# 3.2 Summary of Current Status and Health of Oregon's Marine Ecosystems

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## Report Card

Trends for some indicators illustrate the significant adverse effects that human activities can have on marine ecosystems; conversely, other indicators demonstrate that strong protection can lead to species and habitat recovery. Concerns about possible long-term cumulative effects on ecosystems and resources are raised by other indicators, but also illustrate the high scientific uncertainty associated with limited data availability and predictive ability.

- Some stocks of groundfish are overfished, requiring strong management measures to promote recovery, a process that may take a decade or more of reduced fishing pressure and habitat protection. As a result, the segment of the industry dependent on groundfish is in an economic crisis with little hope of quick recovery.
- Bottom trawling is intense in some offshore areas, but possible adverse impacts on marine habitats and species are uncertain and need to be investigated.
- Marine mammal populations are healthy due to effective species and nearshore habitat protection measures, as well as plentiful food supply.
- Rocky shores are protected from some potential disturbances, but offshore rocky reef habitats that may be important as fish refugia or rearing areas have no special protection; the need for such measures should be reexamined.
- Data on the recurrence and severity of harmful algal blooms is inconclusive, but the potential risks to human health associated with toxins that cause shellfish poisoning in humans make it important to monitor this threat.
- Shoreline armoring after episodes of coastal erosion is increasing along parts of the coast, cutting off the supply of new sand to many beaches; if this trend persists, and sea level continues to rise as expected, some ocean beaches will gradually narrow and be lost to wildlife and recreation use.

### Indicators

1. Exploited fish and shellfish stocks (condition and landing trends).
2. Bottom habitat degradation (trawl areas and intensity).
3. Marine mammals (pinniped population trends).
4. Kelp forests (location, area, and biomass).
5. Marine protected areas (number and area).
6. Harmful algal blooms and toxic shellfish (recurrence and severity).
7. Shoreline armoring and beach loss (armored miles and trends).

# Introduction

Oregon's coastal ocean is part of the larger ecological transition zone known as the Northern California Current Large Marine Ecoregion, an area strongly influenced by both subarctic waters of the Gulf of Alaska and the warmer, subtropical waters off California. Fueled by intense upwelling during summer months, this transition zone is highly productive and rich in natural resources. Familiar exploited species in the region include salmon, crab, shrimp, groundfish, and tuna, along with a complex assemblage of lesser-known organisms adapted to a variety of water column, rocky substrate, and soft bottom habitats. The many thousands of species that make up this assemblage—from microscopic plankton to harbor seals—are intricately linked to one another through the marine food web, and to natural variations in climate and ocean conditions.

People have harvested the ocean's seemingly inexhaustible living resources for thousands of years. Commercial fisheries are still the most visible and important ocean industry for Oregon, whether measured in numbers or pounds of fish caught, dollar value for commercial catches at the dock, or in personal income generated in fishing communities. Fishery resources harvested commercially in local waters are diverse in terms of the numbers of species taken, areas fished, and the type of gear used. Although still one of the mainstays of the coastal economy, the fishing industry has been plagued with problems in recent years, ranging from poor ocean conditions for food production, to declining stocks and catches, and too many fishing boats.

Recreational fishing from private boats and passenger-carrying charter boats is also a significant contributor to the coastal economy in many communities. In the past, salmon were the prime recreational fishing targets, mostly in nearshore waters, but salmon closures and endangered species listings have led to increased emphasis on rockfish, ling cod, halibut, and tuna. Tourist-oriented sightseeing trips focusing on whales, marine mammals, and birds are also an increasingly important ocean charter activity.

As with fishing, marine transportation has been an important use of the ocean for thousands of years, as nations of the world established and expanded trade, and exercised military might to establish far-flung empires. Today, marine transportation is still a very important use of coastal waters. Several thousand ships and barges each year transit along the Oregon coast, calling on coastal and Columbia River ports, delivering cargo, and moving export cargo to distant destinations.

Oil and gas, marine mineral, and kelp resources are also found along the Oregon coast and offshore, but exploitation of these resources has not proved to be economic or has been precluded by state or federal action.

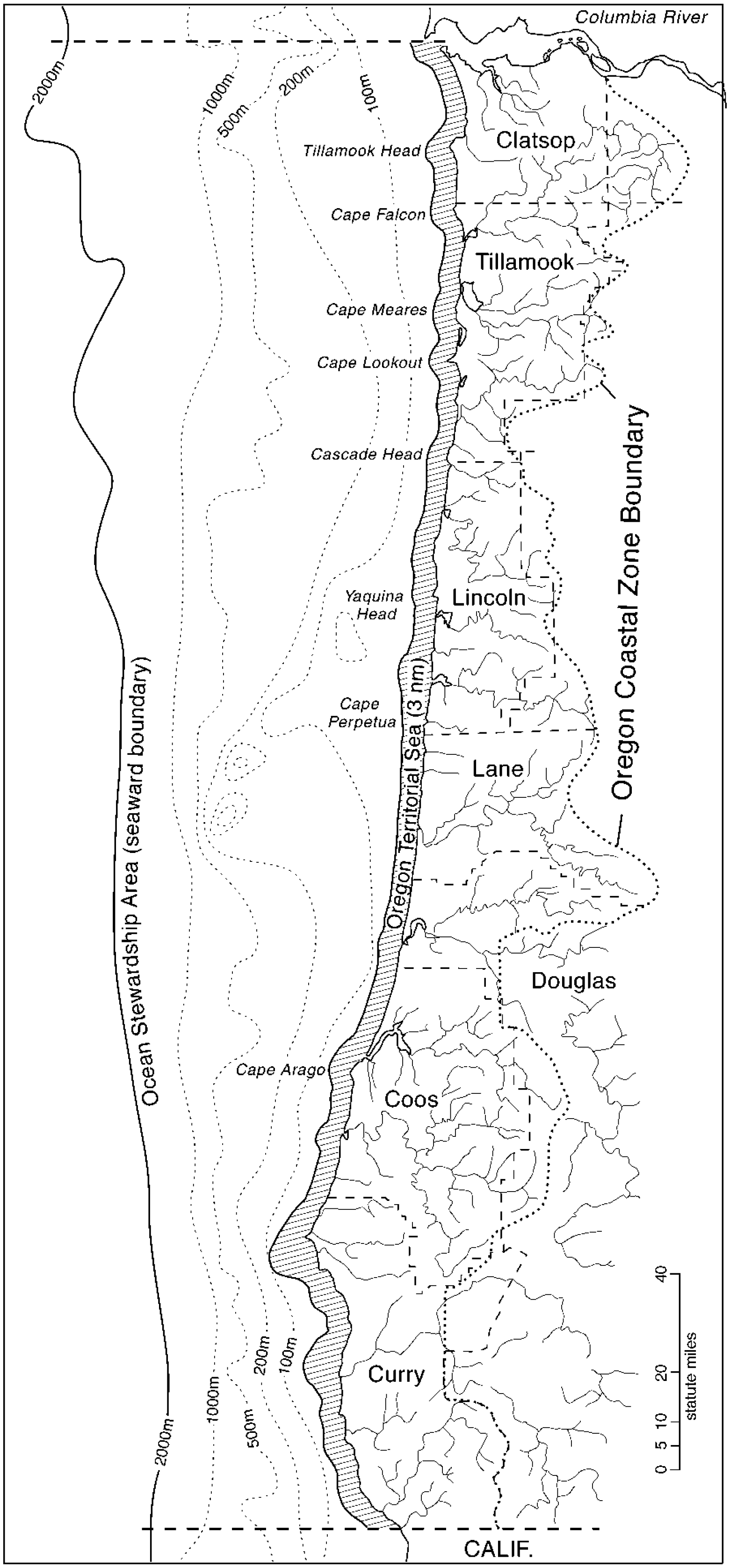
Ocean resource use is governed through a complex framework of international agreements, the U.S. Constitution, federal and state laws, agency rules and regulations, and numerous judicial decisions. The State of Oregon has jurisdiction over natural resources within the territorial sea, which extends three nautical miles seaward of the shore and encompasses more than 1,100 square miles. The federal government retains control over navigation, commerce, pollution, and national security in this nearshore zone and beyond. From three to 200 nautical miles offshore—an area known as the Exclusive Economic Zone (EEZ)—resources are under exclusive federal ownership and jurisdiction, although federal resource managers are required to consult with Oregon on decisions that affect the state's coastal zone. Federal resource management in the EEZ is fragmented, with separate, poorly coordinated regimes for oil and gas, fisheries, marine mammals, navigation and transportation, and pollution control. In contrast, state-level management in Oregon is relatively well integrated, due to farsighted ocean policy adopted in 1977 as part of the Oregon Coastal Management Program (OCMP), ocean planning legislation passed in 1987, development of the Oregon Ocean Plan in 1990, establishment of an Ocean Policy Advisory Council in 1991, and preparation of a Territorial Sea Management Plan in 1994. In the Ocean Plan, Oregon identified an Ocean Stewardship Area (**Figure 3.2-1**), extending from the coast to the edge of the continental margin at 6,000 feet depth. It is within this area that Oregon has "staked out" its interest in marine ecosystem and resource management. This claim is given force by federal consistency provisions of the 1972 Coastal Zone Management Act, which give states with approved coastal management programs a strong say in offshore activities.

## Definition and indicators of marine ecosystem health

Marine ecosystems are healthy when they provide for sustained biological productivity and essential ecological processes, and the maintenance of biotic communities, native species, and genetic and demographic diversity. From a more human-centered perspective, healthy oceans provide sustainable yields of fish, shellfish, wildlife, and many other species they depend upon; as well as sustainable flows of other valued goods and services, such as marine recreation, and pollution assimilation. Still another way of viewing marine ecosystem health is from the policy perspective: are public and private decisions that have potential to affect that health consistent with state and national law and standards?

The use of indicators to evaluate marine ecosystem health has its limitations. First, these dynamic ecosystems exhibit great natural variability at multiple space and time scales. This variability, and our limited (but growing) understanding of it, make it difficult to define indicators of ecosystem health that

**Figure 3.2-1. Oregon's coastal ocean, showing the territorial sea (shoreline to three nautical miles) and the Oregon "Ocean Stewardship Area" (shoreline to the 2000-meter depth contour).**



discriminate between natural and anthropogenic responses to stressors. For example, to what extent can we attribute fishery declines to natural variability in ocean productivity in response to climate shifts as opposed to fishing pressure or habitat damage? These and similar questions are subjects of ongoing, often lively, debate. The lack of good baseline data for some indicators and infrequent monitoring of ocean conditions present additional challenges. Despite these and other limitations, much can be learned from compiling, organizing, and analyzing the data that are available.

The choice of indicators was based on their *significance* as measures of ecosystem health or condition, their *sensitivity* to environmental change, and the *availability of sufficient data* to at least speculate about the direction of change. Seven indicators of marine ecosystem health were selected that fit these criteria (**Table 3.2-1**). Although they might not be ideal measures, collectively the indicators provide insights about the health of Oregon's nearshore ocean ecosystems. Six of the indicators measure aspects of physical or biological structure and function. Five are directly or indirectly related to goods and services society values—plentiful fish and shellfish resources or beach recreation are examples. Four of the indicators also measure the outcomes of environmental policies designed to protect marine ecosystems and resources.

## Current conditions and trends

**Indicator 1: Exploited fish and shellfish stocks (condition and landing trends).** Most marine fish stocks are distributed in federal waters and are managed by the Pacific Fishery Management Council and the National Marine Fisheries Service. Currently, several species of commercially and recreationally important groundfish are overfished and several other stocks are below target levels of spawning stock biomass (**Figure 3.2-2**). The condition of many other species is unknown because a formal stock assessment has not been conducted.

Landing data for major species groups vary significantly over time (**Figure 3.2-3**), although these variations do not necessarily

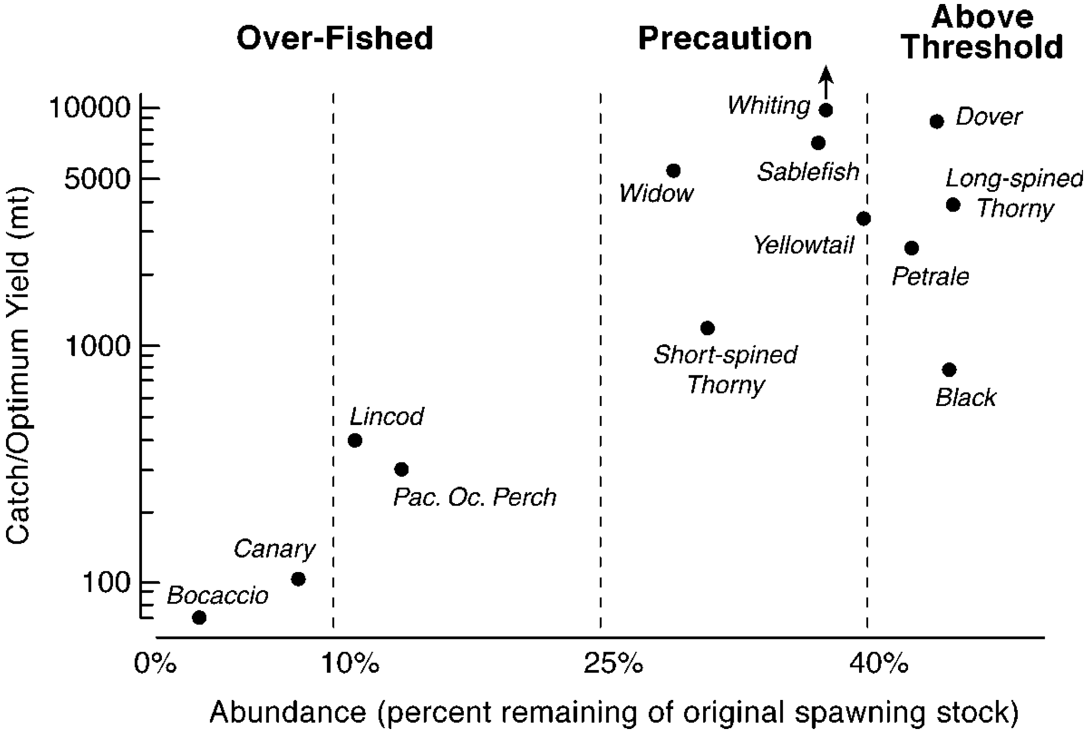
**Table 3.2-1. Marine ecosystem health indicators: type, frame of reference, significance, and data sources.**

| Indicator and Type[1] | Reference Condition | Significance | Data Sources |
|---|---|---|---|
| 1 – Exploited fish and shellfish stocks (condition and landing trends)<br>Type 1, 2, & 3 | Original spawning stock estimates | Illustrates combined effects of natural and human stressors; measures success in managing harvests of food fish | ODFW, 1999<br>PFMC, 1999<br>Steve Berkeley, pers. com. 1999<br>Hal Weeks, pers. com. 1999 |
| 2 – Bottom habitat degradation (trawl area and intensity)<br>Type 1 | Pre-fishing conditions (no habitat alteration) | Shows areas trawled, not actual impacts; does serve as basis for designing future studies of issue | Engel and Kvitek, 1998<br>Freidlander, et al., 1998<br>Waldo Wakefield & Allison Bailey, pers. com., 1999 |
| 3 – Marine mammals (pinniped population trends )<br>Type 1 & 3 | Pre-Euro-American settlement native species | Measures health of species populations and habitat and food conditions | Brown, 1997<br>Robin Brown, pers. com., 1999 |
| 4 – Kelp forests (location, area, and biomass)<br>Type 1 & 2 | 1954 kelp survey as baseline | Keystone species for nearshore rocky reefs; change in biomass and area indicate change in carrying capacity for nearshore environment | Waldron, 1955<br>Ecoscan, 1991<br>ODSL, 1993<br>ODFW, 1998 |
| 5 – Marine protected areas (number and area)<br>Type 2 & 3 | No protection | Shows degree of protection provided to critical marine habitats and marine biodiversity | OPAC, 1994<br>ODFW, 1998<br>O'Keefe, 1999. |
| 6 – Harmful algal blooms (HABs) and toxic shellfish (recurrence and severity)<br>Type 1 & 2 | Natural regime for HABs | Indicator of changing ocean conditions, and of human health risk | Michelle Wood, pers. com., 1999<br>Chris Czeisla, pers. com., 1999 |
| 7 – Shoreline armoring (armored miles and trends)<br>Type 1, 2, & 3 | Natural, unarmored shoreline | Public beach encroachment and potential loss of sand supply, threatening recreational beaches | CNHPWG, 1994<br>Good, 1994 |

[1] Indicator Type 1: Ecosystem structure- and function-based; Type 2: Ecosystem goods- and services-based; Type 3: Environmental policy-based

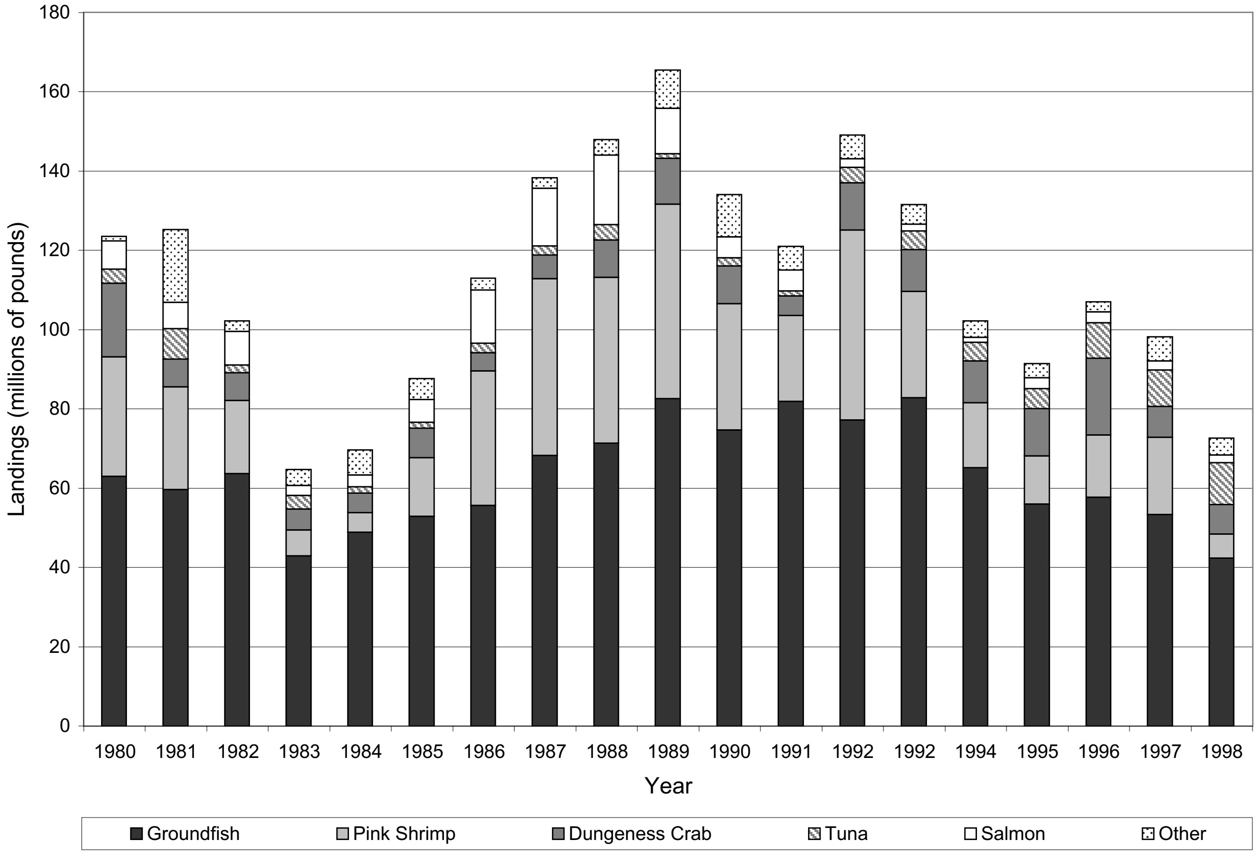
reflect the health of the marine ecosystem. Many factors affect landings including ocean conditions, long term biological cycles, market conditions, and harvest restrictions. Increased landings of albacore tuna reflect elimination of the high seas drift net fishery, warmer ocean temperatures closer to shore, and increased fishing effort as other stocks of fish have declined. Albacore tuna are distributed and fished throughout the entire Pacific Ocean basin, so landings in Oregon probably have little impact on overall stock condition. Recent pink shrimp landings are about one-third the landings in the 1980s, reflecting both the impacts of the fishery and a low period in the production cycle of this species. Dungeness crab landings vary by a factor of four or more over the time period (Figure 3.2-3), but this variation probably reflects natural production cycles more than the impact of fishing or marine environmental health, although these factors cannot be dismissed out of hand. Whiting landings, not shown in Figure 3.2-3, have increased dramatically after a concerted effort was made to develop a market for this species (primarily used for surimi). Whiting now dominates Oregon landings, with 158 million pounds landed in 1998, or more than double the rest of marine fisheries combined. Groundfish, the most important of which are sablefish, rockfishes, flat fishes, and ling cod, have shown a decreasing trend over time, re-

**Figure 3.2-2. Status of assessed groundfish stocks based on the Pacific Fishery Management Council harvest policy, showing overfished status for four stocks, and precautionary status for five stocks.**



(PFMC, 1999)

**Figure 3.2-3. Oregon commercial fishery landings, excluding Pacific whiting, 1980-1998.**



(ODFW, 1999)

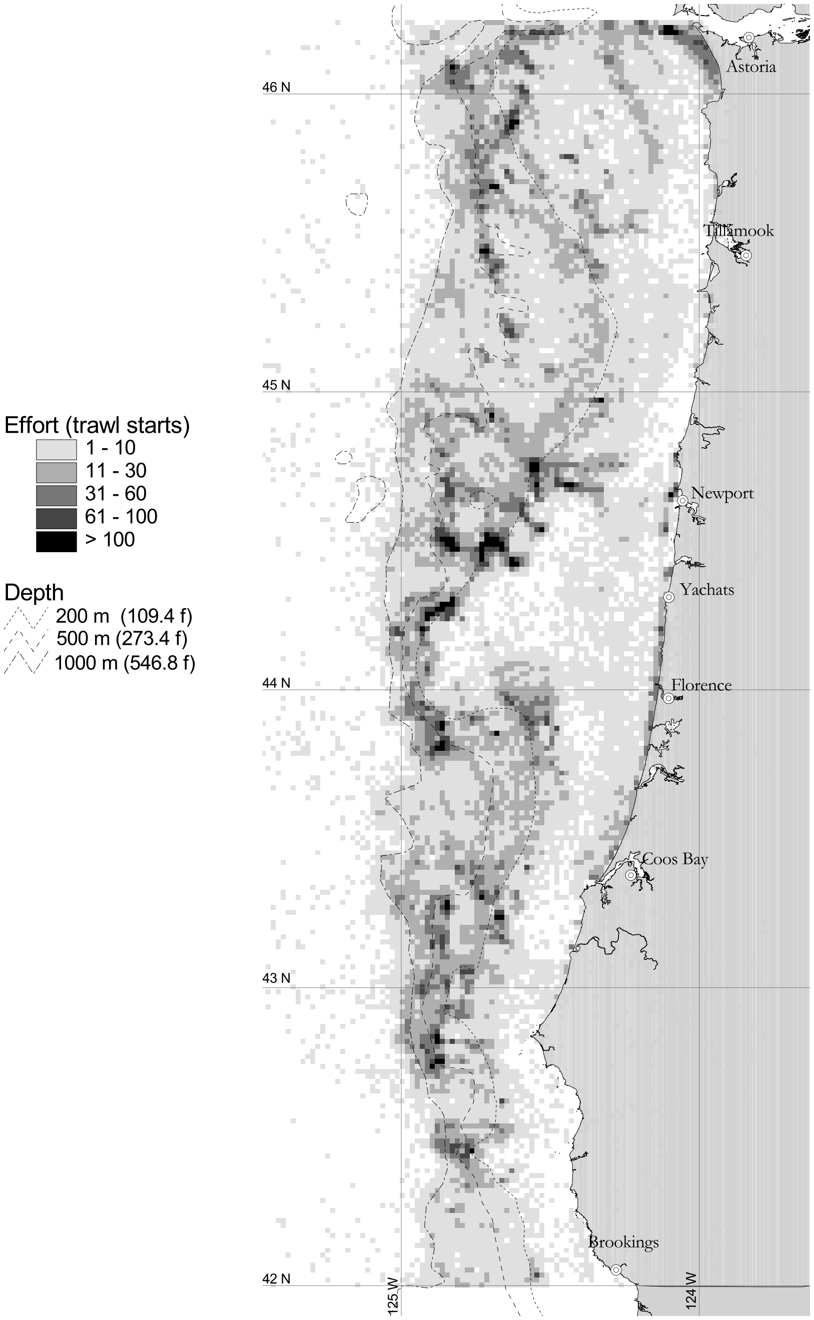
flecting declining stock sizes due to fishing and much-reduced harvest quotas implemented to prevent further declines. Although total marine fishery landings remain high due to the very large volume of Pacific whiting, the decline in other marine fisheries, especially several of the groundfish species, suggests that some parts of marine ecosystems are distorted and not functioning well.

**Indicator 2: Bottom habitat degradation (trawl areas and intensity).** Over the past two decades, concern has increased over the effects of fishing gear on marine bottom habitats. Although no studies have been conducted in Oregon waters, recent work off California (Engel and Kvitek, 1998; Freidlander et al., 1998) and studies from other regions suggest that mobile fishing gear (1) decreases structural diversity of the seafloor; (2) stirs up sediments, potentially altering biogeochemical cycles; and (3) reduces biodiversity while enhancing abundance of opportunistic species.

Although we do not have local data on the effects of fishing gear on bottom habitat, we do know how often different areas are fished. Examination of fisher log book data on bottom trawl starts on one square nautical mile grid cells for a ten-year period shows that fishing pressure is fairly evenly spread out along the coast (**Figure 3.2-4**) (Wakefield and Bailey, National Marine Fisheries Service, unpublished data, 1999). There are concentrations of bottom trawling near the 200 m to 500 m depth contours off Newport, Yachats, Florence, and south of Coos Bay, and few areas inside the 1000 meter contour that have not been trawled. Year-to-year analysis of these data show that trawl starts actually decreased about 15 percent from the early to late 1990s, and that the number of trawl starts in deep water (below 700 meters) increased dramatically in late 1980s, but has since leveled off. The number of trawl starts is now about equally divided among depth zones.

In examining the summaries of trawl start data, it is important to recognize that a map of the distribution of bottom trawl starts for specific blocks of time does not translate directly into a map of adverse impacts of mobile fishing gear on bottom habitats off Oregon. Although trawls do make contact with the bottom, we do not know to what extent this has a negative impact on the physical habitat or the biota. Further, distribution of trawl starts may not reflect impact on the bottom because some habitats and areas are no doubt more sensitive to trawling

**Figure 3.2-4. Bottom trawl fishing effort off the Oregon coast, as indicated by number of trawl starts for 1-minute latitude cells for a ten-year period (1988-97).**



Fishing Data: Oregon Department of Fish and Wildlife Trawl Logbooks
Bathymetry Data: General Bathymetric Chart of the Oceans (GEBCO)
Data Compilation and Cartography: Alison Bailey, NOAA, NMFS, Northwest Fisheries Science Center

than other areas. The fact that the same areas continue to be trawled and continue to produce fish suggests that trawling may not damage the habitat. The uncertainty in these data illustrates the critical need for more thorough investigation of the impacts of mobile fishing gear on different types of bottom habitat off Oregon.

**Indicator 3: Marine mammals (pinniped population trends).** Populations of harbor seals and the endangered Steller sea lions, both of which breed and pup along the Oregon coast, have risen dramatically in the past 25 years to what may be near historic abundance levels (Brown, 1997). Since passage of the Marine Mammal Protection Act in 1972, harbor seal numbers in Oregon have increased from about 2,500 to nearly 10,000. Populations of Steller sea lions, listed as a *threatened* species from California to Southeast Alaska, and as *endangered* west of the Gulf of Alaska, have declined significantly since the mid-1960s throughout most of its range. The exception is southern Oregon, where numbers have steadily increased from about 2,000 animals in the late 1970s to over 4,000 currently. Over the past dozen years, northern elephant seals have also begun to appear, bearing their young at Shell Island near Cape Arago, the most northerly known pupping site for this species. California sea lions do not breed north of San Francisco, but large numbers of male sea lions move northward into Oregon, Washington and British Columbia in the late summer following the breeding season. The four-fold increase of animals passing through Oregon reflects increased breeding population numbers in California.

In contrast to these successes is the story of the sea otter, a keystone species extirpated from the coast of Oregon in the 1800s. An attempt to reestablish sea otters in Oregon in the 1970s was unsuccessful.

**Indicator 4: Kelp forests (location, area, and biomass).** Rocky subtidal regions along the central and southern Oregon coast provide superb habitat for forests of bull kelp (*Nereocystis luetkeana*). Oregon's kelp forests serve an important role in the provision of habitat and food for diverse and productive communities. Among them are seabirds, shorebirds, marine mammals that rest and feed in the surface raft of floating kelp bulbs and fronds, mid-water communities of rockfish, perch, invertebrates, and epiphytes that inhabit the kelp forest canopy, and benthic communities composed of bottom fish, sea urchins, sea stars and understory algae. The ecological value of Oregon's kelp forests as a complex three-dimensional aquatic habitat for marine organisms extends far beyond the modest commercial value of harvestable kelp.

A sequential series of aerial surveys conducted at three offshore reefs indicate that the Orford Reef kelp forest is consistently larger than the beds located at Rogue Reef and Cape Blanco, and that annual variability in the overall size of the kelp canopy is considerable (**Table 3.2-2**). Detailed surveys of kelp canopies by ODFW at five offshore reefs (Cape Blanco, Orford Reef, Redfish Rocks, Humbug Mountain, and Rogue Reef) demonstrated that interannual differences in kelp biomass are dependent upon yearly changes in the spatial extent of kelp canopies and variation in the density of individual kelp plants. Consequently, estimates of the spatial extent (surface area) of kelp forests alone are not a good indicator of the annual biomass (weight) of the kelp plants (ODFW 1998).

Experimental commercial leases for kelp harvest have proved inconclusive about the effects of harvesting bull kelp. Significant questions remain regarding the ecological impacts of sustainable harvests and late-seasonal thinning on the quality of surface habitat, rates of recovery and growth, and the structural arrays of stipes and fronds that support kelp forest communities.

**Indicator 5: Marine protected areas (number and area).** The designation of protected areas is an important tool for preserving marine ecosystems, habitats, and biodiversity. Most protected areas in Oregon are small, do not exclude all uses and activities, and are not designed to protect ecosystems or biodiversity. Rather, they are special management areas, with some limitations designed to protect critical habitat and species. Protected areas, if large enough, can serve as buffers against management misjudgments in multiple-use areas, for example, by providing refugia for reproducing populations of exploited fish species. In some cases protected areas might even increase take levels of exploited species outside the protected area by safeguarding spawning areas and maintaining a natural size and age population distribution.

Many rocky intertidal areas along the coast are "protected" by virtue of their isolation and lack of access. Others are easily accessed and threatened by overuse, prompting their des-

**Table 3.2-2. Area estimates for three Oregon bull kelp forests in hectares (ha[1])**

| Kelp forest location | 1990 ha | 1996 ha | 1997 ha | 1998 ha | 1999 ha |
|---|---|---|---|---|---|
| Cape Blanco | 101 | 33 | 112 | 102 | 283 |
| Orford Reef | 313 | 66 | 159 | 145 | 670 |
| Rogue Reef | 78 | 67 | 29 | 52 | 304 |

[1] One hectare equals 2.47 acres

(ODFW, 1998; David Fox, pers. com., 2000) ignation as Marine Gardens. These include Haystack Rock in Cannon Beach, Cape Kiwanda, Otter Rock, Yaquina Head, Yachats, Cape Perpetua, and Harris Beach. The taking of invertebrates—mussels, clams, and such—is prohibited in these areas. In other less-protected areas, there are limits on the take of food invertebrates, and interpretive signs discourage the collection of tidepool animals such as sea stars (Oregon Territorial Sea Management Plan, 1994).

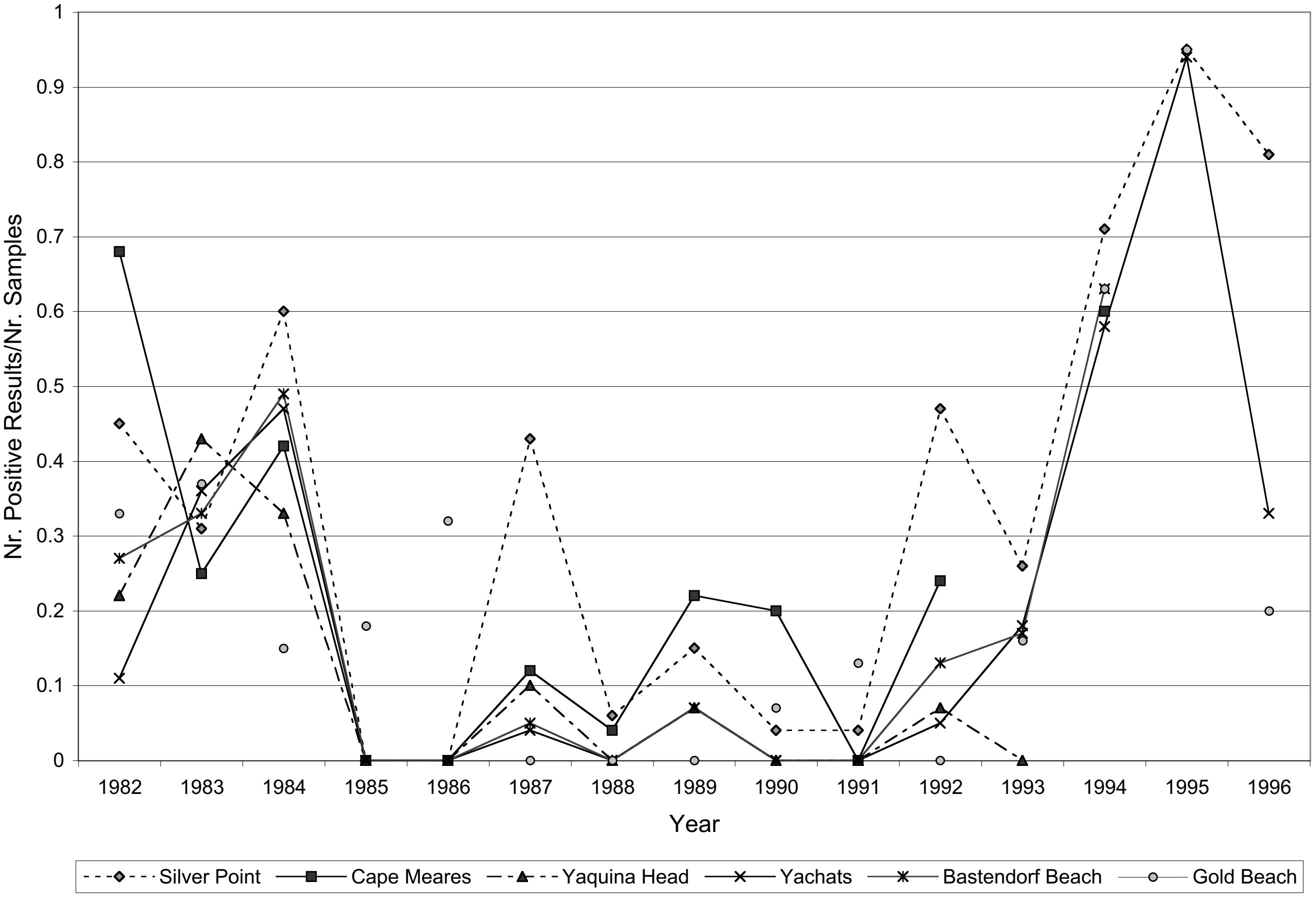
The offshore rocky islands that provide valuable bird nesting habitat and marine mammal breeding grounds, are well protected by Three Arch Rocks and the Oregon Islands National Wildlife Refuges. The more than 1,400 rocks, reefs, and islands in the Oregon Territorial Sea are included in these refuges. Currently, however, neither shallow- nor deep-water marine habitats are designated as protected areas. Although marine sanctuaries and reserves have been proposed in the past, primarily to protect spawning and rearing areas for bottom fish, none have been established, due in part to fishing industry opposition.

**Indicator 6: Harmful algal blooms and toxic shellfish (recurrence and severity).** Molluscan shellfish—clams, mussels, and the like—are particularly good indicators of marine water quality. These filter-feeding organisms accumulate particles from the water column in their tissue and thus serve as sentinels for the presence of toxins or other pollutants. Often these toxins or pollutants occur in the water because particular species of algae or plankton have reached unusually high concentrations and become harmful algal blooms or HABs. Because the population dynamics of the planktonic food sources for shellfish are governed by ocean conditions, it is clear that HABs and shellfish toxicity are linked to the processes that govern the productivity of the coastal ocean.

One toxin of special interest is saxitoxin, which is responsible for Paralytic Shellfish Poisoning (PSP). PSP appears first in shellfish on the open coast and may then spread to adjacent estuaries. PSP shows considerable year-to-year variability in the frequency, intensity, and duration of toxic events (**Figure 3.2-5**). Another toxin, domoic acid, is also responsible for shellfish-related illness, but incidence data are sparse.

**Indicator 7: Shoreline armoring and beach loss (ar-**

**Figure 3.2-5. Saxitoxin at six sites along the Oregon coast over a 15-year period, showing the highly variable frequency, intensity, and duration of toxic events.**



(Woods, unpublished data, 1999)

**mored miles and trends).** Oregon's beaches as we know them today have been in their proximate location for about the last 6000 years, when sea level stabilized after the last glacial period. During the relatively rapid rise in sea level, the coast retreated, and easily eroded dunes and marine terraces cut back more rapidly than the older, erosion-resistant rocks that form headlands today. These headlands divide the coast into a dozen separate pocket beach segments or "littoral cells". Each of these littoral cells is more or less isolated from the others, with relatively independent sources and sinks of beach sand.

Although large, infrequent earthquakes no doubt have dramatic physical impacts on Oregon's coastlines, the main physical processes that shape the coast today are large, storm-generated waves, high water levels, and strong nearshore currents that cut into and lower beaches, erode dunes, and undermine bluffs. Erosion at the base of bluffs in turn leads to slumping or major slides in geologically unstable areas. Erosion of dunes and bluffs and the redistribution of the eroded sand within littoral cells are natural processes that help maintain the physical integrity or size of beaches.

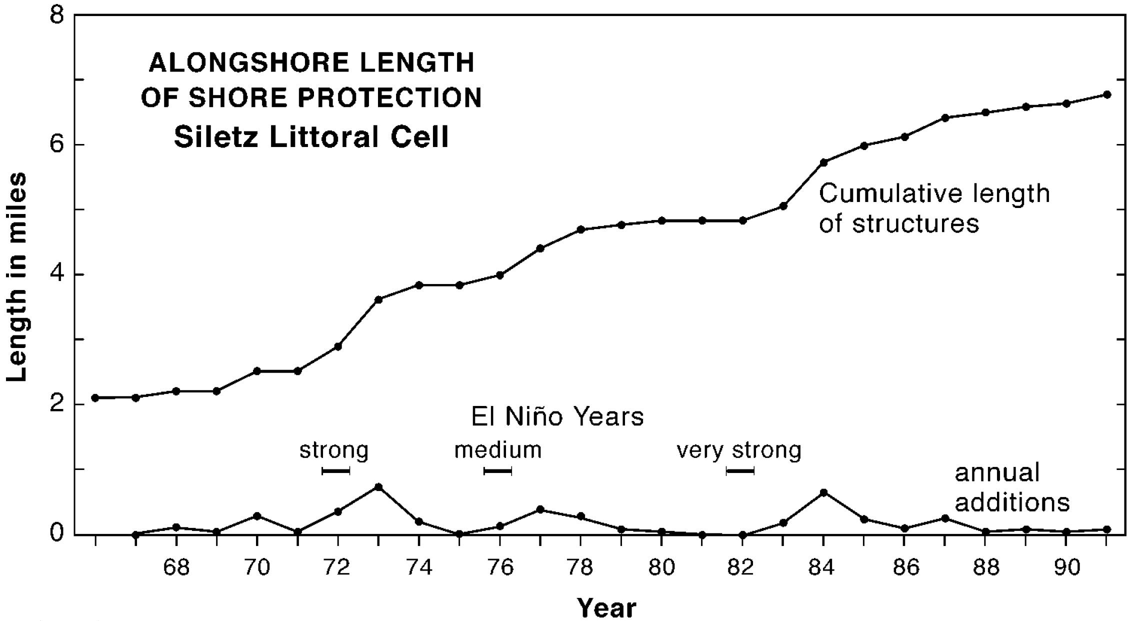
When the coast was sparsely populated, coastal erosion and landslides were viewed as natural events—something to be avoided when building on coastal lands. But as coastal lands were developed more extensively, particularly along oceanfront beaches, erosion and sliding were reclassified as "natural hazards"—something to be controlled in order to protect property. In recent times, that control has involved the construction of large rock walls called "riprap revetments" that extend along and out onto the public beach. Many miles of riprap revetments have been built along the Oregon coast in recent decades and the pace of new construction is steady and probably increasing (Good, 1994).

Oregon Parks and Recreation Department, the state agency that regulates shoreline armoring and other beach construction, has issued nearly 500 permits since 1967, when the Oregon Beach Law established the regulatory program to protect public access and prevent private encroachment on public beaches. Data on shoreline armoring is not available for the entire coast, but a case study of the Siletz littoral cell in north Lincoln County found that at the present rate of armoring, the entire cell would be hardened by 2030 (**Figure 3.2-6**; Good, 1994).

## Strengths, threats, and information needs

The deteriorating condition of a number of marine fish stocks is cause for concern about the overall health of Oregon's marine ecosystem. Coastal coho salmon and some stocks of steelhead and sea run cutthroat trout are listed as threatened under the Endangered Species Act. The health of these stocks is affected by natural variability in ocean conditions, as well as a host of other factors—fishing pressure, mortality at dams, poor habitat conditions in estuaries and watersheds, and more. Although not a reflection of marine ecosystem health, the condition of these stocks nevertheless affects the ability of the marine ecosystem to provide the goods and services people

**Figure 3.2-6. Cumulative and year-to-year length of shore protection structures constructed in the Siletz littoral cell (<1967-1991), showing periodic El Niños and post-El Niño surges of shore protection structure construction.**



(Good, 1994)

expect. For other species, such as rockfish, declines are most likely due to overfishing as well as underestimates of population size and reproduction rates. The most significant risk to condition of fish stocks is our very limited understanding of the complex interactions of natural and human-caused changes in stock health. Furthermore, we understand very little about species and habitat associations and needs, and recruitment and rearing requirements of species and species complexes.

Federal law mandates that the regional fishery management councils that manage fisheries in federal waters to manage for the maximum sustained yield as reduced by relevant social, economic or ecological factors. Attempting to determine a maximum sustainable yield in a dynamic and changing ocean environment with an inadequate research base is a continuing problem. In practice, many stocks around the nation have declined as a result of overfishing. In part this resulted from ecological ignorance, in part from ineffective management measures, and in part from intense political pressure from fishers and others who have a financial interest in maintaining harvest levels. Recent management measures have turned attention to the recovery of West Coast salmon stocks (particularly coho salmon) and rebuilding of several groundfish stocks. These measures will require careful monitoring and evaluation for perhaps a decade or more—at least long enough to allow salmon habitat to recover, and to permit the rebuilding of slow growing rockfish species. Sustainable fisheries, and the economic benefits they provide to fishermen and to coastal communities, are dependent on healthy stocks of fish and the ecosystems that produce them. However, moving toward sustainability is a socially and economically painful process, as shown by the present “crisis” in the groundfish industry.

Additional research on fish stocks and impacts of fishing gear is needed to achieve sustainable fisheries, including (1) increased data collection on species for which stock assessments have not been conducted due to lack of data; (2) habitat-specific distribution and associations of all rockfish and other groundfish species; (3) life history characteristics and basic biology of all the commercial groundfish species to obtain better understanding of the ecology of these diverse communities; (4) sources and sinks for groundfish larvae and spatial patterns of recruitment to allow scientists to evaluate the potential of marine reserves as management tools; (5) studies on food and habitat requirements of all life history stages of the principal groundfish species to allow us to shift from single species to ecosystem management; (6) data on the impacts of bottom trawls and other mobile fishing gear on benthic invertebrate communities; (7) studies of the physical damage done by bottom trawls on different types of bottom habitat; (8) other biological and chemical impacts of bottom trawls on habitat.

The dramatic resurgence in marine pinniped numbers and expansion of the range of some species since implementation of the 1972 Marine Mammal Protection Act and protection of offshore rock and island breeding habitat suggest that strong management measures have clearly offset the effects of natural variability and human-caused stressors—oil spills, marine debris, other pollution, and direct harassment. Increased numbers and expanded ranges (e.g., the northern elephant seal) also testify to the abundance of food sources and the overall health of the nearshore marine ecosystem.

Oregon’s kelp forests are a dynamic and ecologically important site-based marine resource located on submerged rocks and reefs administered under the Oregon Territorial Sea Plan (1994). The kelp beds are subject to the requirements of Oregon Statewide Planning Goal 19 (ORS 197.180), and consequently, bull kelp forests and their associated subtidal marine habitats and communities must be managed for the sustained yield of renewable resources. Oregon’s marine and coastal resource managers currently lack sufficient scientific information to characterize annual variability in the location and spatial extent of kelp forests, and to understand the functional role served by kelp forests in the dynamics of nearshore marine fish, mammals, and invertebrate communities. Additional descriptive information and results from controlled field experiments are needed to assist the next generation of coastal resource managers with sound decisions. Examples of needed research include (1) annual aerial and water-based surveys of the location, spatial extent, plant density, and overall biomass of representative kelp forests in southern and central Oregon, (2) comprehensive descriptions of habitat use of kelp forests by communities of seabirds, shorebirds, marine mammals, fish, and invertebrates, (3) empirical studies to gain increased understanding of the dynamics and interactions among members of plant and animal communities that inhabit kelp beds, and (4) annual estimates and future predictions of commercial and recreational use of kelp forests and their associated nearshore subtidal rocky reefs .

Oregon’s marine protected areas have not substantially changed in size or degree of protection in recent years. With increasing human population, coastal development, and recreation use of marine environments, more protection may be needed, particularly for unprotected nearshore reef ecosystems threatened by overfishing, habitat alteration, oil spills, and dredged material disposal. Difficulties in establishing protected areas in the ocean result from the dynamic, fluid, nature of the habitat and the hesitancy to unnecessarily restrict take of exploitable species, although protection of spawning and nursery areas might actually increase overall take. Political acceptance of increased protection is also a major issue.

The seven Marine Garden designations for sensitive rocky intertidal areas provide some protection to these habitats. However, extensive tourist visitation can damage fragile tidepool organisms and some sites are in danger of being loved to death. Pollution from outside the gardens is also a threat, as demonstrated by the wreck of the New Carissa in winter 1999.

Oregon's rocky islands are protected as part of the National Wildlife Refuge system. Protection, however, only extends down to the mean high water line. A 500-foot buffer zone around the rocks and islands is closed during summer to protect breeding birds and stellar sea lions, affording some protection to subtidal habitat and species as well.

Analysis of limited data on historical trends in the appearance of saxitoxin and domoic acid in estuarine shellfish, seems to follow the earlier appearance of the toxins in mussels or razor clams on the open exposed coast adjacent to the mouths of the estuaries. Given the current state of knowledge regarding the sources and population dynamics of the harmful algal bloom species responsible for Amnesiac Shellfish Poisoning (ASP) and Paralytic Shellfish Poisoning (PSP), it is difficult to assess the future risks to estuarine shellfish from these sources. Algae or plankton producing saxitoxin (toxin in PSP) are known to form resting stages which, in other regions of the world, serve as "seed stocks" to initiate toxic blooms. In Oregon there is no data on where these seed stocks may be located. Enhanced spatial and temporal shellfish monitoring would greatly enhance the ability to assess risks and threats.

Construction of revetments and seawalls along ocean beaches can have a number of adverse effects, blocking public access to or along the beach and worsening erosion on unprotected adjacent property. In the long term, however, it is the gradual cutting off of natural sand replenishment processes that may be the most significant effect these structures have on Oregon beaches (Good 1994). Shoreline areas most at risk are the north and central Oregon coast areas from Cannon Beach to Yachats. These are areas where beachfront lands are mostly in private ownership, where erosion has been most severe in recent decades, and where relative sea level has been on the rise during most of the 20th century. Global sea level rise is expected to accelerate as the 21st century wears on, moving the high water line ever landward. These factors, combined with diminished sand supply associated with shoreline armoring, threaten the health and physical integrity of one of Oregon's important natural resources—its ocean beaches.

Policy statements in the Oregon Beach Law and Oregon's land use program would seem to provide for public beach resources and promote avoidance of natural hazards along adjacent uplands. In practice, however, local comprehensive plans do not really advance hazard avoidance. Instead, development decisions directly or indirectly promote shoreline armoring by allowing variances to setback requirements that put buildings and infrastructure in harms way (CNHPWG 1994).

## Projections and conclusions

- Some groundfish stocks are likely to continue at depressed levels unless strict management controls continue to be applied. Recovery of these long-lived species may take a decade or more of reduced fishing pressure and habitat protection. As a result, the segment of the industry dependent on groundfish is in an economic crisis with little hope of quick recovery.
- Although only limited data exist on the impact of fishing on bottom habitat, high levels of fishing effort with bottom trawls and other fishing gear may be adversely affecting the productivity of the habitat that supports bottom fishes. If so, the carrying capacity of the habitat may be degraded and rebuilding stocks to previous levels may not be feasible or may take much longer than expected.
- Recent weather patterns may be signaling a major decadal climatic shift toward wetter, cooler conditions, and ocean conditions that are more favorable to salmon survival. If so, coho stocks may recover to 1970s levels, allowing resumed fishing. However, unless there is a significant improvement in the health of spawning and rearing habitat, the strength of stock recovery may be weak. This will place coho stocks at even greater risk of extinction when the next unfavorable climatic shift occurs.
- Increased commercial and recreational fishing pressure on nearshore subtidal rocky reef areas for rockfish, lingcod, greenling is primarily the result of the collapse and subsequent closure of the coho salmon fishery. Increased fishing pressure on these nearshore reef species is likely to continue, reducing the size and age structure of these populations and placing them at risk.
- Oregon's nearshore reefs are also sites for expansion of emerging commercial resource uses, including kelp harvest, the live-fish fishery, expansion of the open-access hook-and-line fishery, and the in-situ propagation and enhancement of sea urchins, abalone, and other mariculture species.
- Nearshore reef areas are also a popular destination for recreational boaters, and the kelp forests and rocky subtidal habitats face increased and diversified use by recreational and commercial SCUBA divers.
- Marine mammal populations will stay healthy, barring unforeseen problems with stocks or food availability. Species and habitat protection measures over the past three decades have been very effective.
- Data on the recurrence and severity of harmful algal blooms is inconclusive, but the potential risks to human

health associated with poisonous shellfish toxins warrant monitoring of this indicator to better assess their threat.

- Assuming that present oceanfront development and shoreline armoring practices persist, beachfront property along privately owned shorelines will be increasingly armored as the 21st century wears on. As episodes of erosion increase in frequency and severity, and affect more property, pressure will mount to lift the prohibition on armoring for post-1977 development. As armoring gradually shuts off natural sand replenishment processes, some beaches will gradually narrow and cease to function as viable recreational resources.

## What data are available and how complete are they?

A wide variety of data sources were used in preparing this marine ecosystem health status report, as reflected in the reference section and citations in Table 1 and the text. Confidence in the data for some indicators is high (e.g., marine mammals, fish landings, some stock assessments). For other indicators (e.g., shoreline armoring, kelp, harmful algal blooms), confidence was moderate to low, owing to limited data from geographic case studies or incomplete time series. There are no Oregon-specific data on the impacts on bottom habitat by mobile fishing gear; however, high-confidence data on bottom trawl starts does provide a partial basis for designing needed research. Despite limited data, this latter issue is so important that it warrants indicator status. In all cases, the interpretation of data with respect to marine ecosystem health is based in part on the professional judgment of those scientists who contributed to or reviewed the report. Specific caveats about data quality and interpretation are included in context.

There may be better indicators than those used here for monitoring marine ecosystem health and sorting out natural versus human-caused change. Thus, this report should be viewed as a beginning effort to characterize ecosystem health and suggest causal factors for observed trends. It also presents a challenge the marine science and resource management community—we must identify the best possible indicators of marine ecosystem health, improve monitoring programs to track these indicators, and use the findings to improve decision-making processes and marine resource management.

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