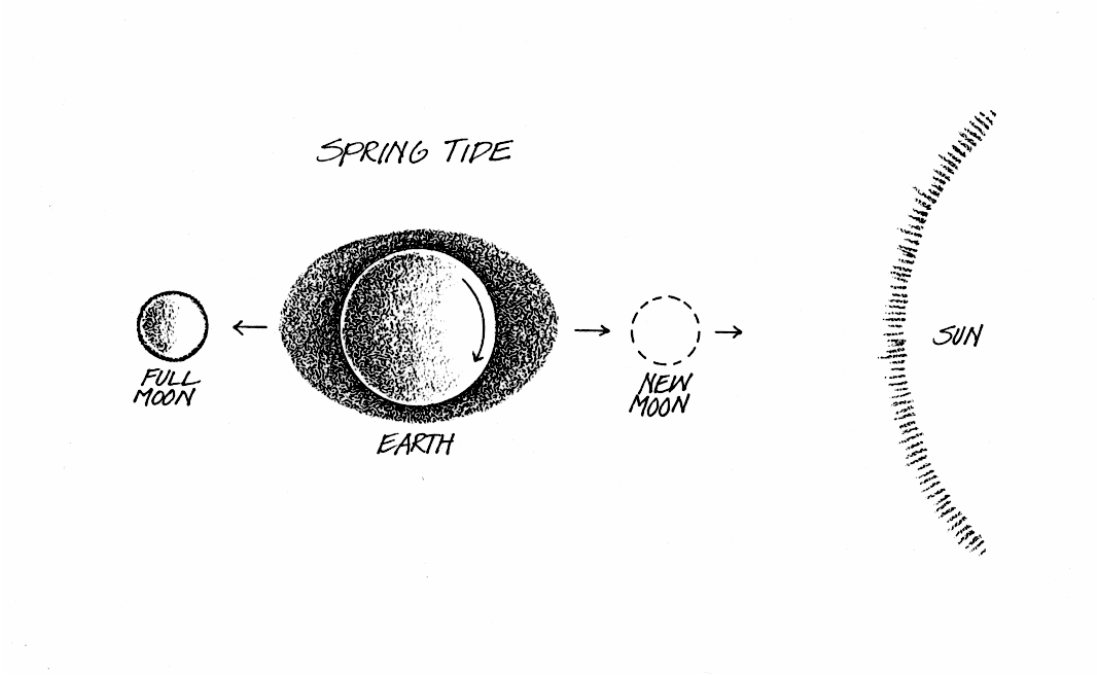
The Causes of Tides

by Kenn Oberrecht



Twice daily the Pacific Ocean intrudes on the shoreline to flood its bays and estuaries. It inundates mud flats and marshes, raises water levels, and surges landward with sufficient force to reverse the seaward currents of rivers and creeks. Salt water mingles with fresh, and within hours the brackish brew slackens briefly to deposit valuable nutrients that feed countless organisms residing in the complex estuarine system. Then the process reverses, and receding waters flush the estuary, carrying organic and inorganic material and even potentially harmful pollutants out to sea.

Salt water mingles with fresh, and within hours the brackish brew slackens briefly to deposit valuable nutrients that feed countless organisms residing in the complex estuarine system.

These predictable and periodic movements of ocean waters are known as tides and are caused by the attractive forces of the moon and sun. Sir Isaac Newton's law of gravitation tells us that any two bodies in the universe are attracted to each other and that the strength of this attraction depends on the bodies' mass and distance from each other.

The sun's mass is 27 million times that of the moon, but it is also 390 times farther from the earth. So although the sun affects our tides, the moon exerts the greater gravitational attraction because of its proximity to our planet. The sun's influence is about 45 percent that of the moon.

Think of the earth as an egg-shaped body with its long axis pointed at the moon. Now imagine the planet completely covered by a deep ocean, so that its watery surface bulges toward the moon. On the opposite side of the planet, centrifugal force creates a similar bulge. These are the high tides. Two coinciding and simultaneous low tides occur at equal distances around the earth between the high tides.

Along the Oregon coast, the mean difference between high and low water is about five to six feet. During periods of extreme tides, particularly in June and December, the tidal range can be double that, or about 10 to 12 feet.

Ideally, this is how the tides work, but nature is seldom ideal or perfect. The great variety of the earth's topography, as well as other terrestrial and extraterrestrial influences, cause our tides to differ in various ways and to exhibit certain similarities.

On the open seas, tides go virtually unnoticed. There, high tide is only two to three feet above low tide. Along the coast, however, tides can vary greatly, depending on topography and other influences.

In some parts of the world, the range of the tidal difference between successive high and low waters is measured in inches. Elsewhere, the disparity can be dramatic. At the Bay of Fundy in Nova Scotia, for example, the difference between high and low water can be as much as 50 feet.

Along the Oregon coast, the mean difference between high and low water is about five to six feet. During periods of extreme tides, particularly in June and December, the tidal range can be double that, or about 10 to 12 feet.

Knowing what causes the tides is the first step in understanding them and how they affect the coastal environment. A knowledge of the tides and their effects is essential for navigation, community planning and development, recreation, and even survival.

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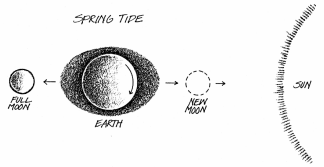
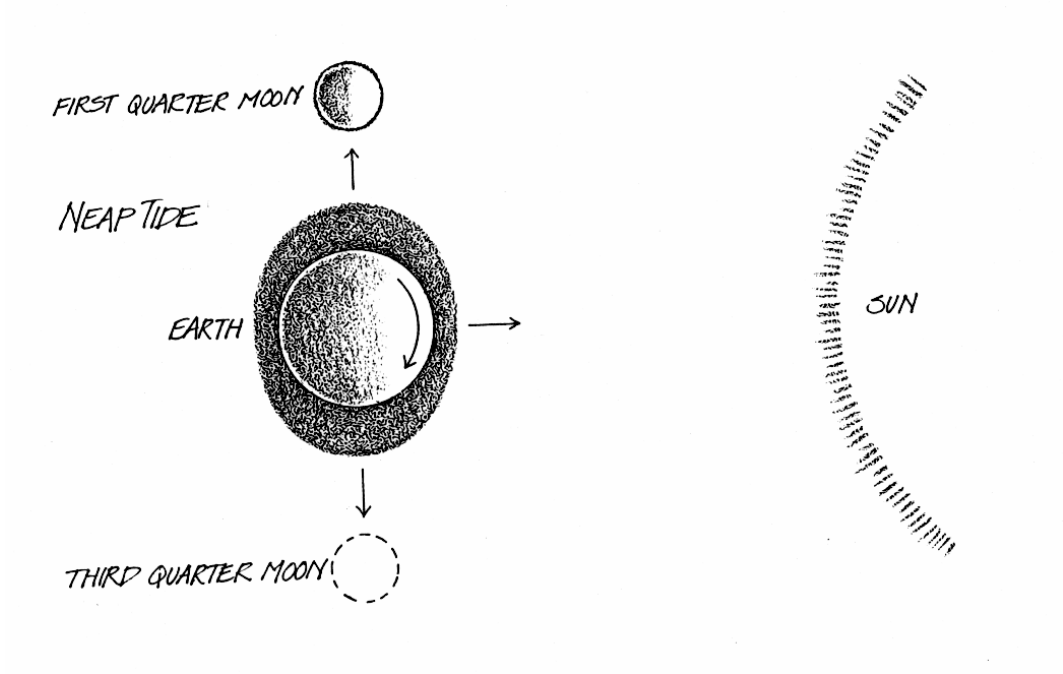
"The Causes of Tides"- Study questions

1. **How frequently do the tides flood and ebb during a day?**
2. **What are the major influences that lead to the rising and falling of the tides?**
3. **What is meant by tidal range and what is the most extreme tidal range along the Oregon coast?**
4. **What are some factors that would influence how high or low tides are?**
5. **Describe a situation where the tides might affect your life.**



Types of Tides and Tidal Currents

by Kenn Oberrecht



At most places on earth, there are two high tides and two low tides a day. They follow a cycle that coincides with the 24-hour 50-minute lunar day, the time it takes earth to make one complete rotation relative to the moon.

Here in the Pacific Northwest, we get mixed tides, two highs and two lows a day, characterized by significant disparity between successive tides.

Along America's Atlantic Coast, two high and low tides occur daily, with relatively little difference between successive high and low waters. Such tides are called semi-diurnal. On the north shore of the Gulf of Mexico, the tide is diurnal, meaning that it moves in and out again but once a day. Here in the Pacific Northwest, we get mixed tides, two highs and two lows a day, characterized by significant disparity between successive tides.

An incoming tidal flow is known as a flood current or flood tide; an outgoing flow is an ebb current or ebb tide. The period between flood and ebb tides, when there is little or no current, is called slack water or slack tide.

The moon is not only the greatest influence on our tides, but its phases also greatly affect their character. As the moon makes its

monthly elliptical orbit around the earth, it aligns with the earth and sun semimonthly, during the full-moon and new-moon phases. At such times, we have extremely high and extremely low tides, known as spring tides, an unfortunate term that has nothing to do with the season that follows winter.

Between these phases, when the moon is in its first and third quarters, it's at right angles to the sun. This position counterbalances the gravitational interaction of the moon and sun, resulting in a period when the range between high and low tides is minimal. These are known as neap tides.

Although riptides may appear as dark or calm paths running through breakers, they can exist where there is no apparent surface commotion.

Under certain conditions, tidal and other currents often conflict and sometimes create hazards to swimmers, boaters, and others. In the partial enclosures of bays and estuaries and at the mouths of coastal rivers, currents often collide and churn. Opposing currents sometimes occur along open ocean beaches, especially near headlands and manmade structures, such as jetties and breakwaters. Where islands are clustered near a rugged mainland in such a way as to create narrow, fjordlike passages, tidal and other currents often create turbulence.

A strong, subsurface tidal current that conflicts with another current or currents causing a violent underwater disturbance, usually in a direction contrary to that of the surface water is called a riptide. Although riptides may appear as dark or calm paths running through breakers, they can exist where there is no apparent surface commotion.

A tiderip, on the other hand, is readily apparent at the surface. This is a rip or stretch of turbulent water at sea or in a bay or strait caused by conflicting tidal currents or a tidal current moving over a rough bottom. Tiderips can appear as stretches of slightly choppy water running alongside glassy-calm water, or they might resemble whitewater rapids amid otherwise placid seas.

A knowledge of the tides makes the coast country more interesting for residents and visitors alike. Those who know the different types of tides and tidal currents are better equipped to enjoy our tidelands and tidewaters in comfort and safety.

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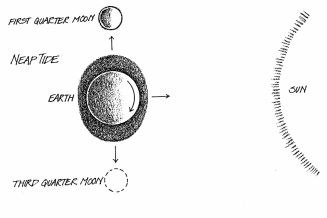
"Types of Tides and Tidal Currents" - Study questions

1. **Where does the tide rise and fall only once a day? What do we call this movement?**
2. **What do we call an outgoing tide? An incoming tide? What do we call the period between tides when there is very little movement of water?**
3. **Extemely high and low tides are known as spring tides. What is the moon doing during the periods of spring tides? How often do we have spring tides?**
4. **Describe a situation where the tides can be dangerous to human beings.**
5. **What is the difference between a riptide and a tiderip?**



Using the Tides and Tide Tables

by Kenn Oberrecht

Anyone who enjoys coastal hiking, beachcombing, canoeing, kayaking, crabbing, clam digging, or fishing must pay special attention to the tides. A person's success and safety depend on a knowledge of the tides, their times, levels, and relationships with other natural conditions.

Those venturing onto beaches, marshes, mud flats, and coastal waterways should first check tide tables, which are published in some newspapers, magazines, and phone directories. Tide tables are also published in the form of pocket-size booklets, sold for under a dollar or given away at most tackle shops, marinas, and sporting-goods outlets.

Those venturing onto beaches, marshes, mud flats, and coastal waterways should first check tide tables, which are published in some newspapers, magazines, and phone directories.

The booklets are best because they provide the most information in handiest form. Times and levels of the month's high and low tides are usually printed on opposing pages.
The tide tables provided in these booklets are derived from schedules furnished by the National Ocean Survey, National Oceanic and Atmospheric Administration. The data compiled are collected at established reference stations and are periodically updated.

Keep in mind that tide tables are only predictions. Strong winds, heavy rains or runoff, and other local and distant weather conditions can cause tides to differ from the estimations in the tables.

Booklets available along the Oregon coast usually provide tide times and levels for the north coast (Astoria), central coast (Yaquina Bay), or south coast (Humboldt Bay, California). They also carry correction tables for specific areas along the coast, even certain points on large bays and rivers.

For example, depending on which tide district a tide book is based upon, the correction tables will direct you to add or subtract hours and minutes to or from the projected time of a tide, and to add or subtract feet and fractions of feet to or from the projected relative depth of the tide.

Keep in mind that tide tables are only predictions. Strong winds, heavy rains or runoff, and other local and distant weather conditions can cause tides to differ from the estimations in the tables.
Some narrow beaches, especially those backed by cliffs, can be hazardous at high tide and might be passable only at low tide. In fact, some flats, outcrops, and spits exposed at low tide might be under several feet of water at high tide. So coastal backpackers, hikers, beachcombers, anglers, and tide-pool explorers need to pay attention to tides to avoid being stranded, or worse.

Big water and bad weather create potentially perilous conditions at the mouths of estuaries, where the seas tend to pile up and break. Even in calm weather and good seas, a swift ebb tide can make the shallow bar dangerous. Any boater caught outside the bar then should wait out the tide and cross on the flood. The smart boater uses tide tables and plans ahead.

Exploring tide pools, gathering mussels, and digging clams are low-water activities, with minus tides best. Crabbers prefer slow or still waters, so most set their gear during the last hour or two of a tide and continue crabbing through slack tide.

Anglers who fish coastal waters also must study the tides, which influence the movement of both forage and predator species. In some places, anglers prefer a flood tide; elsewhere, the ebb is better. For fishing, slack water is seldom as productive as moving water.

No matter what kind of outdoor recreation you enjoy, if you pursue it on the coast, you should know the tides and always check the tide tables before venturing out.

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"Using the Tides and Tide Tables" - Study questions

1. **Where can you get information about the tides for the Oregon coast?**
2. **Is the information presented in tide tables perfectly precise and accurate? Why or why not?**
3. **Why do we need to correct the time and elevation of the tides when we use tide tables?**
4. **How do the tides affect animals in the estuary that we like to harvest such as crabs, fish and clams?**
5. **The area of water near the mouth of an estuary is called the bar. What conditions make the bar dangerous to cross in a boat or ship?**

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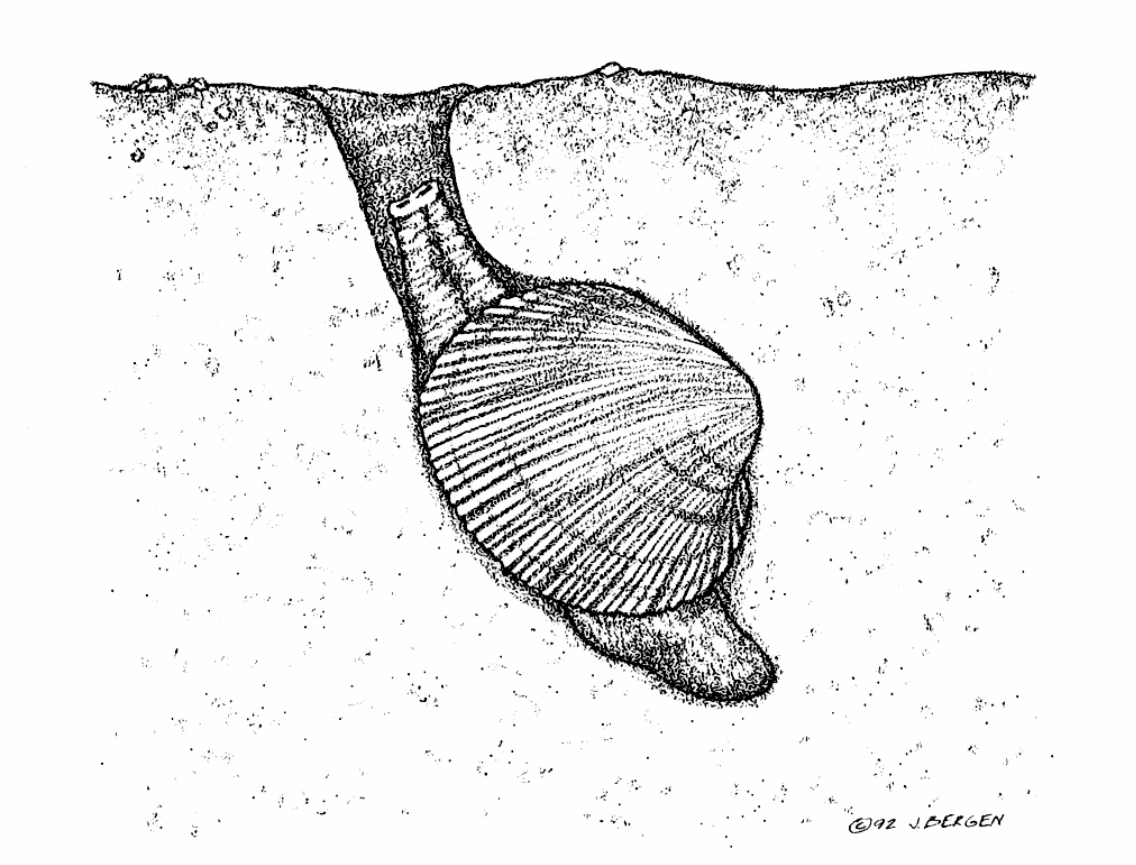
Oregon's Bay Clams

by Kenn Oberrecht



Mollusks are invertebrates that typically have shells, called valves, of one or more pieces completely or partly enclosing their soft, unsegmented bodies. Members of the class Bivalvia, the bivalves are simply mollusks with two shells. They include scallops, oysters, mussels, cockles, and clams.

The most popular clams on Oregon's south coast are the so-called bay clams, which include cockles, as well as littleneck, butter, gaper, and soft-shell clams.

Although more than 150 species of clams reside in Pacific waters from the high-tide line to depths exceeding 6,000 feet only a dozen or so are considered important contributors to the commercial and recreational harvests.

The most popular clams on Oregon's south coast are the so-called bay clams, which include cockles, as well as littleneck, butter, gaper, and soft-shell clams. Two other edible clams found in our

estuaries are the bent-nosed and white sand macomas, commonly called bent-nosed clams and sand clams.

Clams reproduce sexually, and in most species fertilization occurs as eggs and sperm drift through the water. Clam larvae are planktonic ("drifters"), usually for two weeks or more, after which they metamorphose into juvenile form and settle to the bottom.

A juvenile might use its foot to move about the estuary bottom, or might briefly tumble with the currents before burrowing into the bottom sediments. Others temporarily attach themselves, via byssal threads, to rocks or other solid bottom structure, where they remain until they've grown to an inch or more and can then take up residence in sand or mud.

Clams are well built for the two jobs they do best: burrow and eat. Each is equipped with a muscular anterior foot, with which it digs into the substrate. Its symmetrical valves or shell halves give it a wedge shape that facilitates burrowing.

Ensconced in its habitat, and with the efficiency of a submersible pump, the clam puts its two siphons to work. It takes in water and nutrients with its incurrent or inhalant siphon and discharges water and wastes with its excurrent or exhalant siphon.

Bay clams are not only important to people, but also to other predators.

The clam's gills secrete a mucus that collects tiny plants and animals and other fine particles of organic matter on which the bivalve dines. For silverware it has two flaplike structures called palps, with which it moves food from gills to mouth.

Lining the entire shell and forming a tough, rubbery strip along the ventral or opening edge of the shell is a membrane called the mantle. Siphons might be little more than a pair of slits in the mantle edge, as in the cockle. Or they can be two separate, extensible tubes, as in the bent-nosed and sand clams. In gaper and soft-shell clams, among others, the siphons are united into a single neck with two passages.

Bay clams are not only important to people, but also to other predators. Raccoons and otters prey on them, as do various species of fish, crabs, shorebirds, wading birds, and waterfowl. So it seems clams are vulnerable to a variety of predators, no matter the tide stage. Considering that and the fact that clams live out their existence in a wet, cold, gritty, and unforgiving environment, it's difficult to ponder the origin of the expression, "happy as a clam."

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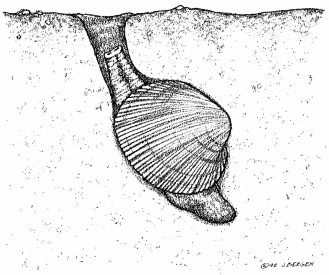
"Oregon's Bay Clams" - Study questions

1. **What is the difference between a bivalve and a mollusk? What are some examples of bivalves?**
2. **How do clams reproduce? Where would you search for larval or extremely young clams? How about juveniles?**
3. **In what ways does a clam move? What organs does a clam use to move with?**
4. **How does a clam feed and what does it eat?**
5. **What other types of animals eat clams besides human beings? What kinds of defense does a clam have against predators?**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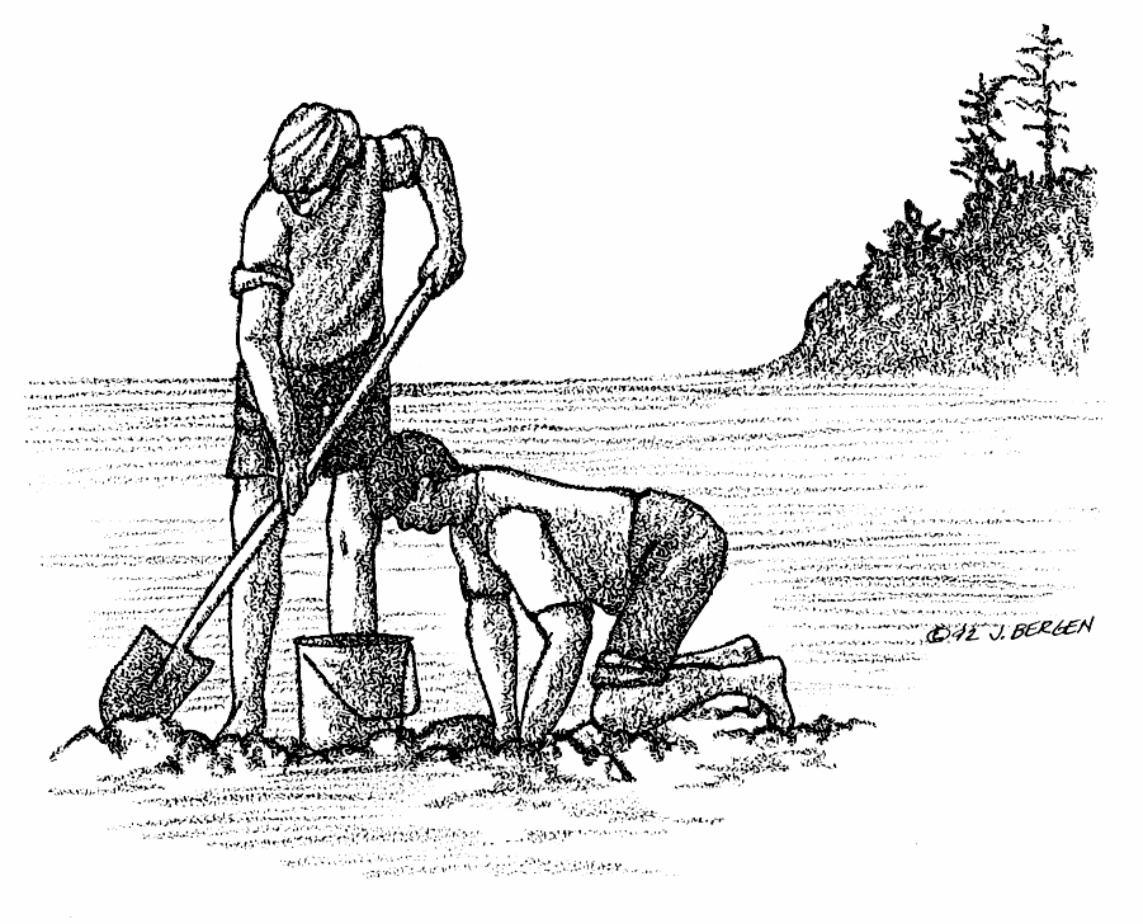
Harvesting Bay Clams

by Kenn Oberrecht



Bay clamming in Oregon requires little equipment, and nothing in the way of trendy attire. It's family fun, good exercise, cheap recreation, and a wonderful way to enjoy Oregon's estuaries. The only equipment required is a shovel or rake and a container for carrying the catch.

In eel grass, walk slowly, feeling for cockles with your feet. Don't rake in the eel grass, which uproots and destroys this valuable plant.

Although any low tide exposes some clam beds, the best are morning minus tides occurring from March through September. May, June, and July offer the lowest and the year's longest series of minus tides.

Cockles are easy to gather. They're found in sandy mud, just beneath the surface or even on the surface, especially in eel-grass

beds. You can harvest them with a shovel, rake, or even with your fingers in soft sand.

On bare flats, look for two tiny holes about a half-inch apart. In eel grass, walk slowly, feeling for cockles with your feet. Don't rake in the eel grass, which uproots and destroys this valuable plant.

The attractive cockle shells have prominent ridges emanating from the hinges. They range in color from beige to orange and are often darkly mottled.

Littleneck clams are other easily gathered shallow dwellers, often found with or near cockles. They're smaller than cockles, which they resemble, and their color ranges from ivory to charcoal gray. Ridges in the littleneck's shell are narrow and crosshatched by concentric ridges absent in the cockle's.

Butter clams reside in sandy mud and gravel, from six to 12 inches below the surface. They grow to four inches and have thick, chalky shells and short necks. Diggers look for half-inch or larger keyhole-shaped holes and harvest the clams with shovels or rakes. Where they've colonized, watch for spouts: streams of water expelled into the air as the clams retract their siphons.

Oregon's abundant and widely distributed soft-shell clams thrive in virtually every estuary.

The most popular bay clam is the gaper, locally known as the empire clam, presumably after the Empire district of Coos Bay, where the clam flourishes in nearby mudflats. Diggers look for round or slightly oval holes in the mud, about an inch or so across. There's no mistaking the gaper's presence when you poke a finger in the hole and feel it's rubbery neck retreat. Average gapers will be four to five inches long, with the largest exceeding seven inches and residing two feet deep or more. It takes effort to dig big ones out, but it's work well rewarded.

Oregon's abundant and widely distributed soft-shell clams thrive in virtually every estuary. Although large specimens resemble and are sometimes confused with gaper clams, they have thinner and more brittle elongate shells and shorter necks. They don't grow as large as gapers and seldom inhabit the same flats. These upbay clams often live in gravely mud. They reside a few inches beneath the surface, nearer the high-tide line than any other clams, and are accessible on any low tide. A good way to find them is by stomping on the gravel as you walk and watching for spouts.

There's no better bargain on the Oregon coast.

Harvesters age 14 or older need a residential shellfish license, but there's no better bargain on the Oregon coast. Clammers can take 20 bay clams a day, of which 12 may be gapers, then dig 36 softshells.

Perhaps the old expression should be "happy as a clammer."

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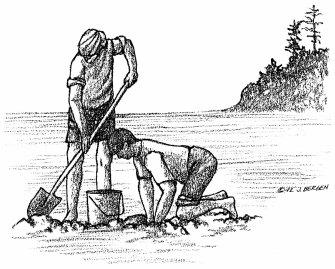
"Harvesting Bay Clams" - Study questions

1. **Although licenses aren't required for harvesting clams, are there any limits or regulations? If so, why do you think these regulations exist?**
2. **What tideflat conditions would be best to harvest the Cockle clam? Is there anything you need to be careful about when harvesting Cockles?**
3. **What causes the holes that indicate where a clam lies beneath the surface? Would the length of time that the tide has been out affect the clam in any way? How?**
4. **Give some examples of different types of clams and the different types of habitat where they are found.**
5. **If you were in charge of protecting Oregon's clam beds, what would you do to ensure that there would be enough clams for everyone in the years to come?**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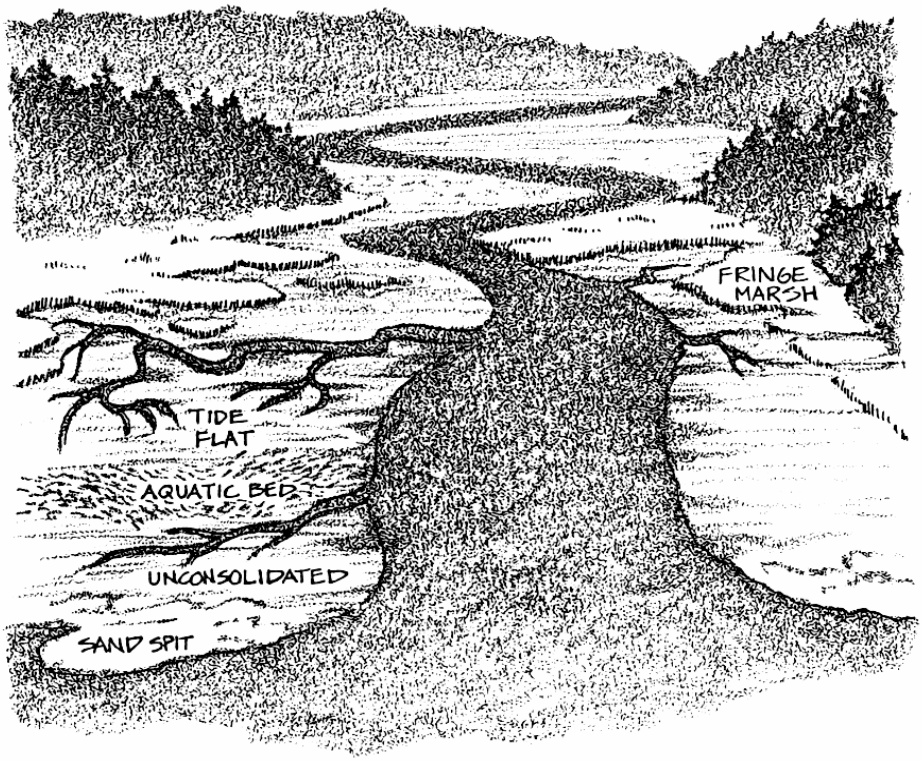
Classification of Estuaries

by Kenn Oberrecht



Although all estuaries are similar, in that they're semi-enclosed bodies of brackish water, scientists have used a variety of criteria to classify them. They once defined them according to their rate of freshwater evaporation, but they no longer use this restrictive system. Instead, they categorize them with regard to geological characteristics, and further distinguish them on the basis of stratification and circulation patterns.

Most estuaries along the East Coast are coastal-plain estuaries; most on the West Coast are considered drowned river valleys.

Geologically Classified

According to their geological characteristics, estuaries are classified as drowned river valleys or coastal-plain estuaries, bar-built estuaries or lagoons, fjord-type estuaries, and tectonically caused estuaries.

Most estuaries along the East Coast are coastal-plain estuaries; most on the West Coast are considered drowned river valleys. Both types were formed by the gradual rise of sea level following the last glacial period, 10,000 years ago. Chesapeake Bay is the largest of these in the U.S.

It's sometimes difficult to distinguish a lagoon from a coastal-plain estuary, because there can be much overlapping of characteristics. Generally, though, lagoons are usually situated parallel to the coastline. Many have narrow outlets to the sea and minimal freshwater inflow, often creating higher salinity levels than in coastal-plain and other estuaries. In the U.S., lagoons occur mainly along the Gulf Coast. There are also some small lagoons along the West Coast.

Fjord-type estuaries, created by glacial action, are characterized by the steep slope of adjacent lands and their great depth. They are common above 45 degrees of latitude, and in North America are most spectacular along the coast of Alaska and British Columbia.

Estuaries created by tectonic processes such as landslides, faulting, and volcanic eruptions are found along coasts where such activity is or has been common, such as the Pacific Coast of North America. These estuaries vary greatly and often share characteristics with other types. The largest of these in the U.S. is San Francisco Bay.

Classified by Stratification and Circulation

A salt-wedge estuary is highly stratified. Salt water moves into it in the shape of a wedge, with fresh water flowing over it. The velocity of the freshwater outflow is usually greater than that of the saltwater inflow, which keeps the salt water from extending very far up the estuary. The Mississippi River estuary is an example of this type, where the tidal range is small and incapable of mixing the stratified layers.

A salt-wedge estuary is highly stratified. Salt water moves into it in the shape of a wedge, with fresh water flowing over it.

The vertically homogenous or well-mixed estuary is characterized by low inflow of fresh water and large tidal ranges. In such estuaries, salt water and fresh water tend to mix vertically, and sometimes laterally as well.

Intermediate estuaries are partly mixed. They exhibit circulation patterns that are somewhere between those of the salt-wedge and vertically homogenous estuaries. This type of estuary, typical along

the East Coast, has a moderate inflow of fresh water and moderate to large tidal range.

These ideally simplified categories are affected by so many variables as to make the subject of estuarine classification a complex matter. The fact is, estuaries don't exist in an ideal state. They are constantly affected by tidal and wave action, prevailing and changing winds, local and distant weather systems, and variations of rainfall runoff and river discharge.

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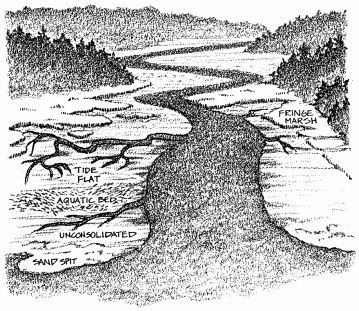
"Classification of Estuaries" - Study questions

1. **Why do we bother to classify the different types of estuaries? What are the different ways that we classify them?**
2. **Which estuary is the largest in the United States and what type is it?**
3. **What are the differences between a lagoon and an estuary?**
4. **Are all estuaries pretty much the same? What factors lead to different types of estuaries?**
5. **What conditions cause a salt wedge estuary to form? A well-mixed estuary?**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Regional Differences Among Estuaries

by Kenn Oberrecht

Estuaries along Oregon's uplifted coast are comparatively small, perhaps amounting to no more than 50,000 acres in the entire state. Generally, those along the Atlantic and Gulf coasts are much larger, mainly because of the lay of the land there.

Along Maine's craggy coast, estuaries are deep, rocky, and fjordlike.

Even within a state or region, estuaries can differ greatly. The North-Atlantic region, for example, extends from Maine to Long Island, New York, comprising nearly 8,000 miles of tidal shoreline. Along Maine's craggy coast, estuaries are deep, rocky, and fjordlike. South through New England, coastal embayments are small, with salt marshes mainly confined to the edges of tidal rivers. In the vicinity of Long Island, however, the marsh-rimmed estuaries broaden and become relatively shallow, more characteristic of the mid-Atlantic region.

Southward, the coast becomes sandy, often forming great barrier beaches and islands and enclosing huge bays and sounds. Rivers

and creeks are tidal for many miles, creating sprawling estuarine habitats and salt marshes that reach far inland.

Along the Carolinas and north coast of Florida the sandy barrier beaches and islands, often battered by storms and turbulent currents, are in a constant state of change. But they afford protection to the estuaries behind them, where the salt marshes remain fairly stable, with human encroachment their worst threat.

At the southern tip of Florida is a rich marine environment supported by a vast estuarine nursery system that has suffered tremendously from the abuses of over-zealous land developers. At the lower end of the Florida peninsula are coral islands and reefs on the Atlantic side and a maze of mangrove forests and islands on the Gulf side.

In the mangroves, shallow gulf waters mix with the tannin-stained freshwater flow from the Everglades and Great Cypress Swamp to create a habitat capable of growing 75 percent of the pink shrimp harvested in the U.S. This is also the rearing and feeding grounds for 75 percent of the sport fishes and 90 percent of the commercial species taken in this part of the state.

Long, narrow, sandy barrier islands and reefs skirt the coast of the Gulf of Mexico from northwestern Florida to Brownsville, Texas. Estuaries here are generally broad and shallow, flanked by extensive marshlands.

On the Pacific Coast, San Francisco Bay is the only estuarine system similar to the large eastern estuaries, both because of its physical makeup and the dense urban and industrial development along its shores.

Along the Texas coast, barrier islands have nearly enclosed narrow estuarine lagoons, leaving only small openings to the gulf. Those with major freshwater inflow are subjected to widely varying salinity levels, while several that receive only minimal fresh water are actually hypersaline.

On the Pacific Coast, San Francisco Bay is the only estuarine system similar to the large eastern estuaries, both because of its physical makeup and the dense urban and industrial development along its shores.

The North-Pacific Region extends from northern California to Alaska and contains some 40,000 miles of tidal coastline. Most coastal rivers here drop quickly from the mountains to the sea and culminate in relatively small estuaries.

Every estuary is unique, yet all estuaries share certain features. Some are similar enough to be grouped or classified according to their shared characteristics. Others are typical of specific regions. All are greatly affected by geology, climate, and a seemingly endless list of other factors, headed by the ever-swelling human population.

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"Regional Differences Among Estuaries" - Study questions

1. **Where are the largest estuaries on the North American continent found? Why?**
2. **If the salt marshes of the southeast are protected from storms by barrier islands, what problems still threaten their health?**
3. **In what way do estuaries help to support the economy of Florida and the Gulf Coast region?**
4. **In what ways is San Francisco Bay similar to east coast estuaries? How is it different from typical west coast estuaries?**
5. **What factors in the Pacific Northwest cause our estuaries to be smaller than those on other parts of the continent? Does this make the Pacific Northwest estuaries less important or productive? Why or why not?**

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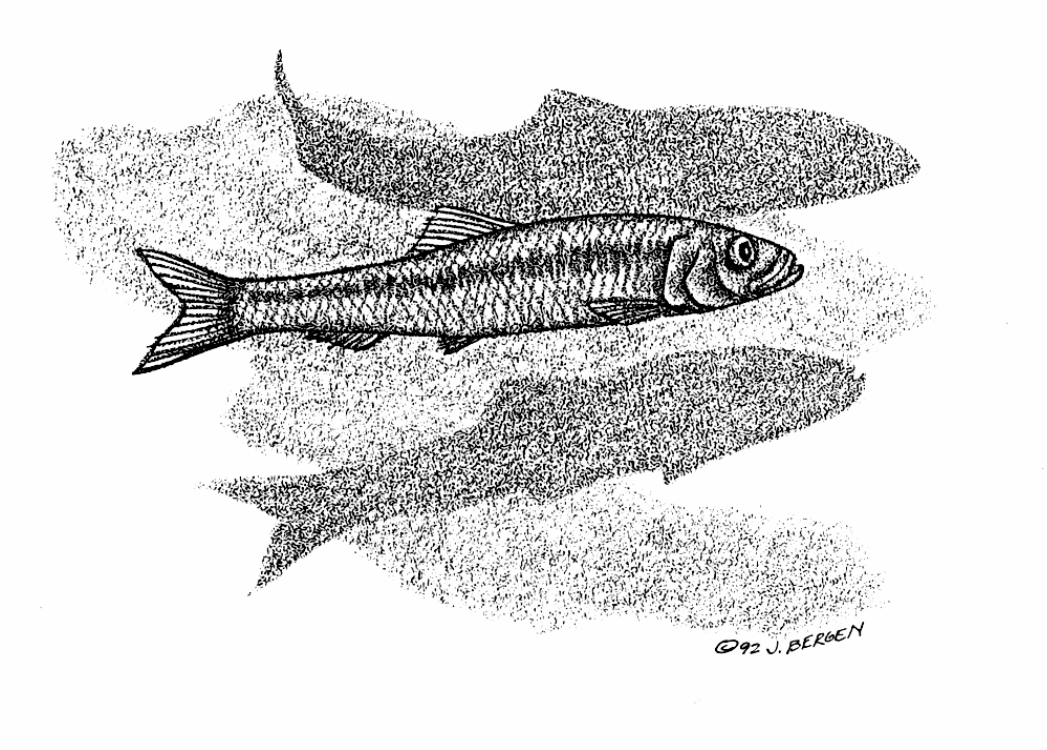
Estuaries as Nurseries

by Kenn Oberrecht



Estuaries are often characterized by labyrinthine tidal creeks winding through shallow marshes, prairies of eelgrass growing on broad mud flats, and a tremendous variety of cover types providing protection and ideal habitat for numerous species of animals. They are the only kind of environment capable of supporting a great diversity of saltwater, freshwater, anadromous, catadromous, and uniquely estuarine residents and passersby.

Salt marshes, the croplands and pastures of the estuary, are among the most fertile areas on the planet.

Salt marshes, the croplands and pastures of the estuary, are among the most fertile areas on the planet. An acre of salt marsh, for example, may produce six times as much organic matter as the average acre of wheat-producing farmland, and may be seven times more fruitful than the waters of the continental shelf and 20 times richer than the deep sea.

Some organisms live out their entire existence within the estuary, while others begin life here and move elsewhere. Still others move to and from estuaries for various reasons, or migrate through them bound for fresh or salt water.

One of the estuary's most important roles is that of nursery, a vital rearing area for many species of fish and shellfish. It's estimated that 65 percent of America's commercial food fishes and shellfishes and nearly all inshore and near-shore saltwater sport fishes are vitally linked to the estuarine environment.

A number of popular food and sport fishes, surf smelt, jacksmelt, herring, and some races of chum and pink salmon spawn in or near the estuaries where their hatchlings grow to fingerlings or young adults before venturing out to sea. Some species remain in or near the estuaries all their lives. Several of the surf perches regularly visit Pacific estuaries to feed and to bear live young there. A few are permanent estuarine residents.

Many species that spawn in the open sea produce young that eventually make their way to the estuaries. Among them are Dover sole, starry flounder, and cabezon, to mention a few.

All of the anadromous fishes, those that spend most of their lives in salt water but reproduce in fresh water, use the estuaries. Similarly, the catadromous species those that mainly live in fresh water but spawn in salt water migrate through the estuaries and may reside there as juveniles. Among the most important anadromous fishes are Atlantic and Pacific salmon, steelhead trout, striped bass, and American shad. The American eel is catadromous.

Many species that spawn in the open sea produce young that eventually make their way to the estuaries. Among them are Dover sole, starry flounder, and cabezon, to mention a few. Estuaries are also rearing grounds for various species of crab and shrimp, some of which are commercially important, while others are critical links in the food chain.

Ambient temperatures and species requirements combine to determine spawning places and times for these pelagic or open-ocean spawners. Eggs and larvae drift shoreward in ocean currents for varied distances, from a few to a few hundred miles. Eventually, they enter the estuary, sometimes in the form of eggs, but usually as larvae or juveniles.

Having reached the nutrient-rich waters that have nurtured their kind for untold eons, the young fish and shellfish will find food

and become food. A few will eventually mature to adults and begin the cycle anew.

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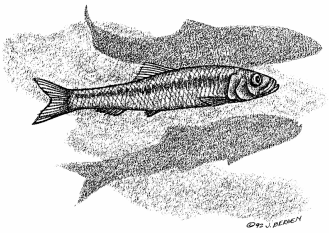
"Estuaries as Nurseries" - Study questions

1. **How are saltmarshes similar to a crop or pastureland? In what ways are they different?**
2. **In what way does an estuary insure that we have seafood from the ocean available to harvest?**
3. **Anadromous fish such as salmon spawn in fresh water. How is the estuary important to these fish? What kinds of ocean spawning animals use the estuary?**
4. **Many estuarine species aren't commercially harvested. What connections might these animals have to the ones we do harvest?**
5. **At what part of their lives do most animals enter the estuary?**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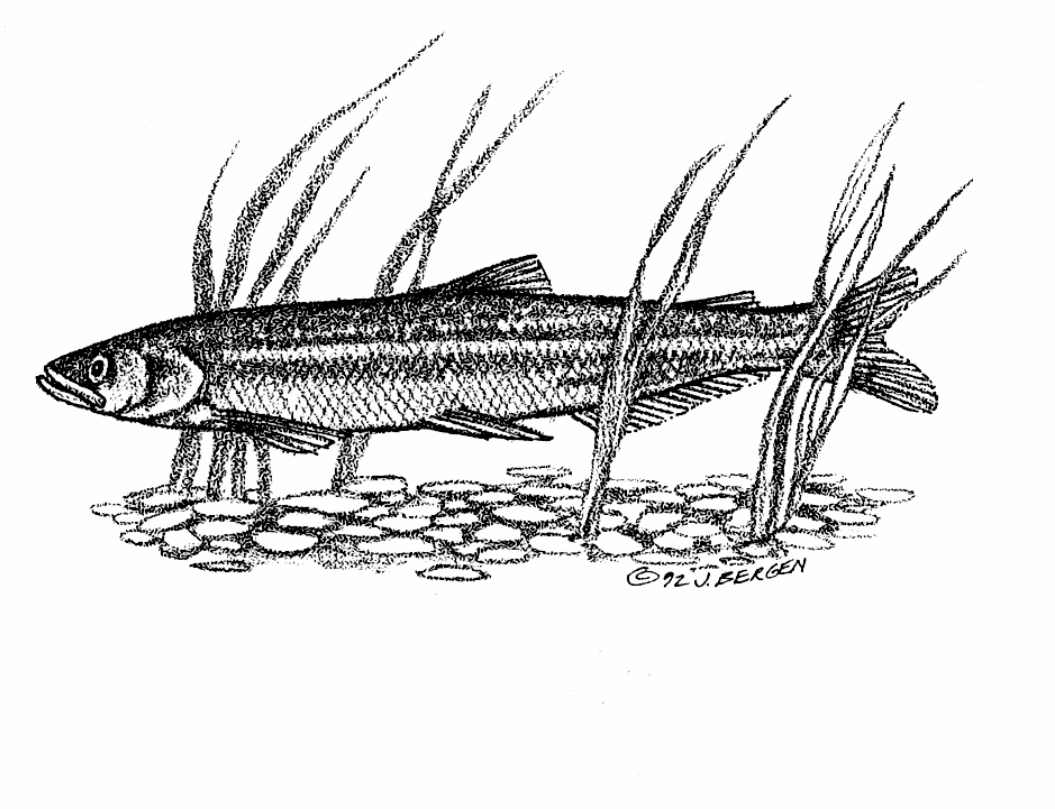
Estuarine Dependence

by Kenn Oberrecht



Estuaries--those diverse and productive areas where rivers end in a tidal swirl of fresh and salt water are environments shrouded in mystery. We know they're important, but wonder how important. We know many estuaries have been damaged by adjacent urban and industrial development and growth, but we're not sure how badly. We know that most commercially and recreationally important fish and shellfish use the estuaries in various ways, but we speculate on whether or not they are actually dependent on these dynamic waterways.

Although entirely estuarine-dependent species are relatively few, many fishes and shellfishes have evolved life histories that indicate at least a partial or temporary dependence. This is especially apparent in ways the nekton, the aggregate of free-swimming aquatic-animal organisms, uses the estuaries as nursery grounds.

We know that most commercially and recreationally important fish and shellfish use the estuaries in various ways, but we speculate on whether or not they are actually dependent on these dynamic waterways.

Many animals have developed complex mechanisms for living in estuaries.

One such mechanism enables passively drifting or weakly swimming larvae, incapable of moving against currents, to find their way into estuaries. Another assists eggs and non-swimming or feeble larvae in reaching estuaries from ocean spawning grounds that might be many miles away.

To illustrate, salt water, which is denser than fresh water, usually enters an estuary in the shape of a wedge that points upstream, with the lighter fresh water flowing over it. Many crab, shrimp, and fish larvae settle to the bottom and ride the salt-wedge currents into the estuaries.

Some even develop daily cycles that enable them to take advantage of such currents in the estuary. For example, as soon as young striped bass are able to swim weakly, they begin moving to the bottom during the day and into the surface layer at night. So they're swept seaward from the head of the estuary at night, and back again during the day, which allows them to remain within a particular area, even though they are not yet strong enough to swim against the current.

It's no accident that here on the Pacific Coast many species that lay pelagic eggs spawn from November through March.

In the Gulf of Mexico, where salt-wedge and tidal currents are relatively weak and insignificant to migrating larvae, some species have evolved winter spawning habits. That's the season of regular onshore winds on the gulf, which result in shoreward currents sufficient to carry larvae into the estuaries and lagoons.

It's no accident that here on the Pacific Coast many species that lay pelagic eggs spawn from November through March. That's our storm season, when prevailing winds are usually onshore. So the same winds that deliver Japanese glass floats and other treasures to beachcombers also help transport larval fish to the estuaries.

Although many of the estuaries' inhabitants and visitors seem to be as mysterious as the estuaries themselves, it appears that a large number of them are not only dependent upon estuaries, but have also developed ways to convey their young to these nutrient-rich nurseries.

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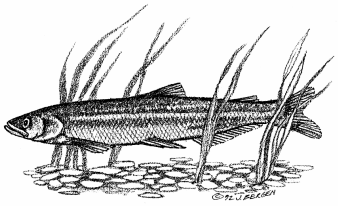
"Estuarine Dependence" - Study questions

1. **How have animals adapted to use the estuary for reproduction?**
2. **What are the advantages of spawning in the winter near an estuary?**
3. **In the Pacific Northwest, how do storms influence larval fish? Can you think of any other effects which the storms have on the flora and fauna of estuaries?**
4. **Describe a change to an estuary that might affect an animal dependent upon that estuary. How would you design a study to investigate this relationship?**
5. **In what ways do humans depend on estuaries?**



Litter Litter Everywhere

by Kenn Oberrecht

Any responsible person who spends time on Oregon's coastal waterways, or who enjoys sightseeing or hiking along our trails and beaches is rightfully appalled by litter that blemishes the region's legendary beauty. Floating trash bobs in the ripples and swirls in the currents of our rivers, heading seaward. Much of it washes up on the shores of our estuaries. Advancing from the ocean, waves dump seaborne garbage on our beaches.

Efforts of 2,665 volunteers led to the collection of 43,200 pounds of trash along 120 miles of Oregon beaches.

As bad as marine litter might seem here at times, problems in other states are much more severe. In fact, if the results of the National Beach Cleanup of last fall are any indication, Oregon's beaches are among the cleanest in the nation. Efforts of 2,665 volunteers led to the collection of 43,200 pounds of trash along 120 miles of Oregon beaches. That worked out to about 360 pounds of garbage per mile, nothing to be proud of, but better than it might have been.

To the south, 16,122 Californians combed 368 miles of beach and found 125 tons of litter, or about 682 pounds per mile. More than 3,000 volunteers in Washington cleaned 60 miles of ocean beaches

and 33 miles along the shores of Puget Sound. They found almost 103 tons, for an average of 2,211 pounds per mile.

Of course, the people who play or work on our waterways and along our shorelines seem the most likely litterers, but they're not the worst offenders. Whether engaged in outdoor recreation or occupation, people discard tons of trash as they go. The litter list is long, including disposable diapers and butane lighters, beverage containers and bottle caps, plastic utensils and six-pack yokes, cigarette filters and candy wrappers, polystyrene cups and fast-food containers, and just about any other kind of trash that can be thoughtlessly discarded.

The worst offenders of all, though, are the world's merchant vessels and passenger ships, most of which dump their refuse at sea. Studies have shown, in fact, that of the ships that dock at U.S. ports, a mere three percent leave trash in the bins provided them.

The U.S. Coast Guard reports that recreational boaters generate about a pound of garbage per boater per day, for a daily total of about 37.5 tons nationwide. According to the National Academy of Sciences, every year, commercial-fishing fleets lose 149,000 tons of non-biodegradable gear such as monofilament lines, traps and pots, polypropylene ropes, and miles of nets. They also discard 26,000 tons of plastic packaging material. The navies of the world are also great ocean polluters, producing as much as three pounds of trash per day per sailor, all of which gets tossed overboard.

The worst offenders of all, though, are the world's merchant vessels and passenger ships, most of which dump their refuse at sea. Studies have shown, in fact, that of the ships that dock at U.S. ports, a mere three percent leave trash in the bins provided them.

Little of the trash discarded these days, whether buried in landfills or jettisoned at sea, breaks down quickly. In fact, most of the litter creating crises around the globe is plastic, in one form or another, that will still be here centuries from now. All litter is an eyesore, and much of it is dangerous. Many of the discarded plastics, whether at sea or washed ashore, are also serious threats to wildlife. We have no alternative but to keep it cleaned up.

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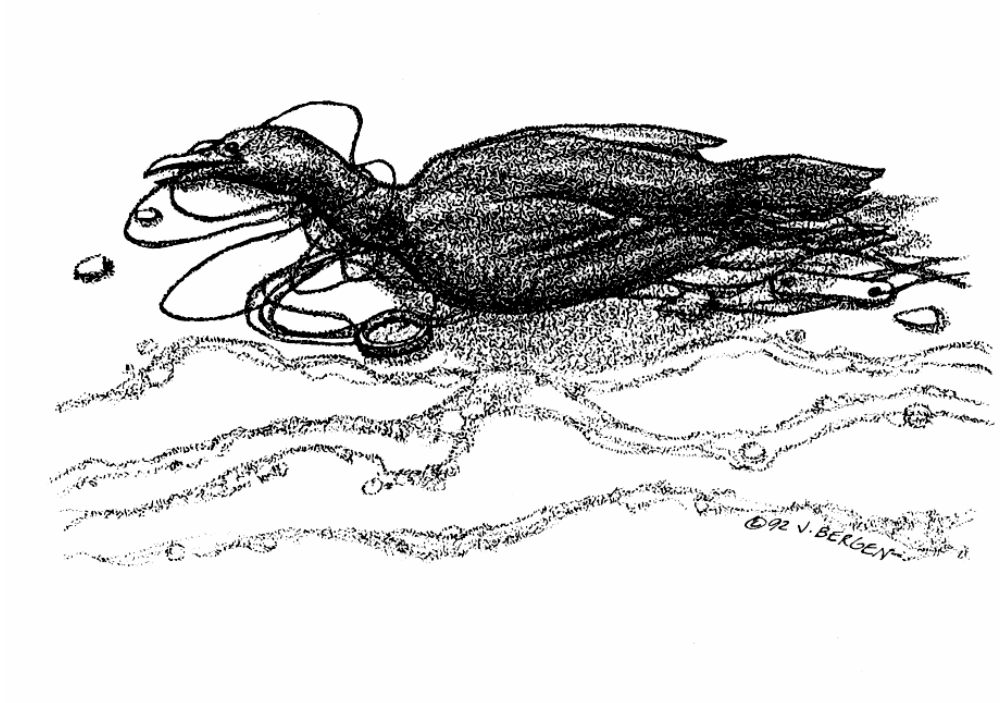
"Litter Litter Everywhere" - Study questions

1. **Which of the West coast states is most highly impacted by ocean borne trash? Why do you think this is the case?**
2. **Who appear to be the major perpetrators of ocean dumping?**
3. **What can be done to stop ocean dumping?**
4. **Why do you think people litter? Describe how trash along the shoreline makes you feel.**
5. **What are some alternatives which might improve the situation?**

Plastics Threaten the Marine Environment

by Kenn Oberrecht



So bad is the international marine trash problem that along the Texas coast alone, 30 tons of garbage, most of it from foreign merchant ships, wash onto the beaches from the Gulf of Mexico every day. A one-mile stretch of Texas beach that volunteers cleaned up at dusk one day was littered by the following morning with another 167 pounds of garbage that had washed in overnight.

During the 1990 National Beach Cleanup, Texas beaches yielded a whopping 2,508 pounds of trash per mile.

Currents are such in the partly enclosed Gulf of Mexico that they carry marine debris, most of it plastic, for great distances and deposit it along Texas's 624-mile coastline. During the 1990 National Beach Cleanup, Texas beaches yielded a whopping 2,508 pounds of trash per mile.

In neighboring Louisiana, it's even worse, with trash drifting down the Mississippi River from inland areas only to join inbound garbage tumbling ashore on nearly every breaking wave. A newsletter published by the Louisiana Sea Grant College Program reported on findings of two researchers who studied the problem,

which is severe enough to have earned Louisiana the unenviable nickname, "The Litter State." Among all the locally generated junk the researchers found on the beaches in their study area were "rice bags from India, soft-drink cans from Singapore, chili pepper cans from Thailand, and even a plastic bottle of bathroom cleaner from Russia."

Aluminum beverage cans tossed into the water usually sink to the bottom, where they function as efficient traps for small fish, shellfish, and other creatures. They're also likely to last for at least a couple of centuries.

It's no wonder that of the states participating in the beach cleanup held in the fall of 1990, Louisiana had the dubious honor of being littered with the greatest density of trash3,289 pounds per mile. Garbage, whatever its form, is always ugly, but some of it is also dangerous. Most of it promises to last for centuries as a continuing threat to the environment.

Aluminum beverage cans tossed into the water usually sink to the bottom, where they function as efficient traps for small fish, shellfish, and other creatures. They're also likely to last for at least a couple of centuries.

Plastic poses one of the greatest and long-lasting threats to wildlife. Nylon gillnet lost at sea keeps right on fishing, and it also entangles sea birds and mammals. A snarl of monofilament line discarded by a careless angler can become a deathtrap for birds and mammals. Plastic six-pack yokes, more efficient than a hangman's noose, have strangled countless fish, birds, and sea mammals.

Coastal states spend millions of dollars every year cleaning up all this plastic and other litter, to protect not only the wildlife but also the multi-billion-dollar tourist industry it threatens.
The plastics threat has reached crisis proportions around the world and doesn't promise to soon subside. Ever-increasing plastics production and application can only compound the problem. Plastic is so lightweight, strong, durable, and long-lasting that it has replaced many other manufacturing materials throughout the world. In the United States, we produce about twice as much plastic as all the steel, aluminum, and copper put together.

Plastic has become so much a part of our lives that we aren't likely to reduce our use of it. We have no choice but to find efficient ways of disposing it.

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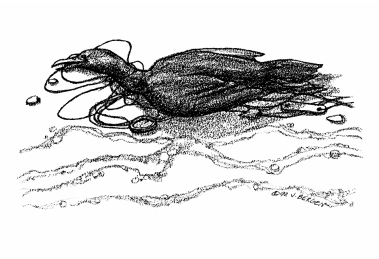
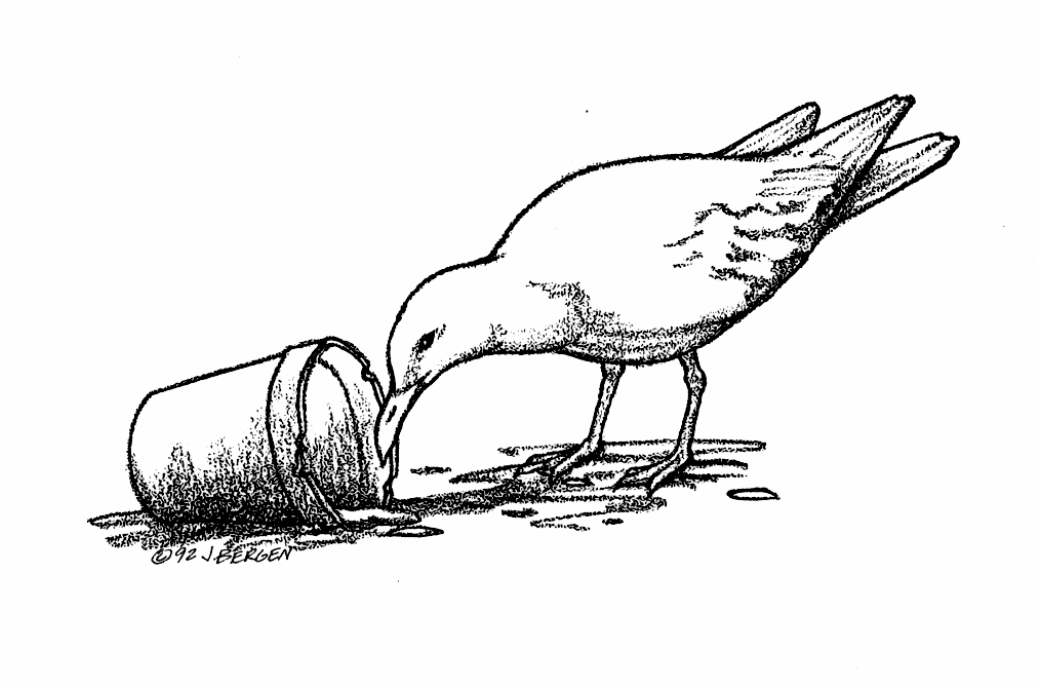
"Plastics Threaten the Marine Environment" - Study questions

1. **How did the state of Louisiana earn the nickname, "The Litter State?"**
2. **How do plastics from other countries wind up on U.S. shores?**
3. **Why is plastic so dangerous in our seas?**
4. **Why is plastic manufactured in such huge amounts?**
5. **What is something you can do to discard of plastic in a safe, efficient manner?**



The Ballooning Problem of Plastic Litter

by Kenn Oberrecht



Just as the castoff plastic from other states and nations can drift in oceans currents and eventually wash up on Oregon's shores, or endanger our migratory mammals, birds, and fish, so can our discarded trash become someone else's nuisance or hazard.

As beachcombers know, some glass floats and other treasures that break free of currents during winter storms and tumble ashore might have been drifting for years. Along with the prizes comes the jettisoned junk of countless freighters, tankers, cruise ships, navy vessels, and fishing boats. They might as well be garbage scows for all the litter they send our way.

The National Marine Fisheries Service reports that about 30,000 northern fur seals die each year as a result of becoming entangled in fragments of nets and cargo-strapping bands discarded at sea.

Much of the flotsam and jetsam riding the currents of the world's oceans is plastic. In fact, researchers at the Woods Hole Oceanographic Institution found 46,000 pieces of plastic per square mile on the open seas. It's no wonder we're losing so much wildlife to this marine menace.

The National Marine Fisheries Service reports that about 30,000 northern fur seals die each year as a result of becoming entangled

in fragments of nets and cargo-strapping bands discarded at sea. During the past 30 years, the population of the species has declined by 50 percent.

Plastic bags drifting in the ocean and presumably resembling jellyfish have lured sea turtles to their death. Similarly, whales and porpoises have ingested plastic bags and sheeting and later died of suffocation.

Both fish and birds ingest carelessly discarded polystyrene "peanuts" used for package dunnage. Resin pellets from which plastic products are made also lure fish and sea birds, possibly because of their resemblance to fish eggs and other small organisms common in their diets.

Resin pellets from which plastic products are made also lure fish and sea birds, possibly because of their resemblance to fish eggs and other small organisms common in their diets.

Plastics kill by entanglement and suffocation. They can poison hapless creatures or cause starvation. They even kill in more bizarre ways, as in the case of a young hawksbill turtle found near Hawaii. An autopsy revealed an intestinal tract so full of plastic bags, polystyrene chips, and monofilament line as to render the animal buoyant and incapable of diving.

Another practice that needlessly litters the earth and the easiest one to stop is the releasing of helium-filled balloons at sporting, political, and other events. Despite what balloon manufacturers would have us believe, these balloons can ride air currents for hundreds of miles and can kill wildlife.

According to the Center for Marine Conservation, as part of an experiment to investigate wind direction conducted during the 1988 National Science and Technology Week, school children released 250,000 tagged, helium-filled balloons. A month later, only five percent of those balloons had been recovered, and one turned up on an island 1,300 miles from the release point. No telling where the remaining 237,500 balloons went. Universities, cities, and states throughout the country have outlawed balloon releases. We can and should prohibit the hazardous practice everywhere.

As to the rest of the plastic littering land and sea and killing wildlife, careful disposal, incineration, and recycling seem the best hopes for the future. Of course, the ignorant and irresponsible will keep tossing their trash wherever they please, and the rest of us will keep picking up after them.

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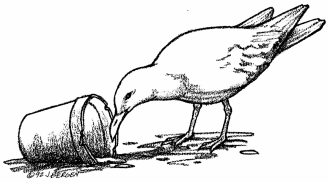
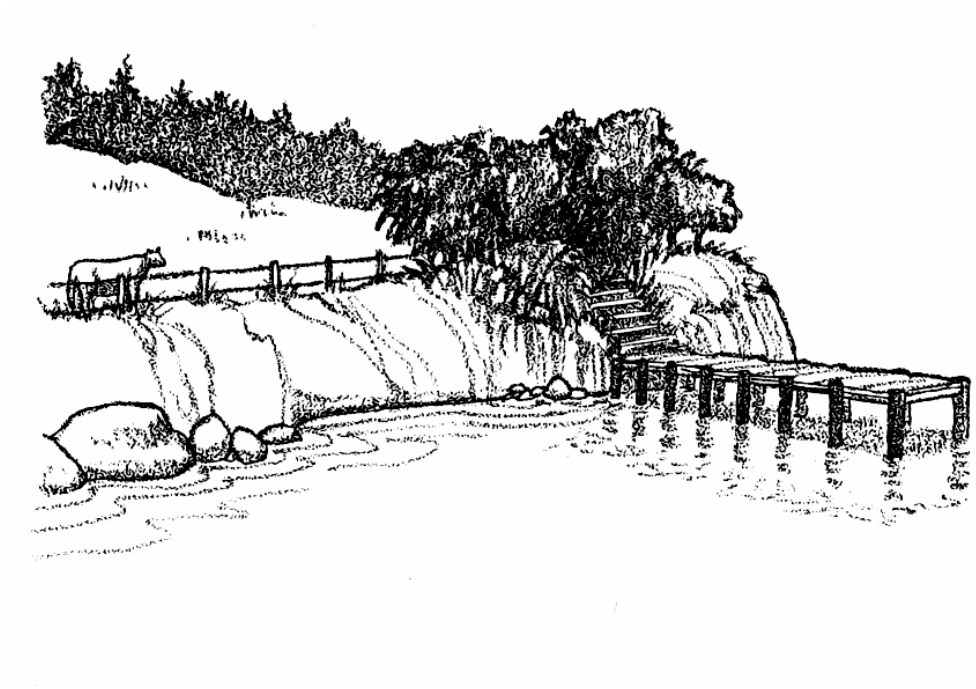
"The Ballooning Problem of Plastic Litter" - Study questions

1. **Of what material is most of the garbage floating in our seas and why do you think there is so much of this material?**
2. **Describe ways in which this material harms or kills wildlife.**
3. **Why does the author say that the releasing of helium balloons should be banned? Do you agree with the author's statement? Why or why not?**
4. **Have you ever personally seen an entangled animal on the beach? What was entangling it? Did you do anything about it?**
5. **Do you think cleaning up our beaches solves the problem? What could solve the problem?**



How Estuaries are Polluted

by Kenn Oberrecht



For centuries, humans have been piling their various wastes on land and dumping them into rivers, estuaries, and seas the world over. We have not only increased our numbers to dangerous levels, but, clever critters that we are, we have also found extremely efficient ways to use up our natural resources and defile nature in almost fiendish ways. What's more, we have created hideous toxins with far-reaching effects, as well as pollutants, contaminants, and trash that will continue to punish our environment for hundreds, even thousands, of years.

It is indeed possible to overharvest the oceans' fish and shellfish stocks and to destroy the breeding and rearing habitat of our most important species with our excessive wastes.

Although the world's oceans have a tremendous capacity to assimilate the human race's waste products, as they've done throughout humanity's brief history, we now know that we're overstressing our coastal waters and open seas with too much filth and debris. It is indeed possible to overharvest the oceans' fish and shellfish stocks and to destroy the breeding and rearing habitat of our most important species with our excessive wastes.

Rivers and creeks are direct recipients of industrial waste and municipal sewage. They also drain urban, suburban, and rural areas where they collect more pollutants and litter. As they move toward the coast, they gather or join the waters of other streams. They eventually reach the sea, usually via an estuary, the area where fresh and salt water mingle. Most of the estuaries themselves are bordered by dense population and industrial development that add significantly to the water's pollution load.

Estuaries are vital links in the life histories of more than two thirds of all our commercially important fishes and shellfishes, most of the near-shore and intertidal sport species, and all anadromous fishes. Pollution of our estuaries is among the greatest threats to our environmental health. Like vandalism, it's also wasteful, costly, and senseless, if not downright criminal.

Estuarine pollution may be defined as the human introduction to an estuary of any substances such as chemicals and waste products that are hazardous or potentially harmful to the estuarine ecosystem. This includes pollutants that are directly toxic to plants and animals, as well as materials that overload the estuary's capacity to assimilate wastes and thus deplete essential oxygen.

We don't have any new estuaries on the drawing board. So it looks like we'll have to protect the ones we have.

Toxic substances commonly found in estuaries include heavy metals, pulp-mill effluents, insecticides, herbicides, and various chemicals and petroleum products. Further stressing estuarine waters are such contaminants as sewage, slaughterhouse and seafood-processing wastes, tree bark and sawdust from sawmills, wood fibers from log-rafting operations, phosphates and nitrates from detergents and fertilizers, and livestock wastes.

Humans have been polluting their environment for as long as they have existed, but the effects were comparatively minor until fairly recently. Now that the population bomb has exploded, we don't have as much environment to go around as we used to.

We don't have any new estuaries on the drawing board. So it looks like we'll have to protect the ones we have.

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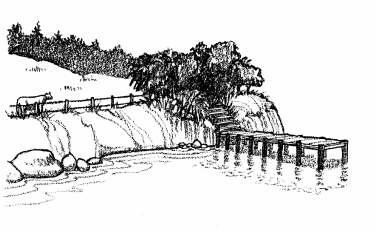
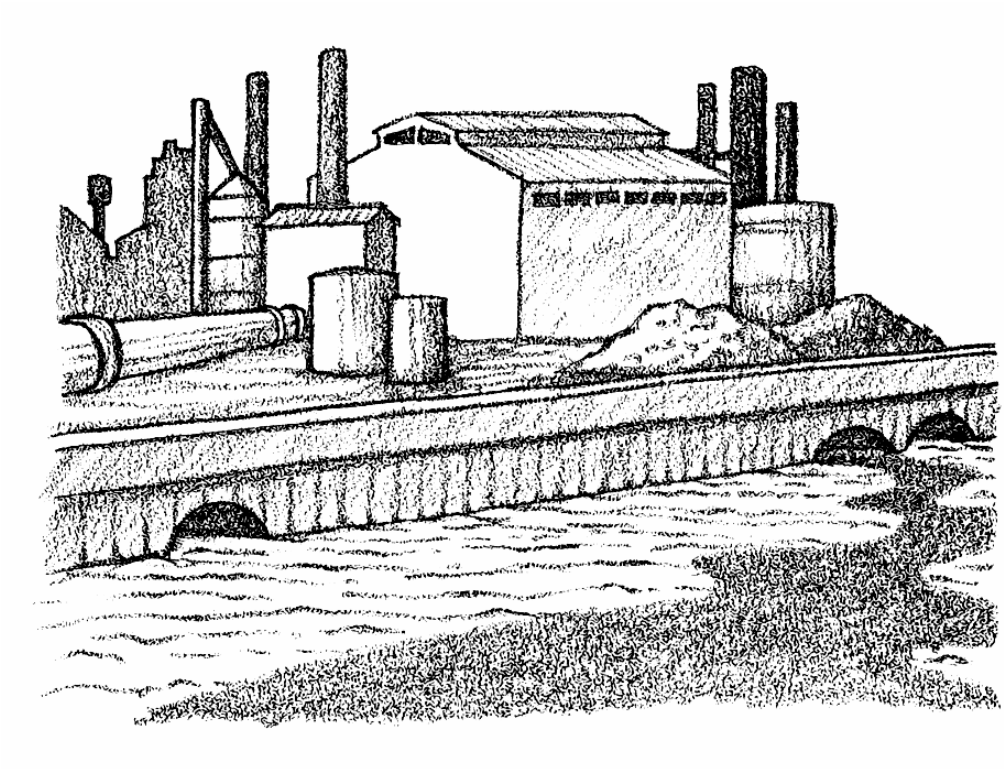
‘How Estuaries Are Polluted” - Study questions

1. **Where have humans historically put their garbage?**
2. **What does it mean to “overstress our coastal waters?”**
3. **Describe several ways in which estuaries receive pollutants.**
4. **Why is polluting an estuary so damaging?**
5. **What are some reasons that pollution has recently gotten so out of hand?**



Effects of Pulp-Mill Effluents

by Kenn Oberrecht



Among the most common forms of pollution found in the estuaries of the Pacific Northwest are pulp-mill effluents, municipal sewage, and agricultural wastes. In fact, our larger estuaries are subjected to all of these and more.

It's safe to say that no body of water was ever improved by the introduction of pulp-mill effluents. Nevertheless, the effects of pulp-mill pollution vary greatly from one mill or mill location to another and are influenced by other factors as well, including temperature, time of year, and even the type of wood or blend of woods being pulped.

A large mill might release more than 50 million gallons of effluent per day into a river or estuary, introducing a variety of toxic materials and tons of organic wastes.

The pulping process employed also affects the quality and amount of the effluent. In the kraft process, wood chips are usually digested in a chemical solution, much of which is recovered before the effluent is discharged into the river or estuary.

The more contaminating sulphite process requires huge amounts of water nearly 500 gallons per ton of pulp. A large mill might release

more than 50 million gallons of effluent per day into a river or estuary, introducing a variety of toxic materials and tons of organic wastes.

Mercaptans are sulphur-containing compounds that cause the horrible stench associated with pulp mills. They can also irritate the gill surfaces of fish, as can the acids and sulphides found in pulp-mill effluents, making it difficult for the fish to breathe. Concentrations of methyl mercaptans can kill fish by paralyzing the nerves of the gill muscles.

Sea salts are natural buffers that help neutralize both excess acidity and alkalinity.

Even low levels of pulp-mill wastes can be harmful to estuary residents. Fish, for example, might experience both breathing and growth problems. Oysters might remain closed longer than usual, and their pumping rates, growth, and reproduction can be reduced. Pulp-mill effluents might introduce acids or alkalies to the estuary, either of which will affect the water's pH, or neutrality, and become potentially harmful to fish and other animals unable to tolerate excessive acidity or alkalinity. To alleviate such problems, operators of some mills mix the acidic and alkaline compounds before release, thus neutralizing the effluent.

Sea salts are natural buffers that help neutralize both excess acidity and alkalinity. So the higher the salinity near a pulp-mill's outfall, the less pH deviation will be a problem.

Breakdown of great quantities of organic material requires an abundance of oxygen in the outfall area. This oxygen demand can create severe problems, especially in small estuaries or those with poor circulation.

Organic wastes in the effluent consist mainly of lignins and wood fibers. Lignins stain the water brown, inhibiting sunlight penetration and photosynthesis, which retards plant growth. Wood fibers also affect photosynthesis and respiration by reducing the exchange of gases in plant cells. When the fibers sink to the bottom to decay, they can reduce or eliminate oxygen there.

Breakdown of great quantities of organic material requires an abundance of oxygen in the outfall area. This oxygen demand can create severe problems, especially in small estuaries or those with poor circulation.

The ideal pulp mill would be one that dumped no pollutants into the river or estuary, one with a so-called closed system, in which no effluents are discharged. But this may be an environmental ideal that's impossible to achieve. Even if the technology were advanced enough to permit it, the closed system might prove too expensive to implement.

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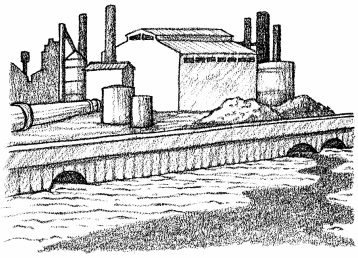
"Effects of Pulp Mill Effluents" - Study questions

1. **How can the effects of pulp mill pollution vary from site to site?**
2. **What are effluents?**
3. **What are some effects that mercaptans have on the environment?**
4. **How can seemingly harmless pollutants like wood fibers hurt our estuaries?**
5. **If you ran a pulp mill, what types of procedures might you follow or develop to keep pollution to a minimum?**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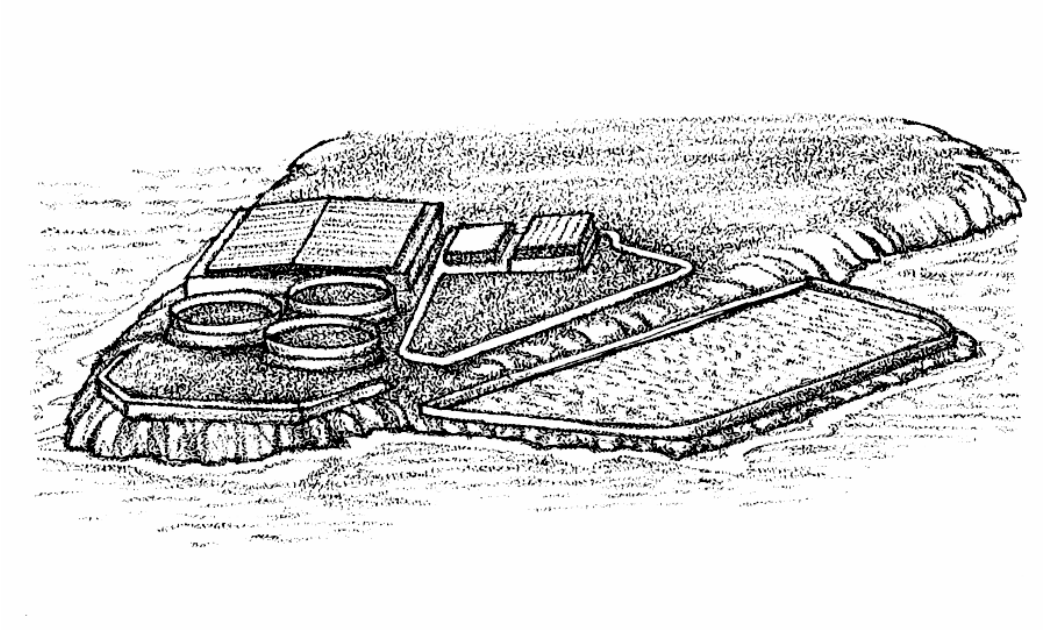
The Effects of Sewage on Estuaries

by Kenn Oberrecht



Sewage usually degrades the waterway where it's dumped. Municipal sewage can be directly toxic to organisms it comes in contact with and can cause oxygen depletion through nutrient enrichment in the waters where it is introduced. The smaller those waters or the poorer their circulation, the worse the effects of sewage will be on the organisms living there.

Despite the seeming abundance of sewage-treatment plants in the United States, raw sewage is frequently discharged into our waterways, especially during storms and periods of peak runoff and snowmelt.

Depending on its content and level of treatment, sewage can wreak havoc all the way up the food chain to humans. Raw, untreated sewage, for example, may contain harmful chemicals, hazardous compounds, heavy metals, and viruses.

Despite the seeming abundance of sewage-treatment plants in the United States, raw sewage is frequently discharged into our waterways, especially during storms and periods of peak runoff and snowmelt. Equipment malfunction and human error also lead to raw-sewage discharges. At treatment plants, sewage might undergo only minimal treatment or be subjected to an array of purification steps. The various levels are known as primary, secondary, and tertiary treatment.

In primary treatment, sewage is screened to remove large particles, then sent to settling chambers. Sludge is raked from the bottom of settling chambers for disposal, and the liquid may be aerated before chlorination and release.

Chlorine is added to kill bacteria. The problem is that it is non-discriminating, killing both the disease-causing bacteria and those that would help break down the sewage after its release.

Most communities in the United States depend on primary-treatment systems.

In secondary treatment, the liquid is aerated and sometimes planted with fresh bacteria. It might also be run through a filter system and sprinkled on a bed of coal or gravel over a broad area conducive to bacterial growth and oxidation. It's usually chlorinated before release. Sludge is removed from settling tanks and treated. It might then be burned or turned into some useful product, such as fertilizer, soil conditioner, or fill material.

Tertiary treatment attempts to remove all contaminants from sewage, which is both difficult and expensive. In some tertiary plants, though, the final product is purer than tap water.

Most communities in the United States depend on primary-treatment systems. Some use a combination of primary and secondary treatment; few employ tertiary treatment. In too many coastal communities, especially the more remote ones, sewage gets only cursory treatment, if it gets anything at all. The rest is left to tidal currents.

Despite the pressures of increasing populations on our overburdened estuaries, there is some promising technology already working at the seemingly overwhelming task of safe sewage treatment and disposal.

In addition to toxins and other pollutants and an abundance of oxygen-depleting organic matter, sheer bulk is another problem sewage creates, especially where population is dense. For example, it's estimated that during the summer months, by the time New York's Hudson River reaches its estuary, 15 to 20 percent of its entire volume consists of municipal sewage.

Despite the pressures of increasing populations on our overburdened estuaries, there is some promising technology already working at the seemingly overwhelming task of safe sewage treatment and disposal.

In one system, after primary treatment, sewage is diverted to a series of ponds and marshes where biological processes remove much of the remaining organic material by decomposition and plant growth. Not only is the sewage effectively treated, but the

newly created marshes, lush with vegetation, attract birds, waterfowl, and other animals, as well as people who enjoy nature.

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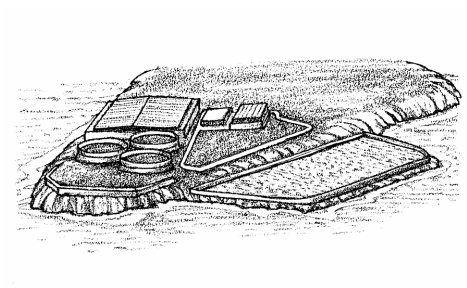
"The Effects of Sewage on Estuaries" - Study questions

1. **Why does sewage discharge cause oxygen depletion?**
2. **During primary treatment, chlorine may be added to the water. Why? What problems may then be encountered?**
3. **Why do most communities in the U.S. use only primary treatment?**
4. **What are some newer, alternative methods for managing sewage?**
5. **What are some uses for the sludge which is scraped from holding tanks during secondary treatment?**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Oil Pollution in Estuaries

by Kenn Oberrecht

Oil is an imprecise term applied to various petroleum products, consisting of hydrocarbon compounds and differing widely from one another. Petroleum pumped from the ground is commonly called crude oil, which is distilled and refined into a number of other products, such as diesel fuel, kerosene, gasoline, benzene, naphtha, machine oils, and lubricating oils of various weights.

Oil is transported in its many forms by rail, truck, ship, airplane, and pipeline. It is also spilled and leaked onto land and into water throughout the world.

Shipwrecks, groundings, blowouts at offshore oil rigs, and other accidents on water account for the worst oil-related environmental disasters, mainly because oil is difficult or impossible to contain in water.

Tankers and supertankers haul vast amounts of crude and refined oil by sea. Smaller tankers also enter estuaries and travel up navigable rivers. Additionally, thousands of naval vessels, merchant ships, and cruise ships carry large quantities of bunker oil as fuel for their engines.

Shipwrecks, groundings, blowouts at offshore oil rigs, and other accidents on water account for the worst oil-related environmental disasters, mainly because oil is difficult or impossible to contain in water. According to the National Academy of Sciences, oil pollutes the global marine environment at a rate of about six million metric tons a year.

Oil pollutes estuaries in a number of ways, including major spills from freighters, tankers, barges, and other vessels going aground or colliding with other ships or structures, and minor spills from small recreational and commercial craft. Emptying of oil-contaminated ballast and bilge water into an estuary is another way of polluting it.

The normal operation of coastal refineries, factories, and mills adjacent to estuaries often leads to oil leakage or seepage into the water.

The normal operation of coastal refineries, factories, and mills adjacent to estuaries often leads to oil leakage or seepage into the water.

Runoff from rainfall and snowmelt carries oil from highways, city streets, parking lots, industrial areas, and heavy-equipment yards into the estuary, either directly or through municipal storm-sewer systems. Thoughtless vehicle owners who discard used crankcase oil in storm sewers only compound the problem.

Open seas have a much greater capacity to assimilate spilled oil and reduce its harmful effects. As many learned when the supertanker Exxon Valdez went aground in Alaska's Prince William Sound, however, near-shore spills can be disastrous, especially when they occur within partly enclosed bodies of water, such as a sound, bay, or estuary.

Riverine and estuarine currents make spills and slicks particularly difficult to contain. They quickly carry the oil to shorelines, marshes, and flats where they do their worst damage.

An oil slick is a threat to most creatures in its path, especially sea birds, waterfowl, and fur-bearing mammals. It can blanket and smother whole communities of shoreline and intertidal organisms, kill the eggs and larvae of fish and shellfish, and taint entire colonies of adult shellfish.

In the confines of an estuary, even relatively small oil spills can wipe out whole populations of certain organisms, thus upsetting the food chain there for years to come.

Although oil is a toxic substance, difficult to contain and clean up in the estuary, the sooner cleanup crews can get to a spill or detected slick, the better their chances of alleviating at least some of the harmful effects. So it's important to immediately report spills to the local Coast Guard or other authorities.

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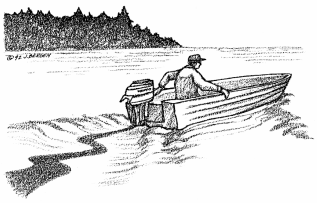
"Oil Pollution in Estuaries" - Study questions

1. **Name some of the products that petroleum pumped from the ground is made into. Which do you recognize and use mostly?**
2. **What are some causes of marine oil spills?**
3. **Have you heard of any methods used to help decrease the risk of an oil spill at sea?**
4. **How does oil get into a body of water from land?**
5. **Why is an oil spill in a sound or estuary more devastating than a similar-sized oil spill in the open ocean?**
6. **What are some long term effects of oil spills to the environment? Devise an "Oil Spill Emergency Response Plan" for the body of water nearest you!**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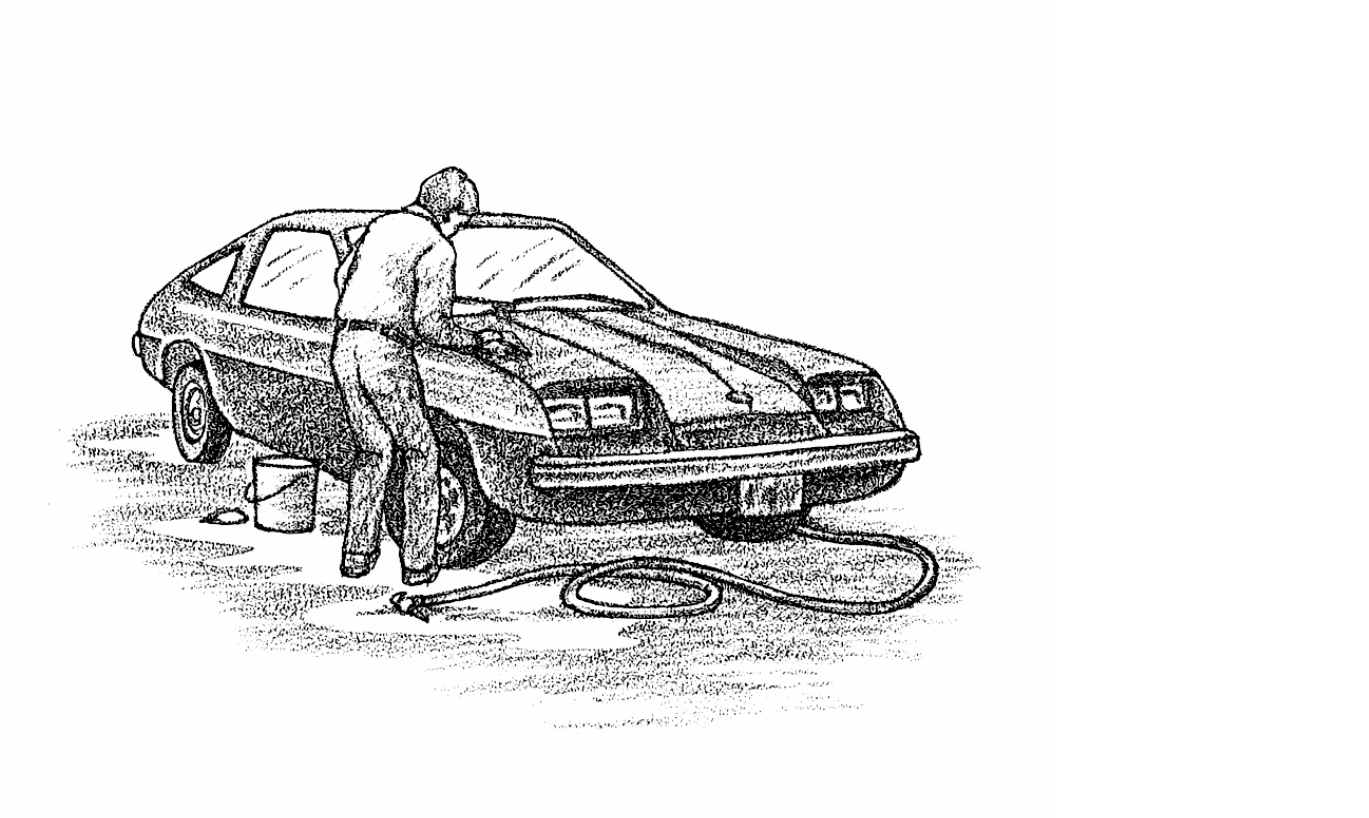
Nonpoint-Source Pollution

by Kenn Oberrecht



In recent years, agencies contending with all the ways we've found to foul our planet's waters have begun focusing their attention on a major source of pollution that, well, you can't really put your finger on. They call it nonpoint-source pollution and define it as "all pollution entering the surface-water system other than from pipes."

According to the National Oceanic and Atmospheric Administration, the sources you can't point to "contribute more than half of the suspended solids, phosphorus, chromium, copper, lead, iron, zinc and fecal coliform bacteria" that pollute our rivers and estuaries.

When pollution comes from a single point, usually a pipe, it's called point-source pollution. Examples are pulp-mill effluents, sewage discharges, and most industrial wastes that get dumped into our rivers and estuaries. You can point to them.

According to the National Oceanic and Atmospheric Administration, the sources you can't point to "contribute more than half of the suspended solids, phosphorus, chromium, copper,

lead, iron, zinc and fecal coliform bacteria" that pollute our rivers and estuaries.
They include soil eroding into creeks and rivers from farms, ranches, construction sites, and logging areas. This soil buries valuable gravel spawning grounds in our streams. It increases turbidity, which diminishes sunlight penetration and retards plant growth. It also causes lakes to fill in and age too rapidly.

Runoff in rural areas usually contains harmful chemicals, fertilizer, livestock manure, and waste oil. Runoff in urban areas isn't much different, carrying, as it does, fertilizers and pesticides used on lawns and gardens, pet wastes, and oil leaked from vehicles.

Toxic chemicals, heavy metals, and oil also reach the rivers and estuaries in the leachings from mine tailings and landfills and runoff from scrap heaps and wrecking yards. Rain and melting snow also flush highways, streets, and parking lots of road salt, oil, metals, and other pollutants. Marinas and boat basins contribute untreated sewage and fish wastes. They add cleaning compounds and anti-fouling paints to the pollution brew, as well as contaminated runoff from nearby parking lots.

Streets that end at the edge of an estuary can be particularly harmful, providing a fast and direct route for polluted runoff.

Nonpoint-source pollution is a severe problem only recently recognized. Both federal and state agencies throughout the United States are now working to find solutions.

A major contributing factor associated with urban growth and industrial development is the vast and rapid replacement of vegetated, undeveloped land with such impervious surfaces as highways, streets, parking lots, and sidewalks. Streets that end at the edge of an estuary can be particularly harmful, providing a fast and direct route for polluted runoff.

A number of states now require new construction to be set back from waterways for distances of 50 to 200 feet or more, leaving vegetated buffers between structures and the water. Some have redesigned street ends to alleviate the runoff problem. Others encourage planting new buffer zones where none existed before. The buffer areas filter rainfall and snowmelt runoff, removing much of the harmful contamination from it before it reaches rivers and estuaries.

These measures, coupled with strict permit systems and review of all new development near rivers, estuaries, and tidal wetlands will

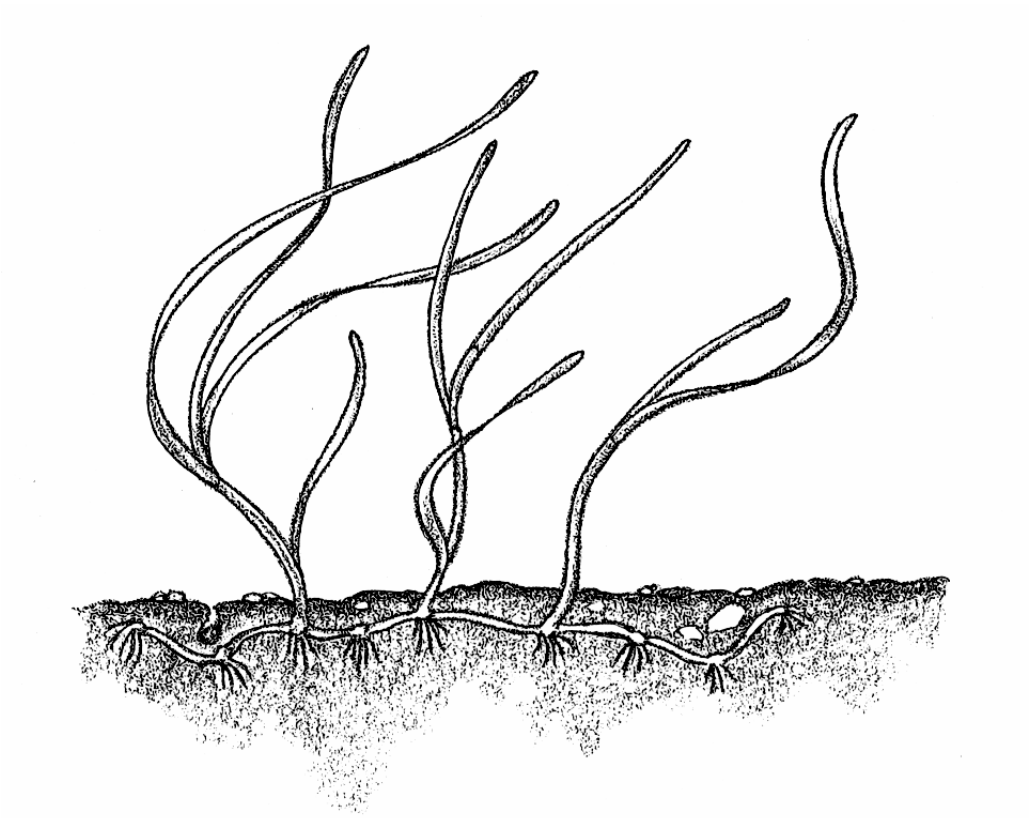
go a long way toward cleaning up our coastal waters and keeping them clean.

"Nonpoint-Source Pollution" - Study questions

1. **What is nonpoint-source pollution?**
2. **What are some possible causes of nonpoint-source pollution?**
3. **How do "buffer areas" help to restrict nonpoint-source pollution run-off and, what is a buffer area?**
4. **Nonpoint-source pollution is a newly recognized problem and is, perhaps, not widely known. In what ways could nonpoint-source pollution be brought to light?**
5. **Trace the path of a drop of motor oil from someone's leaky car to an estuary. Describe what negative effects it has along the way.**

The Estuary as Pollution Trap and Filter

by Kenn Oberrecht



Much the same way estuaries trap nutrients and provide rich and productive nurseries and feeding areas for numerous organisms from the bottom to the top of the food chain, so do they trap pollutants that can harm estuarine residents and others dependent on them.

The wedge of salt water characteristically underlying the layer of fresher water in an estuary tends to move sediments in an unusual way. As the denser salt water moves along the bottom toward the head of the estuary to replace water carried away by freshwater surface flow, it takes with it some of the nutrients the river has brought downstream, thus dispersing them over a wider area in the estuary.

Some salt-marsh and tidal-flat plants are capable of filtering harmful pollutants from the water and storing them beneath the bottom sediments in their roots and systems of runners known as rhizomes.

Similarly, if the river is polluted, contaminants can be carried downstream in the fresh or brackish surface layer, then back toward the head of the estuary after they settle out and into the

deeper salt water. Valuable nutrient-bearing sediments are also capable of carrying and dispersing a variety of dangerous pollutants, including pesticides and heavy metals, which some estuarine organisms are known to store and concentrate.

Some salt-marsh and tidal-flat plants are capable of filtering harmful pollutants from the water and storing them beneath the bottom sediments in their roots and systems of runners known as rhizomes. In this way they function as valuable filters that cleanse the estuary's waters of contaminants.

Studies indicate that salt marshes can receive some sewage without adverse effects on the marsh environment.

Some pollutants, however, such as mercury, the most hazardous of the heavy metals, make their way to the plants' leaves where they either directly return to the water or enter the food chain when plant-eating organisms consume the leaves or leaf particles called detritus.

Studies indicate that salt marshes can receive some sewage without adverse effects on the marsh environment. Additionally, some polluting substances that end up in the marsh sediments will break down and be rendered harmless.

In these investigations, nitrogen and phosphorus of which sewage contains large amounts had no apparent detrimental effects on the marsh. Phosphorus apparently did not retard plant growth, and the nitrogen fertilizer used in the experiments actually increased the growth of higher plants.

These and similar discoveries are leading to technologies that show promise for the future in ways we might come to deal with increasing sewage and pollution loads that overburden our treatment plants and waterways.

One fine example of such technology at work is located on the outskirts of Arcata, California. The college town lies west of U.S. 101, 92 miles south of the Oregon state line. Arcata Marsh and Wildlife Sanctuary, a lush wetland at the northern edge of the Humboldt Bay estuary, annually attracts more than 150 species of sea birds, shorebirds, and waterfowl.

First-time visitors to the marsh find it difficult to believe that the beautiful area, teeming with wildlife, is actually part of the city's sewage-treatment facility. Such created or improved wetlands might be ideal in many parts of the nation. Not only can they help us dispose of our wastes, but they also become valuable wildlife

habitat in the process. Moreover, they represent one small way that humans can begin paying back their environmentally beleaguered planet.

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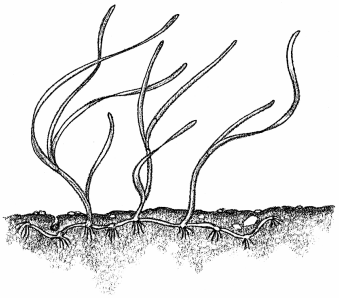
"The Estuary as Pollution Trap and Filter" - Study questions

1. **Describe why an estuary may have a wedge of salt water.**
2. **How does this wedge facilitate spreading of pollutants in an estuary?**
3. **How do saltmarsh plants help to filter the estuary's waters?**
4. **How can dangerous contaminants make their way up the food chain?**
5. **It is said that wetlands have the ability to neutralize sewage waste. Describe how. Discuss how this could be utilized in our growing urban areas and what other problems could arise.**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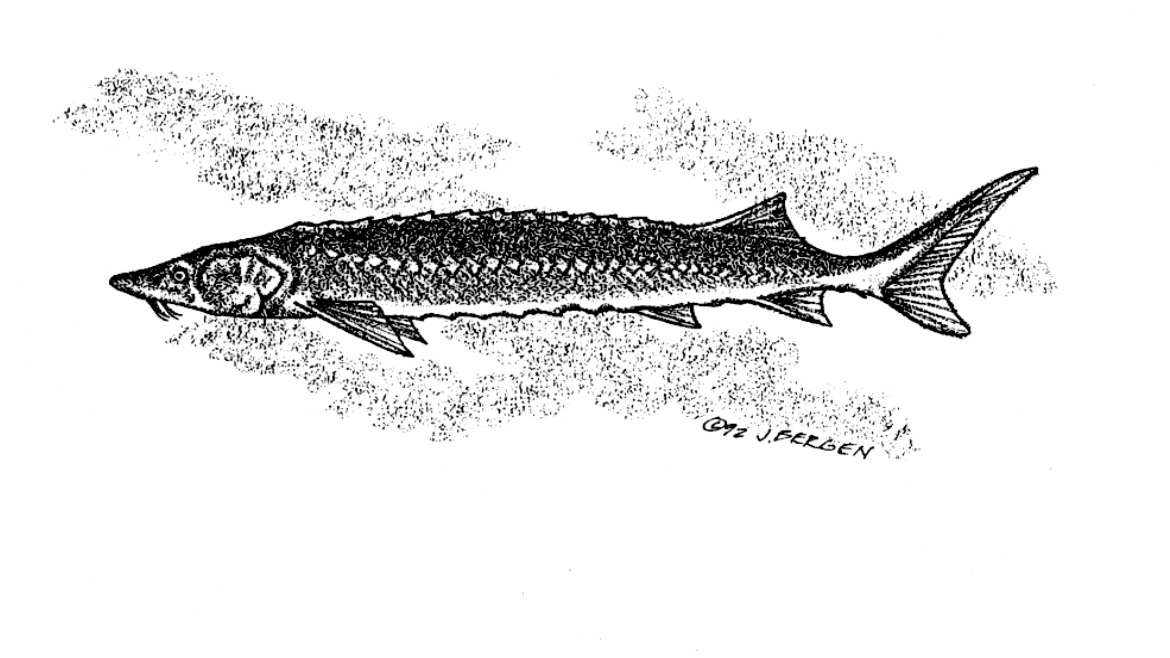
Monsters of the Estuary

by Kenn Oberrecht



Cars, motorhomes, and tractor-trailer rigs ride the rising arches of the McCullough Bridge over Coos Bay, their occupants unaware of the life-and-death drama unfolding in the dark depths below. Beneath the surly surface swirls of water ebbing ever seaward, a torpedo-shaped monster in search of its next meal glides silently and effortlessly, like something oiled, past bridge piers and rip-rap.

In a single sweep of its powerful tail and a subtle turn of the tail's long upper lobe, the huge fish overtakes its hapless prey and consumes it in one slurp.

Characteristic of its species, which developed 40 million years ago, this sleek predator displays a single dorsal fin atop a muscular body wrapped around a skeleton of resilient cartilage. The largest of its kind in North American waters, the great white moves freely from the depths to the shallows and back again. In a single sweep of its powerful tail and a subtle turn of the tail's long upper lobe, the huge fish overtakes its hapless prey and consumes it in one slurp.

Slurp? Slurp! Is this the right word to depict the mayhem of a marauding great white shark with enormous jaws full of teeth best described as indestructible self-sharpening shards? Well, no. Our great white's mouth is more like a vacuum-cleaner hose. While it

shares some characteristics with sharks and comes from the same geological era, its habits and habitats are considerably different. Our bay monster is the white sturgeon. Its prey might have been a smelt, herring, or ghost shrimp.
Sixteen known species of sturgeon swim the fresh, brackish, and salt waters of the northern hemisphere, seven of them residents of the United States. Here on the West Coast, we have two species: the white and the smaller and rarer green sturgeon.

Most sturgeon are anadromous fishes, moving freely from the ocean into the estuaries and rivers to feed and spawn. The green sturgeon, however, which grows to about seven feet and 350 pounds, seldom enters fresh water and seems to prefer the brackish estuaries.

This is a brute of a fish, capable of growing to 16 feet or longer and weighing more than 1,500 pounds. It's a slow grower, though, and often a late breeder, characteristics that call for special measures to assure the survival of the species.

The white sturgeon is tolerant of a wide range of salinity. From Monterey, California, to the Gulf of Alaska, it moves from the ocean and edge of the continental shelf, into the estuaries of large coastal rivers, and often far up the rivers. Some individuals spend most or all of their time in the estuaries and rivers. In fact, dam construction on the Columbia and Snake rivers has landlocked whole populations of white sturgeon many miles inland from the ocean.

This is a brute of a fish, capable of growing to 16 feet or longer and weighing more than 1,500 pounds. It's a slow grower, though, and often a late breeder, characteristics that call for special measures to assure the survival of the species.

Like other sturgeons that flourished for millions of years, the white was nearly wiped out in a brief span from the 1880s to the 1920s. No laws protected the great fish then, when commercial fishermen took so many for their tasty flesh and valuable roe that the brood stock was nearly depleted.

White sturgeon seem to be holding their own now, but only persistent efforts will ensure their survival. We'll need to continue our studies of these ancient creatures, strictly enforce the laws that protect them, and preserve the estuaries that rear and feed them.

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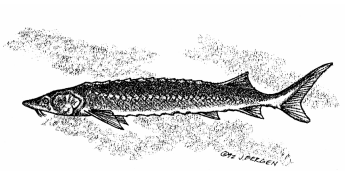
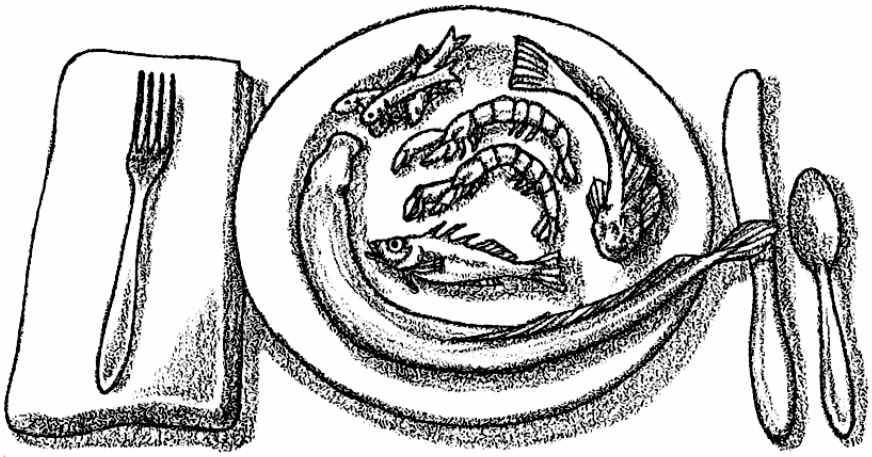
“Monsters of the Estuary” - Study questions

1. **What “monster” is the article referring to, how many species are there and how many do we find on the West Coast?**
2. **What is an anadromous fish?**
3. **It is said that this monster is tolerant of a wide range of salinity. What does that mean and how is it utilized?**
4. **It may grow to 16 feet and 1500 pounds, but it does so slowly, and breeds late in life. What “special measures” do you think are taken to assure its survival?**
5. **Keeping in mind that this “great white monster” is a top predator in the estuaries and seas, describe some effects which may have been noticed had not this fish persevered in the 1920’s.**



How Sturgeon Depend on Estuaries

by Kenn Oberrecht



Of the two species of sturgeon found in Oregon's estuaries, we know more about the habits and life history of the white sturgeon than its smaller cousin. The more mysterious green sturgeon seems to spend most of its time near the mouths of estuaries, moving into fresh water only to reproduce during the fall and winter.

White sturgeon, however, seem to rely much more on the estuaries. In fact, some spend most of their lives in the estuaries of Oregon's largest coastal rivers, such as the Coos, Umpqua, and Columbia.

When schools of smelt, herring, or other forage species migrate into the estuary, sturgeon move in from the ocean to feed on them.

Feeding migrations vary from one locale to another and can be influenced by movement of forage species. Although white sturgeon feed on both plant and animal matter throughout their lives, adults are opportunistic predators, showing a distinct preference for fish and other animals.

When schools of smelt, herring, or other forage species migrate into the estuary, sturgeon move in from the ocean to feed on them. Lampreys and ghost shrimp are other favorite foods. They consume

many kinds of fish, dead or alive, and even move up the rivers to feed on carcasses of spawned-out salmon. They also eat sculpins, sticklebacks, suckers, and even their own kind.

White sturgeon grow slowly but live long. Although growth rates vary from one estuary to another, most young fish grow to about 20 inches in five years and add two inches in length each following year, to about age 35. After that, they grow more in bulk than length.

Male white sturgeon mature sexually any time between 11 and 22 years of age, females between 26 and 34.

Spawning in fresh water, usually in May or June, 35-pound females lay nearly 700,000 eggs, while the largest specimens of 800 pounds or more can produce three to four million eggs, with a mass weight exceeding 200 pounds. Poor parents, the adults leave eggs unattended and let young fend for themselves.

Juveniles consume mainly insect larvae, mysid shrimp, tiny crustaceans, mollusks, and other freshwater and marine invertebrates. After about five years, their preference turns to fish, which then make up about half their diet.

Male white sturgeon mature sexually any time between 11 and 22 years of age, females between 26 and 34. They survive spawning and may reproduce several times during their lives, although intervals between spawning get longer as the fish age. While younger females spawn every four years, older fish might spawn only once every decade. So it's important to protect the brood stock.

Toward that end, Oregon enforces strict size and catch limits, permitting anglers to keep two sturgeon a day: one between 40 and 48 inches, and one between 48 and 72 inches. Larger or smaller fish must be released unharmed.

Old photographs survive showing white sturgeon so big they had to be hauled out of the water with block and tackle or teams of mules. Many fish of 800 to 1,000 pounds or more were caught around the turn of the century. By the 1920’s, the biggest breeders were gone.

Sturgeon of such huge size have lived for 60 to 80 years or more, so replenishing the brood stock is a slow process. Protecting them and the estuaries they depend on is essential if these great fish are to survive.

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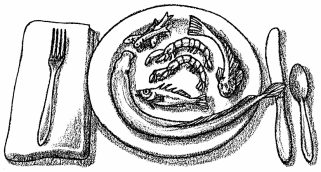
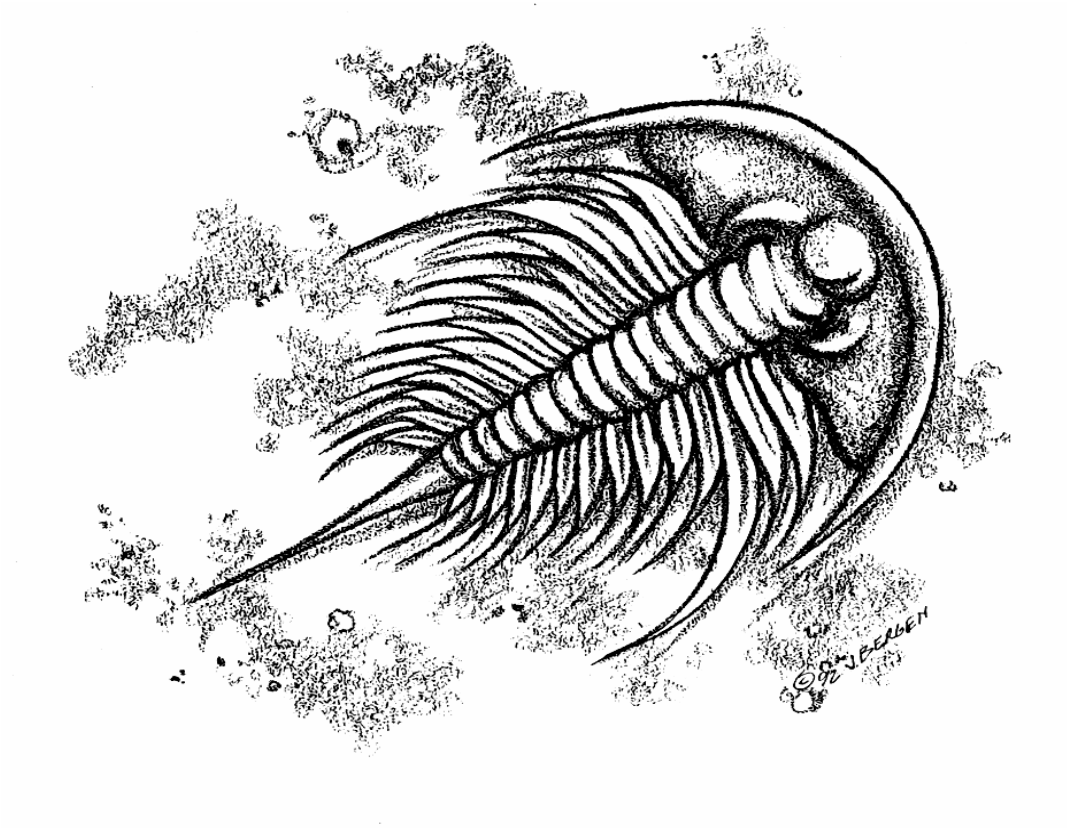
"How Sturgeon Depend on Estuaries" - Study questions

1. **What is an opportunistic predator?**
2. **What causes sturgeon to move in and out of estuaries?**
3. **Why do sturgeon lay so many eggs?**
4. **Why is it important to protect the brood stock and what does Oregon do to protect it?**
5. **Size and catch limits are based upon years of scientific data. How do you think data is collected and analyzed to come up with appropriate limits?**



Geological Time Capsule, Part I

by Kenn Oberrecht



In geological terms, earth's history unfolds in a succession of human-defined time divisions that embrace thousands, millions, even billions of years. The basic unit of geologic time is the period, which comprises two or more epochs. An era is a major division consisting of two or more periods. There are longer and shorter divisions, but these three serve well in any description of the features and events that helped shape the earth into the planet we know and formed the environment in which we exist.

Earth's earliest life forms appeared during the Proterozoic Period.

Beginning some five billion years ago, the Archeozoic Period is the earliest division of the Precambrian Era. During that time, the earth's crust gradually solidified. The barren continents that formed then were about only one-eighth the size of current continents. The atmosphere had excessive carbon dioxide, no free oxygen, and no ozone to mitigate the effects of the sun's fierce ultraviolet radiation.

The Proterozoic Period of the Precambrian Era began about 2.5 billion years ago. During this time of relative calm, continents increased to nearly their present size and formed a great supercontinent. Huge bodies of molten matter known as magma were trapped inside the earth's crust. As they cooled, minerals crystallized and settled out, and great layers of metal formed in the crust.

Earth's earliest life forms appeared during the Proterozoic Period. Blue-green algae began thriving, photosynthesizing, and pumping free oxygen into the atmosphere. Bacteria and primitive multicellular life forms appeared.

The age of marine invertebrates dawned, and shellfish flourished, as did echinoderms, early ancestors of the sea stars, sea urchins, and sea cucumbers.

The Cambrian was the first period of the Paleozoic Era, occurring 570 million years ago, when the earth's landmasses settled in a broad equatorial band. The largest, which geologists call Gondwana, comprised what we now know as South America, Africa, India, Australia, and Antarctica.

Extensive seafloor spreading created high mid-ocean ridges that displaced water and raised sea levels worldwide. Encroaching waters flooded continental lowlands, forming vast, warm, shallow seas, conducive to the development of new species. A greater abundance of free oxygen gave rise to the emergence of many new life forms. The age of marine invertebrates dawned, and shellfish flourished, as did echinoderms, early ancestors of the sea stars, sea urchins, and sea cucumbers.

About 450 million years ago, during the Ordovician Period, Europe and North America began to drift nearer each other. In the ocean that eventually developed into the Atlantic, islands collided and crumbled, creating jagged peaks along the continental shelf. Fungi, seaweed, and the first primitive fishes appeared.

The Devonian Period marked the age of fishes, 405 million years ago.

The Silurian Period began 435 million years ago. Ozone was accumulating in the upper atmosphere then, forming a layer dense enough to filter most of the sun's harmful ultraviolet rays. The first land plants appeared and began to colonize. Modern fungi appeared, and shellfish became abundant.

The Devonian Period marked the age of fishes, 405 million years ago. Earth's first amphibians appeared then, along with primitive insects and land animals. The earliest trees began growing in the lowlands and colonizing to form earth's first forests.

Earth had aged billions of years and had become hospitable enough for complex plants and animals to exist. But more than 340 million years would pass before the primitive ancestors of modern humans would leave footprints in the volcanic ash of Africa's Great Rift Valley.

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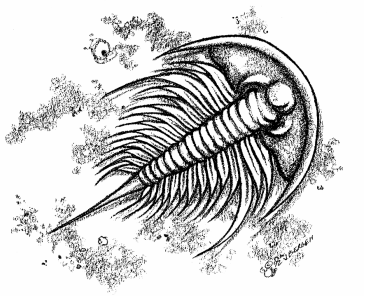
"Geological Time Capsule – Part I" - Study questions

1. **What did the earth look like 5 billion years ago?**
2. **How did great layers of metal form in the earth's crust?**
3. **What were earth's first life-forms and when did they appear? What did they do that enabled other life forms to develop?**
4. **How were the "vast, warm, shallow seas conducive to the development of new species?"**
5. **What was happening during the Silurian Period to make the earth a more habitable place? What is the Devonian Period recognized as?**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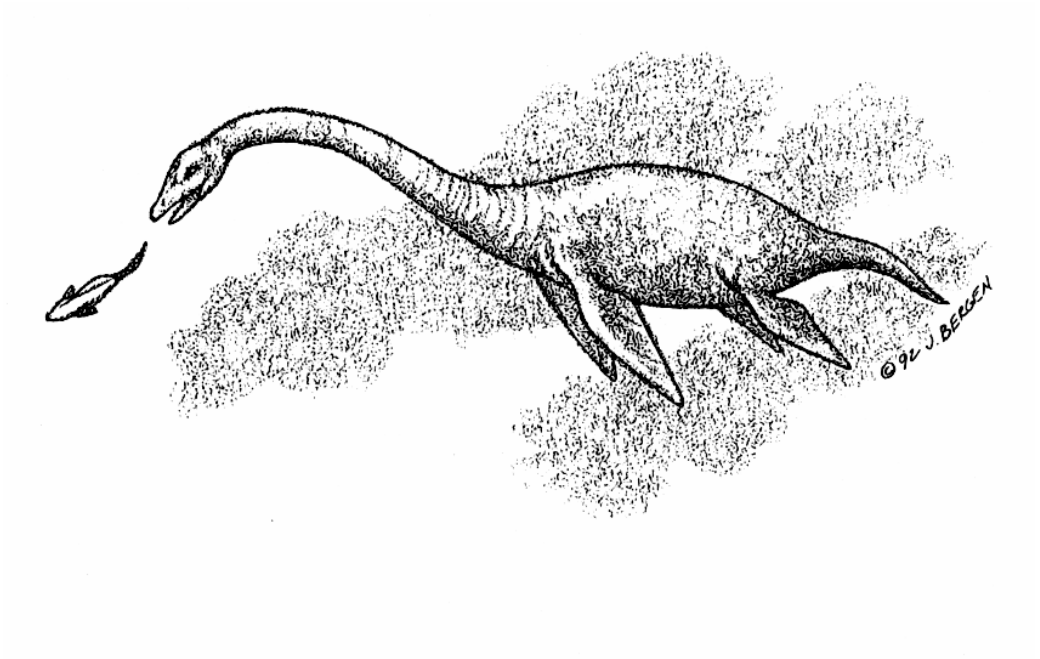
Geological Time Capsule, Part II

by Kenn Oberrecht



Earth was characterized by lowlands and shallow seas in the Mississippian Carboniferous Period of the Paleozoic Era, 345 million years ago. Fern forests appeared then, and the age of amphibians began.

During the Pennsylvanian Carboniferous Period, which began 35 million years later, North America and Europe were aligned along the equator. The southern and central Appalachian Mountains were forming then.

During the Permian Period, 290 million years ago, all the continents except what is now China were a single landmass the geologists call Pangaea.

As polar ice caps advanced and receded, world sea levels fluctuated, and inland seas formed. Silt-laden tributary rivers transported sediments and built swampy deltas where great forests flourished in the steamy climate and eventually formed huge coal deposits.
Near the end of the Carboniferous Period, earth's first reptiles appeared.

During the Permian Period, 290 million years ago, all the continents except what is now China were a single landmass the geologists call Pangaea. By then, colliding crustal plates had thrust the Appalachian Mountains to great heights, blocking rainfall and

creating deserts and arid grasslands where the great coal forests had stood.

The merging of landmasses forced many different organisms to compete, and thousands of species disappeared. As amphibians declined, reptiles began to prosper. Many marine invertebrates became extinct. The first conifer forests appeared.

The age of the reptiles dawned during the Triassic, and the first dinosaurs appeared. Mammals also began to show up.

The Triassic Period ushered in the Mesozoic Era 240 million years ago. Earth was warm then and free of glaciers. The huge, northward-drifting continent of Pangaea included nearly all the planet's land. It was mostly flat and dusty, with dunes, well-worn mountains, and occasional oases. The climate was arid and fairly uniform, volcanoes were numerous, and oxidized iron colored the soil red.

The age of the reptiles dawned during the Triassic, and the first dinosaurs appeared. Mammals also began to show up. Pangaea, the supercontinent, began straining under tectonic forces during the Jurassic Period, 205 million years ago. North America started to separate, and the North Atlantic began to form.

This was the age of dinosaurs. Flying reptiles and the first birds appeared. Mammal populations started increasing.

During the Cretaceous Period, 140 million years ago, Pangaea split into two continents: Laurasia in the north, Gondwana in the south. The two landmasses were separated by a narrow ocean called the Tethys. South America and Africa began to separate. Seafloor spreading raised sea levels dramatically 1,600 feet higher than they are now, inundating 85 percent of earth's surface.

Cretaceous plankton proliferated in the tepid waters of the Tethys Ocean and sank to the bottom as they died. There, they gradually transformed into petroleum and eventually formed the rich oil fields of North Africa and the Middle East.

Dinosaurs, also destined to become crude oil, declined to extinction. Modern insects and flowering plants appeared as the Cenozoic Era was about to commence, 65 million years ago.

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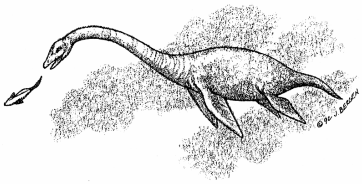
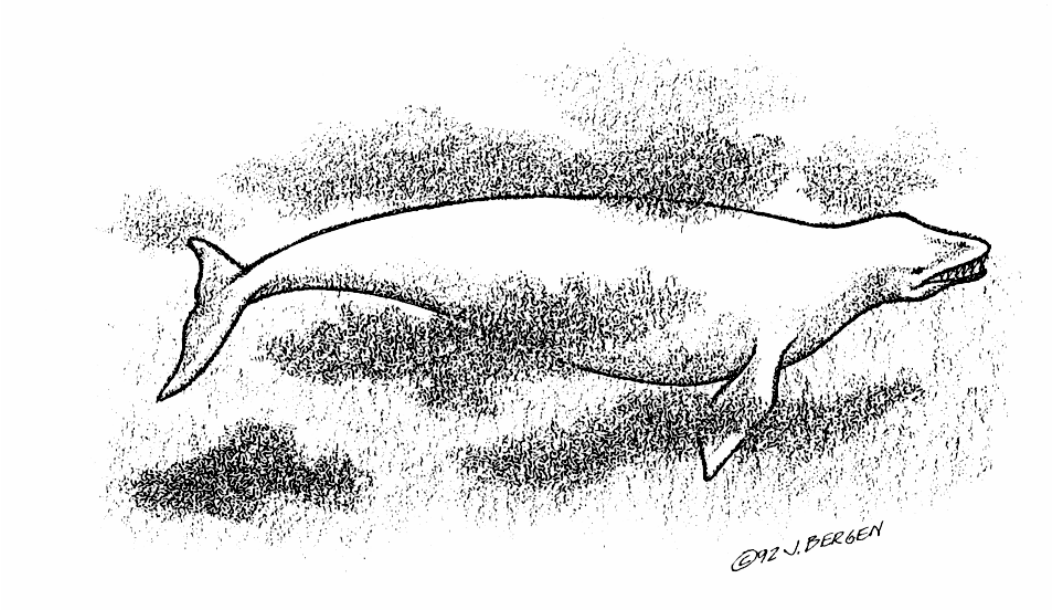
"Geological Time Capsule – Part II" - Study questions

1. **Describe some of the changes occurring during the Carboniferous Period.**
2. **In the Permian and Triassic periods, what did the huge continent of Pangea look like?**
3. **What caused Pangea to break up? What did it break into and what separated these "pieces?"**
4. **What are our petroleum products the remains of? Briefly describe a molecule's journey from floating about as a part of a drifting plankton in the Tethys Sea to your car's engine!**
5. **Why do you think dinosaurs became extinct?**



Geological Time Capsule, Part III

by Kenn Oberrecht



Earth's most recent era, the Cenozoic, began 65 million years ago and continues to the present. It's divided into two periods, the Tertiary and Quaternary, comprising seven epochs.

As continents converged during the Oligocene Epoch, 40 million years ago, mountains were created throughout much of the world.

The age of the mammals dawned and the first primates appeared during the Paleocene Epoch, when the earth's climate ranged from mild to cool. As the climate warmed during the Eocene Epoch, 10 million years later, modern birds and mammals and giant birds appeared.

As continents converged during the Oligocene Epoch, 40 million years ago, mountains were created throughout much of the world. The Mesozoic ocean known as the Tethys was greatly diminished, and the North American and South American continents drifted toward their present positions.

Wildlife populations became isolated in the continental breakup and evolved separately. Saber-toothed cats and large browsing mammals appeared.

By the onset of the Miocene Epoch, 25 million years ago, grazing animals proliferated on widespread grasslands. Apes appeared on land, whales in the oceans.

The Pliocene Epoch at the end of the Tertiary Period, 10 million years ago was a time of change, variety, and contrasts. Earth's climate cooled, and mountain ranges uplifted. Mammals increased in size and numbers.

In the later Pliocene, about three million years ago, plate movement caused ocean floors to collide and raise the Isthmus of Panama, bridging North and South America and allowing animals to migrate in both directions. Many species, including a host of South American marsupials, were unable to survive the competition and eventually died off. Some, such as the opossum and armadillo, thrived in their new northern ranges.

Homo habilis, considered the evolutionary link to modern humans, appeared in the Great Rift Valley of East Africa at the end of the Tertiary Period, 3.6 million years ago.

The Quaternary Period began with the Pleistocene Epoch two million years ago, during which other hominid species followed Homo habilis. Homo erectus roamed the earth and left remains for modern humans to find in such far-flung places as Europe, China, and Indonesia.

Neanderthals, Homo sapiens neanderthalensis, inhabited Europe and western and central Asia from about 100,000 B.C. to 40,000 B.C. The Cro-Magnons, Homo sapiens sapiens, considered the prototype of modern humans, lived on earth at the end of the Pleistocene Epoch, from 40,000 B.C. to 10,000 B.C.

The Holocene or Recent Epoch, which began 10,000 years ago, is marked by the appearance of modern humans, Homo sapiens, who have since colonized earth, overpopulated it, and abused it by every means at their disposal.

The Pleistocene is also known as the glacial epoch, because this was the time of the ice ages. Periods of glaciation, when ice covered much of the earth, alternated with periods of relative warmth. Glaciers also transformed much of the land, gouged out lakes, and scoured mountains and river mouths.

The Holocene or Recent Epoch, which began 10,000 years ago, is marked by the appearance of modern humans, Homo sapiens, who have since colonized earth, overpopulated it, and abused it by every means at their disposal.

Humans have polluted earth's land, water, and air. They have squandered the planet's resources and harmed its atmosphere. In the fouling of their environment, they've managed to speed up geological time, accomplishing in a few hundred years, a nanosecond on the geological clock changes in topography and plant and animal species that might otherwise have taken thousands of years, possibly millions.

It has been said that humans are the only animals capable of suicide.

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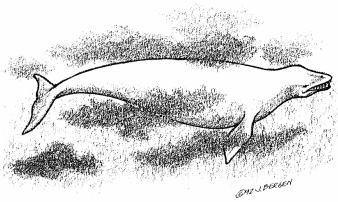
"Geological Time Capsule – Part III" - Study questions

1. **How are mountains formed when continents converge?**
2. **How did wildlife populations become isolated? Why does this mean that they would evolve differently?**
3. **What caused the Isthmus of Panama to rise and what did this then mean for animals?**
4. **Draw a timeline or chart for the appearances of our ancestors. Include the Genus and species name, the time that it appeared and comments about its habits and/or habitat.**
5. **Why is it said that modern humans have managed to "speed up geological time?"**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The Geology of Coos Bay

by Kenn Oberrecht

Geology is the science concerned with the physical history and dynamics of earth. It's not only a study of the rocks and sediments that form our planet, but also of past and present physical, biological, and chemical processes that have shaped and reshaped earth and continue to do so.

Just over half of Coos Bay's 12,380 acres consist of tidal flats.

The major geologic processes in Coos Bay include the tidal movement of salt water, the inflow of fresh water, water mixing, and sedimentation. Flood tides transport sand into the estuary; rivers and creeks carry in silt, sand, and clay. Winds also erode dunes and blow loose sand into the bay.

Deposition of sediments in Coos Bay has created shoals, tidal flats, and tidal marshes. Bottom material of the upper bay is mainly silt,

fine sand, and mud. Downbay, the bottom is predominantly sand and shell fragments. Sand is abundant in the main channel.

Just over half of Coos Bay's 12,380 acres consist of tidal flats. These areas, exposed to air during low tide, are composed of mud, silt, sand, and clay. Content of organic matter varies, but can be high, and sediments are compacted in some places.

About 1,400 acres of lower Coos Bay are eelgrass tidelands--critical habitat for many organisms, including the juveniles of various commercial species. Of like importance are the 2,700 acres of tidal marsh--consisting of organic soils made up of sand, silt, and clay--which support lush growth of vegetation.

The North Spit is mainly deflation plain and beach sand with areas of both unstable and stable sand. Where natural or introduced vegetation thrives, the sand has been stabilized.

On the east side of the bay, along East Bay Drive, are older deposits of deltaic sandstone, siltstone, and beds of coal, covered by sandy or silty loam or loamy sand. These deposits are from the late to middle Eocene Epoch, 40 to 55 million years ago.

Flood plains of the Coos River and major bay tributaries--Ross, Catching, Stock, Willanch, Kentuck, Larson, Palouse, North, and South Sloughs--drain sandstone and siltstone terrain. Sediments there are mostly alluvial deposits of sand, silt, clay, and mud.

Most of the sediment deposits in the estuary are from the Holocene or Recent Epoch, which dates from 10,000 years ago to present. Much of what borders the bay along the south shore, from North Bend to the ocean, however, is made up of ancient marine deposits of sand, silt, and gravel, from the Pleistocene Epoch, dating back two million years.

On the east side of the bay, along East Bay Drive, are older deposits of deltaic sandstone, siltstone, and beds of coal, covered by sandy or silty loam or loamy sand. These deposits are from the late to middle Eocene Epoch, 40 to 55 million years ago.

Human activity also greatly affects geological processes in the bay. Manmade structures, for example, can alter or impede the flow of fresh or salt water, or can influence the way water circulates through the estuary and how sediments are deposited. Coos Bay is a complex environment where countless organisms depend on its well-being, and humans are the only ones who can do anything about it.

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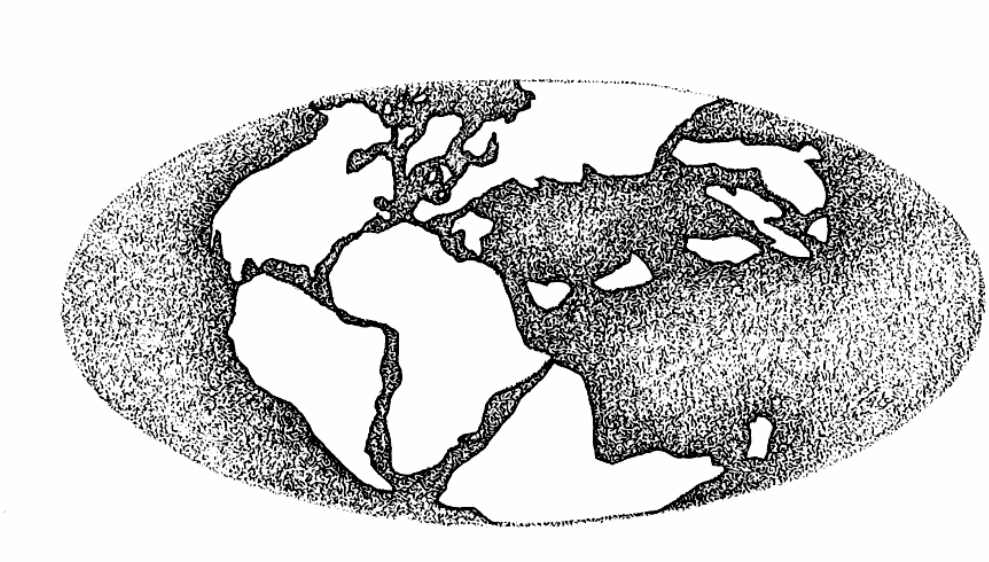
“The Geology of Coos Bay” - Study questions

1. **What is geology? What are the major geologic processes in Coos Bay?**
2. **What are the bottom materials of the bay made up of? Are they spread uniformly throughout the bay’s floor or do their compositions change with position? How and why?**
3. **Why are there unstable sands on the North Spit? How have some sands stabilized?**
4. **What do the major tributaries into the bay have to do with the deposits found in the bay?**
5. **How can human activity change the effect or coarse of a geologic process? Give examples.**

The Theory of Continental Drift

by Kenn Oberrecht



German meteorologist Alfred Wegener wasn't the first to observe similarities among the continents that suggested the landmasses might have once been connected. He was the first, however, to gather ideas and evidence into a palpable theory, which he turned into a treatise entitled "The Formation of the Major Features of the Earth's Crust (Continents and Oceans)."

The earth was cooling, according to the theory, and in the process it was contracting, causing sea levels to rise and cover the land bridges.

In 1912, at age 32, Wegener must have seemed a brazen upstart to the esteemed members of the Geological Association in Frankfurt and the Society for the Advancement of Natural Science in Marburg when he delivered lectures on his theory that defied the geological thinking of the time, which was based on the contracting-earth theory.

Continental similarities were being explained away with the notion that the continents had once been connected by land bridges. The earth was cooling, according to the theory, and in the process it was contracting, causing sea levels to rise and cover the land bridges.

Like others before him, Wegener noticed that the eastern outline of South America fit the western outline of Africa like pieces of a

jigsaw puzzle. He later noticed similar, if imperfect, fits among the other continents.

Geologists, paleontologists, and other scientists had collected a good bit of evidence of matching but misplaced rocks, uncovered fossils in places they shouldn't have been, and discovered evidence of astounding climatological changes.

Plant fossils indicated that tropical forests once existed only a few hundred miles from the North Pole.

Fossil remains of a prehistoric reptile known as the Mesosaurus had been uncovered on both sides of the South Atlantic, yet the creature was no great swimmer. Plant fossils indicated that tropical forests once existed only a few hundred miles from the North Pole.

Glacial sediments were found in sub-tropical areas. Coal seams and sedimentary rock formations on one continent matched those on another. Mountain ranges that ended at one coastline seemed to begin again on another.

Wegener theorized that a single supercontinent he called Pangaea existed sometime during the late Paleozoic Era, 350 million to 225 million years ago. He maintained that the landmass broke up and that its pieces dispersed and drifted, eventually reaching their present positions. Although Wegener's theory had its weak points, his arguments were compelling. The idea of continental drift certainly would explain many mysteries and answer a lot of questions. Nevertheless, the scientific community wanted no part of it, and Wegener's theory was rejected from all quarters.

Prominent geophysicist Harold Jeffreys attacked Wegener's theory as specious. In his rejection of the theory, Jeffreys focused on its greatest weakness: Wegener's failure to explain how continents could move across the hard ocean floor.

Few scientists outside his native Germany ever accepted Wegener's theory or his later additions to it and explanations of it. In fact, by the time of his death in 1930, Wegener's theory seemed well on its way to obscurity.

It would be several decades before new technology, new discoveries, and new thinking would lead to the revolutionary theory of plate tectonics, which incorporated Wegener's theory of continental drift and improved upon it.

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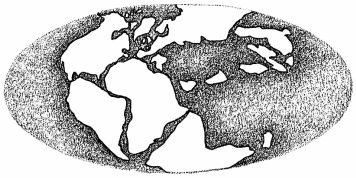
"The Theory of Continental Drift" - Study questions

1. **What was the "contracting-earth" theory of the early 1900's?**
2. **What did Wegener notice about the outlines of our continents?**
3. **What were some of the things noticed that seemed "matching but misplaced?"**
4. **What did Wegener theorize? Why didn't the geologists of Wegener's time agree with his theory? What did they think that Wegener failed to explain?**
5. **Scientists must stand on the shoulders of giants. What does this mean to you? Apply it to the article you just read.**



The Theory of Plate Tectonics

by Kenn Oberrecht

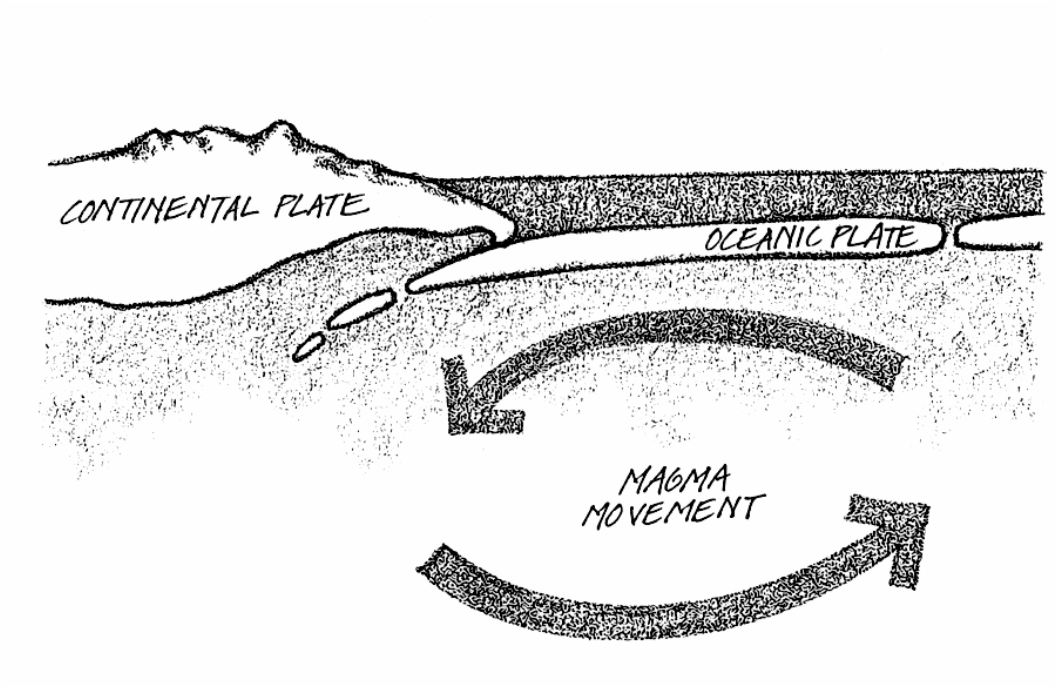


Plate tectonics, possibly the most important geological theory ever developed, incorporated the earlier theory of continental drift, espoused by German meteorologist and lecturer Alfred Wegener in the early 20th century. Although the scientific community of the time ridiculed Wegener and flatly rejected his theory, current-day geologists, geophysicists, and oceanographers live by much of what he had to say about our planet.

The word tectonics derives from the Greek tektonikos, meaning "pertaining to construction."

Dr. Robert D. Ballard, associate scientist at Woods Hole Oceanographic Institution, wrote in Exploring Our Living Planet in 1983: "Plate tectonics not only vindicated Wegener, it transformed geology as profoundly as the theories of evolution and relativity transformed biology and physics."

The word tectonics derives from the Greek tektonikos, meaning "pertaining to construction." In geology, tectonics concerns the formation and structure of the earth's crust.

The theory of plate tectonics--formulated by American, Canadian, and British geophysicists--attributes earthquakes, volcanoes, the

mountain-building process, and related geophysical phenomena to movement and interaction of the rigid plates forming the earth's crust.

According to the theory, the earth's surface layer, or lithosphere, consists of seven large and 18 smaller plates that move and interact in various ways. Along their boundaries, they converge, diverge, and slip past one another, creating the earth's seismic and volcanic activities. These plates lie atop a layer of partly molten rock called the asthenosphere. The plates can carry both continents and oceans, or exclusively one or the other. The Pacific Plate, for example, is entirely oceanic.

Continental plates are composed mainly of granite, while oceanic plates are mostly basalt, which is considerably heavier.

Continental plates are composed mainly of granite, while oceanic plates are mostly basalt, which is considerably heavier. Essentially, the continents are lighter and more buoyant; hence, they float higher on the earth's mantle than the ocean's crust does.

When plates converge, one slips under the other and is said to be subducted. At depths from 185 to 435 miles beneath the earth's surface, the subducted parts of the plate melt and become part of the molten mantle. As new plate material is being formed continuously, and the excess is melted into magma, the earth's rocky crust is constantly recycled.

If both converging plates have oceanic edges, either one might slip beneath the other. But when a plate carrying a continent converges on an oceanic plate, the more buoyant continental plate always slides over the heavier basaltic oceanic plate.

When two continental plates converge, however, neither can subduct. Instead, the two interact to create mountain ranges. Consequently, all subducted plates are oceanic, which keeps the ocean floor in a constant state of change; whereas, the continents change ever so slowly in geologic time.

After Wegener's death in 1930, geological research and technology progressed rapidly, and new discoveries lent credence to much of what his theory of continental drift embodied. Further research and findings over the past 40 years advanced the theory of plate tectonics and allowed scientists to unlock some of the mysteries enshrouding the formation of continents and oceans.

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“The Theory of Plate Tectonics” - Study questions

1. **Briefly, what is plate tectonics?**
2. **How is it possible for the earth’s surface crust, the lithosphere, to move?**
3. **What is the difference between continental and oceanic plates?**
4. **Describe the subduction of a plate.**
5. **How is the earth’s crust “recycled?”**
6. **Draw a diagram of:**

   ⇒ **two converging oceanic plates**

   ⇒ **two converging continental plates**

   ⇒ **a continental and an oceanic plate converging**

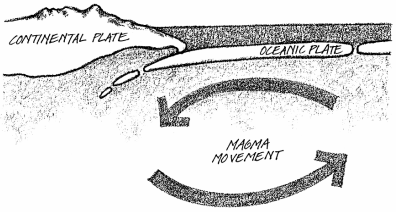
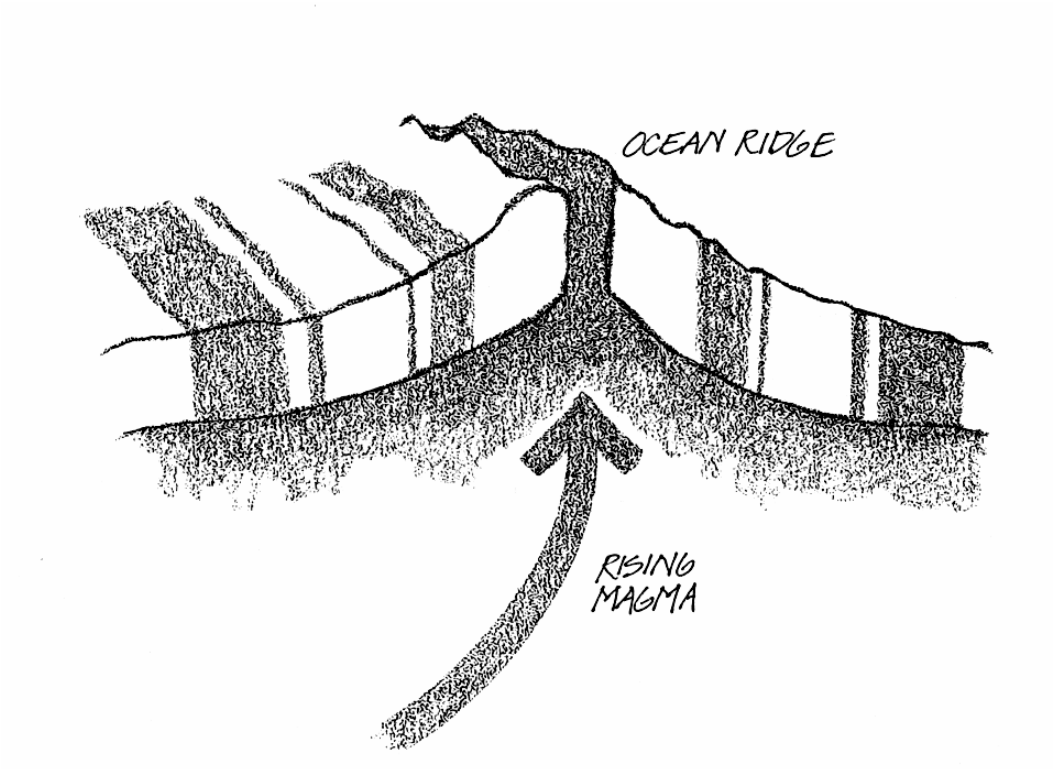


Plate Tectonics at Work

by Kenn Oberrecht



Imagine the earth's surface as a mosaic of tiles--irregular in shape and size--set in a mortar that remains hot and soft, allowing the tiles to move toward and away from one another. This is a simplification of the notion with which scientists were coming to grips during the 1950s and 1960s, as they were formulating the theory of plate tectonics.

They found that along the earth's ocean ridges, which form along rift zones on the ocean floor, magma continuously rises and adds new lava to each side of the ridge in equal amounts, forming series of concentric ridges on each side of the rift.

New technology and discoveries following World War II posed some questions that caused geologists and geophysicists to begin rethinking the whole concept of moveable continents. During this time, scientists discovered the earth's largest geological feature: the Mid-Ocean Ridge, a continuous range of volcanic mountains uplifting from the ocean floor to a height of 12,000 feet. The 1,200-mile-wide range extends 46,000 miles through the world's oceans.

Harry H. Hess, a Princeton geologist, theorized in 1960 that the ocean floor itself moves, and he offered persuasive arguments to support his theory of seafloor spreading. He and other scientists, with the aid of oil-exploration equipment aboard the research vessel Glomar Challenger, found that the sea floor did indeed spread outward from mid-ocean ridges and took the continents with it.

They found that along the earth's ocean ridges, which form along rift zones on the ocean floor, magma continuously rises and adds new lava to each side of the ridge in equal amounts, forming series of concentric ridges on each side of the rift. Scientists knew that the mid-ocean ridges were creating new crust material, but wondered where the excess was going.

The 1953 invention by British physicist P.M.S. Blackett of the astatic magnetometer enabled scientists to detect even the weakest magnetic fields in rocks--a great aid in determining geologic age, which unlocked many of earth's mysteries, but created a few as well. For example, geologists found rocks on land that were determined to be 3.8 billion years old, yet the oldest rocks on the ocean floor are only 200 million years old.

As oceanic plates age, they compress and become denser and heavier.

When Hess theorized that the excess oceanic crust material was disappearing in deep ocean trenches, he might have also shed light on the age disparity between rocks found on land and in the sea. Remember, ocean-floor plates consist largely of heavy basalt. As an oceanic plate moves and converges with a lighter, granitic continental plate, the edge of the former slides under the latter, or subducts. The subducted material gradually sinks, melts, and becomes part of the earth's magma.

As oceanic plates age, they compress and become denser and heavier. So when two oceanic plates converge, the older slab slides beneath the younger, lighter, more buoyant one. So older oceanic crustal material is being continuously recycled, leaving nothing on the ocean floor older than 200 million years.

These are the kinds of discoveries and thinking that ultimately led to the development of the theory of plate tectonics. In just a few decades, we have greatly changed our view of and notions about our planet and the sciences that attempt to explain its existence and development.

As Dr. Robert D. Ballard of the Woods Hole Oceanographic Institution wrote, the drifting of continents "did not just rearrange the map; plate movement also helped ice ages come and go, seas rise and fall, and deserts spread and retreat. It even shaped life itself."

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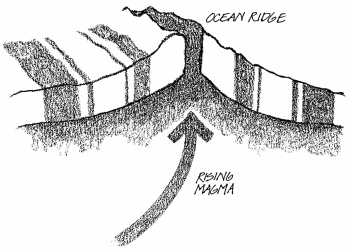
"Plate Tectonics at Work" - Study questions

1. **What is the mid-ocean ridge?**
2. **What is seafloor spreading?**
3. **From where does new crust material come? What happens to it?**
4. **Why are there no rocks on the sea's floor older than 200 million years?**
5. **Why does Dr. Robert Ballard of the Woods Hole Institute write that the drifting of continents, "shaped life itself?"**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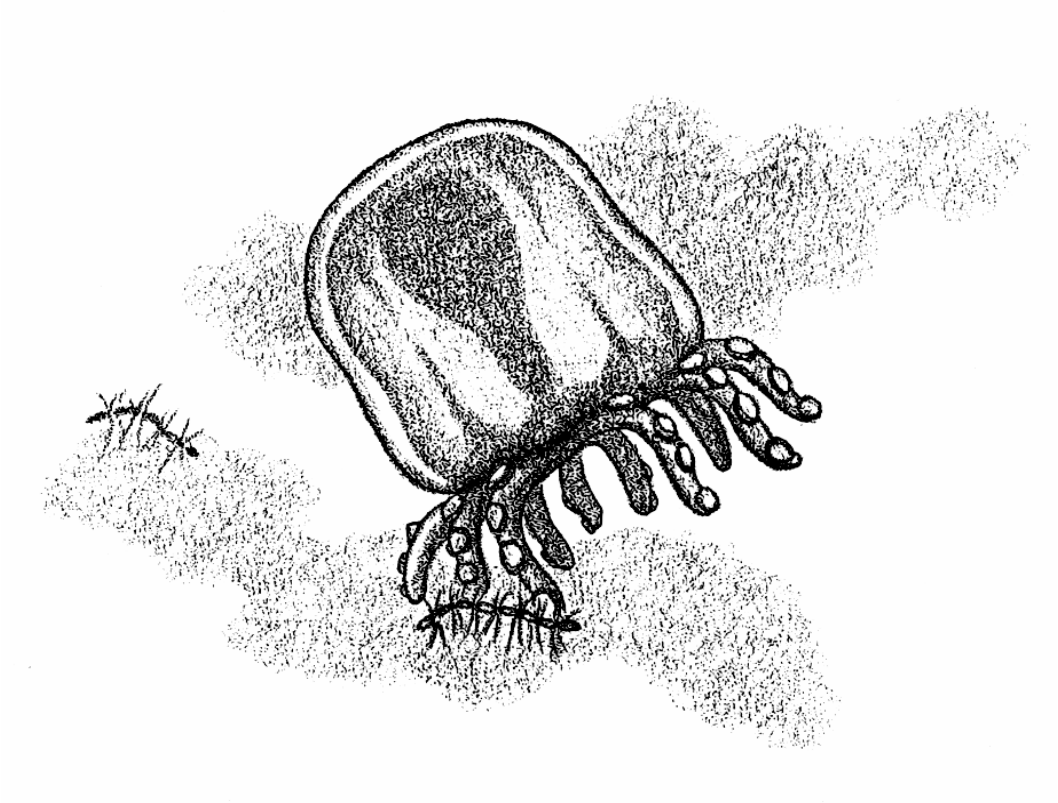
Food Chains and Food Webs

by Kenn Oberrecht



Life on earth, no matter what form it assumes, depends ultimately on sunlight. Whether on land or in the water, green plants use their chlorophyll and energy from the sun to turn carbon dioxide, water, and inorganic salts into complex organic materials--mainly carbohydrates and proteins. This process, called photosynthesis, also produces oxygen as a by-product.

Humans and other animals benefit directly and indirectly from photosynthesis. Some animals, the plant eaters, feed exclusively on plants and are said to be herbivorous. Meat eaters feed only on other animals and are said to be carnivorous. Many predators, including humans, are opportunistic feeders that consume both plants and animals. They're called omnivorous.

Photosynthesis is the foundation of all food chains. It's the basic building block for life on earth.

In one way or another, animals are dependent on plants for nutrition. They also rely on plants for valuable oxygen, essential to

the respiration process. As they breathe, animals take in oxygen and give off carbon dioxide. Plants, in turn, use the carbon dioxide in photosynthesis, and the cycle goes on.
Photosynthesis is the foundation of all food chains. It's the basic building block for life on earth.

A food chain is a series of organisms that are interrelated and dependent according to their feeding habits, with the smallest or lowest form fed on by a larger one, and that one in turn eaten by a larger one, and so on to the top of the chain.

A food web is more complex than a food chain. It's a network of food chains interrelated by predator-prey and consumer-resource interactions representative of an ecological community or system.

The leaves of land plants are the parts best equipped to carry on photosynthesis. They contain chlorophyll, trap sunlight for energy, and absorb carbon dioxide through hundreds of tiny pores known as stomata.

Plants are able to convert no more than about 20 percent of the light energy they receive into photosynthetic materials.

In deep water, plants must float in order to stay in sunlight. Such plants are extremely small, but their surface area is large compared to their volume, which helps them float and absorb essential materials from the water around them. Most are microscopic algae called phytoplankton.

Plants need materials other than those essential to photosynthesis--among them, carbon, hydrogen, and nitrogen. Land plants are able to absorb these and other materials through their root systems. Floating plants, however, must absorb them from their surroundings. So where concentrations of these minerals and elements are low, the growth of phytoplankton is diminished.

Plants are able to convert no more than about 20 percent of the light energy they receive into photosynthetic materials. Some are even less efficient because of a lack of essential minerals. For example, low phosphorus levels often inhibit the growth of water plants. Despite apparent inefficiencies, though, the earth's plants still produce 328 trillion pounds of organic matter a year.

Plants are the primary food producers in food chains and food webs. Plant eaters, herbivores, are the primary consumers, which ingest plant material directly. Consumers higher in the chain obtain plant material directly and indirectly--carnivores indirectly, omnivores both directly and indirectly.

Plants depend on sunlight for energy, which is ultimately converted into essential nutrients for all the consumers in food chains and webs.

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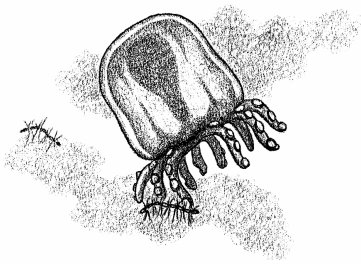
"Food Chains and Food Webs" - Study questions

1. **What do people exhale that plants need to photosynthesize? What is the by-product of photosynthesis that plants "exhale" and people use?**
2. **What is a food chain? A food web?**
3. **In land plants, the leaves are equipped to carry on photosynthesis. What do marine plants do to enable them to carry on photosynthesis?**
4. **What are primary food producers? Primary consumers?**
5. **Using common plants and animals in your area, draw a diagram showing "who eats who." Use arrows to show relationships.**

For example: heron ← fish ← plankton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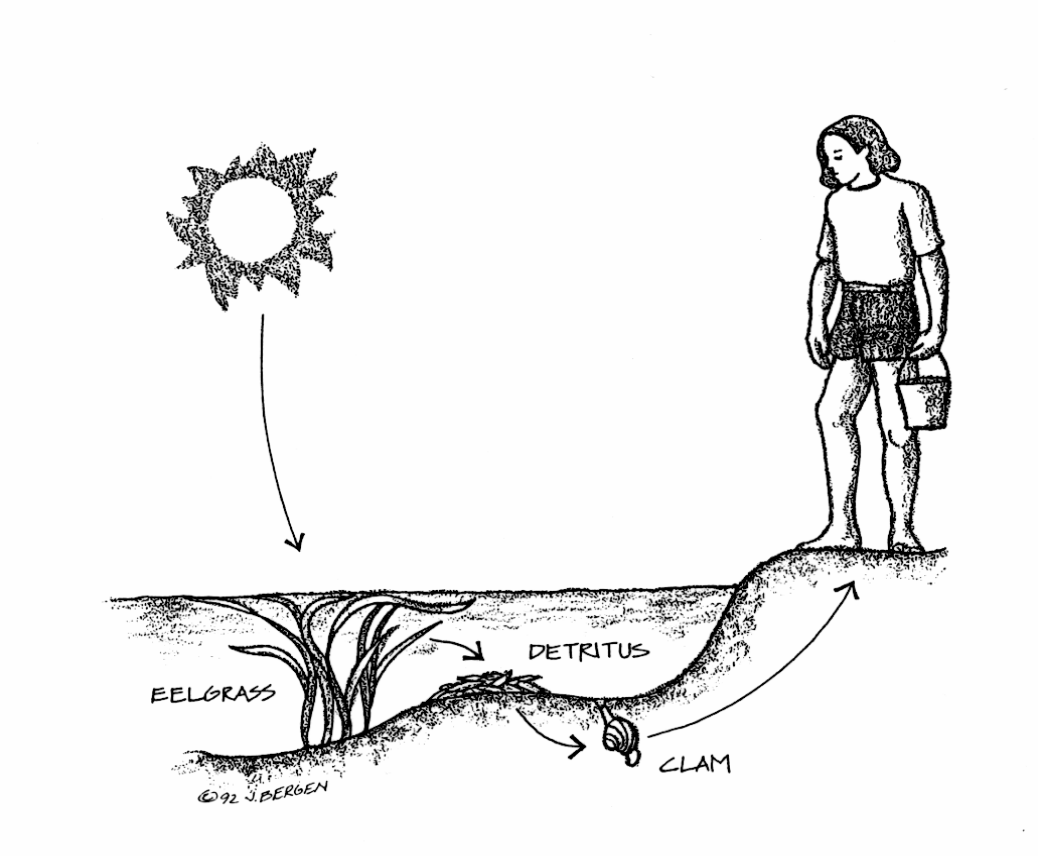
Estuarine Food Chains and Webs

by Kenn Oberrecht



Where the fresh water of a river meets and mingles with the tidal flow of the ocean's salt water, an estuary is formed. This is a highly complex environment where resident and visiting organisms must be able to tolerate frequent and rapid changes in salinity, currents, temperatures, and water levels.

Food chains and food webs here are similar to those elsewhere. They have primary producers, primary feeders, secondary feeders, and tertiary feeders, ranging from single-celled algae to the highly efficient predators at the top of the chain.

The ways in which food is consumed--that is, the pattern of consumption and how it changes with time--is called trophic dynamics.

Ecologists refer to these increments as trophic levels. The term trophic derives from the Greek trophikos, which means, simply, "pertaining to food."

The ways in which food is consumed--that is, the pattern of consumption and how it changes with time--is called trophic dynamics. Inasmuch as an estuary is an environment characterized by rapid and frequent change, which leads to biological diversity, food chains and webs and trophic dynamics in an estuary are complex.
Unlike the open ocean, where phytoplankton are the sole primary producers, estuarine systems usually contain several types of primary producers. In addition to phytoplankton, they include algae, sea grasses, and salt-marsh plants.

Zooplankton graze on phytoplankton in the estuary. These, in turn, become food for plankton-eating fishes, such as herring, smelt, and the larvae and young of larger fishes. These, then, become food for carnivores and omnivores nearer the top of the food chain.

Some animals graze on the larger estuarine plants, but such plants are probably more important food sources after they die and begin to decompose. Here, bacteria and fungi enter the food chain to promote the breakdown of the dead plant material. This organic detritus, as it's called, is an essential source of nutrition for detritus-eating animals and supports a detrital food web.

Estuaries are not only areas of great diversity, with complex and interrelated trophic patterns, but they also support a large number of top predators, including humans.

Benthic, or bottom-dwelling, and bottom-oriented organisms are other important links in estuarine food chains and webs. Clams, for example, reside in the bottom sediments and feed on plankton and other organic matter by filtering it from the water. Oysters and mussels are other filter feeders.

Deposit feeders, such as the various kinds of worms found in the estuary, move over and through bottom sediments where they find food deposited in or on the sediments.

Shrimps, crabs, and other invertebrates are well adapted to bottom feeding, as are many of the estuarine fishes, such as sculpin, flounder, sole, and sturgeon. In fact, most fish species that reside in estuaries or move into them on feeding forays are bottom oriented in their feeding patterns.

Near the top of the estuarine food web are various carnivores and omnivores. Some show marked food preferences, while others are opportunistic feeders. These include diving birds, wading birds, waterfowl, gulls, terns, pelicans, ospreys, trout, perch, striped bass, sharks, and salmon.

At the top of the web are seals, sea lions, and humans, although seals and sea lions are preyed upon by killer whales and the larger sharks, which sometimes enter estuaries and frequent the larger ones.

Estuaries are not only areas of great diversity, with complex and interrelated trophic patterns, but they also support a large number of top predators, including humans.

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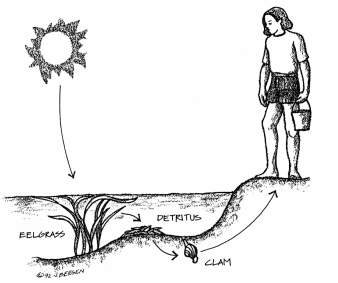
"Estuarine Food Chains and Webs" - Study questions

1. **What are trophic dynamics? Why are they so complex in an estuary?**
2. **What are the primary producers of an estuary? Who feeds on them? Who feeds on those that feed on primary producers?**
3. **How can a plant be more important, to the overall function of an estuary, when it has died?**
4. **How do filter feeders feed? How do deposit feeders feed?**
5. **What would happen if several primary producers in an estuary became extinct or very low in numbers due to a human-caused event (an oil spill or pollution)?**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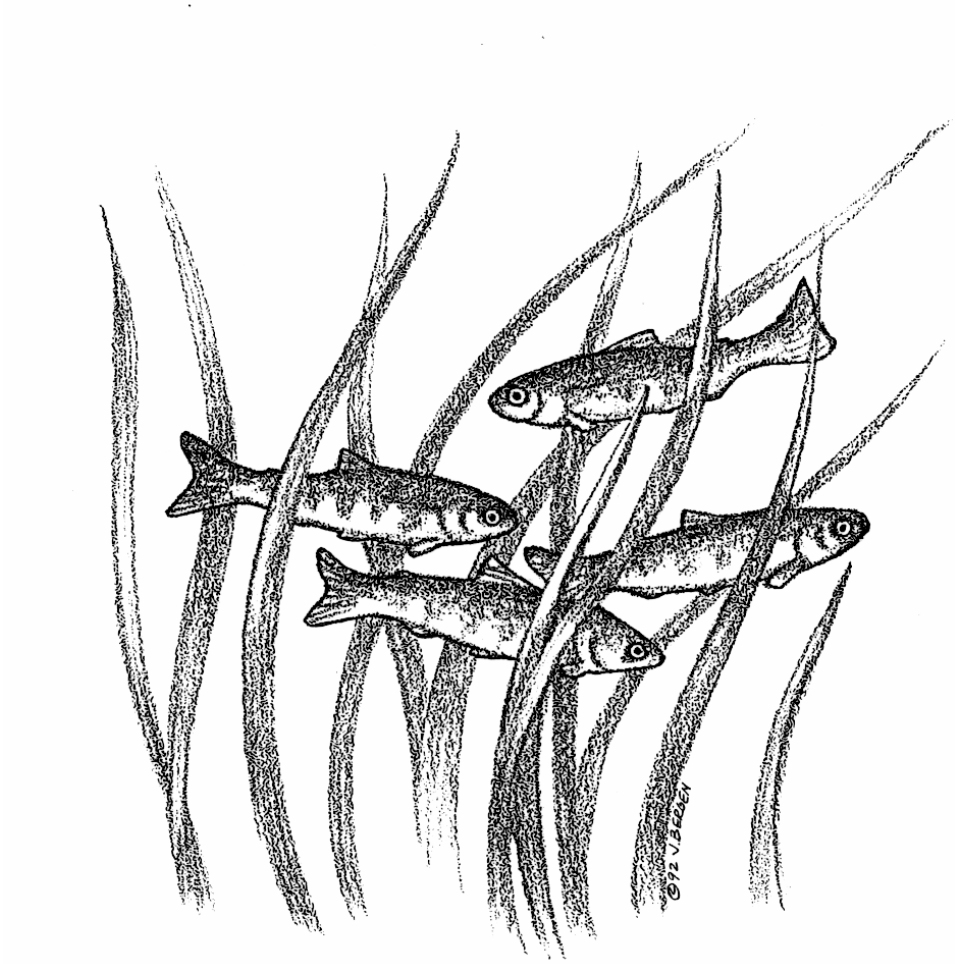
Salmon in the Estuary

by Kenn Oberrecht



In the Pacific Northwest, salmon are the most important of all commercial and sport fishes, yet we seem to have tried our best to place every conceivable obstruction in the path of their survival. We've destroyed their habitat, built barriers to their migration, polluted their waters, and overfished them. Oregon author Anthony Netboy has called salmon the world's most harassed fish.

All Pacific salmon are anadromous, meaning that they spend most of their lives in the ocean but return to fresh water to spawn and die.

Of the six species of Pacific salmon, five occur along the Pacific Northwest coast: pink, chum, sockeye, coho, and chinook. Of those, coho and chinook are the most plentiful in Oregon waters, but chum salmon use several of our coastal rivers. Sockeye seldom appear south of the Columbia River, and there the runs have been

all but wiped out. Pink salmon don't spawn in Oregon but are sometimes part of the offshore catch.

All Pacific salmon are anadromous, meaning that they spend most of their lives in the ocean but return to fresh water to spawn and die. In as much as estuaries are the lower reaches of coastal rivers, where salt and fresh water mix, all Pacific salmon use the estuaries to some extent. They must pass through them on their way to spawning grounds. The migrating young, known as smolt, must also move through the estuary on their way to the sea. Many use the estuaries in other ways as well.

Although some generalities apply to each species of Pacific salmon, certain stocks or races within a species might differ considerably in one or several habits. For example, we say generally that all Pacific salmon spawn in fresh water, but some races of chum salmon actually spawn in estuaries, in tidal areas near upwellings of ground water. Most other chum salmon spawn only a short distance from the estuary, and their young spend about three months feeding in the tidal marshes and eelgrass beds before migrating to the ocean.

Sockeye fry normally migrate into freshwater lakes where they spend one to three years feeding before heading for the ocean. Some stocks, however, instead of moving into the so-called nursery lakes, head downstream to the brackish sloughs and backwaters of estuaries, where they gorge on abundant food for months prior to their seaward migration.

Like the coho, chinook fry remain in fresh water until they become smolt and head for the estuary.

Coho fry remain in their birth streams until they undergo the transformation that will enable them to adapt to salt water. Then as smolts they descend to the estuary. Most linger there for a few weeks, foraging and growing rapidly, but some may stay for as long as a year.

Like the coho, chinook fry remain in fresh water until they become smolt and head for the estuary. Fall chinook might spend only a few weeks or months in the estuary, while spring chinook generally remain as long as 18 months before migrating to sea.

Pink salmon probably spend the least time in the estuary on their seaward migration. But they and others, studies have shown, spend at least two weeks feeding and growing in the rich estuarine waters.

Perhaps one of the greatest values of the estuary to these young salmon is the abundant food that enables them to double or even triple in size before migrating to sea. Size is one of the best defenses against predation. So estuaries are essential to the very survival of these fishes.

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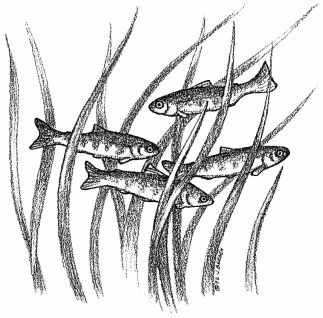
"Salmon in the Estuary" - Study questions

1. **Why does author Anthony Netboy call salmon the world's most harassed fish?**
2. **How do salmon use the estuary?**
3. **Describe the life cycle of any salmon species you chose.**
4. **What is the greatest value of the estuary to salmon? Explain.**
5. **Discuss the importance of salmon to the local economy of a town near an estuary in Oregon.**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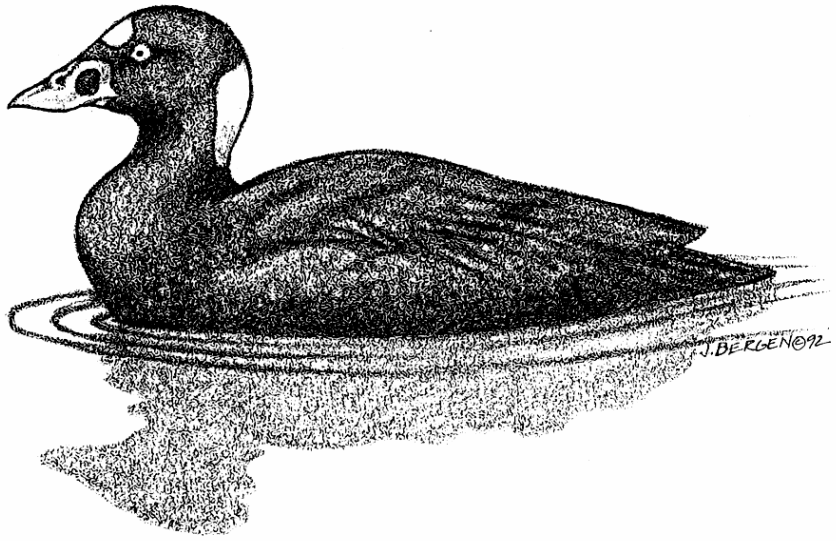
Waterfowl on the Estuary

by Kenn Oberrecht



One crisp, sunny Sunday in January, as motorists sped along U.S. 101 near Coos Bay, between Haynes Inlet and North Slough, a solitary car eased off the highway. Its two occupants stepped out of the vehicle and steadied binoculars on a spectacle no one else seemed to notice.

Mud flats were flooded with a foot or so of water at mid-tide, and strung out across them to the base of the dunes were several thousand ducks--feeding, resting, preening, swimming--seemingly oblivious to all the bustle about them. Hundreds more dozed on shore in a pale patch of sunlight.

The Coos Bay estuary provides such a rich and diverse environment that nearly every species of duck in the Pacific flyway and several kinds of geese are likely to visit the bay sometime during the year.

Nearly a dozen duck species were represented. Plump mallards glistened green-headed in the water or stood sleeping one-footed on the mud. Redheads and both kinds of goldeneyes swam with a raft of lesser scaup. Spritely buffleheads--now you see 'em, now you don't--dived among canvasbacks and ring-necked ducks. Gadwalls and pintails aplenty dabbled in the shallows, and countless widgeons filled in the blanks. Amid the magnificent mayhem swam a gaggle of Canada geese and five tundra swans.

Although waterfowl don't gather on Coos Bay every day in such profusion, similar occurrences are common enough for people to drive by without noticing. The Coos Bay estuary provides such a

rich and diverse environment that nearly every species of duck in the Pacific flyway and several kinds of geese are likely to visit the bay sometime during the year. Others are year-round residents.

Eelgrass beds attract both diving ducks and dabblers. Some feed on vegetation, while others root for small animals and fishes the grass beds harbor.

Not only do the bay's abundant food and water resources invite migrating waterfowl to rest and feed, but our moderate climate also entices many to overwinter.

White-winged and surf scoters spend the winter, gorging on plentiful mollusks and crustaceans. All three species of mergansers eat some of the same foods but mainly feed on small fishes--hence the nickname, "fish ducks."

Eelgrass beds attract both diving ducks and dabblers. Some feed on vegetation, while others root for small animals and fishes the grass beds harbor. Similarly, tidal marshes provide vegetable and animal matter to nourish flocks of foraging waterfowl.

Coos Bay's waterfowl populations begin swelling with the arrival of darting and swerving flocks of green-winged teal in September, followed shortly by the first pintails. Various species of puddle ducks continue arriving sporadically until the first major storms move great numbers of waterfowl before them. Diver ducks pour in by the thousands after Thanksgiving.

During spring migration, the bay's duck population swells again, and by April most migrants and wintering ducks are winging north to traditional breeding grounds in Canada and Alaska. Some mallards, wood ducks, teal, and Canada geese remain to nest and raise young in the bay's adjacent marshes and the forest-fringed sloughs. In good years, some might even have second broods that will barely have learned to fly when the first teal of autumn arrive and the cycle begins anew.

As North America continues to lose its wetlands to corporate agriculture, industrial development, and urban sprawl, Coos Bay and similar estuaries become increasingly important to the continent's precious but dwindling waterfowl populations.

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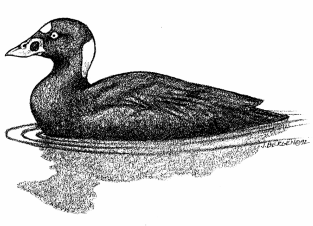
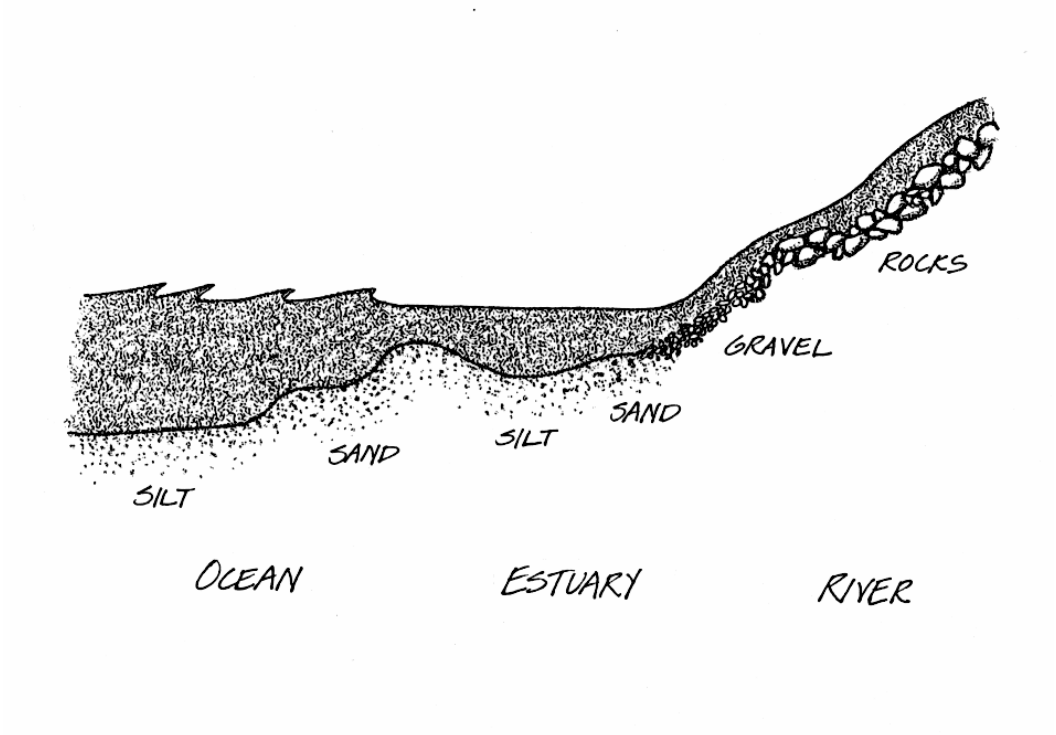
“Waterfowl on the Estuary” - Study questions

1. **What do migrating waterfowl use Coos Bay for?**
2. **What do overwintering populations of waterfowl use the bay for?**
3. **What riches do eelgrass beds harbor for waterfowl?**
4. **80% of all bird species use wetlands during at least a portion of their life. Comment on how loss of wetlands will hurt bird populations.**
5. **What can you do, personally, to assure a continued diversity of bird populations in our wetlands?**



Sediment Transport and Deposition

by Kenn Oberrecht



Sediments entering and settling in the estuary are both terrestrial and oceanic in origin. As rivers and creeks flow seaward, they carry with them sediments from the land. Flood tides bring in sands from the sea. Runoff from rains and snowmelt carry sediments into nearby streams. Removal of vegetation--as from agricultural, logging, and construction operations--promotes erosion and increases the sediment loads of rivers and creeks.

The faster the current, the greater the size of sediment particles a stream can move.

Sediments ranging in size from small rocks and coarse gravel to silt and clay particles as fine as talcum powder enter the water where currents carry them downstream. The faster the current, the greater the size of sediment particles a stream can move.

As a river or creek moves from the mountains or inland areas toward the ocean, its course broadens and velocity gradually slackens. During this process, smaller and smaller particles of sediment drop out and settle toward the bottom, so that the larger

rocks and coarser gravel are found farther upstream and finer sediments downstream, creating what is known as a sediment gradient.

In the slower currents of a river's lower reaches, only the finest sediments will remain suspended in the water. In the tidewater portion of the river, fine sediments begin settling out and are deposited in several ways. In some cases, flood tides are of sufficient size and force as to overcome river currents and stop or even reverse the course of the river for some distance upstream, allowing even finer particles to rain out.

Another phenomenon affecting the way sediments are deposited in the estuary is a process called flocculation, which causes the tiny particles to clump together, become heavier, and settle to the bottom.

While in fresh water, these particles--kept in suspension by their molecular motion--carry negative charges and tend to repulse one another. In the estuary, however, where the fresh water meets and mingles with ionically charged salt water, negative charges are neutralized, and the particles become attractive. As they collide, they tend to coalesce or stick together, forming larger aggregates or clumps of sediments called flocs, which then settle out of the destabilized suspension.

Incoming tides and storm surges bring ocean sands into the estuary and keep the bottom of the lower estuary sandy.

The process of flocculation depends on salinity levels. Consequently, it can change along the course of the estuary. It might vary from tide to tide and season to season, or according to the amount of runoff or size of storm surge.

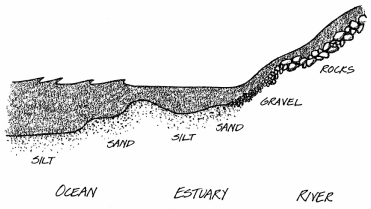
Incoming tides and storm surges bring ocean sands into the estuary and keep the bottom of the lower estuary sandy. The sediment gradient from the mouth to the head of the estuary, then, ranges from coarse to extremely fine. That's why tidal flats in the lower portions of Coos Bay are sandy and relatively firm, while upbay flats are muddy and soft.

Sediments are deposited wherever currents are slowed. On the bend of a stream, for example, sediments will settle and create shallows along the inside of the curve, because the current is slower there. Currents are also slowed as they flow over plants and algal mats, causing nutrient-bearing sediments to sink to the bottom where they nourish the vegetation.

Left alone, an estuary can build its own tidal flats and marshlands and deliver nutrients to countless organisms.

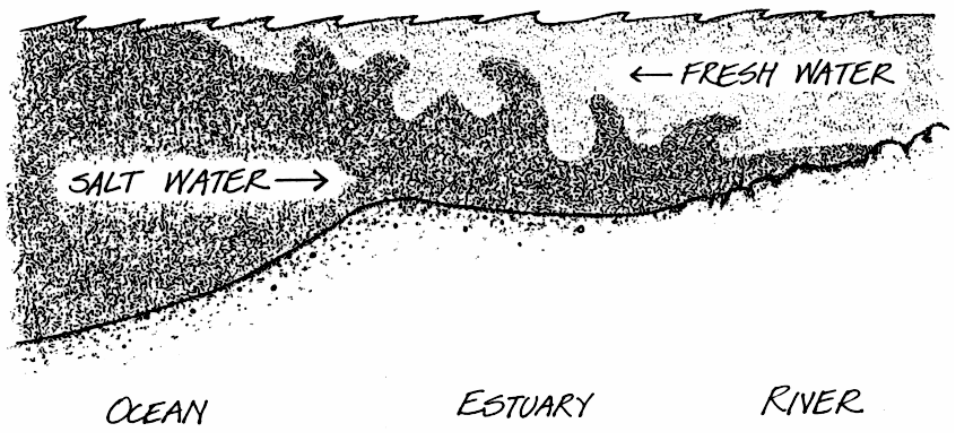
"Sediment Transport and Deposition" - Study questions

1. **How does the removal of trees increase the sediment load of a stream?**
2. **What is a sediment gradient?**
3. **What is flocculation? How do tiny particles react in fresh water as opposed to in salt water?**
4. **Why are the tidal flats in the lower portion of a bay sandy and firm while the upbay flats are muddy and soft?**
5. **Imagine you are a fine, small particle in a stream high in the uplands. Describe a possible path for you -what you see along the way, what larger particles do around you, where you want to come to rest.**



Mixing Fresh and Salt Water

by Kenn Oberrecht



By definition, an estuary is a moving, dynamic body of water where fresh and salt water meet. Because of characteristic differences between salt and fresh water, however, the two don't always easily blend. Sometimes they don't mix at all, but instead stratify or form layers.

Sea water contains about 35 parts per thousand (ppt) dissolved salts, mostly sodium chloride and magnesium chloride, and is denser than fresh water. That is, salt water is heavier than fresh water when the two are at identical temperatures. Salt water is a better conductor of electricity, and light refracts or bends more in salt water than in fresh water.

Circulation is the primary mechanism responsible for estuarine mixing, but at least four other forces affect the process. They are tides, winds, waves, and river runoff.

In most estuaries, the mixing of fresh and salt water is determined by checking the water's salinity level. This is a relatively easy and inexpensive test, accomplished in one of three ways: by measuring a water sample's density, electrical conductivity, or refraction of light.

Circulation is the primary mechanism responsible for estuarine mixing, but at least four other forces affect the process. They are tides, winds, waves, and river runoff.

The tides represent the most important force, often causing large-scale turbulence and mixing in the estuary. They are of greatest significance where and when tidal ranges--the differences between high and low tide--are greatest.

Winds are considered to be of lesser importance. They can be a major force, however, where tidal range is small. Winds also have greater effects on shallow estuaries, especially those with large open areas. Winds also create various surface and internal waves, which can contribute to estuarine mixing.

Mixing processes are by no means simple; nor are they consistent. Tides, winds, waves, and freshwater inflow all vary and differ in their effects--from season to season, even day to day.

River water is more buoyant than ocean water. As it flows seaward in the surface layer, and the denser salt water flows landward in the bottom layer, some mixing can occur.

Mixing processes are by no means simple; nor are they consistent. Tides, winds, waves, and freshwater inflow all vary and differ in their effects--from season to season, even day to day.

For example, the monthly cycle of spring and neap tides can greatly alter the character of an estuary where tides are the major mixing force. During spring tides, when tidal ranges are greatest, increased currents and tidal sloshing can speed up the mixing process. During neap tides, on the other hand, tidal ranges are smaller and might have little effect on mixing, resulting in stratification of the estuary.

In a system known as dynamic classification, estuaries can be labeled according to how they circulate and stratify. A Type A estuary is highly stratified; Type B, partly mixed; and Type C, well mixed.

On Coos Bay, where tidal ranges are relatively large, summer winds and winter storms can enhance mixing. Although occasionally in winter the bay is a Type B estuary, most of the time it's a Type C.

Studies have shown that vertical mixing can increase photosynthesis and the production of phytoplankton in the estuary. It also brings nutrients and food particles up from the bottom into

the surface zone, and it delivers oxygenated surface waters to the estuary's depths.

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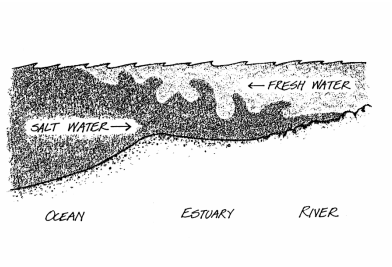
"Mixing Fresh and Salt Water" - Study questions

1. **Salt water has a higher density than fresh water. What does this mean? Why does this cause mixing difficulties?**
2. **How do estuarine waters mix? What is the most influential "mixer?"**
3. **During spring tides, tidal ranges are greatest. During neap tides, tidal ranges are smaller. Based on these facts, and the fact that there is a monthly cycle to these varying tides, can you determine why spring tides are higher and neap tides are lower?**
4. **Why is there sometimes a stratification of salt and fresh water in an estuary?**
5. **How does vertical mixing enhance an estuary?**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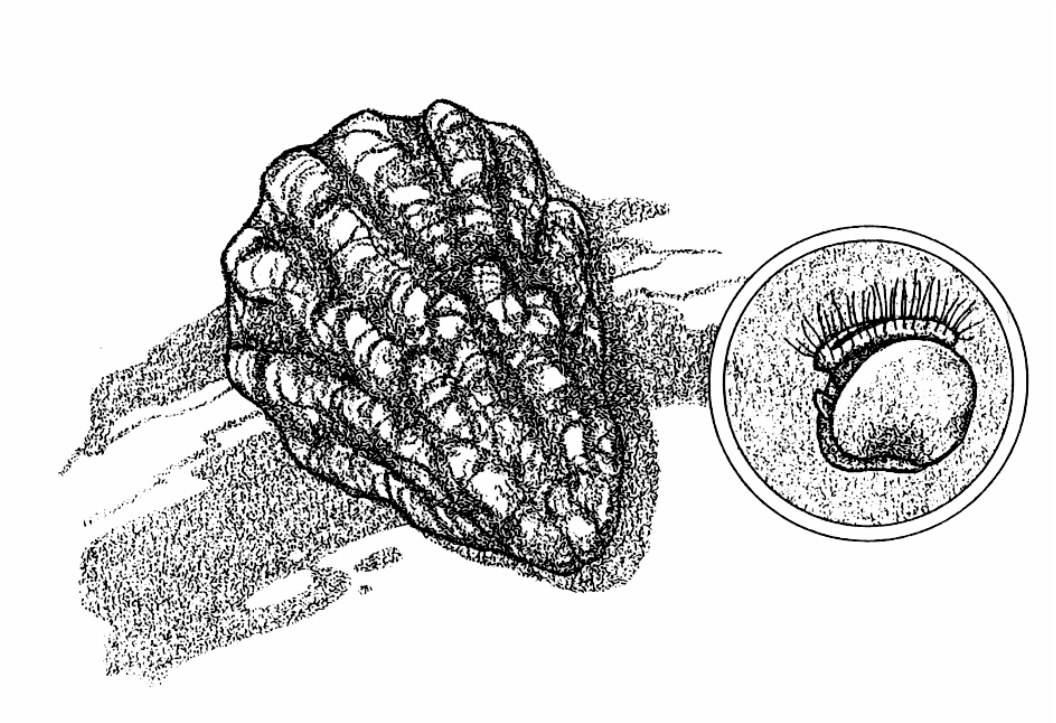
Aquaculture in Oregon's Estuaries

by Kenn Oberrecht



Aquaculture is a kind of water-based farming in which aquatic plants and animals are cultivated in natural or fabricated freshwater, saltwater, or brackish environments. The practice, in its crudest form, may have begun with the ancient Egyptians and was certainly underway during classical Greek and Roman times. It subsequently spread around the globe, but is most widely employed in Asia as a means of providing essential protein to that grossly overpopulated continent. Currently, Asia accounts for nearly 85 percent of the world's aquaculture production, North America for less than two percent.

Commercial aquaculture along coastal Oregon is solely devoted to the cultivation of mollusks--namely oysters and mussels, the latter grown only on the Umpqua estuary, near Winchester Bay.

America's first aquaculture operations began in the 1850s, but it took another century before large-scale cultivation got underway. The history of aquaculture in Oregon's estuaries is as rocky as the Oregon coastline itself.

Although major salmon-ranching facilities were operating on Coos Bay and Yaquina Bay during the past decade, there are no salmon ranches functioning now on any of Oregon's estuaries.
Commercial aquaculture along coastal Oregon is solely devoted to the cultivation of mollusks--namely oysters and mussels, the latter grown only on the Umpqua estuary, near Winchester Bay.

Oysters seem to do well in Oregon's estuaries. Currently, they are under cultivation on Coos Bay, Winchester Bay, Yaquina Bay, Tillamook Bay, and Netarts Bay.

The total worldwide sustainable harvest of commercial aquatic species is estimated to be between 240 and 265 billion pounds a year.

Native oysters are now nearly gone from Oregon's coastal waters. A Japanese species commonly known as the Pacific oyster *(Crassostrea gigas)* makes up the bulk of the commercial-oyster harvest here.
Oregon's coastal waters are too cold for these oysters to spawn naturally, so oyster growers either buy spat (tiny juveniles) to seed their oyster beds, or adult oysters are spawned in special tanks under controlled conditions. After spat attach to old oyster shells, the young oysters are allowed to mature in the estuary--a process that takes from two to three years.

Oysters are grown in a number of ways on an estuary: directly on the bottom, attached to stakes set in the bottom sediments, in trays suspended from floats, in bags attached to racks, in lantern nets, and on lines suspended from floats, racks, or floating docks.

The total worldwide sustainable harvest of commercial aquatic species is estimated to be between 240 and 265 billion pounds a year. We are already taking more than half that annually and will doubtless soon reach the maximum sustainable yield. Presently, aquaculture accounts for only about 10 percent of the world's seafood supply. Potentially, it could increase the total worldwide harvest by tenfold. For estuaries to play a role, however, they must be kept clean and functional.

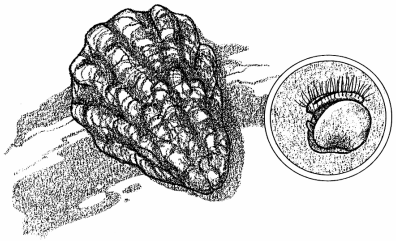
Water quality is extremely important to aquaculturalists, which is one reason Oregon's relatively clean estuaries might prove ideal for various commercial operations in the future. Already, more than half the commercial shellfish beds along the Atlantic coast have been closed because of pollution.

Depending on technological advances, public acceptance or demand, legal issues, and our ability to preserve the integrity of our

estuaries, aquaculture could hold some promise for the future in Oregon and elsewhere along the Pacific Coast.

"Aquaculture in Oregon's Estuaries" - Study questions

1. **What is aquaculture? What types of organisms does it sustain?**
2. **What are oyster spat? What must oyster growers do since Oregon's coastal waters are too cold for oysters to spawn naturally?**
3. **Describe the different methods of oyster cultivation in an estuary. Can you think of any effects –positive or negative—that these methods might have on an estuary?**
4. **How could aquaculture "hold some promise" for the future of the Oregon coast? What must we do to maintain healthy aquacultures?**
5. **If we are already taking half the amount of shellfish that is considered "sustainable," what precautions must we take to avoid reaching or overreaching that sustainability?**



Altering the Estuary

by Kenn Oberrecht

Whether in the name of progress, comfort, safety, or greed, humans have a penchant for modifying the environment to suit their immediate needs and wants. Nowhere is this more evident than along the nation's coasts and particularly in the vicinity of estuaries, which have attracted people and invited settlement throughout the history of human wandering.

We have straightened, deepened, levied, and dammed thousands of rivers and creeks, thereby altering the quality and often the quantity of fresh water that eventually reaches our estuaries.

Consequently, our estuaries--especially the larger ones--have undergone considerable change that has largely coincided with pioneer settlement and subsequent agricultural, industrial, and urban development.

We have straightened, deepened, levied, and dammed thousands of rivers and creeks, thereby altering the quality and often the quantity of fresh water that eventually reaches our estuaries. We have also dredged and channelized the estuaries and ditched, diked, and filled adjacent wetlands.

We have filled in, built on, and dredged out every major estuary, from Boston Harbor to San Francisco Bay. In so doing, we have tremendously decreased their sizes, altered their circulation patterns, impeded their cleansing and filtering capabilities, reduced their biological diversity, and diminished their appeal.

In a few instances, human alteration of estuaries and wetlands has been beneficial to certain wildlife species. For example, some marshes that have been ditched and diked support greater numbers and diversity of bird species than natural, unaltered marshes in the same area. Some birds even prefer nesting in the woody vegetation found along narrow spoil strips adjacent to ditches.

Dredging, of course, greatly affects the estuary bottom. It disturbs bottom-dwelling organisms, kills many of them, and reduces or severely alters their habitat. The deep channels also influence estuarine circulation and can increase salinity by allowing salt water to penetrate farther upstream.

In general, though, alteration is detrimental to plant and animal communities and larger ecosystems, of which humans are a part. Spoil banks and dikes, for example, impede essential water exchange and flushing. They inhibit or prevent sediment deposition, and they interfere with or prevent movement of free-swimming organisms.

Dredging is an expensive, on-going, and never-ending process associated with navigable estuaries. Large estuaries, such as Coos Bay, that function as deep-water ports for large freighters, tankers, and other ships require the deepest channels and most frequent channel maintenance.

Dredging, of course, greatly affects the estuary bottom. It disturbs bottom-dwelling organisms, kills many of them, and reduces or severely alters their habitat. The deep channels also influence estuarine circulation and can increase salinity by allowing salt water to penetrate farther upstream.

Dredging is destructive and expensive but has become a necessary nuisance in Coos Bay and elsewhere. Many other alterations also appear to be permanent and irreversible, such as marshes that have been filled and then highly developed for commercial and residential purposes.

We have the opportunity, however, to operate in the future with a little more intelligence and to be less destructive and counterproductive. Now that we're aware of their importance, we can avoid destroying or damaging any of the remaining tidal marshes and can protect vital eelgrass beds. We can even create new marshes and eelgrass beds to function as nurseries and feeding grounds for important commercial and sport fishes and shellfishes.

Some of our ditched and diked coastal areas are of marginal value as pastures and croplands, whereas they could prove extremely useful functioning in their original capacity as coastal wetlands.

Perhaps the time has come to supplant wetland destruction with wetland restoration.

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"Altering the Estuary" - Study questions

1. **Why are estuaries such a favored area for development?**
2. **What are some ways that we have altered estuaries? Discuss the affects this altering has had.**
3. **How can some alterations be beneficial?**
4. **What are some negative aspects to dredging? Why is dredging necessary?**
5. **A saltwater marsh is diked to create pasture land. Years later, the diked area becomes a freshwater marsh, teeming with songbirds, dragonflies and cattails. But plans call for a site restoration; to remove the dike and allow the tides to carry in salt water and return this freshwater marsh to the salt marsh it had been 100 years ago. What do you think about that? Discuss as many pros and cons as you can.**

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Marsh Succession

by Kenn Oberrecht

As a coastal river flows toward the ocean, tidal influences on riverine waters increase. From the head to the mouth of the estuary, the salinity gradient also increases. In other words, estuarine waters are saltiest near the estuary's outlet to the ocean and become progressively fresher the farther upstream they are. The salinity gradient also influences what sort of vegetation is found on the estuary and in adjacent wetlands.

Low salt and brackish marshes occur along the edges of the estuary in areas that are inundated by high tides most days.

On the West Coast, eelgrass beds typically occur in the lower estuary as subtidal and intertidal wetlands. Bottom sediments here are usually a mixture of mud and sand, heavily populated with bottom-dwelling and burrowing animals.

Low salt and brackish marshes occur along the edges of the estuary in areas that are inundated by high tides most days. Depending

mainly on their locations, such wetlands can be subjected to broadly different salinity levels.

Where salinity is high, typical salt-marsh plants include pickleweed and fleshy jaumea. Low brackish marshes, where fresh water from the river has diluted incoming ocean water, are often characterized by sedges and grasses, such as arrowgrass and Lyngby's sedge.

Farther upland along the estuary, high salt and brackish marshes occur where they are flooded less than daily, usually by the highest tides of the month. Here, tufted hairgrass, common spike rush, meadow barley, and Pacific silverweed are often dominant. A number of other plants grow in the low and high, salt and brackish marshes. Species also overlap a good bit, especially in transition zones between low and high marshes.

All of these wetlands are complex and highly productive. They provide food and shelter for countless organisms and are vital components of the estuary and coastal zone.

Farther inland, as salinity progressively diminishes, brackish marshes give way to freshwater wetlands. Here, cattails and purple loosestrife line the edges. Just beyond, bullrushes grow, often next to water lilies or spatterdock. Farther out, in the open-water areas, a variety of aquatic plants flourish.

We're still learning about the great number of animals that reside in or frequent the marshes. Of course, fishes and shellfishes are the main inhabitants of and visitors to the subtidal and intertidal salt and brackish marshes. Many species of waterfowl, sea birds, shorebirds, and wading birds also depend on these marshes for food and cover. Even birds of prey--including hawks, ospreys, and eagles--hunt the marshes.

Mice and shrews live in the higher marshes, as do many kinds of insects. Abundant food attracts many songbirds, which in turn entice owls and the smaller hawks.

Deer visit the salt and brackish marshes to feed, as do other mammals, such as skunks, raccoons, mink, and river otters. These same species also forage in and around the freshwater wetlands, where beaver and muskrats are often year-round residents.
All of these wetlands are complex and highly productive. They provide food and shelter for countless organisms and are vital components of the estuary and coastal zone.

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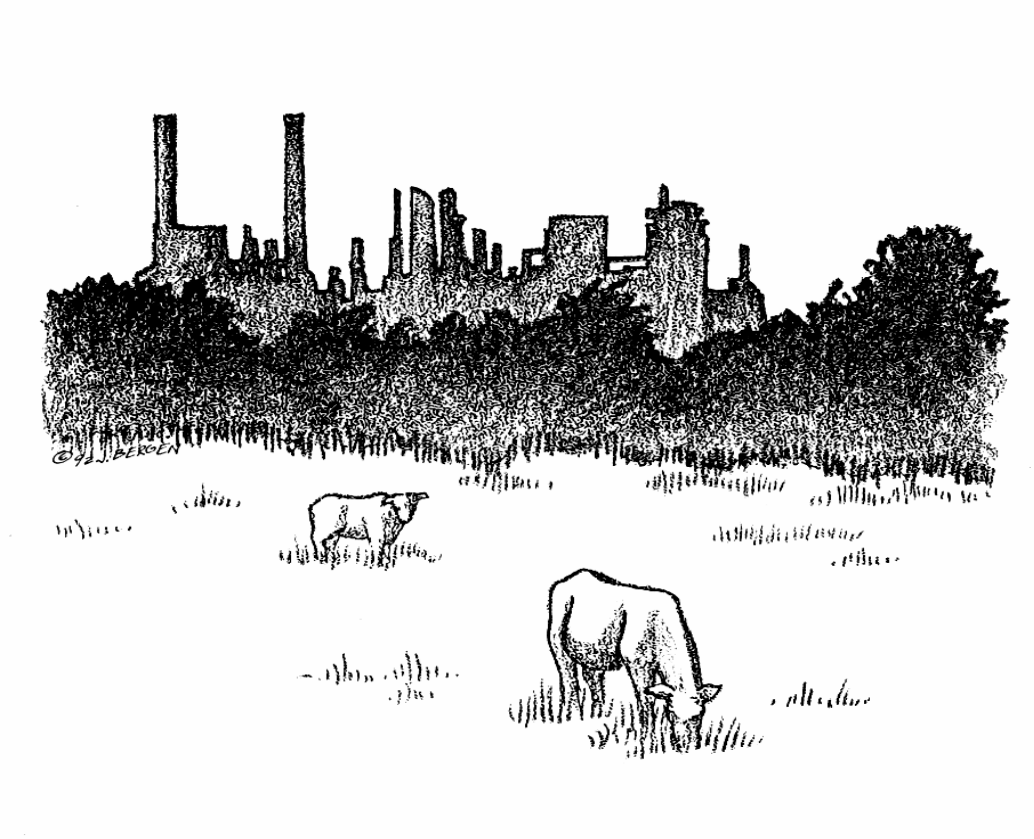
“Marsh Succession” - Study questions

1. **What influences the varying salinities of an estuary?**
2. **What is meant by a low salt marsh? A high salt marsh?**
3. **What are some important species of plants and animals that are dependent on salt marshes? On freshwater marshes?**
4. **Some animals visit the marshes, but do not live there. Where might they live and what are they seeking from the marshes?**
5. **What are the events --natural or human-caused—which may influence the salinity gradient of an estuary?**

Global Warming

by Kenn Oberrecht



Heat-trapping gases in the atmosphere create what is commonly called the "greenhouse effect" and consist mainly of water vapor, carbon dioxide, methane, nitrous oxide, and ozone. These are naturally occurring gases that combine to delay the escape of infrared radiation from earth. Without the greenhouse effect, our planet would be colder by 63 degrees Fahrenheit (33 degrees C.).

So it's not the existence of such gases that has led scientists to speculate on the potential threat of global warming, but rather the excesses that seem to have accelerated the warming process. The effect is called "climate forcing."

Deforestation and the burning of fossil fuels are the chief contributors to increased atmospheric carbon dioxide, up 25 percent since pre-industrial times.

The impacts of human overpopulation, leveling of the world's forests, burning of fossil fuels, global industrialization, the introduction of chlorofluorocarbons (CFCs) to the atmosphere, and

other destructive and disastrous practices associated with human activity have combined to amplify the greenhouse effect by more than 500 percent since the 19th century. Deforestation and the burning of fossil fuels are the chief contributors to increased atmospheric carbon dioxide, up 25 percent since pre-industrial times.

CFCs are industrial compounds found mainly in refrigerants, solvents, and foam insulation. They're also used in the manufacture of semiconductors and were once widely used as propellants in many aerosol products, such as hair sprays, deodorants, and insect repellents.

Although molecules of CFCs in the atmosphere are far fewer than molecules of carbon dioxide, the experts tell us they can be 10,000 to 20,000 times more damaging. What's more, once they've been released into the atmosphere, they take about 100 years to break down.

Rises in levels of atmospheric methane can be traced to the rapid growth of human population, which, in the developing nations, amounts to about a million more people every 4-1/2 days. That's equivalent to reproducing the entire U.S. population every 56 days.

The phenomenon of global warming can be traced to the age of industrialization that burgeoned in the late 19th century.

The more humans on earth, the more crops and livestock we raise, the more garbage we create, the more petroleum products we produce, and the more mining we do. While methane is released naturally into the atmosphere during decomposition in bogs and swamps, as well as during the digestive process of termites, it is also released from rice paddies and landfills and during the digestive processes of cattle and sheep. Moreover, it leaks from gas-production facilities and exposed coal seams.

Scientists aren't sure why levels of nitrous oxide have increased, but some have suggested that greater worldwide use of nitrogen fertilizers might be one cause.

The phenomenon of global warming can be traced to the age of industrialization that burgeoned in the late 19th century. The earth's temperature began to rise ever so gradually in 1890 and has continued since. During the 1980s, a period of increased worldwide emissions of greenhouse gases, the temperature rise accelerated.

During the past century, earth has warmed by about one degree Fahrenheit. In the polar regions, the warming has ranged from four to seven degrees. Granted, that doesn't sound like a great threat, but remember, much of that increase is recent and will continue. In fact, some experts contend that even if it were possible to immediately cease all production of greenhouse gases, global temperatures still might rise another four to 10 degrees Fahrenheit by the year 2020, with results that could be disastrous and certainly will be costly.

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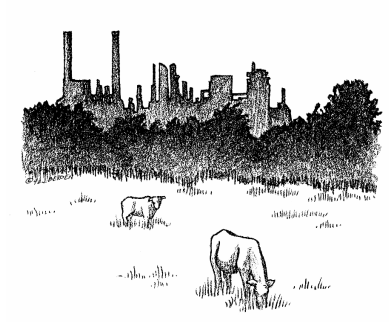
"Global Warming" - Study questions

1. **Describe the "greenhouse effect."**
2. **Describe the phenomena of global warming and what it has to do with the greenhouse effect.**
3. **What is the big deal about CFC's? What are CFC's? Why are they bad?**
4. **Why are methane levels on the rise?**
5. **How might global warming be controlled? If temperatures are bound to remain rising for years to come, even if we cease all production of greenhouse gases, is it worthwhile to begin restricting emissions, etc.?**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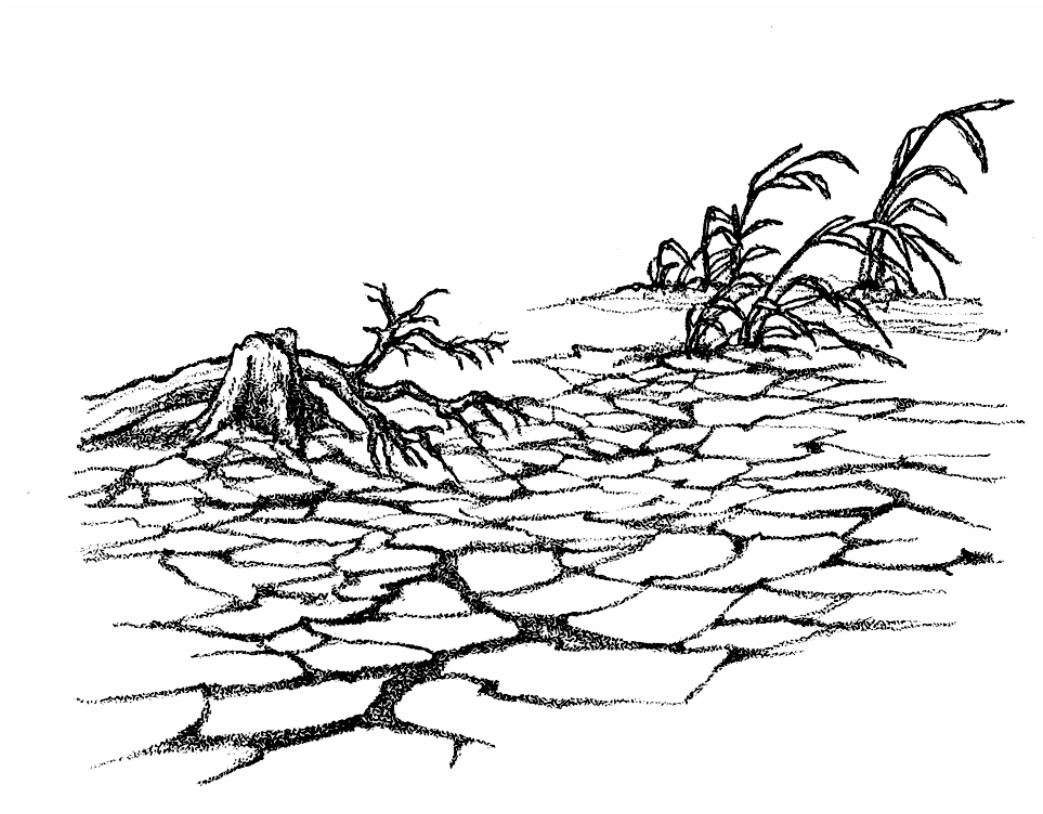
The Effects of Global Warming

by Kenn Oberrecht



Global warming during the past century has been so gradual as to be nearly imperceptible. Neither does it adhere to a regular schedule or predictable pattern, which perhaps explains why doubters and nay-sayers still dispute the whole idea. Their ranks are shrinking, however, in the face of a growing body of evidence.

Experts now tell us that if we do nothing to reduce the release of heat-trapping gases into the atmosphere, we can expect temperatures to rise during the next century from 2.7 to 8.1 degrees Fahrenheit (1.5 to 4.5 degrees C.). Even these increases seem small and no cause for alarm, particularly here on the coast where ocean breezes usually temper even the hottest days.

While many of us might think first of the discomfort, inconvenience, and expense we would have to bear as the planet's climate warms, the greatest effects are likely to be far more catastrophic.

The problem, remember, is global warming; the operative word here is global. The increases will be in average temperatures, and even then we'll still probably experience cool spells, cold snaps,

and years that aren't as hot as we might expect. With rising average temperatures, however, come increases in the probability of warmer days and more of them.

For example, studies indicate that temperate-zone cities now recording maximum temperatures exceeding 90 degrees Fahrenheit 35 days a year will, by the year 2020, swelter under such heat for an additional 50 days a year.

While many of us might think first of the discomfort, inconvenience, and expense we would have to bear as the planet's climate warms, the greatest effects are likely to be far more catastrophic. They include the dieback of forests; severe drought, possibly leading to crop failures and famine; and a rise in sea levels, which could greatly alter our coastlines, not to mention our lifestyles.

We can't solve these problems overnight. In fact, even if we were able to immediately take the most drastic measures to reduce emissions of greenhouse gases, it would take several decades to check the progress of global warming.

We have already done a great deal of irreversible damage to our atmosphere since pre-industrial days. For example, we expect chlorofluorocarbons (CFCs) and related atmospheric greenhouse gases to have doubled by the year 2050. Without dramatic measures to decrease emissions worldwide, the consequences could be dire.

Although developing nations now contribute about 30 percent of the global carbon dioxide released into the atmosphere, scientists estimate that their dense populations and industrialization will increase that amount to more than 50 percent by the year 2025.

The United States and other industrialized nations have been part of the problem for too long. If we are to persuade developing nations to clean up their acts, we must become part of the solution.

We can't solve these problems overnight. In fact, even if we were able to immediately take the most drastic measures to reduce emissions of greenhouse gases, it would take several decades to check the progress of global warming.

So some continued warming is inevitable. Most scientists agree that one certain result will be a rise in the world's sea level. In fact, that process is already underway.

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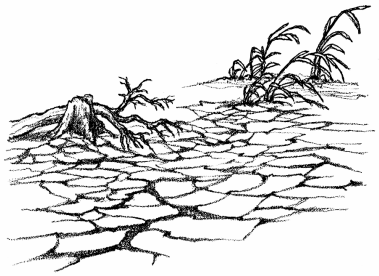
"The Effects of Global Warming" - Study questions

1. **How much will the average temperature rise during the next century? Is this cause for alarm?**
2. **With increasing temperatures, what are the effects that will be had on the environment?**
3. **What lifestyle effects will global warming have?**
4. **What are "developing nations?" What are special problems when it comes to developing nations and global warming?**
5. **Of course, we can not "save the world" overnight. What are some changes that you can make in your lifestyle to positively affect the planet? Are you willing to do them?**



The Effects of Rising Sea Levels

by Kenn Oberrecht

During the earth's long history, global sea levels have fluctuated, falling during the ice ages and rising during periods of global warming. Our most recent ice age ended more than 10,000 years ago. We are now experiencing global warming, which has been accelerated by an excess of heat-trapping gases in our atmosphere.

What makes the current sea-level rise so much more threatening than earlier ones is the worldwide proliferation of humans and their preferences for living in and developing coastal areas. Nearly 75 percent of Americans, for example, live on or within 50 miles of the coast.

Tide-gauge records dating back 100 years indicate a rise in global mean sea level that amounts to one to two inches every 25 years and is increasing. The Environmental Protection Agency (EPA) now predicts a global sea-level rise of about 10 to 15 inches by the year 2025 and an additional 20 inches to more than six feet by 2100.

What makes the current sea-level rise so much more threatening than earlier ones is the worldwide proliferation of humans and their preferences for living in and developing coastal areas. Nearly 75 percent of Americans, for example, live on or within 50 miles of the coast.

Rising seas will increase coastal erosion, pollution, storm damage, and flooding. They'll pose threats to coastal roads, bridges, jetties, breakwaters, docks, piers, and waterfront property. Intruding salt water might contaminate groundwater supplies and threaten landfill and hazardous-waste sites.

Many of the nation's 900 estuaries, where coastal rivers merge with the ocean, could be damaged in a variety of ways. Some would be more vulnerable than others, mainly because of their geology and the amount of shoreline development. Consequently, estuaries along the Atlantic and Gulf coasts would be particularly hard hit, whereas the deep, steep-walled fjord-type estuaries characteristic of the British Columbia and Alaska coasts would be least affected. Here in Oregon, Coos Bay would be one of the estuaries with potential for serious harm.

Rich and productive tidal flats, normally exposed on low tides, might be drowned and left inaccessible to various animals, including humans.

With higher sea level, salt water would intrude farther into the estuary, thus increasing salinity and moving the salt front farther upstream. Such destructive organisms as shipworms, gribbles, and barnacles--which require relatively high salinity to survive--could migrate farther up the estuary, attacking wooden structures wherever they thrive.

If the increased salinity were to alter the mixing and flushing rates of the estuary, pollution could increase dramatically. Loss of adjacent wetlands to encroaching salt water would compound the problem.

Our tidal wetlands not only act as nurseries to most of our important marine fishes and shellfishes, but also filter many dangerous pollutants that rivers and creeks carry downstream to the estuary. They also buffer the effects of storms and floods.

Rich and productive tidal flats, normally exposed on low tides, might be drowned and left inaccessible to various animals, including humans.

Even the deposition patterns of nutrient-bearing sediments could be greatly altered, thus starving out whole populations of bottom-dwelling organisms.

The rise of global sea levels seems to be inevitable, and the experts are warning us to plan for an increase of 2.3 feet by the year 2050. The key word, here, is plan, because that's our best strategy.

Even as we bear down on the 21st century, there's no high-tech solution to these problems; we can't hold back the seas. Even the EPA's best recommendations are to "retreat and relocate," leaving sufficient buffer zones between the water's edge and all future permanent structures.

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"The Effects of Rising Sea Levels" - Study questions

1. **How do sea levels fluctuate over long periods of time?**
2. **We are in a period of global warming and sea levels are rising. Why are rising seas so much more threatening now than earlier sea rising events?**
3. **List some damaging effects rising sea levels could have.**
4. **What would happen to our estuaries if sea levels rose?**
5. **At this point, what can we do to lessen the effects of rising sea levels? Does this mean that the problem is solved? Why or why not?**

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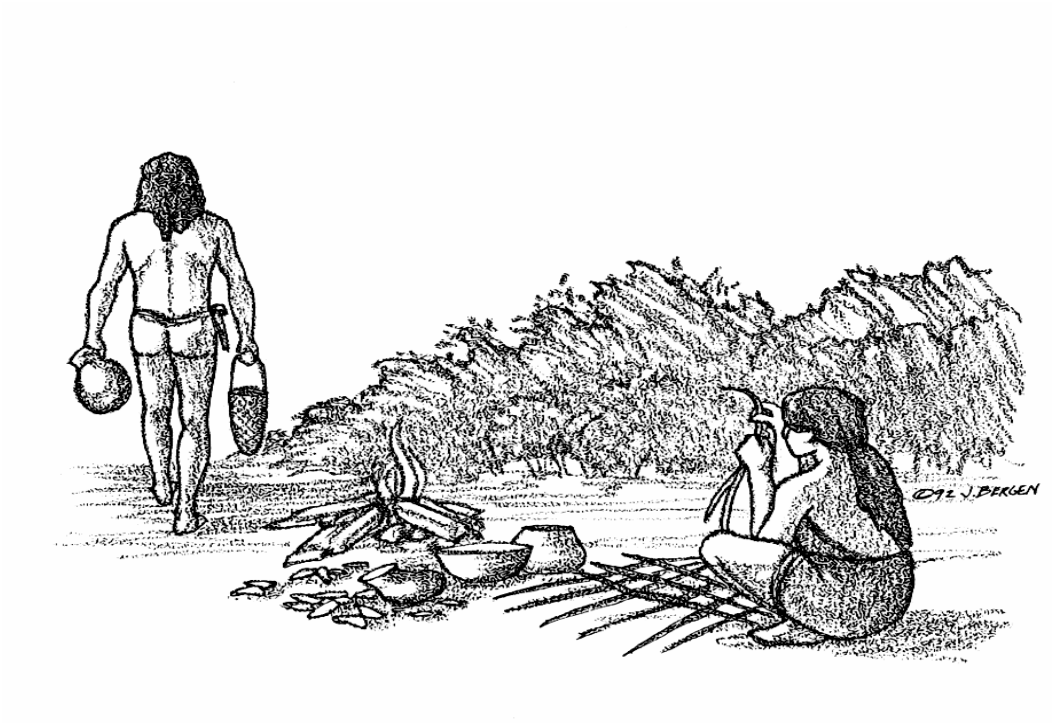
Prehistoric Settlement on Coos Bay

by Kenn Oberrecht



Radiocarbon dating, a process for determining the age of materials of organic origin, indicates that humans have inhabited or regularly visited coastal Oregon for at least the last 10,000 years. It's likely that people were here long before that, but evidence of their residency may be locked up forever in the sediments of the ocean floor, relegated there by the same rising seas that helped create Oregon's estuaries at the end of the last ice age.

Archeologists made one of the most interesting coastal discoveries in 1984 on the west side of Tahkenitch Lake, just north of Reedsport. Materials found at the site in a refuse heap, called a midden, dated back to about 6000 B.C. Surprisingly, bones and shells uncovered were from saltwater species only, indicating that Tahkenitch was not always a freshwater lake.

About 3,000 years ago, the estuary was almost completely closed off from the sea by encroaching dunes.

Scientists now believe that Tahkenitch was once a deepwater estuary, where fresh water from feeder streams mingled with salt water from the ocean in a coastal embayment. Gradually, silt-laden

freshwater runoff and sand-bearing tides raised the bottom and created flats, transforming Tahkenitch into a shallow-water estuary, perhaps much like Coos Bay.

About 3,000 years ago, the estuary was almost completely closed off from the sea by encroaching dunes. Eventually, the waters freshened, leaving a sprawling lake with only a small outlet to the sea.

The Tahkenitch estuary was a rich fishing and hunting area, its abundant fishes, shellfishes, and marine mammals attracting the early nomadic people who regularly visited and ultimately settled there to remain for as long as 3,000 years. We can assume that other estuaries along the Oregon coast, including the Coos estuary, were equally attractive to other tribes, loose gatherings, or families of these prehistoric humans.

Ancient, prehistoric peoples, as well as the generations and different races that followed, including modern Indians and early pioneers, were enticed to settle along America's estuaries. They offered abundant food sources, transportation corridors, and natural protective boundaries.

Whether they were descendants of the so-called Paleo-Indians, thought to have migrated from Asia to North America via the Bering Land Bridge, is a matter of conjecture. Nor do we know if the Paleo-Indians were the ancestors of modern coastal Indians. It could be that later Indians replaced or displaced the Paleo-Indians.

What we do know is that the south coast has been steadily inhabited for thousands of years. Archeologists have uncovered ancient sites at Mule Creek on the Rogue River; on Myers Creek, south of Gold Beach, near the Pistol River; near the mouth of the Umpqua River; and on the lower Coquille River at Bandon and Bullards Beach State Park.

Ancient, prehistoric peoples, as well as the generations and different races that followed, including modern Indians and early pioneers, were enticed to settle along America's estuaries. They offered abundant food sources, transportation corridors, and natural protective boundaries.

The Coos was among the richest of Oregon's estuaries. Its waters teemed with fish and fowl. Its tidal flats held seemingly unlimited bounty. Along its shorelines grew berries and edible plants. Elk and deer roamed the woodlands and meadows. Sources of fresh water were plentiful and always nearby. It was an inviting paradise with a temperate climate that promised an easy life.

In searching for clues to early human settlement along the shores of Coos Bay, "why" soon seems a foolish question. Better to wonder, "why not?"

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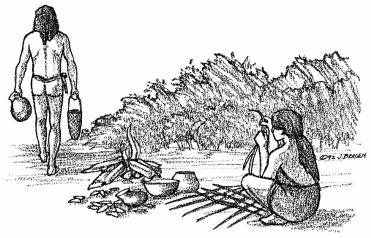
"Prehistoric Settlement on Coos Bay" - Study questions

1. **For how long have people visited or inhabited Oregon's coast? Why might we not be able to find evidence of their cultures?**
2. **Why was the discovery, in 1984, of a midden at Tahkenitch Lake so interesting? In other words, what did it say about the history of Tahkenitch Lake?**
3. **Why were estuaries such an inviting place for pre-historic peoples?**
4. **How do we know about pre-historic people?**
5. **Is it important to study our past? Why or why not?**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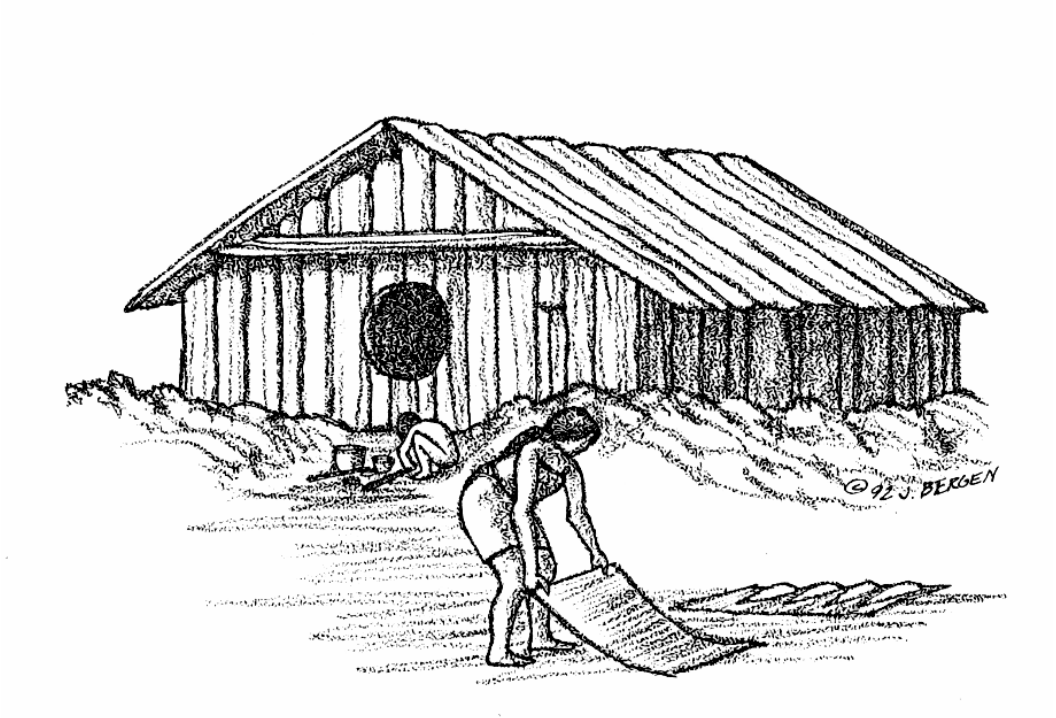
Indian Settlement on Coos Bay

by Kenn Oberrecht



During the centuries preceding American expansion and pioneer settlement of the western frontier, there was no written record of Indian life along the Oregon coast. Much of what we know is pieced together from various sources, augmented by the lore Indians passed on verbally from one generation to the next. For the time being, we have to fill in the blanks with reasoned assumptions (educated guesses).

British and American fur traders were probably the first to make regular contacts with Indians of Oregon's south coast. We know, for example, that Alexander McLeod of the Hudson's Bay Company explored the south coast, including Coos Bay, in 1826 and 1827.

On June 30, 1851, a bedraggled band of nine white men, fleeing from Ewing Harbor (now Port Orford) and a skirmish at Battle Rock, broke through the brush on lower Coos Bay to be greeted by local Indians.

In 1828, the Jedediah Smith Expedition reached the south coast and camped at various spots near and on Coos Bay: Whiskey Run on July 3, Cape Arago on July 4, Shore Acres on July 5, Sunset Bay on July 6 and 7, Charleston on July 8, lower Coos Bay near Empire on July 9, and the North Spit on July 10. Of course, none

of these places went by those names then. There was no community called Empire, and in place of Charleston, as we know it today, was a large Indian village--probably the largest on the bay.

On June 30, 1851, a bedraggled band of nine white men, fleeing from Ewing Harbor (now Port Orford) and a skirmish at Battle Rock, broke through the brush on lower Coos Bay to be greeted by local Indians. John Kirkpatrick, leader of the band, later described the Indians as friendly, generous, and hospitable hosts--a report that's consistent with those of the early explorers and traders.

The Coos Indians, or Coosans, spoke two different languages. Those who spoke Miluk lived on the lower Coquille River, northward along the coast to Coos Bay, on the lower bay, and on South Slough. Those who lived along the main and upper part of the bay spoke Hanis.

Because of the rich bounty of the bay and adjacent lands, the Coosans were a self-sufficient people who lived in relative peace and tranquility.

No one knows for sure how many Indians lived on Coos Bay, but it was a popular and populated area that was also visited regularly by Indians that normally resided farther inland. The best estimates are that 1,500 to 2,000 Coosans lived in plank houses along the bay shore in as many as 40 to 50 villages.

They relied on the estuary to provide most of their necessities. They were hunters and gatherers, taking fish, shellfish, and marine mammals from the bay and its many tributaries. In the bordering forests, meadows, and marshes, they hunted deer and waterfowl, pit-trapped elk, picked berries, and harvested edible plants. They gathered reeds and grasses to make mats and baskets. They used logs to fashion their dugout canoes and build their plank houses and huts.

Because of the rich bounty of the bay and adjacent lands, the Coosans were a self-sufficient people who lived in relative peace and tranquility. They were variously described as robust and healthy in appearance, good-natured and generous in demeanor. And why shouldn't they have been? Theirs was a temperate paradise.

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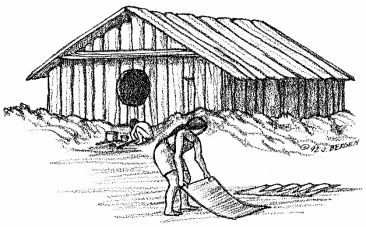
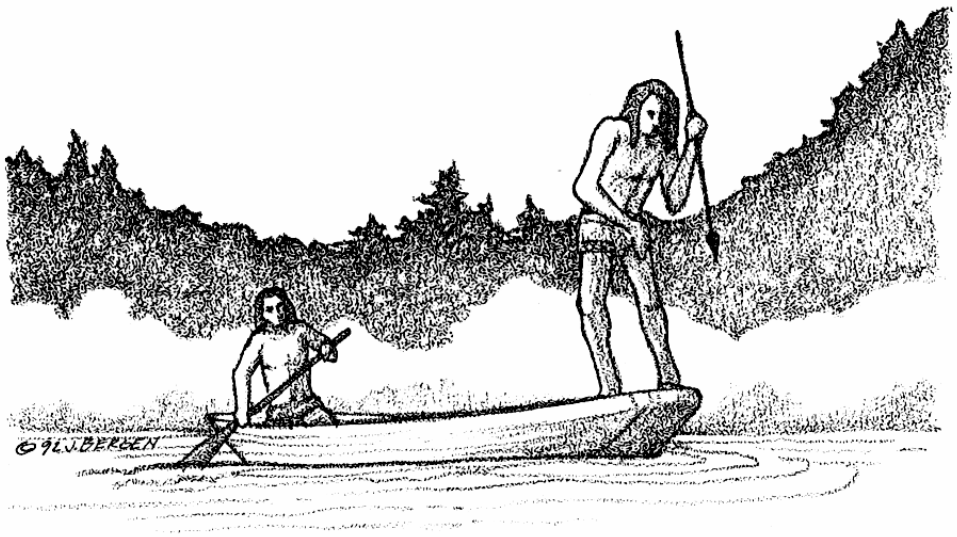
"Indian Settlement on Coos Bay" - Study questions

1. **Describe some of the earliest known contacts with the Indians of Oregon's south coast.**
2. **What were the two languages spoken by the Coosans? What determined which language was spoken? Do you think the two languages were similar or different?**
3. **Were the Coosans a group of people permanently settled or did they migrate from place to place? What are some clues that make you think this?**
4. **What did the estuary provide for the Indians? What did the upland forests provide?**
5. **What do you think happened to these Indians in the coming years?**



How Indians Used Coos Bay

by Kenn Oberrecht



Imagine a dawn on Coos Bay in 1790. No bridges span the bay. No highways, causeways, or railways cross the inlets or sloughs or cut through the vast forests. Great marshes, teeming with waterfowl, spread from the mouths of creeks. The only hints of human habitation are the feint, sweet smell of alder smoke mingled with the morning mists, and the occasional rustling of Miluk or Hanis women, who have left the sleeping mats of their warm plank houses to bathe at the edge of the chilly waters before first light.

One archeologist estimated that 2,000 Coosan Indians might have lived along the shores of Coos Bay then: the Miluk-speaking people on the lower bay, and those who spoke Hanis residing on the main body and upper reaches.

Coos Bay's waters, marshes, and tidal flats provided them with a tremendous bounty. Great flocks of resident, migrant, and over-wintering waterfowl provided food.

Coosans were hunters and gatherers who thrived here the year around. During seasons of plenty, they ate well, but also preserved food to see them through sparse times.

Coos Bay's waters, marshes, and tidal flats provided them with a tremendous bounty. Great flocks of resident, migrant, and over-wintering waterfowl provided food. Other birds were valued for their flesh, eggs, or some part of their anatomy. Wing bones of great blue herons, for example, were fashioned into needles for sewing reed mats and clothing.

Millions of chinook, coho, and chum salmon swam the waters of the Pacific, gorging and growing fat on herring, smelt, squid, and other abundant foods. Seasonally, they migrated by the hundreds of thousands into the bay and up its many tributaries to spawn.

The Coosans built weirs of alder and vine maple to trap the salmon, the flesh of which they consumed fresh and sun-dried or smoked for later use. They also speared salmon and flounder, and they sometimes did so at night, guided by light from fires they built on beds of sand in their dugout canoes. In the upper bay and its tributaries, they captured "eels"--actually eellike, parasitic fish known as lampreys--in basket traps, most of which they preserved for lean times.

Considering all the riches the bay was able to lavish on the people who dwelled on its shores, it's easy to understand why estuaries invite human habitation.

They also pit-steamed clams, mussels, and oysters, then preserved them by drying or smoking. Although they relished the plentiful crabs of the bay, they always ate them fresh instead of trying to preserve them.

They hunted sea mammals, and gladly took advantage of the occasional whale that entered the bay and became stranded in shallow water. They used the whale's flesh and blubber for food and oil. Even the vertebrae from the whale's skeleton served as comfortable camp stools.

In the forests and meadows on the fringes of the bay, they hunted deer and pit-trapped elk. Women and children gathered and dried the plentiful berries and a number of other edible plants.

They also depended on the bay to supply most of their timber--the drift logs washed down by winter floods--from which they made dugout canoes and planks for their houses and huts.

Considering all the riches the bay was able to lavish on the people who dwelled on its shores, it's easy to understand why estuaries invite human habitation.

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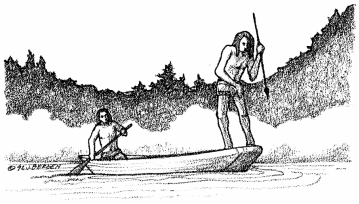
"How Indians Used Coos Bay" - Study questions

1. **Can you describe what the Coos Bay area may have looked like in 1790? Use your own ideas, not the author's!**
2. **How many Coosan Indians lived along the shores in the late 1700's? How many people live here now? What do these numbers have to do with resource availability?**
3. **How did the Indians capture fish? Elk? Sea mammals?**
4. **What food types were prepared for use in lean times? How?**
5. **What uses did the Indians find for the whale bones and blubber? For drift logs? The wings and bones of birds? Anything else?**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Pioneer Settlement on Coos Bay

by Kenn Oberrecht

Early white settlers on Coos Bay had a saying: "When the tide's out, the table's set." The quaint aphorism might lead some to believe that the bounty of the bay is what had attracted those first pioneers, as it had the Indians and perhaps earlier prehistoric humans before them. Such was not entirely the case.

On January 23, 1852, the Captain Lincoln, a coastal steamer out of San Francisco, wrecked on the North Spit, near the mouth of Coos Bay. The ship had been sent to provision military outposts in the Oregon Territory. Soldiers and the shipwrecked crew made it to shore and camped in the dunes. They salvaged as much of the wreckage and stores as they could, met the local Indians, and explored the bay.

During the summer of 1853, members of the Coos Bay Commercial Company found promising coal seams in the bay area and staked 19 coal-mining claims.

Two of the dragoons from the Captain Lincoln and a group of pioneers from the lower Umpqua became the first white settlers on Coos Bay in 1853, after the Coos Bay Commercial Company established Empire City, six miles above the Coos Bay Bar. By

August, the town was divided into lots and was a tent city of 50 men. The first white women and children arrived that autumn. During the summer of 1853, members of the Coos Bay Commercial Company found promising coal seams in the bay area and staked 19 coal-mining claims. Mining began the following year, but the original claim filers lacked the knowledge and resources to make the mines work. It would require regular shipping, capital investment, mining equipment, rail cars, trestles, bunkers, and more. In short, it would take the wherewithal of wealthy men and outside investors.

In 1856, the first sawmills began operating on Coos Bay. Henry Luse built his mill at Empire City; Asa Simpson located his near the big bend on the bay. Two years later, Simpson built a shipyard next to his sawmill, and so began another industry.

Meanwhile, homesteaders cleared land around the bay and up its tributaries. They dug ditches, built dikes, constructed tide gates, and transformed marshes into agricultural land.

Sawmills burgeoned like mushrooms in the woods around the bay. Loggers soon had the lands near the mills denuded and began moving farther into the hills in their attempts to feed the mills that loaded the ships that hauled wood south to lumber-starved San Francisco.

Meanwhile, homesteaders cleared land around the bay and up its tributaries. They dug ditches, built dikes, constructed tide gates, and transformed marshes into agricultural land.

Boomtowns sprang up and died or were absorbed into the larger communities. By the turn of the century, Marshfield was a town of 1,500 people. Boats and ships crowded the bay. Coastal steamers made regularly scheduled runs between Portland and Coos Bay and from San Francisco to Coos Bay. Coal steamers made 20 trips a month over the bar, and they were outnumbered by lumber ships. The industrial era had dawned.

Certainly, abundant fish and game, moderate climate, vast lands, and readily available building materials were enticements to the early pioneers. But it took the promise of wealth and opportunity for exploitation to draw large numbers of settlers to the bay area. It also took some missed opportunities, failed plans, catastrophes, and a smattering of good luck to keep their early dream from becoming our later nightmare. Coos Bay did not become the second San Francisco, as so many thought it would.

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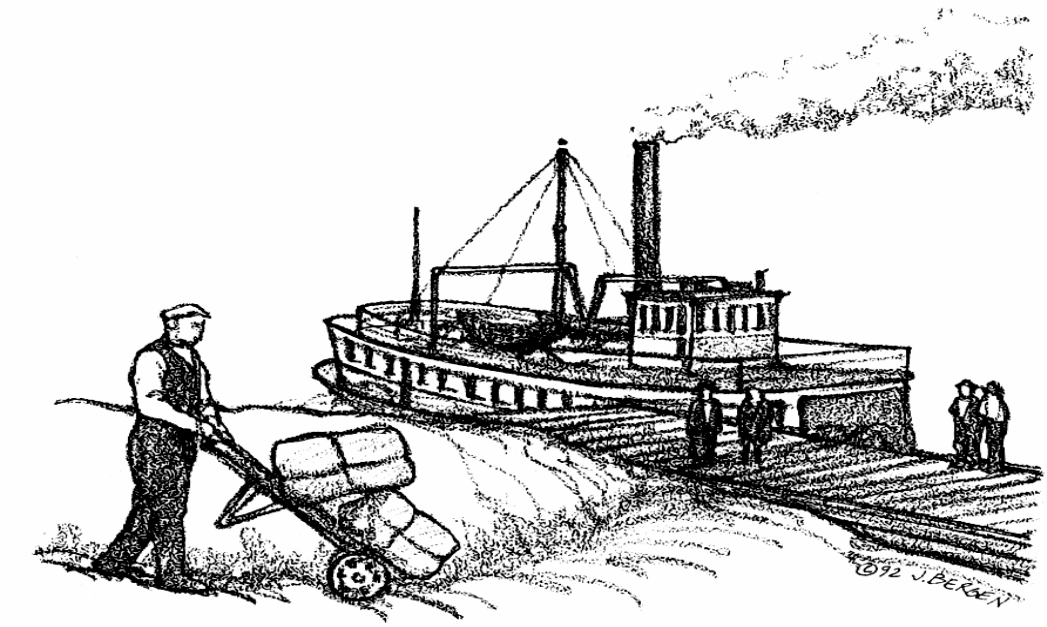
“Pioneer Settlement on Coos Bay” - Study questions

1. **Why do you think some of the members from the Captain Lincoln and a few pioneers from the lower Umpqua chose to settle at Coos Bay?**
2. **Why did mining essentially fail?**
3. **What began the industrial era in Coos Bay? Describe what may have been going on in Coos Bay in the early 1850’s.**
4. **Is it true that “when the tide’s out, the table’s set?” Why or why not?**
5. **What later effects would Coos Bay’s early industrialization have on the environment? On the people who live there now?**

Industrial Settlement on Coos Bay

by Kenn Oberrecht



By 1903, the year North Bend was incorporated, the bay was a busy place, with sternwheelers, sidewheelers, and steam-powered propeller craft carrying goods, farm products, and passengers up and down the rivers and sloughs, throughout the bay, and along the coast. Gasoline launches scooted across the water in great numbers and soon became known as Coos Bay's Mosquito Fleet. The Reverend G. Leroy Hall even conducted Baptist Church services aboard his launch, the Life Line.

In 1916, the Southern Pacific Railroad completed the line connecting the Coos Bay area with the Willamette Valley. Not only did this present new opportunities for the transport of freight and passengers, but it also stimulated the local growth of commercial fishing, because fresh seafood could now be shipped in refrigerated cars.

From 1924 to 1928, the south jetty was built at the Coos Bay entrance, the north jetty was rebuilt, and the channel was dredged to accept a new generation of deep-draft steam ships.

World War I brought boom times to Coos Bay in 1917 and 1918. Logging, wood-products manufacturing, and shipbuilding were better than ever. The end of the war, however, caused an abrupt downturn in these industries. Within a few weeks, as many as 800 families packed up and left the area.

From 1924 to 1928, the south jetty was built at the Coos Bay entrance, the north jetty was rebuilt, and the channel was dredged to accept a new generation of deep-draft steam ships. As a result, the sluggish economy began to stir. Harbor improvements also helped the commercial-fishing industry, and Charleston started to grow and prosper.

By 1930, a network of good roads connected the communities of the bay area. The North Bend Airport opened that year and later received a federal grant for improvements. In 1936, the McCullough Bridge and the Oregon Coast Highway were completed--perhaps the most significant growth event of the 20th century.

Coal mining began declining in 1916 and ceased altogether in the 1940s. By 1915, wood products had become the bay area's main export, and by 1946, Coos Bay was shipping more lumber than Portland.

The bay has been altered tremendously since the arrival of the first pioneers in the 1850s.

The sprawling Weyerhaeuser complex at North Bend opened in 1951, and other wood-products companies followed. Some are still in business, while others have long since ceased operation. Wood products remain the area's economic mainstay, but the business has always alternated between riding the crest and trough of the industrial wave.

While industrial growth and urban development can lead to economic health, they can also threaten the well-being of the estuary, which could eventually wreak financial havoc on the bay area in a variety of ways.

The bay has been altered tremendously since the arrival of the first pioneers in the 1850s. About 50 percent of its valuable marshes and tidal flats have been filled or drained. Dredging, road construction, and shoreline alteration have changed the way water moves through the estuary, carrying nutrients to plants and animals, flushing and filtering urban and industrial waste.

To the early developers and many who succeeded them, wetlands were synonymous with wastelands. The estuary was something to be exploited without regard to consequences.

We know now that estuaries represent the richest, most productive habitat on earth. The bay area's second most important industry--commercial fishing--depends on them. So do tourism, many forms of recreation, and the quality of life of those who live along or near their shores.

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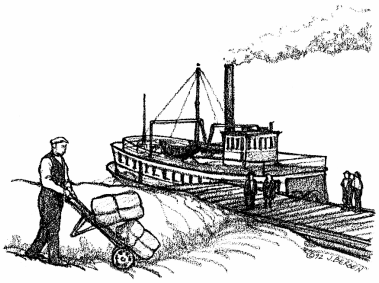
"Industrial Settlement on Coos Bay" - Study questions

1. **What was going on in Coos Bay industrially in the early 1900's?**
2. **How did WWI both positively and negatively influence growth in Coos Bay?**
3. **Coal mining declined and wood products increased. What are some of the possible "crests and troughs" of the wood products industry?**
4. **How is it that the estuary is threatened by industrial development?**
5. **If we are to grow, economically, do we need to continue industrialization along waterways? Are there alternatives?**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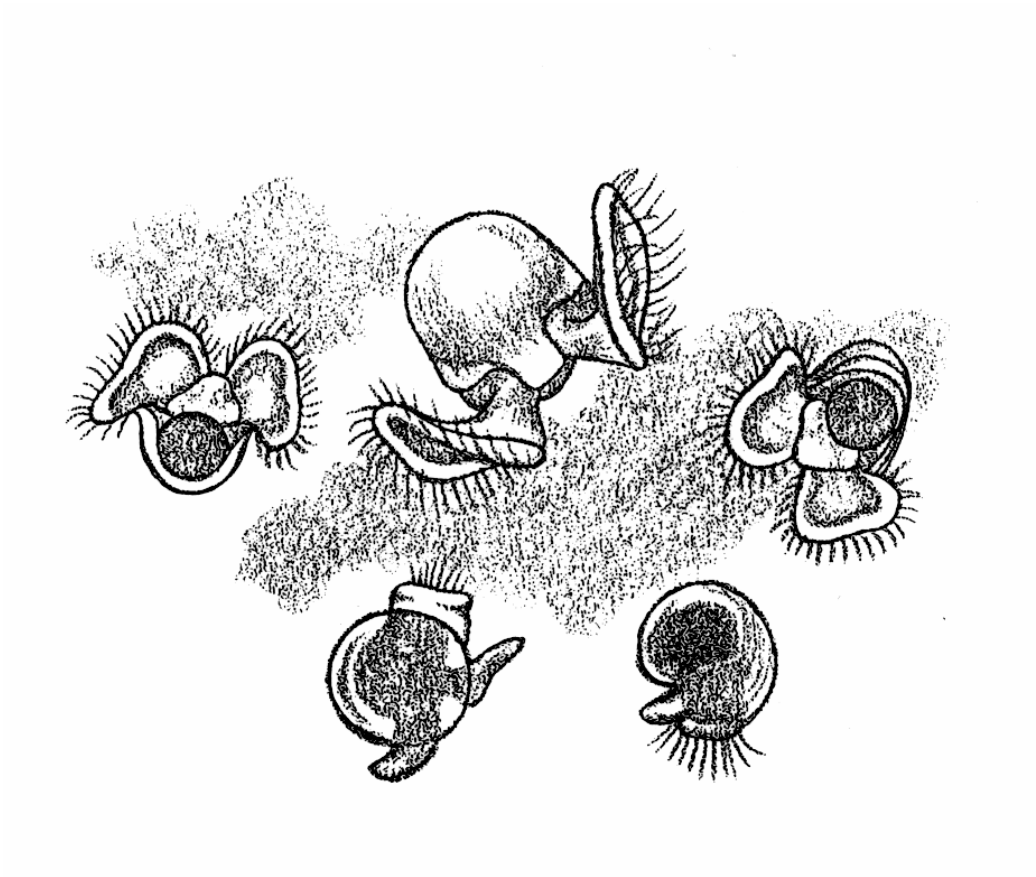
Spring on the Estuary

by Kenn Oberrecht



Spring often roars into Oregon in the form of a pounding storm, something many call an equinoctial storm. Contrary to popular belief, however, such storms have nothing to do with the equinox. The spring or vernal equinox is one of two times during the year when the sun crosses the plane of the earth's equator. This occurs about March 21, when days and nights are of approximately equal length around the world.

Though the day itself might be no different from the one that preceded it or the one to follow, it marks the beginning of a gradual awakening in the estuary. If the winter has been mild, some signs might already be pointing to that awakening, as if the snooze alarm had been going off every few days.

Clams reproduce in the spring, and as free-spawners send their larvae to join the great clouds of zooplankton drifting and swimming in the offshore currents, where they will remain for 60 to 80 days.

During spring, the estuary literally comes to life. As days grow longer and temperatures rise, plant growth increases--from the single-celled phytoplankton thriving in the estuary's nutrient-rich waters to the lush plants foliating in the marshes and the trees rising above them.

Clams reproduce in the spring, and as free-spawners send their larvae to join the great clouds of zooplankton drifting and swimming in the offshore currents, where they will remain for 60 to 80 days. Fittingly, the first good clam-digging tides of the year occur in spring, exposing acres of tidal flats to the morning sun and to eager predators, mostly birds and humans.

Zooplankton populations explode in the spring and continue to flourish well into summer. Among them are the holoplankton, which spend their entire lives in the estuary as plankton and include copepods and mysids; meroplankton are in the estuary temporarily in this form as the embryo and larval stages of such diverse species as clams, shrimps, crabs, sea stars, sea urchins, and fishes.

Some estuaries are hosts to spring migrations of anadromous fishes, moving through on their way to freshwater spawning grounds. For example, spring chinook usually arrive in May, and American shad from late April through May.

Flocks of migrating birds and waterfowl swell the ranks of resident and overwintering populations. Some, such as cinnamon teal, stop only briefly on the estuary to feed and rest. A few linger longer before heading farther north, while others remain to join resident populations that will court and build nests in the marshes, meadows, and forests on the fringes of the estuary. Most will be rearing fledglings by season's end.

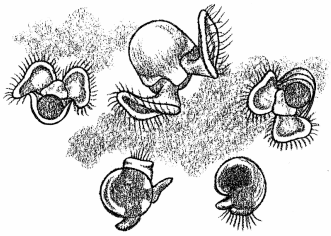
Some estuaries are hosts to spring migrations of anadromous fishes, moving through on their way to freshwater spawning grounds. For example, spring chinook usually arrive in May, and American shad from late April through May. Some marine species spawn or bear live young in the estuaries during the spring. Most popular with anglers are the perches, especially the striped seaperch and redtail surfperch.

Sunny days invite hikers and nature observers to explore the estuary's edges, canoeists and kayakers to paddle its backwaters and sloughs. Fickle weather delights the outdoor photographer, whose subjects, large and small, are endless in the estuarine environment.

Spring on the estuary is a time of vitality and variety. As it ages toward summer, it often seems a reward for our having put up with winter.

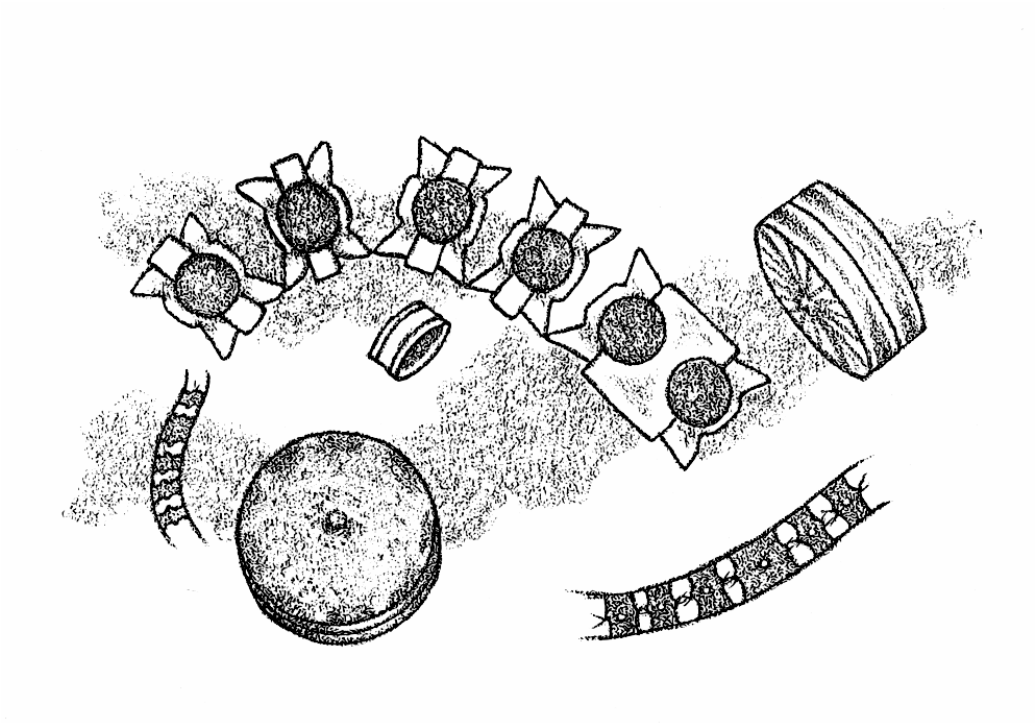
"Spring on the Estuary" - Study questions

1. **What is the spring equinox?**
2. **What happens in the spring that allows plant growth to thrive?**
3. **What is meant by the term "free spawner?"**
4. **What are plankton? What is the difference between holoplankton and meroplankton?**
5. **What might birds utilize from the estuary in the spring? Why might they be there?**
6. **Anadromous fish may be born in a freshwater stream but live for several years in the salty ocean. What do you think would happen if these fish, just freshly born, were dropped directly into the sea? Describe the estuary's roll in anadromous fish development.**



Summer on the Estuary

by Kenn Oberrecht



Were it not for calendar and clock, summer would likely sneak up unnoticed on the Oregon coast. Its official arrival, about June 21, is heralded by the summer solstice, when the sun reaches its northernmost point on the celestial sphere, 23.5 degrees north of the celestial equator. This is one of two times during the year when such distance exists between sun and equator, and is marked by the longest period of sunlight of any calendar day.

Coos Bay's plankton population continues to mushroom until July, when it begins to drop off dramatically. One theory is that by mid-summer they have depleted the supply of nutrients in the estuary.

By the time summer comes to the estuary, many of the processes and activities of the season are already underway. Rainfall has greatly diminished or ceased altogether. Summer temperature patterns have taken over. The volume of fresh water flowing into the estuary declines and becomes warmer. Water clarity increases, allowing for greater sunlight penetration.

Aquatic and terrestrial plants respond by growing faster than at any other time of the year. Plant-eating organisms likewise thrive.

Coos Bay's plankton population continues to mushroom until July, when it begins to drop off dramatically. One theory is that by mid-summer they have depleted the supply of nutrients in the estuary. On the marshes and in the backwaters of the estuaries, mallard, wood duck, and merganser parents trail trains of fuzzy ducklings behind them. Ospreys hover and dive, hover and dive, on their day-long fishing forays, catching food for their hungry and growing broods.

Brown pelicans, so graceful on the wing, make crashing spectacles of themselves when they spot forage fish swimming below. They tuck their wings, stretch their necks, and simply let gravity take its course. They're a summer delight, and their numbers seem to be increasing on the bay--a hopeful sign for a species that's been on earth for 30 million years, but nevertheless barely escaped extinction in the 1970s because its food was so contaminated with DDT.

Lingcod, cabezon, and rockfish--normally associated with offshore reefs--frequently move into the bay during the summer months to feed.

Salinity of the estuary's waters is higher in the summer and early autumn than the rest of the year, causing the saltwater boundary to migrate farther landward, sometimes coaxing estuarine and marine animals farther up the bay. Lingcod, cabezon, and rockfish--normally associated with offshore reefs--frequently move into the bay during the summer months to feed. Young lingcod and rockfish move well up the estuary in search of food. Even adult sharks cruise the bay miles from the ocean and occasionally surprise a perch angler.

Sea-run cutthroat trout move into Oregon estuaries in late August and early September, feeding as they migrate toward fresh water to spawn. Summer steelhead also move through some estuaries and into the rivers in September. Crabbing is often good on the estuary during summer months, but the catch will include crabs in the soft-shell stage, which must be released. Cycles of the year's lowest tides occur throughout summer, exposing many acres of tidal flats for clam digging.

Summer is also a good time to learn about the estuary and its inhabitants. The Oregon Institute of Marine Biology at Charleston offers courses to the public during the summer. The South Slough National Estuarine Reserve has a bevy of workshops, organized nature hikes, and canoe trips on the slough. For those who prefer to go on their own, trails at the South Slough are open all daylight hours.

Summer's a great time to pack a lunch with the binoculars and camera, and get to know Oregon's estuaries.

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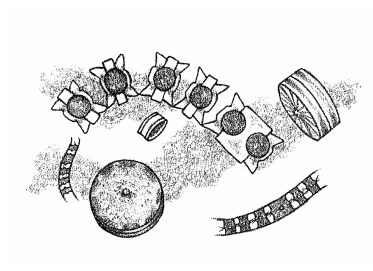
"Summer on the Estuary" - Study questions

1. **What is the summer solstice?**
2. **Why do you think that the water clarity of the estuary increases during the summer?**
3. **Why is it thought that Coos Bay's plankton population grows until July and then dramatically decreases?**
4. **Why is salinity higher on the estuary's summer waters?**
5. **What are some effects that increased salinity has on the estuary?**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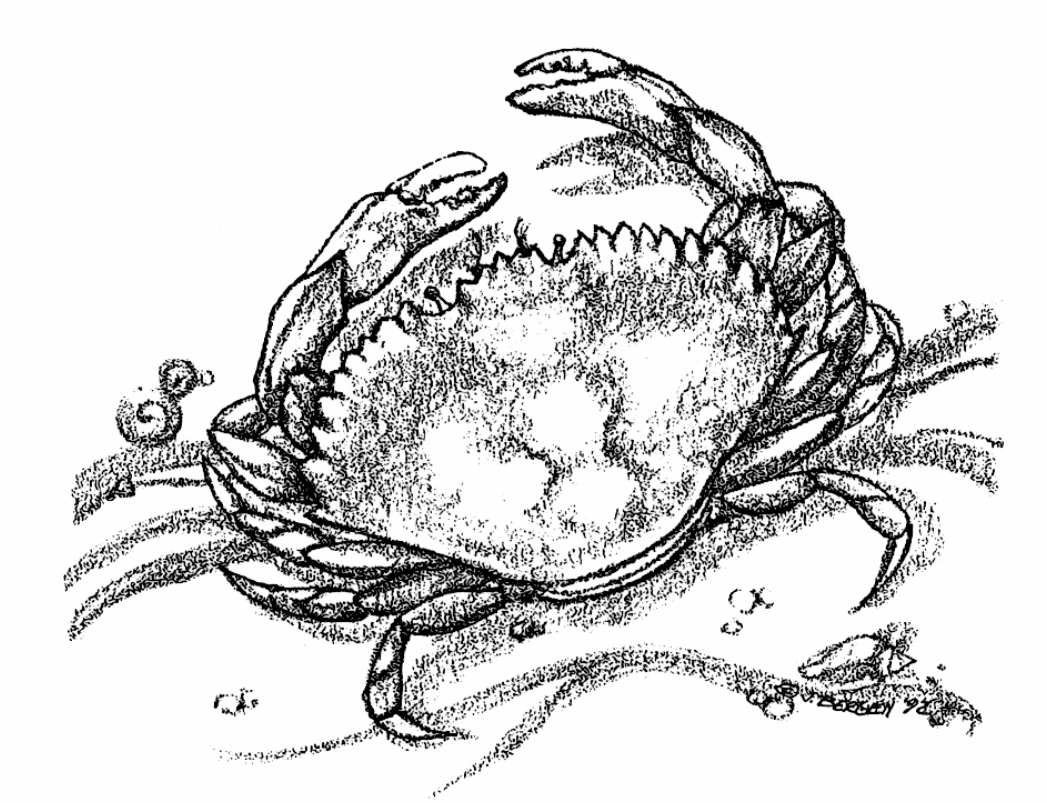
Autumn on the Estuary

by Kenn Oberrecht



Although autumn is generally the most dramatically changeable season on the Oregon coast, early autumn seems only a continuation of summer patterns and processes. Indeed, the streams feeding Oregon's estuaries run clear and low then. Air temperatures remain warm and are sometimes the highest of the year. Correspondingly, estuarine waters are relatively warm and salty.

Marsh plants also begin to die back and decompose, an important process that recharges the estuary's nutrient supply.

By the end of autumn, the estuary will have changed considerably. Tributaries will be running colder and might be high and roilly. The estuary's salinity will have decreased, and the saltwater boundary will have migrated seaward.

Autumn arrives at the point of autumnal equinox, when the sun crosses the plane of the earth's equator for the second time of the

year. That happens about September 22, when days and nights are of approximately equal length.

Warm weather usually continues through September and early October, and might proceed on to November. As the hours of daylight decline, however, the bay begins to cool.

Foliage changes color and dies. Alders lose their leaves. Those that fall into the rivers, creeks, swamps, and marshes darken the water as they decompose, reducing sunlight penetration. Marsh plants also begin to die back and decompose, an important process that recharges the estuary's nutrient supply.

Roughly coinciding with this process is a seasonal upwelling offshore. Flood tides rush into the estuary bearing nutrients from the ocean bottom, triggering an autumn plankton bloom on the bay.

Abundant berries in the thickets along the edges of the estuaries continue to ripen, providing food for many birds, mammals, and humans.

Minus-tide cycles swing to the graveyard shift, and most clam diggers just give up till spring.

Waterfowl and other migratory birds begin arriving. Tiny green-winged teal are the first to show up, usually in September, in their sporadic, darting-and-diving flocks. The first bad weather up north drives other puddle ducks down--the mallards, pintails, and gadwalls. After Thanksgiving, the diver ducks pour in with every storm front.

The rains of autumn change the estuary's salinity and signal the salmon schooling offshore. During times of drought, some coho and fall chinook seem to grow impatient and meander in, a few at a time, rain or not.

Minus-tide cycles swing to the graveyard shift, and most clam diggers just give up till spring. Crabbing, on the other hand can be best of all in the fall, with the catch hard-shelled, plump, and tasty. Torrential rains, however, freshen the estuary and drive the crabs downbay to water of higher salinity.

Autumn at the South Slough Estuarine Reserve is when educational programs get underway for the academic year. During the months that follow, the reserve hosts as many as 3,000 students from throughout the state who come to take advantage of the formal programs offered. Thousands more will visit the reserve on an informal basis, hike the trails, and learn on their own with

materials available at the interpretive center. Although summer hours no longer apply at the interpretive center, the hiking trails remain open all daylight hours all year.

Like spring, autumn offers tremendous variety on the estuary. It's a busy time, too, with opportunities abounding for those who will take the time to observe and participate.

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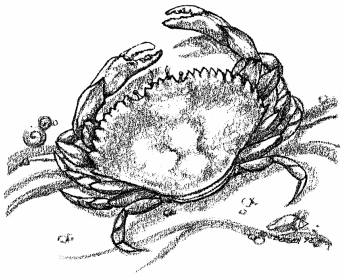
"Autumn on the Estuary" - Study questions

1. **What is the autumnal equinox?**
2. **What typical fall process recharges the estuary's nutrient supply and how does it do this?**
3. **Why aren't clam diggers happy in the fall?**
4. **Describe the relationship between autumn and salmon and the estuary.**
5. **What does it mean that the estuary's "saltwater boundary will have migrated seaward" and why does it do this?**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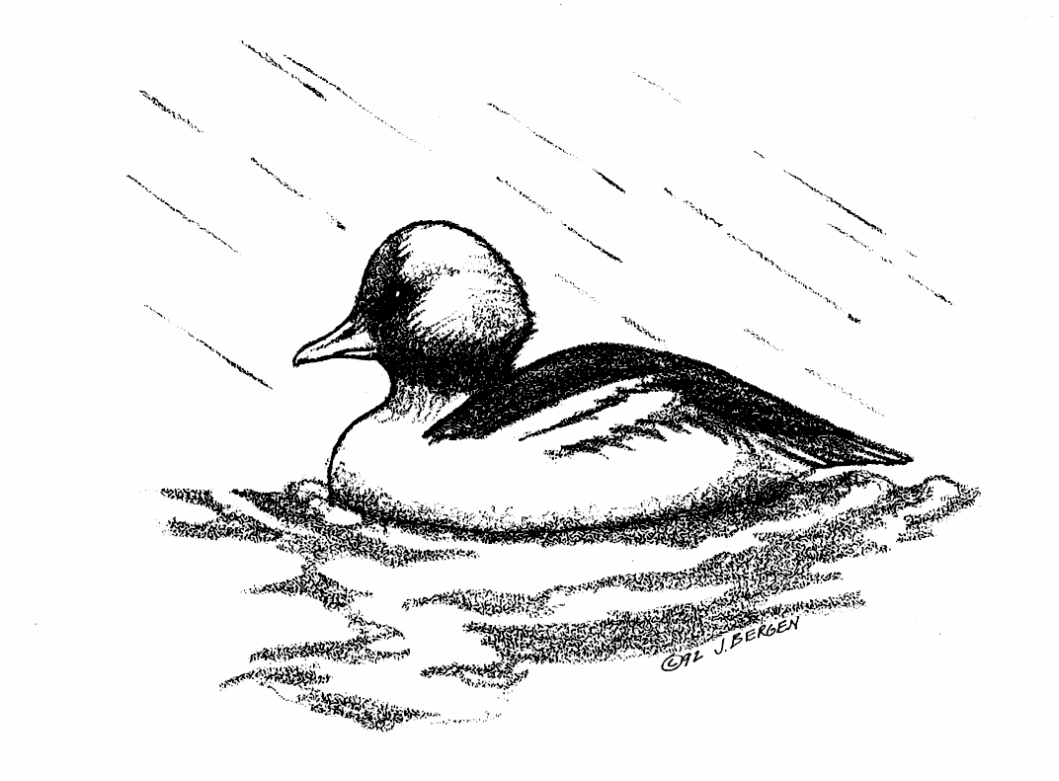
Winter on the Estuary

by Kenn Oberrecht



Winter has earned a bad reputation on the Oregon coast, but if it ever lived up to its full potential, few of us would find it bearable, year in, year out. Sometimes winter lashes the jagged coast and turns the bay a lifeless gray. Storm on storm, wave on ceaseless wave. Trees topple, taking power lines with them. Rivers spill their banks. Occasionally we even get a hard freeze, or the rare bit of snow. But not every winter, and not all winter long.

We get breaks, respites from the storms and norms--blue holes in the skies of our discontent, wisps of warmth carried on foreign breezes, shafts of slanted sunlight that seem to probe the bay for signs of life, reminders of Junes gone by. John Greenleaf Whittier called winter the mother of spring. Hold that thought, John.

Winter's high volume of freshwater inflow greatly decreases salinity in the estuary, driving the saltwater boundary seaward.

Winter solstice is the pistol shot that starts the season. This occurs when the sun reaches its southernmost point, 23.5 degrees south of the celestial equator, about December 22. It's the day of the year we

get the least amount of sunlight. We usually think of it as the year's shortest day or longest night.

Winter's high volume of freshwater inflow greatly decreases salinity in the estuary, driving the saltwater boundary seaward. Many estuarine and marine animals react in kind, moving farther downbay or even into the ocean.

Swollen tributaries also carry an increased silt load, creating turbidity in the bay and decreasing sunlight penetration, impeding photosynthesis. Plankton production plummets.

Coos Bay remains fairly well-mixed all year, but in winter, mixing of fresh and salt water are enhanced by the amount and turbulence of the fresh water entering the estuary. Consequently, oxygen-rich surface waters are churned toward bottom to benefit animals dwelling there.

Water quality can suffer from the excessive runoff of winter. Waterborne sediments carried in the currents of creeks and rivers often bear the pollutants of industry, agriculture, and human habitation.

Marsh vegetation dies back and is broken down to become part of the detritus supply of the bay and nourish the many detritus-feeding organisms.

Local flooding is common during the winter rainy season. When storms combine with high spring tides during persistent westerly or southwesterly onshore winds, lowland flooding is almost assured.

Water quality can suffer from the excessive runoff of winter. Waterborne sediments carried in the currents of creeks and rivers often bear the pollutants of industry, agriculture, and human habitation. One problem on Coos Bay, for example, is the increase of fecal coliform bacteria often associated with heavy rainfall and usually caused by animal wastes being washed into streams feeding the estuary. When levels are too high, the local shellfishery must be shut down.

With overwintering and migrating flocks joining resident populations, bird and waterfowl numbers peak during the winter on Coos Bay. Birders and photographers find the greatest variety and concentration on Pony Slough and North Slough.

The winter months offer some of the best crabbing of the year between storms. During periods of heavy rains and runoff, though, crabs migrate downbay.

A few hardy anglers, crabbers, wildlife watchers, and outdoor photographers get out on the estuary during the winter. For the most part, though, we hunker under the season and button up against it, waiting for her to give birth to spring.

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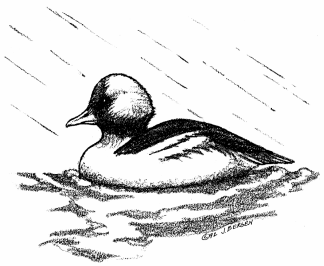
"Winter on the Estuary" - Study questions

1. **What is the winter solstice?**
2. **What changes happen to the estuary's waters in winter? Think about salinity and turbidity. What is turbidity?**
3. **How does the estuary mix more thoroughly in winter? What does this mean for bottom dwellers?**
4. **How does water quality suffer in winter?**
5. **How does an estuary "handle" the flooding common in winter?**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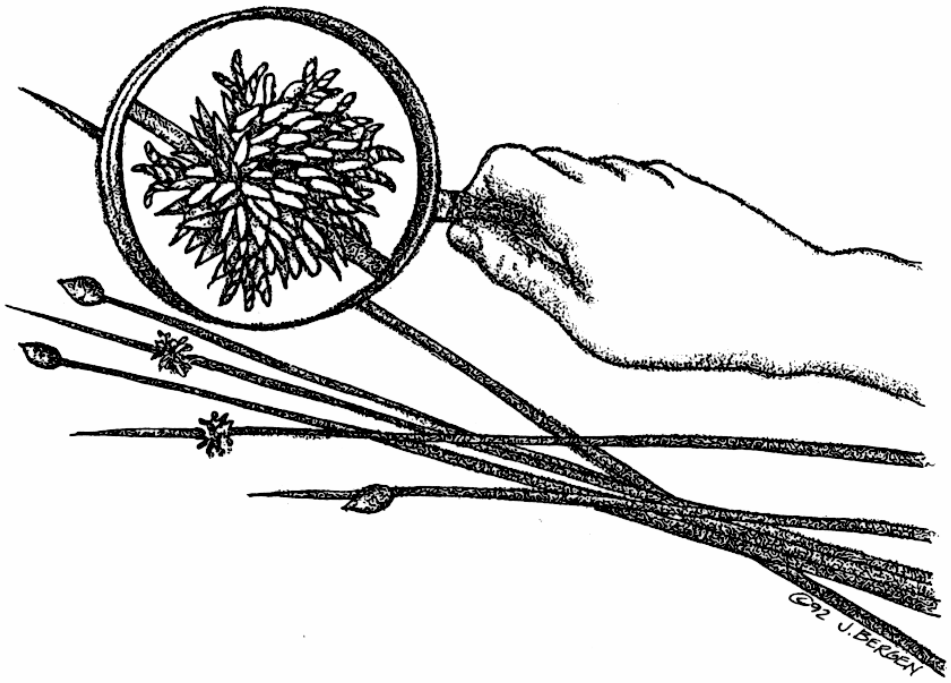
Nature Study for Beginners

by Kenn Oberrecht



Oregon's coastal region is endowed with a rich diversity of wildlife and habitat types. The landscape is characterized by a splendid variety of biological and geological features. Forests and farmlands, dunes and headlands, mountains and meadows, parks and gardens, rivers and creeks, marshes and estuaries, tide pools and beaches--all combine to form an ideal setting for the study of nature. What a wonderful opportunity for the budding naturalist.

Getting started in nature study in a place like this is easy. The first step is to determine where your interests lie, then how you want to approach them.

One possibility is a general approach that would include the study of a variety of organisms and their relationships with one another as well as with their environment. We call that discipline ecology.

Getting started in nature study in a place like this is easy. The first step is to determine where your interests lie, then how you want to approach them.

Perhaps you would prefer a more specific approach--say, the study of insects (entomology), birds (ornithology), fish (ichthyology), amphibians and reptiles (herpetology), or plants (botany). Some even further narrow their studies to become experts on a specific family, or even one species.

The next step is to head for one of our three libraries: Coos Bay Public, North Bend Public, or Southwester Oregon Community College. There you can browse electronically through the files in the COASTLINE computer, punching in such subjects as nature, birds, mammals, fish, waterfowl, trees, wildflowers, insects, reptiles, amphibians, fossils, geology, zoology, weather, astronomy, tidal marshes, and estuaries.

Periodicals on nature, conservation, and ecology abound and range from broadly general to highly specialized. Good ones for starters are National Wildlife, Audubon, and Natural History.

You'll find enough volumes to keep you reading in your subject area for years. If you're unsure of what approach to take, start with a general book about nature, such as Joy of Nature, edited by Alma E. Guinness, or A Practical Guide for the Amateur Naturalist, by Gerald Durrell.

Periodicals on nature, conservation, and ecology abound and range from broadly general to highly specialized. Good ones for starters are National Wildlife, Audubon, and Natural History.

You will eventually want to build your own reading and reference library. Visit local bookstores and browse the shelves for both new and used books. In addition to general books on nature and those on specific subjects, you'll want a good field guide. Alfred A. Knopf publishes the Audubon Society's series of field guides, available at most bookstores. They cover subjects from wildflowers to whales, are vinyl covered, and will fit in a parka pocket.

Nature study is a relatively inexpensive form of outdoor recreation, but you will need some gear when you go afield. A good pair of binoculars is indispensable. Carry a pocket knife, a small magnifier or hand lens, a notebook, and pen. All of this can go into a fanny pack or rucksack, along with rainwear and any food and beverages you care to take on day trips.

This should be a good start for anyone interested in nature. As you learn more and your interests gain momentum, consider taking some courses and enrolling in nature workshops. Join a national

conservation organization, and become active in a local chapter or club. Volunteer to work with local conservation-oriented groups.

Few pursuits allow us to combine education and recreation in such an enjoyable and important way. Nature study, at any level, is uniquely rewarding.

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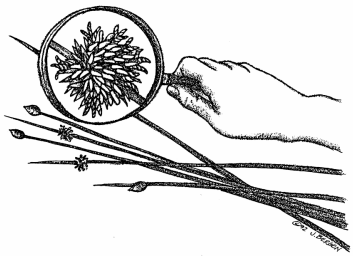
"Nature Study for Beginners" - Study questions

1. **What are some types of wildlife and habitat types found on the Oregon Coast? Which is your favorite?**
2. **What is ecology? Can you describe, briefly, the ecology of a favorite organism and its habitat.**
3. **What are some "tools" you may use to observe nature and to learn more about it?**
4. **Many naturalists keep notebooks or journals and draw, label, or take notes about their observations in these books. Look out the window or imagine your favorite animal, plant, environment or place. Make a "journal entry" about it.**
5. **What is the purpose of nature study?**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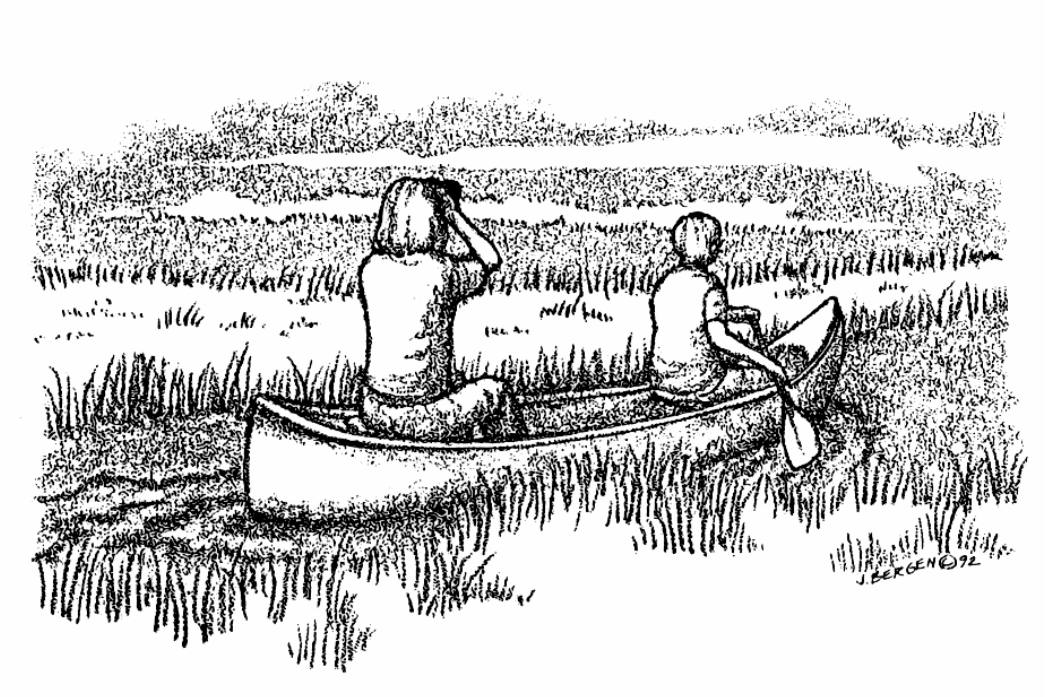
Non-Consumptive Uses of the Estuary

by Kenn Oberrecht



As they approach the sea, most coastal rivers form estuaries: partly enclosed bodies of mingling fresh and salt water where a tremendous array of organisms thrive. Throughout history, estuaries have attracted humans and invited settlement and development. Many have provided safe havens for ships and navigable waters for moving freight and passengers inland or out to sea.

As it has for several thousand years, the Coos Bay estuary continues to provide food for locals, mainly in the form of fish and shellfish, but it also offers a variety of opportunities for non-consumptive uses, some of which many of us take for granted or overlook.

A few hardy souls even keep in shape by skimming their rowing sculls across the bay.

The most obvious non-consumptive recreational use of the bay is boating, with power or sail. Sailboards have increased in numbers and popularity in recent years, and a growing number of people are enjoying canoeing and kayaking, especially in the more protected

waters of the sloughs and inlets. A few hardy souls even keep in shape by skimming their rowing sculls across the bay.

Family hiking along the edge of the estuary can be both recreational and educational, especially if you make a concerted effort to observe and study the plants and animals you'll encounter along the way. At the South Slough Reserve, you can join one of the organized nature hikes, or pick up trail guides at the interpretive center and go on your own. On the North Spit are beaches, trails, and old roads to hike. You can also hike the railroad right-of-way along the North Slough or the mile-long road that skirts the west side of Pony Slough.

Jogging and fitness walking are other ways for couples and families to regularly enjoy the estuary. Whether you work out in town, upriver, or downbay, you can be assured of plenty of wildlife and shipping activities to ward off boredom.

The estuary also provides artists and photographers with unlimited subject matter, any time of the year.

Similarly, bicycling is another superb way to enjoy the bay and reap the benefits of healthful exercise. With a bicycle you have the added advantage of being able to haul extra gear with you or pack along food and beverages on daytrips.

Most of us enjoy picnics, but we needn't confine them to the occasional summer weekend or holiday outing. Combine a sunrise breakfast with a birding trip to the bay during fall and spring migrations. Or break up a stressful work day with a sack lunch or deli takeout at the bay's edge. Some people even conduct business lunches this way.

The estuary also provides artists and photographers with unlimited subject matter, any time of the year. Opportunities range from sunny scenics with big skies and puffy clouds to closeups of wildflowers, or the muted moods and pastels of foggy-morning ship shapes and waterscapes.

Those of us fortunate enough to live here sometimes lose sight of the fact that the Coos Bay estuary is one of the major attractions of the south coast. Tourists and other visitors get to enjoy it only briefly, temporarily. It's there for us any time we choose to use it.

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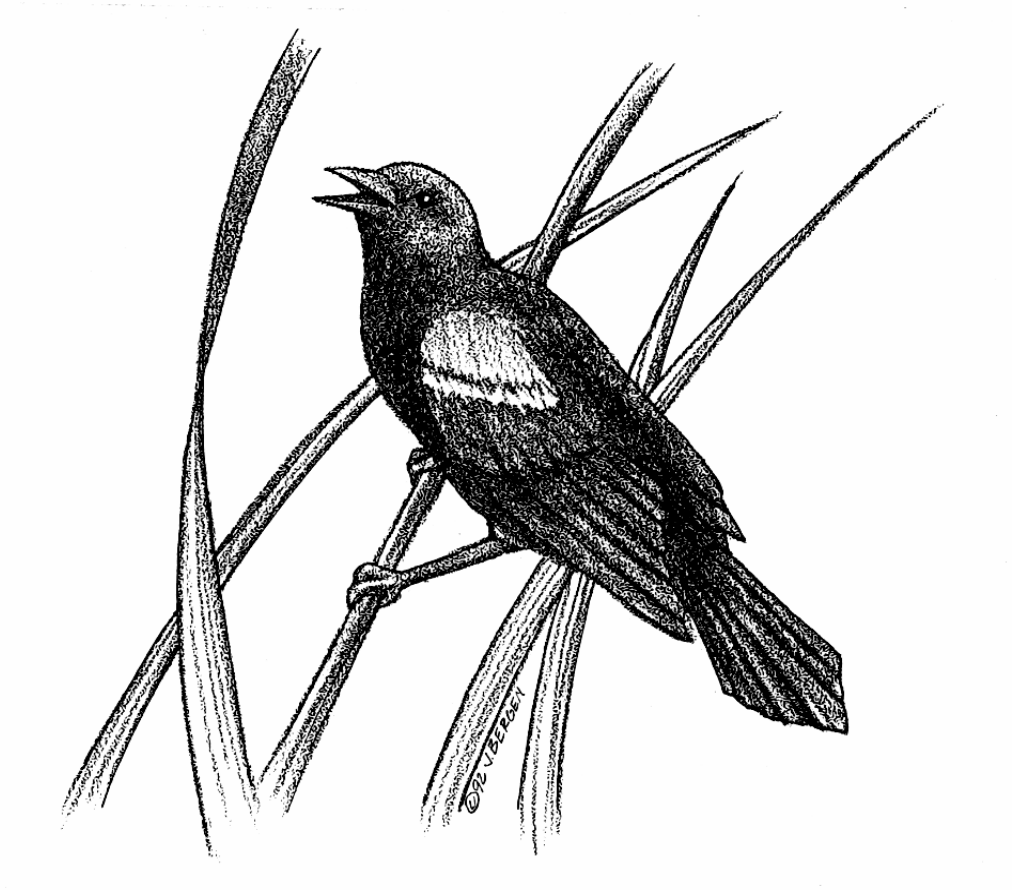
“Non-Consumptive Uses of the Estuary” - Study questions

1. **What does the term “non-consumptive” mean?**
2. **What are some non-consumptive uses of estuaries or wetlands that you enjoy?**
3. **What are some suggestions that the author gives for recreating on the estuary?**
4. **Do you think we gain as much from our estuary when we use it in a non-consumptive way than from a consumptive way?**
5. **If you were the manager of an estuarine reserve, what restrictions might you impose on activities performed along or in the estuary?**

Having a Wetland as a Neighbor

by Kenn Oberrecht



For too many years, Americans have labored under the misapprehension that they knew something about wetlands. What they thought they knew was that the word wetlands was synonymous with wastelands. They had no respect for wetlands and tried every feasible way to destroy them. They ditched, diked, dredged, drained, and filled any wetland that got in the way of what they saw as progress. Consequently, we have lost most of the nation's wetlands.

…between the 1780's and 1980's, 53 percent of the original 221 million acres of wetlands in the contiguous states were destroyed. That works out to an astounding 60 acres an hour for 200 years.

According to the U.S. Fish and Wildlife Service, National Wetlands Inventory Group, between the 1780's and 1980's, 53 percent of the original 221 million acres of wetlands in the contiguous states were destroyed. That works out to an astounding 60 acres an hour for 200 years.

In terms of percentages, California is the biggest loser, with its original five million acres of wetlands reduced to less than a half-million acres, representing a 91-percent loss. In terms of acreage, Florida is the worst of 50 states, having destroyed 9.3 million acres of wetlands.

Florida, Louisiana, Minnesota, and Texas are the states with the greatest acreage losses. Ten other states have destroyed at least 70 percent of their original wetlands. In fact, Alaska, New Hampshire, and Hawaii are the only states that have lost less than 20 percent of their original wetlands. Oregon and Washington have lost 38 and 31 percent, respectively.

Most urban areas have lost more than 90 percent of their wetlands, and what remains has been isolated and degraded. Most such areas probably don't perform many of their original functions.

The most sobering and unfathomable statistics of all are that despite federal, state, and local attempts to halt the plunder of one of the nation's most valuable assets, we continue to destroy 300,000 to 400,000 acres of wetlands every year.

Most urban areas have lost more than 90 percent of their wetlands, and what remains has been isolated and degraded. Most such areas probably don't perform many of their original functions.

Wetlands exist in a variety of types. They include swamps, bogs, sloughs, freshwater marshes, salt marshes, vernal pools, wet meadows, and forested wetlands. Many exist as parts of complex ecosystems and function as highly productive habitat.

Too many people continue to wonder about all the fuss over a bunch of smelly swamps and marshes. Well, the fact is, wetlands are the best neighbors we can have.

They offer protection against erosion by anchoring shoreline soils. They trap sediments, filter pollution from air and water, and retain nutrients with which they support food chains and webs.

They provide critical habitat for fish, shellfish, amphibians, reptiles, birds, and mammals. Many are drinking-water sources for all sorts of wildlife.

Some store ground water and even recharge groundwater supplies. In times of excess, they store damaging flood waters, as well.

Wetlands foster tourism and many forms of recreation. Because of the tremendous variety of plant and animal life they support, they

are natural laboratories for every level of inquiry and education, from grade-school studies to post-doctoral research.

So wetlands are good neighbors. Want to know how to be a good neighbor to wetlands? Just leave them alone.

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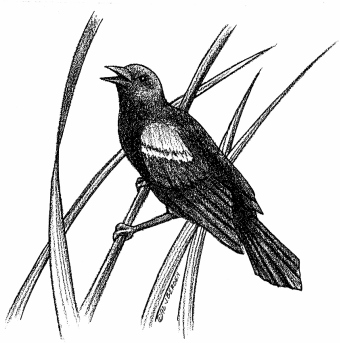
"Having a Wetland as a Neighbor" - Study questions

1. **How have we, as a nation, lost most of our wetlands?**
2. **When a wetland is either isolated or degraded, what types of functions might it lose?**
3. **What are wetlands? Do you visit them? If so, what do you do there?**
4. **What do wetlands do that helps us?**
5. **It has been shown that wetlands help us to filter pollution from the water. Does this mean that we should utilize wetlands as pollutant dumps? Why or why not?**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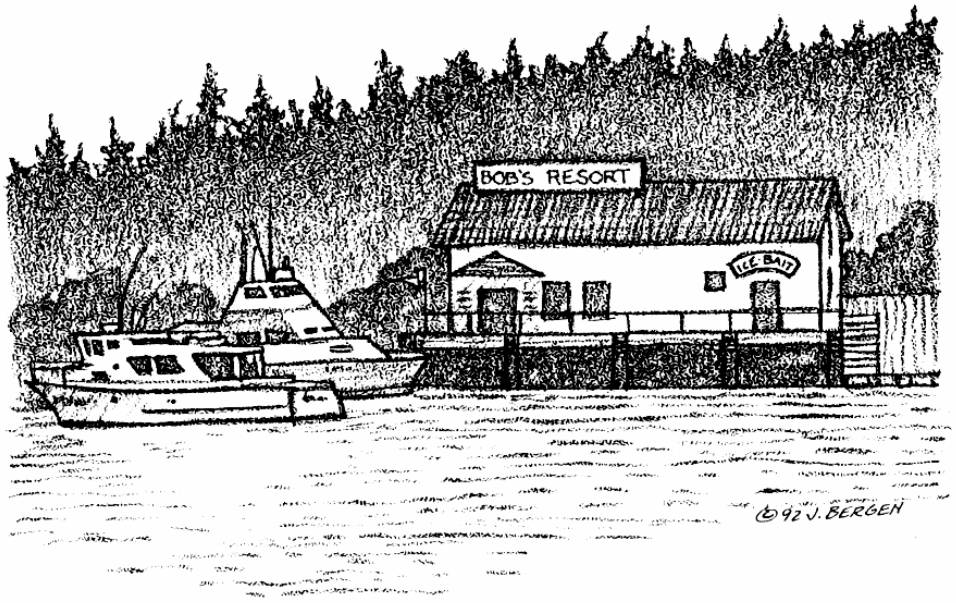
Wetland Restoration and Creation

by Kenn Oberrecht



Faced with the fact that less than half of America's original wetlands exist today, and armed with modern scientific knowledge and technological abilities, can we successfully restore some of the lost habitat and even create new wetlands? Well, maybe. We think so. We hope so.

A term that has gained currency among land-use planners is mitigation. The authors of Wetland Creation and Restoration: The Status of the Science (Island Press, 1990) define mitigation as "the actual restoration, creation, or enhancement of wetlands to compensate for permitted wetland losses."

When we level a forest and replace harvested trees with seedlings, we aren't restoring the forest, with all the functions, complexities, and dynamics of a forest.

Here's how it's supposed to work. Let's say a corporation has acquired a piece of bayfront property to develop into a motel-restaurant-marina complex. Assume the plans will pass all the usual tests and permits will be granted. Part of the land, however, is marsh that must be drained and filled. Elsewhere on the bay is another piece of property where no marsh exists, or perhaps where a marsh once existed but was drained and filled for agricultural use. In exchange for the marsh that construction will destroy, the

developers agree to buy the other property and pay for creating, or re-creating, a comparable marsh there. Although that sounds like a fair trade, it doesn't always work out so simply. In fact, attempts to restore or create wetlands aren't always successful.

When we level a forest and replace harvested trees with seedlings, we aren't restoring the forest, with all the functions, complexities, and dynamics of a forest. We're creating a tree farm--planting a crop.

Similarly, there's more to marsh creation or restoration than acquiring the land, seeing to hydrology problems, then planting grasses, sedges, and other wetland vegetation. To succeed, it must perform as a marsh. Specifically, it must function as well as or better than the marsh lost in the mitigation process. Without the functions, complexities, and dynamics of a marsh, it will be little more than an expensive garden.

We don't know how to plan for permanence, because we don't know what combinations of functions will ensure resilience.

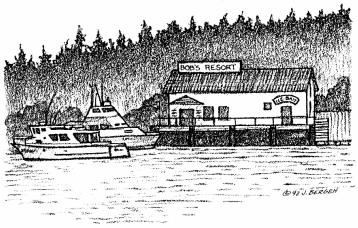
Dr. Joy B. Zedler of San Diego State University has listed nine reasons why wetland functions are so difficult to replace, even though we might have the best intentions:

- ⇒ Original wetlands were not manmade.
- ⇒ We don't have blueprints to follow.
- ⇒ We don't know everything nature used as building materials.
- ⇒ Species don't stay put, as buildings, roads, and other structures do.
- ⇒ We don't know how all the components of a wetland interact and depend on one another.
- ⇒ We find it difficult to plan for a system that's naturally dynamic.
- ⇒ We don't know how to plan for permanence, because we don't know what combinations of functions will ensure resilience.
- ⇒ We don't know enough about wetland configuration and distribution to be sure that there will always be sufficient habitat to serve as refuges from threatening or harmful conditions.
- ⇒ It's difficult to plan a wetland when we can't predict problems that might arise during construction.

Land-use planners, managers, and scientists are working on these and other problems, but it will take time to solve them all. Meanwhile, we need to preserve existing wetlands and continue to look for ways to restore degraded ones. Mitigation is a step in the right direction, but it's no panacea.

"Wetland Restoration and Creation" - Study questions

1. **What is wetland mitigation?**
2. **What is wetland restoration?**
3. **When a wetland is restored, what are some of the things which must be taken into consideration?**
4. **Nine reasons are listed for why wetlands are so difficult to replace. Discuss one of these reasons in detail, in your own words. Can you name any other reasons?**
5. **Do you think mitigation is fair? Is it a good idea? Why or why not?**



The Nation's Imperiled Estuaries

by Kenn Oberrecht

Eventually, the waters of all the nation's streams reach the ocean, most by way of partly enclosed bodies of brackish water near the river mouths known as estuaries. Many of our rivers and creeks rise far inland and drain thousands of square miles of agricultural lands, forests, mining operations, construction sites, densely populated cities and suburbs, and highly developed industrial areas.

Estuaries are our most vital, productive, and important environments; yet, they're also among our most threatened habitats.

Consequently, these waters enter the estuaries bearing the silt and sediments eroded from the land, as well as treated and untreated sewage, animal wastes, pesticides, chemical fertilizers, heavy metals, caustic acids, poisons of various kinds, and every manner of industrial discard. The estuaries themselves, particularly the large ones, are usually flanked by dense populations, industry, farmlands, or some combination of all these.

Estuaries are our most vital, productive, and important environments; yet, they're also among our most threatened habitats. Years of abuse have seriously degraded them: a fact few politicians and bureaucrats seemed aware of or concerned with until 1970. That year, the U.S. Department of Interior released a report entitled The National Estuary Study, which documented how rapidly and vastly our estuaries were being damaged or destroyed.

The purpose of the system is to safeguard our estuarine resources and provide educational and research facilities, that we might learn to better protect these critical habitats, perhaps restore some of the wetlands and tidelands we've abused and degraded, and even create new habitats in place of those we've destroyed.

Subsequently, Congress passed a slew of related legislation, including the Federal Pollution Control Act; the Marine Protection, Research, and Sanctuaries Act; and the Coastal Zone Management Act. One result of the last-named was the establishment of the National Estuarine Research Reserve System, under the auspices of the National Oceanic and Atmospheric Administration (NOAA). The purpose of the system is to safeguard our estuarine resources and provide educational and research facilities, that we might learn to better protect these critical habitats, perhaps restore some of the wetlands and tidelands we've abused and degraded, and even create new habitats in place of those we've destroyed.

The South Slough National Estuarine Research Reserve in Charleston, Oregon--created in 1974--was the first such sanctuary

in the nation. There are now 22 others along the Pacific, Atlantic, and Gulf coasts, as well as in the Great Lakes, Hawaii, and Puerto Rico, with four proposed sites under consideration.

The South Slough National Estuarine Research Reserve in Charleston, Oregon--created in 1974--was the first such sanctuary in the nation.

South Slough's sister facilities on the West Coast are at Padilla Bay on Puget Sound; Elkhorn Slough, between Monterey and Santa Cruz, California; and the Tijuana River, south of San Diego. San Francisco Bay is one of the proposed sites.

The Clean Water Act of 1987 established a National Estuary Program, administered by the Environmental Protection Agency (EPA), with the purpose of identifying nationally significant estuaries and improving their quality and vitality. To date, EPA has given "priority consideration" to 11 of the nation's major estuaries and has initiated programs on six of those.

More than 20 years after the Department of Interior released The National Estuary Study, our estuaries are scarcely improved. In fact, most are in the worst shape ever. A framework has been established, however, and legislative tools put at our disposal, that we might begin to reverse some of the processes that have deteriorated the quality of the nation's most valuable waterways.

Perhaps one day we'll be able to look with pride at all the estuaries we helped bring back from the brink of destruction.

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"The Nation's Imperiled Estuaries" - Study questions

1. Name three laws or acts of congress that helped to protect the waters of the nation's estuaries.
2. What is the purpose of the National Estuarine Research Reserve System?
3. Name three types of pollution that may enter waters which eventually flow to an estuary.
4. What act or law created the National Estuary Program?
5. What land uses or conditions might lead to negative impacts on the waters of the estuary? What are the related impacts? How could these impacts be reduced?
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Romancing the Estuary

by Kenn Oberrecht

One day during the summer of 1991, the mail brought an intriguing invitation from the South Slough National Estuarine Research Reserve in Charleston, Oregon: a request for proposals "from qualified contractors to research, write, and produce 52 newspaper feature articles." The project would entail writing about estuaries--those special places where river and ocean waters meet and mingle--and how these complex environments fit and function in nature's grand scheme. The successful bidder would have approximately six months to finish the job.

The opportunity seemed custom-made for me. I have had a lifelong interest in wildlife, particularly anything that lives in, on, or near water. I earn my living as a writer, and much of my work for the past 20 years has been about nature.

I have had a lifelong interest in wildlife, particularly anything that lives in, on, or near water. I earn my living as a writer, and much of my work for the past 20 years has been about nature.

Nevertheless, I realized the proportions of the task could prove overwhelming, especially in light of my already busy freelance schedule. It could be like hugging an elephant--not impossible, but something requiring careful planning and a big reach.

A few weeks after I submitted my proposal, Marty Giles, Education Coordinator at the South Slough, phoned to tell me I had been awarded the contract. Within days I was busy listing chores, setting up files, and planning my research.

I was interested not only in Oregon estuaries, but also others along the Pacific, Atlantic, and Gulf coasts. So I set to work writing letters to the fish-and-game agencies, Cooperative Extension Services, and Sea Grant College Programs in each of our coastal states. Next, I wrote to various federal agencies, such as the U.S. Army Corps of Engineers, Environmental Protection Agency, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration.

The National Wildlife Federation Conservation Directory provided most of the addresses and phone numbers I needed. From the same volume, I also gathered information about various local, regional,

and national organizations concerned with conservation and management of coastal and estuarine resources.

I'm a writer, not a scientist, but over the years, I have interviewed and corresponded with hundreds of scientists around the world, on topics ranging from astronomy to zoology. They have been willing subjects, often eager to share their knowledge, so I might pass it on to my readers. The estuary project was no exception. Soon, teetering stacks of estuary-related literature covered nearly every square inch of horizontal surface in my office.

It was, from the beginning, a labor of love and a commitment to our estuaries: an on-going project that may well occupy a sizeable portion of the rest of my life.

I spent hours at the North Bend and Coos Bay libraries, punching keys at computer terminals and later poring over the dozens of volumes my search turned up. I also increased the size of my own library by about 50 books and book-length reports. More than 100 new files now crowd two drawers of my file cabinets, and I'm about to assign another drawer to the task of housing the ever-growing body of literature.

This has been much more than a job of research and writing that might have ended with the submission of my 52nd article. It was, from the beginning, a labor of love and a commitment to our estuaries: an on-going project that may well occupy a sizeable portion of the rest of my life.

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"Romancing the Estuary" - Study questions

1. How does the author make his living? Was this work something he had done before?
2. What sources did he use for his research?
3. Name five sources of information that you would use for research on a topic that is so interesting to you that you might dedicate a portion of the rest of your life to its study.
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