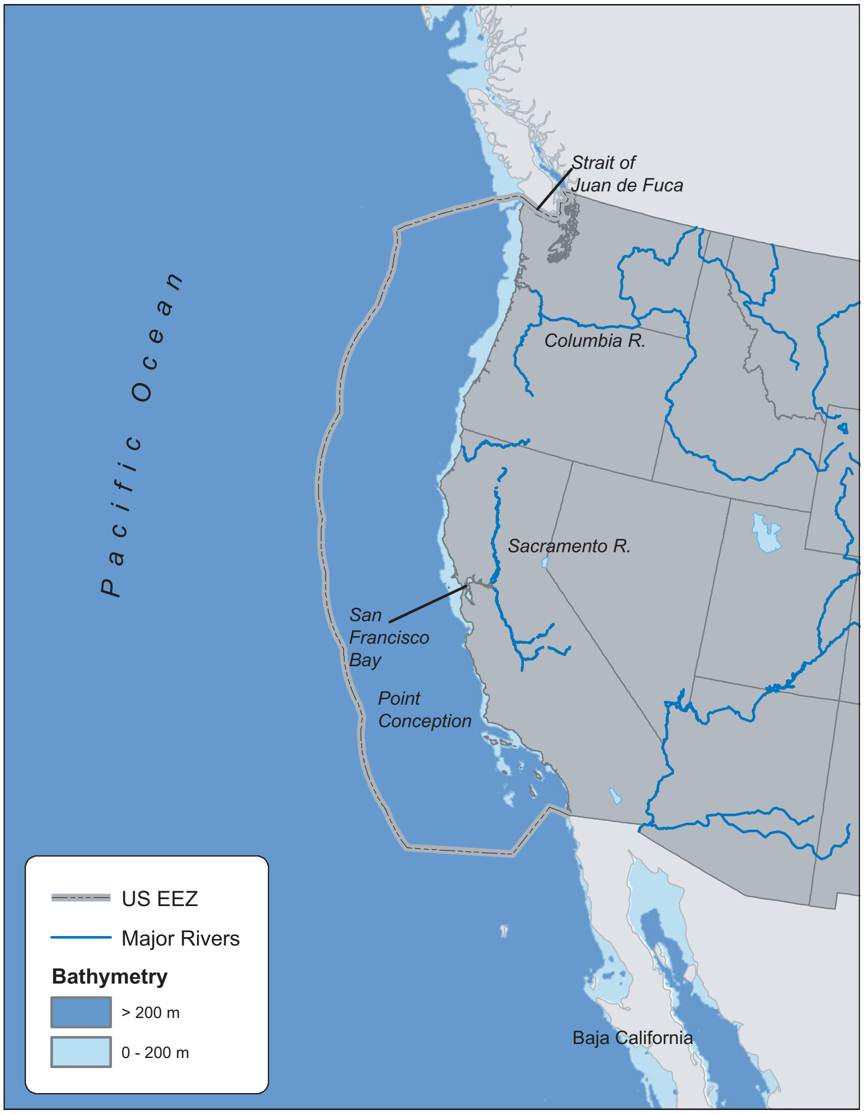
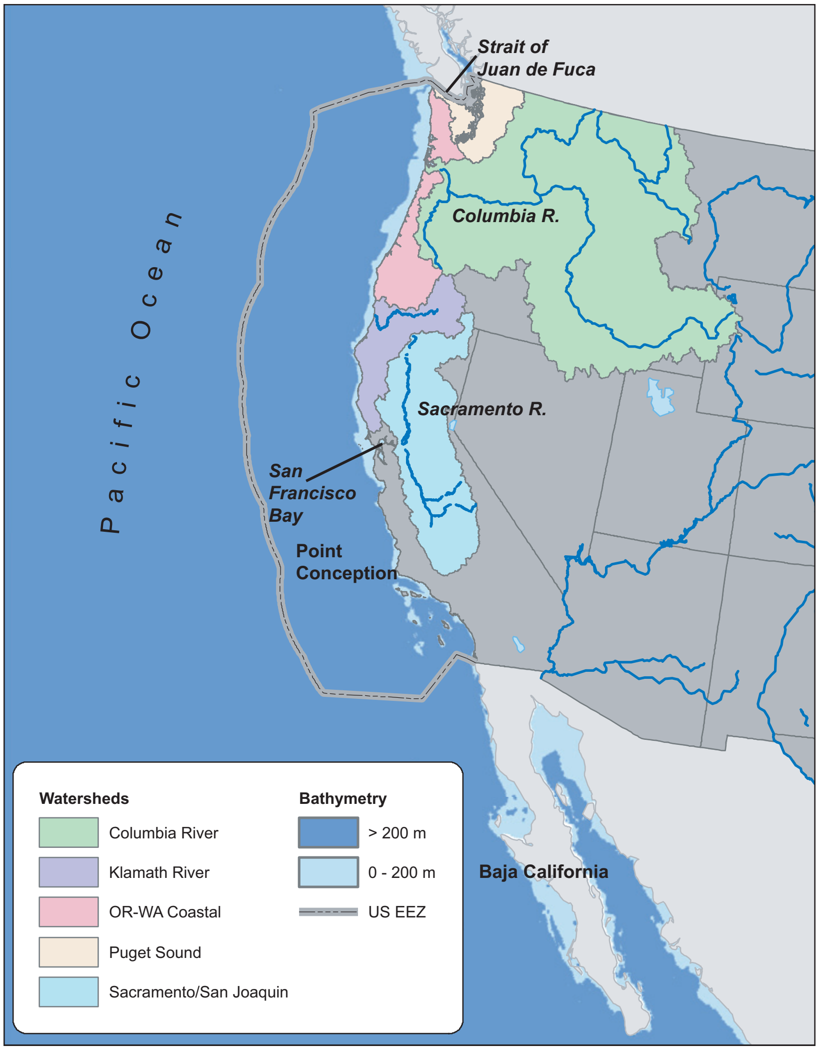
Pacific Coast Region



HABITAT AREAS

The Pacific Coast Region[1] lies adjacent to California, Oregon, and Washington, and encompasses about 7% (812,000 km^2 [237,000 nmi^2]) of the total area of the U.S. Exclusive Economic Zone (EEZ). There are five principal habitat categories in the Region: 1) freshwater streams and rivers, which include most watersheds in California, Oregon, Washington, and Idaho; 2) bays and estuaries; 3) the coastal Continental Shelf system extending

[1]This report divides the U.S. EEZ into geographic regions. These geographic regions do not correspond to the names of the NMFS administrative regions. Administratively, the geographical region described in this chapter falls under the NMFS West Coast Region.



Five major U.S. watersheds draining to the Pacific Coast. Note their distance from the sea.

from the intertidal zone to the 200 m (656 ft) depth contour, which is typically 8–60 km (5–36 mi) offshore in this region; 4) benthic habitats of the offshore Continental Slope extending from about 200 m (656 ft) to over 1,000 m (3,281 ft) depths at the seaward edge of the EEZ; and 5) the oceanic system, comprising pelagic habitats, divided into three broad depth zones—the epipelagic (0–200 m [0–656 ft]), mesopelagic (200–600 m [656–1,969 ft]), and bathypelagic (600 m [1,969 ft] to near the seafloor). Of these five principal habitat categories, the first three correspond directly to the freshwater, estuarine, and shallow marine habitat categories, respectively, used elsewhere in this report. The fourth and fifth principal habitat categories correspond to the oceanic habitat category used elsewhere in this report.

There are two distinct zoogeographic provinces within the Pacific Coast Region, as described by McGowan (1971) and Allen and Smith (1988). The Oregonian Province lies within the Boreal (cold-temperate) Eastern Pacific and is bounded by the Strait of Juan de Fuca, Washington, to the north and Point Conception, California, to the south. The San Diego Province, within the warm-temperate California region, extends from Point Conception, California, south to Magdalena Bay, Baja California Sur, Mexico.

Oregonian Province
(Strait of Juan de Fuca, Washington, to Point Conception, California)

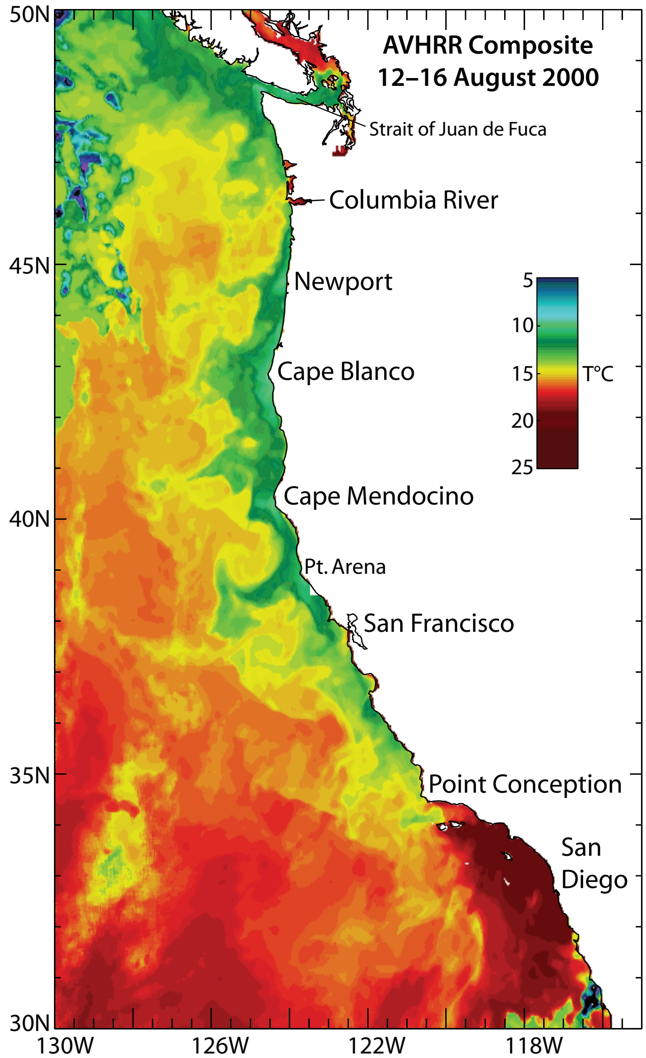
Watersheds in the Oregonian Province drain a diverse geographic area that includes rain forests on the northwest Washington coast, desert and high desert in the interior, and, in some cases, mountains of the interior west. These watersheds contain small (<5 m [<16 ft] wide) tributaries that drain coastal mountains, as well as larger streams. Rivers such as the Sacramento, Klamath, Umpqua, and Columbia drain coastal and interior areas and slopes of the Sierra Nevada (Sacramento River) and Cascade and Rocky Mountains (Columbia River). Thus, the habitats and associated organisms in these freshwater streams and rivers are impacted by natural phenomena and human activities that span much of the Pacific Coast Region.

Three major estuaries and embayments—San Francisco Bay, the Columbia River, and Puget Sound—and several smaller ones (including Gray's Harbor and Willipa Bay, Washington; Yaquina Bay, Oregon; Humboldt Bay, Elkhorn Slough, and Morro Bay, California; and others) are part of this province. Estuarine habitats include mudflats, freshwater and brackish marshes, seagrass beds, and shallow and deep channels. San Francisco Bay is fed by the Sacramento and San Joaquin Rivers, and contains more than half of all wetlands in the Pacific Coast Region. The Columbia River is the largest river on the Pacific Coast and, together with its tributaries, drains 670,000 km^2 (258,688 mi^2). Most estuarine habitats have been significantly altered from historical diking, filling, and dredging, as well as from adjacent farming and other development activities.

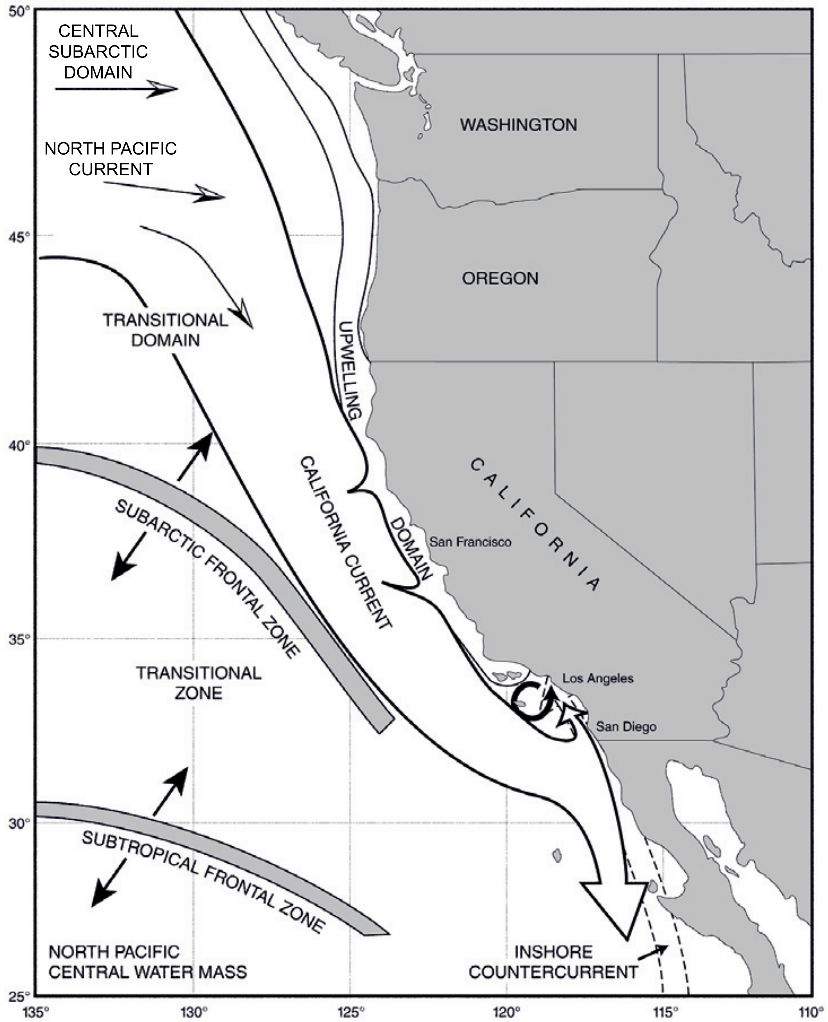
The Continental Margin includes a variety of benthic habitats. Nearshore habitats (intertidal to about 3 km [1.86 mi] offshore) comprise rocky shores and sandy beaches, subtidal rock outcrops, boulders, low-relief sand, gravel and cobble fields, seagrasses, prominent kelp forests, and a few offshore islands. Rocky areas in depths less than 40 m (131 ft) often are covered by extensive kelp beds (giant kelp off southern and central California; bull kelp along the northern California, Oregon, and Washington coasts). Kelp beds and other marine algae in rocky areas provide structural habitat for many species and life stages occurring from the seafloor to the sea surface. Such rock-kelp areas are greatly affected by strong currents, storm waves, and freshwater runoff and thus can undergo dramatic seasonal and interannual changes. Surfgrass is another structure-forming habitat that occurs on rocky substrates. Flowering seagrasses use dense rhizomes to attach to rocks in high-energy intertidal and subtidal zones. Threats to this habitat, which often is slow to recover from disturbance, include shoreline armoring (physical structures that protect the shoreline from coastal erosion), dredging, and disposal of dredge material. The nearshore area continues to be the focus of increased human activities for energy development, sand management operations, commercial and recreational harvest of fish and shellfish, water quality and runoff problems, recreational boating and diving, and research and educational programs.

Seaward of 3 km [1.86 mi] from shore, Continental Shelf habitats include patchy distributions of rock outcrops, pinnacles, and boulder fields surrounded by low-relief sand, mud, and cobbles. Other than a few notable offshore rocky banks (e.g. Heceta Bank, Cordell Bank, Farallon Islands), however, the vast majority of bottom on the Continental Shelf is composed of sand and sandy mud sediments. All of these Continental Shelf habitats have long been targeted by large commercial and recreational fisheries. The offshore Continental Slope habitat is largely expanses of muddy sediment interspersed with hills and gullies, and rock outcrops with scattered boulders. Several submarine canyons (e.g. Astoria Canyon and Monterey Canyon) and large banks (e.g. Heceta Bank and Cordell Bank) are part of the shelf and slope systems. Submarine slumps and landslides continually modify the morphology of the slope. Certain segments of the margin are characterized by venting of fluids, and in some cases include extensive deposits of gas hydrates. These “cold seep” areas harbor unique chemosynthetic biological communities. All of these benthic habitats on the Continental Margin include an important biogenic component comprising many structure-forming macroinvertebrates such as corals, sponges, and brittle stars, among others.

Seaward of the slope are the expansive areas that underlie the oceanic habitat of the California Current, and include complex deepwater habitats at depths of 2,500–4,000 m (8,202–13,123 ft) and beyond: plains, channels, hills, sedimentary fans, volcanically active ridges, and seamounts. The most conspicuous bathymetric features are seamounts, escarpments, and ridges. There are at least six seamounts and seamount groups within the EEZ, with



Satellite sea-surface temperature of the California Current System, August 2000 (modified from Checkley and Barth, 2009).



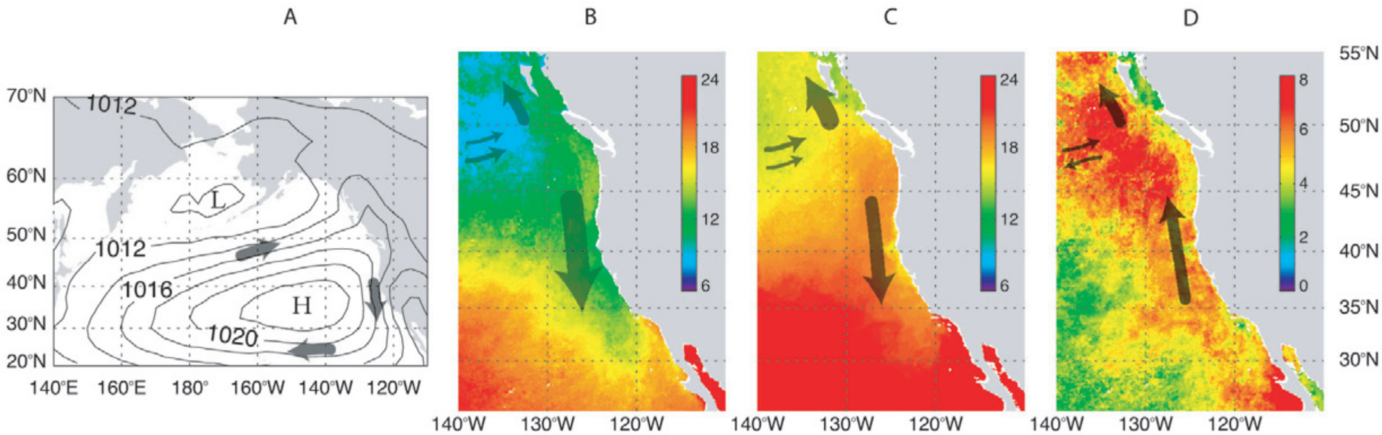
A schematic of the primary ocean currents off the Pacific Coast (modified from PFMC, 2003).

depth of summits ranging from 770 m (2,526 ft) for Pioneer Seamount off San Francisco to 2,229 m (7,313 ft) for Tanney Seamount off Monterey Bay, California. There are an additional seven seamounts located just outside the EEZ of the Oregonian Province boundary. The Gorda and Juan de Fuca Ridges, extending from northern California to Washington, also are significant physiographic features of the Oregonian Province. These two ridges are seafloor-spreading centers—sites where submarine volcanism brings hot magma to the surface of the seafloor and where hydrothermal vents (hot springs) are common. The hydrothermal fluids support unique biological communities that derive chemical energy independent of sunlight.

Oceanic habitat in the Oregonian Province includes coastal and offshore waters that are dominated by the eastern boundary current complex known as the California Current System. Oceanic habitat of the Oregonian Province also includes one of the major coastal upwelling areas of the world, where waters brought up from the bottom by wind-driven currents provide a relatively nutrient-rich environment and high densities of forage for marine species. This area is influenced by various currents and water masses, the shifting nature of which affects the occurrence and distribution of species at particular times of the year and from year to year. Diverse bathymetric features such as headlands, submerged pinnacles, submarine canyons, seamounts, and coastal islands also influence current patterns and concentrations of economically valuable species and their prey.

Large-scale currents within this area include the surface-flowing California Current and inshore countercurrent (Davidson Current), and the subsurface California undercurrent. Water masses within this oceanic system generally include three types: Pacific Subarctic, North Pacific Central, and Southern (or Subtropical Equatorial). Pacific Subarctic water, characterized by low salinity and temperature and high oxygen and nutrients, is advected equatorward along the coast by the California Current. North Pacific Central water, characterized by high salinity and temperature and relatively low oxygen and nutrients, enters the system from the west. Southern water, characterized by high salinity, temperature, and nutrients, and low oxygen, enters the system from the south. The California Current forms the eastern limb of a large clockwise circulation pattern in the North Pacific Ocean. The cold, low-salinity water of the California Current dominates much of the EEZ. Its position and intensity change seasonally and from year to year, with shifts in the southeastern extension of the Subarctic Frontal Zone (California Front). Shoreward it mixes with plumes of cold, more saline upwelled water in the north, or warm countercurrent and gyre water of the Southern California Bight in the south.

Further offshore, the California Current mixes with the oceanic waters of the Transition Zone. The Transition Zone lies between the Subarctic and Subtropical Fronts, separating the Subarctic Water Mass and North Pacific Central Water Mass. During the winter and spring, westerlies in the northern portion of the Transition Zone and



Schematic of California Current atmospheric forcing and ocean circulation during normal and El Niño conditions: A) mean summer North Pacific atmospheric pressure, dominated by the North Pacific High and Aleutian Low, and surface wind forcing; B) typical sea surface temperatures (SST) and ocean transport patterns; C) SST and transport during El Niño periods; D) the anomaly in SST and transport, showing the impacts of El Niño. Figure adapted from Strub and James (2002).

trade winds to the south create convergent fronts where colder, denser water from the north meets warmer, less dense water from the south.

Physical oceanographic features of the Oregonian Province change seasonally, as well as during interannual oceanographic and atmospheric El Niño and La Niña events and during periods of large scale, interdecadal climate regime shifts. The California Current generally flows southward year round, with strongest flows in spring and summer. Inshore, these flows may be reversed by the seasonal appearance in fall and winter of the surface, poleward-flowing Inshore Countercurrent, and locally by spatial gradients in wind-stress forcing and coastal topographic effects. The California Undercurrent intensifies, primarily in late spring and summer, as a narrow ribbon of northward flow, which presses against the Continental Slope at depths of 150–300 m (493–984 ft) beneath the upper layers that flow equatorward. Beneath the undercurrent and extending to depths >1,000 m (>3,281 ft), there occurs a layer where oxygen concentrations are naturally and consistently low. This feature is called the oxygen minimum zone (OMZ), where oxygen concentrations are less than 22 μmol/kg (0.5 mL/L). Every few years, this oxygen-depleted water mass is advected up and onto the Continental Shelf, creating "dead zones" that kill those organisms unable to move to more-oxygenated waters. Coastal upwelling of cold, salty, and nutrient-rich water to the surface occurs primarily in spring and summer in California and into early fall off Oregon, driven by prevailing seasonal winds. Upwelling often is most intense near promontories such as Cape Mendocino and Point Conception. During most El Niño events, ocean and atmosphere forcing, linked to tropical conditions, leads to an anomalously weak California Current transport and an anomalously strong California Undercurrent, which combine to produce a reduced southward transport (northward anomaly). These factors also generally result in weaker than normal upwelling and an upper water column that is anomalously warm and low in nutrients, and relatively unproductive. Climate variability also exhibits considerable multidecadal variability in the system, with alternating periods of warm and cool ocean temperature (Parrish et al., 2000; Peterson and Schwing, 2003). The cooler climate regimes are associated with higher biological production.

The coastline in the northern part of the Pacific Coast Region is relatively unprotected from the force of the sea and prevailing northwest winds, and rugged water and sea state conditions are common. During much of the year, the coastal waters off central Oregon are under the influence of the eastern portion of the eastward-flowing North Pacific Current or West Wind Drift. This current has a moderating influence on coastal temperatures during the summer, when sea surface temperatures may be several degrees warmer off northern Oregon and central Washington than to the north, off British Columbia. Sea surface temperatures during summer are colder off northern and central California because upwelling-favorable winds are stronger in that area. Year-to-year differences in the trajectory and strength of the North Pacific Current, due to global climate variability, create substantial shifts in ocean temperature and nutrient concentrations along portions of the coast (Parrish

The Southern California Bight extends from Point Conception to San Diego, California.

et al., 2000). In this region, the Columbia River's freshwater plume also has a considerable effect on oceanographic features along the northwest coast. The plume flows poleward over the shelf and slope in fall and winter, and equatorward as much as 300–400 km (186–249 mi) offshore of the shelf in spring and summer, extending its influence as far south as Cape Mendocino, California. In late summer, the Columbia River contributes 90% of the fresh water entering the sea between the Strait of Juan de Fuca and San Francisco Bay.

San Diego Province (Point Conception, California, to Baja California Sur, Mexico)

Although the coastline is relatively straight between the Strait of Juan de Fuca, Washington, and Baja California, Mexico, a large bend occurs from Point Conception to San Diego. This bathymetrically complex region is known as the borderland of the Southern California Bight, and differs dramatically from areas to the north and south. The Continental Shelf generally is very narrow, but widens in some areas of the Bight and includes several offshore islands (e.g. the Channel Islands). A series of undersea ridges and deep basins (e.g. Catalina Basin, 1,326 m [4,350 ft] deep; San Nicholas Basin, 1,795 m [5,889 ft] deep) also defines the bathymetry of the Bight. Dissolved oxygen concentrations are reduced in the deep basins; in one case (the Santa Barbara Basin, 613 m [2,011 ft] deep), anoxic conditions persist for extended periods, interrupted by flushing events during periods of intense upwelling.

A portion of the California Current turns in a counterclockwise gyre south of Point Conception. This feature is called the Southern California Countercurrent during years when the northward flow rounds Point Conception, or the Southern California Eddy when the flow recirculates within the Southern California Bight. The ocean generally is warmer and more protected here than in areas to the north, especially inshore of a line roughly drawn from San Miguel Island to San Clemente Island.

Compared to the large river-dominated systems to the north, there is little continuous freshwater input in the southern part of the Pacific Coast Region. Only a few relatively small bays, lagoons, and estuaries occur in this southern area, with the exception of San Diego Bay, which is the third largest California bay after San Francisco Bay and Humboldt Bay. Estuarine habitats are thus limited in area, but include mudflats, freshwater and brackish marshes, seagrass beds, and shallow and deep channels. Eelgrass, found in shallow coastal environments along the entire West Coast, provides a variety of habitat functions. Eelgrass is an important structural component of this environment, serving as refuge from predation and as nursery habitat for a variety of commercially and recreationally valuable finfish and shellfish. Eelgrass also contributes primary and secondary production to the ecosystem, and improves water clarity, nutrient cycling, and sediment stabilization (which can reduce erosion). Approximately 50% of the eelgrass resources in Southern California are located within San Diego Bay.

The coastal shelf system includes a variety of inshore benthic habitats, including rocky shores and sandy beaches, subtidal rock outcrops, pinnacles, boulders, low-relief sand and cobble fields, prominent kelp forests, seagrasses, and many

Anacapa Island, a member of the Southern California Bight's Channel Islands archipelago, provides a diverse range of habitats for both terrestrial and marine plants and animals.

offshore islands. Offshore benthic habitats largely consist of expansive mud fields interspersed with rock outcrops and scattered boulders. Several submarine canyons, large banks, and seamounts are part of the shelf and slope systems in this part of the Pacific Coast Region. Structure-forming macroinvertebrates represent an important biogenic component of all benthic habitats of the San Diego Province, just as they do in the Oregonian Province.

In addition to the natural habitats in this area, there are numerous artificial reefs on the shallow sand shelf, and 26 oil and gas platforms located in water depths from 11 to 363 m (36 to 1,191 ft) (Love et al., 2003). Such anthropogenic structures represent complex habitats with relatively high vertical relief, support a diverse assemblage of fishes and macroinvertebrates, and contribute to local (and perhaps regional) fish production. Some of these platforms and artificial reefs could serve as de facto marine protected areas, depending on the degree to which fishing is restricted around these structures. Additionally, high densities of young rockfishes are associated with some of these structures, indicating that they function as nurseries for some species. However, there also has been some concern that oil platforms and other artificial structures may concentrate fish at the expense of populations on natural reefs.

HABITAT USE

This section describes habitat use by those species found in the Pacific Coast Region that are managed by NOAA's National Marine Fisheries Service (NMFS) under fishery management plans (FMPs) or as protected species under the Marine Mammal Protection Act (MMPA) and/or the Endangered Species Act (ESA) in cooperation with state authority or by international commission.

There are four FMPs within the Pacific Coast Region: 1) Pacific Coast Salmon (some salmon, including steelhead trout, also are protected under the ESA or managed by the states); 2) Coastal Pelagic Species (krill, market squid, Pacific sardine, Pacific or chub mackerel, northern anchovy, and jack mackerel); 3) Highly Migratory Species (tunas, sharks, billfish, and dolphinfish); and 4) Pacific

Table 11
Typical use of the four major habitat categories in the Pacific Coast Region, summarized by FMP and protected-species groups of cetaceans, pinnipeds, and sea turtles.

Habitat use key:
F = frequent
O = occasional
N = never

Fishery management plans [a]	Freshwater habitat	Estuarine habitat	Shallow marine habitat	Oceanic habitat
1. West Coast Salmon [b]	F	F	F	F
2. Coastal Pelagic Species	N	O	F	F
3. West Coast Highly Migratory Species	N	O	F	F
4. Pacific Coast Groundfish [b]	N	F	F	F
Total percentage of all Pacific Coast FMPs with one or more species that use each habitat type	25%	100%	100%	100%
Protected species groups [a]				
Cetaceans	N	O	F	F
Pinnipeds	O	F	F	F
Sea Turtles	N	F	F	F
Total percentage of all Pacific Coast cetacean, pinniped, and sea turtle groups that use each habitat type	33%	100%	100%	100%

[a] Appendix 3 lists official FMP titles. Appendix 5 lists the species.
[b] Some of these species are managed as protected species as well as under an FMP.

Coast Groundfish (rockfishes, flatfishes, sablefish, hake, lingcod, some sharks, and others). These FMPs are the responsibility of the Pacific Fishery Management Council (PFMC) acting on behalf of the Federal Government (NMFS) in managing fishery resources within the U.S. EEZ.

NMFS manages most of the Region's marine mammals (cetaceans and pinnipeds), all of which are covered by the MMPA and some of which are listed under the ESA. The U.S. Fish and Wildlife Service manages the southern sea otter, which is not discussed in this report. Sea turtles, white and black abalone, green sturgeon, steelhead trout, Pacific eulachon, and bocaccio, yelloweye, and canary rockfishes in Puget Sound and Georgia Basin are managed in this Region by NMFS under the ESA. Nearshore species occur in estuarine and/or marine coastal habitats, typically from the intertidal zone to the 5.6 km (3 nautical mile [nmi]) boundary of state waters. Some nearshore species are not managed as part of federal FMPs or as protected species, but rather are the responsibility of the coastal states, with cooperation from NMFS. Pacific halibut are managed by the International Pacific Halibut Commission (IPHC).

Table 11 provides a summary of typical habitat-use patterns in the Pacific Coast Region, organized by FMP and protected-species groups of cetaceans, pinnipeds, and sea turtles (managed by NMFS). The table shows patterns of typical use for one or more species within each group. However, it is important to recognize that these groups include many species, all of which have unique habitat requirements by life stage. Habitat information is lacking for many Pacific Coast species, particularly in the earlier life stages, and such critical information gaps are not captured in this table.

Out of the Pacific Coast's federally managed and protected species, only salmon, and occasionally some pinnipeds (harbor seals), use freshwater habitats. Estuarine, shallow marine, and/or oceanic habitats are all frequently used by at least some species within each of the four FMP groups and by some cetaceans, pinnipeds, and sea turtles. Specific patterns of habitat use depend on species and life stage. Information on habitat-specific productivity is not available for even the most common federally managed and protected species. Habitat-specific growth, reproduction, or survival rates for even one of the habitat categories are available for only a few species and life stages. This lack of detailed information on habitat use is a major source of uncertainty in terms of understanding species-habitat relationships.

Habitat Use by FMP Species

Pacific Salmon—Pacific salmon are managed by several entities. The federal FMP focuses mainly on Chinook salmon, coho salmon, and the Puget

Spawning pink salmon holding in a pool in Bacon Creek, Washington. Note the clean gravel in the riverbed that is clear of mud and silt. This is a requirement of habitat suitable for egg laying.

Sound stock of pink salmon. State and tribal governments, the Pacific States Marine Fisheries Commission, and NMFS work together to help manage and protect stocks of Pacific salmon (e.g. chum salmon, sockeye salmon) and steelhead trout listed under the ESA. Given the general similarity in habitat use among different species and stocks of Pacific salmon and steelhead trout, their habitat-use patterns will be discussed together.

Pacific salmon are anadromous, spawning in fresh water and migrating to sea, where they live from 6 months to 5 years before returning to their natal (home) streams to spawn. Pacific salmon spawn in streams from near tidewater to more than 3,200 km (2,000 mi) inland and have developed diverse life history traits within and among species to exploit various freshwater habitats. Salmon historically inhabited three-fourths of the streams of Washington and Oregon, much of Idaho, and almost all coastal watersheds in California. Their range encompasses ecosystems from sparsely vegetated deserts and semi-arid lands in the interior Columbia watershed, Sacramento–San Joaquin Valley, and southern California to the rainforests of the coastal Pacific Northwest. Hydrology in these streams is highly variable, ranging from rain-dominated systems on the coast to those dominated by snow melt in the interior and mountainous regions. Ocean migrations of some Pacific salmon are very extensive, ranging from estuarine and coastal waters to the eastern Pacific and Bering Sea.

Pacific salmon use a variety of streams, wetlands, lakes, and other freshwater habitats for spawning and rearing. The various species of Pacific salmon have different patterns of habitat use. For example, species such as steelhead trout and Chinook salmon may spawn hundreds of kilometers inland in mountain streams, while chum salmon and pink salmon typically spawn in low-gradient stream reaches near tidewater. Salmon build nests (called redds) and deposit their eggs in clean gravel and cool water with high levels of dissolved oxygen. Juvenile salmon migrate downstream to the marine environment after spending a few weeks to several years in fresh water.

Use of estuarine habitat by Pacific salmon also varies dramatically within and among species. For example, Chinook salmon, cutthroat trout, and chum salmon may spend from just a few weeks to several months in the estuary, while juvenile steelhead trout, sockeye salmon, and pink salmon spend little time in estuaries. While some salmonids spend only a short time in the estuaries, it may be a critical time in their life cycle. Juveniles and adults depend on estuaries for migration and physiological transition between fresh water and salt water. Juveniles also use the estuary for foraging and growth and as a refuge from predators.

The distribution of juvenile Pacific salmon is predominantly within the U.S. EEZ. Juvenile Chinook salmon and coho salmon, in particular, are found in highest abundance within coastal waters along the Continental Shelf, but some portions of these populations migrate into the Gulf of Alaska where they mature. Sockeye salmon, pink salmon, and chum salmon migrate northward through coastal waters, but spend much of their time after their first summer beyond the EEZ in the open ocean of the North Pacific, Gulf of Alaska, or even the Bering Sea. In contrast, juvenile steelhead trout generally migrate directly to the open ocean and do not follow the coastal route as the other salmonids do. Less is known about the offshore habitats of adult salmon, especially in the winter, but they inhabit a large part of the Subarctic North Pacific. Areas of increased upwelling, such as the Continental Shelf, offshore islands, banks, and submarine canyons, can be particularly productive regions and important feeding areas for salmon.

NMFS

NMFS SWFSC

Top photo: krill are small crustaceans closely resembling shrimp. Lower photo: jack mackerel in a tight school.

Coastal Pelagic Species—The Coastal Pelagics FMP includes species such as krill, market squid, Pacific sardine, Pacific mackerel, northern anchovy, and jack mackerel. In addition to being important as harvestable species, many of the small coastal pelagics represent an important forage base for other federally managed fishes, protected species (e.g. cetaceans), and seabirds. Only very general descriptions of Essential Fish Habitat (EFH), such as temperature ranges, have been compiled for small pelagics. Krill (euphausiids), shrimp-like crustaceans approximately 2.5 cm (1 in) in length, are a good example of such a forage species, and they have only recently been included in the Coastal Pelagic Species FMP. Krill graze on microscopic plants and animals and form a critical trophic link in marine food chains throughout the world's oceans. Two species of krill, *Euphausia pacifica* and *Thysanoessa spinifera*, are most common in the diets of higher trophic level predators. *Euphausia pacifica* are distributed in Continental Slope waters around the Pacific Rim, from central Baja California north to Alaska, across the Pacific and south to the Yellow Sea (between Korea and China). They are also found in oceanic waters across the North Pacific Ocean, north of approximately latitude 40° N. *Thysanoessa spinifera* are found only in Continental Shelf and Slope waters of the eastern North Pacific, from central Baja California to the Gulf of Alaska. There are an additional 25 less-common krill species that occur in the eastern North Pacific off the U.S. West Coast. The distribution of each krill species is strongly influenced by a combination of factors that include oceanographic features and conditions, food availability, and seafloor topography. Some species show affinities for cold oceanic or shelf waters, while others are associated with warmer subtropical waters, the latter being more available during warm-water El Niño years. A number of krill species exhibit daily vertical migrations from daytime depths of 180–400 m (600–1,300 ft) to the surface at night (Brinton and Townsend, 2003; PFMC, 2006).

Market squid range from Baja California to southeastern Alaska. The habitat of market squid extends from the shoreline to 160 km (100 mi) offshore. Market squid is an unusual coastal pelagic species, because it spawns on the seafloor and lives less than 1 year. Mature squid form large spawning aggregations in nearshore waters. Female squid deposit capsules containing 200–400 eggs on clay and silt sediments at 10–70 m (33–230 ft) depths. Squid spawn only once in their lifetime, dying soon after spawning. The eggs incubate for 4–6 weeks, depending on temperature. After hatching, paralarvae rise into the water column and remain entrained within the nearshore water mass, where currents are dominated by tidal flow. After 2–3 months, the squid begin to form schools and disperse into more offshore waters. Paralarvae, juveniles, and adults use the neritic zone (water overlying the Continental Shelf) to forage for prey.

The Pacific sardine is found in two distinct habitats of the Pacific Coast Region. The nearshore habitat from Baja California, Mexico, to Central California is occupied by spawning adults in the summer as well as by young-of-the-year during most of the year. The other habitat, offshore in the California Current along the entire coast of North America, is occupied by sardines at spawning time in April, and also while this species migrates to a northern boreal feeding zone that ranges from

Oregon to Alaska. Most life stages of sardine occur in coastal state waters over the Continental Shelf and Slope as well as beyond the EEZ. Habitat data range from information on species distribution, to species density or abundance estimates by habitat, to information on growth, reproduction, and survival rates within habitats. The latter is restricted to the Southern California Bight, where California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys have been conducted since 1985.

The Pacific mackerel mainly occurs nearshore, but also is found outside the EEZ within the California Current. Pacific mackerel spawn in the warmer waters of Baja and southern California and migrate to British Columbia and southern Alaska (54.5° N) to feed. Habitat-specific distribution (presence/absence) data is the primary type of information available for this species.

The Northern anchovy commonly is found in the inshore waters of the California Current system over the Continental Shelf and Slope. Most anchovies inhabit southern and central California waters and are not found beyond the EEZ. Information on habitat-specific growth, reproduction, and survival rates of northern anchovy is available for the period 1979–85, and absolute instantaneous spawning biomass of this species has been estimated. Currently, anchovy biomass is only crudely estimated as larval and egg indices, with no population assessments conducted systematically. Other anchovy populations occur in the nearshore of the Pacific Northwest as far as latitude 51° N, and off southern Baja California, Mexico.

The principal biomass of jack mackerel occurs in the open ocean outside the EEZ, from Guadalupe Island, Mexico, to the base of the Aleutian Island chain in Alaska. They are found seasonally in the south, and spawn and migrate to the north through the spring and summer. The young are found in nearshore shoal waters of rocky coastlines, and the pre-recruits school with anchovy, sardines, and Pacific mackerel of similar swimming ability. After rapid growth nearshore, they reinhabit and spawn in the offshore areas of the entire North American coast. Habitat-specific distribution (presence/absence) data are the primary type of information available on this species.

Highly Migratory Species (HMS)—Most tunas, swordfish, marlin, and pelagic sharks in the Pacific Coast Region occur in offshore, oceanic island, and bank habitats, although some species, like young common thresher sharks, also may use habitat in nearshore and estuarine waters, where there is an abundance of schooling prey. Most HMS occur predominantly in epipelagic (near the surface) waters, with occasional, infrequent forays into the deeper mesopelagic zone. Bigeye tuna and bigeye thresher[2] are exceptions, spending significant amounts of time in the mesopelagic zone. Temperate-water species such as albacore, swordfish, common thresher shark and, to some extent, northern bluefin tuna, occur regularly within the region on a seasonal basis. Many HMS associate with the northerly portion of the Transition Zone that extends across the Pacific, where a front is located at the boundary between the low-chlorophyll subtropical gyres and the high-chlorophyll subarctic gyres. Areas of convergence along this chlorophyll front concentrate phytoplankton and other organisms (shrimp, squid, and other fishes), which serve as forage for higher trophic level predators such as albacore, bluefin tuna, swordfish, marlin, and shortfin mako and blue sharks. Some of the more tropical species, such as the skipjack and yellowfin tunas, pelagic thresher shark, dolphinfish and striped marlin, use habitat in the Pacific Coast Region mostly during warm-water El Niño events. The quality of habitat information ranges from distribution (presence/absence) to habitat-specific density data, though

Mark Conlin / NMFS

A mako shark that has just been tagged near the Channel Islands off the California Coast.

[2]Note that bigeye thresher and pelagic thresher sharks are no longer managed in the HMS FMP, and have been reclassified by the PFMC as ecosystem component species.

many data gaps in habitat-use information exist for various life stages of these species.

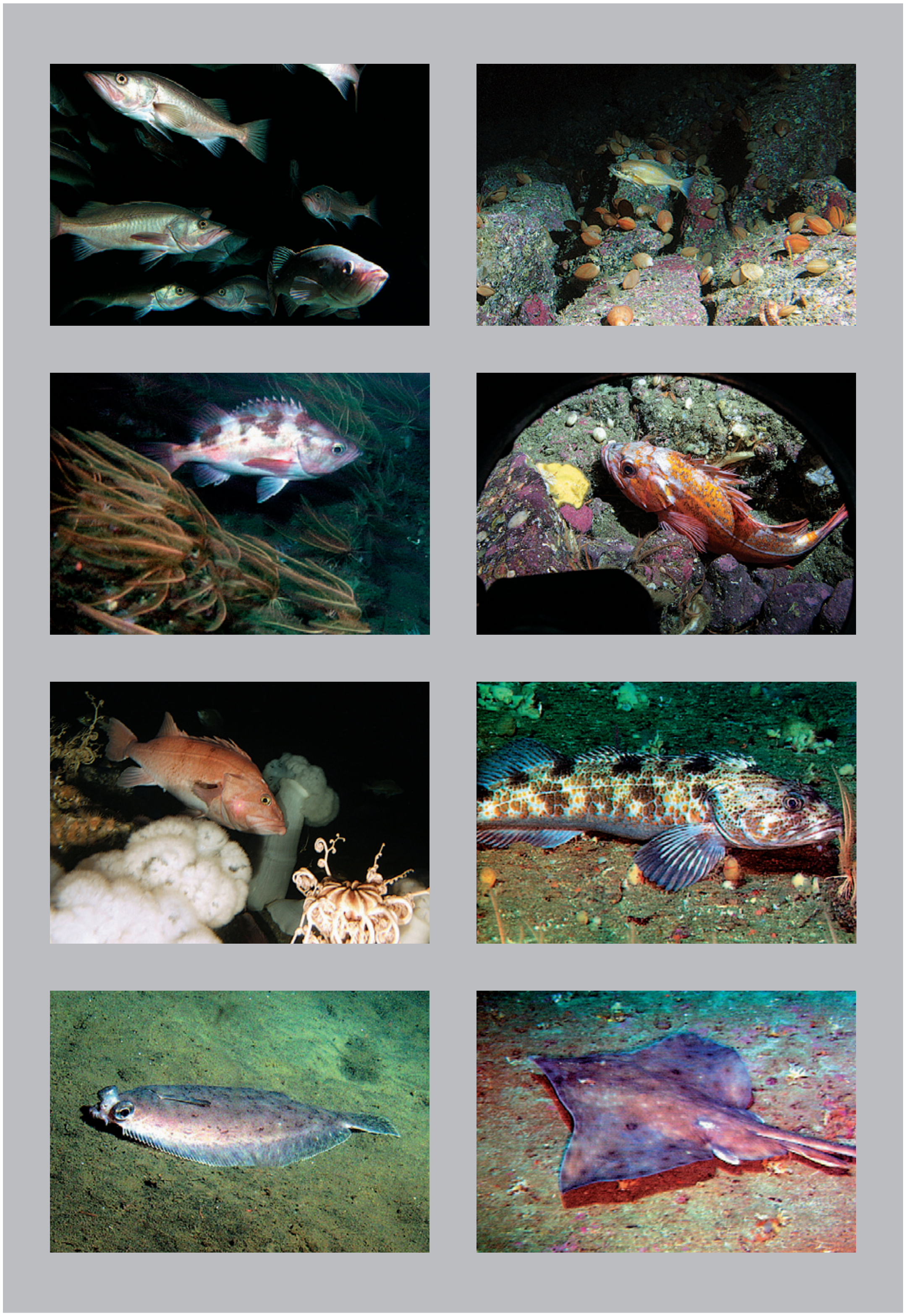
Pacific Coast Groundfish—The PFMC's FMP currently covers 91 species of commercially important groundfishes, including 64 species of rockfishes, 12 species of flatfishes, 7 elasmobranch species of sharks, skates, and chimaeras, and 8 species of various other groundfishes. Groundfish species occupy diverse habitats during all stages in their life histories. In general, species diversity is greatest off southern California, and diminishes to the north and south. Species diversity also is greatest in complex rock habitat and in deep (>30 m [>100 ft]) water on the shelf, but diversity diminishes with increasing depth down the Continental Slope.

Many of these species, particularly some of the rockfishes, can dominate coastal benthic habitats from subtidal kelp forests, to rock outcrops in submarine canyons at depths >200 m (>656 ft), to low-relief mud fields on the shelf and slope in depths >2,800 m (>9,186 ft). Eggs, larvae, and young juveniles of many of the groundfish species are epipelagic and may disperse widely in coastal waters. Settlement of juveniles for many of these species occurs in relatively shallow water, with movement to deeper habitats as the fish develop. A few groundfish species use bays and estuaries as nursery and spawning grounds. The adults of most species of rockfishes are associated with complex (e.g. rock ledges, crevices, cobble and boulder fields, shell debris) or vertical (e.g. rock pinnacles, kelp, macroinvertebrates, or artificial structures) habitats. Flatfishes and adult sablefish primarily are associated with low-relief sand and mud habitats. Hake and some rockfish species are considered to be semi-pelagic, and aggregate in large numbers. Hake are the most migratory groundfish species. They spawn in late winter off southern California and then disperse along the shelf and upper slope from San Francisco to the Queen Charlotte Islands in British Columbia, Canada. Older hake move the furthest north and the extent of northern movement is greatest during El Niño events. Several species of groundfish (e.g. sablefish, shortspine thornyhead, and Dover sole) inhabit the Continental Shelf and shelf break as juveniles and young adults, and make protracted migrations to the upper slope (600–1,200 m [1,969–3,937 ft]) and deeper into the oxygen minimum zone as they age.

Until recently, surveys of benthic marine habitats and associated groundfishes largely were limited to subtidal (<30 m [<100 ft] water depth) observations, and yet most of these species and their fisheries occur in deeper water. Assessing habitat attributes on scales pertinent to groundfish distributions and ecological issues is especially difficult in deepwater marine environments because of restricted access to this system. For two decades, NMFS researchers have been developing new tools, technologies, and partnerships to characterize deepwater fishes and habitats in the Pacific Coast Region. Coupling geophysical techniques of mapping the seafloor with observations made from a variety of underwater vehicles now has made the assessment of fish and their habitats in deep water more feasible nationwide. This approach addresses goals to describe and conserve EFH, identify areas in need of additional protection, improve assessments of groundfish populations, and evaluate ecological effects of fishing.

Currently there are several efforts underway to create comprehensive and easily accessible maps of seafloor habitats for the Pacific Coast Region. These maps are facilitated by the development of a unifying seafloor classification system for benthic habitats (Greene et al., 1999, 2007). Maps and underlying georeferenced databases are critical elements in the identification of EFH for West Coast groundfishes, in comparative risk assessments of anthropogenic impacts (e.g. fishing gear, pollution, dredging, etc.) to these habitats, and in designing and monitoring effective marine protected areas.

These maps are a first step in describing, quantifying, and understanding benthic habitats throughout the entire range of groundfish species in the Pacific Coast Region. These databases and maps comprise varying levels of data quality and verification, and it is absolutely imperative that they be revised as new information is collected. Currently, detailed mapping of groundfish habitat has been accomplished in a few important areas, such as state waters (100% coverage for California, and 50% for Oregon), some offshore banks of the Southern California Bight, and Heceta Bank, Oregon, and is slowly being extended to other areas of the Pacific Coast Region. Habitat data for the diverse groundfish group range from distribution (presence/absence) to habitat-specific densities for some commercial species.



Mary Yoklavich and Waldo Wakefield, NMFS

Representation of habitats for groundfishes off the U.S. West Coast of California and Oregon. Clockwise from the upper left corner, the fish species are bocaccio, squarespot rockfish, vermilion rockfish, lingcod, long-nose skate, Dover sole, cowcod, and darkblotched rockfish. The images were collected from ROPOS, a remotely operated vehicle (ROV), and from the *Delta* submersible.


Bob Shapiro, Cordell Bank National Marine Sanctuary

A pair of large blue whales, each nearly 30 m (100 feet) in length, pause at the surface before diving at the Cordell Bank National Marine Sanctuary.

Habitat Use by Protected Species

Marine Mammals—The Pacific Coast Region supports a wide variety of temperate and subtropical marine mammal species that are managed by NMFS, including about 30 species belonging to the order Cetacea (whales, dolphins, and porpoises) and six species of the order Carnivora (pinnipeds, more commonly known as seals and sea lions). Several large whale species, including blue, fin, sei, humpback, sperm, and North Pacific right whales, are listed as endangered under the ESA because of historical over-exploitation by whaling operations in the North Pacific. One very small population, the southern resident killer whale, is listed as endangered. Although pinnipeds were exploited heavily in historic times and many populations were reduced to very low levels, most populations have rebounded and presently are either increasing or stable. Under the MMPA, a marine mammal stock can be further categorized as "strategic" if human-caused mortality exceeds the potential biological removal level, if the stock is listed as endangered or threatened under the ESA, if the stock is declining and likely to be listed as threatened under the ESA, or if the stock is designated as depleted. In the Pacific Coast Region, several marine mammal stocks have been determined to be strategic, including beaked whales, short-finned pilot whales, and larger whales (including blue, humpback, and sperm whales); however, measures to reduce human-caused mortality have successfully been implemented in most of these cases.

- **Cetaceans**

  About 30 cetacean species are known to regularly inhabit the Pacific Coast Region. They comprise a diverse taxonomic group, including dolphins (nine species), porpoises (two species), sperm whales (three species), beaked whales (eight species), and baleen whales (eight species). Cetaceans of the Pacific Coast Region are known to forage widely on fish and invertebrates in coastal, offshore, and bank habitats. Some species, such as bottlenose dolphins, are occasionally found in estuarine habitats, but cetaceans are almost never found in freshwater systems along this coast. Their habitat-specific distribution and abundance vary by season and year as oceanographic conditions change. Several species undergo long migrations (hundreds to thousands of kilometers), and use available habitats for seasonal foraging or migrations. Many cetaceans in this Region can be divided into temperate species (e.g. Dall's porpoise, northern right whale dolphin) or subtropical species (e.g. short-beaked and long-beaked common dolphins, Risso's dolphin). Some species inhabit waters over the Continental Shelf and Slope (e.g. humpback whales, harbor porpoise), whereas others are primarily found in deeper, offshore waters (e.g. beaked whales, sperm whales). With the exception of the sperm whale, which shows latitudinal differences in the distribution of males and females with offspring, cetaceans are not known to exhibit different distributions by life stage or gender. Their habitat use largely is influenced by dynamic oceanographic and biological processes, which in turn determine the abundance of prey resources. Although a few species (e.g. blue whale) are specialists and exploit patches of their primary prey wherever they can locate large concentrations, many other species (e.g. Pacific white-sided dolphin and common dolphins) are opportunistic and will feed on a wide variety of species in several habitats.

- **Pinnipeds**

  Six species of pinnipeds inhabit the Pacific Coast of California, Oregon, and Washington. They use island and mainland habitats for breeding and molting, and they forage widely in freshwater, estuarine, coastal, offshore, and bank habitats. Unlike cetaceans, pinnipeds exhibit different habitat-use patterns by gender and age. Adults of both genders come together at the breeding rookeries on coastal islands and some mainland sites, whereas males of several species forage more widely than juveniles and females. Sea lions primarily forage in coastal and offshore habitats, but will also feed opportunistically in estuarine and freshwater systems. Elephant seals and two species of fur seals, the northern fur seal and the Guadalupe fur seal, forage widely throughout offshore areas of the North Pacific, including some bank habitats. Harbor seals represent the most coastal pinniped species in the Region, foraging and breeding exclusively in coastal, estuarine, and some freshwater habitats.

Offshore islands such as Año Nuevo on the central California coast offer relatively predator-free habitat for many breeding pinniped species.

Jim Harvey, Moss Landing Marine Laboratories

Sea lions and elephant seals on Año Nuevo Island, off the central California coast. Offshore islands such as this provide habitat for breeding pinnipeds that is relatively free of predators.

Sea Turtles—Four species of sea turtles, the loggerhead, olive ridley, green, and leatherback, are found in the Pacific Coast Region. Sea turtles migrate from tropical nesting beaches in other regions of the Pacific to forage in offshore or coastal waters of the Pacific Coast Region. Loggerheads, olive ridleys, and green turtles are limited to warm water and rarely occur north of Pt. Conception, California. Loggerheads are pelagic in the Region and often associated with pelagic red crabs. Green turtles occur year round in San Diego Bay, which they use as foraging (on seagrasses and algae) and developmental habitat. The leatherback has the largest geographic range of any reptile, occurring from latitude 60° N to at least latitude 42° S in the Pacific Ocean. Shelf and slope waters off California, Oregon, and Washington have been designated as critical foraging habitat for leatherback sea turtles that nest in the western Pacific. Leatherbacks migrate extensively throughout offshore habitats. Their habitat use is influenced by dynamic oceanographic and biological processes, which determine the abundance of prey resources. The presence of leatherback turtles in summer and fall correlates with a seasonal increase in sea surface temperature >15 °C (>59 °F) and the development of large blooms of jellyfish (Scyphomedusae). Leatherback turtles are specialists and exploit large concentrations of their gelatinous prey.

ESA-listed Salmonids—Pacific Coast salmonids have declined dramatically in abundance during the past several decades as a result of human-induced and natural factors. There are 28 distinct population segments (DPS) and evolutionarily significant units (ESUs)[3] of chum salmon, coho salmon, sockeye salmon, and Chinook salmon and steelhead trout that are listed as threatened (23) or endangered (5) under the ESA as of November 2012. These anadromous fishes hatch in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn. Even within species they differ in many aspects of life history: when they migrate to sea; how long they spend in fresh water prior to emigration; how long they stay in the ocean, and where; whether they stay in, and

[3]The ESA provides for listing species, subspecies, or DPS of vertebrate species. A DPS represents a vertebrate population or group of populations considered to be discrete from other populations of the species, and significant in relation to the entire species. An ESU is essentially a DPS specific to Pacific salmon. It is a population or group of populations reproductively isolated from other populations of the same species, and represents an important component of the evolutionary legacy of the species.


Tippy Jackson, California Academy of Sciences

The canary rockfish, a species listed by the ESA as threatened in Washington State's Puget Sound and the nearby Georgia Basin.

how they use, the open ocean and coastal waters; and when they return to their natal streams or rivers. Salmonids are discussed in more depth in the FMP section on page 196.

Non-salmonid Marine Fishes—Five non-salmonid fish species have now been listed by NMFS under the ESA. In 2010, the southern DPS of green sturgeon, which spawns in the Sacramento River Basin, was listed as threatened. Green sturgeon are long-lived, slow-growing, anadromous fish, and the most marine-oriented species of the sturgeon family. This migratory species uses bays and estuaries along the Pacific coast from Alaska to Mexico. Recent telemetry studies have demonstrated an annual fall migration of green sturgeon from the United States (central California) to Canada (central British Columbia) with a return migration in the spring (Lindley et al., 2008). Historical and current spawning locations are not well established, because green sturgeon make non-spawning movements into coastal lagoons and bays in the late summer to fall, and because their original spawning distribution may have been reduced due to harvest and other anthropogenic effects. Presently green sturgeon spawn in the Rogue River, Klamath River Basin, and the Sacramento River. Juveniles spend 1–4 years in fresh and estuarine waters before dispersing to salt water. Green sturgeon have a relatively narrow depth range in marine habitats, from 20 to 70 m (66–230 ft). The principal threat to green sturgeon in the southern DPS is the reduction of available spawning habitat due to barriers constructed along the Sacramento and Feather Rivers. Other threats include insufficient river flow, increased water temperatures, water diversion, non-native species interactions, pesticide and heavy metal contamination, and local fishing and poaching. The migration pattern of green sturgeon may make this species vulnerable to bycatch in bottom trawl fisheries.

The southern DPS for Pacific eulachon (also called Pacific smelt) was listed as threatened in 2010 under the ESA. Eulachon are endemic to the eastern North Pacific Ocean, ranging from the Eastern Bering Sea (Alaska) to Point Conception (central California). Eulachon typically spend 3–5 years in salt water, generally occurring over the Continental Shelf in 20–150 m (66–492 ft) depths, before returning to fresh water to spawn from late winter through mid spring. South of the U.S.–Canada border, most eulachon production originates in the Columbia River Basin, but this species also has been documented elsewhere in California (e.g. Mad River, Redwood Creek, Klamath River), Oregon (e.g. Umpqua River), and infrequently in coastal rivers of Washington. Eulachon populations are at or near historically low numbers and have all but disappeared from several locations. Threats to eulachon include effects of climate change on freshwater and marine habitats, bycatch in the pink shrimp fishery, water management and habitat changes in the Klamath and Columbia Basins, and predation by marine mammals and birds, especially in the Fraser and other rivers of British Columbia.

The DPSs of three species of rockfishes in Puget Sound, Washington, and the Georgia Basin were listed as endangered (bocaccio) and threatened (canary and yelloweye rockfishes) under the ESA in 2010. Bocaccio range from the western Gulf of Alaska to Punta Blanca (Baja California) but are most common between northern California and northern Baja California. In Puget Sound most bocaccio are found south of Tacoma Narrows. Canary rockfish range from the western Gulf of Alaska to Punta Colonet (northern Baja California), and are most common off central Oregon. Juveniles and subadults of bocaccio and canary rockfish are associated with rocky outcrops, kelp canopies, and artificial structures such as piers. Adults move into deeper water with age and are often associated with complex rock substrates in depths of about 95–225 m (312–738 ft). Yelloweye rockfish occur from the Aleutian Islands (Alaska) to Ensenada (northern Baja California), and are common from the Gulf of Alaska to central California. Juvenile and sub-adult yelloweye rockfish can be found in high-relief, rocky, nearshore areas in about 40–50 m (120–150 ft) depths. Adults are closely associated with high-relief rock outcrops and boulder fields, most often in about 90–200 m (300–590 ft). All three rockfish species have been harvested at high levels for many decades along the Pacific Coast. Like most other rockfish species, these bottom dwellers are long-lived and slow to mature and reproduce, which makes them especially vulnerable to overfishing. Threats to these three species include destruction of habitat by active and derelict fishing gear on the seafloor, chemical contaminants, and low levels of dissolved oxygen.

Marine Invertebrates—The white abalone is currently listed as endangered under the ESA. It is an herbivorous marine gastropod that feeds on attached or drift algae. It occurs in relatively deep water (20–60 m; 66–197 ft) from Point Conception, California, southward to Baja California Sur, Mexico. This species lives on complex hard benthic substrates such as rock pinnacles, low-relief boulders, and banks. Once occurring in densities as high as 1 per m^2 (11 ft^2) of suitable habitat, they now are found only occasionally. Surveys throughout the Southern California Bight found white abalone densities ranging from 1.5 to 13 per hectare (2.5 acres) (Butler et al., 2006). Recent surveys on one offshore bank (Stierhoff et al., 2012) suggest that a 78% decline in the total white abalone population has occurred since 2002.


John Butler, NMFS

White abalone off the California coast.

The white abalone is a broadcast spawner. If fertilized, the eggs hatch after only one day, but high concentrations of sperm are required for an egg to be fertilized, necessitating aggregations of adults for successful fertilization. Recent studies suggest that this species has likely suffered reproductive failure resulting from severe overfishing. Because of the white abalone's sedentary lifestyle, repopulating depleted areas via migration is difficult.

Black abalones also were listed as endangered under the ESA in January of 2009. Like white abalones, they are herbivorous marine gastropods and broadcast spawners. Black abalones are most commonly distributed from Point Arena in northern California down to Bahia Tortugas and Isla Guadalupe, Mexico. They are found in rocky intertidal and subtidal habitats down to a depth of 6 m (20 ft), often within the high-energy surf zone wedged into rock crevices, cracks, and holes. They can sustain extreme variation in temperature and salinity. Declines in black abalone abundance are attributed largely to overfishing and a disease known as withering syndrome. For example, the population south of


NMFS

A pair of black abalone.

San Francisco declined 90–99% due to withering syndrome. Habitat destruction, illegal harvest, and ecological factors such as competition and predation have also contributed to population declines. Conservation efforts include a system of California marine protected areas and fishery closures, both commercial and recreational. There has been recent recruitment and some recovery of black abalone at San Nicholas Island (southern California) and at sites within the Monterey Bay National Marine Sanctuary, and the population north of San Francisco has not declined.

Habitat Use by Non-FMP, State-, and Internationally Managed Species

Nearshore invertebrate and fish resources comprise a diverse array of commercial and recreational species including shrimps, crabs, abalones, clams, squids (also managed under the Coastal Pelagic FMP), sea urchins, sea cucumbers, and both cartilaginous and bony fishes that are not federally protected or included in an FMP (e.g. the Pacific halibut, which is managed by the IPHC). Many nearshore species are managed by West Coast states, which, in the case of some species, coordinate their activities through the Pacific States Marine Fisheries Commission and the PFMC. The ranges of many nearshore species overlap state and federal waters, and associated fisheries may be managed separately in those areas. For example, the Pacific Coast salmon fishery in federal waters is managed by the PFMC, but the states manage salmon fisheries in their waters. There is cooperation between the PFMC and the states on setting quotas, etc., but the fisheries are managed separately.

It is beyond the scope of this report to present a comprehensive review of habitats used by all nearshore species. Rather, this section highlights habitat use by some significant commercial and recreational species and groups. Many FMP and protected species use nearshore habitat during all or part of their life cycle; the rockfishes are one example, with about 20 species inhabiting nearshore areas during at least one life stage. Comprehensive reports on nearshore living marine resources have been compiled by Leet et al. (2001) for California and by the Oregon Department of Fish and Wildlife (ODFW, 2000, 2005) for Oregon. The ecology of marine fishes off California and northern Baja California has been thoroughly reviewed and interpreted by Allen et al. (2006).

California and Pacific Halibut—Two types of halibut occur in Pacific Coast waters, the California and the Pacific halibut. California halibut are state-managed and common in nearshore, sandy environments. They generally occur at depths to 30 m (100 ft) and occasionally to 91 m (300 ft) and use bays and estuaries as nursery grounds. Their broad range is from Baja California to Washington, although they tend to be more abundant farther south (Domeier and Chun, 1995). Pacific halibut are managed by the International Pacific Halibut Commission. The Commission was established by a convention between the United States and Canada in 1923 to implement management of and research on Pacific halibut stocks in waters over the Continental Shelf from northern California to the Aleutian Islands and throughout the Bering Sea. Pacific halibut live on or near the seafloor from Punta Chamala, Baja California, Mexico, to the Bering and Chukchi Seas, at depths from 6 to 1100 m (20–3,600 ft). However, they are commonly found in water depths from 27 to 274 m (90–900 ft) and temperatures of 3–8 °C (37–46 °F), and are uncommon south of Cape Mendocino, California. Between November and March, mature halibut congregate at spawning areas near the edge of the Continental Shelf at depths from 183 to 457 m

(600–1,500 ft) in the Bering Sea, Gulf of Alaska, and British Columbia. Halibut eggs and larvae drift passively in deep ocean currents, moving closer to the ocean's surface with development. Counterclockwise currents transport these early life stages sometimes thousands of miles westward of spawning grounds. Upon leaving the planktonic stage, young halibut settle to the bottom of bays and inlets near central and western Alaska and the inner shelf of the Bering Sea, where they occur on mud, sand, and gravel. Halibut move farther offshore as they develop, with fourth-year halibut typically found off southeast Alaska and British Columbia. Pacific halibut, one of the largest fish species in the world, grow to approximately 2.5 m (over 8 ft) and 227 kg (500 lbs), and both males and females live to 55 years (IPHC, 1998).

Dungeness Crab—Dungeness or market crab is the most important species of crab harvested commercially and recreationally along the West Coast. This species ranges from the Aleutian Islands of Alaska to near Point Conception, California. The distribution of Dungeness crab is primarily determined by water temperature, with the 3–18 °C (37.4–64.4 °F) surface isotherms considered to be the limits of the adult range. However, temperature tolerance (10–14 °C; 50–57 °F) of the larvae may be a stronger determinate of geographic range. The benthic life stages of Dungeness crab inhabit sand and sand/mud sediments on the Continental Shelf and in lower reaches of estuaries, from the intertidal zone to a depth of at least 230 m (755 ft); it is less abundant beyond 90 m (295 ft) depths. Juveniles often are found in estuarine areas of soft sediment containing eelgrass and bivalve shells. Adults move onshore in the summer and offshore in the winter. Their populations are determined as much (or more) by environmental conditions than by fisheries.

Rock Crabs—Three species of "rock crab" are harvested along the West Coast: brown rock crab, yellow rock crab, and red rock crab. Of these, yellow rock crabs have a more southern distribution, occurring on soft sediments from northern California to Baja California, Mexico. Brown and red rock crabs occur over rocky substratum as far north as Washington State and Kodiak Island, Alaska, respectively.


NOAA

A small Dungeness crab in eelgrass at the Padilla Bay National Estuarine Research Reserve.

Sheep Crab—Sheep crabs are commercially important in southern California. They are distributed from northern California to Baja California, Mexico, and inhabit a range of habitats from sandy to rocky substrates at depths of 6–125 m (20–410 ft). Sheep crabs also occur on artificial subtrates such as pilings and jetties.

Shrimps—Eleven species of shrimp are harvested commercially throughout the Pacific Coast Region, including Pacific ocean shrimp (also called pink or smooth pink shrimp), spot prawn, coonstriped shrimp (three species), red rock shrimp, ridgeback prawn, and bay/mud shrimp (a complex of four species). The Pacific ocean shrimp and spot prawn range from Alaska to southern California, the former occurring on mud and sand/mud sediments primarily in 73–229 m (240–751 ft) depths, and the latter primarily in 46–488 m (151–1,601 ft) depths on steep soft sediment slopes and on offshore rocky outcrops. Coonstriped shrimp range from Alaska to San Diego, California, in waters of 18–183 m (59–600 ft) depth, primarily in areas of sand or gravel and strong tidal current. Red rock shrimp is a southern species that is distributed from Santa Barbara, California, to Bahia Sebastián Vizcaíno, Baja California, Mexico. They inhabit rocky and algal substrates from the low intertidal to a depth greater than 55 m (180 ft). Ridgeback prawns occur from central California to Baja California at depths of 44–160 m (144–525 ft) on

Shane Anderson, Channel Islands National Marine Sanctuary

A California spiny lobster. Primarily nocturnal, this species relies on rocky habitat for shelter as it hides during the day.

sand, shell, and mud. Bay shrimps inhabit estuaries from Alaska to southern California in areas of mud or sand, but also occur on rocks and in the rocky intertidal zone. They tolerate a wide range of salinity and temperature.

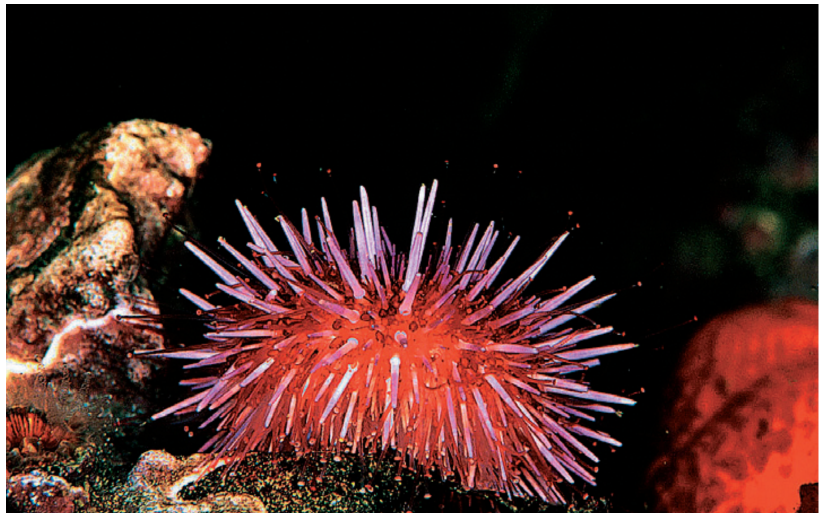
California Spiny Lobster—The California spiny lobster ranges from Monterey Bay, California, to Manzanillo, Mexico, and supports valuable recreational and commercial fisheries in southern California. The population is concentrated from the Southern California Bight to Magdalena Bay, Baja California, with an isolated population at the northwestern end of the Gulf of California. Adults generally inhabit rocky areas from the intertidal zone to depths of at least 73 m (240 ft), where they aggregate in cracks, crevices, and cave-like features, especially during daylight. Adult spiny lobsters move seasonally between shallow water (<9 m [<30 ft]) during warmer months and deep water (>15 m [>49 ft]) during colder months. After a long pelagic period, juvenile lobsters spend their first 2 years in surfgrass habitats. Sub-adults also are found in shallow rocky crevices and mussel beds.

Clams—Pacific Coast clams inhabit estuaries, bays, and open coast sandy beaches, and include razor clams; seven species of littleneck clams, including the introduced Manila or Japanese clam; Washington clams; butter clams; Pismo clams; two species of gaper clams; geoduck; the softshell clam; and others. The Pacific razor clam is generally found on flat or gently sloping sandy beaches with moderate to heavy surf. Littleneck clams of the genus *Chione* are distributed from southern California to Baja California, Mexico (and in one species, to Peru), and occur on intertidal mud and sand flats of sloughs, bays, and coves (with some subtidal occurrences to 50 m [164 ft] depths). Littleneck clams of the genus *Protothaca* have latitudinal distributions extending further to the north than *Chione*, and occur intertidally and in shallow subtidal areas of sand and muddy sand. The Manila clam is found from the intertidal zone to about 9 m (30 ft) depths in gravel, sand, mud, and shell substrates of protected inlets and bays. The Washington clam ranges from northern California south to San Quentin Bay, Baja California, and inhabits intertidal and shallow subtidal sandy mud or sand in estuaries. Butter clams range from Sitka, Alaska, to San Francisco Bay, and are found in habitat similar to that of the Washington clam. The historical range of the Pismo clam is from Half Moon Bay in central California to Socorro Island, Baja California. This intertidal species occurs on sandy beaches of the open coast and at entrances of estuaries and bays. In central California, Pismo clam populations are low, thought to be a result of predation by sea otters. Gaper clams range from Alaska to Baja California and live in fine sand or firm sand-mud in bays, estuaries, and protected areas of the outer coast from the intertidal zone to a depth of at least 46 m (151 ft), tolerating a wide salinity range. The geoduck has a broad latitudinal range from southeastern Alaska to Baja California, including the Gulf of California, although it is not as common south of Washington, and in Oregon it is known only from Netarts Bay, where it was transplanted. One of the largest burrowing clams in the world, the geoduck occurs from the lower intertidal zone to a depth of 110 m (361 ft) in bays, estuaries, and sloughs on mud, sand, and gravel. The softshell clam has expanded its range from San Francisco Bay, California, and now occurs from southeastern Alaska to Elkhorn Slough, California. Softshell clams are found buried 25 cm (10 in) or more in muddy and sandy sediments in the low to middle intertidal zone of the low-salinity reaches of estuaries.

Mussels—There are three species of commercially important mussels within the Pacific Coast Region:

the California (sea) mussel and two so-called "edulis-like" mussels, the Pacific Northwest mussel and the non-indigenous Mediterranean mussel. Mussels attach to hard substrates by secreting byssal threads from the base of their foot. Mussel beds represent a complex structural habitat for a diverse community of intertidal organisms. The California mussel is distributed from the Aleutian Islands of Alaska to Baja California, Mexico, where it forms extensive beds in the surf-exposed rocky intertidal zone and on artificial substrates such as pier pilings and jetties. This species also occurs subtidally in isolated patches to a depth of at least 30 m (100 ft). The Pacific Northwest mussel is found in protected estuaries and bays of the northwestern United States, and along open coasts in the high intertidal zone above beds of the California mussel. It also colonizes exposed rock where physical disturbance has removed the California mussel. The invasive Mediterranean mussel occurs south of the Monterey Peninsula (California), where it has been known to hybridize with the Pacific Northwest mussel.

Abalones—Habitat use for black and white abalone species was discussed in the protected species section, and habitat use for other abalone species is covered in this section. In addition to black and white abalones, Pacific Coast abalone species include red, green, pink, flat, and pinto abalones. An eighth species, the threaded abalone, is now thought to be a southern subspecies of the pinto abalone. Red abalones occur from Oregon to Baja California in association with rocky kelp habitat. In central and northern regions, they are found from intertidal to shallow subtidal depths, whereas in southern regions they are exclusively subtidal and restricted to upwelling locations along California's mainland and the northwestern Channel Islands. Pink, green, and pinto (threaded) abalones occur in warmer waters south from Point Conception, California, to central Baja California and the southeastern Channel Islands. Green abalones are centered at shallower depths in open coast habitat that is shallow and rocky; pink abalones extend from the lower intertidal zone to 61 m (200 ft) depths, but mainly between 6 and 24 m (20 and 80 ft) depths. Flat abalones are found in the cool waters north of Point Conception.

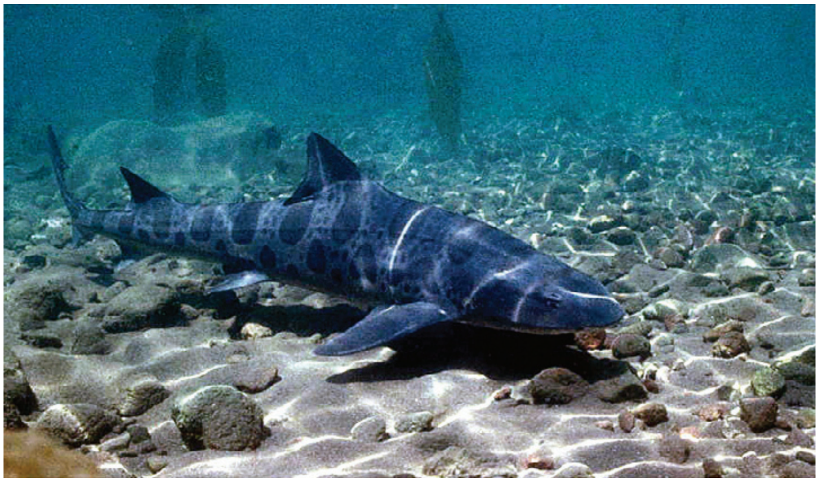


Laura Francis, Channel Islands National Marine Sanctuary

A purple sea urchin in California's Channel Islands National Marine Sanctuary.

Sea Urchins—Red sea urchins and purple sea urchins occur along the Pacific Coast from Alaska to Isla Cedros, Baja California (red sea urchins also occur in the western Pacific). Red sea urchins inhabit lower intertidal and subtidal rocky substrates to a depth of at least 91 m (300 ft). These are locally abundant subtidal herbivores that are important in structuring kelp-forest communities. The tests and spines of red sea urchins provide biogenic habitat for other benthic invertebrates including juvenile sea urchins. Purple sea urchins have a life history similar to that of red sea urchins, but occur in high-energy intertidal and subtidal areas. A third species, the green sea urchin, is common in the rocky intertidal of Puget Sound, Washington, and the outer coasts of Washington and British Columbia, Canada. Aside from these shallow-water urchins, there are several other species of urchins that live in deep sand habitats on the Continental Shelf and Slope.

Sea Cucumbers—The California, or giant red, sea cucumber is distributed from Alaska to Baja California from the low intertidal zone to 244 m (800 ft) depths. At the southern end of their range, California sea cucumbers are replaced in shallow water by the warty sea cucumber. The warty sea cucumber is found from Monterey Bay, California, to Baja California, from the lower intertidal zone to 27 m (90 ft) depths. Sea cucumbers occur over a range of substrates from mud to rock, but are most abundant on sand, gravel, and shell debris.


© Daniel W. Gotshall

Leopard sharks commonly inhabit coastal and bay habitats from northern Mexico to northern California.

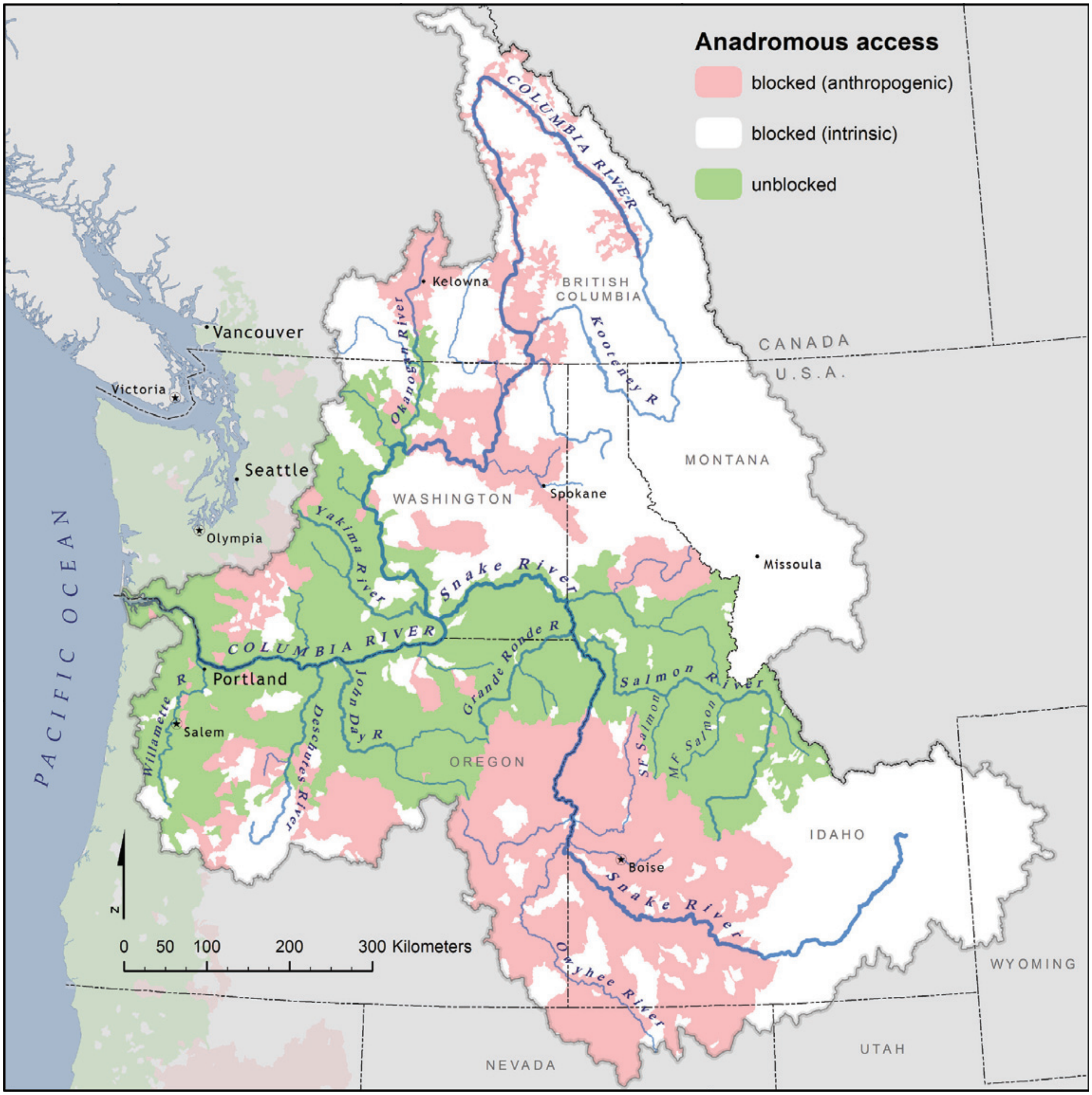
Cartilaginous Fishes—Cartilaginous species include sharks, rays, skates, and ratfishes. Some have been considered in the previous sections on highly migratory and groundfish species. A number of these species use nearshore habitats for all or part of their life cycle. Sharks occurring in the nearshore area of the Pacific Coast Region and targeted by commercial and recreational fisheries include the common thresher, shortfin mako, basking, white, salmon, blue, soupfin, leopard, sixgill, sevengill, spiny dogfish, and others. These species range widely throughout the eastern Pacific, and water temperature is an important determinant of their seasonal distribution. Inshore coastal waters, embayments, and estuaries commonly serve as pupping and nursery grounds.

Skates and rays occur in all marine habitats, from protected bays and estuaries to the outer coast. Two common species are the big skate and the longnose skate, both ranging from the Bering Sea to Baja California, from shallow waters to depths greater than 610 m (2,000 ft). Most stingrays, such as the common round stingray and bat ray, are bottom dwellers, occurring in shallow inshore waters, bays, estuaries, and sloughs, although some also are found in deeper waters.

Bony Fishes—Habitat use by many of the bony fishes has been discussed in earlier sections on FMPs and protected species. In general, these fishes have varying affinities to nearshore ecosystem habitats. Many move between bays and estuaries and the open ocean. Some of these movements are ontogenetic, representing a change in habitat association over the course of development. Many movements are related to spawning events, when fishes congregate at specific habitats. The short duration of the spawning period and rough ocean conditions have made it difficult to accurately define spawning times and locations for most nearshore fishes. Fishes such as the yellowtail, California (Pacific) barracuda, and Pacific bonito are open-water coastal migratory species. Croakers are represented by eight species, which occur primarily off southern California and Mexico, and inhabit shallow water in or near the surf zone along beaches and bays over sand or mud. Rockfishes represent one of the more diverse groups of nearshore fishes, with over 20 species inhabiting rocky areas in waters less than 30 m (100 ft) deep. Smelt are distributed widely throughout the coastal zone, and six species inhabit estuarine or open-coast habitats at one or more life stages. The white sturgeon, like the green sturgeon discussed earlier, is anadromous, ranging from Alaska to Mexico, and inhabits marine, estuarine, and riverine waters over a wide range of sediments. Both species migrate into freshwater streams to spawn in areas containing large cobble and boulders. The Pacific herring is a pelagic species occurring in coastal and offshore waters throughout the Pacific Rim from Japan to northern Baja California and into the Arctic Ocean. Herring spawn in bays and estuaries in both intertidal and subtidal zones, where they lay adhesive eggs on a variety of substrates including aquatic vegetation, rocks, and artificial structures such as pilings and jetties. There are 17 species of viviparous (live-bearing) surfperches in the Pacific Coast Region. Surfperches are distributed from Baja California to Alaska, but many of the species occur primarily off California and Baja California. Although surfperches occur over a broad depth range from the intertidal to 230 m (750 ft), they primarily inhabit estuaries, bays, and nearshore areas in association with a variety of substrates including sand, rock, vegetation, and also artificial structures such as pier pilings.

HABITAT TRENDS

Many Pacific Coast Region habitats have been dramatically reduced from their original pristine state. Major habitat trends include continued reductions in freshwater flows and habitat access



due to dams, estuarine habitat loss, and increased loading of coastal waters with toxic contaminants including metals, pesticides and chemicals of emerging concern, like pharmaceuticals, from agricultural and urban runoff. Trends in habitat quantity and quality also are significantly impacted by continued damage to seafloor habitats during fishing, and climate variability such as El Niño events.

The loss and degradation of freshwater habitat in the Pacific Coast Region has been well documented. For example, in the Columbia River Basin more than half of the streams historically used by salmon are no longer accessible due to large dams. In the last 10 years, there have been many notable examples of dam removal projects that have restored historical access to many miles of river habitat in the Pacific Northwest. In particular, the

Accessible and blocked anadromous fish habitat in the Columbia River Basin. On the Columbia River and its main tributaries, over 250 reservoirs and 150 hydroelectric projects reduce access and use of a majority of the 647,500 km^2 (250,000 mi^2) drainage basin (PSMFC, 2006; McClure et al., 2008).

The Glines Canyon Dam, in Washington State, in the early stages of being dismantled.

removal of the Elwha Dam (completed in 2012) and Glines Canyon Dam (completed in 2014) represent the largest dam removals in U.S. history. These removals will help restore the Elwha River to its natural state and allow Chinook salmon, whose populations prior to removal were a fraction of their historical abundance, return to their native spawning grounds. Still, many river sections, such as those above Grand Coulee Dam, will remain inaccessible to Pacific salmon (see map at top of page 209). Additionally, there has been a minimum estimated loss of 48% of historical stream mileage formerly accessible to Chinook salmon in California's Central Valley watershed. Because steelhead trout penetrate much farther than Chinook salmon into this watershed, aggregate losses summed across all anadromous species are likely to be substantially higher. Remaining accessible freshwater habitats have been greatly simplified and degraded by land-use practices such as logging, grazing, agriculture, urbanization, dredging, diking and filling wetlands, and others. Diversion of fresh water can significantly modify reproductive patterns and success for Pacific salmon, as well as reduce water flow and flushing in bays and estuaries.

Estuarine habitat in the Pacific Coast Region has been dramatically impacted by human activities. More than 70% of the estuarine habitat, both in the Pacific Northwest and along California, has been lost or degraded due to diking, filling, polluting, and other human activities. At least 90% of wetlands, including bays, estuaries, and salt marshes, were lost in California alone from the time of European settlement to the 1980s (Dahl, 1990; Zedler et al., 2001). Much of this change occurred more than 50 years ago, but a recent joint report by NOAA and the U.S. Fish and Wildlife Service found that the coastal watersheds of California, Washington, and Oregon are still losing wetlands—over 2,100 hectares (5,200 acres) between 2004 and 2009 (Dahl and Stedman, 2013). Efforts now are underway to protect and restore these habitats in many areas. In fact, a substantial amount of aquatic habitat has been, or is being, restored and made accessible to fishes and other aquatic organisms along the Pacific Coast via the removal or relocation of dikes and levees. Another clear trend in the status of nearshore coastal habitats is the decline in mainland habitat for breeding pinnipeds, although nearshore rocks and islands continue to support relatively large rookeries.

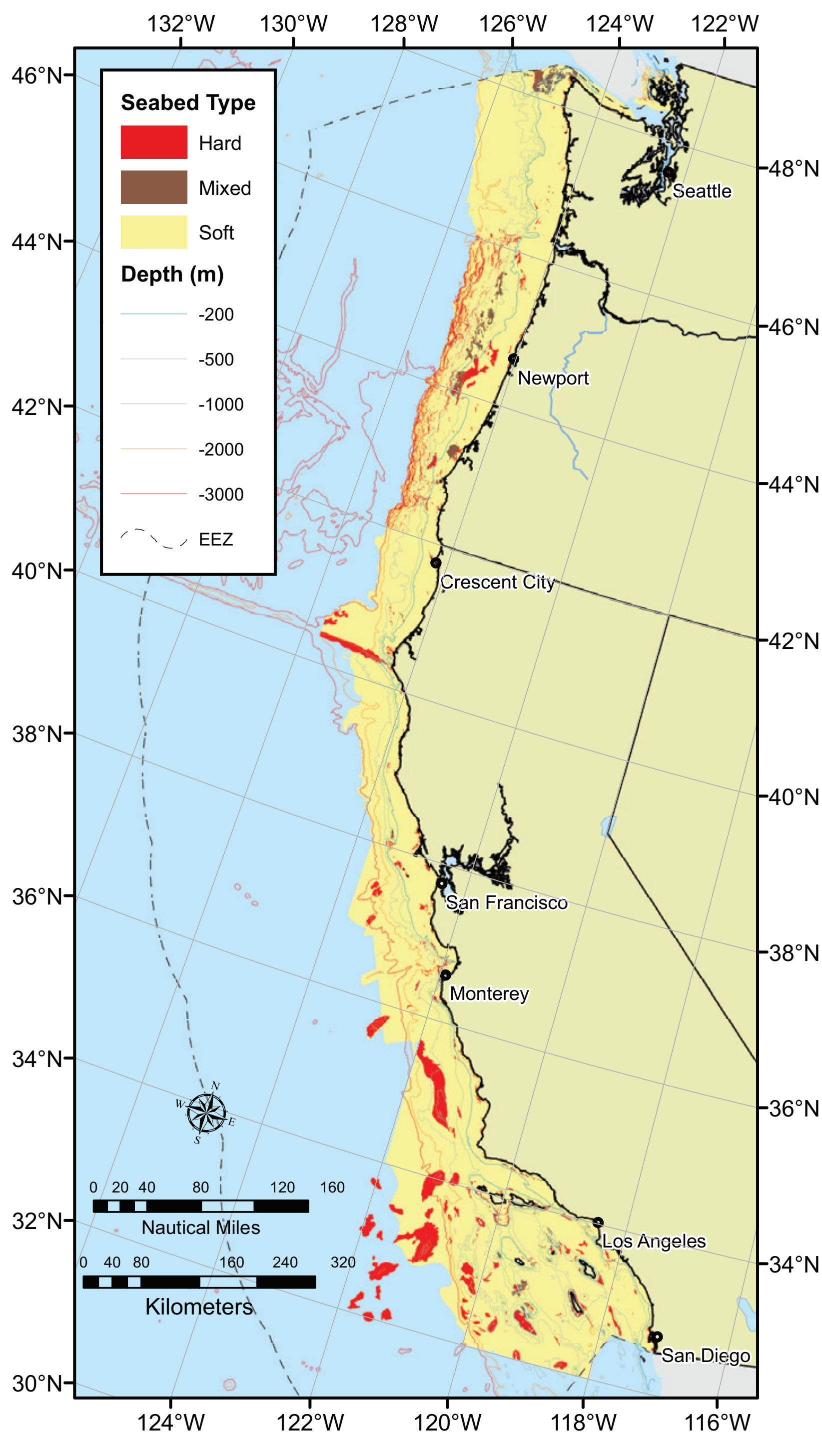
In much of the Pacific Coast Region, the populations of many groundfish species are at historically low levels. Overfishing by both recreational and commercial fishermen and unfavorable oceanographic conditions are significant contributing factors to the severe declines in some populations. Alteration and destruction of habitats could also play a role in diminishing populations of some species, although baseline information on the condition of seafloor habitats prior to commercial fishing is not available. Fishing gear, particularly certain types of bottom trawls, has contributed to the destruction of seafloor habitats, which could in turn diminish the survival of both young and adult groundfish species. We know little about historical or recent impacts of benthic disturbances, and specifically the impact of fishing gear, to groundfish habitats on the West Coast.

The habitat occupied by most highly migratory species of fishes, turtles, and marine mammals within the Region represents a very small portion of their total range. Thus, these species may be further impacted by other factors such as fishing activities and changing environmental conditions outside of the Region. Habitat for these species primarily is located in the upper water column, and thus not affected directly by disturbance to the seafloor by bottom fishing gear.

Large changes in upwelling and ocean temperatures associated with climatic changes, such as the El Niño Southern Oscillation (ENSO) or the Pacific Decadal Oscillation, have dramatic effects on primary and secondary production and subsequently on all levels of predators in the Pacific Coast Region. These large climatic shifts have been correlated with changes in distribution, abundance, reproduction, and survival for many of the managed species and their forage base (e.g. krill) in the Region. While these fluctuations can occur naturally, the potential effects of long-term anthropogenic climate change on these fluctuations are still being studied. However, there has been a trend of decreasing dissolved oxygen in the California Current oxygen minimum zone (OMZ), accompanied by a shoaling of the upper boundary of the OMZ. This hypoxic water has impacted the chemical and biological oceanography and living marine resources on the Continental Shelf. For example, over the past decade, dissolved oxygen off Oregon and Washington has reached hypoxic levels that can be detrimental to fishes and invertebrates (Chan et al., 2008). Effects of long-term climate change may increase or decrease suitable habitat, but definitive answers are presently unavailable for many species.

RESEARCH NEEDS

Habitat-oriented research needs are considered for specific groups of species, although much of this information is needed for all groups. In general, information that relates species' densities, growth, survival, reproduction, and production rates directly to particular habitats is lacking for most species and life stages. These higher levels of information are critical for understanding the relative importance and availability of suitable habitat in affecting the abundance of marine species of the Pacific Coast Region. Table 12 presents an overview of habitat-specific research needs for the Pacific Coast Region, with more detailed information provided in the text that follows.



Map of seabed types in the Pacific Coast Region, produced by C. Romsos (Oregon State University) and J. Bizzarro (University of Washington) for the Pacific Coast Groundfish 5-year Review of Essential Fish Habitat (PFMC, 2012). Map and data sets available at http://efh-catalog.coas.oregonstate.edu/overview/ (accessed May 2015).

Table 12
Overview of research needs for Pacific Coast Region fishery and protected species.

Research Needs	Freshwater habitat	Estuarine habitat	Shallow marine habitat	Oceanic habitat
Identify, quantify, and map critical habitats for each species. For example, identify pupping grounds and core nursery areas of the common thresher shark and shortfin mako shark; characterize dynamic open-ocean habitats for tunas and other HMS, marine mammals, and sea turtles; quantify habitat-specific productivity of overfished groundfish species.	x	x	x	x
Collect high-resolution bathymetric data to characterize the seafloor on the Continental Shelf and Slope, especially in association with conservation areas.			x	x
Collect habitat-specific life history information for all managed and protected species, including early life stages.	x	x	x	x
Determine and better understand impacts of habitat variability and toxic algal blooms on pinnipeds, cetaceans, and turtles.			x	x
Determine ecological effects of fishing, including impacts on marine mammals, biodiversity, and trophic dynamics of ecosystems.	x	x	x	x
Characterize and describe benthic habitats (including biogenic components such as deep-sea coral communities) and associated fish assemblages.		x	x	x
Determine effects of fishing gear on benthic habitat and develop methods to reduce destructive practices, including monitoring of marine protected areas, modification of fishing gear, collection of bycatch information, and evaluating impacts on prey (a component of fish habitat).		x	x	x
Implement remote sensing for oceanography and stock assessment.		x	x	x
Evaluate effectiveness of EFH closures and other conservation areas to protect species and habitats.	x	x	x	x
Understand effects of climate change on habitats.	x	x	x	x

Pacific Salmon

Although Pacific salmon have been the subject of intensive study for many years, there are many key research needs related to fish-habitat linkages that largely remain unaddressed. These include seasonal habitat use in both freshwater and marine environments, relationships between habitat alteration and fish survival and production through all life stages, lethal and sublethal effects of many pollutants on salmon and their prey, the relationships between viability of wild populations and ocean and freshwater conditions, potential effects of climate change on freshwater and marine habitats, and effectiveness of restoration techniques, especially watershed-scale restoration. In addition, research is needed on the response of freshwater habitats and salmon populations to dam removal, linkages between habitat diversity and population resistance and resilience to disturbances, and interactions between hatchery-raised and wild fish, in both fresh water and the ocean.

Coastal Pelagic Fishes

The increasing demands of fishery management for information, and the costs and demands for sea-going research vessels, require new approaches to gather and analyze biomass and ocean habitat data for coastal pelagic species. Continued modernization of satellite oceanography, autonomous underwater vehicles, and acoustic surveys of the epipelagic zone are necessary for effective management of pelagic resources. For example, considerable predictive ability in assessing the Pacific sardine population could be achieved by assembling habitat data that relate to the eddy structure, from the mesoscale to the megascale, of the circulation of the North Pacific subtropical anticyclonic eddy. Mechanisms for developing a functional explanation of the biophysics of sardine reproductive success could be established from juvenile surveys of growth and survival rates. Presently there is no adequate and timely detection of change in biomass of northern anchovy and Pacific jack mackerels that occurs due to environmental forcing. Research needs for the market squid include identification and description of spawning habitats throughout the species range in both unfished as well as fished areas, particularly during El Niño events. Although there is a considerable body of information on the biology of some krill species for subregions of the California Currrent System, a comprehensive coast-wide delineation of primary krill habitats for each life stage under different oceanographic conditions and regimes is lacking. Such delineation can be accomplished with planned acoustic surveys of the entire West Coast.

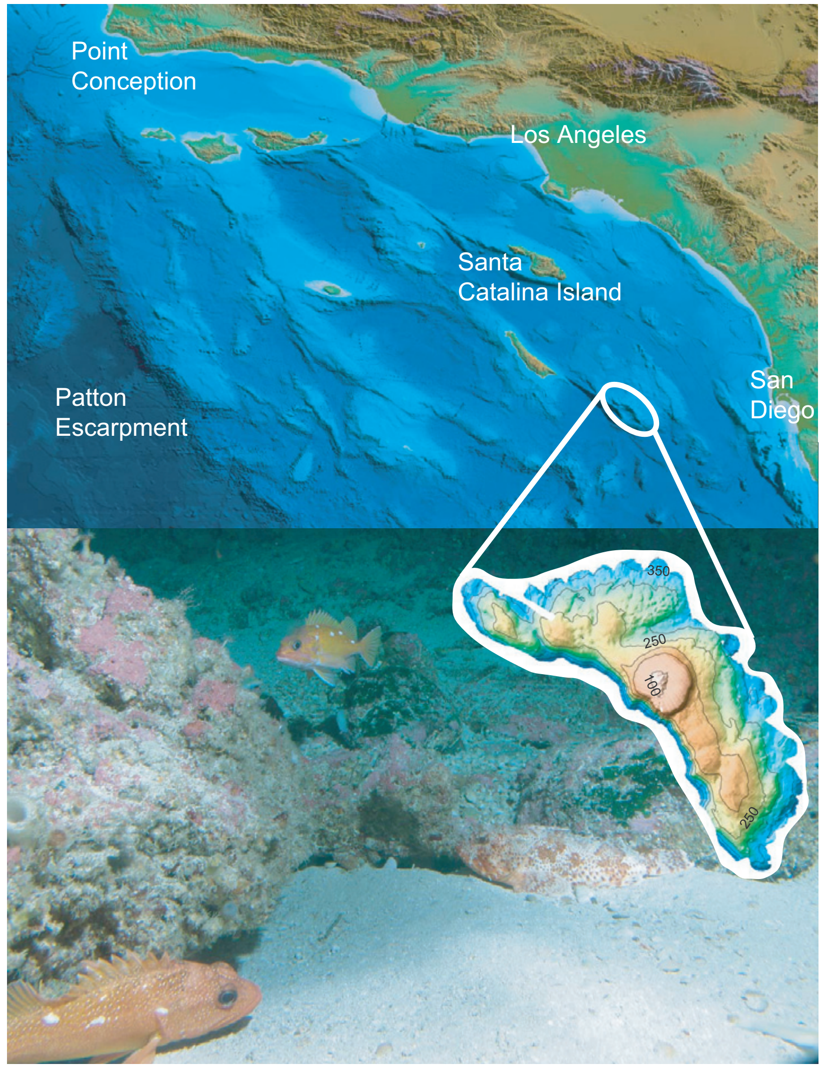
Highly Migratory Species

Research needs for highly migratory species include identification of pupping grounds and core nursery areas of the common thresher shark and shortfin mako shark. These areas, where pregnant females congregate, may be sensitive to perturbation that make aggregated females and pups vulnerable to fishing and other adverse effects. There also is a need to determine seasonal and age-specific use of habitat by deep-dwelling adult albacore, bigeye tuna, and other HMS species in the North Pacific. For other HMS not targeted by fisheries, very little is known about the habitat of various life stages.

Groundfish

There is a critical need for comprehensive, detailed information on benthic habitats and associated groundfish assemblages on spatial scales relevant to fishery management and habitat protection. Development of more efficient and effective visual and acoustic methods to survey deepwater benthic habitats and fishes is necessary, especially in complex, diverse habitats that are difficult to assess with conventional survey tools such as trawl and longline gear. About 120,000 km^2 (46,332 mi^2) of the seafloor still needs mapping to a depth of 1,300 m (4,265 ft) off Washington, Oregon, and California.

Identification and protection of core spawning and nursery grounds also are important, especially in coastal habitats. Priorities for research on groundfish habitat also include improvement of our understanding of the ecological effects of fishing on the biodiversity and trophodynamics of the ecosystems on which these species depend; evaluation of gear impacts to marine benthic habitats on the Continental Shelf and Slope; and the development of ways to reduce adverse impacts, including monitoring marine protected areas, modifying fishing gear, and collecting bycatch information. There also is a critical need to evaluate the role of deep-sea coral communities as groundfish EFH in Continental Shelf and Slope ecosystems. Because large invertebrates, such as sponges and corals, enhance the diversity and structural component of fish habitat and are vulnerable to impacts by at least some fisheries, it may be appropriate to identify them as Habitat Areas of Particular Concern. Fi-



J. Chaytor and C. Goldfinger, Oregon State University

Mary Nishimoto, UC Santa Barbara

An example of benthic habitats at various spatial scales of resolution. A color-shaded map of southern California's ridge–basin topography (top), extending shoreward from the Patton Escarpment (1,000–3,000 m [3,281–9,842 ft] depth). New and archived acoustic sonar data were compiled from Oregon State University, Scripps Institute of Oceanography, NOAA, USGS, and NASA. A high-resolution bathymetric map of one offshore bank is superimposed over typical microscale habitats and associated groundfish species (bottom) surveyed by NMFS from an occupied submersible at a depth of 80 m (262 ft).


Jim Harvey, Moss Landing Marine Laboratories

Researchers on the NOAA ship *David Star Jordan* track a tagged leatherback sea turtle during a survey of the species' use of oceanic habitat.

nally, understanding the relationship between large climate events and abundance, growth, spawning success, and survival of groundfish species is a productive focus of future research.

Pinnipeds

Current understanding of habitat use by pinnipeds has been based largely on tracking studies and food-habit investigations near rookeries. Such studies will continue to improve habitat knowledge for pinnipeds. However, further study of the nature and magnitude of competitive interactions between humans and pinnipeds also is necessary. Such interactions may occur where fisheries are removing prey species that are important to pinnipeds, and when pinnipeds may impact the recovery of commercially valuable, threatened, or endangered fish species. Furthermore, additional research on the impacts of natural habitat variability and toxic algal blooms on pinnipeds is important, as these impacts are known, but not well understood.

Cetaceans

A primary research need is to characterize habitats for cetaceans in the Pacific Coast Region, and to further study movement patterns and local abundances. During the last decade, significant efforts have been made by NMFS to conduct comprehensive abundance and distribution studies for cetaceans in the Pacific Coast Region. These studies generally collect oceanographic data, and habitat-based models of cetacean distribution and abundance have been developed recently for many species. However, this diverse group of species will require more detailed studies to gain a better understanding of important habitats. Continuing studies of human-related impacts, such as fisheries, harmful algal blooms, and pollution, also are important for management and conservation of cetaceans throughout the Pacific Coast Region.

Sea Turtles

There are several research priorities for endangered or threatened sea turtles. Habitat use of turtles during migration and foraging has been characterized recently, but finer-scale studies are needed to examine the spatial and temporal coincidence of leatherbacks and the commercial swordfish fishery. This will allow mitigation of commercial fishery impacts in these habitats. It also is known that jellyfish are important predators of commercially valuable coastal fish and crab species, and the potential role of leatherback turtles in regulating jellyfish predation on these species represents an intriguing research topic with implications for an ecosystem-based approach to management.

Robert Schwemmer, NOAA

A scuba diver photographing kelp forests in the Channel Islands off the California coast. Kelp is a food source for abalone and other invertebrates, as well as important habitat for many marine species.

Protected Marine Invertebrates

Research needs include quantification of white and black abalone habitat, population assessment and monitoring of these species, estimation of the density of cryptic animals (i.e. animals that hide or are difficult to see), evaluation of mobility and aggregation during the spawning season, and determination of threshold distances for successful fertilization.

Additional Research Needs

The Pacific Fishery Management Council also has identified research and data needs specific to the Pacific Coast Region and produces a summary document of these research needs that is updated every few years. Additional research needs to support the Pacific Coast Region FMP species and their habitats can be found at the Council's website on research and data needs.[4]

[4]http://www.pcouncil.org/resources/research-and-data-needs/ (accessed July 2013).

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