Oregon State University Extension Service
MARINE ADVISORY PROGRAM
SEA GRANT

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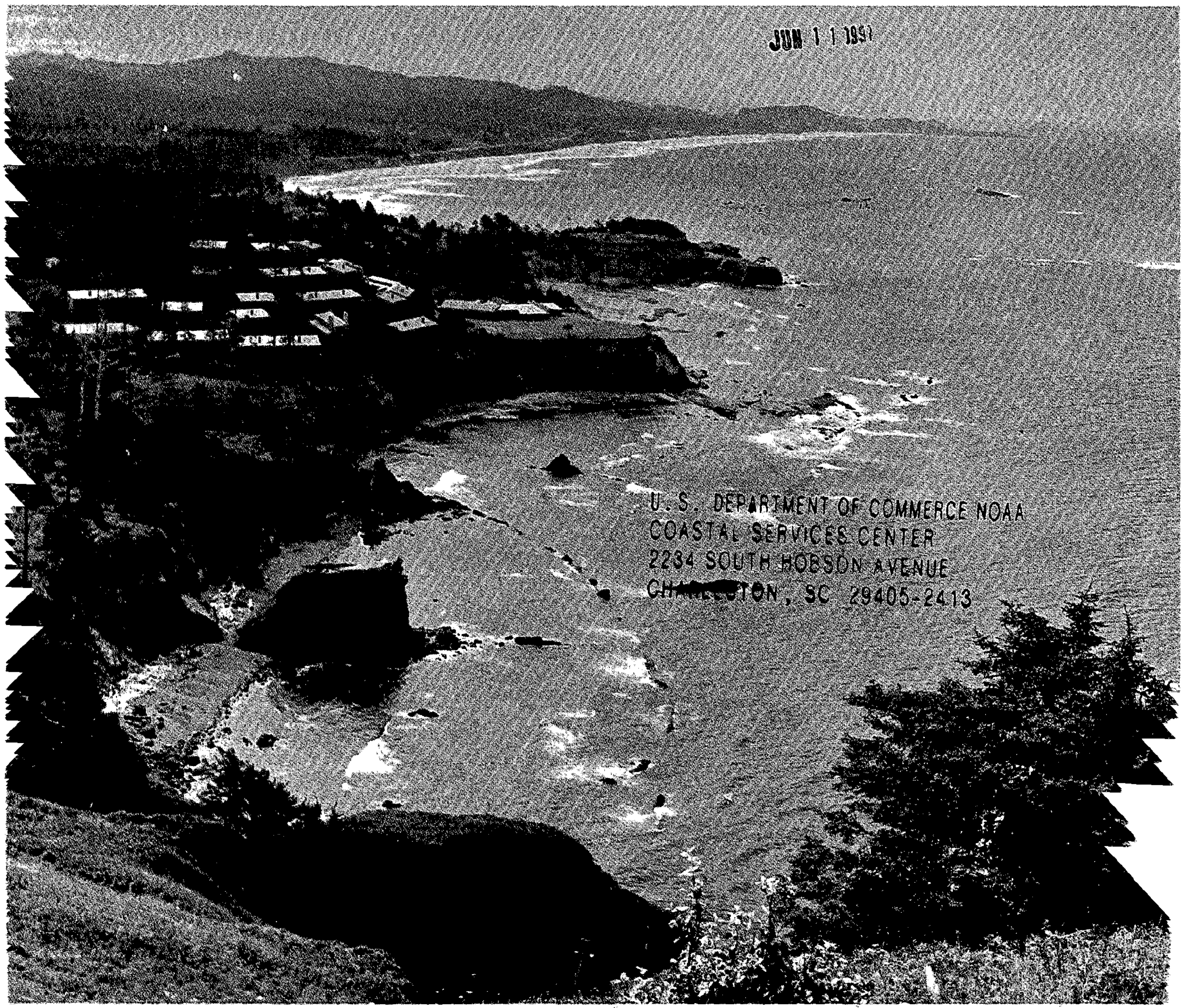


Otter Crest Lookout, facing south . . . Yaquina Head is at the upper right.

Oregon's Nearshore Ocean

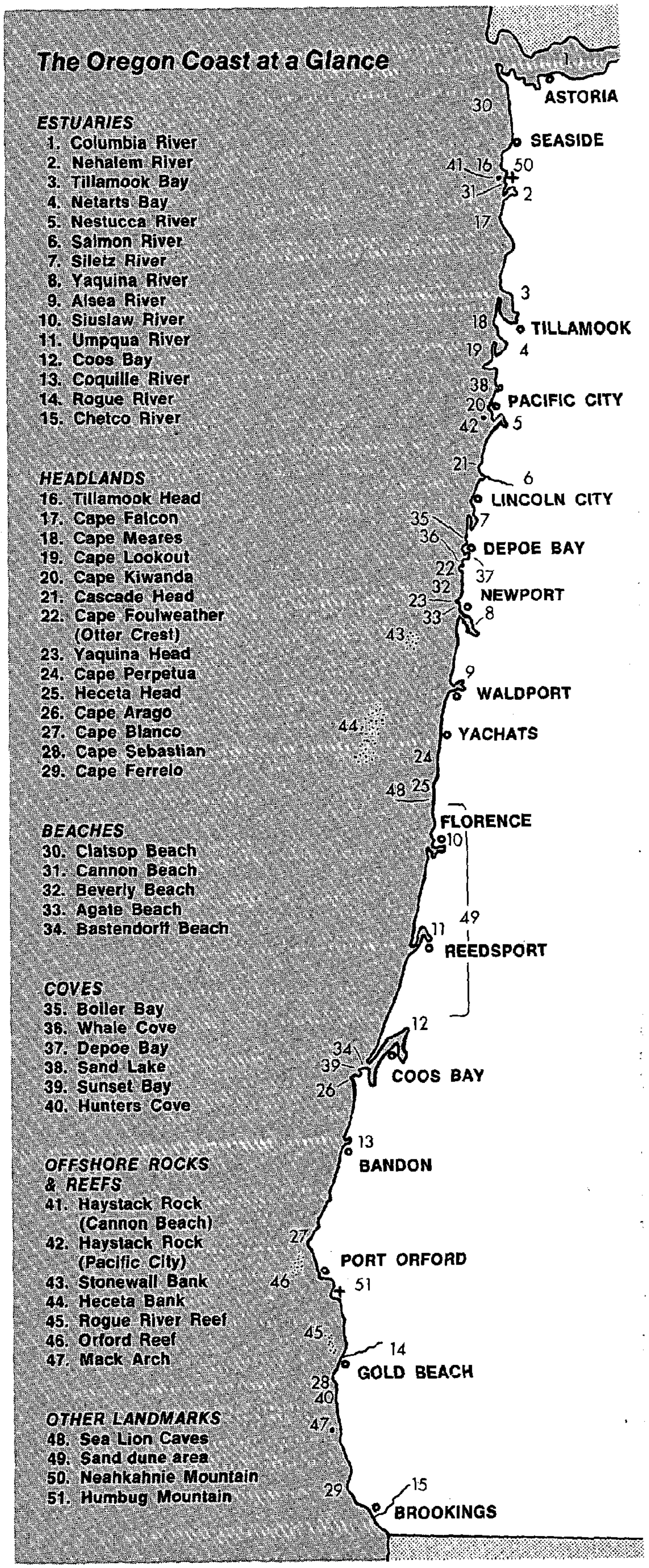
by James E. McCauley, Associate Professor of Oceanography, Oregon State University

South from the Otter Crest Lookout, the Oregon coastline spreads like a map. Small sandy coves nestle between rugged rocky headlands; Yaquina Head juts far to sea. A few miles beyond, a beach is interrupted only by the Yaquina River, whose channel is protected by two massive manmade jetties. Offshore, at Otter Crest, rocks rise above turbulent waters, providing a haven for seals and sea lions and nesting sites for thousands of sea birds. Rocks rising highest above the water are capped white with centuries of bird droppings. Beyond these rocks in the Pacific Ocean, ships move cargoes along the coast, and whales surface to "blow" and renew their air supply. This is the nearshore zone of the ocean; the open sea hides behind the horizon only 28 miles away.

You can stand on any headland and get a similar view: the coves, the beaches, the offshore rocks, and the ocean. The nearshore zone may be wider or narrower, depending on the height of the headland, and the details may differ in shape, size, appearance, and arrangement; but in the Pacific Northwest there is a marked similarity. The rocks are similar, the beach sands are similar, and the processes which have created the coastline are similar. Plants and animals confirm the uniformity of the coastline; in their response to *all* facets of the environment, they are similar from place to place. One headland resembles another; one beach, another.

This nearshore zone is important to the Pacific Northwest. It is the site of important fisheries; it is a valuable tourist attraction; it is essential to the economy and ecology of the region. It is where man's greatest impact on the sea will be felt, for it is here that he can enter the sea or most easily dispose of his wastes. Yet, studies of this nearshore zone are incomplete. Biologists and geologists can tell us much about the shoreline itself: how it was formed, the names of the plants and animals that occur between the high and low tides, and some details about the intertidal ecology. Oceanographers can describe the processes that take place farther at sea (usually at least ten miles from shore), but the region between the coastline and the open sea is difficult to study. Sea captains are reluctant to bring research boats too close to shore; surf and currents are treacherous. The processes that affect the region are complex and dynamic.

However, studies have taught us a good deal about this zone, and one basic finding is that the influences of both land and sea contribute to its ecology. The currents of the ocean sweep through, bringing and removing sea water and the life it contains. Weather far at sea influences coastal weather. Erosional processes shape the coastline itself. Rivers bring sediments and various chemicals to the ocean. Man's activities add pollutants to the waters, and his structures change movements of water and sand.



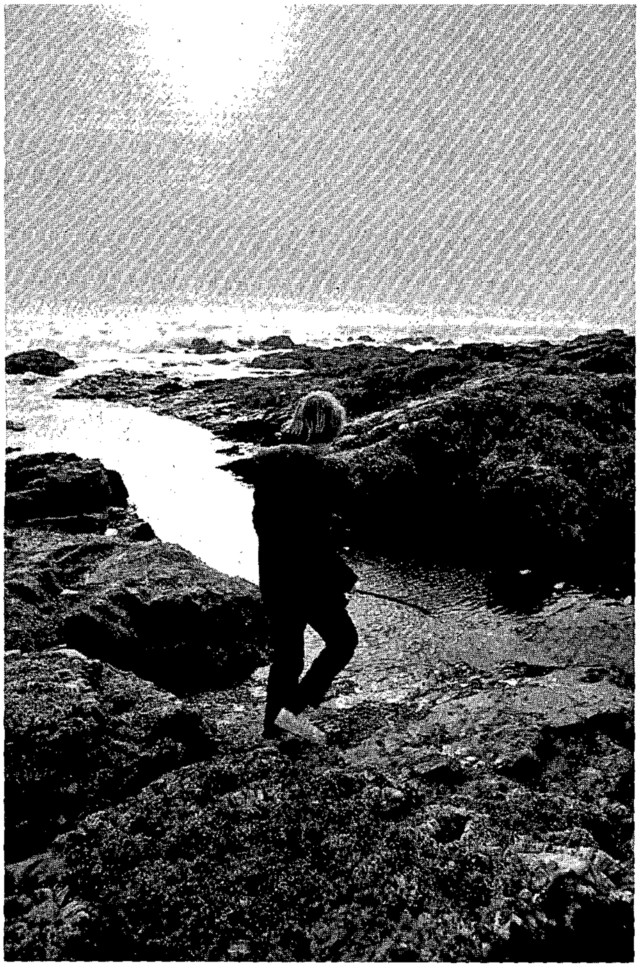
The relatively straight coastline of the Pacific Northwest runs in a north-south direction. Headlands and coves interrupt this straight line locally, and rivers cut across it. Although these rivers and their estuaries significantly influence the nearshore zone, they are not part of it. Estuaries respond to tidal cycles and to variations in the salinity of the water. Estuarine plants and animals and estuarine water chemistry are characteristic of this specialized region where the fresh river water mixes with ocean water. The processes are complex, and there are problems associated with estuaries which do not occur on the open coast, problems which deserve treatment and consideration on their own.

THE COASTLINE: BEACHES, BLUFFS, ROCKY HEADLANDS

The coastline is composed of sandy beaches alternating with rocky headlands. The beaches generally lie at the base of bluffs that are seldom high except in southern Oregon. Some coastal bluffs may be separated from the ocean by sand dunes. Between the mouth of Coos Bay and Sea Lion Caves these dune areas are several miles wide.

The beaches are made up of quartz and feldspar sand; they generally lack the shells and shell fragments that occur on beaches in many parts of the world. The shifting sands do not provide a good attachment base for plants and animals, so the larger seaweeds do not occur. A number of animals live among the sand grains, but in the Pacific Northwest these have not been well studied. A few larger animals burrow into the sand and are typical of the region. The best known of these is the razor clam, *Siliqua patula*. It is abundant at scattered areas and provides major sport and commercial fisheries in southern Washington and northern Oregon. Although clam diggers frequently report a "baby razor clam" in the adult, they are mistaken, for this is a harmless parasite, a nemertean worm. The razor clam does not brood its young but rather sheds eggs and sperm into the water, where the eggs are fertilized. The young then swim about in the water, feeding until they develop enough to settle in their future homesite. Sand dollars, mole crabs, and a few worms can sometimes be found in the sand; but, generally, sandy beaches are not highly populated regions. Although the razor clam is the only large clam on open coastal sandy beaches of Oregon, a number of clams occur in bays and estuaries

A sandy Oregon beach . . . two miles north of Yachats.



A stretch of rocky beach, near Lincoln City . . . . It's fascinating to see what the tide has left behind, but remember: Don't Bring 'Em Back—Dead *or* Alive! Oregon law extends protection to all intertidal (nonfood) animal forms.

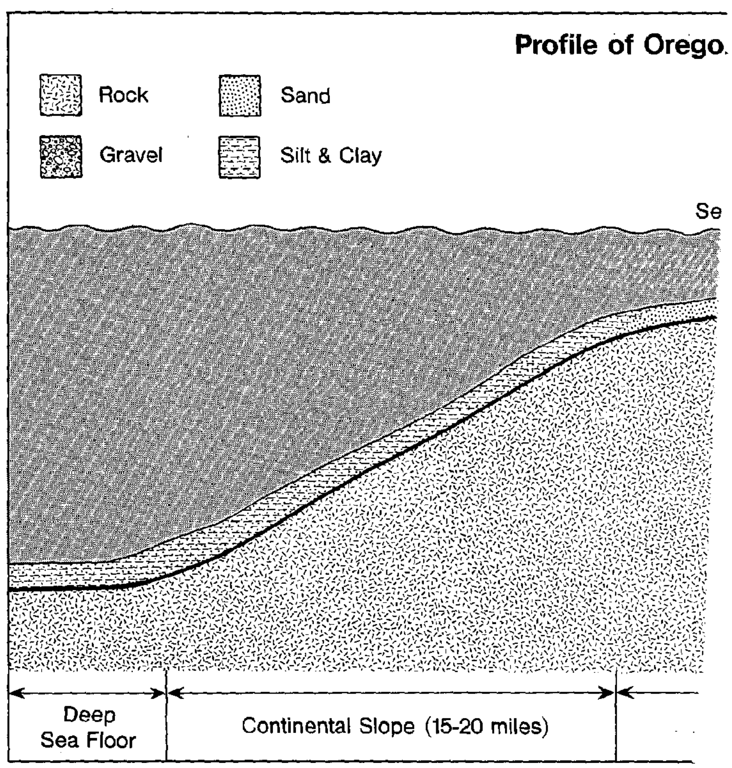
(see *Bay Clams of Oregon,* "Suggested Reading," p. 8).

In sharp contrast to the beaches, rocky headlands support rich intertidal biological areas. Interplay of physical, chemical, and biological forces makes rocky intertidal regions of the Pacific Northwest among the most productive spots in the world. With an average difference of about seven feet between high and low tides, the intertidal zone forms a narrow band of plants and animals that are alternately exposed to air and to water. In the air, living things may dry or become overheated, especially if exposed for a long time on a warm day. The dark colors of the rocks and of many plants and animals absorb radiant heat from the sun, and their temperature may be higher than the air temperature. Although the drying and heat may be harmful or fatal to some animals, these same conditions may be essential to others.

If you examine the rocky intertidal habitat carefully, you can observe vertical zonation of the plants and animals. These zones appear as horizontal bands, sometimes with distinct boundaries between color or texture but more often blending almost imperceptibly into each other. Several hundred plant and animal species can be found in this zone, each inhabiting its own special spot: some high on the rocks, where the only sea water they encounter is spray; others, where they are covered and exposed alternately a couple of times a day; and still others at low elevations, where they are exposed only during the lowest tides. Each species has its own requirements, some more restricted than others. A number of intertidal books discuss these: *Between Pacific Tides* is one of the best (see "Suggested Reading," page 8).

The intertidal zone is exposed to two types of predators. Fish, seals, diving birds, and other sea animals enter at high tide when the zone is submerged; shore birds and land animals can invade at low tide. Man, also, is a predator on the intertidal. Collectors (tourists, school classes, or scientists) and fishermen have caused so much damage to many Oregon areas that regulations now apply to harvest of nonfood animals on all beaches.

When plants and animals in the intertidal zone are destroyed or moved, they must be replaced from natural reservoir populations elsewhere. Some of these may be intertidal on offshore rocks or located in other places inaccessible to man. Other reservoirs may be found below the low-tide mark. Members of these reservoir populations may repopulate an area either by migrating or by producing young that will ultimately settle intertidally. The recent upsurge of scuba diving is now endangering these subtidal reservoir populations.

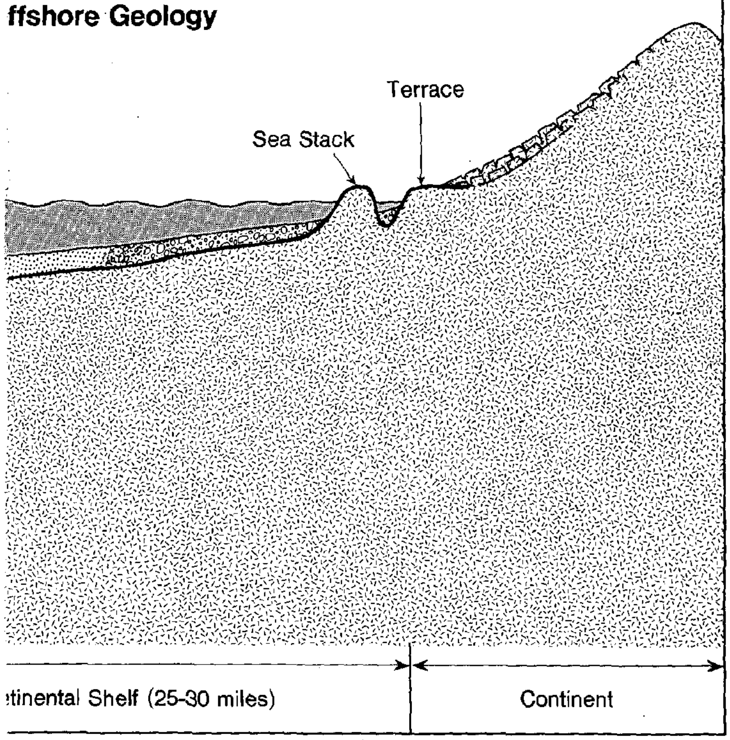


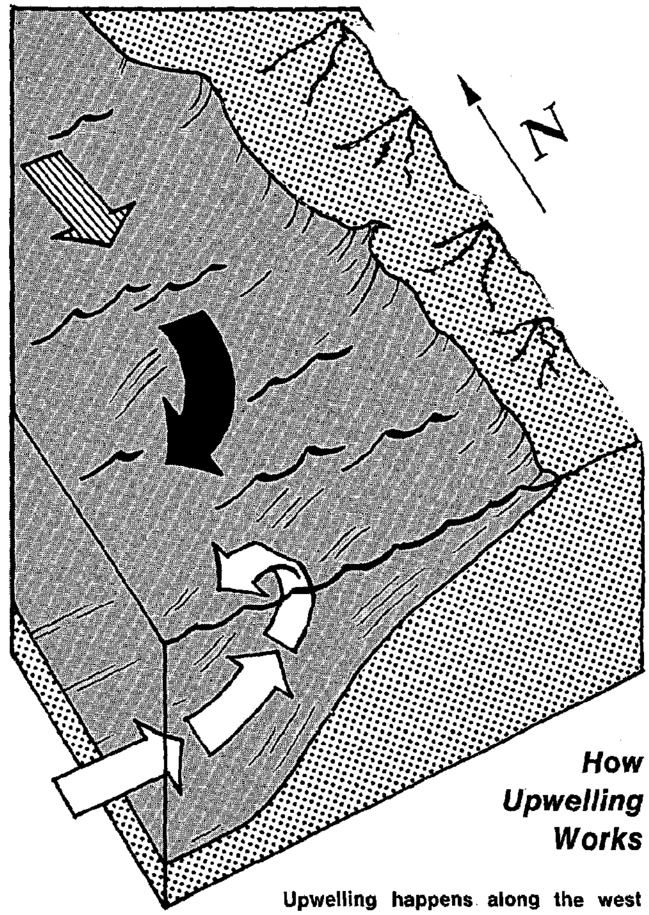
THE OCEAN FLOOR

In the relatively unknown region beyond the intertidal area, the ocean floor slopes gently toward the sea, reaching depths of about 80 feet a mile off shore. The sea floor here is composed largely of sands similar to those found on the beaches. In the first few miles from the coast these sands become increasingly finer, but within five miles of the coast there is almost no mud. Gravel and rocks may be found off the mouths of streams, where overlying sand has been scoured away by the surge of water entering and leaving estuaries as the tide rises and falls. Rocks off headlands may have fallen from nearby cliffs, or they may be sea stacks—isolated, offshore rock pillars—which have resisted erosion. Sea stacks, common off major headlands, may break the action of waves approaching the coast.

Streams entering the ocean bring a load of suspended materials from the land: sand, silt, pesticides, and other chemicals. Much sand is trapped in the estuaries, and most does not enter the ocean; but finer particles, the silts and clays, often are carried far to sea. Chemicals in water may remain dissolved, precipitate (settle to the bottom), or adhere to finer silts and clays. Some chemicals will enter biological cycles and become incorporated in plants and animals. Silt and clay *particles may be important for removing poisonous* substances; molecules of toxic substances (papermill wastes, pesticides) or of heavy metals (mercury, lead) may adhere to suspended particles and not settle to the sea floor until they have been carried far from the coast.

ffshore Geology





How Upwelling Works

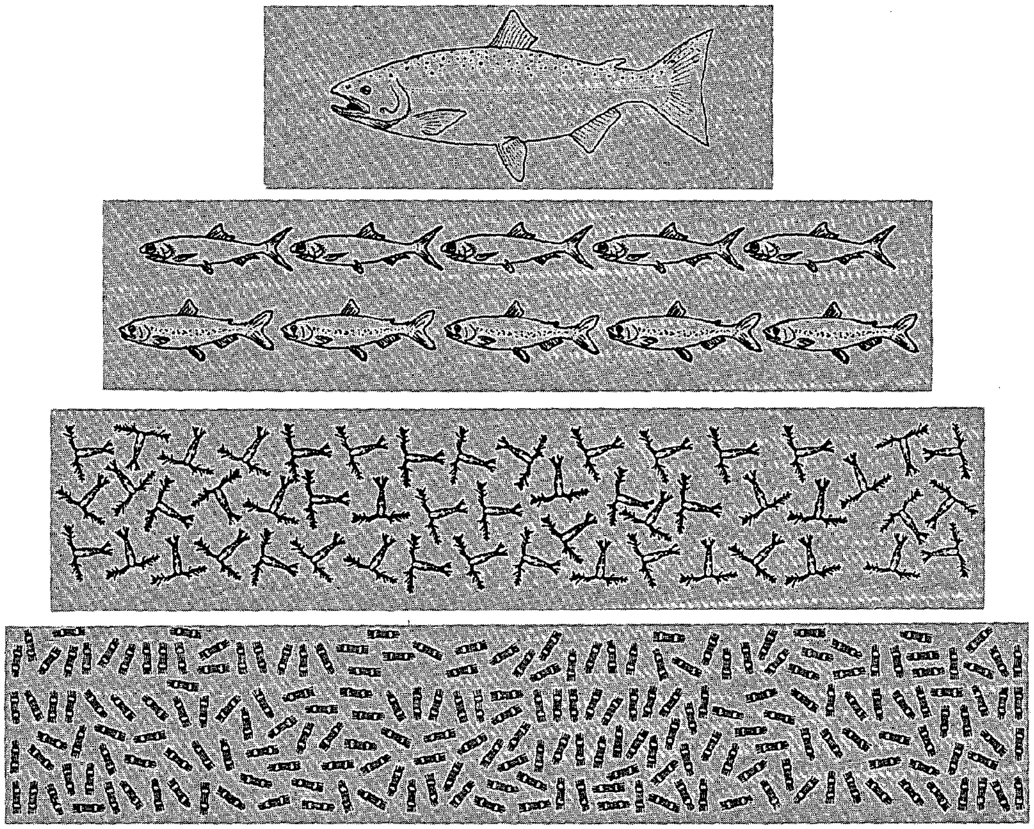
Upwelling happens along the west coasts of continents; intensive study is gradually unfolding its secrets. On the Oregon coast, summer winds come mostly from the north or northwest (striped arrow); combined with the effects of the earth's rotation, these winds push warmer surface waters (black arrow) away from the shore. This displaced surface water is replaced from beneath by colder, deeper waters (white arrows). This upwelling bottom water is rich in phytoplankton and zooplankton—which means a feast for fish, and great opportunities for fishermen. It is estimated that over half the world's fish catch is from upwelling areas.

WEATHER'S BIG INFLUENCE

Weather has a marked influence on the coastal zone; temperature, rainfall, and winds interact with the sea. Perhaps the most dramatic effects are those of the winds. Waves, surf, swells, and currents respond directly to wind forces. During the winter, storms come from the southwest, but, surprisingly, nonstorm winter winds come primarily from the east. During summer, winds come mostly from the northwest. *Swell*—long, even waves caused by winds far at sea—comes from the northwest and averages about 3 feet in height during the summer and 5 feet in winter. Local winds produce waves that are superimposed on the swell and are about 3½ feet high in summer and 9 feet in winter. Waves and swells disturb the ocean floor near the coast, causing sand to be moved slowly along the coast, southward in summer and northward in winter.

The Food Pyramid

This drawing is an extreme simplification. Actually, *millions* of phytoplankton (bottom layer, *Skeletonema* in this example) are needed to sustain *thousands* of zooplankton (next layer, copepod this time); these zooplankton in turn feed the *ten* fish in the next layer (anchovies on top, smelt below), which finally nourish *one* coho salmon. Looked at another way, there is an approximate *weight* ratio of 10 to 1 between levels of the pyramid: it takes about 1,000 pounds of phytoplankton to feed 100 pounds of zooplankton; these would be food enough for ten pounds of anchovies and smelt, which would sustain one pound of coho salmon. And one coho salmon can weigh 35 pounds!



These sand movements disturb animals, cause shoaling, and generally alter bottom topography.

During summer, persistent winds from the northwest combined with rotation of the earth cause surface waters south of Tillamook Head to move offshore. This water is replaced by deeper water from farther offshore in a process called *upwelling* (see *Phytoplankton, Grass of the Sea,* "Suggested Reading," page 8).

Air temperature averages about 58° F in summer and 50° F in winter; average water temperatures are similar. Water temperature does not fluctuate as much as that of air; the average high is 63° F and the low 45° F. Such a small water temperature range is in sharp contrast to many other coastal regions. During summer, cold water brought to the surface by upwelling cools the surface water to 45° F to 55° F, about 9°-12° F less than water 60 miles off shore. Upwelling in this nearshore zone has a marked effect on coastal climate, producing local fog and chilly weather during the summer.

Salinity (salt content) of the nearshore zone water is slightly higher in summer (3.35 percent) than in winter (3.2 percent). Deep salty water brought to the surface by upwelling tends to keep the salinity high during the summer (3.38 to 3.44), and runoff from the coastal streams and the Columbia River tends to lower the salinity in the winter. In summer, water from the Columbia River moves southwest from the mouth and has little effect on the Oregon seashore; but during winter it moves northward close to the Washington shore, lowering the nearshore salinity there to 2.5 percent to 2.8 percent. In June, during peak discharge, salinities near the mouth of the Columbia River (from Seaside to the mouth of Willapa Bay) have been as low as 2.0 percent.

BIOLOGICAL COMMUNITIES

Two dynamic biological communities interact in the nearshore region: those plants and animals living on the sea floor, called the *benthic* community; those that swim, drift, or float in the overlying water, the *pelagic* community. These communities are not easily separated because many animals tend to move from one to the other without regard to arbitrary human boundaries. Some animals like the Pacific herring lay eggs on the bottom, yet young and adults live well up in the water. Many pelagic species behave in this way, producing benthic eggs which hatch into pelagic larvae. On the other hand, almost all benthic animals in the coastal region produce pelagic larvae which are distributed to new locations by currents. Some benthic fishes swim to the surface to feed, and some pelagic animals dive to the bottom to feed. Interactions between the communities are great.

Many benthic animals must remain on the bottom and therefore must depend on food coming to them from above. A continuous "rain" of material settles out of the water above: sand and silt particles, dead and dying plants and animals, fragments of plants and animals, and waste products of animals and men. Bottom animals, bacteria, and fungi use this material for food, and in the process they perform the valuable function of converting it to chemical elements which can then be recycled.

Animals rely on plants for food, directly or indirectly. In the intertidal zone these plants are often attached. Eelgrass and numerous species of large algae form a plant cover where rocks provide a satisfactory place for attachment. In the water near shore, one algal species often forms "kelp forests," with floats on the surface and long stems attached to rocks on the bottom, providing a refuge for fish and smaller animals.

In the pelagic community, most of the plants are microscopic and are called *phytoplankton.* These are the food base for nearly all life in the sea and are fed upon by microscopic animals (*zooplankton*), which in turn are themselves eaten by larger animals. Thus, energy from the sun is converted by photosynthesis into food that is transferred by a series of steps to the animals of the sea.

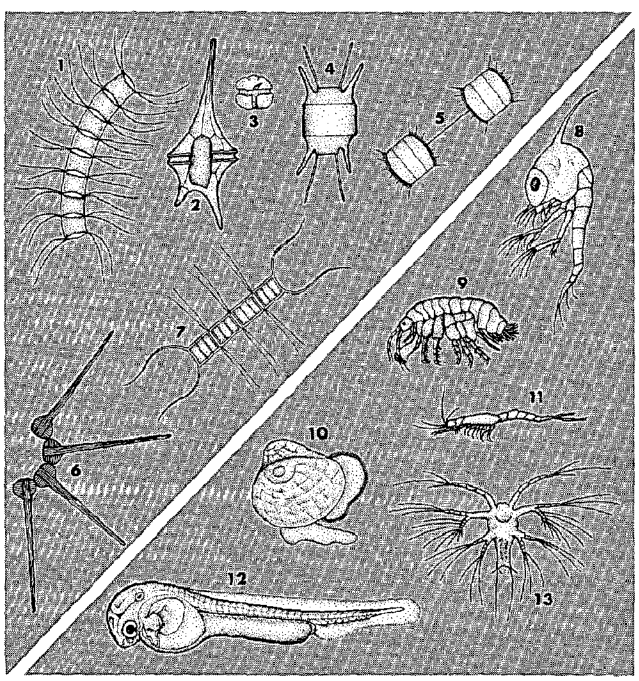
Just as land plants do, algae require nutrients. On land these nutrients come from the soil, but in the sea they are dissolved in the water. When the nutrients are used up, growth diminishes or stops unless more nutrients are added. In our gardens we apply fertilizers, but in the sea we usually must wait for some natural event. Off Oregon and northern California, upwelling brings nutrient-rich water to the surface where algae "bloom." Zooplankton then flourish, and food is plentiful for fish and other larger animals. Consequently, excellent fisheries are associated with upwelling.

Most of the fisheries are beyond the three-mile limit, but some salmon and bottom fishes (flounder, sole, and rockfish) are taken close to shore. The oceanic Dungeness crab fishery is also close to shore.

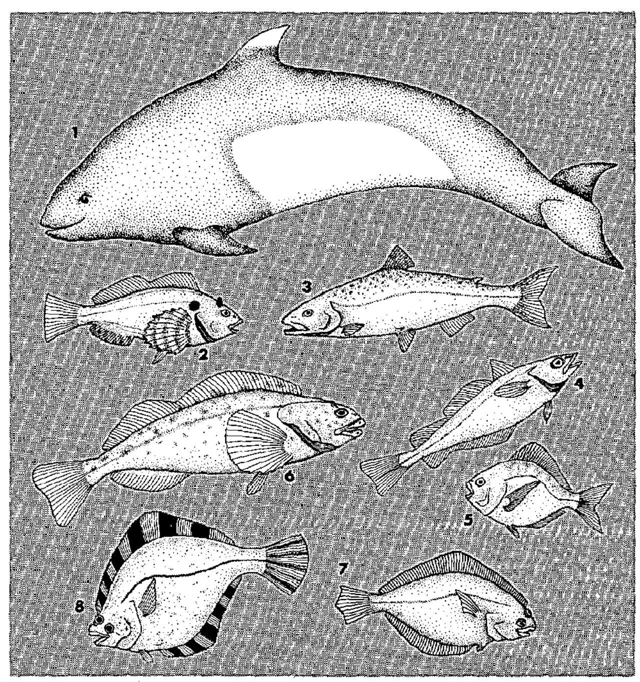
The coastal waters of the Pacific Northwest are still relatively clean. We have had no major oil spills, and the small coastal population is not yet producing catastrophic quantities of pollutants. Industrial and domestic wastes enter the sea from rivers, as do pesticides from agriculture. Three paper mills in Oregon and two in northern California dump wastes into the sea. The interaction of these wastes with the environment is just beginning to be studied in the Pacific Northwest, but the changes they produce in the sea water may affect the plants and animals.

THE NEED TO KNOW MORE

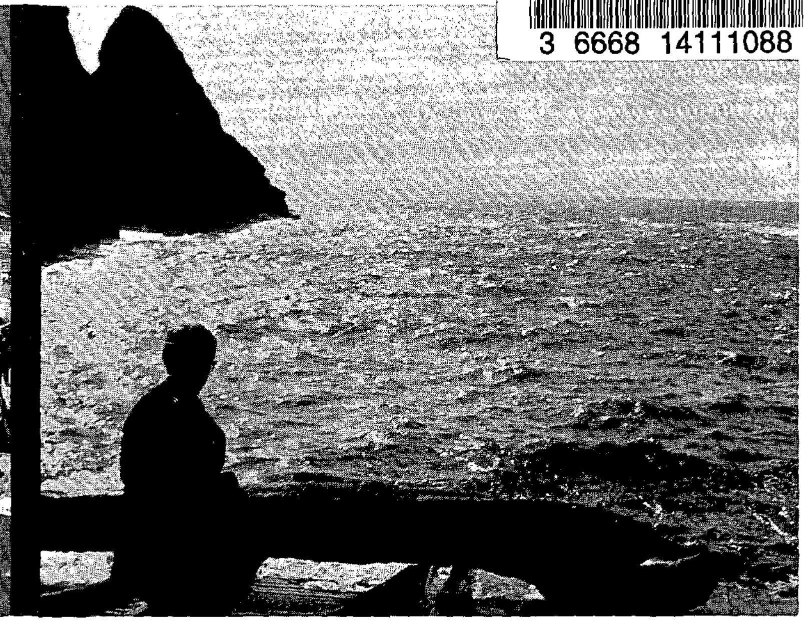
Although we know something about the plants and animals of the coastal region and a great deal about physical, chemical, and geological processes that take place, we are not yet in a position to predict what will



PLANKTON, tiny organisms that drift with currents, include: Phytoplankton (plants)—1. *Chaetoceros curvisetus;* 2. *Ceratium furca;* 3. *Gymnodinium breve;* 4. *Biddulphia mobiliensis;* 5. *Thalassiosira decipiens;* 6. *Asterionella japonica;* 7. *Chaetoceros affinis.* Zooplankton (animals)—8. young crab; 9. amphipod; 10. oyster larva; 11. mysid; 12. fish larva; 13. young shrimp.



NEKTON, creatures that swim and are capable of moving about independently of water motion, include: 1. Dall porpoise; 2. rock greenling; 3. chinook salmon; 4. Pacific hake; 5. walleye surfperch; 6. lingcod; 7. petrale sole; 8. starry flounder. These nekton are drawn in proportion (the porpoise is 5 ft.) and are placed vertically to suggest the depths they actually inhabit.

Oregon ports are busy places . . . and what will the future bring? We need to know more, much more . . . .

happen when the environment is altered. The coastal system is very complex: delicate balances, critical timing of events, and many interacting parts. Interference with any of these may have serious effects where they cannot yet be anticipated. Marine scientists are now looking at the nearshore zone with the specific goal of predicting what happens when man interferes.

SUGGESTED READING

Byrne, John V., and William B. North, *Landslides of Oregon: North Coast,* Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 5 (Corvallis, 1971).

Curl, Herbert, Jr., *Phytoplankton, Grass of the Sea,* Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 9 (Corvallis, 1970).

Marriage, L. D., *Bay Clams of Oregon: Their Identification, Relative Abundance, and Distribution,* Fish Commission of Oregon, Educational Bulletin No. 2 (Portland, 1958). *Out of print.*

Osis, Laimons, and Gary Gibson, *A Guide to Oregon's Rocky Intertidal Areas,* Fish Commission of Oregon, Educational Bulletin No. 5 (Portland, 1970).

Ricketts, E. F., J. Calvin, and J. W. Hedgpeth, *Between Pacific Tides* (Stanford, Cal.: Stanford University Press, 1970).

On a Clear Day You Can See . . .

Location	Altitude (feet)	Approx. Distance to Horizon (statute miles)
Seaside, promenade	**20**	**6.6**
Depoe Bay, bridge	**58**	**10.5**
Whale Cove State Park	**80**	**12.2**
Heceta Head, Devils Elbow Bridge	**120**	**14.7**
Newport, Yaquina Bay Bridge	**138**	**15.8**
Cape Arago State Park	**160**	**17.0**
Cape Blanco	**203**	**19.0**
Sea Lion Caves	**320**	**23.7**
Otter Crest Lookout	**454**	**28.2**
Neahkahnie Mountain Viewpoint	**574**	**31.7**
Cape Sebastian	**700**	**34.8**
Cape Perpetua Lookout	**800**	**37.3**

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OREGON STATE UNIVERSITY EXTENSION SERVICE

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