Marine Resource Bulletin

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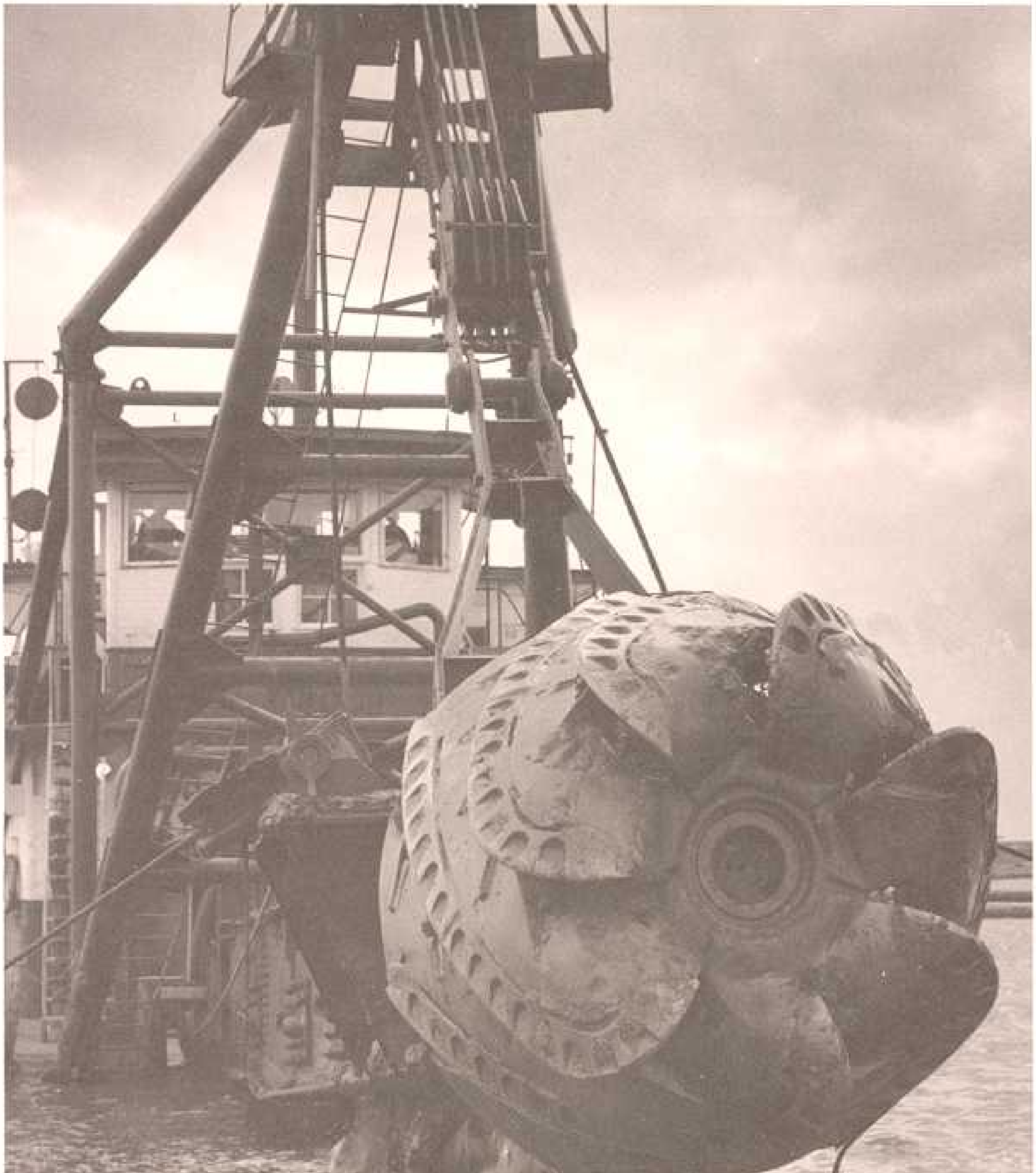

Virginia Sea Grant College Program-Virginia Institute of Marine Science-College of William and Mary

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The Marine Resource Bulletin is a quarterly publication of Marine Advisory Services of the Virginia Sea Grant College Program which is administered by the Virginia Graduate Marine Science Consortium with members at **The College of William and Mary, Old Dominion University, University of Virginia and Virginia Polytechnic Institute and State University**. Subscriptions are available without charge upon written request.

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Sea Grant is a partnership of university, government and industry focusing on marine research, education and advisory service. Nationally, Sea Grant began in 1966 with passage of the Sea Grant Program and College Act.

Cover photo: Cutter head on hydraulic dredge. (Photo courtesy of U.S. Army Corps of Engineers, Norfolk District.)

CONTENTS

Introduction

The history of science, like the history of art, is a story of added dimensions. In fact, science and art are closely linked. As mankind's knowledge of the natural world increased, his ability to recreate that world artistically grew also. From the flat, two-dimensional cave drawings to the three-dimensional works of Michaelangelo, to Surrealism influenced by Freud; art like science has always sought to expose the non-visible forces of life.

Forty years ago, marine scientists could represent coastal processes in only superficial and descriptive dimensions. In the applied world, activities such as coastal construction, dredging, and military operations were forced to base long-range plans in the coastal environment on shallow, primitive "information" and poorly based concepts.

Twenty years ago, scientists increased their knowledge of the physical forces at work in this most dynamic of all marine environments sufficiently enough to add new dimensions. Wave motion, for instance, could be understood in quantitative detail in the four-dimensional realm that it really operates. For the past ten years geophysicists have been moving toward a new capability; the mathematical and conceptual recreations of coastal processes in four dimensions, called modelling.

Dr. L. Donelson Wright, Head of the Division of Geological and Benthic Oceanography of the Virginia Institute of Marine Science, speaks for a handful of leaders in the forefront of coastal geophysics. These researchers are revealing the once unknown and unseen world of physical forces which shape the coastal marine environment, and affect and are affected by the organisms that live there.

Despite futuristic implications of their work, the basis of their research requires an understanding of the actions which took place millions of years ago. "We have to first understand and then separate the historic from the present processes in order to understand the current effects," Wright explains. "For instance, right now we are searching for mineral reserves for the State and also for ancient beds of oyster shells. These relic reserves are all buried beneath sediments. If we didn't know the geological history of the movement of sediments and minerals, we would have no idea where to look for these valuable reserves."

In this issue we will describe some of the most dramatic of the forces which shape Virginia's nearly 5,000 miles of coastline. We will also attempt to convey the exciting research achievements of these scientists, as well as how their work will affect the lives of Virginians in the near future.

The Geological History of Virginia's Coastal Plain

The formation of Virginia's coastal plain, as we know it today, began over 25 million years ago. For most of those years, as ice ages came and went, as oceans changed their boundaries and continents shifted, the area that is now occupied by the Chesapeake Bay and the Eastern Shore was covered by shallow seas which alternately advanced and retreated. Then, about 5 million years ago, beginning in the early Pliocene period, geological events began to shape the present coastal areas.

During this period, shallow seas at times reached nearly to Richmond. There was no Eastern Shore and the Susquehanna River probably did not exist. Other, more southerly rivers, flowed through deep glacier-created valleys from the Appalachian Mountains. Then, as glaciers melted, and sea level rose, the debris trapped in the ice began to move down the rivers, filling in the valleys and depositing sediments which formed the beginnings of the Eastern Shore.

In the Pleistocene period, beginning about 2 million years ago, the ocean retreated again during a new ice age, and the formation of the Bay began in earnest. At the start of this period, the outer coastal plains were deeply carved by major rivers like the James. Barrier islands formed off the coast, but moved freely, alternately growing and receding, sometimes combining and sometimes disappearing altogether. Later in the Pleistocene era, the Susquehanna River grew and flowed eastward across the Delmarva Peninsula into the Atlantic, and the York and the James flowed directly into the ocean to the south.

When this ice age ended, sea level rose again, filling in river valleys, altering the courses of the great rivers. Sea level was only 35-45 feet above its present level, but the Bay was not yet closed in by the Southern Maryland and Virginia portion of the Eastern Shore. The basic outlines of the present western shore peninsulas existed, however.

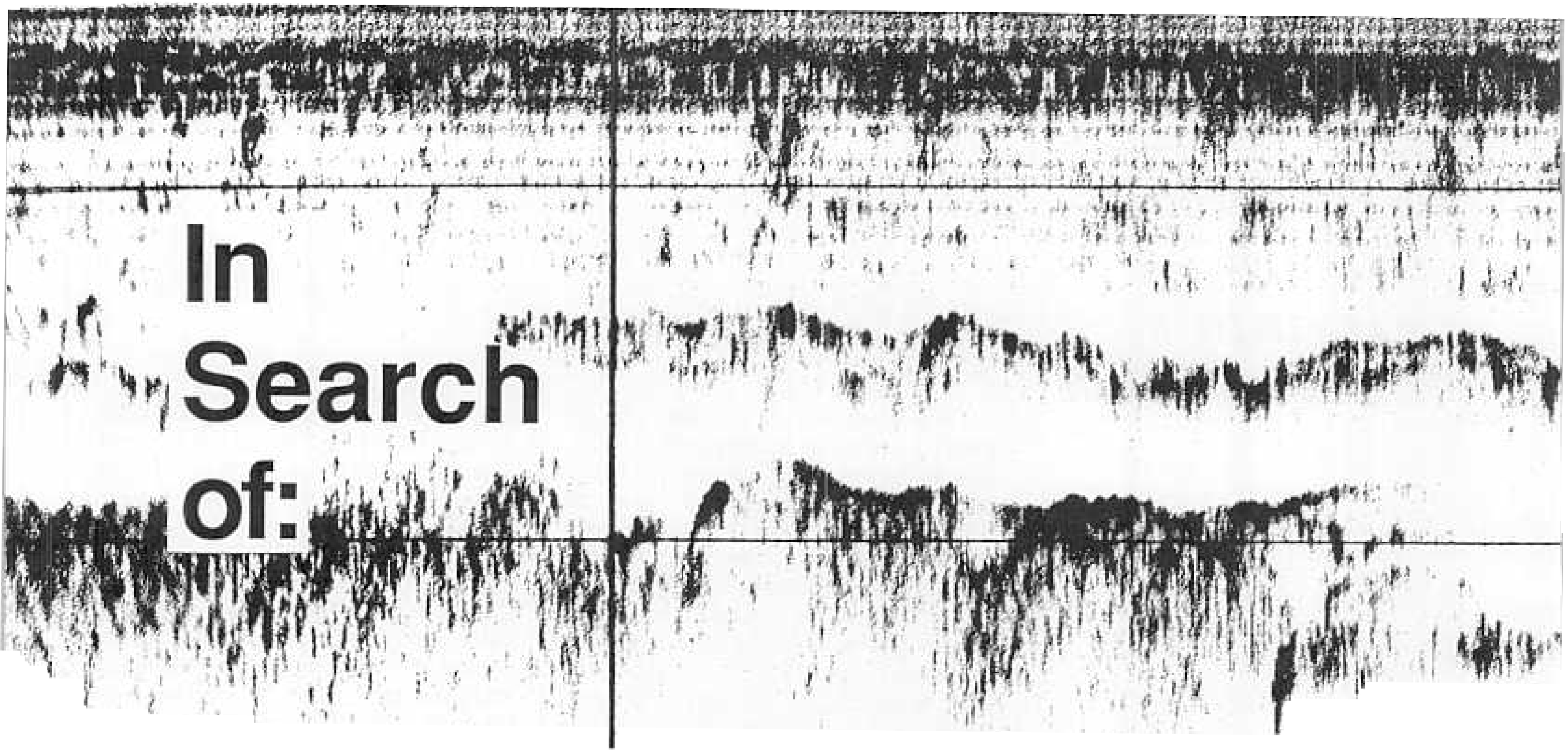
This ancient Bay was destroyed with the last ice age about 140,000 years ago. Sea level dropped 300 feet below the present level. The receding waters deposited sediments in large ridges, particularly near the present Eastern Shore and in the Albemarle Sound area.

Between 18,000 and 5,000 years ago, the present configuration of the Chesapeake Bay and outer continental shelf developed. According to Dr. Gerald H. Johnson of the College of William and Mary Department of Geology, "In historic times, the rise of sea level by two to three feet has contributed to the enlargement of the Bay by inundation of low lying areas and by the erosion of the shoreline by wave and current action. Concurrent with this adjustment of the shoreline, sediment from natural and man-made sources, primarily agricultural and forestral activities, has filled the Bay at or exceeding the rate of sea level rise in many areas."

"The future of the Bay will be controlled by natural and man-made causes. Regionally, sea level, which has been rising at an accelerating rate in the last 100 years, will continue to rise causing erosion and flooding of low-lying coastal areas, especially during tropical and northeastern storms. Until sea level reaches the elevation of another terrace, the broad marshes of the Chesapeake will shrink in area as they are squeezed between man-made shoreline erosion structures and the erosion along their bay-side margin. Judging from the regional geological history, there will be variations of sea level with attendant shoreline changes and depositional processes and the Chesapeake Bay will continue to be a dynamically changing system."

'rom: Guidebook to the Late Cenozoic Geology of Southeastern Virginia by Gerald H. Johnson and Pamela C. Peebles, prepared for the Chesapeake Bay Symposium, National Marine Educators Conference, Williamsburg, Va. 1985.

In Search of:



Oyster Shell

Each year the state of Virginia purchases over 2 million bushels of oyster shell for the Virginia Marine Resources Commission's oyster replenishment program. Private oyster producers purchase several hundred thousand additional bushels of shell. All of the purchased shell is placed on Virginia bottoms in an effort to replace shell taken during the previous harvesting season. Over 1.8 million bushels of shell a year are mined from an ancient oyster reef in Maryland. In 1985 a geologist, Carl H. Hobbs, III, from the Virginia Institute of Marine Science, began a small-scale search for oyster shell in Virginia waters. The initial research was funded by Sea Grant.

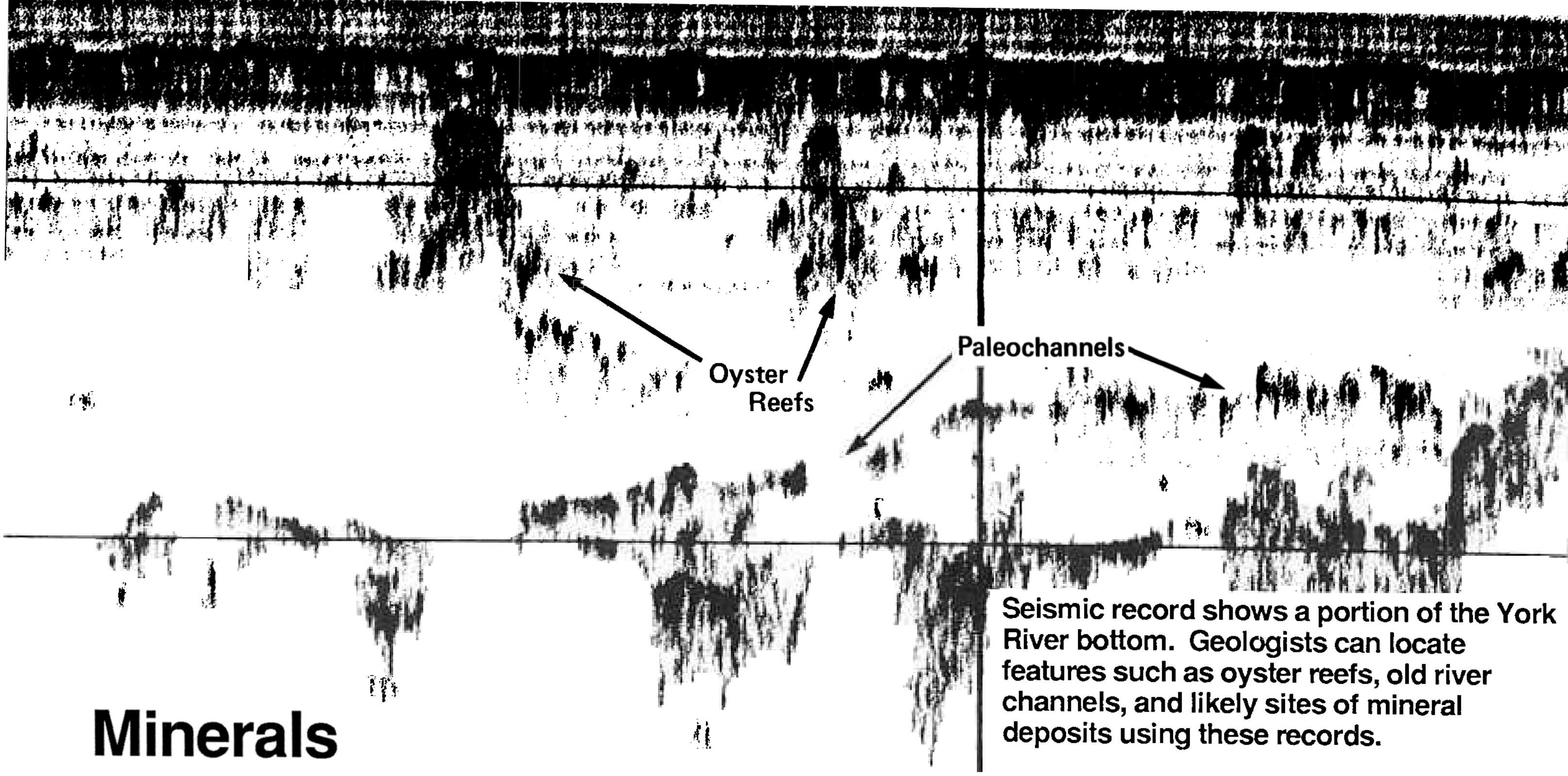
"Traditionally," says Hobbs, "oyster shell has been sought by probing likely spots on the bottom with a metal rod. Obviously, you could only do this in shallow water, and it is not an especially efficient method."

C. H. Hobbs and George Thomas use the shallow penetration seismic equipment ("fish") to record features below the bottom.

Hobbs used shallow penetration seismic equipment which can cover more ground and be used in deeper water to search for reserves of old oyster shell. Within the first year, the geologist had proven that the search method would work and had located some potentially viable shell deposits. By the beginning of 1986, state agencies were interested in the shell search.

Search locations are chosen based on geological information and the observations of local watermen and marine scientists. Geologists believe that the changes in sea level over millenia offer a good clue to locations

Should the reef in Maryland become exhausted or otherwise unavailable, the search for oyster shells in Virginia could become critical. Also, efforts are underway to increase the number of oysters available for harvesting by adding shell to Virginia bottoms and releasing eyed-larvae which attach to the old shell. About half a million bushels of shell come from the shucking houses each year, but that is not nearly enough. Locating and mapping oyster-shell reserves now will allow Virginia a variety of options for the future, as well as increasing our knowledge of the past.



Seismic record shows a portion of the York River bottom. Geologists can locate features such as oyster reefs, old river channels, and likely sites of mineral deposits using these records.

Minerals

They're called "economic placer minerals," which is a kind of shorthand for potentially valuable heavy minerals. Unlike the gold-rush days in California when farmers and cowboys left their homes to join the search for gold, today's prospectors are often marine geologists. Geologists believe minerals eroded from the Appalachian mountains are now concentrated in deposits off the coast of Virginia. Originally, most of these minerals occurred as minute particles locked in granite or other kinds of rock. But nature eroded the granite, releasing the sand-size particles of minerals; and with the retreat of the ancient ocean, deposited concentrations of the minerals in the area now covered by the sea. Interestingly, mining the minerals from hard rock is economically not feasible, but mining the collected mineral sands from Virginia's coastal bottoms may be a major industrial effort in the near future.

The prospecting was generated by research performed by Drs. Bruce Goodwin and J. B. Thomas in 1973 and most recently by Dr. Andrew Grosz of the U. S. Geological Survey in 1983. Grosz searched archived samples from around the United States and promoted, among others, the importance of Virginia's samples. With legislative support and funding, the Virginia Division of Mineral Resources joined with the Virginia Institute of Marine Science in an effort to confirm that the samples from earlier studies were indicative of high mineral concentrations and to see if the minerals could be found in additional Virginia marine locations.

Dr. C. R. Berquist, Jr., a geologist with the Virginia Division of Mineral Resources, and Carl H. Hobbs, III, with VIMS, spent about 20 days at sea over an eighteen month period using side-scan sonar, taking sub-bottom profiles, bottom samples and vibracores, and then analyzing the results.

In addition to searching for mineable quantities of valuable minerals such as titanium, which is of strategic importance, Berquist wanted to track historical sediment movement around the mouth of the Chesapeake Bay. "Geologists have used heavy minerals with some success over the years to correlate rocks or sediments," according to Berquist. "Mapping the concentrations of some of these heavy minerals is like following Hansel and Gretel's trail of bread crumbs," Berquist says.

The most important tool in his own research is "factor analysis." These are set statistical procedures which allow scientists to take dissimilar, but related information and derive a set of patterns. Using factor analysis, Berquist examined minerals deposited over the last 20,000 years and derived a pattern of sediment movement. When sea level fell during the last glaciation, sediments were carried offshore; while sea level rose, some of the same sediments moved back into the bay mouth.

The last major sea level rise moved enough sediment to fill the old Susquehanna River Valley. As an example of quantities, Berquist says that Fisherman's Island, off the southern end of Virginia's Eastern Shore, consists of 160 vertical feet of sediments deposited during the present sea level rise.

By knowing where and how the sediments were laid down, geologists can predict likely locations for mineral searches. The scientists' initial research has already revealed that concentrations of minerals offshore Virginia are high. According to their report to the State, "A framework has been established that will allow the development of predictive models concerning the origin of these heavy-mineral concentrations. These models may be useful as exploration guides."

Dr. C. R. Berquist (r) and assistant drop the seismic "fish" over the side of the research vessel. Berquist will examine the resulting readings for indications of likely mineral deposit sites.

Powerful Forces

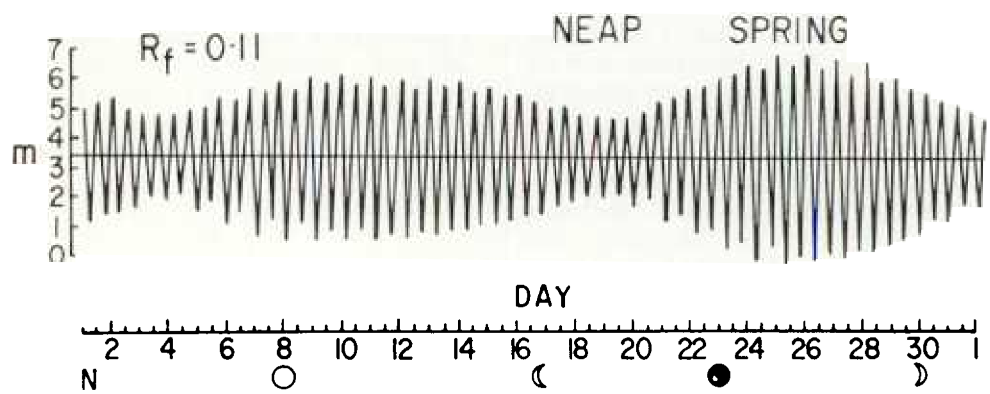
Tides and Waves

The Coastal Plain

Wherever land and water meet, the confrontation is dynamic. Virginia's coastline has exhibited a constantly changing environment for over 25 million years. Only recently have scientists understood how the shape and composition of the land affects the movement of water. At the same time, they are now able to quantify how the movement of water shapes and reshapes the land both at the interface zone between land and water, and beneath the water.

Virginia's coastal plain consists of the area from the piedmont (or eastern side of the Appalachian Mountains), to the continental shelf. Its components include the great and small Virginia estuaries, the mainland forms shaped over eons by glaciers and ocean waters, the Eastern Shore and the Chesapeake Bay. The primary determinants of the characteristics of the coastal plain are: the shape, movement and characteristics of sediments, the tide, types of waves that generally form, the patterns of water circulation, salinity and weather. Thousands of other variables affect the coastal plain at any given time, including man; but these are the strongest forces which regularly shape and reshape Virginia's marine environment.

The Tides



Tides are represented as sine waves. Note the low neap tide and high spring tide.

The waters of the coastal plain--estuarine, Bay and coastal--have distinct properties and patterns of movement directly related to the shape of the bottoms over which they move, the tides, the types of waves which form in each area, salinity, and both long-term weather patterns and significant weather events. The tide cycles are the most apparent event to coastal residents. Dr. John Boon, of VIMS Department of Geological and Benthic Oceanography, has been studying Virginia's tidal patterns for over sixteen years.

Dr. Boon describes the tide as a special class of wave that exists in the ocean, not unlike waves seen at the beach except that the distance between crests is very large (hundreds of miles). Hence tides are often called long waves.

Tides occur because of the gravitational forces of the sun and the moon acting upon the earth. The height of the tides vary with the distance and relative positions of the sun and the moon in relation to any point on the earth, and the depth and shape of the water body at a given location. The ocean tide off Virginia is semidiurnal (twice daily). The tide range along the coast is generally from 3-4 feet, but varies in the Bay and estuaries.

Inlets are one of the most prominent features of the Virginia coasts and they affect the estuarine and Bay tide. The openings range in size from the entrance to the Chesapeake Bay from the ocean, to tiny openings only a few feet wide which dot the tidal creeks of Virginia.

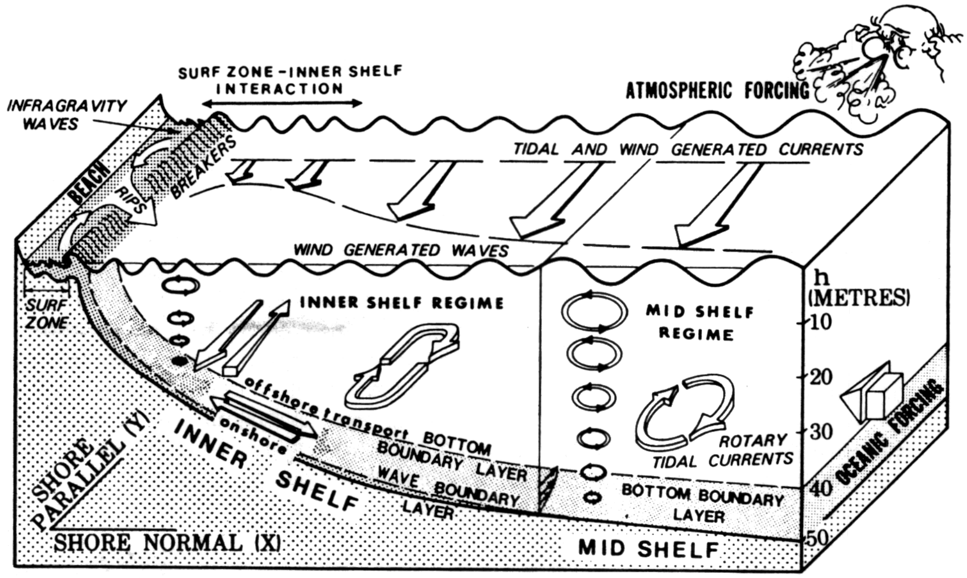
Boon uses a simple analogy to explain how inlets affect the flow of water. "If you put a small hole in a bucket, allowing only a small amount of water to run out, it could take many hours for the bucket to empty. It has a slow response. Another bucket with a large hole in it would have a fast response and empty very quickly." Using this analogy, Chesapeake Bay is a large bucket which has only 6 hours to fill with tidal water on a flood cycle and 6 hours to empty this water on an ebb cycle. The Bay entrance is a big enough hole so that the Bay can respond and admit the full potential volume from the ocean.

NOTE: The Virginia Institute of Marine Science Sea Grant program publishes TIDE GRAPHS quarterly for public distribution. TIDE GRAPHS for Wachapreague, Virginia are based on tidal constants obtained through analysis of tidal height measurements by the VIMS Division of Geological and Benthic Oceanography. Tide graphs are compiled by the VIMS Department of Numerical Analysis and Information Services. Quarterly TIDE GRAPHS for the port of Hampton Roads are also available, complete with a Tidal Difference Table that approximates the times and heights of the tide at many other locations in Virginia. The TIDE GRAPHS are free. Write: TIDE GRAPHS, Sea Grant Marine Advisory Services, VIMS, Gloucester Point, VA 23062.

Waves

Unlike the long period wave that is the tide, the surface phenomena which we usually observe as waves are generated primarily by wind. Waves are deceptive in appearance. No matter how slow-moving and gentle they may appear, waves contain a great deal of energy. The total energy in a wave is proportional to the square of the wave height; therefore doubling the wave height increases the energy by a factor of 4.

The movement of water beneath a wave is actually a circular motion which causes only a very slight net forward progression of the water particles. In deep water, the swell occurs and moves on, leaving little evidence or effect of its passing. With waves, energy is transmitted but there is no net movement of water. Waves generally form as groups of high waves which alternate with groups of low waves, a phenomena called "groupiness." An exception to this is seismically created ocean waves, the giant tsunamis or tidal waves, created by an earthquake or volcanic eruption which can send a single giant wave across an entire ocean.

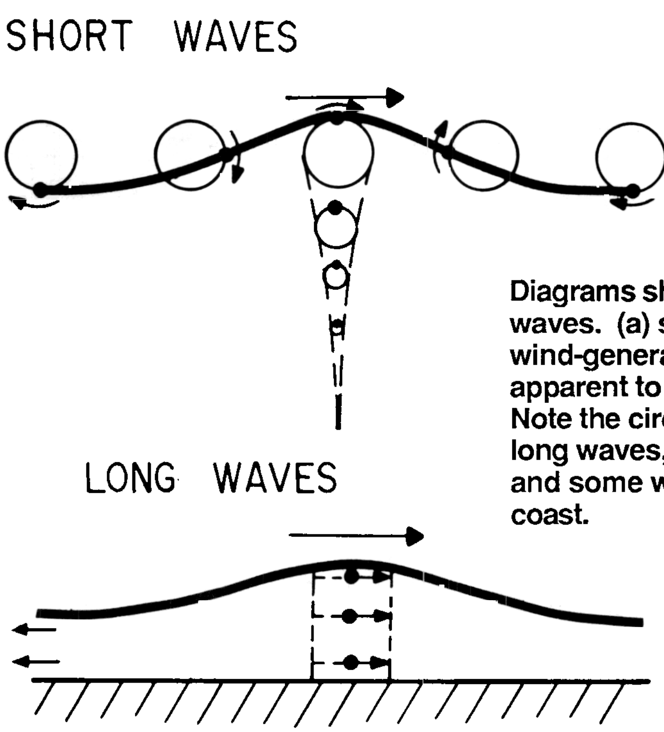


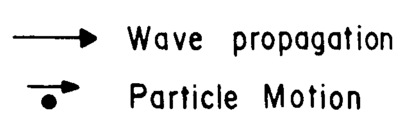
Conceptual diagram shows some elements of the coastal boundary layer.

As the waves approach the more shallow waters of the continental shelf which surround our coasts, their shape is altered by the configuration of the coastal bottom. The amount of energy applied to the shoreface depends on whether there is a long, gently sloped beach to slowly dissipate or transform wave energy, or a steep shore face which will wholly or partly reflect the waves at the end of their long journey.

In most cases, part of the energy is reflected and part is perceived as being "dissipated." In reality, however, the "dissipated" part is not really destroyed but is merely transformed into longshore currents, rip currents or long period waves.

In recent years, it has become widely accepted that long period waves (with periods over 100 seconds) are fundamental in molding beach and surf zone morphology. The waves, also called "surf-beat," move parallel to the shore as well as onshore and offshore. Jeff List, a Ph.D. candidate at VIMS, is using analyses of extensive arrays of field data and computer modelling to study how these waves are generated. His research shows that the "groupiness" of the incoming waves is one source of surf-beat. A computer model developed at VIMS by Dr. Nungjane C. Shi predicts the behavior of long waves after they are altered and often amplified by nearshore features such as sand bars. Another computer model, presently being developed by Chang S. Kim, predicts the bar migration responses to the combined wave motions.





Diagrams show two types of waves. (a) short waves such as wind-generated waves most apparent to coastal residents. Note the circular motion. (b) long waves, such as the tide and some waves along the coast.

People on the water

Keeping Marine T

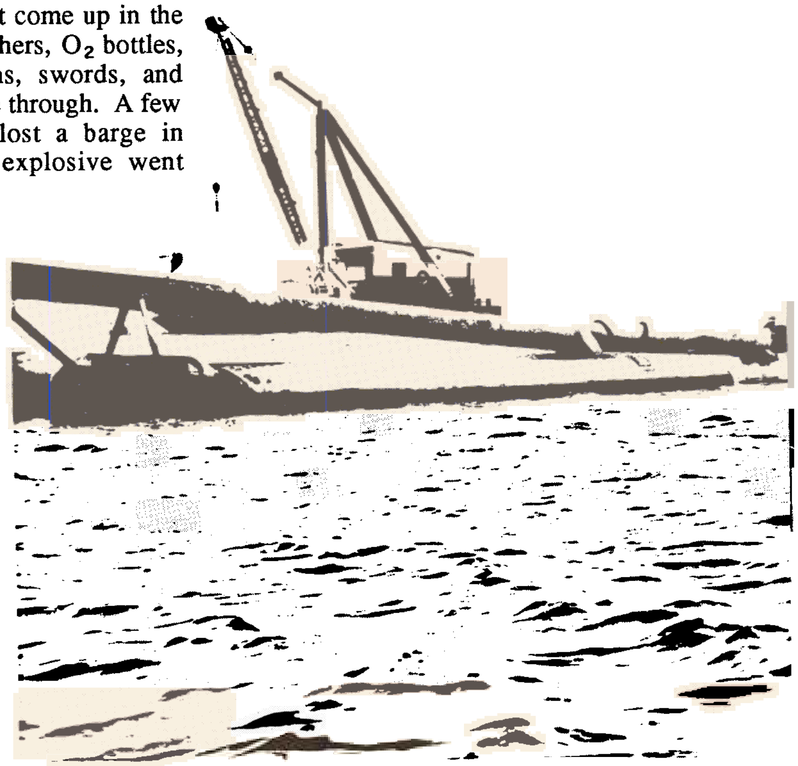
by Wanda Cohen

The ancient art DRE

Dredging is frequently referred to as an "ancient art" by the few who have written on the process. Both Tom Wright and Pat Harris with Atkinson Dredging in Chesapeake echo this sentiment. "There is no school that teaches you how to dredge; there are practically no books that tell you how to do it. It is a hands-on, experience profession," according to Wright, Vice President of Atkinson. Most of the men with Atkinson have been dredging for ten to twenty-five years and crews often include fathers, sons, uncles, nephews and cousins. Touch, feel, sight, and memory dictate the way they guide the huge, clumsy-appearing equipment through harbors, channels, and piers.

Atkinson, one of the earliest East Coast companies to use hydraulic dredging, has been headquartered in Chesapeake since 1931. They operate one 1,600 hp and two 3,000 hp dredges 24 hours a day 364 days a year (closed Christmas Day) from Florida to Virginia. Each unit is self-sufficient with a crew of 30-36 men, 2-3 tenders, 4-5 fuel and pipe barges, pontoons, and power boosters. Moving from one dredge site to another, the floating convoy extends 1/2 to 3/4 miles.

Currently they have dredges working in Hampton Roads at the Norfolk International Terminal and off Ocracoke Island in North Carolina. Within the last year they have travelled from Norfolk, to Wilmington, to South Carolina waters. By Christmas of this year the Atkinson dredge crews will complete the coastal cycle again; widening narrow, small inlets along the inland waterway, deepening channels in open waters along the barrier islands and cleaning terminal piers for submarines and destroyers. When a contract is taken, Wright and Pat Harris, Job Superintendent for Atkinson, take soundings and samples from the site and study previous dredging records to determine the cut necessary to leave behind the required amount of water, the kind of material they can expect to remove, the amount of pipe needed to carry the material to a disposal or containment site and the approximate length of time the operation will take. While there are many variables, "time is the biggest unknown factor," Wright explains, "we have to figure so many days for bad weather, if the wind is over 40 knots we have to shut down; also we never know what might come up in the pump." Fire extinguishers, O_2 bottles, lead pipes, gold coins, swords, and cannon balls have come through. A few years ago, Atkinson lost a barge in Charleston when an explosive went through the pump.



Wright and Harris agree the crew is perhaps Atkinson's most valuable asset. Only the Job Superintendent goes "on the hill" or to the shore base each night. In addition to trouble shooting and maintaining contact with the Norfolk home office, he is the crew's link to home and family. On board, the Chief Engineer is responsible for the maintenance of a million or more dollars worth of equipment including the 3,000 hp diesel engine, the 18 inch dredge and power booster equipment. The Captain oversees the entire operation. Having come up through the ranks, he knows each man's job and every piece of equipment as well as the waters in which they operate. Performing no small task logistically, the cook feeds 30 plus men three times a day and keeps the galley open 24 hours for sandwiches and snacks. Crews rotate 8 hour shifts working three weeks then having five days off.

In simplest terms, the dredge is a huge vacuum cleaner. Cutter blades agitate material and debris, turning it inward to vacuum pump impellers where it is blown through steel and plastic pipe to the containment or disposal site. The vessel pivots on two 80 foot free-falling steel tubes, called spuds, to move forward. One spud is always down so the movement is much like walking. Since the cutter must swing in an arc for the dredge to get ahead and movement back to the center is essentially lost, calculations are based on the geometric principle that increasing the diameter of a circle increases its arc. The dredge is capable of cutting an arc of 90' to 500' and working in depths up to 60'. Therefore, spuds can be moved away from the dredge to increase the arc of the cutter and the efficiency of its motions. Moving ahead 250 feet a day is considered a good rate.

The leverman maneuvers the dredge

raffic Moving

DGING

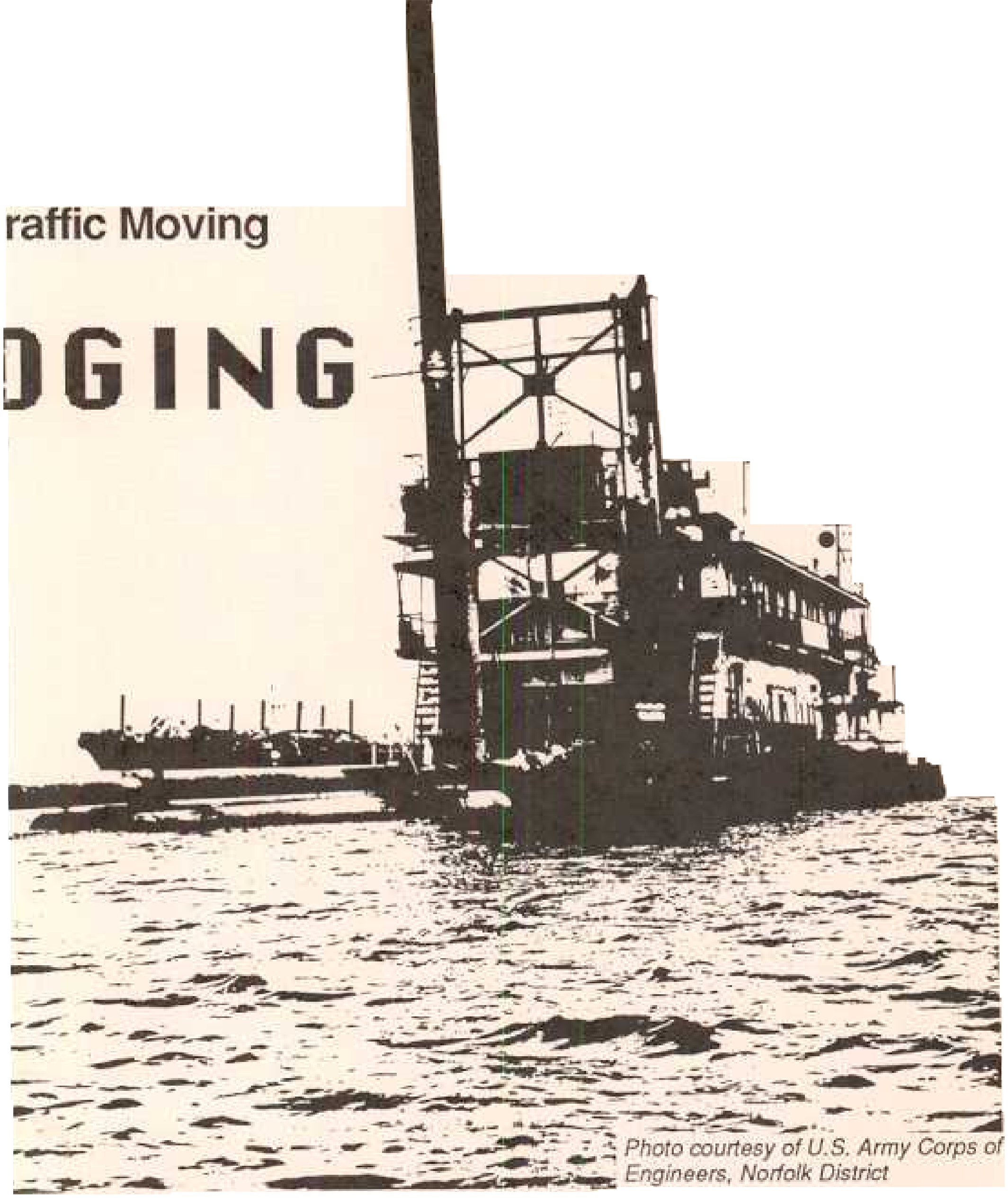


Photo courtesy of U.S. Army Corps of Engineers, Norfolk District

from the leveroom. He maintains a predetermined arc with the aid of a gyrocompass. To prevent the cutter from wobbling, anchor cables are attached to the ladder and anchors are dropped in positions that correspond to the arc of the cutter. While the cutter is running, the leverman constantly monitors pressure gauges and makes adjustments necessary to keep an acceptable balance between vacuum (intake) and pressure (output). He periodically checks his position and progress with soundings that indicate the depth of the water left behind. When ready to move forward, he raises one spud and drops the other. Equipment in the leveroom is simple, but highly sensitive and efficient. Continuous tracings record all movement and changes. Captains say they can read tracings and identify levermen because each man operates the dredge in a distinctive, individual pattern.

Tender crews or deck hands lay the 100 foot sections of steel and plastic pipe that extend from the dredge to the disposal site. If material is to be pumped to a containment area like Craney Island, pipes are pulled into position by tractors or bulldozers. Today, plastic pipe is used except when pipes must be submerged. Unsubmerged pipe is floated on pontoons. Plastic pipe is lighter, easier to maneuver and more durable than steel pipe. The crew can lay the thousands of feet of plastic pipe required to set up an operation in 3-4 hours. Atkinson keeps an inventory of approximately 25,000 feet of pipe. Near the dredge, sections of pipe are added to provide the slack necessary for the dredge to move forward. Tenders with lines to a pontoon align the sections; then deck hands, straddling the pipe, manually couple or uncouple the sections. Pipe is adjusted in sync with the forward movement of the dredge. These crews are particularly vulnerable. Speaking from experience, Pat Harris points out that a man straddling a pipe working on the coupling is not aware of what is going on around him and the wake from a passing boat can throw him off balance. It is work that requires reacting intuitively to the moment while thinking and planning steps ahead.

Disposal sites today can be several miles from the dredge. Atkinson was also one of the first companies to use 3,000 hp booster engines to pump material longer distances. These booster engines are housed on accompanying barges.

Shallow, narrow waterways, especially along the irregular Eastern coastline and inland waterway, can quickly collect enough material to affect both commercial and recreational boating. Coastal storms, inland snow melt, and rain move sand and silt that is eventually deposited along shorelines where waters empty. Each year approximately 5 million cubic yards of material is dredged from the Hampton Roads area. The number and severity of storms, amount of rainfall and kind of traffic passing through determine how often and how much dredging is necessary to keep our waterways safely navigable.

Dredging Facts

- In 1985 dredging in the U.S. amounted to approximately 30 million cubic yards at a cost of approximately $460 million.
- According to U.S. Army Corps of Engineers, from 1975-1985 $100 million was spent on environmental research related to dredging.
- Water Resource Bill of 1985 (HR 6) in Congress is a cost-sharing program to fund 14 major commercial and recreation navigation projects nationwide. This is the first major legislation to improve ports and channels since 1970.
- Under this bill the Norfolk Harbor improvements will include:
  - channels deepened to 55 feet;
  - construction of a 57 foot Atlantic Ocean channel and three fixed mooring areas;
  - deepening of existing Elizabeth River channels to 45 feet and creation of an 800 foot turning basin in the Elizabeth River.

VIMS Geological and Benthic Research

Only occasionally does a scientist or a group of scientists working together define or redefine some basic information about our world. At the Virginia Institute of Marine Science (VIMS), Dr. L. Donelson Wright, Head of the Division of Geological and Benthic Oceanography, is guiding just such a scientific process.

In the mid-seventies, Wright collaborated with Dr. A. D. Short in a study of beach processes at the University of Sydney in Australia. The indented, high-energy coast of southeast Australia is one of the most dynamic in the world, changing rapidly and dramatically from one region to the next and even within a few hundred yards. With funding from the U.S. Office of Naval Research, the two scientists were able to classify beaches into six categories. By expanding and refining these basic models to fit different environments, the scientists developed a predictive model for beach change. Their classifications provided a framework for future study and immediate assistance to planners and engineers working in the coastal environment.

Fortuitously for Virginia, in 1980 Dr. Robert J. Byrne, now Associate Director for Research at VIMS, visited Australia to present a scientific paper. As a result of that visit, several of Wright's students applied to VIMS for graduate studies and Wright was invited to visit. Dr. Wright worked at VIMS on a research sabbatical in 1981, and returned a year later as Department Head for Geological Oceanography.

Wright looks upon that important, but already outdated work as history. His interests now are with the futuristic work being performed by the group of geologists, biologists and physical oceanographers, all leaders in their respective fields, who are working together to produce a multi-dimensional picture of the marine environment never fully understood before.

Photo by Bill Jenkins, VIMS

Dr. L. Donelson Wright, Head of the Division of Geological and Benthic Oceanography, VIMS.

the fate of a beach depends on processes offshore

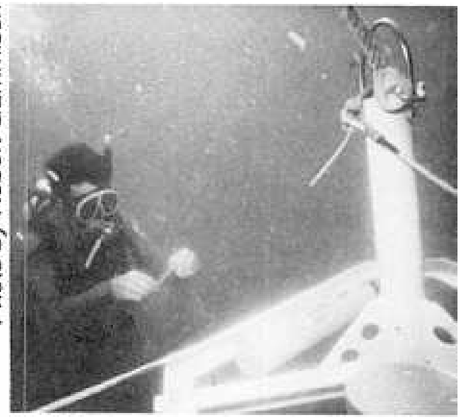
Malcolm O. Green is part of that creative organization. Green began his scientific career as an undergraduate in Sydney taking courses from both Short and Wright. In 1979, after receiving a First Class Honors Degree in Marine Science at Sydney University, he worked for three years on the U.S. Naval Research project headed by Wright. He is now completing his Ph.D. at VIMS.

Green is expanding the understanding of the physical forces that cause beaches to change by studying the links between the beach and the continental shelf. Scientists already know that the wind- and tide-driven currents of the shelf are fundamentally different from the waves that sculpt the surf zone. Green has investigated the transition between the two. Now he is developing a mathematical model of sediment movement in this transition zone, and applying it to a section of coast in Duck, North Carolina, to see how sediment is cycled between the beaches and waters farther offshore. According to Green, the problem is one of determining: "What forces move how much sediment in what direction."

Early studies of beaches were limited by the narrow conception of a beach as a simple profile that changed only between winter and summer. The idea that a beach is a continuously changing, three-dimensional entity with links to other environments has opened new ways of looking at how a beach evolves. "The long-term fate of a beach depends to a large extent on processes that occur in deeper waters farther offshore," Green says. Over the short-term, the net exchange of sediment between the surf zone and the shelf depends on the balance between those fairweather waves and currents which tend to accrete the beach as a whole, and storm waves which tend to strip the beach of sand. "Over the long-term, sea level rise and interruption of sediment supply by structures tips the balance in favor of removal of sand, and you lose beaches. The challenge is to understand the processes and find ways, if any, to control them."

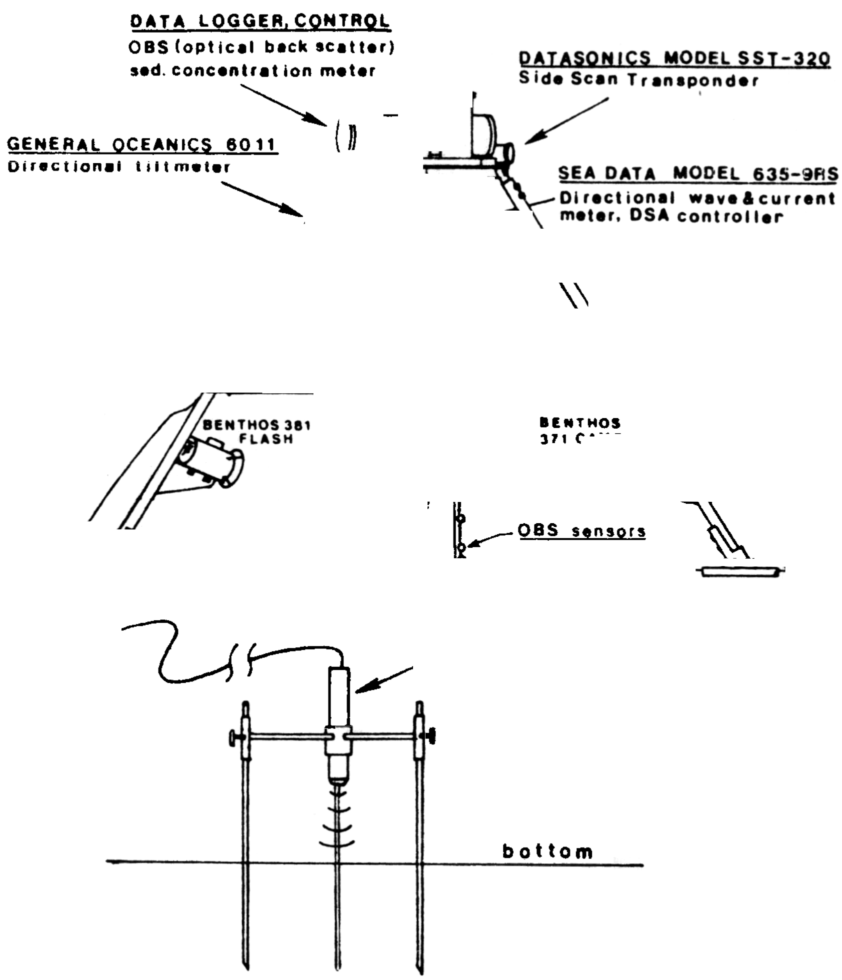
Until recently, equipment used to measure activities in this dynamic environment was either not readily available, or susceptible to loss or damage during storms. A generous private donation of state-of-the-art underwater monitoring equipment a few years ago provided the VIMS' researchers with the ability to monitor the sea floor even during storms. As the studies progressed, much of that equipment has been modified by Dr. Wright, Dr. John Boon, and graduate students Green and Robert Gammisch. Dr. Boon conceived the idea for a large, heavy tripod which could safely hold all of the equipment and withstand the forces in the surf zone and during storms. The group of scientists not only developed the idea from Boon's conception, but literally did the metal work necessary to build the giant tripod.

Photo by Robert Gammisch



Malcolm O. Green works on tripod which holds underwater monitoring equipment.

The monitoring equipment includes programmable wave and current meters, high resolution sonar altimeters, and optical backscattering meters which count suspended particles in the water. All of the equipment is self- contained; the power supply, logic and data storage tape are sealed in a pressure housing and left in the water for several weeks at a time. Combined, all of these devices allow the scientists to monitor changes in bed level, amount of sediment in suspension, rate of water movement (current)--essentially a detailed, second-by-second account of exactly what is occurring near and on the sea floor.



Artist's rendering of tripod with monitoring equipment attached. Called the Benthic Dynamics Instrumentation System (BDIS).

fine grain sediment is very hard to measure

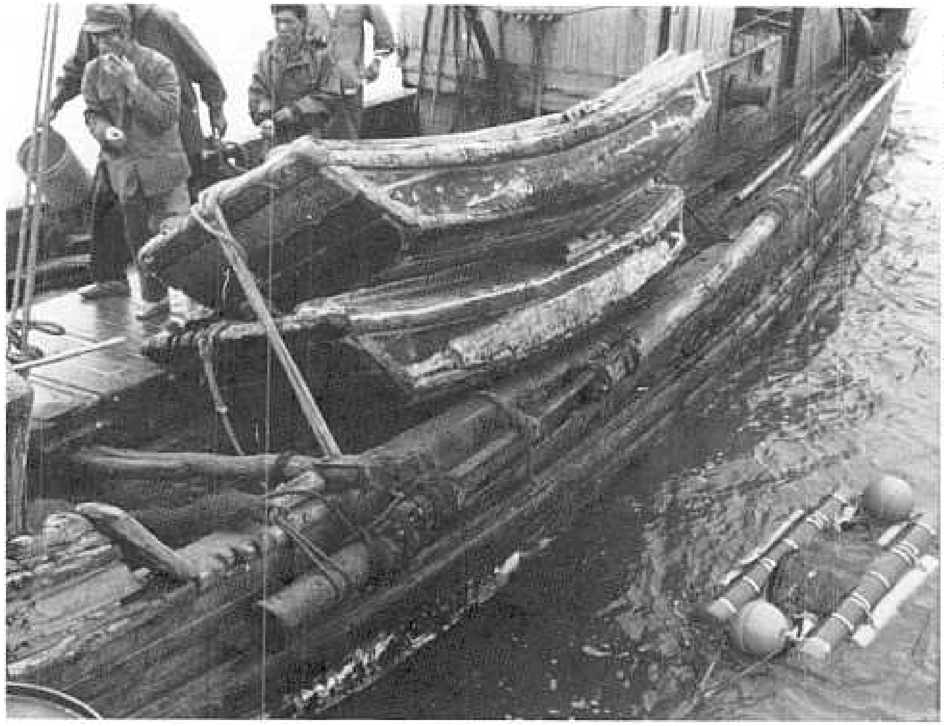


Photo by Robert Gammisch, VIMS

Chinese fishermen with their boats visit the Shandong College research vessel. Monitoring equipment is in water on right.

What emerges is a data set which shows what is happening at the investigation site. The real work of analyzing the information and making sense of what it reveals takes months of the scientists' time.

Can all of this be reduced to equations that describe the real world? "That's the ultimate purpose," says Green. "To develop models, either mathematical or conceptual, for any coastline, that will allow others to make long-range plans for those areas with a degree of accuracy never available before these studies."

In fact, the information is already being put to use on Virginia's beaches and nearshore areas to protect public and private beaches from erosion. Marine Scientist, C. Scott Hardaway, and a group of associates have studied and advised Virginians on shoreline protection for nearly fifteen years. Some of their original experimental work was funded by Sea Grant in the 70s. Today, in addition to continued research for applied solutions to erosion problems, Hardaway is technical advisor to the Virginia Public Beach Commission and the Soil and Water Conservation's Shoreline Advisory Division.

Hardaway is busiest after storms, particularly hurricanes and northeasters. Hardaway and Lab Specialist George Thomas have been monitoring the effects of these storms on shore erosion for several years. These weather events strongly affect Virginia's coastline. For the past five years Hardaway has been studying the effects of offshore breakwaters as a method of shoreline erosion control. Research results on several installations have shown their applicability to shore protection throughout the Bay. Hardaway's observations coupled with the research of Dr. Wright and Mal Green provide the scientific information needed to properly inform the advisory and regulatory state agencies and local governments.

During Green's work in North Carolina, a storm occurred which allowed comparisons of an extreme situation with the general fairweather forces he had been studying. As long suspected, the storm interrupted the fairweather cycle of nearly equal removal and replenishment on the beach and there was a net movement of sand loss from the system.

The study of another extreme phenomena is being carried out by Wright and Gammisch in conjunction with Shandong College of Oceanography off the coast of the People's Republic of China. This study, funded entirely by the U.S. Office of Naval Research and the Chinese government, looks at an estuarine environment which moves billions of tons of sediment into the Gulf of Bohai.

In major Virginia estuaries such as the James River, about 25 milligrams per liter (mg/l) of fine sands are normally suspended in the water; during the worst possible storms, about 250 mg/l. But in the Yellow River in China, 25,000 mg/l is normal; during the high-runoff season it can be as high as 220,000.

According to Gammisch, "Fine grain sediment which predominates in Virginia's estuaries is very hard to measure. Being able to study an environment where you have massive movements of fine silts is like having a special laboratory that makes it much easier to observe the dynamics of the system."

Next October, Wright and Gammisch will return to China for the third year. This time, they'll be observing how high energy storm conditions rework the billions of tons of mud deposited on deltas at the mouth of the Yellow River during the earlier monsoon season.

The geologists are using all the information collected from this seemingly diverse research to answer what would appear to be simple questions: What causes mud to be lifted off the bottom, resuspended in the water, moved, and ultimately deposited? Answering these questions will not only advance scientific knowledge, it will enable precise calculations of sediment transport for interests such as navigation, strategic defense planning, and long-range coastal planning. Additionally, it will permit evaluation of the likely fates of toxic materials contained within bottom sediments.

Because of the importance to the Commonwealth of Virginia, the study of mud transport dynamics is a major emphasis of the Division. Dr. Maynard Nichols has led an active investigation focused on the resuspension and movement of fluid mud. Most recently, he has been concerned with the role of shipping traffic in resuspending contaminated fine sediments in harbor areas such as the Elizabeth River. At the present time, VIMS is recruiting a new scientist who will specialize in the physics of mud transport.

colonies of marine worms alter the bottom

Not satisfied with just the physical answers, these scientists began to question how biological organisms might affect the physical processes. According to Gammisch, "All the models we created before this work were created in flumes (laboratory tanks) without animals. These models fell apart in the real world because animals continuously change the sediment.

Dr. Robert Diaz, also of VIMS' Division of Geological and Benthic Oceanography, was one of the benthic ecologists who had been trying to get this message across for years. Dr. Diaz has been in the forefront of benthic research for over 11 years. He describes the benthos as, "All living organisms within an area 60 cms above and 60 cms below the bottom surface."

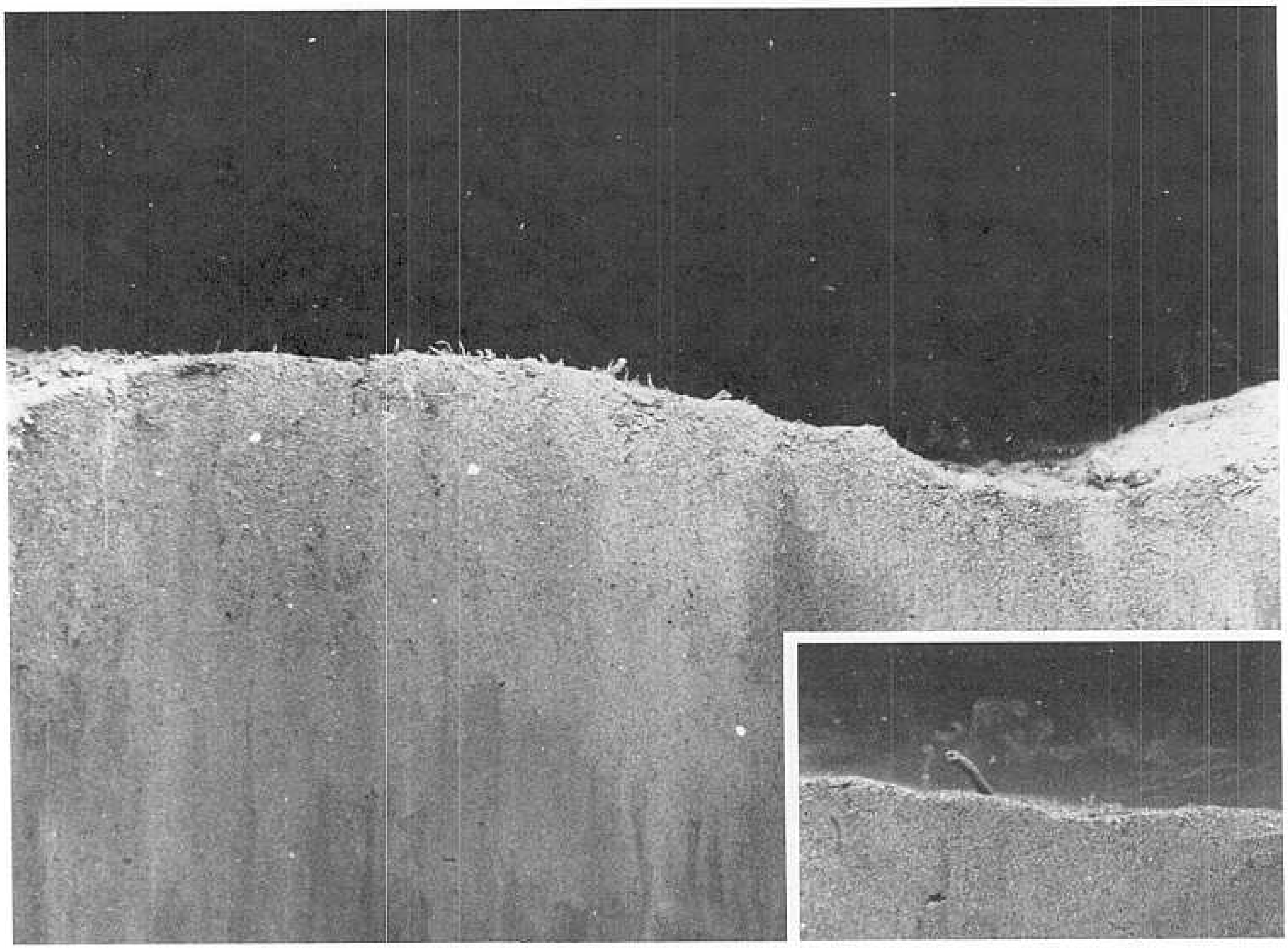
Diaz, along with marine scientist Linda Schaffner, has been able to photograph an area 20 cms above and 20 cms below the bottom surface with a sediment profiling camera. The photographs reveal invertebrates which alter bottom roughness.

Roughness, in this case, refers to various features of bottom topography much like ridges, crests, hummocks and dips on land. Wright's most recent work has shown that bottom roughness alters the frictional drag of currents over the bottom, eventually changing the bottom topography and sediment transport patterns. Gammisch says, "We are categorizing bottoms of the Chesapeake Bay and adjacent continental shelf by bed form, bottom types and activity level."

Now the scientists are examining areas where the degree of bottom roughness is determined by organisms such as marine worms (polychaetes). The biologists want to know if organisms congregate in certain areas because of the bottom composition and/or shape; and the geologists want to know how much effect these organisms have on bottom roughness.

Diaz's group has already found areas in the Chesapeake Bay where abundant summer colonies of polychaetes exaggerate bottom roughness, thus altering waves and currents. In the winter, the worms disappear, the bottom becomes smooth, and modifications to water flow occur.

Understanding the intricate relationships between the physical world and the biological organisms which inhabit Virginia's marine environment is the most important tool for preserving the health and beauty of the coastal plain. Fundamental research such as this provides the foundation for years of continued scientific and applied gains. Internationally, other scientists, planners and engineers will apply the variables of

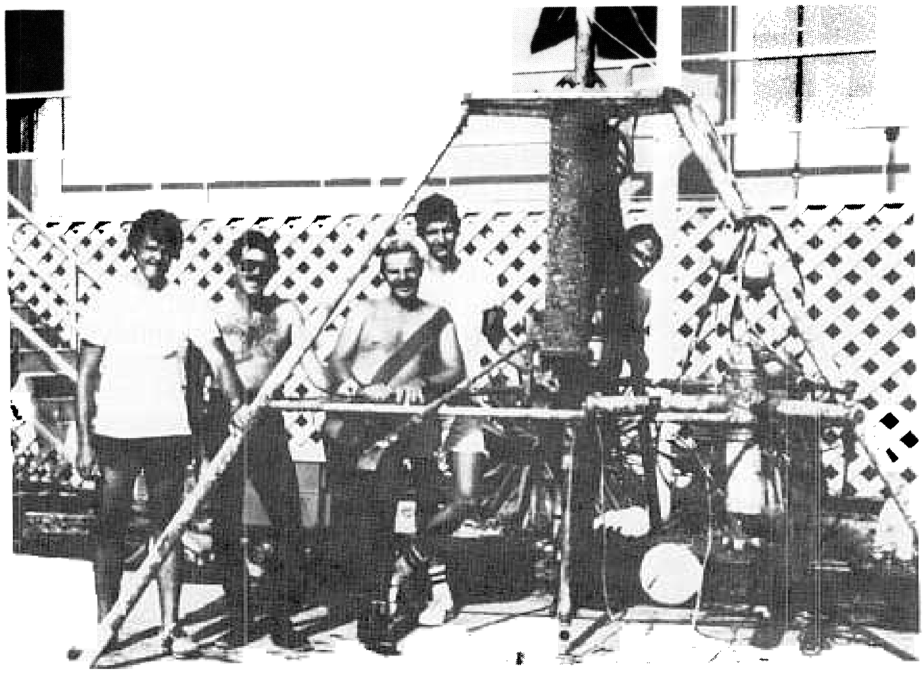


Photograph of benthic boundary layer in Chesapeake Bay showing population of marine worms. Insert shows close-up of marine worm.

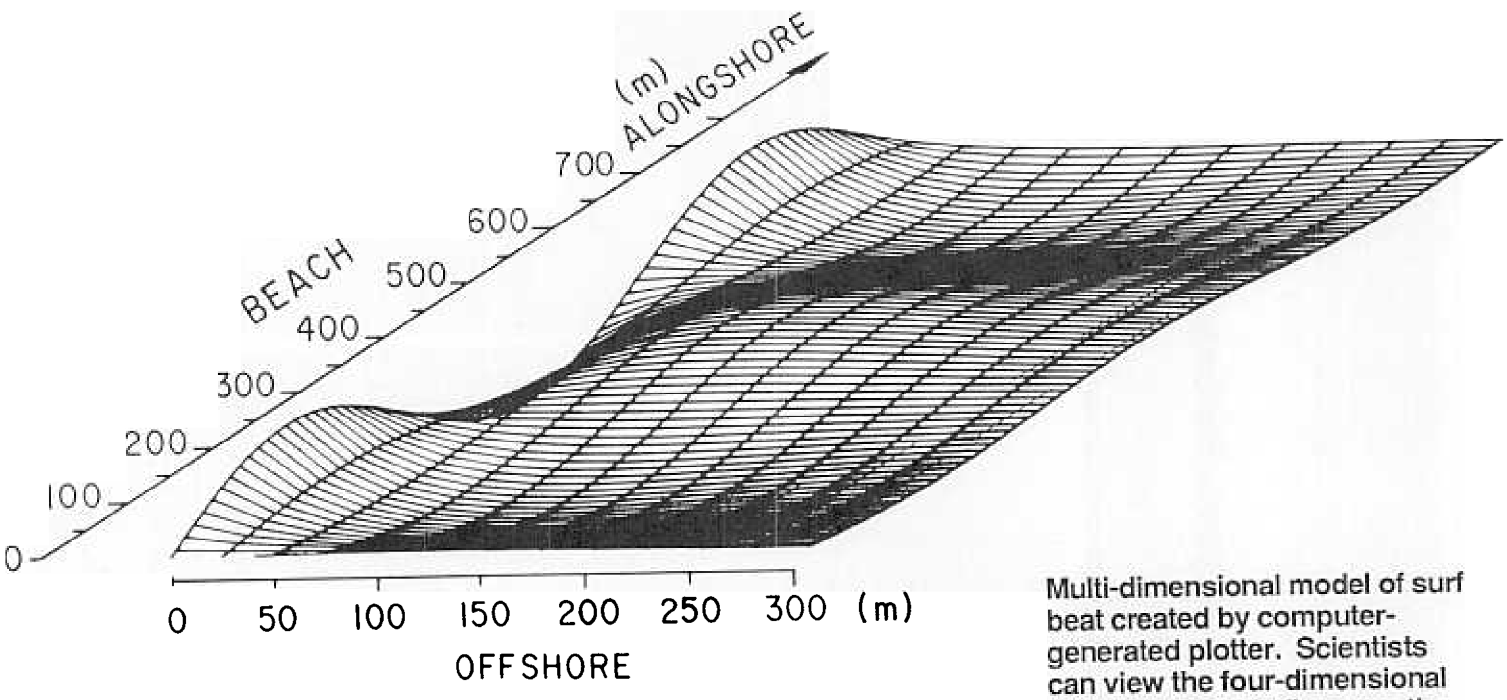
their environments to solve problems on other coasts.

In the very near future, major dredging projects such as the Baltimore Channel and Port of Norfolk will produce millions of cubic yards of dredge material. Using, in part, the work of Dr. Diaz, disposing of the material will be quite different than ever before. Much of the material will be placed back in the marine environment in locations where sediment transport studies, biological studies and historic geological information indicate the material will remain where placed for a long period of time with minimal biological damage.

Engineers will be able to use the mathematical and conceptual models to plan dredging projects, predict storm damage to coastal areas, and design protective measures. Planners and developers will have accurate information for building projects in the coastal area. And for many years to come, other scientists and graduate students will be selecting small portions of the Division's overall work to examine closely in order to add even more precise and reliable information to a body of work which will affect how we live and work on the coastal plain.



Marine Scientists (left to right), Mal Green, Dan Gouge, Robert Gammisch, Jeff List and John Boon with the tripod they created.



Multi-dimensional model of surf beat created by computer-generated plotter. Scientists can view the four-dimensional movement of this figure on the computer screen.

Fish house kitchen

Sold Out

Seafood Seminars

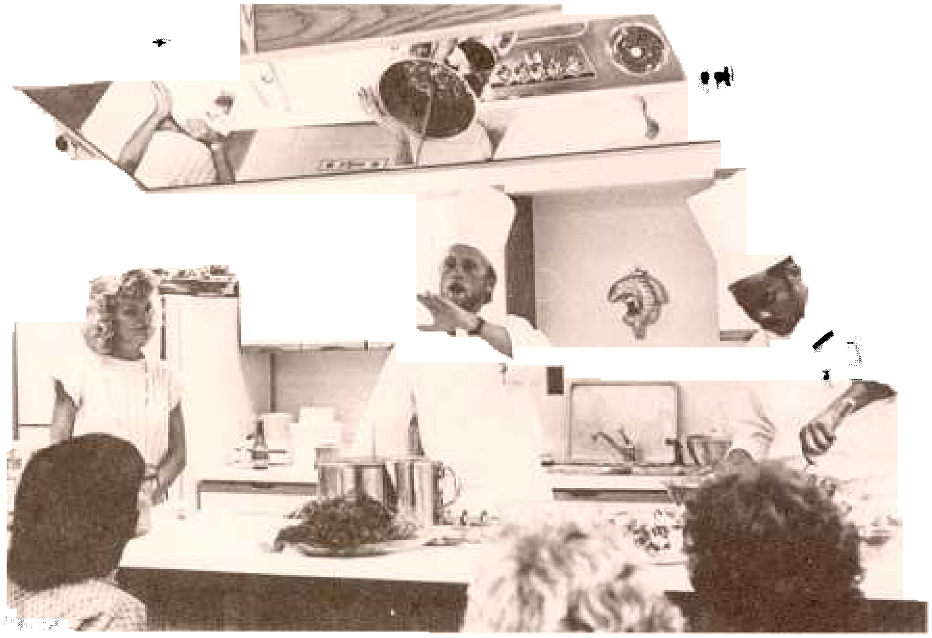


Photo by Nan Brown

Sue Gammisch assists Tom Flynn, Executive Chef and Mace Carson, Sous Chef of Virginia Beach Plaza Hotel as they prepare seafood in the VIMS' demonstration kitchen for seminar participants.

What does a Sea Grant Marine Advisory Specialist who designed and coordinated the largest and most successful National Marine Educators Association conference ever held do for an encore? This year, Sue Gammisch has developed and coordinates a series of seafood seminars so successful there has been a waiting list for each new series before it is announced.

Gammisch, assisted by Donna Soul of Virginia Tech (VPI), began the series in June of this year with a five-part series entitled "Tastes of the Chesapeake." Each of the seafood dinners is prepared in the demonstration kitchen at the Virginia Institute of Marine Science by a prominent Virginia Chef.

The best part of each dinner, participants say, is the eating. The meals are served in front of the new VIMS' aquaria, and during the meal representatives of Virginia wineries discuss the wines they have selected to go with the seafood. For more information about the series, call Sue Gammisch, VIMS, 642-7169.

Here are some of the featured dishes from the first two series.

SOFT SHELL CRAB WITH BASIL-LEMON BUTTER

Makes 2 servings

4 jumbo soft shell crabs (per person)
1/2 tbsp. all-purpose flour
1 tbsp. Old Bay seasoning mix (or to taste)
4 oz. unsalted butter
1/4 bunch basil (fresh)
1 lemon (juice)

Mix Old Bay with flour and dredge crabs lightly. Heat oil in skillet until visibly hot. Saute crabs until golden brown and crispy on both sides. Drain on paper towel.

Heat butter, lemon, basil; season to taste. Pour over crab and serve immediately.

Michael Sigler
Omni Hotel

CRAB SALAD

1 bunch basil (fresh)
2 oz. pignoli nuts (pine nuts)
2 oz. parmesan cheese
2 cloves garlic
1# crabmeat

egg yolks
lemon juice
white wine
olive oil
safflower oil

Combine basil, pine nuts, parmesan cheese and garlic in food processor and puree until a smooth paste.

In mixing bowl, start with egg yolks, lemon juice, white wine or vinegar. Mix on low speed. Add olive oil and safflower oil in thin stream, very slowly until sauce thickens.

Add basil mixture to the mayonnaise and gently toss with crabmeat. Garnish with tomato wedges.

Susan Painter
Ship's Cabin

STIR-FRIED FISH WITH SNOW PEAS

1 1/2 lbs. fish fillets	2 whole bamboo shoots
6 tbsp. cornstarch	peanut oil
4 tbsp. dry sherry	2 cloves garlic
2 tbsp. tree ears	2 slices ginger
1 lb. snow peas	2 dried chili peppers (optional)

Cut fish fillets across the grain into 1/2" x 2" strips. Mix 2 tbsp. cornstarch with sherry and set aside. Using a plastic bag, coat fish with remaining 4 tbsp. cornstarch. Shake off excess cornstarch and spread coated strips on paper towels. Soak tree ears in warm water 15 minutes. Trim snow peas, blanch 15 seconds, refresh under cold water, drain, and dry with paper towels. Cut bamboo shoots into 1/2" strips. Heat 1/4" peanut oil in a skillet. Add fish strips and cook one minute. Return fish strips to paper towels. Drain tree ears and remove any woody bits. Heat a wok. Add 3 tbsp. oil from the skillet and heat the oil. Add garlic, ginger, and chili peppers. When the garlic turns brown, remove and discard garlic, ginger, and chili peppers. Add tree ears, snow peas, and bamboo shoots. Stir-fry two minutes. Add fish strips and stir-fry gently for one minute. Thicken to desired consistency with cornstarch/sherry paste.

Tom Austin
Barret's

TORTELLINI PESCATORE

Cheese filled pasta served in a marinara sauce with shrimp and scallops topped with mozzarella cheese.

7 oz. tortellini	5 oz. marinara sauce
3 oz. shrimp	2 oz. mozzarella cheese
3 oz. scallops	

Marinara Sauce

Saute lightly:	1 minced garlic clove
	6 chopped anchovy fillets
	1/2 tsp. oregano
	1/2 tsp. basil
	1/2 tsp. chopped parsley
In:	tsp. olive oil
And:	2 tsp. anchovy oil
Add Slowly:	4 cups diced Italian tomatoes & juice

Mix with the sauteed seafood and tortellini and garnish with mozzarella cheese.

Tom Flynn
Virginia Beach Plaza Hotel

Sea Grant Communications
Virginia Institute of Marine Science
Gloucester Point, Virginia

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