seascapes

glimpses of our water world

By Jan Hardin

• Marine Advisory Service • University of Delaware • A Sea Grant College •

seascapes

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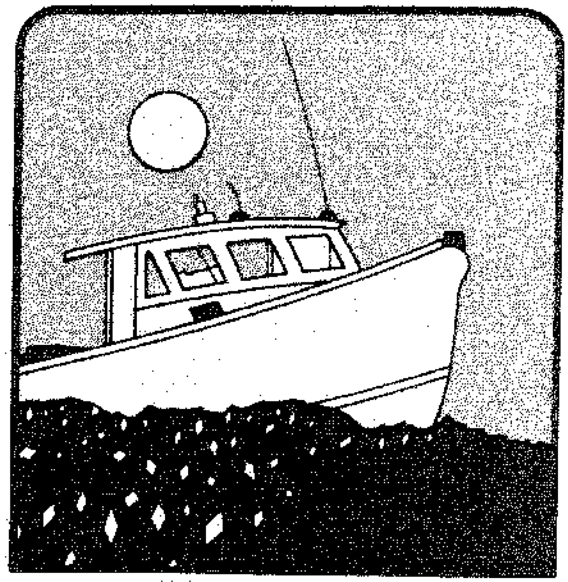


Bioluminescence

Have you ever taken a moonlit stroll along the ocean's edge and noticed patches of tinted light shimmering on the surface of the water? As you rub your eyes and probably dismiss the phenomenon as a prank-playing imagination, you continue to see it, a drifting glow. Strangely beautiful, yet eerie. At one moment brilliant, at the next--vanished!

What you have witnessed is the sea's equivalent of the firefly. And as extraordinary as it may seem, bioluminescence, as this light-giving activity is called, is really quite common among sea creatures--particularly those of the deep. The light, produced in a wide array of colors, is the result of a reaction between the chemical luciferin and oxygen. So efficient is this process that 99% of the energy produced is in the form of light, and less than 1% as heat.

The colors associated with bioluminescent light result from the unique chemistry of luciferin in each marine species as well as the layers of tissue filtering the light as it passes out of the animal. Most marine animals' lights appear blue or blue-green, with yellow and red casts being less common and generally restricted to deep-water fish and squid. Light intensities range from very weak (in most one-celled surface floaters) to vivid or highly concentrated.

Illumination occurs by several methods. In certain marine worms, glands release luminous secretions which may cover the animal's body or rise to the surface. Other animals, such as a number of fish and some squid, carry a crew of luminous bacteria which give off continuous light. To use this light to advantage, the host species have evolved specialized organs or pockets equipped with controls for turning the lights on or off and concentrating or focusing a beam.

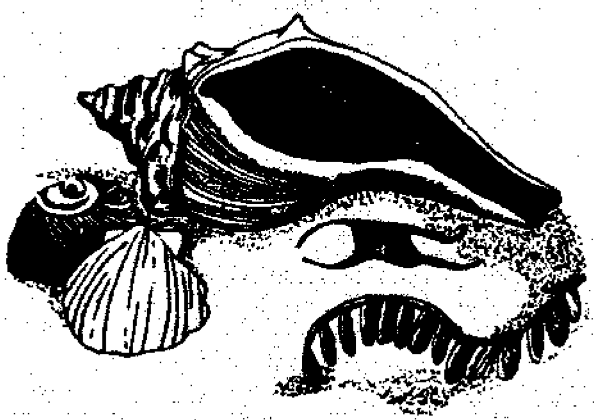
Probably the most common form of bioluminescence is light produced by the animal and retained in its body. In simple one-celled floating or "planktonic" organisms, light is emitted from stationary spots within the cell. Mechanical stimulation, such as a wave splashing against a pier, is all that is needed to evoke a glow in most planktonic creatures. Higher animals, such as fish and squid, have more control over their luminescent properties.

The nighttime flashes on the sea surface are usually produced by groups of dinoflagellates (certain single-celled plankton); jellyfish; and ctenophores (ten-o-fours), or comb jellies, which look like bulb-shaped jellyfish with two tentacles or none and no stinging cells. In Delaware, the "sea walnut," a comb jelly with bright blue-green light aranged in vertical streaks, is common during the summer and produces an intense display. Several luminescent jellyfish may be seen in this area as well as the highly luminous parchment worm which makes its home in a u-shaped tube in sandy mud.

Since no one knows for sure why sea animals possess luminescence, there are many theories. It is obvious that there must be advantages for those animals whose light organs or "photophores" are so complex that they contain reflectors, transparent windows, rotation abilities, muscle-powered diaphragms for light control and colored filters--many of the elements of a good camera, plus options. The exotic lantern fish have large light-producing pouches under their eyes which are effective floodlights during hunting/gathering expeditions. Deep-sea angler fish have light organs dangling like baited hooks before their mouths to attract dinner. Less subtle are those which have sparkling lights inside their gaping jaws! Luminescence in the deep also takes the place of color during mating displays. Most bottom-dwelling creatures are drably suited--an attire which helps them coexist with predators. But mating requires individual recognition.

Spontaneous lighting may also help some animals avoid predators. Some scale worms release luminescent scales when disturbed or frightened. The would-be predator is left behind with the still-glowing scale as the worm swims away. And it is believed that some fish may be momentarily blinded by a sudden flash of light as they bump into a luminous creature or school. Or, the sudden luminescence of one individual may alert others of its species to flee. Squid and some deep-water shrimps release luminous clouds over their attackers to produce confusion and aid their own get-away.

Still, there are many mysteries about bioluminescence which only continued research may reveal. For instance, what is the purpose of light in surface floaters, especially when it is so easily induced? One researcher suggests that their luminescence, when under attack, may summon predators of <u>their</u> predators. Also puzzling is the fact that some luminescent animals are blind! Perhaps the best reason for the continued interest in bioluminescence, however, is its potential as a highly efficient source of energy. Will this prove to be still another invaluable gift from the sea?



Beachcomber's checklist

To anyone familiar with the myriad of life visible in the rocky tide pools of our northern shores, the wide, sandy beaches of the mid-Atlantic states must appear extremely barren. They really aren't, though. It just takes a better sleuth to discover the secrets of the sand. Is all that tidal debris one kicks about while strolling along the beach really just decomposed plant and animal matter, or does it tell stories of the life processes occurring at the depths of the ocean, miles from where we stand?

The ideal time to beachcomb is after a storm when wind-whipped waves are able to throw heavier loads of material on shore. With a little persistence, and low numbers of fellow scavengers, you should be able to discover many of the following items:

1) A shell with a single hole bored in it. Some of the marine snails, such as the oyster drill and larger globe-shaped shark eye are fierce predators which, using a combination of chemical and mechanical abrasion, scrape their way into seemingly well-protected shelled animals such as oysters and other snails to digest the soft animal inside.

2) Oyster shells riddled with tiny holes. The bright yellow boring sponge attaches itself to empty shells by chemically boring into them. The more delicate shells are soon decomposed

by this action which is quite common on the ocean floor.

3) Driftwood filled with holes. The honeycomb of tunnels one sometimes finds in driftwood is made by shipworms which are actually two-shelled mollusks like clams or oysters with long (6-to-12") worm-like bodies and greatly reduced shells of little use to the animal. While young, shipworms bore into the wood to remain there for the rest of their lives. Though the tunnel is enlarged as needed, the small entrance is never widened. The limy substance which lines the burrow distinguishes the work of a shipworm from other wood borers. Also, shipworm tunnels, no matter how curvey, never meet one another. They seem to sense each other's presence.

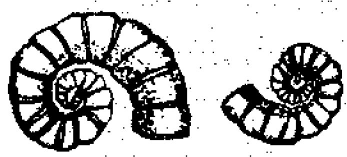
4) "Coral." Feather duster worms produce settlements of calcareous homes which together resemble a ghostly pipe organ. The long twisted tubes are built on halves of shells and house a beautiful animal whose sensory organs around the head are modified into a number of colorful feathery plumes, giving it its name.

5) Honeycomb rock. The sabellarian worm produces dense clusters of tangled tubes made from fine sand mixed with a cementing mucous. The inch-long creatures are capable of building fairly large reef-like colonies, although along these shores, one is likely to find them in chunks of rock resembling porous sandstone.

6) Sand collars. The shark eye snails lay eggs in fragile collar-shaped structures of sand mixed with mucous which is molded around the animal's spherical shell. If found on the beach, the collar will crumble easily in one's hand.

7) Whelk egg cases. Most shore visitors who have seen these odd structures which resemble a series of disks on a rope, probably believe them to be bits of stranded vegetation. But they are produced by the animals in those large spiral-shaped shells with long tails which shell collectors love. In Delaware, there are two varieties of whelk egg cases you might find. One has disks with sharp edges (from the channeled whelk) and the knobbed whelk produces cases with broad edges. If the disks have not yet ruptured, one can feel the beginnings of minute whelk shapes. The mature cases will have a tiny round hole in each disk from which young whelks have emerged.

8) Skate egg cases. Rectangular black packets, sometimes called mermaid's purses, may be found by the fortunate beachcomber. The narrow horns extending from each corner once served to attach the skate nursery to seaweed on the ocean floor.



9) Ramshorn shells. On occasions, one might pick up a small white shell of several loose coils which don't touch one another (looking just like a ram's horn). Contrary to what you might think, it never belonged to a marine snail, but is actually the remains of a deep-sea squid whose remnant shell is really much too small to be of use in protecting the animal. This shell is a wonderful reminder of the relationship which exists between lower mollusks, such as clams and snails, which live within their shells, and the higher mollusks, like squid and octopuses which generally carry their shells within their bodies.

10) Crab fragments. You can spot up to six different types of crab shells in roaming Delaware's shores. Mole crabs are burrowers, usually found near the water's edge. Their sand-colored cylindrical shells are unlike other crab shells in shape and may often be found whole in the debris line. Blue crabs are most easily recognized by the bright blue legs and single sharp spine which projects off each side of the greenish shell. The lady crab is light lavender with purplish spots scattered evenly over the shell in which the front margin ends in five clear-cut teeth to either side of the center. Similar to lady crabs are green crabs which are greenish with eight sharp-tipped legs. In contrast, the last pair of legs in blue and lady crabs are flattened to aid in swimming. Rock crabs have finely speckled shells with front margins broken into nine broad teeth to either side of the eyes. Lastly, those nearly round bumpy bodies of a dull brown color and pointed "snout" belong to the spider crab whose extra long, spidery legs are easily recognized. Horseshoe crabs are not true crabs and will be treated separately at another time.

There are many more less common finds in the flotsam and jetsam of beaches. If you are interested in identifying them, or want to know more about the animals which once lived in those shells, more can be learned by consulting a book on the seashore or a field guide on seashore life.

gulls

Contrary to many shore visitors' beliefs, there is no such thing as a "sea gull" or "common gull." There are, however, at least four types of gulls often seen in Delaware which are fairly easy to identify and fascinating, if not sometimes comical, to observe.

Just after to just before tourist season, one can expect to see good numbers of great black-backed, herring and ring-billed gulls. These generally head north toward Maine and the cool coast of Canada for the breeding season. During the summer, Delaware is the residence of immature and non-breeding gulls of these species and is a breeding area for laughing gulls which nest all along the Atlantic coast in scattered colonies.

How do you know which gulls are which? Some liken the great black-backed gull to an eagle in that it is much larger than other gulls in this area and the conspicuous white head and tail area are disrupted by an expansive black "saddle" which stretches across its back. Because of its size and comparative strength, most other gulls keep a respectful distance from this "king" of gulls. The famous Jonathan Livingston Seagull was a member of this species.

Probably the most widely distributed gull on our shores and far inland is the herring gull with its pearly grey back, white underparts and black wing tips. Ring-billed gulls are very similar in coloration, but much smaller than herring gulls. At close range, a blackish ring near the tip of the bill can usually be seen on this bird. The best way to distinguish the two once and for all, since you will not always be close enough to look for these fine details, is to see them together to note size differences. Lastly, there is no mistaking the black head, white body, and dark "mantle" (a saddle stretching over the back and wings) with white wing tips of the laughing gull. If you are more likely to respond to sound rather than sights on the beach, these birds emit a hearty chuckle which makes one think they have just shared a terrific private joke.

Now, what about the various brownish and dusky-colored individuals that blend into gull groupings? Most gulls take about three years to reach maturity and the characteristic coloration of adults of their species. Which sooty birds will someday develop a laughing gull's black cap or a great black-back's regal appearance is a matter which can cause even experts to throw up their hands in defeat. For the really ambitious beach-goer, field guides on birds do attempt to point out distinctions between the immature gulls of various species, though their methods are not always foolproof.

Because the herring gull is so common, much is known about its habits. For instance, herring gulls nest in fairly crowded colonies, in contrast to great black-backs which have only a handful of neighbors during breeding season. While all herring gulls look pretty much alike to us (there is not even any difference between the coloration of males and females), they are able to recognize the calls and appearances of their lifelong mates. Herring gulls are also capable of remembering where they were born, for subsequent nesting takes place in the same region. The birds may then return not only to the same colony, but to the very piece of ground in the following years.

Female herring gulls are quite liberated. In addition to having mates which spend equal time on the nest, it is the female who takes the initiative in mate selection. Once she begins to show off before the male of her choice, he may respond by threatening other males in the vicinity. As the bond between them grows stronger, the two may pretend to build a nest together, or the male will regurgitate half-digested food for the female's dining pleasure. After a commitment is made, the couple selects a nesting territory which will henceforth be fiercely defended against intruders. Herring gulls do appear to recognize and be more tolerant of those nearest neighbors who may not be able to avoid overstepping their boundaries. Still, some neighbors seem better-liked than others. When the young hatch, the parents apparently learn to identify them, too, and are likely to attack other birds' chicks which mistakenly wander onto their property.

A newly-hatched gull has two lessons which must be learned immediately: to stay near its parents, and to associate food with that red dot on their beaks. Perhaps after instinctively pecking at the ground and other useless places, a chick will randomly tap the right spot, to be rewarded with a regurgitated dinner, similar to that given to the mother during courtship. The smallest chicks eat directly from their parents' bills, while older youngsters will receive their meal in a pile at their feet.

Though we are unlikely to see such activities taking place in Delaware, there are other behaviors one can notice among gulls. Gulls seem to be voracious feeders, being as tempted to eat garbage or consume eggs and fledglings (even though their rather broad beaks are not adapted for predation) as they are to catch scraps of fish tossed out of boats. If you have ever noticed a gull dropping a large clam or crab from the air, you can understand how piles of empty shells accumulate on some beaches. Many gulls appear to react to hard food objects by dropping them from heights to crack the shell for easy entry. However, they seem unable to figure out that dropping clams on a hard surface, such as pavement or rocks, will work much better than wet sand or mud. Observers report watching such futile attempts as a gull dropping a shell into shallow water 39 times.

The next time you are at the beach, put down your magazine and shut off the radio for a few minutes to watch the gulls. You won't be disappointed if you let yourself get to know these very resourceful birds.

Beach erosion

It's a torrid summer day and the thought of toting a beach umbrella, ice chest, blankets, towels, collapsible chairs and kids across seemingly miles of burning sand, is as enticing as a two-week all-expenses-paid visit to Alcatraz. Wouldn't it be better to park at the edge of the sand and tiptoe just inches to the water's edge? If it's any consolation to you (and it really shouldn't be), that day may be coming for many of Delaware's beaches.

To be totally accurate, our beaches are not eroding as much as they are retreating from a rising ocean. While the average rise in sea level has been aobut 5 inches per century over the last 2,000 years, during 8 years in the 1960's alone, the water level climbed 3 inches. At that rate, our beaches could be diminished by up to 9 feet in a year's time. Even so, though seaward loss of beaches may be great, left to its own devices, nature would well be able to compensate for these changes.

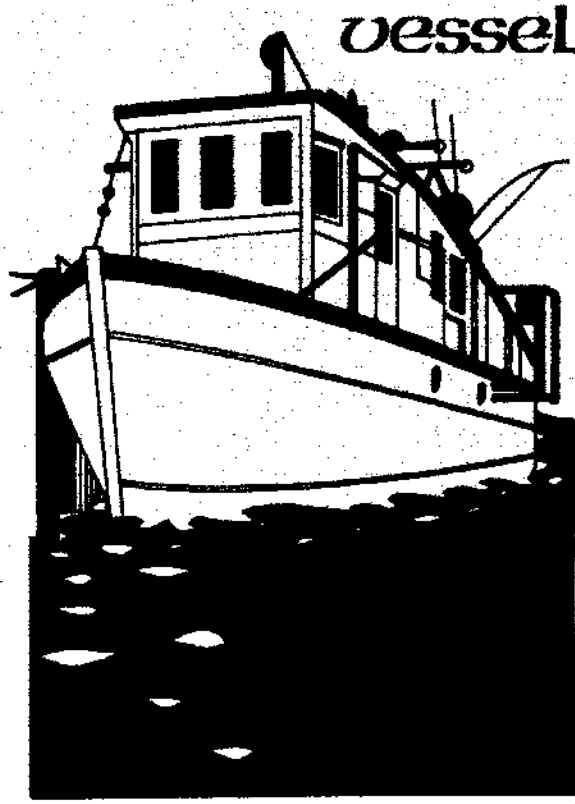
Let's take a closer look at how wind, waves and sand dunes interact to shape the coastline. If one observes an approaching set of waves, he will notice that they usually arrive at an angle, rather than breaking absolutely parallel to the beach. In doing so, waves produce what is known as a "longshore current" which <u>is</u> nearly parallel to the beach. It is the longshore current which is primarily responsible for moving sand from one beach to another--making some beaches very narrow in the process and others luxuriously wide. Up and down the East Coast, there are certain regions where longshore currents typically run in one direction. Because of the location of Delaware with respect to adjacent coastal land masses, in addition to the angle at which vicious northeaster storm winds confront it, most net drift of sand in Delaware is northward. Thus sand is carried from areas that are unprotected by jetties on their north side, such as Fenwick Island and the beaches north of Indian River Inlet, toward Indian River's southern jetty and the northern tip of the spit known as Cape Henlopen.

The purpose of a barrier beach, in the first place, is to protect the delicate life processes going on in salt marshes, or estuaries, from the ravages of the sea. Some barrier beaches contain sand flats, others have dunes. Those in Delaware have both.

Dunes will grow on those beaches located across the prevailing winds of fair weather or high pressure systems. On nice days, the sand is light and may easily be whipped into hilly formations. Delaware dunes attain an average height of 15 feet. Sand retains moisture well and the growth of specialized dune grasses, with their spreading root systems which help hold sand down, is a first step toward dune stabilization. Though dune grasses may appear tough with a high tolerance to salt spray and an ability to survive almost complete burial by sand, they are, in some ways, quite fragile. Once trampled by dune explorers--horses, motorbikes, jeeps and feet--the plants will die. A very stable dune system will contain shrubs and even woodlands, whereas a dune without vegetation is highly susceptible to the devastation wrought by any storm.

Short-lived storms are times of greatest beach erosion. When sand is saturated with water as a result of the rapid wave action of storms, it is more easily moved and removed by ocean currents. Even so, beaches can usually repair themselves within months of a major storm. In winter, the beach may be covered with steep sand cliffs or "scarps." By summertime, the beach profile is usually one of gentle slopes. Problems arise, however, when several severe weather attacks occur in rapid succession and the beach does not recover between battles. Damage can be particularly critical when a storm occurs over several tidal cycles, and water levels and waves are greatly heightened. It is then that the health and size of dunes become crucial in protecting both salt marshes and the man-made structures within otherwise easy reach of raging seas. Where weak areas in the dunes exist because of los of vegetation, human traffic or even building on the dunes, the ocean may breach the line and wash sediment into regions beyond--ultimately attempting t push the beach shoreward. Beach erosio in Delaware is not a problem that we ca afford to ignore.

aboard a research vessel



Anyone who has ever had the luxury of reclining on a beach for several days of rest and relaxation has probably spent part of that time gazing beyond the breakers, wondering about the many mysteries of the great body of water extending into the horizon. For those fortunate enough to be associated with groups harboring the same curiosities, expeditions aboard a research vessel may be chartered from the University of Delaware's Marine Studies Complex in Lewes.

The name of the boat currently in use is the Wolverine. About 47 feet long with a capacity for 15 passengers plus a small crew, the Wolverine contains her 2-4 hour cruises mainly to the outskirts of the Bay--leaving the rougher ocean jaunts to larger ships. One of this year's first outings occurred on a crystal clear, unexpectedly mild day at the end of March. The visitors were a group of sneaker-clad college biology students from Baltimore, all decked out in their best old clothes, expecting (and receiving) a dousing of mud and salt water during their trip.

As the group assembles shortly before sailing time, they receive a brief list of rules and regulations, plus a careful explanation on how the "head" or ship's toilet facilities are to be treated. Now knowledgeable seafarers, all embark, and the Wolverine sets off at a respectable clip.

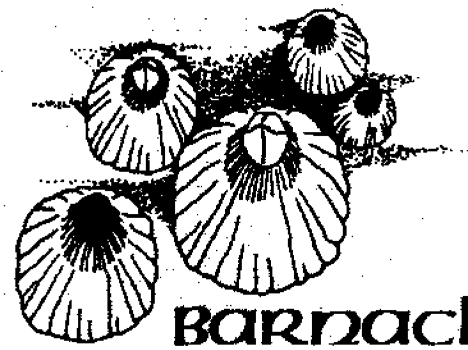
Once underway, the crew wastes no time in setting out the plankton tows. These consist of two funnel-shaped, fine-mesh nets, each with a plastic cup closing off the small ends of the tube. Allowed to trail along the water's surface behind the ship, the mesh sieves minute floating animals and plants (plankton) into the terminal cups. After some time elapses, they are hauled on board and the contents of the plastic cups are examined. Since it is still early in the year, there are not as many floaters as would be expected in a later spring or summer collection. Today, the jars contain an assortment of copepods which are tiny barrel-shaped crustaceans --related to shrimp, though much smaller. The naked eye can observe them swimming around the glass jar they have been placed in, but examination under the microscope is necessary to provide details on their true appearances. Copepods are generally abundant in any plankton sample and are an important source of food for many marine organisms.

The next survey involves use of a clam dredge, an awesome rusty claw with a net at its fingertips. It is dragged along the bottom and scoops up vast quantities of sediment along with an assortment of shelled animals and some fish. As it is hoisted back on ship and the contents are released, it appears that our catch is a net-full of mud. However, a little digging into the pile now sitting on the floor of the boat reveals a large number of horseshoe crabs (which are not true crabs, but closely related to spiders); knobbed whelk shells (which, when found in the ocean, are covered with fine hairs and contain snail-like animals); rock crabs; tiny hermit crabs in periwinkle snail shells; slipper shells attached to horseshoe crabs; and two fish finds--an aquarium-sized ling cod fish and a larger, pancake-thin flounder (summer and winter flounder are distinguished according to the side of the body both eyes are found on). The horseshoe crabs are kept for a graduate student who is studying their behavior; everything else is returned to the bay.

Water samples are then taken using a relatively simple looking container called a Nansen bottle. About thermos-size, two are dropped from lines into the water, one above the other. When brought up, they provide information on water at specific depths. It is easy to tell that the students are interested but not overly impressed until they learn the cost of a Nansen bottle: $600.

Lastly, the otter trawl is put into use. This is a large net submerged into the water and kept open by the use of two heavy wooden doors suspended on either side. Used in eleventh century England, this dredge can, in peak seasons, contain up to a ton of fish. Today the contents of the dredge are similar to those obtained in the clam dredge. Later in the season, however, anything goes. Even sharks have been brought in.

At the end of two hours, a greatly enriched and only slightly soggy group of marine researchers is brought back to shore with windburned cheeks and a much better idea of how oceanographers explore the mysteries of the deep.



Barnacles

The barnacle may be one of the most misunderstood creatures of the seashore. It is virtually ignored by shell collectors, seafood gourmets and aquarium keepers; scorned by barefoot jetty explorers; and known, when found in profusion on family boats, as something that fouls and ultimately reduces fuel efficiency and speed. However, the day may be coming when we will have to offer apologies to the noble crustacean which could play a large part in the medical and dental health fields, aerospace technology and building construction.

While not at all inconspicuous, the barnacle is easy to overlook. People who have seen the tiny, sharp-sided fortresses attached to rocks, ship bottoms, wharves and seashells might dismiss the animals' homes as dried algae or salt deposits--at least, nothing very exciting. But at its best in the shallow tide pools of New England beaches, close observation will prove the barnacle to be a fascinating creature. Though related to the lobster, shrimps and crabs, the adult barnacle is sessile or sedentary and lies upside down in its home glued to the base of the shell by its head. Since all barnacles are hermaphroditic (that is, possessing both male and female parts), it would seem that they might never have to emerge from their shells. However, to insure individual variability, barnacles are not able to fertilize themselves and must project sperm tubes over and into the shells of their neighbors. This method of reproduction must work well, for a colony of barnacles has been known to fill a mile of shoreline with as many as 1,600,000,000 relatives in a year.

When covered with water, the barnacle appears to come alive and indulges in a process known as filter-feeding. Pushing open the calcareous plates composing the roof of the shell, feathery feet emerge to wave like a continually beckoning hand. What does it eat? Almost anything that is broken into small enough particles to be grasped by the pulsating fan.

While we, as yet, do not wholly appreciate the animal as a must for our table, huntry fish, crabs, worms, sea slugs (shell-less snails) and whelks more than make up for our apathy. As far as human food value is concerned, even Euell Gibbons, the famous natural food scavenger, had few suggestions for its use. He suggested only that the larger stalked goose barnacle, as opposed to the acorn barnacle of our rocks, could be used in newburgh dishes as a "poor man's lobster."

In spite of anything that can be said to promote interest in barnacles, the animals will undoubtedly be known primarily for those qualities which we view as very useful or highly annoying. The two which particularly affect our economy are fouling and barnacle glue.

Barnacle fouling has been a major problem as long as ships have been at sea. When heavily fouled, a ship can suffer a 40% increase in fuel requirements. The cost of large-scale fouling is estimated at about $500 million per year in the U.S. alone. As a result, the acorn barnacle, as the major pest today, has been assaulted with radioactive paints (on which barnacles flourish), ultrasonic vibrations (too costly) and non-stick surfaces (barnacles still stick). Most successful to date are paints containing toxic compounds, such as copper and mercury, that are released at a controlled rate. Unfortunately, the toxic material is most abundant when the ship is underway and least susceptible to fouling. Poisons are released very slowly when the ship is anchored and barnacles are easily attached. Still, this method may keep a ship free of barnacles for up to 24 months. One of the most recent controls under investigation is biological. Someday, the artificial application of barnacle hormones may be used to inhibit molting and other growth activities as a limit to barnacle populations.

Barnacle glue is a substance released by specialized glands in the animal which appear when the free-swimming larvae are ready to become permanently attached. As the larva moves over the site of its future home, tiny amounts of glue trickle down its antennae and make contact with the rock. Within minutes, the glue is dry and the animal is stuck fast.

There are many unusual properties found in barnacle glue. It is cured by salt water rather than dissolved--a fact which makes its surgical use inside the salty human body particularly attractive; it endures heat, cold and almost all chemical solutions known; and it is extremely strong--being able to resist the relentless pounding of waves on bare rocks. In fact, a layer of barnacle cement a few ten-thousandths of an inch thick can withstand stress of more than 7,000 pounds per square inch--twice the strength of our best epoxies which bind together spacecraft. The glue may actually be even stronger than previously suspected, because materials used in tests all broke apart before th cement let go. When barnacles are prie from steel ships, for instance, steel fragments are usually found attached to the barnacle's cement.

Because of the minute quantities o glue obtained from each animal, progres on barnacle research is painstaking and slow. In the long run, these efforts should yield rich rewards.

sand

In some parts of the world it is said to sing; in others, it remains silent. Sometimes it is dazzling in whiteness; in other places, it takes on hues of pink or purple, and even dark green to black. It may resemble a coarse meal, or shimmer in salt-sized crystals. But wherever sand appears, it is from the work of time, wind and water wearing down rocks and shells.

The basic ingredient of all sand is quartz--the most common mineral on earth. Various other minerals, organic debris and animal shells combine to give it color. Sometimes uniform particles are sorted and arranged by the wind into layers--a preview of the sandstone which will form in centuries to come. Transported by glaciers, rivers and ocean currents, sands often contain minerals chipped from rock formations miles away.

While scorching hot beaches on a summer day may appear downright hostile to would-be inhabitants, sand's special properties permit an unexpectedly rich variety of animals to live beneath the surface. For example, 20% of the total area in a given volume of sand consists of air spaces in which microscopic life can flourish. Also, the temperature and moisture content only inches below the surface is amazingly constant.

Moving from the landward edge of the beach toward the ocean, one encounters a characteristic assortment of life on each differentiated zone. Once you know what to look for, it isn't too difficult to observe some of Delaware's sand residents.

Yellow-and-black-banded digger wasps, found in the vicinity of the dunes, are unique in their habits of burrowing into and hunting on the fiery hot surface sands. It is not unusual for temperatures of sun-heated sands to rise above 120°F on a hot summer day--no wonder the impulse to wriggle our feet in the sand upon immediate arrival at the beach is so often stifled. To compensate for this scorching condition, the digger wasp, while making its burrow, periodically leaves the job and rises into the air for a cool-off break. Another dune inhabitant, the velvet ant (actually a hairy wasp with an ant-like appearance and a hefty sting), protects itself from the heat with its fur insulation. These black and red insects lay their eggs in the burrows of digger wasps so that the young may feast upon their host and benefactor's larvae. And there is even a non-stinging relative of the tarantula, called the dune wolf spider, living on the dunes. Of formidable size, these hairy animals which live in silk-lined burrows and carry their young in pouches, must track down their dinners rather than wait for meals to come to them.

Sand hoppers or beach fleas may form dense clouds while jumping about on the upper beach. Though insect size, they are actually small crustaceans (like our shellfish) which look like someone has pinched their sides together. The sand-colored ghost crab, whose burrow is often betrayed by surrounding rays of sharp-toed tracks, is another upper beach resident. While this crab is no longer adapted to swimming, it must return to the water to moisten its gills and to release young. At the end of an evening of foraging in the debris, the ghost crab returns to the upper beach, selects a burrow, spends the morning sprucing it up, and then shuts the door until dinner time.

In the wet intertidal area of the shore (that region normally flooded only at high tide), many worms and two-shelled animals live. Donax, a fascinating clam about a quarter to half an inch in size, can remain hidden with only siphon tubes extended like straws to suck in food morsels. All clams use the same method for digging--a strong wedge-shaped foot slips out of the shell and is used as a spade. Living in long, u-shaped tubes beneath the sand, the night-glowing parchment worm uses shuddering movements along its entire body to fan fresh water and food into one end of the tube, and strained, waste water out the other. The "chimney" of the mucous-lined tube may project a bit above the rest of the sand, so look for it. Another sand inhabitant, the lugworm, gives evidence of its burrow by leaving coils of expelled sand on the surface beside the hiding place.

A very famous resident of the intertidal zone is the mole crab.

Between waves, the many pinkish-grey cylindrical bodies exposed in the midst of feeding seem to melt into thin air. Since these creatures are a favorite food of many shore predators, their legs are adapted for both digging and at the same time, spooning sand over their bodies so that only seconds elapse before they are safely hidden. Mole crabs are equipped with special feeding antennae which sieve and retain minute drifting plants and animals. When full, the antennae are rolled toward the mouth, elephant-trunk fashion, and the net's goodies are scraped off.

Below low tide, and beyond our reach, the true sea animals lie buried in the sand. These include flounders, certain sea anemones (those flower-like creatures whose tentacles wave about during undersea films), sand dollars and burrowing sea cucumbers (cucumber-shaped relatives of starfish).

It is quite likely that you will have the opportunity to meet at least some of these sand inhabitants on a shore outing. But before you try to dig up burrows looking for residents, think about how you'd feel if a giant ripped apart your house to examine you. The sea and shore are there for us to look at and respectfully appreciate. The rule should be, "If you aren't going to use it, don't disturb it."

seaweed

What do toothpaste, ice cream, waterproofed cloth, beer and certain fertilizers have in common? Algae. Algae? That's right. Algae.

Seaweed utilization is nothing new in the Orient. In fact, not only is algae used, but more than 75 percent of the seaweed harvested each year in Japan, Korea, and China is consumed directly. One variety, laver, is a particular favorite in Japan. Sold in fragile, darkly mottled sheets, the algae imparts a subtle flavor to soups and to the spicy fish or rice dumplings it is frequently used to wrap. At other times, it may simply be toasted and eaten alone--as we might snack on potato chips.

So popular is this food that the Japanese even cultivate laver--with relative ease. Bamboo placed on the sea floor gives the algae "holdfasts," or footed stalks, a surface for attachment. Since its growth period requires no tending by the sea farmers, they may abandon the crop completely until harvest time.

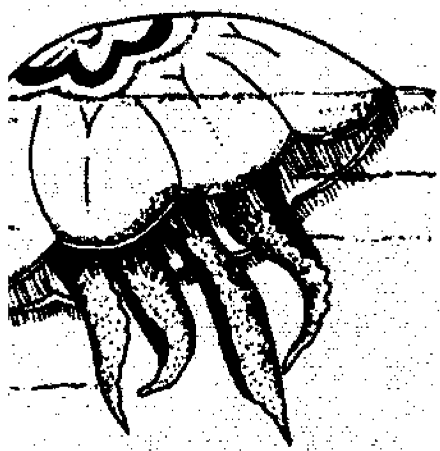
Such attention to seaweed and its culinary value has not been limited to eastern cultures. Vendors in Edinburgh, Scotland sold a brown algae called sugar wrack as late as the mid-19th century. Dulse, a reddish algae found along our coast, was relished in Scotland and Ireland. The Boston Irish continued the penchant for this seaweed and commonly sold it on the streets. An acquired taste, dulse is said to have an agreeable flavor when chewed slowly between meals. It is still eaten in the maritime provinces of Canada and by health devotees elsewhere. As far as palatability to the uninitiated is concerned, the first taste of a seaweed is bound to be anything from bland or mildly disagreeable to absolutely revolting. For those truly adventurous souls who would still like to give algae a chance, Euell Gibbons's book, Stalking the Blue-Eyed Scallop, offers a chapter on eating those seaweeds found on our shores, including tips on which seaweeds may be eaten fresh, and which should be dried or boiled.

Despite its apparent popularity in other parts of the world, there is no need to feel that we are wasting a valuable resource by not succumbing to the gourmet charms of seaweed. Actually, seaweed has very little nutritional value. Unlike land plants which develop root systems and therefore acquire soil nutrients, seaweed's holdfasts serve only to attach the plant. All nutrition acquired by the plant must be absorbed through the "fronds" or its leaves. Harvested seaweed is low in fat and protein content; therefore yielding little of the energy we expect from most foods. Algae may be considered primarily significant, however, for its wealth of vitamins and trace elements needed in minute quantitites by our bodies.

Seaweed is also used in much of the world as cheap, effective fertilizers and even supports sheep herds in the British Isles which have no other food offerings for much of the year. In the United States, seaweed is used primarily for its derivatives. Brown algaes, including giant kelp, yield an extract known as algin which is very similar in properties to the extract, carageenin, derived from red algaes. When added to food, industrial products or drugs, algin and carageenin have the ability to produce liquid or semisolid mixtures from ingredients which would not normally combine--such as oil and water. This is done by suspending one component in minute particles or droplets within the mixture. In addition to guarding against separation of unlike materials (thus stabilizing mixtures), seaweed extracts also thicken and gel the products in which they are included.

The most important use of these extracts, as far as most children are concerned, is in ice cream where their inclusion helps to prevent crystallization and separation of fats. Other uses are: covering fish with thin films of extract to prevent freezer burn; stabilizing and thickening foods like soup, mayonnaise and puddings; and suspending particles in items ranging from toothpaste to beer to insecticides. Red algae, represented by laver, dulse and Irish moss on this continent, also reduce to an extract known as agar, a gel well-known by any scientist who has ever cultured bacterial colonies in a laboratory. Besides being vital to the pharmaceutical industry, agar is used in preserving canned foods, and in cloth and paper waterproofing.

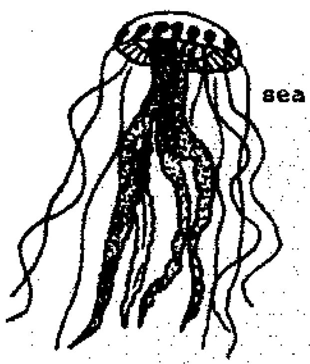
Following the example set by the Japanese, whose first experiments with algae cultivation occurred in 1736, the U.S. is finally getting rolling on its own seaweed farming attempts. We are even investigating the possibility of using the waste energy from power plants, as well as sewage nutrients to enhance algal growth. Artificial farms, consisting of mechanically tended tanks providing aeration and water renewal, are being intensively explored and so far, have been found to be cheaper and more effective in terms of growth rates, control of product quality and labor costs than natural bed tending. With as much as 60 times the profit obtained from earlier cultivation methods, artificial tank farming of those highly important algaes is sure to be an industry you will hear much more about in the coming years.



Jellyfish

For the gore and horror movie lovers among us, the ocean waters bordering Delaware may be a disappointment in their lack of dangerous inhabitants. No one is likely to get pursued by barracuda and moray eels or to die instantly from the bite of an exquisite, yet venemous sea snail as could happen in warm tropical waters. Jaws II might have you believing that a shark attack is a certainty in any shore expedition, but that isn't probable either. Yet before you yawn and resign yourself to a pleasant, though boring, day at the beach, be informed that Delaware does have a few marine creatures that can leave some uncomfortable reminders of that fun in the sun day.

Learning to identify them is the first step--a healthy respect for jellyfish capabilities can be obtained without getting stung. What you probably will not be able to see, when the floating jelly is obvious, are the stinging tentacles which may be dangling beneath or extending for some distance to the side. So don't get too close to examine it. There are four types of jellyfish found on Delaware's shores. The common white or moon disk jellyfish is a frequent visitor. A short fringe of tentacles, harmless to us, border the disk in 8 distinct sections. Together with the four purple reproductive loops clustered at the center, the tentacle arrangement is a good identification mark. Another innocent species is the lion's mane jellyfish which is characterized by a light yellow umbrella from which hangs eight arms, fused into a broad-based column. The worst jellyfish we have to contend with is the appropriately named sea nettle. Though not highly abundant in our area, one should know that the 24 long tentacles circling the disc are characteristic. Lastly, we have the honor of hosting the pink jellyfish or "Red Winter." As the largest jellyfish known, this jelly has been known to reach eight feet in diameter, weigh up to a ton and extend its tentacles to about 200 feet in arctic regions. But there is little chance of someone being engulfed by such a monster at Rehoboth Beach, because in warmer waters it rarely grows larger than eight inches in diameter. Contact with this animal can be irritating, so identify it by the reddish-brown color and tentacles, divided into eight sections, hanging beneath.



sea nettle

In other parts of the world, some jellyfish and their relatives can inflict excruciating pain and even death within minutes of contact with their tentacles. The sea wasp of northern Australia's waters is a documented murderer. In the southern part of this country, another jellyfish relative is known as the Portugese man-of-war--and with good reason. The animal, found drifting in the Gulf Stream current, is really a family unit consisting of a delicately-colored gas-filled float which acts as a sail to ferry the colony of individuals hanging beneath. These "zooids" act as one even though some are specialized to sense and to sting victims; others haul them toward digestive individuals, while still others reproduce. And can this floating arsenal pack a punch! Its chemical warfare consists of a paralytic toxin found to be very similar to cobra venom.

Jellyfish belong to a fairly diverse group classed together because of their possession of a central cavity with only one opening. Few animals are more primitively formed. Two general body types are found among these "hollow gut" animals. One is the "medusa" or jellyfish form which has pulsating muscles that squeeze water out of the umbrella and enable it to swim. The other body type, found in corals and sea anemones, is the "polyp," a usually stationary tubular or vase-shaped form with the head encircled by tentacles. A man-of-war's colonial zooids are really modified polyps.

Many hollow guts have a unique method of reproduction in which polyps and medusa are both produced in alternate generations. In jellyfish, for instance, an egg is released and migrates toward the adult's mouth. There it is fertilized and blasts off the parent as a floating larva to eventually settle on the sea floor. A plant-like form arises from this "seed" that develops tentacles and a mouth. Not long after, the "plant" becomes constricted at intervals along the stem, starting at the top, in preparation for the non-sexual reproduction known as "budding." When the stem is completely severed, a close observer will notice that it is miniature jellyfish which are hurled away like slices from a speed-chopped carrot. The miniatures will grow and start the process all over again.

All jellyfish and their relatives have tentacles loaded with battalions of stinging cells. Each sting cell contains a coiled harpoon filled with venom which extends a short distance outside the cell. When an animal brushes against this trigger, the harpoon flies out, turning inside out in the process, and exposes a poison-coated surface which will penetrate a victim. Only a few of these creatures have any effect on us, however, because most sting cell harpoons are not long enough to penetrate our skin.

The important thing to remember about jellyfish is that even when they appear dead and are washed up on the beach, the stinging cells can still be active. Never use your hands to examine a beached jellyfish. Grab a stick or something that can be thrown away or buried. If you do get stung, first pluck off the tentacles still clinging or they will continue to burn. Then there are several choices of treatment. One method is to lather the area with soap and shave it with a razor. If this doesn't appeal to you, gasoline, meat tenderizer, or ammonia will all help to neutralize the venom. While jellyfish do not pose a severe hazard to Delaware beach visitors, learning to recognize harmful and benign varieties can help us to avoid those few which can dampen an otherwise fine beach day.

shore restaurants

It is the rare shore visitor who doesn't develop a craving for a fresh seafood dinner when confronted with a multitude of crab and fish houses within a short walk from the beach. But the wise diner will know what to order in different regions of the Atlantic in order to taste the freshest locally-caught seafood. When in Maine, try the famous lobster, by all means. Louisiana boasts warm-water shrimp. In Delaware, the blue crab is reknowned, but don't let its reputation overshadow the delicious marine fishes also found here.

For instance, there is the flounder, that comical looking flat fish which shuffles along the sea floor and watches the world above through two beady eyes, both located on the same side of its body. Most restaurants offer some kind of flounder or sole, even if that is the only seafood available. Summer flounder, fluke or plaice are all the same fish which is savored for its subtly flavored, tender white flesh that can appeal to even borderline fish eaters. Flounder is also good for a child's introduction to fish eating. (Fortunately, or unfortunately for the family provider, most youngsters have no trouble cultivating a taste for the more expensive shellfishes like lobster and shrimp.) Besides having a mild, inoffensive flavor, flounder lends itself to all kinds of gourmet preparation, and there is bound to be at least one herb, vegetable, butter and wine combination which will convert even the most finicky eater. Because of the wide dispersal of the fish along the Atlantic Coast, shipments come in from the north when flounder is scarce in Delaware. But there are still a few restaurants around which refuse to serve frozen fish or buy only from their own boats which fish off the shores of Delaware and Ocean City.

Bluefish is another restaurant staple during the summer months. An oily, stronger-tasting fish than flounder, the blue is a favorite of sport fisherman (being a feisty critter) as well as the seafood gourmet. Unlike some of the bottom-dwelling fish such as certain flounder which are scavengers, bluefish prey upon other fish rather than settling for indiscriminate debris. This makes for a firmer, richer-tasting fish. Bluefish is usually served with a minimum of seasoning--salt and pepper, a few herbs, and maybe some lemon juice--and because of its abundance of oils, can retain moistness under broiling and baking.

The weakfish, or sea trout, is truly a local favorite. Though found along a wide stretch of Atlantic Coast, its greatest concentrations are in Delaware and Chesapeake Bays and off the Jersey coast. Common throughout the summer, its meat has a delicate, though decided flavor, not as strong as bluefish, but more pronounced than that of flounder. The name weakfish, incidentally, refers to the weak mouth of the animal, not the taste of its flesh. Weakfish belong to the Drum family of fish, a group possessing the ability to snap muscles against their inflated air bladder for a unique drumming sound which can sometimes be heard at the surface. Relatives of the weakfish which also appear on restaurant tables from time to time include the Atlantic croaker (similar in taste) and kingfish or whiting, whose leaner flesh is somewhat milder tasting.

Rockfish, or striped bass, runs occasionally in our waters at the beginning and end of the summer, but the bulk of the shore visitors miss it. The striped bass was an important food back in colonial times and was protected from use as a fertilizer as early as 1639. Like the weakfish, its flesh is medium strong in flavor because of its moderate fat content. Leaner fish are generally milder because for some reason, flavors are concentrated in fat and skin layers. Sea bass, though not closely related to rockfish, is a fine-tasting fish. Unfortunately, few restaurants will deal with it because of its small size.

A few of the less common fish occasionally brought into restaurant kitchens include the albacore, the only truly white-fleshed tuna; bonito and wahoo, both members of the strong-tasting mackerel group; and dolphin (the fish, not the mammal) which is a popular sport fish as well as a delicacy and sometimes listed by its Hawaiian name, "mahi-mahi." Anything listed as "sole" is probably a flounder or some other mild, filleted white fish. Real "sole" is not found in our waters. And if you should find a restaurant offering eel or shark meat, be adventuresome. The eel is a heavenly treat in many parts of Europe and would be one here if more people were exposed to it. Shark meat, when property cared for as soon as it is caught, can also be unbelievably good, and is often said to be similar in taste to swordfish.

Regional shellfish which might appear on the menu include the blue crab; some local lobster which can be caught way offshore in cooler, deeper water; scallops, both large sea scallops and the more delicate bay variety; oysters, available year-round, but best-tasting in months ending in "r"; mussels, the blue-black smoothshelled animals which latch onto rocks, wharves and each other that are gourmet food in France; soft-shell or steamer clams; and quahogs, which are known as littlenecks when 3-4 years old and cherrystones when 4-6 years of age.

Between sampling the fish and shellfish of the Delaware shore, you may find your tummy starting to resemble that of a pufferfish. Go ahead. Seafood is fairly low in calories, and there's no disputing its healthful properties. As for me, I just eat it because I love it.

Diving mammals

A peevish child who threatens to hold his breath until he turns purple and dies has little chance of attaining his goal, as any parent knows. When our bodies are deprived of oxygen for long enough, the buildup of waste carbon dioxide forces us to breathe, whether we want to or not. For a diver, it is the uncomfortable feeling he gets from carbon dioxide accumulation which signals when it is time to hit the surface. And regardless of whether he is ready to ascend or has just found the sunken treasure of a lifetime, the best human diver can stay under for scarcely more than 3 minutes. On the other hand, whales, which are air-breathing mammals like us, have been known to remain submerged for up to two hours without taking another breath. How do they do it?

One advantage whales have is that their lungs can store more oxygen, in relation to their needs, than can ours. As an animal gets larger, its volume or overall size increases much faster than its surface area. The larger the volume of an animal, the larger the lungs can be. Surface area, however, is what dictates how much oxygen that body is going to require. So if the volume and, therefore, the size of the lungs is growing much faster than the requirement for oxygen, each breath a whale takes will store more oxygen than that of a smaller animal.

Seals, although comparable to us in size, have twice our oxygen-storing capacity. And they are also more efficient at using their available oxygen when submerged. When a seal or any diving mammal goes under for a dive, there is an immediate change in its blood circulation. Only the most vital regions of the body continue to receive blood and the fresh oxygen carried with it. Though the heart and brain continue as before, an organ like the kidney ceases all activity during an underwater excursion, while muscles must either use up their stored oxygen or function without oxygen. Normally, the acid wastes produced during anaerobic respiration (this breathing without oxygen) get into the bloodstream and affect the body's chemical balance. Acid buildup is what causes an athlete, after prolonged exertion, to become fatigued. When he stops and breathes rapidly, oxygen is rapidly restored to the muscles. With a seal, however, acid-laden blood does not leave the muscles during a dive so that waste acids stay put and have less effect on body function.

It is known that whale muscles are also 8 or 9 times more effective in trapping oxygen in their storage spaces than ours. Seal hemoglobin (the oxygen-carriers in blood), similarly is unusually efficient.

Not only is blood rerouted when a marine mammal dives, but the heart slows down to as much as half of its normal rate. This arrangement is necessary because of the reduced distance blood travels during a dive. If blood pressure were maintained at its surface rate, the current would be too strong for the walls of vessels and fatal ruptures in the heart and brain would surely occur.

Another significant adaptation found in whales is their ability to replace almost all stale lung air with fresh air each time they breath. In contrast, humans expel only 10 percent of their lung air with each exhaled breath. All of these breathing modific tions contribute to highly efficient us of a marine mammal's "oxygen tank."

When a diving mammal finally surfaces, it hyperventilates, or "pants," to restore a quick supply of oxygen to its deprived body parts. The well-know whale spout is really fishy-smelling whale breath, combined with a small amount of water lying over the blow hole. We see the spout as a liquid because the warm moist air is released under pressure and in arctic waters, it condenses when meeting the cooler outside air.

Certain human societies living nea and depending on the seas are accustome to diving daily, without air tanks. Women in the Japanese Ama culture, for instance, earn a livelihood by pearl ar shellfish diving to depths of 100 feet all day long. The only equipment they use are goggles, lead weights to aid submergence, and sometimes, lines for return to the surface. An average dive is about 2-1/2 minutes in length.

Polynesian shellfishermen remain under for about 3 minutes, but their dives are much shallower.

In general, humans who dive habitually acquire much greater lung capacities, use less oxygen under water than occasional divers, and are less sensitive to carbon dioxide. There is even a redistribution of blood away from the muscles during human diving as well as a reduced heart rate. In fact, the more a person skindives, the more his body mimics those of his marine relatives. The undeniably close relationship we share with the great whales, dolphins, seals and other diving mammals, in addition to the amount we can learn about our own bodies through studying them, are two good reasons why these facinating sea creatures should be strongly protected.

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of hours.

In our part of the country, we are accustomed to two tide cycles per lunar day (24 hours and 50 minutes). That is, high tide occurs every 12 hours and 25 minutes, with periods between peak high tide and peak low being slightly more than 6 hours apart. Approaching high tide, water is said to rise, when measured vertically on pier pilings, for example, or "flood" (the horizontal distance water spreads on tide flats or beaches). After a high peak, tide falls, ebbs or recedes.

If we were to observe our planet from outer space, we would see the oceans formed into two huge bulges, like headphones on the Earth's ears. The closer the moon is to any one point, the more the oceans are affected by its gravitational pull. So as the Earth rotates, the bulges change locations and cause tidal variations. The bulge which forms opposite the moon side of Earth is explainable only at great length, but this hump accounts for the second daily tidal cycle we experience. More complicated is the reason why some parts of the world have only one tidal cycle per day while others, like our west coast, have irregular cycles.

The extent of high tide is modified by several factors. A predictable change occurs during the spring tides which are about two weeks apart. At these times, the sun, which has a much weaker influence on tides because of its great distance from us, lines up with the Earth and moon to produce combined gravitational forces which result in slightly higher high tides and lower low tides than would normally be expected. Between spring cycles, "neap" tides (from the Scandinavian word meaning "barely touching") produce sluggish tides with less pronounced differences between high and low peaks. The sun and moon, during neaps, are at right angles to one another, with respect to the Earth, and the opposing gravitational pull of the sun partially counteracts the moon's influence.

Once or twice a month, the moon, in its elliptical orbit, swings very close to Earth and that, too, affects tide heights. When this event coincides with spring tides, the year's highest tides occur. Winds and storms also influence tides, and depending on wind directions, may hold tides offshore or push them further inland than normal. When spring tides and powerful storms team up, damage to shore areas can be devastating. In the low countries of northern Europe, storm surges are especially fearful times because of the nearness of settlements to the ocean and the very flatness of the land.

Basin shape is another variable which directs tide heights. In narrow, steep-sided estuaries (tidal rivers), the water level climbs higher because it cannot spread horizontally. Tides in Canada's Bay of Fundy are among the world's highest because the wide bay mouth permits great quantities of water to gush in before the bay narrows sharply at its head. Vertical differences between high and low tides are as much as 50 to 60 feet at the head of the bay. In contrast, tidal variations in the Mediterranean may be 6 inches or less.

Although tide definitely has the upper hand over us, some sea creatures are true masters at taking advantage of it. Intertidal animals like barnacles or clams await the incoming tide so they may gorge on a fresh supply of food.

Other marine inhabitants build their spawning season around the tides. The horseshoe crab, for instance, emerges each spring to lay its eggs around the high tide mark of spring tides. Two weeks later, when the tides again rush over the eggs, the young hatch out and get a ride into the ocean. They may be lowly invertebrates, but their adaptation to the tides could explain why the horseshoe crab, with its clumsy suit of armor, has been around for about 150 million years.

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