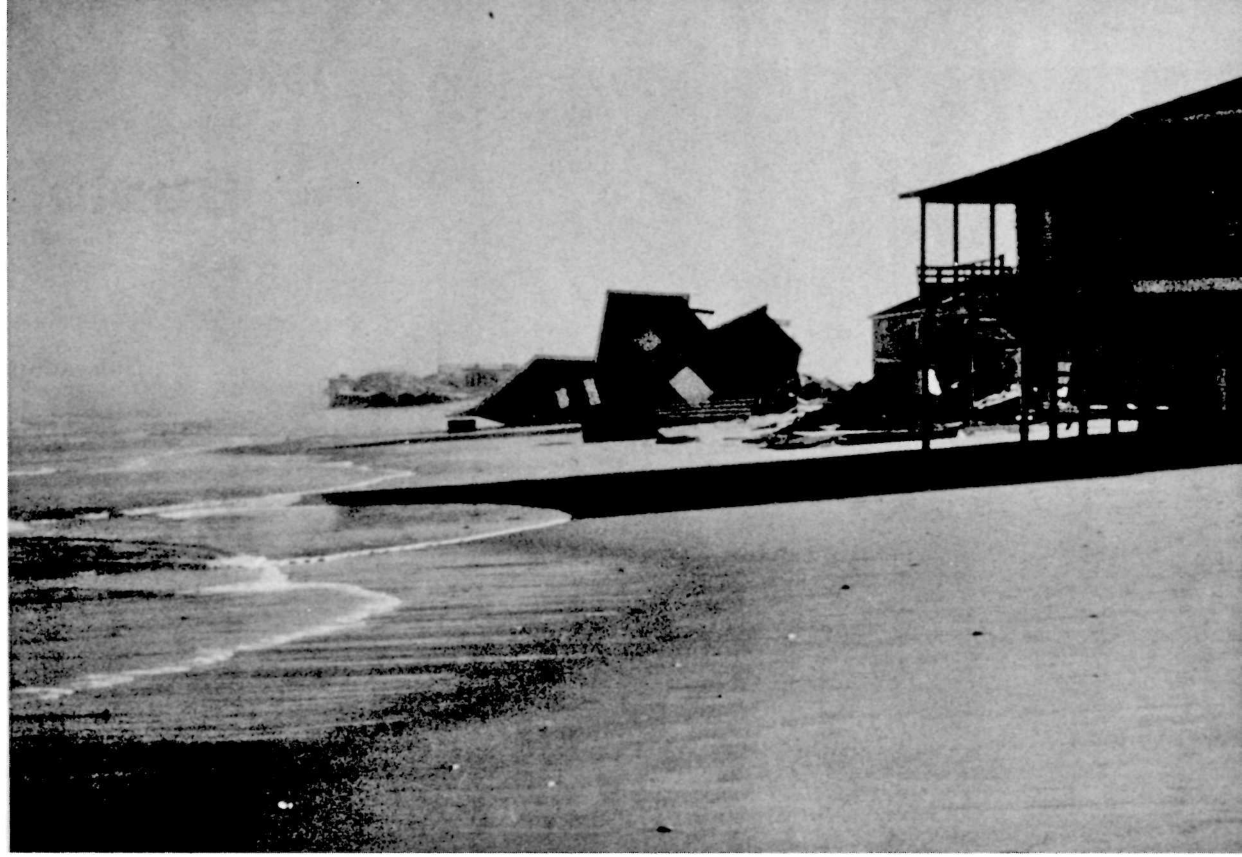
BEACH EROSION AND BEACH NOURISHMENT

CAPE HATTERAS
NORTH CAROLINA

ROBERT DOLAN

U. S. DEPARTMENT OF INTERIOR
NATIONAL PARK SERVICE
OFFICE OF NATURAL SCIENCE
WASHINGTON, D. C.

DUNE STABILIZATION STUDY
NATURAL RESOURCE REPORT NO. 4
1972



BEACH EROSION in the United States has become a serious national problem. Of our more than 100,000 miles of shoreline, about half are subject to erosion and several large areas require extensive and continuous restoration programs. Nevertheless, the zone where land and sea meet remains one of the most desirable settings for recreation, residence, and commercial development, so competition for the undeveloped beachfront property has increased dramatically.

Areas of the mid-Atlantic coast have lost vast quantities of land during the past two decades. Erosion along coastal North Carolina and Virginia is severe because the processes responsible for sand movement are especially strong. Hurricanes and winter "northeasters," such as the Ash Wednesday Storm of 1962, contribute to the vulnerability of the region.

1940

1972

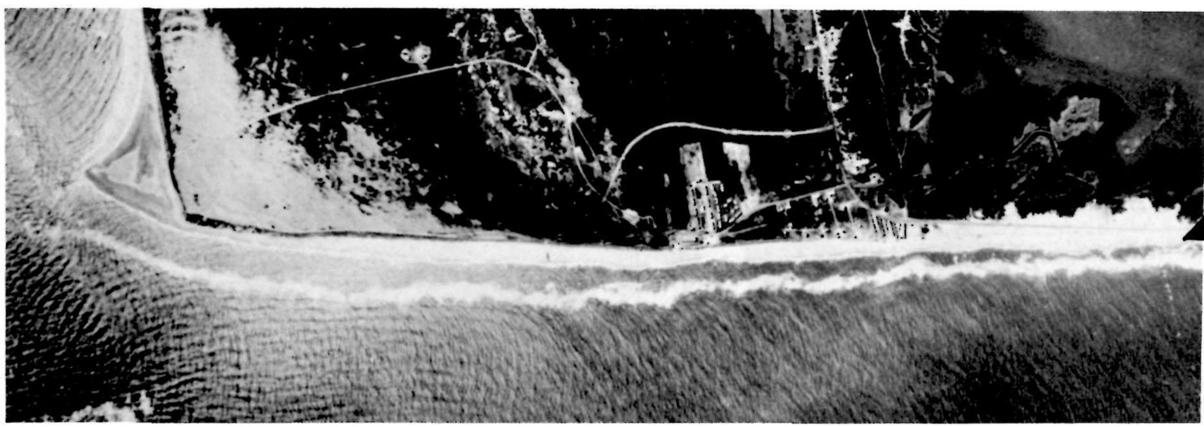
Buxton, N.C.—The Problem

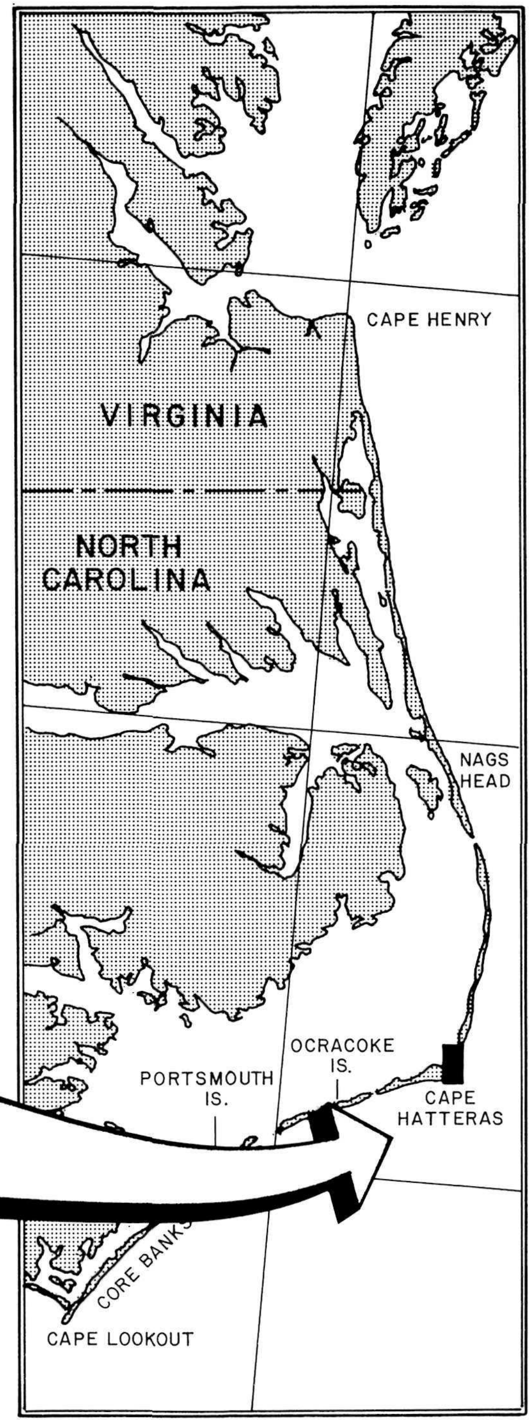
Beaches are constantly changing natural systems, in many respects similar to a river. Even a stable beach is one which undergoes change. Periods of erosion are balanced by periods of deposition. Therefore, stable does not mean permanent, nor does it imply that the beach is fixed, but rather that over a long period of time the processes are balanced.

This balance between erosion and deposition is delicate and it can be easily upset. Three basic factors determine the degree of beach stability: [1] the amount and type of sediment, or materials making up the beach, [2] the strength of erosional forces, mainly waves and currents, and [3] stability of sea level, or long-term trends in the ocean level.

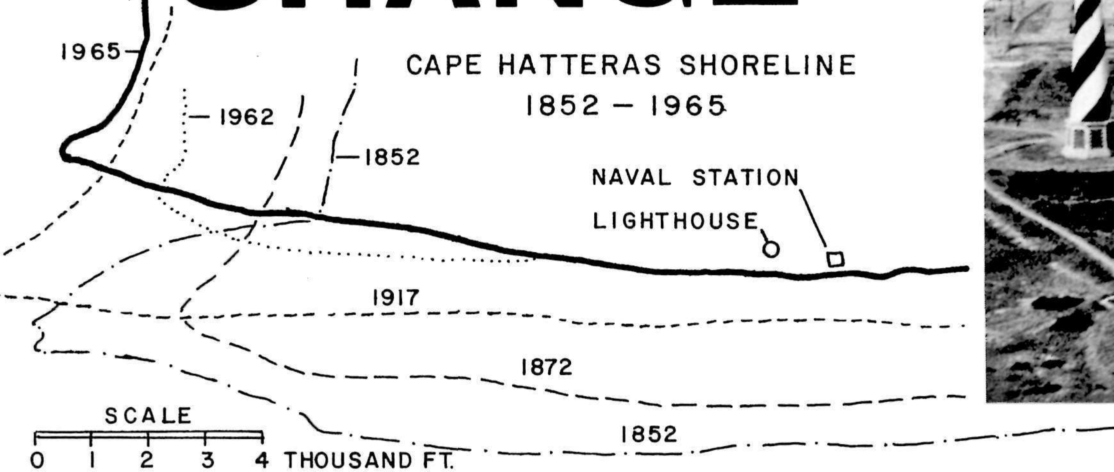
Beaches recede when the forces of erosion exceed the amount of sediment supplied to the beach-energy system. The greater the deficiency of sand, or the higher the wave forces (energy), the more rapid the rate of erosion. Any of three factors, energy, sediment, or sea level, can vary and change the balance between erosion and deposition. The basic problem then is the balance between wave forces and the sediment budget, coupled with the changing level of the sea. It must be stressed that beach erosion is a natural process, similar to the shifting of a stream channel, and becomes a serious problem only when man's structures are placed in the path of shoreline recession.

The erosion problem along the Outer Banks can be traced back to the early development of beach-front property during the 1930's and 1940's. It was inevitable that a serious confrontation would occur since the forces of erosion and shoreline change have been constant through time, and the line of man's development, once it was established, has remained fixed.





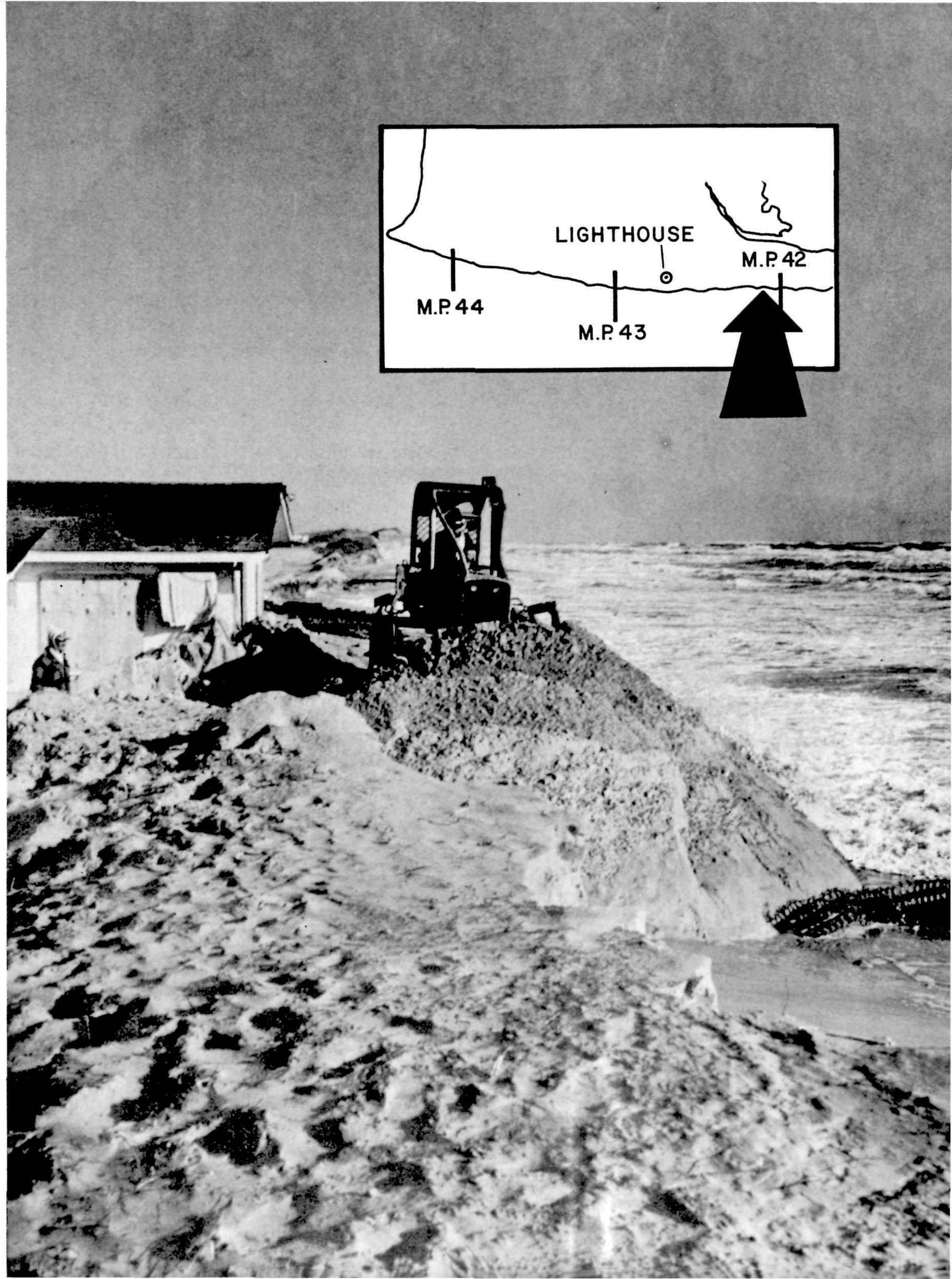
CHANGE



Narrowing of the distance between the line of development near Buxton (Cape Hatteras) and the active surf-zone reached a critical point during the mid-1960's. The distance between the base of the Cape Hatteras Lighthouse and the surf reached 256 feet in 1966, the result of more than 250 feet of erosion since 1958. Overall the rate of shoreline loss for the 10-mile reach between Avon and Cape Hatteras has averaged between 10 and 15 feet per year since 1958.

Buxton is one example of the problems that develop as the distance between the surf-zone and developed property decreases. Within a distance of 4 miles [MP40 and MP44] the following man-made features are threatened by erosion: [1] <u>U.S. Coast Guard Loran Station</u>, [2] <u>The Cape Hatteras Lighthouse</u>, [3] <u>National Park Service Museum</u>, [4] <u>U.S. Navy Station</u>, [5] <u>several private homes</u>, and [6] <u>numerous private businesses</u>.

JANUARY 1972



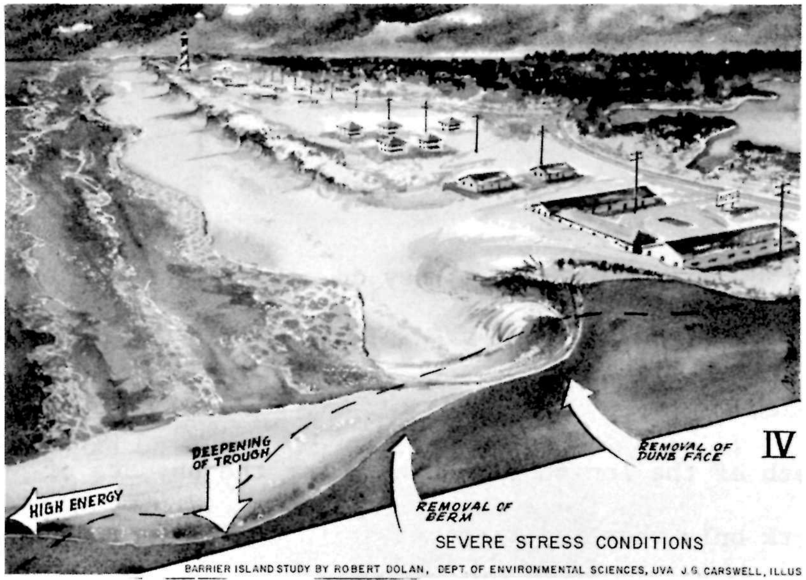
APRIL 1972

SOLUTION

The ideal solution to the beach erosion problem is to plan all developments well inland from the limit of high water, and to design all structures so that periodic storm surges can occur without major damage. The life-expectancy of any development should be planned according to its location. Buildings placed near the upper limit of the storm surge zone should not be designed to last for decades. Since these ideal conditions seldom exist, what alternatives are available? It was stated by William R. Vines that ". . . in no other resources management field is there more misconception, mysticism and generally confused thinking than in beach erosion control. The problem is often approached on an emotional rather than a scientific basis. Amateurish schemes for erosion control abound. The reason for the uncertainties about how to deal with erosion is that erosion control is far from an exact science. The professionals in the field are quick to announce that, although there is a large pool of scientific information on beach erosion, techniques for restoring and protecting eroding beaches must be substantially improved."

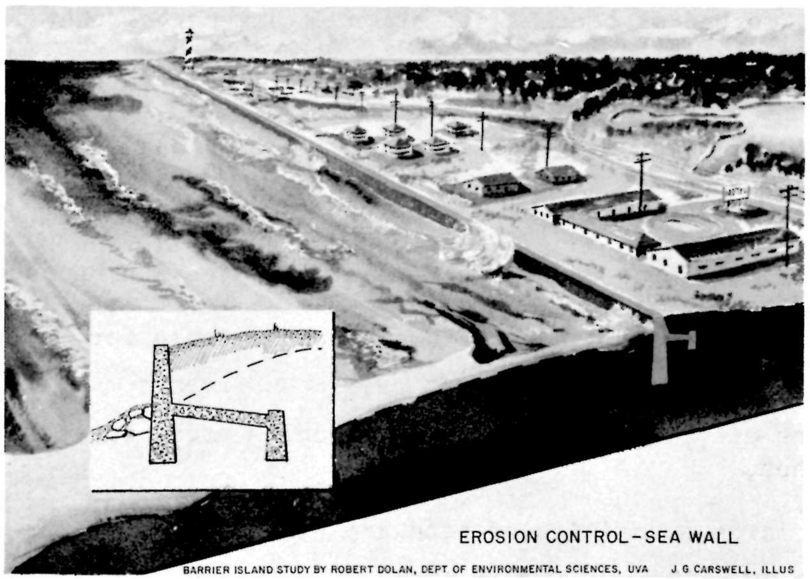
Shoreline protection schemes fall into three categories: Protection designed to [1] inhibit direct attack by waves, such as sea walls, bulkheads, and revetments, [2] structures designed to inhibit currents that transport sand, such as jetties and groins, and [3] beach nourishment.

WHICH LEAVES FOUR ALTERNATIVES....

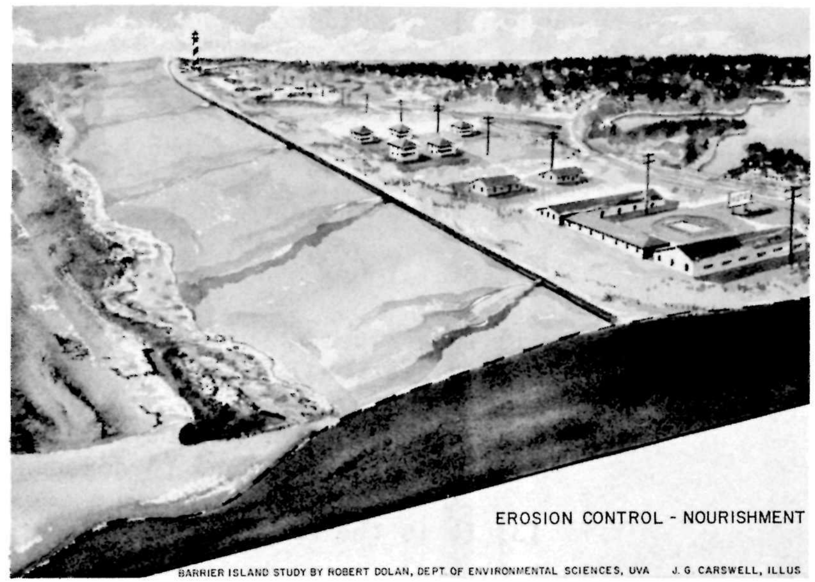


NATURAL

GROIN FIELDS



SEA WALL



NOURISHMENT

NOURISHMENT – WHY IS IT BETTER ?

Sea walls are designed to absorb and reflect wave energy, but they do not prevent the loss of sand in front of the structures. They may, in fact, accelerate the loss of sand as the wall deflects the wave forces downward into the beach deposit.

Groins are obstructions placed in the path of the longshore currents for the purpose of trapping littoral drift. These structures work only when [1] littoral drift sediment is significant in volume,[2] the material is at least sand size, and [3] only when the land down the beach from the groin is considered expendable. The best method of beach restoration is any method that is similar to the natural process. Structures are designed to alter the energy flow, interfering with the natural equilibrium of the beach. Rebuilding beaches artificially, by placing sand in the system, permits the natural process to continue essentially unhampered.

Artificial beach nourishment is considered the most desirable method of protection because:

[1] The placement of sand in the beach-energy system results in a beach suitable for recreational purposes.

[2] Beach nourishment not only checks the effect of erosion in the problem area, but also supplies sand to adjacent beaches.

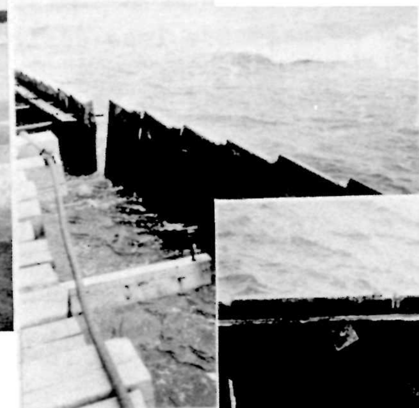
[3] It is the most economical method if large quantities of sand are available.

[4] It does not require a major long-term management commitment. If the beach nourishment does not produce the desired result, it is not as permanent as sea walls or groins.

FAILURES....

SEA WALLS

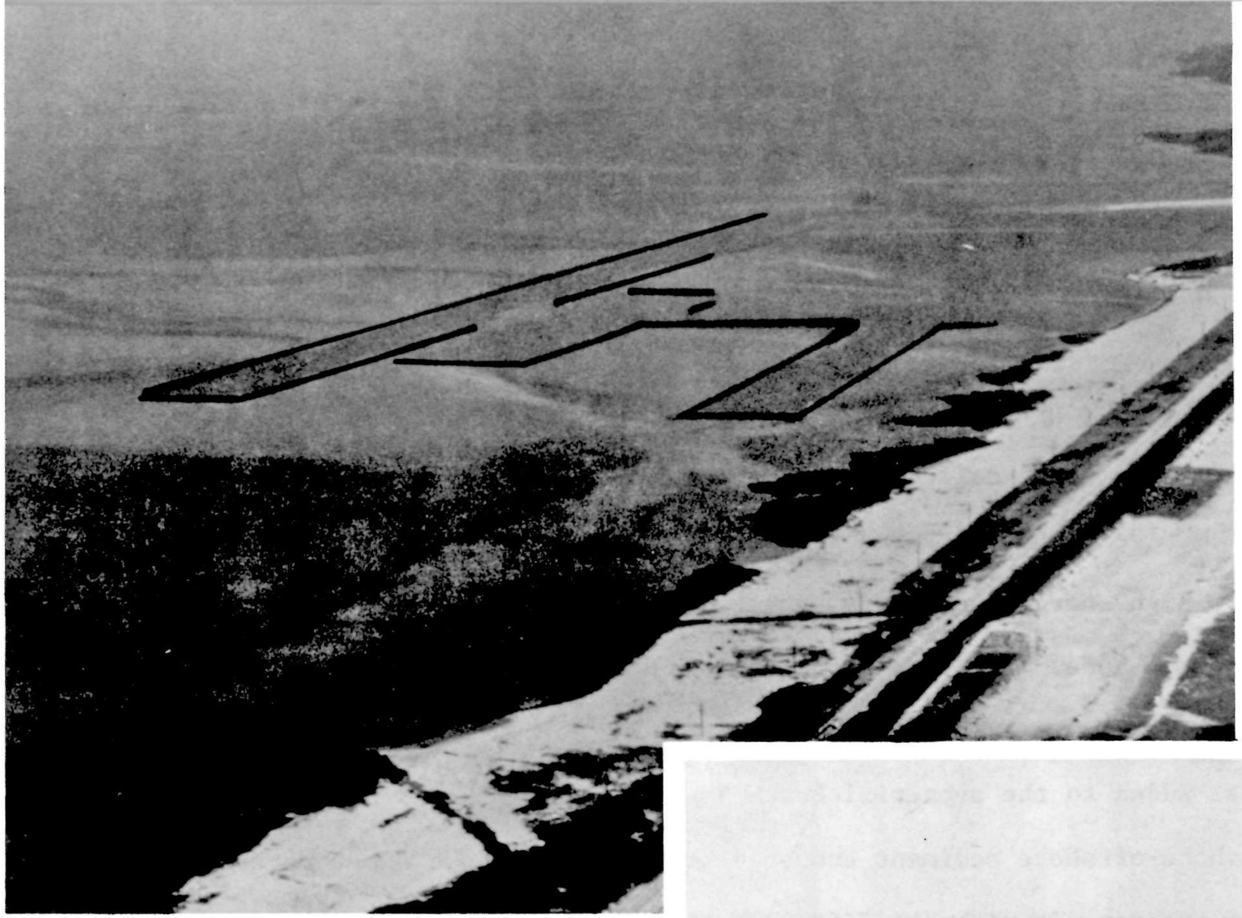
GROIN FIELD—HATTERAS



NOURISHMENT

NOURISHMENT PROBLEMS....

The major disadvantage in artificial nourishment is that great quantities of sand of suitable quality (type and size) may not be available near the problem beach. In the past, sands were dredged from sounds and bays immediately inland from the beach, or transported from inland sources. With the recent concern about estuarine ecology, and the fact that sound materials are usually much too fine to be effective as beach nourishment, estuarine and bay sources are less desirable and no longer as available. The future prospect for large enough quantities of sand to be effective for large beach restoration projects will probably be offshore sources, and materials dredged from the coastal inlets. For example, along the Outer Banks alone, great quantities of high grade beach sediment are dredged from Oregon and Hatteras Inlets and dumped into deep water offshore. Diamond Shoals also represents a major source for beach nourishment--perhaps in excess of ten billion cubic yards.



SOUND EXCAVATION

IMPROPER
MATERIAL

NATURAL TRANSPORT

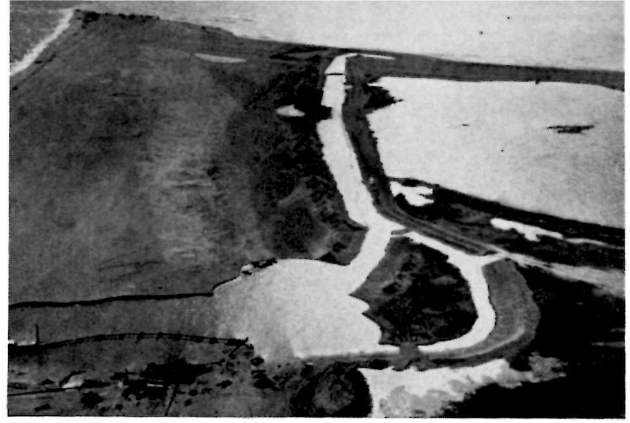
The beach above the water line, called the subaerial beach, is only a small part of a much larger and complex system. Near Cape Hatteras the active beach extends offshore more than 2000 feet. Under moderate to high energy conditions, great quantities of sand are moved from the beach-face into the offshore zone. When the storm waves subside, much of this sand moves back onshore.

Therefore, material added to the subaerial beach as nourishment should be expected to become part of the natural onshore-offshore sediment exchange process. Within a short period of time, following a nourishment program, it might be difficult to detect the original mass of sand on the subaerial beach. This does not mean that the nourishment project failed, but rather that the sand added to the beach system has been redistributed by the natural onshore, offshore, and along-shore processes.

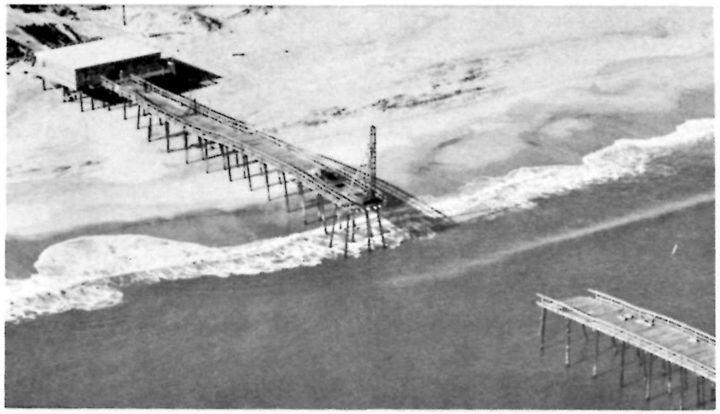
The inshore system consists of a series of crescentic shaped bars and troughs. These features determine the location and intensity of maximum energy reaching the beach-face. The presence of these crescentic forms, called sand waves, is evidenced by the scalloped erosion pattern on the seaward face of the beach berm (natural and artificial), and the failures of structures placed within the surf-zone. For these reasons nourishment added to the subaerial part of the beach should not be expected to remain in place permanently.

NOURISHMENT 2'72

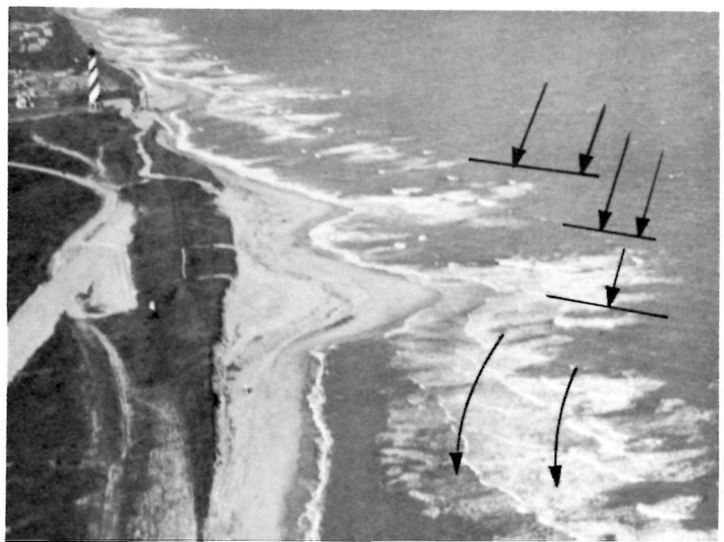
AND
NATURAL
TRANSPORT



THE SOURCE



NEW
TROUGH



AVERAGE
DOWN
ISLAND
TRANSPORT

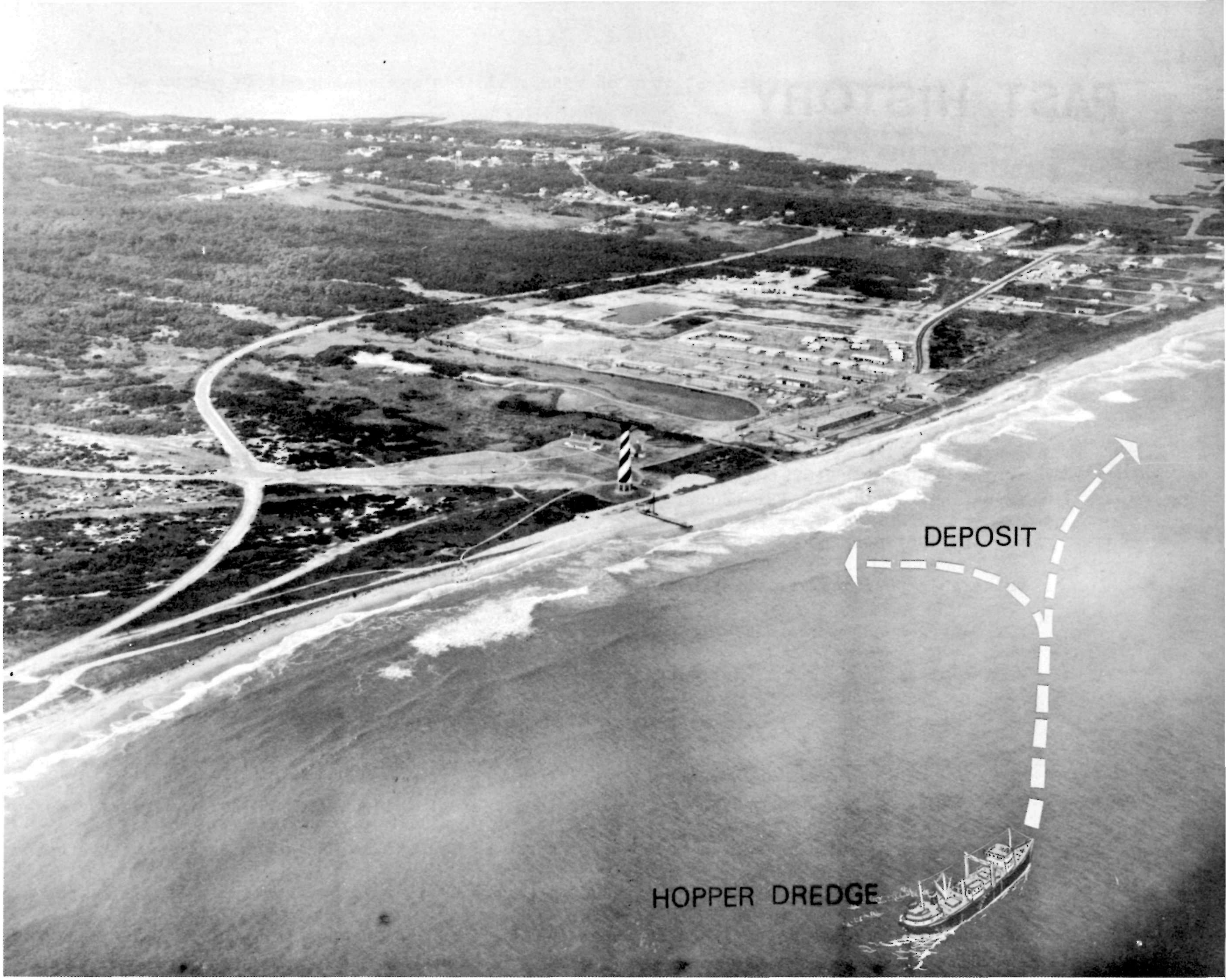
THE DEPOSIT

ECONOMIC IMPLICATIONS

Any form of beach restoration is very expensive, including artificial nourishment. The cost per cubic yard of sand depends upon the source of the material and the method and distance of transport. This can range from about $1.50 per yard for sand pumped by dredge over a short distance, to as much as $5.00 per yard for truck-hauled sand.

The magnitude of the economic problem associated with the Buxton area can be visualized by comparing the erosion rates and sand requirements for a hold-the-line strategy. The average shoreline loss for the period 1958-1972 for the four mile reach between MP 40 to MP 44 was about 150 feet. Using a rule-of-thumb estimate that two cubic yards of sand are lost for each one foot of erosion per foot of beach, four miles of shoreline is 21,000 feet, with 150 feet of erosion, and two cubic yards per foot, equals about 6,500,000 cubic yards of sand and even this is probably inadequate to re-establish the 1958 shoreline. Additional material would be required yearly to hold the beach in a stable position.

The nourishment system of the future will involve the inexpensive transfer of large quantities of sand from offshore sources directly into the inshore bar-trough system. This would eliminate the costly step of placing the material directly upon the subaerial beach--sand added to the subaerial beach ends up deposited within the bar-trough system within a short period of time. This system of sand transfer requires a new concept in hopper dredge design--equipment capable of working in shallow water, perhaps 12 to 18 feet or less.


DEPOSIT
HOPPER DREDGE

PAST HISTORY

Narrowing of the distance between the line of man-made developments near Cape Hatteras and the active surf-zone reached a critical point during the mid-1960's. The distance between the base of the Cape Hatteras Lighthouse and the shoreline reached 256 feet. With little hope for a reversal of the erosion trend, and relocation of the developments virtually impossible, the National Park Service contracted in 1966 to have 312,000 cubic yards of sand placed on the beach within the area of greatest concern.

The borrow material was taken from Pamlico Sound. It was too fine to remain as part of the subaerial beach system and the quantity, 312,000 cubic yards, was too little to have significant impact on the inshore bar-trough system to provide even temporary protection.

By 1967 continuous erosion had placed the Cape Hatteras Lighthouse and U.S. Naval Facility in vulnerable positions to waves and surge. Nylon sand bags were used as an emergency revetment, but the Navy requested the U.S. Army Corps of Engineers to conduct an investigation and plan for permanent protection of the Cape Hatteras Navy Facility.

Following the recommendations of the Coastal Engineering Research Center (Army Engineers), the Navy contracted in the summer of 1969 to have three permanent groins constructed within the problem area. This decision was reached only after considerable discussion and several expressions of apprehension concerning our understanding of the forces within the area, as well as the basic design of the structures. Soon after construction started in 1969 it was obvious that either the groin system was not properly designed and that the forces and characteristics of the system were not properly understood or analyzed. The original design of the groins was modified so that they were partially completed during the spring of 1970.

Although the design of the groins was modified, they do provide protection for the U.S. Navy Facility and the Lighthouse. However, areas adjacent to the groin field, both to the north and to the south, continue to erode at rates equal to, or in excess of, rates recorded before 1969. Therefore, the National Park Service was forced into a "hold-the-line" strategy, using sand bags and spot dune construction, for these newly created problem areas.

During the winter of 1971 erosion north of the Lighthouse became so severe that another beach nourishment project was planned and implemented. The major difference between the 1971 project and the nourishment program of 1966 was that the source for the borrow material was switched from Pamlico Sound to the Cape Point spit, a feature composed of native beach sands.

The 1972 nourishment was effective, but the amount of material added, 220,000 cubic yards, was insufficient. A new project scheduled for 1972-1973 is designed for a sufficient volume of material to have much greater impact on the beach-energy system--approximately 1,000,000 cubic yards.

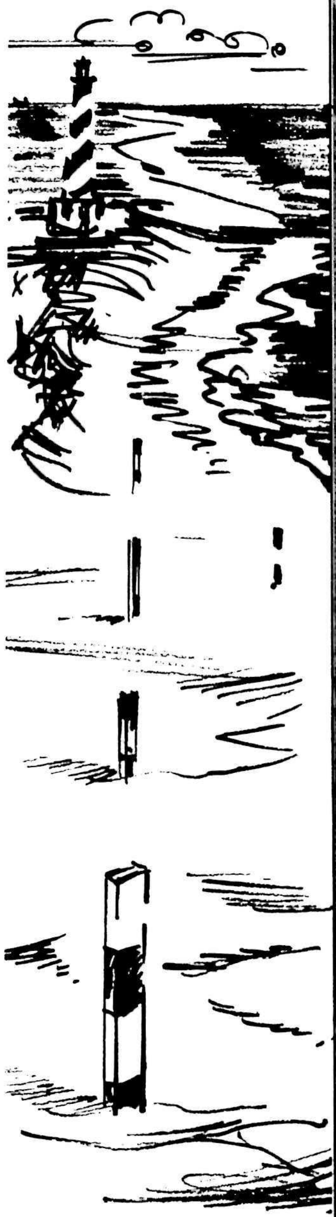
1933 DUNE CONSTRUCTION PICTURED FROM HATTERAS LIGHTHOUSE - LOOKING NORTH

DUNE DESTRUCTION

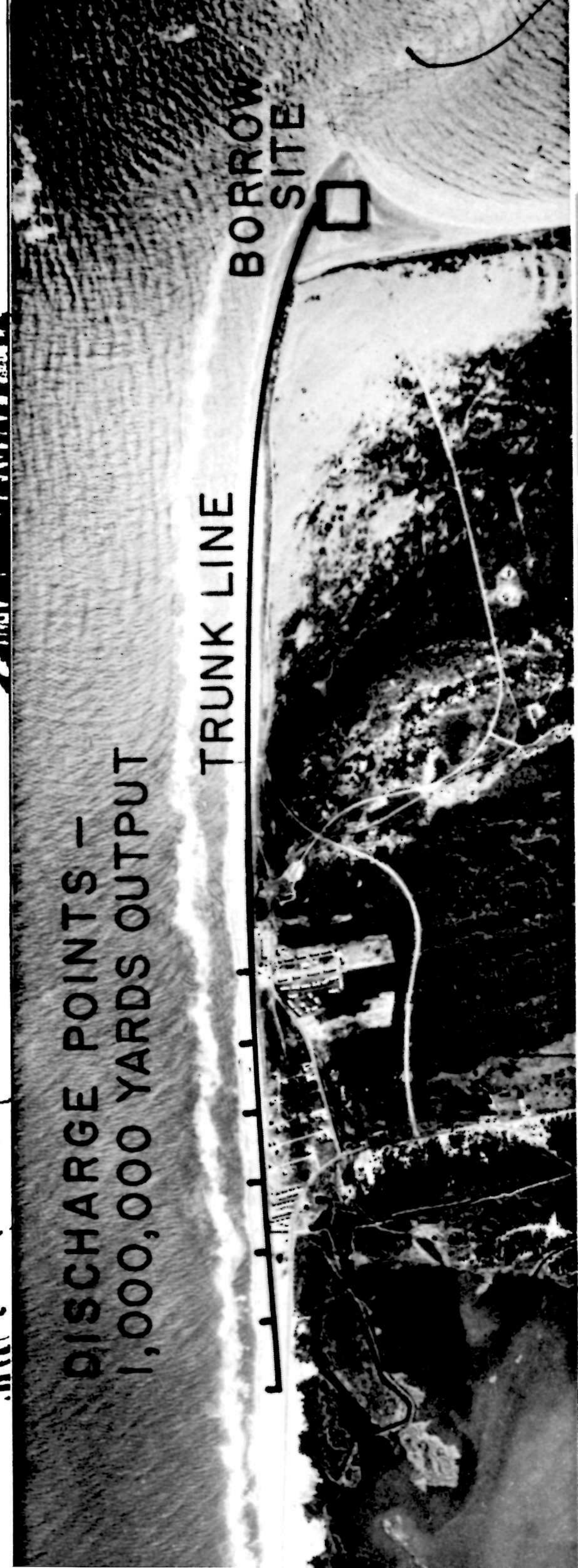
IDENTICAL LOCATION - 1972

THE PLAN: 1972–1973 BEACH NOURISHMENT PROJECT

The 1972-73 Buxton beach nourishment project will consist of a hydraulic transfer of about one million cubic yards of native beach sands from the Cape Point spit three miles to the north, where it will be deposited on the beach. The borrow site is the best available in terms of material characteristics, technology, and environmental impact. Cape Point is, in effect, the terminal point of sand transfer for the northeast facing reach of the Outer Banks. Therefore, the project is actually recycling sands that were originally part of the beach system to the north. At the close of the project, normal overwash processes will fill the borrow pit with beach materials. A detailed investigation will be conducted to determine the [1] effectiveness of the project as an erosion control measure, and [2] environmental impact of one million yards of sand on the beach-energy system.



THE PROJECT



IMPACT ANALYSIS

COST – HOW MUCH ?

In attempts to stabilize and protect property on the beaches along the mid-Atlantic coast, tens of millions of dollars of private and public funds have been invested over the past two decades. The methods available to "correct" erosion problems are limited, and the best method (beach nourishment) leads directly into serious economic and environmental problems. The U.S. Army Engineers recently completed a study that estimates a cost of about $20,000 for restoration of the average 50-foot beach-front lot along the Outer Banks, with an additional $1,000 to $2,000 per year to maintain stability. Investments of this magnitude obviously limit beach erosion control projects to coastal areas where man's confrontation with the sea has implications of national significance. This suggests that a strategy different than that of "man over nature" or "man against the sea" is needed along the Outer Banks of North Carolina.

> "If man wishes to build his works on the fringes of such a battleground (the coast), he must understand that the rules of this ancient battle require the beach, the berm, and the dunes to shift constantly before the assault of the sea. If man tries to change these rules, he can only fail; and in his failure he may even undermine the fragile hold of these outposts against the powerful sea."
>
> (C.J. Schuberth, 1971)