DUNE STABILIZATION AND BEACH EROSION

CAPE HATTERAS NATIONAL SEASHORE
NORTH CAROLINA

ROBERT DOLAN
PAUL GODFREY

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

DUNE STABILIZATION STUDY
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INTRODUCTION

From a geological point of view, the Outer Banks of North Carolina are one of the most dynamic areas under the jurisdiction of the National Park Service. The barrier islands undergo continual change in position. Because oceanic overwash plays an essential role in this process, an unbalanced situation is developing wherever artificial barrier dunes have been built. Further compounding the seriousness of the situation has been the false impression of safety and stability offered by the barrier dunes. Numerous structures, including motels, restaurants, beach cottages, park facilities, and a U.S. Navy base at Cape Hatteras have been built immediately behind the barrier dunes in the mistaken belief that they would provide permanent protection from encroachment by the sea. Instead, the beach has steadily narrowed. Subsequently, the barrier dune has eroded away leaving these structures with little protection from extreme events.

The following illustrations provide, diagrammatically, a sequence of events leading to the "unbalanced" conditions that now exist along most of the islands within the Cape Hatteras National Seashore, and three examples of corrective engineering.

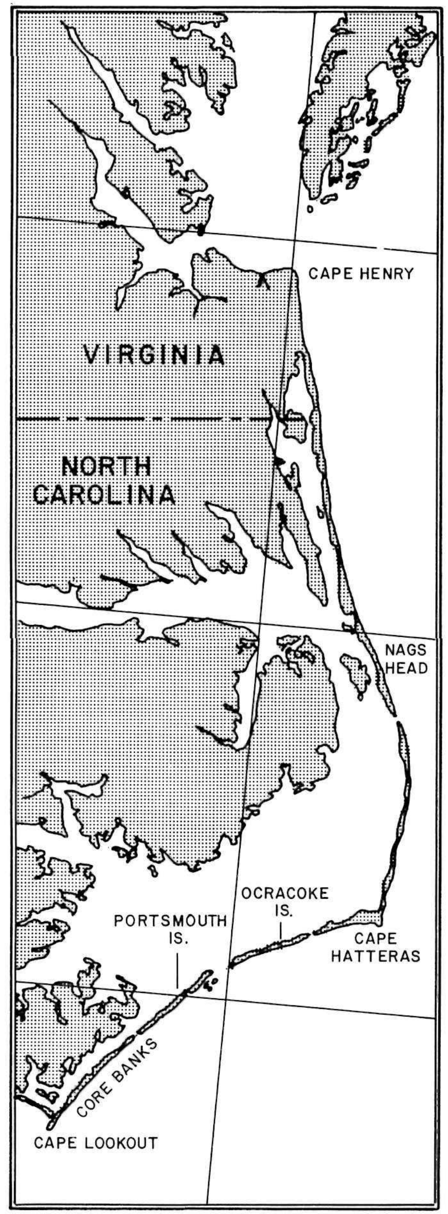
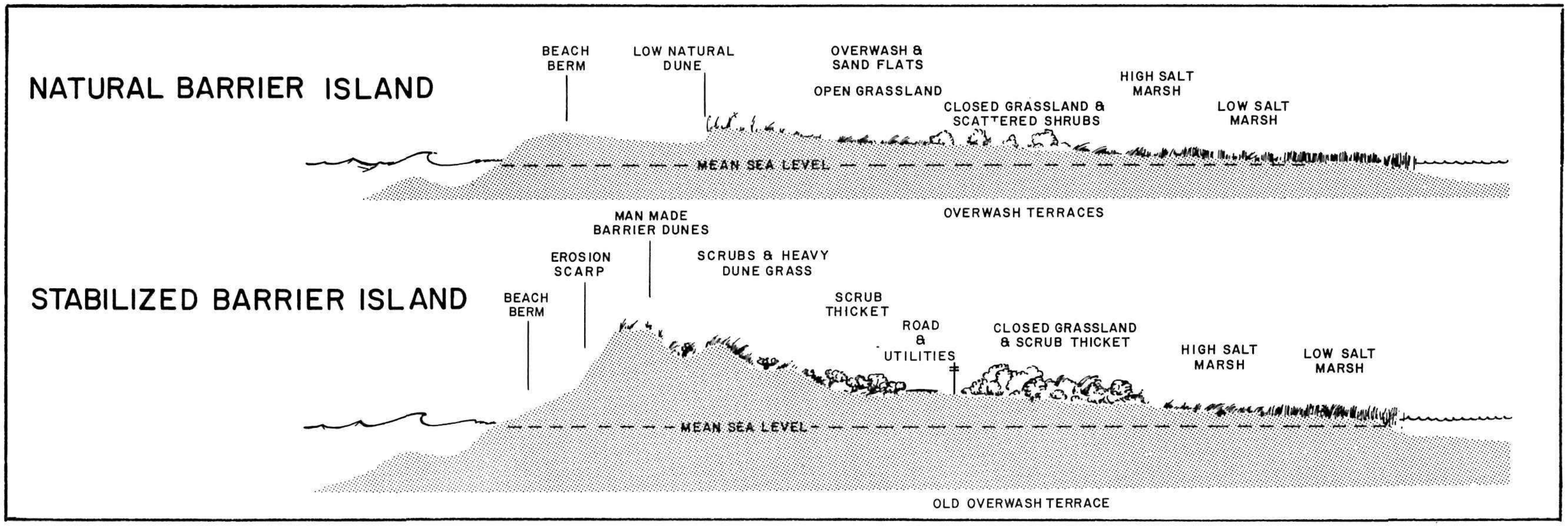


PLATE I. THE NATURAL BARRIER ISLAND

The unaltered barrier system can meet the challenge of periodic extreme storms since there is no permanent obstruction in the path of the waves and surge. Most of the initial stress of an extreme event is sustained by the broad beaches. Because no resistance is created by impenetrable landforms, water flows harmlessly between the dunes and across the islands with the result that wave energy is rapidly exhausted. The combination of high tides and high waves occasionally succeeds in eroding the beach-face and low lying fore dunes and carrying sand and shell inland or completely across the island and into the marshes.

Because of steadily rising sea level (3 inches since 1963) the beaches have, in most places, receded resulting in increased wave energy on the dunes and subsequent overwash and build-up in the interior sand flats and the marshes. The net effect of this process has been a gradual westward movement of the islands. Periodically, during heavy storms, inlets may be opened. The natural and stabilized conditions are illustrated below.



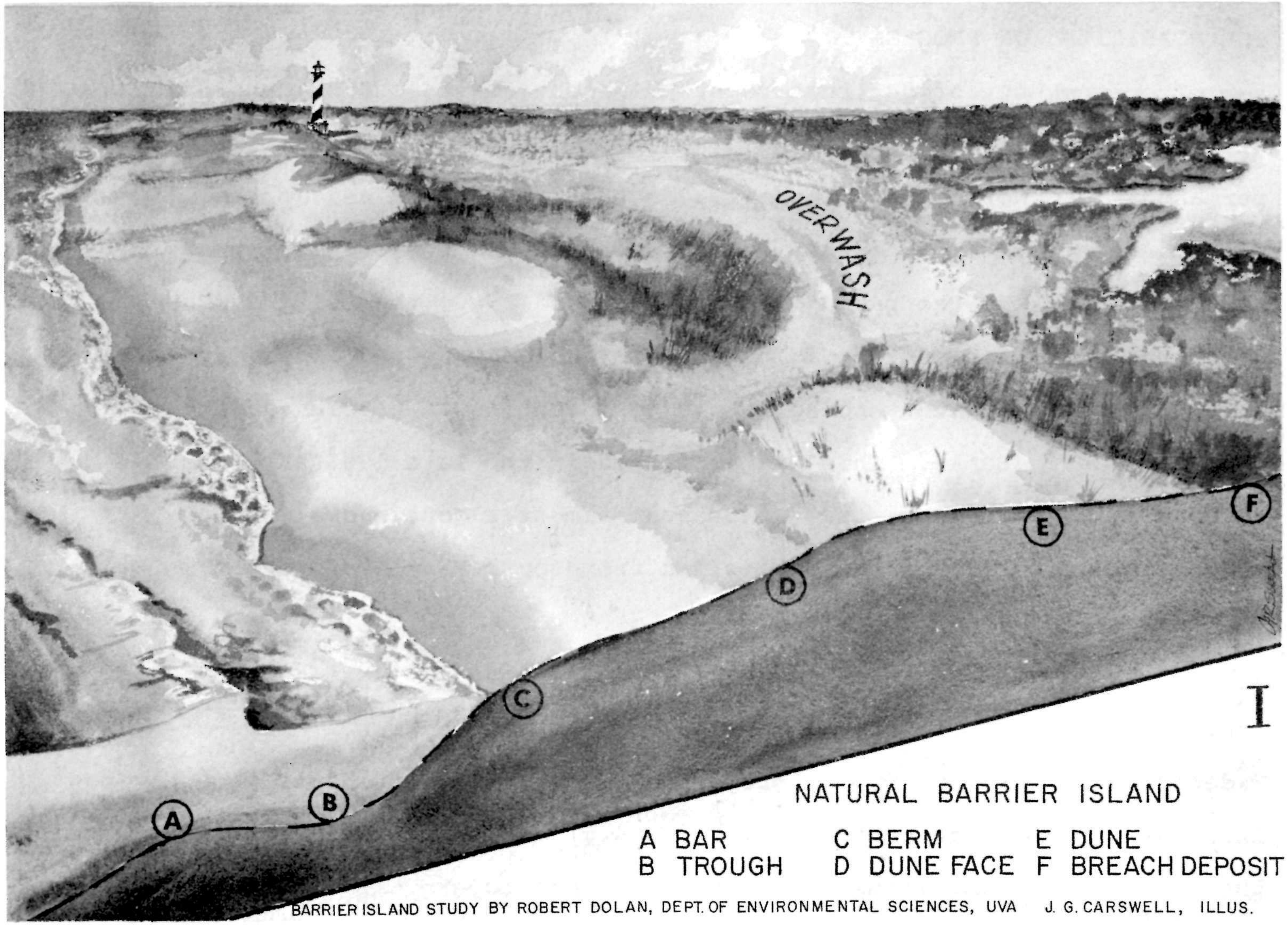

OVERWASH
A
B
C
D
E
F
I
NATURAL BARRIER ISLAND
A BAR
B TROUGH
C BERM
D DUNE FACE
E DUNE
F BREACH DEPOSIT
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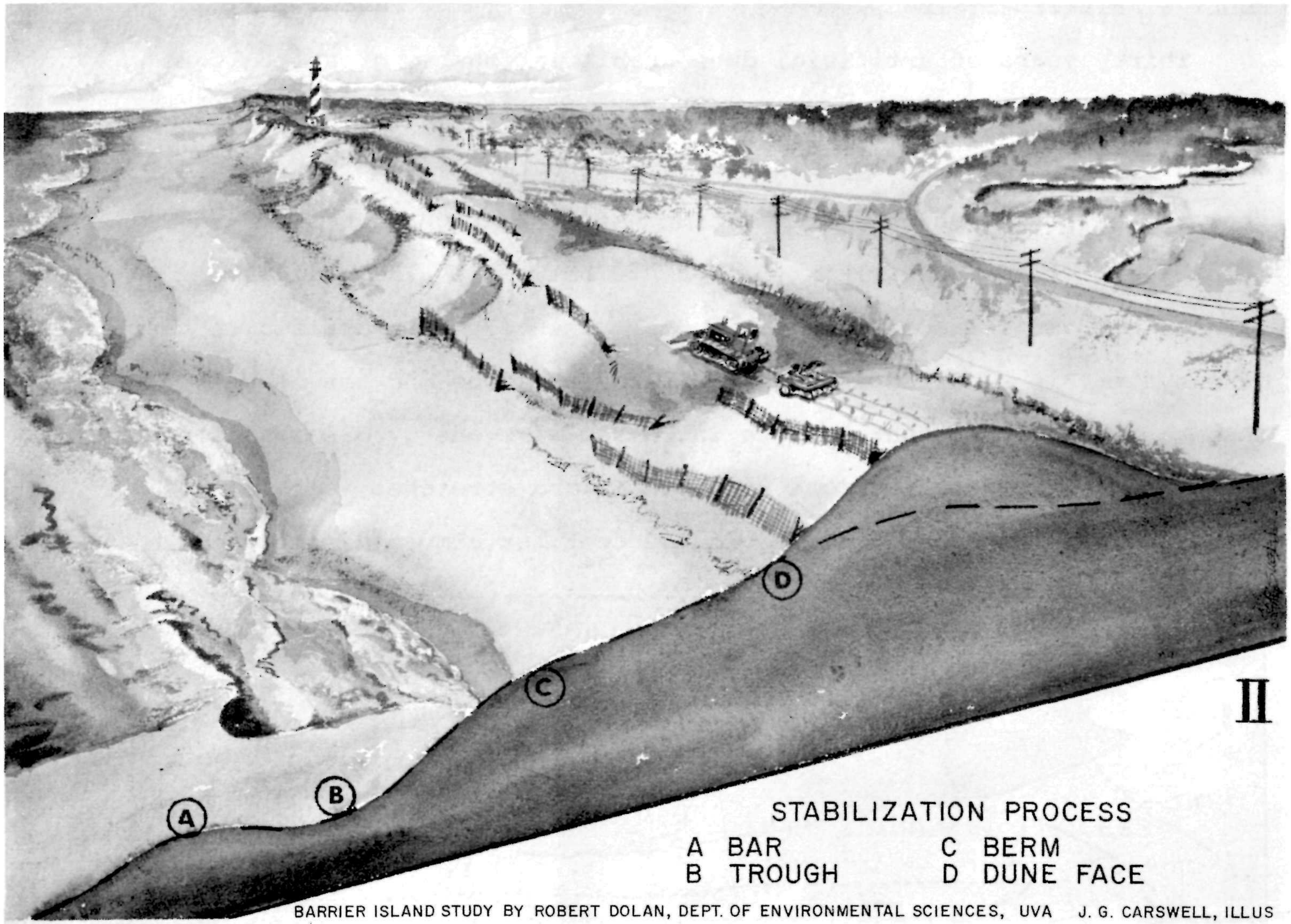
PLATE II

THE STABILIZATION PROCESS

The frequency of destructive storms along coastal North Carolina, with accompanying oceanic overwash, precluded the establishment of a permanent road network until the 1930's. It was determined at that time to construct a protective dune system between the proposed road and the beach. In the period between 1936 and 1940, the CCC and WPA, under the direction of the National Park Service, erected almost 3,000,000 feet of sand fencing to create a continuous barrier dune along the Outer Banks. This was augmented in the late 1950's by the National Park Service so that at present almost a continuous mass of vegetation blankets the barrier island from south Nags Head to the southern tip of Ocracoke Island.

As the system is stabilized, man builds roads and utilities that establish a "line-of-development" which soon becomes a "line-of-defense." Widespread private and public property development contributes directly to increased pressure to protect this line. It is important to stress that the dune lines, road lines, utility lines, or property lines have <u>no natural significance</u>.


A
B
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II
STABILIZATION PROCESS
A BAR
B TROUGH
C BERM
D DUNE FACE
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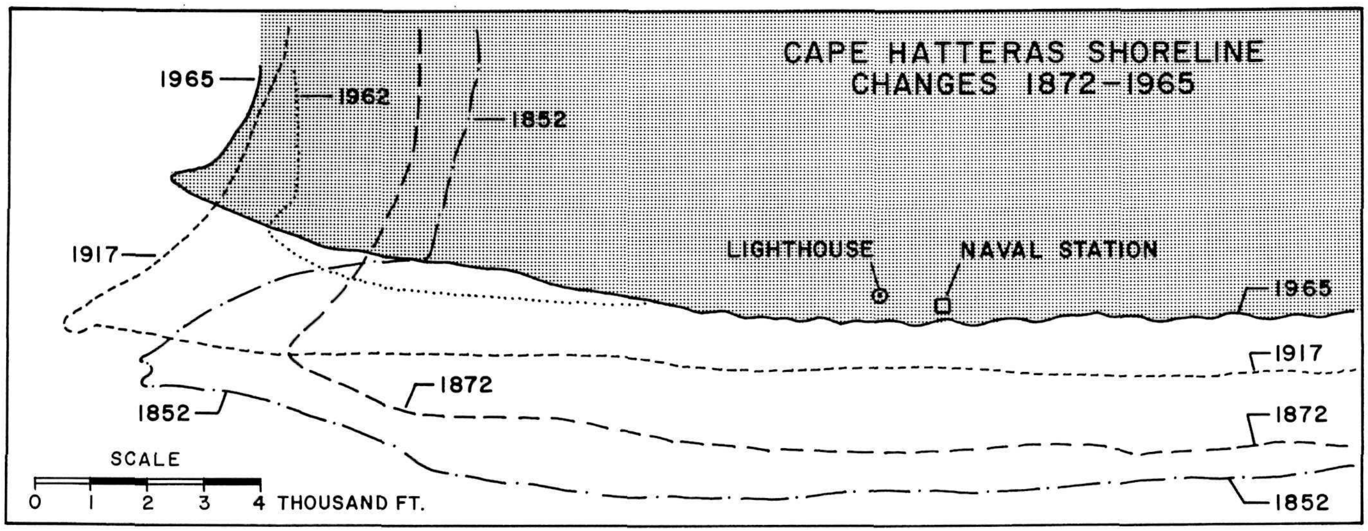
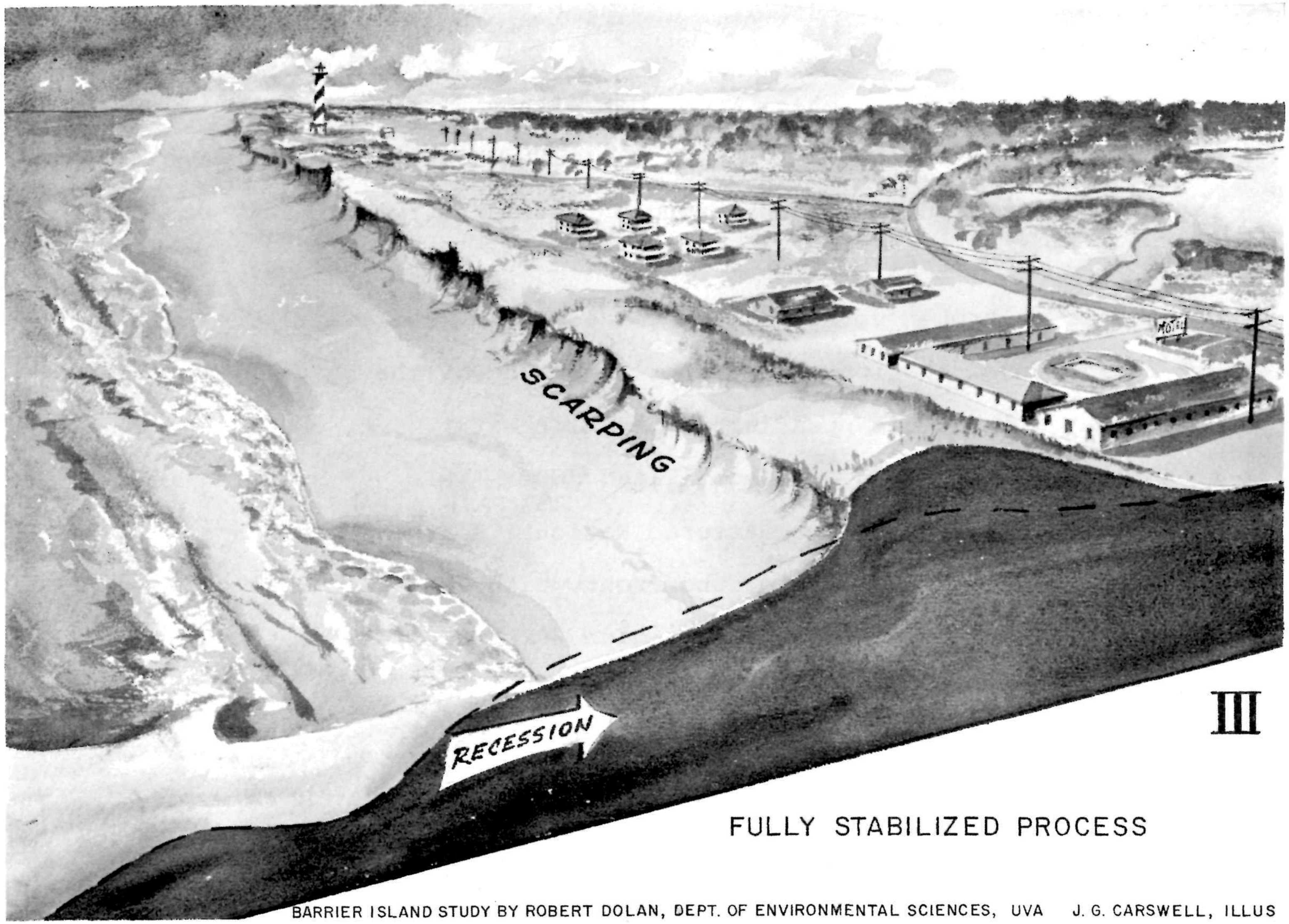
PLATE III

FULLY STABILIZED SYSTEM

Thirty years of artificial dune stabilization has greatly altered both the ecological and geological structure of the Cape Hatteras sector of the Outer Banks. A comparison of cross-sections of Hatteras Island show the extent to which stabilization has brought changes in beach morphology. The most striking difference between the natural and altered barrier islands, other than the presence of the artificial barrier dune system, is a marked difference in beach widths and the deeper inshore water depths that lead to increased wave energy dissipated on the beach-face. Along many of the Hatteras Island stretches, altered 30 years ago, the beach has receded to 150 feet, or almost disappeared.





FULLY STABILIZED PROCESS

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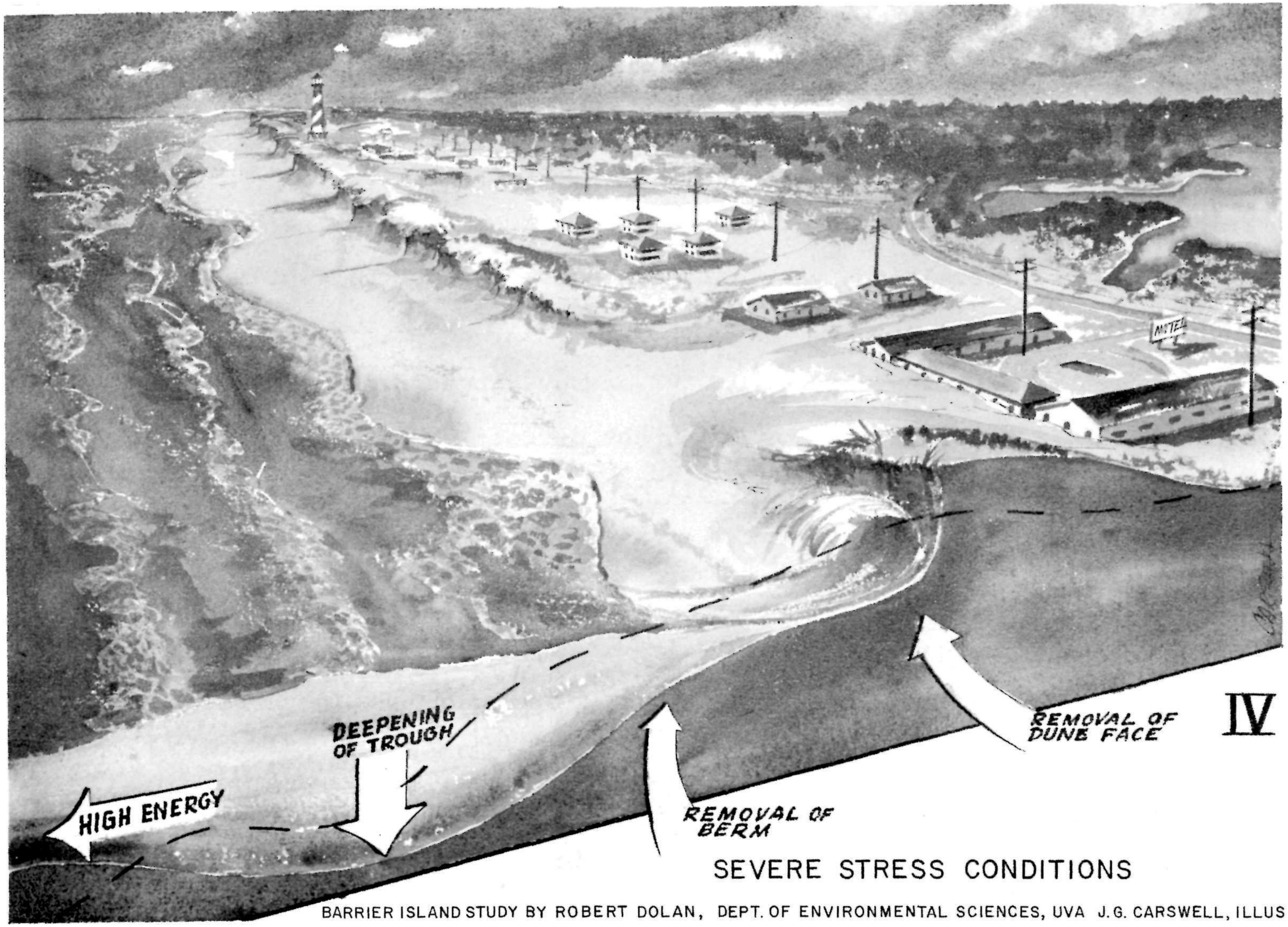
PLATE IV

SEVERE STRESS CONDITIONS

The beach narrowing process, combined with the presence of permanent dune structures, has created a situation in which high wave energy is concentrated in an increasingly restricted run-up area, resulting in a steeper beach profile, increased turbulence, and a tendency for the beach sand to be broken up into finer pieces and washed away. The net effect is increased erosion and further narrowing of the beach. Ultimately the beach may all but disappear above the high water mark, and wave uprush is then applied directly to the stabilized dune. This has occurred in several places within the Cape Hatteras National Seashore and has resulted in a gradual undercutting of the dune front, with eventual destruction of the dune system and endandering of man-made structures behind the dunes.



SEVERE STRESS CONDITIONS

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EROSION CONTROL

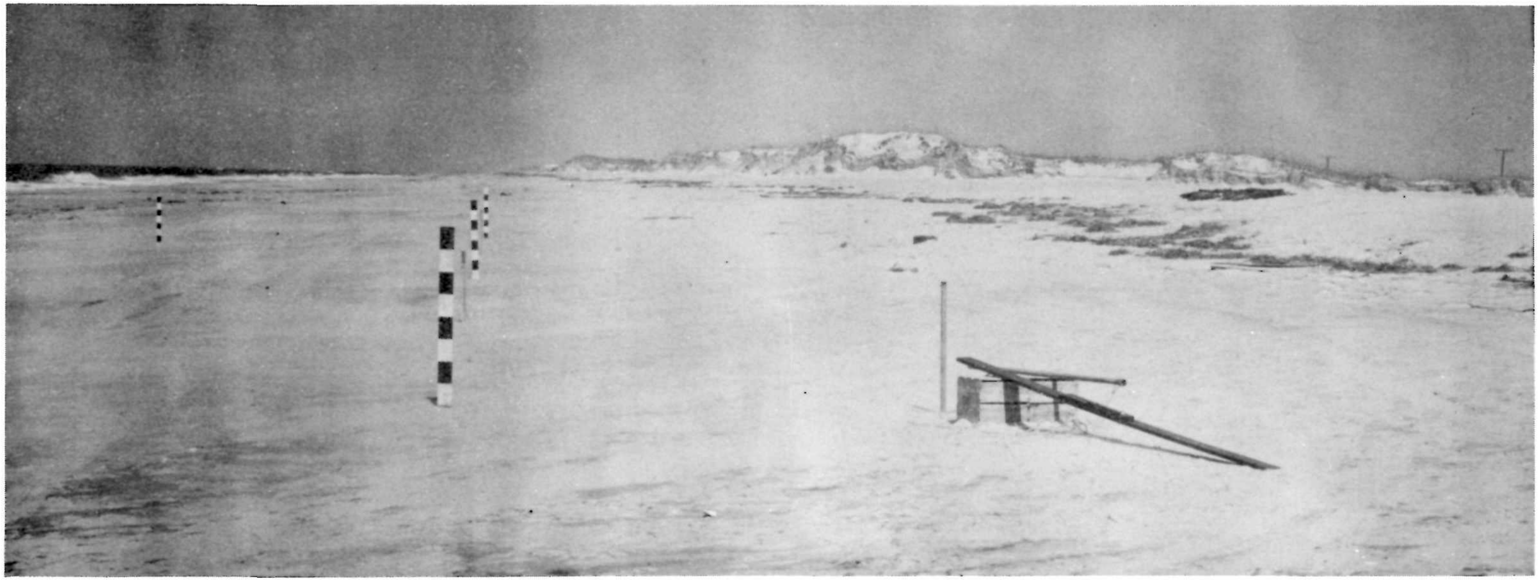
The barrier islands recede when forces of erosion exceed the amount of sediment supplied to the beach-energy system. The greater the deficiency of sediment or the higher the wave forces (energy) the more rapid the rate of erosion. Any of the three factors, wave energy, sediment, or sea level, can vary and change the balance between erosion or deposition.

Along the mid-Atlantic coast, wave energy ranges from modest to high, the sediment budget is mostly on the deficit side, and sea level continues to rise. Unfortunately, all of these are factors that contribute to shoreline erosion. The photos on the opposite page illustrate the magnitude of change during an extreme event (March 1962). This beach on Bodie Island was an experimental site when the storm occurred. The dune face was eroded back over 100 feet, yet overwash only occurred in a few areas.

Shoreline protection schemes can be summarized under three categories: protection designed to (1) inhibit direct attack by waves, such as sea walls, bulkheads, and revetments, and (2) those designed to inhibit currents that transport sand, such as jetties and groins, and (3) artificial beach nourishment.

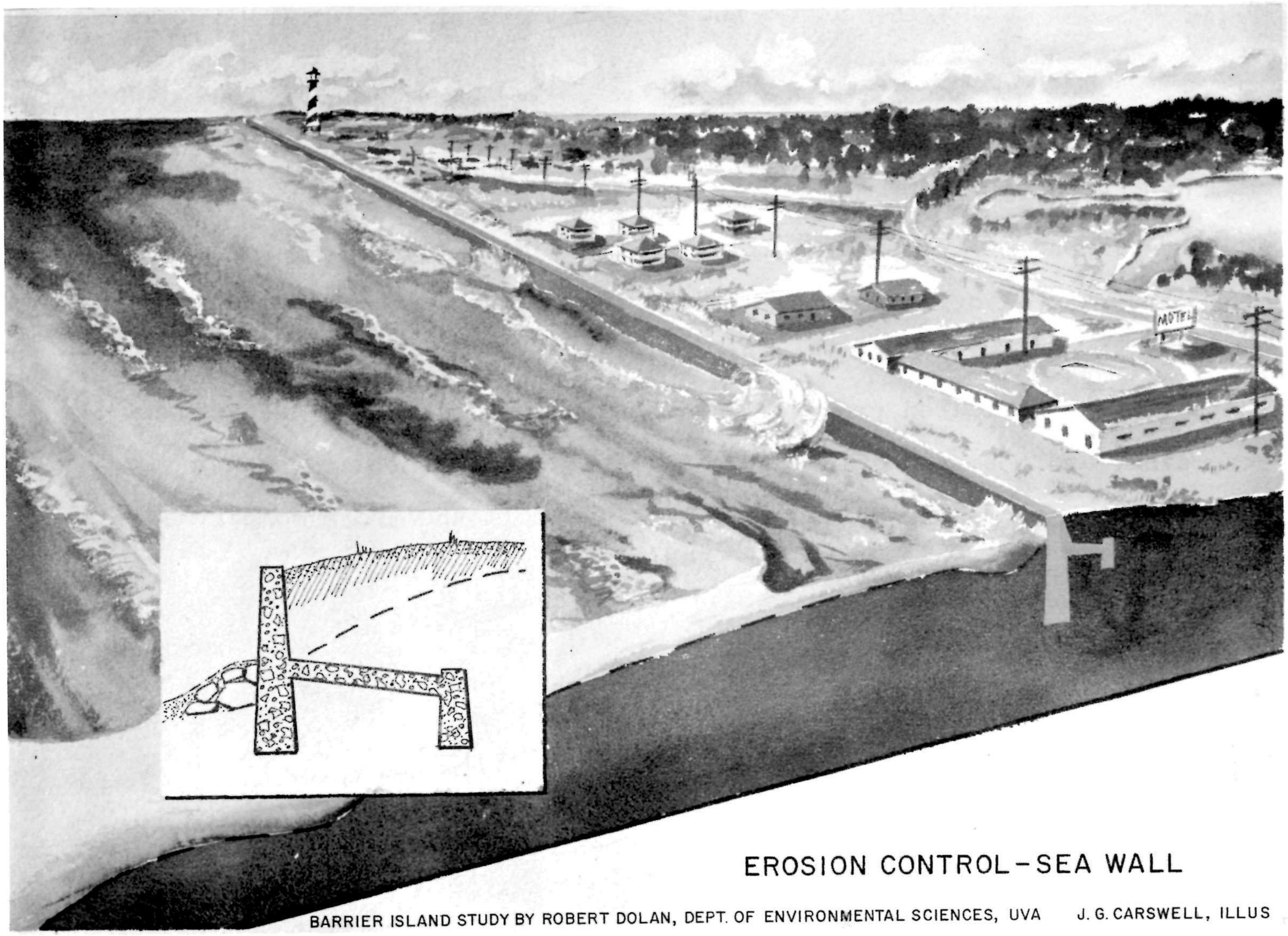
Before Ash Wednesday Storm

Five Days Later



SEA WALL

Sea walls are expensive and only suitable when all other means of protection are impractical. In principle, the sea wall is designed to absorb and reflect wave energy, as well as elevate the problem area above the high water line. Unfortunately, sea walls, bulkheads, and revetments do not prevent the loss of sand in front of the structure. In fact, sea walls commonly accelerate the loss of sand as the wall deflects the wave forces downward into the beach deposit.



EROSION CONTROL – SEA WALL

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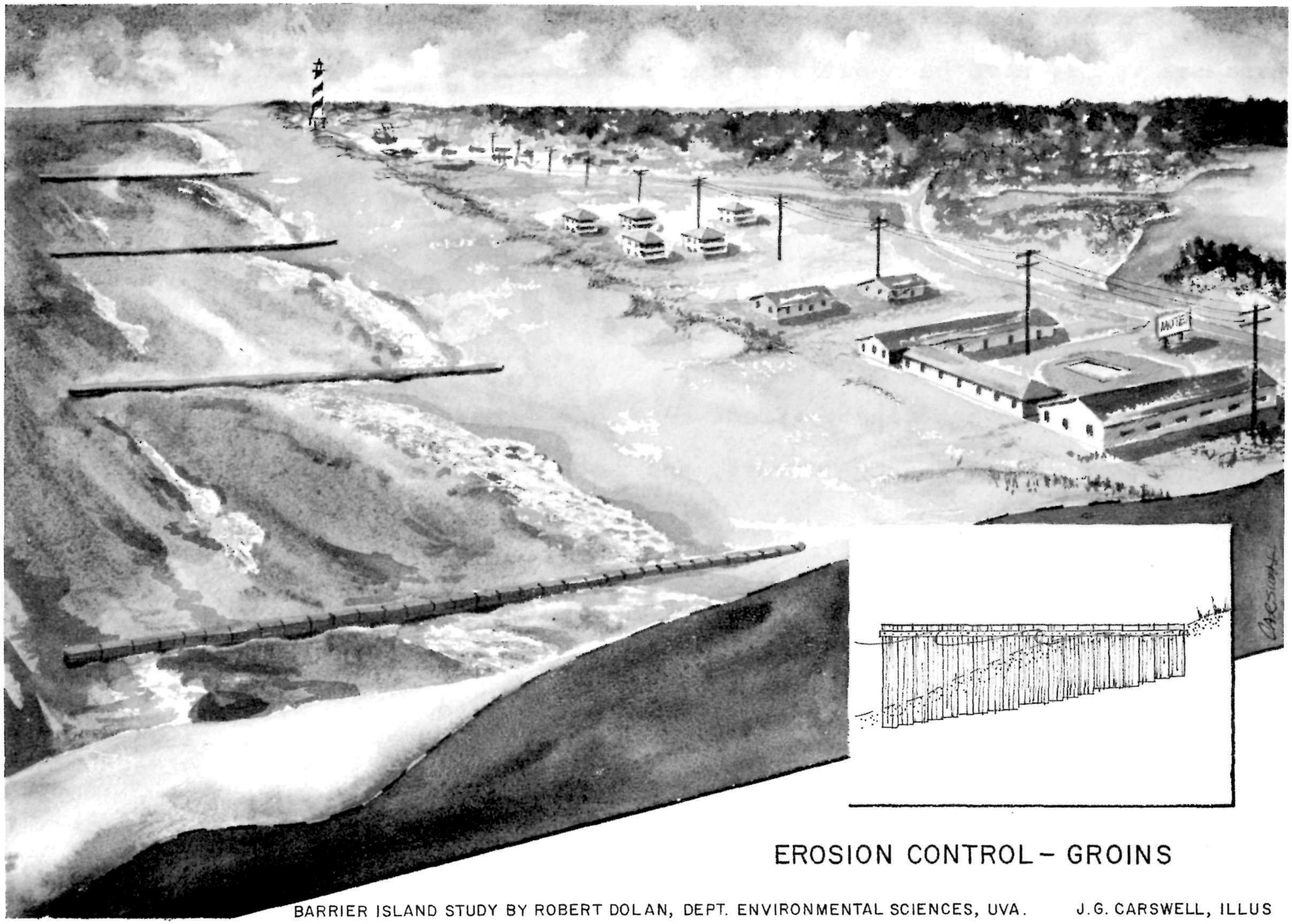
GROINS

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 of significant 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 reason for this is that groins trap sand, and the sand gained at one place must be lost at another. Nourishment is commonly needed to fill or re-fill the groin compartments as the sands are lost.



EROSION CONTROL – GROINS

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NOURISHMENT

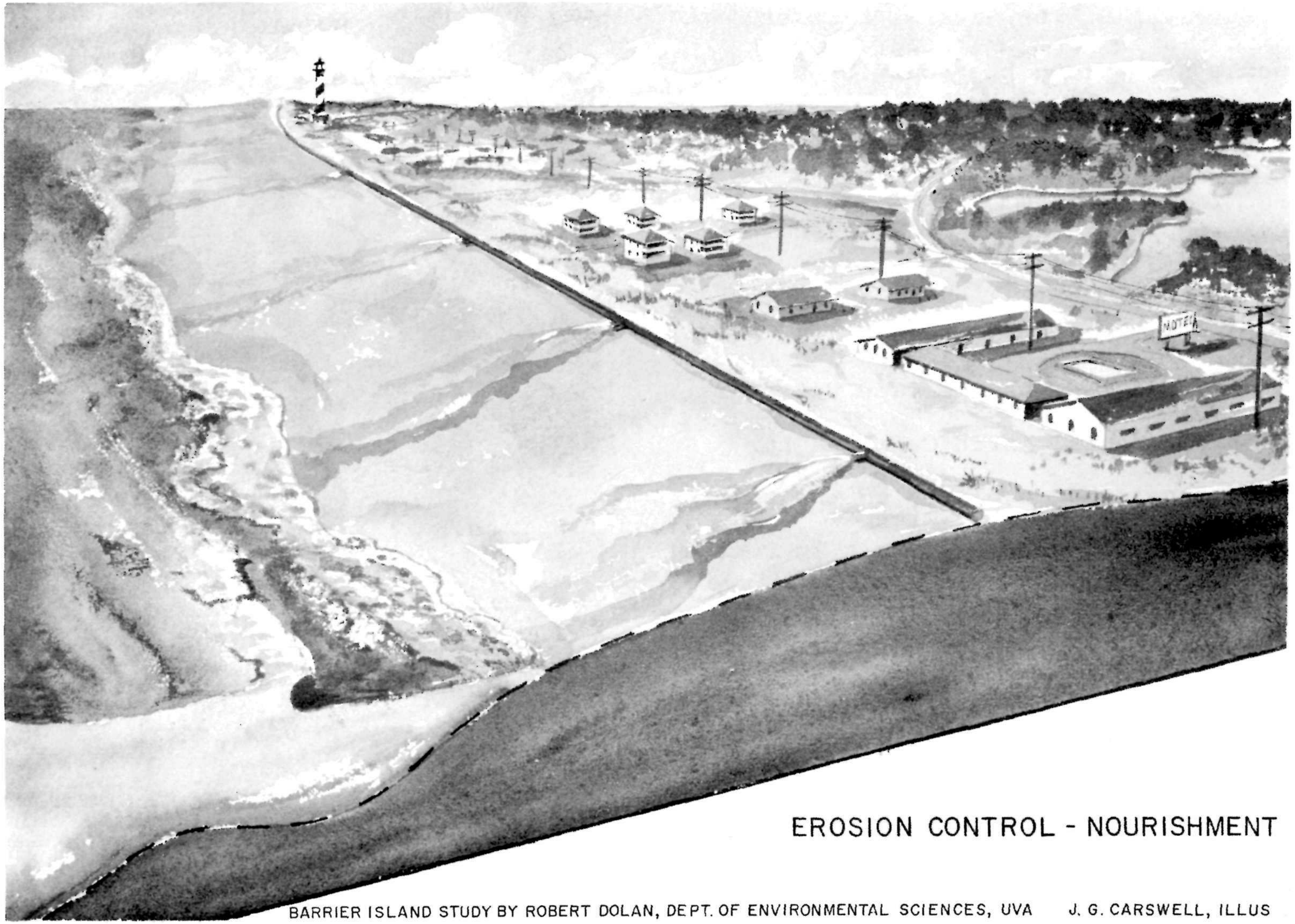
For more than a century, coastal structures, including jetties, groins, and sea walls, have been built in the inshore zone in an effort to trap sand and protect beaches. In general, these structures have collectively aggravated problems rather than resulted in solutions. The disadvantages span a wide range of physical problems. Artificial beach nourishment, on the other hand, has long been considered the most desirable method of protection because:

(1) Placement of sand on a beach does not alter the suitability of the systems for recreation.

(2) Nourishment cannot affect adversely areas beyond the problem area.

(3) If design failure occurs, the results of the "structure" are soon dissipated.

Perhaps the greatest disadvantage to artificial nourishment is that great quantities of sand of suitable quality (type and size) are commonly not readily available. 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 generally too fine to be effective as beach nourishment, estuarine and bay sources are less desirable and no longer as available. The only future prospect for large quantities of sand for nourishment purposes appears to be offshore sources and materials dredged from the coastal inlets.



EROSION CONTROL - NOURISHMENT

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CONCLUSION

Survival of the natural barrier island system along the coast of North Carolina requires a strategy of man-and-nature rather than man-over-nature. We have attempted to "draw a line" and prevent the sea from passing --this may be possible in isolated areas, but the cost will be great. Since the Cape Hatteras portion of coastal North Carolina has already developed in places to the point that it would be very difficult to remove the highway, it must be maintained; however, as the barrier dunes continue to narrow, increased overwash and inlet formation can be forecast. Many of the structures which have been built near the beach will surely be lost and the highway will require re-location within a few years.

In the beginning--1936.

In the end--1972.