U. S. Geological Survey

Washington 25, D. C.

Shore-erosion study of the coasts of Georgia and Northwest Florida

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Prepared for the U. S. Study Commission, Southeast River Basins

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by

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June 30, 1961

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INTRODUCTION

The following report was made at the request of the U. S. Study Commission, Southeast River Basins. Its purpose is to provide source material for the coastal development section of a comprehensive regional plan which the Commission is preparing for the Southeast River Basins - a region that includes Georgia, northwestern Florida and parts of Alabama and South Carolina.

The report is based on a reconnaissance field study and office compilation and collation of pertinent literature, maps, charts, and aerial photographs. The field study consisted of a helicopter flight over the entire coast of the study area and several days of ground study in western Florida. The U. S. Naval Reserve Unit, Jacksonville Naval Air Station, generously provided the helicopter transportation.

This report will deal primarily with the long term trends of shore movement. It will therefore supplement a companion report being prepared by the U. S. Beach Erosion Board which deals more specifically with trends measured during the past century. However, observations on present shore trends were made during the helicopter flight and these are mentioned in this report. The quantitative estimates of very recent erosion or accretion are based on quick visual appraisal made in flight; more precisely, the present shore was sketched on the topographic maps (mostly scale 1:24,000) that were used for notation during the flights. Later, the distance between the present shore and the old shore was scaled from the maps to give the distance of shore movement in feet. The accuracy of this method undoubtedly varied, depending on the type of shore, the tide, and the availability of landmarks to provide guide and scale for the hasty aerial sketching.

The coastal area discussed includes the entire coastal strip of the study area: The Atlantic coast between the mouth of the Savannah River and the northern part of Little Talbot Island, Florida, and the west Florida coast between the mouth of the Suwannee River and Perdido Bay, west of Pensacola. The coast has been divided into 4 principal stretches for purposes of description. Each principal stretch contains a characteristic shore type.

Attention will be focused on the outer, or ocean-facing, shore. Much of the coast under consideration consists of barrier islands and large complex barrier spits behind which are bays, lagoons, and broad tidal estuaries. While the shore of these more or less protected bodies of water are also subject to erosion and accretion, the processes are generally much slower and therefore less critical from the standpoint of planning than on the open coast. Although some remarks on the movement of protected shores are included in the report, time limitations have necessitated an abridged treatment of this subject.

SOME GENERAL CONSIDERATIONS

Present sea level

In the following discussion we will be concerned with interpreting the various geomorphic signs of shore advance and shore retreat, and reference will be made to net shore advance and net shore retreat. By this is meant the history of shore movement since the existing sea level was established. Work by many geologists on the Gulf Coast and at scattered coastal localities about the world indicates that mean sea level as we know it today, that is, within 2 or 3 feet above or below the present datum, came into existence about 5,000 years ago. Before then, during the last part of the Ice Age, sea level was much lower because of the retention of water in widespread glaciers. Starting about 10,000 years ago, sea level began to rise from a position probably well in excess of 100 feet below the present datum, and about 5,000 years ago came to rest at more or less its present level. Since then minor fluctuations of as much as 3 feet may have occurred. The term net advance or net retreat, as used in this report, will therefore refer to the net shore movement in the course of the last 5,000± years.

Coastal terraces

The Pleistocene epoch, or Ice Age, probably lasted over 500,000 years; during that time the great ice sheets formed and disappeared at least 4 times. Intervals of cold glacial climate alternated with intervals of warm non-glacial climate. Just as glacial climates brought about a lowering of sea level, warm interglacial climates had the opposite effect and brought about a rise in sea level. Interglacial intervals were similar to our present stage except that former sea levels, for the most part, seem to have risen to levels higher than today's datum. These Pleistocene higher sea levels have left their mark on the coastal topography of the study area. Beaches, bars, nearshore deposits and coastal marshes constructed during interglacial higher sea levels, are found today as areas of slightly undulating or low hilly topography in most of the coastal zone and generally extend for 10 or more miles inland. These have been called coastal marine terraces (see MacNeill, 1950, for recent description) although the surfaces are not particularly terrace-like in detail. The terrace formed in the highest of these interglacial seas is farthest inland. The terrace of the lowest of these higher sea levels is closest to the present shore and in places (as described in this report) is being cliffed by present seas. From the air one can clearly see on this lowest terrace traces of old beach ridges (described below) and old tidal marshes criss-crossed by typical marshland drainage channels, now abandoned.

Most students of these higher marine terraces have described them in terms of well-defined sea levels above the present datum (viz. +5 feet, +25 feet, +40 feet, etc.). It seems to the writer, however, that recent detailed topographic mapping and the extensive coverage of aerial photographs that is now available puts some of these generalizations in doubt. For example, in the shore zone of the study area it is not certain whether the deposits of one or two, or even three, sea-level stands are involved or what the precise altitude of these sea levels were. For this reason, no attempt will be made in this report to classify the older marine terrace, or terraces, that occur in the shore zone. All of them, however, are between 10 and 40 feet in altitude.

Shore types and recognition features

The shore is a line of delicate equilibrium; it advances and retreats with variations in the energy of the surf, in the supply of sediment carried to it by coastal currents and in the materials of which it is made. Shores therefore differ because of significant differences in the hydrodynamic, sedimentary and geologic factors that are involved in their formation. Three basically different outer shore types occur in the study area. One type is exceedingly mobile, that is, it erodes and builds out (accretes) rapidly; these shores give clear evidence of having undergone alternate cycles of erosion and accretion over the course of thousands of years. A second shore type gives evidence of slow but continuous accretion since the present sea level was established about 5,000 years ago. A third type has apparently undergone negligible to exceedingly slow, but more or less continuous erosion.

Our ability to deduce the history of beach advance or retreat of a given shore over long periods of time is based largely on the interpretation of certain landforms characteristic of coastal areas. Topography provides the clues to the history of shore movement. As shores advance or erode they leave unmistakable signs on the surface of the ground. For example, where the shore has advanced a considerable distance, the surface of the coastal belt is marked with low parallel beach ridges, representing successive positions of the shore. These beach ridges are formed behind almost all beaches by sand that has drifted from the beach proper by wind and storm-wave action. They may

Figure 1.--North end of Blackbeard Island, Ga., showing complex pattern of beach ridges. At least 9 major accretional-erosional cycles are indicated by the unconformities. Also note river-mouth channel off St. Catherine's Sound and marginal sand bars (background).

therefore take the form of fairly high dunes, 20-40 feet high, or may be as low as 5 feet in height. More commonly they are low and, where covered by grass and brush, are very inconspicuous features although they are readily apparent from the air (Figure 1). Old, low ridges are clearly visible from the air because the shallow troughs between the ridges are less well drained and support a more lush vegetation than the crests.

Just as we can read much about the history of a tree by studying the shape, thickness, and unconformities of the growth rings, so we can read much about the history of a coast in the pattern of its beach ridges. The changes in the shape of the shore are accurately preserved by the old ridges. By studying a festoon of beach ridges on aerial photos one can see, for example, how curved shores transformed into a straight coast as the shore built out or how straight shores became curved. From the changes in form of old beach ridges, one can trace the migration of river mouths and the history of the formation of successive sand spits and hooks.

More important, perhaps, one almost invariably sees that periods of more or less continuous erosion alternated with periods of more or less continuous beach accretion. Each period of erosion is marked by an unconformity in the alignment of the beach ridges (Figure 1). From the geomorphic evidence, it seems that each erosional or depositional interval tends to represent a fairly long period of time - that is, something on the order of 40 to 50 years on the average, although cycles both longer and shorter than this undoubtedly occur. From this we can see that an erroneous picture can be conveyed as to the future mobility of a shore if our knowledge is limited to a comparison of detailed surveys that do not go back far enough to exceed the duration of a single erosional or depositional cycle. Moreover, a comparison using only two surveys, even though each survey may have been made in a different cycle (i.e., one erosional, the other accretional), may still miss the fact that considerable shore movement may have taken place between the two surveys.

A coastal belt exhibiting a series of beach ridges generally means that net shore advance has taken place during this sea-level stand. Although considerable erosion may have also occurred, in many places it is clear that the present shore marks an advance from its initial position. On the other hand where no beach ridges exist behind the present beach, then several conclusions are possible: (1) the shore has suffered a net retreat since the establishment of present sea level, (2) the shore has been stable, (3) that the beach ridges have been obliterated or buried or (4) beach ridges never formed, a situation present on part of the Gulf Coast where the shore is marked by marsh. Burial and obliteration of beach ridges may be due to the formation of a large, active dune field and in a few places to the activities of man.

The presence of a sea cliff directly behind the beach is a clear indication of net shore retreat, but only if the cliff is cut into old sediment. That is, current beach erosion may cliff a high dune or a beach ridge that formed during present sea level. This type of cliff does not, of course, signify a net retreat of the shore. On the other hand, a cliff cut in sediments that were deposited prior to the establishment of present sea level, such as the older coastal terraces, leads to the conclusion that present shore represents net retreat and, as a corollary, that there is scant possibility of beach accretion in the future, at least without the help of man.

A rare type of shore occurs for about 100 miles in western Florida, southwest of Apalachee Bay. This shore is described and explained in greater detail below, but in this section it will suffice to call attention to its similarity to the unusual deltaic coast of the Mississippi bird-foot delta. The absence of beaches or wave-sculptured features and the presence of mud and clay at the water's edge attest to the constructional nature of this shore, just as it does at the mouths of the Mississippi. It would seem that this shore has been protected from the erosive effect of large waves during the entire course of its development.

Causes of beach erosion

Breaking waves and the currents they set up in the shore zone are responsible for most beach erosion. The turbulent energy of the surf as it washes up the face of the beach and then flows back down slope stirs up the sand that makes up the face of the beach and carries it away in suspension. Large storm waves are therefore generally more destructive to beaches than normal surf. Offshore obstructions, such as large sand bars, islands, or offshore breakwaters, reduce the wave size, and therefore wave energy, at the shore lying to their lee. This directly affects beach erosion and, indeed, is a factor of some importance in the area under study, as described in the detailed section of this report.

The direction with which waves strike the beach is also a factor of importance in beach erosion. Commonly, waves reach shore at an oblique angle, although this may deviate from normal by only a few degrees. The direction of approach is the expression of the wind direction that produced the waves far offshore, in the open ocean. The obliquity of wave approach produces a wave-induced current along the shore, the longshore current (see Wiegel, 1953, for standard coastal terminology). On some shores there is a dominance of wave obliquity from one quadrant or the other and therefore a dominant direction to the longshore current. Sand eroded from the beach by the waves is transported by this current, a movement called littoral drift. It is important to know whether or not a dominant direction of littoral drift occurs on any given shore if protective works are contemplated.

For example, a breakwater or groin constructed on such a shore will very probably bring about erosion of the shore on its down-current side and sand deposition on its upcurrent side.

Causes of beach accretion

Whether sand is eroded from a beach or whether it is deposited on the beach by the surf depends on a delicate response to changes in such inter-related factors as: the energy characteristics of the surf (multiplicity of wave trains, obliquity of wave approach, wave period, and wave height), availability of sand from offshore, and the sorting, grain size and shape of sand on the beach and in transport. A long stretch of shore that shows net accretion over a long period of time, such as much of the coast of Georgia, must derive part of the sand from sediment that is being carried to the sea by rivers. This river-borne sand is shifted about on the sea floor, sometimes many miles from the river outlet, and may pile up as large bars and shoals. Much of this sand is more or less continually shifted about, and some of it is ultimately carried in to shore where it may be stranded on the beach.

The inter-relationship between erosion and the deposition of beach sand is therefore close and the line that separates them is thin. Most beaches fluctuate almost from one day to the next from the erosional to the depositional condition. However, many beaches are characterized by several long-period cycles of erosion and deposition: a seasonal cycle during which the beach face may erode back in winter as much as 50 feet from its summer position, only to regain this sand in the following summer; a longer period cycle that may vary from 10 years to perhaps as long as several hundred years during which there will be a net annual gain or net annual loss of beach material. The most important factor in the long term cycles is probably offshore hydrography and the effects of large storms. The presence of a large offshore sand bar both shelters a stretch of beach and provides an offshore source of sand. While the offshore bar or shoal exists, net annual beach accretion occurs. The eventual removal of the bar by waves and currents - a process that may take place at any time because of an unusual storm, or may require several hundred years of "normal" storm, wave and current work - then exposes the beach to storm waves, removes the offshore supply of sand, and thereby inaugurates a cycle of beach erosion. On this type of shore, erosion will continue until another bar forms somewhere offshore. Sand is therefore continually shifted about - both on the beach face and offshore. This condition is nowhere so well developed as off the Georgia coast and off the parts of the Florida coast under study.

ATLANTIC COAST

(mouth of Savannah River, Ga., to mouth of Nassau River, Fla., see Plate 1)

General discussion

This entire stretch of coast is homogeneous in structure and origin. It consists of a line of low sandy islands ("sea islands") separated from the mainland by a belt of tidal marshes. The islands are separated from each other by the mouths of rivers emptying into the ocean. Except for the two northernmost islands, Tybee Island and Wassaw Island, all the sea islands are made up of a center section, or core, that consists of an older Pleistocene marine terrace rimmed on the north, east and south sides by beach ridges dating from the present sea-level stand. In many sea islands the rim of beach ridges is separated from the older core by a stretch of tidal marsh. Tidal marsh also marks the troughs between many beach ridges. The separation between sea island and tidal marsh is therefore somewhat poorly defined in the beach ridge sector of many islands. Tybee and Wassaw Islands are all marsh except for a belt of beach ridges along their eastern margins.

The beach ridges of the sea islands reveal a complex history of accretion and erosion (Figure 1), and it is obvious that these islands have been continually changing their shapes. It also is apparent that the river mouths (or "sounds") which separate them have migrated, mostly southward, in the course of the last several thousand years. Most sea islands therefore show the greatest growth on the south side and many are being actively eroded at the present time on the north by southward migrating river channels.

Figure 2.--Looking west over St. Catherine's Island showing coastal belt of tidal marsh in background. Note complex of rivers and drainage channels. St. Catherine's Island is made up of 3 components here, from east to west: (1) modern beach, (2) tidal marsh strip, (3) older marine terrace. Notice how edge of older marine terrace has been scalloped by meandering streams shifting about on the strip of tidal marsh.

The beaches of the sea islands are all of medium fine quartz sand, nearly white in color. They have a gentle slope and when seen were from 100-300 feet wide at about mean high tide. Directly behind the beaches a beach ridge can generally be found rising to heights of 5 to 10 feet above the beach berm; in a few places they are higher and active sand dunes and are spreading westward. Narrow belts of tidal marsh occur here and there either immediately in back of the beach or between older beach ridges. Except for the beaches and the most recently formed beach ridges, the sea islands are covered with vegetation.

The belt of tidal marsh that separates the sea islands from the mainland varies from 3 to 10 miles in width. The marsh seems to consist mostly of gray clay. The surface, which is covered with marsh grasses, lies at an altitude between mean tide and mean high tide; almost all the marsh is flooded at most high tides. The clay is probably derived from the rivers and there are indications that it accumulates rather rapidly. The surface of the marsh is carved up by an intricate network of meandering rivers and streams (Figure 2). These streams carry water into the marsh during flood tide and drain it during ebb tide. During parts of the tidal cycle, stream flow is rapid and in consequence streambeds are scoured to depths of 30 to 40 feet below sea level. The streams shift about rapidly on the marsh and many of them are apparently short lived. Thus at a certain stage of their development some of them seem to close up (by the slumping together of their banks) and disappear while at the same time other streams come into being. The marsh is therefore a very restless surface.

Offshore from the sea islands the bottom is shoal, and along most of the coast a tall man can walk as far as 2 miles from shore at low tide. Many large to small sand bars are exposed between mean and low tides, as far out as 6 miles from shore (Figure 1 and 3). Into this broad sandy offshore shoal, the river mouths that separate the sea islands have eroded deep channels (Figure 1). These channels are deepest at the mouth itself and become increasingly shoal as they pass out to sea. The largest sand bars are marginal to these channels; some are aligned with the channel edge and others fan out from the seaward end of the channel in the manner of large subaqueous sand deltas (Figures 1, 3 and 4).

The offshore movement of sediment - first from the rivers which introduce the sediment, then along the bottom from one sand bar to another, finally onto the beach and then at times off the beach - comprises an interesting onshore-offshore circulation which is characteristic of the sea-island coast. This circulation is controlled by the strong and constant tidal flow in the river mouths. The mean tidal range in the river mouths is large, averaging about 7.2 feet. This creates a strong tidal current into the rivers at flood tide and out at ebb tide, with harmonic reversals of flow occurring 4 times a day. The broad marshes behind the sea island fill up with water at flood tide only to empty at ebb tide via the constricted channelways between the islands. This is, in effect, the old-fashioned reciprocal pump mechanism, with two chambers separated by a narrow orifice, and with

Figure 3.--Sand bars at entrance of Nassau Sound.
South end of Amelia Island in distance.

the pressure in the two chambers always unequal so that an oscillation of flow between the chambers is maintained. A peak tidal current of about 4-5 feet/sec is reported at the mouth of the Savannah River (Waterways Experiment Station Tech. Memo. 2-268). The flow at mid-channel in St. Simon Sound, seen by the writer from the air, appeared to exceed this velocity. It is possible that flows as high as 10 feet/sec occur in some estuaries.

The distribution of the sand, silt, and clay brought down by the rivers is therefore affected by the currents set up in this perpetual squeezing-in and squeezing-out of the water that fills the tidal marshes. Clay and fine silt is carried by the river in suspension and at ebb tide, when river water passes directly out to sea, great aprons of muddy water form off each river mouth. With flood tide much of this muddy water reenters the river mouths to flow up the many drainage channels of the marshes and spread over the mud flats. Moreover at flood tide river discharge is confined by the inward rush of ocean water to the marshes and muddy river water that has never passed out to sea spreads laterally over the marshlands. Here some of the silt and clay fall to the bottom and get deposited in the calm grassy backwaters, slowly building up the marsh flat until the maximum level of high tide is reached. River sand, on the other hand, gets carried out to sea, not in suspension like the silt and clay but as a sort of bed load, in the deeper parts of the river channel. The sand drops to the bottom as soon as the velocity of the ebb tidal current is sufficiently checked off shore. This creates the lateral bars that are marginal to the channel and also the fan-shaped sand delta several miles offshore (Figures 1, 4 and 5).

Sand of the marginal bars gets shifted about by waves and currents. The pattern this movement takes is a large double-celled circulation fronting each sea island (Figure 4). The circulation for each island is more or less isolated by the river-mouth channels and their sluice-like tidal currents. River sand enters the circulation via the marginal bars. From here it gets carried shoreward by wave-induced currents. When it reaches the sea-island shore it moves laterally as littoral drift (this is, assuming it is not deposited on the beach) until it hits the sluice-like tidal current at the end of the island. If the current is flooding, the sand will be carried into the sound and perhaps partly into the marshes and main river channel, but only to get carried out again with the ensuing ebb tide and to come to temporary rest on a marginal bar. If, on the other hand, the tide is ebbing when the sand that is being carried laterally by littoral drift, reaches the end of the island, it will be carried directly out to sea along the margins of the channel and also becomes redeposited in a marginal bar. In both cases the sand is circulated one full round.

On the outer shore of many sea islands a cuspate sand spit juts out about midway. This spit indicates that the circulation just described is broken into two separate units, or cells: the northern one circulating clockwise with a north flowing littoral drift, the southern one flowing counterclockwise with southerly littoral drift. The cuspate spit marks the nodal point of these circulations (Figure 4). The divergent littoral drift is further indicated by the direction with which sand spits develop along the coast.

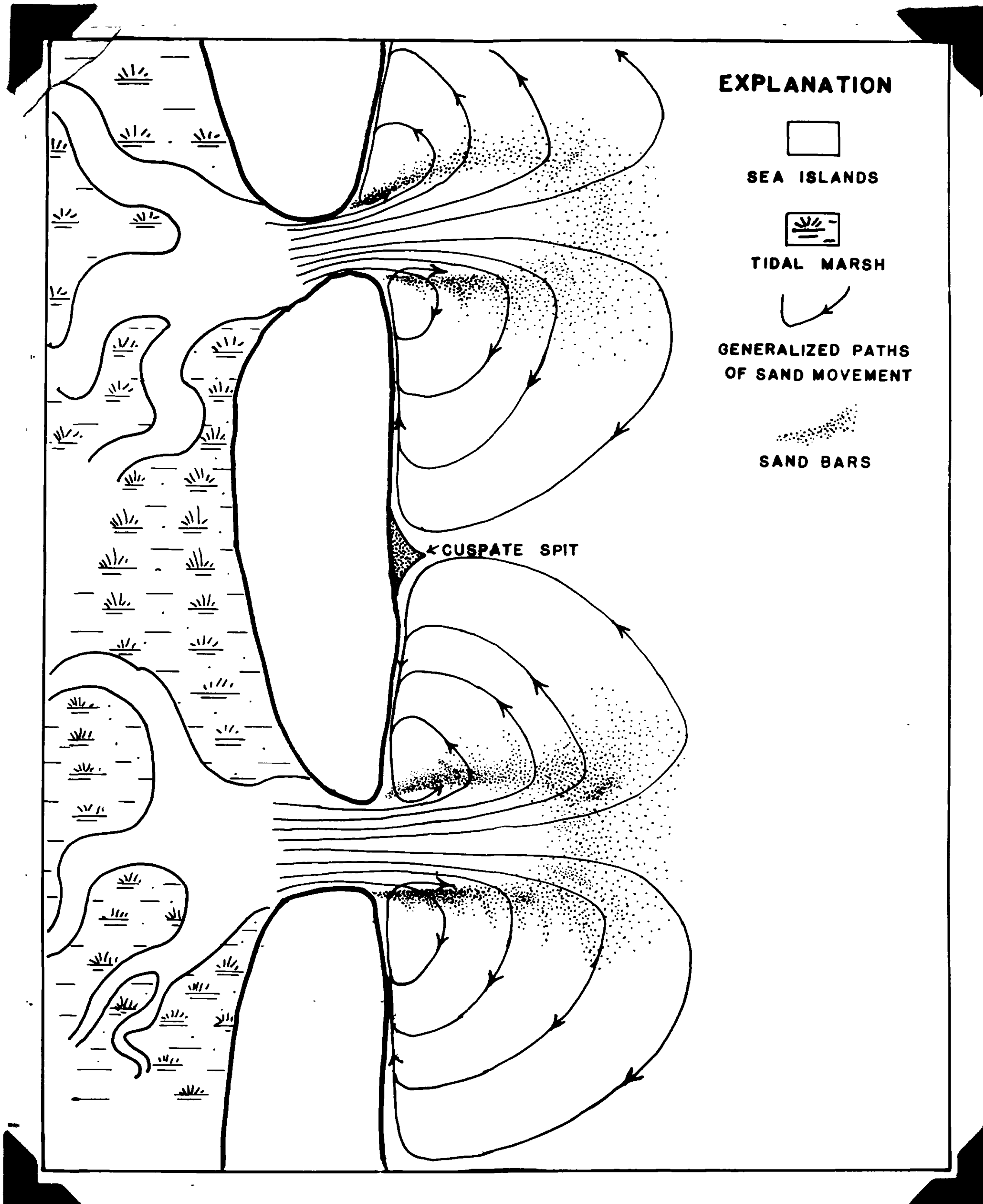

Figure 4.--Idealized diagram of offshore circulation, sea-island coast of Georiga.

There is, however, indication along this coast that a net southerly migration of sand occurs. This means that some sand escapes the closed circulation pattern just described. For the most part, this probably takes place well offshore, beyond the influence of the river-mouth tidal currents. Also during large storms some sand may get carried from the broad shoals in front of the islands into the river-mouth channels. It can then get carried by succeeding tidal oscillations onto the south side of the channel and finally join the frontal circulation of the next sea island to the south. In this manner, a slow southerly shift of sand takes place along the entire sea island shore.

Because there is only a slow removal of sand from a circulation cell, and because rivers continue to carry sand to sea (the actual amount of sand transported by the rivers at any one time may be small), it follows that there is a continual increase in sand within the circulation cells. This accounts for the fact that this stretch of coast, although extremely mobile in detail, is mainly one of net accretion (Plate 1).

Tybee Island

Tybee Island is tidal marsh fronted by a sand beach that gives evidence of great mobility. Here and there projecting through the marsh are short sections of older beach ridges formed during the present sea-level stand (Plate 1). Northern Tybee Island, on which Savannah Beach is built, consists of a bundle of eight beach ridges. The erosion-control structures at Savannah Beach, comprising a series of groins, when seen from the air gave the appearance of having successfully stabilized the beach. Some beach accretion has occurred since they were built and at the time observed by the writer no dominant direction of littoral drift was evident. This is true of the groins on the north and northwest shores as well as those on the open east shore. In addition, considerable accretion has occurred at the south end of Savannah Beach.

The southern part of Tybee Island is exceptionally mobile. The 1942 shore, as shown on the Army Map Service map, is unrecognizable today. Erosion has removed over a thousand feet of shore at the north end and at the same time added this much shore - or even more - on the south and central sections of the coast. The sand is shifted from the shore to bars that are situated slightly offshore. These bars build up to mean tide, or higher, and become almost new beach only, it would appear, to be planed off again. The sand shifts back and forth between one bar and another, successively raising and lowering the bars to beach elevation. Thus new beaches are apparently temporary and the figure of shore advance - for example, as given above - is somewhat illusory.

This mobility between beach and bar, in which a relatively small amount of sand is shifted back and forth, has apparently characterized the entire history of southern Tybee Island. The small beach ridges separated by wide tracks of marsh show that at no time was enough sand available to create a "sea island" of a size comparable to others in the region. The effect of Tybee River and the three Tybee Creeks seems to be responsible for this. All four streams drain only swamps and therefore carry little sand (only the larger rivers draining the sandy mainland transport abundant sand). They are, however, characterized by strong tidal currents at their mouths. As the position and shape of the outlets of these rivers change, the directions taken by their sluice-like currents change, eroding today what was a sand bar or beach yesterday. This process can be seen clearly from the air. For example, the erosion of what was once the southern tip of Tybee Island by Tybee River can be deduced from the truncation of a series of beach ridges at the southwest end of the island. The channel of Tybee River today is almost a mile distant and the island tip is over 2 miles distant from this former outlet. In effect Tybee Island is not unlike a large sand pile upon which three strong hoses play back and forth.

Wassaw Island

Wassaw Island is a festoon of beach ridges about 1 mile wide and 5 miles long fronting a tidal marsh. Today slow erosion is affecting the northern quarter of the outer shore of the island but considerable accretion is taking place on the southern 3/4 of the outer shore and also on the south tip. The tidal marsh lies west of the main sandy beach-ridge section. Here and there single beach ridges, or small groups of beach ridges rise above it. These isolated former beaches and the compact mass of beach ridges that fronts Wassaw Island were all formed during the present stand of sea level. It is clear, then, that Wassaw Island represents a net gain of shore and that a change in regimen from scant to relatively strong beach nourishment has occurred sometime during present sea level. The unconformities in beach ridges on Wassaw Island show 4 and possibly 5 cycles of beach construction that alternated with cycles of erosion. A strong shift in deposition towards the south has marked the last 2 cycles. This is probably caused by the southerly shift of the channel of Wassaw Sound, cutting away a large part of the north end of Wassaw Island. A similar recent shift of Ossabaw Sound southward is reflected in the southerly growth of the island.

An interesting growth phenomena on Wassaw Island is a single beach ridge, or foredune, about 35 feet high that extends down the center of the island. Although it is conformable with earlier and late beach ridges its unusual height suggests that there was a considerable interval of shore stability during which no significant erosion or accretion took place and sand was slowly blown from the beach onto the foredune.

Ossabaw Island

Ossabaw Island consists of a series of beach ridges separated in places by strips of tidal marsh. A northeast trending core of older terrace is located about 3 miles west of the outer shore; it is lightly marked by old beach ridges. From the arrangement of beach ridges of the present sea-level stand, it is evident that Ossabaw Island has grown eastward and southward mostly by the successive formation of new spits and barrier beaches, each new one more or less parallel to the old shore and separated from it by narrow bays one quarter to a mile in width. Moreover, the island had intermittent growth both to the north and the south during the course of at least 3 depositional cycles. The shifting of the large river mouths at both ends of the island have interrupted this growth 3 times. Today, however, accretion is taking place at both ends of the island. A marked cycle of erosion along the northern half of the island coast ended in the early part of this century. Since then marked accretion has taken place starting at about the midpoint of the island and spreading to the north and south. In the last 12 years or so the northeast and southeast tips have grown eastward over 1000 feet. A cuspate spit has formed at the mid-point of the island and advanced the shore almost a mile since the first decade of this century.

St. Catherine's Island

This is a complex island, like Ossabaw Island to the north, with an inner core of older terrace and an outer rim of beach and beach ridges dating from present sea level. The morphology and therefore history of this island is also somewhat similar to that of Ossabaw Island. The island exhibits a fairly recent history (last 2,000 years?) of marked erosion of its outer shore, and marked accretion of its southern end. The erosion of the outer shore has been greatest at the north, diminishing progressively to the south. A very severe erosional cycle appears to be just ending along the entire outer shore. It is estimated that the shore has retreated a maximum of about 2 miles at the north end during this and perhaps earlier erosional cycles. This conclusion is based on the fact that all beach ridges are obliquely truncated by the northern half of the present outer shore. The amount of recession is indicated by projecting the beach trends of the truncated ridges in the southern half of the island. The southern tip of the island has eroded over a half mile during the erosional cycle just past. It appears to be relatively stable at the present time.

A cycle of beach accretion along parts of the outer, or ocean, shore has been under way for the past 40 or so years. The shore has advanced nearly 1000 feet in this interval at the northern end and also along a stretch about 4 miles long in the middle part of the ocean shore. At McQueens Inlet the construction of a large sand hook at the south side of the inlet has produced over 1500 feet of shore advance in the last 20 years (Figure 5). A similar construction occurs at the mouth of a small stream about a mile to the north.

Figure 5.--McQueens Inlet, St. Catherine's Island, Ga., showing marginal sand bars and new beach recently formed on south (left) side of mouth of inlet. Marginal sand bars form at mouths of streams and small rivers for same reasons that they form at the mouths of major rivers.

Beach ridges show that during the course of present sea level the southern tip of the island has grown south well over 3 miles. However the pronounced erosion cycle, that seems to have recently come to a close along the entire outer shore, removed over half a mile of the tip during the past century. The southern tip of the island appears to be stable at the moment. The northern tip, at some interval during present sea level, was deeply eroded and then built northward again during 4 successive depositional cycles. Since then over 1000 feet of shore have been removed. The present shore configuration of the north end of the island appears relatively stable. The stability of this point, like all island points bordering river mouths, depends on the condition of stability of the adjacent river channel. The factors controlling the movement of these river channels are not well enough understood at present to predict future changes.

It is of interest to note the relationship between the large marginal sand bar along the south edge of the river-mouth channel off St. Catherine's Sound and the pronounced beach accretion to its lee. This sand bar extends in a gentle curved path due east of the northern tip of the island. In 1951 the tip of the bar was about 1 1/2 miles east of the shore. Its length has now been doubled. As this bar builds out, beach accretion will probably extend further south along the shore.

Blackbeard and Sapelo Islands

These two islands are morphologically one. Together they form a single unit made up of a core of older terrace and an outer fringe of beach ridges and marsh like that of St. Catherine's and Ossabaw Islands. Blackbeard Island, the northern island, consists entirely of beach ridges of present sea level (Figure 1); Sapelo Island consists of the core of older terraces with a thin rim of recent beach, beach ridges, and foredunes along the outer shore and south end. The two islands are separated by tidal marsh, down the middle of which flows Buttermilk Channel, which interconnects Sapelo Sound with the ocean.

The depositional and erosional history of these islands follows in its larger outlines that of St. Catherine's and Ossabaw Islands. In the course of the last 5,000± years the following events can be read from the geomorphology of the islands: (1) The mouth of Sapelo Sound shifted slowly southward almost 3 miles, cutting into the north end of Sapelo-Blackbeard Island. At the same time the mouth of Doboy Sound eroded a large segment off the south end of Sapelo Island. It may have done this by shifting its channel northward. More likely, however, Doboy Sound is a relatively recent opening to the marsh drainage system lying to the west. It probably represents the enlargement of what was once only a narrow breach at the south edge of the old marine terrace to which the name Sapelo Island has been given. Much the same sort of thing would happen to the south end of Blackbeard Island if, for example, Buttermilk Channel should capture a larger share of the discharge of Altamaha River.

(2) In the meantime beach construction and erosion along the coast has gone through at least 9 cycles of accretion and erosion (one cycle - accretion + erosion) and resulted in 2-1/3 miles of net advance of shore at the present north end of the island. Today the greatest width of beach ridges is at the north end of Blackbeard Island (Figure 1). This may mean that the greatest net accretion was at the northern end or that the greatest net erosion was along the southern half of the island (the contrary of that which has happened to St. Catherine's Island).

At the present time the shore processes appear to be (a) stable at the north tip; (b) erosion of Northeast Point extending to the south of the point for about 3/4 mile; (c) rapid accretion along the southern 1/3 of the shore of Blackbeard Island; (d) rapid accretion at the south side of Cabretta Inlet; (e) marked mobility for about 2 miles south of Cabretta Inlet with alternate points of erosion and rapid deposition, including the formation of a large south-growing spit at the north edge of the small stream mouth about 2 miles south of Cabretta Inlet; (f) rapid beach accretion at the tip and outershore of Sapelo Island, extending north for about 2-3/4 miles. In the last 10 years at the southeast point, beach accretion is estimated to amount to about 600 feet.

In general it is quite clear that Blackbeard-Sapelo Island is currently at the start of an important period of beach accretion.

Wolf Island

Except for a narrow dune fringe and sand beach on the outer shore, Wolf Island is made up entirely of tidal marsh. No older beach ridges or old terrace remnant rise from the interior of the island. The sandy outer shore is eroding rapidly. It is estimated that 400 feet of erosion has taken place along most of the shore in the last 100 years. In 1951, Beacon Creek emptied at the northeast corner of the island. When seen in late March, 1961, the creek let out about half a mile to the south because erosion of the shore had breached the creek channel at this point.

Tidal marshes do not form unless sheltered behind a fairly stable barrier. It would seem, therefore, that a former prograding shore produced a group of beach ridges somewhere to the east of the present coast of Wolf Island and that a cycle of erosion has wiped them away. There is no basis for estimating how far the present erosional cycle has pushed back the shore of Wolf Island or when it will stop.

Egg Island

This is a small patch of tidal marsh containing a few fragments of beach ridge that is fringed on the ocean side by a sandy beach and foredune. It is separated from Little St. Simons Island on the south by a secondary channel of the mouth of the Altamaha River. The small arc of old beach ridge in the interior of Egg Island was probably at one time continuous with the beach ridges on Little St. Simons. The river channel separating the two islands today is therefore a relatively recent development.

The southeast shore of Egg Island is actively receding. It is most probable that the island is undergoing the same erosion cycle as Wolf Island - that is, that its shore is retreating from a former well bettressed position to the east.

Little St. Simons Island and St. Simons Island

These two islands are morphologically very similar to the couplet of Blackbeard and Sapelo Islands. The core of old marine terrace forms the broad inner and larger island, St. Simons Island. Separated from it on the northeast by a 2-mile wide stretch of coastal marsh is Little St. Simons Island, consisting entirely of beach ridges from present sea level with some intervening marsh. A good sized river, Hampton River, a counterpart of Buttermilk Channel on Blackbeard-Sapelo Island, flows down the center of the intervening marsh and lets out on the ocean by way of a breach through the beach ridges at the southern end of Little St. Simons Island.

Beach ridges are less numerous than on Blackbeard Island and for the most part are separated from each other by strips of marsh, indicating that earlier shore accretion took the form of spits and hooks in the same manner as we see happening today.

Relatively little erosion appears to have taken place at the north end of this island. Some marsh and old beach ridge has been lost to the southern branches of Altamaha Sound. From the geomorphology, the eastern shore and the south tip of the island evidently have undergone relatively little erosion.

At the present time the entire shore of the island appears to be undergoing a vigorous period of accretion. Prior to this, the northern part of the outer shore evidently was considerably eroded, for patches of marsh grass can be seen at mean tide at several places hundreds of yards off the north shore. For example, what was formerly the marshy south bank of the river that bounds Little St. Simons Island on the north, now extends seaward as an isolated line of marsh soil, bearing some grass, for half a mile from the point that one would pick as the present river mouth. It is apparent that within the last century or two, a half mile or more of erosion has taken place along the northern part of the coast.

Shore construction today is spectacular and consists largely of the building out of large sand spits and hooks. These start out as sand bars and several have formed that are now approaching the height of mean tide while at the same time broader sand shoals extend several miles offshore. It is evident from these shoals and the shapes of the sand hooks that are in the process of formation that circulation on the very shallow shelf in front of the island is broken up into a number of small eddy-like cells.

At the present time deposition is taking place at the northeast point and a sand hook that first appeared in the 1940's is now being extended to the east. Two miles to the south a new sand hook, measuring a mile from east to west, has been built in the past 10 years. It joins the base of a similarly shaped hook that had been built in the preceeding decade. Each hook is about a mile measured east to west, and the east end of the outermost hook is now about 2 miles from the shore of about 25-30 years ago. This curious double hook is a rare shore feature. Unfortunately it is an unstable type of shore and will probably be eroded or much altered in the near future.

Rapid beach accretion is occurring along the outer shore. At the mouth of Hampton River a broad sand bar juts a mile and a half to the east from the south bank of the river, while a smaller bar flares off to the northeast from the north bank of the river outlet.

On Sea Island Beach, recent beach accretion has added over 50 feet of front lawn to the many houses that face the beach.

Some erosion is taking place at the south end of the island. However, the revetments and small walls along the beach front here seem to have been effective in reducing erosion.

Jekyll Island

Jekyll Island consists of a long central core of old marine terrace fronted on the east by a thin rim of modern beach ridges and on the north and south by broader festoons of beach ridges of the present sea-level stand. The truncation of the beach ridges on the north end by the present shore show that there has been considerable erosion here. This was probably brought about by the southerly shift of the channel of the mouth of the Brunswick River. On the other hand, the south end of the island has grown almost 2 miles by accumulation of beach ridges and the formation of intervening marshes. The absence of a prominent development of beach ridges along the central section of the coast indicates that considerable erosion has taken place here and that there probably has been a net loss of shore since the outset of present sea level.

At the present time slow accretion is taking place on the northern stretch of coast and somewhat faster accretion on the southern end of the coast. Along the central section of the shore a small cliff that is eroded into the foredune at the back of the beach indicates that some erosion is taking place here. However, the rate is undoubtedly very slow. This is deduced from the fact that there is a small field of low dunes behind the beach, a condition which generally takes places only when a beach is relatively immobile.

Cumberland Island

This island resembles Jekyll Island in form and construction although it is over twice as long. It consists of a long central section of older terrace, thinly rimmed on the east by modern beach ridges and foredunes and at the north and south ends by a festoon of somewhat older beach ridges and dunes but still of this sea-level stand. As with Jekyll Island, Cumberland Island exhibits growth to the north and south but a decided net loss of shore along most of the coast. Lateral shifting of the channel of Cumberland River has severely eroded the north and northwest shore. This erosion is continuing. At present the northeast point and the northern third of the outer shore is undergoing rapid accretion. Within the last 4 years (the base map used during the helicopter flight was made from 1957 aerial photos) the beach flanking the mouth of Christmas Creek has undergone rapid accretion. Rapid accretion at the present time is also indicated south of the outlet of this creek for a stretch of about 2 miles. Accretion is taking place along the southern half of the coast with the greatest rate of shore advance at the south tip of the island. The long breakwater protecting the north side of St. Mary's Entrance has accumulated about equal quantities of sand on both sides. The sand on the north - or outer - side of the breakwater must be the result of a dominant southerly littoral drift. The sand on the channel side of the breakwater is probably mostly river sand and shows by its presence that much sand is being carried down to sea by the present rivers.

Dunes reach a height of 55 feet on this island. These form part of one large linear foredune which probably marks a former shore that had been stable for a considerable length of time. In the central stretch of coast this high foredune rises from tree-covered lowlands. Easterly winds have been drifiting part of it to the west burying forest and ponds lying along its western edge (Figure 6).

Off the north end of Cumberland Island a great array of marginal sand bars occur on the south side of the channel of St. Andrew Sound. These extend almost 9 miles out from shore and are broadly exposed at low tide. These bars are probably mainly responsible for the beach accretion that is now taking place along the northern part of the outer shore of the island.

Figure 6.--Cumberland Island, Ga., looking north. High foredune of a former shoreline spreading slowly westward and burying forest at its foot.

Amelia Island

Morphologically this island is very similar to Cumberland Island. There is a long center core of older terrace thinly flanked on the east by a narrow belt of modern beach ridges and fairly high foredunes and on the north and south by festoons of somewhat older beach ridges and dunes. If we consider the old terrace core of the island as the original Amelia Island at the time when present sea level was established, then we can see that the island has grown to the north and the south, as has Cumberland Island, but has probably undergone a small net loss along the center section.

The high dunes along the coast and to the north of Fernandina suggest that the shore was stable for an appreciable period of time. However, during the last century there has been significant accretion at the north end of the island. Much of this is caused by the breakwater, forming the south side of St. Mary's Entrance. Accretion at the south side of the breakwater amounts to 0.8 miles measured from the mid-19th century shore (the mid-19th century shore was at the foot of the dunes). Although some sand is accumulating inside the channel (north side of the breakwater), the rate of accretion is nearly double on the south side. This is probably due more to the sheltering effect of the breakwater than to a dominantly northern littoral drift along this stretch of coast. Indeed, south of the wave shadow formed by the breakwater there is no indication of a dominant northerly drift.

Some erosion of the northwest shore of Amelia Island in the vicinity of Ft. Clinch, has occurred in the last few decades. This probably was brought about by the shifting of the channel of Amelia River towards its right bank and is the same type of right bank migration as that noted for the Cumberland River, on the northwest corner of Cumberland Island.

Most of the shore of Amelia Island exhibits only slight mobility. Slow erosion was apparent in a few stretches but it was not clear whether this was due to a temporary or seasonal cycle of erosion and accretion. On the southern part of the coast, the form of the beach ridges there and the presence of a new beach ridge that is as yet free of grass indicates that slow accretion is taking place.

A group of crescent-shaped sand bars, which rise to between mean and low tides, occur in the mouth of Nassau Sound, off the south end of the island (Figure 3). One of these is shown as Bird Island on the 1957 edition of the U. S. Coast and Geodetic Survey Chart 577. Bird Island was no longer apparent in March, 1961, but several smaller bars to the north were almost chartable as islands. If river and tidal currents were to redistribute this midchannel sand to the north or to the south - a distinct possibility as the river channel shifts - appreciable accretion on the adjoining shores would result.

Little Talbot Island

The north end of Little Talbot Island consists of beach ridges and high dunes. It appears to have undergone a net northerly and easterly growth during the present sea-level stand. A broad fringe of sand shoals that are exposed at low tide indicates that beach accretion is probably occurring at the present time.

GULF COAST; NORTHWEST FLORIDA - (See Plate 2)

Cedar Keys (Levy Co.) - Ochlockonee Point (Wakulla Co.)

This stretch of open coast is characterized by features that are unique in the United States. The coast is a tidal marsh and the shore proper is for the most part the muddy growing edge of the marsh (Figure 7). Sandy beaches are uncommon and, where present, are thin and poorly developed. Both in the form of the shore and the composition of the beach, there is a marked absence of signs of wave erosion. It seems safe to assume, therefore, that this coast is virtually free of all but the smallest waves. The shape of the coast gives indication that the marshy shore is very slowly building out as the tidal marsh spreads.

The only extensive section of muddy open coast that is at all comparable to this is the birdfoot delta at the mouth of the Mississippi. However, the Mississippi delta shore is the result of rapid sedimentation. This Florida coastal stretch, on the other hand, is not obviously deltaic in origin, although the marsh does represent the slow accumulation of clay, silt and fine sand from the several rivers that cross it. The absence of waves at the shore can only be explained by the broad, very shallow bank offshore. Unlike the very shallow mud bank of the Mississippi delta, which protects the shore proper from waves, this Florida bank is apparently caused by a resistant limestone surface that lies at, or close to, the bottom. The limestone platform and other features of the coast will be described in more detail below.

Figure 7.--Waveless marsh coast of West Florida. The marsh appears to be slowly spreading seaward. Note absence of beaches and evidence of wave erosion.

A belt of somewhat intermittent dense cypress swamp, 5-10 miles wide, extends along the entire coast. Altitudes are generally below 25 ft. Fringing the cypress swamp is the belt of tidal marsh that borders the shore. It is one to two miles wide and begins abruptly at the edge of the swamp (Figure 8).

At the seaward edge the marsh level is about mean high tide; the level seems to be slightly higher at the inner edge. The outer, or lower, zone of the marsh is about a mile wide and its inner edge more or less follows the extremely indented shore. This zone has lush tidal-marsh grasses and is broken by many meandering drainage streams. The composition of the marsh soil, as seen during the helicopter reconnaissance, is a dark slightly brownish gray sandy silty clay. Flooding of the inner, or higher, zone is probably rare, and accounts for the absence, in this zone, of the secondary small meandering marsh streams, the absence of dense stands of marsh grasses of the intertidal range (mainly Spartina ~~altinaflora~~ alterniflora) and the presence of sparse stands of salt-loving plants (mainly Salicornia) and barren patches of highly saline soil.

At a few places small sandy tree-covered mounds, commonly sinuous in shape, rise 10-15 feet above the marsh. These mounds and ridges may be sand bars that were built when sea level stood at about the +20 foot level during Pleistocene time. They are shown on Plate 2 as old marine terrace.

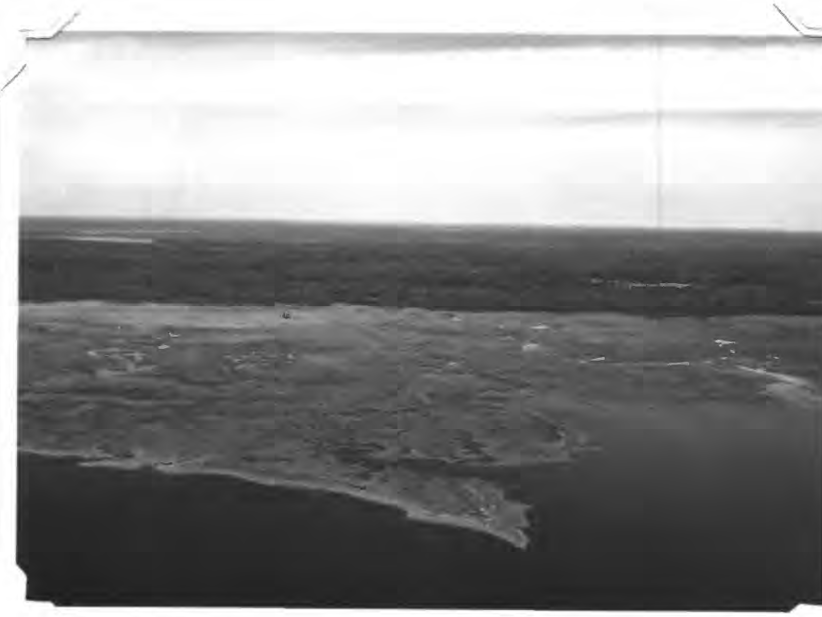

Figure 8.--Marsh coast of West Florida. The low-lying cypress swamp (background) ends abruptly about a mile from coast. Coastal marsh belt is slightly higher inland. The light-colored saline soils and more scanty grass cover of the higher belt can be distinguished (middle distance) from the active tidal marsh (foreground).

The marsh shore is extremely indented and irregular (Figure 7). It is estimated that over 70% of the shore consists of drab colored mud. The "beach" exposed at low tide (mean tidal range here is 2.4 feet) is generally barren mud. The edge of the marsh grass is about at mean high tide. On some stretches of this coast a thin deposit of fine white sand overlying mud is found rimming the shore at about mean to high tide level (Figure 9). Sand, both on the beach and just offshore is prominently visible along the northwesternmost stretch of this coast and where the old marine terrace deposits come close to shore (as at Big Pine and Shired Island, Horseshoe Beach, and for several miles on both sides of Keaton Beach).

Offshore the bottom is very shoal; the 2-fathom contour is generally 5 miles or more from shore. For most of the coast bottom is only 2 to 3 feet below mean low tide 2 miles from shore. From the nautical charts and from the visual impression of bottom sediment as seen from a helicopter, the bottom is mostly clayey or silty mud or a mixture of fine sand, silt, and clay. The charts show that sand becomes dominant further out.

Many bars and reefs occur, particularly along the southern part of this coast, within a mile or two of shore. Many of the reefs are narrow, linear, sinuous to crescent shape structures. In places, particularly in the vicinity of Cedar Keys, and in Oyster Bay, they interconnect into a curious network and rise to levels as high as mean tide (Figure 9). It is thought that these are mainly oyster reefs, formed by the peculiar colonizing properties of oysters. Some of the broader crescent-shaped

Figure 9.--Oyster(?) reefs of marsh coast, Cedar Keys, Florida. Note thin sand accumulation on beach near high tide level.

reefs may consist mostly of sand, although this could not be ascertained during the field reconnaissance. West of the mouth of St. Marks River large sand bars, that rise to above mean low tide, occur 2-3 miles from shore.

A very porous but apparently hard limestone crops out just offshore at a few places on the coast. These outcrops are most abundant off the northern part of the coastal stretch and in the vicinity of Waccasassa Bay, just south of the study area. Outcrops were noted at the following places in the study area: outer edge of Pepperfish Keys, just offshore Dark Island (south of Keaton Beach), Rock Islands, Cobb Rocks, and Grey Mare Rock. In addition many subrounded depressions, probably sinkholes developed in the limestone, were seen on the bottom in shallow water in the northwestern 12 miles of coast.

From the scattered rock outcrops, it seems likely that the entire stretch of coast is underlain at shallow depth by limestone. Indeed, a level to gently sloping limestone platform forming the broad shallow bank would explain the marked peculiarities of this coast. Storm-wave energies are dissipated well offshore, against the resistant rock platform. This permits fine-grained sediments to be deposited on the "beaches" and the marsh to advance slowly seaward.

Ochlockonee Bay - Panama City

General

This stretch of coast is characterized by large continually shifting sand bars offshore and several elongate barrier islands, barrier spits and hooks, all showing signs of high beach mobility. Festoons of beach ridges dating from the present sea-level stand make up most of the islands and spits, as well as parts of the mainland coast, and illustrate the complex history of shore construction and destruction of this coastal stretch.

The balance between erosion and accretion on a given beach is in places controlled by the distribution of sand bars offshore. Several large bars are potential barrier islands, for example, Dog Island Reef (Figure 10), to the east of Dog Island. The piling up of 3 or 4 feet of sand on the crest of this bar will create a new barrier island comparable to Dog Island in size and lying several miles to its east. Or it is quite possible that Dog Island Reef was a barrier island at one time but has since eroded down to its present form. In any case, Dog Island Reef, like South Shoal south of Lighthouse Point, and the broad sand shoals off Cape St. George, St. Vincent Island and Cape San Blas, provides a major source of sediment for the building out of adjacent shores. It is also both a wave deflector and wave energy absorber. If any of the offshore sand masses were to disappear or to change shape or position, the effects would immediately be felt on shore.

Figure 10.--Sand bar northeast of Dog Island, Florida.
At one time this reef may have been a
barrier island.

The mainland shore as far west as Thirteen Mile, about 13 miles west of Apalachicola, is incised in an older terrace and is therefore an erosional shore. Except for a thin sandy beach there is no evidence of significant shore construction during the present sea-level stand on this coastal stretch. The coast west of Thirteen Mile, and thence north along the mainland coast for about 17 miles, is marked by beach ridges that indicate a shore advance of several miles. This shore today is partly marshy and gives evidence of relative immobility. It seems clear then that the protection offered the mainland by St. Joseph's Spit and St. Vincent Island lying just offshore is a relatively recent development. It prevents both significant wave action and shore activity on the mainland shore. From this we can conclude that both St. Joseph's Spit and St. Vincent Island came into existence in the not distant past - say, perhaps, less than 2,000 years ago, possibly very much less.

Bald Point - Peninsula Point

At the present time accretion is taking place on this shore, estimated to be about 300 feet at Bald Point and 100 feet at Peninsula Point since 1943. A small spit, showing north littoral drift, is being built off Double Pond (see: Lighthouse Point, Fla., quadrangle, U. S. Geological Survey). Littoral drift is to the west along the south shore. This long spit has a submerged continuation to the northwest in a narrow sand bar that is exposed at low tide and almost seals off Alligator Harbor.

Alligator Harbor - Camp Gordon Johnson

No change in shore was apparent from the 1943 shoreline on the U. S. Geological Survey quadrangle topographic maps (refer to Appendix), except at Turkey Point. A small cusp and spit has formed on the eastern side of this point and indicates littoral drift to the southwest. A large sand bar off this point shows by its sculpturing that the point is the nodal point (point of convergence) of two nearshore circulations, the stronger of the two flowing in a counterclockwise arc.

West of Turkey Point the shore is well protected by a long complex sand bar paralleling the coast about a mile offshore. This bar is exposed at low tide and a small island occurs at about the midpoint on the bar (Figure 10). This bar may have formerly been a barrier island but is now mostly reduced to a subsea-level surface.

Dog Island

Dog Island is made up largely of beach ridges of the present sea-level stand. Its greatest growth has been to the east, and has been accomplished by the repeated building out of sand hooks (Figure 11). At least 4 cycles of accretion and deposition have taken place. At the present time some accretion is taking place at the northeast point. When seen from the air the rest of the open coast, as far as the west end of the island, showed no detectable change since 1943. Slow accretion is occurring at the west end of the island. The central section of the shore appears to have been stable - or relatively stable - over a long interval.

Figure 11.--East tip of Dog Island, Florida. Beach ridges show that it was built by successive additions of hook-shaped spits. The most recent addition to the series is the small one forming in foreground.

St. George Island

St. George Island is a long narrow (30 miles by 1/2 mile) barrier island. It probably began its existence as a sand bar and built up to the high tide level. Except for the large northwest-directed hook at the west end and a small area on the bay side (Gap Point), there are no beach ridges and no indications that the island has grown either longitudinally or transversally by beach accretion. At the time of the reconnaissance, slight accretion of the beach was indicated along parts of the shore; but because of the fleeting nature of the observation and in the absence of recognizable forms landmarks from which this could be gouged, one cannot be certain about this. The large dune field behind the beach, running the length of the island as far west as Cape St. George, and the absence of beach ridges, as noted, indicate that the shore has been relatively stable for a long interval of time.

At the present time the northwest trending hook on the west end of the island is undergoing accretion.

St. Vincent Island

This triangular-shaped island is made up entirely of beach ridges and intervening marsh (Figure 12). The island has grown progressively during the present sea-level stand from the north shore to the south shore, a distance of about 4 miles. Only 3 erosional intervals of any consequence seem to have interrupted this process of island growth. At the present time accretion is taking place along the south coast and erosion is indicated along the east coast.

Figure 12.--St. Vincent Island, Florida, looking southeast. The beach ridges show how the island has grown progressively from left to right.

Indian Peninsula - Cape San Blas

The center third of this stretch of coast is the mainland and both ends are barrier spits whose surfaces are marked by beach ridges. Since these spits began to form, the central section of the coast appears to have been relatively stable.

The spit that is terminated on the west by Cape San Blas has been built by a southward shore accretion. The accretionary rate has been greatest at the west end; this is responsible for the fan shape (widest on the west) of this barrier spit. Accretion is still occurring at a rapid rate. Since 1943, a new hook, projecting south southeast over 1/2 mile, has formed at Cape San Blas. Moreover, a large eastward projecting hook is now attached to this new cape (Figure 13).

St. Joseph Spit

A narrow, north-south spit, St. Joseph's Spit, extends north of Cape San Blas for about 15 miles. The spit is covered with hook-shaped beach ridges. These show that the spit began to form at Cape San Blas only after the Cape San Blas spit had been considerably eroded along its west end. Before this erosion and the birth of St. Joseph Spit, the Cape San Blas spit may have extended several miles further west.

The earliest St. Joseph Spit was a small structure about a mile long. It grew northward by the addition of successive increments on its seaward side, each new addition projecting further north and with an easterly deflected hook at the north end. In all of this growth the predominant littoral drift was north.

Today erosion is attacking the southern half of the west (outer) shore of the spit. This is shown by tree stumps in the beach (Figure 13) and a cliff eroded into the well formed foredune in back of the beach. Littoral drift along the southern part of this section is now to the south and sand eroded from the spit is in the process of building the new spit that juts south at Cape San Blas, just described.

Very rapid accretion is taking place at the north end of the spit at the present time. It is estimated that St. Joseph's Point has advanced half a mile to the east northeast since 1943.

The foreshore drops off fairly steeply in front of the spit and the beach is washed by large waves. When seen by the writer the beach slope was fairly steep and its surface was highly irregular and unevenly sculptured by a rather rough surf.

Figure 13.--Cape San Blas, looking south along outer shore of St. Joseph Spit. Active beach erosion is shown by stumps of pine trees in beach. New sand spit and hook that has built south from Cape San Blas in past decade is visible in distance over top of trees.

St. Joseph Bay (mainland)

Before the construction of St. Joseph and Cape San Blas spits, the mainland shore underwent an interval of marked accretion. Today the spits protect this stretch of coast and there are scant signs of either erosion or accretion. The shore consists of a narrow sand beach with a few marshy stretches near the south end. However, relatively recent beach ridges paralleling the present shore occur north of Palm Point and indicate that beach accretion has occurred here not too long ago, perhaps before St. Joseph spit had grown to it's present length.

From Mexico Beach to the base of Crooked Island, about 2 miles to the north, several rows of foredunes and beach ridges show net beach advance. Active accretion is occurring on the west side of 2 jetties at Mexico Beach. This suggests eastward littoral drift at the present time at this point.

Crooked Island

In spite of the indications of east littoral drift at Mexico Beach, Crooked Island to the northwest certainly was deposited by westward littoral drift. The history of this barrier spit can be interpreted from the coastal features. Before Crooked Island began to form, Raffield Peninsula, a small spit now lying to the north in St. Andrew Sound and in the protection of Crooked Island, had been built by westward littoral drift. After this spit had grown to about 2 miles in length, Crooked Island spit started to build out from the shore at a point less than a mile to the east of the base of Raffield Peninsula. Crooked Island must have formed rapidly until it terminated in a sizable hook at which point its prolongation was checked. In the early stage Crooked Island was about 4 1/2 miles long. The hook is preserved today as the triangular shaped peninsula on the north side of the island. A second triangular swelling of the island, about 3 1/2 miles to the northwest, represents another terminal hook, similar in form to the hook at the present extremity of the island. This second hook must have formed after the rapid prolongation of Crooked Island from the first hook. A third interval of prolongation to the west advanced the island to its present terminus, a little over 2 miles northwest of the second hook. Thus, Crooked Island seems to have grown in 3 relatively rapid spurts, interrupted by intervals of hook formation.

At the present time Crooked Island seems to be undergoing rapid accretion at the tip and along approximately the easternmost 1/3 of the outer coast. It is estimated that the tip of the hook has been prolonged about 1400 feet to the north since 1943 and is now only about 2,000 feet from the mainland shore.

A stretch of open mainland coast, about 5 miles in length, lies between Crooked Island and Hurricane Island, the next spit to the west. Here it is apparent that accretion, in the form of cuspate spits, is taking place. The large cuspate projection at about midpoint on this stretch of coast is probably due to the meeting and interference of littoral drift coming from the west and from the east (nodal point). The many shallow sand bars just offshore and the unstable and continuously shifting sandy island just off the cuspate spit are a reflection of the two complex interacting currents that occur here. The current flowing west along the outer shore of Crooked Island meets the current flowing east along Hurrican Island at about the midpoint of the stretch. These currents very probably contain secondary eddy circulations. The intersections of this complex of currents appears to be marked by sand deposition, both as offshore bars and as hooks and cuspate spits attached to shore.

Because these currents result in the continual shifting of the sand bars, the entrance to St. Andrew Bay has always been hazardous for boats. The entrance channel and breakwaters on Hurrican Island were constructed to eliminate this danger.

Hurricane Island (also called "Shell Island")

Hurricane Island is a barrier spit that joins the mainland coast at Panama City Beach. At the present time the island is growing rapidly to the east by additions to the terminal hook. There is also marked beach accretion along the eastern 4 1/2 miles of shore. Accretion has taken place on the east side of the breakwaters flanking the entrance channel that has been cut across the island at a point about 5 1/2 miles from the tip. Immediately west of the entrance channel, the beach shows evidence of erosion, but farther west slight accretion is evident in comparison with the 1943 maps.

The irregularities of beach surface along most of the shore indicate that west-flowing longshore currents are dominant. This is further indicated by the distribution of sand behind the two breakwaters. On the other hand it is difficult to reconcile west littoral drift with the accretion at the east end of the island, that is, unless sand at the east end is being brought up from offshore by north-moving waves. Such a mechanism is suggested by the presence of two hook-shaped bars lying less than a mile south of the tip of the island.

Panama City Beach - Pensacola

General

This stretch of coast shows signs of very slow retreat over a long period of time. Offshore the bottom drops off steeply and in this respect this coastal stretch is different from the others in the study area. Along the entire coastal stretch two sand bars parallel the beach and lie about 200 feet and 700 feet offshore. Beach material is everywhere medium fine white sand consisting of more than 98% quartz.

Panama City Beach - Moreno Point

The shore along this stretch is incised into older marine terraces. A cliff 10-30 feet high rises in back of the beach and shows that the present shore represents net retreat during the present sea-level stand. The cliff is generally grass-covered and appears to have been stable for some time. In many places at the toe of the cliff and directly behind the beach a single low beach ridge occurs. The direction of littoral drift along the coast appears to be west. A sand spit at Moreno Point has changed shape and undergone some accretion since 1935, the date of the base map used for plotting in this stretch.

Santa Rosa Island

Santa Rosa Island is a long, very narrow barrier island entirely made up of wide white sand beach and active sand dunes. Here and there the beach gives evidence of a certain amount of erosion of accretion but it is thought that the shore has been relatively immobile over a long period of time. The west end of the island, south of Fort Barrancas, is slightly hooked and the presence of a sequence of beach ridges indicates that accretion has taken place here.

Appendix

Maps and charts of coastal belt of Southeast River Basins

U. S. Coast & Geodetic Survey Charts

Atlantic Coast (listed from north to south)

Number	Name	Scale
440	Savannah River & Wassaw Sound, S.C. & Ga.	1:40,000
573	Ossabaw Sound & St. Catherines Sound, Ga.	1:40,000
574	Sapelo & Doboy Sounds, Ga.	1:40,000
575	Altamaha Sound, Ga.	1:40,000
447	St. Simon Sound, Brunswick Harbor & Turtle River, Ga.	1:40,000
448	St. Andrew Sound, Ga.	1:40,000
453	Fernandina Harbor, Ga. & Fla.	1:20,000
577	Fernandina to Jacksonville, Fla.	1:40,000

Gulf Coast (listed from southeast to northwest)

Number	Name	Scale
1259	Crystal River to Horsehoe Point, Fla.	1:80,000
1260	Horseshoe Point to Rock Islands, Fla.	1:80,000
1261	Apalachee Bay, Fla.	1:80,000
1262	Apalachicola Bay to Cape San Blas, Fla.	1:80,000
1263	St. Joseph &St. Andrew Bays, Fla.	1:80,000
1264	Choctawhatchee Bay, Fla.	1:80,000
1265	Pensacola Bay, Fla.	1:80,000

U. S. Geological Survey Topographic Quadrangle Maps

Atlantic Coast (listed from north to south)

Name	Scale	Date of Coastline	Contour Interval	Hydrog-raphy
Savannah Beach North, Ga.	1:24,000	1951	10'	hydro.
Savannah Beach South, Ga.	1:24,000	1951	5'	hydro.
Wassaw Sound, Ga.	1:24,000	1951	5'	hydro.
Raccoon Key, Ga.	1:24,000	1951	5'	hydro.
St. Catherines Island, Ga.	1:24,000	1951	5'	hydro.
St. Catherines Sound, Ga.	1:24,000	1951	5'	hydro.
Sapelo Sound, Ga.	1:24,000	1951	5'	hydro.
Cabretta Inlet, Ga.	1:24,000	1951	5'	hydro.

Appendix (Cont.)

U. S. Geological Survey Topographic Quadrangle Maps

Atlantic Coast (listed from north to south, contin.)

Name	Scale	Date of Coastline	Contour Interval	Hydrog-rapgh
Doboy Sound, Ga.	1:24,000	1951-52	5'	hydro.
Altamaha Sound, Ga.	1:24,000	1951-52	5'	hydro.
Sea Island, Ga.	1:24,000	1951-52	5'	hydro.
Brunswick East, Ga.	1:24,000	1951-52	5'	hydro.
Jekyll Island, Ga.	1:24,000	1957	5'	hydro.
Cumberland Island No., Ga.	1:24,000	1957	5'	hydro.
Cumberland Island So., Ga.	1:24,000	1957	5'	hydro.
Fernandina Beach, Fla.	1:24,000	1957	5'	hydro.
Amelia City, Fla.	1:24,000	1957	5'	hydro.

Gulf Coast (listed from southeast to northwest)

Name	Scale	Date of Coastline	Contour Interval	Hydrog-raphy
Suwannee, Fla.	1:24,000	1951	5'	hydro.
Shired Island	1:24,000	1951	5'	hydro.
Horseshoe Beach	1:24,000	1951	5'	hydro.
Steinhatchee SW	1:24,000	1951	5'	hydro.
Steinhatchee	1:24,000	1951	5'	hydro.
Crooked Point	1:24,000	1951	5'	hydro.
Keaton Beach	1:24,000	1951	5'	hydro.
Okefenokee Slough	1:24,000	1951	5'	hydro.
Rock Islands	1:24,000	1951	5'	hydro.
Manlin Hammock	1:24,000	1951	5'	hydro.
Snipe Island	1:24,000	1951	5'	hydro.
Cobb Rocks	1:24,000	1951	5'	hydro.
Sprague Island	1:24,000	1951	5'	hydro.
Arran	1:62,500	1938-40	10'	-----
Lighthouse Point	1:24,000	1943	10'	-----
St. Teresa	1:24,000	1943	10'	-----
McIntyre	1:24,000	1943	10'	-----
Dog Island	1:24,000	1943	10'	-----
Carrabelle	1:24,000	1943	10'	-----
Green Point	1:24,000	1943	10'	-----
Sugar Hill	1:24,000	1944	10'	-----
Goose Island	1:24,000	1942	10'	-----
Apalachicola	1:24,000	1943	10'	-----
New Inlet	1:24,000	1942	10'	-----
Cape St. George	1:24,000	1943	10'	-----

Appendix (Cont.)

U. S. Geological Survey Topographic Quadrangle Maps

Gulf Coast (listed from southeast to northwest, cont.)

Name	Scale	Date of Coastline	Contour Interval	Hydrography
West Pass, Fla.	1:24,000	1943	10'	-----
Indian Pass	1:24,000	1943	10'	-----
Cape San Blas	1:24,000	1943	10'	-----
St. Joseph Spit	1:24,000	1943	10'	-----
St. Joseph Point	1:24,000	1943	10'	-----
Port St. Joe	1:24,000	1943	10'	-----
Overstreet	1:24,000	1943	10'	-----
Beacon Hill	1:24,000	1943	10'	hydro.
Crooked Island	1:24,000	1943	10'	hydro.
Long Point	1:24,000	1943	10'	hydro.
Beacon Beach	1:24,000	1943	10'	hydro.
Panama City	1:24,000	1943	10'	hydro.
Panama City Beach	1:24,000	1943	10'	hydro.
Laguna Beach	1:24,000	1943	10'	-----
Seminole Hills	1:24,000	1943	10'	-----
Point Washington	1:62,500	1935-36	10'	-----
Villa Tasso	1:62,500	1935	10'	hydro.
Fort Walton Beach	1:62,500	1934-35	10'	hydro.
Holley	1:62,500	1935-36	10'	-----
Pensacola	1:62,500	1940-41	10'	-----
Fort Barrancas	1:62,500	1940-41	10'	-----

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