A small section of the Snake River near Hells Canyon Dam remains open each year until mid-November. Annual harvest from 2013-2019 averaged 1,161 (range 470-2,700) and anglers spent an average of 75,597 hours (range 40,974 – 119,868) fishing for fall Chinook salmon. In 2019, approval of the Fisheries Management and Evaluation Plan (FMEP) for fall Chinook salmon by the National Marine Fisheries Service (NMFS) allowed the harvest of unclipped adult fall Chinook and additional areas were opened to fishing, bringing the number of river kilometers open to fishing up to 313 km.

Coho salmon in the Snake River have also increased after 2006. More than 5,000 adults have passed Lower Granite Dam in 2011, 2014, 2017, and 2019. Coho salmon seasons have been intermittent but have occurred in 2014, 2017, and 2019. Coho fishing has been open in the mainstem Clearwater and North Fork Clearwater rivers. Seasons typically open in early October and usually last into mid-November. Annual coho harvest ranged from 26 to 150 fish and anglers spent an average of 14,365 hours (range 3,317 – 27,130) fishing for coho.

White sturgeon maintain landlocked populations in the Snake River downstream of Shoshone Falls and the Kootenai River. The Kootenai population is protected as endangered under the ESA. Two reaches of the Snake River maintain viable naturally reproducing populations: Bliss Dam to C.J. Strike Reservoir and Hells Canyon Dam to the Lower Granite Dam Reservoir. Sturgeon have been introduced in the Snake River above Shoshone Falls upstream to the city of Idaho Falls. The Snake River in Idaho waters supports a catch-and-release fishery with conservative regulations.

Anadromous fisheries are important to Idaho. Salmon and steelhead fisheries generate well over $100 million in spending in good years. Much of the spending occurs in rural areas of the state, where it can be significantly beneficial to local economies. The 2001 Chinook fishery, which was an exceptional return year, generated an estimated $90 million in a period of weeks. The City of Riggins received an estimated $10 million in spending, which comprised about 25% of the total spending in Riggins that year. According to a 2011 survey, anadromous fisheries can generate over $5 million in state and local tax revenue. These fiscal metrics illustrate that salmon and steelhead fisheries are consequential to the economic and social well-being of Idaho communities.

3.5.5 Multi-State, Multi-Tribe, and State-Tribe Entities

to be drafted

3.5.6 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 in 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.

Bilateral entities and agreements:

- International Pacific Halibut Commission, implementing the Pacific Halibut Convention between the U.S. and Canada;
- Pacific Salmon Commission, implementing the Pacific Salmon Convention between the U.S. and Canada;
- Agreement between the Government of the United States of America and the Government of Canada on Pacific Hake/Whiting;
- Treaty between the Government of Canada and the Government of the United States of America on Pacific Coast Albacore Tuna Vessels and Port Privileges.

Multilateral entities and conventions:

- North Pacific Anadromous Fish Commission, implementing the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean (Canada, Japan, Russia, and the U.S.);

- Inter-American Tropical Tuna Commission, implementing the Convention for the Establishment of an Inter-American Tropical Tuna Commission and the Antigua Convention (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, with the Cook Islands as a Cooperating Non-Member);
- Western and Central Pacific Fisheries Commission, implementing the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the western and central Pacific Ocean (Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Japan, Kiribati, Korea, Republic of 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, with Belize, Indonesia, Panama, Senegal, Mexico, El Salvador, Ecuador, Thailand, and Vietnam are Cooperating Non-members);
- North Pacific Fisheries Commission, implementing the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean (Canada, China, Chinese Taipei, Japan, South Korea, Russia, the U.S. and Vanuatu, with Panama as a Cooperating Non-member);
- North Pacific Marine Science Organization, implementing the Convention for a North Pacific Marine Science Organization (Canada, Japan, China, South Korea, Russia, and the U.S.);
- International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, scientific initiative to support international HMS management (Canada, China, Chinese Taipei, Japan, South Korea, Mexico, and the U.S.);
- Tri-National Sardine and Small Pelagics Forum, scientific initiative for ecosystem-wide stock assessments (Canada, Mexico, and the U.S.).

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Chapter 4 Environmental Change, Human Activities, and Social-Ecological Dynamics in the California Current Ecosystem Overview

This chapter broadly examines how human and environmental forces interact to affect living marine resources and fisheries communities. For those effects that can be addressed by fishery management measures, the Council can consider, improve and integrate the information that supports decision-making across its FMPs. Ultimately, the Council could use this FEP chapter to inform fishery management measures that help buffer against uncertainties resulting from those effects, and that support greater long-term stability within the California Current and for its fishing communities.

Chapter 4 builds on Chapter 3, considering the complex interactions within the California Current social-ecological system, including the physical environment, biological environment, and the social and economic environment. Chapter 4 examines the interacting effects of human and environmental forces through the lens of the FEP's Goals and Objectives, provided in Chapter 1. As detailed in Table 4.1, below, Sections 4.1 through 4.6 discuss the major components of the CCE interactions and their influences on each other in the same order as they were addressed in Chapter 3, from the physical environment, then the biological environment from lowest trophic levels to highest, to the social and economic environment, and then to the Council's administrative processes within the fisheries regulatory regime.

Table 4-1. Cross-referencing Sections 4.1-4.6 to FEP Goals.

Chapter 4 Section	FEP Goal
Section 4.1, Effects of Climate Variability and Change on the CCE (physical ocean processes and environment)	Goal 6: Promote fishery management that is sufficiently adaptive to account for the effects of climate variability and change, ocean acidification, marine heat waves, harmful algal blooms, and hypoxia.
Section 4.2, Shifts in Species' Abundance and Distribution and their Ecological Relationships (fish stocks, biological environment)	Goal 2: Conserve and manage species' populations and the ecological relationships among them to realize long-term benefits from marine fisheries while avoiding irreversible or long-term adverse effects on fishery resources and the marine environment.
Section 4.3, Effects of Human Activities on Marine Habitats (physical environment and habitat)	Goal 4: Protect and restore marine habitat diversity and integrity to the extent practicable
Section 4.4, Interactions between Fisheries and Protected Species (protected species, biological environment)	Goal 5: Manage fisheries to support goals for protected species' recovery
Section 4.5, Effects of Fisheries Management on Ecosystem Services and the Well-being of West Coast Communities (communities, social and economic environment)	Goal 3: Implement fisheries management that ensures continued ecosystem services for the wellbeing of West Coast communities and the nation.

Chapter 4 Section	FEP Goal
Section 4.6, Framework and Public Forum for Ecosystem Information used in Council Decision-Making (fisheries management process)	Goal 1: Provide a framework and public forum to improve and integrate ecosystem information for use in Council decision-making

4.1 Effects of Climate Variability and Change on the CCE

The Council's interest in our changing environment is articulated in FEP Goal 6: *Promote fishery management that is sufficiently adaptive to account for the effects of climate variability and change, ocean acidification, marine heat waves, harmful algal blooms, and hypoxia.* Climate variability and change are affecting marine ecosystems, often in unpredictable ways (Checkley Jr. et al. 2017). Novel ocean conditions can bring new species (Jacox et al. 2020), new risks (Santora et al. 2020), and new opportunities (Smith et al. 2019) to the ecosystem. General, trends of increasing warming, acidification, and hypoxia may cause increased synchrony in the dynamics of individual populations and entire communities, challenging the ability of species and fisheries to track and take advantage of these changes (Abrahms et al. 2020). Consistent monitoring of and reporting on these trends will help the Council to meet FEP Objective 6a: *Improve monitoring of the ecosystem and climate variability.*

Average sea surface temperature in the CCE is predicted to increase by 0.36 °C per decade in the 21st century, with the greatest increase occurring in summer and a slight shift in the seasonal warming cycle to later in the year. By 2040, annual average sea surface temperatures in the CCE are predicted to exceed even the warmest year during the 1976-2005 almost two-thirds of the time. Water temperature along the west coast of North America displayed the highest 3-year average on record between 2014 and 2016 (Jacox et al. 2018), and conditions similar to the recent "marine heatwaves" (MHW) will become increasingly common in ensuing decades (Jacox et al. 2020).

The CCE is also experiencing ocean acidification more rapidly than the global average, with the nearshore and northern/central regions experiencing the most severe and persistent acidification. (Feely et al 2008; Osborne et al 2020). Direct effects of warming and ocean acidification on living habitats (see Section 4.3) used by Council-managed species, especially in their early life histories, may indirectly modify expectations for stock-recruitment functions.

Levels of oxygen throughout the water column are projected to decline further from current levels, and hypoxia is a growing concern in parts of the CCE. Ocean warming, increased upwelling of nutrient rich, low oxygen deep waters (particularly in the northern California Current), and increased stratification can all have synergistic effects (Christian and Ono 2019, and references therein). Hypoxic and anoxic conditions may affect the catchability of target species directly, with influences on catch per unit effort and the potential for local depletion.

These physical and biogeochemical changes, and others, will produce direct and indirect effects on species and food webs in the CCE (Ainsworth et al. 2010, Marshall et al. 2017). For example, warming events that directly benefit harmful algae will indirectly elevate the mortality rates of marine mammals like pinnipeds that bioaccumulate the biotoxins in their prey. This food web impact could cause consequent reductions in mammal predation rates on Council-managed species, at the least in the short term. In contrast, accumulation of warmer onshore water masses may directly influence the movement of highly migratory species, increasing their availability to fisheries in the CCE. Tracking species' productivity and distribution responses to environmental shifts and expanding scientific work on food webs address aspects of Objectives 6b and 6c, respectively*: Incorporate climate and ecosystem data into* *stock assessments and forecasts when applicable*; and *Assess the effects of climate variability and change on the ecosystem's long term stability and recommend research needed to understand the effects of potential shifts in species' abundance and distribution*.

It is important to note that ecosystem responses to warming may be nuanced and unexpected (Checkely et al. 2016). The surge of anchovy throughout the CCE during the 2014-2016 MHW is a prime example. Anchovy were previously believed to thrive under cold conditions (Chavez et al. 2003, Siple et al. 2020), but this species displayed very high recruitment in 2015 and had historically high spawning stock biomass by 2018 (Thompson et al. 2019). The high anchovy biomass resonated throughout the ecosystem, with increased survival and reproduction of marine predators that are capable of feeding on anchovy (e.g., sea lions). Similarly, recruitment of several rockfishes was historically high during the MHW even though recruitment had been historically low under warm conditions (Schroeder et al. 2018). Our understanding of species' responses to MHW conditions is evolving, and the Council will need multiple avenues, including stock assessments (Objective 6b) for learning about how the ecosystem is affected by novel environmental conditions and anticipating future responses.

Climate-driven shifts in marine species distribution (Objective 6c) are increasingly documented worldwide and are mainly attributed to changes in temperature, oxygen, and food availability (Pinsky et al. 2020). These shifts are often manifested as a poleward expansion in a species' range, a latitudinal change in a population's mean location, or movement to offshore or inshore regions. In the CCE, several studies have documented or developed projections of changes in species' spatial distributions in response to climate variability (e.g. sardines, Tommasi et al. 2016; Pacific whiting, Malick et al. 2019, 2020; salmon, Shelton et al. 2020; groundfish, Pinsky et al. 2013, Thorson et al. 2016, Morley et al. 2018), although to date this work has been limited to a small suite of stocks. Less is known about how marine fauna and fishery resources will respond to long-term directional changes in climate and ocean conditions (see Hazen et al. 2013, Samhouri et al. 2014), although the growing number of studies elucidating the impacts of the 2014-2016 marine heatwave on the CCE can help advance our understanding (Santora et al. 2017, Brodeur et al. 2019a,b, Sanford et al. 2019, Santora et al. 2020, Thompson 2019, 2021). There are likely to be commercially fished species spending less time within the CCE but also new species that may interact with existing fisheries or provide new fishing opportunities in the future (Pinsky et al. 2020). To meet the objectives of FEP Goal 6, we will also need to consider climate-ready management approaches (Pinsky and Mantua 2014, Holsman et al. 2017) to adapt to both extreme events and long-term changes in the CCE. Climate vulnerability assessments provide an expert-based approach to identify species, populations, and fishing communities most at risk from climate variability and change (Hare et al. 2016, Coburn et al. 2016, Crozier et al. 2019). A number of climate informed MSEs are underway, including for sablefish (Haltuch et al. 2020) and Pacific whiting (Jacobsen et al. 2020). These approaches use climate variables to inform recruitment estimates for both scenario testing and quota setting, and have been used to develop climate-informed stock assessments (e.g., Tolimieri et al. 2018, Haltuch et al. 2020). Changes in environmental conditions may cause threshold changes in forecast performance for Council-managed salmon (Satterthwaite et al. 2019), and this phenomenon may be common for other Council-managed species and stocks as well.

4.2 Species' Abundance and Distribution and their Ecological Relationships

Goal 2 of this FEP is to: *Conserve and manage species' populations and the ecological relationships among them to realize long-term benefits from marine fisheries while avoiding irreversible or long-term adverse effects on fishery resources and the marine environment.* Population dynamics are driven by changes in four demographic rates: births, deaths, immigration, and emigration. The balance of changes in these rates, and spatiotemporal variation in them, determine local abundance as well as relative abundance through space (distributions). Changes in demographic rates of fished species are affected by at least four major factors: 1) removals by fishing (targeted or incidental catch) and consequent changes in community structure and energy flow/predation within ecosystems; 2) removals or habitat loss from non-fishing activities, often with greater impacts in freshwater, estuarine, and nearshore systems; 3) species interactions (including predation, competition, parasitism, and disease); and 4) 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.

The FEP's Objective 2a calls for us to: *Map trophic energy flows and other ecological interactions within the CCE to better understand trophic relationships and the potential ecosystem effects of fishing, and to understand the effects of trends in marine mammal, seabird, and other protected species' populations and diets on fish stock abundance.* Shifts in species distributions and overlap can lead to reorganizations of ecological communities, resulting in broken and novel interactions (Gilman et al. 2010, Carroll et al. 2020). This can occur regardless of the mechanism driving these shifts, and can cause cascading effects such as changes in predation and competition dynamics, prey switching, and ecological release, which alter the abundance of predator and prey populations (Gilman et al. 2010, Carroll et al. 2020 and references therein) thus impacting fisheries. Ocean acidification can also evoke changes in community structure through direct impacts on calcifying organisms that are sensitive to changes in pH as well as indirect impacts on predator populations that consume those organisms (e.g. demersal fish, sharks, and Dungeness crab) (Marshall et al. 2017, Hodgson et al. 2018). A unifying theme among studies that have examined ecosystem responses to climate and human pressures is that we should not expect ecological communities to remain the same over time and space, but rather anticipate and manage for constant change. This theme implies that the identities of target species in any one location may change, such that some fishing opportunities diminish while others flourish. Nonetheless, to meet FEP Goal 2, it is important that fishing and other human activities occur in a way that does not erode the resilience (i.e., ability to absorb disturbance and reorganize to retain similar structure and functions by persisting through or rebounding from the disturbance) of the CCE overall, and does not result in an undesirable state.

Although climate variability and climate anomalies have had measurable effects on the CCE food web in recent years, historic patterns of fisheries harvest have also triggered ecosystem responses. For example, the Council's 21st century efforts to rebuild the CCE rockfish populations that occupy low trophic levels as juveniles and mid-high trophic levels as adults, has had effects throughout the ecosystem. In the CCE, juvenile rockfishes are a common offshore prey item of common murres; however, when rockfish are less available due to unfavorable ocean conditions, murres forage closer to shore for northern anchovies. This also leads to seabirds consuming higher quantities of the out-migrating juvenile Chinook salmon that also occupy nearshore waters, which in turn significantly affects salmon survival (Wells et al. 2017).

During the 2014-2016 MHW, CCE phytoplankton production was abnormally low and taxa were generally redistributed farther north than usual. Despite generally lower phytoplankton productivity and biomass during the 2015-2016 MHW, diatoms in the genus Pseudo-nitzschia, which releases toxic domoic acid, thrived throughout much of the west coast of North America. (Bates et al. 2018). Zooplankton also responded to warmer CCE waters with decreased abundance and smaller body sizes of common krill species (McClatchie et al. 2016, Brodeur et al. 2019a) and increased abundance of more tropical krill species in the southern CCE (Lavaniegos et al. 2019).

Responses to the MHW were less predictable at higher trophic levels. For example, overall larval abundances of forage fish were very high, the assemblage was largely made up of species that are typically found to the south and offshore, and species such as Pacific sardine (*Sardinops sagax*) were observed for the first time spawning in the winter off Oregon (Auth et al. 2018). Atypically, northern anchovy (E*ngraulis mordax*) (Thompson et al. 2019b) and multiple rockfishes (Schroeder et al. 2018) that previously flourished under cold conditions had extremely high recruitment from 2014-2016, and adult abundances of anchovy rose to record highs in subsequent years (Auth et al. 2018; Thompson et al. 2019b). Although we typically think of increased forage availability as a positive environmental change for higher-order predators, even favorable changes in the environment can bring new challenges for natural resource management. When anchovy and sardine populations are larger, their distribution can be quite different from our more recent experiences with those populations (see section 4.3). These shifts in distribution and abundance of lower trophic level species often lead to shifts in distribution of higher trophic level species, with possible additional effects on timing and location of fisheries' catch and bycatch.

The recent surge in anchovy resonated with multiple marine predators. California sea lions (*Zalophus californianus*) fed copiously on anchovy beginning in 2015 and had much enhanced pup condition from 2015-2018 (Thompson et al. 2019b). Humpback whales (*Megaptera novaeangliae*), were closer to shore than usual, following shifts in anchovy (Santora et al. 2020). Unfortunately, this caused an increase in whale entanglement rates in Dungeness crab (Metacarcinus magister) fishing gear, which resulted in whale mortality and intermittent closures of the fishery (Santora et al. 2020). Catch of Pacific bluefin tuna (*Thunnus orientalis*) by the commercial passenger fleet off California was very high during the MHW while the tuna foraged on anchovy (Runcie et al. 2019).

These shifts in fisheries' timing, location, and bycatch challenges are linked to Objective 2b of the FEP: *Assess variability in fisheries income and vessel participation rates to ascertain whether CCE fishing rates have affected long-term stability and well-being for fishing communities*. Rigorous analysis of the interplay between exploitation rates, changes in stock abundance, and feedback to fishing communities (such as has been conducted for Alaska salmon; Cline et al. 2010) is a monumental task and a clear research and data need (Cline et al. 2017, Anderson et al. 2017, Beaudreau et al. 2019, Schindler et al. 2019). We address fishing community well-being in Section 4.5. and discuss variability in fisheries income and vessel participation rates in Section 3.4. The Council receives regular reporting on fisheries income and vessel participation rates in SAFE documents for each FMP and in the ESR for the combined West Coast fisheries. Through the Council's third ecosystem initiative, the Climate and Communities Initiative, the Council is taking an unusual cross-fishery look at the potential effects of climate variability and change on future fisheries participation and income.

4.1 Human Activities and Marine Habitats

Goal 4 of this FEP addresses marine habitat: *Protect and restore marine habitat diversity and integrity to the extent practicable*. Under the MSA, the Council is responsible for identifying EFH, "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" [16 U.S.C. §1853(a)(7)]. The Council is also responsible for ensuring that its FMP include measures to the effects of fishing on EFH and for identifying other actions that encourage the conservation and enhancement of EFH. With regard to non-fishing activities, the Council may comment on and make "recommendations to the Secretary and any Federal or State agency concerning any activity authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by any Federal or State agency that, in the view of the Council, may affect the habitat, including essential fish habitat, of a fishery resource under its authority," but *must* comment when such activities may affect the habitat of Council-managed anadromous species [16 U.S.C. §1855(b)(3)]. Monitoring and commenting on non-fishing activities that may affect EFH provides a significant workload for the Council's Habitat Committee.

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. 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, Mazor et al. 2021). 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).

In pelagic habitats, compression of the coastal area experiencing upwelling can squeeze much of the primary and secondary productivity closer to shore (Santora et al. 2020). This pelagic habitat compression can concentrate forage species such as sardine and anchovy, as well as their predators -- including protected and target species. During the 2014-16 marine heat wave, onshore habitat compression contributed to the dramatic rise in whale entanglements in fixed-gear fisheries (Santora et al. 2020, Saez et al. 2020). Looking forward, in years when pelagic habitat is more compressed, there may be a higher incidence of bycatch in these and other nearshore fisheries, greater potential to overexploit more concentrated target species (especially forage), and a general crowding of onshore waters with food web and fishing activities. It is important to mention that habitat compression and upwelling intensity are correlated but do not always co-vary.

Many Council-managed species, including but not limited to groundfish, CPS, and salmon, rely upon nearshore living habitats such as kelp and eelgrass during critical portions of their life histories. For example, many juvenile rockfishes and salmon use kelp and eelgrass habitat to find food and shelter, long before they recruit to fisheries. Older and larger rockfishes and many coastal pelagic species (sardines and anchovy) reside or frequent these habitats as well. Giant kelp is subject to commercial harvest in California, and both kelps and eelgrasses are influenced by a variety of coastal activities from development of structures to nutrient pollution. Indeed, these habitats serve as a biophysical bridge between human activities on land and those at sea. Kelps and eelgrass experience strong variation in areal extent and other characteristics, and in some cases are demonstrating long-term, negative trends (e.g., Reed et al. 2016, Harenčár et al. 2018) and responses to environmental perturbations such as marine heat waves and storms (e.g., Reed et al. 2011, Rogers-Bennett et al. 2019). Protection and restoration efforts for these living habitats are ever-evolving, and require an understanding of the role of climate, trophic interactions, fishing, and other human activities to be successful. More generally, these observations about dynamic pelagic and nearshore habitats underscore how a static concept of EFH is fraught; habitats are spatially and temporally dynamic and so protection measures subject to a set-it-and-forget-it approach will miss their mark.

Salmon are tied to their natal rivers; therefore, their distribution is unlikely to change rapidly, although we have seen coastwide reductions in salmon survival and abundance (Cheung and Frohlicher 2020). Salmonid vulnerability to climate change is highest at the margins of their range (southern & central CA, interior stocks; Crozier et al 2019) which may lead to range contraction. Current commercially important salmon stocks in CCE fisheries (coho and ocean-type Chinook) are fall-migrating; therefore, climate variability will most likely affect their juvenile phases. Some stock-specific re-distribution in the ocean is possible as SST changes (Shelton et al 2021 simulations). Other likely effects of climate change on CCE salmon populations include increasing synchrony among stocks (Kilduff et al 2015; Dorner et al 2018), shifts in ocean distributions (Shelton et al. 2021), and potential loss of estuary rearing habitat as a result of sea level rise (Thorne et al 2018). Droughts may increase vulnerability at ocean entry because of reduced river flows (Friedman et al 2019).

When considering the effects of human activities on habitat, an important concern 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. Activities that disturb or kill structure-forming invertebrates or vegetation have the potential to either prevent those species from recovering within the affected area within their mean generation times, or reduce the known distribution of those species. Activities that alter the geological structure of the ocean floor can reduce the usability of those habitats for fish and other marine species. Pelagic species may rely less on particular ocean bottom characteristics and more on water masses that expand and contract and which are defined by characteristics like temperature and current movement. Activities that alter the chemical composition, turbidity, or temperature of seawater (like those that lead to climate change and ocean acidification) such that the habitat cannot recover to its pre-disturbance state affect the usability of the water column itself.

The FEP's Objective 4a is to: *Maintain a diverse portfolio of protected habitat types in a way that meets the needs of the ecosystem and fishing communities*. Taken together, the EFH of Council-managed species ranges from the salmon streams of Idaho to the outer boundary of the U.S. EEZ. 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. To meet Goal 4, the Council can and does implement management measures that protect marine habitat from the effects of fishing gear, but the Council has no direct authority over nonfishing activities, including the many terrestrial activities that affect freshwater and nearshore marine EFH. Of the Council's four FMPs, only the groundfish fisheries use gear that is likely to come into contact with bottom habitat. Gear used in the CPS, HMS, and salmon fisheries is only likely to affect habitat if it is lost or discarded at sea; therefore, the Council focuses its habitat-protection fishery management measures on groundfish fishing gear and fisheries. Fishing gear that is lost at sea, however, may affect marine organisms and habitat (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, Gove et al. 2019). 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).

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. More information on the Council's priorities for federal and state agencies analyzing or permitting non-fishing activities in the California Current Ecosystem can be found in the draft (see EWG Report 2) Pacific Fishery Management Council Guidance on Agency Activities in the California Current Ecosystem. 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.

Table 4-2. 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 Flotsam and Jetsam Sound 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 Dam Construction/Operation Desalination Dredging and Dredged Spoil Disposal Estuarine Alteration Flood Control Maintenance Forestry Grazing Habitat Restoration Projects Irrigation/Water Management Light Pollution Military Exercises Mineral Mining Nonnative Species Introduction/Spread Nutrient Pollution and Eutrophication Pesticide Use Road Building and Maintenance Sand and Gravel Mining Vessel Operation Wastewater/Pollutant Discharge Wetland and Floodplain Alteration Woody Debris/ Structure Removal

The FEP's Objective 4b is to: *Promote awareness of and encourage lost fishing gear recovery projects, the development of fishing gear recovery technology, and fishing gear recycling programs as a means of protecting habitat from derelict fishing gear and ghost fishing*. Since 2005, the California Lost Fishing Gear Recovery Project has encouraged ocean users to report the presence of lost gear, and hires experienced commercial SCUBA divers to remove gear and other marine debris from near-shore waters in a safe and environmentally sensitive manner. The project continues to help reduce the potential impact of lost fishing gear and marine debris on living marine resources and underwater habitat. Other state agencies offer various programs to incentivize removal of lost and abandoned fishing gear from the ocean. The California Department of Fish and Wildlife's (CDFW's) Trap Gear Retrieval Program,the Oregon Department of Fish and Wildlife's (ODFW's) Post-Season Derelict Gear Recovery Program, and the Washington Department of Fish and Wildlife's (WDFW's) Derelict Fishing Gear Removal Project are all examples of comprehensive government programs that encourage locating, reporting, and removing harmful derelict fishing gear from the ocean. The California Fishing Line Recycling Program encourages responsible disposal of fishing line. In recent years, new companies have offered their services for recycling commercial fishing gear, primarily nets (e.g.,Bureo Inc, Net Your Problem LLC, and Skagit River Steel and Recycling).

4.2 Interactions between Fisheries and Protected Species

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? Goal 5 of the FEP is to: *Manage fisheries to support goals for protected species' recovery*. For fisheries management, meeting this goal usually means minimizing the bycatch of protected species. However, the Council has also taken a more ecosystem-based approach to this goal by thinking about the indirect ways to support protected species' recovery such through the management of their prey. An early example of this is the explicit consideration of recovering seabirds, specifically the Brown Pelican, into the management of northern anchovy and then subsequently the other CPS stocks. In recent years the Council has expanded this ecosystem-based approach to this goal by: prohibiting the harvest of krill and unfished forage fish species managing federal groundfish fisheries to minimize the incidental catch of groundfish stocks that serve as forage for protected species, managing federal salmon and groundfish fisheries to minimize the incidental catch of Chinook stocks that serve as forage for endangered Southern Resident Killer Whales, and proposing annual abundance criteria for Chinook salmon below which directed salmon fisheries would implement specific management restrictions for endangered Southern Resident Killer Whales.

The highly dynamic CCE makes sustainable fisheries management challenging, not least because it results in changing geographic distributions of fished species as well as those that are protected from fishing under MSA, ESA, and MMPA. In recent years, Council FMPs have grappled with management decisions related to climatic influences on bycatch of finfish (e.g., of Chinook salmon, shortbelly rockfish) and protected non-fish (e.g., whales) species alike. New disruptions, attributable to climate change, have put a punctuation mark on this challenge. Each of the Council's FMPs and the MSA itself include some variation on FEP Objective 5b: *Manage and minimize bycatch and bycatch mortality of protected species within and across FMPs to the extent practicable*.

The continued recovery of many non-fished protected species suggests that navigating interactions with protected species is likely to be a focal point for sustainable fisheries management on the West Coast for the foreseeable future (Hilborn 2020). Objective 5a of the FEP is to*: Review the status and trends of protected species' populations to facilitate understanding their role in the ecosystem within and across FMPs*. Although the Council is commonly called upon to manage fisheries to minimize interactions with protected species, it is not responsible for reviewing the status and trends of protected species' populations. A regular review of population trends for those species, possibly as a supplement to the ESR, could help keep the Council abreast of potential near-term interactions between fisheries and protected species.

Fisheries have both direct and indirect effects on protected species. Direct effects include those that occur at the same time and place as fishing activities, such as incidental catch or bycatch (Dayton et al. 1995, Savoca et al. 2020). Indirect effects occur when there is some intermediate cause-and-effect between the fishing activity and the actual effect being evaluated, such as reductions in prey base that serve as forage (Hunsicker et al. 2010, Smith et al. 2011, Pikitch et al. 2012, Pikitch et al. 2014).

In the short- and long-term, changing/unprecedented environmental conditions, fueled by climate change, and successful conservation measures are likely to produce novel direct and indirect interactions between fisheries and protected species. These interactions will arise due to range shifts and changing migration patterns of targeted species, protected species, or both (Lewison et al. 2015, Pinsky et al. 2018), as well as increased consumptive demand of protected predatory species (Chasco et al. 2017, Wells et al. 2017). Existing concerns surrounding interactions between Council-managed fisheries include:

- Bycatch of species (mammals, birds, turtles, fishes) listed as threatened or endangered under the ESA in groundfish fisheries. Accidental entanglement of whales in fixed-gear fisheries, including the sablefish pot fishery, has grown due to increasing whale populations (Barlow and Calambokidis 2020), changes in the timing of migration, and distribution shifts (Santora et al. 2020). Predictive models for blue whales have been developed to reduce ship strike risk (https://coastwatch.pfeg.noaa.gov/projects/whalewatch2/; Hazen et al. 2017, Abrahms et al. 2019) but are also being targeted for use in reducing pot-interactions under anomalous environmental conditions. Direct effects of Council-managed fisheries are captured by the Council's ESA workgroup, but indirect effects such as shifts in fishery participation to avoid entanglement issues related to State-managed fisheries such as Dungeness crab, are not.
- Bycatch of species that are protected under MSA-based regulations, but which are also harvested in limited quantities by directed fisheries. Examples include interactions of the Pacific whiting fisheries with Chinook salmon and shortbelly rockfish. Chinook salmon bycatch in the Pacific whiting fishery is an ongoing West Coast fisheries management challenge, exacerbated recently by the increased consumptive demand of pinnipeds and the needs of ESA-listed SRKWs for Chinook salmon as prey at different life stages (Chasco et al. 2018, Ohlberger et al. 2019 PNAS). Bycatch of shortbelly rockfish in the Pacific whiting fishery during the 2014-2016 MHW suddenly grew to the point where it exceeded the shortbelly rockfish annual catch limit. Shortbelly rockfish are a forage species for several Council-managed target species, which the Council manages with intentionally low harvest limits. The combination of record high Pacific whiting and shortbelly rockfish recruitment during 2013-2016, and shortbelly rockfish's range shift northward, created this novel predicament.
- The protected species that tend to interact with HMS fisheries are usually highly migratory themselves, ranging with tunas and sharks across the whole Pacific basin. The Council's HMS fisheries management includes a variety of measures to minimize bycatch, including: limits on gear depth, soak times, seasonal closures, and pingers to reduce bycatch of sea turtles, sharks, beaked whales and other toothed mammals (Hanan et al. 1993, Barlow et al. 2003, Julia Mason et al. 2019). However, changing distributions of HMS species alter both the catch potential and bycatch risk for West Coast HMS fisheries (e.g. Hahlbeck et a+l. 2017, Smith et al. 2020). Dynamic ocean management tools have been developed for the California Current to predict the distribution and timing of protected species migrations (Eguchi et al. 2017, Hazen et al. 2018) which can be used to inform fishing activity to reduce bycatch risk to protected species (https://coastwatch.pfeg.noaa.gov/ecocast/).

Importantly, the examples above of interactions between Council-managed fisheries and protected species reflect those we know about today and can anticipate in the near future. However, there is widespread agreement that ecological surprises that amplify these concerns are on the horizon. Such concerns are reflected in the future scenarios developed by the Council's Climate and Communities Initiative. These expectations highlight the importance of timely bycatch syntheses (Savoca et al. 2020) at a regional level that allow the Council to respond nimbly to changing conditions, as they did with the shortbelly rockfish bycatch situation. A future challenge to ensuring comprehensive sustainable management across all Council-managed fisheries is to grow such efforts to extend across FMPs as well as across federal and state management jurisdictions.

4.3 Fisheries Management, Ecosystem Services and the Well-being of West Coast Communities

The United Nations' Food and Agriculture Organization (FAO) and the Millenium Ecosystem Assessment (MEA 2005) have explored the role of ecosystem services in human well-being and provide some context for Goal 3 of the FEP: *Implement fisheries management that ensures continued ecosystem services for the wellbeing of West Coast communities and the nation*. From the FAO perspective, human health does not occur in a vacuum and is related to and part of animal, plant, and environmental health (FAO 2011). The MEA explains human well-being as being in opposition to poverty, and as including opportunities for security, access to resources to gain an income or livelihood, health (including food security, freedom from disease, clean air and drinking water, and energy,) and good social relations (MEA 2005). Acknowledging the intrinsic links between ecosystem services and human-wellbeing aligns this FEP with international thinking on best practices for sustainable natural resource management over multiple generations (Leong et al. 2019, Dasgupta 2021).

The MEA defines ecosystem services as the benefits people obtain from ecosystems, including: "provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits" (MEA 2005). While the fisheries management process tends to focus on the food security and recreational benefits that humans derive from fisheries, our work is also deeply affected by and tied into climate and nutrient cycles, with wellbeing of fishing communities linked to our ability to access the ocean and fish. The ESR reports not only on more direct ecosystem services like amounts of fish landed and revenues from fisheries, but also on regulating and supporting ecosystem services like annual snowpack in the mountains that water our rivers and ocean upwelling conditions that support primary productivity (Harvey et al. 2019).

The FEP's Objective 3a is to: *Continue to provide for commercial, recreational, ceremonial, subsistence, and non-consumptive uses of the marine environment*. That objective essentially re-phrases and provides further details on Goal 3, while also invoking the MSA's definition of optimum yield, which calls for fisheries to be managed so as to benefit the nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. Objective 3a ties those national priorities to West Coast priorities to ensure that we continue to provide for ceremonial and subsistence fisheries, with the term "ceremonial" explicitly included to acknowledge the unique status that Council-managed species and their habitats may have for a variety of treaty fishing tribes (NWIFC 2016).

The MSA requires that conservation and management measures, consistent with conservation requirements, take into account the importance of fishery resources to fishing communities by using economic and social data in order to: "(A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities" [16 U.S.C. §1851(a)(8)]. Fishing communities are primarily 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 on fisheries management are only a small part of the sum of elements that make up well-being for any particular fishing community.

Objective 3b is to: *Continue to monitor and engage in opportunities to minimize and mitigate the effects of non-fishing activities on the ecosystem to better ensure that conservation benefits are not undermined by negative impacts of these activities*. As discussed in Section 4.3, the Council usually addresses the effects of non-fishing activities on the ecosystem through the work of the Habitat Committee on EFH. As part of the 2020-2021 FEP re-drafting process, the Council is developing a separate guidance document to more broadly discuss the potential for non-fishing activities to affect the CCE, entitled *Pacific Fishery Management Council Guidance on Agency Activities in the California Current Ecosystem*.

Objective 3c is somewhat outside of the Council's usual responsibilities, except as it applies to Council process participants: *Support education efforts to promote understanding of CCE biophysical processes, how the ecosystem affects human well-being, and of the potential risks and benefits to ecosystem services from climate variability and change*. Since adopting the 2013 FEP, Council process participants have been exposed to significantly more information about how the CCE functions, have had more opportunities with each new ESR to understand the links within the social-ecological system, and have brought more ecosystem information into Council discussions and analyses. In addition to the FEP and the annual ESRs, the ecosystem initiatives offer new opportunities to promote understanding of the CCE. Both Initiative 2 (Coordinated Ecosystem Indicator Review) and Initiative 3 (Climate and Communities) began with public education webinar series designed to help Council process participants understand the CCE itself, how we conduct science to better monitor and understand the CCE, and where scientific uncertainty may affect our understanding of the CCE.

4.4 Framework and Public Forum for Ecosystem Information used in Council Decision-Making

Goal 1 of this FEP is process-oriented: *Provide a framework and public forum to improve and integrate ecosystem information for use in Council decision-making*. To date, the Council has been committed to meaningful public engagement, and has proactively used a variety of approaches to better understand the ecosystem and to use that understanding to inform its decisions. In Chapter 2, this FEP provides annual processes for identifying candidate ecosystem research topics for SSC review in support of revisions to the ecosystem status report, and for considering and developing new ecosystem initiatives. The ecosystem initiatives themselves are a Council invention, processes by which the Council can address issues and challenges that affect two or more Council FMPs or coordinate major Council policies across the FMPs. This administrative goal of maintaining a regular process for Council discussion of ecosystem issues has been part of the FEP since 2013, when the Council recognized that a commitment to regular discussion of ecosystem issues was key to implementing ecosystem-based management. The Council's efforts to meet that goal have significantly improved Council and public awareness of ecosystem states, of climate variability and anomalies, and of the interacting influences of the physical, biological, social, and economic components of the ecosystem on each other.

Through the ecosystem status report process laid out in Section 2.3, the Council meets FEP Objective 1a: *Provide annual and regular opportunities for the Council and its advisory bodies to consider physical, biological, social, and economic information on the CCE with an emphasis on environmental and climate conditions, climate change, habitat conditions, ecosystem interactions, and changing socio-economic drivers*. Ecosystem status reports are presented to the Council, its advisory bodies, and the public each March; new scientific information and analyses that could be of use to that report or to other Council work are reviewed through the SSC each September.

Chapter 5 of this FEP, *Bringing Cross-FMP and Ecosystem Science into the Council Process*, SSC and Council work on Research and Data Needs, and the Council's annual processes detailed in Section 2.3 help the Council meet FEP Objective 1b: *Identify research and monitoring priorities to address knowledge gaps, including indicators and reference points to monitor trends and drivers in key ecosystem features*. While the annual SSC process to review new ecosystem science focuses on the annual ecosystem status report, that process also offers an opportunity for scientists to share new species-specific work (e.g., Tolimieri et al. 2018, Haltuch et al. 2020) and to look into changes in ecosystem modeling practices (Punt et al. 2016, Kaplan et al. 2019). Furthermore, individual FMPs have their own goals and objectives that can be informed by ecosystem considerations.

Objective 1c addresses the role of the Council within wider regional ocean management fora, and within international fisheries management organizations: *Provide a nexus to regional, national, and* *international ecosystem-based management endeavors*. Council members, scientists who participate in and support the Council process, and Council advisory body members also participate in the regional, nationwide, and international organizations and processes discussed in Sections 3.5.5 and 3.5.6. The Council's Habitat Committee ensures that the Council stays informed and comments on the wide variety of non-fishing activities that may affect EFH; the Council's FMP-specific advisory bodies track and share information and comments on regional and international science and management occurring in species-specific forums.

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