MARINE RESOURCE BULLETIN

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Virginia
MARINE RESOURCE BULLETIN

DR. L. DONELSON WRIGHT
Acting Dean and Director
Virginia Institute of Marine Science
School of Marine Science
The College of William and Mary

DR. WILLIAM RICKARDS
Director
Virginia College Sea Grant Program

DR. WILLIAM D. DUPAUL
Director
Marine Advisory Services

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SUSAN C. WATERS, Editor, Writer and Designer
KAY B. STUBBLEFIELD, Graphic Designer

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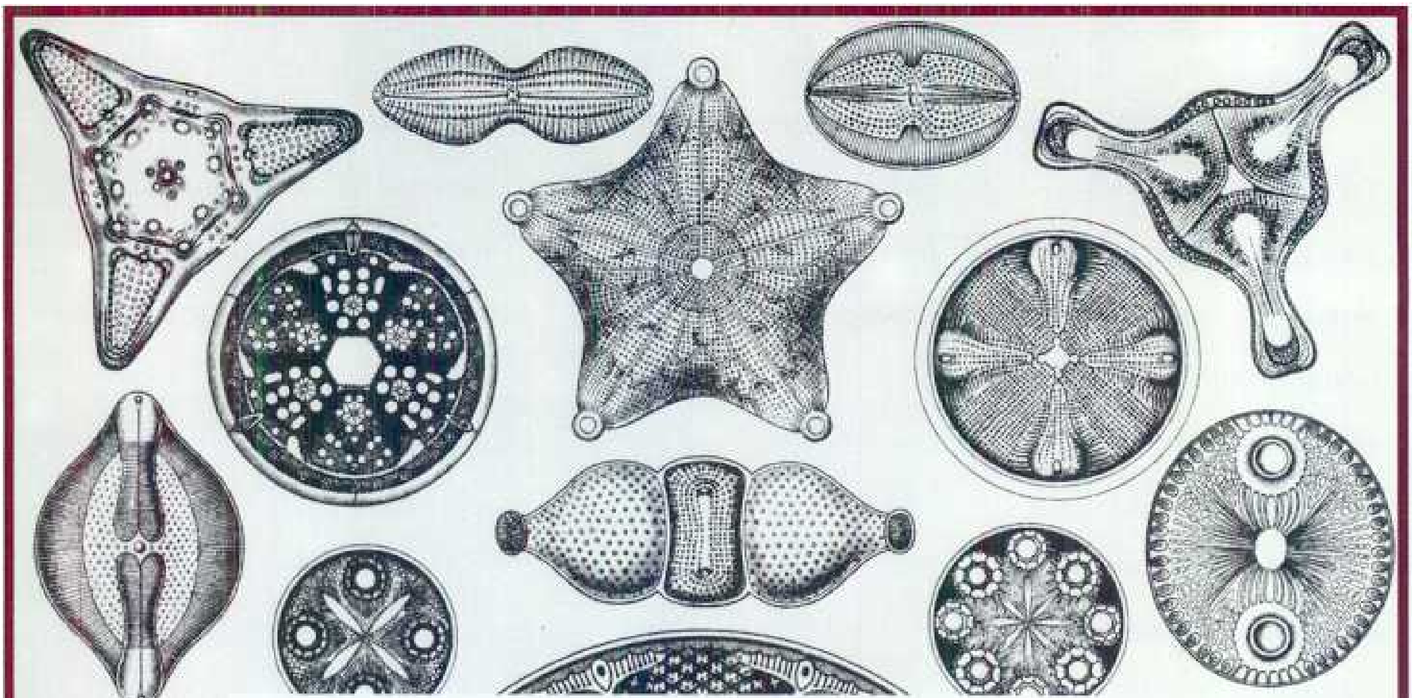
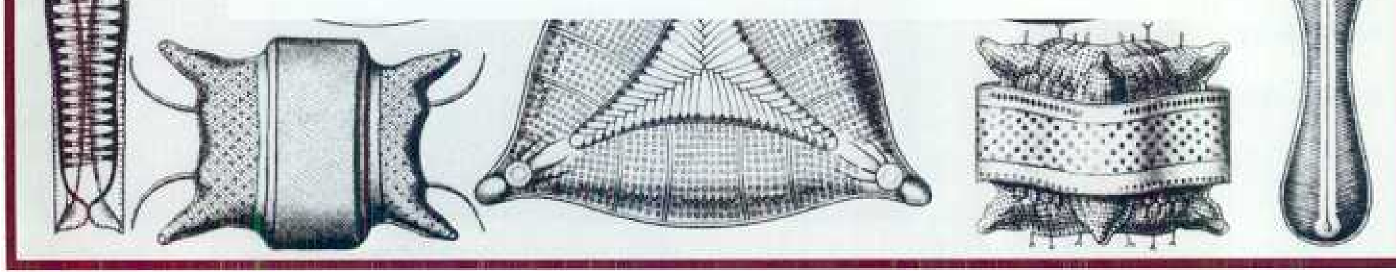
On the right: diatoms, minute members of the plankton community. The illustration is by German biologist and philosopher Ernst Heinrich Haeckel (1834-1919).



Introduction...

The Eastern Shore of Virginia has been in the making and on the move for thousands of years. It is a geological epic filled with sea level rises, sand and organic matter accretion, erosion, and storm events which to this day further alter the island system. Above all, the Eastern Shore's movement is an ongoing event in which the only continuum is motion. In fact, the Shore's barrier island system is one of the most changeable ecosystems in North America. Other systems may take decades or even centuries to change.

(Continued on the next page . . .)

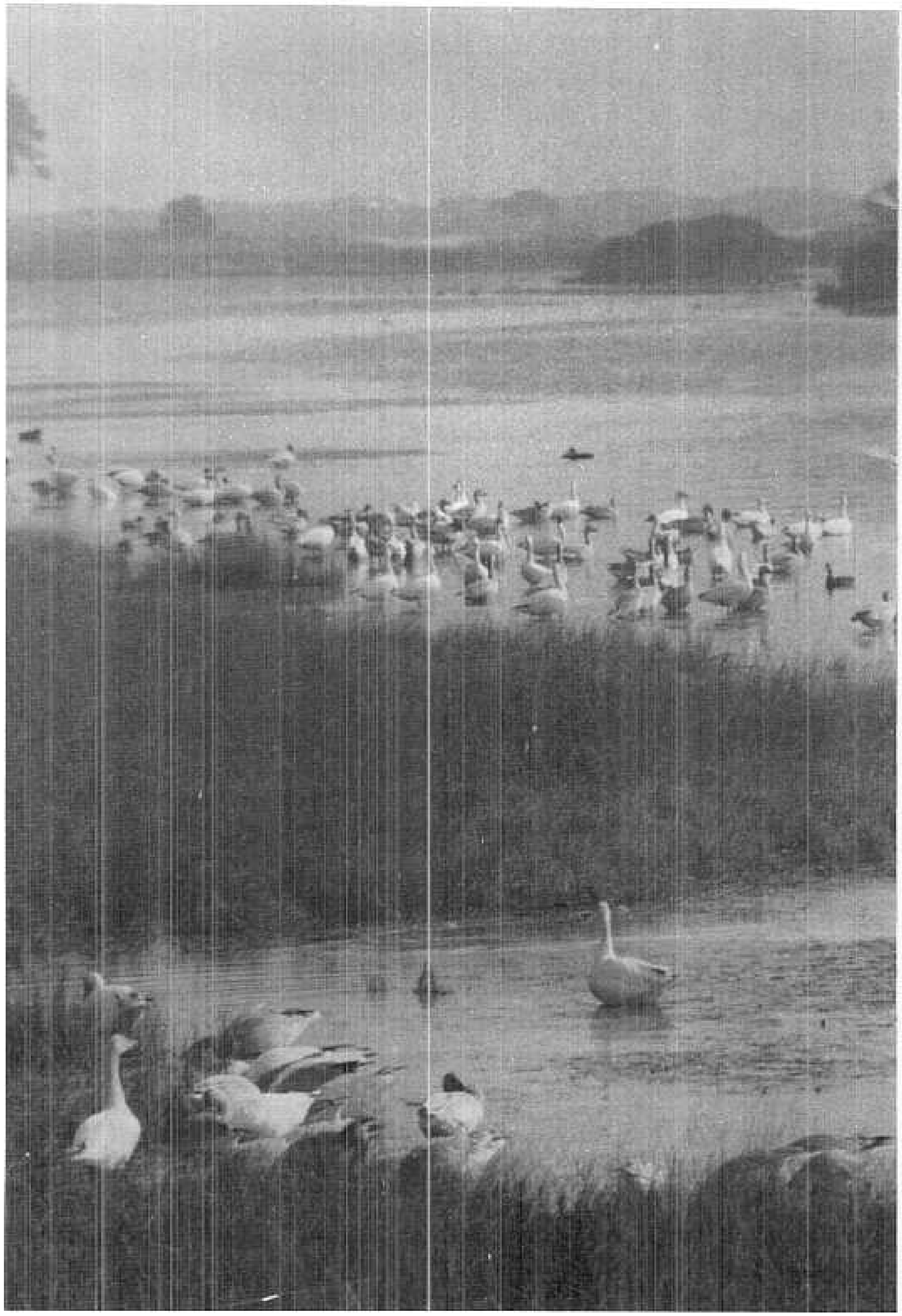


Anthropologically, the Eastern Shore has also passed through many permutations. Initially it was home to native Americans, who left an ample amount of artifacts. It has been a place of plantations, a hiding spot for pirates, and the location of opulent hunting lodges. And when those times were past, the land was still intently farmed and the waters plied and cultivated for food.

Today, the Eastern Shore is an anomaly compared to the rest of the U.S. East

It is rural, mostly undeveloped, and it contains the largest coastal sanctuary of its sort on the country's unglaciated coast. Several state and federally managed parks, nature and wildlife reserves and research centers are located

These include the Assateague Island National Seashore, NASA Wallops Island Research Center, Kiptopeke State Seashore Park, Fisherman's Island National Wildlife Refuge, and the Chincoteague National Wildlife Refuge. The



Nature Conservancy maintains a large barrier island and adjoining marshland preserve.

This issue of the Bulletin, covers, in part, a little known facet of the Eastern Shore, its role as the location of a great deal of research, made possible by its near pristine state.

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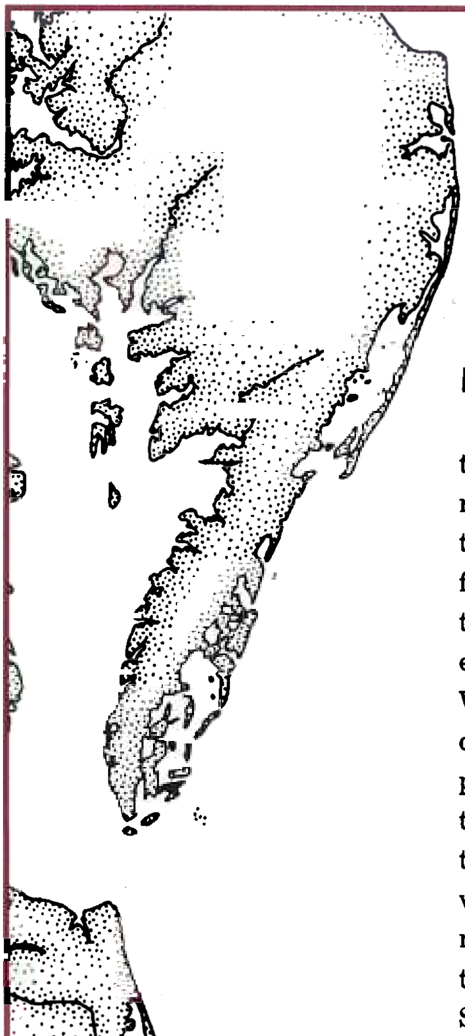
The Eastern Shore Barrier Islands, A Geological Profile



By Bruce Hayden and Julia Hayden

The Virginia Barrier Islands have come and gone many times during the last three million years. In each ice age, up to 100,000 years apart, sea level fell by more than 300 feet, and the coastline was some 50 miles east of its current position. When the sea level was low during an ice age, the Chesapeake Bay was the river valley of the Susquehanna. During such times, the Delmarva Peninsula* was not a peninsula at all, but merely a continuation of lands to the west. Virginia's Eastern Shore was forested with spruce and pine trees like those typical in central Canada today. This boreal forest extended east across the continental shelf and was dissected by many nearly parallel streams or rivers that drained the lands from what is now the center of the peninsula. Modern research ships have mapped extensive sections of the continental shelf between the Norfolk and Baltimore canyons (to the south and north of the Delmarva Peninsula). Traces of these ancient rivers are apparent all the way out to the edge of the continental shelf.

* "Delmarva Peninsula" is the geological designation for the entire landform.

Between each ice age the sea level would rise more than 300 feet, and the ocean would flood Virginia's eastern landscape. Each time the continental shelf and valley of the Susquehanna flooded, the Delmarva Peninsula came into being.

During the brief periods between each ice age, sea level was very much like it is today. The coastline was far closer to its current location than was its Ice Age counterparts. It did not, however, always lie in the place it does today. There is evidence of the shoreline of past interglacial ages in the landscape of the peninsula. On at least two occasions in the last 500,000 years, the shoreline was considerably west of today's shoreline. Satellite images of Virginia's Eastern Shore reveal at least two broadly curving old shorelines of the ancient landscape on its eastern margin.

Around 5,000 years ago, when the rate of sea level rise slowed to current rates of about one-tenth of an inch per year, the barrier islands, lagoons, and marshes of the Atlantic Coast came into being. Up to this time, the Virginia coast was a mainland coast where the continent met the sea. Erosion of these headlands was rapid, and the sea encroached into the forest. The stream channels that traversed the shelf were estuaries that became the repository of our coastal marine fauna and flora. With a slowed sea level rise, the barrier islands came into being. They formed either as elongate spits of sand reworked by alongshore currents or as sand bars established during great storms. In either case, two processes were required. First, the sands had to be piled up to the heights of the highest water levels. Then, during periods of low tides, the winds had to pile the sands still deeper. By this joint partnership of waves and winds, the barrier islands of Virginia's Eastern Shore were formed.

With a modest rate of sea level rise, these barrier islands offered some resistance to the erosive potential of a slower rise in sea level. The shoreline did not migrate westward at such a fast rate. Dunes formed. The land behind the beaches and dunes was flooded by the rising sea level and lagoons formed. Thus came into being both barrier islands and lagoons. The shoreline continued to march landward; beach sands were pushed inland during storms. They replenished the marshes and filled the shallow lagoons as the level of the sea rose. On Virginia's coast this meant that the flat landscape was flooded. Relatively low places became open lagoons, and the flooded lands of high elevation became marshlands within the lagoons. The pattern of marshes is thus a relic of the much older landscape present during the last ice age.

Over the last 5,000 years the marshes and lagoons accumulated new sands and organic matter and grew upward. Lagoonal marshes can grow upward at about one-twentieth of an inch per year; to grow upward faster requires a steady supply of sand and silt. An abundant sand supply is not found everywhere, but the fringing marshes on the lagoon side of the barrier islands have such a supply.

During storms, sand is driven across the islands and through the inlets and deposited on the marshes. Even with a tenth-of-an-inch annual rate of sea level rise, the ringing marshes of the barrier islands, by deposition of sediments, can grow upwards at an equal rate. The lagoonal marshes, however, cannot keep up and so become submerged and eventually die. During the last 5,000 years the extent of marsh and open water has varied as sea level rise rates have varied.

Around 1,200 years ago there began a period of relatively rapid sea level rise, and the lagoons of the Eastern Shore were large open water. After several hundred years, the rate of sea level rise slowed and marshes expanded. Today we are again losing marsh to rising sea level. Since 1852 there has been about an 11 percent decline in lagoonal marshes. Change means perpetuation of the landscape. In a study of Hog Island, one of the Virginia Barrier Islands, it was found that 90 percent of the non-marsh land was less than 120 years old. The land must change to stay the same.

Over the past 150 years, Hog Island has indeed changed and stayed the same. Virginia's barrier islands are sometimes called rotational islands because as one end of an island is eroded, the other end accretes, or accumulates. From 1850 to 1872, the north end of Hog Island eroded and moved toward the Virginia mainland, while the southern shore, accumulating land, moved seaward.

Between 1872 and 1910, this trend reversed itself; the south end of the island eroded landward, and the north end accreted seaward. This trend continued until around 1967, when the accretion/erosion process reversed itself again.

In the 1930s, two events altered the erosion/accretion pattern and life of the island. The aquatic sea grasses that once covered the lagoon bottoms died off from the "wasting disease." With the loss of the seagrass, the scallop industry collapsed, and the Brandt duck population stopped frequenting the lagoons of the Eastern Shore. In addition, the lagoon bottoms were no longer stabilized by the seagrass.

In 1933, a hurricane came to coast at the mouth of the Chesapeake Bay; the Virginia Barrier Islands bore the brunt of the storm. (Hurricanes are always damaging, but this was a hurricane with the force of the more recent hurricanes Andrew in Florida and Hugo in South Carolina.)

Residents reported that the marshes were buried in mud by the force of the hurricane. As a result, the island marshes were elevated higher than normal, and the salt marsh grass on the marshes changed. However, as the sea level rose, so did the height of the marshes as new sediments were slowly deposited. The lagoons became a turbid ecosystem dominated by mudflats.

Although Hog Island ceased to be inhabited after the hurricane, the pattern of rotating accretion and erosion continued. It reversed itself once again in 1967 in what is believed to the fifth reversal since hog Island was first inhabited in colonial times. Scientists believe the reason islands rotate is due to changes in wave climate.

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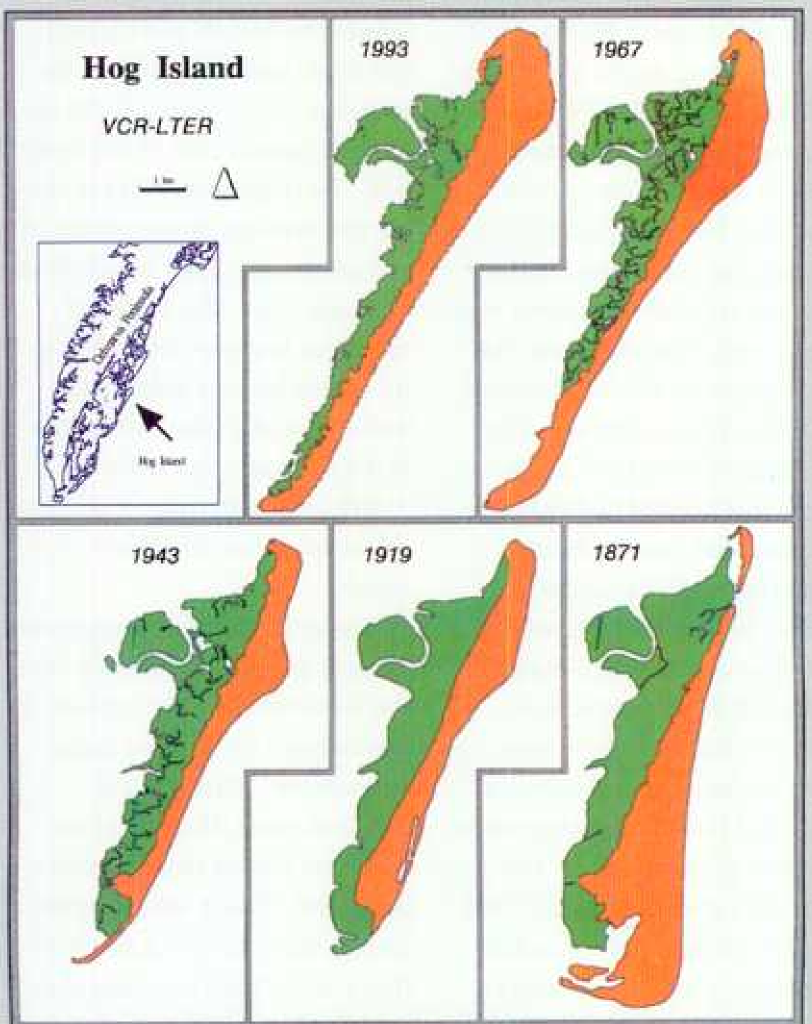


Hog Island, on the sea side of the Eastern Shore, provides a dramatic example of the type of change which can occur in only 122 years, a mere blink in geological history. Once a relatively populous island, at least by small barrier island standards, the Broadwater town had to be abandoned when an encroaching ocean decided to claim it. Most Broadwater residents moved to the mainland in the early part of this century, taking with them most of the structures, which were jacked up and loaded onto barges, or dismantled and later reconstructed. What was left behind? The graveyard, which is now under water. In the graphic the orange represents sand and soil; the green signifies wetlands and marshes.

Pristine Environments

The whole concept of a "pristine" state is infinitely complicated and somewhat debatable. The general population seems to see it as a natural state, one which is untouched by human activity, and is hospitable to life. Change, however, is constant in nature, and habitats can be destroyed by natural forces and even made inhospitable to the life that inhabited the ecosystem before. Agents of change can be fairly "usual" events or occasional phenomena—a dry season; a storm system; a tsunami; a change in weather patterns; the "success" of an animal, plant, virus or bacteria at the expense of another life form. Just as natural forces continually alter the Eastern Shore, humans have a tangible impact. Farming, commercial and recreational fishing, and land development can, in varying measures, modify the Eastern Shore system. The following examples are but a few of the possible ramifications of human activity.

- Runoff from farming can change the number of nutrients in the aquatic system, causing chemical and biological changes, especially on the more sheltered Bay side of the Eastern Shore. At the least, the nutrients could simply modify the composition of the water; at worst, the nutrients could make areas lacking in dissolved oxygen, a necessary requirement for most forms of marine life.

- Commercial and recreational fishing can alter the interconnected, interlocking relationship of organisms in the food chain; if too many higher organisms are caught and few reproductive ones are left in the system, other smaller organisms—for instance, algae—could have an opportunity to thrive. These life forms may or may not be the ones that humans deem "desirable." Removing a species from a system might alter the ecosystem completely. Such was the case with the Bay's native oyster, *Crassostrea virginica*. Oysters, because they can filter large quantities of water, were believed to be an important factor in improving water quality.

- Land development—improperly planned—could interfere with the natural, seasonal exchange of sand between the dune system and the offshore system, resulting ultimately in erosion. The basic amenities associated with housing developments can tax both land and water systems. Paved land equals more runoff; sewer systems mean more nitrates. Human activity does not have to be located on the Eastern Shore to be felt. The atmosphere is highly effective at transporting emissions from other regions to remote areas like the Shore.

Even if the concept of a pristine environment is a relative one, the majority of research groups, scientists and agencies do not endorse a laissez faire attitude toward the stewardship of an ecosystem. Rather, a middle-of-the-road approach is favored by most groups, a position which appears equitable but is difficult to maintain or attain.

The National Long-Term Ecological Research Network

Approaches to understanding ecosystems have been changing drastically, indicative perhaps of a better comprehension of just how complex ecosystems are and how an integrated approach may be the best way of understanding a system as an entirety. One of the more novel approaches is the Long-Term Ecological Research (LTER) program, whose strategy involves coordinated research spanning decades. In prior times, researchers basically dissected a system; individual components were studied—then the whole. LTER studies all the elements at once, resulting in a synthesis. In addition to providing a more three-dimensional portrait of an ecosystem, LTER also has its pragmatic side: the research infrastructure is in place, the system can support many scientists over time, and the equipment needed is purchased only once (as opposed to each individual group investing in its own equipment). The LTER concept appears to be catching on internationally, with a number of countries becoming involved in establishing sites. LTER is a program of the National Science Foundation.

Long term observations of a system are needed by researchers to distinguish short-term variations from long-term trends. Plus, data needs to be collected over enough environmental conditions so that researchers can determine the range of conditions to which the results can be meaningfully extrapolated and applied.

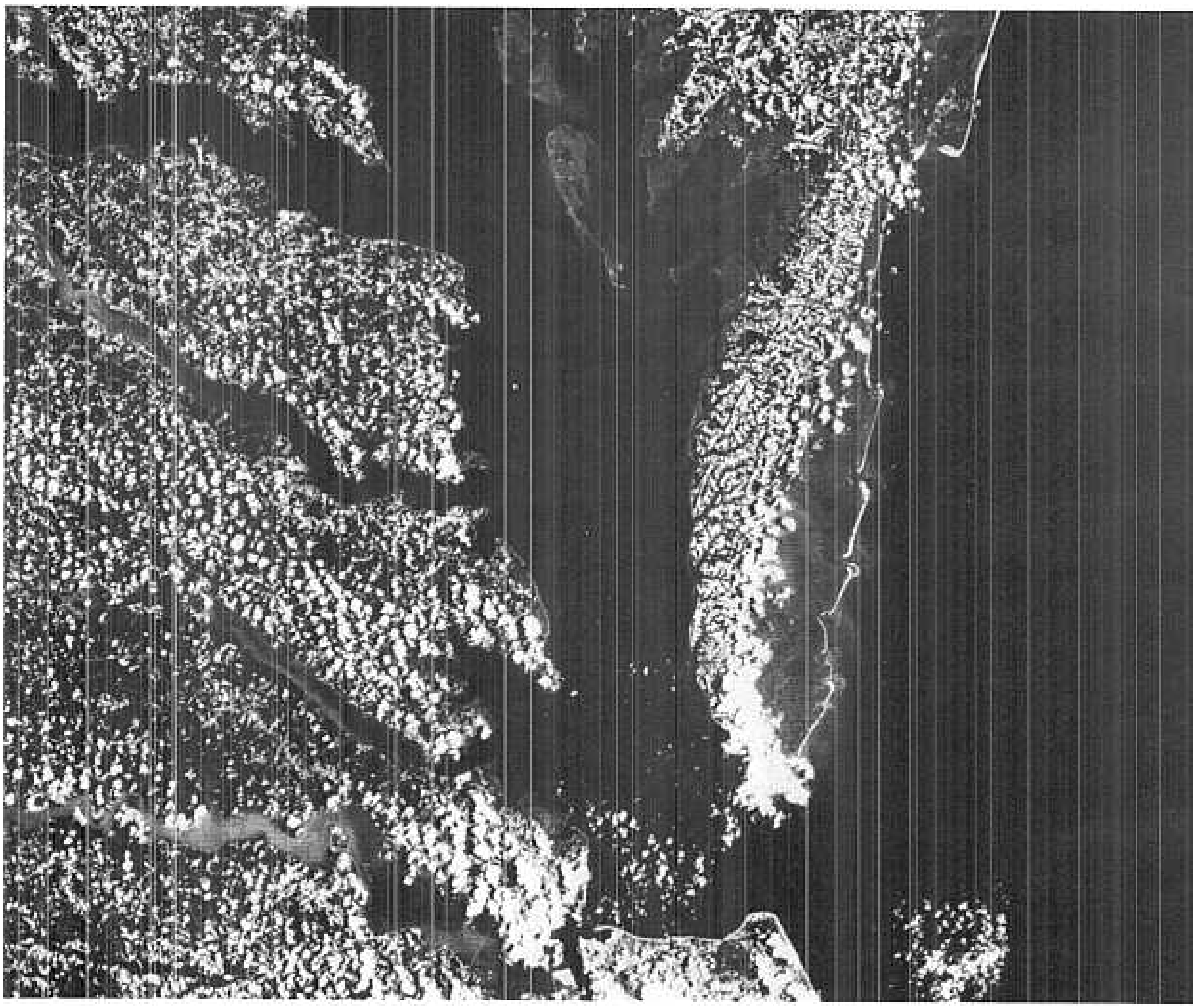
To say that resource use decisions have not always been based upon sufficient information is perhaps the understatement of the century. To facilitate the ability to make decisions based upon sound scientific information, and to advance scientific understanding of ecosystems, a national program was established, LTER.

The Virginia Coast Reserve is the location of the LTER's 16th site. The Virginia Coast Reserve is owned by The Nature Convervancy and is a complex assemblage of 14 barrier islands. The Reserve joins an impressive array of LTER sites in the United States, Puerto Rico and Antarctica, ecological systems which range from a tundra in Alaska to a tropical rain forest in Puerto Rico.

In the past, ecosystems could have been studied as a whole—with research efforts coordinated to achieve a three-dimensional scientific portrait. More than likely they were not, and any comprehensive profile of a system was a compilation of many researchers' work conducted at different times with different methods.

During the past decade a new approach has been used to conduct ecological research, a thematic research program, one in which related areas are studied. LTER employs this strategy with all 18 sites, conducting research in five areas:

- the dynamics of what is called "primary production" of green plants, the total amount (roots included) of organic matter produced by photosynthesis;



the cycling of nutrients;

the structure and pattern of populations and communities;

the role of disturbances* (for instance: storms, fire) in ecosystem structure and dynamics;

and a thematic program specific to the LTER site, one which unites, in this case, the diverse research areas of ecological and geophysical scientists.

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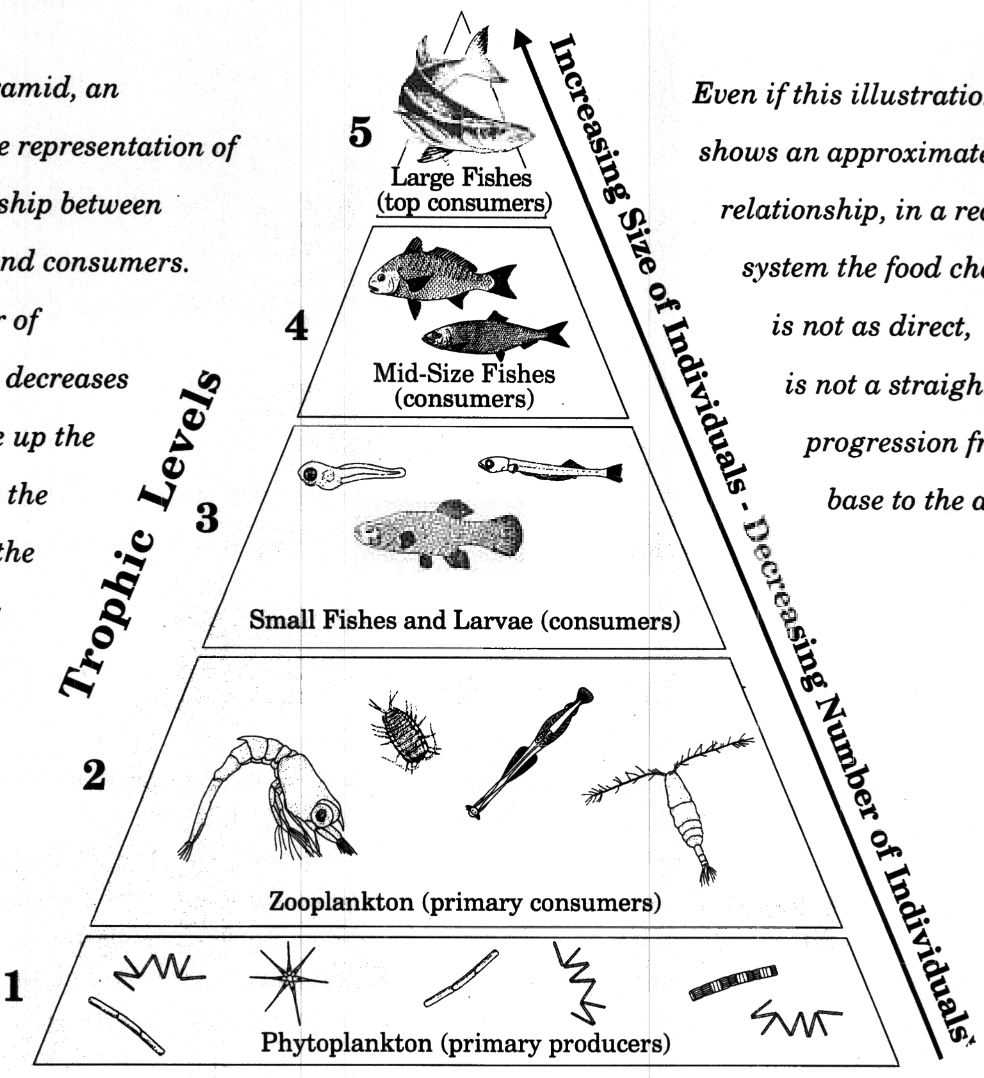
* *Research into the role of disturbances, or what some people would call disasters, has advanced considerably in recent years, sometimes arriving at surprising conclusions. What we consider disorder may constitute part of an order in the scheme of the natural world. Example: nitrogen—a nutrient crucial to life—is made available to the global system in myriad ways—including through forest fires, which release nitrogen into the atmosphere, the most mobile sphere of the planet. Some life forms are even dependent on disturbances. Peters Mountain Mallow—a plant believed only to exist on Peters Mountain in Giles County, Virginia—needs fire to germinate. To what extent disturbances are necessary or even part of a system is up for debate.*

Seaside, Bayside Tidal Creeks, Vastly Different Systems

Coastal lagoon systems are not exactly a mystery from a marine science point of view. Yet these ecosystems, which are fairly similar worldwide, have not received the type of intense, scientific scrutiny that estuaries have. The result in terms of the Eastern Shore's coastal lagoon system? Reasonable policies have been developed to slow down eutrophication* and to enhance the economic and ecological values of the Chesapeake Bay. In essence, these policies apply to the coastal lagoon system, too, even though they may not have as much applicability as originally assumed. Preliminary work by Sea Grant researchers indicate that nutrient dynamics and production are radically different in the tidal creeks in these two systems although they are in a similar area, separated by a few miles.

*Excessive nutrients introduced into a system can cause biological, chemical and physical changes. A main concern is eutrophication, a condition which results in oxygen deficiency—a dire situation for animals in the Bay.

Trophic pyramid, an approximate representation of the relationship between producers and consumers. The number of individuals decreases as you move up the pyramid; at the same time, the size of those individuals increases.

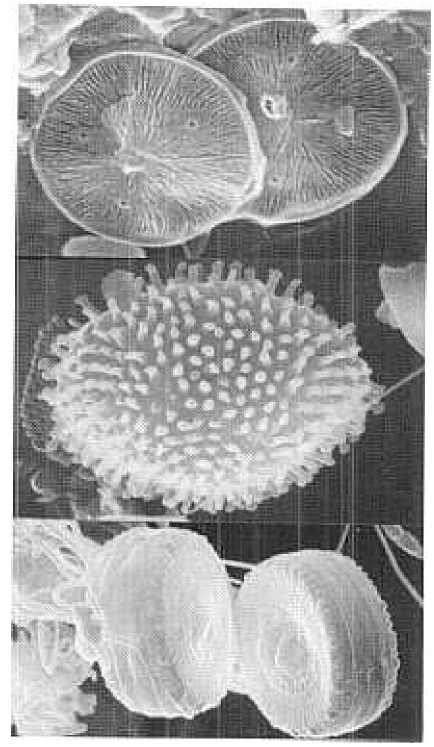


Even if this illustration shows an approximate relationship, in a real system the food chain is not as direct, is not a straight-line progression from the base to the apex.

Estuaries, Coastal Lagoon Systems

Even though the tidal creeks studied were only a few miles distant from each other, they belong to very different physical systems. An estuary, like the Chesapeake Bay, is an enclosed body of water that is unique in this sense: it is where salt water and fresh water meet. Ocean water intrudes from the Bay mouth; substantial amounts of fresh water enter the Bay from tributaries and from the land. Many factors influence this mix of waters, including the intensity of the tides or storm events which bring water into the Bay and the amount of rainfall in any one year. Many gradients of salinity, turbidity and water temperature exist in the system.

A coastal lagoon complex (CLC), like the one which fringes the Virginia's Eastern Shore, is like an estuary in the sense that it has a connection with the open sea. However, the interchange can be far more rapid. An apt description of Virginia's CLC is "restricted" and "leaky." It is restricted in the sense that the system is somewhat isolated from the ocean by barrier islands; and it is leaky since, through deep inlets between the islands, there is a ready exchange of water with the ocean.



Some researchers would contend that a "pristine" environment is a created idea, that the planet has been changing since its inception, and that many times, both plants and animals were agents in the transformations which took place. For example, the increase in free oxygen in the atmosphere, allowed an ecological niche for humans. One of the agents in the dramatic atmospheric change, was the diatom, a minute member of the plankton community, greatly magnified in the photo on the right. Oxygen not needed by a diatom is released into the water. In turn, part of the oxygen diffuses into the atmosphere. Before the oxygen revolution, the Earth's atmosphere would have been toxic to humans.

Nutrient Dynamics and Primary Production

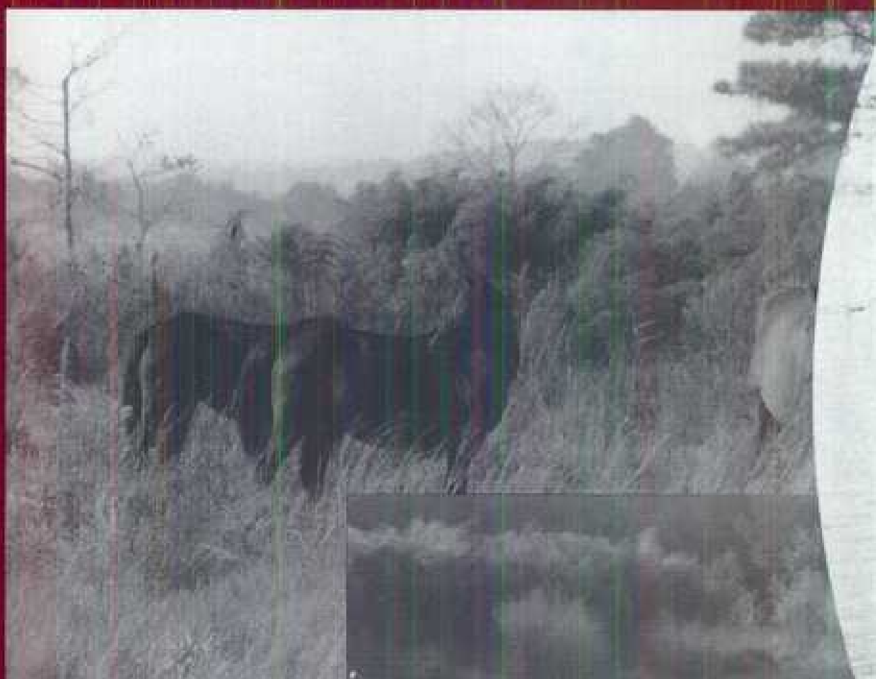
Mostly unseen is what is elemental to any ecosystem, the availability of nutrients (or energy), and the factors which inhibit or facilitate the "production" on the first level of the trophic pyramid, a model used to describe the relationship between producers and consumers in a food chain (see illustration on the left). In an aquatic system, at the base of the trophic pyramid are the primary producers, phytoplankton, minute plants which are part of the plankton community. The "food energy" in the system then travels up the pyramid to the zooplankton, the primary consumers which consume the phytoplankton. On the next level are the consumers—larvae and small fish, and mid-size fish—respectively. At the apex are the top consumers, which are usually larger animals.**

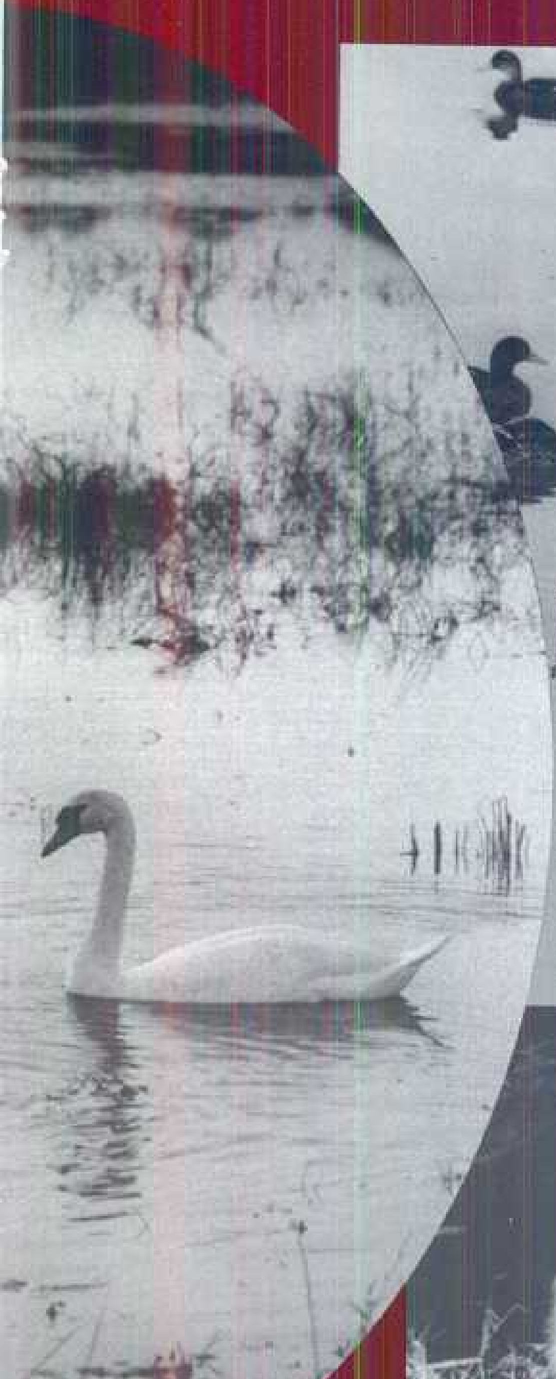
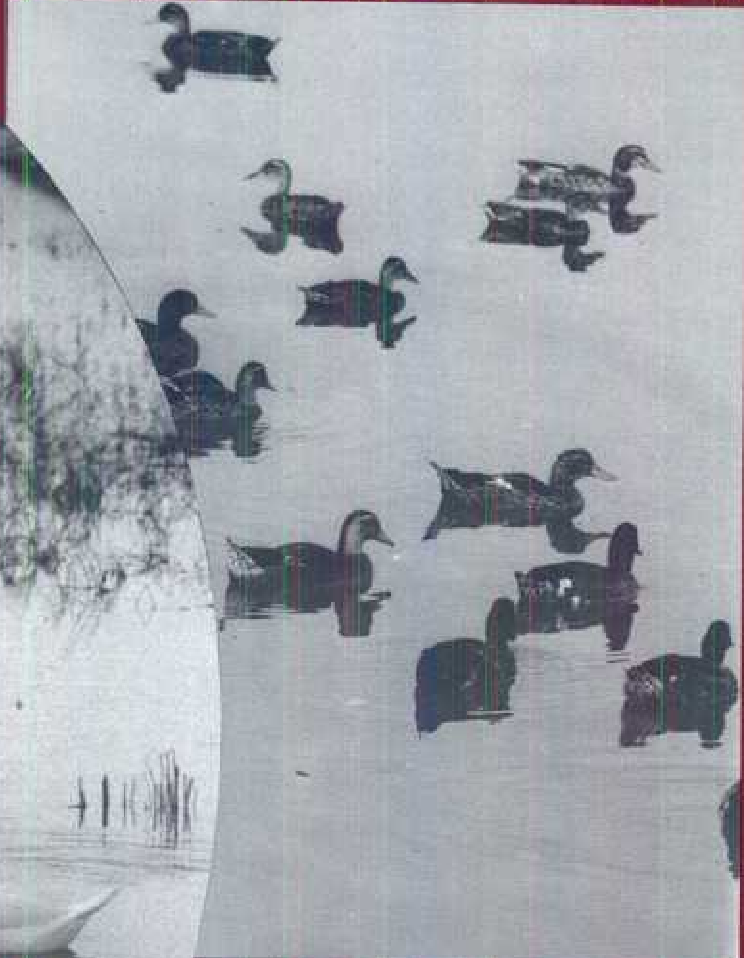
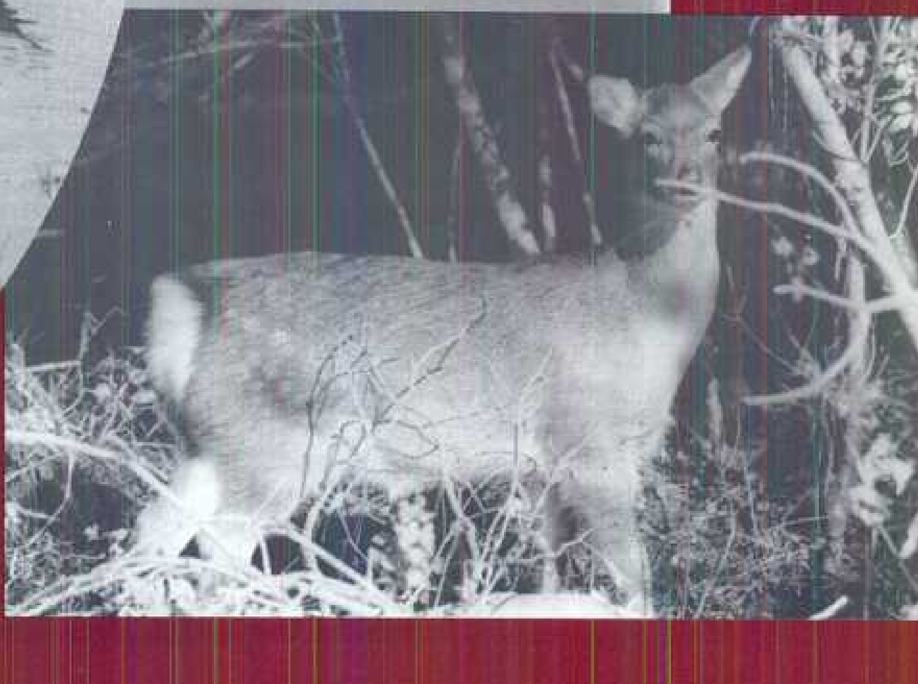
(Continued on page 16 . . .)

**Not all large animals consume mid-size or small fish. For instance, the basking shark (*Cetorhinus maximus*), a gargantuan animal which can grow to a length of 40 or 50 feet, relies on large quantities of plankton which it basically sifts out of the water. The trophic pyramid is a model to show the basic food energy flow.

Assateague Island

Federal reserve and home to a rich assortment of animals and birds.



Life on the minuscule level of the primary producers can be fast and furious, turgid, or anywhere in-between; a complex assortment of biological and physical factors influence production. Some of the variables include temperature, light and nutrient availability, tides, and currents. Even the producers can have a direct bearing on their collective production. For instance, a dense group of primary producers could interfere with light availability, a factor necessary for photosynthesis, the process by which the primary producers convert and use energy. The decrease in light could lead to an overall decline in primary production.

The Sea Grant Study

University of Virginia researchers Linda Blum, Aaron Mills, and Luis Lagera conducted a comparative analysis of the constraints on phytoplankton and bacterial productivity in the tidal creeks on the Bay side and the sea side of the Eastern Shore. In essence, the scientists were focusing on how plankton and bacteria—which make up the first level of the trophic pyramid—relate to the next level. The Sea Grant study appears to be the first direct, deliberate comparison of estuarine/lagoon productivity for sites so closely linked geographically.

Thumbnail Sketches

Data collected and analyzed to date by Blum, Mills, and Lagera highly suggest that the estuarine and CLC tidal creek systems are entirely different spheres in terms of primary production.

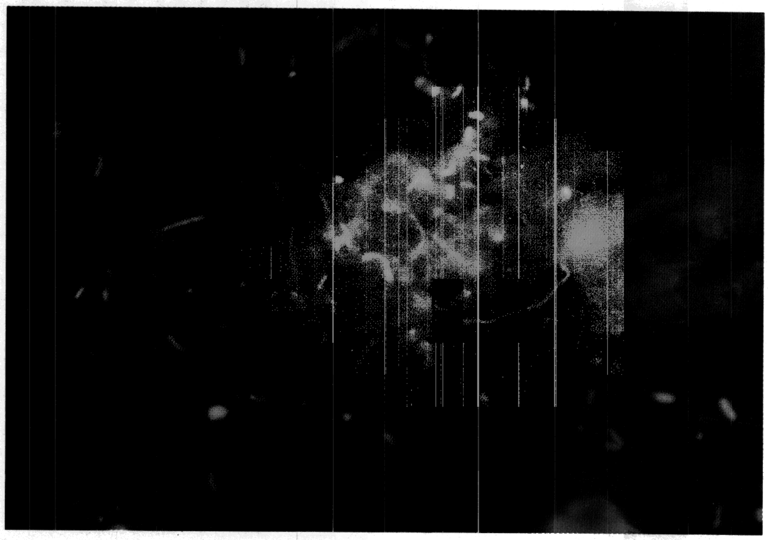
On the Bay side, nitrogen and phosphorus are held in biomass, meaning they are present in living matter. In contrast, in the CLC the elements appear in a dissolved inorganic form and are in the water column. Also, nitrogen and phosphorus exist in far greater amounts in the CLC.

The estuarine tidal creek trophic system is phytoplankton based; the CLC system is not. The apparent reason for the latter deals with the constant and forceful interchange with the ocean, and the light availability. Very strong tidal currents roll across the expansive, shallow mud flats of the coastal lagoon system. This tide action creates high turbidity. In turn, the high turbidity prevents light from penetrating as much it does in the estuarine creeks studied. In other words, although the necessary nutrients are available in the CLC, physical factors apparently prevent the CLC system from being phytoplankton-based.

Sea Lettuce

Specifically, this is how energy moves through the tidal Bay creeks in the study: the Bay creek system contains an abundance of phytoplankton which is grazed upon by bacteria and copepods (minute crustaceans), then the zooplankton and finally the fishes. The bacteria are not grazed upon very much. In the CLC creeks, bacteria are consumed by protozoans, and all the bacteria produced and any new production is consumed. The protozoans are consumed by the zooplankton, which are food for the fishes.

The Insistent Theme of Earth



Birth of a star, a newly discovered far-flung constellation? No, a visual representation of the insistent theme of Earth, the recycling of nutrients. The larger orange mass is decaying seagrass; the pinpoints of light are bacteria, foot soldiers in the long march. Decay bacteria break down complex molecules in plants and animals, making simpler molecules available for use by other organisms in the ecosystem.

Although bacteria come in only three basic shapes, they are a ubiquitous feature of the universe of life on Earth. They can be found almost everywhere on the planet. Bacteria can be photosynthetic or chemosynthetic, and some bacteria produce spores which can tolerate extremes of heat or cold.

Bacteria can even be found in the Hades-like conditions around deep sea vents. In fact, they constitute an important facet of that system. When researchers found this new type of marine community in 1977, they found life in what many would assume is an inhospitable environment some 10,000 feet beneath the surface. Large amounts of hydrogen sulfide were in the water and jets of water reached temperatures of 650°F, a toxic mixture for most forms of life. The life forms in this community were sometimes gargantuan and were able to make a living in unusual ways. The tube worms (genus *Riftia*), which can reach over 10 feet in length, had no immediately obvious mechanism for feeding. They lacked the components used by many organisms to obtain and utilize food: a mouth, a digestive tract. Inside the tube worms were large amounts of bacteria which converted hydrogen sulfide into organic molecules; the bacteria, through chemosynthesis, provided the necessary sustenance for the worms' survival.

In the Future

First with the results, researchers will be able to provide a baseline of information about the current state of water quality in the tidal creeks (Bay- and seaside) of the peninsula. This information will be important to the development of land use management programs for the Eastern Shore. Second, the results should determine the suitability of management models which are currently being used for both the Bay- and seaside—although the systems are very different. The prospect of dire ramifications from nitrogen and phosphorus additions to the CLC system may not be well-founded, for the tide action rips through, lifting an abundance of sediments.

The results from this Sea Grant study are not limited to the Chesapeake Bay area. Although coastal lagoon complexes fringe 13 percent of the coastline worldwide, these areas are rarely studied as ecosystems in their own right.

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VIMS Eastern Shore Lab

The following article lists a multitude of projects which have been conducted, or are currently ongoing at the Eastern Shore Lab of the Virginia Institute of Marine Science (VIMS). The VIMS lab, a small field lab, is located in Wachapreague on the Eastern Shore. The following article does not name the many researchers involved in projects because of space considerations.

The VIMS Eastern Shore Lab in Wachapreague has been, and is the jumping-off place for all types of research, the run-of-the-mill and the innovative. However, if there is a continuum to be found in the research conducted by VIMS on the Eastern Shore, it is in the work performed in the name of aquaculture, and in coastal marine science and education.

Spartina alterniflora

Aquaculture

Aquaculture, in this case, the culturing of marine animals, has had an uneven path in terms of its development. During the past century, aquaculture's terrestrial counterparts—animal husbandry and agriculture—have advanced briskly with spectacular results, even if some would claim these advancements have not been without a potential cost.* Mariculture (the cultivation of marine animals) has been much, much slower in its technological progress. There is a reason for this: the wild harvest, as opposed to cultivation, has been the rule in marine waters of the United States. Depleted stocks, however, have led to a more acute interest in developing mariculture in recent years. Meanwhile, and even before, research has been conducted at the university level for decades. With terrestrial cultivation, the research was often conducted at what commonly were called experimental stations/land grant colleges. Aquaculture was within the purview of some marine labs and universities with Sea Grant components.

*The positive results are obvious: increased yields and disease-resistant strains. The potentially negative results are fairly ominous: some researchers maintain that culturing only a few strains worldwide (often called monoculture) could lead to massive crop failures from disease.

Which brings us back to Wachapreague. Work performed at the Lab was largely responsible for the growth of the hard clam (*Mercenaria mercenaria*) aquaculture industry along the East Coast, an industry which has expanded impressively. In 1994 hard clam aquaculture sales were estimated to be $11 million in Virginia, more than double that of the wild hard clam fishery during the same year. As should be, after techniques were successfully developed by the Lab for any one stage of culturing—hatchery/nursery/growout—industry adopted the technology and the Lab moved on to other research areas. The VIMS Lab remains an active site for ongoing technology transfer in the area of mariculture;

workshops are conducted to instruct people in the necessary and latest technology.

A second shellfish species which is now being explored is *Argopecten irradians*, the bay scallop. In the not so distant past, the bay scallop was native to the area. However, when the eelgrass beds disappeared, so did this small scallop.

Research at the Lab established the biological feasibility of rearing the bay scallop from egg to market size, an important first step in reestablishing the scallop presence in Virginia, even if in a cultured form. A recent demonstration project focused on growout of the animal and acceptability of marketing the bivalve as a whole, in-the-shell, steamed product—the equivalent of a steamed clam. Both restaurants and consumers responded favorably to the product. Work now focuses on ways to best freeze the product so it would be available year-round.

The latest aquaculture project which is being proposed could be fairly monumental, in terms of the Chesapeake Bay, Virginia waters and the mid-Atlantic. The project would be conducted both at the Eastern Shore and the main VIMS campus. Scientists would first seek to identify a non-native oyster which would be "successful" in the Bay, a possible strategy for rebuilding the oyster fishery and for improving water quality. Oysters and other shellfish filter phytoplankton and suspended sediments from water as they feed, thereby improving water quality.**

A second objective of the

**The sketch of the proposal really does not do it justice in the sense that the rigorous controls and issues addressed are not mentioned. The proposal would allow for the introduction of a non-native species only after conformity with all applicable state, federal, and international laws and protocols. Second, the proposal would proceed within the framework of rigorous scientific study and testing which would address all relevant ecological, biological, and economic issues.

Partial view of the VIMS Eastern Shore Lab.

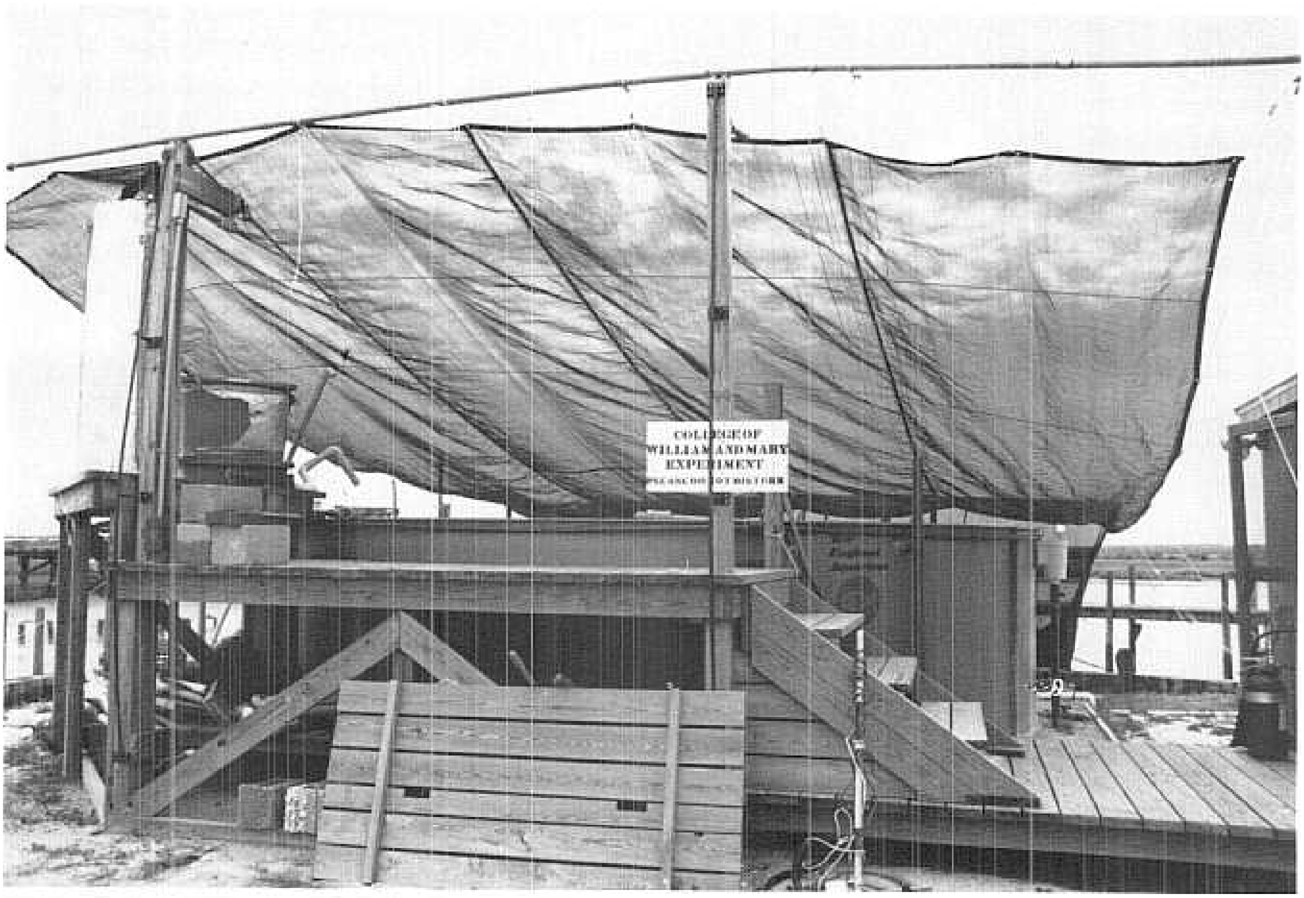
VIMS non-native oyster project would be to determine an estimated geographic range within which the candidate species is likely to be able to reproduce successfully. The second objective would provide essential information with respect to environmental risk associated with non-native species introduction. To a great extent, VIMS would be performing an environmental impact study. Any decision to actually introduce a non-native species would be a fisheries management issue, one out of the purview of VIMS.

Coastal Marine Science Research and Education

Despite its last outpost appearance, the lab has been active in terms of the types of research which have and are being staged there. An expanded emphasis within VIMS on the ecology, geology and hydrology of barrier island salt marsh systems has led to an enhancement of field laboratory capabilities at the site over the past few years. By virtue of its access to the coastal habitats along Virginia's Eastern Shore, excellent water quality and an extensive seawater laboratory, the facility affords educational and research opportunities not available elsewhere within the region.

During the past five years alone, the Lab has supported at least 22 research programs, representing numerous scientific groups and federal agencies. A number of the projects are what one would expect from a marine lab in this location, say the studies of barrier island vegetation, bivalve larval development, stock assessments, the feeding and growth of the softshell clam (*Mya arenaria*).

The Lab's role as a field station allows students to access the facility for educational experiences which would probably not be possible otherwise.



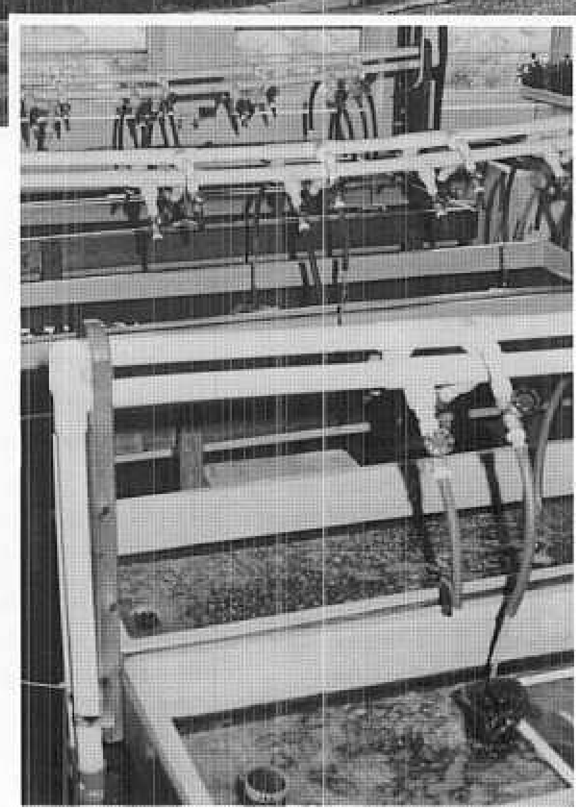
Flow-through filtered tank system used for research on catch-and-release effects.

Other scientific undertakings are grist for the scientific mill, long-term ones which need years of data to provide a realistic profile. Under this category is the VIMS program which maps the distribution and abundance of submerged aquatic vegetation, a massive program which was detailed in length in the last *Bulletin*. Another project under this grouping seeks to elucidate how elements which are fundamental to life on Earth are processed by a system, in this case a salt marsh. The chemical element nitrogen, which in combined form is a constituent of all proteins, has been and is a continuing focus of research as scientists seek to shed light on how this elemental chemical is cycled through a system. VIMS researchers are seeking to determine the exchange of dissolved inorganic and organic forms of nitrogen and carbon between uplands, wetlands, the atmosphere and coastal waters. Ultimately, this project should provide an improved understanding of the role that wetlands and estuarine systems play in modifying anthropogenic inputs of nitrogen and carbon to coastal waters.

Experimental projects at the Lab include a continuing bluefin tuna study. Step by step, researchers are examining the biology of this commercially/recreationally valuable fish to establish whether it would be possible to culture them in offshore pens. Another goal of the tuna study is to obtain more data on the effects of catch-and-release practices. Scientific work conducted in New England appears to indicate that the stress and injury associated with the small bluefin and the giant bluefin catch-and-release fisheries are substantial.

Even if, nationally, education seems to not be a priority, it is a major focus of the VIMS lab. Over the past five years more than 700 students from at least 17 institutions (other than VIMS and the College of William and Mary) have used the facility for short field trips. Education is not restricted to those of college age. Public education includes allowing use of the lab by local schools, 4-H and elderhostel; and by offering courses in clam and oyster aquaculture. With the recent construction of a new building to provide needed classroom and laboratory space, and the ongoing renovation of the dormitory, the lab is being upgraded to meet a growing demand in support of coastal marine science education and research in the region. ❖

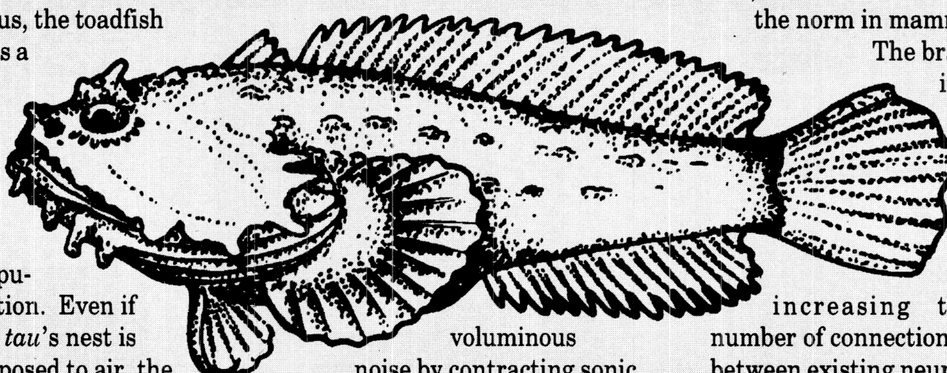
The new building at the Lab provides needed labs, classrooms and offices.



Mariculture projects and broodstock maintenance are part of the work conducted at the Lab.

Opsanus tau,
The Oyster Toadfish

The VIMS lab also serves as a field station for collection, helping facilitate research, such as the work detailed below, at other higher educational institutions.



Opsanus tau, the oyster toadfish does not engender much *positive* attention from humans. No-one wants it in his or her net. Its large mouth filled with blunt teeth, its not all that aesthetically appealing appearance (at least from a *Homo sapiens* point of view), and its slimy skin often make it more prone to spearing and get-it-out-of-the-boat behavior. Plus, the toadfish has a reputation. Even if *O. tau*'s nest is exposed to air, the male will fiercely guard the eggs, may even latch onto a foot if a person provokes, or ventures too near.

Despite its disregarded station in life, the toadfish has its secrets, ones which have caught the attention of researchers at various points in time. Diabetes research and work involving equilibrium and disequilibrium were performed with this animal. The fish has been the recipient of all sorts of scientific attention, but the qualities likely of the most interest to non-biologists are the animal's impressive communication skills, and its ability to produce new neurons—the latter quality having a potential human application.

The Chesapeake Bay can be a noisy place and the oyster toadfish is part of the aquatic chorus. The fish can make voluminous noise by contracting sonic muscles on its swimbladder to the tune of between 200 and 300 contractions a second, according to biologist Michael Fine. Fine has researched many aspects of the animal, including the development of the sonic neuromuscular system of the fish (the system described in this paragraph, the one which produces sound as well as new neurons).

It is the nesting male which produces the courtship call, for hours at a time at a frequency above 200 Hertz. The number of calls can exceed ten a minute, and, the calls differ from region to region and during seasons.

O. tau's neuron-producing ability* could be something humans might envy, for mammals are born with a finite number of nerve cells and cannot produce more. In fact, the death of these cells is the norm in mammals. The brain can, in part, compensate for the cell death by increasing the number of connections between existing neurons, or by another part of the brain attempting to take over the function of a damaged portion. If the world were a place without accidents and strokes, the way in which the brain operates would suffice. It obviously isn't, and work in this general area may—in the futuristic maybe world of scientific discovery—lead one day to remedies for conditions we now think are irreversible.

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*Both teleosts (bony fishes) and elasmobranchs (sharks, rays) have this ability.

Nature Conservancy Lands

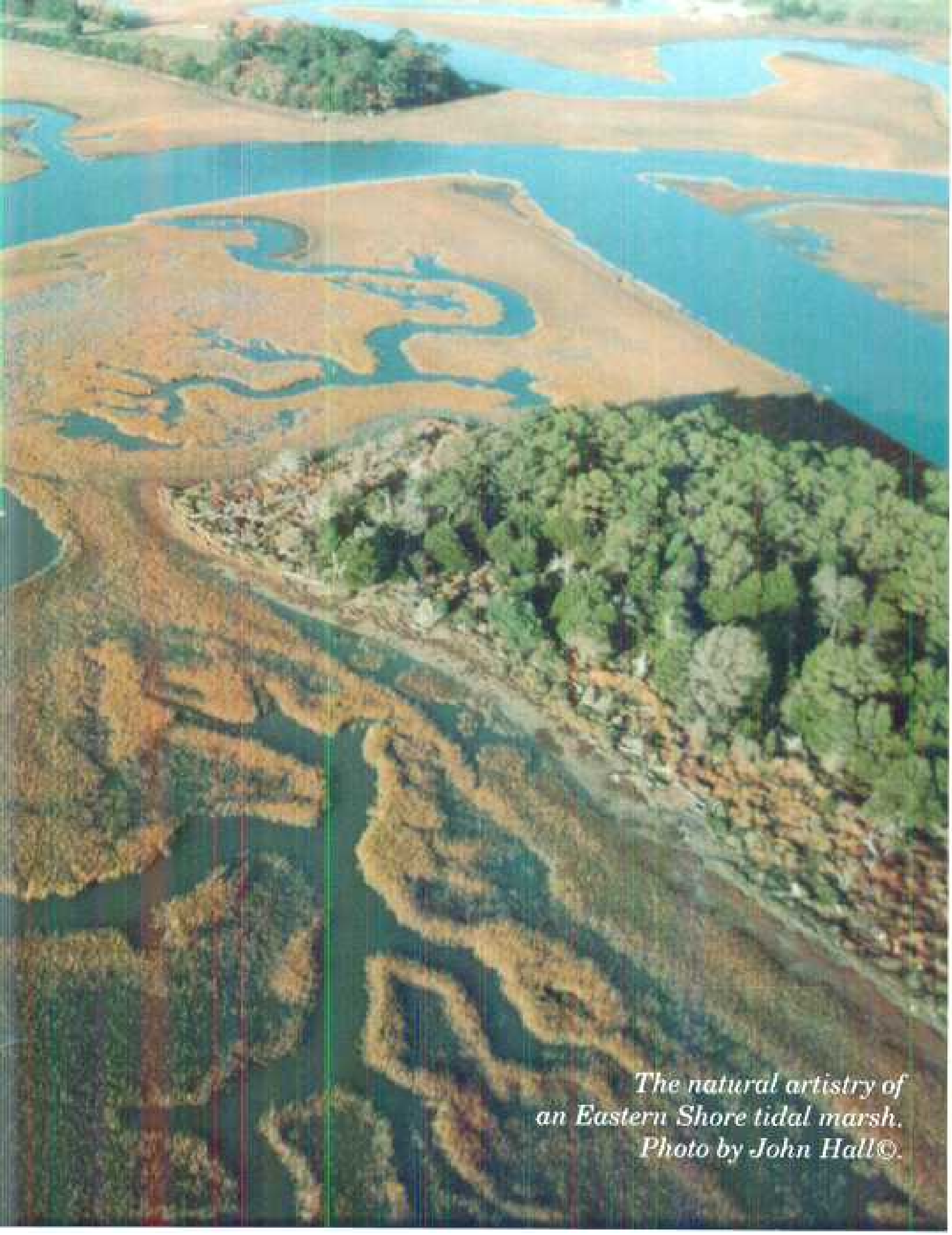
An Impressive Scientific Lab

Most people are not aware that lands owned by The Nature Conservancy probably constitute the largest scientific lab to be found on the East Coast. Which groups access the land? A profusion of Virginia universities and colleges; institutes of higher education in other states; and national or international research groups. Two of the major projects featured in this issue of the *Bulletin* are being conducted there, the Long-Term Ecological Research project and the Virginia Sea Grant work by Linda Blum. In essence, given the nature of their work—specifically, the need for an ecosystem as close to its original state as possible—it would have been extremely difficult for the researchers to find an analogous site.

Not only do the researchers benefit from a research permitting process which facilitates access to lands. The Conservancy, with an aim of making decisions based on scientific research, is able to utilize the information gleaned by scientists. While the Chesapeake Bay has been scrutinized and scrutinized again, the seaside system has not. Thus, the scientific information derived from the sanctuary may be fairly unique, and may provide information not found elsewhere.

The Coastal Sanctuary, Then and Now

The migration to, and the development of the East Coast has been fairly unrelenting during the past 25 years. The shorelines have become a mecca for a segment of U.S. society, as a permanent residence and also as a source of recreation. During the land rush, wetlands were sometimes altered so they were no longer wetlands, houses were perched right on ocean's edge, and large communities which taxed natural systems were built. This was not out of some sort of malevolence, but usually without an understanding of the poten-


The natural artistry of an Eastern Shore tidal marsh. Photo by John Hall©.

tial ramifications of human activities. In 1996 a great deal more about the environment is common knowledge—important ideas, such as the value of wetlands as nurseries and habitats, and as highly effective water filtering systems. Today, more people know that perching a house on the Atlantic's edge is asking for the ocean to claim the building as its own. And the general public is beginning to understand that the future for intense development is finite—that the natural systems upon which they rely may not be able to sustain them.

Virginia's Eastern Shore was bypassed in the land rush. This is not to say that it was not contemplated. Rather, elaborate plans were in place, plans which would have changed the Shore in a monumental way. However, public opposition, new federal wetland laws, a poor economic climate for the developers, and the work of conservationists deflected the move toward fervent development.

Conservationists, environmentalists—what's the difference? Some conservationists will define it as a difference between people who may be more issue driven (the environmentalists), and those who are systems driven, considering the interaction of all parts (conservationists).* By any definition it is a formidable task to find a workable compromise to the problems imbedded in our age: a changing economy, the desire of many rural populations to find a way to maintain their communities without obliterating a way of life, and the pressure to develop for immediate economic gain, a tempting proposition for many people.

Sustainable Development

Most every age has labels for its approaches to communal living and the environment. "Sustainable growth" is a current buzzword which denotes a movement toward incorporating the needs of a community

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*Whether this is a commonly recognized distinction between the two groups is up to the reader's discretion. Of late, some environmentalists have been complaining that they are being stereotyped, demonized, and politicized. They would say that their concerns about impacts because of the interconnectedness of systems, about clean water and air, and about the over-exploitation of land, are far from radical. Rather, they are simply reasonable and reflect what a majority of people believe in the nation.

while preserving the natural values, goods and services that the environment provides. This is the direction The Nature Conservancy is taking, and has since about a decade ago.

The Conservancy's presence on the Eastern Shore started about twenty years ago and marks the start of an extensive conservation project—probably one of the most ambitious private ventures in the United States. Starting out with approximately 2,000 acres, the Conservancy project now extends over 40,000 acres and includes 14 islands, saltmarsh tracts and, to a much more limited degree, some of the adjacent land. The Conservancy has basically been able to establish a large coastal sanctuary which is the last of its sort on the country's unglaciated coast. The assemblage of islands is called the Virginia Coast Reserve.

Back to sustainable development—the balancing of a community's socio-economic needs while protecting the benefits of natural systems. It is a logical enough idea, but it certainly has taken 20th century society long enough to realize it. From the Conservancy's point of view, successful sustainable development needs to be a cooperative effort between the community and its businesses; to be successful, any conservation project needs a strong basis in science and the commitment and leadership of the community.

A fairly new idea in resource protection is that a group cannot simply purchase land, declare it protected, and then expect an ecosystem to be safe from substantial environmental degradation. No group would be able to purchase enough land in this day and age to truly protect or even maintain the integrity of a system. As a result, conservation organizations are turning more and more toward the community for joint solutions which would protect the resource, protect land, and still offer economic benefits for the community. This approach, used by the Conservancy on the Eastern Shore, in the best of all possible worlds, is akin to investing in a way of life. It is also pragmatic. If sustaining an ecosystem results in economic losses to residents, they will have little or no incentive for a cooperative effort. A clearcut example of this can be found in parts of the developing world, where some economically hard pressed people sell off natural resources as quickly as they can—just for an existence slightly above or at the level of subsistence.

In some cases, the efforts toward sustainability involve drawing upon the historic memory of a citizenry, say the farming community. Ideally, and this is a project being worked upon by the Conservancy and some local farmers, an agricultural effort would improve the long-term stewardship of the land by enhancing biodiversity and the quality of soils. Instead of a reliance on substances which could undermine water quality, science and the farmer's expertise would be combined to offer an alternate plan. For instance, instead of spraying crops at the first sight of a predator, a farmer could wait until a certain percentage appeared; spraying kills beneficial insects too, and disrupts the balance between desirable and unwanted insects. Time-released fertilizer could be an option, too, providing plants with nutrients throughout a season, as opposed to many applications which cannot be taken up by the plants immediately, and which may very well end up in the watershed.

In its quest to maintain the quality of a large ecosystem, The Conservancy is now employing a somewhat unusual legal tool: easements designed to protect the long term health of the watersheds and the adjacent salt marshes, bays and tidal creeks. These easements are science driven. Clearly, some areas can withstand more intensive use than others, so each easement is different. However, each is based upon a scientific analysis of features such as the topography; the geological and historical attributes; the hydrologic and soil characteristics; and the biological communities. Either landowners request these easements, or, when land becomes available, easements are designed, representing the landowners' and the Conservancy's interests.

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In Concert

The Nature Conservancy is taking part, along with numerous public and private partners under the leadership of Northampton County and the Town of Cape Charles, in a demonstration project, an Eco-Industrial Park, one of the four President's Council on Sustainable Development Prototypes in the United States.

Modelled after natural ecological systems, an Eco-Industrial Park employs this fundamental concept: the waste of one business becomes the raw material of others. When the Park is up and running, the goal is job creation and enhanced economic prosperity, environmental soundness, pollution prevention, and zero emissions.

The concept of an Eco-Industrial Park is not an isolated idea. It can be loosely connected with what has been coined biorealism. This is not a movement founded with specific goals in mind. Rather, like-minded people across the social spectrum apparently have arrived at the same juncture and are seeking to combine biology and technology for a less resource wasteful world. The following is a sketch of the concepts of the movement.

Biorealism may be an old idea, by necessity practiced by a good portion of the pre-industrial world, but it is now emerging as the perhaps wave of the future. The basic premise behind biorealism is that almost no waste is produced by a society—no pollutants released, zero emissions. In a perfect biorealistic world, every time a waste is produced by a person or process, it becomes a useable product or energy source for another person or for the ecosystem itself.

At the beginning of the 20th century the idea behind biorealism would have been thoroughly understandable by people in rural areas. Using everything to its utmost utility was a maxim of life for farmers at least. All possible plant and farm animal sources of nutrients were spread on the fields to enrich the soil. When animals were slaughtered, all parts of the animal were used, right down to the bones—boiled to make gelatin or soup. Inside the house, the same utilitarian principle held. Fabric was recycled until it was reduced to odd scraps, which were then made into quilts. Ashes from the stove were mixed with water to clean slate and tiles.

Unwanted old books were recycled; recipes might be pasted on the pages. Even hair was reused. Hair from brushes was placed in a container called a hair receiver, and later sold to the traveling peddler who would then send masses of hair to cities to be made into wigs.

The farm at the turn of the century is a microcosm of what is intended by part of the biorealism movement, except biorealism concentrates on using a combination of biology *and* technology to address today's problem of waste. An example of the last notion: instead of using a blue dye (often toxic), optics could be utilized to achieve the color. A blue bird's brilliant color is not because of blue pigment in the feathers. The bird is actually a light brownish color. It is the way the feather is constructed that causes us to see blue. When light passes through the feather sheath it encounters a transparent sheath, colorless cells and then pigment cells. All colors except blue are absorbed by the pigment cells; blue is reflected back via the colorless cells. In a much less specific way, the biorealism movement, as its combines biology and technology, seeks to end resource depletion and waste, an idea which one day could benefit industries in cost-cutting ways.

Around the world, demonstration projects are being conducted using a farming system. Sewage and waste are processed in ponds by algae and aquatic plants. The resulting clean water is home to fish. The plants which cleansed the water are fed to farm animals or used as fertilizer. How are the fish fed? Waterfowl, which found a food source in the algae which was used to cleanse the water, add nutrients to the water. This is a greatly simplified model using a very understandable example. But biorealism seeks to apply this to industry and to provide for a way to manufacture products which do not contain elements which cannot be recycled*

Ultimately, the taxpayer can pay dearly for waste in the form of a more expensive product, or in disposal, or worst of all—in a cleanup which may have taken place too long after damage to, say, the water system.

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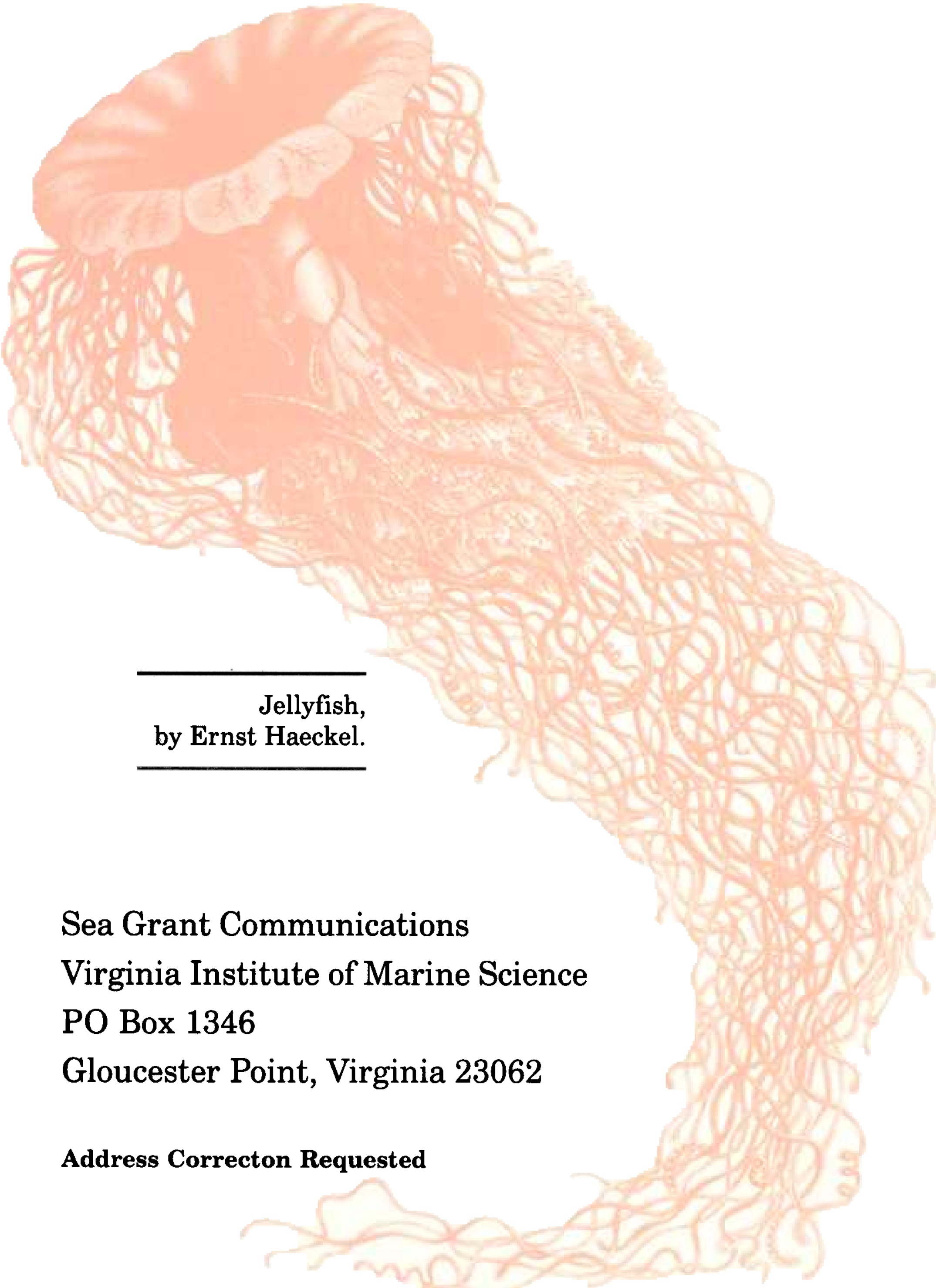
*For an excellent article on biorealism which covers the subject in depth, read Robert Frenay's "Biorealism: Reading Nature's Blueprints" in the September-October 1995 issue of *Audubon*.



Jellyfish,
by Ernst Haeckel.

Sea Grant Communications
Virginia Institute of Marine Science
PO Box 1346
Gloucester Point, Virginia 23062

Address Correcton Requested