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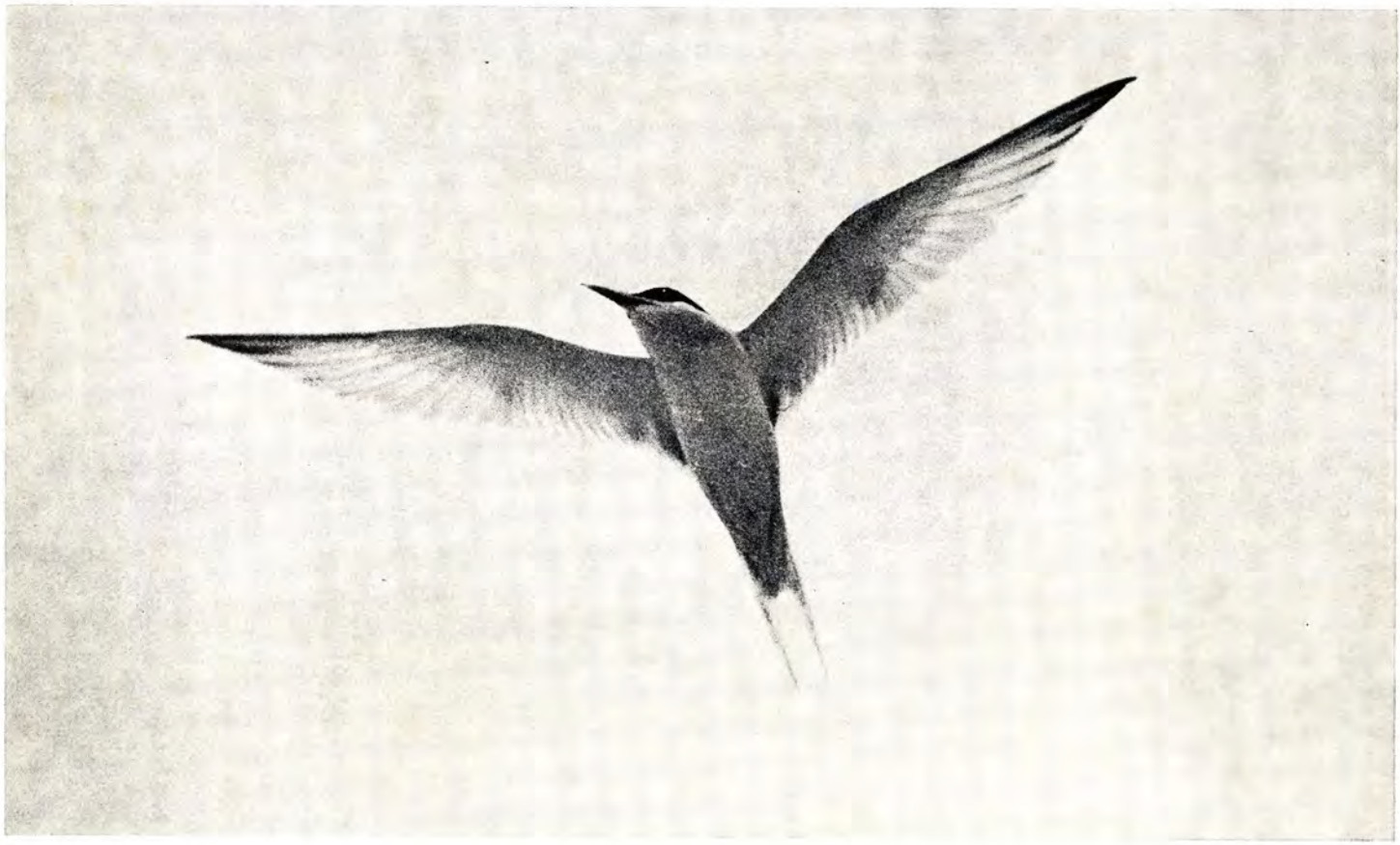

Environmental Studies with Seashore Life

The American Nature Study Society

ANSS Offers Expanded Services to Environmental Education Organizations

The American Nature Study Society is expanding its services to conservation and environmental education organizations, schools, service clubs and other interested organizations. In the last two years it has provided leadership for urban environmental education workshops in Bridgeport, Ct. and Washington, D.C., field trips in San Francisco and Columbus, Ohio, an edible plants conference at Greenwich, Ct. Now an impressive list of members offer opportunities for these and other types of workshops, field trips, and public lectures. In addition the Society sends the ANSS Authors' Book Exhibit upon request to universities, nature centers, schools and workshops.

Among the outstanding people who have agreed to provide these programs are President Richard J. Baldauf, Kansas City; former Presidents Helen Ross Russell of Jersey City and Ruth W. Melvin, Columbus; board members Phyllis Busch, Stamford, Ct., Marshal Case, John Hug, Columbus, Ohio, Michael Shannan, Dayton, Ohio, Jean Milmine, Savannah, Ga.; and Esther Railton, Walnut Creek, Ca. Other members willing to be further involved are Jean Rosner, Albuquerque, N.M., John Briggs, Missoula, Mt. and John Padalino, Dingmans Ferry, Pa. There are still others who have been performing such services upon request for many years and these people are willing to continue to do so.

Participants in the program will present a lecture, conduct a workshop or field trip of one day or several days depending on specific needs. A nominal or no fee will be charged by the ANSS members, and expenses will be restricted to travel, accommodations, meals and supplies. The book exhibit will be sent free of charge on one month's notice when available, the exhibitors paying the return charge.

For scheduling speakers, workshop or field trip leaders, or for a list of topics, contact Dr. Richard J. Baldauf, President, Kansas City Museum of History and Science, 3218 Gladstone Blvd., Kansas City, Mo. 64129, or Ruth W. Melvin, Project Chairman, 8535 Winchester Road, Carroll, Oh 43112. For the book exhibit alone, or in combination with one of the other services, contact John J. Padalino, Route 1, Box 72, Dingmans Ferry, Pa. 18328.

Dennis Varza carries out research on Least Terns along the Connecticut coast.

The Variety of Shore Birds

DENNIS VARZA

I have lived on the shore all my life and my interest in birds is almost as old. As my skills at birdwatching developed so did my appreciation for the shore. Now I cannot think of living anywhere else. The interface of large areas of land and water create such a variety of habitats that it takes time to fully appreciate them. Seeing how birds respond to this unique condition throughout the years enhances ones understanding of the forces of life.

Birds are the most obvious animals in most places, on the shore they are even more obvious in their numbers and their diversity. The diversity of bird life reflects the variety of habitats available for life. When one studies birds one is quick to find out the shore is more than miles of sand beach. There are sand beaches, gravel beaches, ocean fronts, bays, and a variety of marshes and lowland forests, each supporting different birds. The more one studies the shore the more variegated it becomes.

In the marsh one has salt water meeting fresh water. There is not a sharp division between the two but a gradient, depending on the salinity one will find different animals at different places. Rails are birds of the marsh that look like long billed chickens. The fresh water areas of the marsh will have Virginia and King rails, while the salt areas will have Sora and Clapper rails.

Herons on the other hand are large birds and a small section of marsh is too small to support them. To avoid competition the herons have different feeding methods. The Green Heron stays in the marsh taking fish in small channels and other shallow waters. The Great Blue heron is large enough to feed in deeper water and can be found on larger bays and ponds. The Egrets are intermediate in size feeding in the deeper marshes and the shallows of bigger bodies of water. The night herons, as their name implies, feed at night taking crabs and snails as well as fish. They generally take over when the other herons go to sleep.

Because there are so many different environments in one place, each one is necessarily small. To make up for this many birds are migrants or can travel over large areas regularly. There are over twenty species of plovers and sandpipers that visit the eastern shores regularly. Each one has a special bill and leg length to feed in different habitats. Ruddy turnstones have short thick bills to turn stones and feed on what is underneath. Yellowlegs have long bills and legs to take to deeper water for food. Dowitchers have long bills to feed deep in the mud, etc. Most of these birds nest in the arctic but spend a great portion of their time traveling from shore to shore, feeding in a little strip for which they are designed.

There are some shorebirds that do make our shores their home. Their feeding habits are a little more diverse so they can find enough food to raise families. On the beaches it is the Piping Plover in the north and the Wilson's Plover in the south that make their home here. Their color is a pale sandy brown, but during the summer one can see them running down to the dark mud flats for food where at once their pale colors stand out. They lay their eggs in April and by June the babies are running all over the beach. Even the young and eggs are well camouflaged, both being sand-colored and mottled to break up their outline. Further inland and back in the marsh one finds Spotted Sandpipers and Willets nesting. These birds nest in or near the marsh and make use of the available food there.

The shore also makes a great wintering area for many birds. Coastal areas are among the last to freeze and so one finds many species staying there that would normally go further south. Loons, grebes, cormoramts, and many sea ducks, like scoters and scaup, may be seen only during the winter. Thousands of ducks and geese winter along the Atlantic seaboard, some are found way out at sea and others rest in secluded marshes not yet frozen, such as Greenwinged Teal, Shoveler and American Wigeon.

Gulls are perhaps the most recognized shore birds, even the summer weekend beachgoer is familiar with them. They are one of the few groups that stay the year round. Gulls are feathered trash cans, feeding on anything with meat during the summer and going to landfills to feed on our waste during the winter. Because of the winter abundance of food more birds are surviving and creating a population explosion. If you ever stopped to look at gulls you would notice there are more than one species present. If one looks at the grey and white birds three species would be regularly noticed. The big ones with the slate grey backs are the Great Black-backed Gulls. The others are generally Herring Gulls. But, if one looks at these birds closely, smaller ones will be found with a dark ring around the bill, these are Ring-billed Gulls. The brown gulls are not different species, just juveniles of the grey and white forms. It takes four years for a gull to go from brown to the common grey and white. If you take notice during the summer, most of the birds you see are immature. The adults are away on off-shore islands where they nest.

The last major groups is the terns. Terns are small versions of the gulls and are designed to take live food instead of scavenge on the shore. Terns are grey above and white below with a black cap and black wing tips. Their pointed wings and forked tail make them fast fliers. Because they take live food, they must migrate to tap the seasonally abundant food source. There are three species of terns nesting in the northeast and all take the same basic food, but in different ways. The small Least Tern feeds in shallow water and takes fish only on the surface. The common Tern is a third larger and flies further out to sea. Because of their larger size they are able to take fish in a deeper layer of water. The Roseate Tern is a bit larger than the Common and can take fish still deeper.

The weekend or vacation visitor cannot comprehend the life of the shore unaided. At best they may get an impression that something special is there. The best way to get people atuned to the life of the shore in order for them to understand why it should be protected, is to speed up the process of familiarization. They must be taught a capsulized concept of shore life and skills of observation. ANSS sponsored field trips can assist in this important job.

Limulus Polyphemus, A Living Fossil

by ROBERT M. McCLUNG

The tides were higher than usual that day in early June, for there had been a full moon the night before. Everywhere I looked on the public beach in Dennis I saw horseshoe crabs crawling through the shallow waters at the edge of the tide, each big, barnacle-covered female followed by one or more males. At mating time, the female horseshoe crab gives off a scent into the water which attracts the males to her. Finding a female, the successful male hitches a ride by holding onto the rear portion of her shell with fist-shaped claspers on his first pair of walking legs. Sometimes a second and third male attach themselves in tandem fashion behind the first.

I watched one mated pair as they crawled to the very edge of the high tide, where the water was only an inch or two deep. Burrowing into the wet sand with her hoof-shaped shield and legs, the female dug a shallow nest. Then the two crabs paused for a few minutes, a school of hungry minnows darting about them. Although I could not see what was happening, I was certain that the female was laying eggs, and the male releasing spermatozoa to fertilize them. As for the minnows, they were filling up on the newly laid eggs. Soon the crabs moved on, to repeat the performance a few feet ahead.

Searching carefully through the sand of the recently vacated nest, I finally found the eggs — hundreds of them. Averaging about one sixteenth of an inch in diameter, they were perfectly round. Some were pale green, some light brown, some almost white. I gathered a few in a bottle of water to take home, hoping to watch their development in a saltwater aquarium.

Walking on, I saw many other mated pairs of horseshoe crabs depositing their eggs all up and down the beach. Wave action quickly covered the eggs with sand, but not before the darting minnows and the probing plovers and sandpipers had taken their share.

I also saw several people, adults as well as children, hard at work picking up horseshoe crabs as fast as they could and tossing them into the beach grass far beyond the high tide line. Horseshoe crabs were pests, they told me, and should be destroyed because they eat clams and other shellfish. This they do to some extent, I agreed. But I also added that from my point of view they were entitled to their fair share of the food of the sea. Among the most ancient of Earth's living creatures, they are unique and interesting animals. Perhaps, I suggested, they might enjoy watching them rather than killing them. With that, I and several others began to return stranded horseshoe crabs to the waters from which they came.

Tracing its ancestry back to Triassic times, some 200 million years ago, **Limulus polyphemus** is truly a living fossil. Horseshoe crabs almost identical with those I was watching that day were living long before the dinosaurs appeared on Earth. Horseshoe crabs, it is true, do eat small shellfish, marine worms, and other marine animals. But they have been doing that for many millions of years, and the shellfish have managed to survive.

Despite the name, horseshoe crabs are not true crabs at all. Their closest fossil relatives were probably the trilobites; and their closest living relatives are spiders and scorpions.

Four or five different species of horseshoe crabs survive in the world today. All of them are very much alike. Our American species, **Limulus polyphemus,** inhabits coastal waters from Maine to Yucatan. The others are all found on the other side of the world, inhabiting coastal waters from the Sea of Okhotsk north of Japan to the coastal waters of India, the Philippines, and some of the East Indies.

Limulus polyphemus was first described by Thomas Hariot and John White, two naturalists who accompanied Sir Walter Raleigh on his voyages of exploration to the New World in 1588 to 1590. Hariot described the creature and said that the Indians called it "seekanauk." White made a drawing of it, and noted that the Indians "fasten the sharp, hollow tail . . . to reeds or to the end of a long rod, and with this point they spear fish, both by day and by night."

Horseshoe crabs were once much more abundant along our East Coast than they are today. One old report tells of 750,000 of them being taken on a half mile of beach along Delaware Bay in 1855. In the 1920s and early '30s, it is reported that four or five million horseshoe crabs were harvested annually along the shores of Delaware Bay. Stacked and dried, their bodies were ground up and used as fertilizer meal.

The horseshoe crab eggs that I gathered that June day in Dennis were taken home and placed in an aerated saltwater aquarium. After several days the tough opaque shell of the tiny eggs ruptured, and a thinner, transparent sphere formed during development came out. These transparent spheres quickly swelled until they were about twice the diameter of the original eggs. Using a magnifying glass and a binocular microscope, I was able to observe very easily the development of the embryonic crabs within these transparent spheres.

The young horseshoe crabs had no tail spine, but otherwise resembled their parents in general conformation. Day by day I watched as they grew and developed, twisting and turning and waving their tiny legs within their transparent bubbles. Before they finally hatched, each little crab shed its skin twice. Three weeks after I had gathered the eggs, the young began to hatch from them. Breaking out of their transparent prisons, the tiny crabs — each about an eighth of an inch wide — began to swim about the aquarium and to burrow into the sand.

In nature, horseshoe crabs often begin to hatch at the time of the next full moon after the eggs were laid, when tides are higher than usual once again, with waves washing over the sandy nests. The newly-hatched young quickly burrow into the protective sand, for shorebirds, true crabs, and other marine animals eat the little horseshoe crabs just as eagerly as they gobble up the eggs. Those that escape eat microscopic marine life, grow, and shed their skins. By late July most of them have short tail spines. By the time they are a year old, the young horseshoe crabs have molted seven times, and measure about an inch across the shell.

When it molts, a horseshoe crab literally crawls out of its old skin through an opening crack around the front curve of its body. The skin of the newly-molted crab is quite soft. Absorbing water, the body swells up to a larger size. Soon the skin hardens,

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ROBERT McCLUNG is best known as the author of over 35 books for young readers on the life cycles of various animals, including, **Horseshoe Crab.** Many ANSS members know Bob as an outstanding contributor to the society over many years.

— from **The Cape Naturalist**

and **Limulus** is armor-plated once more.

By the time it is three years old, **Limulus** has molted about 11 times, and measures about three inches across the shell. In August you sometimes find the beaches of Cape Cod Bay littered with cast shells of this size. From the age of three years on, the horseshoe crab molts only once a year, until it finally reaches maturity at age nine or ten.

The next time you find a cast shell, pick it up and examine it. It is a perfect, although lifeless, replica of the animal that lived in it. Better yet, examine a living horseshoe crab the next time you see one. Observe how it walks, how it manages to turn itself over in the water when upended. Then let it go its way.

The body of **Limulus** is encased in two hard armor plates or shields. The forward one, a hoof-shaped shield, gives the species its common name. On either side of this shield is a prominent compound eye. At the front midline of the shield are two tiny, simple eyes. All together, these eyes give **Limulus polyphmus** its scientific name. **Limulus** is derived from the Latin **limus**, meaning "a sideways glance"; in Greek mythology, **Polyphemus** was a giant with only one eye, right in the middle of his forehead.

Behind the hoof-shaped forward shield, and attached to it by a hinge-arrangement, is a smaller, triangular-shaped abdominal shield, bristling on either side with spines. And behind this is the long, sharp tail spine. This is attached by a ball-and-socket joint, allowing the spine to move in almost every direction. This tail spine is not a stinger. It is harmless, unless you happeen to step on it with your bare feet when it is turned upward. Most unlikely! **Limulus** uses it as a lever for turning itself right side up, if wave or human action happens to turn it over on its back.

Examining **Limulus** from beneath, you see the six pairs of jointed limbs. The small first pair, called chelicerae, help to clutch food and direct it to the mouth. Next come five pairs of walking legs, the last pair being much the largest. These big hind legs are used rather like ski poles, thrusting into the sand and raising the animal's body upward and pushing it forward.

Between all these legs is an elongated slitlike opening — the mouth. As it walks along on the bottom, **Limulus** probes for food with its chelicerae, which direct it toward the mouth. The food is cut up by many stiff bristles at the base of the legs as it goes into the mouth and digestive tract.

Behind the mouth and legs are six overlapping plates, located on the abdominal shield. The first plate protects those behind, which bear gills. Moving back and forth in rhythm, these gill plates provide multiple surfaces for taking oxygen from the water. Sometimes, especially in early stages of the crab, the gill plates also function as paddles, enabling **Limulus** to swim.

During the long slow process of growing to maturity, horseshoe crabs move out into the deeper waters of the bay. They do not return to shallow water until they are mature, and the age-old instinct to reproduce lures them shoreward. It is then, during the high tides of May and June, that horseshoe crabs gather in great numbers in shallow waters to carry through their ancient ritual.

Many of these mating crabs are hoary with age, perhaps 20 years old or more. Plastered with barnacles, slipper shells, and algae, they present a truly ageless appearance. And why not? With a lineage going back long before the appearance of the dinosaurs, they have shown that they can survive, that they have earned the right to survive in this crowded world of ours.

Union Camp Corporation Gives Barrier Island for Use as South Carolina Wildlife Area

Union Camp Corporation, a leading firm in the forest products industry, on December 1, 1975 donated 1,700-acre Turtle Island to The Nature Conservancy, which immediately transferred it to the state of South Carolina. The state Wildlife and Marine Resources Department will use the South Carolina barrier island, valued at more than $400,000, as a wildlife management area.

Alexander Calder, Jr., chairman and chief executive officer of the company, described the gift as the first in a "Land Legacy Program" under which Union Camp plans to donate a number of selected land areas "to the country and its people" during the Bicentennial year.

"As custodians of 1.6 million acres in six of our nation's most historic and beautiful states," he said, "we are very conscious that our woodlands include many areas of significant historic and ecological value. Therefore, as the country begins to celebrate its Bicentennial, it is our belief that assuring the preservation of these lands is the most appropriate way for Union Camp to participate in this momentous celebration.

"There is no doubt in my mind," he added, "that this action represents the highest and best use for the land areas involved."

Earlier this year, Union Camp – whose woodlands are located in Alabama, Florida, Georgia, North Carolina, South Carolina, and Virginia – completed the donation of 50,000 acres in the Great Dismal Swamp of Virginia and North Carolina. This land gift, initiated in January 1973, was valued at $12.6 million, for which the company was entitled to the normal charitable contribution tax deduction. Corresponding deductions are expected also for gifts to be made under Union Camp's Land Legacy Program, depending, of course, upon the values involved.

In accepting the gift of the 1,700-acre Turtle Island, Governor James B. Edwards said, "This is a happy day for the state of South Carolina to receive such a generous donation from Union Camp Corporation. I am confident that all the citizens of the state share my gratitude in accepting the gift of this island which, while being preserved in its unspoiled state, will be available to all for the enjoyment of nature and for recreational activities such as picnicking and beachcombing."

TURTLE ISLAND
AN UNSPOILED ECOSYSTEM

Turtle Island, except for its beaches which attract fishermen, picnickers, and occasional beachcombers, is little changed from what it might have been in Revolutionary times. There are no canals, power lines, foundations, roads or other evidence of man. Turtle Island is left to the wild creatures and, in this role, it serves a valued purpose in preserving the nature of the South Atlantic Coast.

Much of the island on its western part is salt marsh flooded repeatedly by high tides. Across the narrow strip of high sandy land to the east and at slightly higher elevation lies a smaller marsh of a somewhat different nature. It does not flood so often nor drain so quickly as does the western part. Here the water is brackish and the vegetation is "wiregrass" Spartina mixed with seashore salt grass. Dominating the salt marshes, however, is the taller smooth cordgrass Spartina which produces the long narrow leaves used by basket weavers for the fine handmade products they sell on the streets and in the gift shops of coastal cities.

These Spartina marshes, covering all but about 90 acres of Turtle Island, are typical of the coastal estuaries where fresh and salt water is protected from wave action. They are often unattractive to people because of their mud and insects. But such salt marshes are known as highly productive ecosystems, among the most productive in the world. Their role in nature is to capture the sun's energy and convert it by photosynthesis to materials on which animals can feed and grow. These marsh plants grow rapidly in the warmth and light. Bacteria break down the dead plant materials, enriching the water with detritus which is eventually redeposited in the marsh. Plants and animals – including microscopic forms, invertebrates, and vertebrates – benefit from the nutrients in the detritus. This decay of the dead Spartina continues throughout the year, forming a year-round energy pool for the growing plants and animals.

Sunlight, temperature, water, salinity, and sediment type all play vital roles in determining the productivity of the marsh.

Some creatures of the marsh eat the detritus directly. Among these are the fiddler crabs and the oysters that siphon in the fertile waters that carry their food. Immature menhaden filter the nutrients from the detritus-rich waters, grow rapidly, and become food for the striped bass, a favorite game fish along the Atlantic coast. Commercially important fish for which Turtle Island's salt marsh serves as an important estuarine nursery grounds include star drum, Atlantic croaker, spotted croaker, silver perch, weakfish, and sea catfish, as well as blue crabs and shrimp.

Detritus from the decaying Spartina also indirectly nourishes many other marsh organisms. Much of the detritus, however, flows out into the estuaries to enrich the waters and add to their productivity.

At high tide, much of Turtle Island's broad salt marshes of Spartina are flooded. This marsh covers a large portion of the island's acreage. The brackish marsh is wet and soggy underfoot.

Between these two marshes, and rising perhaps seven or eight feet above the mean high tide, is a ridge that long ago was a barrier beach built of sands carried by the action of tidal wave currents. Today this ridge is a long narrow strip of about 90 acres of woodlands producing a lush stand of pine and palmetto.

The pines rise to heights of 60 or 70 feet, and the shaded earth beneath them is blanketed with pine needles, cones, and palmetto fronds.

The island's narrow beaches are littered with the shells of clams, oysters, and horseshoe crabs and marked by the footprints of countless raccoons that come out of the woods and marsh to search out foods delivered by the ocean.

Birds in abundance occupy Turtle Island both on the beaches and through the marshes. Clapper rails hidden in the marsh grass call repeatedly. Visitors know these coastal marshlands for their abundance of these slender, long-legged, gray-brown birds. Marsh hawks patrol the open marshes. Great blue herons, Louisiana herons, and egrets feed in the shallow ponds. Grackles and other blackbirds move overhead. Seaside sparrows are flushed ahead of the invader and quickly drop back into the grass and out of sight again. On the beaches flocks of gulls, skimmers, and shorebirds rest and feed.

In the brackish marsh of Turtle Island are numerous small potholes with about 12 inches of dark water on beds of soft fertile black mud of undetermined depth. These ponds, linked by narrow snake-like channels half-hidden in the marsh grass, are sanctuaries for waterfowl and wading birds. Included among the ducks that may be flushed from them on an autumn day are black ducks, mallards, blue-wing teal, and widgeon.

Turtle Island's ponds provide a resting and wintering habitat for ducks. In winter, also, the mud flats beyond the salt marsh are inhabited by scaup, as well as surf scoters and other sea ducks, and in times of severe storms these birds seek refuge in the interior of the island.

Using the Seashore to Teach Environmental Studies

by MARSHAL T. CASE

Those teachers who are fortunate enough to live near or visit the seashore have an exciting and varied world to explore — the realm of saltwater plant and animal communities. Within tidal zones, among rocks and jetties, along beaches and mud or sand flats, and throughout salt marshes, thousands of different plants and animals live out their varied lives.

There is so much to see and do at the seashore that people of all ages can find an interest to pursue. In fact, there is such a variety of life that young people from pre-school to college are quickly caught up in the excitement of change and abundance of life. Weather and seasonal change add to teaching possibilities and provide additional interest for the student.

CLASSROOM ACTIVITIES

In addition to the traditional teaching methods used to share information with students in the confines of the classroom, several visual activities are particularly helpful with elementary grades. Student-made hand puppets and finger puppets add excitement to any seashore study unit with emphasis on use of recycled materials from home and the school cafeteria. The entire project can be conducted by students beginning with the collecting of such throwaway items as styrofoam cups, popsicle sticks, pieces of colored fabric, and soda pop caps. Some of the most popular puppets can be a scallop, clam, gull (styrofoam cup with paper wings), and flounder. Students make their own pattern and use their ideas for colors, size and materials. A "talking" scallop whereby a student relays information through the puppet to the other students makes a lively and fun learning experience. Besides a scallop talking about a life history, it can relate to environmental problems such as oil spills and pesticides. The biology of the animal can be discussed as it relates to these problems.

There are enough common animals and plants found at the seashore to allow each student in a classroom to make a different puppet. It is also a useful tool for work with the lower elementary students at the seashore. An introduction at the seashore site as a quick review is followed by the study of living specimens.

Another very useful classroom activity is the setup of a marine aquarium. Since this can be made from something as basic as a one gallon wide-mouth mayonnaise jar, expense need not be a factor.

Marine aquaria are easy to set up and maintain, especially if you intend to make short-term pets of the animals you collect. Spring and fall are the best school year times for collecting specimens. Of course an opportunity to incorporate this activity with a summer class is especially rewarding.

The best container for a small marine aquarium is a three to five gallon clear plastic fish tank. This can be purchased for only a few dollars at most pet or hardware stores.

Ingredients for a successful aquarium include small-grained sand, sea water (or artificial sea water if you live inland) and an aeration pump. If you use a gallon wide-mouth glass jar or an aquarium with just a few specimens, then aeration is not vital.

Clean the aquarium thoroughly, then place an inch or two of clean sand in the bottom. Slowly pour in the salt water using a piece of paper on top of the sand to avoid stirring up the tank. When you have filled the tank about three-quarters full, mark the water level on the outside with a crayon or small piece of adhesive tape. As the water evaporates, add more fresh water to bring the level back to your mark. Fresh water is added because only the water evaporates — not its salt and mineral content. Thus if you add more salt water, you will increase the salinity (salt content) of the tank and kill the marine life. Siphon or dip out about one-third of the water every two weeks and add new salt water to keep the tank fresh and renew the small food supply.

When your aquarium is ready, collect two or three of each of the creatures you find and want to observe. Be certain not to over-crowd the tank; you can always change animals. Some of the most interesting to watch are decribed in the following descriptions.

Fish — One of the easiest salt water animals to keep is the killifish, known to most people as a minnow or chub. You will find them swimming in schools just beyond the tide line or in tidal pools and streams of salt marshes. Feed killifish pieces of earthworm, bits of chopped clams, liver or brine shrimp.

Crabs — As you poke around rocks or watch the sandy bottom of a shallow bay near low tide, you will see shells that suddenly sprout legs and pinchers and run about. These are hermit crabs carrying their houses on their backs. This crab has no protective shell of its own, and thus must find safety in a vacant snail shell such as a periwinkle, moon snail or whelk. As the crab grows and becomes too big for the shell it occupies, it looks for a new, larger one and quickly makes a move from the old to the new house. Include a few empty snail shells of a size slightly larger than those occupied by your crabs, in case one is ready to change its house. Other interesting crabs to collect for your aquarium include small hard-shelled crabs of several varieties, young horseshoe crabs and fiddler crabs.

All crabs are scavengers, feeding along the shore line on bits of dead fish, shellfish and algae. Gather some sea lettuce for a temporary food supply. After you have the crabs established in the aquarium, remove the seaweed and feed them bits of chopped clams, fish, liver, hamburger and brine shrimp. If you tire of observing them, return them to the shore area where you found them.

Barnacles — If you scratch your bare feet while making your way across rocks in the tidal zone, it is probably because you stepped on barnacles. As you sit on a rock or jetty during an incoming tide, watch the barnacles when the water begins to cover them. The shells, tightly closed to conserve moisture while the tide is out, begin to open as soon as the animals are submerged. A cluster of legs, which somewhat resembles a hand, extends out from the shell, feels for food that is being washed by, then rapidly darts back inside. This motion is repeated over and over as the barnacle feeds on minute plants and animals known as plankton.

You can observe barnacles in your aquarium if you have an aerator to keep the water in motion. They are simple to collect — just take home a

small barnacle-covered rock, bottle or piece of wood. Part of the salt water in the aquarium should be changed frequently to give the barnacles new food supplies.

Sea Anemones — These animals, which are often mistaken for plants, are shell-less creatures that live in most of the same places as barnacles. They seem to be attached to rocks or pilings, but actually have the ability to move slowly across a hard surface by means of a gliding action in their single foot. Like barnacles, they live by capturing food as it washes over them. When the tide is out they are almost invisible, lying like folded up blobs among the seaweed. As soon as the water covers them, their tentacles extend, searching for prey. Their tentacles have the power to sting small fish, but (except for some warm-water species) they are harmless to man. Thus, you can take home a rock with an attached anemone and watch it in your aquarium. Feed it pieces of liver with a pair of forceps or tweezers and watch how it eats.

Clams (other than hard shell commercial type) should be placed in jar aquaria two-thirds filled with muddy sand just as it is found (unwashed) on the beach where the clams are dug. They need the mud to help hold their shells together. Pour enough sea water into the jar to cover the mud two or three inches.

It will be interesting to watch the clams dig into the mud and extend their siphons to feed. The foot with which a clam digs may be seen clearly if the clam is placed against the side of the aquarium.

Snails — You can find several kinds of marine snails along the shoreline, including whelks, moon snails, mud snails and periwinkles. The moon snail is named for its moon-shaped shell. It glides along the sandy bottom on its one large foot and often leaves a trail that looks like someone drew a stick across the sand.

Periwinkles (which have ridged shells) and mud snails (which have smooth shells) are important scavengers along the shoreline. At low tide you will see thousands of them gliding across mud and sand flats as they feed on dead plant and animal material. Both are valuable because they help to keep the beaches clean and free of decaying matter. A few periwinkles or mud snails will remove uneaten food and droppings, and keep a proper balance in your aquarium.

FOLLOW UP ACTIVITIES

Students and teachers will become acquainted with a variety of marine animals and will observe them in their native habitat while collecting for their aquarium. This in itself is worthwhile.

By observing the animals in the artificial environment, further knowledge may be obtained and many questions may arise, and answers be discovered.

A variety of organisms maintained in the classroom often helps the student understand what he reads in textbooks.

Adaptations and the environmental requirements of organisms can be studied first hand.

Crabs may regenerate legs.

Barnacles will be seen waving featherlike legs through the water as they gather food. The shadow of a hand waved between them and the light will cause them to close tightly.

Sheds of barnacles, shrimps and crabs may be found in the tank, and perhaps these animals will be observed in the process of shedding.

Oysters will snap their shells together to purge themselves of waste material.

Sea anemones will draw bits of meat into their sac-like stomachs.

Animals may be used for demonstrating reactions to stimuli or to illustrate special structures and behavior patterns.

Many elementary school teachers use salt water animals to motivate instruction in spelling, defining words, and as subjects for composition and art. Pupils whose interests have been aroused are anxious to learn more about sea animals and plants and thus are led to read magazines and books.

Teachers and pupils often go to considerable trouble to return living animals to their native haunts after they have served their classroom purpose. An important lesson which these simple animals may teach all of us is a respect for life.

Salt Marsh — Estuarine Ecosystem; A Liquid Asset

E. ZELL STEEVER

A LUSH GREEN RIBBON of soft, salty, wet low-lying land borders much of the east coast of North America. This ribbon is the tidal salt marshes located in estuaries on the coast, a harsh transitional zone between the land and the sea. Together the salt marsh and the estuary make up a vital system, the salt marsh-estuarine ecosystem. It is possible to have an estuary and no tidal marsh but it is rare to have a salt marsh with no estuary. Salt marshes are generally located on the alluvial plains, where they are sheltered from the tireless grinding and pounding action of water waves by spits, offshore bars, peninsulas, and islands. These marshes are extremely important parts of estuarine ecosystems.

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One definition of an estuary is "a semienclosed coastal body of water that has a free connection with the open sea and with which sea water is measurably diluted with fresh water derived from land drainage." (Pritchard 1967.)

Of great significance is the tidal action that brings about the mixing of salt and fresh water and that is responsible for much of the nature of this ecosystem. Variability is a key feature of the system. Organisms living in this habitat exhibit wide tolerances. Solid substrates in marshes are rare, whereas extensive masses of soft bottom are common and the mud and sand flats are often exposed at low water.

GENERAL HISTORY

The retreat of the Laurentide Glacier occurred about 10,000 to 12,000 years ago. Terminal moraines and coast plains were laid down, and thus Long Island, the Islands, and Cape Cod resulted in New England. This coast was flooded and drowned at its river mouths by the rise of sea water level. The southern coast of North America, on the other hand, has not been recently covered with ice and has had more time, and has thus developed mature salt marshes and estuaries. Birds coming north after the retreat of the glacial ice probably brought with them the first seeds of cordgrass, **Spartina alterniflora,** and eventually this grass and other marsh grass were successful. As the cordgrass began to grow first, at the edge of the water where the tides covered the ground less than half the time, it trapped materials and the land became higher. The salt meadow hay, **Spartina patens,** then grew at upper elevations near mean high water and so a salt marsh begins. (Teal, 1965.)

The salt marshes begin as grassy arctic marshes in the far north of Ellesmere Island and extend to the St. Lawrence River. These are followed by small marshes tucked in coves and bays along the glaciated coast of the Canadian Maritimes into New England. These northern marshes are much younger than the mature, extensive southern marshes, which lie behind the

barrier beaches of the old unglaciated mid-Atlantic coast from New Jersey south to the semitropical salt marshes of Florida. There is no evidence today of the salt marshes in the glaciated coast along the New England coast that must have existed before the glacier of 12,000 years ago. The history of the growth of a New England marsh has been best studied by Dr. A. C. Redfield (1965) in the case of the Barnstable Marsh on Cape Cod. The records go back about 4,000 years, when the sea level was 18 to 20 feet below what it is today. The salt marshes need protection in their formation and thus often associated with that marsh is the sand bar formation, whereas other salt marshes develop in protected drowned river valleys. The marshes and estuaries of New England are not as continuous as are those to the south.

THE PHYSICAL ENVIRONMENT

The seashore is essentially an extension of the marine environment and the permanent animals and plants that live there are almost all of direct marine origin, with the exception of some remarkable plants, the cordgrass, and the salt meadow hay. They are of land origin. Air, water, tides, and waves all interact to produce a very harsh environment. The organisms of the estuary generally resume full life activities only when they are covered by water, which is their natural medium for gaseous exchange, photosynthesis, feeding, breeding, and excretion.

Salt water is a solution varying in salinity from 0% to 35%. It contains many salts and trace elements. Sea water is in many respects like blood, full of nutrients. Sea water is stable with respect to pH (alkaline-acid scale), due to the many chemical buffers that help maintain the pH between 7.5 and 8.4. Most near-shore organisms tolerate a wide range of salinity. The great specific heat of water and the simple volume of sea water make for a stable thermal environment. Sea water acts as a reservoir of heat and as a heat sink. Thus the seasonal changes may not be as severe as those which terrestrial organisms experience but the daily changes are very abrupt, due to the rise and fall of the tide in alternately covering and uncovering the habitats. The tide is considered to be the most important single factor governing life on the shore. The east coast generally has a semidiurnal tidal pattern with a range of 1 foot to 40 feet, depending upon location. The tidal cycle is, of course, directly related to the relative positions of the earth, sun, and moon and the earth's rotation. The tidal pattern is modified by friction, depth, shape of the ocean basin, and coastal geography. Hence, the tidal curves will vary from place to place. Wind and barometric pressure, nontidal factors, will further change and modify the actual water levels and times of high and low water; waves, a function of wind, affect life in two ways — first, by the wetting and splashing and, second, by the mechanical effects of pounding, tearing, and grinding. Substratum and types of material will dictate in part the types of plants and animals found. Rock areas are stable and one finds sessile or semisessile organisms living there. Sandy shores tend to move and shift and thus are more of a biological desert and will have generally burrowing life if any. Sand-mud shores have many burrowing organisms (benthic) and support more life than any other type of bottom. The mud-silt, the most stable bottom physically, supports few organisms because of the interference with many life processes. The clay in this type of bottom clogs gill surfaces. The oyster is an example of a filter feeder that would not do well on a silt bottom. The parent material, be it sandstone, limestone, or glacial granite, will modify the habitat and rate of geological change, and therefore the rate of biological development and evolution. The tidal action resulting in the tidal current which is responsible for mixing and flushing characteristics of the estuary-salt marsh ecosystem is important as: (1) nutrient trap, silt flocculation, and organic and inorganic transport, (2) plankton detritus, and dissolved organic transport, (3) waste removal, and (4) gaseous transport.

Two conspicious physiographic features of the salt marsh are the meandering creeks and the salt pannes or depressions in the marsh surface. The formation of creeks is a complex process (Redfield 1965) and is, in fact, responsible for drainage of tidal waters and the general movement and circulation of water there, as mentioned. This controls, in part, the distribution of organisms in the ecosystem.

PRODUCTIVITY

There is essentially no ecosystem in the temporate zone that compares with the salt marsh-estuary ecosystem in terms of primary productivity (amount of plant material produced per unit area per unit time). Thirty to forty metric tons per hectare per year are produced (Westveld 1963) as follows: (1) the salt marsh vascular plants consist mainly of cordgrass and salt meadow hay, (2) the algal mat and mud algae, and (3) the phytoplankton produce. The tidal marsh-estuary produces an excess of organic material. Less than 5% of annual net productivity is consumed by insects and other herbivores and three-fourths of what is consumed by those herbivores passes through the gut undigested and is available to other organisms (Smally 1959). This excess organic matter is made available to a host of consumers and decomposers. Filter feeds such as the oyster, horse mussel, and clam feed on the phytoplankton as well as the detritus. The mussel, for example, excretes large quantities of pseudofeces, which sink to the bottom and this results in the trapping of such elements as phosphorus. The phosphorous is thus concentrated and will become available for recycling in the ecosystem. The decomposer in the sediment, the bacteria, and other microscopic organisms, make the detritus available to phytoplankton and they in turn are available to the zooplankton and they to fin fish and the fish to birds, small mammals, and man. There exists a complex food web in the estuary as expressed by Shuster (1966).

The mud is generally anaerobic and it is where bacteria and nematodes live and reduce the organics. Thus the marsh is often horizontally stratified, not only with respect to salinity but also to free oxygen available at the surface (with an absence of oxygen in the muds). The exposed banks of the tidal creeks support dense populations of mud algae, diatoms, and dinoflagellates photosynthetically active all year (Pomeroy 1959). Pomeroy states that during the summer at high water the mud algae are most photosynthetically active and during the winter at low water the algae are most active photosynthetically. It is estimated that the marsh plants capture about 6% of the sun's energy reaching the surface of the marsh during the year. Another important aspect of the tidal marsh is the relatively large ratio of surface area to water area — high potential for productivity.

The detritus feeding community is different from a grazing community in several important ways. The plant-eating animals tend to be small rather than large, and the large animals are carnivores rather than herbivores. Food supplies, because of the time required for decay, is evened out over the year; thus the detritus feeders have a constant supply of food available. So the marsh-estuary ecosystem is important in terms of productivity for several reasons: (1) it is a nutrient trap, (2) nutrients are recycled in a relatively short time, (3) growth and production take place the year round, (4) mixing of

fresh and salt water, and therefore nutrient transport and waste removal, is continuous. Ten tons of grass per acre per year or 300 pounds of scallops per acre per year is not uncommon value for estuarine productivity.

PLANTS

The tidal marsh can be seen from the point of view that it is a land form resulting from the invasion of shallow waters by land plants, mainly the cordgrass the salt meadow hay. The tide and salinity are again foremost in the mosaic of the waving acres of grasses that make up the complex, distinctive, and clearly demarked plant and animal associations. The kinds, abundances, and sizes of the vegetation depend upon environmental factors such as (1) air and water temperature, (2) salinity of water and duration of inundation, (3) salinity of ground water and level of water table, (4) the tidal range, (5) marsh elevation, (6) substratum, (7) the climatic considerations, (8) geological evolutions, and (9) man. Salt marshes begin as mud or sand flats and are first colonized by algae and eel grass. As organic debris and sediment accumulate, the cordgrass will be the first to become established. The stiff leafy plant (up to eight feet) grows best along the creek banks where it is submerged during each high tide. The cordgrass forms the low marsh, a marginal step between the open mud flat and the tidal and high marsh grass area and high tide mark. The nest plant is usually the band of short greenish grass, salt meadow hay, and this is covered only at high water. This grass is so heavy and forms such a tight, dense mat, that few other plants grow in this zone. The next zone on higher ground is the black grass, a rush, **Juncus geradi.** Often near the high tide mark between the cordgrass and the rushes may be zones of poorly drained saline areas or disturbed areas where sea wort, **Salicornia europaea,** or **S. virginica,** a fleshy succulent jointed stem plant, grows, often wth stunted cordgrass. Above the black grass grows a belt of switch grass, **Panicum virgatum.** The upper limit of the marsh is reached with such species as the cattail, **Typha** (fresh water areas), the reeds, **Phragmites communis,** goldenrod, **Solidago sempervirens,** and **teniufolia,** and marsh elder, **Iva frutescens. Distichlic spicata,** a salt grass, may be found in all belts above the low marsh and seems to have wide ecological tolerance. Miller and Egler (1950) discuss in detail the zones of vegetation in a salt marsh in southern New England. Salt marsh pannes support a distinctive vegetation of two types: (1) the firm bottom panne of sufficient depth to support dense growth of wigon grass, **Ruppia maritima,** and is surrounded by forbes, especially sea-lavender, **Limonium carolinianum,** (2) The shallow depression often has heavy algal growth, crusts, and sea wort often occurring with stunted cordgrass and small forbes.

AN INDISPENSABLE ECOSYSTEM

A majority (two-thirds) of our commercial fish and shellfish come from or at least live part of their life cycle in the estuary-salt marsh ecosystem. There are organisms that live and spawn at sea and come to the estuary to mature, such as the mullet, menhaden, and shrimp. Other species spawn in the estuary, such as sea trout, and live at sea. Others pass through the estuary-salt marsh going to spawning grounds in fresh water. Such species are the striped bass, shad, and alewife. Some organisms spend their entire life in the estuary, such as shellfish, crabs, and bait fish.

Many birds (some 60 species) are known to inhabit the marsh either as permanent residents or migrants. It is breeding ground for some and place of rest and food for others. The marshes and estuaries have existed all along the coast for thousands of years. Fish and birds have evolved, depending on finding marshes all along the coast and if the habitat is destroyed we will destroy the species that depend upon this habitat.

The variety of the estuary-salt marsh ecosystem is essential to the health of nature. The area can be broadly considered an ecotone, a transition between the land and the open sea. The marsh will, in itself, be marked by a lack of variety — but in spite of this it lends a variety to the larger scene. The marsh ecosystem bears a strong resemblance to the artificial agro-ecosystem. But, interestingly, the marsh is free of devastating pests. The harshness of this environment apparently keeps it simple and free from "pests."

Then the marsh becomes a model for study — for the salt marsh is one of the most productive food factories in the temperate region. The marsh is also a storm buffer and a flood control agent. Probably the most significant fact is that the marsh is a beautiful, viable, dynamic part of man's total environment. As a comment on the imminent destruction of many of our salt marshes, Pogo may be quoted: "We have met the enemy and he is us!"

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Tidal Pools — Miniture Oceans

by LINDA PERRY PLAKE

HOW OFTEN HAVE YOU WANDERED over a stretch of rocky beach at low tide and passed pools of water trapped in the rocks, giving them no more than a casual glance? Little did you know the experience you were missing, as these small pools harbor an interesting and assorted population.

Tidal pools are found in the intertidal region of rocky shores, usually as a result of the jumbled array of boulders and rocks, or in a depression or crack in the rock face that forms the shore line. At high tide these areas are covered by water, but as the tide ebbs some of the water is trapped to form tidal pools, which remain until once again the tide washes in.

Although in the title I have referred to tidal pools as miniature oceans, this is perhaps not entirely correct. The conditions of the tidal pool are in many ways unique and present their own special problems, which do not exist in the ocean. In our local area the tides are semidiurnal, meaning there are two complete cycles in every 24 hours — two highs and two lows. This means that the tidal pool is isolated from the ocean for periods ranging from 6 to 11-plus hours, depending on where in the intertidal region

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from **Pequot Trails**

the pool is located (a pool at the mean high-water mark would be formed once the tide began to recede and would not be inundated until the tide reached that height again nearly 12 hours later). To add further to this situation of isolation, some tide pools are reached only by spring tides with every new and full moon leaving them isolated for the intervening weeks. Thus, for a period of several hours or days this trapped water is the complete support system for the inhabitant of the pool. In a deep pool with a not overly abundant growth of algae but a large faunal population, the oxygen level may drop to a critical level before the tide is due to return. For organisms which cannot simply close up, as the barnacles can, this may prove detrimental. In a shallow pool with a large surface-to-volume ratio the wind may provide enough agitation at the surface to put oxygen into solution and to bolster the available supply, and in this way alleviate the problem of oxygen consumption.

Temperature is a factor to be reckoned with. On a sunny day if you were to measure the temperature of a shallow pool you would discover that it is quite warm, 26°C or so. When you consider that the temperature of the North Atlantic ranges from 10° to 20° C, the temperature of the tidal poo! water becomes significant. The flora and fauna must be able to withstand these daily extremes as the pool is alternately isolated and flooded. Temperature also affects the problem of oxygen supply, although it may not figure significantly in most tidal pools. The relationship is that cold water holds more oxygen in solution than warm water and, theoretically at least, as the water of the tidal pool is baked by the sun, some of the oxygen would be forced out of solution.

A third factor is salinity. If water evaporates from the surface of the pool the salts are left behind, and this increases the salinity of the remaining water. This alone can have a strong selective effect on an organism, as many cannot tolerate an appreciable increase beyond the average oceanic salinity of 35%. On the other hand, some pools are subject to considerable dilution by precipitation, or fresh-water runoff and seepage, or both. The resulting alkaline conditions naturally support a somewhat different community.

The final major factor to consider is light. Sunlight being essential for photosynthesis to take place, naturally the degree to which the tidal pool is exposed or shaded will affect the growth of algae, which in turn will in part determine the size of the faunal population. Also, water temperature and evaporation rate will be influenced by the exposure of the pool.

Having some notion, now, of the major physical factors which influence the microenvironment of a tidal pool we can discuss some of the permanent members of the tidal pool community. It must be kept in mind that these factors, and the degree to which they influence conditions, vary from pool to pool, and thus the community does also, but it is this variability that contributes to the fascination of the tidal pools.

As you seat yourself beside a pool, probably the first thing you would notice would be whatever is present in greatest profusion. Often this proves to be great masses of **Enteromorpha intestnalis,** a bright-green alga whose individual thalli have a narrow tubular blade, which is often crimped or twisted in places, hence its specific name. The length of the blade varies with the degree of agitation of the water. The usually calmer water (in comparison to the surf) of a tidal pool results in longer blades. Overlying the **Enteromorpha,** which grows on the sides of the pool, may be a zone of rockweed or **Fucus**, a brown alga. When the tide is in and the pool is under water, the **Fucus** is erect, but with the water level below the flotation bladders the **Fucus** flops over on top of the **Entermorpha.** This actually proves to be beneficial in that the **Fucus** protects the **Enteromorpha** from the sun, and the **Fucus** itself is very resistant to dessication.

Another green alga to be found is **Cladophora,** which is usually present in tidal pools as dense tufts of fine grass-green filaments only a few inches in height. Another alga — also common but not likely to be confused with **Cladophora** — is the red alga **Chondrus crispus**, or Irish moss. Its tufts are easily distinguishable not only by color but by the flattened blade which is dichotomously branched repeatedly, resulting in a bushy effect. **Chondrus** is collected for human consumption in some areas along the shores of the North Atlantic.

A final touch of color is added by two encrusting red algae: **Hildenbrandia prototypus,** which is scarlet, and **Phymatolithon laevigatum**, which is a dusty rose color. Both cover rocks and shells in a thin layer, adhering to the point of almost becoming part of their substrate.

Such then is the plant life of the tidal pool. This algal jungle is by no means devoid of inhabitants. First, one may not notice the periwinkles (**Littorina sp.**) usually in abundance, moving over the algae-encrusted rocks and up and down the thalli of the macroscopic algae. As they move they are grazing, their radulae constantly scraping, scraping, loosening the microscopic algae and the epithelial cells of the macroscopic forms that compose their diet. The radula is a fleshy strip wth rows of chitonous teeth, the arrangement of which has been used in classifying different groups of gastropods. There are several species of periwinkles found in tidal pools; the smooth or common periwinkle (**Littorina litorea**), which is delicious to eat, is found throughout the intertidal region. Like the rough periwinkle (**L. Saxatilis**), it can withstand long periods of exposure and is found permanently even in the upper limits of the tidal zone. The small, yellow, smooth-shelled periwinkle may well be **L. palliata.**

Two other gastropods that may also be found attached to a substrate or slowly moving about are **Crepilula** and **Acmaea.** The genus **Crepidula** has an oval, boat-shaped shell, hence its common name of boat shell (also called slipper shell and jingle shell). The three species common to our area are: **C. fornicata,** having a white shell 2.5 to 3.7 cm long, the most boatlike in appearance, the separate gastropods often found stacked one on the other; **C. glauca,** smaller and grey-green in color; and **C. plana**, flat, a shiny, translucent white in color, and usually found cemented to the interior of discarded shells. **Acmaea testudinalis,** the common limpet, is slightly similar in appearance to **Crepidula,** having an unwhorled shell and no operculum (both characteristics of **Littorina**), but is more conical in shape and lacks the diaphragm ("deck") of **Crepidula**. These organisms are said to return to the same spot after every foraging expedition, a trait not attributed to **Littorina** or **Crepidula.**

Mytilus edulis, the edible blue mussel, is found in many tide pools, its two-tone blue shell holding the color of the sky. When undisturbed the two valves of the shell open approximately 0.4 cm, revealing a soft-brown convoluted mantle. The gastropods we have just examined move about and hold themselves in place by means of a powerful foot. The mussel's foot is weak and instead is equipped with glands to spin a byssus of strong, coarse fibers, which the mussel uses to anchor itself or move about in a slow manner. These fibers also trip debris, which is washed into the pool by the tide, adding some variety to the algal diet available, and also giving any "riders" a chance to move off into the pool. Continued next page

Fiddler Crabs

Spring in the salt marshes brings out one little animal which has been spending the winter in semi-hibernation several feet below the surface. This is the fiddler crab, of which there are several species, **Uca pugnax** being most common in the marshes. The males have one very large claw, and the name fiddler comes from its analogy to a violin held up against a bow, the smaller claw. The big claw serves a number of purposes, to threaten other males, to fight, to communicate with others, even to attract the female of the species.

Uca pugnax is not found much farther north than Cape Cod. Another species, **Uca pugilator,** which ranges as far north as Boston, lives on sandy and muddy beaches near the high-water mark. The two kinds are hard to tell apart. The difference, aside from their habitats, lies in the large claw of the males. The inside of **pugnax's** claw has a rough, oblique ridge which is lacking in **pugilator.** A third, less common species, found from Cape Cod to Texas, is the big, or red-jointed fiddler crab, **Uca minax.** It is much larger than the other two species and is found far up in the salt marshes where the water is brackish to fresh.

These entertaining little crabs, which can scuttle fairly rapidly into their holes when danger approaches, live, at least in northern latitudes in large communities. They make many burrows into the mud which slant down nearly three feet and end in horizontal rooms, with entrance holes that can be plugged and sealed off against tidewater. When burrows are being dug fiddlers roll mud, or sandy mud, into little balls which are pushed out from the holes onto the surface.

Fiddler crabs feed on minute animals which they pick out of the sand and mud. Although they shed their eggs into the water when the embryos are just at the hatching stage, and the larvae are water-born for about the first month of their existence, adults are unable to swim. They feed on what the water brings them. In other words, tidal waters bring in large quantities of nutrients to the peat and mud banks where the fiddlers live, so that they can have their food at their doors, and do not need to swim. Those which live along the beaches can take advantage of salt water plankton that gets washed in by the tide and is left in ridges or windrows of sand.

TIDAL POOLS Continued

Although many people think the acorn or rock barnacle (**Balanus balanus, B. balanoides**) is a mollusk because of its calcareous plates, it is actually a crustacean. The animals often occur in such number as to cover the rocks completely. When extremely crowded, the shell will loose its flat-topped cone shape and instead become extremely elongated. In any case, as you watch you will realize that at the rate of 80 to 100 times per minute the opercula are opening and the barnacles' cirripeds, or "feathery feet," are extended and waved in a regular rhythmic motion. This is how the barnacle feeds, its cirripeds straining the plankton from the water. In summer if you look inside the empty shells of barnacles that have died you might well find many tiny periwinkles seeking refuge.

Another crustacean you may have met (accidentally) by this time is the green crab, **Carcinus maenus.** It is small, 3.7 to 5.0 cm long, and may be found lurking among the algae, especially the prostrate **Fucus.** As its name indicates, it is green in color.

This is by no means a complete discussion of what might be found in a tidal pool, but rather gives some of the permanent population which may be readily recognized. When the tide comes in, it brings transient organisms; it mixes the water and replenishes the supplies of oxygen and nutrients. Once this periodic rejuvenation is completed, though, and the tide recedes once more, the tide pool reappears, essentially unchanged — in some ways a comforting recognition.

Major Review of U.S. Plants For Endangered Status

More than 10 percent of all plant varieties in the United States are being reviewed for possible classification as endangered or threatened species. The areas where the plants exist are also being studied to determine if they qualify as "critical habitats."

The review, announced by Keith M. Schreiner, Associate Director of Interior's U.S. Fish and Wildlife Service, was undertaken in response to a report prepared by the Smithsonian Institution. The Smithsonian was directed to review the status of plants by the Endangered Species Act of 1973. The report found that of the more than 22,000 kinds of seed plants and ferns native to this country, about 2,800 are likely candidates for either the threatened or endangered lists. The report also found that 355 kinds of native plants are thought to be extinct.

A majority of the plants to be reviewed are found in Hawaii, California, Florida, and Texas. In Hawaii over 1,100 species, almost 50 percent of the State's native plants, are on the list. Other major concentrations of the plants are found in the Pacific Northwest and the Southern Appalachian regions. At least one plant on the list is found in each State.

Many types of wildflowers are on the list such as lilies, irises, orchids, primroses, and columbines along with the more bizarre species such as the venus fly trap and some pitcher plants. Cacti are particularly hard hit with an estimated one-third of all their species believed to be either threatened or endangered. Among the trees to be reviewed are the Florida royal palm, a 120-foot giant with nine-foot leaves, and several types of oak, ash, cypress, willow, and hawthorne. A considerable number of shrubs and grasses are also on the list. None are major food sources for humans.

The precise reasons for their decline are not yet known; however, it is generally agreed that the destruction of habitat and commercialization have been major causes. Plant habitats are continuously being eliminated by strip mining, overgrazing, timber harvesting, suburban development, road construction, flooding, irrigation, stream channelization, fire, and the drainage of bogs, swamps, and marshes. Commercial and private collectors have been largely responsible for threatening the survival of certain groups of plants, especially cacti. Some of the most rare and beautiful cacti are collected by the truckload and may bring several hundred dollars each. Competition from foreign species has also afected native plants. Over 2,000 species of foreign plants have been introduced into the United States. Some, such as the common dandelion from Europe and the honeysuckle from Asia, can become firmly established in new areas and choke off older and more delicate plant types. Disease and pollution have also depleted these plant populations.

Today most of the plants to be reviewed have extremely limited ranges and are often confined to bogs, marshes, river banks, mountain tops, canyon rims, and similar inaccessible areas.

"This is the first attempt ever made to assess the status of plant life on a national scale," said Schreiner. "Many of the plants have never been intensively studied before and little is known of them in terms of population trends, growth, and reproductive rates.

"Naturally, in large scale reviews such as the one we are now undertaking, the actual listing of the species and the determination of their critical habitats could take several years. However, as in our listing of animal species, priority is being given to those species which could best be helped by listing."

The Fish and Wildlife Service is seeking the views of the Governors of the States in which these plants are thought

Nature's Newest Gauntlet

EDMUND NORTHRUP MOOT
"The Penner of Pinewald"

Nature is NOW meeting its most severe challenge. Man, in his desire to master the universe, pays little heed to NATURE's long evolutionary trek from the origins of life, on this globe, to the present explosion of our population. Thus in our efforts in straight nature study education we MUST expand our intensive efforts in social, economic and public relations areas. The public, generally, has hidden its head in the sands of total indifference to our global environment.

The Pinewald Society, in its annual "Think Tank" sessions in the beautiful Beargulch Valley of historic Schoharie County, N.Y., suddenly discovered the atmosphere of the "Cap'n Bill" philosophy. His Atlas of his hometown of Norwell, Mass. has added inspiration to this eleven-year-old society. The Pinewald Society has no officers, no yearly dues and never has a stated speaker at its annual sessions. The visiting interchange, during one whole day, has developed many new ideas which man, in his rapid thrust into the future, has forgotten.

More than six hundred deeply interested folks have attended the Pinewald "get-together" in the past eleven years. Every person who comes to this high spot on the edge of the northwestern Catskills has been steeped in the philosophy of Thoreau, Muir, Burroughs, Liberty Hyde Bailey, Governor Pinchot, and many others who have seen, experienced and forecast the fate of man's encroachment on nature's domain.

The thrust of thinking of those who share in Pinewald philosophy digs deep into early land history, change of cultural outreach, and those elements of *modernity* which have literally changed the face of the American continent. Man's urgent quest for energy has caused huge machines to literally tear up the face of the earth in many places where hidden energy sources have lain submerged as our globe evolved. New sources of energy *must* be found. Yankee ingenuity, which has made America reach its present state of technical excellence and affluent prestige, must be revived. The "thinkers" at Pinewald would like to see our government establish incentives for the back woodshed, small barn or cellar workshop where men with mechanical skill could set aside effort, time, and inventive skill for the future of mankind, away from the congested *city ghetto* type of life which, if allowed to further expand, can smother all of us.

The first requirement of the direction to which all of our national resources must be directed, is the discovery of *new* sources of energy which do not deplete the reserves which have taken nature millions of years to develop. Sunlight *must* be harnesed to provide heat as well as electric energy. Some future genius could contrive to construct a small, family size machine for the conversion of household waste into electricity.

The men now engaged in research on the control of wind resources should have all the encouragement possible. The old style wind mill, as well as the new wind wheel constructed in the back room of an ingenious mechanical technician, and perhaps some form of wind tunnel to force electrical generation, should have the complete sympathy of our engineering colleges and government services, regardless of whether or not the innovator has a university degree. We have known for a long time that mechanical skill is a separate type of potential of certain individuals who may not show proficiency in routine educational patterns.

Incentives, not necessarily monetary, should be used in developing pride in land ownership. Today the curse of added taxation when one beautifies one's own property discourages proper landscaping and care of wooded areas. The tax men seem to be just "watching" for that citizen who has intense pride in the care and maintenance of his own land.

Hundreds of thousands of our citizen families have sought "homes away from home," usually in areas where land has proven to be unprofitable for basic agriculture. This land is often covered with a "brush lot" type of flora, especially where the land has been neglected for many years.

Nature Study education should be directed toward these family units which flee the fate of megalopolis living. Any family unit, when working in unison and when following the sound tenents of *natural care* of the land, can turn small acreage into a landed paradise. The young boy or girl who gets his or her hand or fingers in a piece of soil and notes how nature can blossom its full regalia, has deeper respect for creation, the astounding phenomena of growth and the fruitful way in which nature responds to T-ender L-oving C-are.

Many of the annual visitors to the Pinewald Society meetings are encour-

The meeting of the Pinewald Society, June, 1974.
Photograph by the staff of Outdoor Biology Instructional Strategies (OBIS) Lawrence Hall of Science, University of California, Berkeley

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to occur. Other interested persons are encouraged to submit any factual information relevant to this review to the Director, U.S. Fish and Wildlife Service (SE), Department of the Interior, Washington, D.C. 20240.

A Can of Sea Worms

by DONALD J. ZINN

The world of marine worms has been known to man for as long as he has lived along the shores of salt waters. For hundreds of years, all worm-shaped marine invertebrates were considered to be closely related with the result that the first naturalists, and indeed many of their colleagues of later centuries, failed to notice the striking structural and environmental differences that warranted their being placed in distinct groups.

So it is that the varied natural and man-made beaches and subtidal bottoms of the Cape Cod shoreline are inhabited by an unexpectedly large number of interesting species of unrelated groups of free-living worms. Perhaps the best known class of local worms living in the sediments washed by the tides are the polychaetes (Polychaeta) whose most economically important member is the iridescent clam worm, **Neanthes virens** (formerly called **Nereis virens**) which reaches a maximum length of about 18 inches and is a bait much sought by coastal fishermen.

Polychaetes live in sand and mudflats, and once their tracks and trails become sufficiently familiar they can be collected with relative ease. Worms, being soft bodied, self-destruct easily and should be narcotized with fresh water or Epsom salts or refrigeration, and then preserved with seven to ten percent neutral formalin. Worm burrows may be distinguished from other holes in the sand or mud by their characteristic piles or casts of material, their conical sunken depressions or elevated cones, or by the presence of bits of detritus incorporated in tubes barely extending above the sand surface.

It is not always easy to dislodge a burrowing worm. Those living in long, relatively deep tubes may be able to descend as fast as the shoveller can dig. They or their tubes may be easily broken or fragmented, or they may disappear altogether if the substrata around the dug hole caves in. The plumed worm, **Diopatra**, for instance, lives in long parchment tubes into which are woven camouflaging bits of shell, seaweed and other debris. The shovel must be pressed quickly into the sand close behind the tube of this animal with as little mechanical disturbance to the substratum as possible, and the now-unearthed tube containing the animal grasped immediately underneath to prevent the worm from rapid escape.

Polychaetes are close marine relatives of terrestrial earthworms and fresh and saltwater leeches, and together with these other two groups form the segmented round worms that belong to the phylum Annelida. Rings around their bodies, both internally and externally, separate annelids from all other worm groups. Polychaetes typically have paired bristle-like appendages on each segment (Polychaeta means many-bristled), and along the sides of the body there are fleshy paddle-like lobes, filaments or other paired structures which may be used for swimming, burrowing and/or respiration, depending on the species. The bristles have a great variety of shapes and are often used to distinguish one species from another.

Polychaetes live in many ways: most often as tube dwellers that trap and filter their food, and sometimes as nomadic predatory animals feeding on other soft-bodied creatures. Nearly all of them have varying combinations of tentacles, antennae, cirri (slender small projections) and palps concentrated near the anterior end that provide acute senses of taste and touch and most polychaetes have at least one pair of these structures on the roof of the head. Sexes are usually separate. Eggs and sperm are shed freely in the water, sometimes in response to temperature change, but often cyclically in tune with the tides. The egg hatch into larvae which drift with the currents for a varying number of days before settling to the bottom and metamorphosing into adult worms.

The crawling polychaetes live beneath stones and shells on the large algae and in communities of sessile organisms such as mussels and barnacles. They include such forms as **Neanthes virens,** the clam worm and its close relative, **Nereis limbata; Cirratulus** with its long threadlike filaments that function spectacularly as gills; and the scaleworms, **Harmothoe** and **Lepidonotus**, with their peculiar dorsal, paired, platelike scales. The burrowers like **Glycera**, the beakthrower; **Lumbrinereis**; **Ophelia**; the capitellids; **Arenicola,** the lug worm; and the magnificently colored **Cirratulus**, the fringed worm, all move through the sand or sand mud substratum by peristaltic contractions.

Polychaetes live in a variety of ways; many of them have become tube dwellers. Among these are the carnivorous worms. **Diopatra,** the plumed worm, incorporates fragments of its environment into its membranous three-foot tube. **Clymenella**, the bamboo worm, lives head downward intertidally in delicate sand tubes. The beautiful fan worms or feather dusters include such common forms as **Sabella, Potamilla, Hydroides, Serpula** and **Spirorbis,** that build either straight tubes of sand grains and mucus or uniquely-shaped calcareous tubes attached to different kinds of surfaces. **Pectinaria,** the mason or gold-tooth worm, builds delicate-appearing but sturdily formed tubes in the shape of ice-cream cones. It is commonly found in many of our sand flats, as is one of the most beautiful of our coastal worms, **Amphitrite ornata.** The phosphorescent cream-white parchment-tube worm, **Chaetopterus,** lives in a two-foot-long, U-shaped tube of self-manufactured parchment, often with a species of the symbiotic pea crab, **Pinnotheres,** keeping it company.

Another group of common, but far less well-known, marine polychaetes are the possibly primitive archiannelids, charactristically tiny worms that live mostly intertidally on or between the sand grains, in mud or among algae. They differ structurally from the polychaetes mostly in the possession of very few setae (bristles), the reduction or absence of parapodia and certain other appendages, and the addition of external hairlike cilia that en-

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DR. ZINN is Professor of Zoology at the University of Rhode Island and author of the recently published "Handbook for Beach-strollers" (University of Rhode Island Marine Bulletin #12) from which this article was adapted. — from **The Cape Naturalist**

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aged to use their own acres of wooded land to help teach "the man" on the street that it takes a whole century to grow a marketable tree, that nature *must* be respected in the deep forest, and that careful weeding is essential in the development of any floral species. Nature has its own way of natural selection of the fauna to survive, but man *must* use his knowledge to ensure survival of endangered species.

Study of *nature,* where it is happening, can plant seeds of inspiration in the mind of any active boy or girl, or geriatric man or woman. Those of us who are older must not isolate ourselves from the Mod scene. We must be inside it and nosing around, discovering and adding to the spirit of preservation of our environment. Our appeal, as emanating from the Pinewald Society is: let the ghettoized mass of humanity know what takes place with the *Flora* and *Fauna* in Nature's World.

NEWS and NOTES *for Environmental Education . . .*

ERDA-Supported Study Says Solar Heating Competitive With Electric (Baseboard) Heat

Solar heating can now compete economically with electric baseboard heating for well-insulated new homes in major population centers throughout most of the United States.

This is a conclusion of a new study prepared for the Energy Research and Development Administration (ERDA) by the METREK Division of the MITRE Corporation. The study also suggests that if the cost of solar heating drops 25 percent from the present level, it would then be competitive with fuel oil or electric heat pumps in many areas.

According to the study, a solar system is considered to be "economic" if annual fuel savings exceed annual payments of principal and interest on the solar system within five years, or if it pays for itself through lowered fuel costs within 15 years. By this definition, a solar heating system is now considered economic as a principal replacement for electric resistance (baseboard) heating in each of the 13 cities studied with the exception of Seattle, where electric rates are among the lowest in the nation.

"Our goal," said Dr. Henry H. Marvin, Director of ERDA's Division of Solar Energy, "is a 50 percent reduction in the cost of solar installations by 1980, through market competition, improved performance, reduced cost of equipment and installation, and possibly incentives."

"At that price, solar heating could be competitive with all fuels, including natural gas, in most regions of the country."

The study involves fuel cost and weather conditions and analyzes the cost of ownership in regions of the United States centered at Atlanta; Bismarck; Boston; Charleston, South Carolina; Columbia, Missouri; Dallas-Ft. Worth; Grand Junction, Colorado; Los Angeles; Madison, Wisconsin; Miami; New York; Seattle; and Washington, D.C.

It is assumed in the study that the homes are new and are not old ones being retrofitted; that the homes have a brick veneer, an asphalt roof, storm windows and 12 inches of insulation in the attic; and that the solar system is the primary heating system with a conventional heating system as backup.

Dr. Marvin said: "This study can assist a prospective homeowner in determining whether he can save money by installing a solar system for heating and hot water when building his new home. But it must be used with caution because there are many factors that can change the estimated savings in any specific application."

Chief among these factors are the price the homeowner pays for his solar heating system and a comparison of this cost with operation of increasingly expensive conventional heating systems. Data in the study assume that a typical installed solar system today costs the equivalent of $20 per square foot of flat-plate collectors used in the system. The homeowner must determine how long it will take to repay his capital investment based on his particular interest rate, fuel costs and upkeep. Savings accrue due to the rising costs of gas, oil, or electric heating.

Optimum collector sizes generally range from 20 to 30 percent of the square-footage of the house, depending on local conditions. Thus, the $20 per square foot cost would mean a price of $6,000 to $9,000 for a well-insulated residence with 1,500 square feet of living space.

The present market offers systems at both lower and higher prices than $20 a square foot, and with different levels of performance. The study chose a representative cost and performance.

If a solar system comparable to the study model could be purchased for $15 per square foot installed (a reduction of 25 percent), it would be competitive with electric heat pumps in Bismarck, Grand Junction, Los Angeles, Madison, and New York City, and with oil in Atlanta, Bismarck, Charleston, Grand Junction, Los Angeles, and Miami.

According to the study, if the price drops to $10 a square foot by 1980, solar can be competitive with oil in all cities studied and with natural gas in all except Bismarck, Charleston, Columbia, Madison and Seattle.

The MITRE report will be published soon by the Government Printing Office. Further information on solar heating, including price and instructions for ordering this report, may be obtained from the National Solar Heating and Cooling Information Center, P. O. Box 1607, Rockville, Maryland 20850, or by telephone toll-free from 800/523-2929 (in Pennsylvania 800/462-4983).

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able them to glide on and through their tortuous habitat.

Animal behaviorists have found certain polychaetes particularly useful in studies of associations among animal species in widely separated groups. For example, Demorest Davenport discovered a puzzling series of alliances involving food-sharing between certain scaleworms including **Harmothoe,** and a variety of echinoderms including starfish, brittle stars, sea-urchins and sea-cucumbers. In one case, a species of starfish was found able to release sufficient chemical attractant into the surrounding water to stimulate the approach of the polychaete from quite a distance away. It was also found that wounded or dying echoniderms had a repellant action on the scale worms, thus sparing the polychaete a relationship that would yield no food.

Additional studies in this field indicated that one species of polychaete was a willing partner (commensal) with 13 kinds of animals belonging to four phyla, and that different species of small scale worms live with certain forms of tube worms, presumably sharing the food of their large, fat, soft cohabitors.

A classic case of commensalism occurring between **Nereis** and certain species of hermit crabs has been investigated by inducing both the worm and the crab to accept an artificial shell of glass. According to R. V. Gotto, it was then observed that **Nereis**, which normally occupied the upper whorls of the shell, would glide forward when the crab was feeding, seize a bit of food from the crab's mandibles and quickly retreat with it to the depths of the shell.

Attention ANSS Members !

Dick Baldauf has suggested that I extend my activities as coordinator of ANSS Workshops (or institutes) to include public lectures. Those of you who are doing workshops for ANSS and others whom you recommend, as well as public lectures on related subjects, will be listed in some national magazines. Those of you who are not involved in such an activity for ANSS at the present time are hereby officially approached to serve, if and when such requests are made that can be conveniently scheduled by you. Our expenses should be restricted to travel, accommodations, meals and supplies. Perhaps you will wish to specify how

many times per year you would be willing to participate in such a program.

It is evident that the workshop idea by special ANSS members is growing. We would like to include more names for this service as well as those who prefer lectures only. Perhaps something of this kind has been done before by ANSS and I don't know about it. Such a service where requested within decent proximity to the person's own base should not work a hardship on most of us, busy as we may be.

We would like to have your comments, and if you are willing to participate in such a program, we would like to have you prepare a statement of your background, experience and topics for lectures or kind of workshop you would be willing to conduct. If you have names of others whom you recommend without reservation please include such names with your own personal statement.

Enthusiastically,
Ruth W. Melvin
Chairman

Environmental Education Activities Manual

The second printing of the *Environmental Education Activities Manual* is now available for distribution.

This six volume series of over 300 classroom activities is designed to help students understand basic environmental education concepts, develop problem-solving skills, clarify environmental values and become involved in community action. The series also provides guidelines for integrating environmental education into existing curriculum, K-12.

This privately published Manual has been enthusiastically received in colleges and universities, school systems, agencies, environmental centers and nature centers in most of the states and many foreign countries. The series has been used extensively as a text for college courses and workshops for teacher training.

The editors are William B. Stapp, Chief, Environmental Education Unit, UNESCO, Paris, France, and Dorothy A. Cox, classroom teacher, Clarenceville Public Schools, Farmington Hills, Michigan.

Environmental Education Activities Manual. Six volume series. William B. Stapp and Dorothy A. Cox, editors. 1974. 1016 pp. $10.00 postpaid. Available from Dorothy A. Cox, 30808 LaMar, Farmington Hills, Michigan 48024.

ANSS Book Exhibit

Any American Nature Study Society member who wishes to have his or her published work displayed in the 1977 American Nature Study Society Book Exhibit is urged to send the book(s) to John J. Padalino, coordinator.

We are trying to update the exhibit by obtaining books from ANSS authors who have not yet participated in the exhibit and by obtaining new books from publishers who have. Any ANSS member who has written, edited, or illustrated a book on nature study is eligible to participate. Those interested should contact:

John J. Padalino
Pocono Environmental Education Center
R. D. 1, Box 268
Dingmans Ferry, PA 18328
(717) 828-2319

In an effort to update the exhibit, we recently requested publishers of all the books in the 1976 exhibit to send new editions; so far, many have complied.

The 1976 exhibit was displayed July 5-18 at the New Jersey Audubon Summer "Vacation with Nature" workshops at the Pocono Environmental Education Center. Participants used the exhibit as a resource library as well as to learn what has been published in the nature study field.

The exhibit will be displayed at the New York Outdoor Education Association Conference October 8-11. Anyone wishing to obtain the exhibit should contact Mr. Padalino at the above address for an application form.

MacFarlane Awarded Medal by Humane Society

John C. Macfarlane of Pembroke, Mass. has been awarded the Joseph Wood Krutch Medal of the Humane Society of the U.S. for his lifetime efforts to obtain humane treatment of livestock. His statement follows:

"For 50 years I have tried to the best of my limited ability to encourage human attitudes that would be constructive and humane. These are trying times in human history, and unless we learn to use wisely the knowledge that is available to us all, we may one day reach a point of no return – and suddenly find that our genus is no more.

"Each year, because of human indifference, we waste enough meat to feed almost two million human beings – most of it preventable. We "hot" brand cattle and ruin millions of hides; we handle livestock in such ways that build up high stress levels that cause them to be classified as "dark cutters" and "stiff" cattle – that sell for less when they are slaughtered.

"We lose 20 million pigs out of every 100 million farrowed, and at least 30% of this loss is man-caused.

"When man decides that he will no longer live with a disease, and he strengthens his attitude to "get the job done," he most always gets the success he seeks.

"Perhaps one day man will change his attitude toward his own *unwillingness* to look upon cattle, sheep, swine, *et al* as living, sentient creatures – and not "things."

"If and when that day comes, we will have taken a forward step toward that moment in human history when we will deserve to be called "civilized."

New York and New Jersey Respond to Aluminum Recycling

The amount of aluminum turned in for recycling by consumers in New York State and New Jersey during the past year is impressive.

According to figures released by Reynolds Aluminum Recycling Company which has just completed its first full year of area-wide operations, the equivalent of more than 74 million aluminum beverage cans were collected. If laid end-to-end, these cans would cover a distance of more than five thousand miles!

Over one-half million dollars in cash was given to school children, housewives, and other interested persons for the beverage cans, foil, food trays, and other household aluminum they brought to Reynolds mobile recycling vans which now cover both states.

More than 1600 tons of recycleable aluminum was collected during the past year.

Although the first year can be counted as successful, the future should be even more promising. Since Reynolds began its consumer recycling program in 1968 it has seen growth every year.

In the last nine months of 1975 across the country, more than two and one-half times the aluminum collected in 1974 has been turned in for recycling. About 63 million pounds have been turned in compared with about 25 million during the same period last year. Reynolds has paid out nearly $10 million to the general public in 1975 for beverage cans and household aluminum compared with $5.4 million in all of 1974.

"We've found it takes several months before collection volume builds up in an area," a Reynolds spokesman explains. "But once the public becomes aware of the benefits of recycling and finds out how easy it is to make extra money and

contribute to their community's ecological efforts, then we see a steady flow."

For instance, at the twice monthly recycling van stops at a shopping center in Schenectady, New York, an average of 4000 pounds is collected each month. Eight months ago the average poundage per month at the same stop was about 3200.

In one city with a population of over 300,000, collections are less than 1100 pounds a month. Just a few miles away, a city one-tenth that size is turning in over 3000 pounds a month.

"We're not discouraged over the time it takes for volume to build up," a Reynolds spokesman continues. "We are sure that in the long-run each community will make an important and vital contribution."

Special stops can be arranged to locations with large quantities of aluminum. A case in point is Hudson, New York. In late 1974 the Retarded Children's Center collected 650 pounds of cans for the Reynolds truck. This summer, when the van returned, there were 2400 pounds of aluminum (over 55,200 cans) to recycle and the Center was $360 richer.

Whereas paper and glass recycling programs became victims of the recession as demand for scrap dropped, the need for aluminum continued to grow. While the price of old newsprint dropped from $60 a ton to as low as $5 a ton – if a buyer could be found – the price of aluminum rose by 50%. During 1974 Reynolds increased its price per pound of recycleable aluminum to 15 cents. (It takes about 23 empty beverage cans to equal a pound.)

Currently aluminum is purchased by Reynolds for $300 a ton, making it one of the most profitable materials to collect for recycling.

Sea Otter Population Expands

The sea otter, within its present range, is probably more abundant now than it has been for centuries.

Because of its fur, one of the finest in the world, the sea otter played a major role in the history of Alaska, and from the 1740's until the beginning of this century was hunted to the point of extinction. The early Russian settlement of Alaska was largely a result of the sea otter industry. When the United States bought Alaska in 1867, the sea otter was diminished in numbers, but hunting continued.

Finally, in 1911, the animals were given full protection under the Fur Seal Treaty signed by the United States, Great Britain, Russia, and Japan. In the years since, the sea otter has increased its numbers in some parts of its range to the point that it has created serious conflicts with commercial and sport fishing interests.

An annual report summarizing developments concerning marine mammals has been published in the *Federal Register* as required by the Marine Mammals Protection Act of 1972. The report describes the current status of sea otters.

The sea otter's range is limited to the northern waters of the Pacific Ocean. Its populations are resident, showing no migratory behavior. Sea otters seldom range offshore beyond the 180 foot depth curve. In North American waters, these mammals are found from central California north to Alaska's Prince William Sound and west along the chain of the Aleutian Islands. On the other side of the Pacific, sea otters are found among the Soviet Union's Commander Islands, along the southern edge of the Kamchatka Peninsula, and among the Kurile Islands north of Japan.

In 1956 the world population of sea otters was estimated to be about 23,000 to 35,000. No current figures are available for populations in waters off the Soviet Union, but surveys in American waters reveal sizable increases. A 1973 census of Alaskan waters estimated sea otter numbers there to range from 100,000 to 120,000. This contrasts with a 1956 estimate of 25,000 sea otters in Alaskan waters. Off the coast of California sea otters numbered about 150 in 1938, and in mid-1973 the population was estimated to be about 1,600 to 1,800 animals.

Sea otters are actually members of the weasel family and are related to mink and land otters rather than to seals, sea lions, and walruses. They have webbed hind feet for swimming and deft toes on the forefeet for handling food which includes fish, sea urchins, rock oysters, crabs, mussels, other mollusks, and octopus. Unlike seals, which rely on a heavy layer of blubber for insulation in the cold waters of the northern Pacific Ocean, the sea otter must depend upon air trapped in its fine dense fur to maintain its body temperature. Hence these animals are extremely vulnerable to oil spills.

Sea otters are raising problems since their comeback in recent years. In several Aleutian Island areas the over-population has depleted the otter's food resources to the danger point. Off the coast of California the sea otter continues to expand its range both north and south and preys on commercially valuable abalone and clams. Pressure from commercial and sport fishing interests is mounting for population control of sea otters and the establishment of refuge areas away from fishing areas.

The sea otter is protected by the Marine Mammals Protection Act of 1972 and in California is listed as a completely protected species. The States of California and Alaska employ biologists full time to study the sea otter, and in 1974 the Fish and Wildlife Service assigned one additional biologist in Alaska to study the animal, making a total of two Federal scientists investigating the life history of this creature.

Summer Fishkills

PAUL KELSEY

During winter when lakes are covered for extended periods with ice and snow, it is not uncommon to have fishkills, for water and atmosphere are separated by ice, preventing interchange of gases. When fish living in the pond, and plants decaying in the bottom of the pond, have used up all the oxygen, the fish suffocate from lack of oxygen. It is a surprise to many people that the same thing can happen during the summer when there is no ice cover.

When you got your first aquarium you learned that by keeping some plants in it, they would give off enough oxygen through the process of photosynthesis to keep your fish supplied with their needs. Why then, in some of our most fertile ponds, where there is an abundant supply of aquatic plants, do we sometimes have fishkills during the summer when plants should be growing at their best?

The complete story of photosynthesis is not quite as simple as stated above. When light is not available the second phase of the photosynthetic cycle goes into effect – called photosynthesis reversal. Instead of absorbing carbon dioxide and giving off oxygen, as it does in sunlight, it gives off carbon dioxide and absorbs oxygen. This occurred in your aquarium, but it didn't cause any trouble because the total effect favored the oxygen. It does, however, mean that oxygen content of the water may vary considerably during the course of twenty-four hours, being at its peak at about sunset and its lowest at dawn.

Another important use of oxygen in the water is to help in the decay of organic material. This is going on all the time, and is one of the key causes of winter oxygen deficiencies. Fertile ponds have the most plant material to decay and are the most subject to fishkills.

The sequence of events leading to a summer fishkill is something like this. All lakes have one-celled plants, or algae, suspended in the water. During the warm months these plants reproduce very rapidly. The more fertile the body of water, the more of these little plants will develop, often turning the water into a pea-soup consistency. If the pea

soup is thick enough it will cut light penetration to as little as one foot. Since these plants require sunlight to live, those beyond the reach of the light die. When they die, they decay, and as they decay they require oxygen. The total mass of these one-celled plants that die and decay may be so great that all the oxygen is used.

If this point should be reached during a period of cloudy windless weather, the problem is magnified. There is less light for the process of photosynthesis and it penetrates less deeply, so fewer plants are producing oxygen, and these are only in the top layer of the water. Windy weather won't solve all of the problems, but wind and waves do cause a certain amount of mixing of the water and consequent dispersal of oxygen.

The useful availability of oxygen to fish is lower in the summer than winter because warm water will not absorb as much oxygen as cold water. To further compound the problem, fish require more oxygen during warm weather than during cold.

The reason that fish require more oxygen during the summer than winter is that their metabolic rate increases with the temperature. Under the ice, fish are not very active. Some, in fact, go into a state of suspended animation and require very little oxygen. During the summer, while they are active in the warm water, largemouth bass and northern pike need at least 2.3 parts per million of oxygen in their water just to survive. Under the ice, while they are lethargic, a bass can tolerate as little as 0.6 and a pike can survive at 0.3 or 0.4 parts per million of oxygen.

Most of our waters are "richer" than they were a few decades ago because of increased fertility that man has dumped into them, or has let drain into them through carelessness. The possibility of summer fishkills is steadily increasing.

The second ANSS Summer Institute was a fantastic success thanks to the leadership of Dr. Helen Ross Russell. Thirty-four inner city teachers from Washington and Baltimore representing several grade levels and subject areas, participated in the unique course which was conducted in Washington, D.C. during June and July. The Institute was co-sponsored by the Audubon Naturalist Society of the Central Atlantic States, Inc. and American University and was supported by a grant from the Eugene and Agnes Meyer Foundation of Washington.

In keeping with the purpose of the Institute, course sessions focused on practical ways to use inner city parks and school sites for environmental studies. Helen concentrated on short studies and direct learning experiences designed to acquaint teachers with basic ecological and environmental understandings as well as a working knowledge of urban natural history.

In addition to Helen, five other ANSS members volunteered their time to help make this summer's Institute a success. Allan Morich, Education Director for the Audubon Naturalist Society, served as Assistant Director in charge of the overall operation of the Institute. Miriam Dickey of Massachusetts Audubon contributed four days and shared her wealth of knowledge of city plants and animals. Harry Betros donated a day of his time to help the teachers understand city soils. Mary Houts shared her varied experiences as urban environmental education specialist for the city of Harrisburg, Pa. Gerald Schneider, an environmental consultant in Washington, conducted an effective role-play activity concerned with city planning.

Helen's unique ability to both teach and, at the same time, generate a sense of wonder and excitement towards the natural world was the key ingredient in the Institute's success. As a result of the Institute, ANSS has made many new friends among the teachers of Washington and countless inner city children will have the opportunity to study nature, perhaps for the first time. The ANSS Urban Institute project is a highly effective way to bring environmental education expertise to where it is most needed and carry on the purpose and objectives of the American Nature Study Society.

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