


the OREGON NEARSHORE STRATEGY




Chapter 6: Nearshore Habitats

2016
Oregon Department of Fish and Wildlife
OregonConservationStrategy.org

Table of Contents – Chapter 6: Nearshore Habitats

PDF Content Last Updated November 7, 2016

This PDF is a chapter of the Oregon Nearshore Strategy, the marine component of the official State Wildlife Action Plan for Oregon. The complete Oregon Conservation Strategy is available online at http://oregonconservationstrategy.org/. Since Conservation Strategy content will be updated periodically, please check the website to ensure that you are using the most current version of downloadable files.

Contact ODFW

*For more information on the Oregon Nearshore Strategy or to provide comments, email **Nearshore.Strategy@state.or.us** or write to Oregon Department of Fish and Wildlife, Marine Resources Program 2040 SE Marine Science Drive, Newport, OR 97365*

Recommended Citation

Oregon Nearshore Strategy. 2016. Oregon Department of Fish and Wildlife, Salem, Oregon.

Cover Photos

Banner: Copper Rockfish, © Janna Nichols; Red Sea Urchin, © Scott Groth; Black Oystercatcher, © Kelsey Adkisson; Steller Sea Lions, ODFW; Bull Kelp, © Janna Nichols; Wolf Eel, © Taylor Frierson

Featured image: Bull kelp forest, © Janna Nichols

Photo Credit: Janna Nichols

NEARSHORE HABITATS

The coastal and marine habitats described here encompass the area from the 3 nautical mile outer limit of Oregon's territorial sea, where water depths average 66 m and range from 17 m to 194 m, to the supratidal areas of the shoreline affected by wave spray and overwash at extreme high tides and the portions of estuaries where species depend on the saline waters which enter from the Pacific Ocean. These are the waters and habitats that define the Nearshore ecoregion and are the focus of the Nearshore Strategy. This chapter describes how to classify habitat types and the major habitat types found in Oregon's nearshore, including: neritic, soft bottom subtidal, rocky subtidal, rocky shore, sandy shore and estuaries. Riverine portions of estuaries are currently covered in the Oregon Conservation Strategy.

OCEANOGRAPHIC CONTEXT – THE CALIFORNIA CURRENT SYSTEM

The distinct suite of oceanographic features and physical forcing agents that help define the Nearshore ecoregion include the northern portion of the California Current System and the annual seasonal upwelling/downwelling cycle that are responsible for its high productivity (Figures 6.1 and 6.2). The eastern boundary current called the California Current System is a part of the North Pacific gyre that moves cold water from the North Pacific toward the equator. It has a southward flowing current over Oregon's shelf and slope and a northward flowing undercurrent over the slope in spring and summer. In winter, the current over the shelf consists primarily of the northward flowing Davidson current (Figure 6.1).

During spring and summer, winds blowing from a northerly direction drive an upwelling system that brings cold, nutrient-rich, and oxygen-poor waters from depth up onto the continental shelf (Figure 6.2a). The upwelling process is highly variable on many time scales and is generally stronger and more persistent on the south Oregon coast and more intermittent on the central and northern Oregon coast. In addition to nutrients derived from upwelling, river discharge from the Columbia River provides a major source of nutrients to the Oregon continental shelf, especially along the north coast. The upwelling and river-plume nutrients fuel high phytoplankton productivity which drives an extremely productive marine ecosystem off of Oregon. In the fall and winter months winds blowing from a southerly direction cause seasonal downwelling that bring well oxygenated water from the surface downward in the water column (Figure 6.2b).

Superimposed on these large-scale processes are smaller scale eddies, gyres, fronts, and other oceanographic phenomena, which together serve to create a complex spatially and temporally dynamic ecosystem.

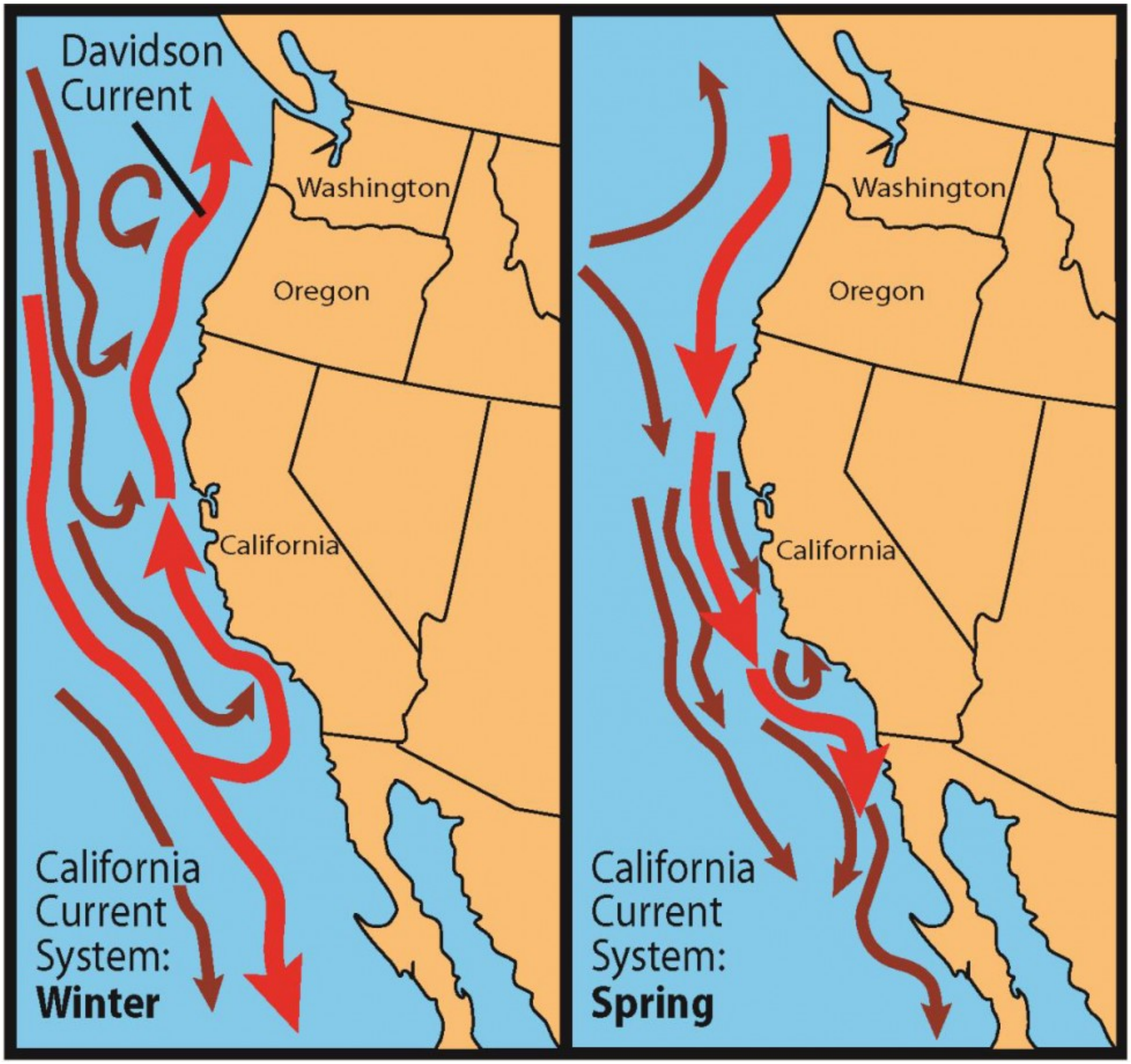


Figure 6.1. The California Current System typically varies seasonally. (Source P. T. Strub).

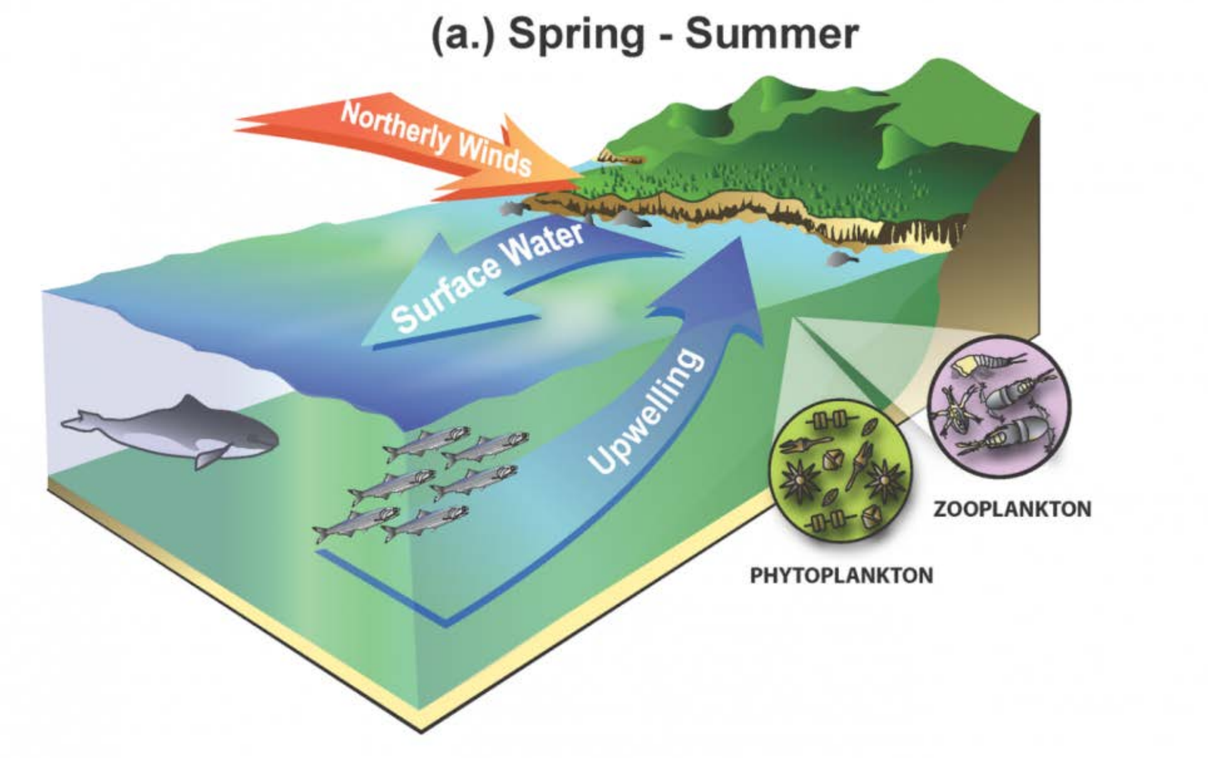


Figure 6.2a. Annual seasonal cycle of spring-summer upwelling.

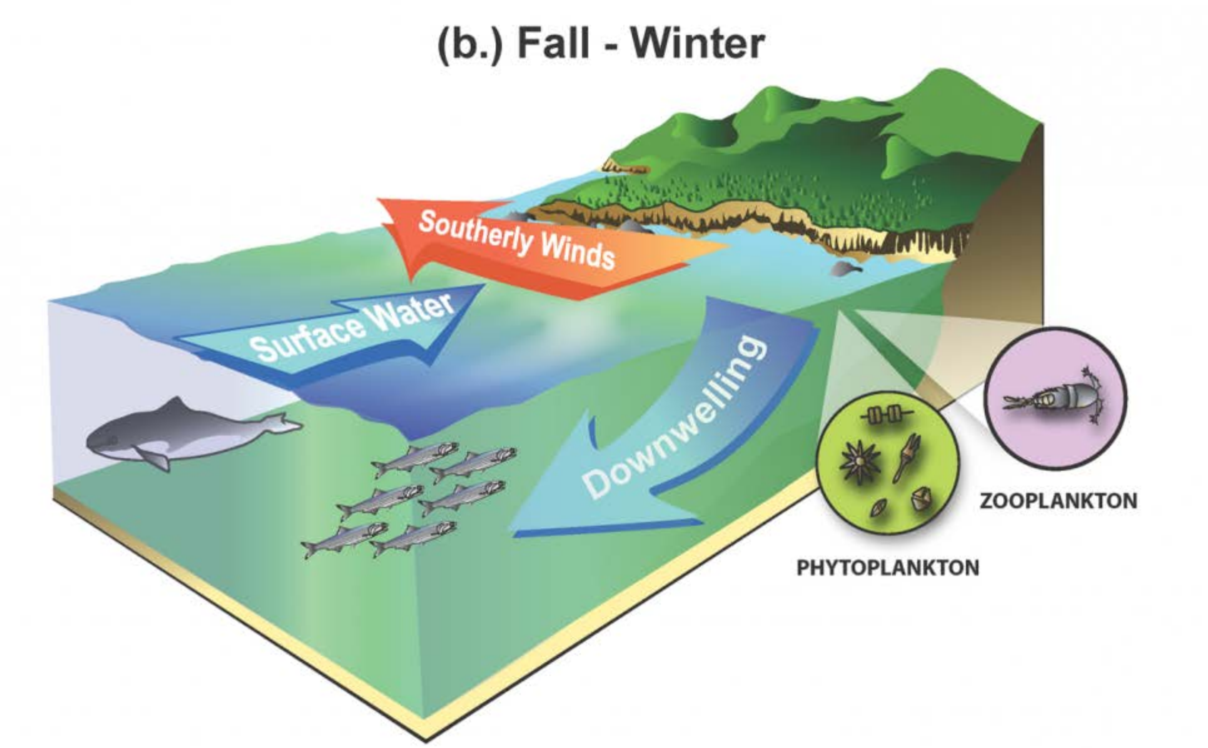


Figure 6.2b. Annual seasonal cycle of fall-winter downwelling.

CMECS FRAMEWORK

In 2012 the Coastal and Marine Ecological Classification Standard (CMECS) was adopted in the United States (Federal Geographic Data Committee 2012) as a means to provide a common framework for describing habitat, using a simple, standard format and common terminology (Figure 6.3). The goal of using CMECS is to both enhance scientific understanding and to advance ecosystem-based and place-based resource management through better communication. As the name implies, CMECS is increasingly being incorporated into scientific descriptions and being used in management documents. For the 2016 Oregon Nearshore Strategy, components of the CMECS classification framework have been incorporated – in particular, the CMECS approach to evaluating and describing habitats.

The CMECS framework is flexible. It allows classification and description of habitat using one or both of its two broad based settings and one or more of its components. Not all settings or components need be used for all purposes. It is designed so that the components selected can effectively describe the ecological units observed to the level of detail needed by a broad range of users across a wide variety of spatial and temporal scales. The components utilized may vary depending on the objective, but the common system of standards provides comparability. For example, both anthropogenic and naturally-occurring physical structures in an environment are geoform components in CMECS. Geoform components describe the physical structure of the environment across spatial and temporal scales without affecting the larger classification of the system, subsystem, or zone. It helps to think of systems, subsystems, and zones as being like nouns, with geoform and other components being like adjectives used to describe that noun. Biotopes, the combination of abiotic habitat and associated species in the CMECS framework have yet to be fully described for most coastal and marine waters in the U. S. including Oregon.

The Biogeographic Settings have a hierarchical structure composed of Realm, Province, and Ecoregion. The hierarchical structure of Aquatic Settings are composed of System, Subsystem and Tidal Range. Tables 6.1 and 6.2 provide the reader with an overview of the Biogeographic and Aquatic Settings for the species and their habitats in Oregon's coastal and marine waters encompassed in the Strategy.

The descriptions of familiar Nearshore habitats (below) will include some of the relevant CMECS components for each habitat described. Use of CMECS is just beginning. It will evolve over time as it is put to more use and information that has been collected is put into the framework. This is a work in progress that is anticipated to benefit scientific research and monitoring efforts, management decisions and conservation efforts and actions over the decades to come.

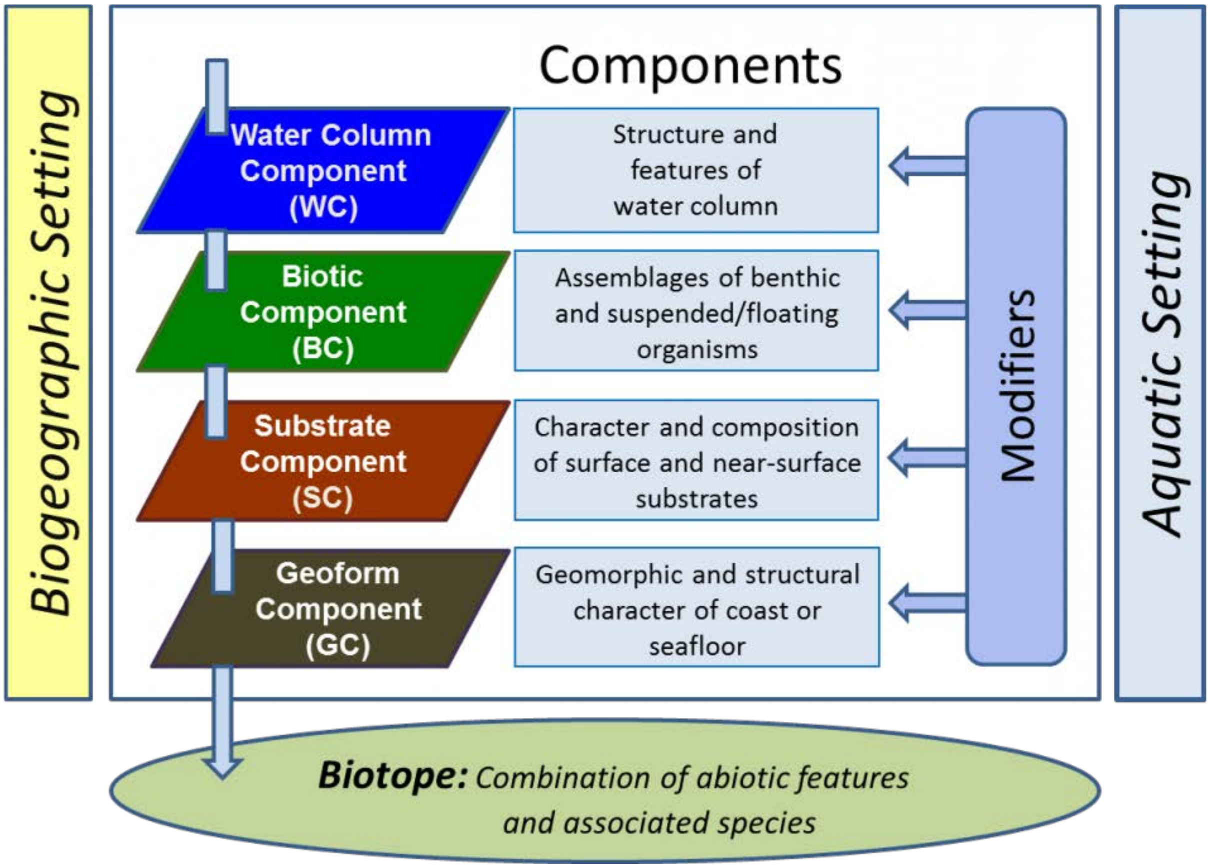


Figure 6.3. Overview of the Coastal and Marine Ecological Classification Standard framework (Source FGDC 2012).

Table 6.1. Overview of the hierarchical structure of the Biogeographic Setting for Oregon's Coastal and Marine Habitats

Hierarchical Level	Definition[1]	Oregon's Coastal and Marine Habitats
Realm	Very large regions of coastal, benthic, or pelagic ocean across which biota are internally coherent at higher taxonomic levels, as a result of a shared and unique evolutionary history. Realms have high levels of endemism, including unique taxa at generic and family levels in some groups. Driving factors behind the development of such unique biota include water temperature, historical and broad scale isolation, and the proximity of the benthos.	Temperate Northern Pacific
Province	Large areas defined by the presence of distinct biota that have at least some cohesion over evolutionary time frames. Provinces will hold some level of endemism, principally at the level of species. Although historical isolation will play a role, many of these distinct biota have arisen as a result of distinctive abiotic features that circumscribe their boundaries. These may include geomorphological features (isolated island and shelf systems, semi-enclosed seas); hydrographic features (currents, upwellings, ice dynamics); or geochemical influences (broadest-scale elements of nutrient supply and salinity).	Cold Temperate Northeast Pacific
Ecoregion	Areas of relatively homogeneous species composition, clearly distinct from adjacent systems. The species composition is likely to be determined by the predominance of a small number of ecosystems and/or a distinct suite of oceanographic or topographic features. The dominant biogeographic forcing agents defining the eco-regions vary from location to location but may include isolation, upwelling, nutrient inputs, freshwater influx, temperature regimes, ice regimes, exposure, sediments, currents, and bathymetric or coastal complexity.	Oregon, Washington, Vancouver Coast and Shelf

[1] The definitions in CMECS were drawn from Spalding et al. 2007.

Table 6.2. Overview of the hierarchical structure of Aquatic Settings for Oregon's Coastal and Marine habitats

<table>
<tr><th>System</th><th>Subsystem</th><th>Tidal Range</th><th>Oregon's Coastal and Marine Habitats[2]</th></tr>
<tr><td rowspan="4">Marine[3] Defined by salinity which is typically ~ 35 parts per thousand, but may vary considerably especially in areas near river mouths. Includes all non-estuarine waters from the coastline to the central oceans. The landward boundary of this system is either the linear boundary across the mouth of an estuary or the limit of the supratidal splash zone affected by breaking waves.</td><td>Offshore: Extends from the 30 meter depth contour to the continental shelf break, which generally occurs between 100 – 200 meters depth.</td><td>Subtidal: The substrate is continuously submerged in this zone and includes those areas below Mean Lower Low Water (MLLW).</td><td>Neritic, Rocky Subtidal, Soft Bottom</td></tr>
<tr><td rowspan="3">Nearshore: Extends from the landward limit of the Marine System to the 30 meter depth contour.</td><td>Subtidal: The substrate is generally continuously submerged in this zone and includes those areas below MLLW.</td><td>Neritic, Rocky Subtidal, Soft Bottom</td></tr>
<tr><td>Intertidal: The substrate is regularly and periodically exposed and flooded by tidal action. This zone extends from MLLW to Mean Higher High Water (MHHW).</td><td>Rocky Shores, Sandy Beaches</td></tr>
<tr><td>Supratidal: This zone includes areas above MHHW that are affected by wave splash and overwash but does not include areas affected only by wind-driven spray. This zone is subjected to periodic high wave energy, exposure to air, and often to variable salinity.</td><td>Rocky Shores, Sandy Beaches</td></tr>
</table>

System	Subsystem	Tidal Range	Oregon's Coastal and Marine Habitats[2]
Estuarine[4] The Estuarine System is defined by salinity and geomorphology. This System includes tidally influenced waters that (a) have an open-surface connection to the sea, (b) are regularly diluted by freshwater runoff from land, and (c) exhibit some degree of land enclosure. The Estuarine System extends upstream to the head of tide and seaward to the mouth of the estuary. Head of tide is identified as the inland or upstream limit of water affected by a tide of at least 0.2 foot (0.06 meter) amplitude. The mouth of the estuary is defined by an imaginary line connecting the seaward-most points of land that enclose the estuarine water mass at MLLW. Islands are included as headlands if they contribute significantly to the enclosure.	Estuarine Open Water: The Estuarine Open Water Subsystem includes all waters of the Estuarine System with a total depth greater than 4 meters, exclusive of those waters designated Tidal Riverine Open Water.	Estuarine Open Water Subtidal: The substrate is generally continuously submerged in this zone and includes those areas below MLLW.	Estuaries
	Estuarine Coastal: The Estuarine Coastal Subsystem extends from the supratidal zone at the land margin down to the 4 meter depth contour in waters that have salinity greater than 0.5 (during the period of average annual low flow).	Estuarine Coastal Subtidal: The substrate is generally continuously submerged in this zone and includes those areas below MLLW.	Estuaries
		Estuarine Coastal Intertidal: The substrate in this zone is regularly and periodically exposed and flooded by tides. This zone extends from MLLW to MHHW. The Coastal Intertidal is exposed regularly to the air by tidal action.	Estuaries
		Estuarine Coastal Supratidal: This zone includes areas above MHHW; areas in this zone are affected by wave splash and overwash. It does not include areas affected only by wind-driven spray, which may extend further inland.	Estuaries

[2] The habitats identified here are described and classified by additional Water Column, Geoform and/or Substrate Components.

[3] The Oregon Ocean Management Plan established that the marine interest of Oregon and its citizens extends to seaward to the continental margin which includes the Offshore and portions of the Oceanic CMECS subsytems, which fall outside the focus of the Nearshore Strategy which focuses on species and habitats within the Oregon Territorial Sea.

[4] The Riverine Open Water and Riverine Coastal subsystems are parts of the Estuarine Strategy Habitat not addressed in this document. Although these subsystems are critically important to the ecology of estuaries they are not the primary habitat for the species covered here. Riverine portions of estuaries are addressed in Estuary Strategy Habitat section of the Oregon Conservation Strategy.

NEARSHORE HABITAT MAPPING

Habitat survey data, collected using modern high-resolution sonar technologies, now cover approximately 53% of Oregon's Territorial Sea. This is a major improvement from the approximately 6% of the Territorial Sea that had been mapped with these advanced technologies, when the original Nearshore Strategy was published in 2006. Habitat maps using these new data and the CMECS substrate classification have been created (Figures 6.4a and 6.4b) and are a significant improvement over previous maps. The areas that have now been mapped were chosen strategically and include almost all of Oregon's rocky subtidal reefs. Similarly, recent mapping efforts have updated previous estuary maps completed in the 1970's with more recent data and have started to map some of the CMECS components (see the estuaries section of this chapter).

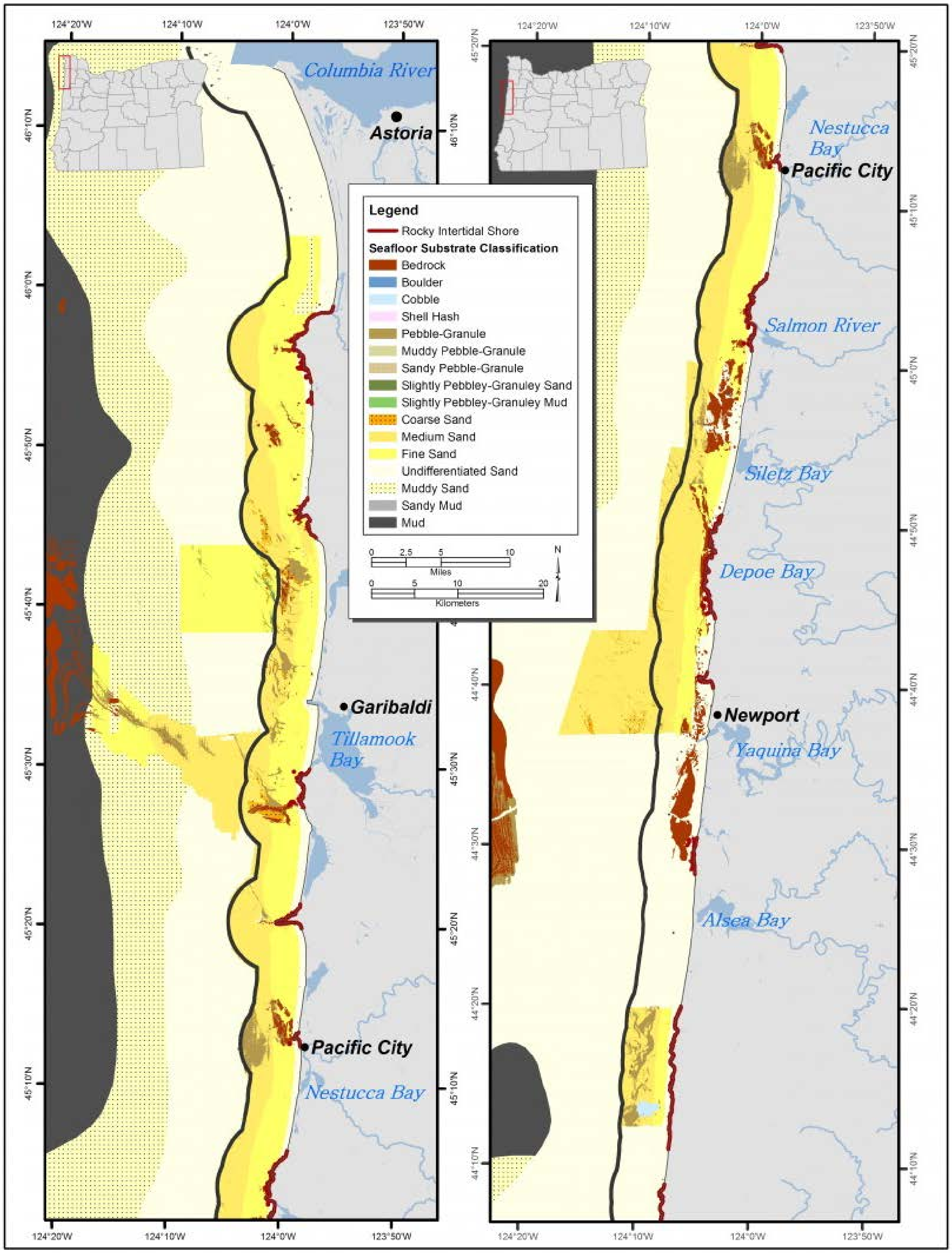


Figure 6.4a. North Oregon coast bottom substrates in marine system. Note that several abrupt boundaries evident on the map are artifacts of surveys locations not abrupt substrate changes.

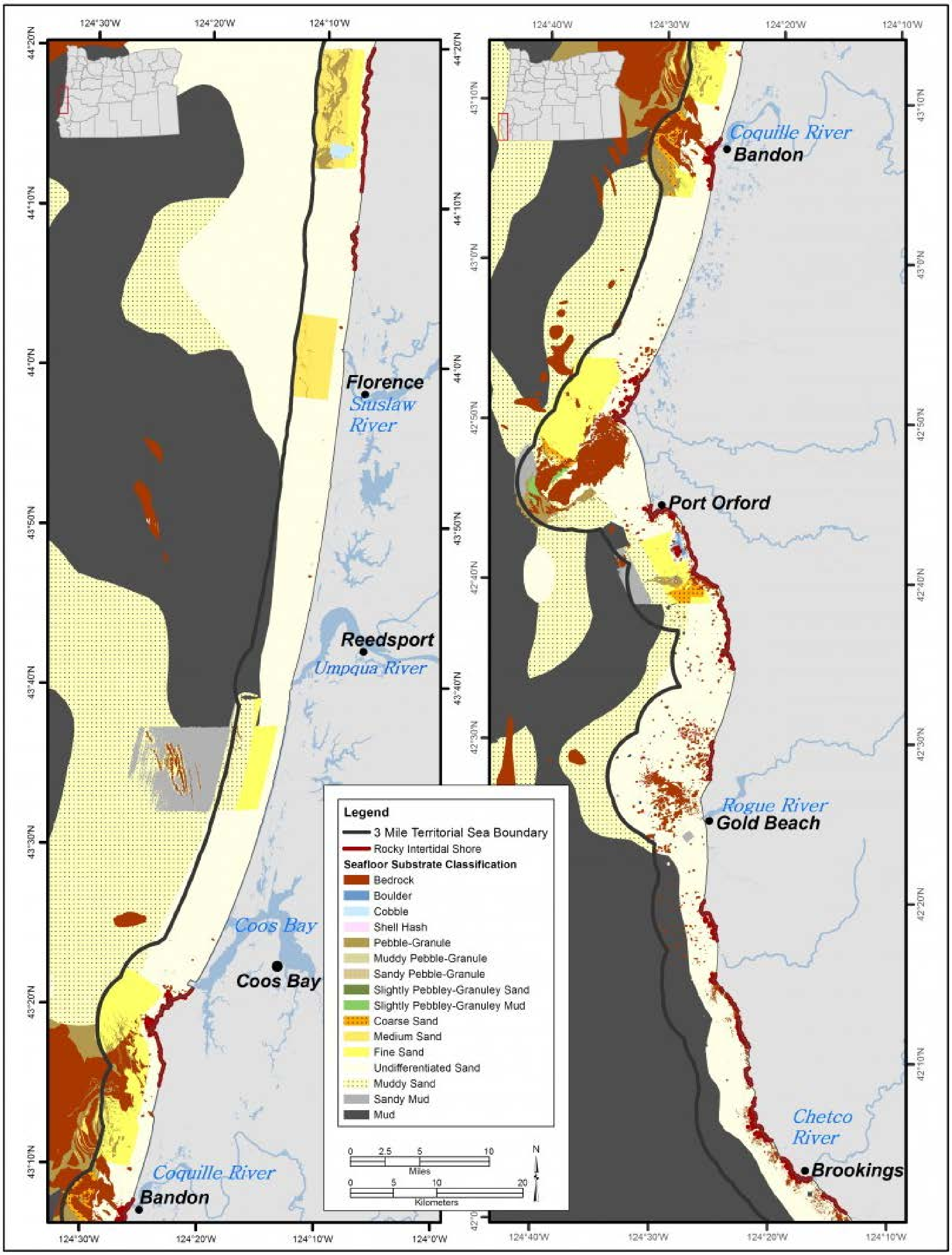


Figure 6.4b. South Oregon coast bottom substrates in marine system. Note that several abrupt boundaries evident on the map are artifacts of surveys locations not abrupt substrate changes.

SPECIES-HABITAT ASSOCIATIONS

Habitat associations for nearshore Strategy Species, Watch List Species, and commonly associated species are identified to provide insight into the biological communities affiliated with specific habitats. This combination of abiotic habitat information and their associated species will help define the CMECS biotopes (areas of uniform environmental conditions, habitat, and assemblages of animals and plants) for Oregon's coastal and marine environment.

Habitat association matrices for specific life history stages of Strategy Species provide information about the distribution of these species in the Nearshore (Table 6.3). Strategy Species that have any part of their life history commonly occur in a specific habitat are included in the species-habitat association. Readers should assume that information provided on species-habitat associations is based on published literature for the west coast of the U. S. and may or may not specifically be known for Oregon. However, there is Oregon-specific information available for many species such as kelp greenling (Figure 6.5). General habitat association matrices for Watch List Species and commonly associated species can be found in Appendix E and F, respectively.

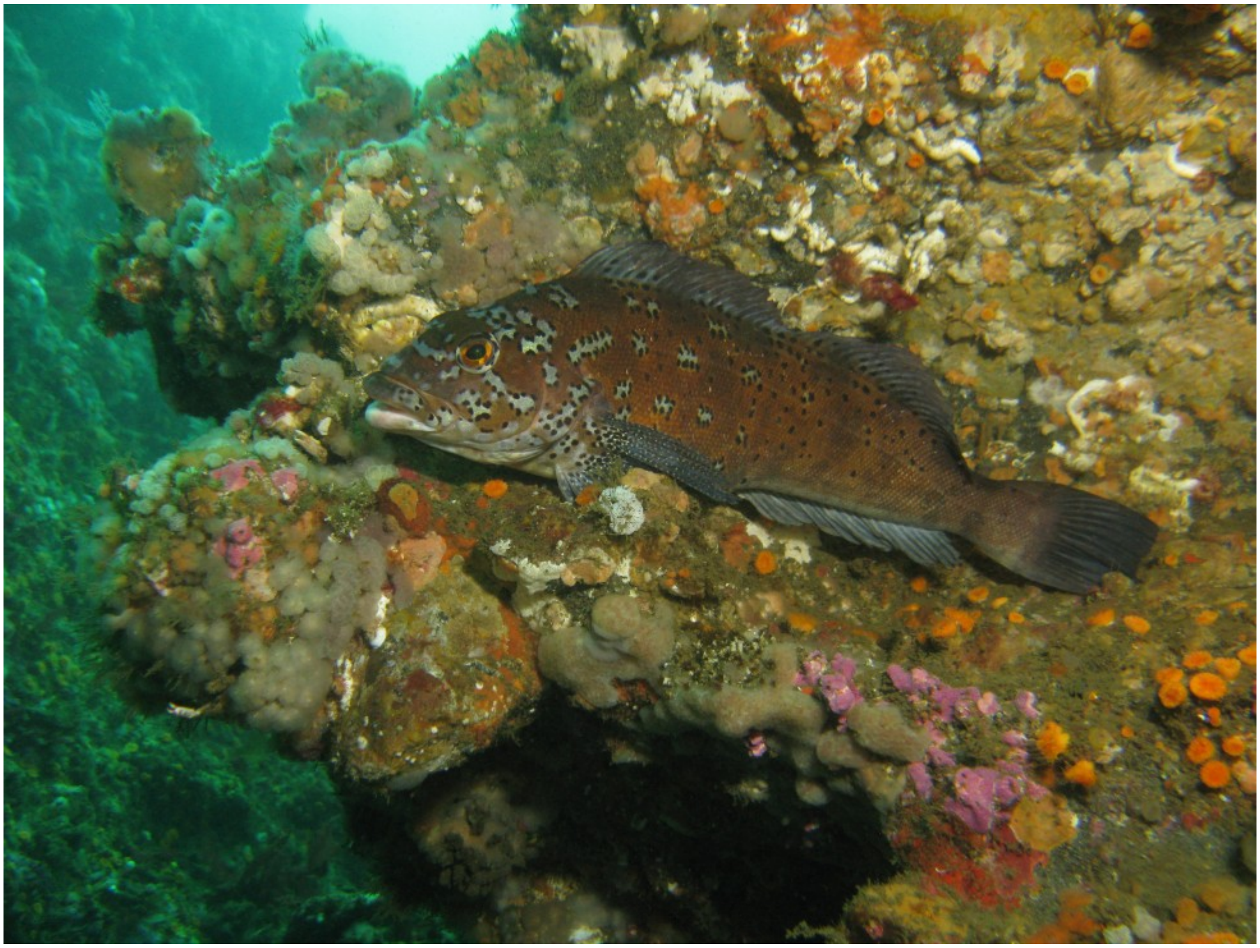


Figure 6.5. Kelp greenling in subtidal rocky reef habitat. Photo Credit: © Janna Nichols

Table 6.3. Strategy Species habitat usage, by life history phase: Adult (A), Spawning/Mating (S/M), Eggs/Parturition (E/P), Larvae (L), Juveniles (J)

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Birds								
Black brant *Branta bernicla nigricans*						A		Estuaries used by wintering and staging adults; feeds on marine and estuarine vegetation.
Black oystercatcher *Haematopus bachmani*	A, S/M, J	A, S/M, J				A, J		Breeding pairs use same territory over many years; feeds on small mollusks and invertebrates. Nests primarily above the supratidal zone on both islands and rocky headlands.
California brown pelican *Pelecanus occidentalis californicus*					A			Breeds and nests near coast but not in nearshore area. Feeds primarily on small marine fish.
Caspian tern *Hydroprogne caspia*		A, S/M, J			A	A, S/M, J		Forages in bays and estuaries for fish. Nests on estuarine islands.
Fork-tailed storm petrel *Oceanodroma furcata*					A			Breeds and nests in rocky cliffs or sandy burrows primarily on offshore islands. Forages at ocean surface.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Leach's storm petrel *Oceanodroma leucorhoa*					A			Breeds and nests on offshore islands. Forages by hovering or skimming over water; feeds primarily on small crustaceans.
Marbled murrelet *Brachyramphus marmoratus*					A			Nests inland in old growth forests. Forages by diving; feeds on small fishes.
Rock sandpiper *Calidris ptilocnemis*	A, J					A, J		Forages in nearshore waters during winter.
Tufted puffin *Fratercula cirrhata*	S/M,				A			Winters at sea, spends spring and summer months in the nearshore; nests on coastal headlands and offshore islands.
Western snowy plover *Charadrius alexandrinus nivosus*		A, S/M, E/P, J						Resident or short-ranged migrant.
Fishes								
Big skate *Raja binoculata*				A, S/M, E/P, J				Soft seafloor spawning habitat. May be affected by wave energy development.
Black rockfish *Sebastes melanops*	J		A, J	J	A, L, J	A, J	S/M, E/P	
Blue rockfish *Sebastes mystinus*	J		A, S/M, J	J	L, J	J	E/P	
Brown rockfish *Sebastes auriculatus*			A, S/M, E/P, J			A, S/M, E/P, L, J		
Cabezon *Scorpaenichthys marmoratus*	J		A, S/M, E/P, J		L, J	A, S/M, E/P, L, J		

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Canary rockfish *Sebastes pinniger*	J		A, E/P, J	J	L, J		S/M	Will inhabit artificial reefs.
China rockfish *Sebastes nebulosus*			A, E/P, J		L, J		S/M	Will inhabit artificial reefs.
Chinook salmon *Oncorhynchus tshawytscha*			A		A, J	A, J	A, J	Anadromous; substantial data gaps regarding habitat usage in nearshore waters; sometimes caught near rocky reefs and in open neritic waters.
Chum salmon *Oncorhynchus keta*					A, J	A, J	A, J	Anadromous; substantial data gaps regarding habitat usage in nearshore.
Coastal cutthroat trout *Oncorhynchus clarki clarki*					A, J	A, J	A, J	Anadromous; substantial data gaps regarding habitat usage in nearshore waters.
Coho salmon *Oncorhynchus kisutch*					A, J	A, J	A, J	Anadromous; substantial data gaps regarding habitat usage in nearshore waters.
Copper rockfish *Sebastes caurinus*			A, J	J	E/P, J	A, S/M, E/P, L, J		Will inhabit artificial reefs.
Deacon rockfish *Sebastes diaconus*	J		A, S/M, J	J	A, L, J	A, J	J	Newly described cryptic species found in OR waters.
Eulachon *Thaleichthys pacificus*					A, L, J	A, L		Anadromous; spawn in fresh water. Also school offshore.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Grass rockfish *Sebastes rastrelliger*	J		A, E/P, J	J	L			Shallow rocky reefs; sometimes found in tidepools.
Green sturgeon *Acipenser medirostris*	A		A	A	A	A, S/M, E/P, L, J		Northern DPS listed as species of concern. Uses all nearshore waters and estuaries. Most marine-oriented of sturgeon species.
Kelp greenling *Hexagrammos decagrammus*			A, S/M, E/P, J		L, J	A, S/M, E/P, L, J		Will inhabit pilings and jetties.
Lingcod *Ophiodon elongatus*			A, S/M, E/P, J	A, J	L, J	A, S/M, E/P, L, J		Will inhabit pilings and jetties.
Northern anchovy *Engraulis mordax*					A, S/M, E/P, L, J			Pelagic forage fish; commonly found in nearshore kelp beds and bays.
Pacific herring *Clupea pallasii*					A, J	A, S/M, E/P, L, J		Pelagic forage fish. Utilizes estuary spawning habitat in OR.
Pacific lamprey *Entosphenus tridentatus*							A	Anadromous. Requires fine gravel beds in freshwater for spawning. Gaps in knowledge of habitats used in marine life history phase.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Pile perch *Rhacochilus vacca*			A	A		A	S/M, E/P, J	Rocky shores; around kelp, pilings and underwater structures. Unknown habitat associations for some life history stages.
Quillback rockfish *Sebastes maliger*			A, E/P, J	J	L, J	A, S/M, E/P, L, J		Will inhabit artificial reefs.
Redtail surfperch *Amphistichus rhodoterus*				A		S/M, J	E/P	Juveniles and adults found in estuaries along CA and OR coasts. Unknown habitats for some life history stages. Estuaries and sandy surfzone.
Rock greenling *Hexagrammos lagocephalus*			A, E/P, J	A		S/M, J	E/P	Found in subtidal algae beds and rocky reefs during spawning.
Shiner perch *Cymatogaster aggregata*			A	A		A, J	S/M, E/P	Adults are common in estuaries as prey for salmonids.
Spiny dogfish *Squalus acanthias*			A, J	A, E/P, J	A, S/M, J	A, E/P, J		
Starry flounder *Platichthys stellatus*			L, J	A, S/M, J	E/P, L	A, S/M, E/P, L, J		Will inhabit areas with pilings.
Striped perch *Embiotoca lateralis*			A, J		A	A, J	S/M, E/P	Unknown habitats for most life history stages.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Surf smelt *Hypomesus pretiosus*		S/M, E/P		S/M	A, L, J	A		Extremely specialized habitat requirements for spawning beaches (temperature for substrate and air, light). Intertidal spawning habitat on beaches.
Tiger rockfish *Sebastes nigrocinctus*			A				S/M, E/P, L, J	Rocky reefs. Note that this is designated shelf rockfish in federal FMP, but defined as nearshore fish in ORS and is a component of both commercial and sport fishery harvest in nearshore waters. Will inhabit artificial reefs.
Topsmelt *Atherinops affinis*			A	A	A, J	A, S/M, E/P, L, J		Specialized spawning habitat in shallow waters with vegetation for eggs to adhere to.
Vermilion rockfish *Sebastes miniatus*			A, J	J	L, J		S/M, E/P	Rocky reefs; life stage history gaps. Will inhabit artificial reefs.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Western river lamprey *Lampetra ayresii*							A	Anadromous. Movements and habitat use of adult life stage for the approximately 10 weeks they are in marine habitats poorly understood, but thought to be limited to nearshore and estuarine areas.
White sturgeon *Acipenser transmontanus*				A		A, L, J		Anadromous. Movements in marine habitats poorly understood.
Wolf-eel *Anarrhichthys ocellatus*			A, S/M, E/P, J		J		L	Benthic, rocky subtidal.
Yelloweye rockfish *Sebastes ruberrimus*			A, E/P, J				S/M, L	Will inhabit artificial reefs. Juvenile usage of nearshore.
Yellowtail rockfish *Sebastes flavidus*	J		A, S/M, E/P, J	A, S/M, E/P, J	L, J			Juvenile usage of nearshore.
Invertebrates								
Blue mud shrimp *Upogebia pugettensis*						A, S/M, J		Marine water dependent estuarine species.
California mussel *Mytilus californianus*	A, S/M, J		A, S/M, J		E/P, L			Rocky intertidal, pilings.
Dungeness crab *Cancer magister*		A, E/P, J		A, S/M, E/P, J	L	A, S/M, J		Oceanic conditions linked to larval survival. Will inhabit pilings.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Flat abalone *Haliotis walallensis*			A, E/P, J		S/M, E/P, L			Rocky subtidal, gaps in life history knowledge.
Native littleneck clam *Leukoma staminea*	A, J	A, J		A,J	S/M, E/P, L	A		Marine water dependent estuarine species. Distinct from introduced Manila littleneck clam (*Venerupis philippinarum*).
Ochre sea star *Pisaster ochraceus*	A, J		A, J		S/M, E/P, L	A		Rocky intertidal and subtidal. Keystone species. Recent population decline due to sea star wasting syndrome.
Olympia oyster *Ostrea lurida*						A, S/M, E/P, L, J		Shells sometime found on the outer coast, but no coast wide surveys have been conducted.
Pacific giant octopus *Enteroctopus dofleini*	A		A, S/M, E/P, J	A, E/P	J			Rocky shore, found in low intertidal.
Purple sea urchin *Strongylocentrotus purpuratus*	A, J		A, J		S/M, E/P, L			Associated with habitat with adequate algae for foraging.
Razor clam *Siliqua patula*		A, J		A, J	S/M, E/P, L			Susceptible to disease and natural events such as El Niño. Increased occurrence of closures due to domoic acid concentrations in recent years.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Red abalone *Haliotis rufescens*	A, E/P, J		A, E/P, J		S/M, E/P, L			Do not mate at northern end of range (Cape Argo, OR).
Red sea urchin *Mesocentrotus franciscanus*	A, J		A, J		S/M, E/P, L			Adjacent to kelp forest habitat.
Rock scallop *Crassadoma giganteus*	A, S/M, J		A, S/M, J		S/M, L, J		E/P	Will inhabit pilings and jetties.
Sunflower star *Pycnopodia helianthoides*			A	A	S/M, E/P, J			
Algae and Plants								
Bull kelp *Nereocystis luetkeana*			A, S/M, E/P, J		S/M, E/P			Shallow subtidal. Reproduce by spores, with alternating generations.
Native eelgrass *Zostera marina*				A, S/M, E/P, J	S/M, E/P	A, S/M, E/P, J		Angiosperm. Shallow estuarine and marine waters with muddy or sandy bottoms. Requires clear waters.
Sea palm *Postelsia palmaeformis*	A, S/M, E/P, J				S/M, E/P			Mid to low intertidal. Reproduce by spores, with alternating generations.
Surf grass *Phyllospadix spp.*	A, S/M, E/P, J				S/M, E/P			Low intertidal and shallow subtidal. Areas exposed to high wave action. Angiosperm.

Strategy Species	Rocky Shore	Sandy Beach	Rocky Subtidal	Soft Bottom Subtidal	Neritic	Estuarine	Habitat Unknown	Comments
Marine Mammals								
Gray whale *Eschrichtius robustus*				A, J	A, J			Mating and parturition occurs within lagoons in Baja California. Feed in soft bottom. Animals from Pacific coast feeding group summer in OR waters.
Harbor porpoise *Phocoena phocoena*				A	A, S/M, E/P, J		A, S/M, E/P, J	
Killer whale *Orcinus orca*					A, S/M, E/P, J	A, J	A, S/M, E/P, J	Southern resident DPS have been tracked in OR waters.
Northern elephant seal *Mirounga angustirostris*		A, S/M, E/P, J	A, J		A, J	A		Mating and parturition is on sandy beaches. In OR pups have been born at Cape Arago.
Pacific harbor seal *Phoca vitulina*	A, J	A, S/M, E/P, J	A, J		A, S/M, J	A, S/M, E/P, J		
Steller sea lion *Eumetopias jubatus*	A, S/M, E/P, J		A, J		A, J	A		Mating and parturition on islands, rocky shores. Most reproductive activity in OR occurs on the south coast.

Photo Credit: Geoff Shester, Oceana

NERITIC (OPEN WATER)

The neritic habitat includes the waters and biological communities living in the water column over the continental shelf. The neritic habitat is characterized by CMECS as including the nearshore and offshore marine subsystems, and includes the surface, upper water column, pycnocline, and lower water column layers. Neritic habitat also occurs beyond the planning area, westward to deeper oceanic habitats that start at the continental shelf break at approximately the 200 m depth contour. The waters of the neritic habitat are in constant motion. The California Current System, seasonal upwelling and downwelling, El Niño/La Niña events and changes in the Pacific Decadal Oscillation are all examples of physical events that move the waters in this habitat over varying time scales. The water is replaced many times over during an average human lifetime. The setting for the CMECS biotic component of this habitat is planktonic biota and the plankton varies with the water mass. The ecology of the neritic habitat is affected by processes taking place at scales varying from global to local. The dynamics of the neritic habitat affect all of the other habitats described later in this section.

Physical Environment

Many physical and chemical environmental factors affect neritic ecology. These factors include but are not limited to solar light and radiation influence, salinity, temperature, layer position, physical mixing, hydrostatic pressure, biogeochemical composition, atmospheric exposure and influence, surface and under water currents, swells, waves, and water mass movements. Many of these factors can change by location and time of year. The neritic habitat encompasses many water column habitats that shift, expand, and contract over time and space in both predictable and stochastic patterns.

Coastal upwelling is perhaps the most defining feature of Oregon's neritic habitat with its alternating upwelling-relaxation events. Upwelling is a water column hydroform, described by CMECS as an upwardly-directed current caused by divergence of water masses. In spring and summer months, strong northerly winds push surface and upper water layers westward towards the deep ocean. This movement causes deep, cold, oxygen-poor but nutrient-rich waters to rise to the surface near the coast replacing the water that was driven offshore. These nutrients, brought to the upper layers of the water column help propagate and sustain the rich biota of Oregon's coastal waters. The relaxation events, when the northerly winds briefly cease or reverse, allow the upper water layer to move back towards shore bringing its rich biotic content with supplies of food, larvae, and juvenile organisms. In fall and winter months when winds blow predominantly from the south, the surface and upper water layers move shoreward and downward in a process called downwelling. Downwelling is an important part of the annual seasonal cycle that forces oxygen rich waters from the upper layers downward in the water column. Surface water temperatures provide a good indication of these seasonal wind forcing differences that bring the cold, nutrient-rich waters to the surface in the summer (Figure 6.6a) and the warmer waters from offshore to the coast in the winter Figure 6.6b).

Large-scale changes in water masses, temperatures and currents result in changes in plankton species composition and abundance, which impact the survival and distribution of organisms within coastal and oceanic ecosystems. These large scale oceanic events, such as El Niño/La Niña and the Pacific Decadal Oscillation, occur at multi-year or decadal time scales. Recently, scientists have made strides in understanding how El Niño/La Niña events and the warm and cool regimes of the Pacific Decadal Oscillation influence Oregon’s coastal and marine water ecosystem.

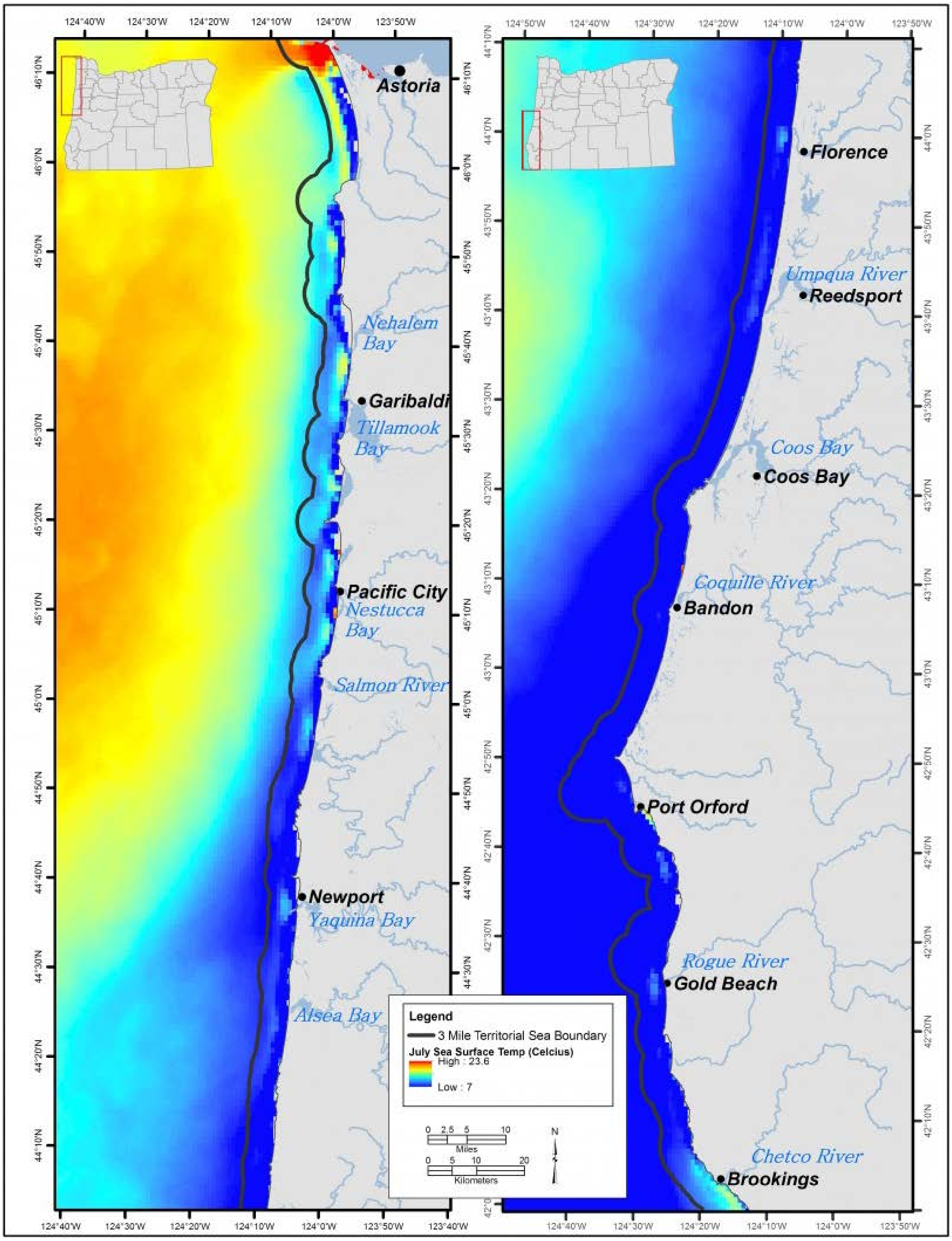


Figure 6.6a. Average sea surface temperature for July (1997 – 2003). Note colder water nearshore. (Source: Juan-Jorda Masters Thesis/College of Oceanic and Atmospheric Sciences/ Oregon State University/2006.

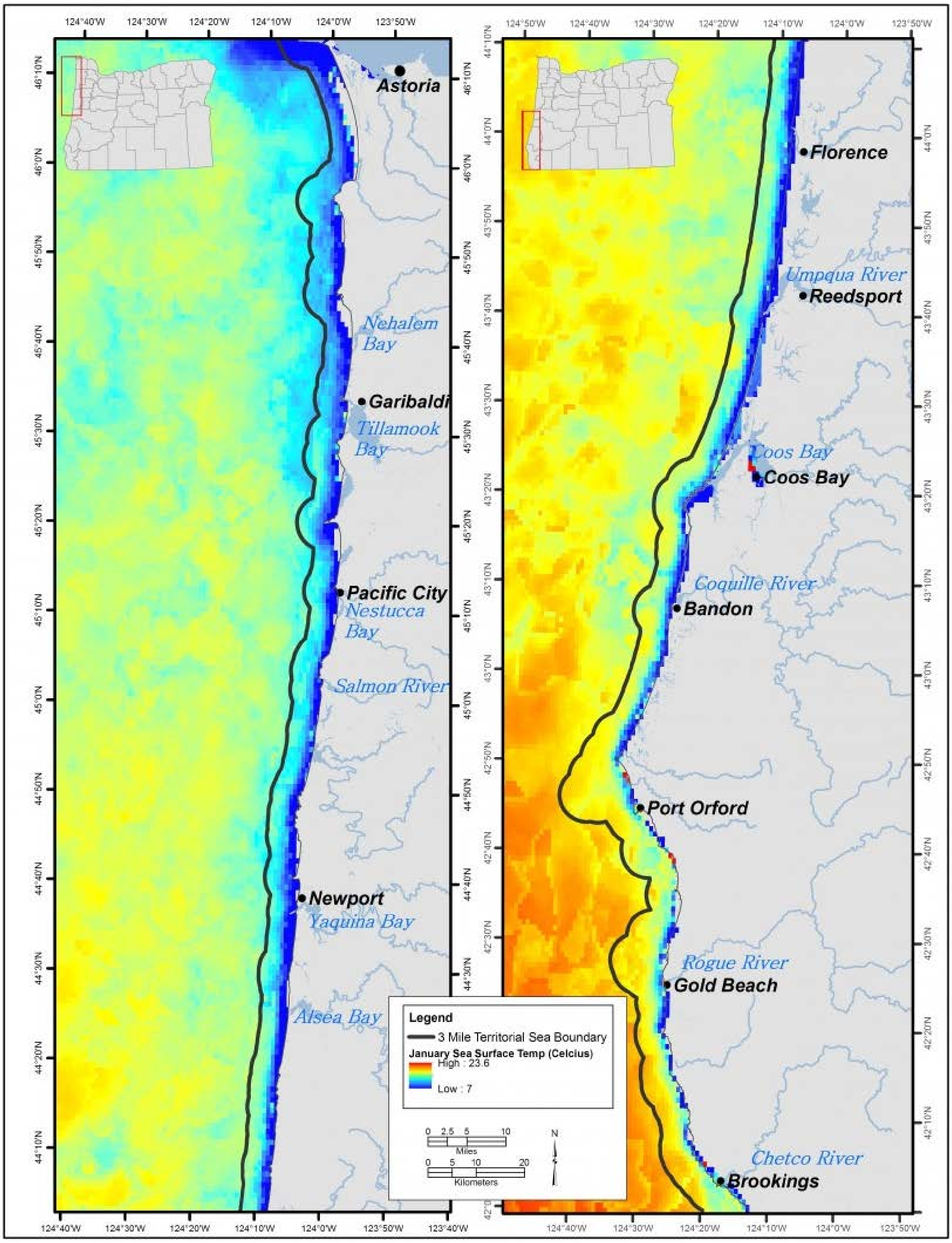


Figure 6.6b. Average sea surface temperature for January (1997 – 2003). Note warmer water nearshore. Source: Juan-Jorda Masters Thesis/College of Oceanic and Atmospheric Sciences/ Oregon State University/2006.

Another water column component that affects Oregon's neritic habitats is river plumes. CMECS does not characterize the marine waters affected by these plumes as estuarine because they are not meaningfully enclosed by landforms. Riverine waters entering the ocean often carry high concentrations of nutrients, create gradients in salinity, cause physical mixing, and create areas of high turbidity. Large river plumes, such as that from the Columbia River, may serve as a microhabitat within neritic habitats and can potentially act as biogeographic barriers between marine areas to the north and south. The Columbia River plume stretches hundreds of miles offshore and shifts predictably over the course of each year. In the summer the plume spreads south and offshore from the river's mouth, while during the winter the plume is found to the north of the river mouth and is usually directly adjacent to the coast. This plume has important ecological effects, not only to neritic habitats, but to nearshore and offshore habitats as well. The oceanographic fronts created by the Columbia River plume in the marine systems generate productive conditions that attract many species of invertebrates, fish, seabirds, and marine mammals.

Biological Characteristics

Neritic habitats support two basic types of marine organisms: plankton and nekton. Planktonic organisms live in the water column and are incapable of swimming against currents, instead drifting with them. Plankton are often categorized as either phytoplankton or zooplankton. Phytoplankton are microscopic photosynthesizing organisms (e.g., diatoms), and are the primary producers that form the base of the marine food web. Huge surges in phytoplankton populations, known as "blooms," are commonly associated with upwelling events. Zooplankton are heterotrophic organisms that range in size from microscopic single-celled organisms to enormous jellyfish a meter or more in diameter. Some plankton, called holoplankton, like many diatoms, copepods, krill and jellyfish spend their entire lives as drifters in the water column. Many species like sea urchins, mussels, crabs, some snails and many fishes have planktonic stages as eggs or larva, called meroplankton, before either settling to the bottom or growing large enough to be nekton. The CMECS biotic component uses these planktonic classes and subclasses to describe the open water neritic zone. They can be further refined by taxonomic groups and communities that are dominant in any given area of interest. Dramatic changes in plankton communities occur in Oregon waters with water masses changes. For example warm water species are brought in to nearshore water with El Niño events.

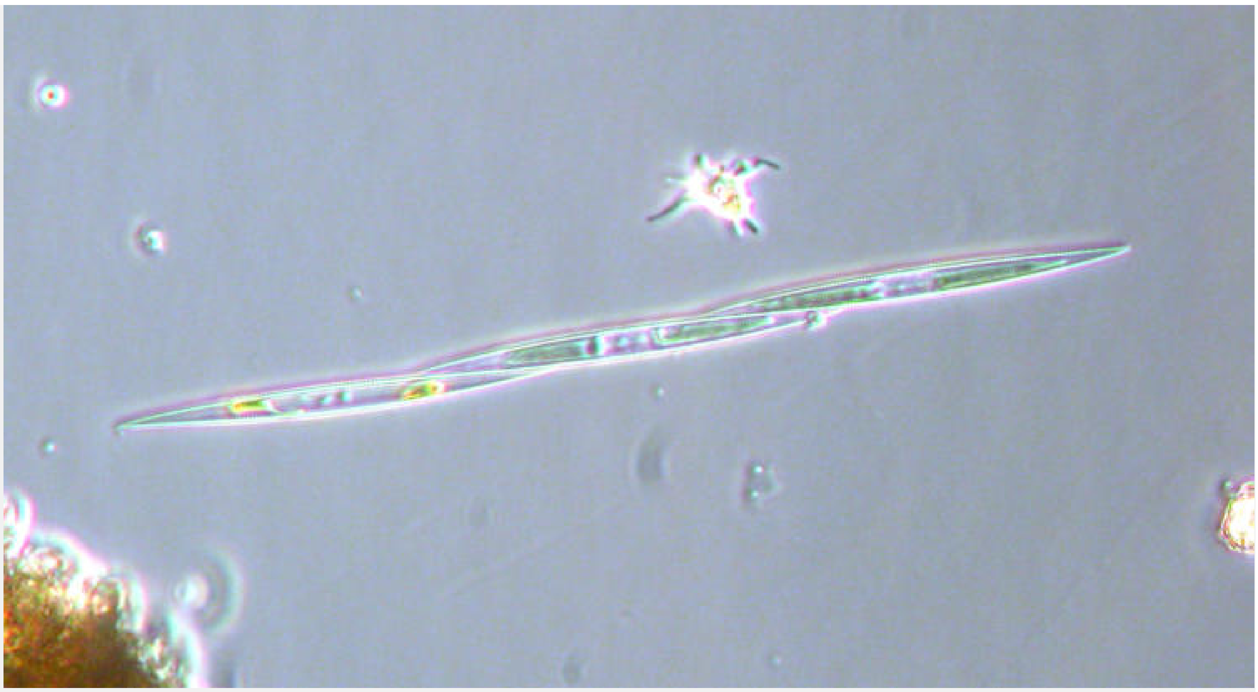
In contrast, nektonic marine organisms are capable of swimming against currents and include animals such as adult crustaceans, mollusks, and vertebrates. Highly migratory and schooling species are typical of nekton in neritic habitats. Many species of invertebrates, fish, birds, and marine mammals travel and forage exclusively or occasionally within this habitat.

Many nearshore Strategy, Watch List and commonly associated species utilize the open water neritic habitat during their life history (Table 6.3, Appendix E and F). Many forage fishes such as northern anchovy, Pacific herring, topsmelt, surfsmelt, Pacific sandlance and longfin smelt feed in this open water neritic habitat. Juvenile rockfish are found in the water column. Breeding birds such as tufted puffin and common murre are central place foragers that feed on the forage fish and other species while nesting. In all, 59 of the 73 nearshore Strategy Species depend on this habitat for some phase of life. This is also the habitat that supports primary production by phytoplankton and secondary production by zooplankton, which is at the base of the food web for the nearshore ecosystem. Ocean currents transport and disperse larvae and juveniles of many invertebrate and fish species throughout the region.

Human Use

Human uses of the neritic habitat include commercial and recreational fishing, nonconsumptive recreational pursuits such as boating or whale watching, scientific research, commercial maritime transportation, and military operations. Development of renewable energy sources from both wind and waves is an emerging use of the neritic habitat.

STRATEGY SPOTLIGHT: HARMFUL ALGAL BLOOMS IN MARINE WATERS



Pseudo-nitzschia is a genus of diatom that can produce domoic acid, a neurotoxin that causes amnesiac shellfish poisoning. Often found as chains of overlapping cells, Pseudo-nitzschia algal blooms can cause illness or death in seabirds and marine mammals that consume forage fish that accumulate the toxin when they eat the algae. Amnesiac shellfish poisoning can cause short term memory loss, brain damage and death in humans that consume toxic shellfish. Closures of shellfish fisheries due to human health concerns from domoic acid accumulation can have devastating effects on local economies. Photo Credit: ODFW

Phytoplankton, the microscopic algae that live in marine waters and drift with ocean currents, are a key component of the marine ecosystem. These primary producers at the base of the food web create the food directly consumed by many marine animals. The productivity of the marine waters off of the Oregon coast, like that of all ocean waters, is closely tied to this primary production of food from sunlight, water, carbon dioxide and nutrients by phytoplankton. Filter feeding bivalve shellfish such as clams, mussels, scallops and oysters extract and ingest these algae along with small drifting animals, called zooplankton, as they pump water through their bodies to feed and respire. Similarly, many forage fish species such as northern anchovy, Pacific herring and Pacific sardine feed on both phytoplankton and zooplankton.

However some types of phytoplanktonic algae produce biotoxins that accumulate in animals that eat them causing illness and death in seabirds and mammals higher up the food web. Other types of these algae produce surfactant-like proteins that create foam on the water's surface. Seabirds exposed to the foam lose the waterproof coating on their feathers which keeps them dry resulting in death from hypothermia or a restricted ability to fly. Problems occur when there are blooms of these types of algae. These harmful algal blooms (HABs) cause losses of natural resources, economic losses to coastal communities, and have resulted in human illnesses and deaths. Although these blooms largely occur in the open water habitats off our coast the effects of HABs are often most acutely felt along the shorelines.

The most direct effects on people along the west coast of the U.S. result from biotoxins produced in two types of HABs. Blooms of dinoflagellates in the genus *Alexandrium* produce saxitoxin, a neurotoxin that causes paralytic shellfish poisoning in humans. Blooms of diatoms in the genus *Pseudo-nitzchia* produce domoic acid that causes amnesic shellfish poisoning in humans. Paralytic shellfish poisoning cases were first recorded on the west coast of North America in 1793, when members of Captain George Vancouver's crew became sick after eating a breakfast of mussels collected from the shores of what is now British Columbia, Canada. Paralytic shellfish poisoning can cause death from respiratory failure due to paralysis. Amnesic shellfish poisoning causes gastrointestinal and neurological disorders in humans and can be life-threatening. *Pseudo-nitzchia* is known to have been present off the west coast since at least the 1920s, but the first documented outbreak of problems related to poisoning from domoic acid on the U.S. west coast occurred in 1991 with a die off of sea birds in California and contamination of razor clams and Dungeness crabs in Washington, Oregon and California. Although never confirmed, 25 cases of amnesiac shellfish poisoning were suspected in Washington during the 1991event.

Monitoring for these HABs and sampling shellfish for food safety have resulted in closures or opening delays for both recreational and commercial shellfish fisheries in Oregon as well as in Washington and California over the years. Fisheries for razor clams, California mussels, Dungeness crab, northern anchovy and several other species have been affected. These closures have had economic consequences for coastal communities, but are necessary for public safety. Monitoring efforts can be conducted at two levels: sampling waters to monitor the phytoplankton for HABs and sampling organisms that consume phytoplankton to monitor for the accumulation of the disease causing toxins. The Oregon Department of Agriculture currently monitors several species of shellfish for accumulation of biotoxins. From 2005 to 2012, ODFW in collaborations with OSU, UO and the NOAA Northwest Fisheries Science Center utilized funds from a federal to develop an integrated HAB monitoring and event response program. For ODFW, this resulted in monitoring phytoplankton directly at ten sites along the Oregon coast which provided ODA with an early warning system about potential HAB events. This work also stimulated collaborative research leading to insights into the occurrence of HABs off our coast. Oregon has not directly sampled its coastal waters for HABs since 2012 due to a lack of ongoing funding to do so. To assure human safety, monitoring of selected bivalve shellfish species for biotoxins by ODA continues in Oregon and has expanded in scope to include Dungeness crab for the foreseeable future due to events in 2015 and early 2016. Information about recreational harvest closures for shellfish can be found on the ODA website.

While HABs are often localized events, research suggests that the frequency and spatial extent of HABs off the west coast has increased over the last several decades. A geographically extensive and long lasting bloom of *Pseudo-nitzchia* that affected marine wildlife and fisheries along the west coast began in the spring of 2015. The bloom stretched from Alaska to California and persisted far longer than what is considered normal. Scientists called this an unprecedented event. Some west coast fisheries remained closed through May of 2016. NOAA's Northwest Fisheries Science Center provides an excellent overview and more information on HABs.

Photo Credit: ODFW

SOFT BOTTOM SUBTIDAL

Soft bottom subtidal habitat includes all of the unconsolidated substrate areas (e.g., mud, sand, granule pebbles and various mixes thereof) on the ocean bottom. Soft bottom subtidal habitats are characterized by CMECS as being within the subtidal zones of the nearshore and offshore marine subsystems. Subtidal soft bottom habitats are diverse based on distinct organism assemblages that are influenced by differences in substrate type (sand vs. mud), organic content and bottom depth. The distribution and relative abundance and mixes of these substrates are not yet well described for much of Oregon's nearshore ocean waters.

Physical Environment

The primary substrate types in Oregon's soft bottom subtidal areas range from sand to pebble. CMECS defines unconsolidated mineral substrates based on particle diameter. Here we consider soft bottom habitats to be composed of the various mixes defined by CMECS of particles <64 mm in diameter. Because the Oregon coast is primarily an exposed, high energy environment, most soft bottom subtidal areas are sandy. However, mud can be the more prevalent substrate type in areas receiving less energy from water movement, including isolated and sheltered areas, and deeper areas. The distribution of these unconsolidated sediment types in Oregon waters is influenced by currents in both the nearshore and offshore subsystems. Areas close to outfalls and discharge pipes would be expected to show localized differences based on the displacement of substrate and the increased availability of organic and small particulate material. The smaller the particle size, the smaller the pores (or spaces between the particles) are. Pore size dictates the amount of water and the water chemistry of the substrate, which can define what types of organisms can live in that sediment.

Biological Characteristics

Most soft bottom subtidal communities are dominated by infaunal (burrowing) invertebrates such as polychaete worms. However, other organisms such as crustaceans, echinoderms and mollusks may be locally abundant. Common epifauna (found on the sediment surface) can include species of shrimp, crabs, snails, bivalves, sea cucumbers, and sand dollars. Dungeness crab are an important component of soft bottom subtidal communities and are found both on the surface as well as buried in the substrate. Sea pens (*Ptilosarcus* sp.), colonial relations to sea anemones, are common on more muddy bottoms.

Common fish in this area include several species of flatfish (e.g., sanddab, English sole, and sand sole), and important burrowing forage species such as Pacific sand lance and sandfish.

Species associated with soft bottom subtidal habitats provide a spectrum of ecosystem services. Most widespread but least apparent of these services are the nutrient cyclers: deposit feeders and microbes living within the sediments. Emergent species such as sea pens in more quiet areas are only found in this habitat. There are a vast array of worms and other invertebrates that live in the soft subtidal bottom. Soft bottom habitats are important to many Strategy, Watch List and other commonly associated species at various life stages (Table 6.3, Appendix E and F). For example, big skate, starry flounder, sand sole, Pacific sand lance burrow or cover themselves to hide in these sediments. Gray whales feed by sifting buried amphipods from the sediments. Many invertebrates like razor and native littleneck clams live in the subtidal soft bottom habitat. Both juvenile and adult Dungeness crab forage here and sometimes hide in these soft sediments. The young of commercially valuable fish species can often be found here and utilize these areas as nursery habitat. The young of many species use the nearshore area for foraging, and are themselves prey for larger fishes and birds. Sand lance is a particularly valuable forage species for birds, other fishes, and marine mammals. Diving birds such as the common murre forage for food for their young in soft bottom areas taking juvenile flat fish back to their chicks while they are nesting.

Human Use

Commercial and recreational harvest of Dungeness crab, surf perch, and species of nearshore flatfish are the principal human uses of the soft bottom subtidal habitat. Sand and mud from dredging projects are sometimes deposited over soft bottom habitats. Soft bottom subtidal habitats could also soon be utilized for siting renewable energy projects and their associated infrastructure. Finally, the soft bottom subtidal offers many opportunities for scientific research.

STRATEGY SPOTLIGHT: A LOOK AT SOFT BOTTOM SPECIES AND HABITATS

This remotely operated vehicle (ROV) is a tool ODFW uses to survey the ocean bottom and its inhabitants. Photo Credit: ODFW

Soft substrates make up much of the Nearshore subtidal bottom habitat. Two of Oregon's most economically valuable commercial fisheries, Dungeness crab and pink shrimp, occur in soft bottom habitat. Like many crustaceans, both of these species begin their lives as plankton drifting in the water column with the ocean currents before settling out to the bottom as they develop and grow. Both of these species can be found as adults in Oregon nearshore waters as well as in the deeper waters outside and adjacent to Oregon's territorial sea. Though the pink shrimp fishery is primarily conducted in deeper waters outside of Oregon's territorial sea, roughly half of the crab pots targeting Dungeness crab are typically set in Oregon's Nearshore waters at depths of 30 fathoms or less.

This short video was captured by ODFW's Marine Resources Program researchers using a remotely operated vehicle equipped with a high definition camera transiting over soft bottom habitat in Nearshore waters. Although many soft bottom dwelling species live in the sediments out of view of the camera, both pink shrimp and Dungeness crab as well as a number of other species that live in or on the soft bottom are seen in their natural habitat. Adult pink shrimp, several sea whips, an adult Dungeness crab, a sea anemone, and a sunflower star are in the first section of the video. The second section captures video of newly settled juvenile Dungeness crabs in high densities. The final video clip shows a small section of a vast sand dollar bed.

Photo Credit: Ian Chun

ROCKY SUBTIDAL

Rocky subtidal habitat includes all hard substrate areas of the ocean bottom. The geologic origin substrate components include cobble and boulder in the CMECS unconsolidated mineral substrate class and bedrock and megaclasts in the rock substrate class. Anthropogenic origin hard substrates are also here. Anthropogenic reefs include any areas where hard, persistent material has been placed either purposely or accidentally by humans. Examples include rock jetties at the entrance to many bays, shipwrecks, anchoring systems for renewable energy projects, and unburied portions of underwater cables or pipelines. Rocky subtidal areas are often referred to as reefs, rocky reefs, rocky banks, pinnacles, or "hard bottom." Rocky subtidal habitats, including both the natural and anthropogenic components, are characterized by CMECS as being within the subtidal zones of the nearshore and offshore marine subsystems. Although most areas are never exposed to air, the CMECS subtidal definition does include areas that are exposed intermittently each month when tide levels fall below the Mean Lower Low Water (MLLW) level. Rocky subtidal habitats are found in both the nearshore subsystem and offshore subsystem and some of the differences are discussed below.

Some rocky subtidal areas are extensions of shoreline rocky features such as headlands, cliffs, or rocky intertidal habitat, while others exist as isolated regions of rock surrounded by habitat with soft bottom substrate. Rocky reefs have varied topography; some may barely come above the surrounding seafloor, while others may rise from the seafloor many meters, or extend above the surface to form islands in the Territorial Sea. There are more than 1,800 islands off the coast of Oregon, the bases of which form rocky subtidal habitat.

Physical Environment

The physical characteristics of rocky subtidal habitats reflect proximity to shore, depth of the water, local seafloor geology, erosional forces, and biological influences. The geology of many rocky subtidal areas mimics the geology of adjacent landforms, often consisting of erosion-resistant basalts or metamorphic rock common in Oregon's rocky headlands. Over geologic time, the underwater rock features have been uplifted, bent, deformed, and alternately exposed to ocean and terrestrial erosional forces as successive ice ages and geologic forces caused massive sea level changes. These forces have shaped a variety of physical habitat features within reefs, including flat rocky benches, stacks, jagged ridges, broken boulder fields, and a vast number of cracks and crevices that provide shelter and substrate to abundant life.

Oceanographic processes and features strongly influence the rocky subtidal environment. Subtidal reefs are exposed to pounding wave action, underwater currents, and the physical and chemical properties of the water. These factors in turn influence the biological communities on the reefs. Generally, nearshore reefs are more exposed to wave action than offshore reefs, and the wave action is much stronger in winter than during summer. Wave action is a key factor in determining the types of organisms that can live on the very shallow reefs. Ocean currents vary widely by location, time of year, and over tidal cycles. Currents influence reefs in a variety of ways including direct erosion, sand scour or burial of reef areas, and movement of organisms to and from reefs, including plankton and larva. Large-scale or long-term variation in the ocean environment such as upwelling, seasonal current directional shifts, shifts in ocean circulation, water temperature variation, local and global weather patterns, ocean acidification, and biological processes combine to determine the ambient chemical and physical composition of the water in rocky subtidal habitats. The CMECS water column components can be used to describe important features of the waters surrounding and overlying rocky reefs that are important in shaping the biological communities which live there.

The 30 m depth contour is defined by CMECS as the boundary for the nearshore subsystem and the offshore subsystem. Nearshore rocky reefs differ from offshore reefs in some key physical characteristics. Light penetration is adequate to support algal life on nearshore reefs, while offshore reefs support far less algal growth. For example kelp is only found in nearshore subsystem rocky areas. Wave action, currents, and storms produce a higher energy environment on nearshore reefs than their deeper counterparts. Organisms adapted to higher energy environments are more prevalent in the nearshore area. On some reefs, strong currents can scour and seasonally bury or expose the rocks with sand, considerably influencing the types of organisms that can utilize those rocky subtidal environments.

The difference in detail in the new habitat maps, compared with those available for the 2006 version of the Nearshore Strategy is striking. Use of the CMECS substrate component system also provides far more detail. A good example is the area off Cape Arago (Figure 6.7) where at a larger scale the differences are very apparent.

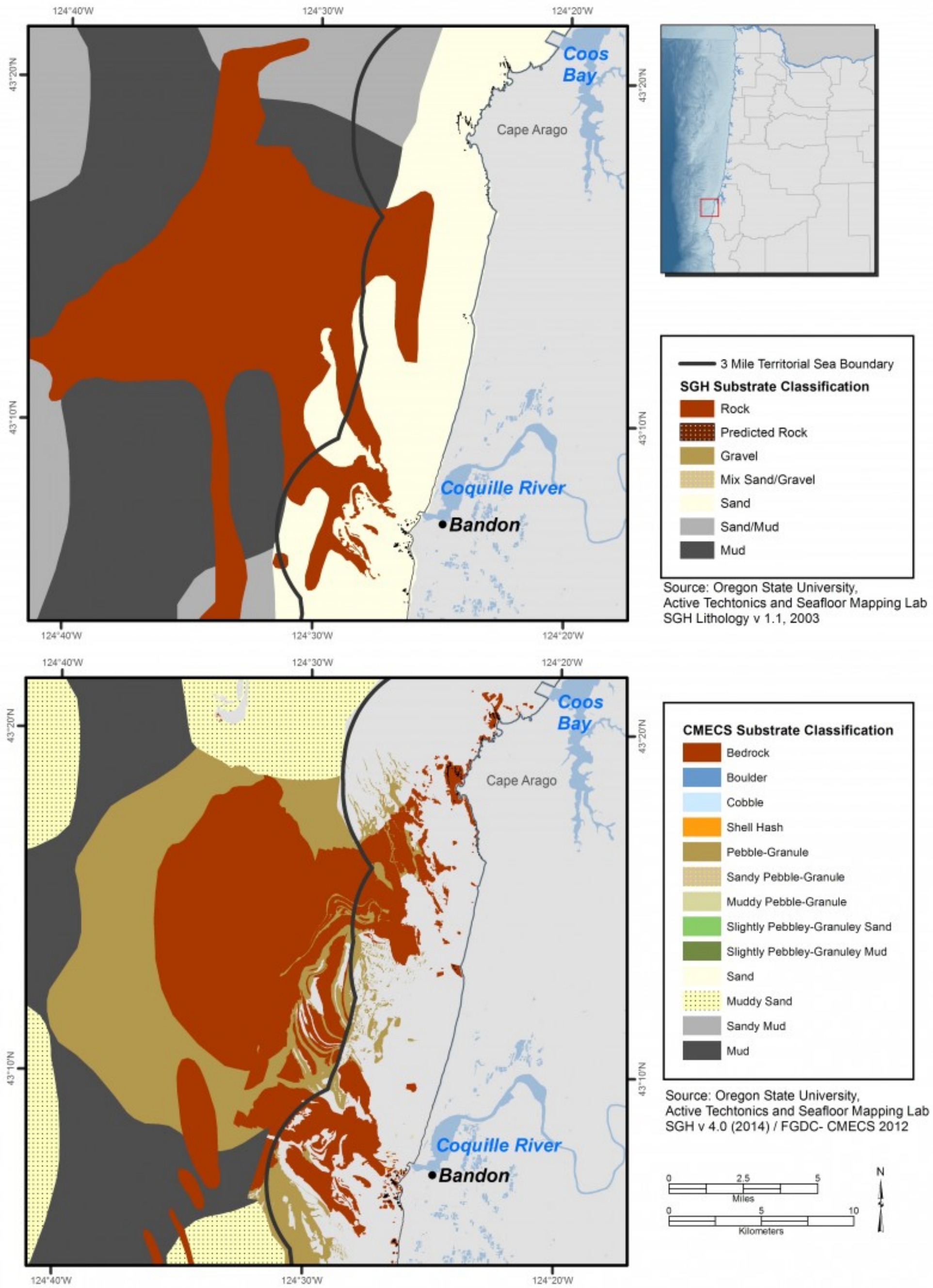


Figure 6.7. Detail map of the area off Cape Arago, Oregon included in original version of the Oregon Nearshore Strategy (top) and map of the same area that incorporates data from surveys with modern sonar technologies and the CMECS classification of substrate components (bottom).

Biological Characteristics

Subtidal rocky reefs are known for their abundant and diverse biological communities. The variety in topography, substrate characteristics, and depths within and among rocky reefs produces a plethora of microhabitats, often within relatively small geographic areas. This in turn provides for a diversity of species adapted to life in these different microhabitats. Habitat-forming organisms, such as kelp or attached invertebrates, provide additional microhabitats used by reef species.

Most nearshore rocky reefs have rich algal, invertebrate, fish, bird, and marine mammal communities. Depending on water depth, light penetration, wave energy, and other physical and biological processes, algae and macroalgae can provide extensive or sporadic cover and food for other species in the nearshore subsystem. Algae and macroalgae include encrusting forms that grow close to the rock surface, turf forms that can create a dense layer up to a foot thick or more, subcanopy forms that provide added subsurface habitat structure, and canopy forms that create kelp "forests" which may break the surface of the water. Offshore rocky reefs in deeper water do not have kelp forests. Free-swimming (nektonic), drifting (planktonic), and attached invertebrates are common in both the nearshore and offshore rocky subtidal habitats.

Many Strategy, Watch List, and other commonly associate species inhabit rocky subtidal habitats (Table 6.3, Appendix E and F). Fishes such as black, blue, china, deacon, copper and quillback rockfish, wolf eel, pile and stripped perch, lingcod, cabezon and greenlings, along with a large variety of smaller sculpins, gunnels, poachers, blennies and others are associated with rocky subtidal habitat. Diving seabirds and marine mammals forage extensively in rocky subtidal areas. A wide variety of filter or suspension feeding invertebrates attach to hard substrates such as sponges, anemones, barnacles, bryozoans, hydrozoans, tunicates, and coldwater corals. Mobile invertebrates abound here as well. Red and purple urchins, red and flat abalone eat algae attached to the rocks. Ochre, sunflower and other sea stars forage in subtidal rocky habitats as do crabs, shrimps, brittle stars, nudibranchs, chitons, and worms.

The diversity of producers and consumers found in the rocky subtidal creates complex food webs and interdependencies among organisms. Reefs are linked to surrounding environments by ocean currents and organism movements. Reef topographic structure often slows currents, enhancing the local community's ability to capture drifting organisms, an effect enhanced by the occasional presence of large kelp beds. Many organisms move on and off reefs, some in large-scale migrations and others in short feeding forays to other areas. While most nearshore reef fishes occupy both nearshore and offshore reefs, there are differences in depth preferences of some species and life history stages.

Several fish species depend on nearshore rocky reefs during early life history stages before moving off to deeper reefs, the continental shelf, or other areas as they grow. Conversely, some fish depend on estuaries or rocky intertidal habitat for early life history stages before moving to rocky subtidal areas as adults. For example kelp greenling, cabezon, and grass rockfish tend to be more prevalent on the nearshore reefs. Canary and yelloweye rockfish move from nearshore to offshore reefs as they grow. Many fish species are entirely dependent on reefs for parts of their life cycle, while others are visitors. Common visitors include herring, smelt, sharks, ratfish, and salmon.

Ecological linkages within and between rocky subtidal habitats help to shape their biological communities and the diversity of species found in this habitat type. Currents bring in planktonic organisms and transport drifting larvae to and from disparate rocky subtidal habitats. The location of reefs with respect to other “upstream” or “downstream” reefs has a dramatic effect on the types, abundance, and recruitment rates of the reef’s communities and organisms. This complexity of organism interrelationships makes the outcome of natural or human disturbance to reefs difficult to measure or predict.

Additional Biological Component: Kelp Beds

Bull kelp forms extensive kelp beds in places along the Oregon coast. The extent of these kelp beds changes with oceanographic conditions each year as this alga lives up to about 18 months at most. Photo Credit: Bastet Photography

Kelp beds are a significant subset of Oregon’s rocky subtidal habitat. CMECS classifies kelp beds as a biotic component of Oregon’s rocky subtidal habitat, and more specifically as canopy-forming algal beds. Kelp beds, found on many of Oregon’s nearshore rocky reefs, consist of an aggregation of one or more species of brown macroalgae that generally grow from the seafloor to the ocean surface and form a floating canopy of kelp. While kelp beds can be found all along the Oregon coast, the strip of coast from Cape Arago south contains approximately 92 percent of the state's kelp beds (Figures 6.8a and 6.8b). Most kelp beds in Oregon consist of bull kelp (*Nereocystis luetkeana*). While kelp beds appear common due to their visibility from shore, they are actually relatively scarce habitats in Oregon's waters, covering less than one percent of the nearshore area.

The presence and attributes of kelp beds depend on a number of physical and biological variables. The primary variables determining where kelp might exist include water depth and substrate availability. In Oregon's waters, kelp beds only form on rocky substrate and are limited to the nearshore subsystem. Beyond that depth, low light levels on the seafloor limit the growth of kelp. However, light and substrate are not the only limiting factors; many rocky reefs in the appropriate depth range rarely or never support kelp beds. Factors that may limit kelp on these reefs include seasonal sand burial of the reef, sand scour of the rocks, overexposure to wave and storm energy, locally high turbidity, lack of nutrients, distance of the reef to "seeding" sources of kelp, abundance of organisms that consume kelp (e.g., sea urchins), and competition with invertebrates and other algae for rock substrate available for attachment.

Kelp beds in Oregon display pronounced seasonal and annual variation in extent and density. Bull kelp beds grow rapidly in spring and summer, followed by a winter period when storms dislodge much of the algae, leaving little or no surface canopy. The biomass of kelp beds can also vary ten-fold or more from year to year due to interannual variation in the combinations of physical and biological variables that affect their growth.

Kelp beds are biologically rich habitats due to both the primary productivity of the kelp and the effect kelp beds have on the surrounding environment. Bull kelp is one of the fastest growing organisms in the world, annually providing a large biomass available for consumption directly or as detritus after the kelp dies. Kelp furnishes a vertical habitat structure that otherwise would not exist on the reef. Kelp beds also slow water currents and reduce waves and wind chop, helping to trap drifting larva and nutrients and providing shelter.

Kelp beds and their canopies can also support a rich understory of algal and attached invertebrate cover. On Oregon reefs, dense understory algae coverage gives way to dominant invertebrate cover at about 5 to 10 m water depth. Thick kelp cover reduces light penetration and can limit the density of understory algae. The kelp bed and underlying reef support a diverse array of fish and invertebrate species and provide cover and foraging areas for diving seabirds and marine mammals. In Oregon, the mix of fish species on kelp bed and non-kelp bed reefs is similar. In most parts of the world where kelp beds have been studied, reefs with kelp beds have much higher densities of fish than similar reefs without kelp. In Oregon, this does not appear to be the case. However, there have been no quantitative comparative studies to confirm this.

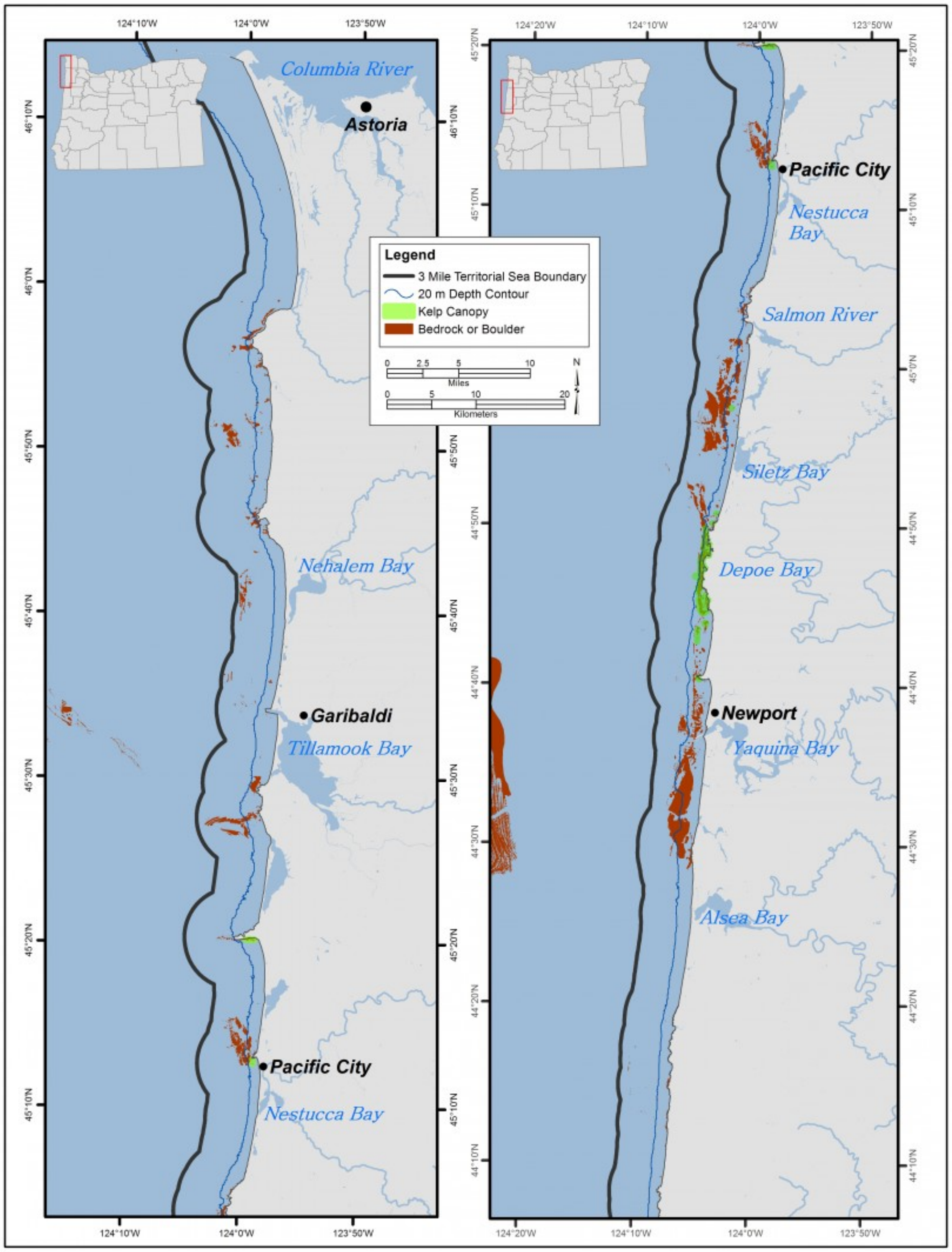


Figure 6.8a. Kelp beds along the north Oregon coast. Map shows maximum extent of kelp beds based on surveys.

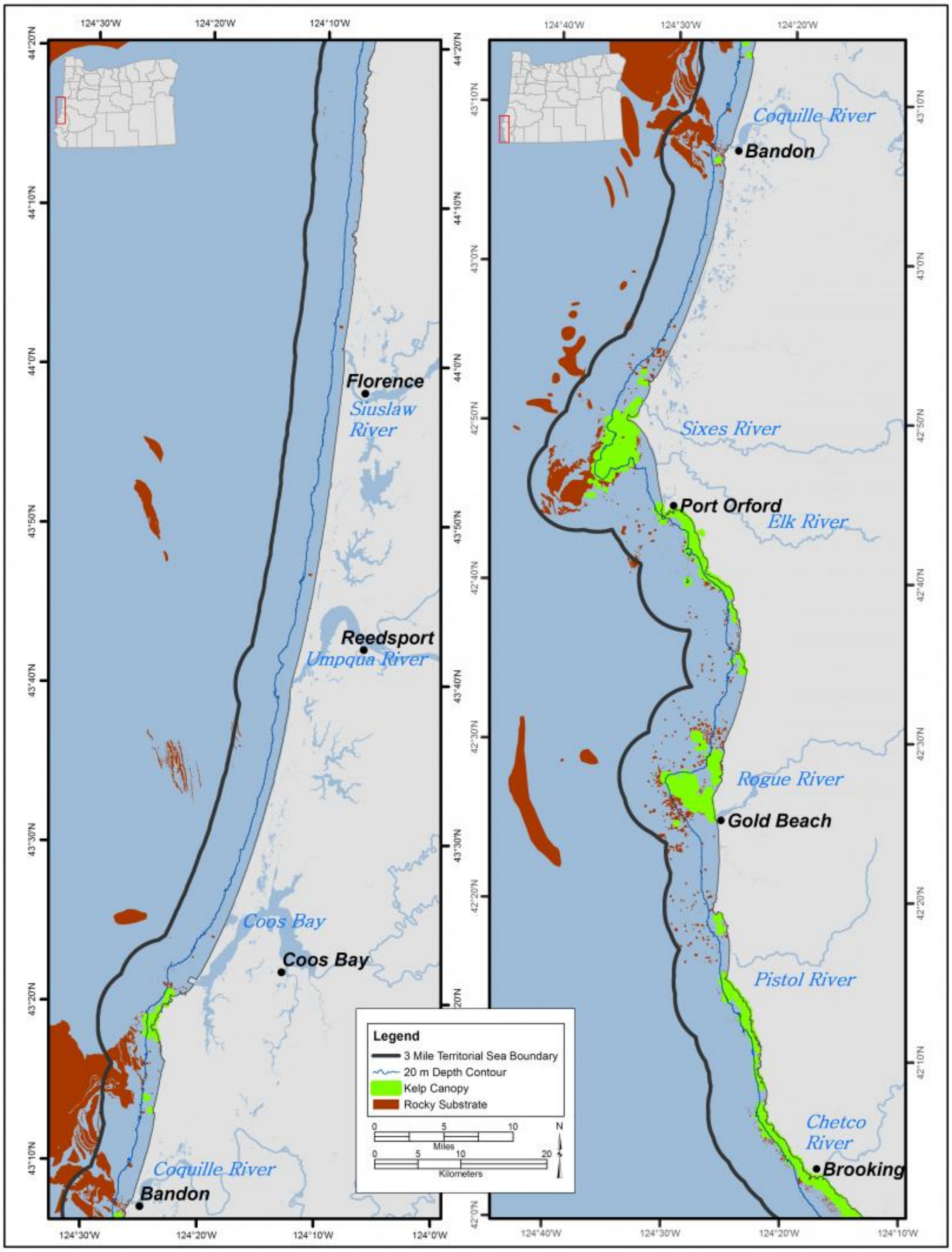


Figure 6.8b. Kelp beds along the south Oregon coast. Map shows maximum extent of kelp based on surveys.

Human Use

Human uses of nearshore rocky reefs include fishing, scientific research, sightseeing, and a number of other recreational and industrial pursuits. Commercial and recreational fishing for many types of rockfish species, lingcod, cabezon, and kelp greenling are the primary human uses of this habitat to date. SCUBA diving and underwater photography are among the other less prevalent uses. Much of the commercial live fish fishery takes place on shallow nearshore reefs. Recreational anglers also favor shallow nearshore reef, if they are available. Commercial fishing effort targeting nearshore species tends to be higher on the south coast and recreational effort more prevalent on the north coast. A unique potential commercial use is the harvest of kelp. Commercial kelp harvest has been tried several times in Oregon on a small scale in the past. Currently there is no commercial harvest of kelp. Many reefs are used recreationally by SCUBA divers, sea kayakers, boaters, and surfers. Reefs with extensive kelp beds and islands provide sightseeing and bird watching opportunities for coastal residents and visitors. However, many reefs have no features extending to the ocean surface, and thus many people are unaware of the teeming life existing just below the water's surface.

STRATEGY SPOTLIGHT: SAMPLING SUBTIDAL ROCKY HABITAT

A video lander designed by ODFW being retrieved after sampling rocky subtidal habitat. Photo Credit: ODFW

Many nearshore species that inhabit subtidal rocky reefs are important both ecologically and economically. Black, blue, China, deacon, copper and quillback rockfishes, cabezon, kelp greenling, lingcod, sea urchins and abalone are examples. Investigating and sampling the fish and wildlife species that inhabit rocky reefs is thus of great interest to scientists and fishery managers. But sampling rocky reef habitats has proven to be challenging.

Bottom trawls, a sampling method widely used in soft bottom marine habitats to help assess populations of fish, cannot be used effectively in rocky habitat as the nets tend to get hung up and entangled on the rough rocky bottom. Modified trawl gear can be used in some rocky locations, but its use can dramatically alter the rocky habitat by displacing rocks along with things such as anemones and corals that live on those rocks.

A variety of visual sampling methods have been used in rocky reef habitats over the years including SCUBA and remotely operated vehicles surveys. More recently video landers developed for use in Oregon waters by ODFW staff have been utilized to sample rocky reef habitat. Each method has pluses and minuses. Some highlights of video collected from a video lander provide a glimpse into life in rocky reef habitat. ODFW is using all of these visual survey techniques to sample the community of species that inhabit rocky reefs to investigate how best to use these sampling techniques to assess populations, examine the community structure, and refine our knowledge of habitat utilization by these species.

Photo Credit: Gregory Krutzikowsky

SANDY BEACHES

Sandy beaches are a widespread feature of the entire Oregon coast and make up approximately two-thirds of the coastline. Their distribution is interrupted by rocky shores, rocky headlands, river mouths, estuaries, and human constructions. Oregon's sandy beaches are characterized by CMECS as marine nearshore areas in the intertidal and supratidal zones that are composed of very fine to very coarse sand substrate; they extend in a continuum from the Mean Lower-Low Water line to the areas above the Mean Higher-High Water line that are affected by wave splash and overwash at extreme high tides, but not areas affected only by wind-driven spray. Sandy beaches stretch inland until they are stopped by a continuous line of vegetation, debris, rocks, or other barrier. Everything beyond the reach of the waves and splash zone is considered terrestrial habitat.

Physical Environment

Oregon's sandy beaches are high-energy environments that experience significant wave and wind energy. Several million cubic meters of sand are transported to the nearshore area annually by river systems. Seasonal variation in wind and wave energy and currents move substantial amounts of sand onto or off beaches, which results in significant changes in beach character as underlying rock structures (bedrock and/or cobble) are exposed. In some areas, patches of ancient forest where the land dropped during past subduction zone earthquakes may become exposed. Currents and wave energy are other significant factors in moving sands onto or off of beaches at elevations that are frequently immersed; the lateral width of the beach will govern the area over which current and wave energy is dispersed, and hence determines the slope of the beach as sands are deposited or swept away. At higher elevations that are dry and experience infrequent immersion by tides, wind is the predominant factor in distributing sand, and can create windrows and mobile dunes from a few centimeters to several meters tall, while dunes further inland may be several stories high.

The lateral (north-south) extent of sandy beaches is punctuated by rivers or rocky headlands where the transition from sand to volcanic rock can be quite abrupt. Rivers can frequently become "bar-bound" during the summer and early fall months when river flows diminish due to reduced precipitation, and the energy of flowing water is in sufficient to maintain an open, flowing channel to the sea. In such cases, the river or stream will flow *through* the sand in its final stages. Bar-bound rivers are generally freed by fall rains on the Oregon coast that increase river flows and wash sand out of the river mouths to re-establish a channel of flow. Fall rains and the breaking of blocking bars are important in restoring access to fresh-water streams for anadromous fishes.

The supratidal zone and upper range of the intertidal zone are subject to the greatest variation in temperature and moisture and the least physical energy from the ocean. The intertidal zone, particularly its lower reaches, receives much greater physical energy from waves and currents, and also experiences the least variation in temperature.

Biological Characteristics

The movement of sand by water and wind energy makes sandy beaches largely unsuitable for rooted and attached organisms. However, between the grains of sand in the intertidal zone is a vast multitude of life too small to see with the naked eye, including diatoms, harpacticoid copepods, amphipods, and algae, among others. Larger invertebrates can be found here as well, including crustaceans, mollusks, and diverse worm taxa. Many of the resident invertebrates burrow in the sand during periods of exposure for protection from desiccation and/or predation, and emerge to forage as tides permit.

Biological communities of the upper intertidal and supratidal zones of sandy beaches are often based on the resources provided by the incoming tides and deposited at the high tide line. Once in the intertidal zone, the detritus is broken down by the mechanical force of waves pounding against the shore and the industry of the many organisms that live and forage there. Organisms of the mid and lower intertidal, particularly the small invertebrates, provide food resources for numerous larger invertebrate, fish, and bird species. Some marine mammals intentionally use this zone to rest, hauling themselves out of the ocean to lay on the sand.

Strategy, Watch List, and commonly associated species that are associated with general sandy beach habitats, or specific to distinct sandy beach types, are listed in Table 6.3, Appendix E and F), respectively. Surf smelt use particular beaches to lay their eggs in the intertidal zone. Native littleneck and razor clams burrow below the sand and feed on plankton when the ocean water covers them. Western snowy plover nest either in the supratidal zone or above and feed in the intertidal sandy areas. Sanderlings gather in loose flocks in the winter months to feed on the rich array of invertebrates under the sand as the waves recede. Harbor seals rest on sandy beaches and northern elephant seals come ashore to molt, usually in the supratidal zone.

Human Use

Harvesting razor clams at low tide is a popular beach activity. Photo Credit: ODFW

Sandy beaches attract substantial human use at all levels of the intertidal and supratidal. Their easy access and wide variety of organisms and ecological processes attract scientific interest. Thanks to their uniform, comfortable surface, sandy beaches are valued for a wide variety of recreational activities including sightseeing, picnicking, walking, running, agate-hunting, and kite flying. Lower portions of beaches are also launch and recovery areas for surfers, windsurfers, kite boarders, sea kayakers, and some sailboats, power boats, and personal watercraft. Wildlife found at sandy beaches is highly valued by humans for everything from bait or dinner to instructional or aesthetic uses. Driving is permitted on some Oregon beaches, but not all. All beaches in Oregon are free for the public to access.

Photo Credit: Gregory Krutzikowsky

ROCKY INTERTIDAL

Oregon's rocky shores, often referred to as rocky intertidal or tidepool areas, form parts of the shoreward boundary of the nearshore planning area and can extend from the extreme low tide to the extreme high tide. They are characterized by CMECS as marine nearshore areas in the Intertidal and Supratidal zones, which include all hard substrate areas along the shoreline that are alternately exposed and covered by tides or are affected by wave splash and overwash, but not areas affected only by wind-driven spray. Everything beyond the reach of ocean waves is considered terrestrial habitat. The substrates making up Oregon's rocky shores include both volcanic and sedimentary bedrock as well as megaclasts, boulder, cobble and human-made (anthropogenic) structures. Some rocky shore areas are extensions of other shoreline rocky features such as headlands or cliffs, others exist as isolated regions of rock surrounded by sandy beach habitat, and some are anthropogenic in origin, having been deposited intentionally or unintentionally by humans. Oregon's coastline has approximately 152 linear miles of rocky shore habitat, and some 20 miles of jetties.

An example of a naturally-occurring geoform component found in Oregon's rocky shores would be a tidepool. Some of the anthropogenic geoforms found in Oregon's rocky shores include breakwaters, jetties, and rip rap deposits. All rocky shore habitats in Oregon are contained entirely within the Strategy's planning area.

Physical Environment

The physical characteristics of rocky shores reflect local shoreline geology, exposure to ocean waves and currents, and biological influences. The Pacific Ocean exerts tremendous energy on Oregon's rocky shoreline, eroding coves, widening crevices, and reducing bedrock to rubble. On the north and central coast volcanic basalt dominates the hard shoreline, but sedimentary sandstone and mudstone rock can found at several locations. Between Coos Bay and the Coquille River the geology is characterized by sedimentary rock. South of the Coquille River, headlands and rocks are primarily remnants of ancient metamorphic rocks over 200 million years old. Because of the variety of geologic origins and processes, Oregon's rocky shores consist of an assortment of cliff faces, wave-cut platforms, boulder fields, outcrops, and rubble. Each geoform presents a unique mixture of habitats that provide shelter and substrate to support a wide variety of life.

Ocean forces and weather strongly influence rocky intertidal environments. Tides are the primary influence on organisms and communities. The physical environment of intertidal areas changes dramatically as the tide rises and falls, alternately covering everything with salt water or exposing it to air, fresh water from rain and runoff, and the sun. Wave exposure also has a primary influence on this environment. Intertidal areas protected from waves due to shoreline orientation or geology provide dramatically different habitat than areas directly exposed to wave action. Local alongshore currents and ocean circulation processes introduce additional variables in the habitat, including sand scour of rocks, seasonal sand burial of rocky areas, and transport of nutrients, larvae, and adult organisms to and from intertidal sites.

Biological Characteristics

Rocky shore habitats are known for and crucial to their abundant and diverse biological communities. The variety in tidal elevations, wave exposure, and geologic structure within and among intertidal habitats produces a variety of microhabitats, often within relatively small geographic areas. This, in turn, provides for a diversity of species adapted to life in these different microhabitats. Organisms contribute to the variety of habitats as well. For instance, mussels and algae attach themselves to the rocks, sometimes in huge numbers, providing additional structure and biogenic habitat used by intertidal species. Anthropogenic geoforms often take on similar biological characteristics of natural rocky shore geoforms, with similar biological communities using them.

Biological communities associated with rocky intertidal habitat include algae, marine plants, attached and mobile invertebrates, fish, marine mammals and birds. Strategy, Watch List, and other commonly associated species that utilize rocky shore habitat can be found in Table 6.3, Appendix E and F. Algae cover many intertidal areas with dense growth, often layered with several different species. Surfgrass, a marine vascular plant, often forms thick beds in lower intertidal areas, providing additional habitat structure for invertebrates and fish. Most rocky shore areas are extensively covered with attached invertebrates. Common types of attached organisms include sponges, anemones, barnacles, bryozoans, tunicates, and mussels. The rocks, algae, and attached invertebrates provide homes for a variety of mobile invertebrates such as crabs, snails, limpets, sea stars, urchins, brittle stars, nudibranchs, chitons, and worms. Free-swimming invertebrates, such as shrimps and drifting (planktonic) invertebrates also occur in tidepools or drift in with the tides. The algal and invertebrate communities in rocky intertidal areas often form distinct horizontal bands or zones of life according to the amount of time exposed to the air or covered by the tides.

The upper reaches of the supratidal and intertidal zones experience the greatest variation in moisture, exposure, and salinity, and are often highly dependent on strong wave action to bring in nutrients and life. Compared to other rocky shore areas, fewer species are found in the high intertidal and supratidal. These zones are typically characterized by vegetated rocks and boulders, along with isolated crevices and tidepools that hold water even during low tides. Greater abundance and diversity of life is associated with the lower intertidal areas. The distribution of organisms living in the mid-intertidal is generally limited at upper elevations by environmental stressors (such as high temperatures and desiccation) and at lower elevations by biological interactions (such as predation and competition). Organisms in the lowest parts of the rocky shore area experience almost continual tidal inundation, and must be able to withstand the mechanical and biological stresses associated with this high-energy environment.

The low intertidal serves as an important connection in the marine food web. Wave activity helps convert kelp and other organic debris into small fragments that are consumed by grazers and filter feeders and provide some nutrients to algal communities. Invertebrates and small fish provide a source of food for numerous bird species that forage along rocky shores.

Fishes using the rocky shore include species adapted to live in tidepools and subtidal species that move in and out of the intertidal area with the tides. Tidepool fishes include a variety of sculpins, gunnels, and pricklebacks, among others. Rockfish species, greenlings, and surfperch often move into the intertidal area during high tide to feed and take refuge from subtidal predators. The rocky shore area is especially important to juvenile life stages of these fishes. The rocks and islands associated with Oregon's rocky shores and the subtidal rocky reefs provide important seal and sea lion haulout and pupping areas, and support some of the largest seabird nesting colonies on the contiguous U.S. West Coast. Islands are another example of geoforms in the CMECS framework. Several seabird species that do not nest in colonies in Oregon do feed and take refuge here, including black oystercatchers, black turnstones, and surfbirds.

Rocky shores are linked to surrounding habitats by ocean currents and organism movements. Currents bring in planktonic organisms that help feed intertidal animals, and transport drifting larvae to and from intertidal environments. Currents also bring nutrients that feed the lush algal growth. Many organisms move in and out of intertidal habitats to feed or take refuge. Fish move in during high tides and terrestrial animals move in during low tides. Rocky intertidal areas are also linked to each other, primarily through transport of larvae by ocean currents. The proximity of intertidal habitat to other "upstream" or "downstream" habitats has dramatic effects on the types, abundance, and recruitment rates of communities and organisms.

Ecological linkages within and between rocky shore areas help to shape biological communities and contribute toward the biological abundance of this habitat type. The diversity of producers and consumers in the intertidal create complex food webs and interdependencies among organisms. This complexity of organism interrelationships makes the outcome of natural or human disturbance to rocky shore habitats difficult to predict or measure. For instance, while human foot traffic can result in inadvertent trampling of organisms, anthropogenic structures such as jetties provide a unique and valuable rocky shore habitat at the transition between estuaries and the marine environment.

Human Use

Exploring tide pools is a favorite activity for coastal residents and visitors. Photo Credit: Gregory Krutzikowsky

Human uses of rocky intertidal areas include fishing, invertebrate and algae harvest and collection, education, scientific research, sightseeing, and other recreational, economic, and social pursuits. Due to their accessibility and the fascinating array of marine life, rocky intertidal areas receive more public use than many other marine habitats. Visitation by school groups and others curious about marine life comprises the majority of public use. For many visitors, their first and sometimes only interaction with the wonders of marine life comes from tidepool visits. Visitation of rocky shore areas has generally been increasing over the past five decades.

Rocky shores are used extensively by researchers as a natural laboratory to increase understanding about general marine ecological principles. Currently, there are fifteen intertidal and subtidal sites along the Oregon coast that have special regulations limiting harvest or collection of organisms in order to enhance scientific research, as well as education and enjoyment benefits.

Detailed descriptions of types and amount of human use at individual rocky shore sites along Oregon's coast can be found in the *Oregon Rocky Shores Natural Resources Inventory* (ODFW 1994).

STRATEGY SPOTLIGHT: SEA STAR WASTING SYNDROME

Shot in Yellow Point, which is about a 30 minute drive south of Nanaimo on Vancouver Island, BC. Photo shows a sick purple ochre sea star which has dropped one of its arms, Photo Credit: Steve Rumrill, ODFW

The concept of a keystone species, one that affects its biological community assemblage, in both direct and indirect ways which are out of proportion to its biomass, is based on research done on the ochre sea star, *Pisaster ochraceus*, in the rocky intertidal zone (Paine 1969). Dr. Robert Paine's concept that a keystone species shapes it biological community continues to influence ecological theory and has been expanded from the rocky intertidal environment to most ecoregions on earth. The predatory ochre sea star selectively feeds on mussels effectively creating space and opportunities for many other species to live and thrive.

The ochre star is familiar to Oregonian tide pool visitors, divers and aquarium goers. The species ranges from Alaska to Baja, California. In June 2013, researchers monitoring tide pools along the Washington coast noticed great numbers of ochre stars dying through a process called sea star wasting syndrome. Sea star wasting syndrome is characterized by a set of symptoms that include appearance of external lesions, followed by tissue decay, fragmentation of the body and death. Sometimes an affected sea star looks deflated before other symptoms are visible. While these symptoms are typical of sea stars stranded high and dry out of their normal habitat, what is unusual in sea stars experiencing wasting syndrome is that they are found in normally suitable habitat often with many others of the same species that are also affected. Sea stars may die within a few days of the first symptoms appearing.

Outbreaks of sea star wasting syndrome occurred previously in the 1970s, 1980s and the 1990s. What is different this time is that the geographic area over which it is occurring and the numbers of sea stars affected appear to be unprecedented. After first being documented on the Washington coast, outbreaks in Canada's British Columbia, California, Washington's Puget Sound and Alaska were found. Not long afterward outbreaks in Oregon and Mexico were discovered. At the rocky intertidal sites along the Oregon coast monitored by Oregon State University researchers for many years, ochre sea star populations declined by 85 to 90 % in a matter of months. Sea star wasting syndrome is affecting a variety of other sea star species on the Pacific Coast including: mottled stars (*Evasterias troschelii*), leather stars (*Dermasterias imbricate*), six-armed stars (*Leptasterias*), sunflower stars (*Pycnapodia helianthoides*), rainbow stars (*Orthasterias koehleri*), giant pink stars (*Pisaster brevispinus*), giant stars (*Pisaster giganteus*), sun stars (*Solaster*), vermillian stars (*Mediaster aequalis*), and bat stars (*Patria miniata*).

The cause or causes of sea star wasting syndrome, the reasons for the outbreak, and the ecological consequences are not fully understood. Research is underway at universities around the nation. A number of factors that may be involved such as warmer than normal water temperatures, salinity, pH, water pollution, and the role of pathogens like the bacteria, viruses and protezoa are being investigated as well as combinations of these factors. One pathogen, a densovirus, has been identified as a likely agent of infection, but evidence that this pathogen has been present along the Pacific coast for over 70 years suggests that other factors are involved in this widespread outbreak of sea star wasting syndrome (Hewson et al. 2014). There is evidence that warmer water temperatures may be a factor that increased disease rates and mortality in ochre stars in some areas (Eisenlord et al. 2016), but in Oregon that did not appear to be the case (Menge et al. 2016).

The ecological effects of population declines of the keystone predator, the ochre star, are also under investigation. Long term studies of intertidal species and habitat along the Oregon coast allowed Menge et al. (2016) to document the dramatic declines in both density and biomass of adult ochre stars caused by sea star wasting syndrome, measure the immediate decline in their predation rates on mussels from its long term average, observe an unprecedented increase in recruitment of young ochre stars and provide ecological perspective on these events. Continued research and monitoring will be the key to understanding why these outbreaks occurred, what the ecological consequences will be, and if sea star populations will recover.

Photo Credit: Gregory Krutzikowsky

ESTUARIES

Estuaries are characterized by tidally-influenced waters that have a surface connection to the sea. The connection may be permanently open, restricted, or intermittently closed. Oregon's estuaries are part of the Coast Range ecoregion and are a critical interface between the terrestrial environment of coastal watersheds and the nearshore marine environment. Estuaries are designated as a Strategy Habitat in the Oregon Conservation Strategy and the riverine portions are discussed there. The Nearshore Strategy focuses on species and habitats where saline marine waters influence the ecological communities.

The estuarine system extends from the mouth of the estuary, defined by an imaginary line connecting the two most seaward portions of land, upstream to the head of tide where the average difference in water level caused by tides is 0.2 feet (0.06 m). Estuarine tidal basins are generally narrow and elongated throughout their upper riverine regions, and may be broad and shallow in the middle and lower regions before making the connection to the sea. These basins are typically drained and filled by a primary tidal channel that is connected to numerous secondary and tertiary channels, inlets, sloughs, and tidal creeks.

Physical Environment

Within the CMECS framework, the Oregon estuarine aquatic system is defined by geomorphology of the tidal basins and by the salinity regime of the brackish waters. The estuarine system is composed of several subsystems, including: (1) tidal riverine coastal; (2) tidal riverine coastal –diked (3) tidal riverine open water; (4) coastal; (5) coastal – diked; and (6) open water. Although the riverine subsystems greatly influence the lower portions of the estuaries, the species and habitats in the nearshore ecoregion all occur in the coastal and open water subsystems where the average salinity during the summer dry season / low freshwater flow period is greater than 0.5 practical salinity units.

Oregon's estuaries exhibit a wide variety of CMECS geoform components such as bays, beaches, berms, boulder fields, channels, coves, deltas, islands, lagoons, levees, marsh platforms, mega-ripples, rubble fields, shoals, shoreline, sloughs, spits, stacks, tidal creeks, tidal flats, and tidepools. The estuaries also contain a diverse variety of geoforms with biogenic origin such as burrows, bioturbation areas, and shell beds. Anthropogenic origin geoforms are widely represented in the Oregon estuaries and include aquaculture structures, boat launches, breakwaters and jetties, bridges, bulkheads and seawalls, dikes and levees, docks and piers, dredged channels, dredge deposit and fill areas, harbors and marinas, intakes and outfalls, pilings, rip-rap, and wharves.

Mapping efforts of Oregon's estuaries utilizing CMECS components is underway and an online tool for viewing estuary maps is available at: http://www.coastalatlas.net/estuarymaps/. This is a work in progress and data for various CMECS components is not yet complete. It is designed to help with planning efforts and is administered by the Oregon Coastal Management Program. An example of a geoform components map of Yaquina Bay shows a number of its geoforms for which data are available (Figure 6.9).

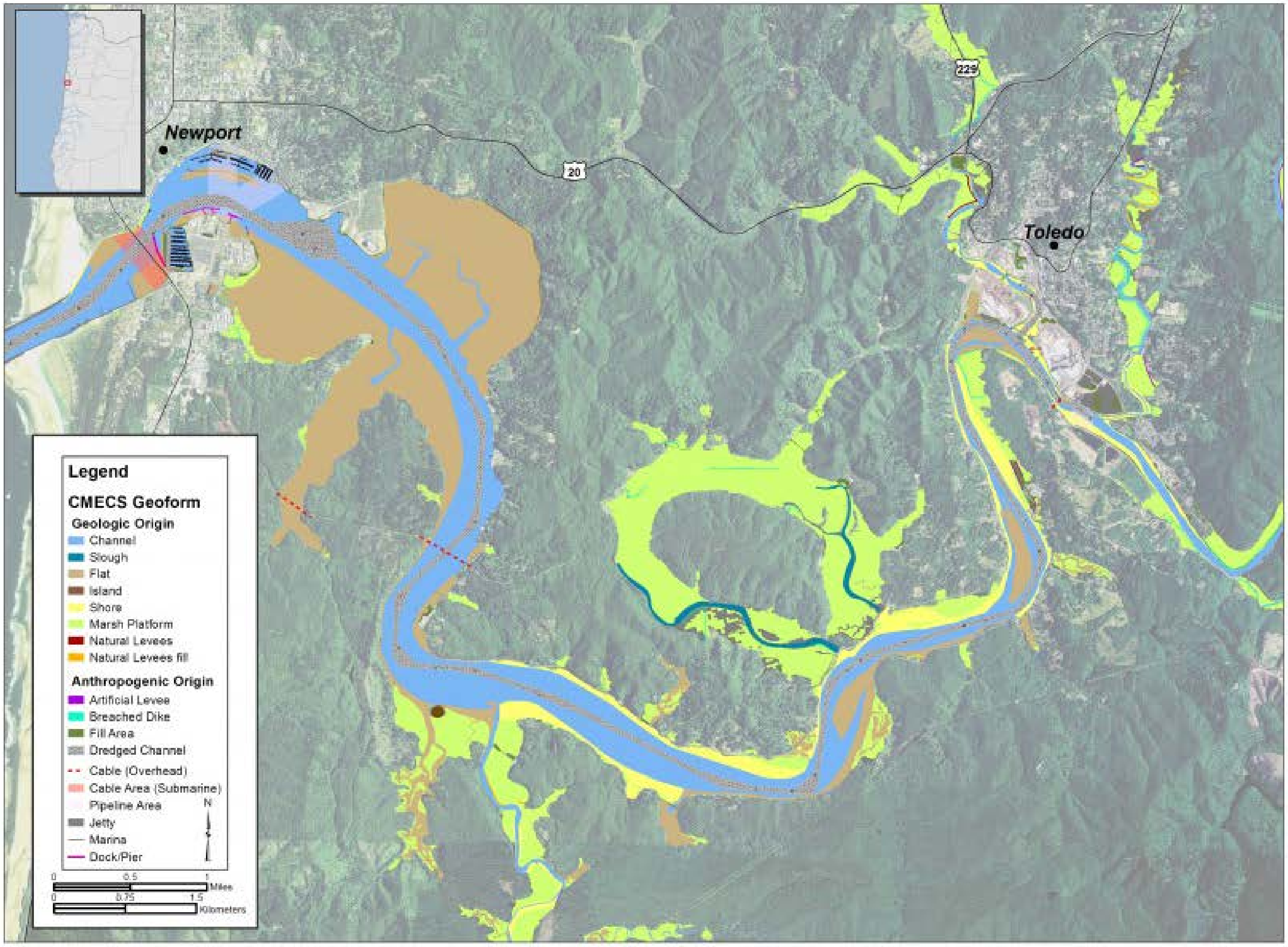


Figure 6.9. Map of Yaquina Bay depicting CMECS Geoform Components of geologic and anthropogenic origin.

Biological Characteristics

Oregon's estuaries are dynamic and productive components of the nearshore coastal ecosystem. They harbor a rich diversity of species, habitats and ecological communities. This highly complex, productive habitat is critical for many fish and wildlife species, including salmon, crabs and other shellfish, juvenile marine fish, marine mammals and birds. Primary production in estuary habitats is among the highest of any on earth, meaning that both the visible and microscopic plants produce a tremendous amount of carbon material (from photosynthesis) that supports the base of the food web. Tidal marshes are particularly productive and produce plant material that, when it dies seasonally, is broken down by microscopic bacteria to serve as food for many organisms which in turn are eaten by larger ones as material is distributed throughout the estuary with the tides. Estuaries and eelgrass beds are habitat types that have been designated as a Habitat Area of Particular Concern under NOAA Fisheries' Essential Fish Habitat regulations for salmon and groundfish species. Efforts to maintain and restore estuaries will benefit many wildlife and commercially important species.

Many Strategy, Watch List, and other commonly associated species utilize Oregon's estuaries during parts of their life history (Table 6.3, Appendix E and F). For some, such the blue mud shrimp and Olympia oyster, the adult and reproductive stage is entirely in estuaries. Longfin smelt also spawn in estuaries. Native eelgrass is an important habitat forming species in estuaries. Native eelgrass and the habitat it provides is utilized by several Nearshore Strategy Species, for example: Black brant, Dungeness crab, black rockfish, copper rockfish and kelp greenling. Eelgrass is also an important spawning substrate for Pacific herring, an important forage fish species. Complex ecological communities occur in the different regions of Oregon bays and estuaries. Many invertebrates such as gaper clams, butter clams, native littleneck clams, softshell clams, and cockles live in the soft sediments along with polychaete worms, amphipods and burrowing shrimp. Other species, like barnacles, mussels, oysters, tunicates, and hydroids live attached to hard surfaces. More mobile species such as fishes, sea stars, birds and marine mammals utilize a wider variety of habitats. Starry flounder, English sole, sand sole, staghorn sculpins, and sturgeon are benthic feeders that utilize subtidal habitat to locate their prey. Salmonid species that utilize and move through estuaries include Chinook, coho, and chum salmon, steelhead and coastal cutthroat trout. Pelagic fishes like eulachon, topsmelt, Pacific herring, longfin smelt, surf smelt, northern anchovy, and Pacific sand lance also utilize Oregon estuaries. Estuaries provide important wintering habitat for waterfowl and migration feeding area stopovers for or a wide variety of shorebirds. The tidal channels, sand flats, and mudflats are also used regularly by raccoons and river otters.

The CMECS biotic components are determined by the dominant biota, defined as those with the greatest percent coverage. Although planktonic maps and maps of fauna associated with bottom substrate are possible, most mapping work in Oregon estuaries has focused on vegetation cover. An example of a biotic component map for Yaquina Bay (Figure 6.10) shows available CMECS biotic information along with more specific work that focused on eelgrasses. Gathering data to improve mapping the biotic components of Oregon's estuaries is a work in progress that is anticipated to be valuable for planning, management, research and monitoring purposes.

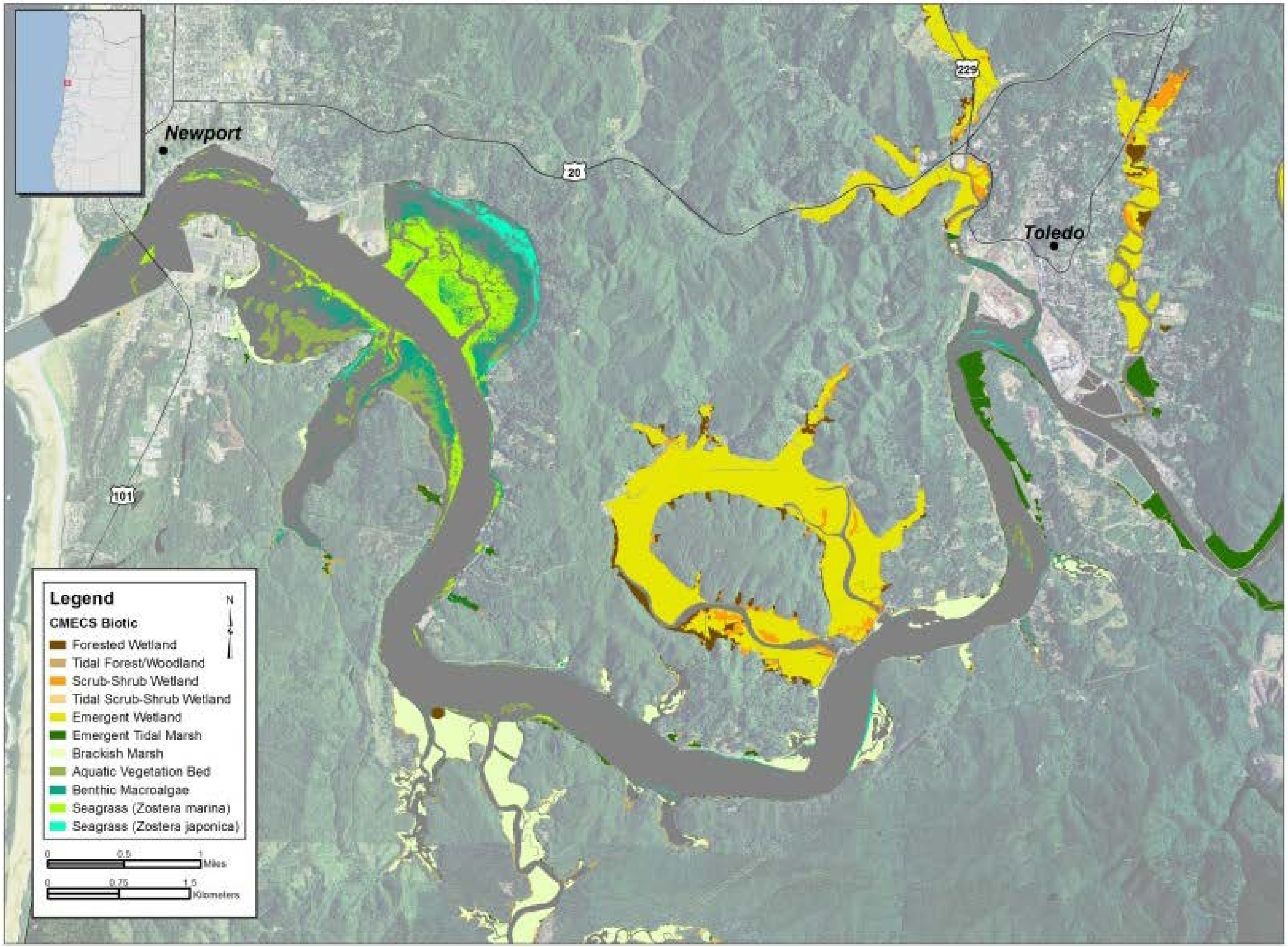


Figure 6.10. Map of Yaquina Bay with CMECS Biotic Components.

Human Use

Many estuaries have human communities on their shorelines and serve as ports and venues for recreational boating. Photo Credit: Gregory Krutzikowsky

Oregon has 22 major estuaries (Figure 6.11) and many other smaller estuaries along its coast. Many coastal cities developed around estuaries. People use estuaries for recreational and commercial harvest of fish and shellfish, navigation and shipping, ports for recreational and commercial vessels, shellfish aquaculture, hunting, sightseeing, bird watching, sailing, and other recreational and commercial activities. Portions of most of the larger estuaries have been altered through dredging, filling or diking. Many of the smaller estuaries remain in a more natural state. Twenty-two cities, seven counties, and thirteen port districts have planning or management responsibilities for Oregon's major estuaries and work with the Oregon Coastal Management Program and other state and federal agencies. Oregon utilizes a four level estuary classification system that defines the level of development permitted: natural; conservation; shallow draft development; and deep draft development. Natural estuaries are usually little developed for residential, commercial or industrial uses and include Sand Lake, Salmon River, Elk River and Pistol River. These estuaries do not have maintained jetties or channels. Conservation estuaries are within or adjacent to urban areas which have altered shorelines. These include the Necanicum River, Netarts Bay, Nestucca River, Siletz Bay, Alsea Bay and Winchuck River. Like natural estuaries maintained jetties and channels are absent. Shallow draft estuaries include Nehalem Bay, Tillamook Bay, Depoe Bay, Siuslaw River, Umpqua River, Coquille River, Rouge River, and Chetco River. These estuaries have maintained jetties and a main channel maintained by dredging to 22 feet (6.7 m) or less. Oregon's three deep draft estuaries, the Columbia River, Yaquina Bay and Coos Bay, are maintained by dredging to depths of 22 feet or deeper and have maintained jetties. This management classification system is designed to preserve the inherent diversity among Oregon's estuaries, and to guide the process of residential and industrial development in estuaries that have been altered and which can support further urbanization.

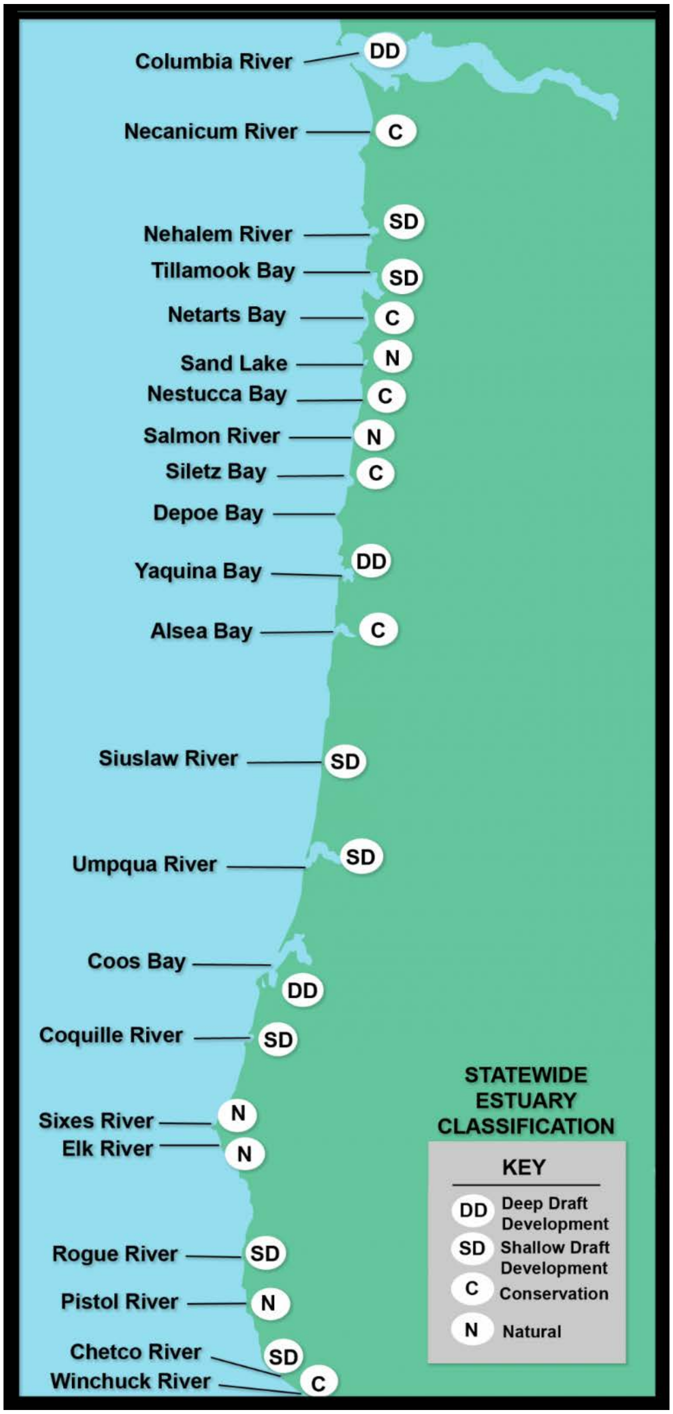


Figure 6.11. Oregon's 22 major estuaries are classified into four levels for development and planning purposes.