Sand Wars

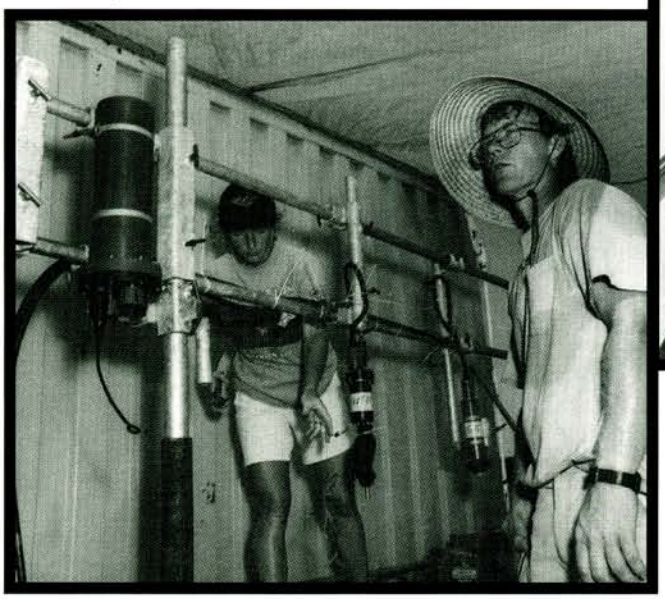
A billion-dollar battle is waged each year to maintain and replenish sand on America's beaches. Scripps is participating in an effort to define how coastal processes affect the shoreline.

BY CHUCK COLGAN

Sometimes Scripps research looks more like battlefield action than academic pursuit. This was the case in July along North Carolina's Outer Banks as scientists from the Center for Coastal Studies (CCS) Shore Processes Group launched their phase of DUCK94, a four-month-long coastal survey mobilizing dozens of investigators from 16 universities and government agencies.

The assault took place about 60 miles south of Norfolk, Vir-

LARC, an amphibious vehicle, assists nearshore instrument deployments.



Staff researcher Michael Clifton (at left with straw hat) oversees construction of a SPUV instrument array. When completed, it is lifted onto a vehicle for transport to the beach.

ginia, at the U.S. Army Corps of Engineers' Field Research Facility at Duck, North Carolina, where a unique assortment of research support facilities and equipment are stationed.

The mission was to advance fundamental understanding of the forces that create and destroy beaches by mobilizing an unusually large program of field measurements and numerical modeling. Scripps oceanography professor Robert Guza summed it up simply, "We're trying to understand what causes sand to move around."

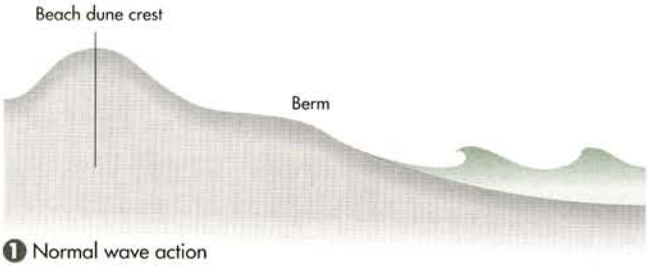
The movement of sand on beaches, called sediment transport, is not a trivial national issue. Nearly one-half of the U.S. population lives in coastal areas, and that number is expected to increase in the next 20 years. Coastal conditions are critical to a host of human activities affecting commerce, industry, transportation, health, safety, recreation, and national defense.

DUCK94 provides an experimental setting in which investigators can test nearshore instruments and data-collection strategies in preparation for an even larger project, called SANDYDUCK, scheduled for October 1997.

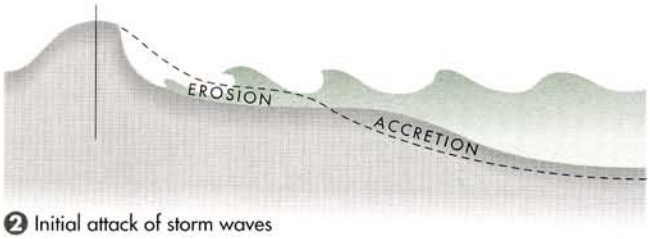
A long-term goal of the two studies is to predict the evolution of the conditions of a beach given the initial bathymetry and sediment characteristics, and the temporal variation of the wind, tide, and wave fields. "Such predictions are not presently possible because we do not understand fully the complex and interacting fluid and sediment processes," according to William Birkemeier of the U.S. Army Corps of Engineers, chief of the Duck research facility.

The amassed effort at DUCK94 is the result of 30 independently developed investigations being integrated into a single large experiment. Support is from the Office of Naval Research, the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the National Science Foundation.

The CCS installation team began a month-long process of instrument deployments within a survey area 600 yards alongshore, which extends nearly 1,100 yards offshore. In the following weeks, other investigators deployed instruments as the survey grid was laden



❶ Normal wave action



❷ Initial attack of storm waves

with 95 electromagnetic current meters, 55 pressure gauges, 68 optical backscatter sensors, and 33 sonar altimeters. Miles of cables ran up onto the beach and along the facility's 1,840-foot pier. At any one time, up to a hundred participants occupied the field support building and trailers where more than 30 computer workstations were installed and networked to the instruments in the water and to each other.

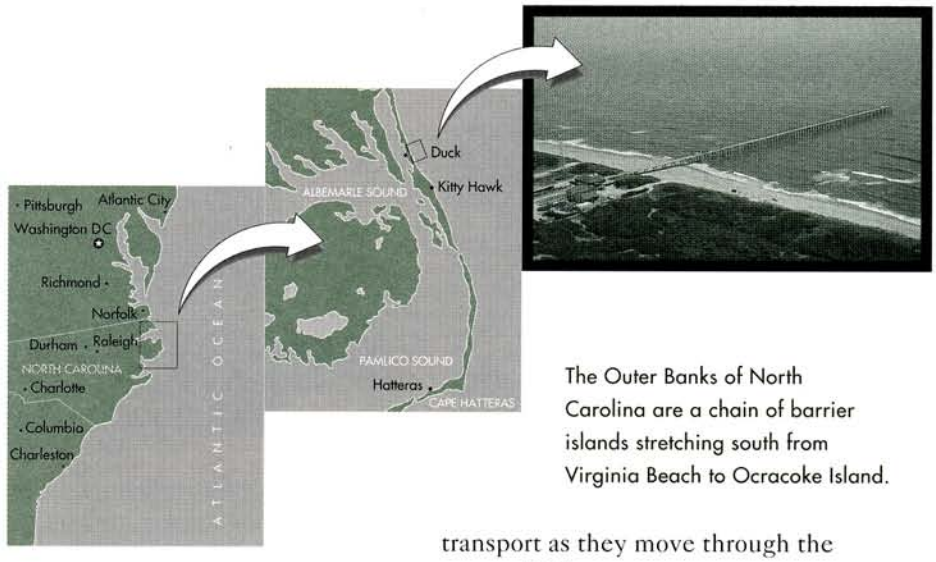
On the first day of installations, the CCS team of about 20 researchers, engineers, technicians, divers, and graduate students gathered at 7:30 a.m. for a briefing. Some were already physically stressed from unloading and setting up several tons of equipment and supplies shipped cross-country from Scripps. Guza and co-investigator Steve Elgar, a professor of electrical engineering at Washington State University (and former Scripps student), resembled field commanders as they sat at the table, listening to Scripps staff researcher Michael Clifton lay out the day's operations much like a military blitz.

The day's mission was to begin underwater installation of instrument arrays incorporating highly sensitive electronic devices. Known collectively as SPUVs, the instruments are the first to measure beach erosion in real time over an area sufficient to reveal the beach's changing profile. SPUVs are named from the instruments that comprise them: a sonic altimeter (S), a pressure sensor (P), and a current meter that measures how fast the current is moving in two directions – cross-shore (referred to as U) and long-shore (referred to as V).

The sonic altimeters aboard SPUVs measure changes in the height of the seafloor by sending out and receiving back acoustic pulses. Taking two readings per second, they allow scientists to monitor erosion as it occurs at small spatial scales. By placing arrays of SPUVs at varying distances offshore, it is possible to profile the submerged shore almost continuously and determine the affects of waves and nearshore currents on sediment transport as they move through the survey field.

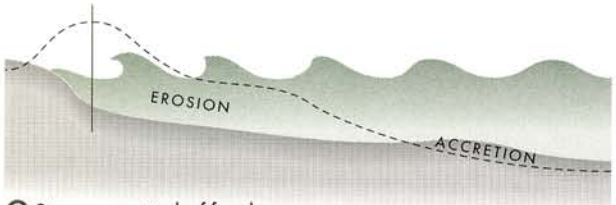
The briefing concluded and the group broke into two teams. The first and smaller team stayed onshore to mount SPUVs on large metal-pipe frames ranging from 6-foot by 6-foot hurdle-like structures to 12-foot by 12-foot X shaped structures, and to run computer systems. The larger group donned scuba gear to do the first installation at the furthest offshore position, about 930 yards out and at a depth of about 30 feet.

The divers boarded a 33-foot-long amphibious vehicle called LARC (Lighter, Amphibious, Resupply, Cargo), originally built for the Army to transport freight be-

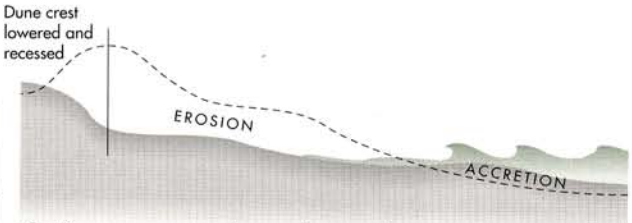


The Outer Banks of North Carolina are a chain of barrier islands stretching south from Virginia Beach to Ocracoke Island.

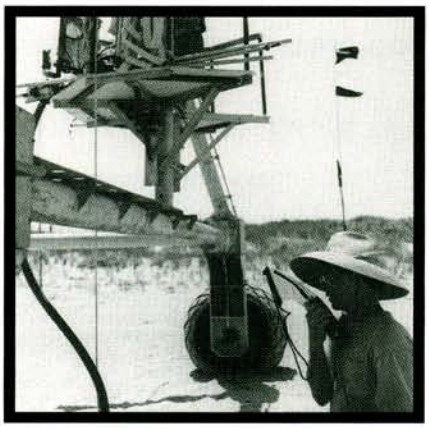
❶ Normal wave action on a typical beach profile. ❷ As storm waves begin their attack, erosion eliminates the berm and wear on the dune. ❸ When the storm is in full force, the foredune is washed away and the crest lowers. ❹ After the storm, normal waves return, however, the beach is eroded and the dune has receded.



❸ Storm wave attack of foredune



❹ After storm wave attack, normal wave action



On the beach, Clifton radios instructions to divers at the end of the Duck pier to launch their rafts.

Pioneers at the Ocean's Edge

The science of geology in the United States moved from the land to the seafloor in the 1920s with near simultaneous research efforts on the west coast by Scripps's Francis P. Shepard and on the east coast by Henry Stetson at Woods Hole Oceanographic Institution.

Shepard became a marine geologist by simply wading and rowing out from shore to examine the topography of the seafloor, where he discovered the local submarine canyons. At first he used sounding lines–weighted lengths of rope that measured the distance from the surface to the bottom–then hard-hat divers, scuba divers, echo-sounders, underwater cameras, and submersibles. Shepard spent nearly 40 years mapping nearshore features in coastal regions around the world. He became world famous for his work on the distribution of sediments and the evolution and structure of submarine canyons.

One of Shepard's students after World War II was Douglas L. Inman, who joined the Scripps staff upon completing his Ph.D. in 1953. By adding to marine geology the principles of physics and fluid mechanics, Inman created a unique oceanographic program concentrating on the nearshore. The resulting group now known as the Center for Coastal Studies (CCS), advanced understanding of rip currents, edge waves, nearshore circulation cells, and the transport of sand by waves. CCS scientists developed electronic instrumentation to study beaches and applied aspects of coastal engineering to test the design of jetties and breakwaters and to build sand-transfer systems.

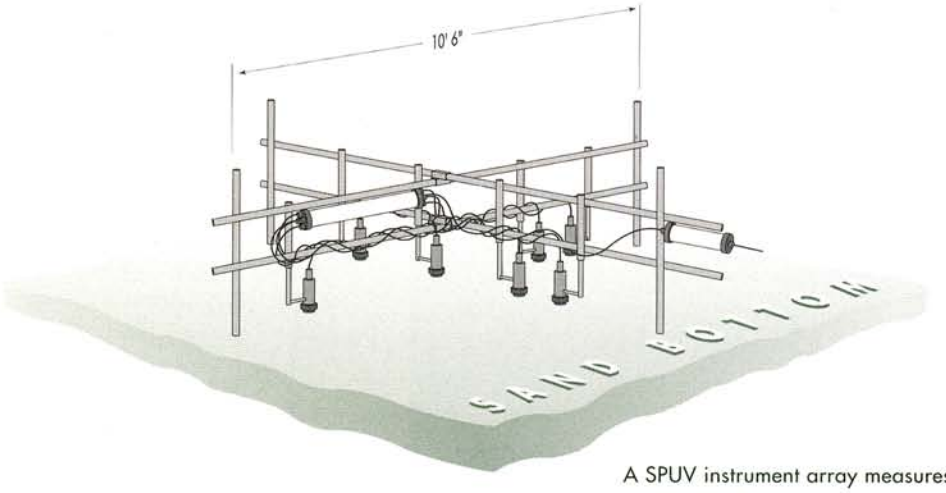
Today, under the direction of oceanography professor Clinton Winant, CCS continues nearshore studies encompassing five areas: sediment transport, nearshore hydrodynamics, estuarine and bay dynamics, coastal circulation, and coastal meteorology.

tween ships and land. LARC's forward and aft sections look much like a regular ship, but the middle section is a low platform with no side rails from which divers and instruments can be easily placed into the water. The strangest part becomes visible as LARC crawls out of the surf, onto the beach, exposing four large tires that propel it on land.

LARC lumbered out of the research station's service yard, up over the beach's 20-foot-tall barrier dune, and lurched down onto the beach, rolling smoothly across the sand. The bow breached the water, and LARC pitched forward, causing crew and divers alike to grab onto anything stable. Within seconds the LARC was afloat, gently riding the small breakers. Now in its element, it was able to pick up speed and maneuver easily.

Once at the deployment site, a raft was launched and joined by a larger one that had come out through the surf. Under Clifton's

Francis P. Shepard (second from left) with field crew, including Douglas L. Inman (right), and suspended sediment trap, 1948.



A SPUV instrument array measures the beach's changing profile. The four pipe ends are jetted into the sand to hold the instruments steady. Sonic altimeters send out and receive back acoustic pulses that record any changes in the distance between the instrument and the sandy bottom as waves and currents move through the survey field.

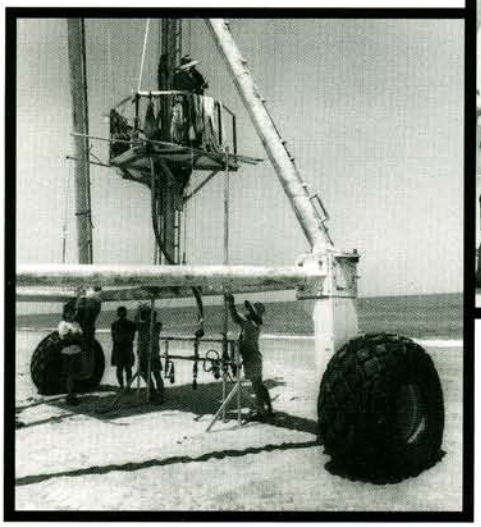
direction, an instrument array was released from LARC and towed by raft to a previously surveyed location. As soon as the array was in place, eight divers entered the water and submerged to anchor it to the bottom. Within an hour, the divers were back aboard, heading for land. By then, the next SPUV array had been assembled and was waiting on the beach to be lifted onto LARC and deployed. Two more arrays went out in the afternoon.

While the arrays were being installed, CCS electrical engineer Bill Boyd supervised the process of connecting cables from the offshore instruments to computers onshore for data collection and for monitoring instrument performance. At the heart of the data communication system was a computer-based data logger that Boyd designed for this application. Meanwhile, Elgar and others used a powerful computer workstation to check the data quality using a battery of specialized software.

The next day, the dive team reassembled. They worked in shallow waters, so the LARC was not needed. It was time to bring out the CRAB (Coastal Research Amphibious Buggy), a unique three-wheeled vehicle that looks like a giant tripod. CRAB has 35-foot-long, aluminum-tubing legs supported at the end by five-feet-diameter, water-filled heavy equipment tires. At the apex of the tripod is a platform just big enough to support the operator, motor, and up to 400 pounds of equipment or personnel. CRAB was driven into the surf with its long legs disappearing into the water, supplying a mobile, yet stable, platform for nearshore work.

An instrument array was tied to CRAB's base, and it slowly rolled to the deployment site where it was met by the dive team in the rafts—and the work continued. This process was repeated day by day until 10 SPUV arrays and two other instrument 'stacks' were positioned in the survey area. During the ensuing days and weeks, other research groups arrived at the field station to install their instruments.

The DUCK94 battle plan called for taking the most intense series of measurements in August (a time when waves approach the area from the south), and in October (when the waves approach from the north-



Last minute inspections ensure the SPUV is securely attached to CRAB.

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east). During these periods, considerable effort was made to make all measurements synchronous and accurately timed. In addition to the hundreds of fixed instruments, movable sleds outfitted with vertical arrays of current meters and pressure sensors were towed through the survey area, and a large crane on the facility's pier lifted instruments into and out of the water. Meteorological measurements were made along the water's surface to define the wind fields, and cores of sediments were collected to examine sand particle size and composition. Creating a three-dimensional view of wind, water, and sediment on scales from inches to a hundred yards on time-scales ranging from seconds to weeks was crucial to the study.

The massive amount of data resulting from DUCK94 will take years to analyze; however, according to Guza, it should arm engineers with information on how to prevent beach erosion, including how to better design jetties and sea walls. Often after building such structures, beaches still need to be replenished with sand, and frequently the sand just disappears again.

"Nourishing beaches is very expensive," Guza said. "Fifty million dollars is not an inordinately high price tag to nourish a stretch of coast a few miles long. But how long will the sand stay there after we put it back? A month? Twenty years? What size of sand should we put on the beaches to stay there? Coarse, fine, mixed? That's the kind of question that ultimately this kind of research will answer."

Final instructions are given to CRAB's driver, and the unusual research buggy enters the surf (opposite page) where divers will lower the SPUV to the seafloor.