A Report on the Deposition of Petroleum Tars and Asphalts on the Beaches of the Northern Gulf of Mexico, with Notes on the Beach Conditions and the Associated Biota

by

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Introduction

For many years petroleum residues have been washing ashore in the northern Gulf of Mexico. However, except for a few comments by observers along the coast they have gone unnoticed. The lonely stretches of long sandy beaches, formerly so characteristic of the Gulf Coast, are now being developed as resort areas and this places a premium on clean sandy beaches. The present study was made in order to gather information on the extent of beach contamination by petroleum residues. In addition, information on the organisms that live on the beach was desired, because they may be affected by contamination. A study of this type should become increasingly important as the development of tideland oil and recreational beaches continue.

Historical Review

Pre-Columbian Indians found a number of uses for "asphaltite". T. N. Campbell (1952) states that the Karankawa Indians used asphalt to waterproof and decorate pottery and to attach arrowheads to the shaft. Hildebrand examined some of the pottery in the office of Doctor Campbell at the University of Texas. The pottery is light and rather porous and the inner sides of the pottery sherds were smeared with asphalt. In an older culture below the pottery, Doctor Campbell was able to reconstruct the type of basket weave from impressions left on small lumps of tar. On the basis of carbon-14 dating of a site in Uvalde County that contained

similar arrowheads, Doctor Campbell estimated the age of the Liveoak Peninsula site as between 1,000 and 1,500 years old. He comments as follows on the presence of asphalt in the midden. "Martin reports finding a lump of asphalt 'several pounds in weight' near the base of the test pit which he dug at the Kent-Crane site. Duffen's excavations revealed no lumps of this size but a large number of smaller lumps were scattered throughout the shell deposit" (p. 73).

The possible source of this asphaltite is of considerable interest. Since the Karankawa Indians were a nomadic people who subsisted at least in part on shellfish and fish, it seems highly probable that they gathered the asphalt along the beach. Although the pre-Columbian Huastec Indians were known to gather asphalt from the seeps in northern Vera Cruz (Muir, 1936, p. 155), the great distance involved and the nature of the intervening terrain would seem to preclude inter-tribal trade as a source.

DeGolyer (1918) reviews the literature on asphalt in Cuba. He found that the first reference to asphalt in the New World was made by Oviedo in 1533. Sebastian Ocampo careened and tarred his ships after finding liquid bitumen in the Bay of Havana, Cuba in 1508. Oviedo further noted a deposit of bitumen near the coast in Puerta Principe province and another on the shores of Havana Bay.

In the northern Gulf of Mexico the first reference to asphalt on the beaches is contained in the account of the vicissitudes of the survivors of De Soto's expedition. The survivors sailed westward from the mouth of the Mississippi and finally reached the mouth of the Panuco River in Mexico. The section concerning bitumen is quoted from Galtsoff (1954, p. 14). "One day, because of bad weather, the ships sought refuge in a

small cove. While some of the Spaniards were gathering shellfish along the shore they found some slabs of black bitumen almost like tar which the ocean had cast upon the beach. Garcilaso, who tells this story (Garcilaso de la Vega, Varner's translation, 1951, p. 601), says, 'This substance must come from some spring which flows into the sea or which is born in the sea itself. The slabs weighed 8, 10, 12 and 14 pounds; and they were found in quantity.' The tar-like substance was successfully used by the Spaniards to repair the leaky vessels and after spending a few days on shore they continued westward." The site of this cove is in dispute. However, Price (1933) accepts Sabine Pass as the probable site.

Shortly after the Texas War of Independence, Kennedy (1941, p. 118) reported asphalt on the Galveston Beach. Price (1933) found and reported asphalt on the Gulf beaches from the Rio Grande to Matagorda. He states, "Asphalt on Gulf beaches either floats ashore from oil seepages in the Gulf, from oil wastes of ships, as asphalt eroded from South American asphalt lakes, or in barrels from lost cargo and is of general distribution along the offshore bar beach."

Of particular interest are the reported occurrences of oil spots in the Gulf of Mexico. Information on these spots has been compiled from a private report submitted to Humble Oil and Refining Company by A. H. Glenn and Associates (1948) and from Lynch (1954).

A. H. Glenn and Associates tabulated reports of oil spots in the Western Gulf of Mexico from charts and reports of the U. S. Hydrographic Office. During the years 1905 to 1907 ships' masters were supplied with special current reporting forms. A number of oil spots were reported

and these were plotted by Lt. John C. Soley when he compiled his current charts for the Gulf of Mexico.

Table I[1]

Oil Spots in Gulf of Mexico According to Current Charts

Location	Date	Approximate Depth (fathoms)	Dimensions
28 51 92 28 29 00 93 54 29 02 94 06	8/4/? 8/4/? 8/4/?	10 to 15	Strip 90 miles long trending ESE-WNW.
27 06 92 02 28 03 90 23	12/16/? 12/16/?	60 to 800	Strip 105 miles long trending NE-SW.
27 00 91 56	12/4/?	800	---
26 44 91 49 27 23 93 12	12/6/? 12/6/?	270 to 970	Strip 85 miles long trending SE-NW.
26 20 91 49 26 30 91 48	1/?/06 1/?/06	900 to 1000	Strip 12 miles long trending N-S.
26 47 91 48 27 30 90 38	2/?/? 3/?/?	400 to 1100	Strip 80 miles long trending NE-SW.
26 14 92 57 26 48 92 07 27 15 91 24	4/?/? 4/?/? 4/?/?	500 to 1000	Strip 105 miles long trending SW-NE.

"In addition to the above locations, Soley's forecast chart indicates an "oil pond" about ten miles square centered at 29° 48' N., 93° 57' W. in 3.5 fathoms near Sabine Pass, an elliptical-shaped area of oil with dimensions of twelve by forty miles centered at 28° 58' N., 93° 15' W. in 12 fathoms of water, and a football-shaped "oil field" twenty by one hundred and ten miles in size centered at 27° 30' N., 91° 03' W. in 600 fathoms of water."

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[1] From A. H. Glenn and Associates (1948).

Table II[2]

Oil Spots in the Western Gulf of Mexico Reported from 1902 to 1924

Location 'N	Location 'W	Date	Approximate Depth (fathoms)	Remarks
28 15	89 07	8/30/13	500	Several patches of oil on surface.
29 32	91 34	3/?/23	23	Circular oil spot about 200 feet in diameter.
28 23 to 29 00	92 06 to 93 50	8/22/09 8/22/09	11 to 25	Numerous patches of oil on surface. One very thick patch was especially large, spreading as far as eye could see in all directions, and was dark brown in color.
29 05 to 29 16	94 14 to 94 36	9/10/23 9/10/23	8 to 10	Sea covered with heavy oil as far as could be seen.
28 42 to 29 00	92 43 to 93 53	8/04/06 8/04/06	10 to 20	Sea covered in all directions with layer of crude oil of a dark yellow color and having a very strong odor.
27 39	90 55	3/8/24	500	Oil spot one square mile in extent.
27 32	91 04	3/8/24	500	Small oil spot.
27 27	91 50	9/3/06	400	Stream of oil on surface.
26 48 to 27 20	91 46 to 92 38	12/06/06 12/06/06	400 to 970	Continuous oil spot.
27 10	92 02	10/09/02	600	Large and very well marked patches of oil at frequent intervals, with oil appearing to bubble up from the sea.

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2 From A. H. Glenn and Associates (1948).

Table II Cont'd.

Location	Date	Approximate Depth (fathoms)	Remarks
27 15 91 58	11/27/02	860	Stream of kerosene oil about 50 feet wide with direction about 240° W.
26 51 92 00 to 26 42 92 13	1/2/23 1/2/23	800	Patches of oil that could be seen for about 2 or 3 miles.
26 42 91 34	6/3/22	980	Oil slick about one mile wide extending north and south as far as eye could see.
26 51 91 40	9/10/09	900	Area of water about one mile in extent which was discolored by oil bubbling to surface in three jets.
26 40 92 10	6/30/15	890	Oil slicks in streaks observed throughout watch while ship ran about 16 miles.
26 30 92 00	9/15/17	1000	Surface covered with apparently blue oil extending one mile east and west and 500 yards wide.
25 20 89 49	7/02/17	1950	Large field of floating oil similar to crude oil.

Lynch (1954) plots thirty reported occurrences of oil spots or seeps in the Gulf of Mexico. Although he does not list his sources, he says these spots were compiled from nearly 50 years of record. All of these spots are west of the Delta and only two are south of 26° N. They are concentrated between 91°-93° W. and 26° 30' - 27° 30' N. He does not speculate on the origin of the spots.

Apparently none of the oil spots have ever been chemically analyzed. The reported composition of the spots varies from kerosene to crude oil. Furthermore, they have been described as oil slicks and as bubbling jets of oil. Some of these spots were several scores of miles long.

Around 1900 the so-called oil ponds off Sabine Pass in 3 to 4 fathoms were the center of controversy. Although they had been recorded on hydrographic charts, it seems that no one had actually observed any oil film on the surface. Phillips (1900) stated that the quiet water was due to a very fine mud containing large amounts of decayed organic matter which when stirred by the waves produces the same effect as oil spread on the surface. This view was attacked by Hayes and Kennedy (1903) on the grounds that these areas of calm water do not appear to be intimately connected with any peculiarity of topography of the Gulf bottom, or with the special abundance or peculiarity in the forms of animal or vegetable organisms living there. Presumably the "oil ponds" still exist off Sabine, as it is the one area off the Texas coast where one may frequently launch a skiff into Gulf waters. The description of and explanation by Morgan et al (1953) of a "mud hole" five miles west of Mulberry Island in Louisiana may also apply to these so-called oil ponds off Sabine. The Mud Hole consists of a calm area approximately 1/3 mile in width and extends about 1/2 mile along shore. They explain the calm area as follows: "At the Mud Hole relatively deep water close to shore and the presence of fluid clay tends to form a calm area during storms. The gelatinous ooze which covers the bottom is stirred up when the water is rough. This ooze gives the water a greater density and has a damping effect on the waves" (p. 32).

The first method of prospecting for oil was to search for oil seeps; consequently, the seeps along the land areas bordering the Gulf of Mexico were reported long ago. Two areas in Mexico and one in Cuba are well known as sites of asphalt seeps. One reported seep on the north end of St. Joseph Island still requires verification, although Price (1933) says that it has been reported by local observers. Presumably the two wells drilled on the island prior to 1920 were located on the strength of this seep.

Asphalt type seeps are numerous in the area from San Jose de la Rusias to the Tuxpan River and according to DeGolyer (1932) more than 6,000 individual emissions of asphalt have been mapped and counted in the Cerro Azul alone. According to Muir (1936) these seepages vary in character from a viscous oil to a liquid asphalt. Seepages vary in size from a small dribble coming out of a crevice to small lakes about fifty or more meters in diameter. In the Cerro Azul where they drain into arroyos the asphalt may travel one to two kilometers. Presumably asphalt is often intruded into water courses in the region, although there are apparently few references to this phenomenon. Crowther (1868) described seepages on the banks of Laguna Tampamachoco, north of Tuxpan. Urbina (1918) described an asphalt seep in the intertidal zone. Presumably this occurrence is south of the Tuxpan River and it is thought that he refers to an area in the San Martin Tuxtla region. A few seeps in rivers and streams in the Tampico-Tuxpan region have been described.

The fabulous oil wells in the Tampico-Tuxpan region occasionally flowed wild in the early development of the field and dumped vast quantities of crude oil into the Gulf of Mexico. The following passage is from Muir (1936, p. 4). "At 2:00 A. M., 27th December, 1910, Potrero

del Llano No. 4 of the Aguila Company was drilled in. The well flowed wild for sixty days, the oil going through the Buenavista and Tuxpan Rivers into the Gulf of Mexico. The well was finally capped and under a 21-day gauge showed a production varying from 100,000 to 110,000 barrels of oil daily. The total production to the end of 1933 was about 93,000,000 barrels, which does not include oil lost while the well was wild and during the fire (1914)."

Seeps are known on the Isthmus of Tehuantepec in what is usually called the Minititlan Field. These seeps are mostly of the asphalt type and presumably some asphalt enters the Gulf of Mexico via the rivers and streams in the region, but specific references to such an occurrence have not been seen.

Another area of seeps is in the region of central and western Cuba. Although some of these seeps border the Gulf, they are of little interest because the Florida Current would carry any asphalt into the Atlantic Ocean rather than northward into the Gulf. Whitney (1932) stated that the Mariel asphalt mine, six miles south of Port of Mariel, contained an estimated reserve of three to six million tons of asphalt and that 250,000 to 450,000 tons had been mined up to 1930.

Methods and Equipment

The methods of this survey were relatively simple and they will be briefly described. A four-wheel jeep was driven slowly (5 to 15 miles per hour) along the beach. Stops were made at regular intervals, usually five miles apart, but the intervals varied from closer together on developed beaches to farther apart on undeveloped beaches. Furthermore, additional stops were made when anything of particular interest or objects unrecognizable from the jeep were sighted. Essentially the whole northern

Gulf coast was covered, from northern Mexico to Bradenton, Florida. On the Texas coast most of the beaches were driven twice, because usually there was only one way on and off the beach. Five days were spent on Mustang-Padre Island beaches, but usually only a single day was spent on a given section of the beach. The areas visited are marked in figure 1. In Louisiana such sections as Terrebonne Island, Timbalier Island, Chenier au Tigre, Mulberry Island and Big Constance Island were visited by boat, and the beaches examined on foot. Where the beach was highly developed, such as Galveston Beach and the islands off Tampa Bay, all or sections of the beach were examined on foot. Hildebrand made practically all of the examinations. Hildebrand and Gunter together made one traverse of the Mustang-Padre beaches.

Each regular stop was called a station and a certain minimum amount of information was recorded for each and usually several pictures were taken. At each station information on the location, date, composition of the drift, topography, vegetation on backshore and the seaward side of the foredunes was recorded. At a few stations additional information was gathered on the organisms living in the foreshore area by sieving the sand.

In determining quantitatively the amount of tar on the beach, the method adopted was to count all pieces of tar along a section of the beach. Since the pieces of tar varied greatly in size, the unit adopted was a flat piece of tar one inch in diameter. Although it was easy to compare subjectively the amount of tar from one area to another, considerable difficulty was experienced in arriving at objective comparisons for several reasons. First, the swash marks followed a winding course over beach cusps and embayments and on some beaches these were

more highly developed than on others. Secondly, on some beaches most of the tar was concentrated in one swash mark, while on others it was distributed in various swash marks both on the foreshore and the backshore and even at times back into the dunes. Thirdly, tar was often partly concealed by large amounts of drifting sargassum or sand. Where the tar occurred in several swash marks, a section of the beach, two feet wide, was scraped from the beach crest to the shore line, in order to collect all the tar for a count.

Definitions

Backshore: The part of the shore lying between foreshore and the coastline covered by water only during exceptional storms or tides. This definition should be modified slightly for the purposes of this paper since the crest formed by the existing regime of tides and winds was used for the boundary between the foreshore and backshore. In other words this crest would change slightly in position although tides were not abnormally high or low due to the changes from equatorial to tropical tides and moderate changes in wind velocity.

Beach: The deposit that rests on the shore.

Beach cusp: A small triangular ridge that extends seaward from the high tide crest.

Beach embayments: Scooplike indentations that separate the cusps.

Beach crest: The landward edge of the backshore.

Coastline: Boundary between the shore and coast, marking the seaward limit of the permanently exposed coast.

"Coffee grounds": Finely divided organic material.

Coppice dune: A mound formed by wind in conflict with bunch vegetation.

Copse: A thicket.

Foredunes: Dunes nearest the beach.

Foreshore: The intertidal zone.

Longshore bar: A ridge that is submerged at least at high tide. The first longshore bar would be the one nearest the high tide line.

Longshore trough: The depression between the longshore bars.

Nip: A small wave cut cliff.

Pelagic: floating.

Raft: A dam-like accumulation of driftwood in a river. These rafts were prevalent before the settlement of Texas.

Sessile: Attached to a substrate.

Shoreline: The line of contact between water and sea. This line, of course, migrates up and down with the tides.

Swash: The intermittent landward flow of water across the beach. This water is carried up and across the beach by the forward momentum of the breakers.

Swash marks: Swashes which cross the water table leave a ridge of sand and debris at the point of farthest advance. This ridge is called a swash mark. A section of beach may have a series of swash marks which are formed as the tide falls, but all except the highest ones will be destroyed by incoming tides.

Washover: A shallow channel cut by the spilling of water across the barrier island during times of storm tides. These channels are closed by sand and as nearly all of them are very shallow, they appear as dry washes.

The following account is based upon Hildebrand's trip around the northern Gulf coast by jeep and, except for the South Texas coast, the observations are purely his and are recorded in his words.

Mexico

The east coast of Mexico is briefly discussed because of oil developments near the Gulf coast from Tampico to Coatzacoalcos and the presence of long sandy beaches similar to Texas beaches. Much information on the biological effects of petroleum residues on sand beaches might be obtained here because of the escapement of high asphalt crude oils into the rivers of Vera Cruz. Moreover, Urbina (1918) has described beach cobble many feet in diameter made up of tar or asphalt from seepages in basalt dikes in the tidal zone. Furthermore, this region may be the source of some of the contamination of the northern Gulf beaches because a long-shore current as outlined by Leipper (1954) sets northward along the Mexican coast.

Hildebrand visited a few localities along the east coast of Mexico between the Rio Grande and the Rio Coatzacoalcos at various times during the past three years. At no time was he particularly searching for petroleum residues along the beaches, but nevertheless a few comments appear in his field notes.

Five miles south of the mouth of the Rio Cucharas in the Laguna de Tamiahua was an extensive flat, probably 200 acres in extent, that was covered with a hard asphalt coating. This flat is normally above high tide during the dry season, but during the rainy season the water level in the bay is raised. The asphalt adhered tightly to the clayey soil beneath it and, as noted elsewhere in the northern Gulf, notably on the exhumed marsh clays near the mouth of East Little Constance Bayou, the asphalt instead of washing higher on the beach adheres tightly to the clay in the intertidal zone.

Along the Miramar (north) jetty of the Port of Tampico the entire intertidal zone was a gummy oily mess but below this zone several species of algae grew luxuriantly and they sheltered a number of small animals. However, the adjacent public beach behind the jetty was found to be surprisingly free of oil on December 23, 1953.

Data on the occurrence of tars in the drift along the sand beaches of Tamaulipas are scanty. Tar was found on shells that were collected 8 miles south of Boca Jesus Maria and it is highly probable that petroleum residues occur along the entire coast.

The Mexican tourist industry has noted the beach developments north of the Rio Grande by Cameron County and they have followed with plans of their own for the development of Washington Beach east of Matamoros. At the present time (November 1954) the only tangible evidence is the construction and paving of a road to the beach. Rumors of large luxury hotels and other developments in the planning stage have been rife in Matamoros and Brownsville.

On August 14, 1954 Hildebrand visited Washington Beach and drove approximately 10½ miles to the mouth of the Rio Grande. The slope of the fine sand beach is very gentle and at this time the little beach cusps and embayments that extend out from the high tide crest were barely perceptible. Near Washington Beach the backshore ends against large sand dunes more or less stabilized on their seaward face by seaside oats, goatweed, goatfoot morning-glory and wiregrass. Plants were rare on the backshore and it supported only a few patches of Sporobolus and impoverished Tidestroma and Sesuvium plants. As one approached the Rio Grande the backshore ended in coppice dunes of Sesuvium, a few of which were invaded

by seaside oats, and back of the coppice dunes were active dunes. Where the Rio Grande turns north and parallels the beach for nearly a mile before entering the Gulf there were only coppice dunes of Sesuvium or bare sand as on the spit at the mouth. Drift, except for a few logs, was relatively rare on this beach. Shells drift consisted mostly of arcid shells although a number of different pelecypods were also present. Sargassum was found in very small amounts on the backshore and no fresh sargassum was floating ashore. Tars could be found by searching anywhere along the beach but no great quantity was observed. It was estimated that there was one piece one inch in diameter to the yard along the shore.

Boca Chica

Although Brazos Island was the first barrier island along the Texas coast to be developed exclusively as a recreational area, it was already of considerable historical interest. General Zachary Taylor's men had camped on its shores and later after the Civil War when it appeared that Maximilian could only be dislodged from Mexico by United States intervention, troops under the command of General Sheridan arrived. The development of Brazos Island was one of the minor projects undertaken by Sam Robertson in his effort to develop the islands and beaches from Ransom Island in Redfish Bay to the Rio Grande. A fine concrete highway was built from Brownsville to Boca Chica and cabanas and other structures were built along the beach in the Twenties. All but the concrete highway fell victim to the great hurricane of 1933. Since that time there has been no development of the beach although hundreds of people visit the beach every summer to fish and swim. Recently southern Padre Island has been chosen for real estate development because the

less than six miles of suitable beach at Boca Chica are inadequate for the recreational use of the growing valley population and the tourist industry. However, large numbers of people will continue to go to Boca Chica to fish on the jetty and to see the mouth of the storied Rio Grande.

Boca Chica inlet once separated Brazos Island from the mainland. This inlet is now closed although it still retains all the characteristics of a washover and, indeed, water spills over into South Bay during equinoctial and storm tides. Closure of the Boca Chica inlet may be due to the disposition of spoils along the mouth of South Bay. Approximately one mile north of Boca Chica inlet is another wide flat washover with a pool of salt water in its deepest part. The backshore is very wide. I measured distances of 300 to 450 feet. Blown sand drifts across the backshore and makes small drifts where it is caught by sargassum or logs. The dunes are low and they are not well stabilized on their seaward faces. The goatfoot morning-glory, goatweed, and seaside oats are the dominant plants.

The foreshore area has been considerably modified by traffic, but the slope of the beach is gentle, although low nips up to a foot in height were developed in the high tide ridge near the Rio Grande. On August 12, 1954 when I visited the beach the tide was low and the first longshore bar was exposed. Drownings on this coast are usually attributed to an undertow by the local press. However, deep holes and other variations in the usual longshore bar structures occur during times of high water in the Rio Grande.

Undoubtedly the accumulation of drift on the beach had been altered by extensive grading of the foreshore and backshore when the jetty was

being repaired earlier in the summer. This would tend to place the sargassum higher on the beach where it would dry rapidly and blow inland. At the time of my visit only a little blackened sargassum, nearly covered by sand, was present on the backshore and no fresh sargassum was drifting ashore. The tide was low and the surf was very weak. A series of fine swash marks with small twigs and pieces of plant debris formed in the intertidal zone (figure 2). A considerable amount of rotting plant debris was trapped along the jetty and it drifted ashore in a zone extending south for one tenth of a mile. I could recognize large amounts of water hyacinths, a little red algae and fragments of sea-grasses, chiefly Halodule in the drift. A large flock of sanderlings and turnstones were searching the debris for small organisms.

Shells were not abundant in the drift. I found arcid shells, chiefly Arca incongrua, Arca transversa and Noetia ponderosa, as the dominant group. Locally near Brazos Santiago a number of large oyster shells were observed on the backshore.

Tar was definitely rare and the maximum concentration observed was six pieces, one inch in diameter, per one hundred yards of beach. There was no fresh tar washing ashore, and it is possible that tar washed ashore previously was mostly covered by sand drifting across the back shore.

Among the larger animals only the ghost crab (Ocypode albicans) finds the backshore a suitable homesite. The sand lizard, (Holbrookia propinqua) sometimes wanders onto the backshore from the dunes. A number of insects and a few crustaceans are able to live on the backshore.

The sandy foreshore has myriads of small sandhoppers under every piece of damp debris and when the tide is out many insects, chiefly dipterans, light on the damp sand. Corixids were especially conspicuous

and one species apparently breeds in salt ponds and even in tidal pools. I found rice shells (Olivella) and Callianassa holes common on the exposed first longshore bar and trough. In one place the sand had a greenish tint from a small blue green algae. Sieving revealed a considerable population of small coquina clams and Emerita in the intertidal zone.

Padre Island

Press release after press release has extolled the long sandy beach of Padre Island as a playground and tourist center, and now the island is linked to the mainland at both its northern and southern ends by causeways. Nueces and Cameron County have developed parks at the northern and southern end of the island respectively. These parks have been developed somewhat differently and they will be described separately.

Cameron County's Isla Blanca Park has been operating for only a single summer and it is located at the southern end of the island adjacent to the jetty at Brazos Santiago. The jetty serves as a fishing pier so all funds have been spent on development of bathing beach and overnight cabanas. The foredunes were leveled and bathhouses, concession house and a number of cabanas were built on this ridge at least ten feet above high tide. All buildings are of cement blocks. Hundreds of people used the park during the summer of 1954 and I have seen cars parked almost solid along five miles of beach. Although the park is operated all year, very few visitors use it during the winter.

Besides the public development on the southern end of Padre Island there has been a well advertised real estate promotion by John Tompkins and associates. Lots have been sold for private homes, hotels and motels on the island. At the present time only two homes have been built and one more is being built. However, real estate values have soared. For

example, thirty-one acres of land were sold to Cameron County for thirty thousand dollars during November, 1954. If there are no hurricanes for several years, it is likely that several miles of beach will develop as homesites.

Nueces County completed its park development several years before work commenced on Isla Blanca Park. The main attractions of the Nueces County park are the free fishing pier and the beach. Many visitors motor either north or south of the park before stopping along the beach, and a few private concession houses exist beyond the confines of the park. The park contains a bathhouse, museum and several concession houses. Most of the structures are made of wood and they are only two to four feet above normal high tide. Drifting sand is a big unsolved problem in the park and it even blocks some of the roads at times. There has been no private development of a residential district along the beach, but a few structures including a motel have been built along Packery Channel on the bay side of the island.

One other major project is planned for Padre Island and the bonds for this improvement have been voted by Willacy County. The plan calls for a channel across the island and the development of a causeway from Port Mansfield to Padre Island.

Since sections of the beach are impassable to automobiles most of the time, one of the most talked about improvements is the building of a road down the center of the island. This would make the beach accessible to the motorist along its entire length and would certainly hasten the development of the island as a tourist center.

According to the Coast Pilot, Padre Island is a low barren storm-swept strip of sand separating Laguna Madre from the Gulf of Mexico.

Indeed, there are few landmarks for the traveler along the beach. From north to south the main landmarks are Bob Hall Pier, Standard of Texas offshore platform, Yarborough Pass, S. S. Nicaragua (old boiler), beach rock, and the buildings on the southern end of Padre Island. Since Corpus Christi Pass has filled at the northern end the island is now joined to Mustang Island.

The topography of Padre Island is shaped by the wind and the sea. The most conspicuous features are the sand dunes and the washovers. Sand dunes do not reach a great height on Padre Island and although I took no measurements, I doubt that any are over thirty feet high. The highest dunes that I have seen along the Gulf Coast were at Boca Chachalaca near Vera Cruz where I measured with a hand level a dune that was one hundred and twenty-five feet high. Many of the dunes on Padre Island are small; particularly along the edge of washovers there are small incipient dunes that I am calling coppice dunes in this paper. Although active dunes are present at both ends of the island, they are more common at the southern end of the island where the rainfall is slightly less. I counted forty washovers from twenty miles south of Yarborough Pass to Isla Blanca Park. There are no washovers on the northern end of Padre Island. These varied from large ones approximately a mile across to ones only fifty to one hundred yards back into the dunes. At least two of the washovers were cut below the water table and they contained ponds of salt water. Most, if not all, of these washovers were cut by hurricane tides, after which a beach ridge forms across the mouth and blocks the further spilling of water across the beach except during storm tides. Vegetation invades the washovers very slowly and, as there is normally nothing to catch drifting sand, dunes do not form. The first invader

is the sea-purslane (Sesuvium portulacastrum). As it grows, sand collects around its base and it builds a pimple like mound or coppice dune. After this mound reaches a certain height, if it is not dissolved by a storm tide, it is invaded by other plants, usually seaside oats on Padre Island. However, in a few very wide washovers such as old North Pass on St. Joseph Island where there are no other plants adjacent, coppice dunes up to six feet in height are built solely by Sesuvium. Normally other plants would crowd out the Sesuvium before the coppice dune exceeded three feet in height. Since Padre Island has not been hit by a major hurricane since 1933, it is probable that many washovers have been completely eliminated. According to local observers, the dunes have encroached on the beach.

Only two small chunks of beach rock located approximately twenty-three miles north of Isla Blanca bathhouse interrupt the sand beach. According to Dale Goyer, the hermit of Padre Island, there used to be a blue clay on a section of beach near the S. S. Nicaragua but the clay is now covered by dunes. No analyses of beach sands were made during this investigation. However, Bullard (1942) and Lohse (1951) have discussed the distribution of heavy minerals along the beach. Magnetite sands, which appear as blackish lines or stains in the sand, seemed to be more common south of Yarborough Pass than elsewhere on the Texas coast. Such blackening might be laid to petroleum products by the uncritical observer who found tar in the swash marks.

Mollusks form a considerable part of the beach material in certain areas. Little Shell and Big Shell are two names well known to the surf fishermen on Padre Island. Big Shell is supposed to be an especially good locality for bull redfish (Sciaenops ocellata). However, these

areas are rather difficult to delimit and they vary in extent depending on recent wave and current action. M. E. Coleman, who has made his living beachcombing on the south Texas coast for twenty-five years, informs me that Little Shell starts ten miles north of Yarborough Pass and reaches the pass, while Big Shell starts three miles south of Yarborough and extends ten to twelve miles further south. On my three trips down the island I would not have noted Little Shell except that I knew where it should occur. Although the backshore had been disturbed by grading, I did note that coquina shells (Donax) were more common than usual on the beach. The high tide crest is steep and this coupled with soft shell sand on the backshore makes passage difficult for a passenger car. Big Shell differs from Little Shell in being composed only of large heavy shells, such as Noetia ponderosa and Echinochama arcinella, which can withstand the wave action for long periods of time. Mostly, however, the shells are fragmented and the fragments form ridges and cusps on an otherwise steep beach. It is only at extremely low tides that Big Shell is passable to a passenger car. From about twenty miles south of Yarborough to Isla Blanca considerable numbers of heavy shells are found on the backshore along and among the dunes. This shell is carried up the beach by storm tides and deposited at the base of dunes. Such a tide occurred on November 11 and 12, 1954.

Most of the shells are hard shell clams (Venus) and in some areas they almost form a pavement. Since most of the hardshell clams are old and badly worn and no fresh ones were noted anywhere on the beach, it is possible that they do not thrive in the region today and grew in the area when the mouth of the Rio Grande was further north. An occasional oyster shell (Crassostrea virginica) is found along the beach, and other durable shells, such as Noetia, are not rare on the backshore. In

general one could conclude from the shell drift on the high tide ridge and the foreshore that Padre Island has an arcid beach. However, if one considers the living shells in the intertidal zone, it should be called a Donax community. Besides Donax variabilis, Terebra cinerea, Polynices duplicata, Olivella mutica and Oliva sayana are locally common. Live Dinocardium robustum, Arca incongrua, Noetia ponderosa and Arca campechiensis were taken in the intertidal zone on the north end of Padre after the high tides of November 11 and 12, 1954, and they probably washed in from slightly deeper water.

Plants along the backshore on Padre Island are very rare and little variety is found on the seaward face of the foredunes. No trees or shrubs occur in the foredune area and it is only on the dunes along Packery Channel that any native shrubbery -- live oak and prickly ash (Zanthoxylum)-- occurs. Seaside oats (Uniola paniculata) is the dominant foredune plant and other common plants are sea purslane (Sesuvium portulacastrum), goatfoot morning-glory (Ipomoea pes-caprae) and goat weed (Croton punctatus). Very few plants invade the backshore area although some were observed growing on the sand covered sargassum drift. Sesuvium and Sporobolus were not uncommon in this situation.

A number of exotic seeds drift ashore on the beach at Padre Island. Undoubtedly the most common is the Gulf bean (Entada scandens). Mucuma sloanei is not uncommon and at least three other species were more or less common on the beach. Drift near the south end of the island consisted of sea-grasses (Halodule and Thalassia) from the bays and water hyacinth stalks of fresh-water but unknown origin. Accumulations of rotting and finely divided plant material were rare. A small patch of such material was noted on November 8, 1954 near the Standard of Texas platform.

The pelagic weed (Sargassum) drifted ashore in great abundance throughout the spring and early summer. This brown algae is sterile and it reproduces entirely vegetatively when pelagic. It has not yet proved possible to establish definite specific affinities with any of the pelagic weeds and sessile relatives from which they must be, or have been, derived (Parr, 1939). There are annual variations in the amounts of floating weed and Parr presents evidence of such variations for the Sargasso Sea. However, whether the enormous strandings of sargassum on the Texas coast were due chiefly to a greater abundance of the weed in the Gulf because of favorable growing conditions or whether they were due primarily to unusually favorable winds and currents is not known. Several residents at Port Aransas stated that vast amounts of the weed strand once every twelve years on the Texas coast, but I was unable to find any corroboration of such statements from other sources. Normally the sargassum would drift onto the beach slowly, dry out, and then be blown off the beach, but this year it accumulated in dense masses along the beaches and even in the longshore troughs and rotted. It was necessary to use road graders to clear the bathing beaches on Padre Island and Mustang Island. Later in the summer the weed that drifted on the backshore became sanded over and raised the level of the backshore. It provided a rich compost in which watermelon seeds and a variety of beach plants, such as the dew plant (Tidestromia), sprouted and grew. Plants were more luxuriant on the east Texas coast than Padre Island. However, the high tides in November swept the backshore clean and even cut six to ten inch nips around the bases of the foredune, so there was no building up of the backshore because of the presence of sargassum. Sandhoppers and other small crustaceans and insects found the sargassum a particularly favorable environment.

Freshwater and terrestrial snails wash ashore on the Texas beach. However, the only large conspicuous snail in the group is a large apple snail (Pomacea paludosa) that occurs in the rivers of Georgia, Florida, Cuba and possibly Mexico. Shell collectors prize this species and although I did not find any on Padre Island, they occasionally occur.

Small, usually rounded pebbles of pumice are common on Texas beaches. These rocks are more common on Mustang and Padre Island than elsewhere on the Texas coast. Where they originate is unknown, but it is probable that they originate from the volcanic salients in the State of Vera Cruz. However, more distant volcanoes in the West Indies may have produced the pumice.

Life in the foreshore area does not differ appreciably from that described for Boca Chica. Donax, Terebra, Polynices, Olivella and Oliva are common in the intertidal zone, as well as certain crustaceans such as Emerita and Lepidopa. The fish fauna was not sampled except for observations of fishermen's catches and two sweeps of a pushnet. Certainly the surf whiting, Menticirrhus littoralis, and the common pompano, Trachinotus carolinus, were common. One difference in the foreshore area of the middle of Padre Island is that the longshore bars do not parallel the shore, but form what the fishermen call "blind guts" along the shore. Sometimes tidal pools form and in one of these troughs I took a number of small mojarras. Previous work of Gunter (1945) and unpublished observations by me would indicate that this is not the case along the remainder of the Texas coast.

Leipper (1954) refers to the graveyard of ships as a one hundred square mile area twenty miles east and forty miles south of Aransas Pass.

He further states that there is now ample evidence that this is an area of convergence. If one examines the wrecked boats along the shore, he is impressed by the fact that they are most numerous in the vicinity of Yarborough Pass. Mr. M. E. Coleman stated that he has been observing tar on the Texas beaches for over twenty years, while searching for lumber along the beaches. At times tar is so common that he is convinced that he could gather over a ton in a few hours. Three to four hundred pound chunks often occur on the beaches, but they soon "sand down" and are lost to view. I have not seen any pieces of tar that large, but I observed large pieces that may weigh forty to seventy pounds several times along the beach in the northern Gulf. I observed three large balls of tar along Padre Island on August 11, 1954, but I did not see a single one when driving the beach on November 8, 1954. In reply to my question, Coleman stated that he found the greatest abundance of tar on Padre Island in the area between Big Shell and the S. S. Nicaragua. My observations would indicate a more uniform distribution of tars along the shore of Padre Island. However, conditions change and there is no uniform rate of accretion of tars on the Gulf beach. In fact it seems to come ashore in surges, probably propelled by favorable winds and currents and it may be several weeks or months between these relatively large contaminations by tar. For example, I examined Isla Blanca Park on August 16, 1954 and I found very little tar and certainly none of it was fresh. Yet, two days later Jack Blackwell, who was taking publicity shots on the beach, complained to me that his model got her feet black with tar.

Tar is carried on the beach by the sea and it is more or less sorted depending on size. The very finest pieces are most common near

the water's edge. Swash lines are rarely straight on the beach. The deep indentations of the swash lines correspond to the valleys between the beach cusps and they usually accumulate most of the tar with relatively little on the cusp itself. Furthermore, high storm tides may push the tar back into the dunes and at Port Aransas I have observed accumulations of tar two hundred or more yards back in the dunes. Along the edges of the washovers on Padre Island one often finds pieces of tar. This all adds up to a difficult problem of quantitatively sampling the beach. On Padre Island tar was found in all swash marks and at no time did I pass through an area where it could not be found during four trips along the island beach. Fresh tar was not uncommon at the northern end of the island on August 11, 1954. I counted seventeen fresh blobs of oil four to eight inches in diameter along one hundred yards of beach near the Standard of Texas offshore platform. Fresh tar was common elsewhere on the island and it apparently stranded on the night of August 10, 1954. At least that is when tar stranded on Mustang Island beach in objectionable quantities.

Mustang Island

Since the closure of Corpus Christi Pass in 1949 there seems to be no valid reason for considering Mustang Island separately from Padre Island. However, Mustang Island was developed first and it has a much larger permanent population. Port Aransas had 545 inhabitants in 1950. The town is built behind the sand dunes at the north end of the island, and there are no structures on the open Gulf beach except South Pier, a free fishing pier. Port Aransas is exclusively a tourist center, although formerly it had some importance in the commercial fishing industry on the

Texas coast. At certain seasons of the year a few beach seines are still operated by commercial fishermen on the island, but the yearly commercial fish catch is very small. The island is connected with Aransas Pass by a ferry and causeway and to the Padre Island causeway by a road down the center of the island. The road down the center of the island was opened during October, 1954 and it opens new land for development. Undoubtedly tourist facilities on the island will be greatly expanded and additional miles of beach will be used more often for recreational purposes.

The foreshore of Mustang Island is a gently sloping beach of fine sand and it is passable to passenger cars at all times during low tides. As on Padre Island, the dominant organism living in the foreshore area is the coquina clam. This little clam is able to move up and down with the tides and it occurs in great abundance in the embayments between the beach cusps. Associated with these clams are Terebra cinerea, Olivella, Polynices and Oliva shells.

The backshore is approximately one hundred and fifty feet wide from the high tide crest to the base of the dunes. Here the ghost crabs dig their holes. The smaller ones dig closest to the beach. This backshore was covered with a dense cover of sargassum during the spring and summer of this year. However, the high tides of November 11 and 12, 1954 swept the beach clean clear to the dunes. Several plants grew in this backshore area, notably Tidestromia and a weedy plant, probably Atriplex arenaria.

The foredunes on Mustang Island are nearly all stabilized by seaside oats. However, the small incipient dunes at their seaward base are more or less active and they have goat-weed, seaside oats, dropseed grass,

wiregrass and goatfoot morning-glory as very common plants. The foredunes support a large population of sand lizards (Holbrookia propinqua).

Although a large variety of shells may be found in the drift, the arcid shells predominate. Other conspicuous shells are Dinocardium, Pecten, Anodontia, Anatina and Mulinia shells. Whether shells were ever abundant enough to form beach cusps on Mustang Island is unknown to me. At the present time many shells are gathered by shell collectors almost as soon as they wash ashore. One soft coral (Leptogorgia setacea) seems to be more abundant on the north end of Mustang Island than elsewhere on the Texas coast.

Aside from sargassum, which has been mentioned previously, very little plant debris was observed on the beach. The thin swash marks are often composed of woody debris but the amount is usually small. I have noticed for the past several years that debris coming from Aransas Pass usually strands in a section of beach extending from South Pier to Big Hill. Often near South Pier, particularly after a rise on the rivers, one may see the beach coated with fine plant debris. This area is the chief swimming beach because of its proximity to the tourist courts. I noted drift of the seagrasses, chiefly Thalassia and Halodule, in this area during the summer. These grasses do not grow in the Gulf off the Texas coast, but they are common in some of the bays. Tropical beans, such as Entada and Mucuna, were common on the beach along with a bulky oval-shaped seed of the cabbage bark.

The beach was badly contaminated by tar on August 10, 1954. Between the jetty and South Pier there was a blob of tar at least four inches in diameter per yard of beach. However, the number varied as one moved down

the island. In one mile I counted thirty-six blobs, four to eight inches in diameter, and a count made while traversing another mile of beach was only two. There were smaller pieces of fresh tar and a considerable amount of old tar scattered throughout the swashmarks.

St. Joseph Island

St. Joseph Island is approximately twenty miles long and it is bounded on the south by Aransas Pass and on the north by Cedar Bayou. At various times in the past Cedar Bayou has closed and during my trip on August 19, 1954, I could not find more than four inches of water crossing the bar at any point during low tide. The island is now a ranch and the only inhabitants are the few ranch employees. However, at times a few squatters live along the channel across from Port Aransas. St. Joseph Island was settled before Mustang Island and it was a port during the early settlement of Texas. The village was destroyed during the Civil War and it was not rebuilt. At the present time the island is visited by fishermen. A boat runs daily between the jetty and Port Aransas and many fishermen fish from the jetty. A few commercial fishermen occasionally drag nets on the Gulf beach. Cedar Bayou is more isolated and the sports fishermen, who favor that spot for fishing, charter a boat or a light plane.

Aransas Pass has been stabilized in its present position by jetties but in 1856 it was a mile north of its present position. This pass, together with North Pass, formed a wide flat nearly five miles wide at the southern end of St. Joseph Island. The Army Engineers built a dike across this flat and North Pass so that all the water would pass through the ship channel. Nevertheless, except for a mile of island near the

jetty, dunes have not formed across this flat and even during weak storm tides, water passes through North Pass. Sesuvium portulacastrum has built a number of coppice dunes across a part of the old pass. The north end of the island is covered with sandy dunes in the foreshore area. It differs chiefly from Mustang Island in that the small active drifts common at the base of the dunes on Mustang Island are rare or absent on most of St. Joseph. Vegetation is very similar to that of Padre Island, but backshore plants are more common and the dew plant flourishes in the backshore area.

Two crews were drilling for oil in the shallow offshore area when I visited the island. One of these sites proved to be a dry hole.

Except near the jetty, where arcid shells predominated and a large number of other species were sparsely represented, the beach was almost devoid of any type of shell. The beach is fine sand and slopes very gently. No large beach cusps were present. The backshore is wide and covered with blackened sargassum which in turn is partially covered by sand.

Tars were present everywhere in the swash but they were not abundant. Approximately one piece, one inch in diameter, per foot of beach was found. It was not widely distributed as among the various swash marks on Mustang and Padre Island, but it was chiefly confined to the highest swash mark. No fresh tar was drifting ashore, but in one locality I found finely divided tar in the intertidal swash marks.

At Cedar Bayou I found three large ampullarid snails (Pomacea paludosa) with the operculum still in place. This snail is not a native of Texas.

Matagorda Island

Matagorda Island is approximately thirty-four miles long and it is bounded on the south by Cedar Bayou and on the northeast by Pass Cavallo. The entire island with the exception of a small air force establishment at the northern end of the island is devoted to ranching. In addition to the cattle that graze on the island there is a large population of deer and I was seldom out of sight of them. The only means of access to Matagorda Island is by boat and it does not appear likely that a causeway will be built in the near future. However, there has been talk of a causeway to the island and at least one rancher is actively promoting the idea.

Matagorda Island receives more rain than the islands to the south and except at the southern end dunes are not a conspicuous part of the landscape. A few old dunes exist along Pass Cavallo and a considerable distance off the beach on the northeastern two-thirds of the island but they are rare. Seaside oats is replaced by wiregrass as the dominant plant on the beach ridge.

The beach is fine sand and slopes very gently. Shells were nearly absent in the drift. One of the commonest shells was small Periploma clams. Black sargassum was common on the backshore where it formed a compost that was invaded by dew plants (Tidestromia).

In one area (Station 27) there was a lot of shell among low dunes. This shell was chiefly arcids (Arca campechiensis and Noetia ponderosa). One arcid pelecypod (Arca secticostata) that is rare on the Texas coast was also observed.

Tar was as abundant as it was on St. Joseph Island, approximately one piece per foot, but it is likely that some tar was missed because

of the concealment of the backshore by a black sargassum. I observed tar in the water at only one station but it may have been moved by a rising tide from previous deposition in swash marks.

Noteworthy on Matagorda Island was the presence of four seeds of the red mangrove (Rhizophora mangle) and a single Pomacea paludosa. Tropical beans, including Entada, Mucuna and the large wrinkled oval seed of the cabbage bark, also occurred but they were not common. Emerita, Donax and Terebra live in the foreshore area. Donax seemed much less abundant than on Mustang Island.

Matagorda Peninsula

Eleven miles of coast from Decros Point to Greens Bayou were not examined during this investigation. This area is isolated and difficult to reach. At one time a hunting and fishing club was maintained on the island but this club ceased operation during the spring of 1954. Decros Point is reputed to be a good fishing spot for redfish at certain times of the year.

I drove the seventeen miles from Greens Bayou to the mouth of the Colorado. Here the peninsula is low and flat without any dunes and the bayside is cut by numerous bayous. Except for a single fisherman's shack the entire area is devoid of buildings and it is used as a cattle range. A very characteristic feature of the beach is the amount of drift wood on the beach ridge. The source of most of this wood is the Colorado River and possibly much of it derived from the breaking up of the raft in the Colorado nearly thirty years ago. In this region the salt cedar, Tamarix gallica, occurs in copses along the coast. Any

recreational development of this region other than by fishermen who want to get away from the crowds is unlikely in the near future.

Greens Bayou is a shallow channel with a strong tidal current. It is cutting back against the southwest shore and the northeast shore is bordered by a wide sand flat. Much blackened sargassum wrack is present on this flat. White "rods", which are probably worm tubes, were common in the lower swash marks. Although shells do not carpet the area, old Crassostrea, Rangia and Arca campechiensis shells are common. Large hinged Donax shells were common and a few hinged shells of Arca incongrua and Dosinia discus were also observed. Noteworthy was the appearance of several shells of Macrocallista nimbosa because one of them had nearly the original polish.

Tar stranded in considerable quantities on the shore of the bayou. Two large pieces twelve to twenty-four inches in diameter and two inches thick were observed on the beach and four other pieces slightly smaller were observed. Lesser amounts of tar were entangled among the black sargassum wrack and it was difficult to detect without a close examination. Along with the tar I found two red mangrove seeds, three Entada and one Mucuna bean.

From Greens Bayou to the Colorado River the beach is more or less gently sloping except that the beach ridge is rather steep on its seaward face and a few small dunes are developed near the Colorado River.

Shell cusps composed chiefly of Rangia are well developed in an area extending for three miles north and east of Greens Bayou. Crassostrea, Venus and Arca campechiensis are not rare in these cusps and several other shells including Dosinia, Dinocardium, Tellina alternata and Macrocallista nimbosa were present. Thin shells would be soon broken into bits

by the wave action and only heavy shells survive long. The remainder of the beach is chiefly a sand beach with the usual complement of living Terebra, coquinas and Emerita in the foreshore area. In some areas there is a pavement of Rangia, Crassostrea and Venus shells on the beach ridge.

Tar was present but it was not abundant, and it was difficult to assess quantitatively because of the black sargassum wrack. One piece one inch in diameter per foot of beach was the estimated abundance.

The beach at the southwest side of the Colorado River is building out and several ponds are present in the swale behind the main beach ridge. No accumulation of tar was noted on the beach adjacent to the Colorado River.

A paved road extends from Matagorda to the mouth of the Colorado along the east bank of the river. A small development, including a few small beach cottages, a dance hall, bait stands and trailers, has sprung up at the mouth of the river. This area would grow rapidly if boats could safely enter the Gulf, but the shallow water over the longshore bars prohibits the use of the Colorado River as an exit to the Gulf except on very calm days.

From the Colorado River to Brown Cedar Cut, the surrounding land is low and it is cut by back bayous on its bay shores. The bayous may be closed off from the bay by a sill as well as from the Gulf by a beach ridge. One such bayou that was nearly dry was examined. Tagelus gibbus was very abundant and many freshly dead shells were observed in the mud. Oysters occurred in small clumps and a single dead hardshell clam (Venus) lay in the drying mud. A large number of mullet swam in the pond and some dead ones were seen on the shore.

Seven miles of the beach nearest Brown Cedar Cut were covered with heavy shell. Crassostrea formed large beach cusps in contrast to the predominance of Rangia near Greens Bayou. In addition to Crassostrea there were lesser amounts of Rangia, Venus, Arca campechiensis and sandstone in the cusps. This same condition prevailed on the beach ridge. Flat pieces of sandstone up to eight inches long were common on the beach ridge and smaller pieces were present in the cusps.

The amount of tar present varied from one to four pieces per foot of beach. Considerable drift of sargassum was present. Entada beans, wrinkled oval cabbage bark seeds, and pumice stones were also found in the drift.

Plant cover on the ridge and in the backshore area was similar to the western end of the peninsula. Seaside oats was much less abundant and the variety of plants on the beach ridge was greater than further south in Texas.

Brown Cedar Cut was noteworthy for the large amount of tar on both shores. Brown Cedar Cut is a shallow tidal channel with strong tidal currents. It is cutting back against the west shore and leaving a cliff and bench of exhumed clay along the channel shore and building out on the beach end. Along about 300 feet of channel at the bay end was a heavy contamination of tar. Four pieces, at least two feet in diameter, were observed on shore and tar was abundantly smeared in all swash marks. Oysters and Louisiana clams were the most abundant shells on both sides of the cut. A number of other shells including species common to the bay and to the sand beach were present. These shells included:

Arca transversa
Arca incongrua
Arca campechiensis
Anomia simplex
Chione cancellata
Venus mercenaria

Mytilus recurvus
Crassostrea virginica
Rangia cuneata
Tagelus gibbus
Pecten irradians
Macoma constricta
Dinocardium robustum
Lucina sp.
Lucina jamaicaensis

The east side of Brown Cedar Cut is characterized by a wide flat barren of vegetation and scalloped by bayous. Several ponds which are probably filled chiefly by wind driven tides were present. The flat was thickly covered elsewhere with a carpet of black sargassum wrack. The little ponds had a leathery blue green algal floor in which corixids thrived. Three large balls of tar 33 x 42 x 2, 12 x 20 x 1½, and 6 x 8 x 3 inches respectively were found. Small pieces of tar were distributed throughout the swash marks.

Between Brown Cedar Cut and the San Bernard River it is obvious that most of the beach is eroding badly. Instead of a beach ridge there is a nip two to three feet in height. Between the San Bernard and Sargent Beach there are several places where marsh clay is exhumed in the intertidal zone. One such section is 1,500 feet long. Much drift wood is present along the beach and on the ridge. The beach slopes gently away from the cut bank. Behind the ridge, beyond the Sargent Beach development, is a narrow marshy area that contains Choctaw and Cedar Lake. Barges passing through the Intracoastal Waterway can be seen from the beach. Louisiana clams and lesser amounts of oysters and Arca campechiensis are present on the beach and in the intertidal zone. Except near Brown Cedar Cut most of the cusps are composed of small sandstone pebbles with only a little shell. Tar is not common; it varied from one to six pieces per yard.

Seaside oats is very rare and the dominant beach plant is wiregrass although a variety of other plants contributed to the flora of the beach ridge.

Beach development on Sargent beach is entirely one of beach cottages for week-end and summer visitors. These are all built on pilings and a real estate developer is active in the area. If the Intracoastal Waterway is bridged at the San Bernard, the beach should develop much more rapidly. However, beach erosion is going to be a serious problem. Beach cabins are nothing new in this area. One Bay City resident told me that his parents had a summer home on Cedar Bayou around the turn of the century. He stated that beach erosion had been severe over the years.

Brazoria County

The three and one half miles of beach between the mouth of the San Bernard and the New Brazos were not visited. This area has not been developed and it is apparently of limited interest even to fishermen.

Bryan and Quintana Beaches are located between the mouth of the New Brazos and the Freeport Ship Channel. These beaches are wide and flat and are not being developed at the present time. Even a slight rise in the Brazos River would flood all of Bryan Beach. One interesting feature of this area is that the waves are cutting back into an oyster grass marsh near the mouth of the Brazos and in this area the intertidal zone is composed of exhumed marsh clay filled with Spartina roots. Wave action is apparently too severe to permit growth of Spartina in the intertidal zone. A beach ridge of sand is thrown up between the exhumed clay and the living marsh. Tar is not abundant in this area although it is common in the swashmarks near the jetty where the beach is relatively narrow and waves are cutting back into a spoil bank.

Shells are not common on the beach. Near the mouth of the New Brazos Pholas campechiensis was the dominant shell with lesser amounts of Tagelus gibbus and Macoma constricta.

Recently a high bridge has been completed over the Intracoastal Waterway to Surfside. The beach from San Luis Pass to the Freeport Ship Channel is developing rapidly and thousands of people use the beach on Sunday afternoons during the summer. Several real estate developers are promoting large areas of this beach as a place for beach cottages. When the much discussed bridge over the San Luis Pass is authorized and built the area will be used much more than at present.

At the time of my visit the beach had been recently graded from San Luis Pass to the Velasco jetty. Furthermore, a continual stream of traffic along the beach tended to pack any petroleum contamination into the sand. Tar was not a particular problem. It occurred in all the upper swash marks but none of it seemed fresh. An estimated one piece one inch in diameter per foot of beach was made for the area, although I counted eight to ten pieces per foot near the jetty.

Shells are not abundant and the more attractive species are quickly gathered by tourists. The shell cusps that I had noticed near San Luis Pass on a previous trip had been removed. Hard shelled clams (Venus) are not uncommon on the beach ridge, but no fresh shells were noted in the foreshore zone.

Wiregrass is the dominant plant on the beach ridge and seaside oats was very rare.

Galveston Island

San Luis Pass is the only channel cutting across the barrier from West Bay to the Gulf. There is a wide sand flat on the Galveston Island side of the San Luis Pass. A little tar, less than one piece to the foot, was found in the swash marks.

Galveston, the port and playground of the southwest, is a city of 67,000 inhabitants and it is the largest city on the open beach in the northern Gulf. It is protected from hurricane tides by seven miles of seawall. Plans for an addition to the seawall at its western end have been approved but work has not been started. Erosion is apparently a serious problem at the western end of the seawall and groins have been built to reduce it. There has been extensive deposition of sand behind the jetty at the eastern end of the island. This longshore drift of sediments increases the contamination by debris near the jetty while the eroding sections along the seawall are relatively free of debris.

The beach along Galveston Island slopes very gently and the foreshore area is very wide. At the time I visited the island the tide was low and the surf was very weak; consequently, the water-logged plant debris was not washing ashore but stranding in the longshore troughs. More net fishermen work more hours along the westernmost nineteen miles of beach on Galveston Island than is the case elsewhere in Texas because there is a ready market for most of the fish in the island cafes. One can tell where the net fishermen have dragged their seine by the appearance of the beach. "Coffee grounds", finely divided organic debris, and larger plant debris are carried upon the beach from the longshore troughs by the seines. I did not find any especially heavy accumulations of tars in these patches of organic debris, so it is improbable that the tar is sinking to the bottom and contaminating the troughs. Near the shoreline, a veneer of small mollusks is deposited. Mulinia lateralis is the most abundant mollusk although in places omphuid worm tubes are very common. Large shells were rare, probably due in part to the hundreds of tourists who frequent the beaches nearly every summer day.

Galveston Island was plagued with sargassum weed throughout the spring and early summer. Additional city employees were necessary in order to keep the beaches clean. Beyond the developed section of beach, blackened sargasso wrack was still present on the backshore. Plants were still drifting ashore singly and they were drying out and blowing up on the beach.

Wind drifted sand was present on the backshore and it formed small dunes along the beach ridge. None of these dunes were over six feet in height. Goatweed, Hydrocotyle and wiregrass were the dominant plants on the dunes. Tidestroma, Atriplex and Sesuvium occurred on the backshore area. Seaside oats was apparently completely absent from the island shore. Tars occurred in swashmarks all along the shore. It appeared in objectionable quantities along the main bathing beaches. In Stewart Park it followed the windings of the high swash mark and was nearly all concentrated in an area a foot wide along the beach. It was more abundant in the little valleys formed between the beach cusps. I estimated eight pieces one inch in diameter per yard in the enclosed beach area. Along the eroding section of the shore it was not common but it accumulated in areas near groins and fishing jetties. I noted that it was particularly common in Termini Park. However, the tar was not the source of many complaints to the beach stand operators, although I heard a few bathers complain. The concession stand operators blame the oil tankers for the beach contamination and I was informed that the beach was relatively clean when I saw it. In sections of the beach where there is heavy traffic, the tar is squashed flat and it becomes heavily impregnated with sand and it is then no longer objectionable to the bather. On the

undeveloped western end of the island I estimated one to five pieces per foot. A few old tar fragments were noted at the base of the dunes.

The operation of the beach seines indicated a considerable population of fish along shore. Emerita and coquinas were not uncommon in the shore zone, but they seemed much less abundant than further south. The ghost crab still occurred in the backshore zone but did not seem as abundant as further south.

Bolivar Jetty to Sabine Pass

Bolivar Peninsula is a narrow strip of land separating East Bay from the Gulf of Mexico. A highway runs the length of the peninsula and a number of cottages are scattered along the beach. The largest development and the most frequented beaches are in the Caplan and Gilchrist areas. Summer beach cottages have been built at six different places between the jetty and Caplan, but nevertheless most of the peninsula is still grazing land for livestock. A number of new cottages were being built and the number of beach cottages will probably continue to increase for some time although the very low coast offers no protection from hurricanes.

The beach slopes very gently along the entire area and the only section of extensive deposition is behind the jetties at Bolivar Pass. Here the extremely wide sand flat contains several tidal pools. A little Spartina alterniflora grows along the border of this flat. At the time of my visit it had been heavily grazed by cattle. The presence of fiddler crabs is unusual for the open Gulf Beach in Texas. About a mile east of the jetty a small bayou draining the back marsh crosses the beach ridge. On this wide flat several plants occur that are not normally found on the Gulf beach. Salicornia bigelovii and Distichlis occurred in small patches.

In general the beach ridge is stabilized by a number of grasses, but where drifting sand occurs, such plants as Croton punctatus and Ipomoea pes-caprae thrive, while on the backshore the dew plant was very common. On the backshore near the Bolivar Jetty, Salsola, probably accidentally introduced by man, was growing.

Considerable amounts of "coffee grounds" drifted behind the jetty, but, in general, except for a little sargassum there was little drift on the beach. Shells were not numerous. Arca campechiensis predominated on the upper beach and Mulinia lateralis was the commonest clam in the foreshore area.

No accumulation of tar was sighted anywhere in this area. I estimated one to three pieces per foot occurred uniformly throughout.

I saw only three buildings between the east end of MacFadden Beach and five miles south of the turnoff to High Island. The road follows closely the beach ridge and in some places less than three feet of land protects the road from wave attack. In places there are sections of an older road that is now being eroded by the sea. Behind the ridge is a marsh that encroaches everywhere on the beach except in the area of the High Island salt dome. Except for the wide MacFadden beach, the beach ridge is nearly everywhere stabilized by grasses. One of the dominant plants on the ridge is Panicum amarulum. The dew plant is the common plant on the backshore.

The slope of the beach is almost imperceptible and when I visited it the first longshore bar was exposed. Tide pools were developed behind this bar and the cutouts (channels through the bar) occurred quite regularly at approximately one tenth of a mile intervals. The bottom of

these tide pools was formed by a few inches of sand on top and then a dark clay. One of these tide pools near High Island was examined for larger organisms. The only fish entrapped in the pool were a number of small silversides. Corixids were observed swimming in the water and several were caught. Two live coquina clams were taken, but one was on the surface in distress, so apparently such a situation is not favorable for them.

Sargassum wrack occurred along the entire beach, but it was all old and blackened. Plant debris in general was uncommon. Exotic seeds were rare, but several Entada beans were found as well as one or two of the other tropical seeds encountered further south in Texas. No red mangrove seeds were observed. Pumice stone was also found in the wrack and it, along with the seeds, seemed most common on the High Island beach.

Approximately fifteen miles of beach were fouled with menhaden. Most of the menhaden were ashore in a section of beach ten to fifteen miles east of the High Island turnout. From here to the end of MacFadden beach the number of menhaden decreased from an estimated twenty-five menhaden to a yard to three to the yard. I calculated that approximately 20,000 pounds of menhaden had washed ashore. At one place there was a long windrow of menhaden bones. The windrow was approximately one hundred yards long, six inches to a foot deep in the center and approximately two feet wide. Apparently longshore currents had dumped these menhaden bones in that area because they were not common elsewhere.

In addition to the menhaden there was considerable oil pollution. Large thick globs of what appeared to be an oil, rather than the usual tar, washed ashore (see figure 8). This oil was especially prevalent

in the tidal pools. However, tar, while present elsewhere in the area under consideration, was not abundant. Estimates of two to three pieces, one inch in diameter, per foot of beach were made by me.

The reason for the dead menhaden on the beach is not known to me. However, menhaden boats were working inshore and some menhaden, although killed, would not be recoverable from their nets. The clerk in the concession stand on MacFadden beach stated emphatically that the pogie boats were responsible and that they had been working several days near shore.

A lot of small shell was seen along with the menhaden bones. Some of this shell looked fresh, particularly the dominant Mulinia lateralis. Hinged coquinas, Arca incongrua, and a single hinged Periploma shell were seen. From High Island to Sabine, Pholas and Barnea were the dominant shells in the high swash marks.

From the end of MacFadden Beach to Sabine Jetty is an area of salt marsh. The beach ridge is not passable to a jeep and oyster grass grows in the intertidal zone which is chiefly marsh clays. Fiddler crabs are common along the edge of the beach. Four live arcids (Arca campechiensis) were observed living at the lower edge of the intertidal zone. Only a few pieces of tar were sighted in approximately two miles of beach that I walked. The remaining six miles of beach were not examined but the charts show the same type of marsh as that which I checked. A beach ridge is thrown up in the back marsh and piles of small shell, mostly Mulinia, accumulate in great abundance in the small indentations of the shoreline.

The back marsh is almost exclusively Spartina alterniflora, but several small black mangrove plants (Avicennia nitida) were seen near

the beach. A few black mangroves were also observed in the back marsh at the mouth of the new Brazos. Otherwise this plant occurs along the Texas coast in a few areas in Aransas and South Bay.

Cameron Parish

When the present roads that are now under constuuction are completed, Holly Beach and the remaining coast between Sabine and Calcasieu Pass will be readily accessible to the major population centers of Lake Charles and Port Arthur. At the present time no paved roads lead to this section of the coast and the cutoff from Port Arthur across Sabine Lake to the Louisiana shore has not been completed. However, the beach is slowly being developed and new cottages are being built. The beach is higher and offers better building sites than does the section of the coast between Gilchrist and Sabine, Texas. On the old chenier ridge at Ocean View Beach there are elevations of ten feet above high tide. At the present time Holly Beach is the only sizable settlement and it consists mostly of summer cottages with the attendant service businesses such as grocery stores and gasoline stations. Most of the beach front is pasture land and even along the mile long Holly Beach there is open range. Cattle may be seen standing in the water with the bathers.

In general the beach ridge is well stabilized and on some sections huisache occurs in dense clusters. Behind the ridge is a back marsh where oyster grass, Spartina alterniflora, is the dominant plant. The beach varies from a hard-packed sand with considerable amounts of organic material and mud to a muddy intertidal zone. The salt marsh extends to the coast in the vicinity of Calcasieu Jetty and for approximately five miles along the beach east of Sabine Pass. In these areas the shore line

is composed of mud with oyster grass growing in the intertidal zone in scattered clumps and it also grows above the normal high tide line. A low beach ridge that is built back in the marsh has slightly different vegetation and the most conspicuous plant is the marsh elder (Iva frutescens). At the edge of the high tide zone the mud will dry and crack. At the time of my visit the back marsh was very dry and jeep trails led to the Sabine jetty. I drove within two miles of the jetty before returning to Holly Beach. In general the muddy shores were free of tar and I found only one large piece, ten by twenty inches, in the oyster grass about two miles from Sabine Pass. The dominant organism along the muddy shore was the fiddler crab. Sargassum drift was common alongshore, but shells were rare.

The remaining twenty-two miles of beach is a hard sand. Usually there is a nip at the base of the beach ridge and from there the beach slopes very gently offshore. The surf was light and the longshore bars were not strongly developed. The water was very muddy, which is the usual condition in this area. A number of shells wash ashore, and a number of rather delicate shells like wentletraps (Epitonium) were not uncommon. Approximately twenty-five miles west of Calcasieu Pass a bayou drains across the beach ridge into the Gulf. On the wide muddy beach near the mouth of the bayou I found more shells than elsewhere on the beach. Polynices duplicata was the most abundant mollusk in the drift, but a number of other snails, including Busycon pyrum, Thais and Epitonium, were common. Twenty-five old fighting conchs were seen on one hundred yards of beach. I did not find this species in greater abundance anywhere else on the northern Gulf beaches. Arca campechiensis, Barnea truncata and Pitar texasiana were not uncommon.

In general the commonest drift was old sargassum wrack. In some areas water hyacinth was common. I did not note any pumice stones or any of the plant seeds that occurred to the westward. Tar was rare, and my estimates ran from one piece per five yards to one per ten yards. One resident of Holly Beach said that oil did not strand here.

East of Cameron the beach is not passable by car. Two miles of beach east of the circle were examined. The circle is a beach hotel and for its guests to go swimming they have a catwalk extending over the intertidal zone and out to the second longshore bar where there is hard sand. The intertidal zone is muddy, and behind the low beach ridge is a back marsh of oyster grass. Some oyster grass grows in small clumps in the intertidal zone. This same condition prevails in the area between the circle and the east jetty of Calcasieu Pass. Cattle have tramped thoroughly the beach in this area, where I found only a few pieces of tar. Sargassum wrack was common on the backshore and in the corner behind the jetty was lots of organic debris including sargassum and water hyacinths.

Vermilion Parish

A beach ridge, three to six feet high, forms the border between the large uninhabited marshes and the Gulf along most of the coastline of Vermilion Parish. This beach can only be reached by boat from the larger cheniers such as Pecan Island through the numerous canals. Except for cattle ranches on Mulberry Island and Chenier au Tigre the entire coastal area is devoted to game refuges and muskrat trapping. In recent years an introduced fur bearer, the <u>nutria</u>, has become commercially important. The beach ridge slopes rather steeply toward the sea, but the foreshore area slopes very gently.

The top of the ridge was covered chiefly with a weedy yellow flower (Sideranthus). The back side of the ridge had marsh elders (Iva frutescens) and sea oxeye (Borrichia frutescens) and it graded from here into the salt marsh vegetation which consisted almost exclusively of oyster grass. Oyster grass also grows in front of the ridge in a few places, particularly near the bayous and out in front of Chenier au Tigre and Mulberry Island where new land has been built by deposition of mud in front of the beach ridge.

Between the Cameron Parish line and Little Constance Bayou the beach ridge was shell and silty sand. Thousands of Arca campechiensis shells occurred on the beach and these together with windrows of Mulinia and other small mollusks in the lower swash marks characterized the beach. Other common mollusks were Polynices, Barnea, Pitar texasiana, Busycon pyrum and Busycon contrarium. At the mouth of the bayous, where exhumed marsh clay was present on the shore, Macoma constricta was common. In a few localities large oyster shells were present and they probably indicate a reef offshore.

Tar was present in scattered chunks along the entire beach. The pieces averaged larger than those found elsewhere, many of them being three to four inches wide. At the mouth of East Little Constance Bayou a piece of tar about one-half inch thick and two square feet in area adhered tightly to the underlying marsh clay. Wave action is not very efficient in breaking such chunks of tar loose from the clay and moving them upon the beaches.

Mulberry Island is the headquarters of Martin Miller's ranch and all the inhabitants are ranch employees. The coastline off the island is building rapidly seaward by the deposition of mud in front of older

marsh elder covered beach crest. Between the older crest and the open sea, oyster grass grows in a zone approximately two hundred feet wide.

Beach wrack, consisting chiefly of water hyacinth, is grounded in the front marsh about sixty feet from the seaward border of the oyster grass. Besides large amounts of water hyacinths a bryozoan, probably Bowerbankia, was common in the drift. The mud in the intertidal zone is very soft and difficult to traverse on foot. Very few shells were seen and these were chiefly Mulinia, Polynices and Petricola. The absence of Arca campechiensis is peculiar in that it occurs in abundance in the older beach ridges and fresh shells are not uncommon around Big Constance Bayou. The dominant organism in the intertidal zone was the fiddler crab. Mollusks, such as Volsella demissus, Littorina irrorata and Melampus which are common in oyster grass in the back marshes, were not found here. No tar was found but a ranch employee said it occurred along the shore a mile to the westward.

Chenier au Tigre is approximately twelve feet high at its highest point and it is covered by a number of trees. At one time, about thirty to forty years ago, this chenier was an important resort. During the summer season tourists were brought to Chenier au Tigre by a boat from Abbeville. However, the beach development was ruined by a hurricane and later, extensive deposition of mud on the foreshore completely spoiled the beach for bathing. A few ranchers and trappers still reside at Chenier au Tigre. There has developed a wide oyster grass marsh between the beach and the chenier except in a small section about one-half mile east of the tower where the sea is still cutting back against the chenier. The water is very muddy, even on calm days. The beach was hard and consisted chiefly of a fine silty sand, although broken oyster shells were

conspicuous in some places. Very few shells were washing ashore. Mulinia was the most common shell and on the depositing shore Macoma constricta was common. Besides a few logs there was only a little water hyacinth along with a few fragments of organic material in the drift. No sargassum was sighted.

Tar was rare and broken in small fragments. I estimated one piece, one inch in diameter, per yard. However, the beach had been heavily trampled by livestock which would tend to obscure contamination.

Timbalier Island

One phenomenon of the coast between Terrebonne Island and Atchafalaya Bay has been the severe erosion that has reduced the size of the outer islands during the past century. For example, during the middle of the nineteenth century Isle Derniere was an important resort center. Now it is reduced to a beach ridge with a narrow marshy backshore. The same situation is true of Timbalier Island, although it was apparently never used for any purpose besides ranching. I examined two miles of beach on the western end of the island. The island is very low and tides only a foot above normal would flood most of the west end of the island. The beach slopes very gently and during my visit the tide was very low but rising. Large sawfish, mullet, two small lemon sharks and a number of small killifish (Fundulus similis) were active along the beach and they swam in and out of the tidal pools behind the second bar. The surf was weak and the water was very clear, a very unusual situation for this coast.

According to the Coast Pilot a clockwise eddy with an average velocity of one-fourth knot covers most of the bay formed by the curving coastlines between Southwest Pass and Timbalier Bay. The drift on Timbalier Island was strikingly different from that on Grand Isle to the east and

Chenier au Tigre to the west. Fresh sargassum formed a windrow on the shore approximately fourteen inches wide and twelve inches deep. No fresh sargassum was drifting ashore during my visit, but the tide was very low and the sea was very calm. A number of red mangrove seeds (one per twenty yards of beach) were seen. Along with these seeds were a few black mangrove seeds which may have originated locally and three globular nuts that were similar to drift nuts on the Texas coast.

Tar was common. It occurred in rolled rather than flat pieces and it apparently was rolled up the gentle, sloping beaches by the waves. It was soft and appeared to be fresh. Most of the tar was in the high swash mark, but I noticed some along the edge of a cutout through the second longshore bar. I heard reports previously of the stranding of tar on Timbalier Island and according to my informant, Dr. Sewell Hopkins, it was supposed to strand more frequently there than anywhere else in Louisiana. This coast is not frequented by bathers and I was impressed by the amount of marine life visible about the island and on its shore. The detrimental effects of tar strandings, if present, are not apparent.

Fresh shells, particularly hinged discus shells, and Arca incongrua were very abundant. Barnea truncata and Polynices shells were also common and on the second longshore bar I found several living Oliva snails.

Birds were very common. Pelicans, cormorants and sanderlings were particularly noted because of their abundance.

Grand Isle

Grand Isle is the most important resort center on the open Gulf in Louisiana, and it is the closest Gulf beach to New Orleans. The beach is made up of sand, but it is rather dark due to organic materials. In

recent years the sea has destroyed a considerable area on the front beach and erosion continues to be a very serious problem. A number of groins have been built and in addition spoil has been pumped into the front beach. However, onshore waves had already removed a portion of this fill a month later. Much beach property is being lost to the sea and before the pumping of the fill some of the houses were sitting on piling in the intertidal zone.

I visited Grand Isle twice during this investigation and I found the beaches surprisingly free of drift on both trips. On October 17, 1954 I noticed an accumulation of finely divided rotting organic debris on the beach near Caminada Pass, but it covered an area less than one-fourth mile long. Small amounts of "coffee grounds" together with fecal pellets occurred elsewhere on Grand Isle, but it formed a thin veneer in the lower swash marks.

Tars were very scarce and I had to search carefully to obtain a large enough sample for analysis on September 7, 1954. Tars were even scarcer on October 17, 1954 when I found none between the shoreline and the beach crest. Personnel at the Texas A. & M. Research Foundation informed me that they had never found large amounts of oil on the beaches and that they had received no complaints.

Very few shells were present on the beach, which may be due in part to the activity of tourists. A few Macoma constricta, Mulinia, Donax, Arca incongrua and Dosinia discus shells were noted.

Very little plant drift, besides the debris mentioned above, was found on the beach. Oyster grass and alligator weed were found on the beach during September. Nothing was found on the beach that could not have come from Barataria Bay or the Delta.

Bryozoans comprised most of the drift on the eastern end of the island on October 15, 1954. Zoobotryon, Bugula and Bowerbankia all occurred in the low swash marks. Bryozoans often collect in the longshore troughs rather than wash ashore.

One biologist informed me that he had noted layers of oil and sand in the beach sediment at Grand Isle, and that mud shrimp (Callianassa) were killed. This is not taking place at the present time. I did not note any such layering of sediments and I checked the beach for Callianassa. A very low tide, which exposed parts of the second longshore bar, revealed hundreds of holes of the mud shrimp and I could secure them easily by digging. In general the intertidal zone at Grand Isle was much richer in marine organisms than a similar section of Texas beach. Along the passes and in all tidal ponds there were numerous small fish and a few crustaceans visible even to the casual observer.

Terrebonne Island

At one time there was a sugar plantation and an elaborate drainage system on this island. Now it has eroded away until there is a narrow sandy beach ridge and on the bayside a marsh of oyster grass and black mangroves.

Terrebonne, like Grand Isle, was clear of sargasso weed and according to local residents on Grand Isle no large quantities of sargassum had washed ashore this year. A little oyster grass and alligator weed were observed in the swash, but the beach was very clean. A few Donax, Mulinia, Macoma, Periploma and Tellina shells had drifted ashore. Thais shells with the common hermit crab, Clibinarius vittatus, were observed on the Gulf beach. This little crab, while common in the bays, does not normally live on the Gulf beach.

Tar was very rare. I estimated one piece, on inch in diameter, per ten yards of beach.

St. Bernard Parish

I did not visit the Chandeleur Islands. These islands are rather inaccessible, although recently they have proved interesting to sports-fishermen. A flying service in New Orleans regularly flies fishermen to the Chandeleurs. I received no reports of tar on the beaches although one person said he had seen tar on neighboring Breton Island.

Mississippi

If tourists can be attracted to an area by artificial improvements of the landscape, certainly the state of Mississippi is one of the leaders in the field. Thousands of tourists come every year to the Mississippi coast and the State and private individuals have expended much effort and money to improve the tourist facilities. A seawall has been built from Bayou Caddy to Biloxi and twenty-seven miles of artificial beach has been built by pumping white sand from the bottom of Mississippi Sound. The maintenance of this beach is a big problem and two bulldozers are used almost continually to spread the sand when it blows against the seawall. In addition, at least one of the larger resort hotels keeps a beach sanitizer, a machine which picks up debris, to keep its section of the beach clean.

One would not expect to find any tar on such a well-tended beach and indeed, I did not find more than a few well-sanded pieces. Furthermore, I did not once hear a complaint concerning oil pollution at any time in the past.

Drift of any kind was rare on the beach. I saw a little roseau cane, oyster grass and a little finely divided plant debris. Very few shells were found and the only common species was the razor clam, which occurred locally in some abundance.

A much discussed project is the construction of a causeway to Ship and Deer Island and later connecting Horn Island to Ship Island. That such a project has not yet been undertaken can be blamed on the hurricane of 1947 which destroyed the small development on Ship Island. Earlier the great hurricane of 1918 not only destroyed a casino but it also destroyed the small island, the isle of Caprice, on which the casino stood. This little island is now a small shoal between Horn and Ship Island.

I visited Ship Island on October 14, 1954 and I walked a mile of beach near the western end. The eastern end is the broad foreland with pine trees and it tapers to a narrow treeless flat at the western end. The island at Fort Massachusetts is very narrow and consists of a sand beach and a low grassy area with ponds and channels along the bay shore. The white sand beach is frequented by swimmers during the summer and at the eastern end of the island is located the officer's club of Keesler Air Force Base. At the time of my visit the island was overrun by mosquitoes, but they are kept in check during the main tourist season by spraying.

The beach slopes gently seaward and a backshore approximately one hundred feet wide ends against low dunes, six to eight feet high. Ipomoea littoralis, seaside oats and Iva frutescens were common. Panicum amarulum and goatfoot morning-glory were present but rare.

I did not find a single piece of tar on the beach and only a little sargassum and woody debris. On the bay side at Fort Massachusetts a lot of sea-grass (Halodule) had stranded along the beach.

I found very few shells. Arca and Dinocardium were the most abundant mollusks.

Apparently the islands in Mississippi Sound are relatively free of tars or it strands infrequently because I heard no complaint concerning contamination.

From Ocean Springs, Mississippi to Cedar Point in Alabama there has been no major beach developments. Ocean Springs and Pascagoula have their own beach development but the length of coast line involved is only a few miles. I examined the natural beaches at Graveline Bayou and Swetman's Landing between Ocean Springs and the mouth of the Pascagoula River. The very narrow white sand beach ends against a bank on which pine trees are flourishing. Near Swetman's Landing the beach had eroded and stumps were still standing in the intertidal zone. Tar was very rare, and only two pieces were found along two hundred yards of beach near Graveline Bayou. I did not take any tar along the two and one half miles of beach at Pascagoula.

Dauphin Island

Dauphin Island, the most populous island in Mississippi Sound, is now undergoing a large real estate development. The State of Alabama is constructing a causeway to the island and it is scheduled for completion by June 1, 1955. The little fishing village will be greatly changed if present plans are realized.

The island is densely timbered with pines and a few oaks at its eastern end. The western two-thirds of the island is a narrow low marsh that is used exclusively as grazing land. There has been some erosion at the eastern end of the island and near the pass several groins have been constructed. A few tree stumps can be seen in the intertidal zone on the eastern third of the island. The vegetation on the island has been altered by overgrazing particularly by goats. One of the commonest and most characteristic plants on the dunes is the goatweed, Croton punctatus. On the low marshy end of the island a sedge, Fimbristylis, is one of the most abundant plants. At one place there are enormous active dunes, which are undoubtedly some of the highest in the northern Gulf. Only the tips of some of the pine trees are sticking out above the dunes. In general, the white sand beach slopes gently seaward except at the western end of the island where the beach is steep.

Aside from the driftwood on the beach there was only a continuous swash mark of sargassum on the beach. Sargassum occurred only sparingly on the beaches in Alabama during the past spring and summer.

Except for large numbers of old valves of the hard shell clam, in the swale behind the beach ridge on the western third of the island shells were not numerous. The little clam (Divaricella) was noted as common on the sand beach at the western end of the island. Live coquina shells were noted in a tidal pool, but they did not seem to be abundant anywhere.

Tar was rare and I found tar in the drift at only a single station, approximately three miles west of the eastern end of the island. Even here the pieces were heavily impregnated with sand. For about one

hundred yards I found tar at the rate of one piece, one inch in diameter, per foot of beach.

One large piece (eight inches long) of pumice was found on the west end of the island. This was one of the two pieces of pumice that I found in the eastern Gulf. The other piece of pumice was found on the beach at Miramar, Florida.

Cedar Point

I examined three hundred yards of beach near Cedar Point. On the west side of the point and extending along the shore of Mississippi Sound is a ridge composed almost entirely of oyster shells. The top of the ridge is heavily vegetated with woody shrubs including Baccharis halimibolia, Ilex, Gaura and Iva frutescens. Behind the ridge is a marsh and the dominant and indeed only vegetation in most of it is the black rush. No signs of oil contamination were found along the ridge.

Mobile Bay

Mobile Bay has narrow beaches and a wooded shore. Most of the shore is private property and numerous homes dot the shore. An artificial beach is now being built by pumping onshore sand from the bay bottom in an area near Mobile.

Baldwin County

A beautiful white, sugary sand beach extends from Mobile Point to Alabama Point. The backshore is narrow and it averages between eighty and one hundred feet wide, but in a few areas it is as narrow as ten feet. The beach is steep and debris normally accumulates in the trough at the base of the high tide ridge. The backshore is bordered nearly

everywhere by dunes on which seaside oats flourishes. Although other plants, such as goatfoot morning-glory and goatweed, which are common on the Texas coast occur, they are very rare. Iva frutescens is the common plant on the backshore near the base of the dunes.

Drift mollusks were rare on the steep beach. Chione intapurpurea, Divaricella, Donax and Dinocardium seemed the most abundant.

Live coquinas, Emerita and Lepidopa were taken in the intertidal area. The water was very clear and numerous holes, possibly Callianassa holes, were seen on the longshore bar and trough.

Drift on the beach was rare, and the high tide ridge was too steep for algae and other plant debris to lodge. Breakers high enough to carry the debris over the high tide ridge and onto the backshore must have been rare or non-existent for a couple of weeks before my visit or there would have been some drift on the backshore. Algae move back and forth in the trough except for the heavier plants that sink to the bottom. Algae proved objectionable to bathers, particularly, since most of the algae was a sticky filamentous brown algae called Pylaliela fulvescens, and many complaints were received by the chief marine biologist of Alabama. Several other algae, including sargassum, formed a part of the drift.

Tar was not observed on the backshore or in the longshore trough. However, tar appeared in the swash marks that ran back in the dunes. When this tar was deposited on the beach or how many years accumulation it represents is unknown. I made estimates of three to five pieces, one inch in diameter, per yard of beach. However, most of the swash mark was concealed by sand and it is not known if much tar was buried.

The chief marine biologist of Alabama told me that he had received one complaint from a tourist court operator near Alabama Point about oil contamination on the beach during the summer of 1954.

Except at Gulf Shore, Alabama and Alabama Point there has been no development of the open beach. Much of the beach, particularly the narrow strip between the Gulf and Little Lagoon, is not suitable for development. At the western end on the shores of Mobile Bay is the Fort Morgan State Park.

Florida Point to Pensacola Bay

This area is similar in nearly every way to the beach in Baldwin County, Alabama, except that there is even less development along the shores. The outstanding landmark is the ruins of an unfinished hotel at Gulf Beach, Florida. The major development is the Rosemond Johnson beach, which is a beach for colored people, and the site includes a few tourist cabins.

The major difference between this area and Alabama was the stranding of a small amount of sargassum and turtle grass on the backshore. Tar, if anything, was less frequently exposed. I found one area where I estimated one unit of tar per foot at the base of the dunes. The sand on the beach was soft and it was very difficult to drive the backshore.

Santa Rosa Island

Santa Rosa Island is a narrow strip of white sand that extends from Fort Pickens to East Pass. A recreational area has been built at Pensacola Beach by Escambia County and a number of motels have been built to accommodate tourists. The cabins are built on a ridge formed by leveling the foredunes and pushing up sand until the desired height (approximately ten feet) is obtained. The island beach is fine sand and it is only passable in a four wheel drive jeep. Needless to say, the island is only developed where there are roads. A road runs westward from Pensacola

Beach to Fort Pickens and it extends less than five miles eastward of Pensacola Beach. From Pensacola Beach to where The Narrows are bridged at Fort Walton there are no roads. Fort Walton Beach has a fishing pier and other tourist accommodations. The advertising slogan of Santa Rosa Island beach is that it is the most beautiful beach in the world.

In general, the backshore on Santa Rosa Island is narrow and it ranges from seventy to one hundred and thirty feet in width. It ends against foredunes that are stabilized on the seaward side by a dense growth of seaside oats, although other flowering plants, such as Heterotheca latifolia, Hydrocotyle, Galactea, occur but they are not abundant. Iva frutescens is the conspicuous plant at the base of the dunes and on the edge of the backshore. Seaside oats sometimes invades the backshore, but it is not common. The dunes behind the foredunes have large bare areas and are often partially covered with a scrubby woody vegetation such as yaupon, live oak and Chrysoma pauciflosculosa. Pines are common along the shore of Santa Rosa Sound. Some of the higher foredunes (up to 40 feet high) along the coast appear to be remnants of the older dune system and they have woody vegetation including live oaks, yaupon, Chrysoma, and Magnolia foetida on the summit. Although sand drifts around the base of the dunes at times, common plants along the Texas coast such as goatweed and goatfoot morning-glory were very rare.

The high tide ridge is steep and most of the time it was mandatory to drive on the backshore. The ghost crab occurred on the backshore, and although it maintained holes here, it would bury itself immediately in the soft sand when disturbed. The water along shore is very clear, and even with a moderate surf it was only a little turbid where the waves broke against the high tide ridge. The water deepens, as one moves

seaward, more rapidly here than elsewhere in the northern Gulf. The foreshore area seemed rather barren of life although a coquina clam (a different species than the common one on the Texas coast) occurred sparingly.

Mollusk shells were uncommon along the beach. Donax, Chione intapurpurea and Lucina radians predominated. Dinocardium, Macrocallista nimbosa and Strombus occurred sparingly in the drift. The beach could be characterized by the meagre shell drift as a Donax-Chione beach.

Sargassum wrack occurred in a single swash mark along the entire island. In a few places a little algae of other species occurred, but it was not abundant except near the west end of the island where it occurred in the trough along shore. From Fort Walton Beach to East Pass turtle grass occurred in the drift.

Tar was found along the beach from the very high dune one mile west of Pensacola Beach to a point twenty-five miles westward of the water tower. No tar was observed on the main bathing beach and it was found in only two stations in the sargassum wrack on the backshore where I estimated one piece of tar every twenty yards. However, where the swash had spilled over around the base and into the dunes and had not subsequently been covered by sand, tar was not uncommon, and I estimated quantities of one piece per foot of beach to one piece per yard. One large tar "ball" was found and photographed (figure 10). It was located along the base of the dunes approximately seven miles east of Pensacola Beach. This tar at the base of the dunes was old and it may have been accumulating for a long number of years. That such accumulations occur over a period of years is supported by the fact that I received no complaints of oil pollution and I was told emphatically that it never occurred by one marine biologist who works in the area.

Drift of plant seeds was very rare and I found only two Mucuna sloanei seeds on the beach. Furthermore, I did not see any pumice stones.

Birds have been rare along the beach and in general marine life seemed sparse. It seems that a beautiful beach is also a sterile one.

East Pass to St. Andrew Bay

Beautiful white sands and clear water have attracted thousands of visitors to the summer resorts around Panama City. One of the most highly developed sections of the Gulf coast is the coastline from Inlet Beach to St. Andrew State Park. Although the number of tourist courts is very impressive, it is said that the accommodations are not nearly adequate for tourists on busy summer week-ends. Further construction of tourist accommodations to the eastward is blocked by Tyndall Field and by the very limited extent of white sand beach. Therefore, most of the development is to the westward. The main highway runs along the first row of dunes from Destin to Frangista beach and then it makes a broad arc behind the back lagoons and swamp and meets the coast again near Inlet Beach. At no point is the highway more than four miles from the beach, and small beach developments such as Grayton and Seagrove Beach have developed where access roads have been constructed.

The foreshore of the beach slopes very steeply and the backshore is narrow (70 to 130 feet wide) and it ends against low dunes. Many of the dunes have been altered by construction along the coast. The usual method is to level the dunes and push up additional sand from the backshore, if more sand is needed to reach the desired height above high tide. Nearly all the natural foredunes have been stabilized by a dense growth of seaside oats. At the base of the dunes and extending a few feet

on the backshore one finds Iva frutescens as the most conspicuous plant although small clumps of seaside oats invade this situation. Both the common morning-glories occur locally but they are rare. On some of the low dunes near where the back lagoons are very close to the coast, such as at Destin, Florida, Panicum amarulum is common. Palmetto grows on some of the higher foredunes and pine trees approach the coast, but the pines grow behind the foredunes.

From Frangista Beach to Inlet Beach the back lagoon is broken up into a series of small ponds and lakes that drain across the beach ridge. I counted ten major outlets in the above area, but some are mere washovers while others are connected with the Gulf at times of high tides. From Inlet Beach to the western end of Grand Lagoon the drainage pattern has been altered by tourist developments, but several outlets artificially confined cross the dune ridge and enter the Gulf.

The steep foreshore with a high crest acts as a barrier to the passage of drift upon the backshore except at times of very high or storm tide. Plant debris commonly accumulates in some of the deeper holes in the longshore trough. I noted a swashline of sea-grasses all along the backshore that varied in width from a few inches to nearly a foot, but it was not abundant enough to be objectionable to bathers except in a few localities. Manatee grass was the most abundant plant in the drift. Turtle grass was conspicuous but it was not abundant. Other components of the drift were sargassum and in a few localities I recorded the presence of a small amount of red and other brown algaes. Sea-grasses grow luxuriantly in the bays and several species, particularly manatee grass, are common offshore in shallow water. Sea-grasses often

strand on bay beaches in large windrows. Several insects breed in this decaying plant drift including a fly which is particularly obnoxious because of its bite. Panama City developed rapidly as a beach resort after this insect was controlled by spraying.

I did not find any oil contamination along this beach, and it apparently rarely occurs, if ever, as I was informed that it did not by local residents. The beach was also clear of other drift objects such as tropical seeds. I found only a single piece of pumice stone, and it was found on Miramar beach.

Shell drift was very scanty to say the least. All along the beach coquina shells formed the most characteristic and abundant component of the drift. Large shells were definitely rare although the odd Dinocardium valve was found at all stations. At some localities Lucina radians and Divaricella were common components of the drift.

Mexico Beach to Port St. Joe

Crowded between St. Andrew Point and St. Joseph Point is a small section of Gulf beach that is now being developed primarily as home-sites for employees at Tyndall Field. This beach is white sand with a moderately sloping foreshore and it narrows and finally disappears at the mouth of the canal connecting St. Joseph Bay to the Intracoastal Waterway.

I found sea-grasses very abundant in the drift and turtle grass became particularly abundant on the beach of St. Joseph Bay. The long-shore troughs contained considerable quantities of sea-grasses and one species of Bryozoa. Neither petroleum residues nor tropical seeds were found. Shells were especially numerous and varied on the beach protected by St. Joseph Point.

Cape San Blas to Peninsula Point

The beach from Indian Pass to Cape San Blas is a wide flat beach with a gently sloping foreshore. Except where the coast is flanked by Money Bayou and Indian Lagoon there are small foredunes covered with seaside oats. Goatweed and goatfoot morning-glories are common near Cape San Blas. Pine trees grow along the beach behind the foredunes. The area has been subdivided and a tourist development is planned except around Cape San Blas which is a military reservation.

When I visited the coast a strong onshore wind was blowing and the surf was rather heavy. The water was a very muddy brown as far as I could see. The beach sand is finer and darker than the sand further westward.

The foreshore teemed with life. Thousands of coquina clams, very close if not identical to the common species on the Texas coast, were rising as the swashes moved across the beach. Numerous Terebra shells were also present among the coquinas. One live horseshoe crab was found along the beach. Although this crab has been reported as common in the Chandeleurs, this was my westernmost locality for the species on this trip.

As along the Texas coast, the common shells in the drift were members of the family Arcidae. Arca campechiensis and Arca incongrua were particularly abundant. Noetia ponderosa and Arca transversa were found in lesser abundance. Another common shell was Chione cancellata. Pecten irradians and Pitar texasiana were present but rare.

The beach was very clear with very little plant wrack. A little drift of sea-grasses was noted in the swash line. No petroleum residues were found.

St. Vincent Sound, Apalachicola Bay and St. George Sound are more or less protected by the barrier islands of St. Vincent, St. George and Dog Island respectively. St. Vincent Island is a bird refuge and it was not visited. Dog Island is a five mile long island that will be connected by a ferry with Carrabelle by June, 1955. I visited only the largest island, St. George, which will also be connected with the mainland by a ferry by June, 1955. St. George Island has not been developed although a big real estate development is planned. St. George Island has been cut into by the dredging of a small pass across the island. However, it is probable that the pass will soon sand over, because one can see breakers on the longshore bars across the mouth at the present time. There has been some erosion along the shore near the cut and apparently the Gulf shore of the island is retreating as pine stumps are exposed in the intertidal zone near the cut.

The beach on St. George is white sand and the foreshore slopes rather steeply. The backshore was soft sand and difficult to drive. It ends against dunes which are covered with seaside oats. Some of the higher dunes have woody vegetation including live oaks, yaupon and palmetto. Except for the eastern one-fourth of the island it is densely wooded with pines behind the foredunes.

Sea-grasses contributed most of the material to the drift, and in some areas small windrows were formed along the beach. Manatee grass was very common but a considerable part of the drift was composed of turtle grass. Sponges were noted particularly on the eastern part of the island. Shell drift was not particularly conspicuous. The beach could be classified as an arcid beach because of the predominance of Noetia ponderosa and Arca transversa. On the eastern part of the island broken fragments of Dinocardium were very abundant, and over a dozen

hinged cockles were found in one locality near the middle of the island. Paper fig shells occurred sporadically all along the beach.

No petroleum residues were observed on the island. Walter Yearty, who has probably spent more time on St. George Island than any other man in the Apalachicola region, told me that I would not find any oil on the beach unless some had been blasted loose by the seismographers. Some oil from a sunken ship had washed ashore during the war, but aside from that he had never noticed any tars on the beach.

The mainland shores were also examined at several points in this area. In many places there is a very narrow beach of white sand which sometimes is filled with pine stumps. One small beach section is Carrabelle Beach. This beach is opposite open water between Dog and St. George Island. It has a relatively wide white sand beach and low dunes at the edge of the backshore are covered with seaside oats. Turtle grass and some manatee grass drift ashore and form large windrows of drift. Hinged coquina shells were observed on this beach. Lanarck Beach is another small section of beach on the mainland shore. It has a narrow white sand beach, but offshore is muddy bottom and it is bounded on the northeast by oyster grass in the intertidal zone. Small narrow white sand beaches occur at St. James and St. Theresa. Pine trees occur right along the edge of the beach. The foreshore area is very flat and shallow water extends a considerable distance from low tide.

Peninsula Point to Ochlockonee Bay

The peninsula separating Alligator Harbor from the Gulf has been chosen by a number of residents of Tallahassee as a site for summer cottages. The beach is composed of white sand. The narrow backshore

ends against a series of low dunes. The dunes are chiefly stabilized by seaside oats and wiregrass. Hydrocotyle is common on the dunes although it is not an important stabilizing plant. Atriplex and Sesuvium were both found along the edge of the backshore.

The foreshore slopes moderately seaward. Live coquina clams were abundant in this area.

Near Peninsula Point large cockle shells (Dinocardium) were very abundant. Otherwise the shell drift was not conspicuous although this may be due to beachcombers. Venus, Pecten, Noetia and Anatina were particularly noted on the peninsula. The chief drift along the beach was sea-grass wrack that was composed almost entirely of turtle grass, although two other grasses, manatee grass and Cuban shoal grass, were also found in the drift. Large windrows of sea-grasses nearly covered the backshore zone near the point.

From the base of the peninsula to Lighthouse Point the beach is eroding badly and pine stumps are exposed in the intertidal zone. The beach is relatively narrow here and it is difficult to drive because of the stumps. A small roadside park has been built in this area, and a bathing beach developed by clearing the intertidal zone. The beach is narrow, and sea-grass wrack was common. Spisula was the most common large shell along this section of the beach.

From Lighthouse Point to Bald Point the beach is undeveloped but a road parallels the beach. It is located several hundred yards inland. Parking spaces are provided along the side of the road. The intervening area is mostly sand dunes. Many of them are partially active, but woody vegetation, including pines and palmettos, is common. Sea-grass wrack was very abundant in this area, but the beach was particularly characterized

by the abundance and variety of the sponges washing ashore. This sand beach ends of Ochlockonee Bay where a black rush marsh forms the shore zone.

No petroleum residues nor tropical seeds were discovered along the beach. All the drift could and undoubtedly did come from nearby localities.

Mashe's Island to Clearwater Beach Island

Mashe's Island and Clearwater Beach Island both have white sand beaches but the intervening coastline is characterized by black rush salt marshes or mangroves.

Mashe's Island is a very small island on the northeast point of Ochlockonee Bay, and it has a small roadside park with a bathing beach. The white sand beach is narrow, but the foreshore is very flat due to a spit that extends several hundred yards offshore. The island is separated from the mainland by a black rush marsh with tidal channels. The small sand dunes along the edge of the backshore are stabilized by seaside oats and a few pines. Large amounts of turtle, manatee and Cuban Shoal grass were washed ashore in windrows. There were a few pieces of petroleum residues along the beach. The presence of the carapaces of a number of horseshoe crabs and Melongena shells with hermit crabs was particularly noted. The circuit of the beach to the northeastward by motor vehicle was blocked by tidal creeks and oyster grass.

From Mashe's Island to Clearwater Beach Island the beach is nearly impassable for motor vehicles. A few access roads connect isolated points on the beach with the highway. The shoreline in this area is a typical bay beach bordered by salt marsh vegetation with some sand and marl collecting on the points. The elevation of the points or spits is slightly higher than the adjacent coastline. On these points fishermen have built their

homes, and usually the points contain woody vegetation such as pines, live oaks, palmetto and cabbage palms. From Mashe's Island to Cedar Key the beach was visited at Shell Point, Adam Beach, Jug Island, Keaton Beach and Horseshoe Point. The beaches at all these places are flat and shallow water extends a considerable distance from land. There is little or no surf here and most of the winds are offshore, and the shoreline and even the intertidal zone are often overgrown by the black rush. Oyster grass is rare, but it occurs along the borders of some of the intertidal creeks. The shore fish are typical bay fishes as they do not normally occur on unprotected beaches. Various species of cyprinodonts were very abundant. The intertidal zone and the marsh were alive with fiddler crabs. Mollusks were rare except for the common marsh species, such as Littorina irrorata, Melampus coffeus and Volsella demissus, which live on the vegetation or in the mud. Drift of the common sea-grasses was found along the entire coast, and it was sometimes common on the sides of the points. No oil or tar contamination was discovered.

Cedar Key is a commercial fishing and tourist center on the west coast. It is chiefly noteworthy because of the extensive development of mangroves along the shore and on the small offshore islands. There is a single artificial beach in the area that has been developed as a roadside park. This beach is approximately a block long and it was developed near the municipal wharf. The beach is a muddy sand and the presence of oyster shells along the beach serves to illustrate the difficulties involved in building artificial beaches along this section of West Florida. There is a narrow sand beach on what is locally called the sandspit. The beach is bordered in part by black mangroves and during the time of my visit, manatee grass was fouling the area and it was still drifting ashore.

Between Cedar Key and Clearwater Beach, I visited the coast at Bird Creek (near Yankeetown), Aripeka, Tarpon Springs, Crystal Beach, Ozona, Dunedin and Clearwater. Most of the coast line is marshy and bordered for the most part by mangroves. In some places the mangroves have been cleared and a retaining wall built such as along the shore at Dunedin and Clearwater. I found no tar in this area and no bathing beaches except for a small artificial beach at Tarpon Springs.

From Clearwater Beach Island south to Marco all Gulf frontage with a white sand beach is very valuable property. I visited Clearwater Beach Island, Sand Key, Treasure Island, Long Key and Anna Maria Island in the Tampa-Bradenton area. The beach along all these islands is highly developed as a tourist attraction. Motels and resort hotels line the beaches. Most of the beaches are private and access to the beach is often difficult. A few short sections of the beach have been developed as public beaches. Probably the largest public beach is the one at Pass-a-Grille. The beach is a fine white sand and the foreshore slopes very gently seaward. The backshore has been altered considerably by constructions of one kind or another. Often small seawalls, or more correctly retaining walls, have been built along the beach. The water was clear and the surf weak, which is the usual condition in this area. Nevertheless, beach erosion is severe on all these offshore islands and numerous groins have been installed. Originally these islands consisted of a narrow sand beach and a back marsh of mangrove trees. Most of the mangroves have been removed and the low marsh filled by dumping spoil from the dredge.

The significance of the small amount of drift found on all the beaches is unknown. It may be due chiefly to the continual cleaning of the beach by property owners. Red algae were particularly noted adrift or lying on

the bottom of some of the longshore troughs. Except around the passes such as John Pass where algae accumulated in considerable abundance, plant debris was rather rare.

Shells were abundant and varied. Worn Chione cancellata seemed to comprise the bulk of the shell drift, but this may be due to the unattractive appearance of the shell and the consequent disdain of the shell collectors. Other common and conspicuous shells were Trachycardium, Pecten, Anodontia alba and Arca occidentalis.

No tars were found in the beach and if petroleum contamination ever occurs, it is apparently very rare as I received no complaints.

Venice Beach and Casey Key were also examined for petroleum residues. None were found on these white sand beaches.

In general the dune plants are much the same as in Texas. Seaside oats, goatfoot morning-glory, seaside morning-glory and Chamaesyce were found. The main difference was the presence of such tropic plants as the seagrape and a shrub with a purplish drupe which was probably Eugenia.

General Discussion and Recommendation

Tars:

Strandings of petroleum residues along the Gulf Coast are not new. An asphaltite has been found in the middens on Liveoak Peninsula, and the Indians had developed several important uses for the tar. The only known source of supply was the Gulf beach. The survivors of De Soto's expedition in 1542 found lumps of tar on the beach with which they tarred their boats. The exact location of the cove where they tarred their boat is in dispute, but it was certainly somewhere on the Texas coast.

People who lived along the Gulf coast have noticed and commented on tar along the beaches. One of the earliest records is Kennedy's (1841)

report of tar on the Galveston Beach. In Vermilion Parish, the residents of the marshes knew this tar as seagum. According to Hampton Greene of Abbeville, Louisiana, who donated a piece of seagum, this tar was softened by adding a little tallow and it was then chewed. Fishermen along the Texas coast have told us that they have observed "tars" on the beaches for many years.

Seeps are well known along the Gulf Coast and they are apparently concentrated in the Tampico-Tuxpan and the Isthmus of Tehuantepec areas of Mexico. A smaller concentration, which probably does not affect the northern Gulf of Mexico, occurs in central and western Cuba. Fernando Urbina (1918) gives the only report of a seep in the intertidal zone, although seeps are known to occur in some of the water courses and in Laguna Tampamachoco. These seeps consist of an asphaltic oil with high sulphur content.

Oil spots are known in the Gulf of Mexico and Lynch (1954) presents a map showing the occurrence of thirty oil spots in the western Gulf of Mexico and none in the eastern Gulf. In this connection, it is known that vast quantities of oil were discharged into the sea during the early development of the Tampico-Tuxpan oil field, because of uncontrolled gushers. Even today, the Rio Panuco and Rio Tuxpan appear black with oil as they enter the Gulf. However, it is probable that at present no great quantity of oil escapes into the Gulf. Oil may also escape to the Gulf through the Rio Coatzacoalcos, although not much oil pollution was noticed during a brief visit in the locality during January, 1954. However, there seems to be no connection between the sighting of oil spots in the Gulf of Mexico and the escapement of crude oils from the Mexican rivers. For example, when Potrero del Llano No. 4 poured nearly 6,000,000 barrels of

crude oil into the Gulf of Mexico during December, 1910 and January, 1911, there were no reported occurrences of oil spots in the Gulf of Mexico for either 1911 or 1912. Nevertheless, it must be admitted that data on both the escapement of crudes and oil spots in the Gulf of Mexico are scanty. Oil wastes from ships and seeps have also been given as a source of the oil spots. It seems unlikely that oil shipments were great enough to cause some of the tremendous oil spots reported before World War I. Inasmuch as the oil spots are concentrated over depths of 400 to 1200 fathoms, the hypothesis of seeps seems tenuous also.

Petroleum residues along the Gulf Coast from Mashe's Island, Florida to Washington Beach (10 miles south of the Rio Grande) were found during this investigation. Previously, Hildebrand had seen tar from the coast of Tamaulipas near Boca Jesus Maria and it is probably of general occurrence all along the coast of Tamaulipas. No petroleum residues were observed along the west coast of peninsular Florida between Mashe's Island and Venice beach. However, most of the intervening coastline is marshy and it could only be examined at isolated spots. Nevertheless, it seems clear that strandings of tar are rare, both from discussions with local observers and the nature of the winds and currents in that area. Hildebrand has seen a very small sample of tar which was taken from a tidal current on Long Key in the Florida Keys. No natural sand beaches exist in the Keys and most of the shores are lined with mangrove. Although such conditions make examination of the beach difficult, there have been apparently no large strandings of petroleum residues in that area. Except for bitumen in Havana Bay, no references to tars on the beaches in northwestern Cuba were discovered.

The strandings of tars along the Gulf coast are variable, but certain areas are affected much more than others. Strandings to the east of the

Mississippi are very light. The only section of the eastern Gulf where any abundance of tars was found was in the area from Mobile Point to Fort Walton Beach. However, this tar was not fresh and it may have been accumulating at the base of the dunes for many years. Only one large tar "ball" was found in the eastern Gulf and it was found on Santa Rosa Island, seven miles east of Pensacola Beach, Florida.

In the western Gulf there seem to be two main regions of strandings although there is not a mile of beach where at least a little petroleum residue is not present. Sometimes tar is locally concentrated around tidal inlets such as Brown Cedar Cut, but the neighboring beaches will have little tar. The two areas of greatest strandings were Timbalier Island and the adjacent Louisiana coast to as far west as the Cameron Parish line and about 25 miles of beach on Padre Island centered around the wreck of the S. S. Nicaragua. The Padre Island strandings are the greatest and three local observers, who have spent years beachcombing on Padre Island, all independently said the area of greatest strandings is in the vicinity of the S. S. Nicaragua. Our limited observations indicated a much more uniform distribution of tars along the Padre Island beach.

M. E. Coleman reported frequently finding masses of tar up to 400 pounds and he has seen masses of asphalt up to a ton in weight on the beach. One type of tar comes ashore in the shape of a barrel although no trace of the barrel remains. Presumably these tar lumps represent lost cargo from ships. The tar is brought into town and sold. The other stranding is of the asphalt type, and it sometimes floats ashore in large masses, some of which are at least three feet thick.

Lewis Rewalt stated that he had seen enormous masses of the "bulk" asphalt wash ashore on the beach. He estimated the weight of the largest

mass that he had ever seen as two to three tons. These strandings are sporadic and they do not occur every year. Although he could not precisely recall the time of the year that the asphalt washed ashore, he thought that most of it came ashore during the spring equinoctial tides.

Dale Goyer, the sole permanent resident of Padre Island, has seen both the "tar barrel" type of petroleum residue, which commanded a ready market in Port Isabel and Port Aransas, and the bulk type. He seemed to think they were the same material, but that the bulk material represented tar that had melted and become mixed with sand.

We did not see any large tar sample that resembled a barrel in shape. The large tar samples seen had a typical circular shape, but they are only two to four inches in thickness and approximately three feet in diameter. If they do not become sanded down shortly after landing, this shape may change by melting under the hot sun and then flowing laterally. Some of the tarry materials that have lodged in the intertidal zone have fouling organisms, chiefly hydroids, growing on them.

Most of the tar particles that come ashore are small, and for the purpose of quantitatively assessing the abundance of tars, a flat piece of tar, one inch in diameter, was used as a standard unit. The tar was more or less assorted by size and the larger pieces were in the highest swash marks. Furthermore, the tar was concentrated along the sides of the embayments as one would expect, rather than uniformly distributed along the beach across embayment and beach cusp alike. Some of the tar was soft, particularly that which came ashore on August 10, 1954 on the Mustang Island beach. Blobs of soft tar or viscous crude oil were present on the Sabine-High Island beach together with many dead menhaden on September 3, 1954.

The stranding of tars on the beaches seems to be fairly rapid and it is undoubtedly related to favorable winds and currents. No one section of the beach was checked for a long enough period of time to draw many conclusions concerning the frequency of the landings. However, considerable amounts of viscous tarry substance came ashore on Mustang Island and presumably Padre Island beaches on August 10, 1954. Perhaps the landing was later on southern Padre or the source of the tarry material was different. (See page 26.)

A cursory examination of some of the larger pieces of tar for the possibility of determining origin by the identification of inclusions of foreign material did not reveal any inclusions that could definitely be separated from local contaminants.

Sulphur content of petroleum residues:

Samples of petroleum residues from a number of localities in the Gulf of Mexico were analyzed for sulphur content. These analyses are tabulated in Appendix B.

In general, the sulphur content varied and indicated a multiple origin for the residues. This is not unexpected as it seems improbable that all the petroleum residues on the beach originate from a single seep, well, shipment of oil or locality. Furthermore, the sulphur contents of crude from a single field may vary. Wilson (1918) found the sulphur content of crudes from three wells in Campo de Tanhuijo oil field to vary from 1.69% to 4.79% sulphur. Inasmuch as most of the samples contained 2.0% sulphur or more and the north coast crudes contain little sulphur (1.5 to 0.3%), it would seem that neither tankers nor oil fields along the northern Gulf coast are an important source of contamination. However, it is probable that low sulphur-content petroleum residues on Galveston

beach represented waste from ships. In the light of existing knowledge, only crudes and asphalt seeps in Tampico-Tuxpan, Isthmus of Tehuantepec and Trinidad area are suspect as a source of most of the "tars" because of their high sulphur content, and the ease of transport to northern Gulf shores by ocean currents.

Seeds:

A number of large tropical seeds are carried ashore by the wind and currents. It was thought that possibly these seeds could be used to indicate current patterns and also the general region of origin of the petroleum residues. There are a number of difficulties involved in such a method but when more information is accumulated, this approach may prove promising. The fact that nearly all the strandings of tropical seeds were in the western Gulf is significant.

The red mangrove (Rhizophora mangle) seeds were found most abundantly on Timbalier Island and a few scattered seeds were found on Matagorda Island. Red mangroves thrive in the American tropics and they grow as far north as Tampico in the western Gulf and sparingly as far north as Cedar Key in the eastern Gulf.

A number of beans drift ashore and they were much more abundant in the western Gulf than in the eastern Gulf. The largest and most abundant bean was Entada scandens. This species is abundant in Jamaica and it probably occurs elsewhere in the American tropics. At least one authority has identified the Entada bean which occurs in the Mexican state of Tabasco as this species. Another common bean on the Texas coast belongs to the genus Mucuna. This genus is widespread in southern Mexico and the tropics.

Several other seeds, not yet identified as to species, and the common coconut also drift ashore on the Texas coast and they are very rare in the eastern Gulf. Thorns belonging to one of the oxhorn acacias were found on St. Joseph Island beach. According to Marshall Johnston, these thorns belong either to Acacia sphaerocephala or Acacia cornigera. Both of these species are common in southern Mexico and the latter species also ranges into Central America.

The lack of botanical exploration and critical taxonomic reviews of the genera occurring in the drift reduces the usefulness of botanical specimens as indicators of currents and possible origin of the tars. However, the concentration of such objects on the Texas coast south of the mouth of the Colorado and their rarity elsewhere in the northern Gulf is perhaps highly significant. Furthermore, many of these species occur in the tropics or in Mexico and they are rare or absent on the Florida peninsula and they definitely do not grow on the northern Gulf coast.

Sargassum:

The Sargasso Sea is named for this genus of brown algae. Some species live attached to rocks and other bottom material, while others apparently live only as drifting plants in the tropical oceans. During the spring and summer of 1954 sargassum drifted ashore in the western Gulf in enormous quantities. More sargassum drifted ashore on the Texas coast than elsewhere and apparently from Grand Isle eastward strandings of sargassum were very light. A little fresh sargassum was drifting ashore on nearly all the beaches from the Rio Grande to St. George Island during this investigation, but it was abundant only on Timbalier Island. The reason for the isolated stranding of this species on Timbalier Island during

October, 1954 is unknown. Perhaps it indicates a current pattern which brings drift material close to the beach in that region.

Freshwater and Terrestrial mollusks:

Dr. Elmer P. Cheatum identified three specimens of a large freshwater snail as Pomacea paludosa. This species ranges from Georgia to Cuba and it possibly also occurs in Mexico. However, additional information is required before my specimens can be assigned to a definite locality. Stranded specimens of this species were found only in the western Gulf on St. Joseph and Matagorda Island.

Other small terrestrial and freshwater mollusks were found on the beaches. These were not analyzed as to country or origin, but many of them certainly came down the rivers draining the northern coastal plain.

Pumice stones:

Small rounded pebbles of pumice stone drift ashore on the Gulf Beach. These stones are much commoner south of Port Aransas than elsewhere on the northern Gulf coast. In fact only two pieces were found in the eastern Gulf. However, the origin of this pumice is unknown, but the closest possible site is one of the volcanic sectors in the state of Vera Cruz, Mexico. However, these stones may have come from more distant volcanic rocks in the Caribbean.

Sea-grasses:

Five species of sea-grasses occur in the drift along the northern Gulf coast, but only three, Thalassia testudinium, Cymodocea manatorum and Halodule Wrightii are common enough to build windrows of wrack. These grasses grow everywhere where there is suitable substrate and enough

light. In the muddy waters of Louisiana they are rare and never form an important part of the drift except possibly in Chandeleur Sound. The same is true of the Gulf beaches in Texas, although Halodule Wrightii is very abundant in some of the Texas bays. In the clear shallow waters off the coast of Florida they thrive and during the fall of the year they form large windrows of drift on the beach. The strandings along the steep beaches from Pensacola to Panama City are not as great as along the gently sloping beaches farther east and south in Florida.

Beach plants:

The harsh conditions imposed by salt spray or salt water prove insurmountable for all except a few species of plants. The Gulf coast visited during this investigation can be divided roughly into sand beach, mangrove swamps and salt marshes. Sandy beaches are characterized by relatively few species of plants. The most common plant was the seaside oats. Other common and widespread plants were the goatfoot morning-glory and goatweed. The number of woody plants such as Cocoloba uvifera and Eugenia increases as one enters more tropical climes. The salt marsh vegetation varies from predominantly oyster grass in Louisiana to predominantly black rush on the west coast of Florida. Mangrove swamps start near Cedar Key and extend southward into the tropics. However, one species of mangrove, the black mangrove, occurs in Louisiana and in the south Texas bays. From the composition of the plant drift on the shore one could tell something about the recent longshore drift by the habitat of the plants that drifted ashore. For example, on Grand Isle the alligator weed and oyster grass that were present on the shore probably came from the Delta of the Mississippi.

Shell drift:

Beaches can be characterized by the kind of shells that drift ashore. Although shells were noted on all the beaches, they add little to the study of oil contamination on the beach. However, if the tar sample had had inclusions of shell material, one might have been able to speculate on the origin of the material by the included shells. Tars coming ashore on a shell beach tend to remain visible longer as they do not become obscured by sand.

Recommendations

1. Detailed analyses of some of the tar samples including trace elements should be considered. It is particularly important to have such analyses for the offshore fields on file.
2. Investigations directed at solving the origin of the petroleum residues should be fruitful. Consideration should be given the Tampico-Tuxpan area of Mexico as a source of the tar. An investigation of the fate of oil pollutants as they enter the Gulf of Mexico from the Panuco River should be especially instructive. This area should also merit consideration in the study of the effects of oil pollution on marine organisms.
3. Information on the landings of tar on the northern Gulf beaches is still very scanty. Information is needed on a year round basis. This could, perhaps, be best accomplished by a survey of a limited section of the Gulf beach. Padre Island would seem to be the best locality for such a survey because of the heavy landings of tar in that area.
4. More information on currents in the Gulf of Mexico would help solve the origin of the tars.

Summary

Petroleum residues occur on all beaches in the northern Gulf coast from Washington Beach, Tamaulipas to Fort Walton Beach, Florida. In general, it is most abundant around tidal inlets. Petroleum residues are not common in the eastern Gulf, and none were found on the west coast of peninsular Florida between Mashe's Island and Venice, Florida. Most of the petroleum which strands consists of small flat pieces less than two inches in diameter. Some larger chunks weighing forty pounds or more were seen, and reports by local observers of chunks weighing two to three tons are included in this report.

Correlated with the greatest strandings of tars were the greatest strandings of tropical seeds, pumice stones, and ampullarid snails.

Asphalt seeps are known in the Tampico-Tuxpan and the Isthmus of Tehuantepec areas of Mexico and in central and western Cuba. Other seeps are known in Trinidad and in northern South America.

Oil slicks have been reported in the western Gulf of Mexico but Lynch (1954) does not chart a single one for the eastern Gulf.

Petroleum residues may have a multiplicity of origins, but there is a striking similarity in the sulphur analyses for samples from widespread areas in the northern Gulf. It would seem that offshore oil wells on the basis of chemical analyses can be eliminated as a major source of contaminants. Possible origins are seeps in Mexico and northern South America. Submarine seeps in the Gulf of Mexico, oil wastes from ships, and pollutants from rivers draining oil fields in Mexico may also contribute to the drift.

Strandings of petroleum residues are very old in the northern Gulf of Mexico. They occurred in pre-Columbian times, and the coastal Indians made considerable use of asphalt.

Bibliography

Berl, E. 1940. Role of carbohydrates in formation of oil and bituminous coals. Bull. Am. Assn. Petrol. Geols. 24: 1865-1890.

Bullard, F. M. 1942. Source of beach and river sands on Gulf coast of Texas. Bull. Geol. Soc. Am., Pt. 2, 53 (7): 1021-1044.

Campbell, T. N. 1952. The Kent-Crane site: a shell midden on the Texas coast. Bull. Texas Archeol. Paleo. Soc. 23: 39-77.

Crowther, Benjamin. 1868. Petroleum wells in Mexico. Am. Jour. Sci. 46: p. 147.

DeGolyer, E. 1918. The geology of Cuban petroleum deposits. Bull. Am. Assn. Petrol. Geols. 2: 133-167.

_____. 1932. Oil associated with igneous rocks in Mexico. Bull. Am. Assn. Petrol. Geols. 16 (8): 799-808.

Emery, K. O. and J. F. Gale. 1951. Swash and swash mark. Trans. Am. Geophysical Union. 32 (1): 31-36.

Galtsoff, Paul S. 1954. Historical sketch of the explorations in the Gulf of Mexico. In: Gulf of Mexico, its origin, waters, and marine life. Fishery Bull. Fish and Wildlife Service 55: 3-36.

Garcilaso, de La Vega. 1605. The Inca. The Florida of the Inca. A History of the Adelantado, Hernando de Soto ... Translated and edited by J. G. Varner and J. J. Varner, 1951, 655 pp., Univ. Texas Press, Austin.

Glenn, A. H. and Associates. Report on oil spots in the western Gulf of Mexico. Private report for Humble Oil and Refining Company. Pp. 2-6.

Harris, G. D. 1910. Oil and gas in Louisiana with brief summary of their occurrence in adjacent states. Bull. U. S. Geol. Surv. 429. 192 pp.

Hartley, Burton. 1921. The oil fields of Mexico. Bull. Am. Assn. Petrol. Geols. 5 (4): 504-07.

Haseman, J. D. 1921. The humic acid origin of asphalt. Bull. Am. Assn. Petrol. Geols. 5: 75-79.

Hayes and Kennedy. 1903. Oil fields of the Texas-Louisiana Gulf coastal plains. Bull. U. S. Geol. Survey 212: 174 pp.

Hedgpeth, Joel. 1953. An introduction to the zoogeography of the northwestern Gulf of Mexico with reference to the invertebrate fauna. Publ. Inst. Mar. Sci. Univ. Texas 3 (1): 111-224.

Kennedy, William. 1841. Texas (reprint Malyneaux, Fort Worth 1925) p. 118.

Launey, Walton S. 1938. Report on the occurrence of petroleum and asphalt material along Galveston and Bolivar beaches, Galveston and Chambers Counties, Texas. Humble Oil and Refining Co. South Texas 94.

Leipper, Dale. 1954. Physical oceanography of the Gulf of Mexico. In: Gulf of Mexico, its origin, waters, and marine life. Fishery Bull. U. S. Fish and Wildlife Service. 55: 119-137.

Lohse, Alan. 1952. Shallow-marine sediments of the Rio Grande delta. Dissertation for the Ph.D. degree, Department of Geology, Univ. Texas (manuscript) 113 pp.

Lynch, S. A. 1954. Geology of the Gulf of Mexico. In: Gulf of Mexico, its origin, waters, and marine life. Fishery Bull. U. S. Fish and Wildlife Service. 55: 67-86.

Morgan, J. P., Jack R. Van Lopik, Lewis G. Nichols. Occurrence and development of mudflats along the western Louisiana coast. Office Naval Research Project No. 7. Technical Report No. 2: 1-34.

Melton, Frank A. 1940. A tentative classification of sand dunes and its application to dune history in the southern high plains. Jour. Geol. 48: 113-145.

Muir, J. M. 1936. Geology of the Tampico region, Mexico. 280 pp. Am. Assn. Petrol. Geols., Tulsa, Okla.

Parr, A. E. 1939. Quantitative observations on the pelagic sargassum vegetation of the western North Atlantic. Bull. Bing. Oceanog. Coll. 6 (7): 1-94.

Phillips, W. B. 1900. Texas petroleum. Bull. Univ. Texas 5.

Price, W. A. 1933. Role of diastrophism in topography of Corpus Christi area, South Texas. Bull. Am. Assn. Petrol. Geols. 17 (8): 907-962.

_____ 1954. Shorelines and coasts of the Gulf of Mexico. In: Gulf of Mexico, its origin, waters, and marine life. Fishery Bull. U. S. Fish and Wildlife Service. 55: 39-65.

Redfield, Arthur H. 1921. Campos petroliferos Mexicanos en el istmo de Tehuantepec. Bol. del Petroleo 11 (4): 293-303.

Standley, P. C. 1920-26. Trees and shrubs of Mexico. Contr. U. S. Nat. Herb. 23: 1721 pp.

Thompson, Warren O. 1937. Original structures of beaches, bars and dunes. Bull. Geol. Soc. Am. 48: 723-752.

Thorne, Robert F. 1954. Flowering plants of the waters and shores of the Gulf of Mexico. In: Gulf of Mexico, its origin, waters, and marine life. Fishery Bull. U. S. Fish and Wildlife Service 55: 193-202.

Urbina, Fernando. 1918. Los yacimientos petroliferos submarinos. Bol. Petroleo. 5: 337-377.

Whitney, Lewis J. 1932. Occurrence of oil in igneous rocks in Cuba. Bull. Am. Assn. Petrol. Geols. 16 (18): 809-818.

White, I. C. 1913. Petroleum fields of northeastern Mexico between the Tamesi and Tuxpan Rivers. Bull. Geol. Soc. Am. 24: 253-74.

Wilson, Eduardo M. 1918. Petroleo crudo del campo de Tanhuijo. Bol. Petroleo 5 (1): 20-26.

Plate I

Fig. 1. Map of the Gulf of Mexico showing asphalt seeps, oil spots, localities visited and sulphur content of tar samples.

Plate II

Fig. 2. Intertidal swash marks, Boca Chica beach.

Fig. 3. Beach embayment on Padre Island showing distribution of petroleum residues.

Fig. 4. Large tar "ball" on east shore of Brown Cedar Cut.

Fig. 5. Petroleum residues on Galveston Beach near Termini Park.

Plate III

Fig. 6. Dried sargassum wrack on Gulf beach on Bolivar Peninsula.

Fig. 7. Fresh petroleum residues and menhaden skeletons on beach 10 miles east of High Island.

Fig. 8. Fresh petroleum residues and menhaden on beach approximately 11 miles east of High Island.

Fig. 9. Water hyacinths and sargassum wrack on beach near Cameron, Louisiana and catwalk for bathers over the muddy foreshore.

Plate IV

Fig. 10. Large tar "ball", Santa Rosa Island.

Fig. 11. Windrows of sea-grasses, Carrabelle Beach, Florida.

Fig. 12. Salt marsh (Juncus roemirianus) shore line at Adam Beach, Florida.

Fig. 13. Typical sand beach showing swash marks of red algae in the Tampa area (Bellaire Beach).

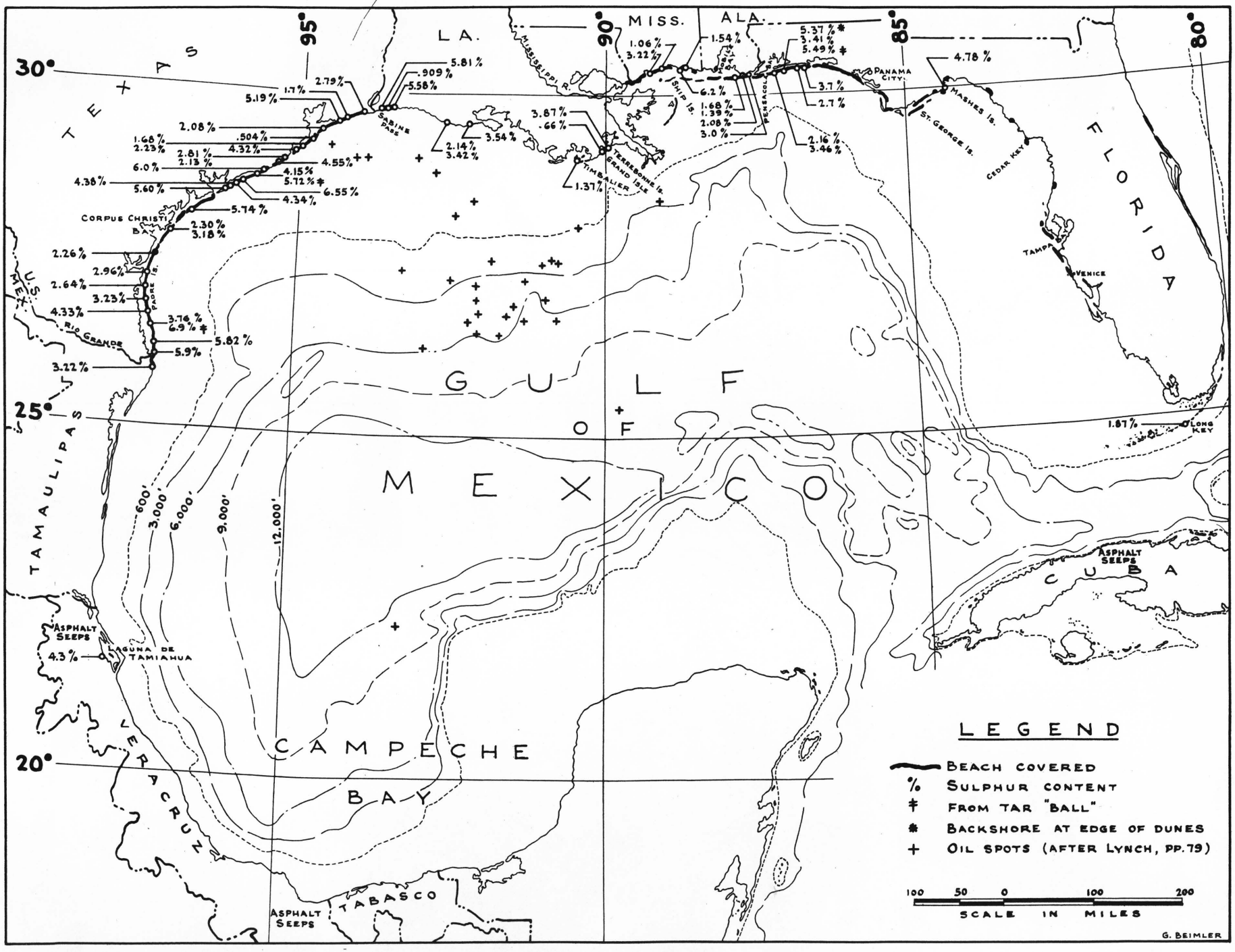

Plate I Figure 1

Plate II

Figure 2

Figure 3

Figure 4

Figure 5

Plate III

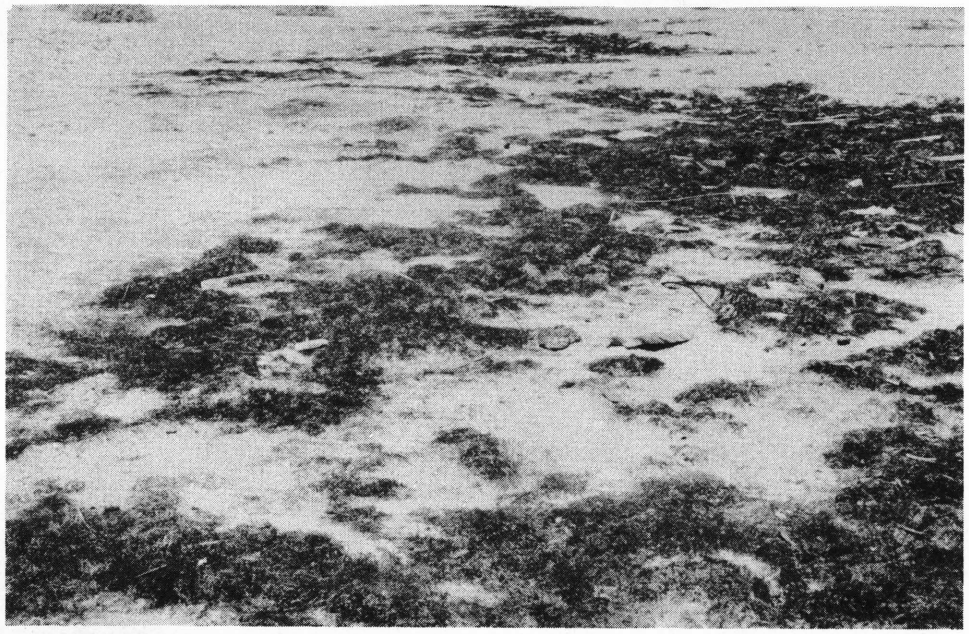

Figure 6

Figure 7

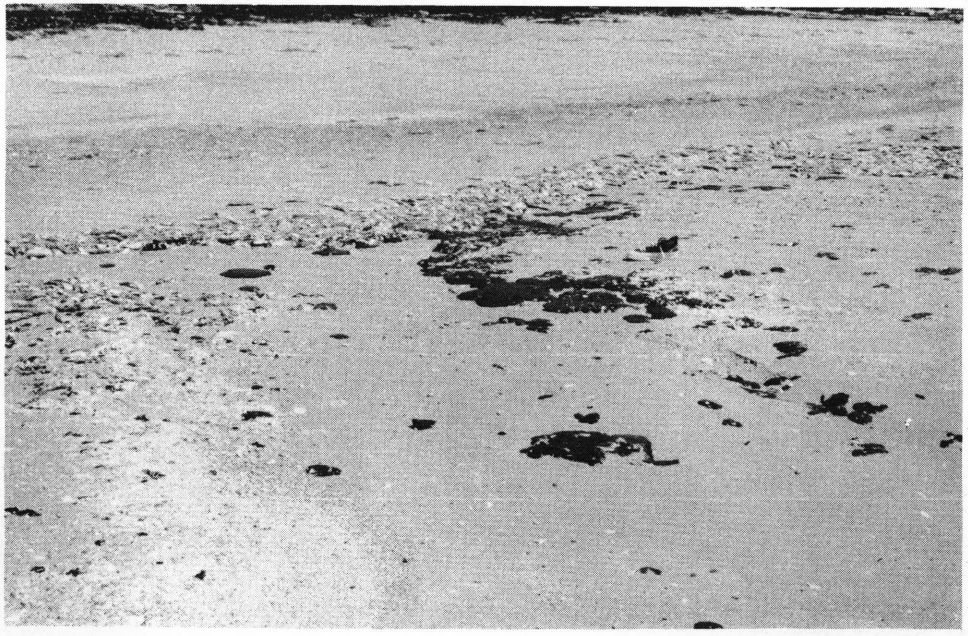

Figure 8

Figure 9

Plate IV

Figure 10

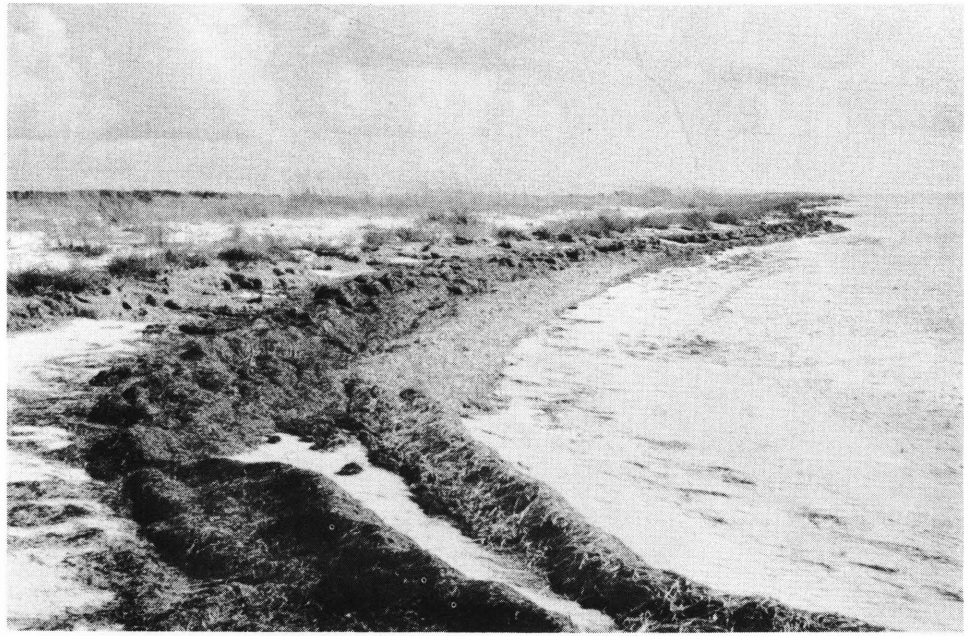

Figure 11

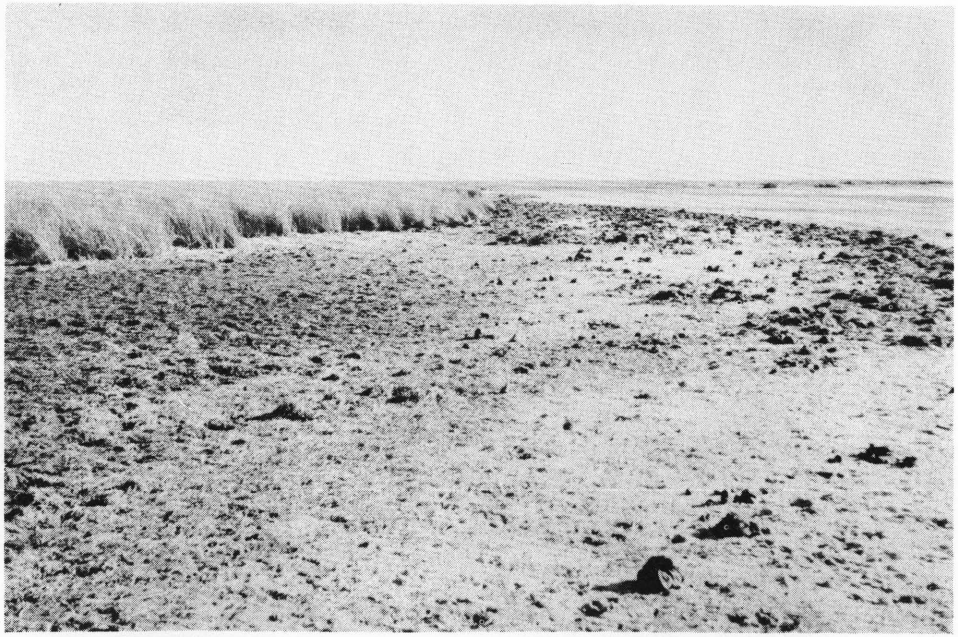

Figure 12

Figure 13

Appendix A.

Algae

Phaeophyceae ----------Brown algae

Sargassum spp. ----------Sargasso weed

Pylaliela fulvescens ----------

Rhodophyceae ----------Red algae

Seed plants

Pinus spp. ----------Pines

Cymodocea manatorum ----------Manatee grass

Halodule Wrightii ----------Cuban shoal grass

Thalassia testudinum ----------Turtle grass

Panicum amarulum ----------

Spartina patens ----------Wiregrass

Spartina alterniflora ----------Oystergrass

Sporobolus virginicus ----------Dropseed grass

Phragmites communis ----------Roseau cane

Eragrostris oxylepis ----------

Uniola paniculata ----------Seaside oats

Distichlis spicata ----------Saltgrass

Fimbristylis castanea ----------Sand sedge

Cocos nucifera ----------Coconut

Sabal minor ----------Palmetto

Sabal palmetto ----------Cabbage palm

Eichornia crassipes ----------Water hyacinth

Juncus roemerianus ----------Black rush

Quercus virginiana ----------Live-oak

Atriplex arenaria ----------Beach-ovach

Salicornia Bigelovii ----------Glasswort

Salsola Kali ----------Russian thistle

Tidestroma lanuginosa ----------Dew plant

Alternanthera philoxeroides ----------Alligator grass

Batis maritima ----------Saltwort

Sesuvium portulacastrum ----------Sea-purslane

Magnolia foetida ----------Magnolia

Cassia ----------Senna

Acacia farnesiana ----------Huisache

Acacia cornigera ----------Oxhorn acacia

Acacia sphaerocephala ----------Oxhorn acacia

Entada scandens ----------Gulf bean

Mucuna spp. ----------

Andira spp.----------Cabbage bark

Galactia spp. ----------Milk-peas

Zanthoxylum ----------Prickly ash

Chamaesyce ----------Spurge

Croton punctatus ----------Goatweed

Ilex ----------Yaupon

Tamarix gallica ----------Tamarisk

Eugenia ----------

Rhizophora mangle ----------Red mangrove

Oenothera Drummondi ----------Drummond's primrose

Gaura ----------

Hydrocotyle spp. ----------Pennywort

Seed plants cont'd.

Ipomoea pes-caprae ----------Goatfoot morning-glory

Ipomoea littoralis ----------Seaside morning-glory

Avicennia nitida ----------Black mangrove

Iva frutescens ----------Marsh elder

Baccharis halimifolia ----------Marsh elder

Sideranthus spp. ----------

Heterotheca latifolia ----------

Chrysoma paucifloscula ----------

Barrichica frutescens ----------Sea oxeye

Invertebrata

Porifera ----------Sponges

Leptagorgia setacea ----------Whip coral

Trichocorixa spp. ----------Corixid

Callianassa spp. ----------Mud shrimp

Emerita ----------Mole crab

Lepidopa ----------

Clibinarius vittatus ----------Hermit crab

Sesarna reticulatum ----------Marsh crab

Ocypode albicans ----------Ghost crab

Littorina irrorata ----------Marsh periwinkle

Epitonium spp. ----------Wentletraps

Strombus alatus ----------Fighting conch

Polynices duplicata ----------Moon snail

Ficus papyratia ----------Fig shell

Thais haemastoma ----------Oyster drill

Melongena corona ----------Crown conch

Busycon pyrum ----------Pear conch

Oliva sayana ----------Left-handed conch

Olivella mutica ----------

Terebra cinerea ----------

Melampus coffeus ----------

Pomacea paludosa ----------Apple snail

Arca campechiensis ----------

Arca incongrua ----------Incongrous ark.

Arca secticostata ----------Cut-ribbed ark.

Arca transversa ----------Transverse ark.

Arca umbonata ----------Mossy ark.

Arca occidentalis ----------Turkey-wing

Noetia ponderosa ----------Ponderous ark.

Mytilus recurvus ----------Bent mussel

Volsella demissus ----------Marsh mussel

Atrina serrata ----------Penshell

Pecten irradians ----------Scallop

Anomia simplex ----------Jingle shell

Crassostrea virginica ----------Oyster

Divaricella ----------

Lucina radians ----------

Lucina spp. ----------

Lucina jamaicaensis ----------Jamaica lucine

Anodontia alba ----------Buttercup shell

Dinocardium robustum ----------Great heart cockle

Trachycardium spp. ----------

Echinochama arcinella ----------Spiny chama

Chione cancellata ----------Cross-barred venus

Chione intapurpurea ----------Mottled venus

Dosinia discus ----------Discus shell

Macrocallista nimbosa ----------Sun-ray shell

Pitar texasiana ----------

Venus spp. ----------Hardshell clam

Petricola pholadiformis ----------False angel wing

Anatina caniculata ----------Channeled duck

Mulinia lateralis ----------Little surf clam

Rangia cuneata ------ ----------Louisiana clam

Spisula solidissima ----------Surf clam

Donax variabilis ----------Coquina

Donax spp. ----------Coquina

Tagelus gibbus ----------Stout razor

Macoma constricta ----------Constricted macoma

Tellina alternata ---------- ---Lined tellin

Tellina spp. ----------

Ensis minor ----------Razor clam

Barnea costata ----------Angel wing

Pholas campechiensis ----------Wing shell

Periploma angulifera ----------

Bowerbankia ----------Bryozoan

Zoobotryon ----------Bryozoan

Bugula ----------Bryozoan

Vertebrata

Menidia beryllina ----------Silverside

Trachinotus carolinus ----------Common pompano

Eucinostomus ----------Mojarra

Holbrookia propinqua ----------Sand lizard

Appendix B

Sulphur Analyses

LAGUNA DE TAMIAHUA		
4.7 miles South of Rio Cucharas	4.3	% S.
TAMAULIPAS		
5 miles South of the Rio Grande	3.22	% S.

TEXAS

BOCA CHICA BEACH		
South Jetty Brazos Santiago	5.9	% S.
PADRE ISLAND		
10 miles north of Isla Blanca Park	5.82	% S.
33 miles north of Isla Blanca Park from a tar "ball"	6.9	% S.
34 miles north of Isla Blanca Park	3.76	% S.
S.S. Nicaragua (approximately 45.5 miles north of Isla Blanca Park)	4.33	% S.
62.5 miles north of Isla Blanca Park	3.23	% S.
Big Shell (approximately 72.5 miles north of Isla Blanca Park)	2.64	% S.
Yarborough Pass (approximately 82.5 miles north of Isla Blanca Park)	2.96	% S.
Standard of Texas Offshore Platform (approximately 100 miles north of Isla Blanca Park)	2.26	% S.
MUSTANG ISLAND		
Big Hill 4.5 miles south of Aransas Pass Jetty	2.30	% S.
5.5 miles south of Aransas Pass jetty	3.18	% S.
MATAGORDA ISLAND		
12 miles north of Cedar Bayou	5.74	% S.
MATAGORDA PENINSULA		
Greens Bayou	5.60	% S.
5 miles northeast of Greens Bayou	4.38	% S.
Mouth of the Colorado River (westside)	4.34	% S.
Mouth of the Colorado River (eastside)	6.55	% S.
Brown Cedar Cut (east side)	4.15	% S.
Brown Cedar Cut (west side) large tar "ball"	5.72	% S.
Sargent Beach	6.0	% S.
BRAZORIA COUNTY		
Mouth of the San Bernard River (westside)	4.55	% S.
Quintana Beach (near jetty)	2.13	% S.
5 miles east of east jetty at Freeport	2.81	% S.
GALVESTON		
5 miles east of San Luis Pass	4.32	% S.
13 miles east of San Luis Pass	1.68	% S.
13 miles east of San Luis Pass	2.23	% S.
Galveston Beach near Termini Park	.504	% S.

BOLIVAR - Sabine

6 miles east of Bolivar Pass jetty	2.08	% S.
High Island oil derricks	5.19	% S.
10 miles east of High Island	1.7	% S.
Mac Fadden Beach	2.79	% S.

LOUISIANA

CAMERON PARISH

22 miles west of Holly Beach	5.81	% S.
17 miles west of Holly Beach	.9090	% S.
10.5 miles west of Holly Beach	5.58	% S.

VERMILION PARISH

Seagum donated by Hampton Greene	4.65	% S.
Big Constance Bayou	2.14	% S.
Beach between Big Constance and East Little Constance Bayou	3.42	% S.
Chenier au Tigre	3.54	% S.

TIMBALIER TO GRAND ISLE

Timbalier	1.37	% S.
Grand Isle	.66	% S.
Terrebonne Island	3.87	% S.

MISSISSIPPI

MISSISSIPPI SOUND

Pass Christian Isles	3.22	% S.
Gulfport Yacht Club	1.06	% S.
Graveline Bayou	6.2	% S.
Swetman Landing	1.54	% S.

ALABAMA

BALDWIN COUNTY

14 miles east of Mobile Point	1.39	% S.
16.5 miles east of Mobile Point	1.68	% S.
Gulf Shore	2.08	% S.
3 miles west of Alabama Point	3.00	% S.

FLORIDA

PERDIDO PASS TO FORT WALTON BEACH

5 miles west of Pensacola Beach	2.16	% S.
1 mile west of Pensacola Beach	3.46	% S.
7 miles east of Pensacola Beach (backshore at edge of dunes)	5.37	% S.
7 miles east of Pensacola Beach (foreshore)	3.41	% S.
7 miles east of Pensacola Beach (from large tar "ball")	5.49	% S.
20 miles east of Pensacola Beach	2.7	% S.
27 miles east of Pensacola Beach	3.7	% S.

MASHES ISLAND

Mashes Island	4.78	% S.

MONROE COUNTY

Long Key	1.87	% S.