SHORELINE CONDITIONS NEAR HOBCAW POINT, WANDO RIVER, CHARLESTON HARBOR, CHARLESTON, SOUTH CAROLINA

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1 Introduction

Background

A container ship terminal (Wando Terminal - State Pier 41) was constructed by the South Carolina State Ports Authority (SCSPA) in 1979 upstream from Hobcaw Point. A 1.5 mi[1]*-long Federal navigation channel was constructed up the Wando River and past Hobcaw Point to connect the terminal to the Drum Island Reach of the Charleston Harbor channel. Figure 1 shows the location of the point and the general layout of the harbor.

There are local concerns that the terminal and related activities have changed bed sediment conditions and caused or contributed to shoreline retreat in the area southeast of the Wando River Channel between Remley Point and the Wando Terminal, including Hobcaw Point. At the request of the SCSPA, the U. S. Army Engineer Waterways Experiment Station (WES) performed an investigation of sediment conditions and possible erosion due to channel or terminal activities near the subject site.

The Wando, Cooper, and Ashley Rivers are subestuaries which converge and form the estuary of Charleston Harbor. The mean tide range at the Customs House gage at Charleston (approximately 2.5 miles from the study area) is 5.2 ft (1.6 m*). Prior to 1942, freshwater inflows to Charleston Harbor were 82 cfs (cubic feet per sec*) from the Wando, 72 cfs from the Cooper, and 261 cfs from the Ashley River. The average inflow from the Cooper river was 15,600 cfs between 1942 and 1986 as a result of the South Carolina Public Service Authority's Diversion Project, and has been 4,500 cfs since 1986 as a result of the Army Corps of Engineers' Cooper River Rediversion Project. These increased flows were used for hydropower generation. Harbor maintenance dredging increased from 0.1 to 10 million cubic yards per year as a result of the diversion which increased sediment inflow and changed estuarine conditions (Teeter 1989). Harbor maintenance dredging decreased appreciably after the rediversion.

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[1]*1 mi = 1.61 km; 1 ft = 0.305 m; 1 cfs = 0.02832 cu m/sec.

The area of interest is a marsh-fringed shoreline and adjacent mud, sand, and shell shallow sediment bottom. Depths in this area are shown in Figure 2. Depth contours of the area show that the shallow water area off Hobcaw Point is a relatively narrow feature which gives way offshore to the navigation channel.

Surface current patterns observed by WES in June 1996 on maximum ebb and flood tidal phases are shown in Figures 3 and 4. Maximum flood tidal current speeds in the shallowest water measured were about 1.0 ft/sec (0.3 m/sec), while maximum-ebb tidal currents were about 2.1 ft/sec. Maximum current speeds in the channel off Hobcaw Point were about 3.5 ft/sec and 5.5 ft/sec for flood and ebb tidal phases, respectively. Higher current speeds occur northwest of the navigation channel, away from Hobcaw Point. Maximum tidal discharges for the same period of measurement were about 153,000 cfs and 201,000 cfs for flood and ebb tidal phases, respectively.

The objective of this study was to review existing information and make site visits to assess the effects of the channel and vessels traversing the channel on the shoreline and near-shore sediment conditions near Hobcaw Point. At least five possible causes of shoreline retreat are thought to be possible here. The overall channel cross section might enlarge as a result of increased tidal flows or decreases in sediment load, and affect the shoreline. The shoreline might suffer erosion by vessel waves and/or by wind waves. The shoreline would also retreat in response to increases in sea level. The following sections describe what and how information was obtained at the site, what was indicated, and what conclusions could be drawn from available information.

2 Procedures

Reconnaissances of sediment conditions were performed by boat over several days in 1992 and again in1997. While at the site we examined water depths, bed sediments, and shoreline areas, collected water samples and wave height data, and observed the passage of several vessel types, including large container ships inbound and outbound from the Wando Terminal. The first site visit was made in 1992. On 5-6 May of that year, WES staffAllen Teeter and Howard Benson looked for indications that erosion might be taking place. We examined National Ocean Service (NOS) charts (NOS 470 dated Oct. 1964, and NOS 11524 dated April 1978 provided as attachments 1 and 2) from before the South Carolina State Ports Authority (SCSPA) constructed the terminal, and roughly compared the present shoreline and depth conditions with those that existed before the construction of the terminal facility. (Since the area of interest here is outside the Federal channel, it is not surveyed routinely by the Army Corps of Engineers). Bed sediments were examined by collecting push cores from water depths less than about 12 ft, and box cores from deeper water depths. Water samples were collected by pump sampler.

The recent field reconnaissance survey was performed 29 April through 1 May, 1997 by WES staff Allen Teeter, Howard Benson, and Chris Callegan, again to investigate possible erosion in the vicinity. A Coastal Leasing, Inc. absolute-pressure wave gage was installed on a piling off the southern entrance to Hobcaw Creek and recorded 4 times per second. Water depth was about 6.5 ft. Mid-depth water samples were collected at several locations along the 10 ft depth contour. Bottom samples were collected by push corer at the same sites and at numerous sites inshore at 2-5 ft depths. Photographs (14) of the shoreline were taken. We inspected the shorelines both upstream of the Wando Terminal and along the Cooper River. Shoreline surveys performed for SCSPA (George A. Z. Johnson, Jr., Inc., 1997) for the purpose of documenting shoreline conditions were examined.

3 Results and Discussion

We saw no indications of gross erosion in the shallow area off Hobcaw Point or along the shoreline. As compared to restricted waterways where vessel waves and draw down strongly impact the shoreline, this area is relatively natural. Photographs of the shoreline are presented in Photos 1-14. Depths appeared to be quite similar to those charted before construction of the terminal and channel.

The navigation channel was aligned to follow the previous natural channel, and the shallow water area off Hobcaw Point was naturally a narrow feature prior to 1979. The previous natural channel had deepened between 1964 and 1978, possibly as a result of the diking of the shallow water area which is now the southern end of Daniel Island. The dike extended along the 6-ft mean low water (mlw) contour on the opposite side of the channel from the study area, reducing the channel width. The charts show natural channel depths increased by 5-8 ft off Molasses Creek from 1964 to 1978. Comparison of those charts also shows that the shoreline in the area of interest retreated by roughly 60 ft. (The date of the survey on which the 1964 charted shoreline was based is not known but could be 1934).

The special shoreline surveys performed for the SCSPA in 1979, 1981, 1992, and 1996, and summarized by George A. Z. Johnson, Jr., Inc. (1997), showed a trend of shoreline retreat, but due to an uncertainty in which elevations were contoured, quantification of that trend was not feasible. Apparently, different definitions of "shoreline" were used. The mean low water datum is the official water elevation used to define water-land intersection as delineated on NOS charts. However, the shoreline has recently been defined by the South Carolina Coastal Council in relation to the edge of marsh. The latest surveys follow both the 0.0 ft mlw and marsh-edge definitions. The contour lines form two groups based on their proximity to each other. If the contour lines so grouped are assumed to define the shoreline and 0.0 ft mlw, then the earliest surveys tend to fall toward the Wando River and the 1996-1997 contour lines fall on the landward edge of the groups. Qualitatively then, shoreline has retreated about 35 ft on average and the 0.0 ft mlw line has moved about 25 ft toward the shore over the period since 1979. There are appreciable local variations in these trends.

The shoals which occur at the mouths of Hobcaw and Molasses Creeks were charted on the 1964 and 1978 NOS charts in about the same configuration as they exist today. The southern entrance to Hobcaw Creek is actually more open now than in 1964. These shoals are bar formations common to tidal creeks where they intersect larger tidal rivers.

There was a dramatic change in sedimentation in the Harbor after the 1986 Cooper River rediversion which could have led to the adjustments in channel cross sections and to impacts on shallow water and shoreline areas. The U. S. Army Engineer District, Charleston is performing a study on the effects of the rediversion on cross sections in the Cooper River. Bank-to-bank bathymetric surveys have been performed in Charleston Harbor, but not in the Wando River. Still, this study should provide some important information on the response of the harbor to the rediversion, and on the third and fourth factors listed earlier for the harbor in general. The Cooper River Rediversion Project reduced shoaling rates in the harbor. It is likely that some channel adjustment to the new flow and sedimentation conditions has occurred. The study report will be published soon.

A previous study of the Cooper River west of Daniel Island examined the effects of contraction training dikes (Teeter, et al., 1992). A comparison of bank-to-bank bathymetric surveys from 1934 and 1978 showed changes in the shallow areas near the shoreline away from the influence of the dikes. Typically these areas shoaled about two feet, and the shoreline on the east bank of the Daniel Island Reach of the Cooper River advanced toward the channel. There were dramatic increases in sedimentation caused by the diversiǒn of flow into the Cooper River, as described earlier. It is likely that sedimentation in the Wando River was also increased by the diversion. It is also likely that sediment beds and channel cross sections have or will readjust themselves to the 1986 rediversion which reduced sedimentation. No information was located on what effect the construction of the navigation channel had on flows in the Wando River.

Bed sediment sampled during both site visits at 10 ft mlw depths were found to be firm but with a thin surface flocculent layer indicating that sediments were neither eroding nor depositing rapidly. Samples taken during the 1997 field reconnaissance survey at 5 to 2 ft mlw depths, bed sediments were typically overlain with 0.05-0.15 ft of brown sand, with soft fine-grained material below. At one location, 0.4 ft of surficial sand was encountered, and at two other sites, the sandy surface overlaid what appeared to be a stiff marl. Bed sediments were sandier and tougher toward Remley Point. Samples taken during the 1992 reconnaissance were restricted to 5-10 ft depths and did not encounter sand.

Waves from three container ships were measured. Wave gage data plots for the periods of the passages of the S. S. Tillie Lykes, S. S. Timm Mexico, and the S. S. Nol Risso are provided in Figures 5, 6, and 7. The vessel waves were superimposed on water levels which changed with tidal phase, as can be seen in the plots. The average wave height (Hw) was about 15 cm and the average wave period (T) was about 2.1 minutes for these vessel passages. Wave characteristics such as wave lengths (Lw) and maximum orbital current speed at the bottom (U) can be estimated from Hw and T, for a given water depth (D), based on linear they exist today. The southern entrance to Hobcaw Creek is actually more open now than in 1964. These shoals are bar formations common to tidal creeks where they intersect larger tidal rivers.

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Ship waves:

Hw, m	T, sec	D, m	Lw, m	U, m/sec	Stress, Pa
0.15	125	2	681	0.20	0.046
0.15	125	1	588	0.35	0.079

Hw = Wave Height (m)
T = period (sec)
D = water depth (m)
Lw = Wave length (m)
U = orbital speed (m/sec)

1 Pa = N/m²
1 N = 1 kg m/s²

Wind Waves:

Hw, m	T, sec	D, m	Lw, m	U, m/sec	Stress, Pa
0.5	2.5	2	21	0.31	0.50
0.5	2.5	1	7	0.61	0.97

The wind waves on this table are characteristic of the chop observed during the 1992 site visit. The fetch up the Wando River to the north-northeast from Hobcaw Point is almost three miles and winds from that direction can produce waves of greater duration and magnitude than the occasional ship wave. Winds were from that direction and 10-12 miles per hour on one of the days we visited the site. While a 0.5 m chop was produced, waves damped out in shallow water and there were no signs that bed or bank erosion was produced.

Computed wave shear stresses indicate that commonly-occurring wind waves are much more erosive than vessel waves, at least in a 1-2 m water depth.

We observed erosion scarps on some marsh banks exposed to the north, indicating that during some periods of high tidal elevation, waves from that general direction produced bank erosion on certain marsh edges. These scarps were oriented perpendicular to incident waves rather than along channel streamlines, indicating that they resulted from wave attack rather than from erosion by tidal currents. Given the relative shear stresses developed by vessel and wind waves, wind wave erosion was the most likely process involved.

The most severe vessel waves observed were generated by passing tug boats and service craft. These displacement vessels operate at higher Froude numbers or Taylor quotients (vessel speed divided by the square-root quantity gravity times vessel waterline length) than container ships maneuvering in the Wando River. Underway tugs typically are near their hull speeds and the ones we observed in 1992 near the terminal generated moderate waves that diminished as they moved from the channel. While no erosion was observed, it is possible that some vessel passages might produce erosion at the site.

Sea level is rising on a global basis at about 0.0062 ft/yr based on records from 1890 to 1980 (Douglas 1991). Local sea level variations change with time, and depend on factors such as postglacial rebound, tectonic movements, and sedimentary subsidence. The local apparent sea level rise at Charleston has been reported to be 0.0105 ft/yr based on 1930-1980 data (Douglas 1991) and 0.0112 ft/yr based on 1940-1986 data (Hicks and Hickman, 1988). While sea level rise should not affect the positions of elevation lines surveyed to a common vertical control, sea level rise leads to inundation of land and the loss of land through the erosive effects of water. Over the 18 years of 1979-1997, the average sea level at Charleston has risen about 0.1948 ft or 2.33 inches.

4 Conclusions

The shoreline and shallow water depth contours between Remley Point and the Wando Terminal have moved landward by perhaps an average of 1.4 ft per year over the period 1979-1997. This retreat has been occurring at least since 1964 probably as a result of a combination of factors. Inspection of sediment conditions indicated that sediment degradation or erosion is a relatively slow process, not greatly affecting the characteristics of surficial bed sediments. None of the five factors assessed can be entirely ruled out as possible agents in the shoreline retreat. Previous diking of Daniel Island, construction of the Wando Channel, and rediversion of the Cooper River have each affected channel cross sections, and may continue to do so for years before an equilibrium is established between sediments, flows, waves, and geometry of this channel. Waves produced by container vessels do not appear to be as important as wind waves or even as waves produced by smaller displacement vessels in generating shear stress forces on the sediment bed. Vessel waves are solitary and infrequent in comparison to wind waves. Wind wave erosion of marsh edges was indicated, suggesting that wind waves may have eroded sediments at lower elevations as well. Sea level is rising in the harbor which also contributes to land loss along the shoreline.

References

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Hicks, S. D., and L. E. Hickman, Jr. 1988. United States sea level variations through 1986. Shore & Beach, 56(3), pp. 3-7.

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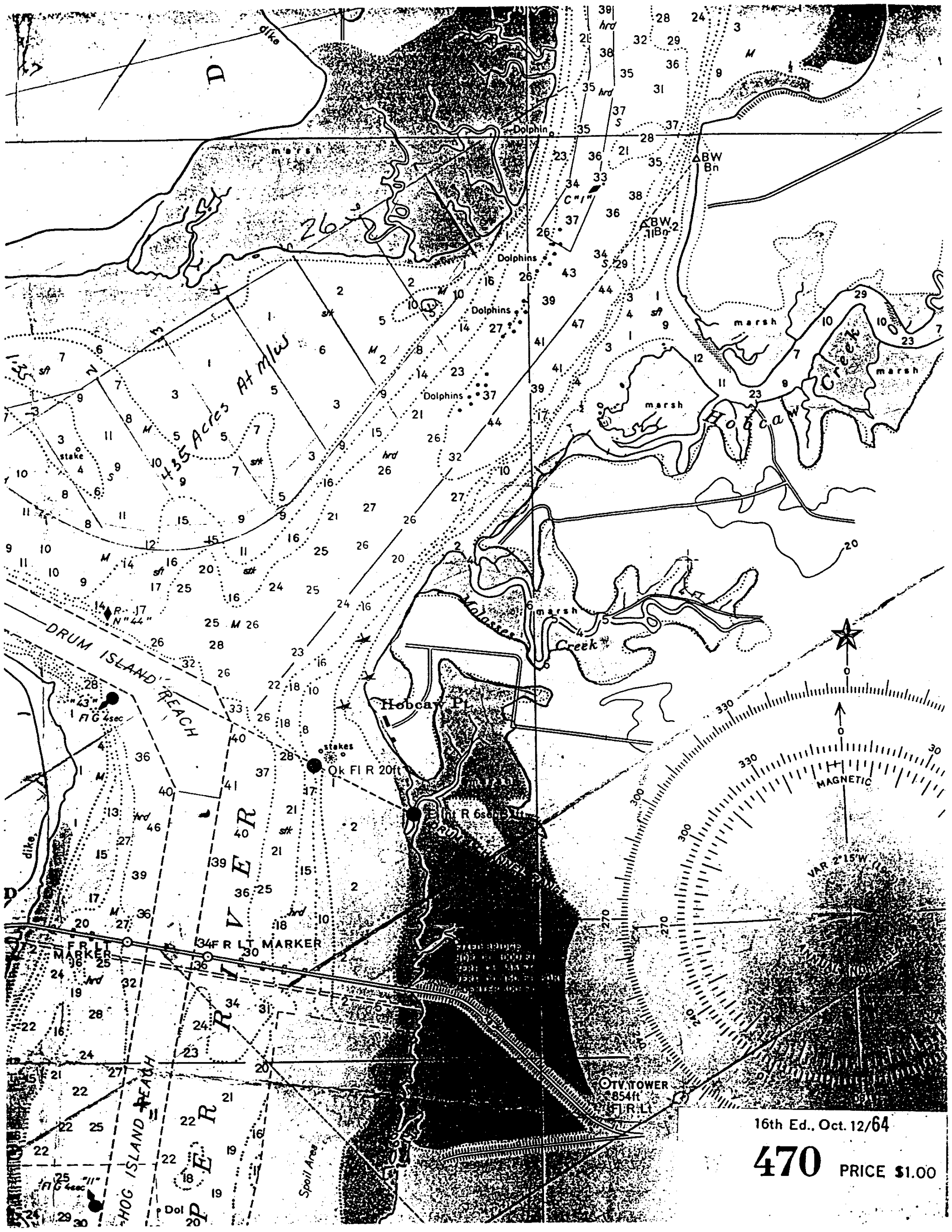
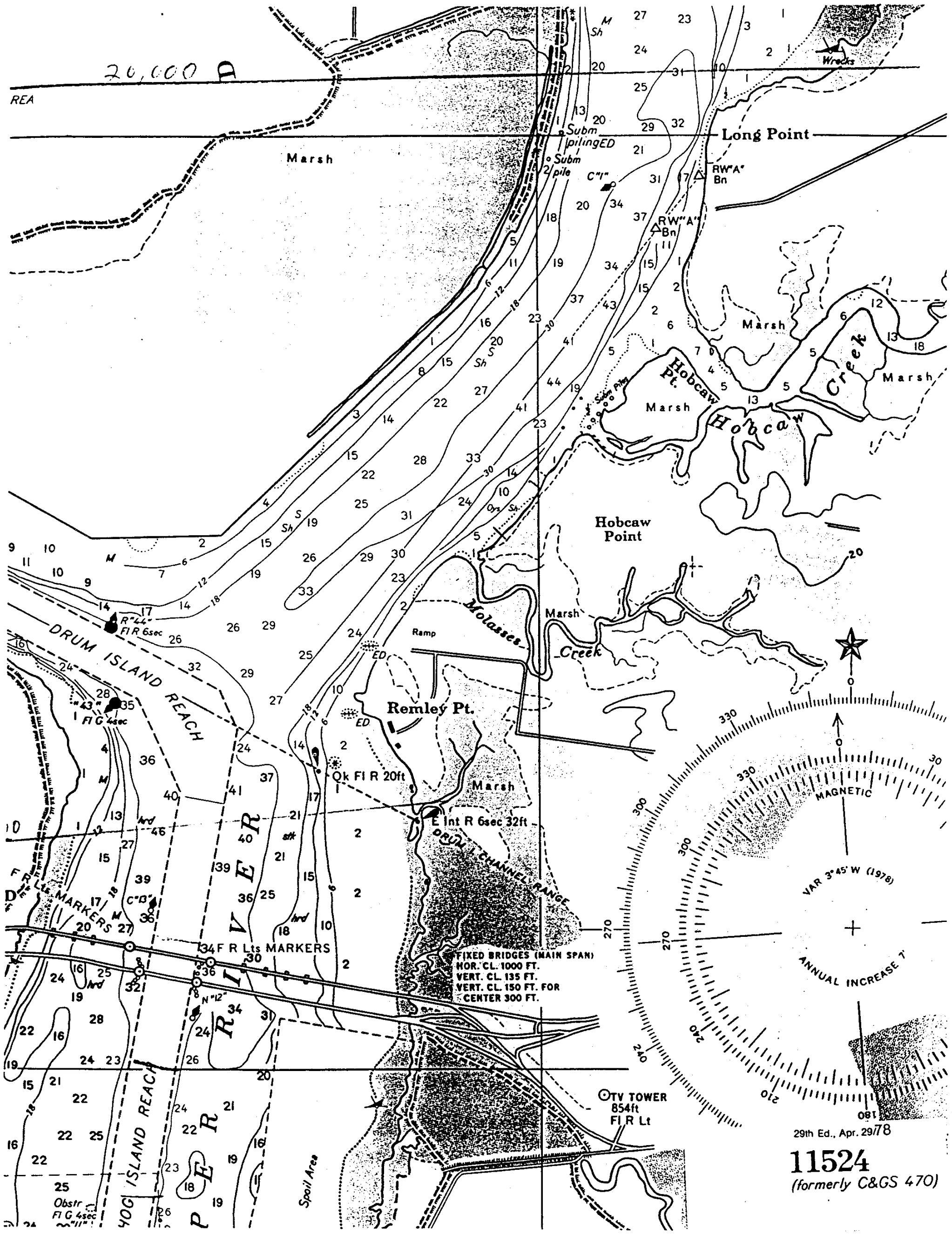
Teeter, A. M., Pankow, W., Heltzel, S. B., and S. C. Knowles. 1992. Effectiveness of contraction training dikes at Charleston Harbor, Charleston, South Carolina. Msc. Paper HL-92-1, WES, Vicksburg, MS.



ATTACHMENT 1



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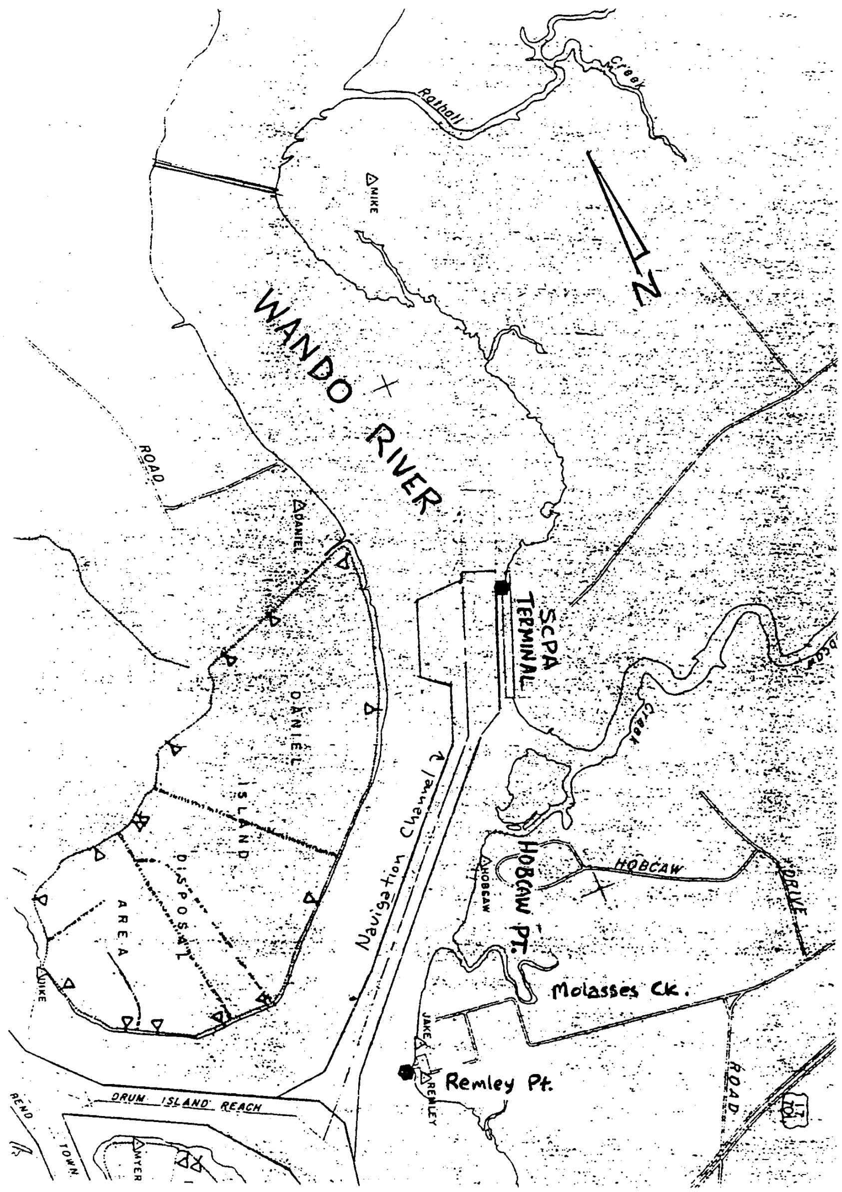


Figure 1. Sketch of the area between Remley Point and the SCPA Wando Terminal

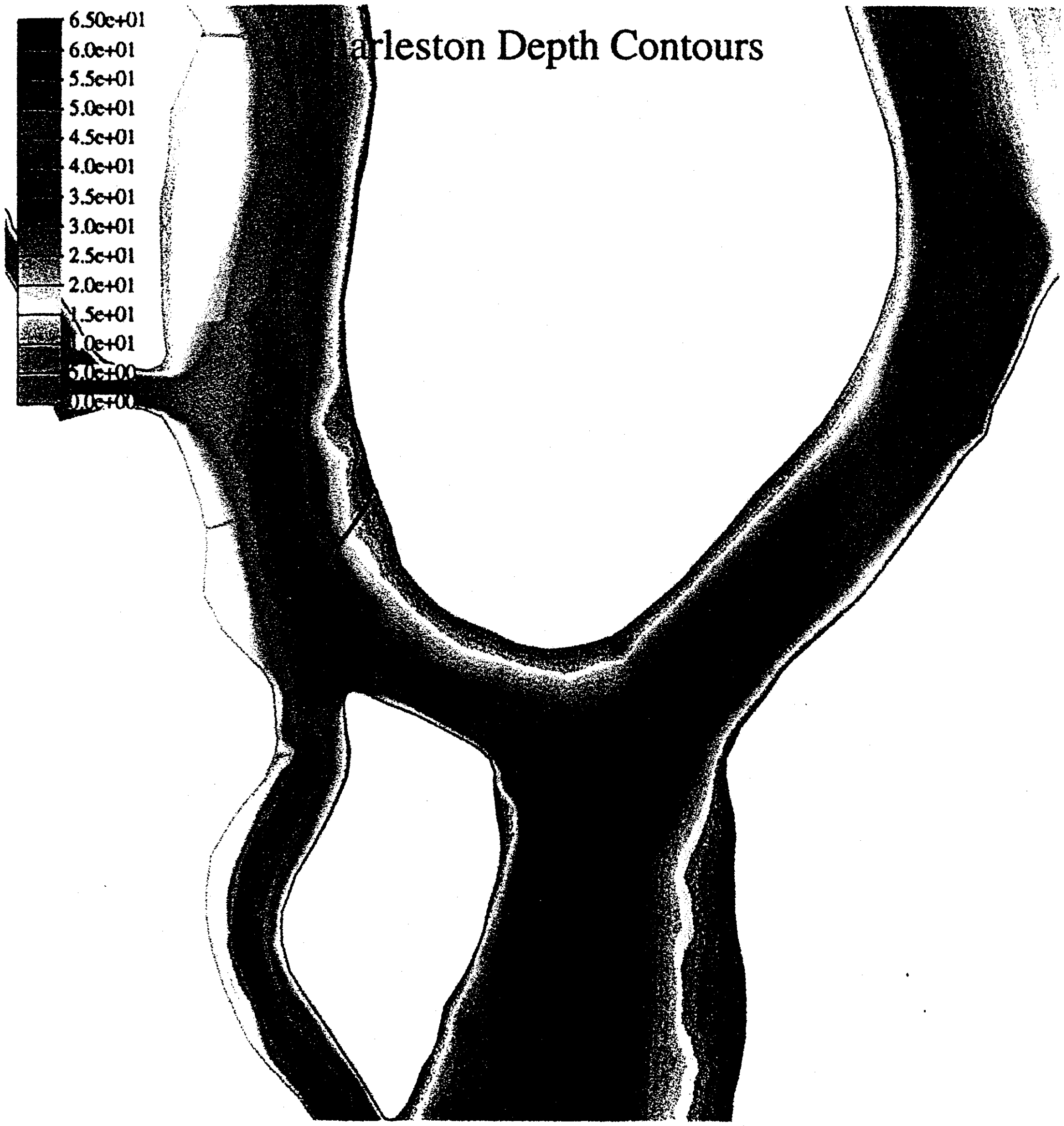


Figure 2. Depths near the study area in Charleston Harbor

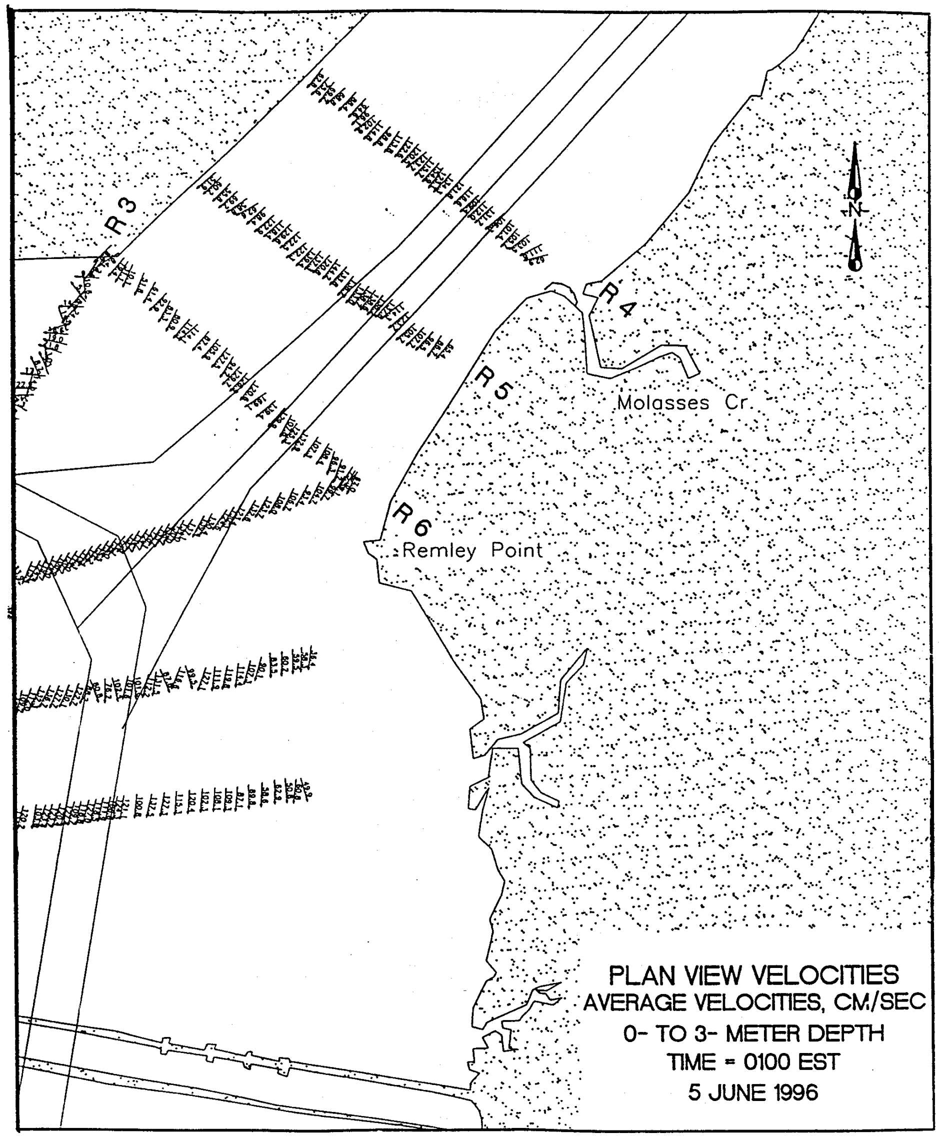


Figure 3. Near-surface current velocity vectors, maximum ebb tidal phase (out going tide)

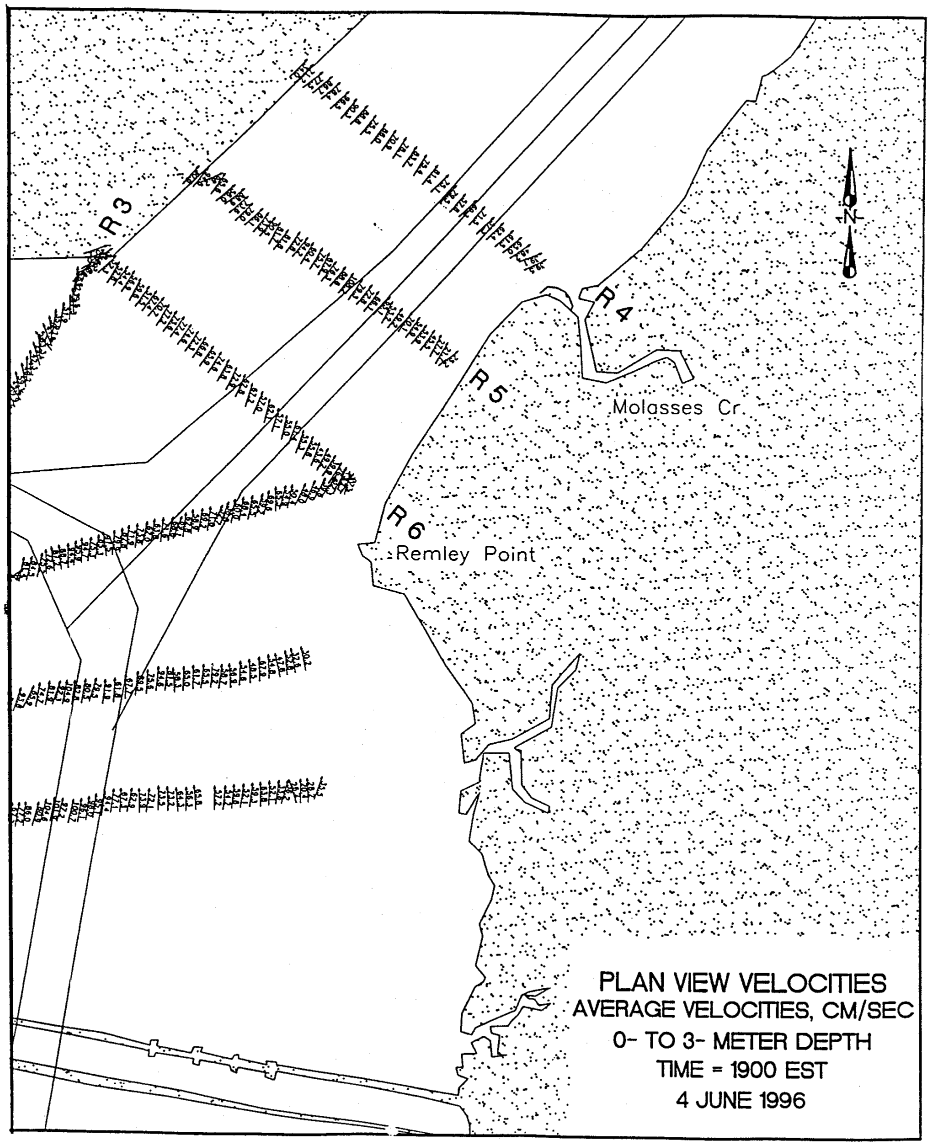


Figure 4. Near-surface current velocity vectors, maximum flood tidal phase (tide coming in)

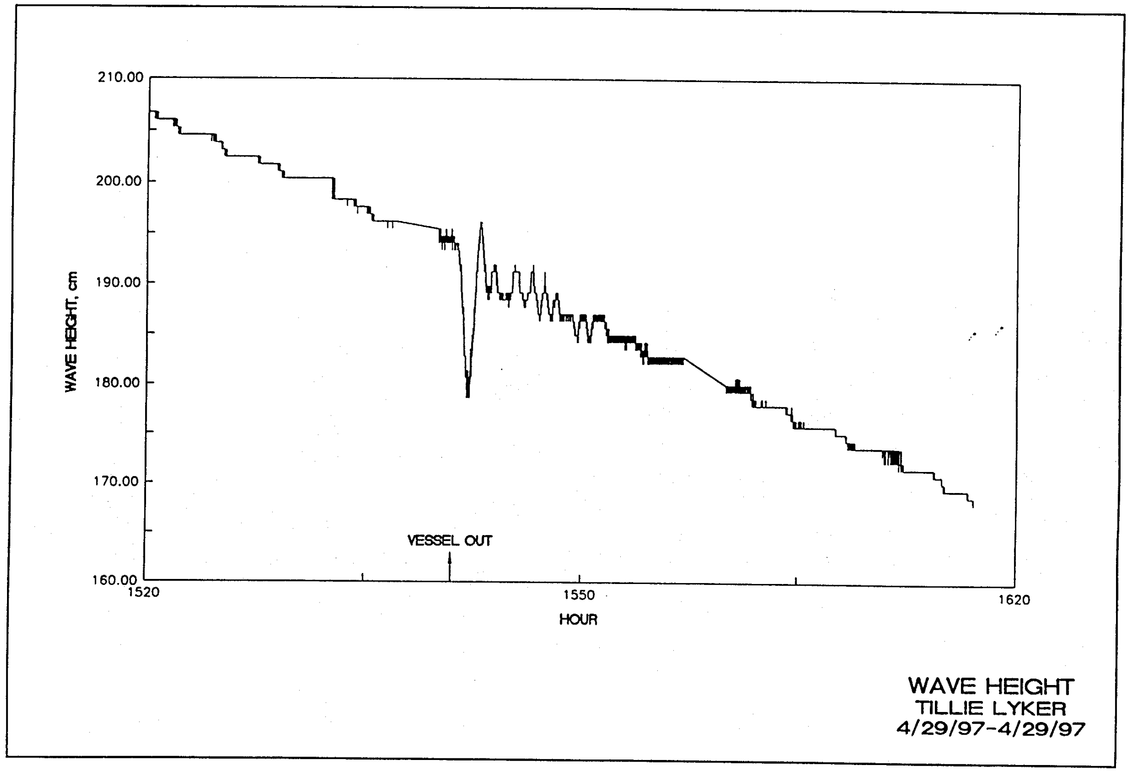


Figure 5. Vessel wave observed during the 1997 field reconnaissance survey from the S.S. Tillie Lykes

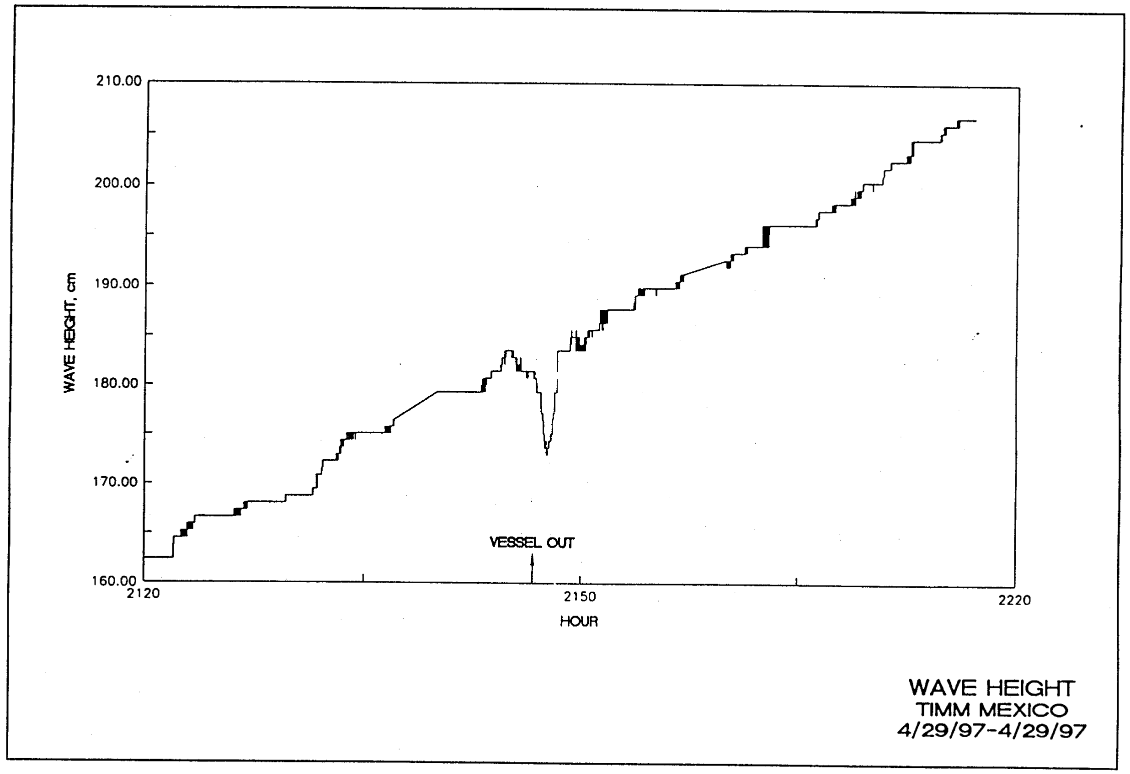


Figure 6. Vessel wave observed during the 1997 field reconnaissance survey from the S.S. Timm Mexico

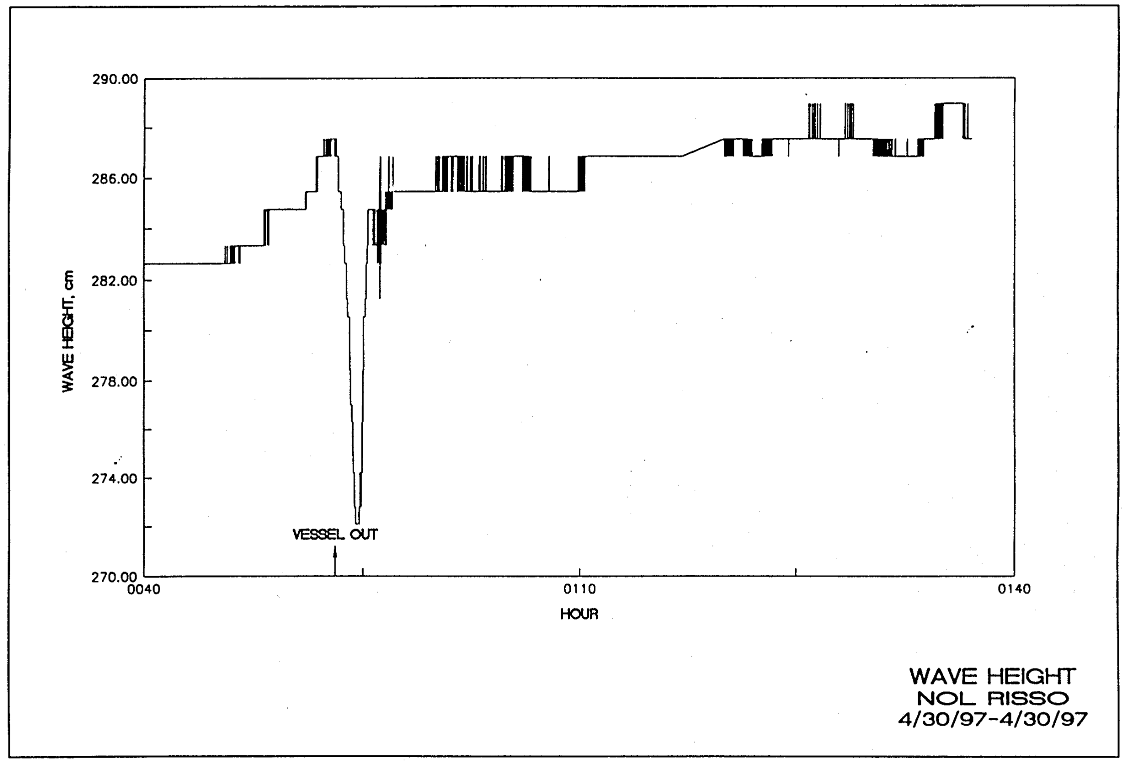
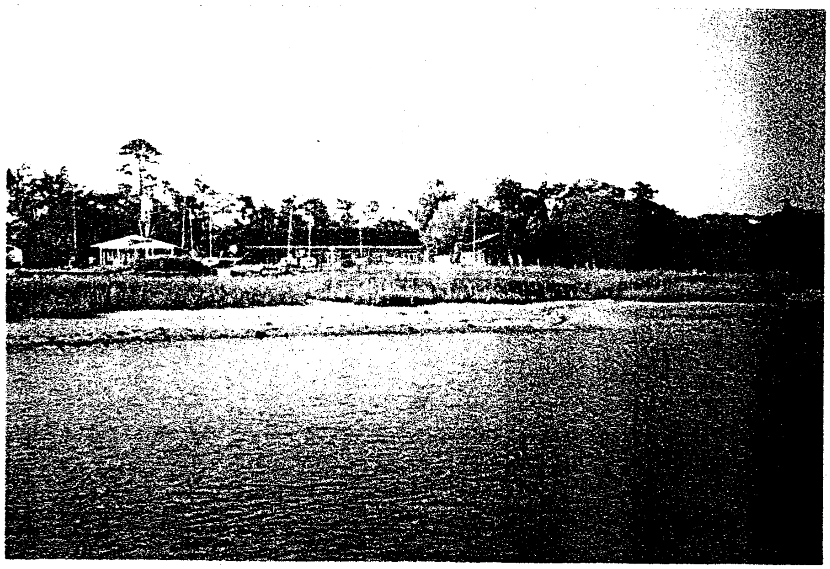
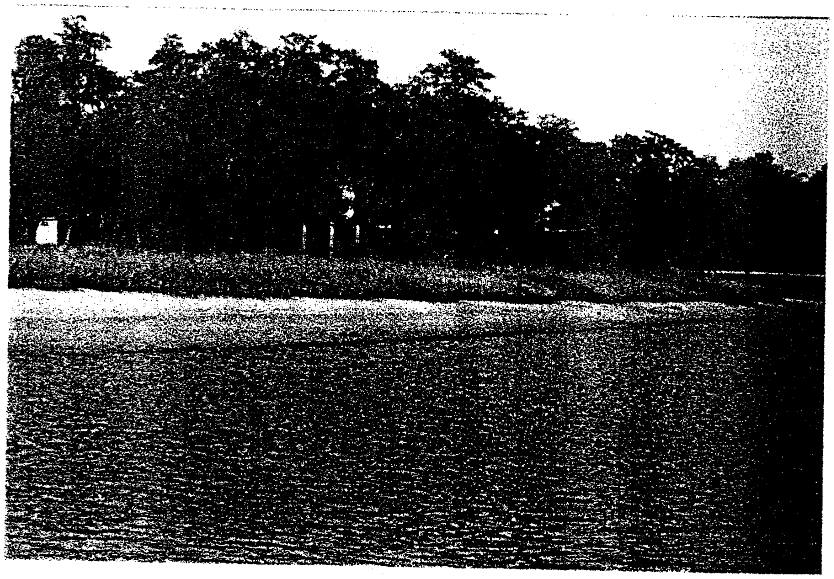
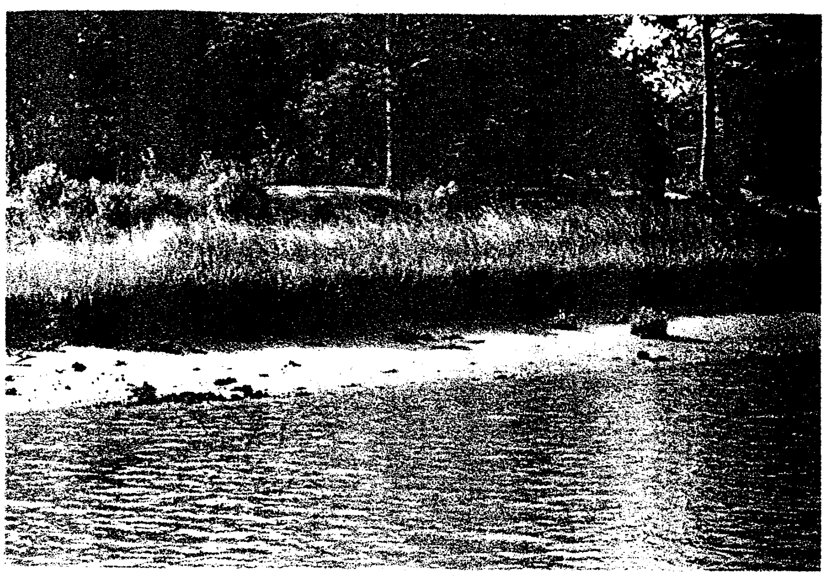


Figure 7. Vessel wave observed during the 1997 field reconnaissance survey from the S.S. Nol Risso

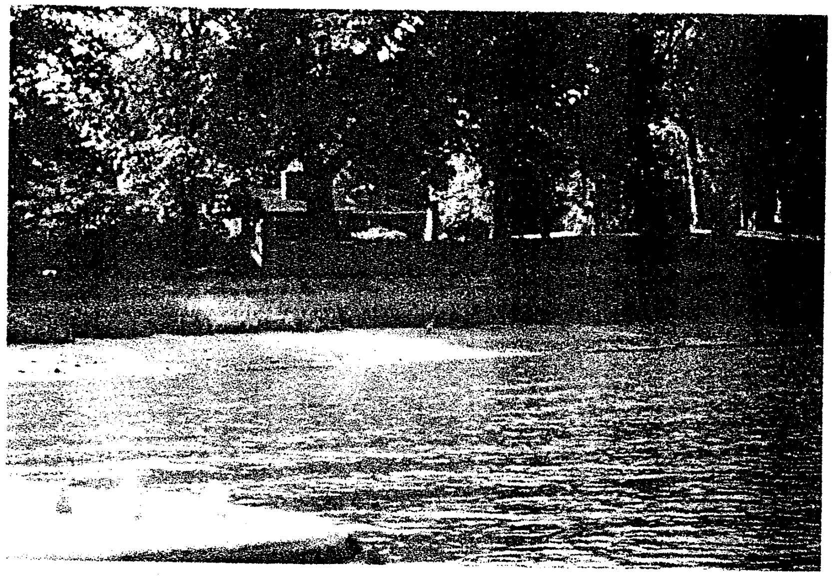




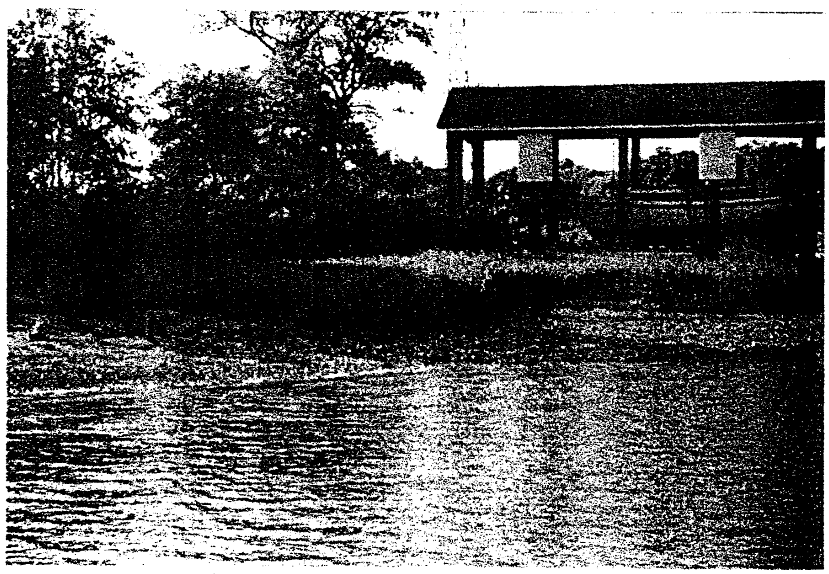
Photos 1-2. The shorline from Hobcaw Point seaward to Remley Point



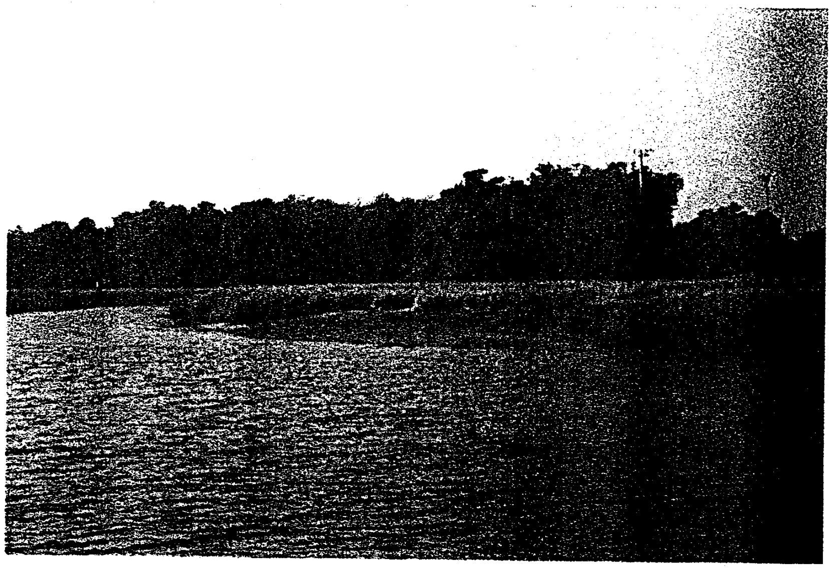
Photos 3-4. The shorline from Hobcaw Point seaward to Remley Point

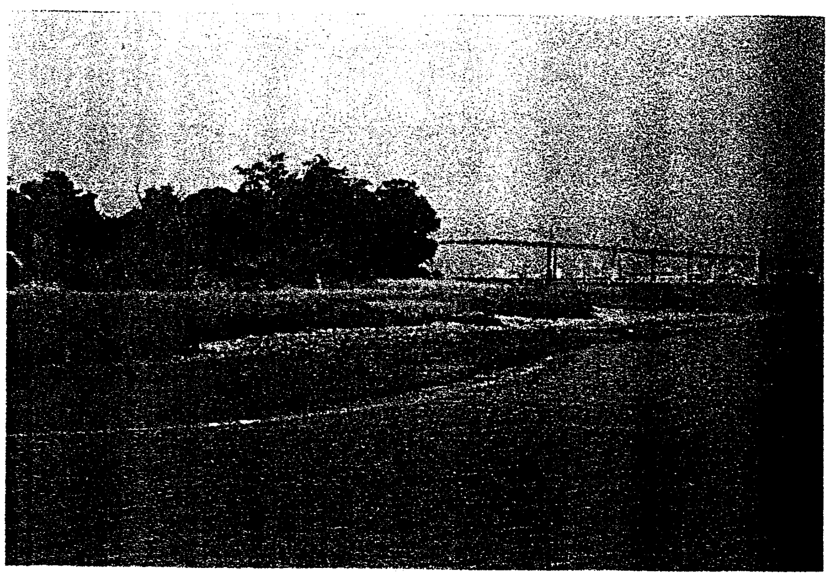


Photos 5-6. The shorline from Hobcaw Point seaward to Remley Point

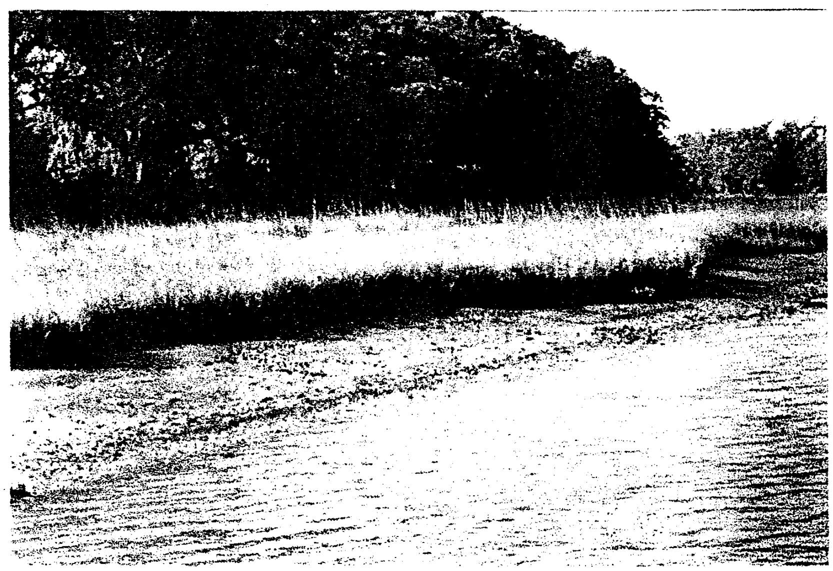


Photos 7-8. The shorline from Hobcaw Point seaward to Remley Point

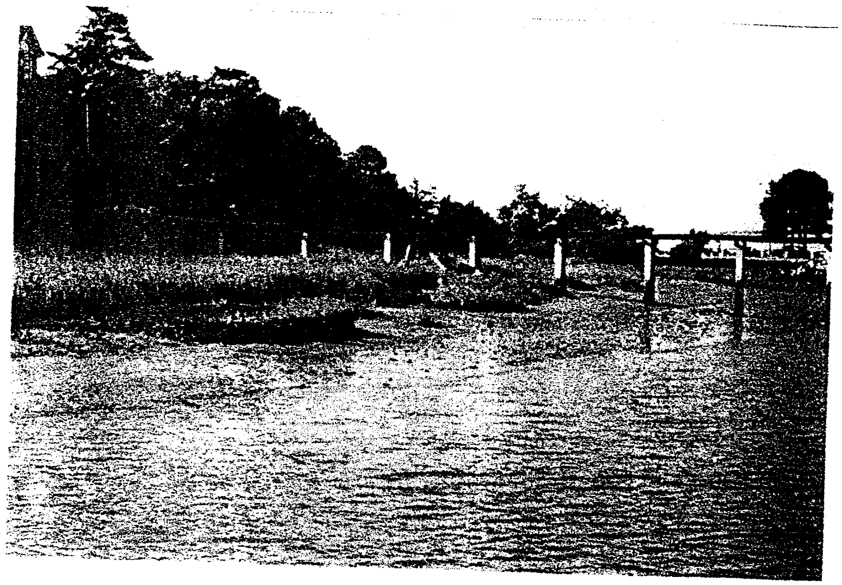


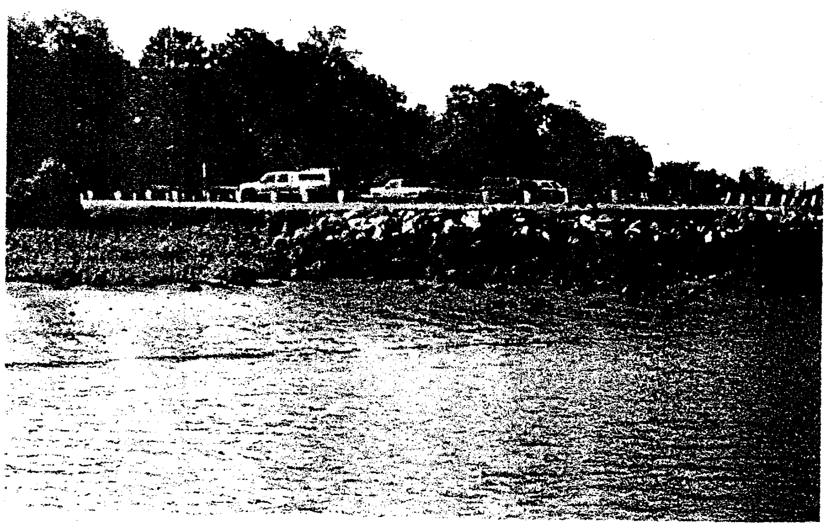


Photos 9-10. The shorline from Hobcaw Point seaward to Remley Point



Photos 11-12. The shorline from Hobcaw Point seaward to Remley Point





Photos 13-14. The shorline from Hobcaw Point seaward to Remley Point