PHOTOGRAPHY RELATED TO INVESTIGATION OF SHORE PROCESSES*

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INTRODUCTION

THERE are many ways in which photographs can be used to assist in the study of shore processes and in tracing the history of shoreline development. Storm waves cause important changes to shorelines. The observer finds it difficult to determine the nature of the wave attack because of the rapid and confused motion, but photographs allow more leisurely examination of the wave character. Furthermore, photographs obtained before and after storms show graphically the changes which beaches have undergone. The retreat of coastal cliffs can often be determined by a comparison of the present cliffs with old photographs. The camera is particularly useful in conveying to others the special phenomena which an investigator finds on beaches. A photograph is usually more convincing than a sketch although both are needed to some extent.

Photographs from planes are essential in order to show the larger features which are badly foreshortened by photographs from the land surface. Currents are often indicated by a difference in transparency of the water. Taken from the land, these differences scarcely show; but they are strikingly clear when viewed from the air. Where the water along the shore is clear, aerial photographs serve to indicate channels and bars which exist along the shore in many places. Finally, the airplane is capable of making aerial compilations which produce the most accurate types of shoreline maps.

WAVE PHOTOS

Waves can be photographed to best advantage from piers where the waves pass beneath the photographer, or from cliffs against which the waves are breaking. Where large waves are breaking on a gently sloping foreshore, photographs from the beach are generally disappointing unless telephoto lenses are used.

There are two types of breakers which result from wind waves, spilling and plunging. These are illustrated in Figures 1 and 2 respectively. Although both types have steep fronts, the spilling breaker lacks the almost vertical fall of the water that characterizes the front of a plunging breaker. Spilling breakers are characteristic of waves which are breaking with strong onshore wind in storm areas. Plunging breakers occur where waves have far outrun the area of storm generation, and are particularly pronounced when there is an offshore wind. Waves are likely to spill if they move in along a gently sloping beach, and the same waves will plunge if they encounter a steep foreshore. All gradations exist between the two types.

Tsunamis (popularly known as tidal waves) are not unlike ordinary wind waves in appearance along the shore (Figures 3 and 4) partly because they usually have wind waves superimposed on top of them. Actually they are very different in their open sea characteristics because they have very low heights in the open ocean and occur at intervals or periods of from about 10 to 20

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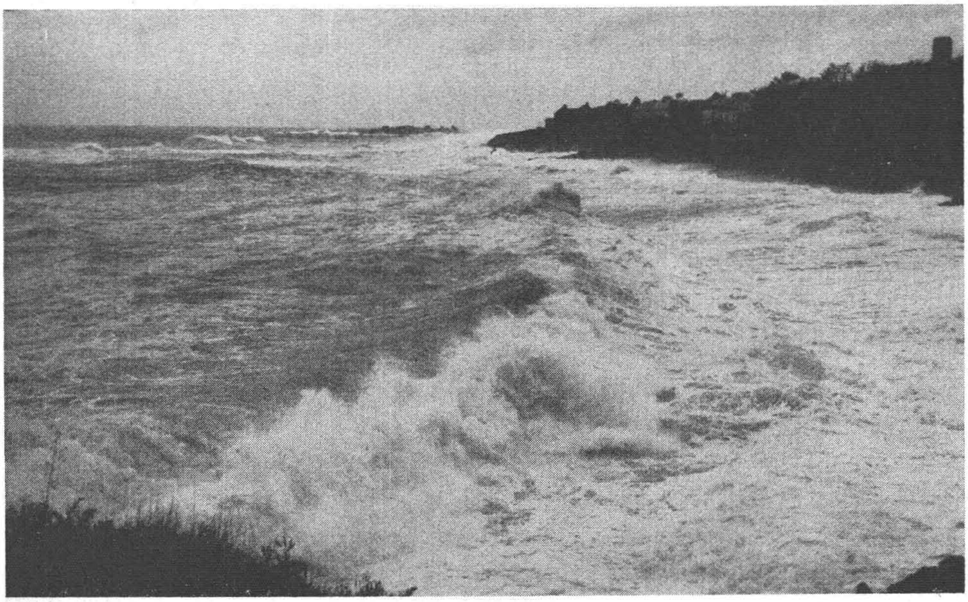

FIG. 1. A spilling breaker taken during a gale at Marblehead Neck, Mass., September 12, 1950.

FIG. 2. A plunging breaker at La Jolla, Calif. Note the apparent concavity of the wave front in the portion which has not yet broken.

FIG. 3. The tsunami (tidal wave) of April 1, 1946, at Kawelo Bay, Oahu. The advancing wave is crossing a lagoon inside a coral reef. It covered the entire foreground a few seconds later.

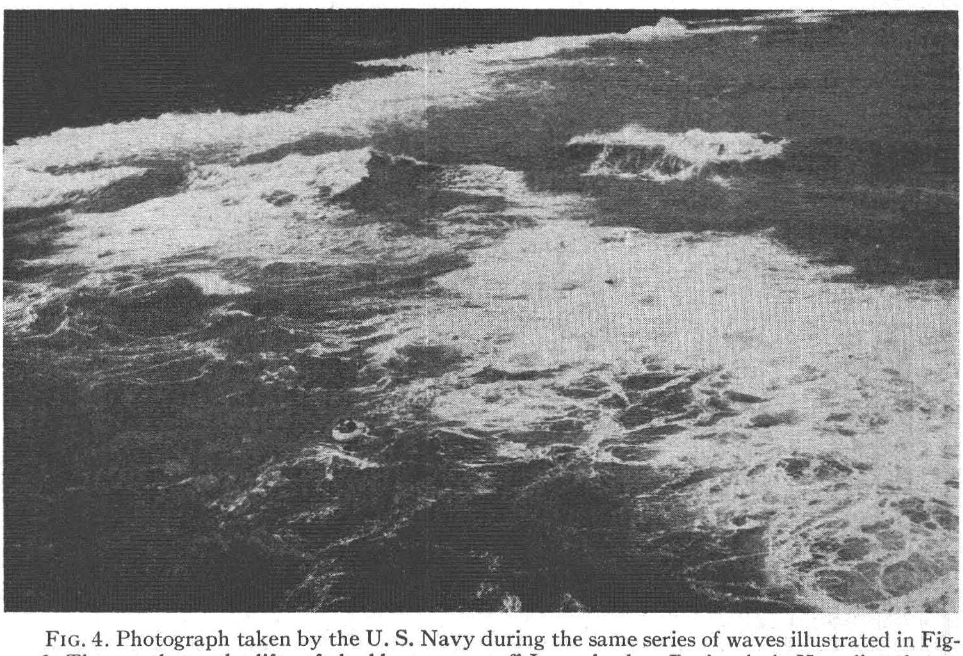

FIG. 4. Photograph taken by the U. S. Navy during the same series of waves illustrated in Figure 3. The people on the life raft had been swept off Laupahoehoe Peninsula in Hawaii and were rescued by U. S. Navy fliers who dropped them a raft. The photograph was apparently taken during the rise of one of the waves onto the coast.

minutes whereas wind waves have periods from about 2 to 20 seconds. Along shores tsunamis rise to great heights, this rise being much faster than but often similar to the rise of the tide. The piling up of the water to great heights produces extensive damage often carrying away houses like those shown in Figure 5. The advantage of taking photographs during a tsunami can be well imagined since the excitement of the moment makes it most difficult to recall exactly what was happening especially where the wave is coming directly at one as was the case in the photograph which the author obtained in 1946 (Figure 3).

The variability of wind wave height along the shore is well illustrated by plane photographs (Figure 6). The differences are generally the result of convergence and divergence of trains of waves approaching the coast. In Figure 6 the almost complete absence of breakers in one area is the result of a divergence caused by the existence of a submarine canyon on the sea floor.

RIP CURRENTS

"The undertow is dangerous on this beach" is a common but meaningless statement. It can be translated into actual demonstrable fact by saying "There are strong offshore currents along this beach." Undertow as a strong subsurface current is probably a rare phenomenon, but strong currents which carry bathers out from the shore either at the surface or below are by no means unusual in

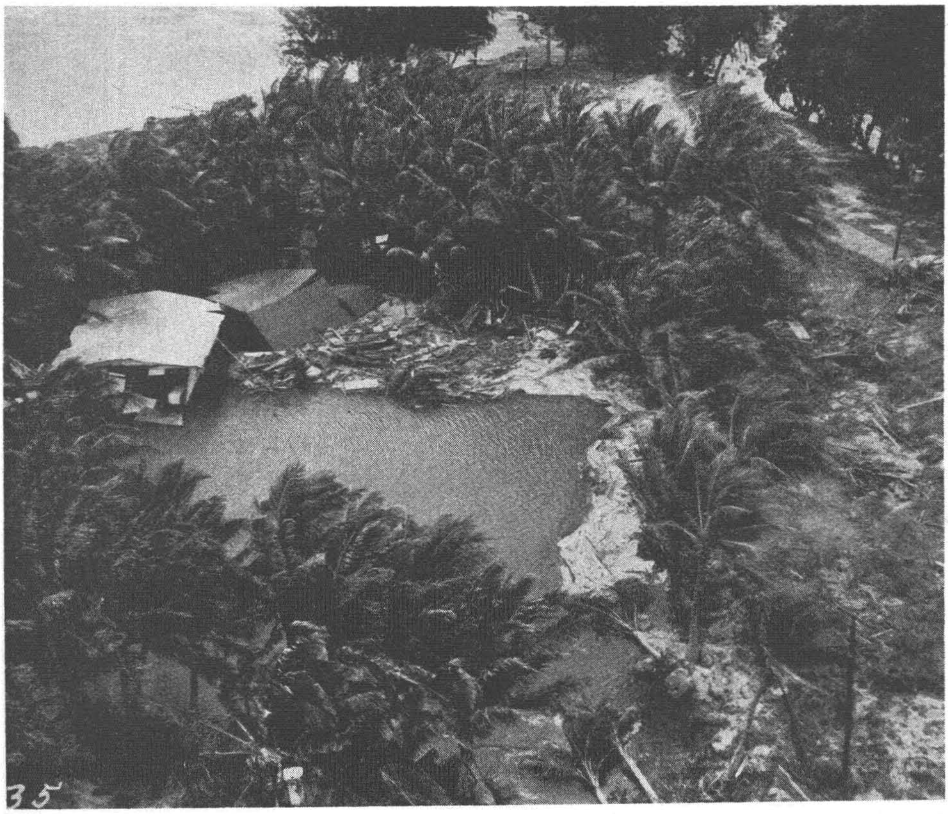

FIG. 5. Photograph by U. S. Navy of a portion of Kawelo Bay after the large waves of April 1, 1946, showing how two houses were washed into a small sink hole lake and completely demolished.

high surf. These outward moving currents are known locally as *rip tides* or *sea pusses*, but the name *rip currents* seems preferable especially since the phenomenon has no relation to the tide, and the origin of *sea pusses* is a bit uncertain, possibly originating as *sea purse.*

The roiled water in the rip currents gives them a distinctive appearance which can be seen best from an elevation. An airplane photograph (Figure 7) is particularly helpful in showing the nature of these currents. They are generally concentrated into a narrow band as they move out through the breakers,

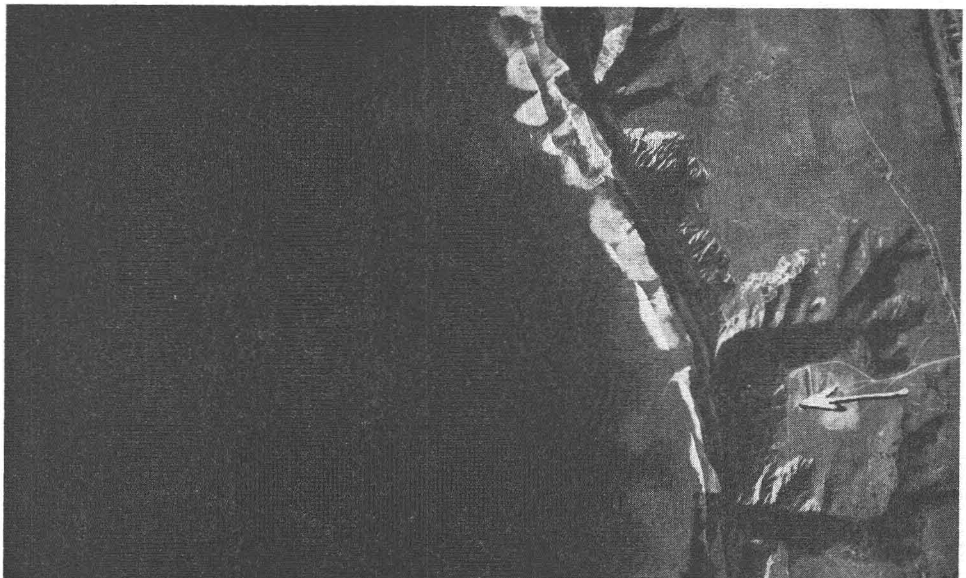

FIG. 6. Illustration of the effect of a submarine canyon (located outside the arrow) in reducing breaker height. Note that the surf zone which is well developed on both sides virtually disappears in this zone. Photo by U. S. Navy, 1944.

but become diffused on the outside and often take on the form of large eddies. Where waves are breaking against rock cliffs, masses of foam develop. The outward movement of rip currents carries the foam seaward in lines as indicated in Figure 8.

The movement of muddy water out over the sea surface is very evident after a large rain storm. This is the result of the lower salinity of the water from the land which is entering the ocean. The water may move out very much like a rip current. Similar phenomena are seen off rivers which empty directly into the sea. In the case of rivers like the Amazon, these muddy top flows can be traced for hundreds of miles out to sea. A marked color contrast exists at the boundary between the murky water and the clear water beyond.

BEACH PHENOMENA

In *Douglas Johnson's* "Shore Processes and Shoreline Development," a considerable number of photographs were used to illustrate the special features

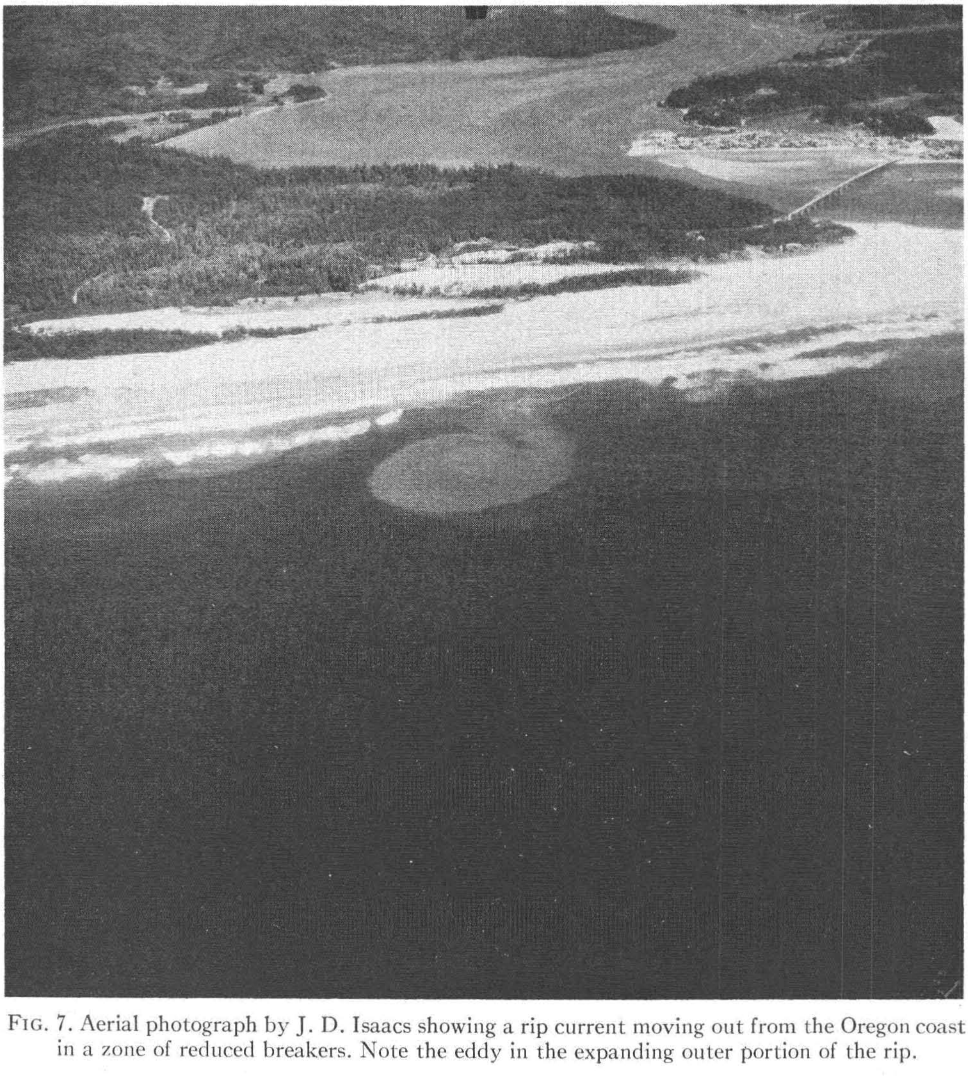

FIG. 7. Aerial photograph by J. D. Isaacs showing a rip current moving out from the Oregon coast in a zone of reduced breakers. Note the eddy in the expanding outer portion of the rip.

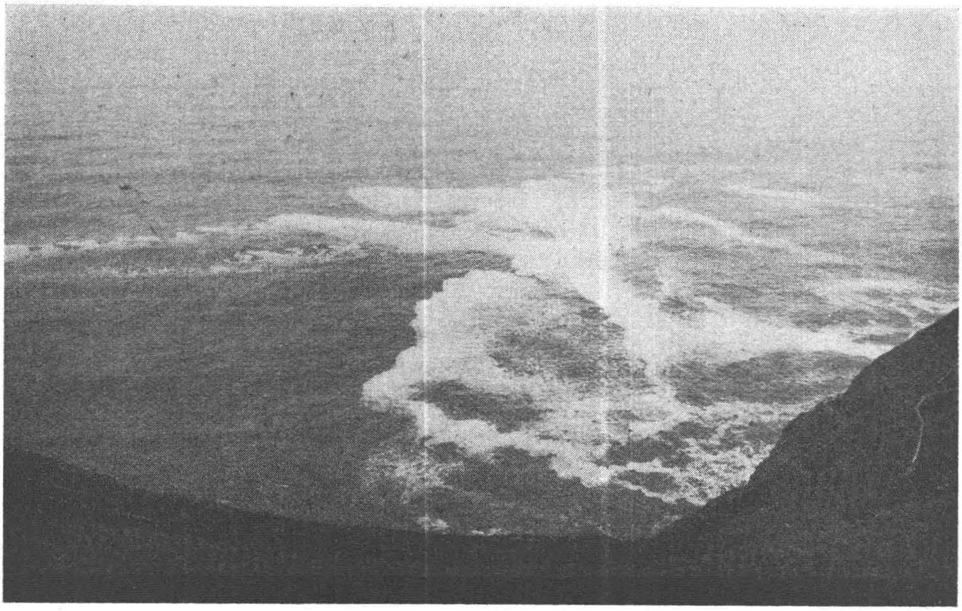

FIG. 8. A rip current carrying masses of foam out to sea. Photograph taken from the Oregon Coast Highway at Sea Lion Cave, June 16, 1950.

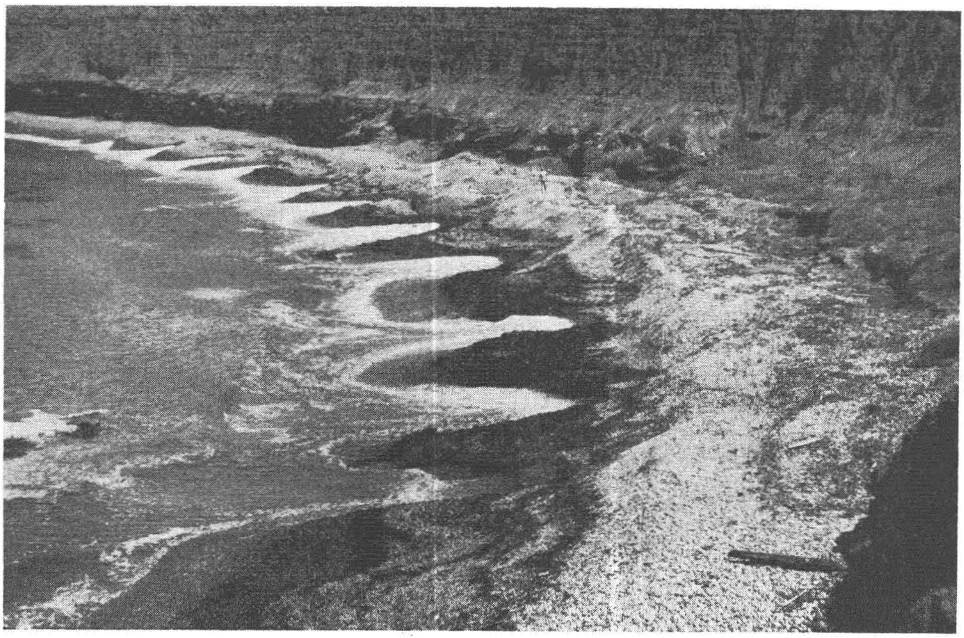

FIG. 9. Beach cusps formed from cobbles at Punta China, Lower California. Note the backwash in the troughs between the cusps. Photographed August 6, 1950.

of beaches. Study of these same features has continued and new phenomena have been discovered which lend themselves to photography.

Beach cusps are often developed in sand but they are most striking in cobble beaches (Figure 9). The photographs show how the small ravines between cusps are kept open by the concentration of the backwash in the initial depressions. Airplane photographs give indications of the relation between cusps, beach trends, and angles of wave approach.

The longshore bars and troughs which are commonly developed where beaches have gentle seaward slopes are partially exposed at low tide. Photographs show the effects of strong currents which have been flowing at high tide

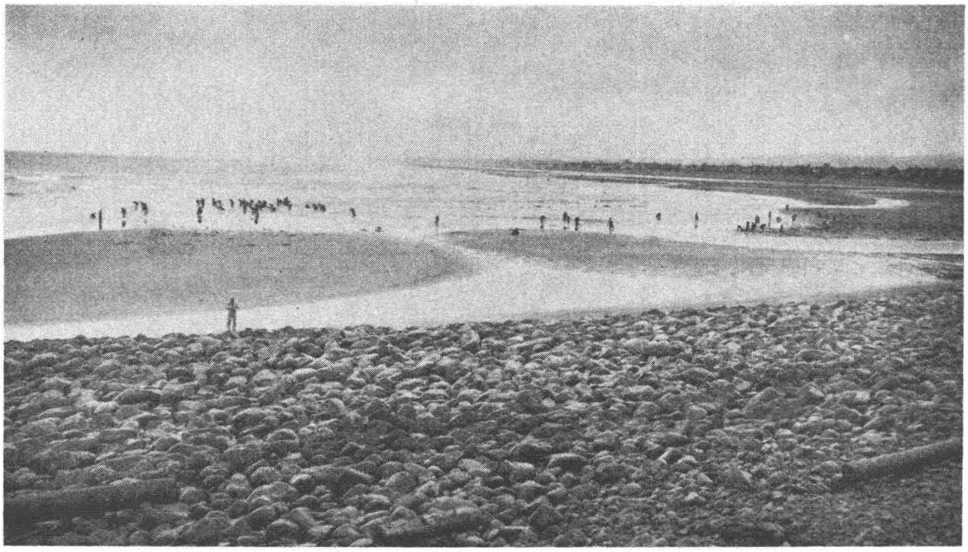

FIG. 10. An early morning low tide at Seaside, Oregon, June 17, 1950. Clam diggers are working on the exposed longshore bars. Note the longshore trough in the middle ground and the seaward connections through the bar formed by rip currents at higher stages of the tide.

along the troughs and have left striking irregularities (Figure 10). In places air photos show the bars and troughs through the clear water (Figure 11).

A great variety of ripple marks develop on beaches and on their submerged continuations. The development of *backwash ripples*, characteristic of fine sand beaches with gentle seaward slopes, is illustrated in Figure 12. These ripples are almost always separated by one to two feet, whereas ripples of about 3 inch wave length are found in the submerged slope directly outside. Sometimes at low tide one set is found superimposed on the other, but ordinarily the short ripples disappear as the water withdraws and longer ripples are formed by the backwash.

BEACH CYCLES

During the summer season, when small waves prevail in most areas, the beaches grow broader and the sand piles higher. During winter storms, however, the beaches are likely to be denuded. These changes are illustrated in Figure 13. However, the changes may be partly in the nature of sand shifting along the shore. Figure 14 shows a beach which grows in summer at the north end because the waves are approaching from the south, whereas the south end of the same beach is actually denuded during the same period. When winter storms

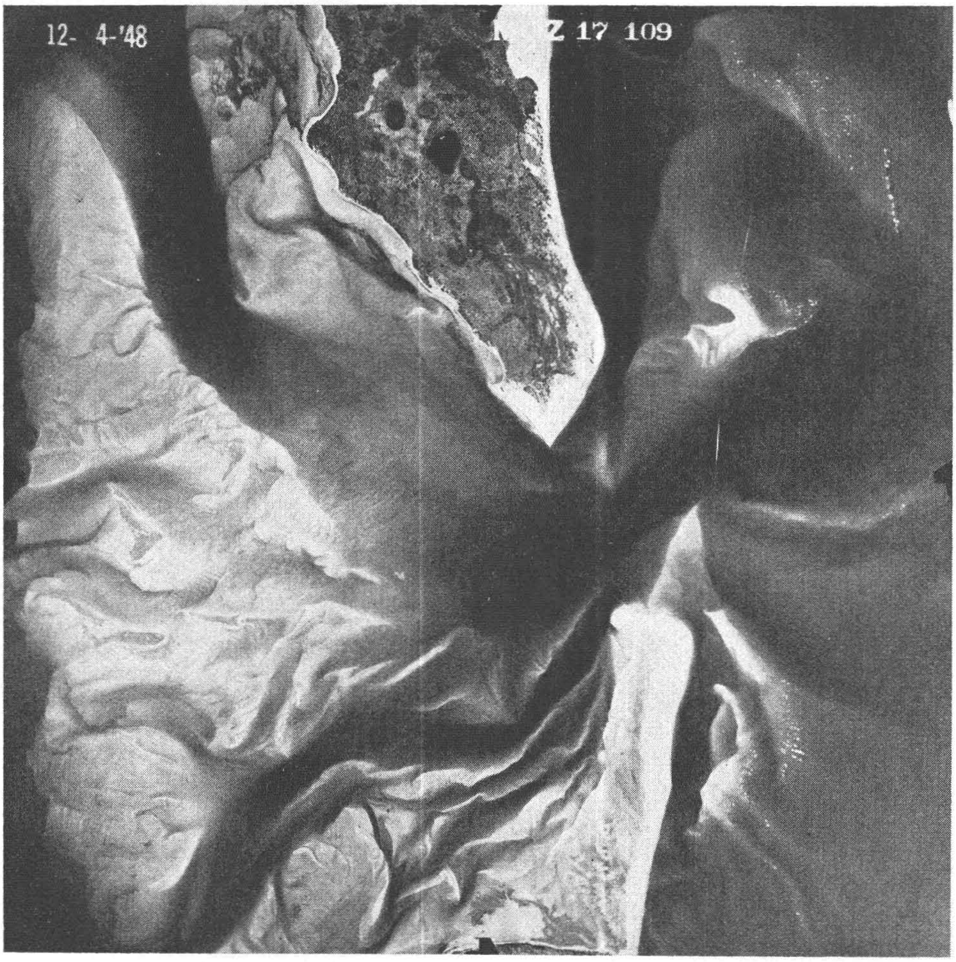

FIG. 11. Aerial photograph by Gulf Oil Company on the coast of Mozambique, Africa, kindly supplied to the author by Dr. H. D. Hedberg. Note the troughs and bars along the coast and the intricate tidal channels on the inside. Unusually clear water made this submarine photography possible.

come in from the northwest, the northern portion of the beach is cut down to rock, whereas the southern portion receives a sand cover, although there is an actual loss of total sand on the entire beach.

Photography of beaches after large storms shows that in general the large waves straighten the slope cutting away the flat berm, but piling up the sand at the inner margin of the beach and to some extent building up the lower beach.

COAST EROSION

In some areas it is possible to tell the extent to which a coastal cliff has retreated during historical times, by the use of old maps which show how portions of towns have been worn away due to the attack of the waves. In general, however, little information is available to indicate what has happened to coasts since man inhabited them. Photography is of some assistance. Fortunately, the shore has been a popular place to take photographs. This gives us a possible

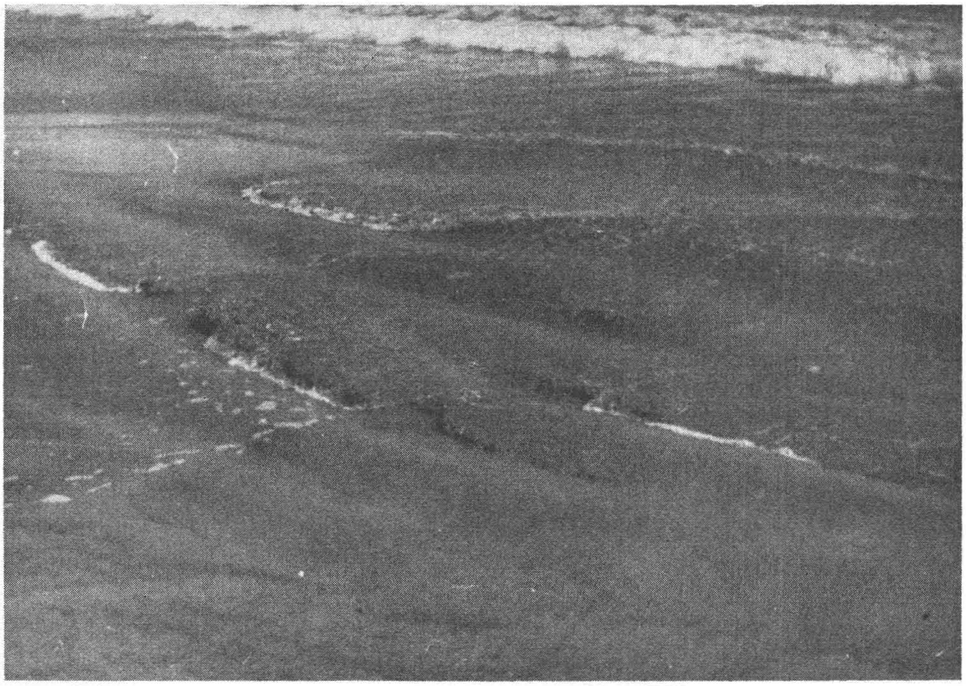

FIG. 12. Formation of backwash ripples by the backflow of a wave moving seaward down a fine sand beach. Photograph by R. L. Wisner at Mission Beach, California, July 14, 1947.

check over a period of about one century. There are often enough buildings still remaining to give some notion of retreat. In the case of rock coasts, if erosion has been very slow, concretions or other special features of the rock face can be recognized in the old photographs. An example of very small erosion indicated by the presence of the same concretions after an interval of 42 years is shown in Figure 15. It is surprising how many similar cases of little change can be found on coasts where wave attack is relatively violent. On the other hand significant changes seem to be common on rocky coasts where arches or stacks stood out beyond the general trend of the coast. Such a case is illustrated in Figure 16. The disappearance of sea arches has often served to give the impression to local inhabitants that coasts are retreating far faster than is actually the case.

The difficulty of getting dates for old photographs should convince photographers of the importance of dating their present day films. The help to future geologists of such dating may be tremendous.

(*The remaining figures are shown on the following pages*)

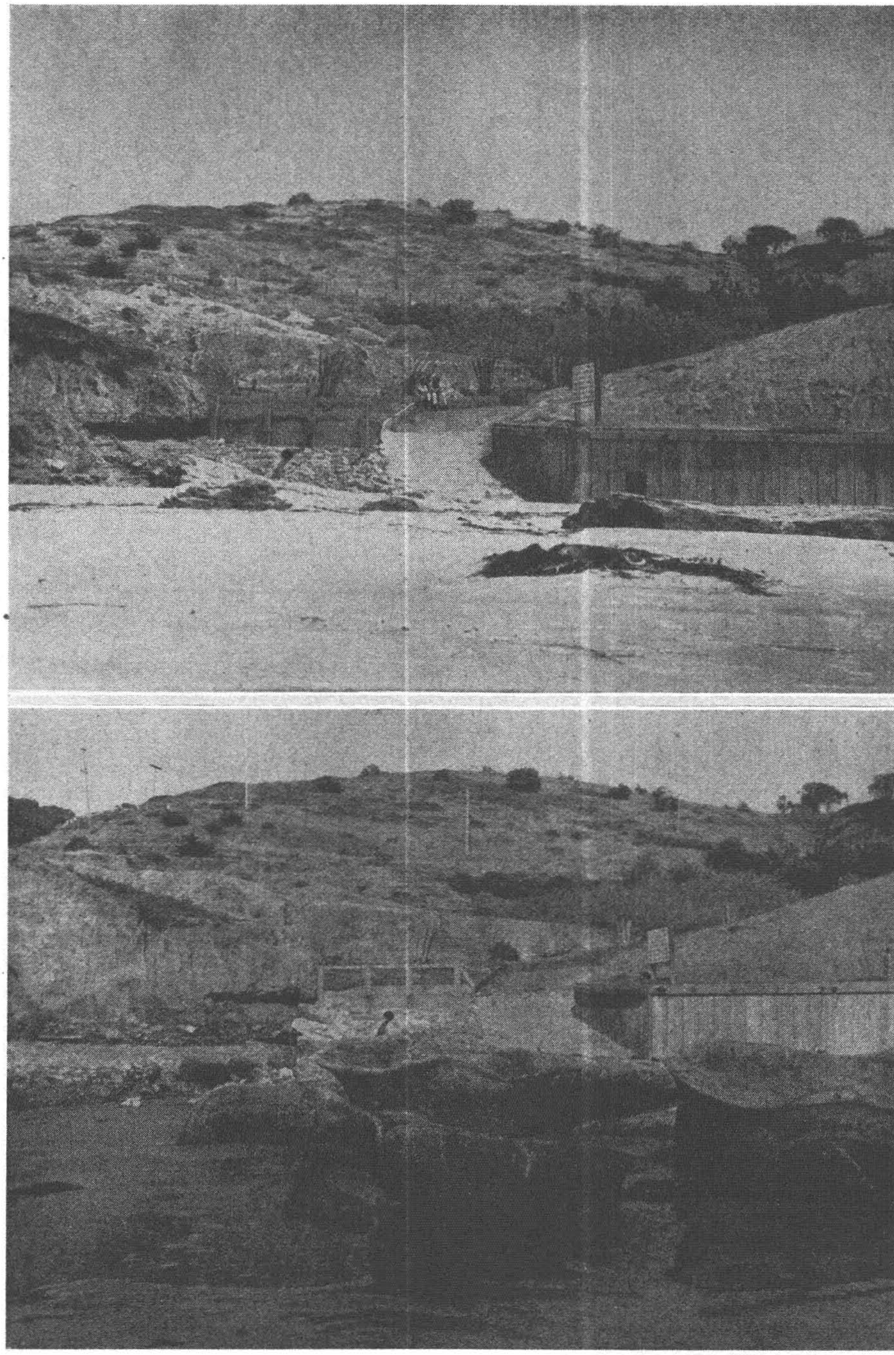

FIG. 13. Filled state of the beach (upper view) at Scripps Institution in August, 1938, and (lower view) the cut state in March 1938. Note that the rocks are almost entirely covered in the upper photograph.

FIG. 14. Illustration of the shifting of sand from one end to the other of a pocket beach at La Jolla, California. The upper view was taken in September, 1948 after a period of waves with southerly approach had moved the sand towards the rocks on which the photographer stood. The lower view of the same locality shows the denuded beach in November, 1947 after a period of northwesterly approaching waves. Careful examination will show that there has been some growth of the beach in the background.

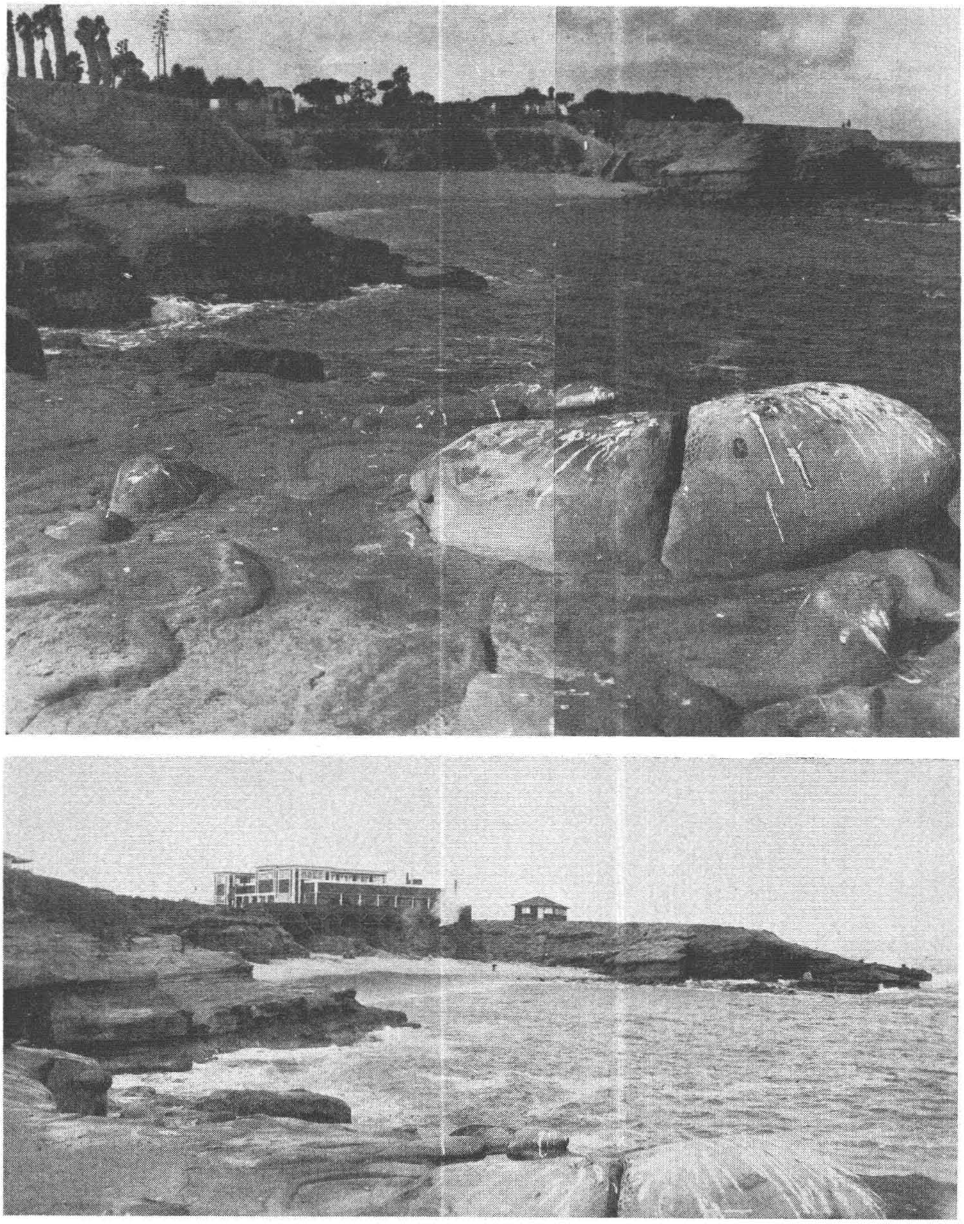

FIG. 15. The absence of appreciable erosion of the sandstone cliffs at La Jolla, California, during an interval of 42 years. The upper photograph was taken in 1948 by *U. S. Grant IV* and the lower one in 1906. Note the large number of common concretions that can be identified in both photographs.

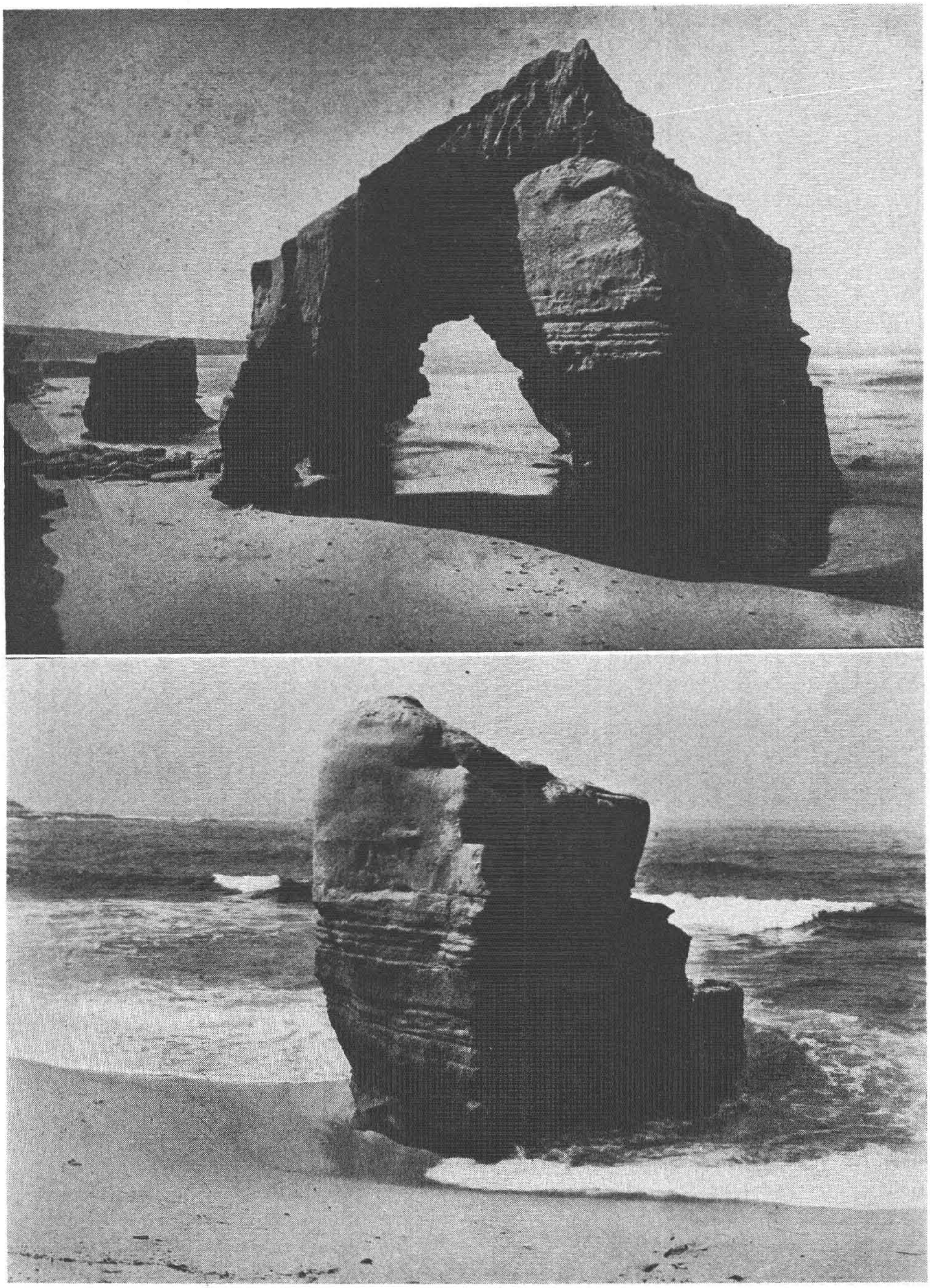

FIG. 16. Cathedral Arch at La Jolla, California, which was destroyed about 1900. The upper photograph was taken in 1897, and the lower one was taken in 1945 by *U. S. Grant IV*. The lower photograph shows the remaining right buttress of the arch. The other portions have completely disappeared.