ECOSYSTEM WORKGROUP REPORT ON THE FISHERY ECOSYSTEM PLAN UPDATE

At the March 2020 meeting, the Council updated its Fishery Ecosystem Plan's (FEP's) Vision Statement, Purpose Statement, Goals, and Objectives. For this September 2020 meeting, the Council asked that the Ecosystem Workgroup (EWG) provide a draft Chapter 3, an overview of the California Current Ecosystem (CCE). The Council also asked that the EWG provide revisions to the draft outline for Chapters 4 and 5 of the FEP that the EWG had presented to the Council in March (see Appendix 2: https://www.pcouncil.org/documents/2020/03/g-2-a-supplemental-ewg-report-1.pdf/).

Draft Chapter 3 is provided in this advance briefing book report. The EWG plans to review and re-draft outlines for Chapters 4 and 5 in a supplemental report. The draft Chapter 3 presented in this report is not complete and some sections have not yet been updated from 2013. We recognize that Chapter 3 is long and anticipate that readers may have comments both at and following the September meeting. While we welcome any comments from the Council, its advisory bodies, and the public, it would be particularly useful to receive comments and ideas at the September meeting on:

- Section 3.2.3, *Habitat Classification.* This is a new section for 2020, and replaces the 2013 section on Benthic Habitat with the intent of making the section inclusive of more habitat types. We would be grateful for comments from the Habitat Committee on whether this section highlights the appropriate data and classification methodologies.
- Sections 3.4.2 – 3.4.6, within *Fisheries of the CCE*. We are testing a revised framework for this section and, for this September meeting, recommend that readers focus on the overall organization of this section, although comments on details are welcome. The EWG plans to hold a discussion session with social scientists at its September 2020 meeting to elicit ideas and guidance for this section.
- Section 3.5.2, *Ecosystem-Based Management Measures Within FMPs*. Comments from the management teams and advisory subpanels would be particularly helpful to updating this section.
- Section 3.5.4, *Tribal and State Fisheries Management.* Comments from the tribes on the proposed organization of the discussion of tribal fisheries management would be helpful for re-drafting this section. The 2013 FEP version of this section is included for context.

Finally, in revising and updating Chapter 3, the EWG recommends moving the following text from the 2013 introduction to Chapter 3 into the updated Chapter 2:

2.4 Geographic Range of the FEP

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

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 mediates 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, 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.

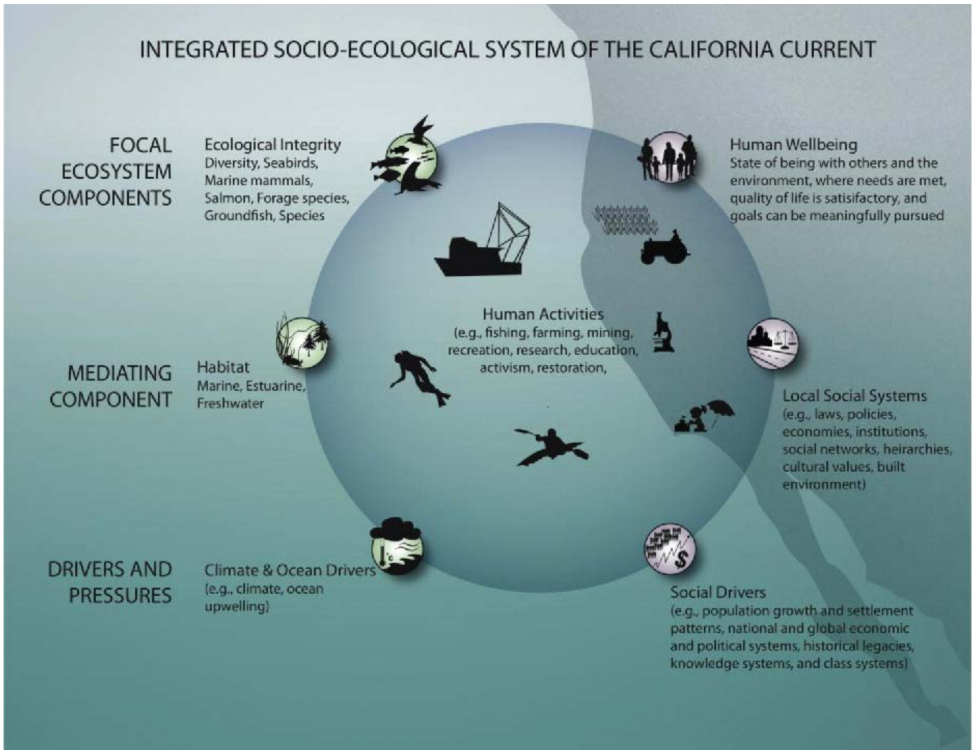

Figure 3-1 A conceptualization of the social-ecological system of the California Current showing broad biophysical and social drivers, the potential mediating effects of habitat and local social systems and the management endpoints of ecological integrity and human well-being. (From Levin et al. 2016).

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 experiences differences in physical and oceanographic features such as wind stress and freshwater input, the intensity of coastal upwelling and primary productivity, and in the width and depth of the continental shelf. Regional scale features like submarine ridges and canyons add to the distinct character of each sub-region. 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 hydrologies 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 like that observed at the Columbia River mouth behaves as a “buoyancy flow,” where a buoyant freshwater jet rides over the dense saline oceanic water and moves poleward (Wiseman and Garvine 1995). Two generalized flow regimes have been observed with the Columbia River freshwater plume: (1) southward upwelling-favorable wind stress causes the Columbia River plume to meander southward and offshore and (2) northward downwelling-favorable wind stress causes the plume to meander poleward and along the coastline.

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

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 cyclonic gyre in the Bight area that mixes cooler CCE water with warmer waters from the southeast (Hickey and Banas 2008). To the east of a line running south of Point Conception, winds are weak, while further offshore, to the west, wind speeds are similar to those along the continental shelf of the central sub-region. The Santa Barbara Channel remains sheltered from strong winds throughout the year.

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 very different from more northern sub-regions.

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

This new Section 3.2 is a combination of Oceanographic features from 2013 Section 3.1, plus Geological Environment (existing 3.3.1), and Water Column Temperature and Chemical Regimes (existing 3.3.2). Sections in the current 3.3 that discuss habitat and vegetation/plants will move to Biological Environment.

Ideas from existing 3.3.4, Human Effects on Council-Managed Species' Habitat, to be moved to Chapter 4.

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 northern 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. 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 Washington (Cummins and Freeland 2007). Upon colliding with the landmass, the NPC then 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).

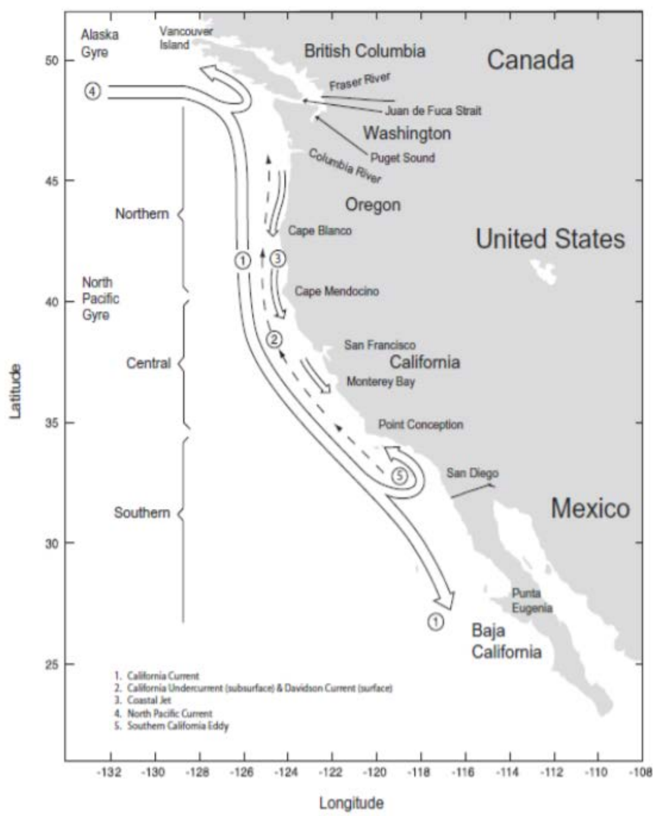

Figure 3-2. Dominant current systems off the U.S. West Coast.

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 leading to increasing 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).

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 correlated with salinity, nitrate and chlorophyll-a 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).

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 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. **23 Marine ecological units (and subunits) defined from 13 geoform components and 46 substrate components. Data and mapping tool available at https://geo.nwifc.org/ocean/. For more information see the project story map at https://nwifc.maps.**

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. Habitat map from the FRAM data warehouse mapping tool. Red – hard substrate; brown – mixed substrate; yellow – soft substrate. Data and mapping tool available at https://www.webapps.nwfsc.noaa.gov/data/map.

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 marine habitat data is limited and relatively coarse scale. Available data have been compiled into GIS maps to aid with management planning and EFH designations, with some available through online mapping tools. A basic CMECS habitat map is available through the FRAM Data Warehouse (Figure 3-4; https://www.webapps.nwfsc.noaa.gov/data/map), depicting hard, mixed and soft substrates in the CCE, which was used during the most recent groundfish EFH designations. To better define EFH 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 develop 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. Work is currently underway to add the water column and biotic components to this dataset.

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).

September 2020 Note for Reviewers: This Section 3.3.1 text is exactly the same as provided in the 2013 FEP at Section 3.3.3. The EWG plans to update this section during the September 2020 – February 2021 period, but would particularly appreciate comments on this section that include new scientific information published since 2012.

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

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

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

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

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

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

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

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

September 2020 Note for Reviewers: This Section 3.3.2 text is exactly the same as provided in the 2013 FEP at Section 3.2.1.3. The EWG plans to update this section during the September 2020 – February 2021 period, but would particularly appreciate comments on this section that include new scientific information published since 2012.

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

- Small pelagic fish -- includes baitfish and other forage fish, such as sardine (*Sardinops sagax*), anchovy (*Engraulis mordax*), smelts (*Osmeridae* spp.), etc., which are relatively small as adults and feed on phytoplankton and/or zooplankton
- Ichthyoplankton – small larval stages of fish that feed on both phytoplankton and zooplankton, including the larvae of the small pelagics listed above, plus the larval stages of large pelagic fish and groundfish, such as Pacific whiting, jack mackerel (*Trachurus symmetricus*), and rockfish (*Sebastes* spp.)

- Euphausiids (*Euphausiacea* spp.) – krill, relatively large, often swarm- or school-forming crustacean zooplankton that feed on both phytoplankton and zooplankton
- Gelatinous zooplankton- soft-bodied zooplankton, such as jellyfish, pelagic gastropods (*Gastropod* spp., primarily pteropods), salps (*Salpidae* spp.), doliolids (*Doliolida* spp.), and apendicularians (*Appendicularia* spp.)
- Other crustacean zooplankton – this group includes shrimps, mysids (*Mysidae* spp.), and other less numerically dominant but important organisms that consume other zooplankton, phytoplankton, and microzooplankton
- Copepods (*Copepoda* spp.) – smaller crustacean zooplankton, often the numerically dominant multi-cellular organism in many areas of the CCE that feed on both phytoplankton, other zooplankton, and microzooplankton
- Microzooplankton – uni-cellular zooplankton that feed at high rates on phytoplankton, other microzooplankton, and bacteria

Small pelagic fish, such as sardine and anchovy, comprise an integral part of the CCE, feeding nearly exclusively on phytoplankton (typically diatoms), small pelagic crustaceans, and copepods (Emmett et al. 2005). A large portion of what are known as the "forage fish" of the CCE are comprised of small pelagic fish; this group functions as the main pathway of energy flow in the CCE from phytoplankton to larger fish and the young life stages of larger predators (Crawford, 1987; Cury et al. 2000). Thus, small pelagic fish form a critical link in the strong, upwelling-driven high production regions of the CCE. Ichthyoplankton, the larvae of larger fish, are also a key prey resource for larger fish and other marine organisms. A summary of over 50 years of the ichthyoplankton community gives some sense of the relative abundance of various ecologically important species in the CCE (Moser et al. 2001). Six of the top 10 most abundant species throughout this long time period are northern anchovy, Pacific hake, Pacific sardine, jack mackerel, and rockfish (shortbelly rockfish (*S. jordani*) and unidentified Sebastes, as most species are not identifiable to the species level). The 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 lead to production in higher trophic levels (Brodeur et al. 2011). Gelatinous zooplankton include a variety of forms, from free-floating jellyfish that passively ambush zooplankton and small larval fish prey, to appendicularians that build large gelatinous "houses" used to filter large quantities of the smallest phytoplankton classes from the water column. While gelatinous zooplankton grow at high rates, and have high feeding rates, their bodies are mostly composed of water; as a result, gelatinous zooplankton are not typically a good food source for larger organisms, with the exception of certain turtles that specialize in gelatinous prey. Thus, systems dominated by gelatinous zooplankton as the primary predators of phytoplankton tend to have limited production of fish species, and are generally considered “dead-end” ecosystems. Typically, gelatinous zooplankton blooms are found offshore in oligotrophic regions, although blooms occasionally predominate nearshore during warmer periods. An exception are pteropods, pelagic gastropods that form large gelatinous nets, much larger than their body size, used to capture falling detritus in the water column. Unlike the other taxa in this group, pteropods are known to be an important food source for at least salmon, and possibly other fish species (Brodeur, 1990).

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

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

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 hake, the most abundant groundfish in the CCE, shows strong ontogeny in food habits, since younger, smaller hake feed primarily on euphausiids and shrimps, switching to an increasing proportion of herring (*Clupea pallasii pallasii*), anchovies (*Engraulis mordax*), and other fishes (as well as other hake) as they reach 45-55 cm length, and are almost exclusively piscivorous by 70-80 cm.

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 hake 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 hake 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 hake 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 X). 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.X.X
#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 fresh and 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 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 fluctuates 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 did not elucidate 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 (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 X). 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 require 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, groundfish, and other prey; Carretta et al. 2008), and simple bioenergetic estimates suggest that pinnipeds may consume as much as an additional million tons (Hunt et al. 2000), mostly fish and squid. Comparable estimates for seabirds are limited; Roth et al. (2008) estimated total annual consumption by common murres (the most abundant resident species in the CCE) at approximately 225,000 tons; however, Hunt et al. (2000) estimated summer consumption by all seabirds throughout the CCE at considerably lower levels. There have been few efforts to explicitly model interactions between fisheries and marine mammal population dynamics (although, see Yodzis et al. 2001 and Bundy et al. 2009). However, there is a rich body of literature linking seabird productivity to prey availability that helped guide the development of harvest control rules 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, it is clear that such trade-offs exist, can be estimated for a multi-species system, and can be considered in the context of strategic decision making. 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 look at all of the FMP fisheries together, minimizing duplication of descriptions in the Council's FMPs. This section provides a background on historic fishing in the EEZ and discusses cumulative CCE fisheries harvest, West Coast fisheries capacity levels, and the cumulative socio-economic effects of Council-generated fishery management measures on fishing communities.

3.4.1 Historical CCE Fisheries

The perception of the effects of fisheries exploitation on the environment has varied over time. Freon et al. (2005; see also MacCall et al. 2009) have defined a set of time periods that help frame the history of exploitation and the accompanying evolution of associated science. The period before the 20th 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 that they exploited. 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 industrial fisheries, and the collapses that followed led to what might be considered the conventional management period of 1950-1975.

The mid-20th century saw the development of most of the basic foundations of contemporary fisheries science, including functional relationships addressing productivity, such as fisheries oceanography, spawner/recruit relationships, as well as population dynamics models such as surplus production models and virtual population 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 saw the world's largest fisheries failure, the crash of the Peruvian anchoveta (*Engraulis ringens*) fishery, which had been responsible for up to one quarter of global fisheries landings at the time. The anchoveta fishery collapse had tremendous ecosystem consequences (Jahncke et al. 1998) and led to what Freon described next as the "doubt" period from the mid-1970s through the mid-1990s.

The late-20th 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. Next arose the classic tale of the rise and fall of the California sardine fishery, and subsequent fisheries for anchovy, mackerel, herring, and squid (*Doryteuthis opalescens*). Throughout the past two centuries, some fisheries grew unsustainably fast, rapidly depleting resources (typically low turnover resources) in short pulses, including fisheries for: abalone, black and white seabass, and various elasmobranchs such as basking, soupfin, and dogfish (*Squalus acanthias*) sharks. Fisheries for many groundfish, including Pacific and California halibuts, sablefish, lingcod, Pacific ocean perch (*S. alutus*), and other rockfish seemed to be sustainable at low levels prior to the 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 production or availability of sardines, contributing to that fishery's expansion throughout the early 1920s and the early 1930s. The observation that current abundance of sardines and other CPS is far lower than the historical abundance could be, in part, a function of the differences in predation mortality between these periods. Populations of most marine mammals in the CCE have recovered to, with some perhaps even exceeding, historical levels of abundance in recent decades. Appreciation for the historical impacts of whaling and sealing, and the potential cascading impacts to marine ecosystems, has grown as marine mammal populations have recovered (NRC 1996, Springer et al. 2003, Estes et al. 2006), and a basic understanding of the relative significance of both contemporary and historical trends and abundance of predators should be an integral component of an ecosystem approach to managing CCE fisheries.

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

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

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

Pacific halibut and other groundfish 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 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

**September 2020 Note for Reviewers: We are trying a new approach to descriptions of current West Coast fisheries and would particularly appreciate comments on whether describing fisheries by habitat type is a useful revision. **

This section presents brief descriptions of the main commercial fisheries occurring in the CCE followed by a general treatment of recreational fisheries. Most commonly we think of a "fishery" in terms of the gear used, the species caught, the objective (profit, recreation, identity), and the regulatory framework. Thus we may talk about 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.

3.4.2.1 General characteristics of commercial fisheries

Table 3-6 shows the total number of vessels, average annual inflation adjusted ex-vessel revenue, and average annual landings for most of the fisheries described in the next section, derived from the PacFIN database by geographic region (based on IOPAC Port Groups). This gives a picture the regional importance of various fisheries.

The Dungeness crab pot fishery is by far the most economically important, accounting for $157 million annually on average over the past decade, or a third of total coastwide revenue. It is followed by market squid ($59 million) and pink shrimp trawl ($38.5 million). Notably, these are all largely state-managed fisheries. The Dungeness crab pot, albacore hook-and-line (pole/troll), and salmon troll fisheries 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 (for example, only 15% of landings of vessels participating in the salmon troll fishery come from that fishery, see Table 3-3). Vessels in the groundfish nearshore fixed gear fishery, largely managed at the state level, also participate in other fisheries at a high rate using this metric. 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. Pelagic longline vessels are also highly specialized, although participation is relatively low (because this gear type is prohibited in the West Coast EEZ and most vessels hail from Hawai'i).

Table 3-3, shows the percent of landings and revenue attributable to the "target fishery." Vessels were categorized based on whether landings were made in a fisheries category. Next, total landings are categorized according to whether the landings occurred in the fishery in question (the "target") or in some other fishery, and then aggregated from the vessel level. This gives an indication of cross-participation in fisheries. For example, 46% of landings and 36% of revenue of vessels participating in the albacore fishery came from that fishery, while the remainder of landings and revenue came from other fisheries. These are aggregate, or average, values; individual vessels vary in their focus on a particular fishery.

Table 3-3. Percentage of landings and inflation-adjusted ex-vessel revenue derived from "target fishery," last 10 years. Target fishery landings and revenue identified using fishery classifications in the PacFIN comprehensive table (see footnote).

Fishery	Target percent (landings)	Target percent (revenue)
Surface Hook-and-Line Fishery for Albacore	46.3%	35.8%
CPS Seine	41.1%	15.4%
Dungeness Crab Pot	23.0%	63.5%
Harpoon	15.5%	24.9%
Large Mesh Drift Gillnet	28.0%	34.3%
HMS Purse Seine	7.9%	11.7%
Groundfish Nearshore Fixed Gear	21.8%	26.0%
Sablefish Fixed Gear	32.8%	36.6%
Pelagic Longline	88.6%	90.6%
Pink Shrimp Trawl	65.2%	55.6%
Salmon Troll	15.0%	27.0%
Shoreside Whiting Trawl	30.0%	49.0%
Shoreside Nonwhiting Trawl	95.4%	76.8%
Market Squid	70.2%	86.1%
Whiting Catcher-Processor	*	*
Whiting Mothership	*	*

This variation among fishery participants can be seen in Figure 3-5, which shows the number of vessels that caught albacore according to the proportion of their catch coming from the target fishery. As with other fisheries with a high level of cross participation, there is a distinct bimodal distribution in the number of vessels. Vessels where catch in the albacore fishery accounts for 90% or more of their landings are the largest share of vessels, followed by vessels for which fishery landings account for less than 10% of their total catch. Interestingly, it is not the “pure” specialists (deriving 90% or more of landings from albacore) that have the highest per-vessel average albacore, but rather the near-specialists who derive around four-fifths of their landings from albacore. Fisheries vary in terms of this sort of specialization depending on regulations, capital intensity, seasonality of the fishery, and other factors. Participation in the albacore fishery is not limited by permit (it is open access) and very seasonal (most landings occur from July to October), factors that encourage a large amount of casual participation.

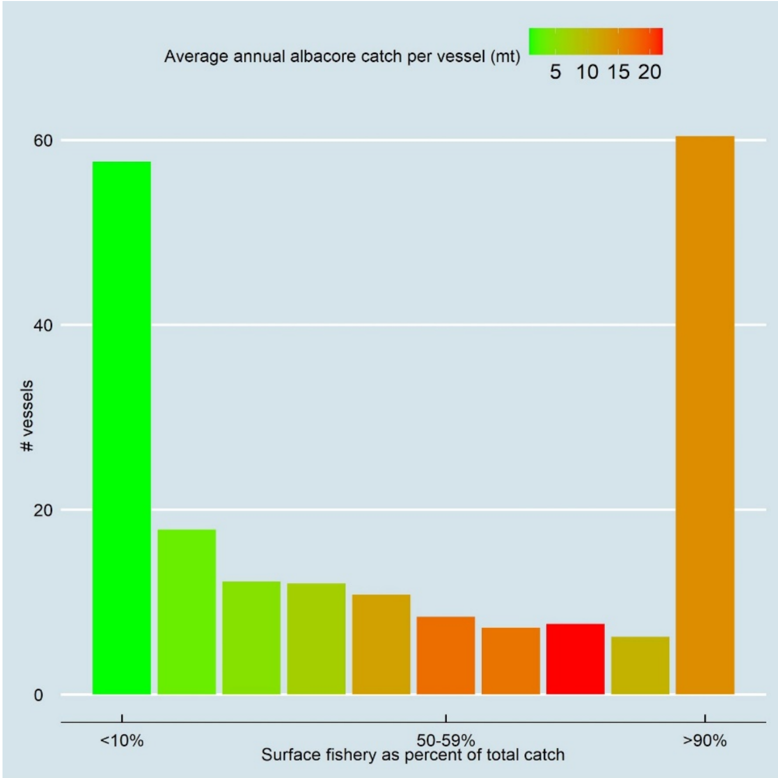

Figure 3-5.. For vessels landing albacore, number of vessels by percent of catch attributed to the albacore surface fishery, previous 5 years.

Holland and Kaperski (2016) developed a metric of fishery revenue diversification, called the Effective Shannon Index (ESI), for vessels with West Coast or Alaska landings. The ESI measures the distribution of vessel revenue in terms of scope (the number of fisheries the vessel participated in) and distribution (how evenly revenue is distributed across those fisheries). A higher score generally means the vessel participated in more fisheries *and* its distribution was not skewed towards one fishery or another. (For example, a vessel that participated in three fisheries and gained an equal amount of revenue from each would obtain a score of three but if the revenue mainly came from one fishery the score would be less than three.) This metric has been regularly updated and results for various vessel groupings (by state, vessel size, gross revenue, etc.) and presented in section 6.2 of the Annual CCIEA Report.

Revenue diversification is another way to gauge cross participation in fisheries by individual vessels. Other things being equal, greater revenue diversification (or cross participation) should result in a more stable income stream, or, put another way, reduce financial risk for participants. Revenue diversification has generally declined over the time period examined (1981-2018), with a slight increase in the early 1990s and a significant decline thereafter. Considering the fleet of 2,560 vessels that made West Coast landings in 2018 and averaged more than $5,000 in annual ex-vessel revenue, the average ESI value was 1.79 for the 1981-1990 period versus 1.58 for the 2010-2018 period. This relatively small change in nominal value belies the clear trend illustrated in Figure 3-6 Most of these vessels entered West Coast fisheries after 1981, the beginning of the time series, and more recent entrants have tended to have lower fishery diversification scores. 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. The slight increase in average ESI into the early 1990s may reflect unconstrained growth in participation across fisheries that prompted these management interventions. As noted above, and analyzed in detail by Holland and Kaperski (2016), revenue diversification or cross participation varies across different types of vessels. Their analysis demonstrates this by means of general characteristics (vessel length, revenue amount, etc.) but one might speculate that different fisheries (as discussed below and reported in Table 3-4 and Table 3-6) might attract, or deter, participating vessels from pursuing a diversification strategy. Thus, for any particular vessel, the fisheries it participates in is likely a function of the particular barriers to entry to a given fishery, and the resulting choices made by individual owners would affect their revenue diversification.

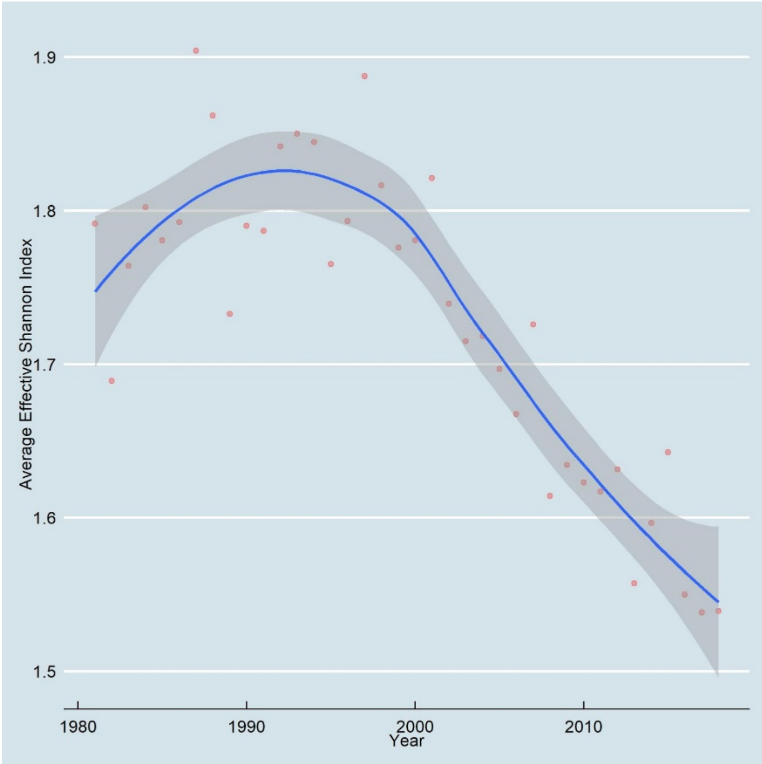

Figure 3-6. Average Effective Shannon Index scores for the population of vessels that made west coast landings in 2018 and had average annual revenues greater than $5,000. (Source data provided by Dan Holland.)

3.4.2.2 Descriptions of Major Commercial Fisheries in the CCE

The major West Coast commercial fisheries are briefly described below, categorized broadly by those targeting species in the water column and off the ocean bottom (pelagic) and those with gear that contacts the ocean bottom (benthic) and gear categories. According to the data in Table XX-b, these fisheries account for 89% of coastwide landings and 69% of ex-vessel revenue during the past 10 years. Most of the fisheries described here are federally managed under one of the Council’s four FMPs although, as noted above, some of the most economically important fisheries are state managed.

Pelagic Net Gear

Vessels targeting pelagic species with round haul gear (purse seine, drum seine, lampara net). This fleet has a long and storied history (see section 3.4.1) targeting Pacific sardine, northern anchovy, market squid, and tunas (skipjack, yellowfin and Pacific bluefin tuna) (See Table x). Incidental catch /bycatch is low and the operation of the gears allows the release of undesirable species with low mortality. Mackerels are the most common bycatch within the range of species that are incidentally caught in this fishery (CPS SAFE Table 4-1). These 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. Vessels must have a federal limited entry permit to target sardine, anchovy, and mackerel, while a California state permit limits the number of vessels that may target squid. A single vessel may hold both these permits and there is substantial overlap in the vessels pursuing these strategies, although the gear and fishing methods differ depending on the target. Squid landings are higher in winter months, peaking in November, while sardine landings are concentrated between July and September (see Figure 3-7). When targeting tuna, vessels operate in the Southern California Bight from May to October when intrusions of warm water from the south, typically during periodic El Niño episodes, bring tuna species within range of this fleet. Similarly, purse seine vessel operators will target the higher-valued temperate water bluefin tuna when they enter the coastal waters of the Bight.

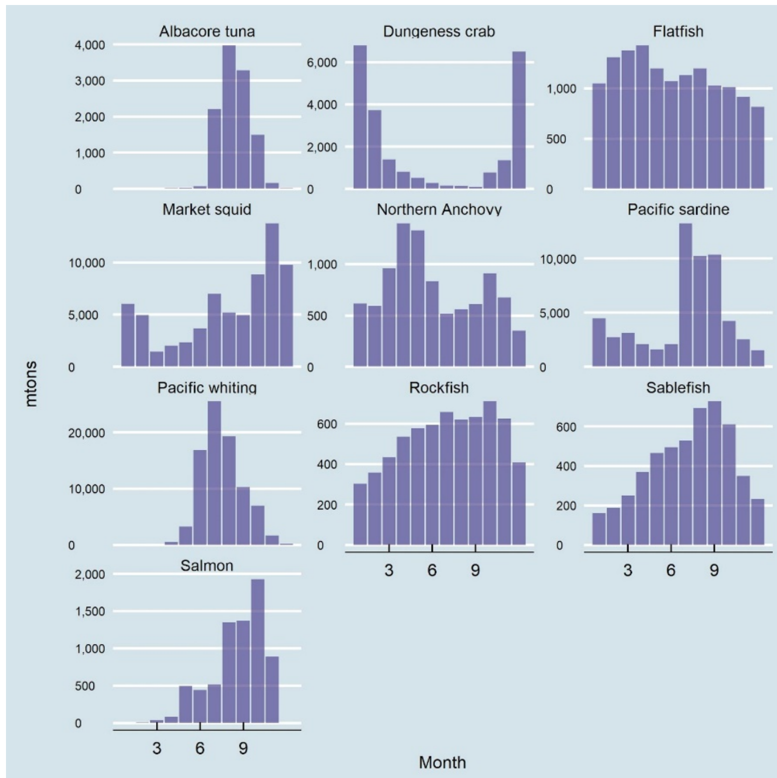

Figure 3-7. Seasonal pattern of landings for selected species and species groups, average for the past 20 years.

According to Table XX, round haul fisheries targeting CPS (sardine, anchovy, and market squid) averaged $69 million annually in the past 10 years or 14% of average coastwide revenue.

Table 3-4. Average annual landings by round haul gear (PacFIN gear code SEN) in the last 20 years.

Species	Average Annual Landings (mt)	Percent of Total
Squid	67,978	55%
Sardine	38,929	32%
Anchovy	8,960	7%
Mackerel	5,667	5%
Tuna	573	0%
Other CPS	439	0%
Other species	29	0%
Total	122,575	100%

Vessels targeting sardine and northern anchovy using scoop, brail, or purse seine gear to provide live bait for recreational fisheries targeting pelagic species. Incidental/bycatch includes "white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), Pacific and jack mackerels, and various small fishes collectively known as "brown bait" that can include juvenile barracuda (*Sphyraena argentea*), Osmerids, Atherinids, and market squid" (CPS SAFE). (Commercial vessels, principally baitboats targeting albacore, also catch live bait for use in their fishing operations). Live bait is held in floating pens where it is sold directly to recreational vessels. About a fifth of the catch is delivered to charter vessels, the remainder to private vessels. Catch also may be delivered to restaurants or small producers of specialty products for human consumption (https://californiawetfish.org/pdf/SEfile.pdf). Other species such as Pacific herring (Oregon) and market squid (Southern California) are occasionally caught for the live bait market. The fishery mainly occurs in nearshore areas, especially bays and estuaries. Characterizing landings and revenue from this fishery using PacFIN data is difficult, because before 2019, when California implemented an electronic fish ticket program, catch was not reported consistently by means of landings receipts (a voluntary logbook program recorded catch in earlier years). According to the PacFIN database, in 2019, 161 mt of Pacific sardine and northern anchovy were landed as bait by seine and other net gear in California; significant quantities were also landed in Washington and Oregon but cannot be reported due to confidentiality restrictions.

Vessels targeting swordfish and common thresher shark with drift gillnet gear off of California (mostly in the Southern California Bight). Historically, the fishery occurred as far north as off central Oregon. The fishery operates seasonally from September to January. The fishery is closed from February to April to protect shark pupping grounds, and little fishing occurs during summer months because swordfish in sufficient quantities for this gear type are not available in waters off California. This gear has a relatively high level of incidental/bycatch including tunas, other pelagic sharks, and ocean sunfish (*Mola mola*). 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. Participation and landings peaked in the 1980s with more than 100 vessels and annual landings over 1,000 mt. According to the HMS SAFE, in the last decade around 20 vessels have participated in the fishery, with landings ranging from 93-237 mt annually. As shown in Table XX, landings averaged 188 mt annually worth $915,000. California has enacted a program that would phase out state permits for the fishery.

Pelagic Hook-and Line Gear

Vessels targeting North Pacific albacore with troll gear or baitboats using hook-and-line gear. These gear types are selective and there is minimal bycatch in the fishery. Historically, the fishery occurred off California and delivered to canneries in Southern California. In the last three decades, the fishery has shifted north and now occurs mainly off Oregon and Washington. The main ports of landing are Newport, Oregon, Columbia River ports, and Westport, Washington. Fishing can occur far offshore, even outside the West Coast EEZ, depending on the distribution of albacore. A treaty between the U.S. and Canada allows vessels from each country to fish in the waters of the others. This is a seasonal fishery typically running from July through October, with landings peaking in August-September (see Figure 3-7). According to the HMS SAFE, in the last decade, around 600 vessels participated in the fishery each year. As shown in Table 3-6 annual landings averaged about 10,000 mt worth $37.5 million.

Vessels targeting tuna and swordfish with pelagic longline gear. The HMS FMP prohibits pelagic longline fishing within the west coast EEZ and the retention of striped marlin. Targeting swordfish using the “shallow-set” gear configuration was prohibited based on the ESA section 7 consultation on the HMS FMP. The Council has declined to adopt measures that would authorize an ESA-compliant fishery. However, vessels permitted under the WPFMC’s Pelagics FEP may target swordfish and land in West Coast ports. The number of Hawai’i permitted pelagic longline vessels making landings on the West Coast has increased from six in 2010 to a high of 21 in 2018 (declining to 17 in 2019). In the last decade, swordfish have accounted for 40% of landings, although tunas (mostly bigeye) have become an increasing proportion of the landings and account for slightly more than half of landings in 2019. Other frequently landed species include dorado (mahi mahi) and opah. According to the HMS SAFE, landings by Hawai’i permitted vessels peaked at 2,031 mt in 2000; as shown in Table 3-6. In the last decade, landings have averaged 618 mt annually worth $4.6 million.

Vessels targeting Chinook and coho salmon with troll gear. Although this fishery focuses on just two species, characterizing it is complicated by the many separate salmon stocks encountered in the fishery and the ensuing management complexity. These stocks represent distinct spawning populations returning to natal rivers and streams at different times of year. Furthermore, many stocks are listed under the ESA so management of the fishery revolves around minimizing incidental take of listed stocks while providing opportunity to catch stocks that are not ESA-listed, many of which are the result of hatchery operations in freshwater spawning areas. Salmon stocks are grouped according to regions and freshwater drainages where spawning occurs. Fisheries may target salmon feeding offshore and closer to shore when targeting fish on their spawning migrations to natal rivers. 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). According to Table 3-6, salmon troll fisheries have averaged $38.4 million in ex-vessel revenue annually or 4% of average coastwide revenue.

Pelagic Trawl Gear

Vessels using midwater trawl gear (which is towed off bottom in the water column) to target Pacific whiting (Merluccius productus). 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. Operationally, vessels are divided between at-sea and shoreside fisheries. The at-sea sector is 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). Fish are processed and frozen at sea, stored in the processing vessel’s freezer hold, and offloaded as a commodity. The shoreside fishery delivers to processing plants on land with Westport and Ilwaco, Washington; and Astoria, Oregon being the principal ports for shoreside landings. As these ports of landing indicate, the fishery mainly occurs off of Washington and Oregon; it is prohibited south of 40°10’ N latitude. Vessels fishing from shore fish in slightly shallower depths than the two at-sea sectors, around 100 fathoms versus 150-200 fathoms for catcher-processor vessels and catcher boats delivering to motherships. In the last ten years 11 vessels participated in the at-sea sector and eight vessels in the mothership sector. Respectively, these sectors landed on average annually over the past 10 years 91,419 mt and 51,666 mt, worth $20.9 million and $12 million. Forty-three vessels in the shoreside sector landed 99,027 mt annually, worth $$22 million during this period.

Vessels targeting pelagic rockfish species (principally widow rockfish and yellowtail rockfish) using midwater trawl gear. 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-2010a. Fishing generally occurs in depths less than 100 fathoms and most commonly around 50 fathoms. According to data provided by the NWFSC Catch Shares Economic Data Collection Program, between 2012 and 2018 this fishery averaged 2,351 mt per year in landings worth $1.6 million. But since its reemergence in 2012, this fishery has grown steadily, with landings reaching 1,153 mt in 2018, worth $6.6 million.

Other Pelagic Gear

Vessels targeting swordfish with harpoons. This fishery has operated since the early 1900s in the Southern California Bight. The number of vessels participating in this fishery has declined over the decades to 10-20 vessels in recent years. Some vessel operators work in conjunction with a spotter airplane to increase the search area and to locate swordfish difficult to see from the vessel. This practice tends to increase the catch-per-unit-effort compared to vessels that do not use a spotter plane, but at higher operating cost. Since the gear is very selective, there is virtually no bycatch. In the last decade, no more than three dozen vessels have participated, with annual landings ranging from 5-28 mt.

Benthic Trawl Gear

Vessels targeting groundfish with bottom trawl gear. These vessels engage in at least two different strategies. Vessels may target Dover sole, thornyheads (*Sebastolobus spp*.), 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 / bycatch. Vessels participating in this fishery must possess a federal limited entry permit, which also covers vessels delivering Pacific whiting to shore-based processors. This fishery is managed under an individual fishing quota (IFQ) program. Implementation of the IFQ program was partly motivated by management restrictions imposed to address regulatory bycatch of overfished rockfish species. (Regulatory bycatch results from management constraints rather than market factors; in this case, low landing limits for overfished species contributed to discarding.) With the IFQ system, each vessel (or permit holder) is accountable for total catch according to their quota limits, which has helped to reduce bycatch. The fishery occurs primarily off Washington and Oregon with some activity in Northern California. Major ports of landing include Columbia River ports (Astoria and Warrenton, Oregon); Newport Oregon; and Eureka, California. According to Table 3-6, this fishery averaged $27.2 million in ex-vessel revenue annually or 6% of the coastwide total. As shown in Table 3-5, the Dover sole / thornyheads / sablefish (“DTS”) strategy accounts for around two thirds of landings and revenue in the fishery followed by vessels fishing on the continental shelf (“non-DTS”) with about a quarter of landings and revenue.

Table 3-5. Landings (mt) and ex-vessel revenue by different fishing strategies in the nonwhiting trawl IFQ fishery, annual average 2009-2018. (Data provided by NWFSC Catch Shares Economic Data Collection Program.)

Fishery	Metric Tons		Revenue	
	Average	Percent	Average	Percent
DTS trawl with trawl endorsement	1,356	65%	$19,542,629	67%
Non-whiting midwater trawl	235	11%	$1,594,343	6%
Non-whiting, non-DTS trawl with trawl endorsement	507	24%	$7,831,593	27%

Vessels targeting pink shrimp (Pandalus jordani) with single and double-rigged shrimp trawl gear. Pink shrimp occur on sandy and mud bottoms all along the West Coast, although the fishery is centered in Oregon. The pink shrimp season is open April 1 through October 31 and vessels generally fish in depths ranging from 50 to 140 fathoms. Pink shrimp vessels use bycatch reduction devices and light emitting diode (LED) lights to reduce bycatch including protected species such as eulachon. According to Table 3-6, this fishery averaged $38.4 million in ex-vessel revenue annually or 8% of the coastwide total.

Vessels targeting California halibut (Paralichthys californicus) with bottom trawl gear. This fishery occurs in nearshore areas in Central California, primarily off of San Francisco and around Point Conception (Richerson, et al. 2019). This fishery has bycatch of the southern distinct population segment of green sturgeon (*Acipenser medirostris*), which was listed as threatened under the ESA in 2006; however, because this fishery is not federally managed, it is not directly subject to mitigation pursuant to the ESA. According to PacFIN data, in the past 10 years a total of 61 vessels using trawl gear to catch California halibut landed 106 mt (of which 90 mt was California halibut) annually on average, worth $1.2 million per year on average.

Benthic Fixed Gear (longline and pot gear)

Vessels using fixed gear (longline and pot) mainly to target sablefish on the continental slope (depths greater than 80 fathoms). Fishing strategy is affected by a complex federal permitting system. Some vessels have permits, making them eligible for specific allocations to be used during a “primary season” stretching over a seven-month period from April 1 to October 31. Other vessels without this type of federal permit (or without any federal groundfish permit) may still land small amounts of sablefish and may target other groundfish species, including thornyheads, rockfish, and flatfish. Finally, vessels with a Federal trawl permit may use their IFQ to catch sablefish and other groundfish with fixed gear. Bycatch is primarily composed of spiny dogfish shark, Pacific halibut, rockfish species, and skates. Vessels without the sablefish permit endorsement operate mainly out of California (particularly Morro Bay) while those with the endorsement are more prevalent in Washington and Oregon Ports. Vessels targeting sablefish fish at approximately 150-200 fathoms.

Vessels using fixed gear and other hook and line gear types to target rockfish and other groundfish in nearshore waters. This fleet operates from northern Oregon to southern California. Gear is set and retrieved multiple times a day and catch is generally landed on a daily basis in depths of 20 fathoms or less. These vessels fish in depths around 10 fathoms.

Vessels catching Pacific halibut with bottom longline gear. Pacific halibut comprise a single stock from Alaska to the California. The International Pacific Halibut Commission, formed through a bilateral convention between the U.S. and Canada, plays a central role in managing the fishery by assessing the stock and allocating yield between areas in U.S. and Canadian waters. Bottom longline gear is the only permissible gear for directly targeting halibut and the non-tribal commercial fishery occurs in a short derby each year.

Vessels using crab pots to catch Dungeness crab. “Pots are predominantly set between 10 and 50 fathoms (60-300 feet) although Dungeness crab commonly occur from intertidal areas to 200 fathoms (1200 feet)” (https://www.dfw.state.or.us/mrp/shellfish/commercial/crab/). This fishery generally accounts for the largest share of West Coast ex-vessel revenue although landings (and thus revenue) vary in a cyclical multi-annual pattern.

Vessels in the Southern California Bight landing California spiny lobster with traps (pot gear). Traps are generally set in depths less than 100 feet (31 m) in nearshore areas and around islands (CDFW 2016). The

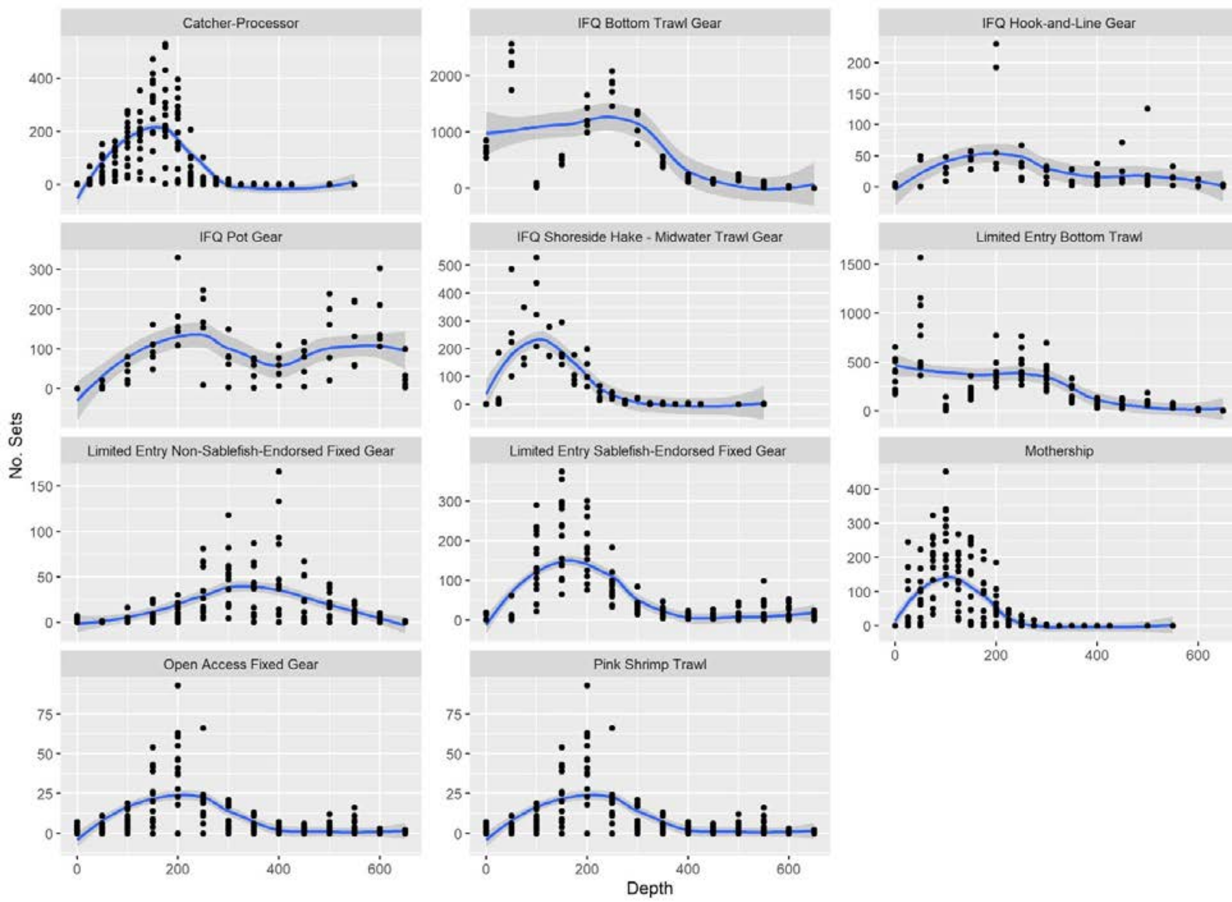

Figure 3-8. Depth distribution of hauls in groundfish IFQ fisheries and Pacific whiting at-sea sectors, 2002-2015. Source: Somers, et al. 2016)

fishery is managed by the State of California primarily through a permitting system and a minimum size limit. Since 1976, traps must have an escape port to allow sublegal size lobsters to escape. Nonetheless, the main component of bycatch is sublegal lobsters followed by various invertebrates and benthic fish such as cabezon and lingcod. Post release survival is likely high for tended traps. but mortality may be high in the case of lost or abandoned traps. Since the 1990s, participation in the fishery has declined substantially but fishing effort (measured by the frequency of trap retrieval) has increased. This is likely due to a substantial increase in market value over the past two decades, measured by average landed price per pound. According to PacFIN data, inflation adjusted average price per pound increased from $9.07 in

2001 to a peak of $20.38 in 2015 but subsequently declining markedly to $12.97 in 2019. In the last 10 years 348 vessels participated in the fishery, averaging 354 mt annually in landings (of which 348 mt was lobster) resulting in $14.5 million per year. According to Table 3-6, this fishery averages $14.9 million in revenue annually on 357 mt in average landings, reflecting the high value of this species. Accounting for 2.5% of coastwide revenue this fishery is quite significant in comparison to other major fisheries.

Table 3-6. a.) Total number of vessels, b.) average annual inflation-adjusted ex-vessel revenue ($1,000s), and c.) average annual landings (metric tons) by fishery and geographic region, last 10 years. (Because a vessel may make a landing in more than one region the totals in panel a may not be the sum of the corresponding rows/columns.)

A. Vessels

Fishery	Puget Sound	Washington Coast	Astoria	Oregon Coast	Northern California	Central California	Southern California	Total
CPS Seine	0	48	41	26	22	65	216	250
Squid Seine	0	0	0	47	58	122	283	200
Harpoon	0	0	0	0	0	0	67	51
HMS Purse Seine	0	0	0	0	0	0	20	19
Large Mesh Drift Gillnet	0	0	0	0	10	25	62	43
Pelagic Longline	0	0	0	0	20	0	33	19
Surface Hook-and-Line Fishery for Albacore	77	717	346	1,337	380	167	56	1,643
Groundfish Nearshore Fixed Gear	0	1	8	395	241	233	147	896
Sablefish Fixed Gear	26	146	38	280	352	215	178	911
Shoreside Nonwhiting Trawl	13	20	55	77	48	7	0	124
Shoreside Whiting	0	23	31	26	10	0	0	43
Salmon Troll	33	313	252	1,373	1,930	689	32	1,903
California Lobster Pot	0	0	0	0	0	7	427	367
Dungeness Crab Pot	240	397	181	670	1,291	150	23	1,476
Halibut Longline	29	254	47	488	25	0	0	593
Pink Shrimp Trawl	0	59	63	185	45	6	3	147
Other	7,069	5,115	820	983	1,505	1,043	1,636	4,276
Total	1,416	741	1,727	1,938	1,422	1,589	412	

b. Revenue

Fishery	Puget Sound	Washington Coast	Astoria	Oregon Coast	Northern California	Central California	Southern California	Total	Percent of Total
CPS Seine	$0	$2,619	$3,278	$90	$57	$1,623	$2,652	$10,319	1.7%
Squid Seine	$0	$0	$0	$722	$3,657	$11,794	$42,584	$58,758	9.8%
Harpoon	$0	$0	$0	$0	$0	$0	$195	$195	0.0%
HMS Purse Seine	$0	$0	$0	$0	$0	$0	$924	$924	0.2%
Large Mesh Drift Gillnet	$0	$0	$0	$0	$59	$200	$655	$915	0.2%
Pelagic Longline	$0	$0	$0	$0	$1,936	$0	$2,697	$4,633	0.8%
Surface Hook-and-Line Fishery for Albacore	$739	$21,809	$3,781	$9,974	$721	$143	$284	$37,451	6.2%
Groundfish Nearshore Fixed Gear	$0	$0	$2	$1,386	$718	$1,517	$379	$4,001	0.7%
Sablefish Fixed Gear	$1,400	$2,416	$568	$5,564	$3,219	$2,341	$3,290	$18,798	3.1%
Shoreside Nonwhiting Trawl	$0	$937	$9,939	$8,403	$7,171	$755	$0	$27,205	4.5%
Shoreside Whiting	$0	$5,956	$8,451	$7,653	$49	$0	$0	$22,109	3.7%
Salmon Troll	$57	$2,528	$428	$5,019	$8,444	$1,895	$28	$18,399	3.1%
California Lobster Pot	$0	$0	$0	$0	$0	$7	$14,850	$14,856	2.5%
Dungeness Crab Pot	$5,526	$33,689	$10,907	$41,955	$60,620	$4,005	$17	$156,718	26.0%
Halibut Longline	$157	$458	$149	$1,037	$14	$0	$0	$1,815	0.3%
Pink Shrimp Trawl	$0	$9,311	$5,224	$20,556	$3,165	$114	$0	$38,370	6.4%
Other	$101,798	$44,190	$6,355	$4,760	$6,240	$3,444	$20,020	$186,807	31.0%
Total	$109,677	$123,912	$49,083	$107,120	$96,069	$27,838	$88,575	$602,273	100.0%

c. Landings

Fishery	Puget Sound	Washington Coast	Astoria	Oregon Coast	Northern California	Central California	Southern California	Total	Percent of Total
CPS Seine	0	9,477	11,856	222	462	9,876	12,419	44,312	13.0%
Squid Seine	0	0	0	684	4,482	14,639	54,871	74,675	21.8%
Harpoon	0	0	0	0	0	0	16	16	0.0%
HMS Purse Seine	0	0	0	0	0	0	829	829	0.2%
Large Mesh Drift Gillnet	0	0	0	0	12	41	135	188	0.1%
Pelagic Longline	0	0	0	0	357	0	513	870	0.3%
Surface Hook-and-Line Fishery for Albacore	207	6,299	993	2,681	193	40	87	10,500	3.1%
Groundfish Nearshore Fixed Gear	0	0	1	217	99	105	31	453	0.1%
Sablefish Fixed Gear	205	357	81	766	554	448	412	2,823	0.8%
Shoreside Nonwhiting Trawl	0	905	8,032	5,850	4,364	385	0	19,537	5.7%
Shoreside Whiting	0	31,012	36,444	31,333	237	0	0	99,027	29.0%
Salmon Troll	5	204	35	393	674	135	2	1,447	0.4%
California Lobster Pot	0	0	0	0	0	0	357	357	0.1%
Dungeness Crab Pot	564	4,303	1,529	5,666	8,445	411	2	20,919	6.1%
Halibut Longline	14	42	12	85	1	0	0	154	0.0%
Pink Shrimp Trawl	0	6,848	3,782	14,518	2,502	51	0	27,701	8.1%
Other	14,799	11,546	1,767	1,705	2,750	602	4,832	38,000	11.1%
Total	15,795	70,992	64,533	64,121	25,132	26,733	74,504	341,809	100.0%

3.4.3 Tribal Fisheries Other Than Commercial

3.4.4 Recreational Fisheries

3.4.5 Fishery Related Data Systems

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

Under the MSA, a "fishing community" is a community that is "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and U.S. fish processors that are based in such community" (16 U.S.C. §1802). Social scientists have used that definition to develop profil es of West Coast fishing communities (Norman et al. 2007), and to define and quantify community involvement in commercial fisheries and their vulnerability to changes in fishery conservation and management measures (Sepez et al. 2007, Clay and Olson 2008, Alsharif and Miller 2012). NOAA's Technical Memorandum NMFS-NWFSC-85, Community Profiles for West Coast and North Pacific Fisheries: Washington, Oregon, California and other U.S. States (Norman et al. 2007) provides detailed social and demographic analyses of over 100 West Coast communities, which the FEP will not repeat here. However, that document provides a framework for thinking about coastal communities' vulnerability to changes in available commercial fishery harvest levels and available recreational fishing opportunities. National Standard 8, social vulnerability (CCIEA Annual Report sec. 6.1)

This section summarizes the variation in West Coast fishing community characteristics across [seven] broad regions. For each region the main ports and fisheries are identified (in terms of landings amount and composition, processing capacity, and other fishery related infrastructure along with demographic characteristics. The NWFSC Human Dimensions Team has published profiles of west coast fishing communities developed Community Social Vulnerability Indicators (CSVI) analyses (reported in the

Annual CCEIA Report), which are granular resources for considering regional variations in community characteristics.

Tables were created for each region showing landings, revenue, and vessels by ports ranked by landings amount. For the purposes of this section the portion of each table showing those top ranked ports accounting for more than 90% of landings in the region would be shown. An example table is shown below. Tables for showing data for all ports in each region may be accessed online.

Comment on the organization of these regions and the inclusion of port landings and revenue tables is sought.

3.4.6.1 Puget Sound

This region is not part of the CCE as defined in this FEP, but is part of the larger social-ecological system. Include/exclude?

3.4.6.2 Washington Coast

Example of the table excerpt described above.

Port	Average landings (mt)	Average revenue ($1,000)	No. vessels	Percent of total	Cumulative percent
Westport	54,856	$59,545	1,207	77.2%	77.2%
Ilwaco	8,501	$18,362	641	12.0%	89.2%
Neah Bay	2,110	$8,601	1,379	3.0%	92.2%

3.4.6.3 Astoria

More landings by volume are made into the port of Astoria than any other west coast port although it ranks third (after Westport, Washington, and Newport, Oregon) in terms of landed value. Comment sought on whether this should be treated as a separate region.

3.4.6.4 Oregon Coast

3.4.6.5 Northern California

3.4.6.6 Central California (San Francisco, Monterey Bay - Morro Bay)

3.4.6.7 Southern California Bight (Santa Barbara - San Diego)

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 3-9 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.

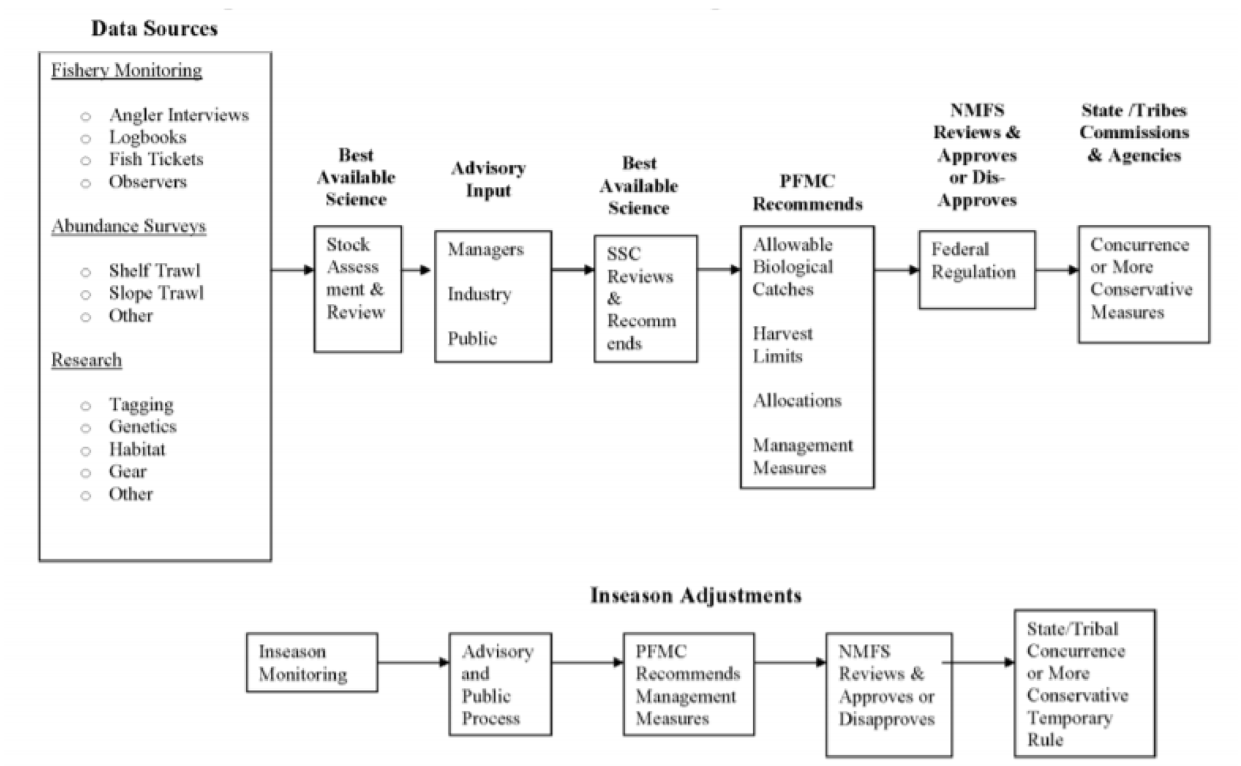

Figure 3-9. State/Tribal/Federal management process overview.

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 Pelagics Species FMP, which includes Pacific sardine, market squid, and other, related 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

September 2020 Note for Reviewers: This Section 3.5.2 text is exactly the same as provided in the 2013 FEP at Section 3.5.1.2. The EWG would particularly appreciate receiving advisory body corrections, updates, and other comments on this section at this meeting.

This section identifies existing ecosystem-based principles and management measures within current FMPs, particularly management measures that were either taken to mitigate the impact of fishing on the environment or ecosystem, or measures that take into account the effects of the biophysical environment on managed species. Additional protective management measures have also been promulgated under the ESA and MMPA. The fisheries are managed to include these protection measures. For each measure listed under the species group FMPs, we indicate in brackets the FMP species groups or protected species that may benefit from the measure listed. The following lists, separated by FMP, are current through February 2013.

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 West Coast ecosystem. These ecosystem conservation principles enhance fishery management by protecting, to the extent practicable, krill resources, which are an integral part of the ecosystem [HMS, groundfish, salmon, CPS, marine mammals, birds]
2. Conservative Management Strategy: The Council has demonstrated a consistently conservative approach to CPS harvest management in response to their ecological role as forage and importance to West Coast fisheries. The Council frequently reviews new science in support of stock assessments and management strategies and conducts annual stock assessments for the actively-managed species because of the annual variability that can occur in the biomass of CPS. In the late-1990's, the Council chose the most conservative HCR for Pacific sardine when presented a wide range of FMP harvest policies. The rationale for this harvest policy, like the other harvest controls rules in the FMP, is oriented toward maximizing biomass versus maximizing catch. Because of this, the annual harvest levels that result from the rule never exceed 12 percent of the estimated biomass for that year. [HMS, groundfish, salmon, CPS, marine mammals, birds]
3. Environmental Indicators: The intent of the existing environmental parameter in the Pacific sardine HCR is to explicitly adapt harvest levels in response to environmental variability. The existing environmental parameter is one of the Council's priority research needs and new science suggests a need to explore a broader range of ecological indicators of Pacific sardine productivity. Additionally the annual Stock Assessment and Fishery Evaluation (SAFE) document for CPS includes an 'Ecosystem Considerations' chapter that provides a summary of oceanographic trends and ecological indicators being tracked by NMFS in the CCE and potentially having an effect on CPS stocks. [CPS]
4. Cutoff Parameters: CPS HCRs have long utilized "Cutoff" parameters to protect a core spawning population and prevent stocks from becoming overfished. The Cutoff is a biomass level below which directed harvest is not allowed. Cutoff values are set at or above the overfished threshold and have the effect of automatically reducing harvest rates as biomass levels decline. This mechanism serves to preserve a spawning stock size. For Pacific sardine, the Cutoff value is 150,000 mt or three times the overfished threshold and is part of the Council's conservative management approach. [HMS, groundfish, salmon, CPS, marine mammals, birds]
5. Monitored stock harvest strategy: The ABC control rule for monitored stocks consists of a 75 percent reduction from the species overfishing level. This precautionary approach is in response to greater scientific uncertainty about stock status or management. [HMS, groundfish, salmon, CPS, marine mammals, birds]
6. EFH: EFH for CPS finfish species is temperature-based. The east-west geographic boundary of EFH for CPS is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C to 26°C. The southern boundary is the U.S.-Mexico maritime boundary. The northern boundary is more dynamic, and is defined as the position of the 10°C isotherm, which varies seasonally and annually. [CPS]
7. Ecosystem Component (EC) Species: The CPS FMP contains two EC species, jacksmelt and Pacific herring. In recognition of their role as forage, bycatch and incidental catch of these species is specifically monitored, along with all other bycatch/incidental catch, annually in the CPS SAFE document.

8. Bycatch provisions: Incidental catch provisions are often included in annual management recommendations for CPS. These provisions are included to allow for small allowances of incidental catch of a specific CPS species, for which the directed fishery may be closed, in other CPS fisheries to prevent and reduce discard. [CPS]
9. ESA incidental take protections: CPS fishing boat operators and crew are prohibited from deploying their nets if a southern sea otter is observed within the area that would be encircled by the purse seine. [otters]

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, is set extremely low to accommodate incidental catch while discouraging any fishery development, to ensure that it retains its role as prey for other (non-human) predator species. [Groundfish, HMS, salmon, marine mammals, seabirds] **September 2020 note: EWG recommends revising this item to read, “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 requiring fishery participants to sort their catch by species, ensuring better long-term data on the hugely varied groundfish species catch and landings. [Groundfish]
12. For whiting, participation in a U.S.-Canada bilateral treaty organization to jointly manage and conserve Pacific whiting to ensure that harvest of the cross-boundary resource remains within sustainable parameters. [Groundfish, marine mammals, seabirds]
13. Implementation of the Individual Fishing Quota trawl rationalization program, which has demonstrated reduced bycatch of non-target species such as halibut and overfished species of concern since its inception in January 2011. [Groundfish, Halibut]

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 3-7, 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 3-7. [Table 3.5.5] ESA-listed species that may occur in U.S. West Coast EEZ

Species	Status
Marine Mammals	
Blue whale *(Baleaenoptera musculus)*	Endangered
Fin whale *(Baleranoptera physalus)*	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Sei whale (*Balaenoptera borealis*)	Endangered
Sperm whale (*Physeter macrocephalus*)	Endangered
Killer whales, southern resident DPS (*Orcinus orca*)	Endangered
North Pacific Right whale (*Eubalaena japonica*)	Endangered
Steller sea lion, eastern DPS (*Eumetopias jubatus*)	Threatened
Southern sea otter (*Enhydra lutris nereis*)	Threatened
Guadalupe fur seal (*Arctocephalus townsendi*)	Threatened
Birds	
Short-tailed albatross (*Phoebastria albatrus*)	Endangered
Marbled murrelet *(Brachyramphus marmoratus marmoratus)*	Threatened
California least-tern *(Sternum antillarum browni)*	Endangered
Xantus's murrelet *(Synthliboramphus hypoleucus)*	Candidate
Sea turtles	
Leatherback turtle (*Dermochelys coriacea*)	Endangered
Loggerhead turtle, North Pacific Ocean DPS (*Caretta caretta*)	Endangered
Olive Ridley (*Lepidochelys olivacea*)	Endangered/Threatened
Green Sea Turtle (*Chelonia mydas*)	Endangered/Threatened
Marine invertebrates	
White abalone (*Haliotis sorenseni*)	Endangered
Black abalone (*Haliotis crachereodii*)	Endangered

Species		Status
Fish		
Green Sturgeon, southern DPS (*Acipenser medirostris*)		Threatened
Pacific eulachon, southern DPS (*Thaleichthys pacificus*)		Threatened
Yelloweye Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes ruberrimus*)		Threatened
Bocaccio, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)		Endangered
Canary Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes pinniger*)		
Yelloweye Rockfish, Puget Sound/Georgia Basin DPS (*Sebastes ruberrimus*)		
Salmonids		
Chinook (*Oncorhynchus tshawytscha*)	Sacramento River winter ESU	Endangered
	Central Valley Spring ESU	Threatened
	California Coastal ESU	Threatened
	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 3-8:

Table 3-8. [Table 3.5.6] MMPA-protected species that may occur in U.S. West Coast EEZ

Species	Stocks
Cetaceans	
Harbor porpoise (*Phocoena phocoena*)	Various
Dall's porpoise (*Phocoenoides dalli*)	CA/OR/WA stock
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	North Pacific stock; CA/OR/WA stock
Risso's dolphin (*Grampus griseus*)	CA/OR/WA stock
Bottlenose dolphin (*Tursiops truncatus*)	California coastal stock

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

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 non treaty 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 3-9). 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 3-9. [Table 3.5.5]: Coastal Treaty Tribes commercial fisheries.

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

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 over-arching 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). The Snake River, the Columbia River's largest tributary, and most of its watershed lie 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. The following accounts focus on sport 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 runs 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.).

3.6 References

Abrahms, B., Welch, H., Brodie, S., Jacox, M.G., Becker, E.A., Bograd, S.J., Irvine, L.M., Palacios, D.M., Mate, B.R. and Hazen, E.L., 2019. Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species. Diversity and Distributions, 25(8), pp.1182-1193.

Ainley, D.G. and T.J. Lewis. 1974. The history of Farallon Island marine bird populations, 1954-1972. Condor 76: 432-446.

Ainsworth, J.C., M. Vance, M.V. Hunter, and E. Schindler. 2012. The Oregon recreational Dungeness crab fishery, 2007-2011. Oregon Department of Fish and Wildlife Information Report 2012-04, Marine Resources Program, Newport, OR. 62p. Available at: http://www.dfw.state.or.us/MRP/shellfish/crab/reports.asp

Allen, L.G., D. J. Pondella and M.H. Horn (editors) 2006. The Ecology of Marine Fishes, University of California Press, Berkeley.

Allen, P.J., M. Nicholl, S. Cole, A. Vlazny and J.J. Cech, Jr. 2006. Growth of larval to juvenile green sturgeon in elevated temperature regimes. Transactions of the American Fisheries Society 135: 89-96.

Alsharif, K.A. and N. Miller. 2012. Data envelopment analysis to evaluate the reliance and engagement of Florida communities on Gulf of Mexico commercial red snapper fisheries. Fisheries 37: 19-26.

Anderson, D.W., F. Gress, K.F. Mais and R.R. Kelly. 1980. Brown pelicans as anchovy stock indicators and their relationships to commercial fishing. California Cooperative Oceanic Fisheries Investigations Reports 21:54-61.

Auster, P. J. 2005. Are deep water corals important habitat for fishes? In A. Freiwald and J.M. Roberts (editors) Cold-water corals and ecosystems. Springer Berlin Heidelberg: New York. pp. 747-760.

Bakun, A. (1973). Coastal upwelling indices, west coast of North America. US Department of Commerce. NOAA Technical Report, NMFS SSRF-671.

Bakun, A. (1975). Daily and weekly upwelling indices, west coast of North America. NOAA Tech. Rep, 16.

Bakun, A. 1996. Patterns in the Ocean: Ocean Processes and Marine Population Dynamics. California Sea Grant.

Banas, N.S., P. MaCready and B.M Hickey. 2008. The Columbia River plume as cross-shelf exporter and along-coast barrier. Continental Shelf Research 29(1): 292-301.

Banas, N. S., P. MacCready, and B. M. Hickey (2009a), The Columbia River plume as cross-shelf exporter and along-coast barrier, Cont. Shelf Res., 29(1), 292–301, doi:10.1016/j.csr.2008.03.011.

Banas, N., P. McDonald, and D. Armstrong (2009b), Green crab larval retention in Willapa Bay, Washington: An intensive Lagrangian modeling approach, Estuaries Coasts, 32(5), 893–905, doi:10.1007/s12237-009-9175-7.

Barlow, J., M. Kahru and B.G. Mitchell. 2008. Cetacean biomass, prey consumption, and primary production requirements in the California Current ecosystem. Marine Ecology Progress Series 371: 285-295.

Baskett, M.L., M. Yoklavich and M.S. Love. 2006. Predation, competition, and the recovery of overexploited fish stocks in marine reserves. Canadian Journal of Fisheries and Aquatic Sciences 63: 1214-1229.

Baumgartner, T.R., A. Soutar and V. Ferreira-Bartrina. 1992. Reconstructions of the history of Pacific sardine and northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California. California Cooperative Oceanic Fisheries Investigations Reports 33: 24-40.

Beacham, T.D., C.M. Neville, S. Tucker, and M. Trudel. 2017. Is there evidence of biologically significant size-selective mortality of coho salmon during the first winter of marine residence? Transactions of the American Fisheries Society 146:395-407.

Beamish, R.J. and C. Mahnken. 2001. A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change. Progress in Oceanography 49: 423-437.

Beamish, R.J., L.A. Weitkamp, L.D. Shaul, and V.I. Radchenko. 2018. Ocean ecology of Coho Salmon. Pages 391-554 in The Ocean Ecology of Pacific Salmon and Trout, R.J. Beamish, ed. American Fisheries Society, Bethesda Maryland.

Becker, E.A., Forney, K.A., Redfern, J.V., Barlow, J., Jacox, M.G., Roberts, J.J. and Palacios, D.M., 2019. Predicting cetacean abundance and distribution in a changing climate. *Diversity and Distributions*, *25*(4), pp.626-643.

Benson, S. R., T. Eguchi, D. G. Foley, et al. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):art84. doi:10.1890/ES11-00053.1

Berman-Kowalewski, M., Gulland, F.M.D., et al. 2010. Association between blue whale (*Balaenoptera musculus*) mortality and ship strikes along the California Coast. Aquatic Mammals 36: 59–66.

Bi, H., W.T. Peterson, and P.T. Strub. 2011. Transport and coastal zooplankton communities in the northern California Current system. Geophysical Research Letters 38:L12607. doi:10.1029/2011GL047927

Block, B., I.D. Jonsen, S. Jorgensen, et al. 2011. Tagging of Pacific pelagics: tracking apex marine predator movements in a dynamic ocean. Nature 475: 86-90.

Bjorkstedt, E., R. Goericke, S. McClatchie, et al. 2010. State of the California Current 2009–2010: regional variation persists through transition from La Niña to El Niño (and back?). California Cooperative Oceanic Fisheries Investigations Report 51: 39–69.

Block, B., I.D. Jonsen, S. Jorgensen et al. 2011. Tagging of Pacific pelagics: tracking apex marine predator movements in a dynamic ocean. Nature 475: 86-90.

Bograd, S.J., Hazen, E.L., Maxwell, S., Leising, A.W., Bailey, H. and Brodeur, R., 2016. Offshore ecosystems. *Ecosystems of California—A source book*, pp.287-309.

Bograd, S.J., Schroeder, I., Sarkar, N., Qiu, X., Sydeman, W.J. and Schwing, F.B., 2009. Phenology of coastal upwelling in the California Current. *Geophysical Research Letters*, *36*(1).

Bosley, K. L., J. W. Lavelle, R. D. Brodeur, W. W. Wakefield, R. L. Emmett, E. T. Baker, and K. M. Rehmke. 2004. Biological and physical processes in and around Astoria submarine Canyon, Oregon, USA. Journal of Marine Systems 50: 21–37.

Botsford, L. and C.A. Lawrence. 2002. Patterns of covariability among California Chinook salmon, Coho salmon, Dungeness crab, and physical oceanographic conditions. Progress in Oceanography 53: 283-305.

Brinton, E. and A. Townsend. 2003. Decadal variability in abundances of the dominant euphausiid species in southern sectors of the California Current. Deep-Sea Research II 50: 2449-2472.

Brodeur, R.D. 1990. A synthesis of the food habits and feeding ecology of salmonids in marine waters of the North Pacific. FRI-UW-9016, Fisheries Research Institute, University of Washington, Seattle, Wash.

Brodeur, R.D., W.T. Peterson, T.D. Auth, H.L. Soulen, M.M. Parnel, and A.A. Emerson. 2008. Abundance and diversity of coastal fish larvae as indicators of recent changes in ocean and climate conditions in the Oregon upwelling zone. Marine Ecology Progress Series 366: 187-202.

Brodeur, R.D. J.J. Ruzicka and J.H. Steele. 2011. Investigating alternate trophic pathways through gelatinous zooplankton and planktivorous fishes in an upwelling ecosystem using end-to-end models. Interdisciplinary Studies on Environmental Chemistry—Marine Environmental Modeling and Analysis. TERRAPUB, Tokyo, 57-63.

Brodeur, R.D., and C.A. Morgan. 2016. Influence of a coastal riverine plume on the cross-shelf variability in hydrography, zooplankton, and juvenile salmon diets. Estuaries and Coasts 39:1183-1198.

Bundy, A., J.J. Heymans, L. Morissette and C. Savenkoff. 2009. Seals, cod and forage fish: A comparative exploration of variations in the theme of stock collapse and ecosystem change in four Northwest Atlantic ecosystems. Progress in Oceanography 81: 188-206.

Calbet, A. and M.R. Landry. 2004. Phytoplankton growth, microzooplankton grazing, and carbon cycling in marine systems. Limnology and Oceanography 49(1): 51-57.

California Current Integrated Ecosystem Assessment (CCIEA): Phase II. 2012. P. Levin and B. Wells (editors) http://www.noaa.gov/iea/.

California Department of Fish and Wildlife. 2018. 2018 Master Plan for Fisheries A Guide for Implementation of the Marine Life Management Act. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=159222&inline

Capotondi, A., Wittenberg, A.T., Newman, M., Di Lorenzo, E., Yu, J.Y., Braconnot, P., Cole, J., Dewitte, B., Giese, B., Guilyardi, E. and Jin, F.F., 2015. Understanding ENSO diversity. *Bulletin of the American Meteorological Society*, *96*(6), pp.921-938.

Carlson, S.M. and W.H. Satterthwaite. 2011. Weakened portfolio effect in a collapsed salmon population complex. Canadian Journal of Fisheries and Aquatic Sciences 68: 1579-1589.

Carretta, J.V., K. A. Forney, E. Oleson, et al. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2010. NOAA-TM-NMFS-SWFSC-476. http://www.nmfs.noaa.gov/pr/pdfs/sars/po2010.pdf.

Cayan, D.R. and D.H. Peterson. 1989. The influence of North Pacific atmospheric circulation on streamflow in the west. Geophysical Monograph 55: 375-397.

Chavez, F.P., J. Ryan, S.E. Lluch-Cota and M. Niquen. 2003. From anchovies to sardines and back: Multidecadal change in the Pacific Ocean. Science 299: 217-221.

Chan, F., Barth, J.A., Lubchenco, J., Kirincich, A., Weeks, H., Peterson, W.T. and Menge, B.A., 2008. Emergence of anoxia in the California current large marine ecosystem. Science, 319(5865), pp.920-920.

Chasco, B., I.C. Kaplan, A. Thomas, A. Acevedo-Gutierrez, D. Noren, M.J. Ford, M.B. Hansen, J. Scordino, S. Jeffries, S. Pearson, K. N. Marshall, and E.J. Ward. 2017. Estimates of chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. Canadian Journal of Fisheries and Aquatics Sciences 74:1173-1194.

Checkley, D.M. and J.A. Barth. 2009. Patterns and processes in the California Current System. Progress in Oceanography 83: 49–64.

Childers, J., S. Snyder, and S. Kohin, S. 2011. Migration and behavior of juvenile North Pacific albacore (Thunnus
alalunga). Fish. Oceanogr. 20:157– 173.

Christian, J.R., Ono, T. [Eds.] 2019. Ocean Acidification and Deoxygenation in the North Pacific Ocean. PICES Special Publication 5, 116 pp.

Checkley, D.B., J. Alheit, Y. Oozeki and C. Roy. 2009. Climate change and small pelagic fish. Cambridge University Press: Cambridge.

Clapham, P.J., S. Leatherwood, I. Szczepaniak, and R.L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13:3: 368-394.

Clay, P.M. and J. Olson. 2008. Defining "Fishing Communities": Vulnerability and the Magnuson-Stevens Fishery Conservation and Management Act. Human Ecology Review 15: 143-160.

Cobb, J.N. 1930. Pacific Salmon Fisheries. Appendix XIII to the Report of the Commissioner of Fisheries for 1930. Bureau of Fisheries Document No. 1092.

Cox, S.P., T.E. Essington, J.F. Kitchell, et. al. 2002.Reconstructing ecosystem dynamics in the central Pacific Ocean, 1952-1998. II. A preliminary assessment of the trophic impacts of fishing and effects on tuna dynamics. Canadian Journal of Fisheries and Aquatic Sciences 59: 1736-1747.

Columbia River DART (Data in Real Time) Columbia Basin Research, School of Aquatic & Fishery Sciences, University of Washington. Accessed 05/11/12: http://www.cbr.washington.edu/dart/

Crawford, R. J. M. 1987. Food and population variability in five regions supporting large stocks of anchovy, sardines, and horse mackerel. South African Journal of Marine Science 5:735–757.

Crowder, L. and E. Norse. 2008. Essential ecological insights for marine ecosystem-based management and marine spatial planning. Marine Policy 32: 772-778.

Cummins, P. F., and H. J. Freeland. 2007. Variability of the North Pacific Current and its bifurcation. Progress in Oceanography 75:253-265.

Cury, P., A. Bakun, R. J. M. Crawford, A. Jarre, R. A. Quiñones, L. J. Shannon, and H. M. Verheye. 2000. Small pelagics in upwelling systems: Patterns of interaction and structural changes in "wasp-waist" ecosystems. ICES Journal of Marine Science 57:603–618.

Cury, P.M., I.L. Boyd, S. Sylvain Bonhommeau, et al. 2011.Global seabird response to forage fish depletion—one-third for the birds. Science 334 : 1703-1706.

Dahms, H.U. 1995. Dormancy in the copepoda — an overview. Hydrobiologia 306:199–211.

Dale, K.E., E.A. daly, and R.D. Brodeur. 2016. Interannual variability in the feeding and condition of subyearling Chinook salmon off Oregon and Washington in relation to fluctuating ocean conditions. FIsheries Oceanography 26:1-16.

Daly, E.A., and R.D. Brodeur. 2015. Warming ocean conditions relate to increased trophic requirements of threatened and endangered salmon. PLoS ONE 10(12): e0144066. doi:10.1371/journal.pone.0144066

Daly, E.A., R.D. Brodeur and L.A. Weitkamp. 2009. Ontogenetic shifts in diets of juvenile and subadultcoho and Chinook salmon in coastal marine waters: Important for marine survival? Transactions of the American Fisheries Society 138: 1420-1438.

Dayton, P.K., M.J. Tegner, P.B. Edwards, and K.L. Riser. 1999. Temporal and spatial scale of kelp demography: The role of oceanographic climate. Ecological Monographs 69:219-250.

Di Lorenzo, E., Mantua, N., 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change 6, 1042–1047. https://doi.org/10.1038/nclimate3082

Di Lorenzo E., Schneider N., Cobb K. M., Chhak, K, Franks P. J. S., Miller A. J., McWilliams J. C., Bograd S. J., Arango H., Curchister E., Powell T. M. and P. Rivere, 2008: North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophys. Res. Lett., 35, L08607, doi:10.1029/2007GL032838.

Dorner, B., R.M. Peterman and S.L. Haeseke. 2008. Historical trends in productivity of 120 Pacific pink, chum, and sockeye salmon stocks reconstructed by using a Kalman filter. Canadian Journal of Fisheries and Aquatic Sciences 65(9): 1842-1866.

Dorner, B., M.J. Catalano, and R.M. Peterman. 2018. Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences 75:1082-1095.

Dufault, A.M., K. Marshall, and I.C. Kaplan. 2009. A synthesis of diets and trophic overlap of marine species in the California Current. U.S. Department of Commerce NOAA Technical Memorandum NMFS-NWFSC-103, 81 p.

Emmett, R. L., R. D. Brodeur, T. W. Miller, S. S. Pool, P. J. Bentley, G. K. Krutzikowsky and J. McCrae. 2005. Pacific sardine (*Sardinops sagax*) abundance, distribution, and ecological relationships in the Pacific Northwest. California Cooperative Oceanic Fisheries Investigations Report 46:122–143.

Engel, J. and R. Kvitek. 1998. Effects of Otter Trawling on a Benthic Community in Monterey Bay National Marine Sanctuary. Consevation Biology 12: 1204-1214.

Essential Fish Habitat Review Committee. 2012. Pacific Coast Groundfish 5-Year Essential Fish Habitat Report to the Pacific Fishery Management Council, Phase 1: New Information. 452 pp.

Estes, J.A., D. P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell (editors). 2006. Whales, Whaling, and Ocean Ecosystems. University of California Press, Berkeley, CA.

Etnoyer, P. and L. Morgan. 2005Habitat-forming deep-sea corals in the Northeast Pacific Ocean. . In A. Freiwald and J.M. Roberts (editors). Cold-water corals and ecosystems Springer, New York, NY. pp. 331-343.

Federal Geographic Data Committee, 2012. Coastal and Marine Ecological Classification Standard. FGDC-STD-018-2012.

Fenchel, T. 1988. Marine plankton food chains. Annual Review of Ecology and Systematics 19: 19-38.

Field, J.C. and R.C. Francis. 2006. Considering ecosystem-based fisheries management in the California Current. Marine Policy 30: 552-569.

Field, J.C., R.C. Francis, and K. Aydin. 2006. Top-down modeling and bottom-up dynamics: linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68: 238-270.

Field, J.C., K. Baltz, A.J. Phillips and W.A. Walker. 2007. Range expansion and trophic interactions of the jumbo squid, *Dosidicus gigas*, in the California Current. California Cooperative Oceanic Fisheries Investigations Reports 48: 131-146.

Finney, B.P., I. Gregory-Eaves, J. Sweetman, M.S.V. Douglas and J.P. Smol. 2000. Impacts of climatic change and fishing on Pacific Salmon abundance over the past 300 years. Science 290: 795-799.

Ford, M. T. Cooney, P. McElhany, et al. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Northwest. U.S. Department of Commerce NOAA Technical Memorandum NMFS-NWFSC-113, 281 p.

Francis, R. C., J.E. Little and J.A. Bloeser. 2009. Matching spatial scales of ecology, economy, and management for groundfish of the US West Coast marine ecosystem: a state of the science review. A report to the Lensfest Ocean Program at the Pew Charitable Trusts. http://nsgl.gso.uri.edu/washu/washut09008.pdf.

Fréon, P., P. Cury, L. Shannon and C. Roy. 2005. Sustainable exploitation of small pelagic stocks challenged by environmental and ecosystem changes. Bulletin of Marine Science 76: 385-462.

Fréon, P., J. Arístegui, A. Bertrand, et al. 2009. Functional group biodiversity in Eastern Boundary Upwelling Ecosystems questions the wasp-waist trophic structure. Progress in Oceanography 83: 97-106.

Freon, P., M. Barange, J. Aristegui. 2009. Eastern Boundary Upwelling Ecosystems: Integrative and comparative approaches. Progress in Oceanography, 83, 1-4, 1-14, doi.org/10.1016/j.pocean.2009.08.001

Friedman, W.R., B.T. Martin, B.K. Wells, P. Warzybok, C.J. Michel, E.M. Danner, and S.T. Lindley. Modeling composite effects of marine and freshwater processes on migratory species. Ecosphere 10(7):e02743. 10.1002/ecs2.2743

Fujioka, K., H. Fukuda, Y. Tei, S. Okamoto, H. Kiyofuji, S. Furukawa, J. Takagi et al. 2018. Spatial and temporal variability in the trans-Pacific migration of Pacific bluefin tuna (Thunnus orientalis) revealed by archival tags. Prog. Oceanogr. 162:52–65.

Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun Bays. In: D.W. Kelley (ed.) Ecological Studies of the Sacramento San Joaquin Estuary: Part I; Zooplankton, Zoobenthos, and Fishes of San Pablo and Suisun Bays, Zooplankton and Zoobenthos of the Delta. California Department of Fish and Game. Fish Bulletin 133.

Garfield, N. and C. Harvey. 2016. California Current Integrated Ecosystem (CCIEA) State of the Californai Current Report.

Giddings, S.N., MacCready, P., Hickey, B.M., Banas, N.S., Davis, K.A., Siedlecki, S.A., Trainer, V.L., Kudela, R.M., Pelland, N.A., Connolly, T.P., 2014. Hindcasts of potential harmful algal bloom transport pathways on the Pacific Northwest coast. Journal of Geophysical Research: Oceans 119, 2439–2461. https://doi.org/10.1002/2013JC009622

Gordon, B.L. 1987. Monterey Bay Area: Natural History and Cultural Imprints. Boxwood Press: Pacific Grove.

Greene, H.G., M.M. Yoklavich, R.M. Starr, et al. 1999. A classification scheme for deep seafloor habitats. Oceanologica ACTA. 22(6): 663-678.

Gustafson, R.G., M.J. Ford, P.B. Adams, J.S. Drake, R.L. Emmett, K.L. Fresh, M. Rowse, E.A.K. Spangler, R.E. Spangler, D.J. Teel, and M.T. Wilson. 2012. Conservation status of eulachon in the California Current. Fish and Fisheries 13:121-138.

Haltuch, M.A., Tolimieri, N., Qi, L., Jacox, M.G. 2020. Oceanographic drivers of petrale sole recruitment in the California Current Ecosystem. Fisheries Oceanography 29: 122–136. DOI: 10.1111/fog.12459.

Hamlin, J. S., Jr. 1974, The Structure of the Upper Monterey Submarine Fan Valley. M.S. Thesis, Naval Postgraduate School, U.S. Navy, Monterey, CA.

Hanan, D.A., D.B. Holts, and A.L. Coan. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Vol. 175. State of California, Resources Agency, Department of Fish and Game, 1993.

Hannah, R.W., M.J.M. Lomeli, and S.A. Jones. 2013. Direct estimation of disturbance rates of benthic macroinvertebrates from contact with standard and modified ocean shrimp (*Pandalus jordani*) trawl footropes. Journal of Shellfish Research, 32(2):551-557.

Hannah, R.W., S.A. Jones, M.J.M. Lomeli,and W.W. Wakefield. 2011. Trawl net modifications to reduce the bycatch of eulachon (*Thaleichthys pacificus*) in the ocean shrimp (*Pandalus jordani*) fishery. Fisheries Research 110:277– 282.

Hartwell, S.I. 2008. Distribution of DDT and other persistent organic contaminants in Canyons and on the continental shelf off the central California coast. Marine Environmental Research 65: 199-217.

Harvey, C., N. Garfield, G. Williams, N. Tolimieri, I. Schroeder, K. Andrews, K. Barnas, E. Bjorkstedt, S. Bograd, R. Brodeur, B. Burke, J. Cope, A. Coyne, L. deWitt, J. Dowell, J. Field, J. Fisher, P. Frey, T. Good, C. Greene, E. Hazen, D. Holland, M. Hunter, K. Jacobson, M. Jacox, C. Juhasz, I. Kaplan, S. Kasperski, D. Lawson, A. Leising, A. Manderson, S. Melin, S. Moore, C. Morgan, B. Muhling, S. Munsch, K. Norman, R. Robertson, L. Rogers-Bennett, K. Sakuma, J. Samhouri, R. Selden, S. Siedlecki, K. Somers, W. Sydeman, A. Thompson, J. Thorson, D. Tommasi, V. Trainer, A. Varney, B. Wells, C. Whitmire, M. Williams, T. Williams, J. Zamon, and S. Zeman. 2019. Ecosystem Status Report of the California Current for 2019: A Summary of Ecosystem Indicators Compiled by the California Current Integrated Ecosystem Assessment Team (CCEIA). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NWFSC-149. https://doi.org/10.25923/p0ed-ke21

Hazen, E.L., Jorgensen, S., Rykaczewski, R.R., Bograd, S.J., Foley, D.G., Jonsen, I.D., Shaffer, S.A., Dunne, J.P., Costa, D.P., Crowder, L.B. and Block, B.A., 2013. Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change*, *3*(3), pp.234-238.

Hazen, E.L., Abrahms, B., Brodie, S., Carroll, G., Jacox, M.G., Savoca, M.S., Scales, K.L., Sydeman, W.J. and Bograd, S.J., 2019. Marine top predators as climate and ecosystem sentinels. *Frontiers in Ecology and the Environment*, *17*(10), pp.565-574.

Henderson, M., J. Fiechter, D.D. Huff, and B.K. Wells. 2019. Spatial variability in ocean-mediated growth potential is linked to Chinook salmon survival. Fisheries Oceanography 28:334-344.

Herke, W. H. and B. D. Rogers. 1993. Maintenance of the estuarine environment. In C. C. Kohler and W. A. Hubert (editors) Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland. pp. 263-286.

Hertz, E., M. Trudel, S. Tucker, T.D. Beacham, C. Parken, D. Mackas, and A. Mazumder. 2016. Influences of ocean conditions and feeding ecology on the survival of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 25:407-419.

Heublein, J., R. Bellmer, R.D. Chase, P. Doukakis, M. Gingras, D. Hampton, J.A. Israel, Z.J. Jackson, R.C. Johnson, O.P. Langness, S. Luis, E. Mora, M.L. Moser, L. Rohrbach, A.M. Seesholtz, T. Sommer, and J.S. Stuart. 2017. Life history and current monitoring inventory of San Francisco estuary sturgeon. NOAA-TM-NMFS-SWFSC-589

Hickey, B.M. 1998.Coastal oceanography of Western North America from the tip of Baja California to Vancouver Island. In A.R. Robinson and K.H. Brink (editors) The Sea, Volume 11. John Wiley and Sons: New York.

Hickey, B., S. Geier, N. Kachel, and A. MacFadyen (2005), A bi-directional river plume: The Columbia in summer, Cont. Shelf Res., 25(14), 1631–1656, doi:10.1016/j.csr.2005.04.010.

Hickey, B.M. and N.S. Banas. 2008. Why is the northern end of the California Current system so productive? Oceanography 21(4): 90-107.

Hickey, B.M., R.M. Kudela, J.D. Nash, et al. 2010. River influences on shelf ecosystems: Introduction and synthesis. Journal of Geophysical Research, 115: C00B17, doi:10.1029/2009JC005452.

Hixon, M. A. and G. P. Jones. 2005. Competition, predation, and density-dependent mortality in demersal marine fishes. Ecology 86:2847–2859.

Hixon, M.A. and B.N. Tissot. 2007. Comparison of trawled vs untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. Journal of Experimental Marine Biology and Ecology 344: 23-34.

Holbrook, S. J. and R. J. Schmitt. 2002. Competition for shelter space causes density-dependent predation mortality in damselfishes. Ecology 83: 2855–2868.

Holt, C.A. and N. Mantua. 2009. Defining the spring transition: regional indices for the California Current System. Marine Ecology Progress Series 393: 285-299.

Howell, E., D. Kobayashi, D. Parker and G. Balazs. 2008. TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles *Caretta caretta* in the Hawaii-based pelagic longline fishery. Endangered Species Research 5: 267-278.

Hoss, D. E. and G. W. Thayer. 1993. The importance of habitat to the early life history of estuarine dependent fishes. American Fisheries Society Symposium 14:147-158.

Hunt, G.L. Jr., H. Kato and S.M. McKinnell. 2000. Predation by marine birds and mammals in the subarctic North Pacific Ocean. PICES Scientific Report No. 14.

Hunter, M. 2008. 2006 Clatsop Beach Razor Clam Fishery Status Report, Shellfish/Estuarine Habitat Projects Data Report, ODFW. 17p. http://www.dfw.state.or.us/MRP/publications/docs/Razor_2006.pd

Idaho Department of Fish and Game. 2019. Fisheries management plan 2019–2024. Idaho Department of Fish and Game, Boise.

Irving, J. S. and T. C. Bjornn. 1981. Status of Snake River fall Chinook salmon in relation to the Endangered Species Act. Prepared for the U.S. Fish and Wildlife Service.Unpubl.manuscr., 55 p. Available: Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, ID 83843.

Jacox, M.G., Hazen, E.L., Zaba, K.D., Rudnick, D.L., Edwards, C.A., Moore, A.M. and Bograd, S.J., 2016. Impacts of the 2015–2016 El Niño on the California Current System: Early assessment and comparison to past events. *Geophysical Research Letters*, *43*(13), pp.7072-7080.

Jacox, M.G., Edwards, C.A., Hazen, E.L. and Bograd, S.J., 2018. Coastal upwelling revisited: Ekman, Bakun, and improved upwelling indices for the US West Coast. *Journal of Geophysical Research: Oceans*, *123*(10), pp.7332-7350.

Jagielo, T.H., A. Hoffman, J. Tagart and M. Zimmermann. 2003. Demersal groundfish densities in trawlable and untrawlable habitats off Washington: Implications for the estimation of habitat bias in trawl surveys. Fishery Bulletin 101: 545-565.

Jahncke, J., D.M. Checkley Jr. and G.L. Hunt, Jr. 2004. Trends in carbon flux to seabirds in the Peruvian upwelling system: effects of wind and fisheries on population regulation. Fisheries Oceanography 13: 208-223

Kabata, Z. 1969. *Phrixocephalus cincinnatus* Wilson, 1908 (Copepoda: Lernaeoceridae): Morphology, metamorphosis, and host-parasite relationship. Journal of the Fisheries Board of Canada 26: 921–934.

Kaeriyama, M., Nakamura, M., Edpalina, R., Bower, J.R., Yamaguchi, H., Walker, R.V. and K.W. Myers. 2004. Change in feeding ecology and trophic dynamics of Pacific salmon (*Oncorhynchus* spp.) in the central Gulf of Alaska in relation to climate events. Fisheries Oceanography 13(3): 197–207.

Kaplan, I.C., I.A. Gray and P.S. Levin. 2012. Cumulative impacts of fisheries in the California Current. Fish and Fisheries.

Kendall, A.W. Jr. and J.R. Clark. 1982. Ichthyoplankton off Washington, Oregon, and Northern California April-May 1980. NWAFC Processed Report 82-11. 44 p.

Kim, J., H. Cho, and G. Kim. 2018. Significant production of humic fluorescent dissolved organic matter in the continental shelf waters of the northwestern Pacific Ocean. Scientific Reports 8:4887 | DOI:10.1038/s41598-018-23299-1.

Kitchell, J. F., C. Boggs, X. He, and C. J. Walters. 1999. Keystone predators in the Central Pacific. In Ecosystem approaches to fisheries management, p. 665 – 683. Univ. Alaska Sea Grant Rep. AL - SG-99-01, Anchorage, Alaska.

Kleppel, G. S. 1993. On the diets of calanoid copepods. Marine Ecology Progress Series 99: 183-183.

Koehn, L.E., Essington, T.E., Marshall, K.N., Kaplan, I.C., Sydeman, W.J., Szoboszlai, A.I. and Thayer, J.A., 2016. Developing a high taxonomic resolution food web model to assess the functional role of forage fish in the California Current ecosystem. Ecological Modelling, 335, pp.87-100.

Krieger, K. J. and B.L. Wing. 2002. Megafauna associations with deep-water corals (*Primnoa* spp.) in the Gulf of Alaska. Hydrobiologia 471: 83–90.

Lafferty, K.D. S. Allesina, M. Arim, et al.. 2008. Parasites in food webs: the ultimate missing links. Ecology Letters 11: 533-546.

Lafferty, K.D. Fishing for lobsters indirectly increases epidemics in sea urchins. Ecological Applications 14: 1566-1573.

Lehodey P., I. Senina and R. Murtugudde. 2008. A spatial ecosystem and populations dynamics model (SEAPODYM) Modelling of tuna and tuna-like populations. Progress in Oceanography 78: 304-318.

Leising, A.W., J.J. Pierson, C. Halsband-Lenk, R. Horner and J. Postel. 2005. Copepod grazing during spring blooms: Does *Calanus pacificus* avoid harmful diatoms? Progress in Oceanography 67(3): 384-405.

Levin, P.S., E.E. Holmes, K.R. Piner and C.J. Harvey. 2006. Shifts in a Pacific Ocean fish assemblage: The potential influence of exploitation. Conservation Biology 20: 1181-1190.

Levin, P. and B. Wells, eds. 2011. Discussion Document: Development of an annual report on conditions in the California Current Ecosystem. Pacific Fishery Management Council November 2011 Agenda Item H.1.b., Attachement 1. Available online: http://www.pcouncil.org/wp-content/uploads/H1b_ATT1_DD_CA_ECO_NOV2011BB.pdf

Li, Q.P., P.J.S. Franks and M.R. Landry. 2011. Microzooplankton grazing dynamics: parameterizing grazing models with dilution experiment data from the California Current Ecosystem. Marine Ecology Progress Series 438: 59-69.

Lindholm, J., M. Kelly, D. Kline, and J. deMarignac. 2009. Patterns in the Local Distribution of the Sea Whip, *Halipteris willemoesi*, in an Area Impacted by Mobile Fishing Gear. Marine Technology Society Journal 42: 64-68.

Lindholm, J., M. Gleason, D. Kline, L. Clary, S. Rienecke, and M. Bell. 2013. Central Coast Trawl Impact and Recovery Study: 2009-2012 Final Report. A Report to the California Ocean Protection Council, Grand #10-058, 49 pp.

Lindley, S.T., Grimes, C.B., Mohr, et. al. 2009. What caused the Sacramento River fall Chinook stock collapse? NOAA Tech. Memo. NMFS NOAA-TM-NMFS-SWFSC-447.

Lindley, S.T., D.L. Erickson, G.D. Williams, and O. Langness. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108-122.

Liu, Y., P. MacCready, and B. M. Hickey (2009a), Columbia River plume patterns in summer 2004 as revealed by a hindcast coastal ocean circulation model, Geophys. Res. Lett., 36, L02601, doi:10.1029/2008GL036447.

Liu, Y., P. MacCready, B. M. Hickey, E. P. Dever, P. M. Kosro, and N. S. Banas (2009b), Evaluation of a coastal ocean circulation model for the Columbia River plume in summer 2004, J. Geophys. Res., 114(C2), C00B04, doi:10.1029/2008JC004929.

Logerwell, E.A., N. Mantua, P.W. Lawson, R.C. Francis, and V.N. Agostini. 2003. Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (*Oncorhynchus kisutch*) marine survival. Fisheries Oceanography 12:554-568.

Lucas, B. G., S,M. Verrin and R. Brown. 2007. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Fisheries and Oceans Canada.

Lundsten, L., Schlining, K. L., Frasier, K., et al. 2010. Time-series analysis of six whale-fall communities in Monterey Canyon, California, USA. Deep Sea Research I 57:1573-1584.

Lyman, R.L. 1988. Zoogeography of Oregon coast marine mammals: the last 3,000 years. Marine Mammal Science 4(3): 247-264.

Lynn, R. J., S.J. Bograd, T.K. Chereskin and A. Huyer. 2003. Seasonal renewal of the California Current: The spring transition off California. Journal of Geophysical Research: Oceans (1978–2012): 108(C8).

MacCall, A.D. 1996. Patterns of low-frequency variability in fish populations of the California Current. California Cooperative Oceanic Fisheries Investigations Reports 37: 100-110.

MacCall, A.D. 2002. Fishery management and stock rebuilding prospects under conditions of low frequency environmental variability and species interactions. Bulletin of Marine Science 70(2): 613-628.

MacCall, A.D. 2009. A short scientific history of the fisheries. In Checkley, D., J. Alheit, Y. Oozeki and C. Roy (editors) Climate Change and Small Pelagic Fish. Cambridge University Press.

MacCready, P., N. S. Banas, B. M. Hickey, E. P. Dever, and Y. Liu (2009), A model study of tide- and wind-induced mixing in the Columbia River Estuary and plume, Cont. Shelf Res., 29(1), 278–291, doi:10.1016/j.csr.2008.03.015.

Magnuson, W.G. 1968. The opportunity is waiting… make the most of it. In D.W. Gilbert (editor) The Future of the Fishing Industry of the United States. University of Washington Publications in Fisheries 4: 7-9.

Mallett, J. L. 1974. Inventory of salmon and steelhead resources, habitat, use and demands. Job performance report F-58-R-1. Idaho Department of Fish and Game, Boise.

Mann, K.H. and J.R.N. Lazier. 1996. Dynamics of Marine Ecosystems. Blackwell: Cambridge.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6): 1069-1079.

Mantua, N.J. and S.R. Hare. 2002. The Pacific Decadal Oscillation. Journal of Oceanography 58(1): 35-44.

Marliave, J.B., K.W. Conway, D.M. Gibbs, A. Lamb, and C. Gibbs. 2009. Biodiversity and rockfish recruitment in sponge gardens and bioherms of southern British Columbia, Canada. Marine Biology 156: 2247-2254.

Mason, J.E. and A. Bakun. 1986. Upwelling index update, U.S. west coast, 33N-48N latitude. U.S. Dept. of Commerce, NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-67.

Mason, J.G., Hazen, E.L., Bograd, S.J., Dewar, H. and Crowder, L.B., 2019. Community-level effects of spatial management in the California drift gillnet Fishery. Fisheries Research, 214, pp.175-182.

Mathews, G. and R. Waples 1991. Status Review for Snake River Spring and Summer Chinook Salmon. U.S. Department of Commerce NOAA Technical Memorandum NMFS-F/NWC-200.

Matsura, H. and G.A. Cannon. 1997. Wind Effects on Sub-Tidal Currents in Puget Sound. Journal of Oceanography 53: 53-66.

McDonald, P.S., Jensen, G.C., Armstrong, D.A. 2001. The competitive and predatory impacts of the nonindigenous crab *Carcinus maenas* (L.) on early benthic phase Dungeness crab *Cancer magister* Dana. Journal of Experimental Marine Biology and Ecology. 258(1): 39–54.

McEvoy, A.F. 1986. The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980. Cambridge University Press.

McEvoy, A.F. 1996. Historical interdependence between ecology, production, and management in California fisheries. In D. Bottom, G. Reeves and M. Brookes (editors) Sustainability Issues for Resource Managers. USDA Forest Service Tech Rep. PNW-GTR-370.pp 45-53.

Miller, J.A., D.J. Teel, A. Baptista, and C.A. Morgan. 2013. Disentangling bottom-up and top-down effects on survival during early ocean residence in a population of Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Science 70:617-629.

Miller, J.A., D.J. Teel, W.T. Peterson, and A.M. Baptista. 2014. Assessing the relative importance of local and regional processes on the survival of a threatened salmon population. PLoS ONE 9(6):e99814. doi:10.1371/journal.pone.0099814

Miller, T.W.and R.D. Brodeur. 2007. Diet of and trophic relationships among dominant marine nekton within the Northern California Current ecosystem. Fishery Bulletin 105: 548-559

Morgan, C.A., Beckman, B.R., Weitkamp, L.A. and Fresh, K.L., 2019. Recent ecosystem disturbance in the Northern California Current. Fisheries, 44(10), pp.465-474.

Moser, H. G., R. L. Charter, P. E. Smith, D. A. Ambrose, W. Watson, S. R. Charter, and E. M. Sandknop. 2001. Distributional atlas of fish larvae and eggs in the Southern California Bight region: 1951-1998. California Cooperative Oceanic Fisheries Investigations Reports Atlas 34. 166pp.

Moser, M.L., J.A. Israel, M. Neuman, S.T. Lindley, D.L. Erickson, B.W. McCovey Jr, and A.P. Klimley. 2016. Biology and life history of Green Sturgeon (*Acipenser medirostris* Ayres, 1854): state of the science. Journal of Applied Ichthyology 32(Suppl. 1):67-86.

Muhling, B., Brodie, S., Snodgrass, O., Tommasi, D., Dewar, H., Childers, J., Jacox, M., Edwards, C., Xu, Y.,

Synder, S. 2019. Dynamic habitat use of albacore and their primary prey species in the California Current System. CalCOFI Rep., Vol. 60

National Marine Fisheries Service. 2012. National Coastal and State Input/Output Model website. Accessed on October 10, 2012: https://www.st.nmfs.noaa.gov/apex/f?p=160:1:3937876959984309

National Marine Fisheries Service. 2011. Fisheries Economics of the United States, 2010. U.S. Department of Commerce NOAA Technical Memorandum NMFS-F/SPO-118, 175p. Available at: https://www.st.nmfs.noaa.gov/st5/publication/index.html.

National Marine Fisheries Service. 2010. Fisheries Economics of the United States, 2009. U.S. Department of Commerce NOAA Technical Memorandum NMFS-F/SPO-118, 172p. Available at: https://www.st.nmfs.noaa.gov/st5/publication/index.html.

National Marine Fisheries Service. 2005. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. April 6, 2005. Federal Register 70(65):17386-17401.

National Research Council . 1996. The Bering Sea Ecosystem. National Academy Press: Washington DC.

Nickelson, T. E. and P. W. Lawson. 1998. Population viability of coho salmon (*O. kisutch*) in Oregon coastal basins: application of a habitat-based life history model. Canadian Journal of Fisheries and Aquatic Sciences 55: 2383-2392.

Norman, K., J. Sepez, H. Lazrus, et al. 2007. Community profiles for West Coast and North Pacific fisheries–Washington, Oregon, California, and other U.S. states. U.S. Department of Commerce NOAA Technical Memorandum NMFS-NWFSC-85, 602 p.

North, W.J. and C.L. Hubbs. 1968. Utilization of kelp-bed resources in southern California. California Department of Fish and Game, Fish Bulletin, pp. 264.

Ogden, A. 1933. Russian sea-otter and seal hunting on the California coast: 1803-1841. Quarterly of the California Historical Society 12: 217-251.

Oregon Department of Fish and Wildlife. 2005. Wildfish: Chapter 6. Http://www.dfr.state.or.us/ODFWhtml/Research&Reports/WildFish/Chapter6.html.

Orsi, J. A., J. A. Harding, S. S. Pool, et al. 2007. Epipelagic fish assemblages associated with juvenile Pacific salmon in neritic waters of the California Current and the Alaska Current. American Fisheries Society Symposium 57:105–155.

Pacific Fishery Management Council. 2012. Proposed Harvest Specifications and Management Measures for the 2013-2014 Pacific Coast Groundfish Fishery and Amendment 21-2 to the Pacific Coast Fishery Management Plan: Draft Environmental Impact Statement. (May 2012 draft).

Pacific Fishery Management Council. 2010. Appendix E to the 2011-2012 Groundfish Harvest Specifications Draft Environmental Impact Statement: Update of the 2006 Community Vulnerability Analysis. (http://www.pcouncil.org/wp-content/uploads/1112GF_SpexFEIS_ApdxE_vulnerability_analyis_100806b.pdf)

Pacific Fishery Management Council. 2008. Assessment of factors affecting natural area escapement shortfall of Klamath River fall Chinook salmon in 2004-2006. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Paffenhofer, G. A. 1976. Feeding, growth, and food conversion of the marine planktonic copepod *Calanus helgolandicus*. Limnology and Oceanography 39-50.

Parkhurst, Z. E. 1950. Survey of the Columbia River and its tributaries-Part VII.Snake River from above the Grande Ronde River through the Payette River. U.S. Fish and Wildlife Service Special Scientific Reports Fish. 40, 95 p.

Parrish, R.H., C.S. Nelson and A. Bakun. 1981. Transport mechanisms and reproductive success of fishes in the California Current. Biological Oceanography 1(2): 175-203.

Parrish, R.H., F.B. Schwing, and R. Mendelssohn. 2000. Midlatitude wind stress: The energy source for climate regimes in the North Pacific Ocean. Fisheries Oceanography 9: 224-238.

Pearcy, W.G. 2002. Marine nekton off Oregon and the 1997-98 El Niño. Progress in Oceanography 54: 399-403

Pearse, J. S., and A.H. Hines. 1979. Expansion of a central California kelp forest following the mass mortality of sea urchins. Marine Biology, 51: 83–91.

Perkins, P. S., and R. Gartman. 1997. Host-Parasite relationship of the copepod eye parasite, *Phrixocephalus cincinnatus*, and Pacific Sanddab (*Citharichthys sordidus*) collected from wastewater outfall areas. Bulletin of the Southern California Academy of Sciences 96:87–104.

Peterman, R.M., B.J. Pyper and J.A. Grout. 2000. Comparison of parameter estimation methods for detecting climate-induced changes in productivity of Pacific salmon *(Oncorhynchus* spp.). Canadian Journal of Fisheries and Aquatic Sciences 57(1): 181-191.

Peterson, W.T. and F.B. Schwing. 2003. A new climate regime in northeast pacific ecosystems. Geophysical Research Letters 30: 1896-1899.

Peterson, W.T., J.L. Fisher, C.A. Morgan, S.M. Zeman, B.J. Burke, and K.C. Jacobson. 2019. Ocean ecosystem indicators of salmon marine survival in the Northern California Current.

Phillips, E.M., J.K. Horne, and J.E. Zamon. 2017. Predator–prey interactions influenced by a dynamic river plume. Canadian Journal of Fisheries and Aquatic Sciences 74:1375-1390.

Pirtle, J. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. M.S Thesis: Washington State University. http://cordellbank.noaa.gov/science/pirtle_invertfishhab_ms_thesis.pdf

Polovina, J.J., M. Abecassis, E.A. Howell and P. Woodworth. 2009. Increases in the relative abundance of mid-trophic level fishes concurrent with declines in apex predators in the subtropical North Pacific, 1996-2006. Fishery Bulletin 107: 523-531.

Pyper, B.J., Mueter, R.J., Peterman, R.M., Blackbourn, D.J., Wood, C.C. 2001. Spatial covariation in survival rates of Northeast Pacific pink salmon (*Oncorhynchus gorbuscha*). Canadian Journal of Fisheries and Aquatic Sciences 58(8): 1501-1515.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento San Joaquin Delta with observations on food of sturgeon. In: D.W. Kelley (ed.) Ecological Studies of the Sacramento San Joaquin Estuary: Part II; Fishes of the Delta. California Department of Fish and Game.Fish Bulletin 133.

Raimonet, M., and J.E. Cloern. 2016. Estuary–ocean connectivity: fast physics, slow biology. Global Change Biology 23: 2345-2357.

Research Group, The. 2009. Oregon Marine Recreational Fisheries Economic Contributions in 2007 and 2008, ODFW and Oregon Coastal Zone Management Association (OCZMA) 30 p. http://www.dfw.state.or.us/fish/commercial/docs/ODFW_Marine_Rec_Ec_Effects_2008.pdf

Richardson, S. L., and W. G. Pearcy. 1977. Coastal and oceanic fish larvae in an area of upwelling off Yaquina Bay, Oregon. Fishery Bulletin 75: 125-145.

Riddell, B.E., RD. Brodeur, A.V. Bugaev, P. Moran, J.M. Murphy, J.A. Orsi, M. Trudel, L.A. Weitkamp, B.K. Wells, and A.C. Wertheimer. 2018. Ocean ecology of Chinook salmon. Salmon. Pages 555-696 in The Ocean Ecology of Pacific Salmon and Trout, R.J. Beamish, ed. American Fisheries Society, Bethesda Maryland.

Rockwood, R.C., Calambokidis, J. and Jahncke, J., 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the US West Coast suggests population impacts and insufficient protection. PLoS One, 12(8), p.e0183052.

Roth, J.E., N. Nur, P. Warzybok and W.J. Sydeman. 2008. Annual prey consumption of a dominant seabird, the Common Murre, in the California Current system. ICES Journal of Marine Science 65:1046-1056.

Ruckelshaus, M., T. Essington and P.S. Levin. 2009. How science can inform ecosystem-based management in the sea: Examples from Puget Sound. In K.L. McLeod and H.M. Leslie (editors). Ecosystem-based management for the Oceans: Applying resilience thinking. Island Press. pp 201-226.

Runyon, D.. 2009. Fishing, Hunting, and Wildlife Viewing, and Shellfishing in Oregon, 2008 State and County Expenditure Estimates. Oregon Department of Fish and Wildlife, 23p + appendices.

Ryer, C.H., A.W. Stoner and R.H. Titgen. 2004. Behavioral mechanisms underlying the refuge value of benthic habitat structure for two flatfishes with differing anti-predator strategies. Marine Ecology Progress Series 268: 231-243.

Sanford, E., Sones, J.L., García-Reyes, M., Goddard, J.H. and Largier, J.L., 2019. Widespread shifts in the coastal biota of northern California during the 2014–2016 marine heatwaves. *Scientific reports*, *9*(1), pp.1-14.

Satterthwaite, W.H., K.S. Andrews, B.J. Burke, J.L. Gosselin, C.M. Greene, C.J. Harvey, S.H. Munsch, M.R. O’Farrell, J.F. Samhouri, and K.L. Sobocinski. 2020. Ecological thresholds in forecast performance for key United States West Coast Chinook salmon stocks ICES Journal of Marine Science 77:1503–1515.

Scammon, C.M. 1874. The marine mammals of the northwestern coast of North America. John H. Carrmany and Co. (Reprinted by Manessier Publishing Co. 1969).

Shchepetkin AF, McWilliams JC (2005) The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. Ocean Model 9:347–404.

Scheuerell, M.D., and J.G.Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14:448-457.

Schindler, E., M. Freeman and B. Wright. 2012. Sampling Design of the Oregon Department of Fish and Wildlife’s Ocean Recreational Boat Survey (ORBS). Oregon Department of Fish and Wildlife, 27 p. http://www.dfw.state.or.us/MRP/salmon/docs/ORBS_Design.pdf

Schreier, A., O.P. Langness, J.A. Israel, and E. Van Dyke. 2016. Further investigation of green sturgeon (*Acipenser medirostris*) distinct population segment composition in non-natal estuaries and preliminary evidence of Columbia River spawning. Environmental Biology of Fishes 99:1021–1032.

Schreier, A.D., and P. Stevens. 2020. Further evidence for lower Columbia River green sturgeon spawning. Environmental Biology of Fishes 103:201–208.

Schwing, F. B., O'Farrell, M., Steger, J., and Baltz, K., 1996: Coastal Upwelling Indices, West Coast of North America 1946 - 1995, NOAA Technical Memorandum NMFS-SWFSC-231.

Scofield, W.L. 1948. Trawling gear in California. California Department of Fish and Game, Fish Bulletin 72.

Seitz, A.C., M.B. Courtney, M.D. Evans, and K. Manishin. 2019. Pop-up satellite archival tags reveal evidence of intense predation on large immature Chinook salmon (*Oncorhynchus tshawytscha*) in the North Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences 76:1608-1615.

Sepez, J., K. Norman, and R. Felthoven. 2007. A quantitative model for ranking and selecting communities most involved in commercial fisheries. NAPA Bulletin 28: 43-56.

Seung, C.K. and E.C. Waters. 2005. A review of regional economic models for Alaska fisheries. Alaska Fisheries Science Center, NMFS, AFSC Processed Report 2005-01, 129 pp.

Shelton, A.O., W.H. Satterthwaite, E.J. Ward, B.E. Feist, and B. Burke. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Canadian Journal of Fisheries and Aquatic Sciences 76:95-108.

Sherr, E. B., B.F. Sherr and P.A.Wheeler. 2005. Distribution of coccoid cyanobacteria and small eukaryotic phytoplankton in the upwelling ecosystem off the Oregon coast during 2001 and 2002. Deep Sea Research II 52(1): 317-330.

Sibert J, J. Hampton, P. Kleiber and M. Maunder. 2006. Biomass, size, and trophic status of top predators in the Pacific Ocean. Science 314: 1773–1776.

Smith, A.D.M., C.J. Brown, C.M. Bulman, et al. 2011. Impacts of fishing low-trophic level species on marine ecosystems. Science 333: 1147-1150.

Springer, A.M., J.A. Estes, G.B. van Vliet, et al. 2003. Sequential megafaunal collapse in the North Pacific Ocean: an ongoing legacy of industrial whaling? Proceedings of the National Academy of Sciences 100(21): 12223-12228.

St. Martin, K., Hall-Arber, M., 2008. The missing layer: Geo-technologies, communities, and implications for marine spatial planning. Marine Policy, The Role of Marine Spatial Planning in Implementing Ecosystem-based, Sea Use Management 32, 779–786. https://doi.org/10.1016/j.marpol.2008.03.015

Sutherland, D. A., P. MacCready, N. S. Banas, and L. F. Smedstad (2011), A model study of the Salish Sea estuarine circulation, J. Phys. Oceanogr., 41(6), 1125–1143, doi:10.1175/2011JPO4540.1.

Sydeman, W.J., Hester, M.M., Thayer, J.A., et al. 2001. Climate change, reproductive performance and diet composition of marine birds in the southern California Current System. Progress in Oceanography 49: 309-329.

Sydeman, W.J., K.L. Mills, J.A. Santora, et al. 2009. Seabirds and climate in the California Current – a synthesis of change. California Cooperative Oceanic Fisheries Investigations Report 50: 82-104.

Sydeman, W. J., S. A. Thompson, J. C. Field, W. T. Peterson, R. W. Tanasichuk, H. J. Freeland, S. J. Bograd et al. 2011. Does positioning of the North Pacific Current affect downstream ecosystem productivity? Geophysical Research Letters 38.

TCW Economics. 2008. Economic analysis of the non-treaty commercial and recreational fisheries in Washington State. December 2008. Sacramento, CA. With technical assistance from The Research Group, Corvallis, OR.

Tegner, M.J. and P.K. Dayton. 2000. Ecosystem effects of fishing in kelp forest communities. ICES Journal of Marine Science 57: 579-589.

Thayer, J.A., Hazen, E.L., García-Reyes, M., Szoboszlai, A. and Sydeman, W.J., 2020. Implementing ecosystem considerations in forage fisheries: San Francisco Bay herring case study. *Marine Policy*, p.103884.

Thomson, R. E., and M. V. Krassovski. 2010. Poleward reach of the California Undercurrent extension. Journal of Geophysical Research: Oceans 115.

Tissot, B.N., M.M. Yoklavich, M.S. Love, K. York, and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea corals. Fishery Bulletin 104: 167-181.

Tomaro, L.M., D.J. Teel, W.T. Peterson, and J.A. Miller. 2012. When is bigger better? Early marine residence of middle and upper Columbia River spring Chinook salmon. Marine Ecology Progress Series 452:237–252.

Tonnessen, J.N. and A.O. Johnsen. 1982. The History of Modern Whaling. University of California Press: Berkeley.

Trosper, R.L. 2003. Resilience in pre-contact Pacific Northwest social ecological systems. Conservation Ecology 73(3):6.

U.S. Fish and Wildlife Service. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: State Overview - September 2012.

U.S. Fish and Wildlife Service. 2008. 2006 National survey of fishing, hunting, and wildlife-associated recreation. U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. January 2008.http://wsfrprograms.fws.gov/Subpages/NationalSurvey/reports2011.html.

U.S. GLOBEC. 1994. Eastern Boundary Current Program: A Science Plan for the California Current. U.S. Global Ocean Ecosystems Dynamics Report Number 11. U.S. GLOBEC Scientific Steering Coordination Office, Berkeley, CA.

Van Eenennaam, J.P., J. Linares-Casenave, X. Deng and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon, *Acipenser medirostris*. Environmental Biology of Fishes 72: 145-154.

Veit, R.L., P. Pyle and J.A. McGowan. 1996. Ocean warming and long-term change in pelagic bird abundance within the California Current system. Marine Ecology Progress Series 139: 11–18.

Walters, C. J., V. Christensen, S. J. Martell, and J. F. Kitchell. 2005. Possible ecosystem impacts of applying MSY policies from single-species assessment. ICES Journal of Marine Science 62:558.

Walters, C. and J.F. Kitchell. 2001. Cultivation/depensation effects on juvenile survival and recruitment: Implications for the theory of fishing. Canadian Journal of Fisheries and Aquatic Sciences 58: 39-50.

Warrick, J.A., and K.L. Farnsworth. 2009, Dispersal of river sediment in the Southern California Bight. In Lee, H.J., and Normark, W.R., eds., Earth Science in the Urban Ocean: The Southern California Continental Borderland: Geological Society of America Special Paper 454, p. 53–67.

Waples, R, R.P. Jones, B. R. Beckman, and G. A. Swan. 1991. Status Review for Snake River Fall Chinook Salmon. U.S. Department of Commerce NOAA Technical Memorandum NMFS F/NWC-201.73 p.

Washburn, J. O., D. R. Mercer, J. R. Anderson, and others. 1991. Regulatory role of parasites: impact on host population shifts with resource availability. Science 253:185–188.

Washington Department of Fish and Wildlife. 2012. WDFW websites on its mission and goals, regulations, and policies: http://www.wdfw.wa.gov.

Welch, H., Hazen, E.L., Briscoe, D.K., Bograd, S.J., Jacox, M.G., Eguchi, T., Benson, S.R., Fahy, C.C., Garfield, T., Robinson, D. and Seminoff, J.A., 2019. Environmental indicators to reduce loggerhead turtle bycatch offshore of Southern California. *Ecological Indicators*, *98*, pp.657-664.

Wells, B.K., C.B. Grimes, J.C. Field and C.S. Reiss. 2006. Covariation between the average lengths of mature coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) and the ocean environment. Fisheries Oceanography 15: 67–79.

Wells, B.K., J.A. Santora, M.J. Henderson, P. Warzybok, J. Jahncke, R.W. Bradley, D.D. Huff, I.D. Schroeder, P. Nelson, J,C. Field, and D.G. Ainley. 2017. Environmental conditions and prey-switching by a seabird predator impact juvenile salmon survival. Journal of Marine Systems 174:54–63.

Whitmire, C.E. and Clarke M.E. 2007. State of Deep Coral Ecosystems of the U.S. Pacific Coast: California to Washington. pp. 109-154. In S.E. Lumsden, Hourigan T.F., Bruckner A.W. and Dorr G. (editors) The State of Deep Coral Ecosystems of the United States. NOAA Tech. Memo., CRCP-3, Silver Spring, MD 365 pp. http://coris.noaa.gov/activities/deepcoral_rpt/Chapter3_PacificCoast.pdf

Williams, E.H. and S. Ralston. 2002. Distribution and co-occurrence of rockfishes (family: Sebastidae) over trawlable shelf and slope habitats of California and southern Oregon. Fishery Bulletin 100: 836-855.

Willson, M.F., R.H. Armstrong, M.C. Hermans, and K. Koski. 2006. Eulachon: a review of biology and an annotated bibliography. AFSC Processed Report 2006-12. Alaska Fisheries Science Center, National Marine Fisheries Service. Juneau, Alaska.

Wiseman, W.J. Jr., and R. W. Garvine. 1995. Plumes and coastal currents near large river mouths. Estuaries. 18(3): 509-517.

Wyllie-Echeverria, S. W. and J. D. Ackerman. 2003. The seagrasses of the Pacific Coast of North America. In E. P. Green and F. T. Short (editors)World Atlas of Seagrasses. University of California Press, Berkeley. pp 199 – 206

Yoklavich, M.M., H.G. Greene, G.M. Cailliet, et al. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: An example of a natural refuge. Fishery Bulletin 98: 625-641.

Yoklavich, M.M., G.M. Cailliet, R.N. Lea, et al. 2002. Deepwater habitat and fish resources associated with the Big Creek Ecological Reserve. California Cooperative Oceanic Fisheries Investigations Reports 43: 120-140.

Yoklavich, M.M. and V. O'Connell. 2008. Twenty years of research on demersal communities using the Delta submersible in the Northeast Pacific. In: Reynolds, J.R. and H.G. Greene (editors) Marine Habitat Mapping Technology for Alaska. Alaska Sea Grant College Program.

Yodzis, P. 2001. Must top predators be culled for the sake of fisheries? Trends in Ecology and Evolution 16(2) 78- 84.

Zador, S.G., Gaichas, S.K., Kasperski, S., Ward, C.L., Blake, R.E., Ban, N.C., Himes-Cornell, A., Koehn, J.Z., 2017. Linking ecosystem processes to communities of practice through commercially fished species in the Gulf of Alaska. ICES J Mar Sci 74, 2024–2033. https://doi.org/10.1093/icesjms/fsx054.

*****Additional new references to be cleaned up and integrated into 3.6.*****

New references added to groundfish section:

Malick, M.J., Hunsicker, M.E., Haltuch, M.A., Parker-Stetter, S.L., Berger, A.M., Marshall, K.N. 2020. Relationships between temperature and Pacific hake distribution vary across latitude and life-history stage. Marine Ecology Progress Series 639: 185–197. https://doi.org/10.3354/meps13286

Ralston. S., Field, J.C., and Sakuma, K.M. 2015. Long-term variation in a central California pelagic forage assemblage. Journal of Marine Systems 146: 26-37.

Sakuma, K.M., Field, J.C., Mantua, N.J., Ralston, S., Marinovic, B.B., and Carrion, C.N.. 2016. Anomalous epipelagic micronekton assemblage patterns in the neritic waters of the California Current in spring 2015 during a period of extreme ocean conditions. California Cooperative Oceanic Fisheries Investigations Reports Rep 57: 163-183.

Santora, J.N., Hazen, E.L., Schroeder, I.D., Bograd, S.J., Sakuma, K.M., and Field, J.C. 2017. Impacts of ocean climate variability on biodiversity of pelagic forage species in an upwelling ecosystem.

Marine Ecology Progress Series 580: 205-220.

Schroeder, I.D., Santora, J.N., Bograd, S.J., Hazen, E.L., Sakuma, K.M., Moore, A.M., Edwards, C.A., Wells, B.K., and Field, J.C. 2019. Source water variability as a driver of rockfish recruitment in the California Current Ecosystem: implications for climate change and fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 76 (6): 950-960.

Stewart, J.S. Gilly, W.F., Field. J.C., and Payne, J.C. 2012. Onshore–offshore movement of jumbo squid (Dosidicus gigas) on the continental shelf. Deep Sea Research Part II: topical studies in oceanography 95: 193-196.

Tolimieri, N, Haltuch M.A., Lee, Q., Jacox, M.G., and Bograd S.J. 2018. Oceanographic drivers of sablefish recruitment in the California Current. Fisheries Oceanography 27: 458–474.

Watson, J., Mitarai, S., Siegel, D., Caselle, J., Dong, C., McWilliams, J., 2010. Realized and potential larval connectivity in the Southern California Bight. Marine Ecology Progress Series 401, 31–48. https://doi.org/10.3354/meps08376

Watson, J.R., Siegel, D.A., Kendall, B.E., Mitarai, S., Rassweiller, A., Gaines, S.D., 2011. Identifying critical regions in small-world marine metapopulations. Proceedings of the National Academy of Sciences 108, E907-E913. https://doi.org/10.1073/pnas.1111461108

References for section 3.4.2

California Department of Fish and Wildlife Marine Region. 2016. California Spiny Lobster Fishery Management Plan. April 2016.

Daniel S. Holland & Stephen Kasperski (2016): The Impact of Access Restrictions on Fishery Income Diversification of US West Coast Fishermen, Coastal Management, DOI: 10.1080/08920753.2016.1208883

NOAA Fisheries NWFSC. 2020. Fisheries Observation Science on the West Coast. https://www.fisheries.noaa.gov/west-coast/science-data/fisheries-observation-science-west-coast. Accessed: various dates.

Richerson, K. , J.E. Jannot, Y. Lee, J. McVeigh, K. Somers, V. Tuttle, S. Wang. 2019. Observed and Estimated Bycatch of Green Sturgeon in 2002-2017 U.S. West Coast Groundfish Fisheries. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

Somers, K.A., Y.-W. Lee, J.E. Jannot, & J. McVeigh. 2016. Depth summary, 2002-2015. Last updated: 1 August 2016. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

Steiner, E. 2019. Economic Data Collection Program Catcher Vessel Report (2009-2016). National Marine Fisheries Service Northwest Fisheries Science Center.

PFMC. 2020. Review of 2019 Ocean Salmon Fisheries; Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. February 2020.

PFMC. 2019. Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches Stock Assessment and Fishery Evaluation 2018 Including Information Through June 2018. April 2019.

PFMC. 2020. Status of the U.S. West Coast Fisheries for Highly Migratory Species Through 2019. Stock Assessment and Fishery Evaluation. January 2020.