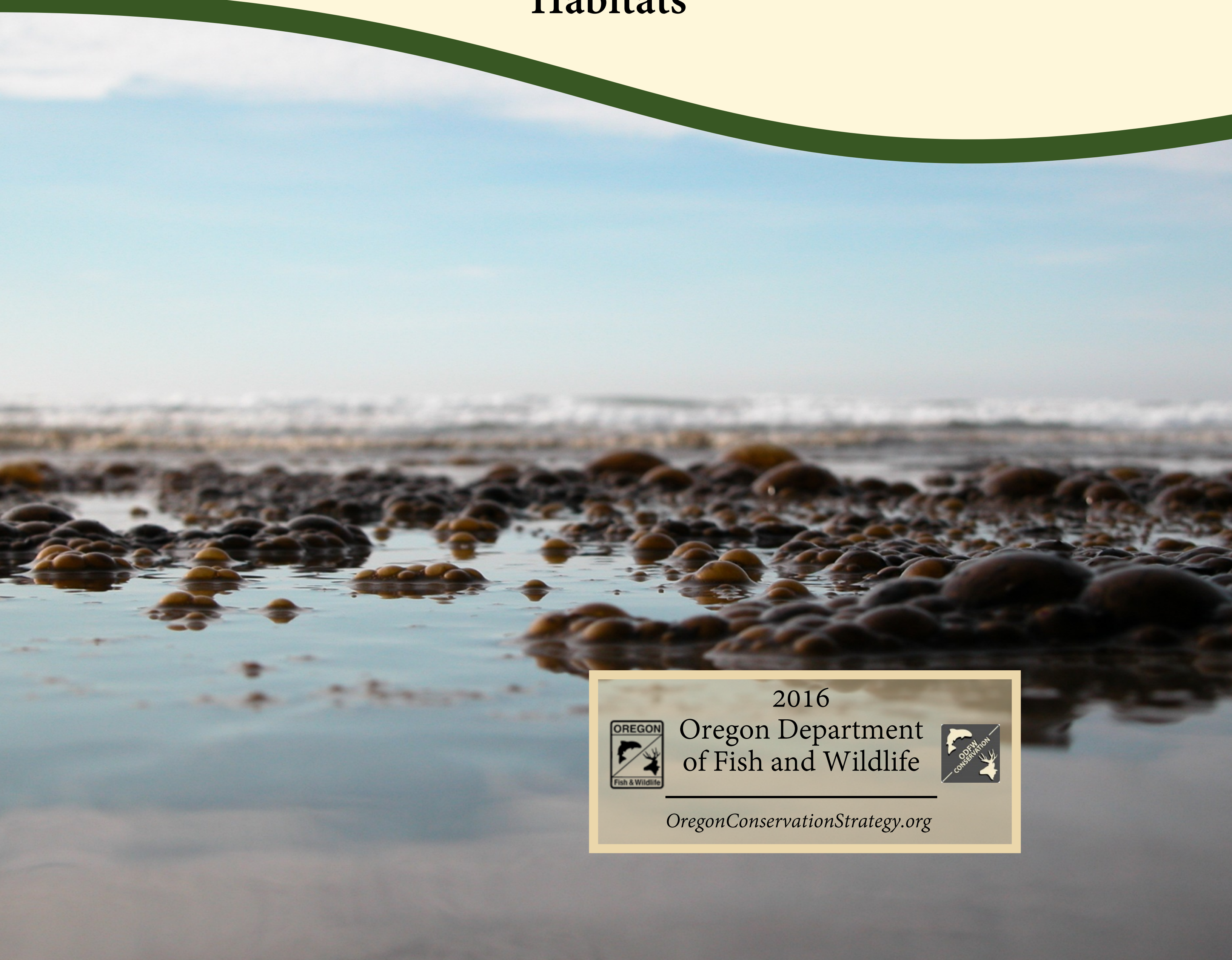



the OREGON NEARSHORE STRATEGY




Chapter 7: Factors Affecting Species and Habitats



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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*

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FACTORS AFFECTING SPECIES AND HABITATS

As human populations and activities in and around Oregon nearshore waters increase, so too do the impacts on fish, wildlife and the habitats they utilize. The factors affecting species and their habitats are often intertwined, and anthropogenic impacts may be exacerbated by naturally occurring processes. This chapter identifies factors that could adversely affect key nearshore habitats and species, and possibly require management action. Cumulative impacts should be considered in addition to individual effects. The list of the factors affecting Strategy Species and their habitats initially developed for the original Nearshore Strategy has been revised here in light of new information from scientific literature and input from researchers, subject matter experts, and the public.

Over the last decade, new research has provided a better understanding of factors that may impact Oregon's nearshore environment. For example, ongoing research on the impacts of global climate change and ocean acidification to organisms and habitats in Oregon's nearshore waters is beginning to describe the far-reaching effects of these stressors (Figure 7.1). Impacts of the increase of atmospheric carbon dioxide and other greenhouse gasses on the marine environment include, but are not limited to, increasing ocean temperatures, sea level rise, changing circulation and weather patterns, and changes in ocean chemistry all of which may affect species and their habitats (Bindoff et al. 2007, Osgood 2008, Brierley and Kingsford 2009, Hixon et al. 2010, Mote et al. 2010, Hoegh-Guldberg and Bruno 2010, Rhein et al. 2013). There are new analyses that provide insight into the vulnerability of many species to overfishing (Essington et al. 2015, PFMC 2014), and to its effects on ecosystems. There is more information available about sustainable levels of harvest and fishing practices (Dick and McCall 2010, Essington et al. 2015). Additionally, new resource issues have arisen in the last ten years that could potentially affect species, habitats and biological communities. For example, the widespread emergence of sea star wasting syndrome along the west coast and the work on offshore renewable energy development have raised conservation concerns in Oregon since 2006. Table 7.1 and text briefly summarize the natural and anthropogenic factors that impact Strategy Species and their habitats, along with the potential sources of those factors.

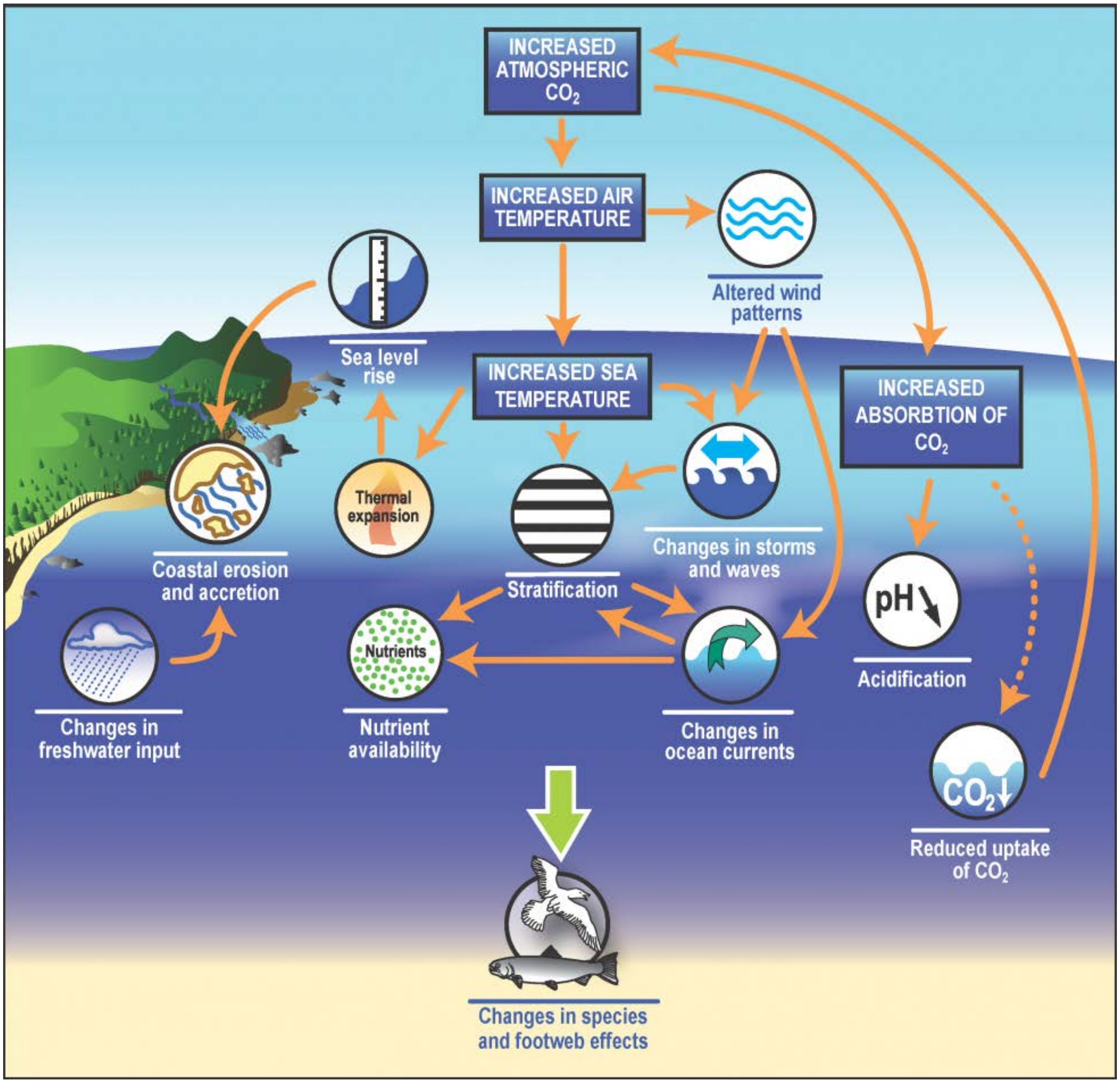

Figure 7.1. Diagram depicting the effects of increased atmospheric carbon dioxide on global oceans including Oregon's coastal and nearshore environments and the species living there.

Table 7.1. Factors Affecting Nearshore Strategy Species and Habitats

Natural Factors	**Potential Sources**
Alteration of oceanographic regimes	• El Niño • La Niña • Droughts (alters freshwater inflow) • Pacific Decadal Oscillation
Disease and biotoxins	• Harmful algal blooms • Sea star wasting syndrome
Loss / alteration of habitat	• Earthquakes / tsunamis / volcanic eruptions • Large storms • Droughts (alters freshwater inflow)
Water quality degradation	• Hypoxia events • Naturally occurring toxic compounds such as arsenic
Anthropogenic Factors	**Potential Sources**
Invasive species (including disease introduction)	• Aquaculture • Aquarium pet trade • Research facilities and public aquariums • Some fishing operations (e.g., herring roe which may entail importing kelp on which the roe can be deposited) • Transport of live animals and plants • Vessel operations / transportation / navigation • Ballast water
Loss / alteration of habitat and oceanographic regimes	• Agriculture and forestry practices • Altered freshwater inflow (created by dams upstream, etc.) • Artificial reefs • Aquaculture • Beach grooming • ***Climate change (global warming)*** o ***Increased air and water temperature*** o ***Changes in upwelling and ocean circulation patterns*** o ***Sea level rise*** o ***Altered river inputs*** o ***Larger storm events (coastal erosion)*** o ***Ocean acidification and hypoxia*** o ***Ocean stratification*** o ***Erosion*** • Beach nourishment

Table 7.1. Factors Affecting Nearshore Strategy Species and Habitats

	• Coastal and estuary development • Dredging and dredged material disposal • Diking • Fishing methods and gear (including derelict gear) • Fish processing waste (increased turbidity and surface plumes) • Harvest of habitat-forming organisms (e.g., kelp, mussels) • In water structures (e.g., jetties, seawalls) • Marine mining • Oil / gas exploration / development / production • Offshore renewable energy development • Overwater structures (e.g., mooring buoys, floating docks) • Point source discharge • Removal, resulting in loss, of keystone species • Submarine cable and pipeline installation • Trampling (on rocky intertidal) • Vessel operations / transportation / navigation • Water intake structures / discharge plumes • Wetland and aquatic fill
Noise pollution / noise disturbance	• Dredging • Oil / gas exploration / development / production • Offshore renewable energy development • Seismic studies • Submarine cable and pipeline installation • Vessel operations / transportation / navigation • Pile driving/sea wall construction
Oil spills	• Non-point source runoff from coastal areas (roads, parking lots, driveways, etc.) • Oil / gas exploration / development / production • Other spill sources (highways, trains) • Vessel operations / transportation / navigation • Offshore renewable energy development
Overexploitation	• Bycatch and incidental catch associated with commercial and recreational fishing, and scientific collection • Collection for scientific, educational, and public display • Commercial fishing / harvest • Poaching / illegal harvest • Recreational fishing / harvest

Table 7.1. Factors Affecting Nearshore Strategy Species and Habitats

Water quality degradation	*Non-point source pollution:*
	• Agricultural / nursery runoff
	• Changes in river temperature (land use practices)
	• ***Climate Change (global warming)***
	   o ***Changes in temperature (global warming)***
	   o ***Hypoxia events***
	   o ***Ocean acidification***
	• Fish processing waste
	• Land development
	   o Road building and maintenance
	   o Run off from faulty septic tanks
	   o Storm water runoff
	   o Urban / suburban development
	• Pesticides / fertilizers
	• Silviculture / timber harvest
	
	Point source pollution:
	• Aquaculture
	• Dredged material disposal
	• Dredging
	• Fish processing waste
	• Marine mining
	• Ocean dumping
	• Offshore renewable energy development
	• Oil / gas exploration / development / production
	• Sewage discharge
	• Submarine cable and pipeline installation
	• Vessel operations / transportation / navigation

Wildlife disturbance	• Aircraft • Boating (recreational and commercial) • Hiking / human presence / trampling • Light pollution • Noise pollution • Oil / gas exploration / development / production • Offshore renewable energy development Scientific research • Vehicles (driven on the beach) • Whale watching and other wildlife viewing

CLIMATE CHANGE AND OCEAN ACIDIFICATION

The Intergovernmental Panel on Climate Change found that the Earth's climate is warming as a result of increase in atmospheric carbon dioxide concentrations (IPPC 2007). Broader changes in the earth's climate will certainly influence the dynamics of the Oregon nearshore ocean. Additionally, the uptake of carbon dioxide changes the chemical equilibrium of seawater, resulting in ocean acidification (IPCC 2007). Impacts of climate change on the marine environment include increased ocean temperatures, sea level rise, changing oceanic circulation and weather patterns, ocean acidification and other changes to ocean chemistry. From 2013 to 2015, the West Coast Ocean Acidification and Hypoxia Science Panel, a group of scientists from California, Oregon, Washington, and British Columbia, convened to identify strategic data gaps, and develop research and management recommendations for state and federal decision-makers. During the last 10 years, ocean acidification has become a priority for decision-makers regionally and nationally, including commitments and policy attention by the Pacific Coast Collaborative, the West Coast Governor's Alliance on Ocean Health, the National Oceanographic and Atmospheric Administration, among others.

Due to the complexity of the ocean and the relative scarcity of studies at varying scales, the specific impacts of climate change and ocean acidification to Oregon's nearshore environment are not entirely clear but there are indications (Mote et al. 2010, Hixon et al. 2010). In order to provide insight into potential impacts of climate change and ocean acidification, as well as guide future management efforts, ODFW developed a policy analysis of climate change factors that are known to or are anticipated to impact nearshore resources, for the 2012 Strategy update. This analysis is laid out in a technical supplement designed for use by resource managers and decision makers, as well as in a series of fact sheets highlighting impacts in Nearshore Strategy habitats (ODFW 2012a, 2012b, 2012c, 2012d). The technical supplement and fact sheets are included as appendices in this updated edition of the Nearshore Strategy (see appendices A through D).

WATER QUALITY DEGRADATION

Poor water quality can stem from both natural and anthropogenic sources, and has far-reaching and direct impacts on nearshore species and their habitats. Natural sources include harmful algal blooms that produce toxins and sediments from storm runoff that increase turbidity. Anthropogenic point source and non-point source pollution can substantially alter marine and estuarine water quality. Urban runoff and storm water discharge are the leading sources of pollution in coastal waters in the United States, according to the Environmental Protection Agency's 2012 Coastal Condition Report (EPA 2012). These discharges can include pesticides, heavy metals, sediments, trash, nutrients, bacteria, petroleum products, and sewage overflow. Beach closures, due to health risks from pollution discharges, are a concern in Oregon with increasing coastal development and population growth. Atmospheric carbon dioxide absorbed by ocean waters has resulted in more acidic ocean waters in Oregon (Feely et al. 2008). All of these factors may differentially impact nearshore species and their habitats, and may have more severe cumulative effects when they occur together.

ALTERATION OR LOSS OF HABITAT

All of the habitats found in nearshore environments are vulnerable to habitat alteration or loss, and resulting impacts on species that use these areas during spawning, rearing, breeding, feeding, shelter, and other life stages. Factors that can degrade habitats result from both natural and anthropogenic causes. Examples include coastal development and associated construction, shoreline armoring, and alteration of hydrologic regimes; dredging and dredged material disposal; aquaculture; and global climate change. Effects can be direct or indirect, of varying intensity and duration, and multiple factors may interact to produce significant cumulative impacts.

Surf smelt and Pacific sand lance offer an example of species affected by alteration of sandy intertidal habitats. These forage fish species spawn on beaches in the intertidal zone. Anthropogenic beach modifications reduce the number of offspring produced by surf smelt and also may affect Pacific sand lance spawning and winter rearing habitat (Rice 2006, Krueger et al. 2010). Estuarine habitats have been altered or lost due to human development activities, such as dredging, filling, diking, hydrologic modifications, and urbanization. Salt marshes and other tidal wetland types have been diked, drained, and converted to pasture, resulting in substantial habitat alteration or loss. Industrial and residential development, new pilings, docks, or bridge structures, and aquaculture practices that reduce eelgrass beds and disturb winter waterfowl are also associated with habitat alteration or loss. Estuarine development closer to the ocean can impact habitats, as well. For example, building and maintaining jetties, piers, breakwaters, marinas and navigation channels including disposal of dredge materials can alter the habitat and impact Oregon Nearshore Strategy Species.

Derelict fishing gear includes nets, lines, pots, or other commercial or recreational fishing debris that is abandoned or lost and left unattended in the marine environment. Derelict fishing gear may disturb rocky reef and soft-bottom subtidal habitats. In addition, derelict gear poses a hazard in the neritic zone as well, where it may continue to catch and wound or kill fish, shellfish, birds, and marine mammals that become entangled. An estimated 10,000 crab pots are lost and become derelict annually (ODFW 2014). Collaborative projects between ODFW and the fishing industry to remove derelict gear in 2009 and 2010 recovered more than 3,100 crab pots and associated buoy lines off the Oregon coast with the majority of them still in usable condition. Marine organisms recovered in these pots were returned to the sea including over 6,000 legal sized Dungeness crab. These efforts have continued and there is now a permit program for vessels to voluntarily collect derelict crab pots each year once the crabbing season is over. In 2014, almost 650 pots were recovered. Loss of other gear types is less well documented.

As the earth warms with global climate change the main reservoir for heat energy is the ocean. Oregon's coastal surface waters (< ~650 feet or 200 meters) have warmed an average of 0.5º F (0.3º C) per decade over this time period and are predicted to increase by approximately an additional 2.2 º F (1.2º C) by the mid-21st century (Mote et al. 2010). Warming ocean temperatures appear to be causing a northward shift in the distribution of fish and other mobile animals, likely associated with species-specific temperature requirements (McKinnell et al. 2010, Perry et al. 2005). Poleward movement of marine fishes may actually increase species richness at temperate latitudes. Species exhibiting these shifts or range expansions tend to be smaller, which will change the energy flow through the food web and alter the dynamics of the ecosystem. Poleward population shifts may also be linked to temperature-associated food source availability. Some fish species exhibit enhanced growth and survival when cool water zooplankton is available because this food base provides greater biomass and higher energy content.

ALTERATION OF OCEANOGRAPHIC REGIMES

Nearshore ecosystems depend on dynamic oceanographic processes such as currents, upwelling, freshwater input and sediment transport. Alteration of oceanographic regimes can stem from both anthropogenic stressors (e.g., climate change or altered flow regimes from dams), or from natural factors (e.g., El Niño and the Pacific Decadal Oscillation).

Coastal upwelling, driven by spring and summer northerly winds, provides the nutrients that make Oregon's ocean environment so productive. Part of the reason Oregon's nearshore ecosystem is productive is the particular pattern of upwelling that starts in early spring and then occurs intermittently through the spring and summer (Menge and Menge 2013). There is growing evidence that, over time, upwelling will increase in intensity, be less intermittent, and start later in the year due primarily to changes in wind patterns resulting from global climate change (Bakun 1990, Barth et al. 2007, Iles et al. 2012, Sydeman et al. 2014). These shifts in the upwelling pattern will change the ecosystem off of Oregon, but the exact nature and severity of the changes is not yet known. Water temperature is a key factor in determining the strength of mixing in the nearshore, with higher temperatures inhibiting mixing because stratified layers of warm surface waters mix less easily with colder, deeper water. As the climate warms, the upper ocean will almost certainly be more stratified on average. The thermocline (the relatively distinct layer of steep temperature gradient) is 32 – 65 feet (10 – 20 meters) deeper off Oregon in the early 21st century, compared with the middle of the 20th century (Huyer et al. 2007). Stronger stratification will make ocean mixing due to wind patterns less effective at bringing nutrients to the surface, thereby reducing primary productivity (Hoegh-Guldberg and Bruno 2010).

The Oregon coast has a complex shoreline consisting of beaches, estuaries, and rocky shores, along with manmade structures such as jetties. Jetties, breakwaters, and other structures built out into the water from shore can alter the depth and shape of nearby sand bottoms and can alter localized oceanographic characteristics such as patterns of currents and sediment transport. In Oregon, jetties exceed 19.5 miles in total length, with about nine miles of structure extending out into the ocean beyond the high tide line (ODFW 1994). Shoreline stabilization structures, such as riprap and seawalls, have been constructed in many developed areas along the Oregon coast to protect coastal property from erosion due to wave action. These structures can block or alter the natural littoral drift of sand along the coast and can deprive some beaches of sand, while in other areas increase the deposition of sand (Brown and McLachlan 1990).

Alteration of the hydrologic regime in upper freshwater systems can have downstream effects on estuarine and nearshore environments. Dams located on rivers may serve as sources of hydropower, act as reservoirs for water storage, or be used for flood control. Dams can change the amount and timing of freshwater influx into estuaries and the nearshore ocean. This may result in an alteration of river plume fronts within the marine environment, including changes in the direction of flow of the river plume, availability of nutrients and sediment being brought into the marine system, and changes in water chemistry composition from suppressed mixing of fresh and saltwater. These alterations can in turn affect the species that are dependent on river plume microhabitats, and alter species composition within the area.

Hypoxic (low oxygen) events have occurred frequently off the central Oregon coast in the past decade. In 2002, a particularly strong hypoxic event resulted in kills of crab and fishes in the nearshore environment. Retrospective analyses suggest that these dense, cold, low-oxygen waters are transported from the Gulf of Alaska southward along the shelf break, where they can then be drawn up onto the continental shelf by the upwelling conditions that characterize the Oregon coast during the summer. During 2002, this hypoxic water transport coincided with a subsequent period of calmer winds that led to stratification of the coastal waters, limited water mixing and exacerbated the hypoxic event leading to the observed fish kills (Grantham et al., 2004). Hypoxic events in coastal waters were also been observed in 2004 and 2005. In 2006, anoxic conditions were first documented in Oregon's nearshore waters and after examining five decades of available records, scientists concluded that these types of hypoxic and anoxic conditions on the inner continental shelf off Oregon were not evident before 2000 and may be a result of climate change and related changing ocean chemistry (Chan et al., 2008).

OVEREXPLOITATION

State and federal management of Oregon's fisheries adheres to strict mandates for sustainability, using the best available information and employing a precautionary approach when data are sparse or uncertainty is high. Because of this, Oregon is recognized as a leader in fishery monitoring and management. Despite many successes, unsustainable overexploitation via excessive harvest, bycatch or collection continues to be a concern for some nearshore species and habitats. This includes harvest of nearshore resources for human consumption or use, incidental bycatch in fisheries, and illegal poaching along with collection for scientific research, aquarium display or educational purposes. Overexploitation affects targeted or bycatch species populations directly, and it indirectly affects nearshore species through alteration of food webs and community dynamics.

An example is the removal of large predators from neritic waters. Large predators are often key in determining the depth distribution and aggregation of prey. Their removal can result in changes in the foraging behaviors and success of a whole suite of other predators in the system (Dayton et al. 2002). Furthermore, many nearshore rocky reef species are vulnerable to overexploitation due to the cumulative effects of low productivity and infrequent recruitment, compounded by incidental bycatch in non-targeted fisheries (e.g., yelloweye rockfish).

NOISE POLLUTION

Noise caused by vessel operations, sonar, offshore energy development or production, dredging, construction, and seismic studies may disturb marine mammal and fish populations in nearshore and estuarine habitats. Acoustic disturbances may stress, displace, or even damage individuals in the affected area. Marine mammals rely heavily on sound to communicate and navigate the oceans. Numerous studies have demonstrated behavioral changes of marine mammals responding to exposure of anthropogenic activities (Nowacek et al. 2007). These responses have ranged from subtle short-term behavioral changes, to longer-term population level impacts (Richardson et al. 1995, Lusseau 2003, Consantine et al. 2004). Cetaceans are particularly vulnerable to noise disturbance, particularly harbor porpoise (Tougaard et al. 2012), along with gray whales (Malme et al. 1983).

Most fish species have hearing capability, but specific studies on hearing have only been conducted on a very small fraction of species, and there are very few studies on the effects of anthropogenic noise on fish. Thomsen, et al. (2006), Hastings and Popper (2005), Popper and Hastings (2009), and Popper et al. (2014) reviewed peer-review and grey literature on the effects of noise on fish, and Popper, et al. (2014) have proposed sound exposure guidelines for fish. Noise can affect fish behavior, communication and, in extreme cases, cause direct tissue damage resulting in immediate or delayed mortality (Thomsen, et al.

2006; Hastings and Popper 2005; Popper and Hastings 2009; Popper et al. 2014). Behavioral avoidance of noise can alter fish migration and schooling which can impact foraging, predator avoidance, or reproductive success.

OIL SPILLS

Oil spills can have devastating effects on nearshore fish, wildlife and habitats. Sources of oil spills may include tanker accidents, unintended spillage from the cleaning of oil tanks at sea, and runoff from upland sources such as roads. The water-soluble components of various types of crude oils and refined petroleum products contain compounds that are toxic to many types of marine plants and animals. Feathers of marine birds exposed to oil lose their water repellant qualities and the birds may ingest oil which poisons them. Marine birds that feed intertidally in sandy beach habitat or in the surf-zone are especially vulnerable to oiling, which can lead to death (Brown and McLachlan 1990; Clark 2001). In addition, large amounts of stranded oil may smother and kill marine organisms.

All of the habitats found in Oregon's waters are vulnerable to oil spills. The type of oil spilled, how weathered the oil or petroleum product is when it reaches the shore, characteristics of the substrate, and level of exposure to wave energy are all factors that contribute to the degree of damage to shoreline habitats and associated organisms.

Offshore, water-soluble fractions of crude oil and refined petroleum products can cause immediate toxic effects on all life stages of marine organisms near the water's surface. Plankton occurring in the top layers of the water column are assumed to be particularly at risk since they would be exposed to the highest concentrations of the water soluble compounds leaching out of the spilled oil. Alterations in phytoplankton production caused by an oil spill can result in indirect effects on microfauna and macrofauna that are dependent on the quantity and quality of phytoplankton primary productivity. Alterations to phytoplankton productivity appear to only last for short periods of time and have greater effects on oceanic than coastal species (Brown and McLachlan 1990; Clark 2001, González et al. 2009).

Kelp beds are vulnerable to exposure to crude oil and refined petroleum products, because the floating oil is more likely to have an impact on plants and animals on the water's surface than those residing deeper in the water column. Studies in Washington State found that weathered diesel fuel was the most toxic to bull kelp (*Nereocystis luetkeana*). The study also found unweathered intermediate fuel oil, unweathered diesel fuel, weathered intermediate fuel oil, unweathered crude oil, and weathered crude oil have decreasing amounts of toxicity, respectively (O'Clair and Lindstrom 2000).

INVASIVE SPECIES

Globalization has increased the rate at which non-native species are introduced to new habitats where they can be invasive. Non-native and invasive species are a concern for Oregon's estuaries and nearshore waters. Non-native species arrive in a variety of ways including aquaria releases, aquaculture escapes, intentional introduction, hitch hiking on boats or recreational equipment, seafood packing and disposal, and perhaps most importantly, ballast water. Ship ballast water is known to carry viable organisms from one body of water to another and it is estimated that over two-thirds of recent species introductions in marine and coastal areas are likely due to this ship-borne vector. International shipping (including its ballast water component), followed by aquaculture, have been identified as the two greatest sources of introductions of marine and estuarine invasive species worldwide (Molnar et al. 2008).

Non-native species can adversely affect native species by various means including competing for food and space, spreading diseases new to the area, producing toxins. Detecting the first arriving individuals of non-native species may be the “key” to managing invasions because they can be the most readily eradicated or contained. This highlights the importance of prevention and monitoring programs. Invasions are more complicated to respond to over time as populations expand.

One well-documented invasion in Oregon is the Griffen’s isopod (*Orthione griffenis*), native to Asia and likely introduced via ship ballast water during the 1980’s. This parasitic isopod can draw enough blood from the blue mud shrimp (*Upogebia pugettensis*) to prevent it from reproducing. The introduction of this parasite has been linked to substantial population declines of blue mud shrimp in many Pacific Northwest estuaries (Griffen 2009, Dumbauld et al. 2011, Chapman et al. 2012).

Another well-documented invasion is the European green crab (*Carcinus maenas*), native to the northeast Atlantic and Baltic Sea coasts, which was first seen in San Francisco Bay in 1989. Pelagic *Carcinus* larvae can survive for up to 80 days in coastal waters and then return to adjacent bays and estuaries to settle. The expansion of *Carcinus* from San Francisco Bay likely occurred on coastal currents south to Monterey Bay and northward to Humboldt Bay, California. The spread to Coos Bay, and Yaquina Bay, Oregon, Willapa Bay and Grays Harbor, Washington, and the west coast of Vancouver Island occurred following the strong El Niño of 1997/1998. The expansion of *Carcinus* up the east coast of the U.S. to Maine occurred over an approximately 120 year period, culminating in the collapse of the soft-shell clam industry in Maine. *Carcinus* could possibly threaten Dungeness crab, oyster and clam fisheries and aquaculture operations in the Pacific Northwest.

Larvae of the European green crab and the Asian Griffen’s isopod have relatively long pelagic phases that survive only in the ocean. The recently introduced purple varnish clam *Nuttallia obscurata* has spread down the coast via planktonic dispersal. Coastal ocean conditions are thus critical determinants of biological invasions of estuaries, but the processes and possible management strategies for limiting ocean dispersal of invasive species are unknown.

Estuaries are especially susceptible to adverse impacts from invasive plants and animals. Invasive plants can alter water circulation and sediment patterns. For example, common cordgrass , which has been documented in two Oregon estuaries and is well-established in Washington and California, reduces mud flat habitats, disrupts nutrient flows, displaces native plants and animals, and traps sediments, which changes the beach profile and water circulation. Three other cordgrass species have invaded the Pacific coast and could potentially pose a threat to estuaries.

During the 2012 Nearshore Strategy updates, ODFW staff first worked with experts to identify non-native species and potentially invasive species known to occur in the nearshore ocean and estuaries of Oregon, California, and Washington. This information is updated in the 2015 revision. More than 200 non-native species have been identified in Oregon marine and estuarine waters, of which 14 were classified as invasive (see Appendix G).

WILDLIFE DISTURBANCE

Rocky shores, sandy beaches, estuarine areas and adjacent terrestrial habitats are important to marine birds, shorebirds, pinnipeds, and other wildlife species as foraging areas, nesting places, and haulout sites. Human presence can disturb wildlife using these important areas. Adverse effects stemming from wildlife disturbances may include short-term or permanent abandonment of eggs or young by adults, changes in foraging or other behaviors, and greater susceptibility to predators. Human presence resulting in wildlife disturbances may be from activities such as walking/hiking, wildlife viewing, boating (motorized and man-powered), aircraft flying in the vicinity, educational excursions, or scientific research.

HARMFUL ALGAL BLOOMS

Harmful algal blooms in marine waters can kill fish, marine mammals and birds, and threaten human health when resulting toxins are concentrated in shellfish and other species consumed as food. Harmful algal blooms have been increasing worldwide (Gilbert et al. 2005) and this increased frequency and intensity has been linked to climate change. Two primary forms of toxic effects are linked to harmful algal blooms in Oregon marine waters: paralytic shellfish poisoning and domoic acid poisoning (Lewitus et al. 2012). Both toxins can affect marine birds and mammals as well as humans. Paralytic shellfish poisoning has been linked to a suite of toxins produced by blooms of phytoplankton diatoms belonging to the genus *Alexandrium*. Several species of diatoms in the genus *Pseudo-nitzschia* produce domoic acid, which causes amnesiac shellfish poisoning in humans. These diatoms and the toxins they produce are concentrated by organisms that feed on them directly. Numerous species including razor clams, mussels, Pacific littleneck clams, geoduck and manila clams, Pacific oysters, Dungeness and rock crabs, Pacific sardines, Pacific anchovies, and market squid are reported to be bioaccumulators of toxins. In addition, thousands of marine birds were killed off Oregon and Washington in 2009 by a temporary bloom of a dinoflagellate which produces a surfactant-like foam that destroys the water resistant coating of their feathers.

DISEASE

In 2013, an outbreak of Sea-Star Wasting Syndrome was discovered along the west coast, which led to rapid degeneration, mortality and disappearance of many sea stars in Oregon's nearshore waters. Similar outbreaks have occurred intermittently during the last four decades, although never before at the magnitude of the most recent outbreak. The ochre star (*Pisaster ochraceus*) and the sunflower star (*Pycnopodia helianthoides*), are two of the many species susceptible to Sea-Star Wasting Syndrome. Because both of these species are keystone predators, there are likely to be changes to the lower trophic levels, although the degree is still unknown. Currently, the cause of the disease is unclear, but there appears to be a link to a Densovirus (Hewson et al. 2014). Further research and monitoring is needed to better understand the causes and potential effects.

More information on diseases that are of management concern to nearshore species, including those affecting marine mammals, birds, fish and invertebrates is presented in the Oregon Conservation Strategy along with diseases affecting terrestrial and freshwater species.

SENSITIVITY TO ADVERSE EFFECTS FROM NATURAL AND ANTHROPOGENIC FACTORS

The extent and severity of adverse effects will depend on specific events, environmental conditions, species presence, co-occurring factors, etc. Some of the factors described in this section are small-scale, localized, and/or short-term, with potential adverse impacts limited in geographic and temporal scope. Others may have much more widespread effects. Table 7.2 presents the most likely sensitivities of each Strategy Species to the major categories of anthropogenic and natural factors.

Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Big skate *Raja binoculata*			x	x			x			
Black brant *Branta bernicla nigricans*		x			x		x			
Black oystercatcher *Haematopus bachmani*		x			x	x	x			
Black rockfish *Sebastes melanops*			x							
Blue mud shrimp *Upogebia pugettensis*		x				x				
Blue rockfish *Sebastes mystinus*			x							
Brown rockfish *Sebastes auriculatus*			x							

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	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Bull kelp *Nereocystis luetkeana*	x	x	x		x				x	
Cabezon *Scorpaenichthys marmoratus*			x							
California brown pelican *Pelecanus occidentalis* californicus		x	x		x		x		x	
California mussel *Mytilus californianus*	x	x			x		x	x	x	
Canary rockfish *Sebastes pinniger*			x							
Caspian tern *Hydroprogne caspia*		x					x			
China rockfish *Sebastes nebulosus*			x							
Chinook salmon *Oncorhynchus tshawytscha*	x	x	x						x	
Chum salmon *Oncorhynchus keta*	x	x	x						x	

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	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Coastal cutthroat trout *Oncorhynchus clarki clarki*	x	x	x						x	
Coho salmon *Oncorhynchus kisutch*	x	x	x						x	
Copper rockfish *Sebastes caurinus*			x							
Deacon rockfish *Sebastes diaconus*			x							
Dungeness crab *Cancer magister*	x					x			x	
Eulachon *Thaleichthys pacificus*		x	x						x	
Flat abalone *Haliotis walallensis*	x	x	x		x	x		x	x	
Fork-tailed storm petrel *Oceanodroma furcata*		x			x	x	x			
Grass rockfish *Sebastes rastrelliger*			x							
Gray whale *Eschrichtius robustus*		x	x	x			x			

Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Green sturgeon *Acipenser medirostris*		x	x			x				
Harbor porpoise *Phocoena phocoena*			x	x			x			
Kelp greenling *Hexagrammos decagrammus*			x							
Lingcod *Ophiodon elongatus*			x							
Leach's storm petrel *Oceanodroma leucorhoa*		x			x	x	x			
Longfin smelt *Spirinchus thaleicthys*		x					x			
Marbled murrelet *Brachyramphus marmoratus*		x		x					x	
Native eelgrass *Zostera marina*	x	x							x	
Native littleneck clam *Leukoma staminea*		x	x			x				
Northern anchovy *Engraulis mordax*		x				x			x	

Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Northern elephant seal *Mirounga angustirostris*			x				x			
Ochre sea star *Pisaster ochraceus*		x			x		x			x
Olympia oyster *Ostrea lurida*	x	x	x					x		
Pacific giant octopus *Enteroctopus dofleini*			x							
Pacific harbor seal *Phoca vitulina*							x			
Pacific herring *Clupea pallasii*		x				x	x			
Pacific lamprey *Entosphenus tridentatus*	x	x								
Pacific sand lance *Ammodytes hexapterus*		x							x	
Pile perch *Rhacochilus vacca*			x							
Purple sea urchin *Strongylocentrotus purpuratus*		x	x		x		x		x	

Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Quillback rockfish *Sebastes maliger*			x							
Razor clam *Siliqua patula*	x		x			x		x	x	x
Red abalone *Haliotis rufescens*	x	x	x		x	x		x	x	
Red sea urchin *Mesocentrotus franciscanus*		x	x		x				x	
Redtail surfperch *Amphistichus rhodoterus*			x			x				
Rock greenling *Hexagrammos lagocephalus*			x							
Rock sandpiper *Calidris ptilocnemis*		x			x					
Rock scallop *Hinnites giganteus*			x							
Sea palm *Postelsia palmaeformis*		x	x							
Shiner perch *Cymatogaster aggregata*			x							

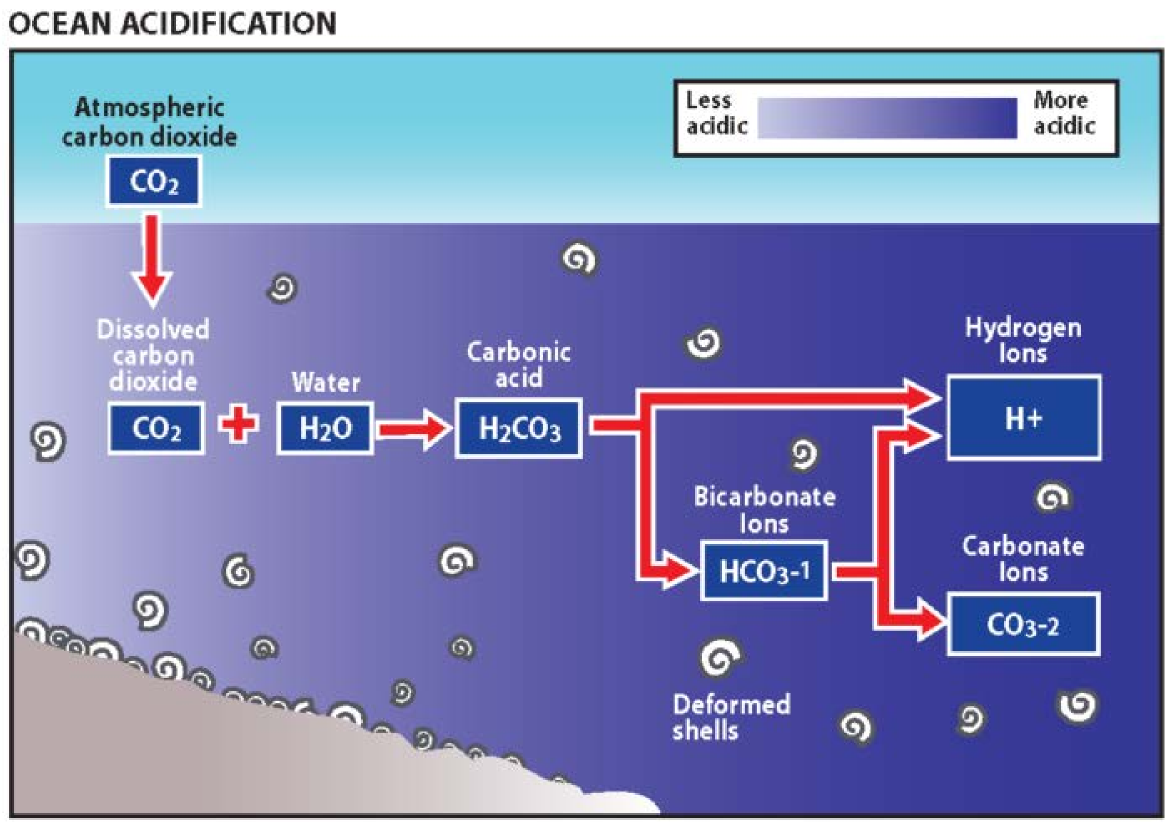
Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Southern Resident Killer Whale *Orcinus orca*				x			x			
Spiny dogfish *Squalus acanthias*			x				x			
Starry flounder *Platichthys stellatus*			x							
Steller sea lion *Eumetopias jubatus*			x				x			
Striped perch *Embiota lateralis*			x							
Sunflower star *Pycnopodia helianthoides*		x							x	x
Surf grass *Phyllospadix spp.*		x			x				x	
Surf smelt *Hypomesus pretiosus*		x							x	
Tiger rockfish *Sebastes nigrocinctus*			x							
Topsmelt *Atherinops affinis*		x				x			x	

Table 7.2. Sensitivity matrix for Strategy Species and Factors

	Sensitivity To									
	Anthropogenic Factors							*Natural Factors*		
Strategy Species	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Overexploitation	Noise pollution / Noise disturbance	Oil spills	Invasive species	Wildlife disturbance	Water quality degradation	Loss / alteration of habitat and oceanographic regimes	Disease
Tufted puffin *Fratercula cirrhata*		x			x		x		x	
Vermilion rockfish *Sebastes miniatus*			x							
Western river lamprey *Lampreta ayressii*		x							x	
Western snowy plover *Charadrius alexandrines nivosus*		x					x		x	
White sturgeon *Acipenser transmontanus*		x	x			x				
Wolf-eel *Anarrhichthys ocellatus*			x							
Yelloweye rockfish *Sebastes ruberrimus*			x							
Yellowtail rockfish *Sebastes flavidus*			x							

STRATEGY SPOTLIGHT: OCEAN ACIDIFICATION



Gases from earth's atmosphere are absorbed in ocean waters. The amount of carbon dioxide in the earth's atmosphere has increased substantially since the industrial age that began roughly 150 years ago. Dubbed the "evil twin" of global climate change, ocean acidification results from carbon dioxide added to earth's atmosphere being absorbed by ocean waters. Roughly a third of the carbon dioxide added to earth's atmosphere from human causes has been absorbed by ocean waters. The capacity of the ocean to absorb and be a "sink" for atmospheric carbon dioxide will decrease in the 21st century. Although ocean acidification and climate change are often lumped together, they are by no means the same thing. This ocean "sink" has slowed the accumulation of carbon dioxide in our atmosphere and its effects on earth's climate, but the result is a change in the chemical balance of seawater that is unique to the ocean environment. More information about the potential effects of both global climate change and ocean acidification on Oregon's nearshore species and habitats can be found in the 2012 supplements to the Oregon Nearshore Strategy (see Appendices A-D).

Carbon dioxide dissolved in seawater is a component of an equilibrium chemical reaction. The balance shifts to create more carbonic acid as the amount of dissolved carbon dioxide increases. More acidic seawater decreases the availability of the carbonate ion building blocks that are necessary for marine organisms to form their skeletons and shells (see diagram). Deep ocean waters naturally have lower carbonite ion availability and are more acidic. Spring and summer upwelling that brings deep nutrient rich waters to Oregon's nearshore waters also brings more corrosive acidic waters. Exposure to more acidic water has been shown to inhibit shell formation, reduce individual size and population abundance, and to cause behavioral changes that affect survival in marine organisms. California mussels, gooseneck barnacles, pelagic marine snails called pteropods that are food for salmon, hermit crabs and marine fishes are among the organisms for which these effects have been documented. A new study conducted at NOAA's Northwest Fishery Science Center found that ocean acidification may slow development and reduce survival of Dungeness crab larvae.

The video Ocean Acidification – Changing Waters on the Oregon Coast provides information on the causes of ocean acidification, its effects on marine life in our coastal waters and why Oregon is at the forefront of these changes taking place in our oceans.

The major findings and recommendations of the West Coast Ocean Acidification and Hypoxia Science Panel, released in April 2016, provide additional information and steps that can be taken to address this issue.