Gary B. Eames. THE LATE QUATERNARY SEISMIC STRATIGRAPHY, LITHOSTRATIGRAPHY, AND GEOLOGIC HISTORY OF A SHELF-BARRIER-ESTUARINE SYSTEM, DARE COUNTY, NORTH CAROLINA. (Under the direction of Dr. Stanley R. Riggs) Department of Geology, June 1983.

Seismic and core analysis of the Roanoke Island area, Dare County, North Carolina have revealed a complex late Quaternary stratigraphy. The over-all stratigraphy and time relationships of the stratigraphy were acquired by analyzing 1) 585 km of 7kHz acoustic sub-bottom profiles, 2) 100 km of high resolution Uniboom seismic sub-bottom profiles, 3) 59 vibra-cores, 4) 37 rotary-drill cores, and 5) over 100 carbon-14 age dates from material in cores.

Seismic profiles reveal a highly channeled sub-surface throughout the study area. Most shallow channels within the estuaries are Holocene in age while deeper inshore and offshore sub-surface channels are Pleistocene in age except for offshore channels of the Albemarle system which is Holocene. The channels were formed during episodes of emergence of the area and subsequently infilled with sediment during the following transgression over the area.

The general stratigraphy consists of a repetitive series of low angle, eastward dipping, imbricate, barrier island sand sheets with associated facies; these sand sheets rest atop an earlier widespread marine unit. The stratigraphic units have been divided into five depositional sequences. The first is the basal nearshore marine facies. The remaining four sequences are barrier island-estuarine systems consisting of one or more of the following facies: (1) nearshore marine

facies, (2) barrier island facies, (3) back-barrier estuarine facies, (4) inlet channel facies, (5) filled lateral estuary facies, (6) filled trunk stream facies, and (7) peat facies. Each depositional sequence is the result of eustatic sea-level fluctuations; each sequence was deposited during a transgressive cycle and eroded and reworked during the subsequent regression. The transgressive maximum for each depositional sequence is marked by the westernmost position of the barrier island facies. The resulting barrier ridges may be correlatable to similar barrier island ridge systems in southeast Virginia. All but the last of the depositional sequences are late Pleistocene in age. The last and present depositional sequence is a product of the Holocene and Recent transgressive cycle.

THE LATE QUATERNARY SEISMIC STRATIGRAPHY, LITHOSTRATIGRAPHY, AND GEOLOGIC HISTORY OF A SHELF-BARRIER-ESTUARINE SYSTEM, DARE COUNTY, NORTH CAROLINA

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by

Gary B. Eames

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INTRODUCTION

The Roanoke Island area in northeastern North Carolina is characterized by estuarine and open marine shelf environments. The study area (Fig. 1) forms the junction where Albemarle Sound, Pamlico Sound and the Atlantic Ocean converge. The estuarine system is separated from the Atlantic Ocean by the Outer Banks barrier island system. The Dare County mainland east of the Alligator River forms a peninsula between Albemarle, Croatan and Pamlico Sounds. The peninsula is topographically low (generally less than 1.5 m) and dominated by swamp forest with marsh growth around the perimeter. Relict dunes are found along the northeast edge of the mainland which reach a height of 3 m.

Roanoke Island is situated east of the mainland peninsula and west of Bodie Island, a portion of the Outer Banks, separated by Croatan Sound and Roanoke Sound, respectively. Roanoke Island is a NNW-SSE trending arcuate island (convex eastward) with a maximum length of 15.8 km and an average width of about 3.5 km. Its northern end is moderately tapered with a smooth shoreline and is dominated by relict dune fields along the northeast corner. The southern end of the island gradually widens to a broad irregular shoreline dominated by low marsh islands.

Croatan Sound, which separates Roanoke Island from the Dare County mainland, is a relatively narrow thoroughfare between Albemarle and Pamlico Sounds. It has a maximum width of nearly 8 km and a minimum width of 4.2 km. Average water depth is 3 m with deeper scour areas up to 6 m deep. Croatan Sound is slightly restricted at the ends of

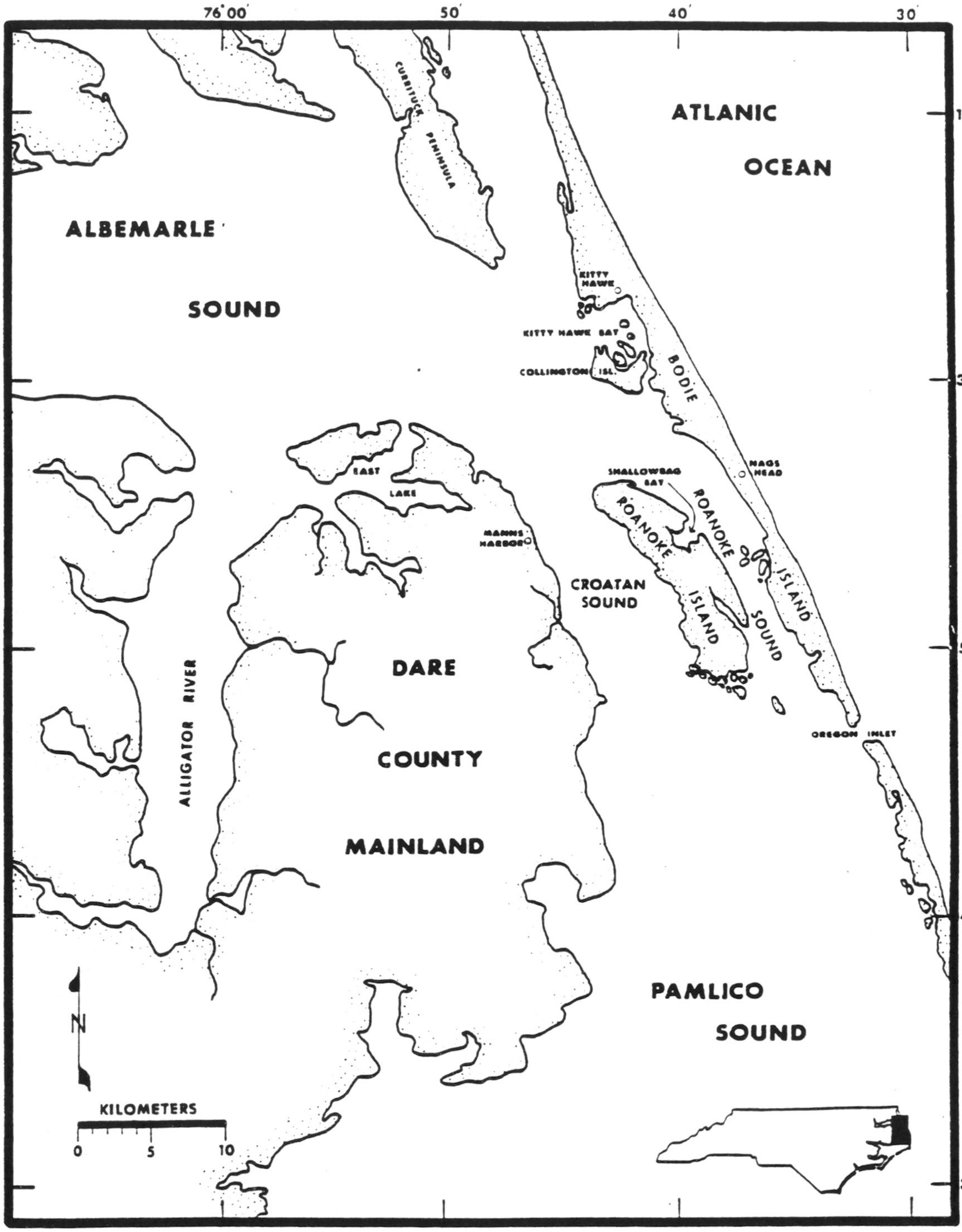


Figure 1. Location map of the Roanoke Island area.

Roanoke Island and widens adjacent to the concave portion of the island. The deeper portions of the sound are located in the zones of restriction.

Roanoke Sound, located between Roanoke Island and Bodie Island, is a smaller estuary between Albemarle and Pamlico Sounds. Depths are generally less than 1 m except in the northern portion where historic inlets passed through the barrier. Roanoke Sound narrows southward from Albemarle Sound to the mid-point of Roanoke Island where it measures less than 1 km in width at the site of a relict flood-tide delta. The sound widens again southward into Pamlico Sound.

The Albemarle Sound and its lateral estuaries, such as the Alligator River, represent a complex system of drowned river drainages produced by the modern transgression. The bathymetry of Albemarle Sound is very shallow and consistent throughout the main water body, measuring 4.5 to 5.5 m and shallows to about 2 to 3 m as it approaches Roanoke Island. The maximum width of the sound is on the order of 20 km or more. This necks down to about 9 km north of Roanoke Island, and 4.2 km at Croatan Sound, through which the majority of the Albemarle system discharge is carried.

The Albemarle system discharges through Croatan Sound and into the Atlantic Ocean by way of northern Pamlico Sound and Oregon Inlet. Presently, Oregon Inlet is the northernmost inlet of the Outer Banks. In the historic past, numerous inlets have been active further north, but subsequently closed by accretion. The Outer Banks within the study area are linear features which trend approximately N 25° W, have smooth shorelines on the Atlantic side, and highly irregular shores on the landward side. Island width ranges from 0.5 km to 5.0 km with topographic dunes which average 9 m in height and are locally up to 42 m.

Shoreface profiles along the Atlantic Ocean tend to steepen southward from the Chesapeake Bay area of Virginia to Cape Hatteras, North Carolina (Swift, 1975). The upper shoreface slope along the Outer Banks in the study area is quite steep. In some areas, the bottom drops 9 m (30 feet) within 600 m (.32 nautical miles) from shore (Fig. 11). The slope generally decreases at depths of 20 to 25 m (65 to 80 feet) within 3 to 5 km (1.6 to 2.7 nautical miles) or more from shore (Fig. 2). The slope of the continental shelf is relatively low throughout to the shelf slope break; however Figure 2 shows extensive inner-shelf sand shoal systems as described by Swift (1975). Littoral drift along the Outer Banks is primarily southward through the entire region, yet local northward drift has been identified on the north side of Oregon Inlet (Swift, 1975).

The Roanoke Island study area is a system which has resulted from a complex Pleistocene and Holocene history. Most significant to the evolution of the system have been the Pleistocene transgressive and regressive episodes and the present Holocene transgression. The objective of this thesis is to describe and analyze the surface and subsurface geologic features of this area and to produce a geologic interpretation of the origin and history of development of these features through time.

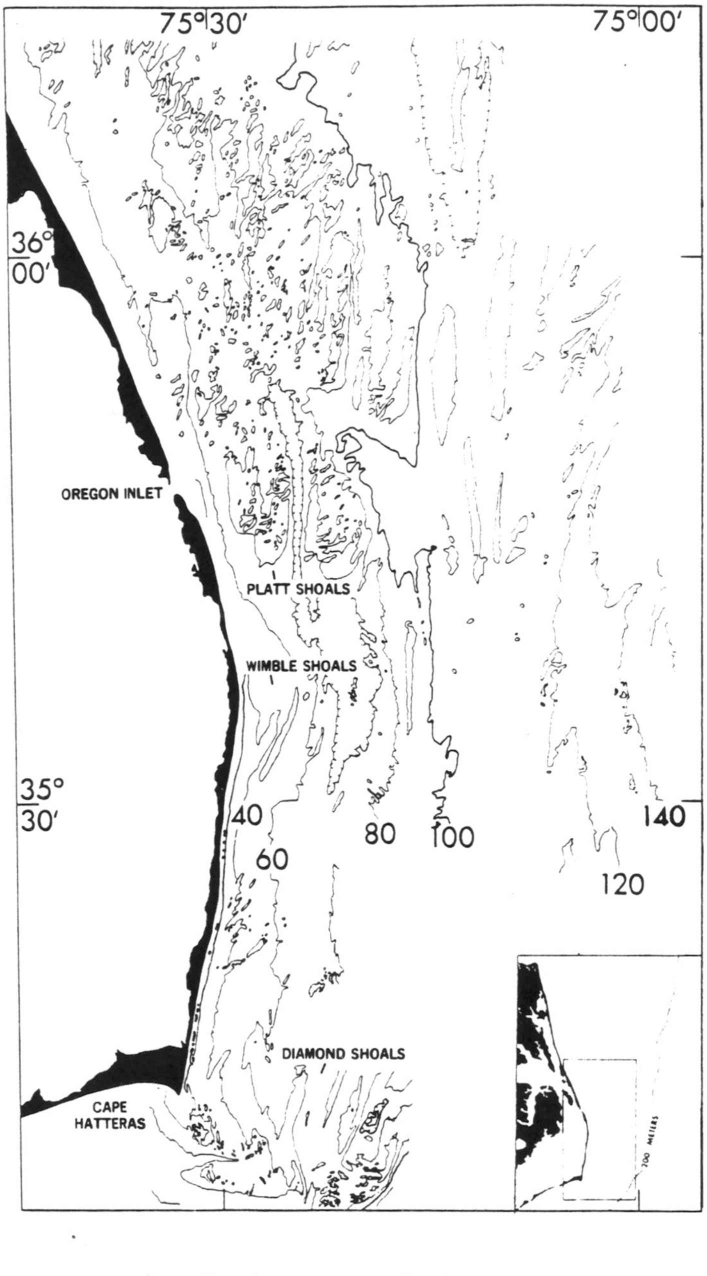


Figure 2. Bathymetry of the North Carolina shelf adjacent to the Roanoke Island study area. Contours in feet below mean sea level (from Swift et al., 1972).

REGIONAL GEOLOGIC SETTING

The coastal plain and continental shelf of North Carolina consists of a gently eastward dipping, seaward-thickening wedge of Mesozoic and Cenozoic terrigenous and carbonate sediments (Fig. 3). This sedimentary wedge grades from 1.5 to 2.0 km thick through the study area with a basal dip angle of around 1.5 degrees. Regional structures including the Cape Fear Arch, Hatteras Embayment and Fort Monroe High (Fig. 4) have in part controlled deposition in this region since the mid-Mesozoic (Denison et al., 1966; Richards, 1974; Skeels, 1950; and Spangler, 1950). These features have had a decreasing affect on sedimentary characteristics through time with little influence on Pleistocene and Holocene sedimentation (Brown et al., 1972). However, effects of crustal warping due to Pleistocene glacial loading/unloading north of the study area, and regional subsidence adjacent to the study area possibly influenced the distribution of Quaternary sediments (Dillon and Oldale, 1978; Harrison et al., 1965; Hicks, 1972; and Zullo and Harris, 1979). Quaternary sediments rest on a post-Miocene eastward dipping angular unconformity. Quaternary sediments range from 500 to 700 m in thickness within the onshore segment of the study area, while offshore the thickness varies due to basal seaward dip and irregular bottom erosion and/or shoaling. The Quaternary section includes pre-Wisconsin sands and clays and a thin, discontinuous Holocene sand sheet. The Holocene surface is dominated by north- to northeast-trending ridge and swale topography. Shelf break morphology variations suggest differential rates of Holocene sedimentation and shelf development (i.e.,

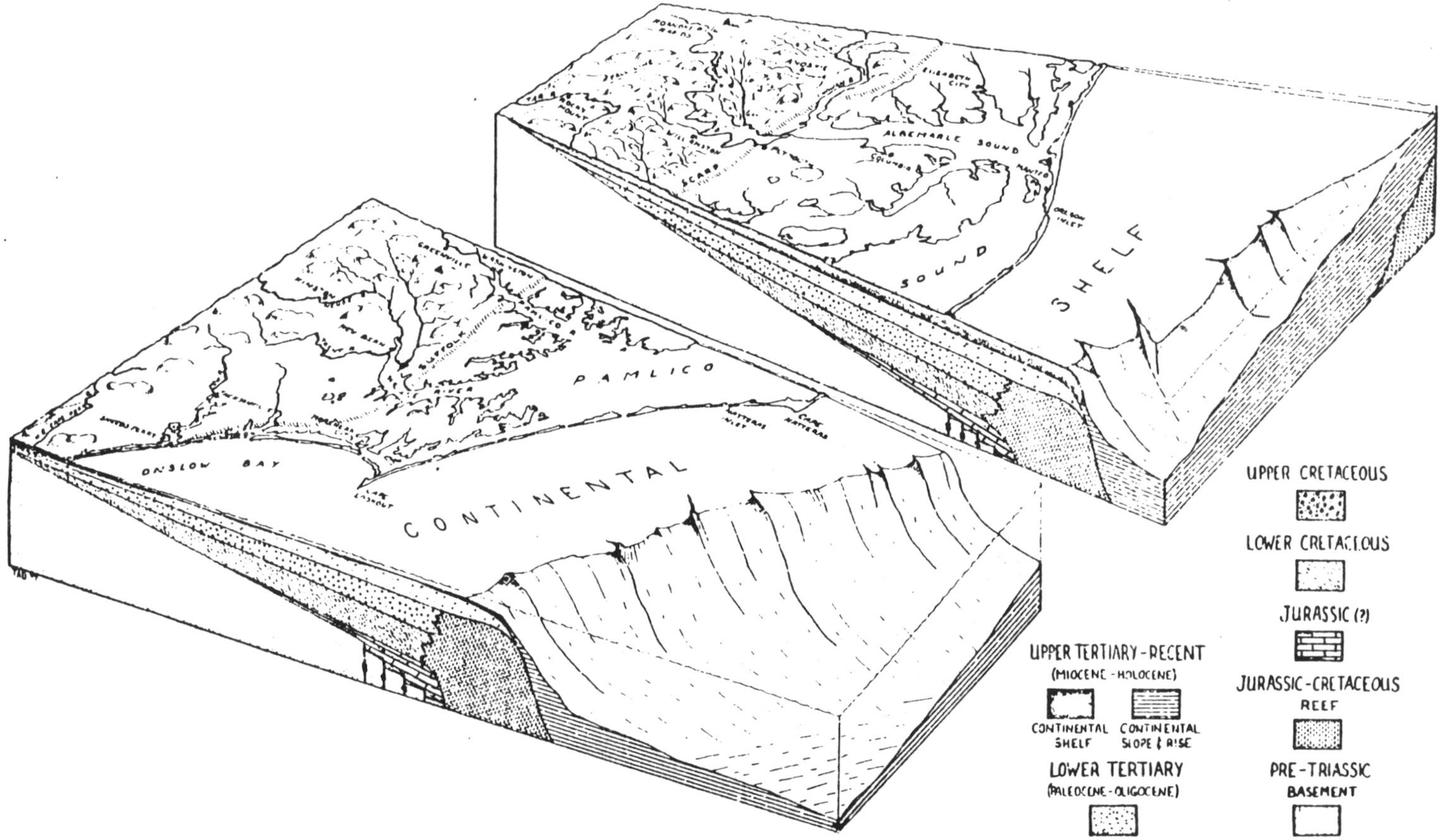


Figure 3. Stratigraphic cross section of Eastern North Carolina (from Riggs, 1979).

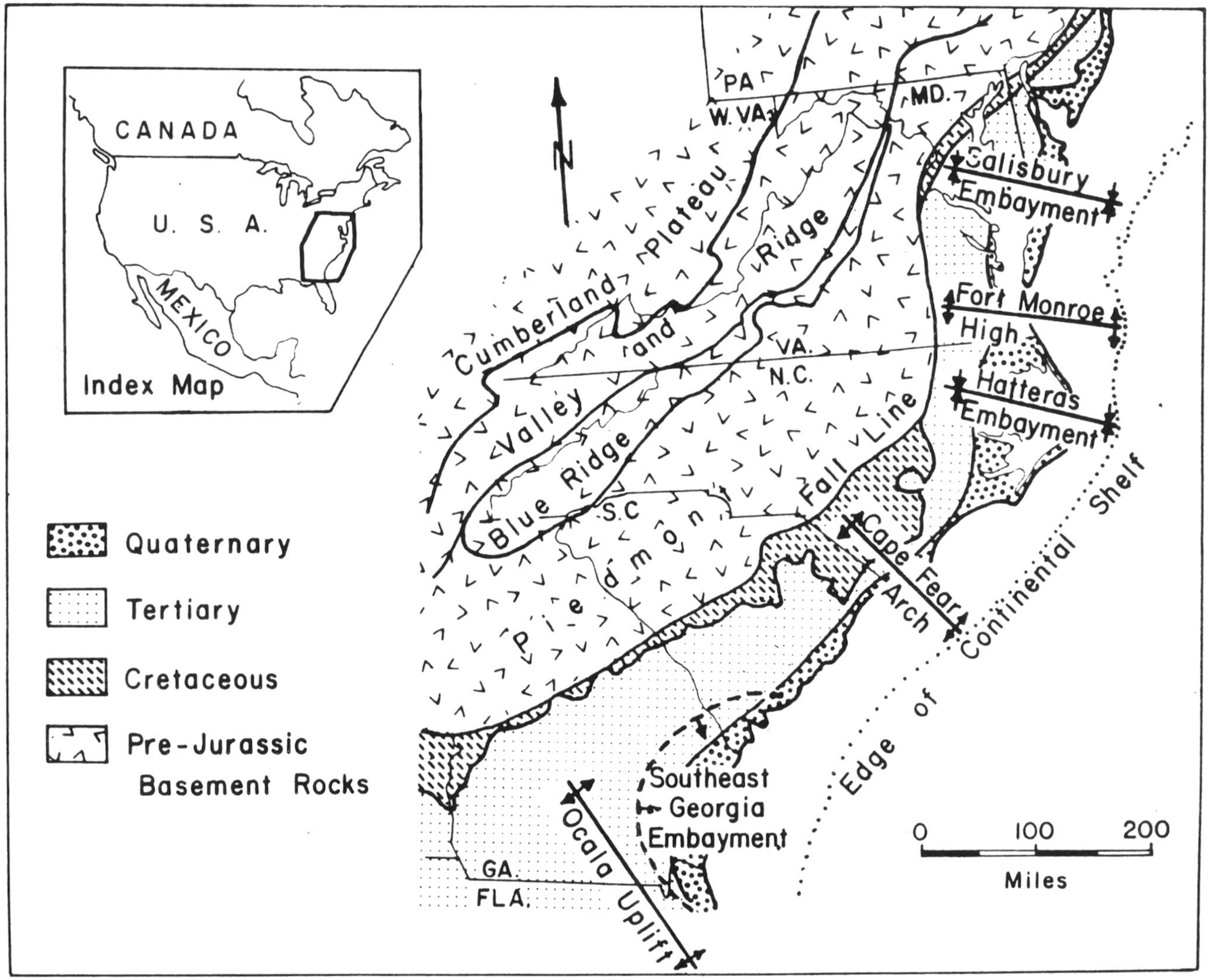


Figure 4. Major structural features of the Atlantic continental margin (from Oaks and DuBar, 1974).

progradation). Shelf development is minimal towards Virginia and maximal near Cape Hatteras (Shideler and Swift, 1972).

PREVIOUS INVESTIGATIONS

Quaternary sands and clays crop out along the coastal plain east of the Surry Scarp (Fig. 5) and on the continental shelf for an undetermined distance (Oaks et al., 1974). The entire Atlantic coastal plain is dominated by scarps and ridges formed during eustatic sea-level highs. Correlation of these features in northeastern and east-central North Carolina is very problematic. Insufficient data, low and subsiding topography, and coalescence of ridge features create subjective interpretations (Oaks and DuBar, 1974; O'Connor and Riggs, 1974; and Pierce and Colquhoun, 1969). Most authors agree that Roanoke Island and the Currituck Peninsula were once semi-continuous. Oaks and DuBar (1974) correlate the Hickory Scarp of northeast North Carolina and southeast Virginia to a relict shoreline just west of the Alligator River, North Carolina (Fig. 6). They also correlate a relict shoreline just east of the Alligator River to one of the southward coalescing beach ridges of southeast Virginia and northeast North Carolina.

Riggs and O'Connor (1974) did extensive coring, sub-bottom profiling, and carbon-14 age dating within the Roanoke Island area. The stratigraphic section of the Roanoke Island area consists of (1) a lower fossiliferous muddy sand unit, interpreted to be a near-shore environment, (2) an intermediate sand and gravelly sand unit, considered to be a transgressive and/or regressive barrier deposit, and (3) an upper unit consisting of late Holocene marsh, estuarine, channel fill, barrier and beach sediments. Extensive channeling was recognized throughout the Roanoke Island area consisting of both fluvial and inlet

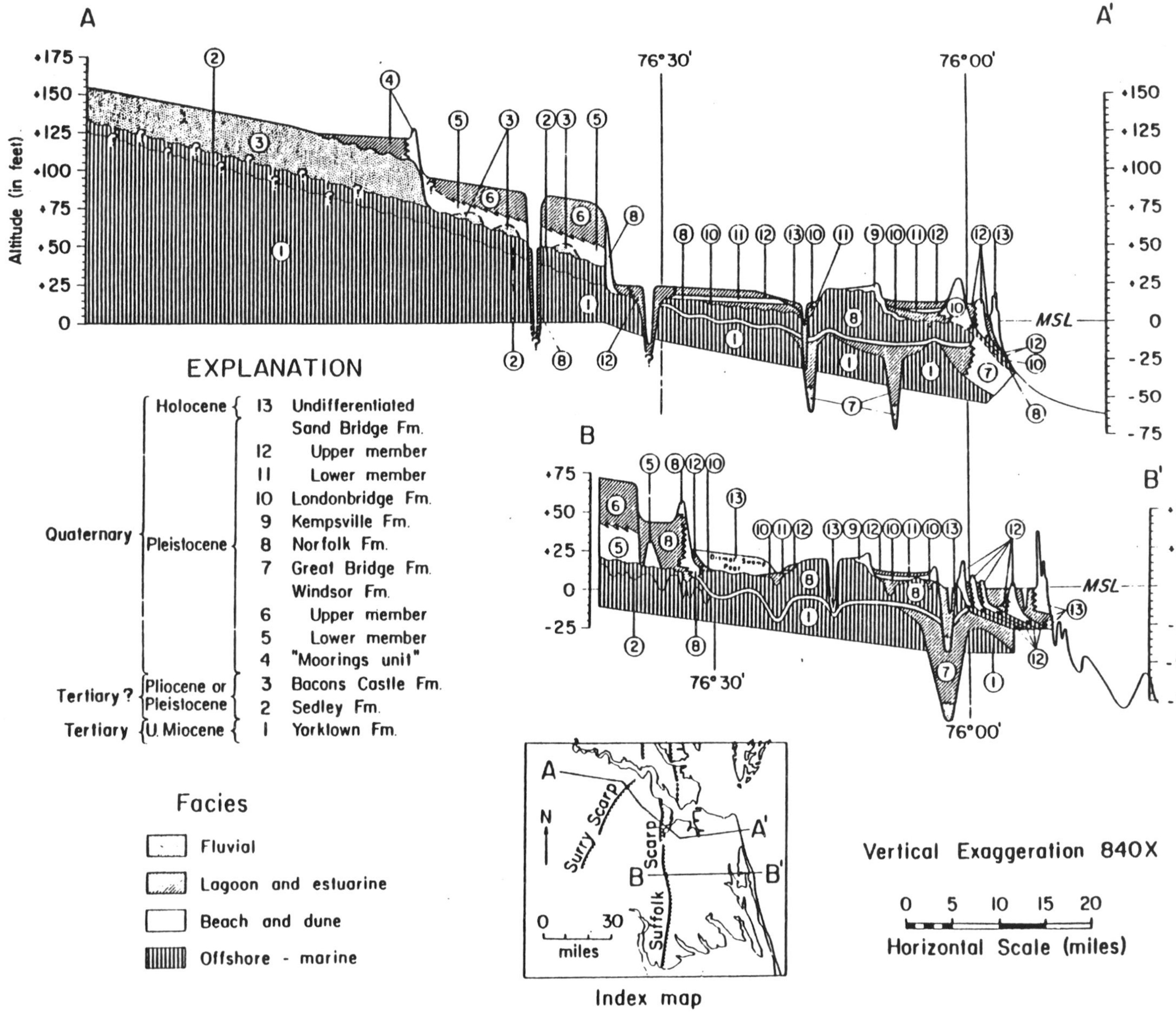


Figure 5. Cross section of southeast Virginia showing Quaternary stratigraphic units (from Oaks et al., 1974).

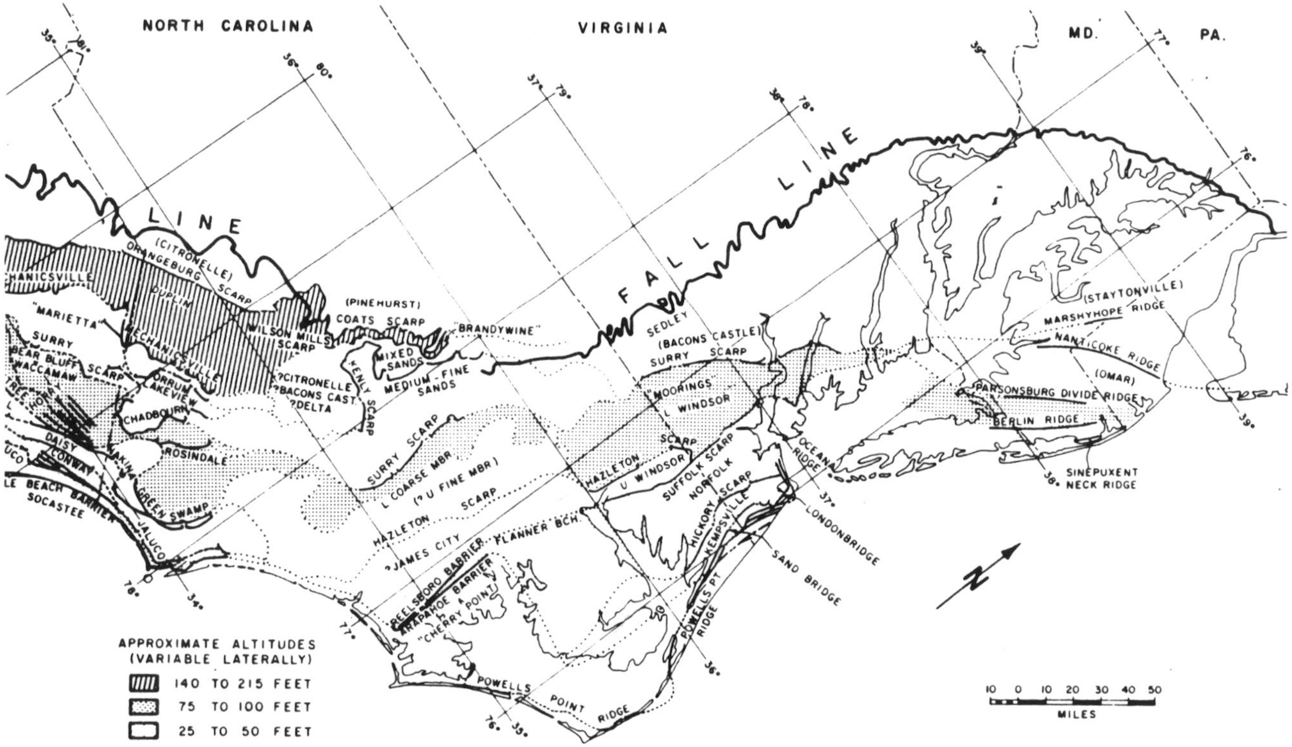


Figure 6. Regional correlation of shoreline ridge features along the upper Atlantic coastal plain (from Oaks and DuBar, 1974).

systems, some occurring parallel and some perpendicular to the present coastline. A clay wedge located beneath Croatan Sound, which thickens to the north, was interpreted to be an estuarine channel fill resulting from the transgression following the mid-Wisconsin low stand of sea level.

Miller (1982) completed a faunal analysis in the Stetson borrow pit of mainland Dare County. He found a similar sediment sequence and was able to assign distinctive depositional environments by analyzing fossil assemblages. His study included analysis of units exposed within the borrow pit and in an extended core drilled 12.5 m below the pit floor. The following are his paleoenvironmental interpretations in ascending order: "(1) inner shelf marine associations, (2) transitional assemblages of both marine and estuarine fauna, (3) transported estuarine associations, (4) shoal flank associations, (5) oyster biostrome associations, (6) sand and shoal associations, and (7) assemblage of various estuarine associations."

Sampair (1976) conducted a survey of the Roanoke Island area using sub-bottom profiles and shallow vibra-cores. The primary objective was to define the oyster shell resources and involved minimal geologic interpretation. No significant oyster reserves were located, but review of the data reveals extensive fluvial channeling within the upper 5 m of sediment throughout eastern Albemarle Sound. The channels observed on the sub-bottom profiles were not cored.

Benton (1980) studied the Holocene marsh deposits in the Broad Creek area of Roanoke Island. Based on carbon-14 age dating, it was found that marsh deposits of Roanoke Island began to form no more than

6000 years B.P. in response to the present transgression. These deposits have continued to thicken with rising sea level.

Ingram and Otte (1982) mapped the distribution and thickness of peat throughout the Dare County mainland (Fig. 7). Analysis of this data provides a paleotopography of the mineral soils during the Late Wisconsin low which reveals abundant fluvial channeling throughout the area.

The deeper stratigraphy of the near-shore shelf adjacent to Roanoke Island has been investigated using a multitude of seismic methods (Grow and Markel, 1977; Hersey et al., 1959; and King and Costain, 1982). Shallower units were studied by Shideler and Swift (1972) in the nearshore shelf from Cape Henry, Virginia to Cape Hatteras, North Carolina. Their study found post-Miocene sediments on top of a regionally extensive Tertiary angular unconformity. This is the same unconformity that Steele (1980) found further south beneath Bogue Banks, North Carolina. This unconformity is believed to be the result of extensive shelf emergence during the late Tertiary or early Pleistocene. Seismic data of Shideler and Swift suggests that the unconformity surface dips to the southeast at less than 0.25 degrees. The Pleistocene units above the unconformity are interpreted to be the result of transgressive/regressive cycles related to glacial-eustatic sea level processes.

Duane et al. (1972) studied the occurrence of linear shoals within the inner continental shelf of the Atlantic coast. The shoal features were described as very common planoconvex sand lenses, typically at

Figure 7. Isopach map of peat deposits of Dare County. Contours are thickness in meters below the surface. Dot pattern indicates sand at the surface (after Ingram and Otte, 1982; and Riggs and O'Connor,1974).

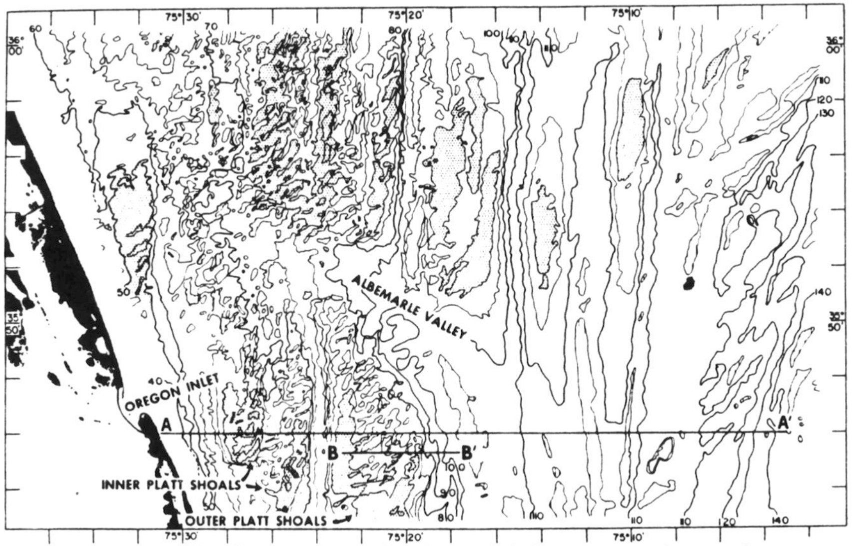
acute angles to the shoreline, trending northeast. The shoals have relief of up to 9 m and may or may not be connected to the shoreface. Radiocarbon ages suggest a Holocene age for the shoal features.

Swift et al. (1972) explained the ridge and swale topography of the inner continental shelf as a stable end configuration formed by shoreline retreat during transgression. The ridges are maintained by trough scour and are locally deepened. Duane et al. have identified remnant features in the nearshore region adjacent to the Outer Banks. These features include a relict Albemarle valley (Fig. 8a) and the adjacent shoal retreat massifs formed by the modification of the inlet and its ebb tide delta through transgression as depicted in Figure 8b.

Swift (1975) described the inner continental shelf as a series of terraces. Superimposed on these terraces is a discontinuous sheet of lagoonal sediments, on top of which rests a discontinuous sand sheet formed by erosional barrier island retreat. Swift finds no evidence of drowned barriers and therefore suggests barrier island genesis to be associated with the terrace structures. During low stillstands, barrier islands are formed due to coastwise spit progradation or inland beach detachment (flooding behind strandplain dune fields). Maximum slope is achieved along the stillstand shoreface as a result of shoreface erosion forming a terrace as transgression occurs.

The seismic lines of Pearson (1979) recorded detailed stratigraphy of the upper 50 m of sediment in a zone from Oregon Inlet to just north of Kitty Hawk, North Carolina, extending to a maximum of 10.5 km offshore. Core data consisted of 1.5 to 2.0 m vibra-cores which showed

A



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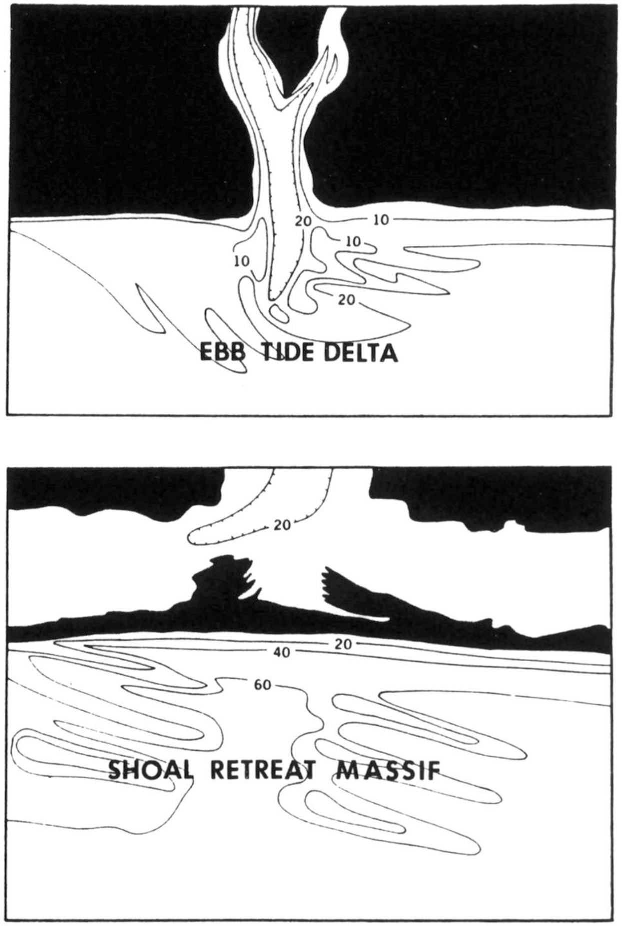


Figure 8a. Bathymetry of the offshore region adjacent to Roanoke Island showing major shoal features and location of the proposed Albemarle Valley. Contours are in feet below mean sea level (from Swift et al., 1972).

Figure 8b. Schematic model for the evolution of an inlet associated shoal (ebb tide delta) into an inner-shelf ridge system (shoal retreat massif), based on the flooded Albemarle fluvial system. Fluvial ebb tide delta is modified by wave energy following submergence and coastal retreat. Contours are in feet below mean sea level (modified after Swift et al., 1972).

the shallow sediment relationship of the near offshore area. The results of these data will be discussed in subsequent sections.

PROCEDURES

Data

I. Drs. Stanley R. Riggs and Michael P. O'Connor of East Carolina University, Greenville, North Carolina, 1970 through 1973, Sea Grant Project of the National Oceanographic and Atmospheric Administration. Data obtained during this period includes: (1) 585 km of 7 kHz acoustic sub-bottom profiles (Edo Western, Model 578 Survey Depth Recorder) (Fig. 9), (2) forty 5.5 to 12 meter vibra-cores, (3) thirty-seven 15 to 24 meter rotary drill cores (Fig. 10), and (4) over 100 carbon-14 age dates.

II. Stanley R. Riggs, Albert C. Hine, and Daniel R. Pearson, 1978, grant from the Coastal Plains Regional Commission and Department of Administration, State of North Carolina. Data includes: (1) 100 km of high resolution Uniboom seismic sub-bottom profiles (EG & G Uniboom System) (Fig. 9), and (2) nineteen 1.5 to 2.0 m vibra-cores (Fig. 11).

Seismic Reduction

In the reduction of the 7 kHz acoustic profiles, profile position was plotted on the N.O.A.A. navigation chart number 1229 (N.O.A.A., 1970). Range and cross-range plots of shore and channel markers were used to obtain chart positions. Range and cross-range positions were marked on the profile tape. Profiles were plotted as straight paths since minor variations and drift due to environmental conditions could not be measured. This undoubtedly results in some degree of error in the correlation of profile positions.

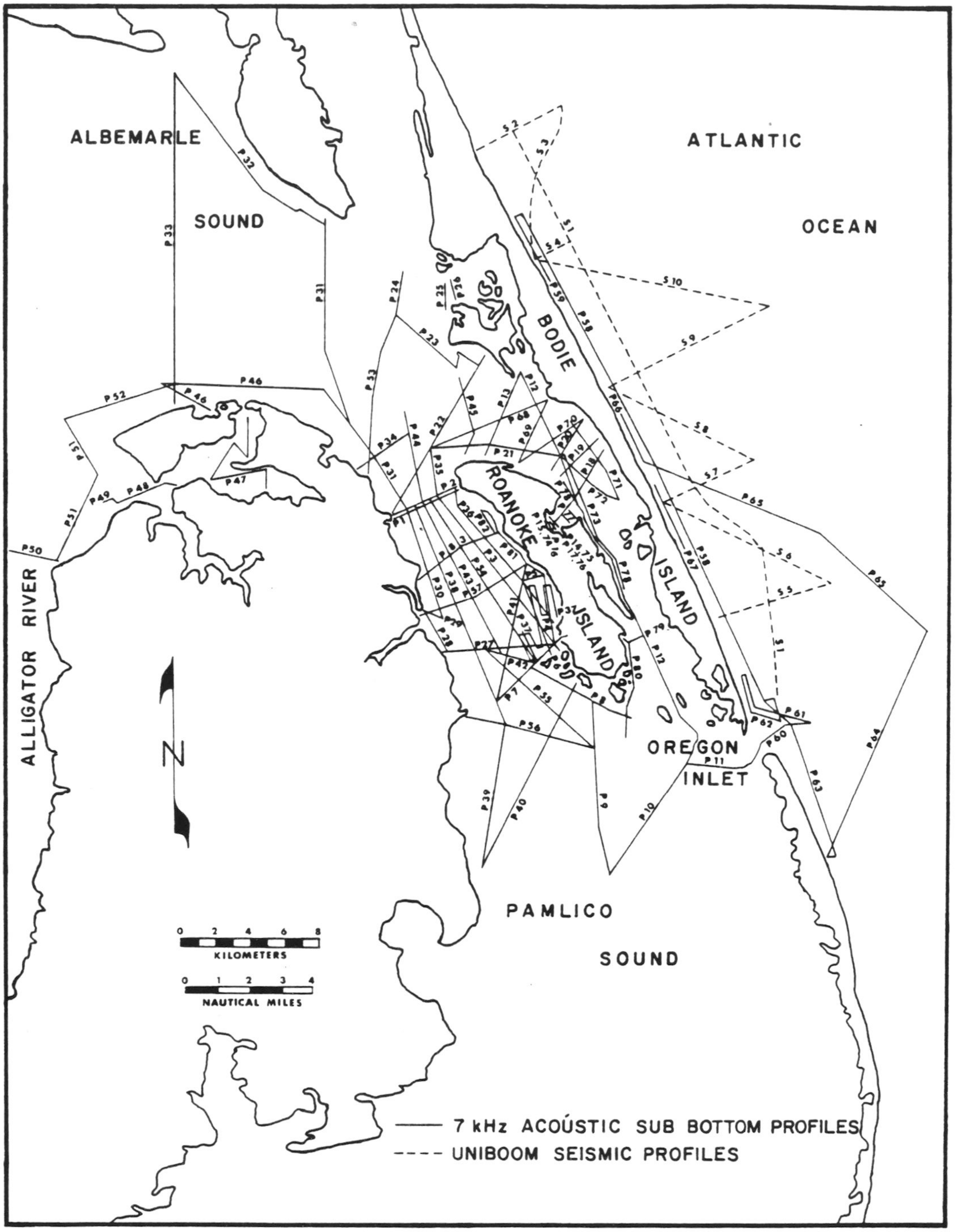


Figure 9. Location map of profiles.

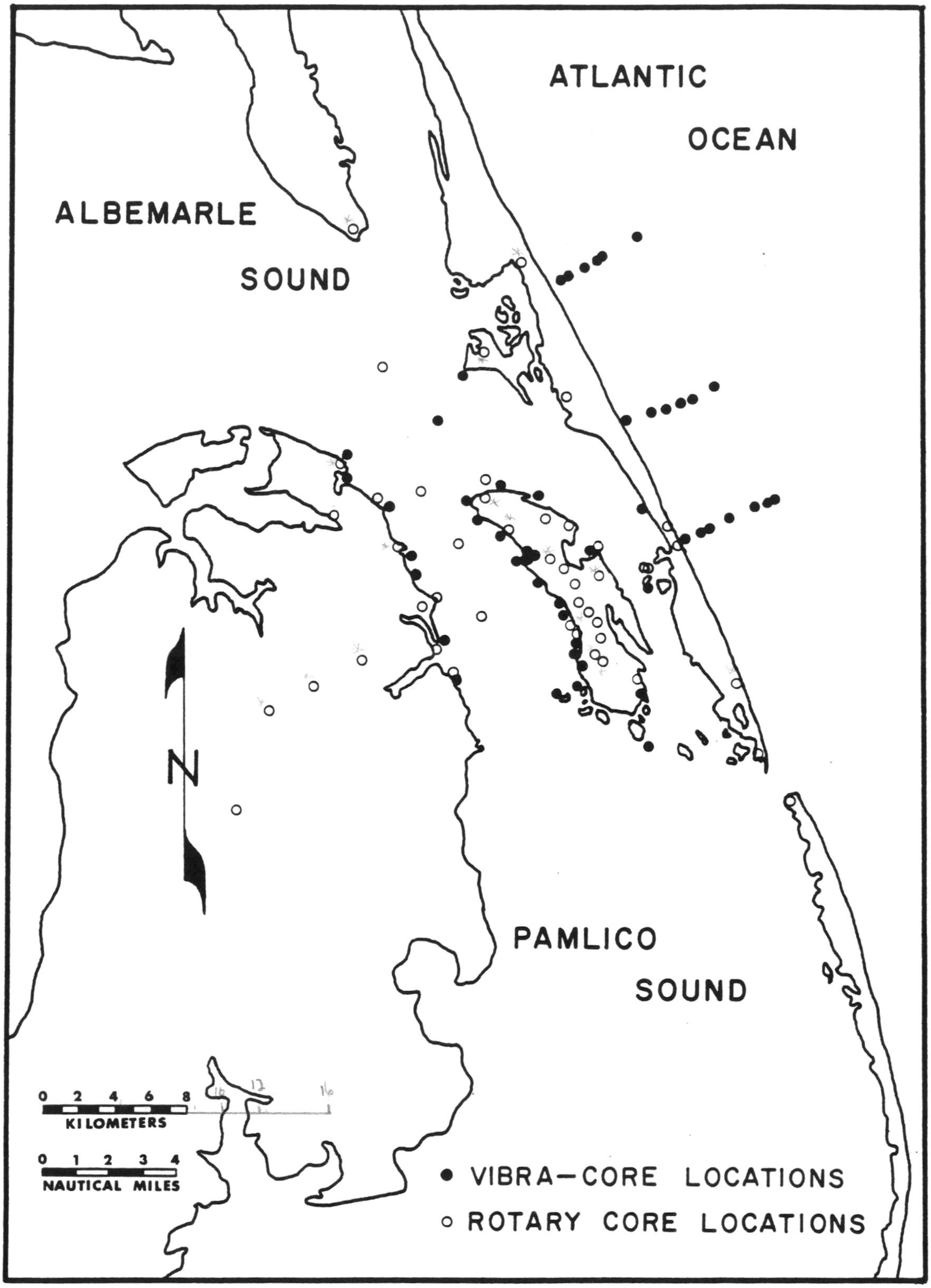


Figure 10. Location map of vibra-cores and rotary-drill cores.

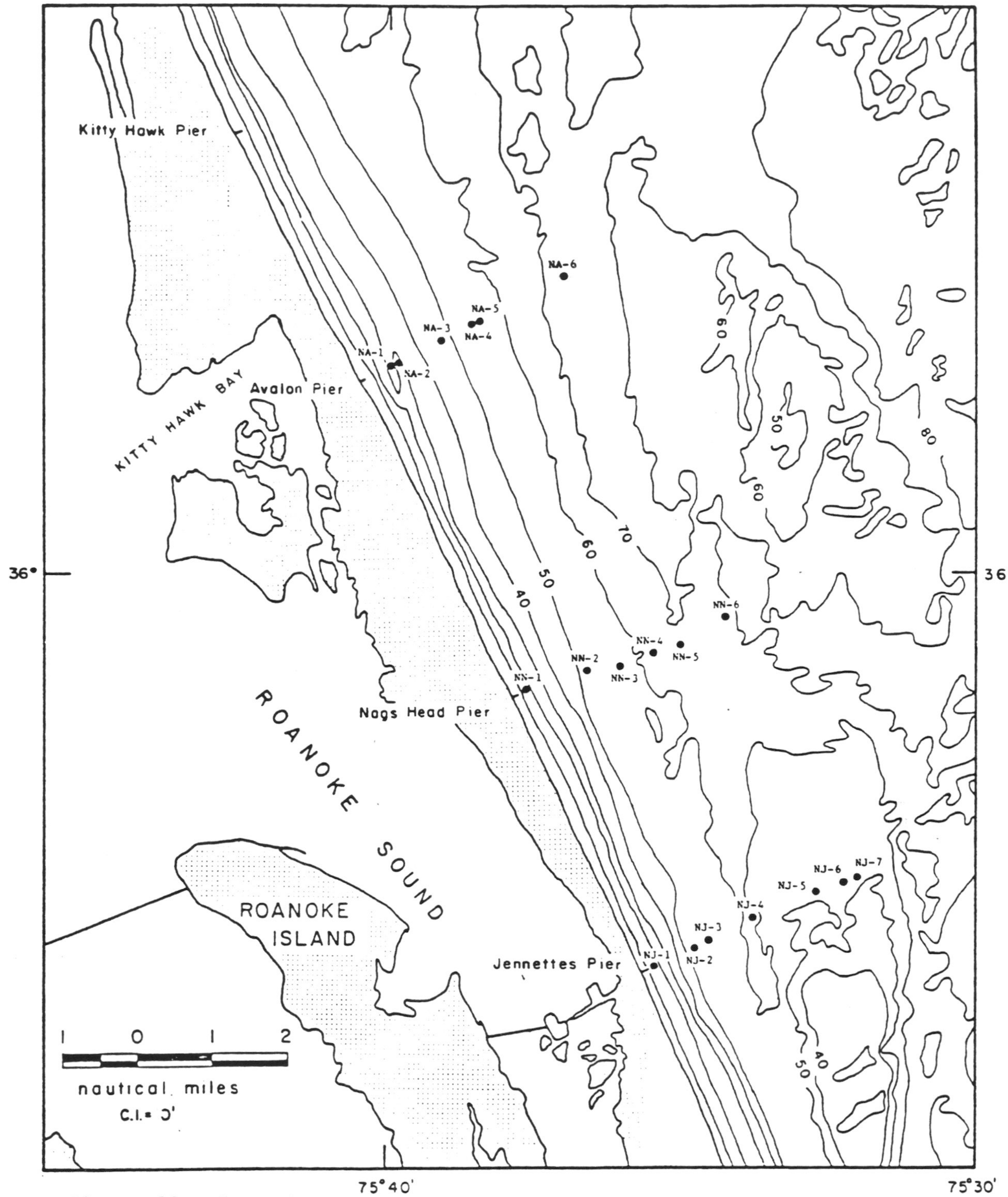


Figure 11. Location map of offshore vibra-cores (from Pearson, 1979).

In the reduction and analysis of the profiles, the position of range markers on the tapes were plotted on the navigation chart. Distance in kilometers was then determined between each range marker on the navigation chart using the chart scale. In this manner, distance in kilometers from one range position to the next could be determined for each seismic tape. Distances between range markers were divided into 100 m intervals on each tape. This method was used instead of dividing the entire distance of the profile into equal 100 m intervals in order to eliminate problems of unequal distance covered per unit time during data acquisition. Bathymetry and reflector patterns were identified and traced on transparent over-lays. Acoustic reflectors obtained from the profiles were then transfered to graph paper (10 squares to the inch), each square representing 100 m horizontally and 1 m vertically to produce a vertical exaggeration of 100x.

The Edo Western system tape read-out is calibrated in feet below sea level using a sound velocity in water of approximately 1500 m/sec. Simple metric conversion of bathymetry depths in feet to those in meters were plotted on graph paper. Bathymetry of the profiles will be assumed to be below mean sea level throughout this thesis. Since tidal range is relatively small in this area (less than 1 m) and the fact that tides may change the bathymetry not only from one profile to the next, but within a single profile, it is best to assume a constant sea level. Depths to sub-bottom reflectors were measured by using an assumed average velocity in sediment of 1675 m/sec. The 175 m/sec increase in velocity from that of water was accounted for when determining the distance below the sediment/water interface. Sub-bottom reflectors were then transferred to graph paper. Relative differences in intensity of signal were noted as being strong, moderate or weak and is designated on each profile line drawing by line width.

Points of intersection of profiles located on the navigation chart and the profile reference map in Figure 9 are often inaccurate due to varying amounts of boat drift or range location errors. For this reason, points of actual intersection of profiles were determined by superimposing intersecting profiles on a light table and moving the profiles laterally from the proposed point of intersection to a point having common depths of reflector patterns on both profiles. Bathymetry may or may not line up exactly at these points of intersection due to slight tidal influences of each profile. Profile intersections may still be in error in this study, for there is often more than one point of possible intersection.

The EG & G high resolution Uniboom sub-bottom profiles were taken in the nearshore shelf region adjacent to the barrier islands. Northeast-southwest trending Uniboom profiles were also recorded, but were not available for analysis during this investigation. Analysis of the Uniboom profiles was done by Stephen W. Snyder following the same methods described for the analysis of the 7 kHz acoustic profiles.

Core Analysis

The vibra-cores were obtained using a water pump-tamper system devised by Riggs and O'Connor. Cores ranged in depth from 5.5 to 12.0 m. Cores CS-2 through CS-58 (Fig. 12) are less than 8 m in length and located along positions of SCUBA diving traverses of an earlier study.

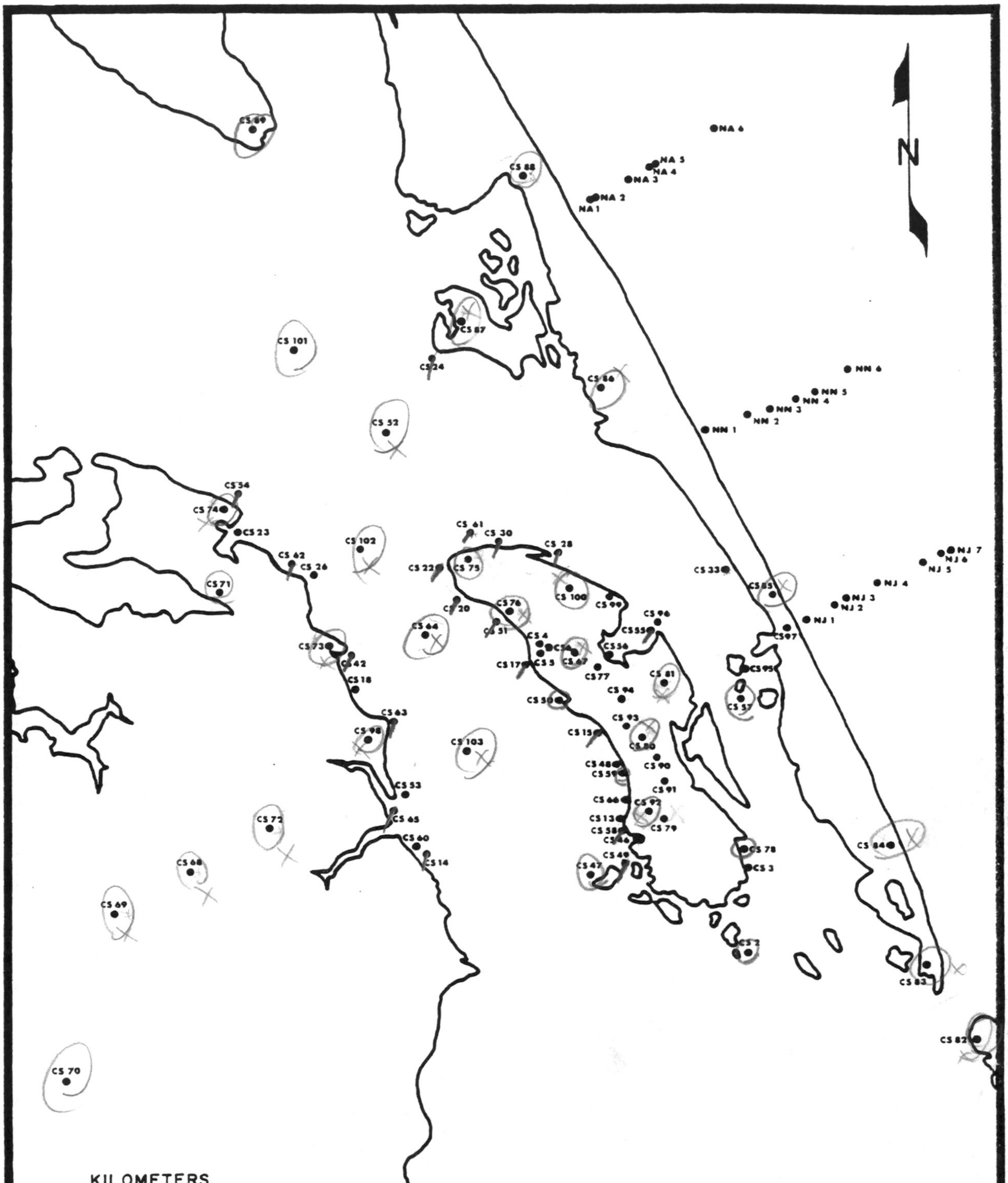


Figure 12. Location map of all cores.

The cores were therefore not numbered consecutively and some numbers between 2 and 58 were omitted. Thus, between CS-2 and CS-58, only 32 cores exist. Cores CS-59 through CS-66 are the deeper cores and are numbered normally. Detailed lithic logs were produced for each core.

Carbon-14 age dates were obtained on fossils and organic materials by Isotopes Incorporated. Carbon-14 age dates ranged from 2,595 years B.P. to 40,000+ years B.P. with an absence of dates occurring between 10,000 and 22,000 years B.P. This gap is interpreted to be the result of the latest major Wisconsin regression in this region. Due to the controversial nature of carbon-14 age dates over 15,000 years B.P. (Riggs, personal communication), only those dates within the last 10,000 years will be used in this study.

The offshore vibra-cores were obtained along Uniboom profiles S-4, S-7, and S-9 (Fig. 11) by using a diver-operated pneumatic vibra-corer with a plastic lined 3 inch by 8 foot aluminum core barrel. Cores were analyzed by Pearson (1979) and subsequent lithic logs were produced for each.

SEISMIC STRATIGRAPHY

Seismic stratigraphy within shallow coastal waters is quite problem ridden. Soft substrates and the lack of acoustically dense sub-bottom structures lead to poor acoustic penetration with a limited number of reflectors recorded. These sub-bottom reflectors are often indistinct and are commonly lost in multiple bottom reflections which are relatively abundant in shallow water. The data accumulated under these conditions must be interpreted with the constant reminder that it is often incomplete with potential for possible error.

Seismic data in the study area are dominated by channel reflectors which have destroyed most of the horizontal reflectors. Due to the importance of channel reflectors, they were classified as follows (Fig. 13): Type I - symmetrical, single reflector channel, representing a single phase of channeling; Type II - symmetrical, multi-reflector channel, representing even infilling of a larger channel; Type III - asymmetrical channel having multiple reflectors on one side, representing channel migration; and Type IV - asymmetrical channel having multiple reflectors on both sides, representing channel migration and/ or infilling. Since variations as well as exceptions to each of these channel types exist, the channel classification cannot be applied rigidly. When important variations and exceptions are recognized, they will be noted.

Since areas of soft substrate often result in poor penetration and thus poor reflectors, if any at all, a linear structure such as a channel may or may not be recorded on successive profiles. If recorded,

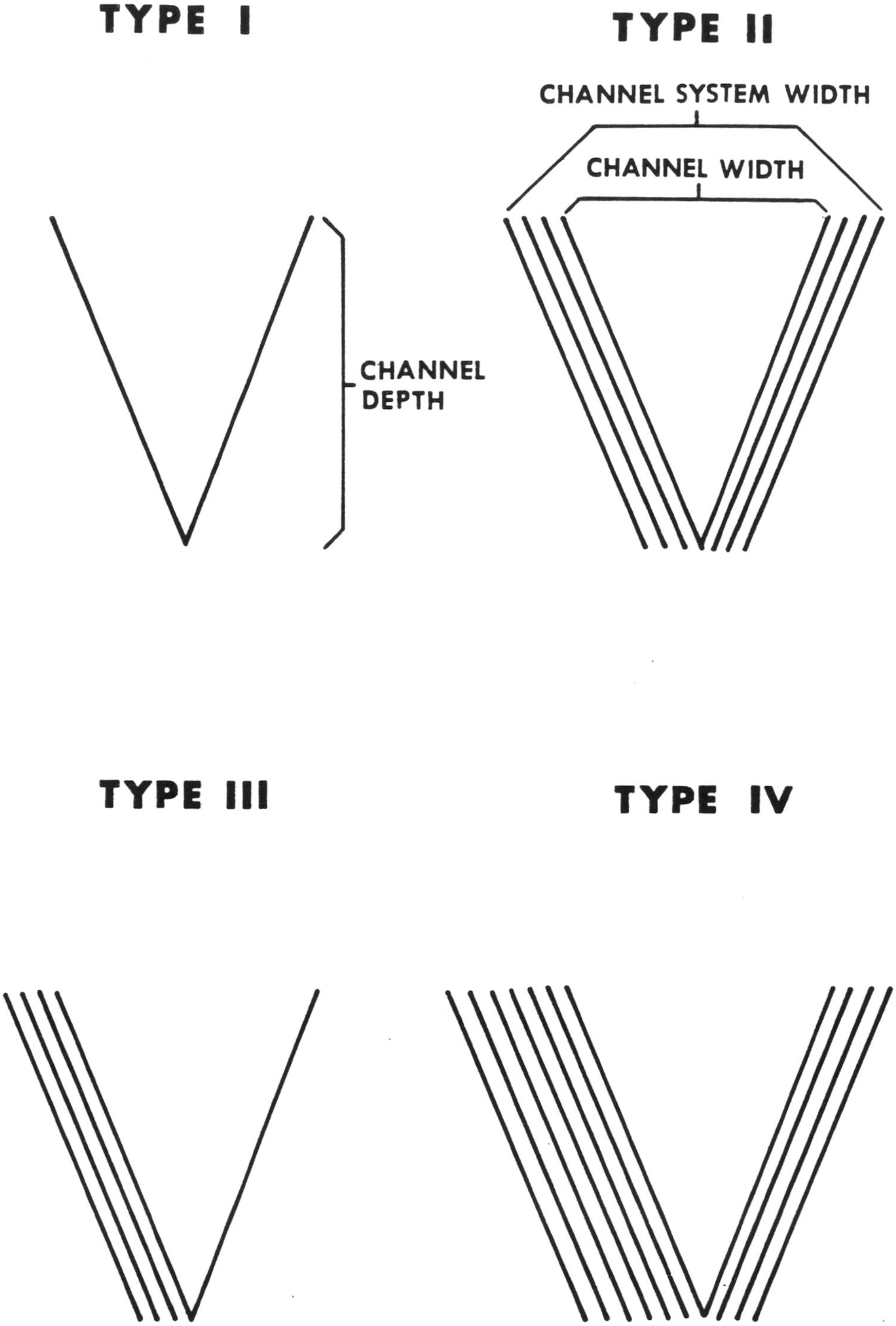


Figure 13. Channel reflector pattern classification scheme including channel dimensions used.

channel structures are often masked by multiples as reflector depth increases. Thus, deep Type II channels in which the lower reflectors are masked appear the same as shallower, broader Type II channels. These channels are described as 'open' bottomed and are interpreted cautiously.

Orientation of channels is approached with caution unless tight profile control is available. Due to the great vertical exaggeration of seismic reductions, all channel structures approach a V-shaped configuration. The sharper the angle of the channel structure, the more V-shaped, the closer the seismic profile approaches perpendicular with the channel. As the seismic profile orientation deviates from the perpendicular, a more U-shaped channel structure is observed with an increase in channel width (Fig. 14).

The seismic stratigraphy of the study area will be discussed in a systematic region-by-region approach. The study area has been divided into four regions (Fig. 15). Region I consists of Albemarle Sound and its adjacent waterways, including (1) the northern Alligator River, (2) East Lake, (3) Kitty Hawk Bay, and (4) the northern half of Roanoke Sound including Shallowbag Bay. Region II is restricted to Croatan Sound, bounded to the north by Region I at the Croatan Causeway and to the south by Region III at P-7. Region III consists of the northeastern Pamlico Sound area and the southern half of Roanoke Sound. It is bounded on the northwest by Region II at P-7, and on the northeast by Region I at the Roanoke Sound Causeway. Region IV is the nearshore shelf area east of the barrier islands. Four regions have been established only to simplify the presentation of data.

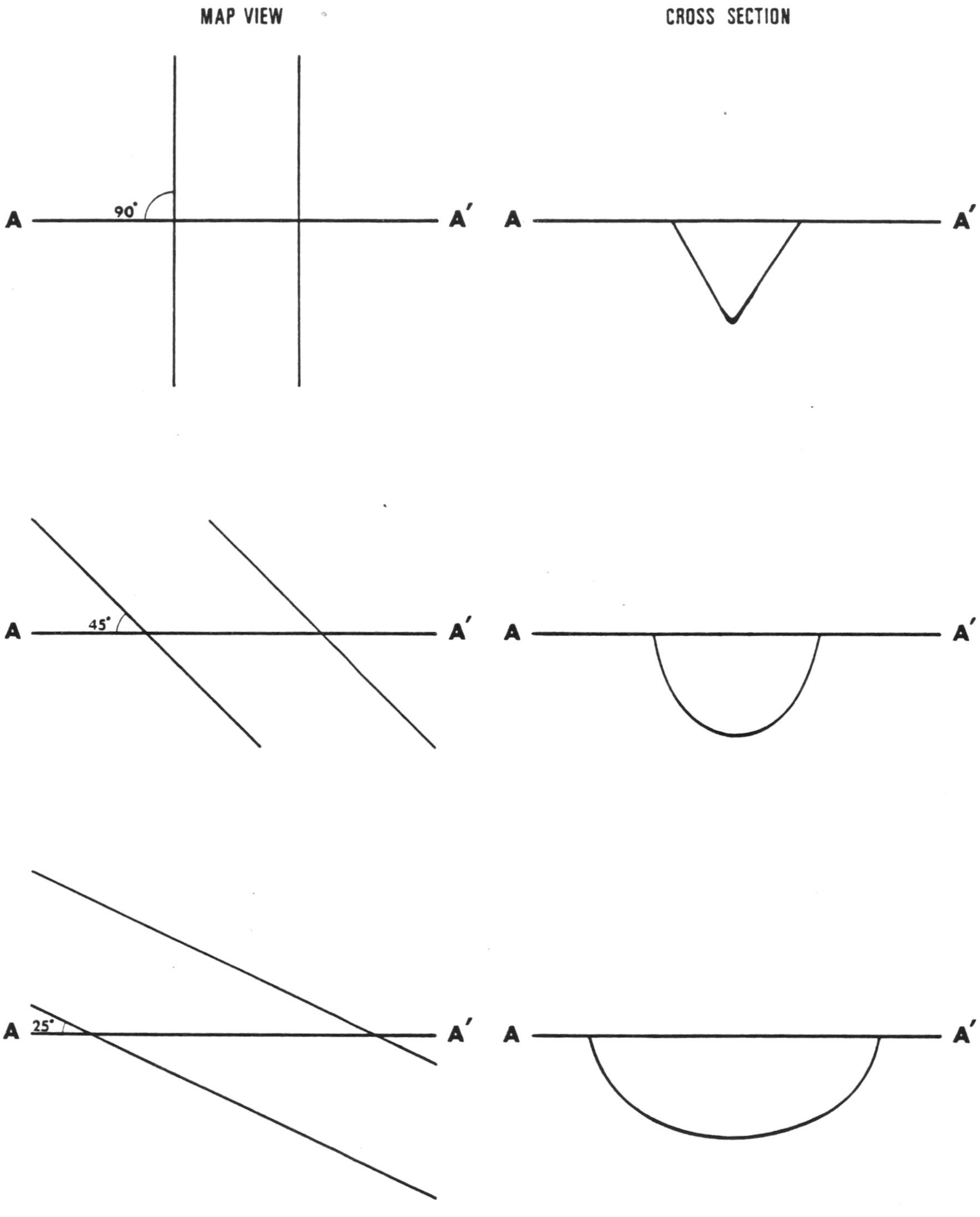


Figure 14. Schematic representation of the general appearance of seismic reflector patterns with changing orientation of the channel to the seismic profile.

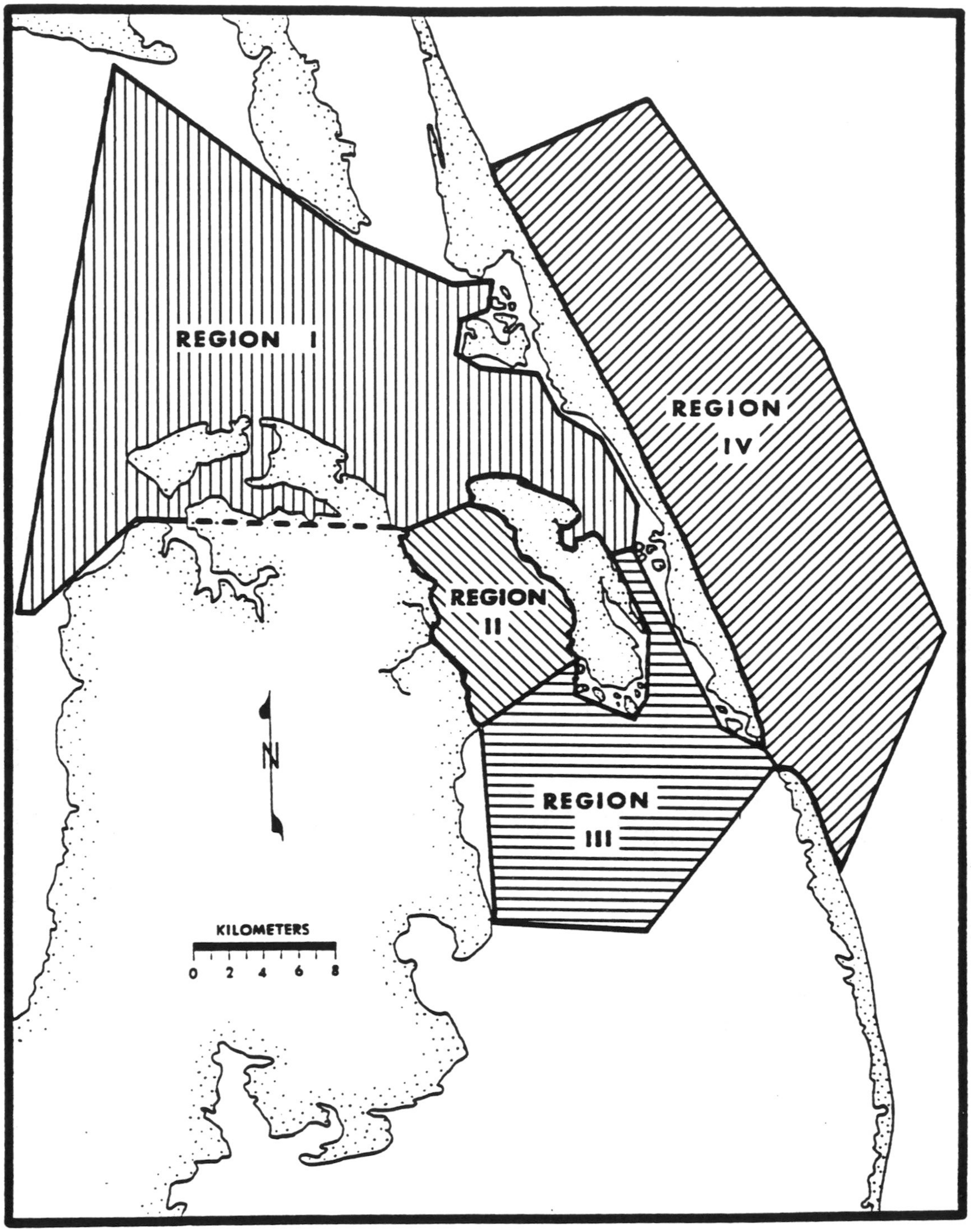


Figure 15. Location map of the four sub-divided regions of the study area used in the discussion of seismic stratigraphy.

Region I

Region I is a channel dominated area. All forms of channel types are found in this region, yet most are minor Type I channels or Type II channels of varying dimensions. The channels are variable in width, depth (both top and base of channel), and orientation. The determination of channel parameters is often subjective due to poor acoustic penetration and/or indistinct reflector patterns. In general, acoustic penetration is less than 6 m below the sediment/water interface (mbs), with occasional features visible to 16 mbs. Reflectors are moderate to weak in the northeastern portion of the region and intensify to the east. This increased acoustic intensity is probably due to increased contrast of the substrate with increasing development of discrete gravel, shell, and mud layers toward the marine environment.

The majority of Region I is contained within the broad open waters of Albemarle Sound. As seen in P-31 and P-33 (Fig. 16), this area is transected by many channels with an east-west orientation. Sufficient data is not available in these upper portions to plot channel courses. The channels are mostly Type II and are interpreted to be fluvial channels which were active during the late Pleistocene or early Holocene. The channels are 100 to 300 m wide and channel systems are often over 1 km in width. The tops of most channels are less than 1 mbs, usually about 6 m below mean sea level (msl), with a thin blanket of Holocene sediment on top. Channel depths are a minimum of about 1 mbs, while most reflectors extend to greater than 6 mbs (11 m below msl). The channel bottoms are often not seen in the reflector patterns due to

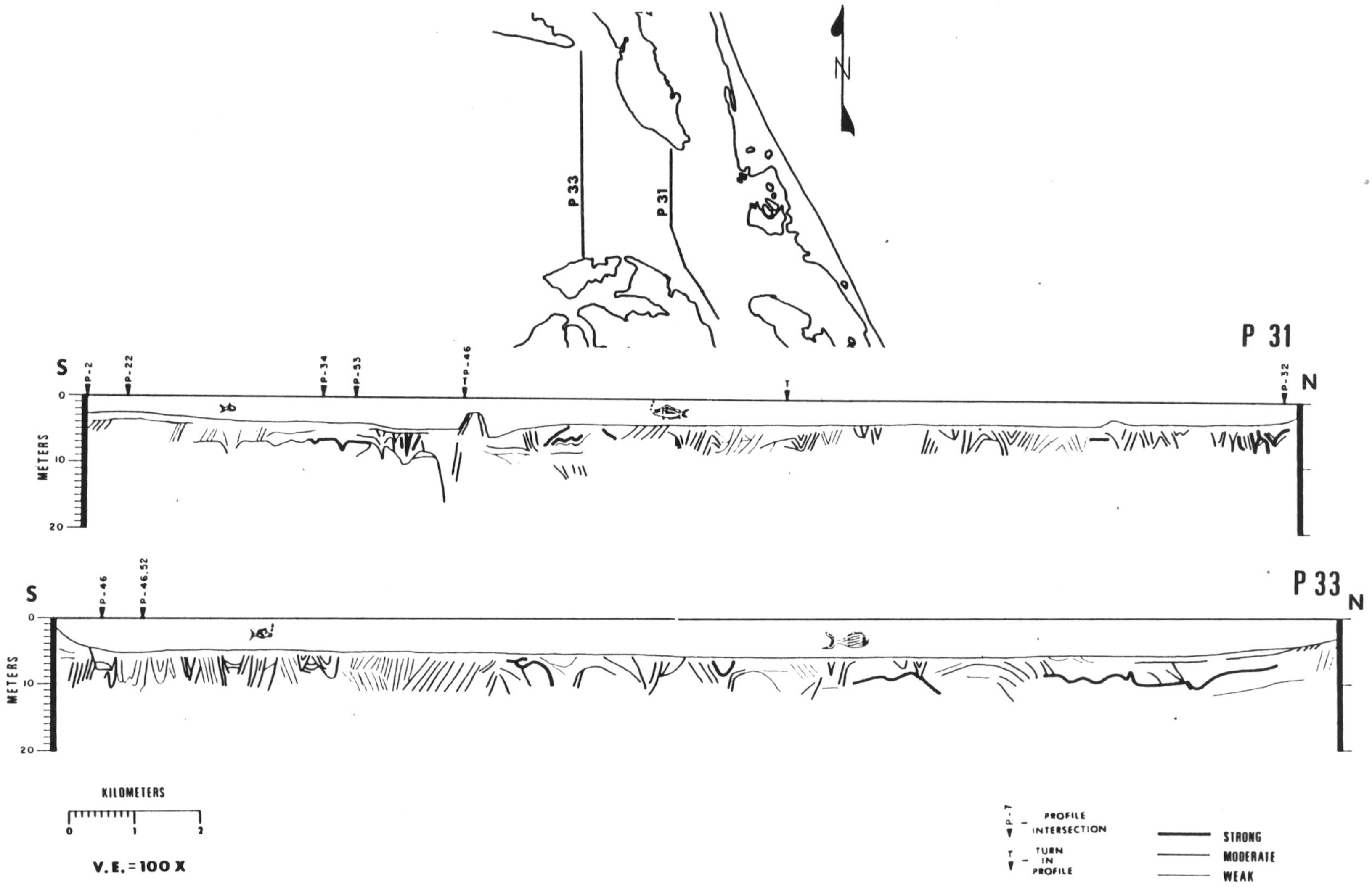


Figure 16. Seismic profile line drawings of P-31 and P-33.

poor penetration, and are the open-bottomed reflector patterns (Fig. 16).

Horizontal reflectors occur adjacent to the present land masses. These reflectors are interpreted to represent the land surface that was drowned by the present transgression. Many Type I channels dissect the horizontal reflectors (Fig. 17). Channels occurring on these surfaces are relatively small; channel widths are 100 to 300 m and depths are usually less than 3 m. Some larger channels do occur. The Type I channels are interpreted to represent a local drainage system that formed during the late Pleistocene sea-level lowstand prior to Holocene inundation. The horizontal reflectors have moderate to good intensity compared to the weak to moderate intensity reflectors of the channels due to the formation of an acoustically more prominent surface during emergence.

P-47 in East Lake (Fig. 18) reveals several Type III channels with tops at 3 mbs (5 to 6 m below msl) and bottoms which are open. The channel widths are 200 to 300 m and channel systems are up to 600 m wide. These channels extend eastward and are continuous with channel features found in P-31; they are truncated just east of P-31 by the Croatan Trough. Reflectors at the extreme north and south ends of P-47 suggest that there is a set of channels with a top-depth of 1 mbs. These shallower channels are therefore assumed to be slightly younger than adjacent deeper channels. The shallow channels are interpreted to represent part of a drainage pattern during the last emergence and tie into the drainages depicted in Figure 7 (Ingram and Otte, 1982). The

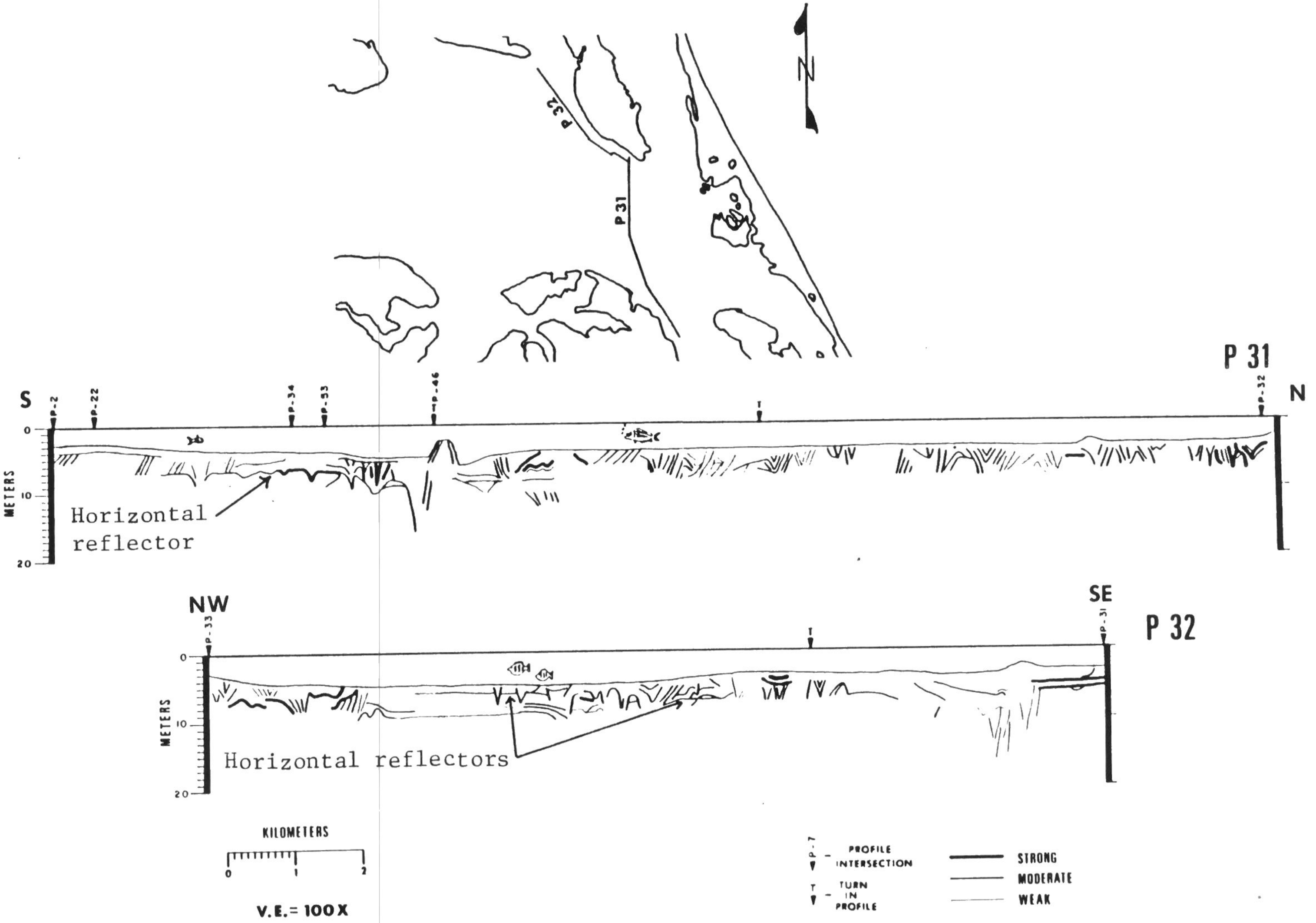


Figure 17. Seismic profile line drawings of P-31 and P-32.

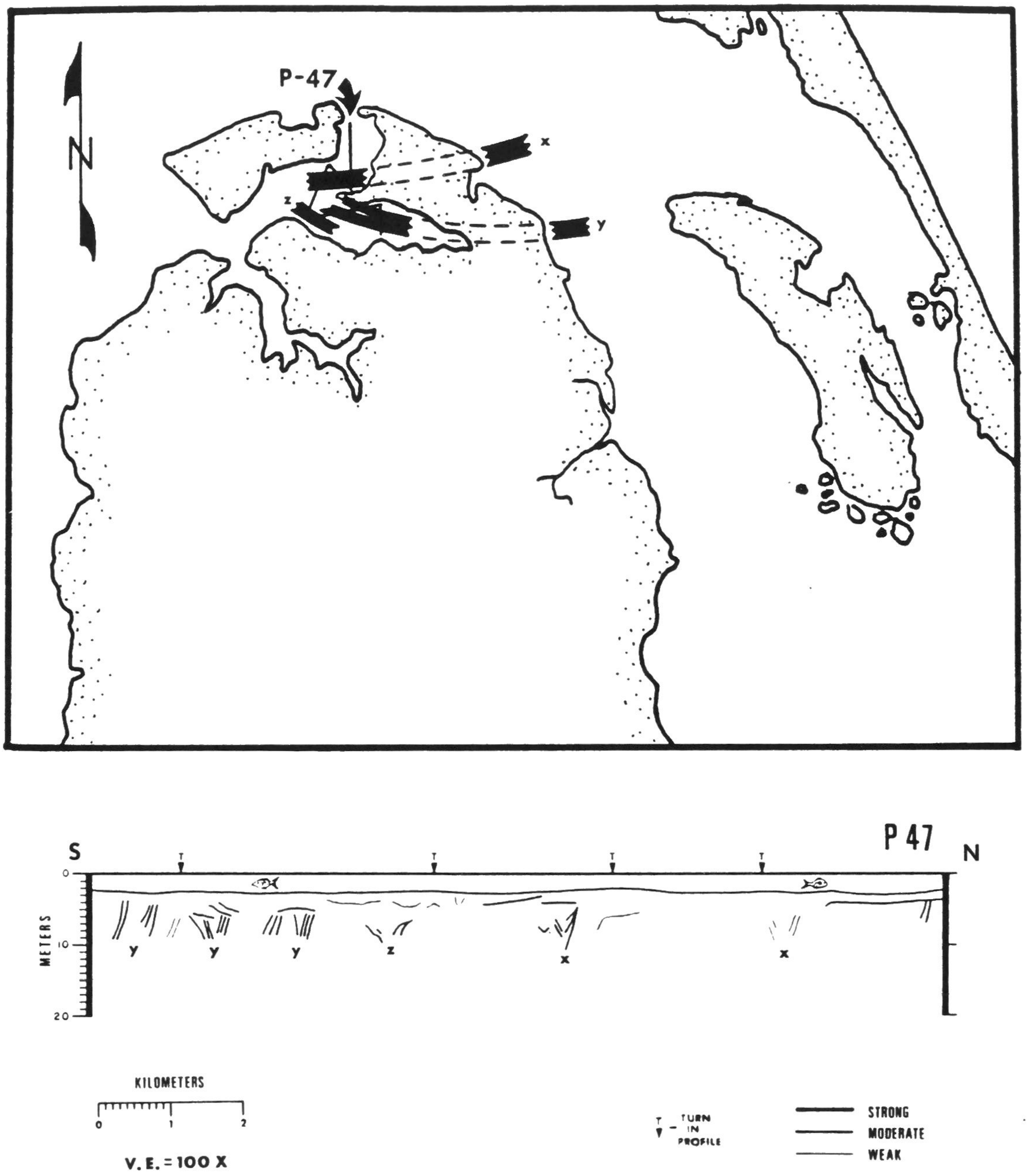


Figure 18. Seismic profile line drawing of P-47 and a reconstruction of channel positions through P-47 and laterally into Albemarle Sound where they are truncated. Channels are designated as channels x, y, and z for locating on the profile.

deeper adjacent channels probably formed during earlier stages of emergence.

Channels persist in the easternmost part of Albemarle Sound and northern Roanoke Sound (Fig. 19) and are interpreted to be late Holocene in age. These Type II channels are the lateral equivalents of some of the channel structures observed in the western portion of Region I. The tops of the channels are often 1 to 2 mbs (3 to 5 m below msl). Horizontal reflectors are often observed above the channel structures, indicating a 1 to 2 m blanket of later Holocene sediment. Channel depths are generally 5 to 10 mbs, with the deepest portions to the east near sites of historic and pre-historic barrier inlets. Channel widths are variable depending on their orientation and channel systems are up to 1.5 km wide. The location of these channels (Fig. 20) was dictated by the position of Roanoke Island and the location of historic and pre-historic tidal inlets through the present barrier island system which is migrating with the transgression.

A few deeper channels have also been located in northern Roanoke Sound (Fig. 21). The shallowest of these (Channel a in Fig. 21) is 5-6 m below msl at the top. The base is open but is measurable to at least 12 m below msl. The channel system is at least 1.3 km wide, and is oriented to the northeast, approximately 45 degrees from the seismic line.

Two additional deep channels (Channels b and c) may be seen in P-72 (Fig. 21). The true dimensions of these channels are obscure due to truncation of the top and poor refelctors at the bottom. Channel b

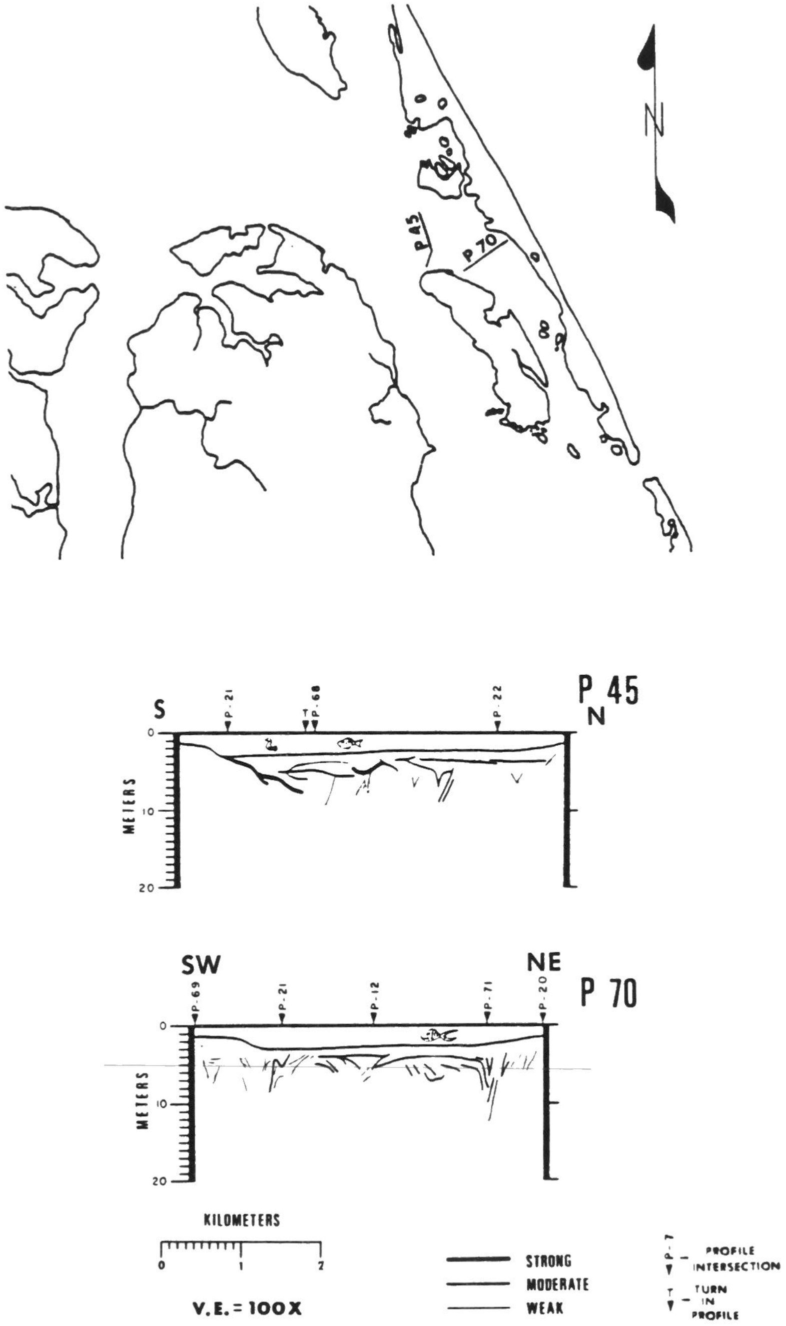


Figure 19. Seismic profile line drawings of P-45 and P-70.

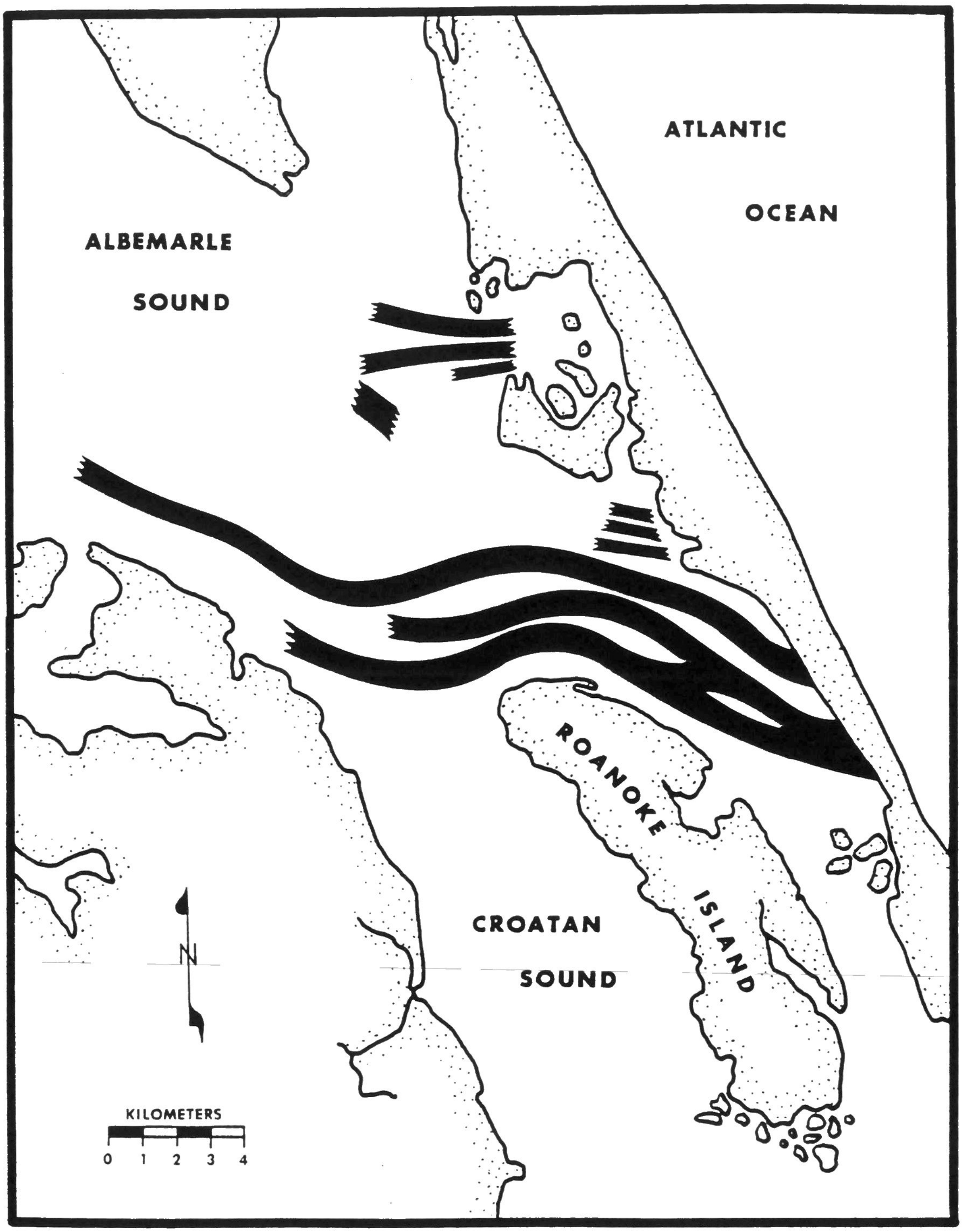


Figure 20. Map showing the distribution of shallow late Holocene fluvial channels within Region I.

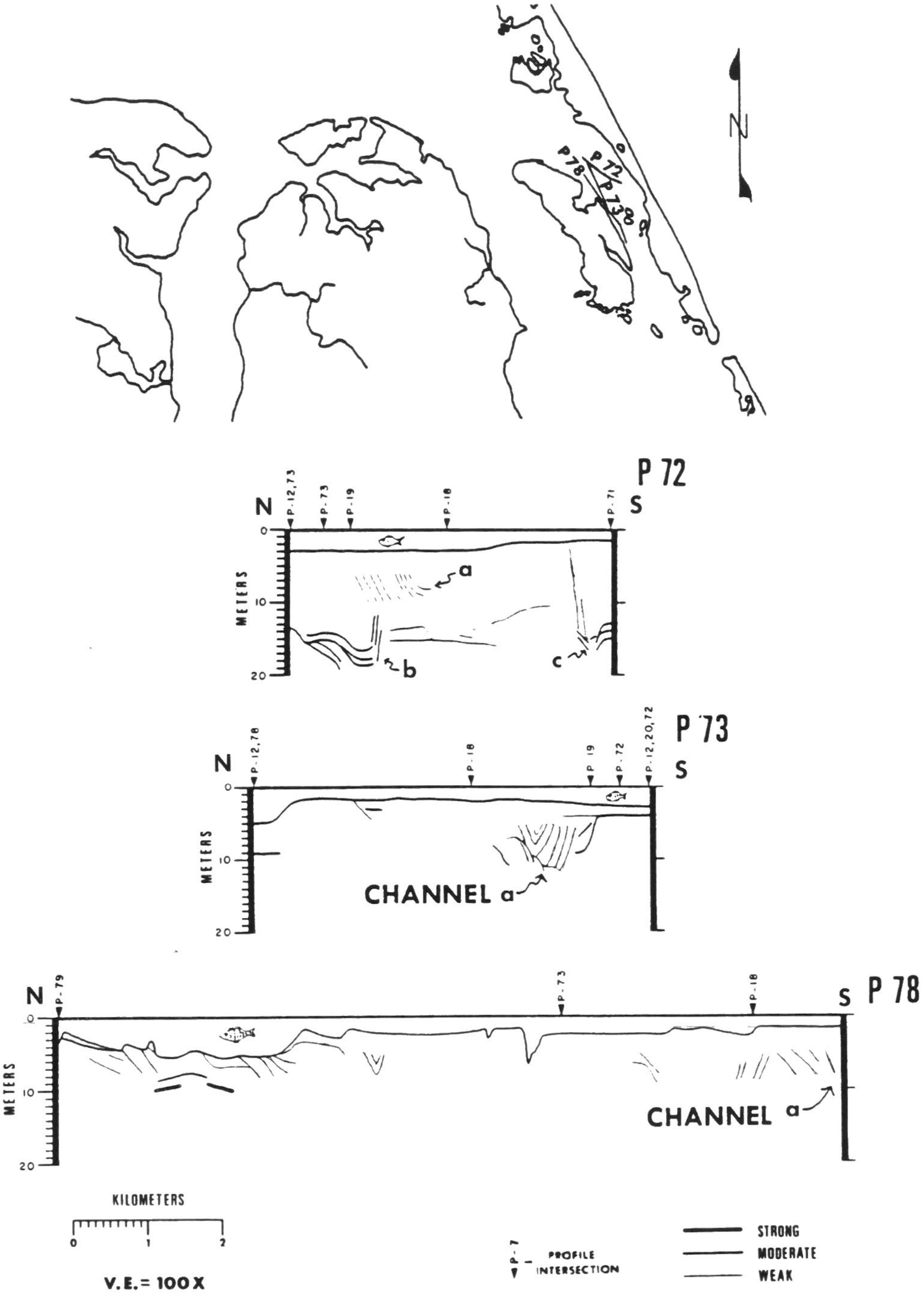


Figure 21. Seismic profile line drawings of P-72, P-73, and P-78 showing the positions of Channels a, b, and c.

measures 11.5 m and 19 m below msl at the top and base respectively. Channel c measures 13 m and 16.5 m below msl at the top and base respectively. Channel b and possibly Channel c correlate to channel structures found in Region II.

Within Shallowbag Bay, several short, semi-overlapping profiles (Fig. 22) show evidence of two channels which might connect the channels in northern Roanoke Sound to those in Croatan Sound (Region II). Penetration in this area was very poor due to soft substrate and resulted in poor reflection patterns. In P-15, the channel structure crops out at about 2.5 m below msl. The deepest reflector recorded for either channel is 15 m below msl, while most reflectors average 8 m below msl at their deepest point. Depth to the top of the channels range from 2.5 to 5.0 m below msl; widths of these channels cannot be determined.

Region II

The seismic stratigraphy of Region II, located within Croatan Sound, is highly variable. The northern and central portions are characterized by estuarine fill structures with a moderate to minor channeling. The southern portion is dominated by late Pleistocene and Holocene channels.

Region II is located between two relict barriers producing a topographic low susceptible to drainage development and erosion during emergence and embayment and infilling upon submergence. A reflector surface designated as R-1 (Fig. 23) is interpreted to be the surface upon which late Pleistocene channeling and erosion took place during

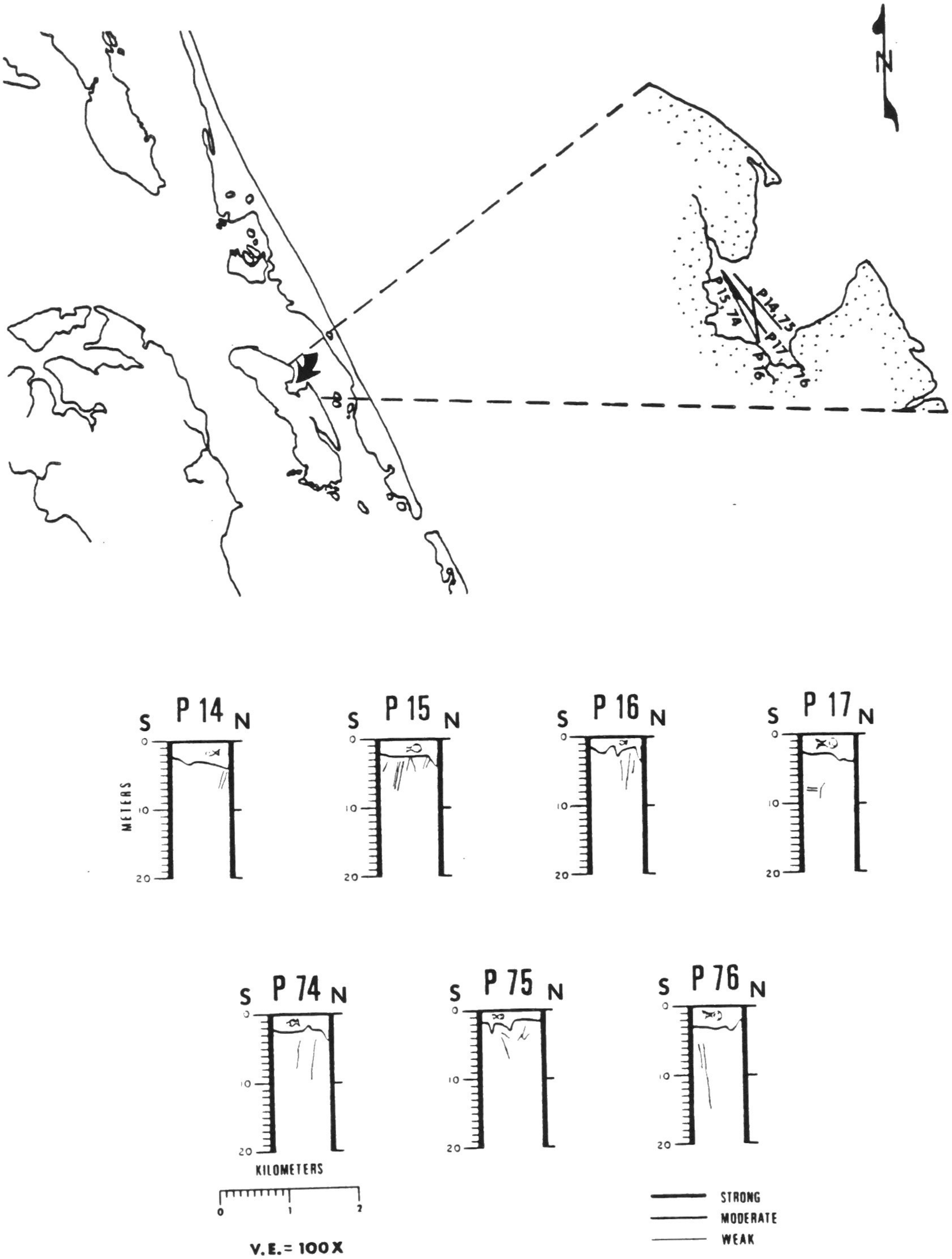


Figure 22. Seismic profile line drawings of P-14, P-15, P-16, P-17, P-75, and P-76.

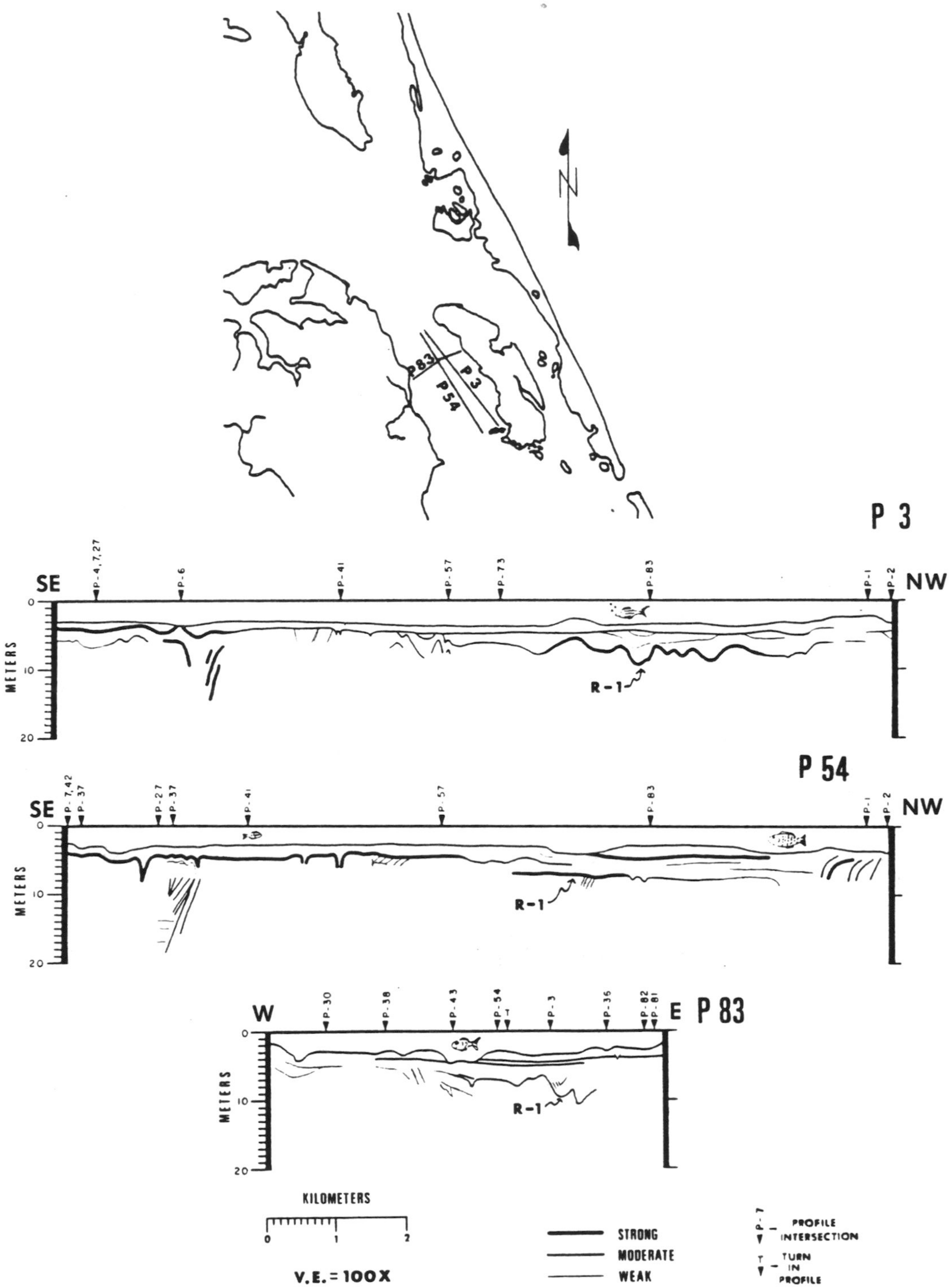


Figure 23. Seismic profile line drawings of P-3, P-54, and P-83 showing reflector surface R-1.

the last lowstand and forms a relatively distinct surface upon which Holocene organic-rich muds were deposited during the present inundation. This surface is very irregular, owing to its erosional origin. The depression, herein referred to as the Croatan Trough, is an asymmetrical, open-ended trough which dips to the north (Fig. 25). Many smaller lateral drainages enter from the east and west. The deepest portion of the trough runs along eastern side of Croatan Sound and opens into Albemarle Sound. The shape of the Croatan Trough appears to be influenced mainly by the two adjacent barrier structures and the drainages from these structures. Eastward dipping reflectors to the west of the Croatan Trough (Fig. 24) are interpreted as relict shoreface features which may have controlled the formation and position of the Croatan Trough. The shoreface bedding may have forced fluvial drainages to the east against the west side of Roanoke Island. P-1 and P-2 suggest erosion extended to 12 to 13 m below msl during the late Pleistocene and early Holocene. The eroded trough was later filled with late Holocene organic muds. A carbon-14 age date taken from organic mud near the base (20 m below msl) of the Holocene mud lens in core CS-102 gives an age of 9,695 years before present (Riggs and O'Connor, 1974).

Using core data from Riggs and O'Connor (1974) and Sampair (1976) and the acoustic profiles in Region II, the approximate position and geometry of the Croatan Trough and the adjacent barrier sands were determined (Fig. 25). The contours on the bottom of the trough demonstrate that the mud lens thickens to the northwest and thins out

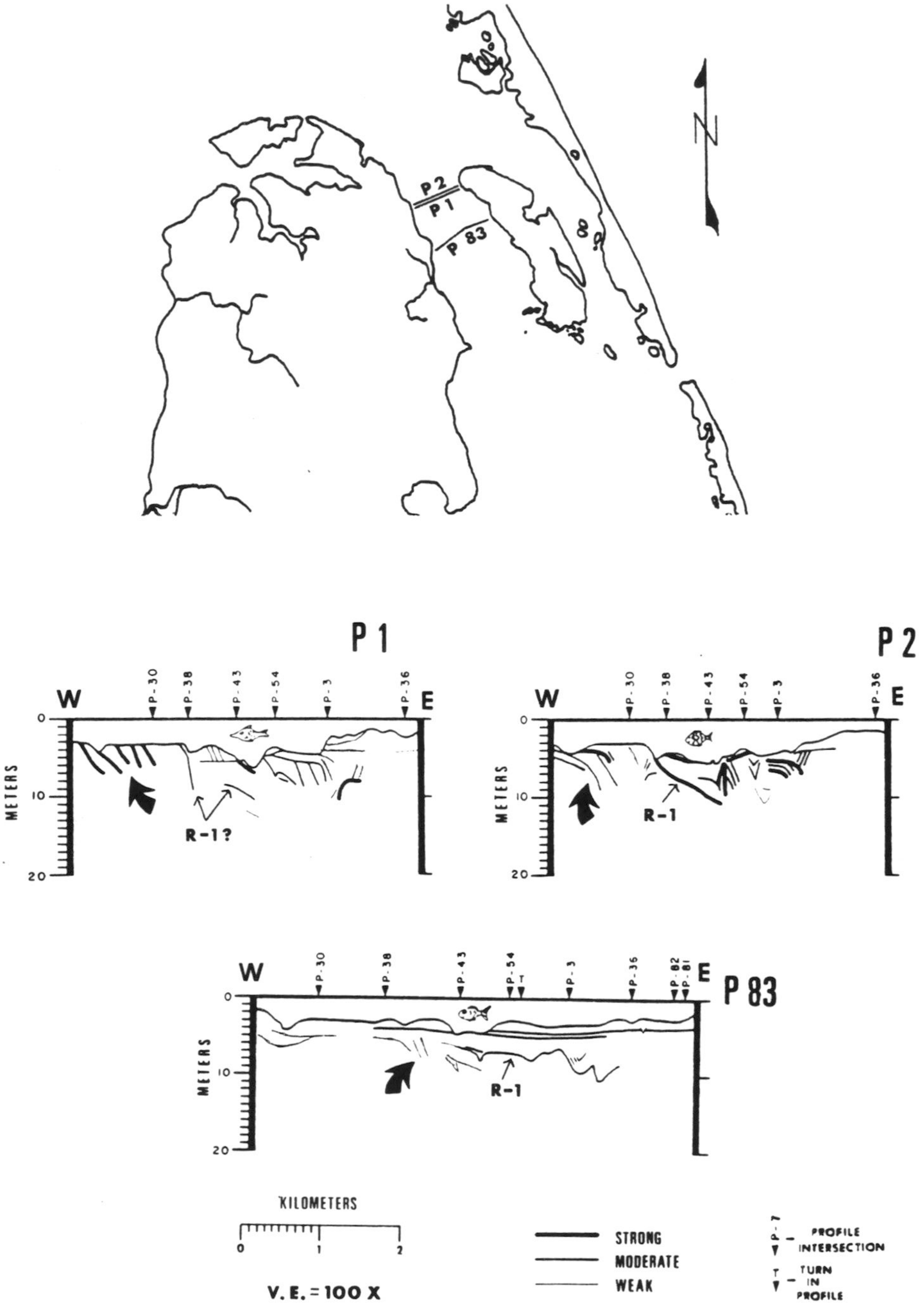


Figure 24. Seismic profile line drawings of P-1, P-2, and P-83 showing reflectors interpreted to be the result of shoreface deposition (arrows). The base of the Croatan Trough is indicated by surface marked R-1.

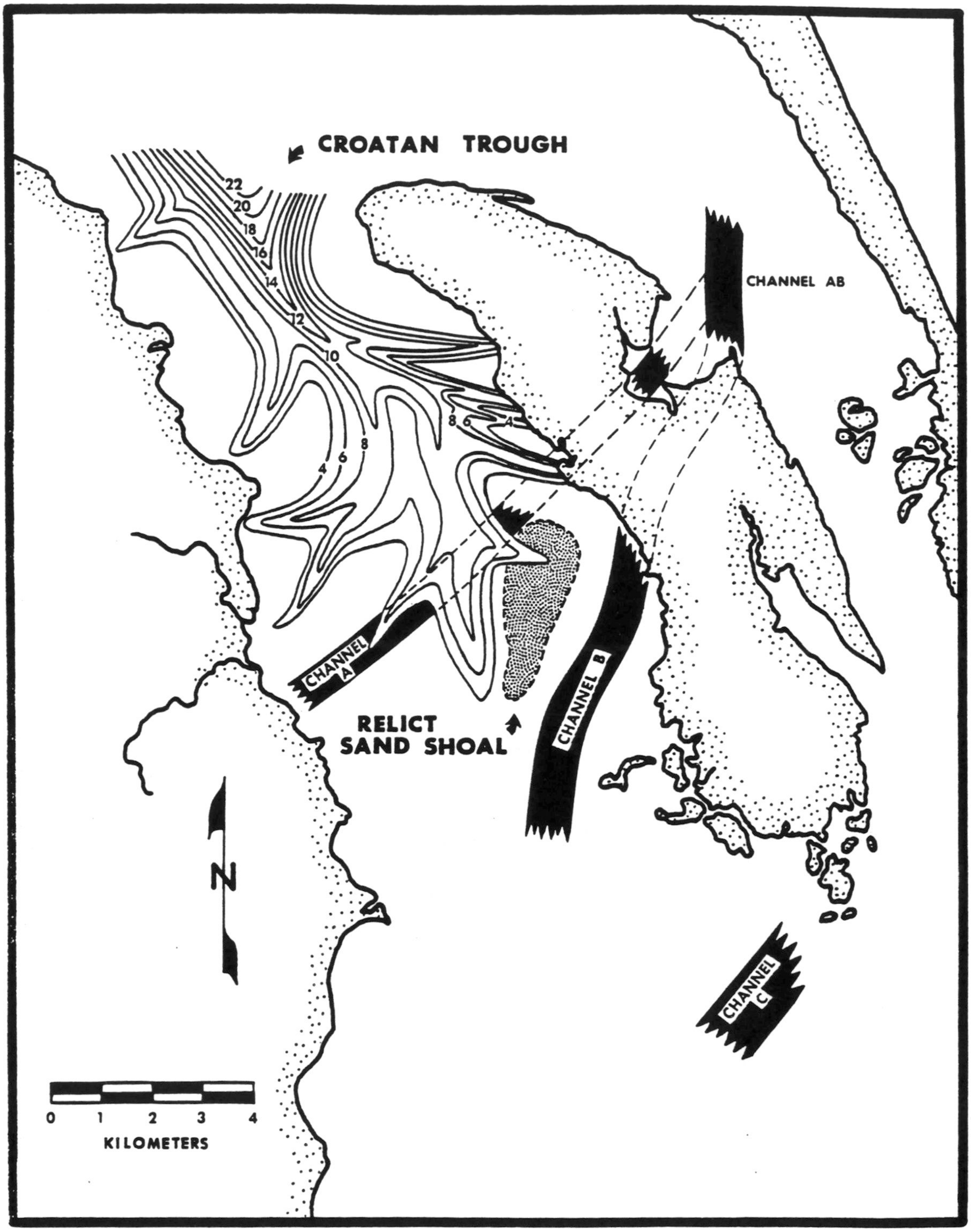


Figure 25. Structure contour map on the base of the Croatan Trough. Contours are in meters below mean sea level. Also located are the relict sand shoal feature and relict fluvial channels A, B, and C.

laterally against barrier island sand bodies to the east and west. The trough opened toward Albemarle Sound where the mud lens interfingered with fluvial sands which infilled the Albemarle channel.

In the up-dip portion of the Croatan Trough, a relict sand shoal (Fig. 25) partially controlled the geometry of the upper trough. The shoal is located adjacent to Roanoke Island and may be the remnant of a flood tide delta formed when Roanoke Island was an active barrier island. The mud lens filling the Croatan Trough thins southward onto and partially dissects the shoal feature, indicating that the shoal is pre-Holocene.

Two major fluvial channels have been identified in Region II and are designated as Channel A and Channel B (Fig. 25). Channel C in this figure is located within Region III and will be discussed in a later section. Channels A and B trend northwest and are of the Type II variety. The top of Channel A is about 1 mbs (4 m below msl) in P-38 (Fig. 26), but toward the west in P-28, the top is at 9 mbs. This may be the result of poor acoustic penetration in P-28 or possible truncation of the channel structure in that area. The base of the channel is at least 16 mbs (19 m below msl). Channel width is uncertain, but channel system width is slightly more than 1 km. Channel A is truncated by the Croatan Trough, suggesting that it is older than the trough. The stratigraphic position of Channel A suggests that it extends northeastward beneath Roanoke Island and may be correlatable with the deep fluvial channels recorded in profiles of Shallowbag Bay (Fig. 22).

Channel B reflector patterns extend downward at least 19 m below

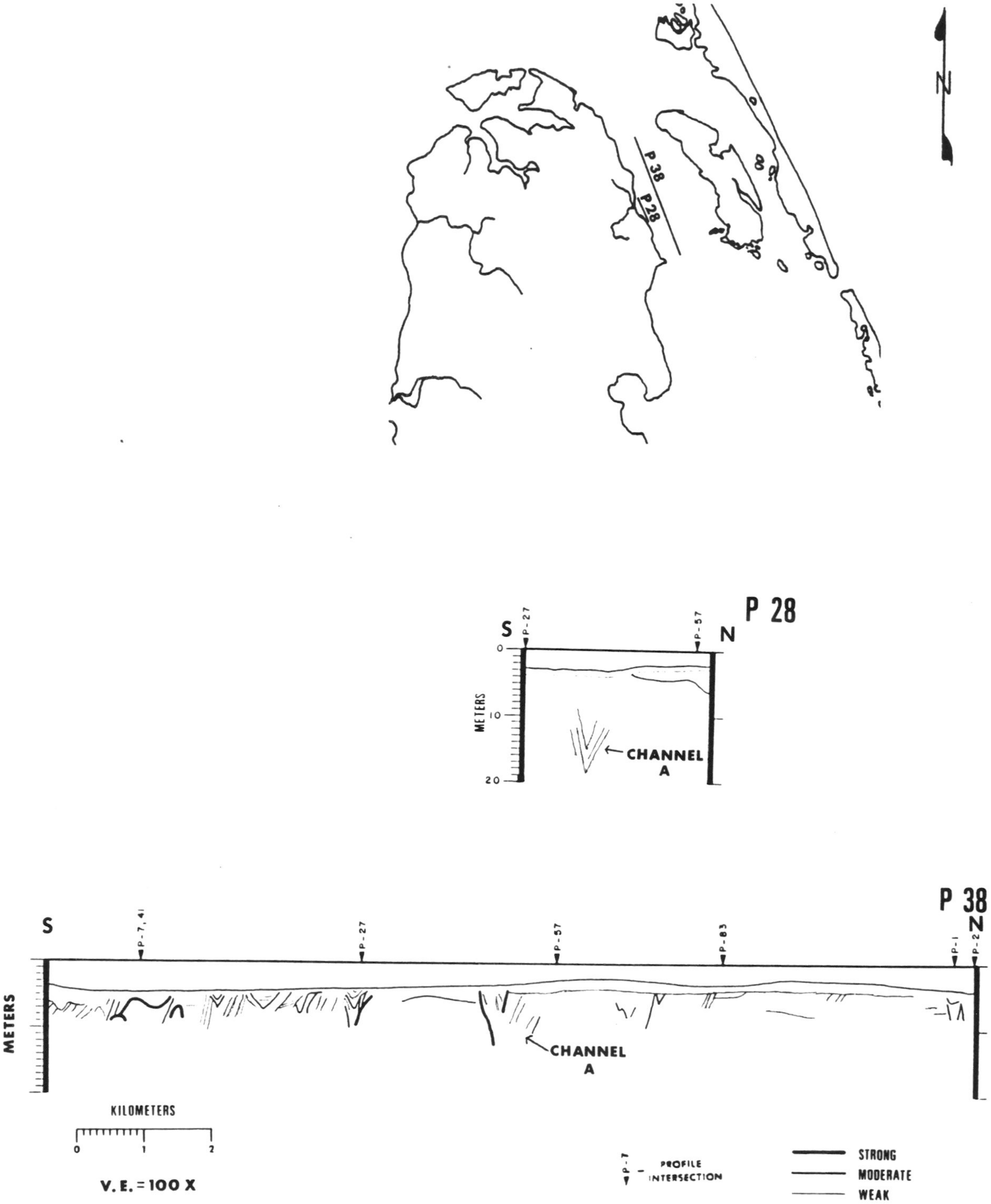


Figure 26. Seismic profile line drawings of P-28 and P-38 showing position of Channel A.

msl. In some profiles, the channel reflectors extend upward to within 1 mbs (4 m below msl), yet in most profiles, the channel is over-topped by horizontal reflectors which are 2 to 3 mbs. Shallow core data from Sampair (1976) prove that the horizontal reflectors are the base of a mud layer which infills the upper portion of the channel. Width of Channel B is difficult to determine, but the channel system is approximately 1.2 km wide. Positions of the channel with respect to stratigraphic units suggest that Channel B passes beneath Roanoke Island and possibly correlates to Channel a in Figure 21.

Channels A and B appear very similar in channel system width and depth, which suggests similar gradients in response to a common base level; thus, they would be contemporaneous channels. If extrapolated, Channel A appears to converge with Channel B at the mouth of Shallowbag Bay. Channels A and B would have been active during lower sea level stands and prior to the transgressive emplacement of Roanoke Island.

The time at which Roanoke Island was emplaced is believed to have occurred during the late Pleistocene. The larger combined Channel AB probably drained into the Albemarle system to the northeast and west of the Roanoke Island barrier which was located further to the east of its present position. As the Roanoke Island barrier migrated upward and landward of the junction between the Albemarle and Channel AB, the combined Channel AB would have produced an inlet through the barrier system as it migrated to its present position. The hydraulic force of the fluvial system would maintain the inlet until flooding diverted the discharge elsewhere. The inlet would then begin to shoal and close up.

The closing of the inlet is believed to have occurred shortly before Roanoke Island reached its present position.

If the inlet was indeed maintained through the migration of Roanoke Island as a barrier, the inlet could account for (1) the very low topography of the middle section of Roanoke Island, (2) the presence of Shallowbag Bay, and (3) possibly the presence of the relict sand shoal in Croatan Sound. Thus, the low topography in the central portion of Roanoke Island (Fig. 27) is thought to be the remnant of the shoaled inlet. The extensive marsh system developed in response to the Holocene transgression. Maps of this area dating from the late 1500's (Connor, 1907; and Cumming, 1966) show only a minor development of what is now Shallowbag Bay. Shallowbag Bay has been formed by shoreline erosion and recession of the low marsh in response to rising sea level.

The sand shoal in Croatan Sound (Fig. 25) is observed in several profiles, and core data (Sampair, 1976) reveal a slightly muddy sand for the shoal compared to clay units laterally at the same depth (below 1.5 mbs). This sand shoal is interpreted to be a remnant flood-tide delta associated with the pre-existing inlet.

Along the west side of the Croatan Trough in P-43, there are features which are interpreted to be filled inlets. The same chaotic cross-cutting and channeling relationships may be seen in this profile as occur in P-61 and P-62 (Fig. 28) of the present day Oregon Inlet. The width of the inlet channel is approximately 1.8 km and reflectors indicate a depth of at least 14 m below msl. As in P-61 and P-62, P-43 is oriented approximately parallel to the barrier through which an

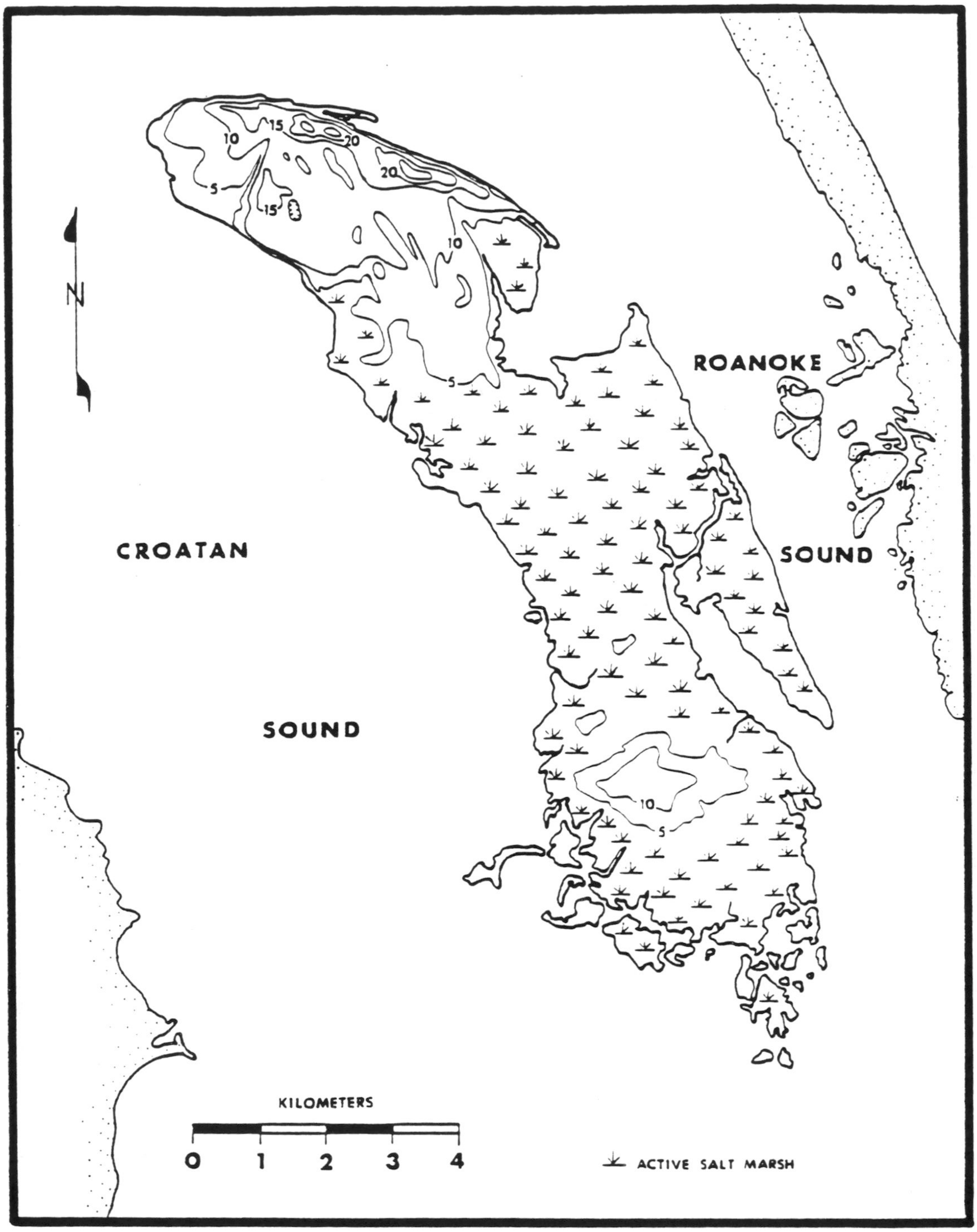


Figure 27. Topographic map of Roanoke Island. Salt marshes indicate that much of Roanoke Island is at or near mean sea level. Contours are in feet above mean sea level.

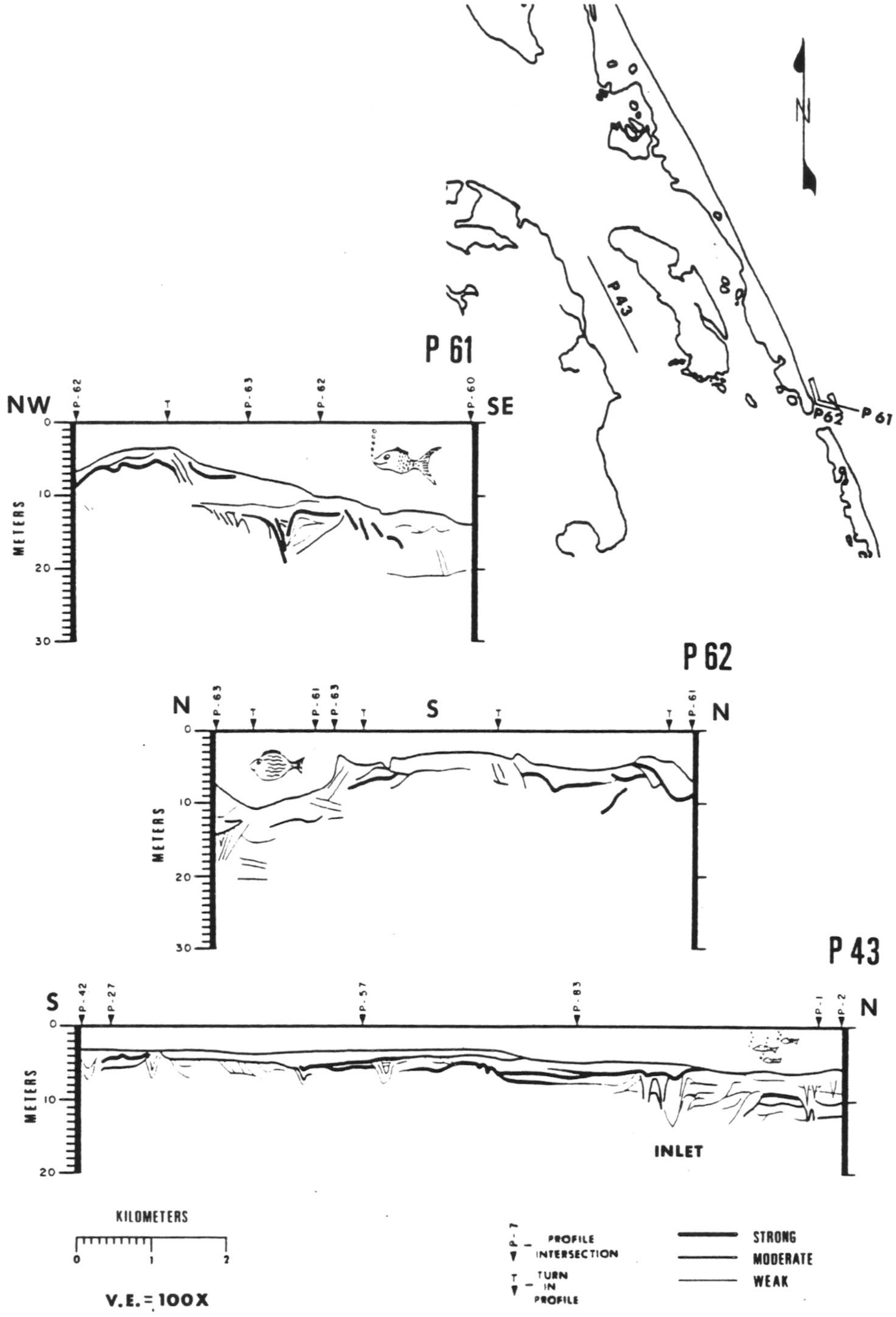


Figure 28. Seismic profile line drawings of P-61, P-62, and P-43 showing inlet reflector patterns.

inlet cut. The ancient barrier occurred in mainland Dare County and runs sub-parallel to the western shore of Croatan Sound.

Type II and a few Type III and IV channels are located within the southern portion of Region II. These channels are fairly numerous and occur for the most part south of P-27, extending into Region III. Most of the channels are moderate in size, extend within 1 mbs (5 m below msl), and typically have open bottoms down to 10 m below msl. Channel and channel system widths are highly variable, generally less than 0.5 km. The channels are thought to be the result of fluvial erosion during times of emergence, and possibly they represent several episodes of emergence.

Region III

The western section of Region III is an extension of the southern portion of Region II. Region III consists of relatively shallow depth Types II and IV fluvial channels which drained the adjacent Dare County mainland during periods of low sea level. Figure 7 shows at least two, and possibly three east-flowing drainage patterns which, if extended, would pass through P-39 and P-40 (Fig. 29). The reflector patterns of these channels show wide channel systems due to oblique angles and channel migration. The larger channel systems are up to 1.5 km in width and individual channel width is often 300 to 400 m. The tops of the channels are within 1 mbs (5 m below msl) and bottoms are often open with a maximum depth of 9.5 m below msl.

Small Type I channels in western Region III occur within the upper 3 to 4 mbs. These narrow 100 to 200 m wide, north-south trending

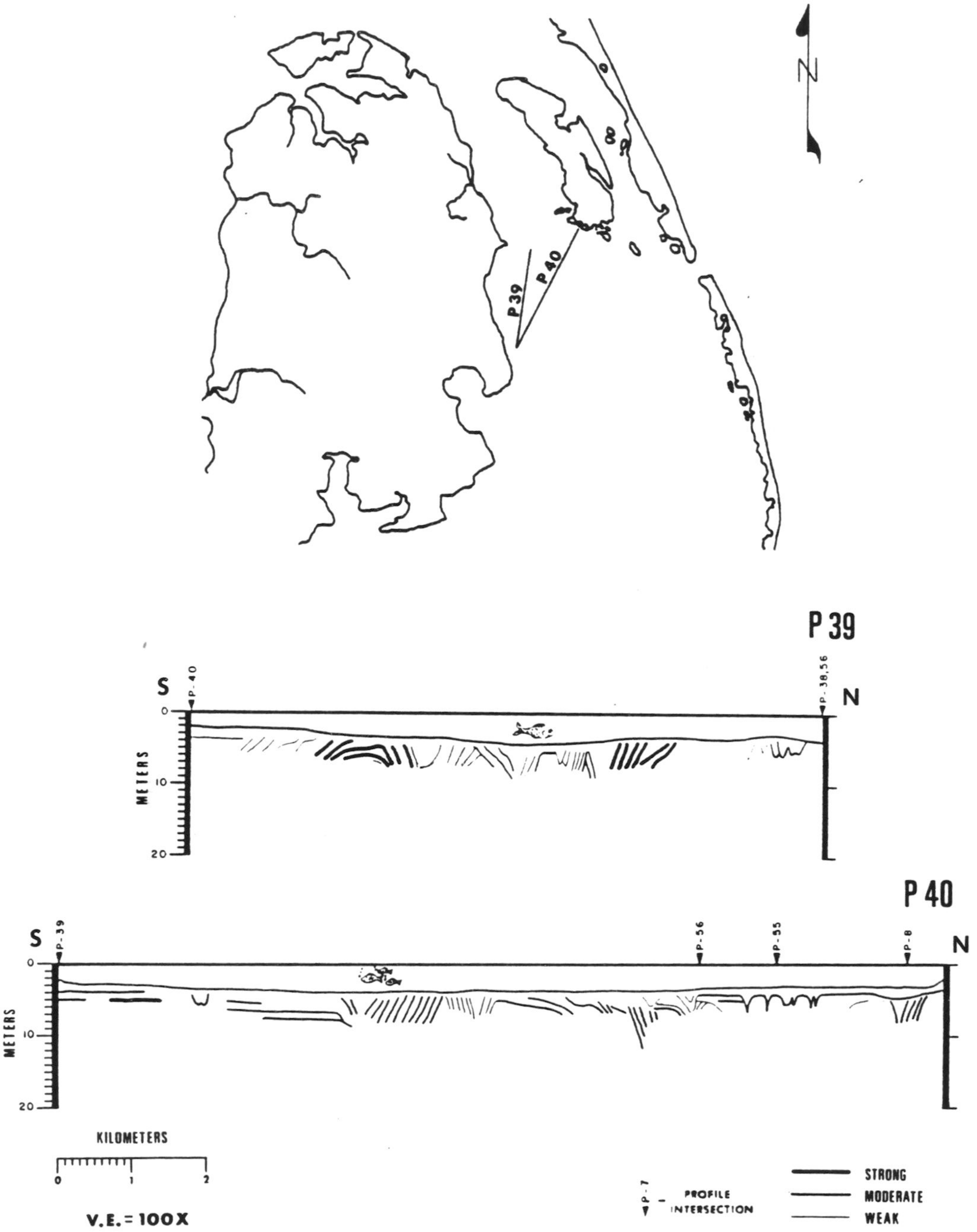


Figure 29. Seismic profile line drawings of P-39 and P-40.

fluvial channels were possibly cut during erosion of pre-existing marshes occurring in Croatan Sound (Fig. 30). Prior to 1817, discharge from Albemarle Sound was carried north of Roanoke Island and to the sea through Roanoke Inlet (O'Connor and Riggs, 1974). Roanoke Island was still part of the mainland peninsula being connected by marshes as rising sea level flooded across the crest of the interstream divide. As sea level continued to rise, the marsh eroded, opening Croatan Sound as a lateral estuary (Riggs and O'Connor, 1975). Roanoke Inlet closed in 1817, diverting the Albemarle discharge through Croatan Sound, increasing the erosion of the shoreline and sound bottom between Roanoke Island and mainland Dare County. Initial discharge through the marshy area probably occurred as deep scour channels which were later partially filled and preserved in the sub-surface as Croatan Sound widened.

In P-9 and P-55 (Fig. 31), a very deep Type II channel (Channel C) is oriented northeast-southwest. Channel C extends to a depth of 15 mbs (18 m below msl), has a channel system width of over 2 km, and a channel width of about 200 m. The shallower channels in P-39 and P-40 (Fig. 29) may be upstream parts of the same channel system as Channel C.

The seismic profiles in Region III are dominated by fluvial channeling. Consequently, the few horizontal reflectors which do exist, are difficult to interpret.

Region IV

Region IV is the nearshore shelf area which was covered by both acoustic and Uniboom profiles. The acoustic profiles in Region IV are better than the estuarine profiles due to deeper water and thus fewer

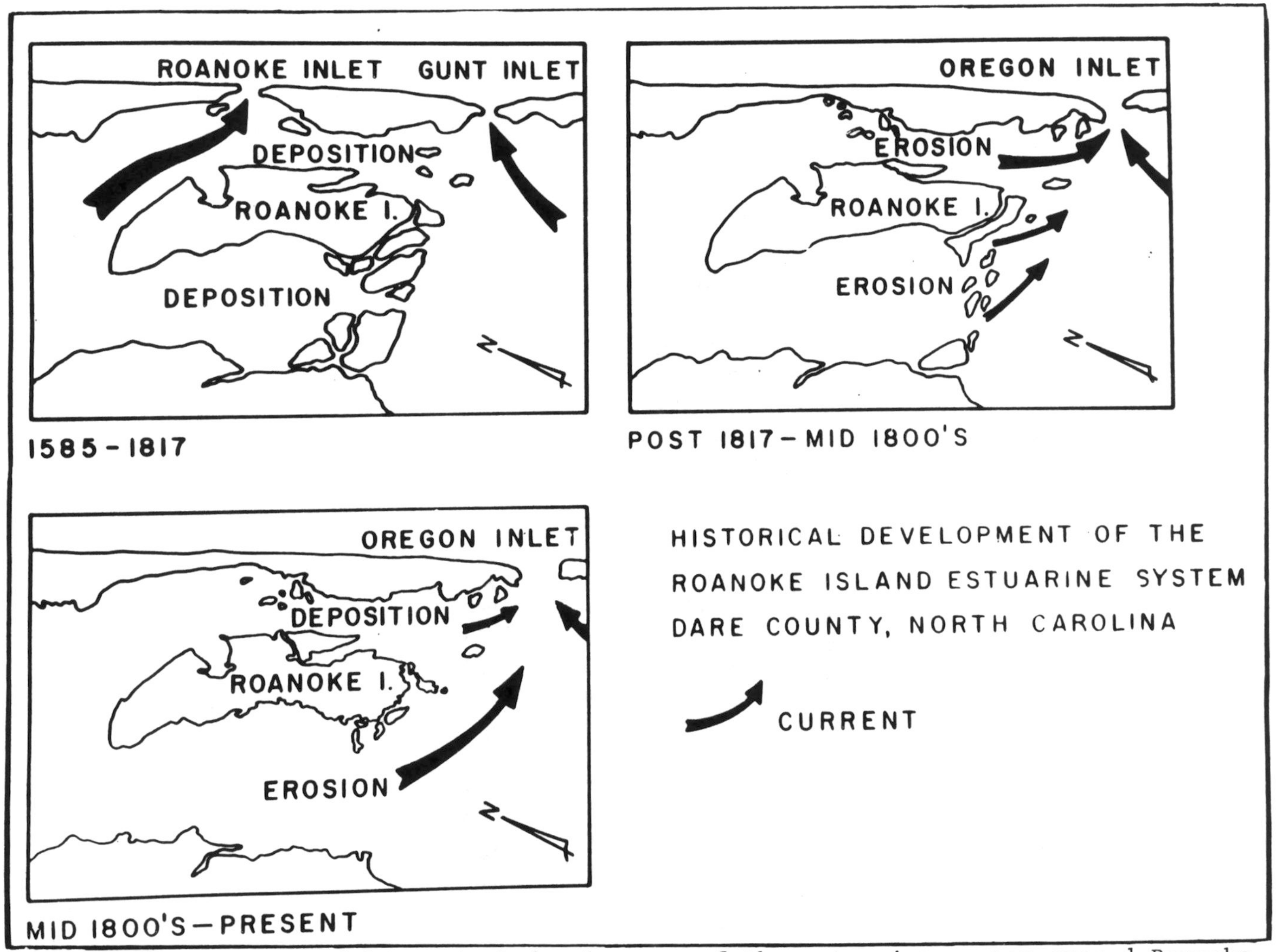


Figure 30. Interpreted historical development of the estuarine system around Roanoke Island, from 1585 to the present, in response to inlet processes. The size of each arrow represents the relative volume and direction of fresh water discharge (from Riggs and O'Connor, 1974).

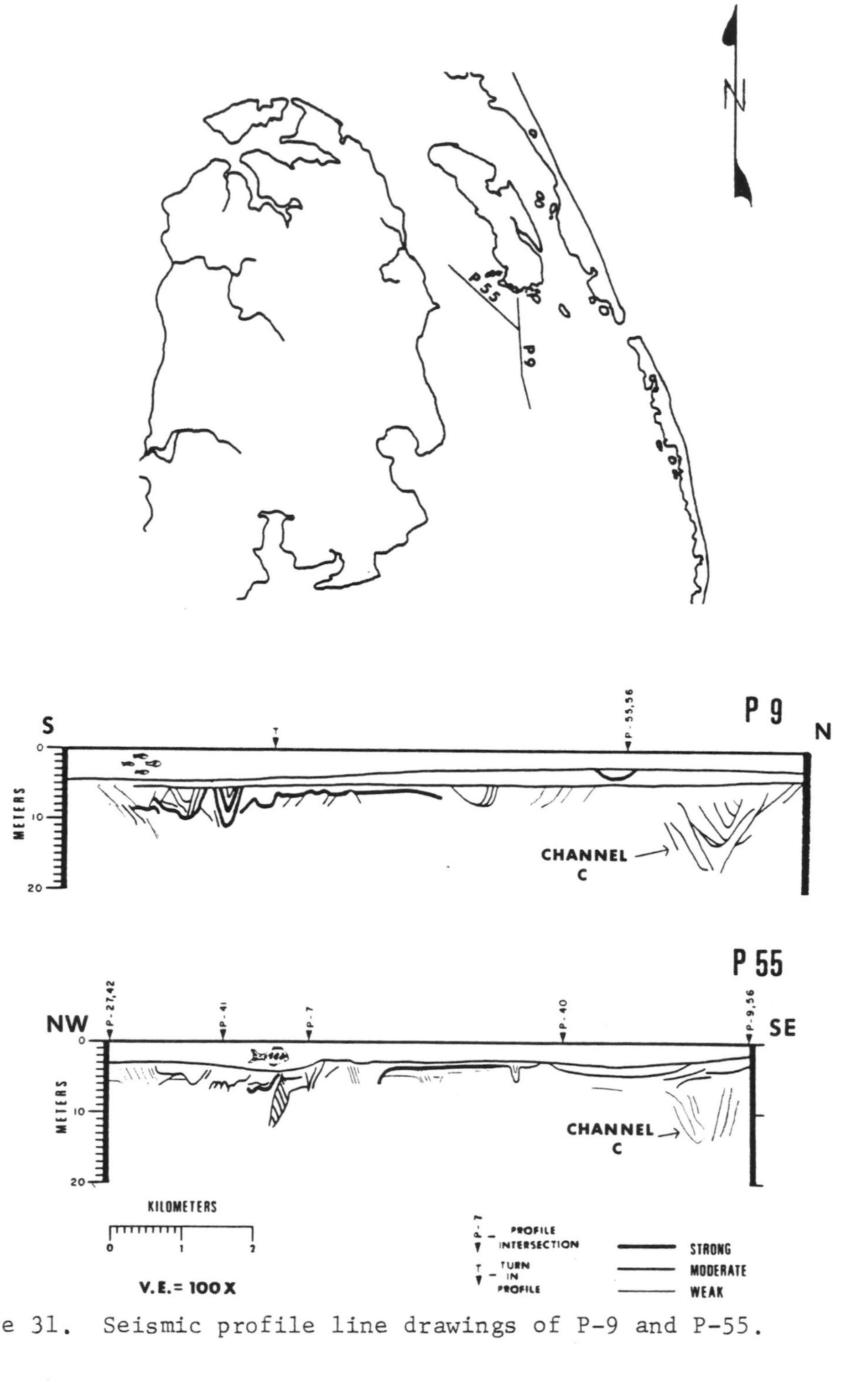


Figure 31. Seismic profile line drawings of P-9 and P-55.

multiples, firmer substrate and thus better penetration, and stronger sub-surface reflectors. The Uniboom profiles provided information to depths of over 50 m below msl.

The nearshore shelf region is dominated by moderate to very strong intensity, gently dipping reflectors. For discussion, successive reflectors have been designated as offshore reflectors A through D (OR-A through OR-D), in ascending order. OR-A through OR-D occur in the southern portion of Region IV dipping southeast (Fig. 32). Northward, OR-B through OR-D are successively truncated. It is expected that OR-A is similarly truncated further to the north.

If reflector surfaces OR-A through OR-D (Fig. 33 through 36) represent depositional surfaces, then there is a significant change in the depositional regime through time. The strike surfaces OR-A and OR-B are slightly east of north, forming an angle approximately 45° to the present shoreline (Fig. 33 and 34). Reflector surface OR-C is not planar and a general strike cannot be determined. However, the strike of reflector surface OR-D is parallel to the present shoreline (Fig. 36). This change in strike direction is believed to be associated with the changing depositional patterns along the North Carolina coastal zone. The coastal zone in the southern portion of the study area built seaward more rapidly, while the northern portion was relatively stationary due to slower sedimentation or erosion through time.

Interpretation of Region IV reflector patterns is difficult since there are no deep cores in this area. Offshore cores of Pearson (1979) are available along Profiles S-7, S-9, and S-4 (Fig. 11), but these

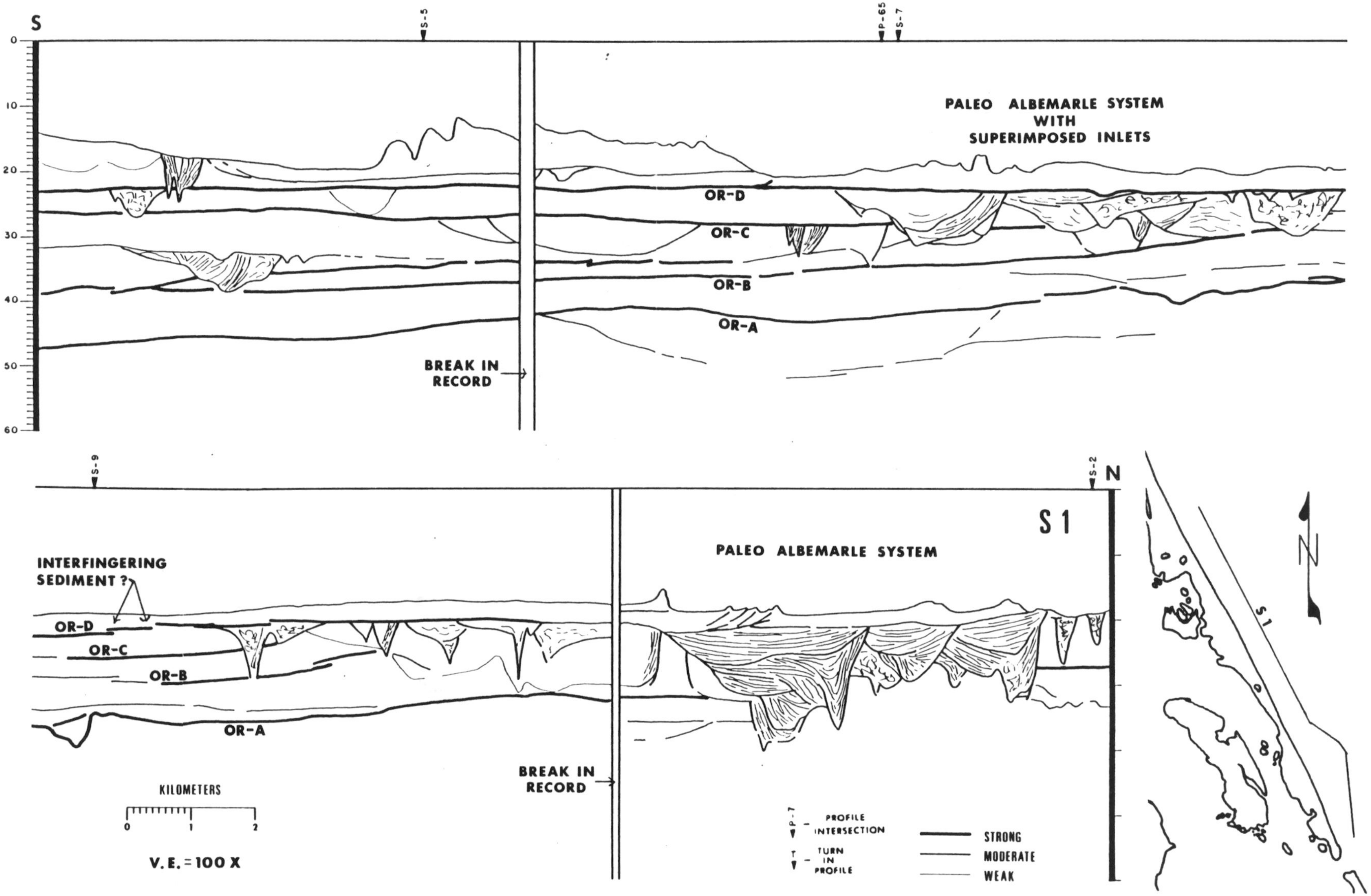


Figure 32. Seismic profile line drawing of profile S-1. Vertical axis is meters below mean sea level.

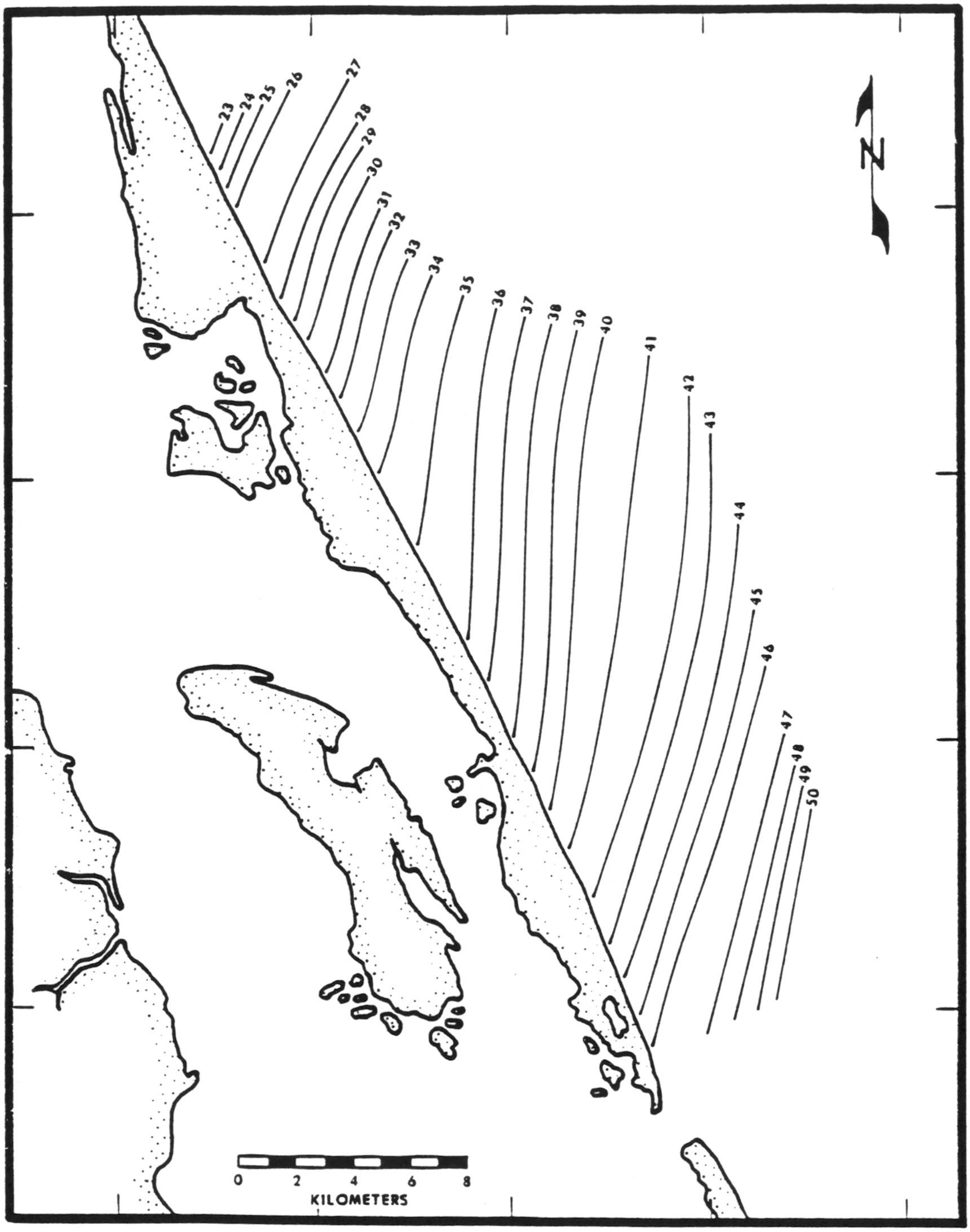


Figure 33. Structure contour map on the OR-A reflector. Contours are in meters below mean sea level.

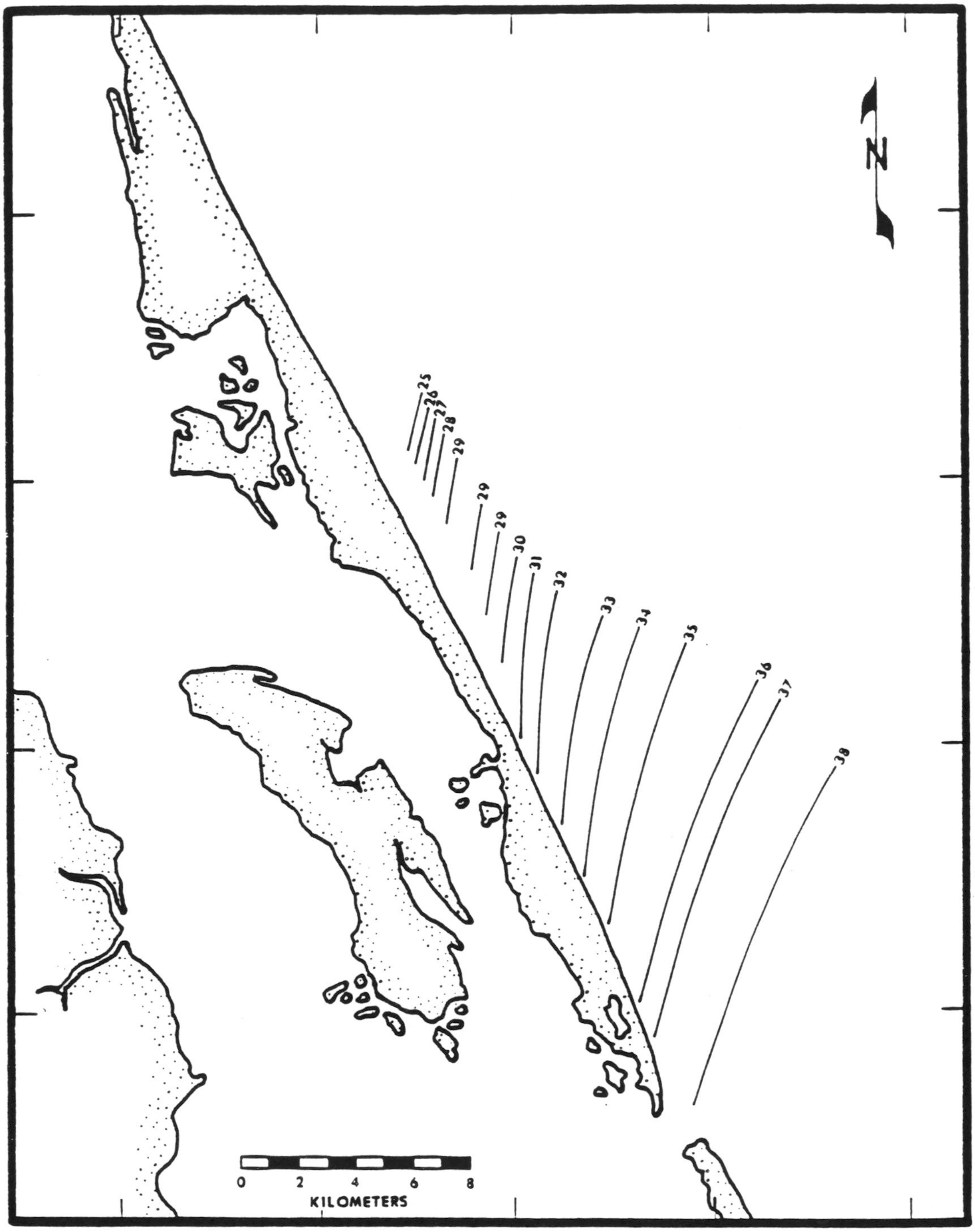


Figure 34. Structure contour map on the OR-B reflector. Contours are in meters below mean sea level.

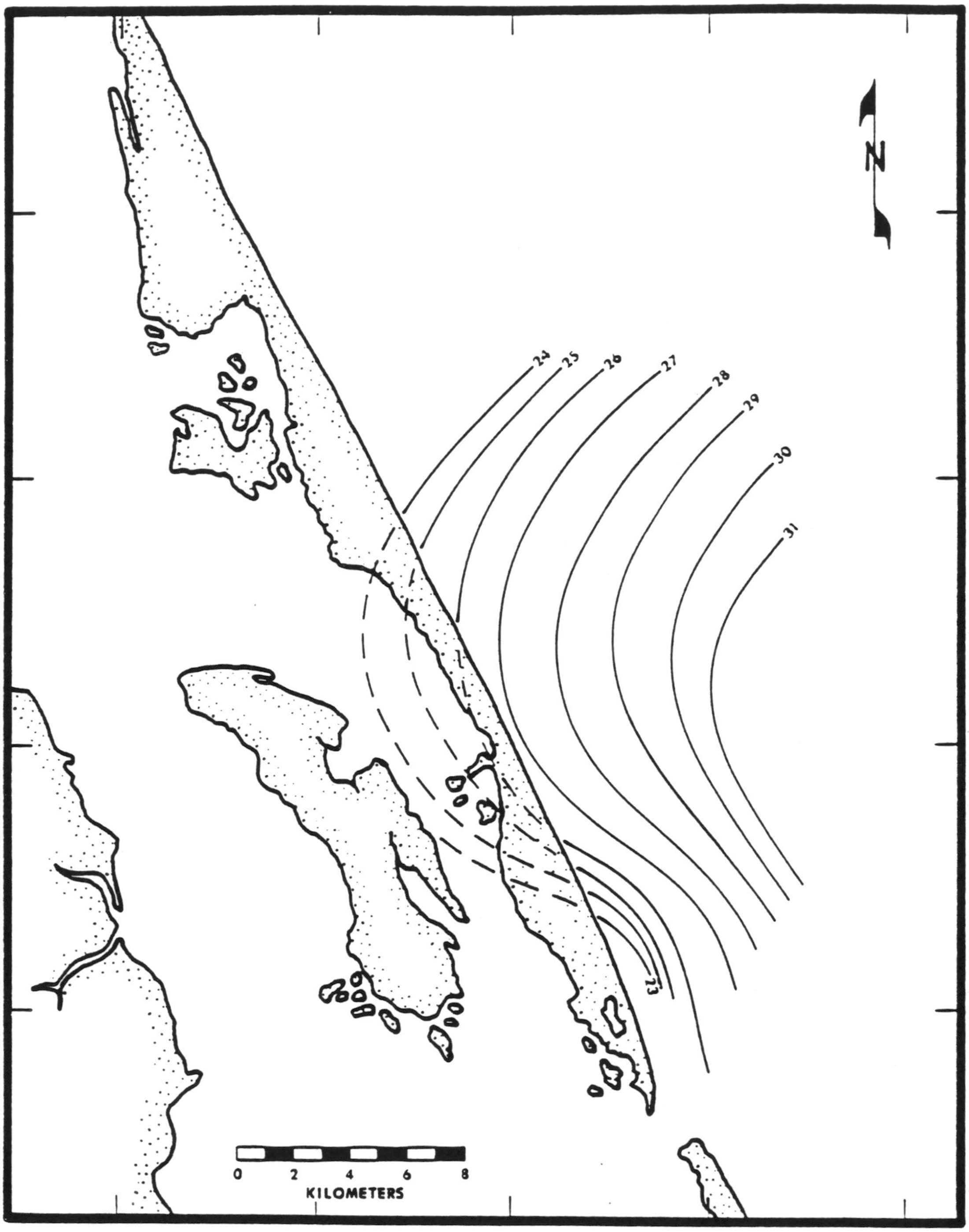


Figure 35. Structure contour map on the OR-C reflector. Contours are in meters below mean sea level.

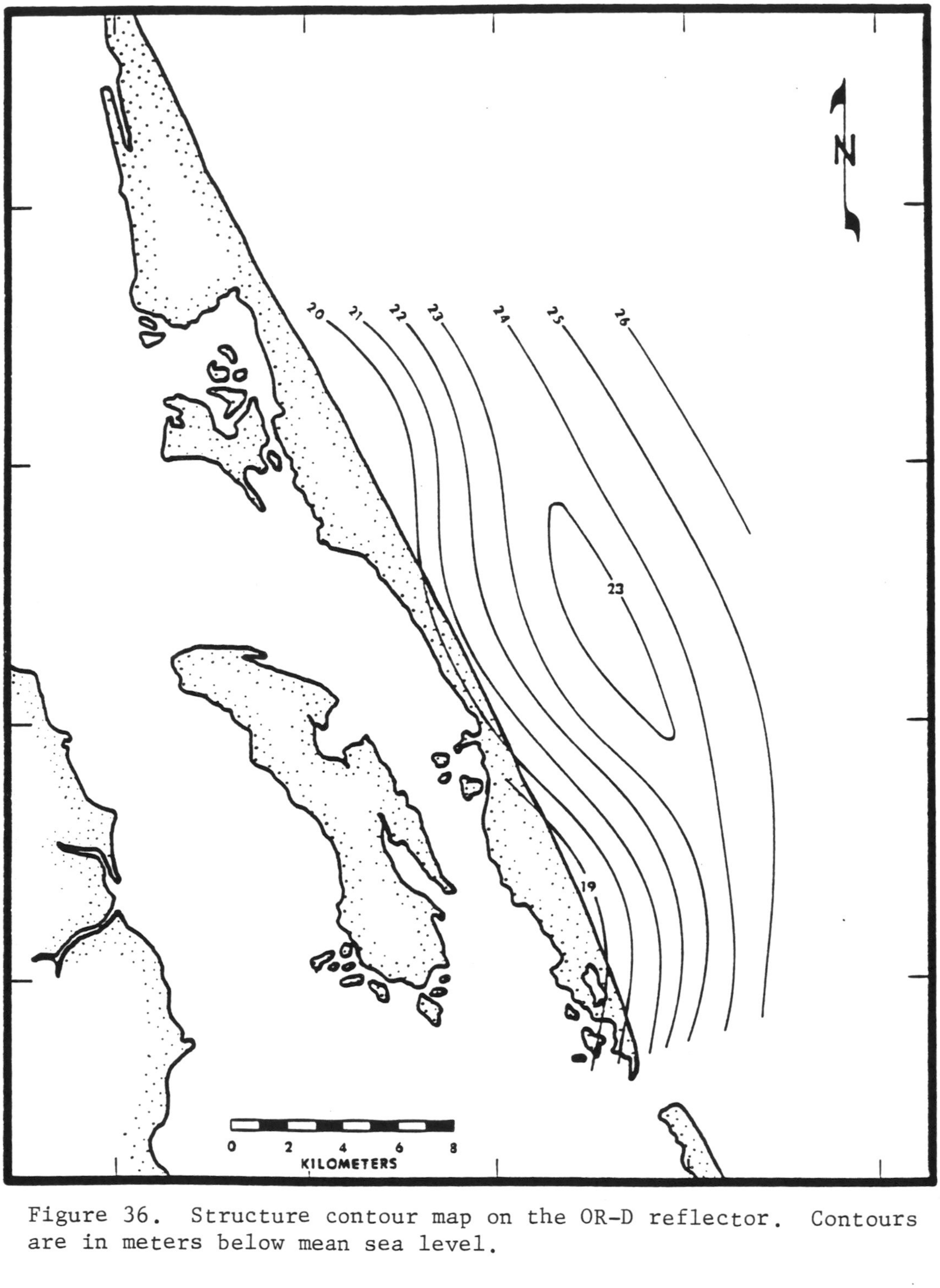


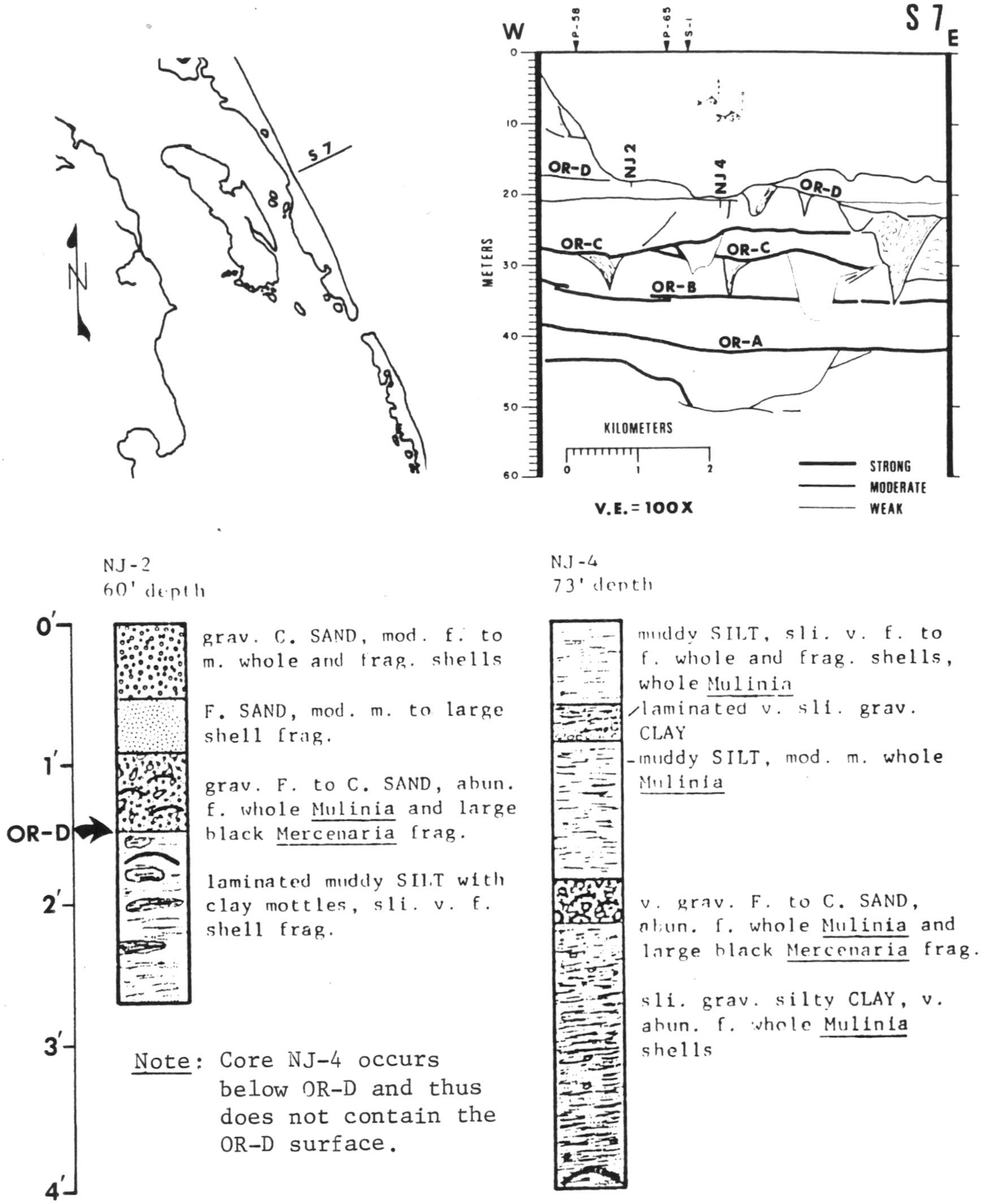
Figure 36. Structure contour map on the OR-D reflector. Contours are in meters below mean sea level.

cores reach a depth of only 2 mbs. Correlation of reflectors to deep onshore cores is subjective.

Based on (1) fossil association and (2) character of the reflector, OR-D is interpreted to represent the contact between the Roanoke Island barrier sand sheet and its associated lagoonal facies. Cores NJ-2 and NJ-4 (Profile S-7, Fig. 37) contain the bivalve Mulinia, a fossil typically found within the lagoonal facies (IVb) beneath the Roanoke Island barrier sand sheet (Fig. 43). The sediments of core NJ-4 are beneath OR-D and indicate a possible correlation with the lagoonal facies beneath Roanoke Island. Core NJ-2 contains Mulinia within a fine to coarse sand and appears to be reworked from the underlying lagoonal sediments. Profiles S-7 and S-9 (Fig. 38) suggest that shoreface retreat has eroded all reflectors and sediment units down to 20 m below msl including OR-D, the Roanoke Island barrier sand sheet, and all subsequent units within the offshore region.

On Profile S-1 just north of S-9 (Fig. 32), OR-D appears to fade out, but is not truncated. This area corresponds to the location where an ancient 'Albemarle Sound' would have existed during the transgressional migration of the Roanoke Island barrier. The fading out of OR-D could have resulted from the change to estuarine and fluvial sediments.

Several channels are associated with OR-D and to a lesser extent with other reflectors (Fig. 38). Narrow V-shaped channels indicate an orientation perpendicular to seismic profiles S-5, S-7, and S-9 (Fig. 38). Since these profiles are perpendicular to the present shoreline, the channels must be oriented parallel to the present shoreline.



Note: Core NJ-4 occurs below OR-D and thus does not contain the OR-D surface.

Figure 37. Seismic profile line drawing of profile S-7 showing the location of cores NJ-2 and NJ-4. Cores show the lithologic relationship to seismic reflector OR-D (cores from Pearson, 1979).

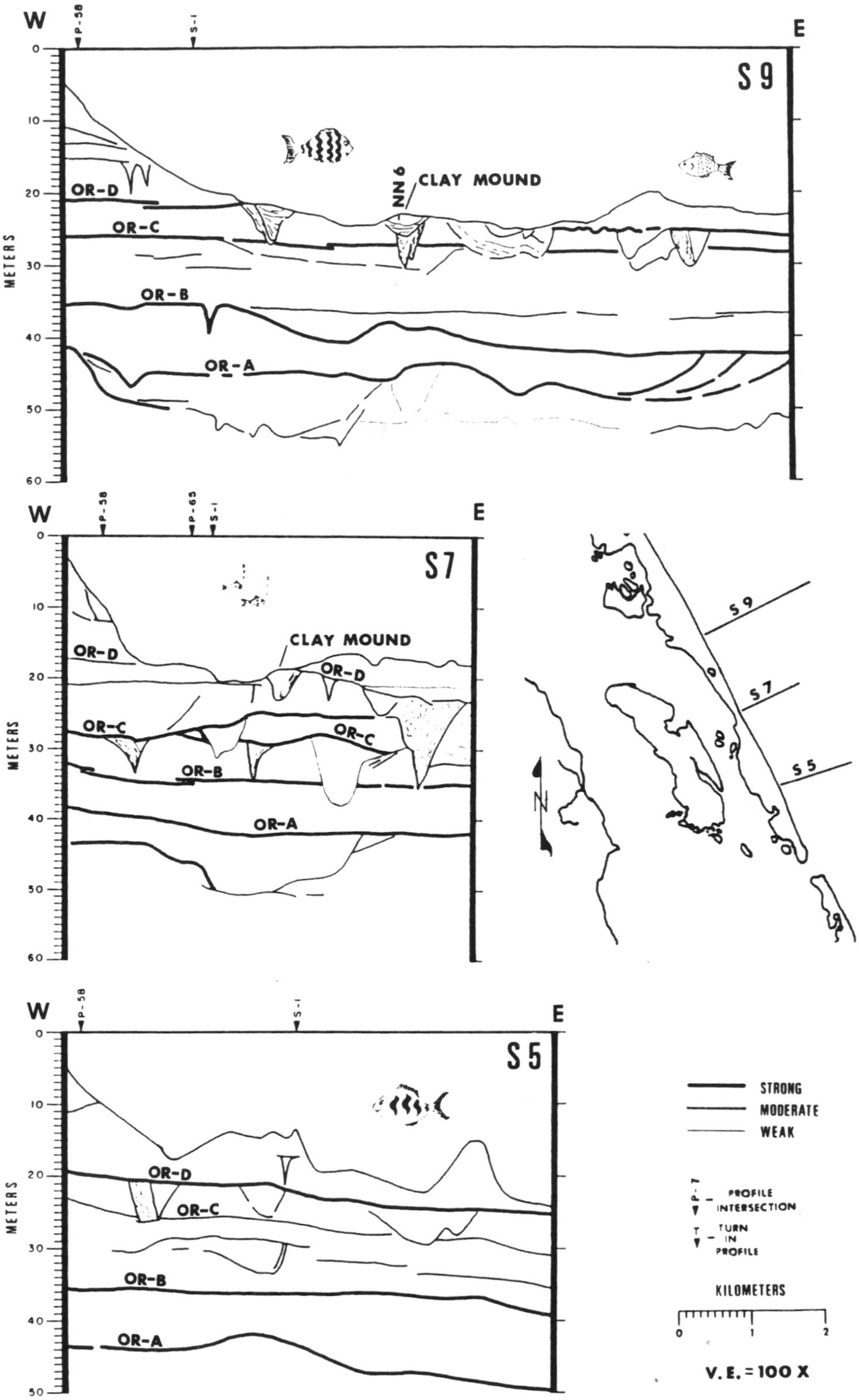


Figure 38. Seismic profile line drawings of profiles S-5, S-7, and S-9.

Therefore, these channels must be laterals to a major piedmont trunk stream. Since these channels would be parallel to a barrier coastline system, they were probably topographically controlled by barrier ridges which formed by sea-level pauses during intermittent regressions (Oaks et al., 1974). The resulting topographic features produce a trellis-like drainage pattern.

The following transgression would flood the lateral channels forming estuaries, very similar to the process which is occurring in lateral tributaries to the Albemarle and Pamlico Sounds today. These flooded tributaries would trap and fill with thick wedges of suspended sediments, as found in core NN-6 of Profile S-9.

As the transgression continues, earlier formed topographic ridge structures are submerged and eroded. Shoreface retreat eroded the upper sands, the tops of the channel fills, and down into the lagoonal unit through which the channels cut. Evidence for the simultaneous truncation of the channel tops and the lagoonal unit may be observed in the sharp angle contact between the two features (Fig. 38). The same type of relationship occurs on OR-C along Profile S-7 and in other isolated occurrences in the offshore profiles. When exposed, the clay infilling creates a mounding effect due to the erosional resistance of the clay compared to adjacent sand or sandy mud units (Fig. 38). Thus, shore-parallel, estuarine mud-filled channel features form topographic highs in the offshore profiles.

Profile S-1 (Fig. 32) trends parallel to the present shoreline from Oregon Inlet to just north of Kitty Hawk. Within Profile S-1, from just south of the S-7 intersection to the S-9 intersection, channels are associated with OR-D surface. Small, shallow inlet channels occupied this interval during the Holocene transgression. This was the location of the previously discussed Roanoke Inlet until 1817 (Fig. 30). During the late Pleistocene, the area from S-7 to S-9 was occupied by a set of deeper (at least 32 m below msl), larger fluvial channels which are interpreted to be a main trunk stream of the Albemarle drainage. The complex channel system was produced by a major fluvial channel which migrated over an 8 km wide zone. Due to the stratigraphic association with OR-D (Fig. 32), it is interpreted that the fluvial channel system was active during the latest Pleistocene sea-level lowstand and the early stages of the Holocene transgression.

Sometime during the latest Pleistocene to early Holocene, the Albemarle drainage system changed its course from near Roanoke Island and Nags Head to a more northerly position just north of Kitty Hawk, from about 3 to 16 km north of Profile S-9 (Fig. 32). Channels within this 13 km wide system extend to depths of at least 40 m below msl and possibly deeper. The Albemarle drainage is believed to have occupied this area during the Holocene until the present transgression flooded Albemarle Sound and altered the discharge route of the Albemarle from a single channel fluvial system to an estuarine-barrier island system with inlet discharge through the Outer Banks. Channels in Profile S-1 opposite Kitty Hawk Bay are stratigraphically the most recent. The channels extend to about 37 m below msl and are about 3 km wide; this is much the same width as Kitty Hawk Bay. The last position occupied by the major drainage system north of S-9 is in the area of Kitty Hawk Bay (Fig. 1), which is interpreted to be an inlet feature connecting the Albemarle to the Atlantic Ocean with Colington Island being the remnant flood tide delta. Thus, this inlet was closed prior to European settlement of the Outer Banks, for earliest historic maps show the same general morphology as today (Connor, 1907; and Cummings, 1966).

Large sand shoal structures occur on the nearshore shelf within the study area. Platt Shoals occurs off Oregon Inlet and Albemarle Shoals occurs offshore from Nags Head (Fig. 39). Duane et al. (1972) explain the offshore shoals as shoreface detachment structures. The shoals are generally attached to the shoreface at low angles and eventually detach as the shoreline retreats due to transgressive migration.

P-64 bisects the eastern portion of Platt Shoals (Fig. 40). This is an acoustic profile which picks up more detailed reflection patterns than Uniboom profiles. The shoals are marked by steeply inclined reflectors off both flanks. The surface appears to exhibit some sand waves whose orientation cannot be determined.

Albemarle Shoals off Nags Head is bisected by P-65 (Fig. 40). The internal structure on this shoal is not as spectacular as Platt Shoals, however slightly inclined reflectors may be observed on the eastern face. Large migrating sand waves are present to the east of Albemarle Shoals.

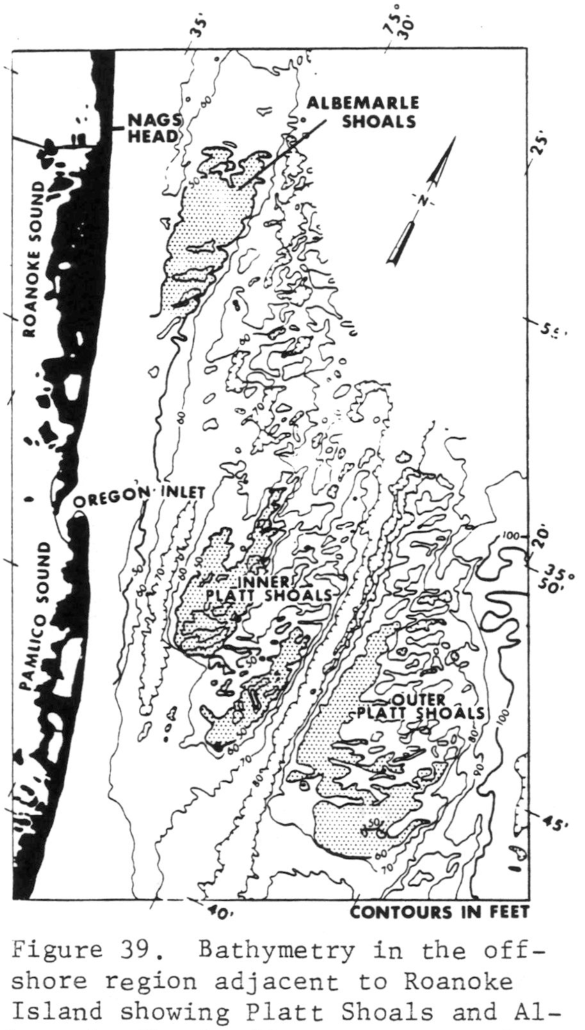


Figure 39. Bathymetry in the offshore region adjacent to Roanoke Island showing Platt Shoals and Albemarle Shoals (from Duane et al., 1972).

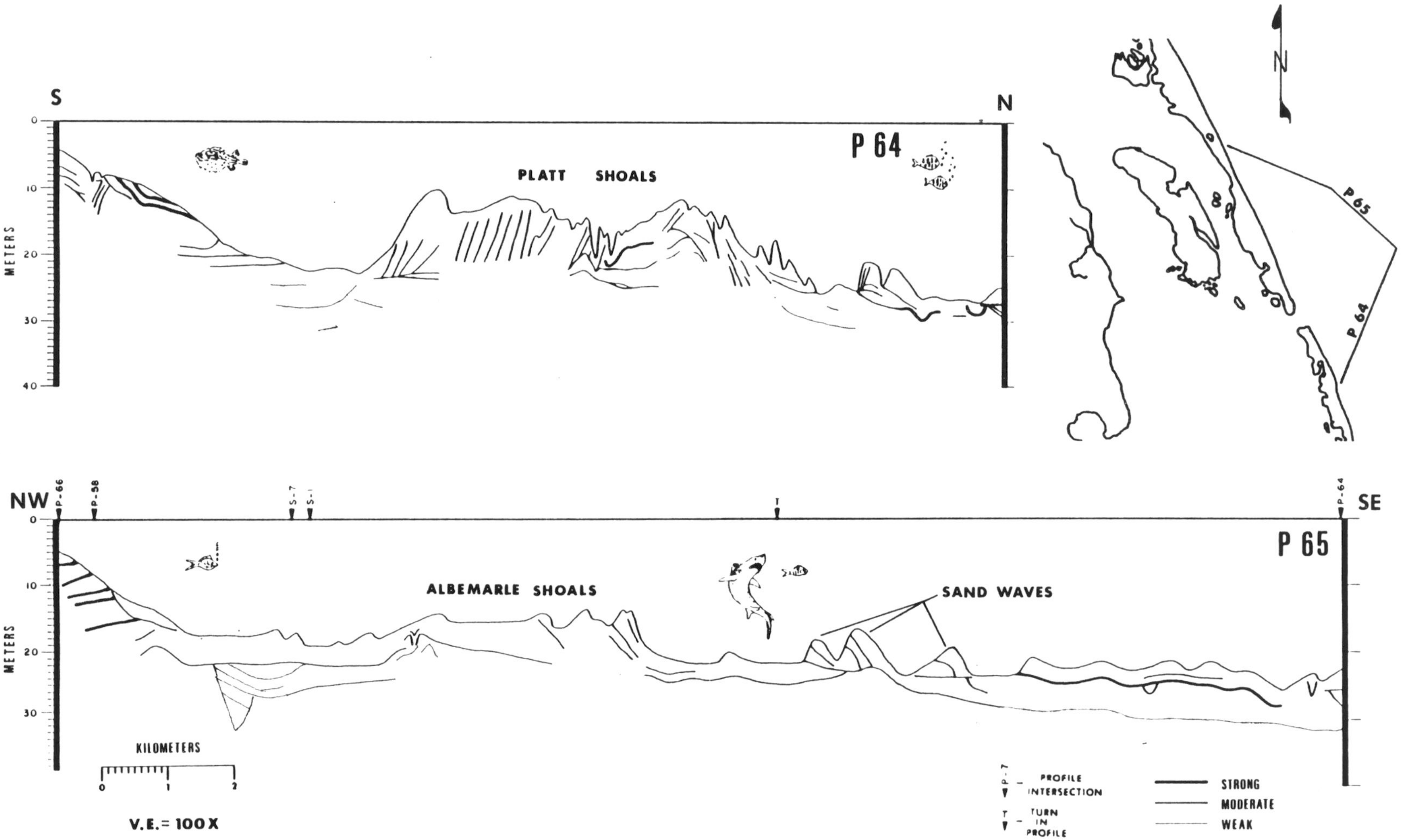


Figure 40. Seismic profile line drawing of P-64 and P-65 showing cross sections of Platt Shoals and Albemarle Shoals respectively.

LITHOSTRATIGRAPHY

Lithostratigraphic units studied throughout the Roanoke Island area are Pleistocene and Holocene in age and are represented in a series of six cross sections (Fig. 41). Three of these (A-A', B-B', and C-C') are oriented sub-parallel to the present barrier system. The remaining sections (D-D', E-E', and F-F') are oriented approximately 70, 90, and 60 degrees respectively to the trend of the present barrier system. Each cross section is a composite based upon core data and seismic profiles.

In general, the stratigraphic section in the study area is the result of multiple transgressive/regressive cycles which have produced a complex set of depositional-erosional sequences. Each depositional sequence is the result of the transgressive portion of a cycle; the subsequent regressive portion may have eroded and altered the original depositional character of previous sequences. Five depositional sequences have been identified in the study area. In an attempt to simplify the complex stratigraphy, the five depositional sequences will be presented individually in depositional order. Each depositional sequence consists of one or more facies which will be described individually including: (1) sediment character, (2) distribution and geometry, and (3) lateral and vertical sediment variations. A discussion of results will be provided for each depositional sequence with a brief lithostratigraphic summary at the end.

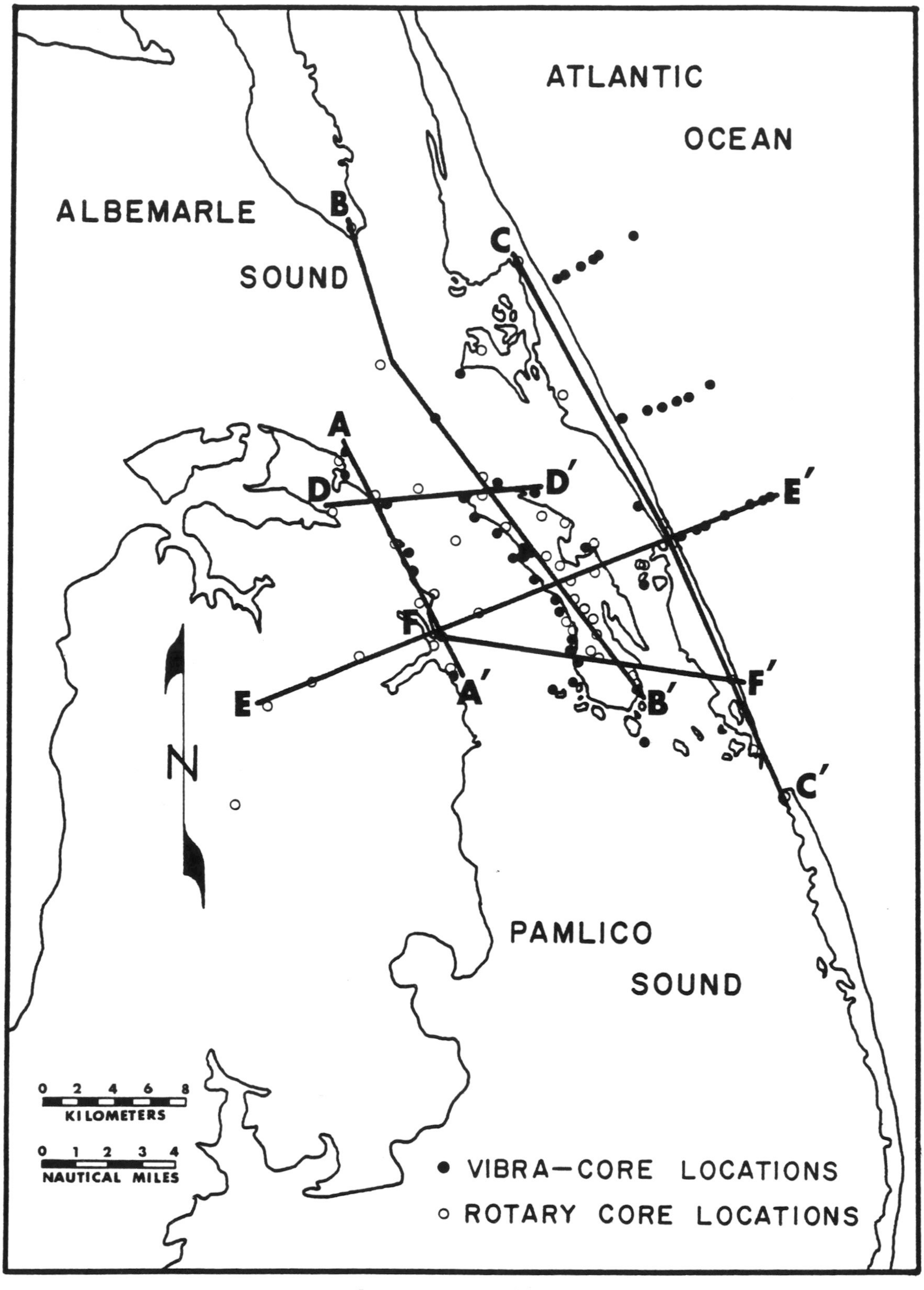


Figure 41. Location map of cross sections.

Depositional Sequence I

Facies I. The basal unit for this investigation is a widespread marine unit designated as Facies I. This marine facies is generally a fossiliferous, fine- to coarse-grained, quartz sand which is occasionally granular and occasionally muddy. Fossils are the whole, broken, and abraded shells, and shell hash of the following genera: *Arca*, *Busycon*, *Ensis*, *Lucina*, *Macoma*, *Mactra*, *Mercenaria*, *Mulinia*, *Nassarius*, *Oliva*, *Pecten*, *Polinices*, *Solen*, *Tagelus*, *Tellin*, and *Venericardium*. The genera of primary interest in Facies I are *Mercenaria* and *Ensis*. The remaining fauna are either scarce or are not indicative of a unique environment and therefore were not used for comparison. The genus *Mercenaria* is a robust form which lives in nearshore to near-offshore environments with moderate to high energy regimes. *Ensis*, on the other hand, is a delicate form which lives in offshore, lower energy regimes. The two genera will not normally occur together due to their different environments.

Facies I is laterally extensive. It is identified in cores from the central Dare County mainland to central Roanoke Sound, and from Oregon Inlet to the tip of the Currituck Peninsula. Facies I was not cored in other areas. A structure contour map of the top of Facies I has been constructed (Fig. 42). Facies I core data from Oregon Inlet and Currituck Peninsula were omitted from this map due to their isolated nature. The depths of Facies I at Oregon Inlet and Currituck Peninsula correspond with the general contour trend, measuring 20 m and 15 m, respectively. The upper surface of Facies I dips approximately

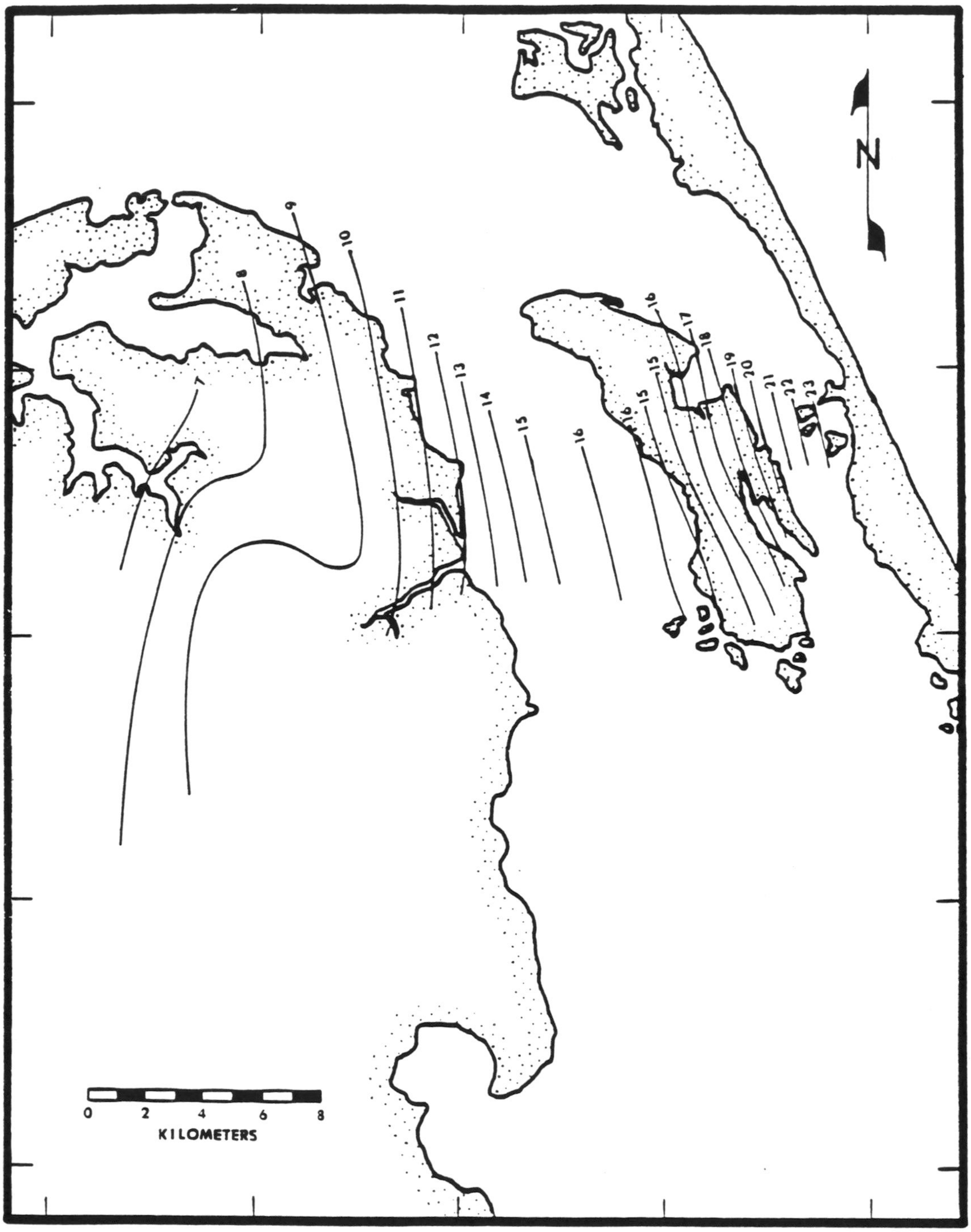


Figure 42. Structure contour map on the top surface of Facies I. Contours are in meters below mean sea level.

N 75° E and is slightly undulatory. In the up-dip portion, Facies I is 7 m below msl and extends down-dip to 23 m below msl at CS-95. Cores seaward of CS-95 were not deep enough to intersect Facies I. Thickness of Facies I is unknown since cores penetrated no more than 6.5 m of Facies I on the Dare County mainland (Fig. 43).

The terrigenous component of Facies I reveals no apparent lateral or vertical variations. The fossils in Facies I are often abraded and fragmented. Abraded shells and shell hash of all of the previously listed fauna are most common in cores of mainland Dare County throughout the entire Facies I interval (6.5m). Within the Dare County mainland, Mercenaria is found mainly in upper Facies I, while whole and fragmented Ensis shells are found only in the lower portions at 11 to 12 m below msl. Down-dip within Facies I, there is a gradual reduction in the amount of abraded shells and shell hash and Ensis occurs closer to the top. In the area beneath eastern Roanoke Island, only minor shell hash occurs at the top of Facies I with underlying whole and fragmented Ensis shells. Mercenaria is not found in Facies I beneath Roanoke Island.

Discussion of Depositional Sequence I. Facies I is considered a nearshore or inner shelf marine unit which was deposited during a high sea-level stand. The associated shoreline is believed to be a relict shoreline which occurs west of the Alligator River. The Alligator River shoreline (Fig. 6) is correlated to the Hickory Scarp in southeast Virginia by Oaks and DuBar (1974). Depositional Sequence I is correlated with the Kempsville Formation which was deposited in front

CROSS SECTION KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
▨	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
▨	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES LOCATED ON CROSS SECTIONS:

CONFORMABLE - ———

UNCONFORMABLE - ▬▬▬

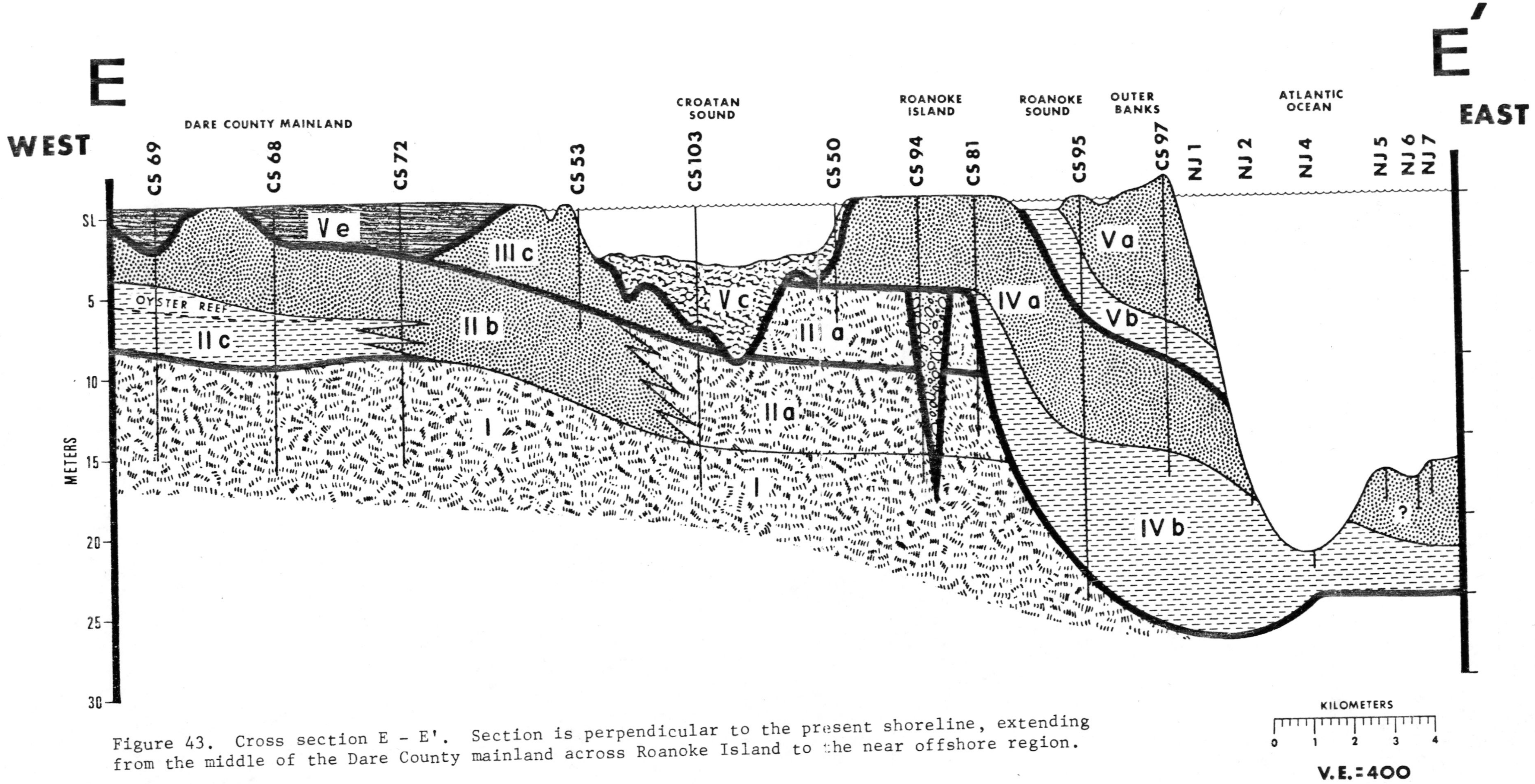


Figure 43. Cross section E - E'. Section is perpendicular to the present shoreline, extending from the middle of the Dare County mainland across Roanoke Island to the near offshore region.

of the Hickory Scarp. If this is correct, then sea level at the time the Kempsville shoreline was occupied was approximately 6 m above the present level. This high stand would have produced water depths of from 13 m to 29 m or more in the Roanoke Island area. Uranium series age dates of 62,000 and 86,000 years B.P. were determined from driftwood samples within the Kempsville Formation (Oaks et al., 1974).

The sediment characteristics of Facies I support the interpretation of a nearshore environment. The terrigenous sediments are highly variable, occurring as fine- to coarse-grained and occasionally gravelly or muddy sands. As determined by Pearson (1979), the present offshore surface sediments are laterally variable with the distribution of sediment types being dictated by local topography (Fig. 44 and 45). The higher shoal structures are predominantly fine- to medium-grained sands and lower troughs contain gravels and/or muds. As sediment bedforms shift across the seafloor, a layering of various sediment types may occur. The cores intersecting Facies I similarly consist of interlayered gravels, sands, and to a lesser extent, muds. This may indicate that the Facies I surface had a similar ridge and swale topography as is found throughout the present Atlantic offshore zone (Duane et al., 1972).

Fossil associations generally agree with a nearshore interpretation for Facies I. Minimum shell hash occurs with the delicate *Ensis* in the down-dip, lower energy portion of the environment below Roanoke Island. Abundant and highly abraded shell hash occurs with *Mercenaria* in the up-dip, shallower, higher energy portion of the system beneath

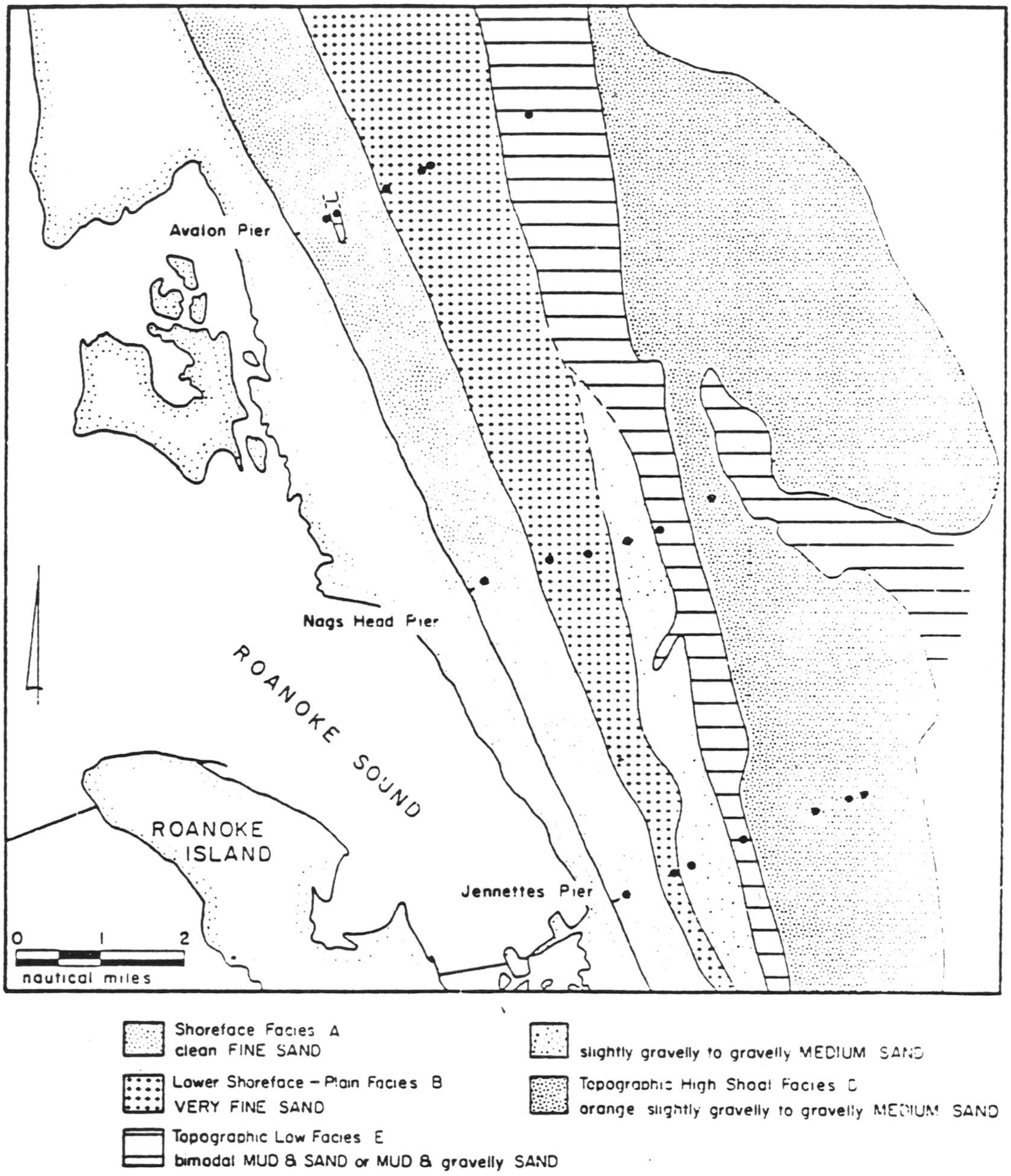


Figure 44. Nearshore marine surface sediment distribution east and northeast of Roanoke Island (from Pearson, 1979).

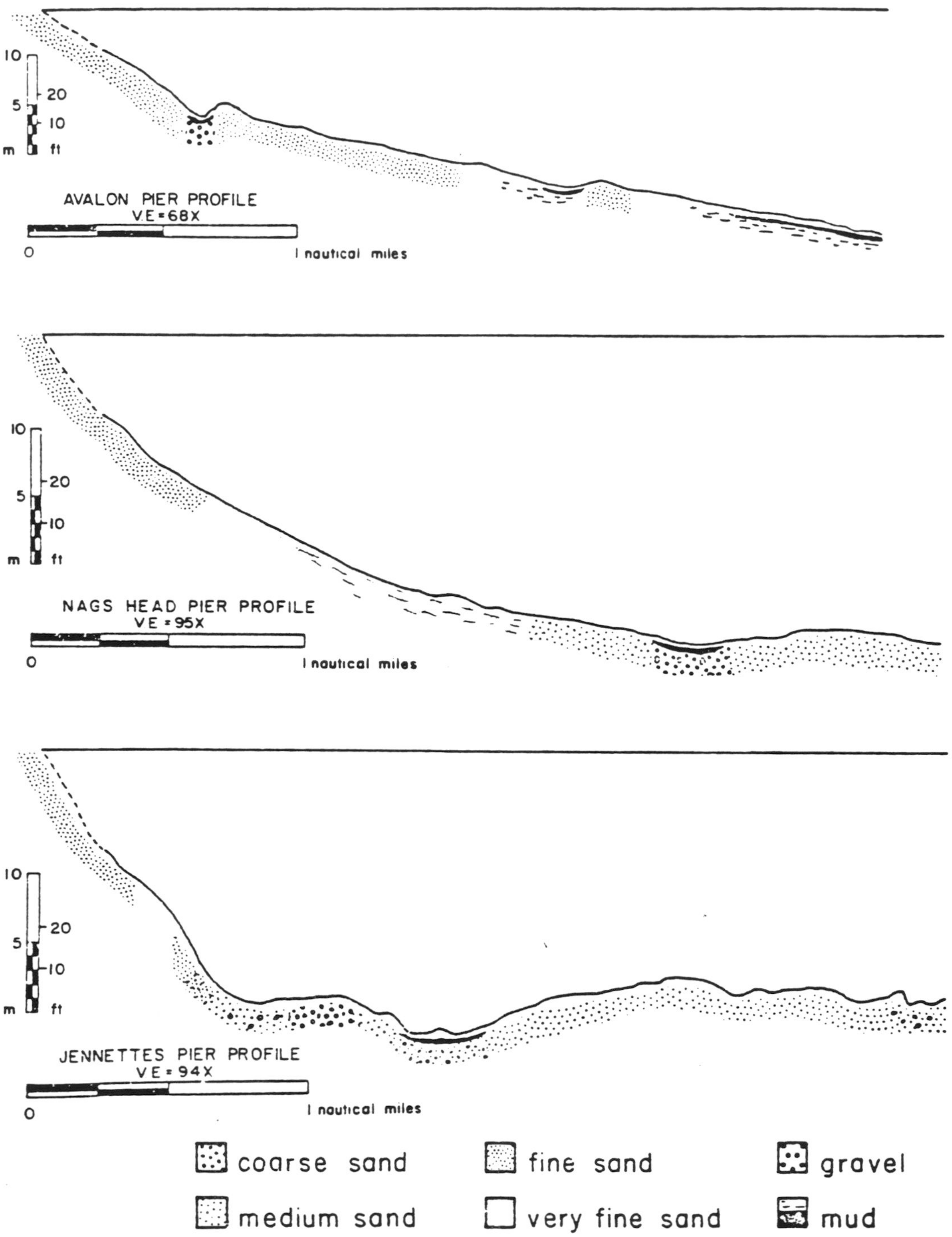


Figure 45. Near-offshore surface sediment distribution along pier profiles of Figure 43. Surface sediments show association of sediment type to the offshore topography (i.e. gravels and muds within the troughs and sands on higher ridges)(from Pearson, 1979).

Dare County mainland. The uppermost layers of shell hash in the western part of the study area may be the result of reworking during the post-Kempsville regression. Oaks et al. (1974) suggest the regression was a minimum of 9 m. From evidence in Depositional Sequence II, the post-Kempsville regression in the Roanoke Island area is interpreted to be approximately 16 m, resulting in a sea level 10 m below the present sea level. The resulting shoreline would be on the -10 m contour of Facies I (Fig. 42) near the west shore of Croatan Sound. As seen on the structure contour map (Fig. 42) and on cross section E-E' (Fig. 43), a break in the slope of the Facies I surface occurs at a position of -10 m. The steeper lower slope is interpreted to be the result of shoreface erosion during the low sea-level stand.

A distinct iron-rich oxidation zone at the upper contact of Facies I is exhibited in CS-74. Iron oxidation zones are typically indicators of prolonged periods of subaerial exposure of an iron-bearing sediment (Pierce and Colquhoun, 1970). The oxidized surface occurs west of the proposed shoreline and is present at -9 m below msl and is therefore above the proposed -10 m sea-level position.

Comparing the surface structure contour pattern of Facies I to offshore reflector contour patterns (Fig. 42 and 35), OR-C is slightly below the top surface of Facies I. Whether the surface of Facies I and OR-C are truly correlative is questionable and should be tested with deeper offshore cores along the seismic profiles. The contour pattern of OR-C possibly suggests a large post-Depositional Sequence I erosional feature such as the Albemarle drainage system.

Depositional Sequence II

Depositional Sequence II consists of three distinct facies. These are (1) nearshore marine facies (Facies IIa), (2) barrier island facies (Facies IIb), and (3) back-barrier estuarine facies (Facies IIc). The facies relationships of Depositional Sequence II are best observed on cross section E-E' (Fig. 43).

Facies IIa. Facies IIa consists of a gray, slightly fossiliferous, fine- to medium-grained, quartz sand. Sediments are occasionally slightly muddy or granular. The upper surface consists of orange to red iron-stained sands. Fossils found in Facies IIa consist of abundant Mulinia with minor occurrences of Nassarius, Oliva, and Venericardia.

The lateral distribution of Facies IIa is not fully known. Facies IIa terminates to the west along the western half of Croatan Sound where it grades into Facies IIb (Fig. 43), and terminates to the east by erosional truncation near the east side of Roanoke Island as demonstrated in cross sections D-D' and F-F' (Fig. 46 and 47). North-south cross section B-B' (Fig. 48) through central Roanoke Island reveals an irregular surface. The structure contour map on top of Depositional Sequence II displays the irregular surface more clearly (Fig. 49). Facies IIa is situated somewhat higher in elevation beneath the northern half of Roanoke Island than in the southern portion due to a paleotopographic high. The top of Facies IIa dips to the south as the surface drops from 7 m below msl in the up-dip direction to 12 m below msl down-dip. In general, Facies IIa is 7 to 8 m thick in the north and

CROSS SECTION KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
░	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
▨	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES
LOCATED ON CROSS SECTIONS:

CONFORMABLE - ────────

UNCONFORMABLE - ━━━━━━━━

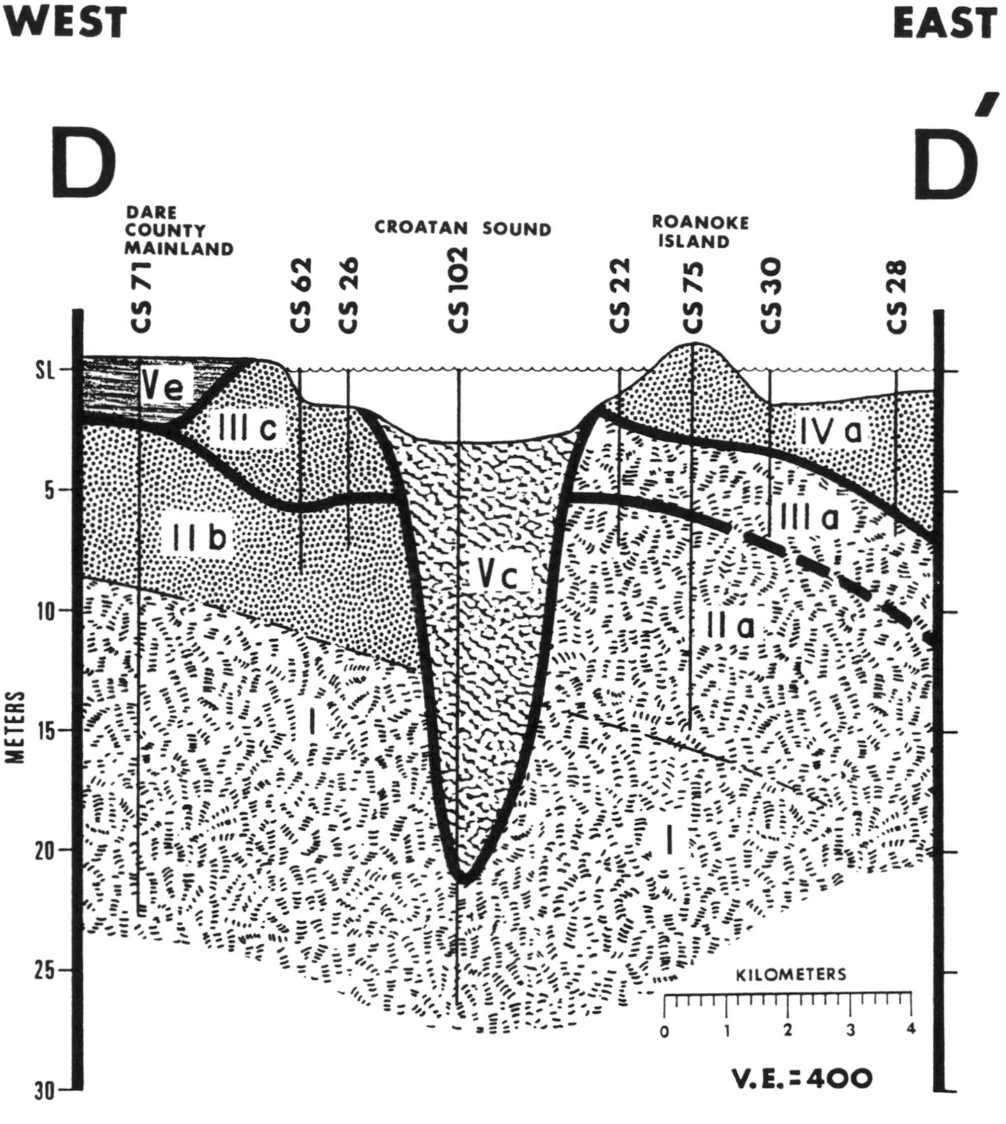


Figure 46. Cross section D - D'. Section is perpendicular to the present shoreline extending from the Dare County mainland to the northern end of Roanoke Island.

CROSS SECTION KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
░	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
░	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES LOCATED ON CROSS SECTIONS:

CONFORMABLE - ───

UNCONFORMABLE - ━━━

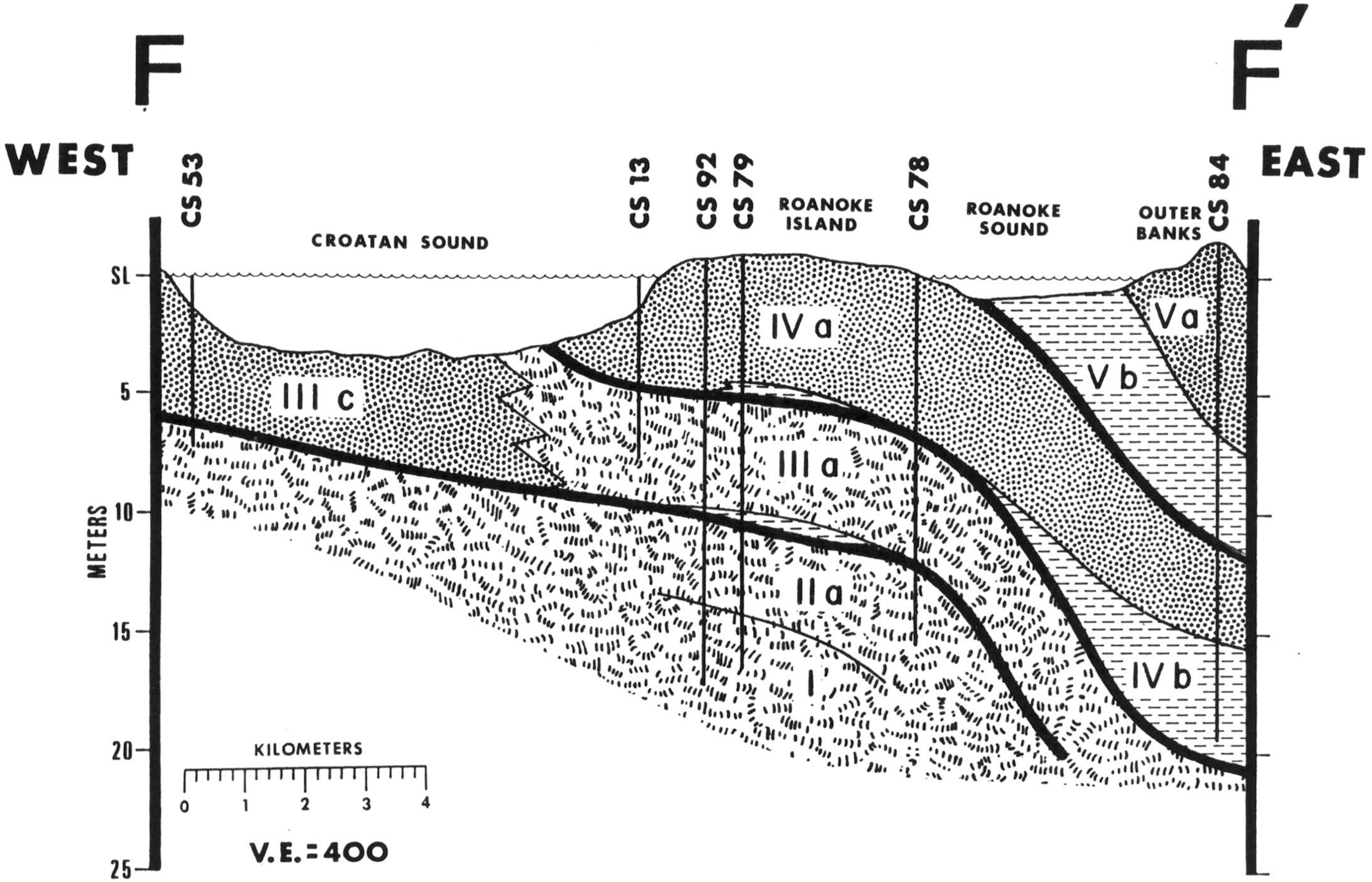


Figure 47. Cross section F - F'. Section is perpendicular to the present shoreline extending from the Dare County mainland to the southern end of Roanoke Island.

CROSS SECTION
KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
⁙	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
▨	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES
LOCATED ON CROSS SECTIONS:

CONFORMABLE - ―――

UNCONFORMABLE - ━━━

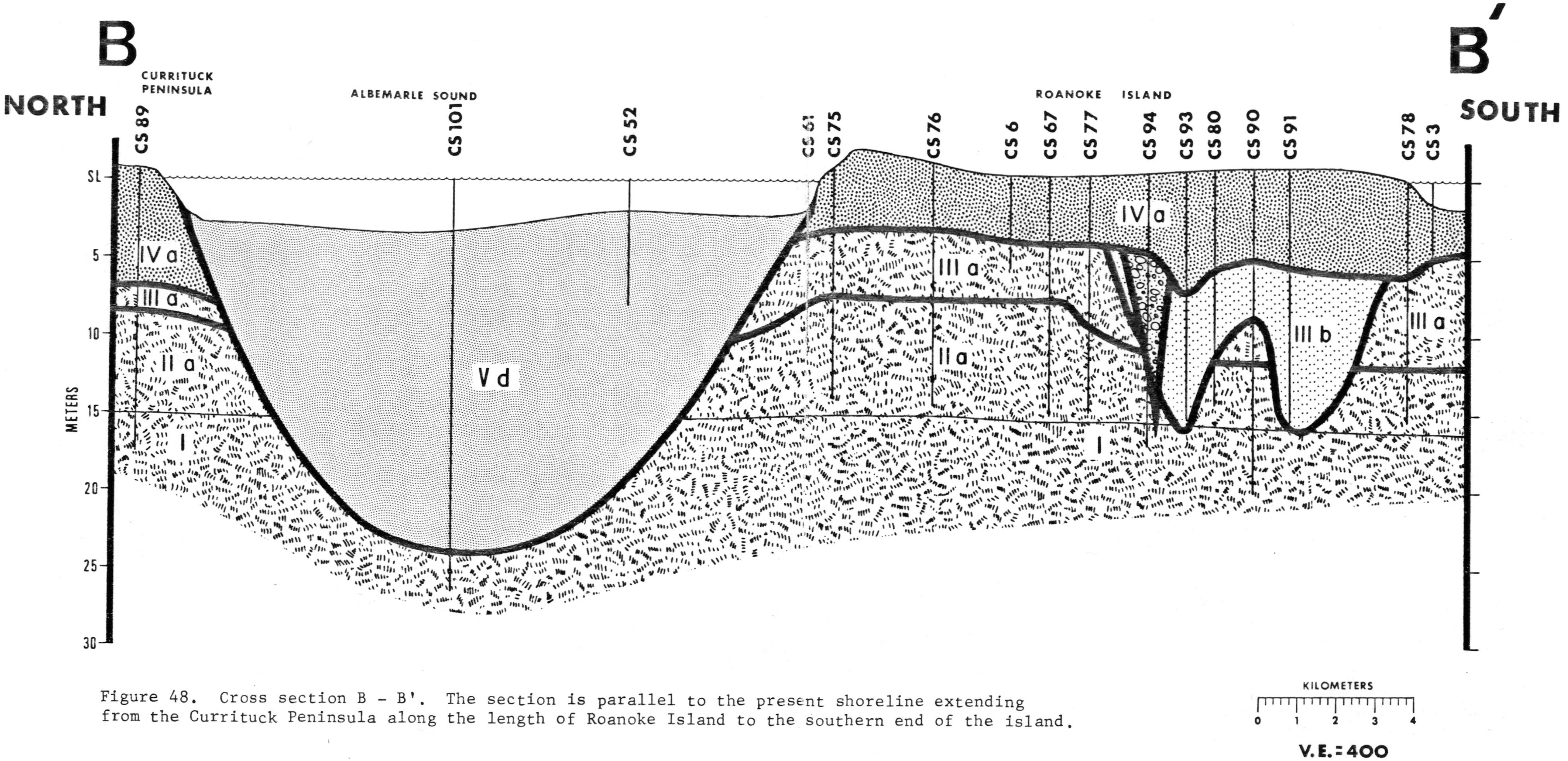


Figure 48. Cross section B - B'. The section is parallel to the present shoreline extending from the Currituck Peninsula along the length of Roanoke Island to the southern end of the island.

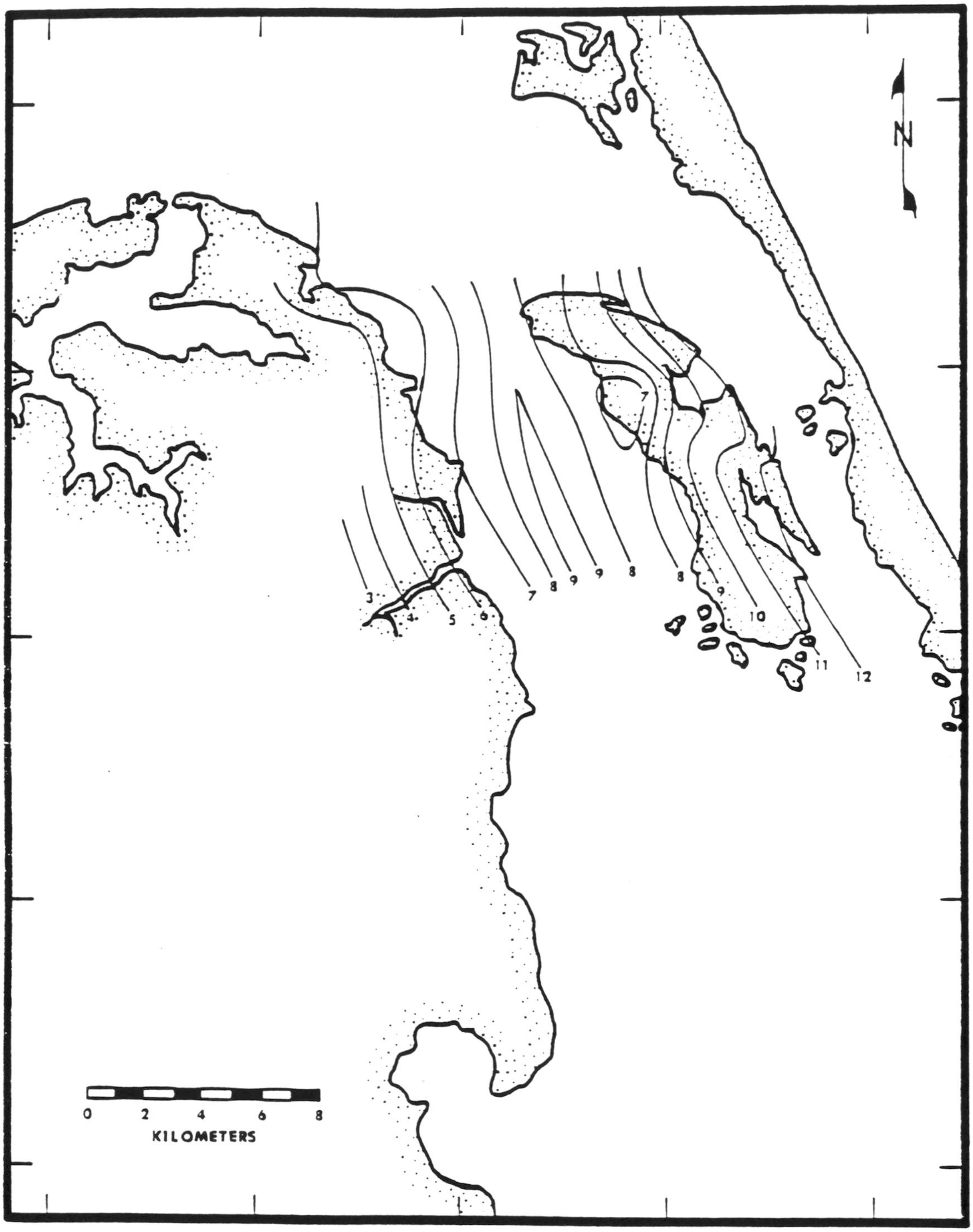


Figure 49. Structure contour map on the top surface of Depositional Sequence II (Facies IIa and IIb). Structure contours are in meters below mean sea level.

thins to about 4 m thick to the south.

The sediment generally fines in an eastward direction. Beneath western and central Roanoke Island, Facies IIa is composed of a persistant, medium-grained sand with occasional granular layers and abundant *Mulinia*. Fine-grained sands are more common below eastern Roanoke Island with decreasing concentrations of *Mulinia*. *Mulinia* is found only as abraded shell hash west of Roanoke Island.

Facies IIb. Facies IIb consists of a clean, slightly fossiliferous, fine- to medium-grained, quartz sand with occasional layers of granular and gravelly sand. Iron-stained sands are common on the upper surface of Facies IIb. Fossils in Facies IIb are mostly unidentifiable shell fragments and some *Mercenaria* fragments.

Facies IIb extends from the western half of Croatan Sound, where it grades into Facies IIa, westward into the Dare County mainland where it crops out (Fig. 43). The outcrop pattern is dictated by subsequent fluvial channel disection and may easily be seen on the peat distribution map of Ingram and Otte (1982) (Fig. 7). Facies IIb is about 5 m thick in the down-dip direction and thins westward onto the Dare County mainland as it over-tops Facies IIc (Fig. 43). In cross section A-A' (Fig. 50), Facies IIb appears to thin northward from 5 to 3 m.

In the eastern extent of Facies IIb, the sediment is a fine- to medium-grained sand with common granular and gravelly sand layers and shell hash. Sediment fines westward to a clean, fine quartz sand in CS-72 and CS-70 on the Dare County mainland. There appears to be more granular and gravelly sand layers in the northern portions of Facies

CROSS SECTION KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
░	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
▨	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES LOCATED ON CROSS SECTIONS:

CONFORMABLE - ———

UNCONFORMABLE - ━━━

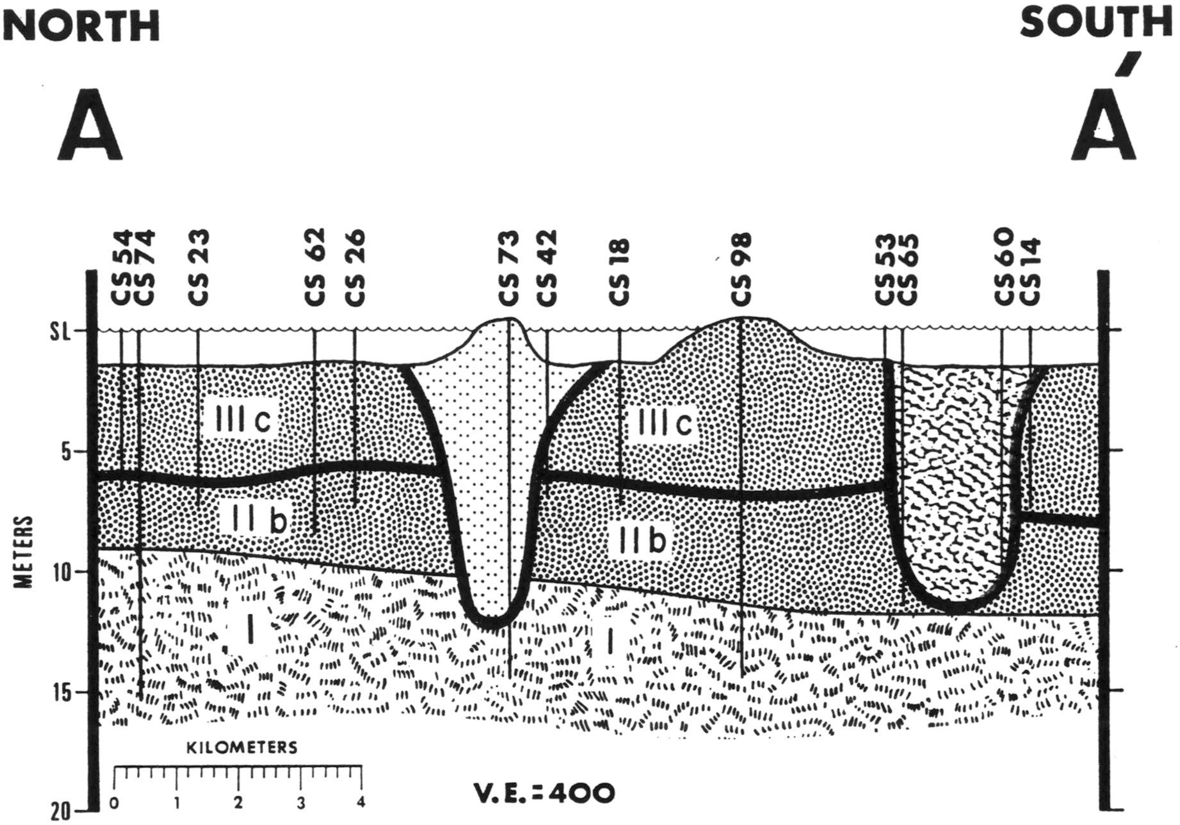


Figure 50. Cross section A - A'. The section is parallel to the present shoreline extending along the western shore of Croatan Sound.

IIb than in the southern portions.

Facies IIc. Facies IIc consists of two sediment types. The lower zone is a silty clay to muddy fine-grained quartz sand with rare unidentifiable fossil fragments and occasional interlaminated clays. This muddy sand zone is overlain by a slightly muddy, fine-grained sand with abundant fossils of Crassostrea virginica.

Facies IIc is encountered in cores CS-72, CS-68, CS-69, and CS-70 within the Dare County mainland (Fig. 12). Facies IIc interfingers with Facies IIb at CS-72 and is assumed to be the eastward extent of Facies IIc (Fig. 43). Core data is insufficient to determine the lateral distribution in remaining directions. Thickness of Facies IIc varies from 2.5 m at CS-72 to 4.5 m at CS-69. The upper layer of Facies IIc is 0.5 m thick in CS-68 and thickens westward to 2 m at CS-69 (Fig. 43). Sediment variation within Facies IIc appears to be minimal on the basis of the few available cores.

Discussion of Depositional Sequence II. Depositional Sequence II is interpreted to be a barrier island system consisting of a nearshore marine facies, a barrier island facies, and a back-barrier estuarine facies. Previous discussion of Depositional Sequence I established that the post-Kempsville regression dropped sea level to about 10 m below the present sea level. At this low sea-level stand, moderate erosion occurred landward of the shoreline while deposition continued seaward of the shoreline. The contact between Depositional Sequence I and II is therefore unconformable west of the low-stand position as shown by the distinct boundary between the two sequences in cores on the Dare County mainland (Fig. 43). To the east of the low-stand position, beneath Roanoke Island, the two sequences do not possess a sharp boundary and may represent either continuous deposition or various degrees of reworking prior to and during the deposition of Facies IIa.

The initial Depositional Sequence II shoreline (post-Kempsville) was approximately at the -10 m contour of Figure 42. During this sea-level stillstand, the shoreline prograded seaward to the position of the -13 or -14 m contour of Figure 42. The abundant sediment needed for such progradation may have been provided by increased sediment loads in the piedmont trunk streams during the colder climates (increased glaciation) associated with the regression. In addition, there is a significant increase in fluvial derived gravels, producing the large amount of granular gravelly sands in the easternmost barrier sands of Facies IIb.

Facies IIa developed in the nearshore region during the post-Kempsville sea-level minimum and during the early stages of transgression. The eastward fining of sediment is due to decreasing energy in the offshore direction. Slightly muddy and granular zones within Facies IIa are interpreted to be the result of sediment patterns associated with offshore ridge and swale topography as explained in Depositional Sequence I. Fossils within Facies IIa are all capable of living within the nearshore environment. The dominant fossil, *Mulinia*, is usually considered to be a muddy substrate, estuarine form (Dodd and Stanton, 1981; Snyder and Katrosh, 1979). However, *Mulinia* has been described as a very opportunistic species which occurs in a temporally and spatially sporadic manner in large numbers as environmental conditions fluctuate (Levinton, 1970). *Mulinia* has been found in brackish water estuarine to hyper-saline waters (Moore, 1960), as well as in the nearshore regions of South Carolina (Cazeau et al., 1964). *Mulinia* could have existed in the nearshore region of Depositional Sequence II, in the muddy sediments within the swales of ridge and swale topography.

The transgression which followed the post-Kempsville sea-level low stand resulted in the development and growth of a barrier island system. Sea-level rise resulted in vertical growth of the barrier and subsequent formation of a back-barrier estuary and the deposition of Facies IIc. Continued rise in sea level resulted in landward migration of the barrier island over the top of Facies IIc (Fig. 43). The westward extent of the barrier island migration is believed to be a shoreline position slightly east of the Alligator River as implied by Oaks and DuBar (1974) (Fig. 6). They correlate this shoreline to the Oceana Ridge in southeast Virginia; therefore, Depositional Sequence II would correlate to the Londonbridge Formation of southeast Virginia (Oaks et al., 1974).

Characteristics of the Londonbridge Formation are quite similar to that of Depositional Sequence II. The two units rest partially unconformably on the Kempsville Formation and its correlative Depositional Sequence I, respectively. The western boundary of the lagoonal sediments in the Londonbridge Formation consists of an extensive sequence of north-south trending *Crassostrea virginica* oyster reefs. A similar association occurs in Dare County and constitutes the upper Facies IIc.

The Oceana Ridge represents the barrier structure of the Londonbridge Formation (Fig. 51). According to Oaks et al., sea level during the Londonbridge reached a maximum of 7 to 8 m above present sea level. The majority of the barrier structure of the Oceana Ridge formed during this high stand has been destroyed by extensive post-Londonbridge erosion during an emergent episode (Oaks et al., 1974).

Major erosion during the post-Londonbridge regression is also evident in the Roanoke Island study area. A widespread weathered zone occurs at the upper contact of Depositional Sequence II. The normally gray, clean sands grade upward into an orange to red iron oxide-stained surface layer which is present in nearly all cores penetrating this unit. The weathered zone suggests subaerial exposure during the post-Londonbridge emergent episode. The total extent and duration of the regression is unknown, but core data of this investigation suggests a sea level at least 11.3 m below the present sea level.

Depositional Sequence III

Depositional Sequence II consists of three facies. These are (1) nearshore marine facies (Facies IIIa), (2) inlet channel facies (Facies IIIb), and (3) barrier island facies (Facies IIIc). Facies relationships are most easily observed on cross sections B-B' and E-E' (Fig. 48 and 43).

Facies IIIa. Facies IIIa consists of a light gray to light brown, slightly fossiliferous, fine- to coarse-grained, quartz sand with granular quartz sand layers and occasional mud layers. The upper surface

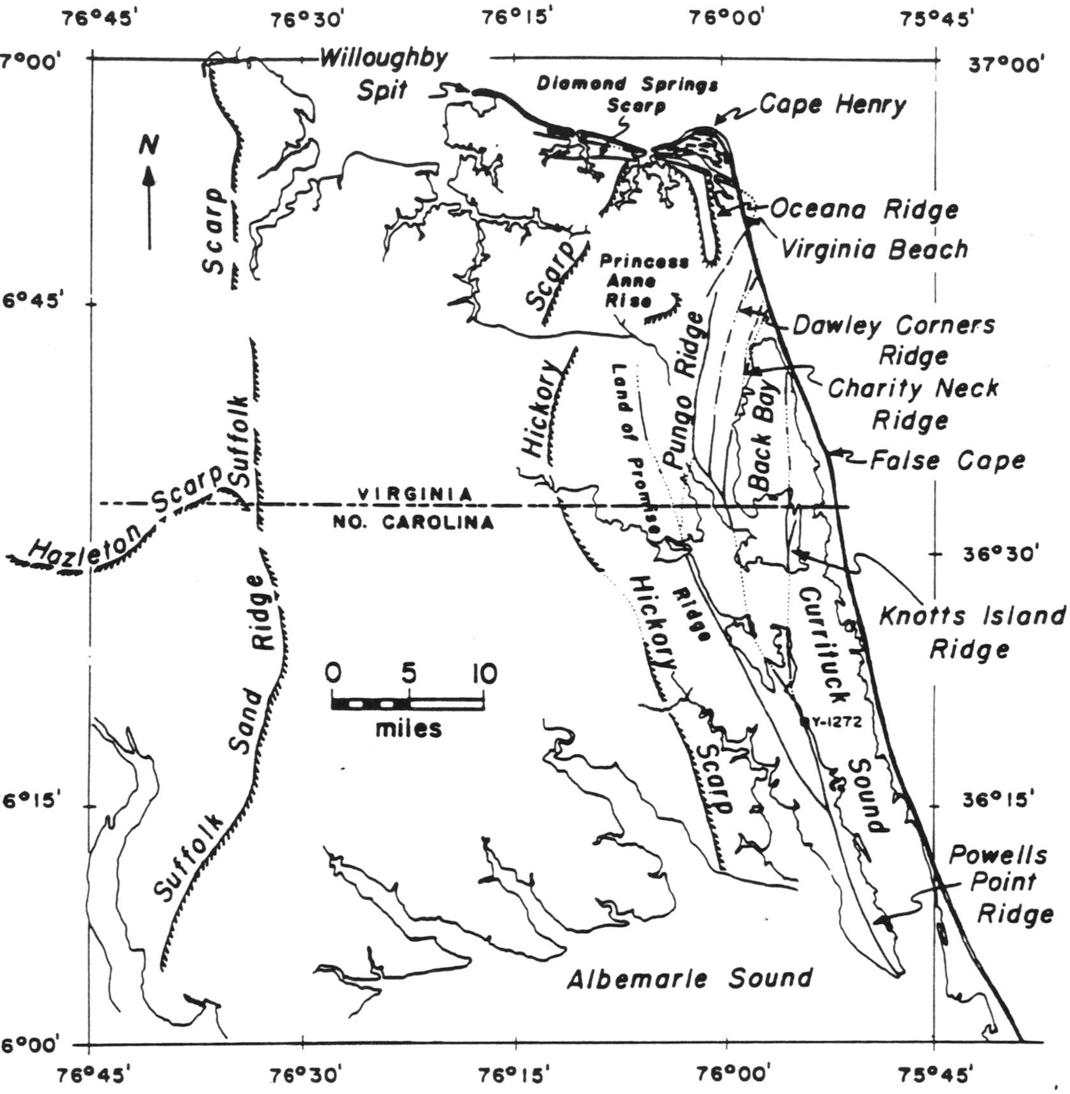


Figure 51. Map of Pleistocene shoreline positions within southeast Virginia (from Oaks et al., 1974).

has a distinct weathered zone consisting of orange to red, iron-stained sands. Fossils of Facies IIIa consist of shell hash and abraded shells of the genera _Mactra_, _Mercenaria_, _Mulinia_, and _Oliva_.

Facies IIIa occurs primarily beneath Roanoke Island. Cross section E-E' (Fig. 43) shows the east-west relationship between Facies IIIa and IIIc. Since the barrier island facies has been removed by erosion of the Croatan Trough, the western extent of Facies IIIa is eastern Croatan Sound in the northern Roanoke Island area (Fig. 43), and approximately the center of Croatan Sound in the southern area (Fig. 47). Facies IIIa is terminated on the east side of Roanoke Island by erosional truncation of Depositional Sequence IV (Fig. 43). The position of truncation is uncertain to the north in cross section D-D' (Fig. 46) and to the south due to inadequate core control. Cross section B-B' (Fig. 48) shows Facies IIIa being bisected on the north by the fluvial sediment of the Albemarle drainage system, and reappearing on the Currituck Peninsula. Facies IIIa extends for an undetermined distance to the south. Thickness ranges from 4.5 m in the north to 6 m or more in the southern limit of this study area. The upper surface is irregular with a slight southward dip (Fig. 48).

Sediment variations within Facies IIIa are minor. Granular sands and shell material decrease southward. A vertical variation is not evident.

Facies IIIb. Facies IIIb is an inlet feature and consists of fossiliferous, granular to gravelly, medium- to coarse-grained, quartz sand. Fossils of Facies IIIb consist of highly abraded shells of the genera Mactra, Mercenaria, Mulinia, Nassarius, Oliva, Ostrea, Venericardium, and various unidentifiable fragments.

Facies IIIb has a very local distribution which can only be seen in the north-south cross section B-B' (Fig. 48). The inlet consists of two deep channels which are connected at the top of the sediment unit. The inlet structures are 10 to 12 m in depth (over 16 m below msl). The top of Facies IIIb extends about 7 km from beneath the southwest corner of Shallowbag Bay to nearly the southern end of Roanoke Island. The east-west extent of Facies IIIb is unknown.

Sediment variations are few in Facies IIIb. The gravel component increases downward toward the base of the channels. Lateral variations in the facies do not exist.

Facies IIIc. Facies IIIc consists of a non-fossiliferous, clean, very fine- to medium-grained, quartz sand which occasionally becomes coarse to granular.

The distribution of Facies IIIc trends parallel to the western shoreline of Croatan Sound. In northern Croatan Sound, Facies IIIc is truncated to the east by the Croatan Trough (Fig. 43 and 46). In the southern part of the study area, Facies IIIc grades eastward into Facies IIIa beneath Croatan Sound (Fig. 47). Maximum thickness is about 7.5 m along the east side of the Dare County mainland (Fig. 50).

Sediment variation in Facies IIIc is minor. The sand fractions are commonly mixed fine- to medium-grained sands and occasionally coarse sands with some granular layers. No sediment pattern is apparent.

Discussion of Depositional Sequence III. Depositional Sequence III is interpreted to be a nearshore marine-barrier island system. The entire sequence was transgressively emplaced on top of the down-dip portion of Depositional Sequence II. The unconformable contact between the two sequences is characterized by the iron-stained zone at the top of Depositional Sequence II which indicates a subaerially exposed surface. Stratigraphic positions of Depositional Sequence III suggest a transgressive sea-level maximum of 2 to 4 m above present sea level. Depositional Sequence III is tentatively correlated to the Lower Member of the Sand Bridge Formation in southeastern Virginia.

The offshore unit, Facies IIIa, contains muddy and granular sand layers which were probably formed within offshore topographic swales. They became interbedded with the sands as the bedforms migrated. The truncation of Facies IIIa to the east is believed to be the result of erosion by the Albemarle fluvial system. The Albemarle drainage system may have occupied a position somewhat eastward of Roanoke Island during a subsequent regression. The increased gradient associated with the lowstand would enhance erosion in the area. The subsurface contour of reflector OR-C (Fig. 35) may represent the general position of the Albemarle valley during this low stand of sea level.

Facies IIIb is an inlet feature which cuts into Facies IIIa. The inlet is a relatively short-lived feature because there is no evidence of the inlet to the east or west of cross section B-B'. The inlet would have been active while the barrier structure of Depositional Sequence III was in the position of present day Roanoke Island and closed as environmental conditions changed.

A deep fluvial channel cuts through the northern part of Facies IIIb at CS-94 (Fig. 48). The fluvial channel is composed of a non-fossiliferous, coarse-grained sandy, granular, quartz gravel. The fluvial channel is interpreted to be Channel B of Figure 25, which cut through Facies IIIb during the regressive episode which followed the emplacement of Depositional Sequence III.

Facies IIIc is the barrier island facies. The clean and generally fine-grained nature of the facies possibly indicates a large dune and back-dune sediment component mixed with the shoreface sands. Steeply eastward dipping seismic reflectors of Profiles 1, 2, and 83 (Fig. 24) have been interpreted as shoreface reflectors corresponding to the shoreface of Facies IIIc.

A major problem in interpreting Depositional Sequence III is the apparent lack of an estuarine facies below and behind the barrier island facies. Cross section F-F' (Fig. 47) shows a very limited amount of muddy sediment below the barrier island sand sheet. A time equivalent estuarine facies also does not exist behind Facies IIIc on the Dare County mainland. The lack of preservation of the estuarine facies may be due to erosional characteristics of the system. It has been suggested earlier that back-barrier or lateral estuaries between relict Albemarle and Pamlico Sounds may experience extensive erosion or non-deposition when there are no inlets in the barrier system north of the Pamlico Sound region (Fig. 30). A lack of inlets to the north will force fluvial discharge of the Albemarle system through the lateral estuaries with extensive erosion as they flood across the interstream divide of the Pamlimarle Peninsula. If this situation is maintained, estuarine sediments would neither be deposited nor preserved through the transgression. This is the exact situation that exists within the modern coastal system of Croatan Sound. Such may be the case for Depositional Sequence III.

The uppermost surface of Facies IIIa is iron-stained. This indicates a regressive episode and emergence of the region following Depositional Sequence III. The extent of emergence is unknown, however iron-stained sediment in the easternmost cores suggest the emergence was at least 6.5 m below present sea level.

Depositional Sequence IV

Depositional Sequence IV consists of two facies: (1) barrier island facies (Facies IVa), and (2) back-barrier estuarine facies (Facies IVb). The facies relationships are best observed on cross section E-E' (Fig. 43).

Facies IVa.

Facies IVa consists of a very slightly fossiliferous, well sorted, clean, fine- to medium-grained, quartz sand and a few areas with granular sands. In the subsurface, the top of Facies IVa is an iron-stained orange to red sand layer. Fossils within Facies IVa consist of abraded fragments of *Crassostrea* and *Mercenaria*.

The lateral distribution of Facies IVa is restricted to Roanoke Island and its down-dip equivalent beneath the Outer Banks (Fig. 43 and 52). Facies IVa is truncated on the modern shoreface east of the Outer Banks by modern shoreface erosion. Facies IVa extends southward to at

CROSS SECTION KEY

DEPOSITIONAL SEQUENCE V

Va	FACIES Va (BARRIER ISLAND)
Vb	FACIES Vb (BACK-BARRIER ESTUARY)
Vc	FACIES Vc (FILLED LATERAL ESTUARY)
Vd	FACIES Vd (FILLED TRUNK STREAM)
Ve	FACIES Ve (PEAT)
⬚	INLET FILL

DEPOSITIONAL SEQUENCE IV

IVa	FACIES IVa (BARRIER ISLAND)
IVb	FACIES IVb (BACK-BARRIER ESTUARY)

DEPOSITIONAL SEQUENCE III

IIIa	FACIES IIIa (NEARSHORE MARINE)
IIIb	FACIES IIIb (INLET CHANNEL)
IIIc	FACIES IIIc (BARRIER ISLAND)
▨	FLUVIAL CHANNEL

DEPOSITIONAL SEQUENCE II

IIa	FACIES IIa (NEARSHORE MARINE)
IIb	FACIES IIb (BARRIER ISLAND)
IIc	FACIES IIc (BACK-BARRIER ESTUARY)

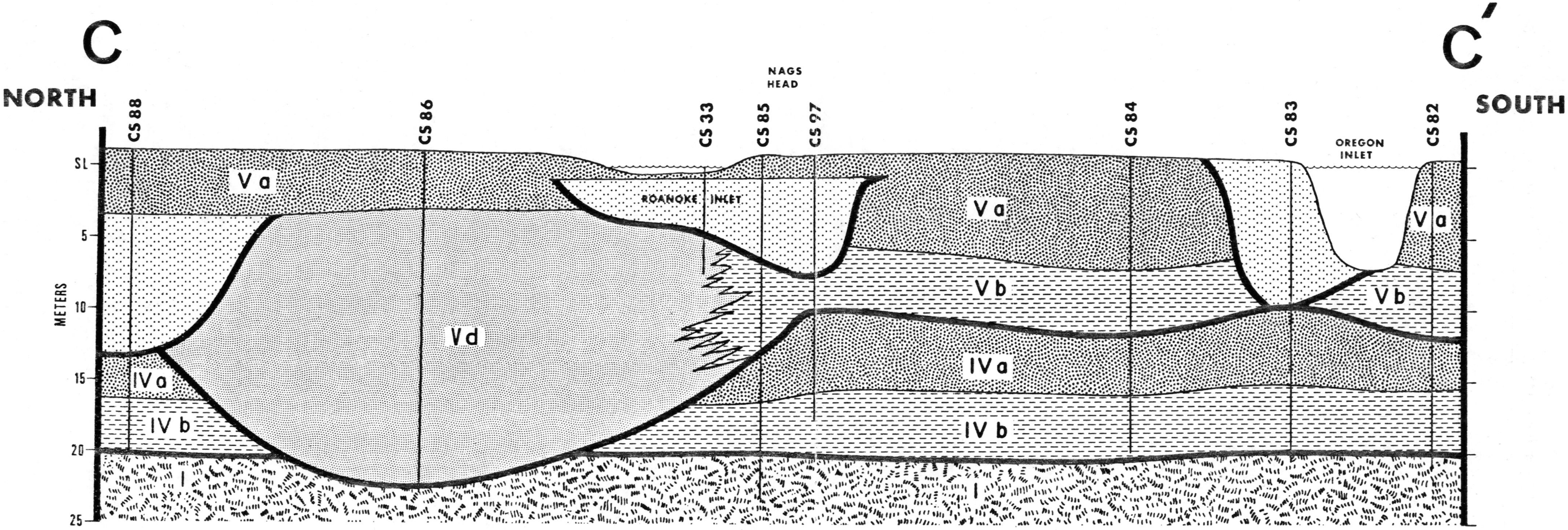
DEPOSITIONAL SEQUENCE I

I	FACIES I (NEARSHORE MARINE)

INTER-FACIES BOUNDARIES LOCATED ON CROSS SECTIONS:

CONFORMABLE – ———

UNCONFORMABLE – ▬▬▬



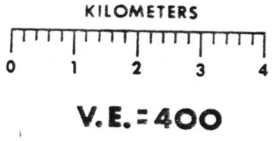


Figure 52. Cross section C - C'. The cross section is parallel to the present shoreline extending along the Outer Banks from Kitty Hawk to Oregon Inlet.

least the south side of Oregon Inlet and northward to at least northern Kitty Hawk Bay (Fig. 52). Facies IVa thins from nearly 7 m on southern Roanoke Island to about 4 m at the north end of the island and is about 4 to 6 m thick beneath the Outer Banks. The facies is bisected by the Albemarle fluvial system to the north of Roanoke Island.

Sediment variation within Facies IVa is minor. Within Roanoke Island, Facies IVa consists of a persistent, clean, medium-grained, quartz sand. In the down-dip portion beneath the Outer Banks, Facies IVa changes to a very slightly fossiliferous, fine- to medium-grained, quartz sand. Fossil fragments occur sparsely in only one core (CS-83). The only occurrence of coarse quartz granules within Facies IVa is in cores CS-85 and CS-97 (Fig. 52).

Facies IVb. Facies IVb consists of a fossiliferous, clayey silt to very muddy, fine-grained sand. Fossils found in Facies IVb consist of the genera Crassostrea, Lucina, Mactra, Mulinia, Nassarius, Tagelus, and Venericardia. The unit appears to be dominated by Mulinia.

Facies IVb pinches out laterally under eastern Roanoke Island as indicated in cross sections E-E' and F-F' (Fig. 43 and 46). Facies IVb extends offshore for an undetermined distance, extends southward to at least the south side of Oregon Inlet, and northward to the north side of Kitty Hawk Bay (Fig. 52). The maximum thickness of Facies IVb is over 8 m, while the unit averages about 5 m.

The sediment within Facies IVb grades from dominantly a sand component associated with the Albemarle fluvial system, southward into estuarine muds. The section close to the Albemarle system contains highly inter-bedded sands and muds.

Discussion of Depositional Sequence IV. Depositional Sequence IV is interpreted to be a barrier island (Facies IVa) and back-barrier estuarine (Facies IVb) system. This system transgressively migrated onto the lower portion of Depositional Sequence III, preserving an unconformable surface between the two sequences. The absence of the estuarine Facies IVb beneath Roanoke Island may have resulted from the change in slope over which the barrier island system migrated. Until the barrier system migrated to within 5 m of the present sea level, local slope was relatively steep (Fig. 43). Therefore, a vertical rise in sea level resulted in minimum landward migration. Above 5 m below present sea level, local slope of the migration surface was nearly horizontal. Therefore, a rise in sea level resulted in extreme landward migration. Barrier migration may have occurred too rapidly from this point to allow estuarine sediments to accumulate.

The Roanoke Island barrier formed during Depositional Sequence IV has been correlated to Powells Point Ridge on the Currituck Peninsula (O'Connor and Riggs, 1974; Oaks and DuBar, 1974). Therefore, Depositional Sequence IV is interpreted to be correlative to the upper member of the Sand Bridge Formation in southeast Virginia. Sea level maximum during the transgressive episode is estimated to have been about 4.5 m above present sea level (Oaks et al., 1974).

Facies IVa consists of clean, fine- to medium-grained sands except in cores CS-85 and CS-97, where granular sands are present. Facies IVb grades from estuarine muds in the south, to interbedded sands and estuarine muds near CS-85 and CS-97, and northward to coarser sediment resulting from the Albemarle fluvial system.

Abnormal thickness within Facies IVb (Fig. 43) may be due to depositional infilling of previous erosional features. The lower surface of Facies IVb (cross section E-E', Fig. 43) appears to follow reflector surface OR-C and fill the U-shaped fluvial erosional pattern, as discussed in Depositional Sequence III. The upper surface of Facies IVb is interpreted to correspond to reflector surface OR-D. Facies IVb correlates to the '*Mulinia* Unit' of Pearson (1979).

The upper surface of Depositional Sequence IV is marked by a well developed iron-stained sand. This surface indicates the last major emergent episode in the Roanoke Island area prior to Holocene inundation. According to Oaks et al. (1974), this regressive sea level was at least 55 m below present sea level, while Oaks and Whitehead (1979) place the regression at about -120 m. This regression marked the end of the Pleistocene Epoch in the Roanoke Island area and was followed by the Holocene transgression which is still in progress.

Depositional Sequence V

Depositional Sequence V consists of five facies. These are the (1) barrier island facies (Facies Va), (2) back-barrier estuarine facies (Facies Vb), (3) filled lateral estuary facies (Facies Vc), (4) filled trunk stream facies (Facies Vd), and (5) peat facies (Facies Ve). Facies relationships may best be observed in cross section E-E' (Fig. 43).

Facies Va. Facies Va is a well sorted, light-blue to gray, clean, fine- to medium-grained, quartz sand. Coarse shelly gravels which now appear on the modern beachface of Facies Va are not found in cores.

Facies Va is a linear, lens-shaped unit restricted laterally to the approximate surface position of the Outer Banks and slightly seaward (Fig. 43). Facies Va extends the full length of the Outer Banks, occasionally bisected by modern and relict inlets and by the Albemarle system (Facies Vd). Thickness averages about 6 m and is a maximum of 8 m thick within the southern portion of the study area (Fig. 52).

The sediment of Facies Va is a very persistent, clean, fine- to medium-grained, quartz sand without fossil material. The only sediment variations are those associated with inlet structures (Fig. 52). The inlets consist of fossiliferous and granular, fine- to coarse-grained, moderately to poorly sorted, quartz sands.

Facies Vb. Facies Vb is a dark greenish gray, fossiliferous, sandy mud to muddy, fine- to very fine-grained, quartz sand. Fossils consist of the genera *Arca*, *Crassostrea*, *Ensis*, *Lyropectin*, *Macoma*, *Pholus*, and *Tagelus*.

The lateral distribution of Facies Vb is similar to Facies Va, except slightly more extensive in the east-west direction. Facies Vb extends into, and is formed in the back-barrier estuary west of the Outer Banks. Facies Vb extends slightly seaward of Facies Va and is truncated by modern shoreface erosion along the lower shoreface of the barrier islands (Fig. 43). The north-south distribution of Facies Vb is consistent with the distribution of Facies Va. Near cores CS-33 and CS-85, Facies Vb begins to interfinger with fine-grained sands of the Albemarle fluvial-estuarine system. The northernmost core on the Outer Banks (CS-88) does not contain Facies Vb due to the presence of a relict inlet. Facies Vb extends southward to at least the south side of Oregon Inlet. Facies Vb averages 4 to 5 m thick. No significant sediment variations have been recognized within Facies Vb.

Facies Vc. Facies Vc consists of fossiliferous silts and organic muds with abundant plant fragments. Fossils consist of Barnea, Crassostrea, Ensis, and Mulinia.

The distribution of Facies Vc corresponds to the mapped position of Croatan Trough (Fig. 25), and represents the sediment infilling of the trough. The trough is deep and narrow in the north end of Croatan Sound and thins southward as it spreads out laterally into a dendritic drainage pattern. The top of Facies Vc is generally flat with minor scour channels due to modern erosional processes operating within Croatan Sound.

Sediment variations within Facies Vc includes a southward decrease in the amount of sands and silts. Sands from the Albemarle fluvial-estuarine system (Facies Vd) interfinger with the muds in the mouth of the Croatan Trough. Oyster bearing muds occur in the lower portions of Facies Vc along the bottom of the trough. Plant fragments are found throughout Facies Vc.

Facies Vd. Facies Vd is a gravelly sand at the base which grades upwards to a slightly fossiliferous, clean, well-sorted, fine- to very fine-grained quartz sand throughout most of the unit. Fossils consist of minor fragments of the genera *Anomia*, *Barnea*, *Ensis*, *Crassostrea*, and *Venericardia*.

The distribution of Facies Vd is poorly known since it was only encountered by four cores in this investigation. Approximate positions have been suggested in cross sections B-B' and C-C' (Fig. 48 and 52). The facies has an approximate trend through the center of Albemarle Sound and extends to a depth of 24 m below msl or more.

Facies Vd consists of a fining upward sequence with most size change occurring in the lower portion of the section. In the vicinity of cores CS-33 and CS-85, Facies Vd interfingers with Facies Vc, producing interbedded fine sands and muds.

Facies Ve. Facies Ve is a muddy to relatively clean peat deposit. Ingram and Otte (1982) should be consulted for a complete compositional analysis of the peat in this facies.

Distribution of Facies Ve is displayed in Figure 7. The peat deposits fill relict fluvial drainages and are therefore distributed in a somewhat dendritic pattern between the sand highs of older facies. The peats average about 1.5 m thick and are a maximum of about 4 m thick within the Dare County mainland (Ingram and Otte, 1982).

Sediment variation within Facies Ve consists of a westward change from very muddy peat in core CS-72 to a cleaner peat in CS-68 (Fig. 43). Relatively clean peat is found in all cores west of CS-72.

Discussion of Depositional Sequence V. Depositional Sequence V is a result of the ongoing Holocene transgression. The rate and extent of sea level rise has influenced the Holocene sediment package. Before discussing the sedimentary facies, I will discuss the Holocene sea-level history for the study area.

Holocene sea-level fluctuations along the Atlantic coast are quite controversial. Much of this stems from sea-level curves produced for the late Pleistocene based on Carbon-14 age date analysis. Depending on the curve used, the last low stand occurred between 15,000 and 19,000 years B.P. (Blackwelder et al., 1979; Curray, 1965; Dillon and Oldale, 1978; and Milliman and Emery, 1968).

For various reasons, Holocene sea-level curves should be used only for local interpretations. Evidence from Dillon and Oldale (1978) suggest differential crustal warping has occurred along the northern to central Atlantic coastal margin due to early Holocene glacial loading and unloading. Such movements affect sea-level curves differently in various localities along the coast. A study by Newman and Rusnak (1965) propose crustal warping to have continued into the late Holocene along the Atlantic coast. Their data indicates continued eustatic rebound for at least the last 4,500 years in the vicinity of Connecticut and Massachusetts. Relative stability or subsidence occurs in New Jersey to Virginia and southward. Late Pleistocene to early Holocene sea-level history may have been further complicated by a short-lived structural uplift in the Chesapeake Bay area (Harrison et al., 1965). The effect of this uplift subsided through the Holocene. More recent sea-level fluctuations from 1900 to 1970 have been analyzed by Hicks (1972). Hicks shows that the trend of Newman and Rusnak is still continuing today with the relative sea-level rise to be greatest in southeast

Virginia at 0.3 cm/year and decreases linearly northward to 0.07 cm/year in Maine. South of North Carolina, sea-level rise appears to be stable at an average rise of 0.06 cm/year.

Holocene sea-level curves along the Atlantic coast will differ slightly from one locality to the next due to the above variations. Holocene Carbon-14 analysis from previous studies in the Roanoke Island area (Riggs and O'Connor, unpublished data, and Benton, 1980) are presented in the sea-level curve of Figure 53. This data represents the best approximation of sea-level rise during the last 10,000 years within the study area.

The sea level began to encroach and flood fluvial drainages within the Roanoke Island study area about 10,000 years B.P. Many sedimentary processes and features began to occur simultaneously at this time. A general decrease in the rate of Holocene sea-level rise occurred between 5,000 to 7,000 years B.P. (Blackwelder et al., 1979; Curray, 1965; Dillon and Oldale, 1978; Milliman and Emery, 1968; Newman and Rusnak, 1965; and Redfield, 1967). In the Roanoke Island area, the sharpest decline in sea-level rise appears to be 5,000 to 6,000 years B.P. This corresponds to an elevation of 3.5 to 5.5 m below present sea level, at which time it is believed that most present day features were being emplaced.

Facies Va and Vb are assumed to have migrated up-slope with the Holocene transgression. In at least the later portion of their migration history, the local slope has been such that shoreface erosion has truncated Facies Va and Vb on the seaward side (Fig. 43) through

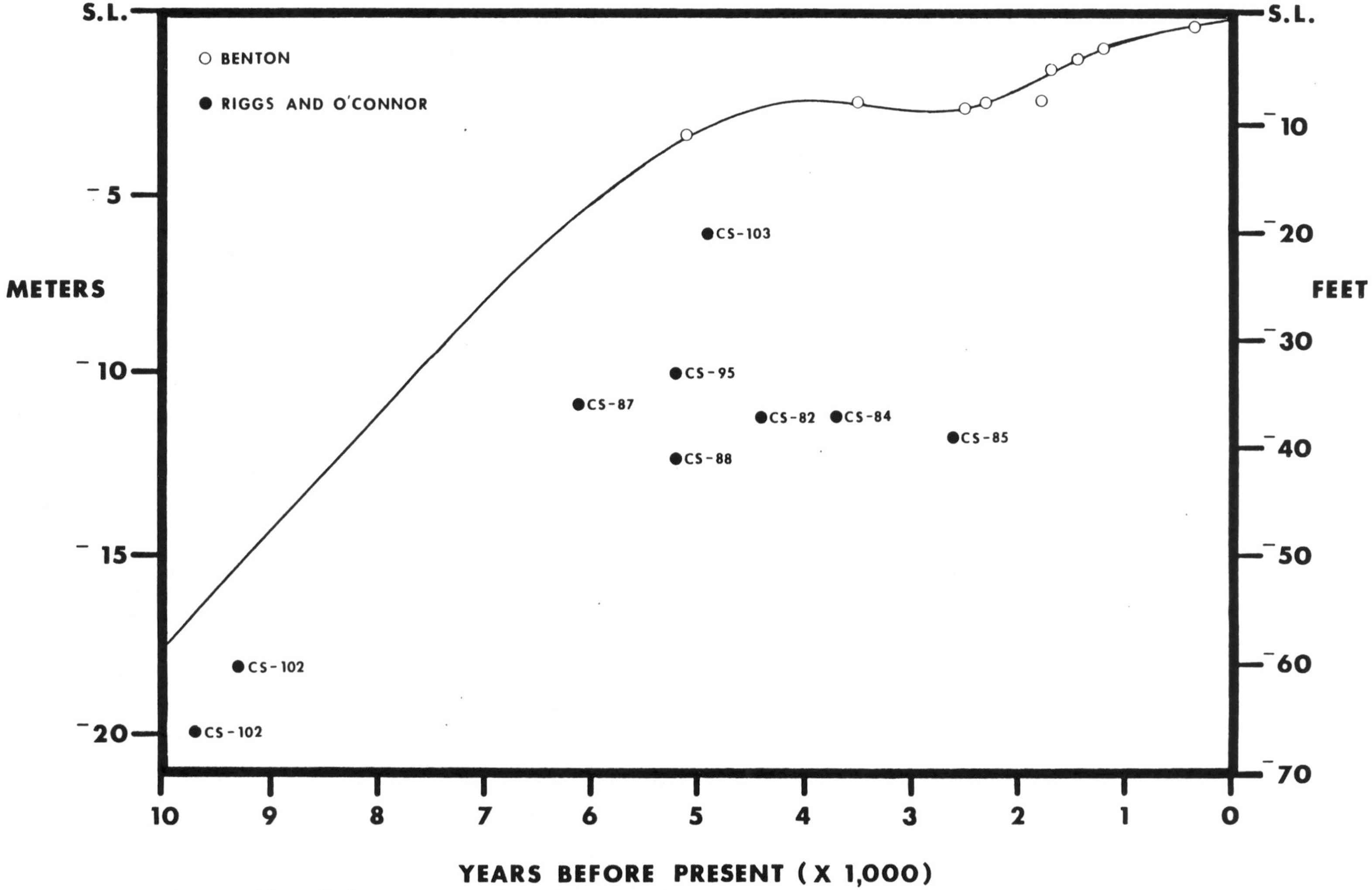


Figure 53. Holocene sea-level curve for the Roanoke Island area. Dates are based on Carbon-14 age dates from Benton (1980)(taken from in-place peat) and Riggs and O'Connor (unpublished data). Material dated by Riggs and O'Connor is listed in Appendix C for each core.

migration. Whether shoreface truncation has occurred throughout the Holocene is questionable.

If Facies Vb is as uniform in extent and thickness as implied in cross section C-C' (Fig. 52), then it may be assumed that Facies Va and Vb migrated over a surface parallel to the present shoreline. The above assumption contradicts the pre-Holocene barrier island configuration of Oaks and DuBar (1974) as represented by the Powells Point Ridge (Fig. 6). If Powells Point Ridge was initially the shape implied by Oaks and DuBar, then as Facies Va migrated into its present position, a continuous north-south trending estuarine facies would not be present beneath Facies Va. In addition, the configuration of the Powells Point Ridge of Oaks and DuBar (1974) appears to be based on the presence or absence of a soil horizon along the contact of Depositional Sequence IV and V beneath the Outer Banks as described by Pierce and Colquhoun (1970). Soil horizons located by Pierce and Colquhoun are based on the presence of iron-stained sands which were not found north of Oregon Inlet. However, in this thesis, four cores (CS-83, CS-84, CS-85, and CS-97) north of Oregon Inlet encountered an iron-stained horizon at the depositional contact between Depositional Sequence IV and V. It is therefore concluded that the original Powells Point Ridge did not consist of the irregularly shaped configuration of Pierce and Colquhoun, but was instead parallel to and slightly landward of the present Outer Banks.

Three inlets occur within Facies Va (Fig. 52). The northernmost inlet was active in the pre-historic past and existed at the site of

Kitty Hawk Bay. The central inlet associated with Facies Va in cross section C-C', is the relict Roanoke Inlet which closed in 1817 (Fig. 30). The southernmost inlet feature is the infilled channel of the modern Oregon Inlet which has had a net southward migration since it opened in the mid-1800's.

During the Holocene inundation, pre-Holocene erosional features such as the Croatan Trough began to be infilled producing Facies Vc. As the Croatan Trough was flooded, it produced a protected estuary in which minimal drainage was present. Silts and organic muds accumulated within the trough. The Croatan Trough joined the Albemarle system at the northern end of what is now Croatan Sound, resulting in interfingered fine sands and muds from these two environments. As sea level rose, Croatan Trough eventually flooded across the inter-stream divide, producing a continuous open lateral estuary between Albemarle and Pamlico Sounds which was dominated by erosional processes.

Flooding also resulted in the continued submergence of the Albemarle fluvial system. As the Albemarle embayed from oceanic flooding, its deep pre-Holocene valley was filled by slightly muddy, fine-grained sands over basal fluvial gravelly sands. Core control is poor, but the deepest portion of the fluvial channel is estimated to extend along a line from core CS-101 to CS-86 (Fig. 48 and 52). This orientation and position corresponds well to the offshore channel position found by Swift et al. (1972) (Fig. 8).

Pre-Holocene erosional drainage patterns on Dare County mainland are also experiencing submergence (Ingram and Otte, 1982). Since these channels represent the upper extremities of the dendritic drainage system, they are higher in elevation and last to be flooded. Data from Ingram and Otte (1982) and Benton (1980) show that peat development on the Dare County mainland and Roanoke Island, respectively, began when sea level was about 4.5 m below present (5500 years B.P.). The subsequent slow rise in sea level during the last 5,000 to 6,000 years enabled the upslope expansion and vertical growth and maintenance of the peat deposits, while the outside perimeter of the peat underwent severe erosion as the estuaries expanded. Presently, the peat covers a large percent of the Dare County mainland and large portions of central and southern Roanoke Island (Fig. 7).

Lithostratigraphy Summary

A total of five distinct depositional sequences have been identified in the Roanoke Island study area. Each depositional sequence is a product of the sedimentary responses to a sea-level transgression and the erosion and/or reworking during subsequent regressions. Each maximum sea-level stand is marked by the westward extent of a barrier island sand sheet. Only the most recently formed barrier islands remain topographically high within northeastern North Carolina. Earlier developed barrier island systems are surficially indiscrete due to subsequent erosion and possible subsidence and burial by the Holocene sediments of Depositional Sequence V. Subsurface coring and seismic profiling have delineated the positions of the successive barrier island sand sheets.

The barrier island systems may be correlated northward to similar barrier island systems described in southeast Virginia by Oaks et al. (1974). Positions of sea level during the late Pleistocene proposed for the Roanoke Island area are either those of Oaks et al. or slightly modified to meet local stratigraphic indications. Correlations of stratigraphic units of this thesis to those of Oaks et al. are summarized in Table I along with interpreted sea-level positions during each major interval.

UNIT OF THIS AUTHOR	CORRELATIVE UNIT IN SOUTHEASTERN VIRGINIA	MAXIMUM ELEVATIONS OF SEA LEVEL (METERS)
DEPOSITIONAL SEQUENCE V (HOLOCENE)	MODERN SYSTEM	MSL ±1
(EMERGENCE)		-120
DEPOSITIONAL SEQUENCE IV	SAND BRIDGE FORMATION (UPPER MEMBER)	+4.5
(EMERGENCE)		more than -6.5
DEPOSITIONAL SEQUENCE III	SAND BRIDGE FORMATION (LOWER MEMBER)	+2 to 4
(EMERGENCE)		more than -11.3
DEPOSITIONAL SEQUENCE II	LONDONBRIDGE FORMATION	+7 to 8
(EMERGENCE)		-10
DEPOSITIONAL SEQUENCE I	KEMPSVILLE FORMATION	+6

Table I. Correlation chart of depositional units of this investigation to units in southeastern Virginia as described by Oaks et al. (1974). Estimated sea level elevations are listed for each maximum and minimum sea level position.

GEOLOGIC HISTORY

The geologic history of the Roanoke Island area consists of Quaternary transgressive/regressive cycles. Since the formation of Depositional Sequence I during a sea-level high stand, evidence suggests four regressions and subsequent transgressive episodes. The three late Pleistocene cycles and last Holocene transgression produced similar stratigraphic features. The geologic history of these cycles is summarized in Table I.

Depositional Sequence I correlates to the Kempsville Formation of southeast Virginia, and formed in response to a late Pleistocene sea-level high stand of approximately 6 m above the present sea level. This sea-level stand produced the Hickory Scarp (Oaks et al., 1974) west of the Alligator River (Fig. 54), which is believed to be the shoreline for Depositional Sequence I. Only the position for the Kempsville-Depositional Sequence I shoreline is designated in Figure 54, since little is known about the three dimensional configuration. Oaks et al. (1974) provide a radio-carbon age of over 38,000 years B.P. and uranium series ages between 62,000 and 86,000 years B.P. for the Kempsville in Virginia.

Following the occupation of the Hickory Scarp an emergent episode lowered sea level to about 10 m below the present level. This placed the shoreline just west of Croatan Sound (Fig. 55). Subsequently, the barrier island prograded seaward to a position along the western shore of Croatan Sound. As the barrier system developed, nearshore marine sediments deposited to the east while the area west of the barrier was

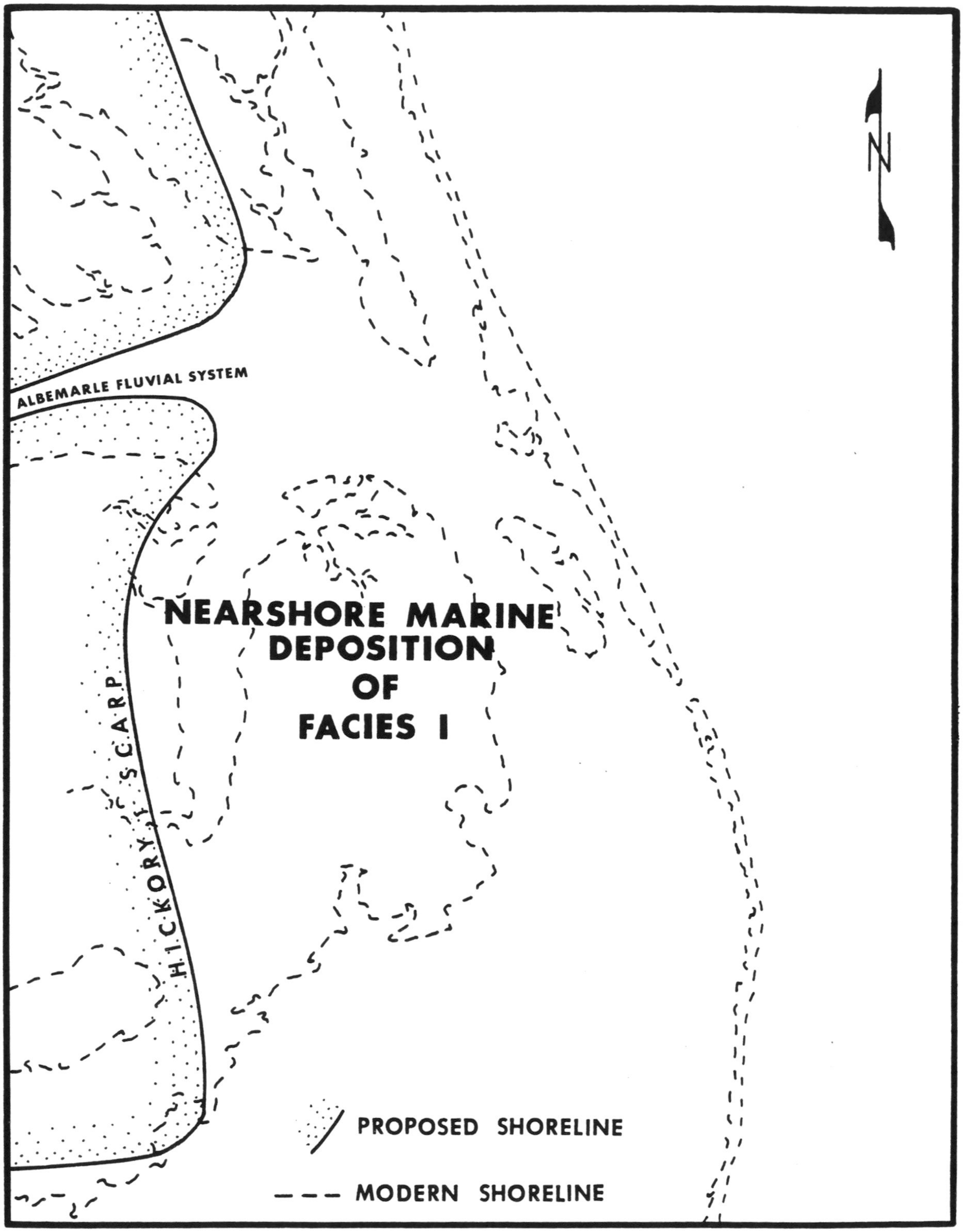


Figure 54. Proposed shoreline position during the transgressive maximum of Depositional Sequence I. Facies I was deposited seaward of the shoreline in the nearshore marine environment.

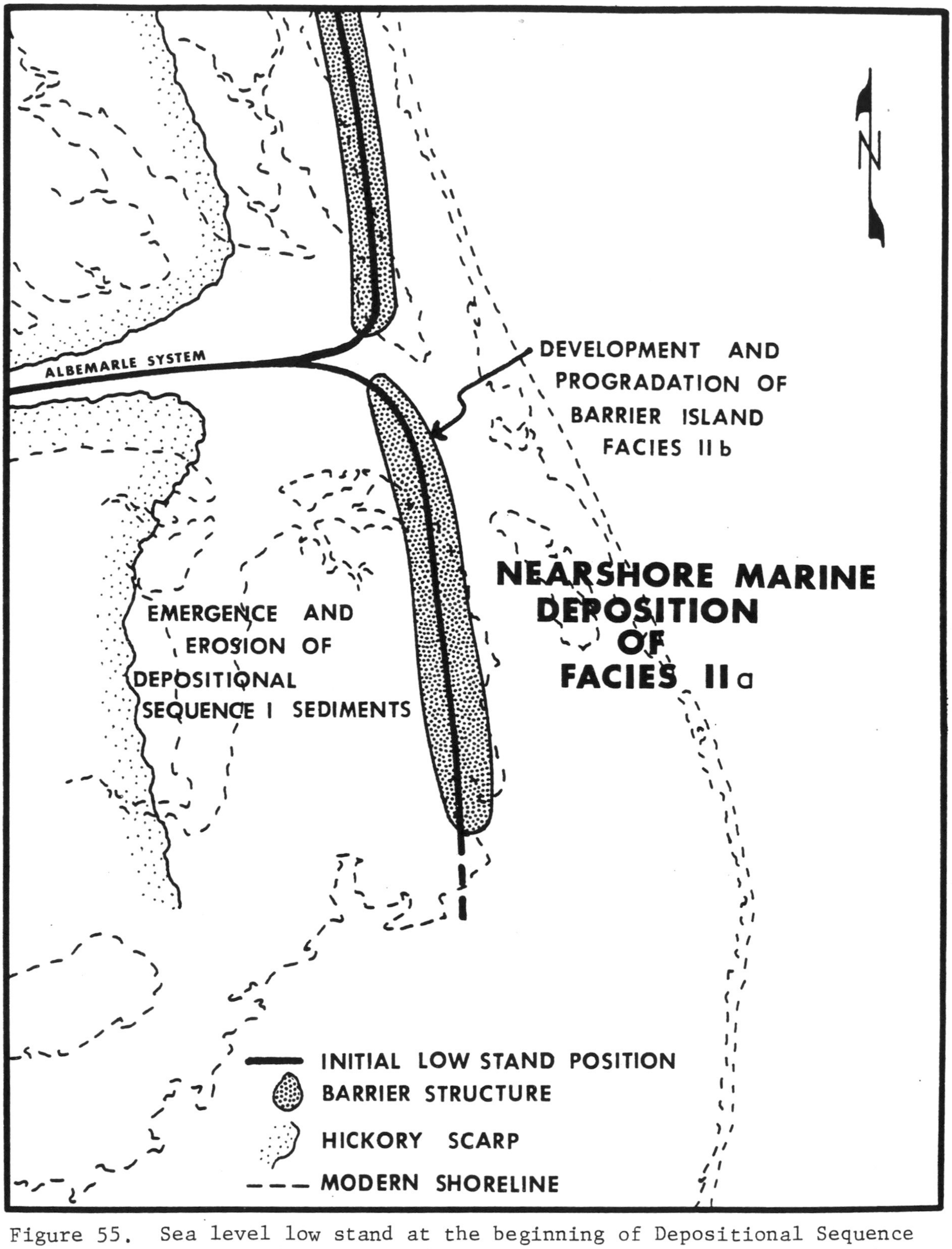


Figure 55. Sea level low stand at the beginning of Depositional Sequence II; position indicated by the bold line. Barrier island formation and progradation occurs in the position of the dot pattern. Deposition of Facies IIa occurs seaward of the barrier and emergence and erosion of Depositional Sequence I occurs behind the barrier island.

exposed. As sea level began to rise, an estuarine facies developed west of the barrier. With transgression, the barrier structure (Facies IIb) over-rode estuarine deposits (Facies IIc) and migrated westward to a position just east of the Alligator River (Fig. 56). Sea level during this time reached a maximum of 8 m above present sea level. The shoreline consisted of a north-south trending, broad barrier with the Alligator River region existing as an estuary. Depositional Sequence II correlates to the Londonbridge Formation in Virginia which occupied the position of the remnant Oceana Ridge (Oaks et al., 1974).

After the Depositional Sequence II high stand, an episode of emergence resulted in sea level falling more than 11 m below present sea level. The extent of this emergence is unknown. The low stand produced a shoreline position east of the present Roanoke Island; fluvial erosion and the development of a weathering profile modified Depositional Sequence II west of the shoreline.

The subsequent transgression resulted in the development and migration of the Depositional Sequence III barrier sand sheet. The maximum extent of this transgression produced a shoreline along the western shore of present-day Croatan Sound (Fig. 57) with maximum sea level approximately 2 to 4 m above present sea level. The orientation of the Depositional Sequence III shoreline is estimated to be N 30° W in contrast to the north-south trending shoreline of Depositional Sequence II. The difference in shoreline orientation results in the intersection of the two barrier structures (Facies IIb and IIIc, Fig. 57) in the vicinity of East Lake. The back-barrier system of Depositional

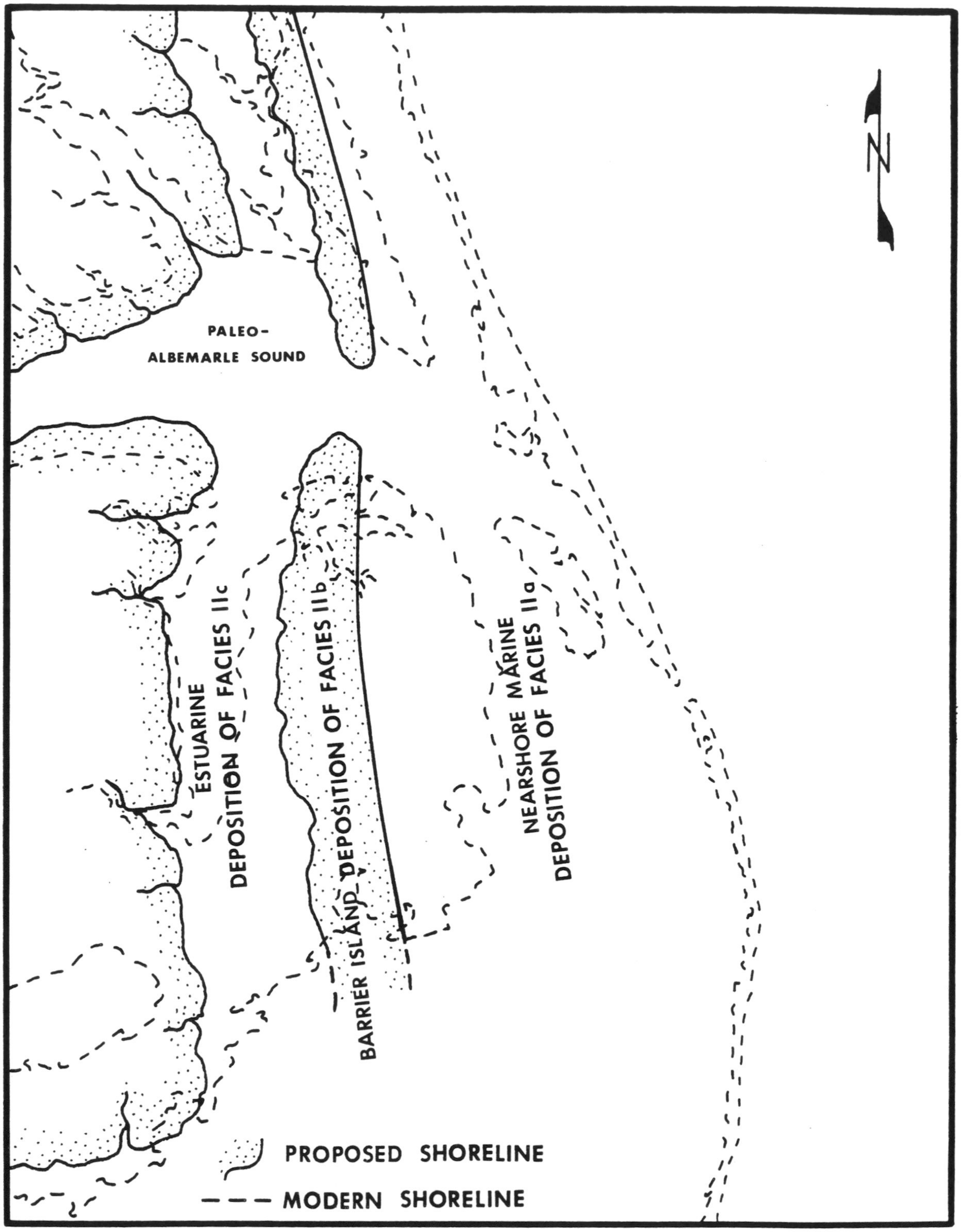


Figure 56. Proposed shoreline and depositional environments during the transgressive maximum of Depositional Sequence II.

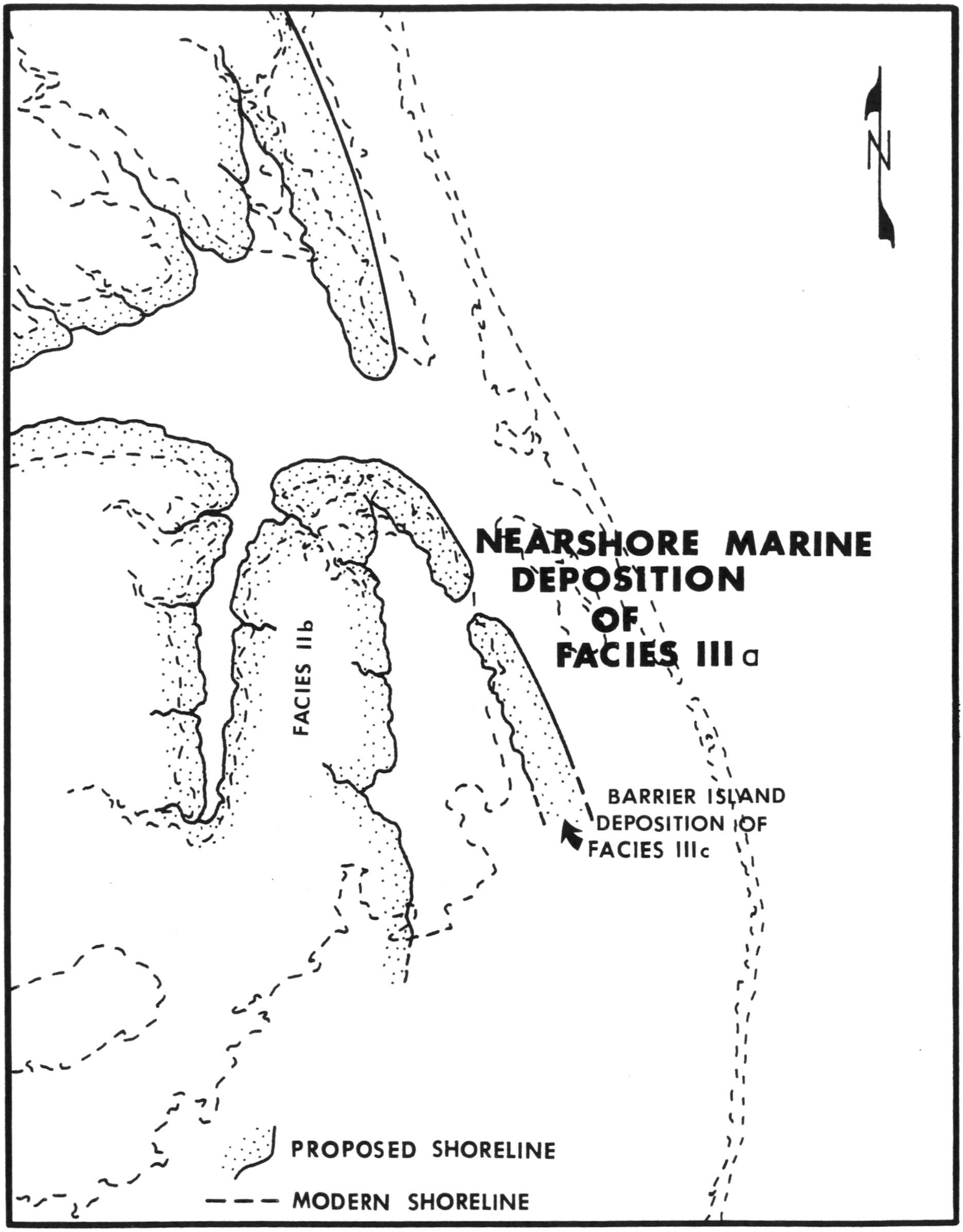


Figure 57. Proposed shoreline during the transgressive maximum of Depositional Sequence III with Facies IIIa and IIIc positions indicated. Estuarine facies may have been developed in the back-barrier region but later eroded away.

Sequence III may have developed an extensive mud facies and possibly peat as suggested by the minor layers of mud found in cores CS-71 and CS-72. Much of the inter-barrier estuarine sediment, including the majority of the Depositional Sequence III barrier structure, was eroded during subsequent emergent episodes. Depositional Sequence III correlates northward to the Lower Member of the Sand Bridge Formation in southeast Virginia. The Lower Sand Bridge shoreline occupied the Land-of-Promise Ridge which coalesces southward to Powells Point Ridge along Currituck Peninsula (Fig. 51).

The high stand during Depositional Sequence III was followed by another regression, placing the shoreline east of the present shoreline. Sea level during this time lowered to a minimum of 6.5 m below the present sea level. During the low stand, two and possibly three major channel structures were formed (Channels A, B, and C). The first two (Channels A and B) occurred in southern Croatan Sound, passed through Roanoke Island (Fig. 25), converged just east of the present-day Roanoke Island, and ultimately united with the Albemarle system. Both channels were eroded to maximum depths of 19 m below msl. The third channel (Channel C), observed in P-9 and P-55 within Region III (Fig. 31), was oriented approximately northeast-southwest. The time relationship of Channel C is uncertain.

Extensive erosion truncated Depositional Sequences II and III near cores CS-81 and CS-95 (Fig. 43) at some time during the emergent episode (Fig. 43). Structure contours on seismic reflector OR-C (Fig. 35), offshore channel structures along Profile S-1 (Fig. 32), and offshore

Albemarle trough features described by Swift (1975) and Duane et al. (1972) (Fig. 8) suggest the presence of the Albemarle discharge route slightly east of Roanoke Island during this time. The close proximity of the Albemarle channel during low sea-level stands may have provided sufficient gradient for major erosion in the area.

The subsequent transgressive episode resulted in the westward migration and emplacement of Depositional Sequence IV (Fig. 59). Depositional Sequence IV contributed significantly to the present geomorphology of the area. Roanoke Island is the surficial expression of the barrier island structure and Croatan Sound is the back-barrier estuary. In Figure 58, a proposed inlet is indicated for the central Roanoke Island area prior to the barrier reaching its maximum transgressive extent. Cores CS-55 and CS-96 reveal a change in sediment character from typical clean medium-grained barrier island sands to fossiliferous granular to gravelly fine-grained inlet fill sands. While the inlet was active, Roanoke Island was situated in the Roanoke Sound area. As indicated by Figure 58, the inlet occurred in the fluvial channel paths of earlier periods. The coarse sediment fraction is considered to be reworked fluvial sediment. Fluvial channels formed during the previous low stand would have retained their positions until flooding of the area decreased the hydraulic pressure on the inlet. When other inlets opened, the fluvial discharge was diverted, the old inlet was closed, and barrier island sediments were deposited on Roanoke Island throughout the remainder of the transgression. No evidence of later inlet activity is present on Roanoke Island. The presence of this inlet late in the transgressive cycle may be responsible

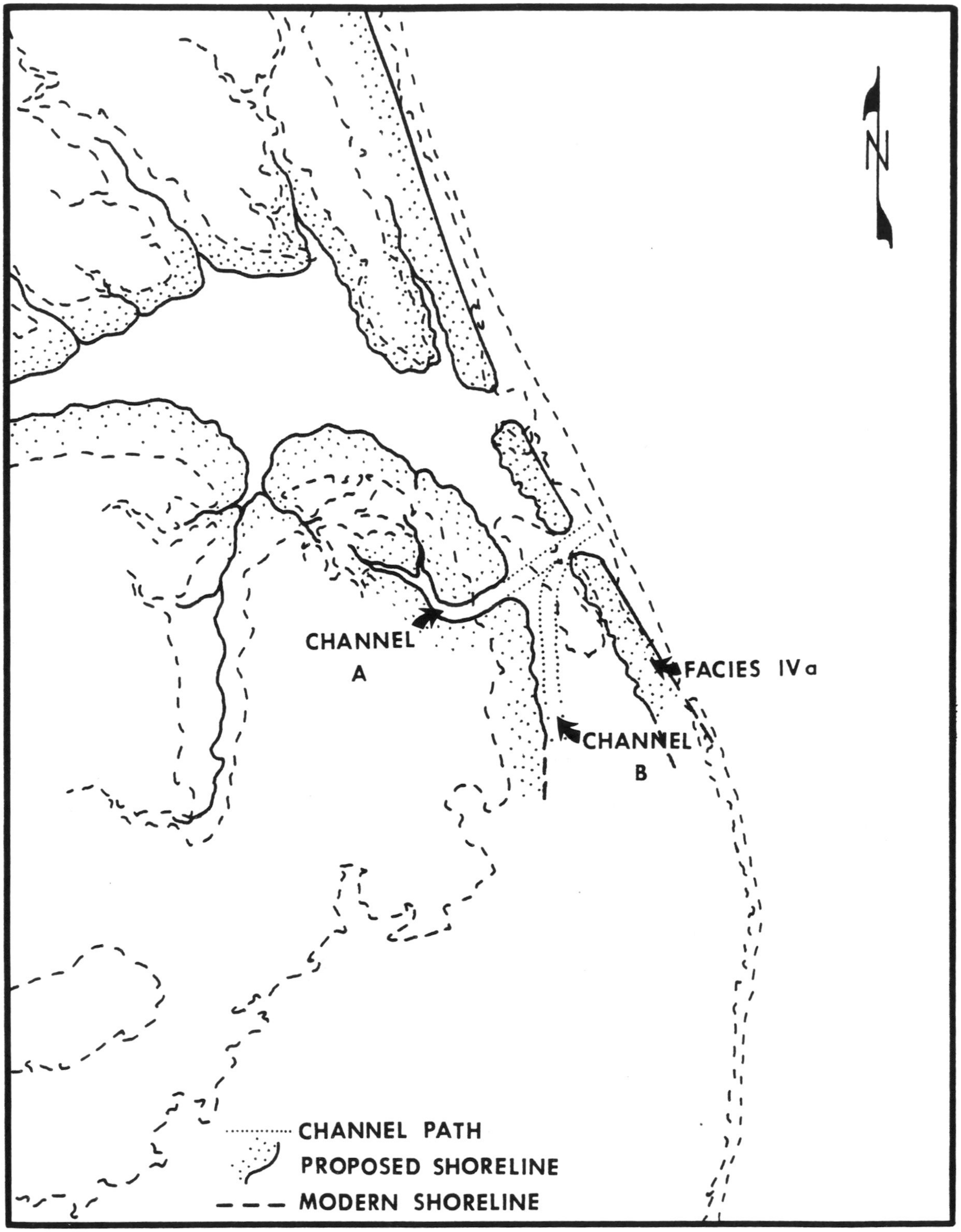


Figure 58. Proposed shoreline position prior to the transgressive maximum of Depositional Sequence IV in which Channel A and B maintained an inlet through central Roanoke Island. The inlet subsequently closed resulting in low topography in central Roanoke Island and a relict sand shoal structure in east-central Croatan Sound.

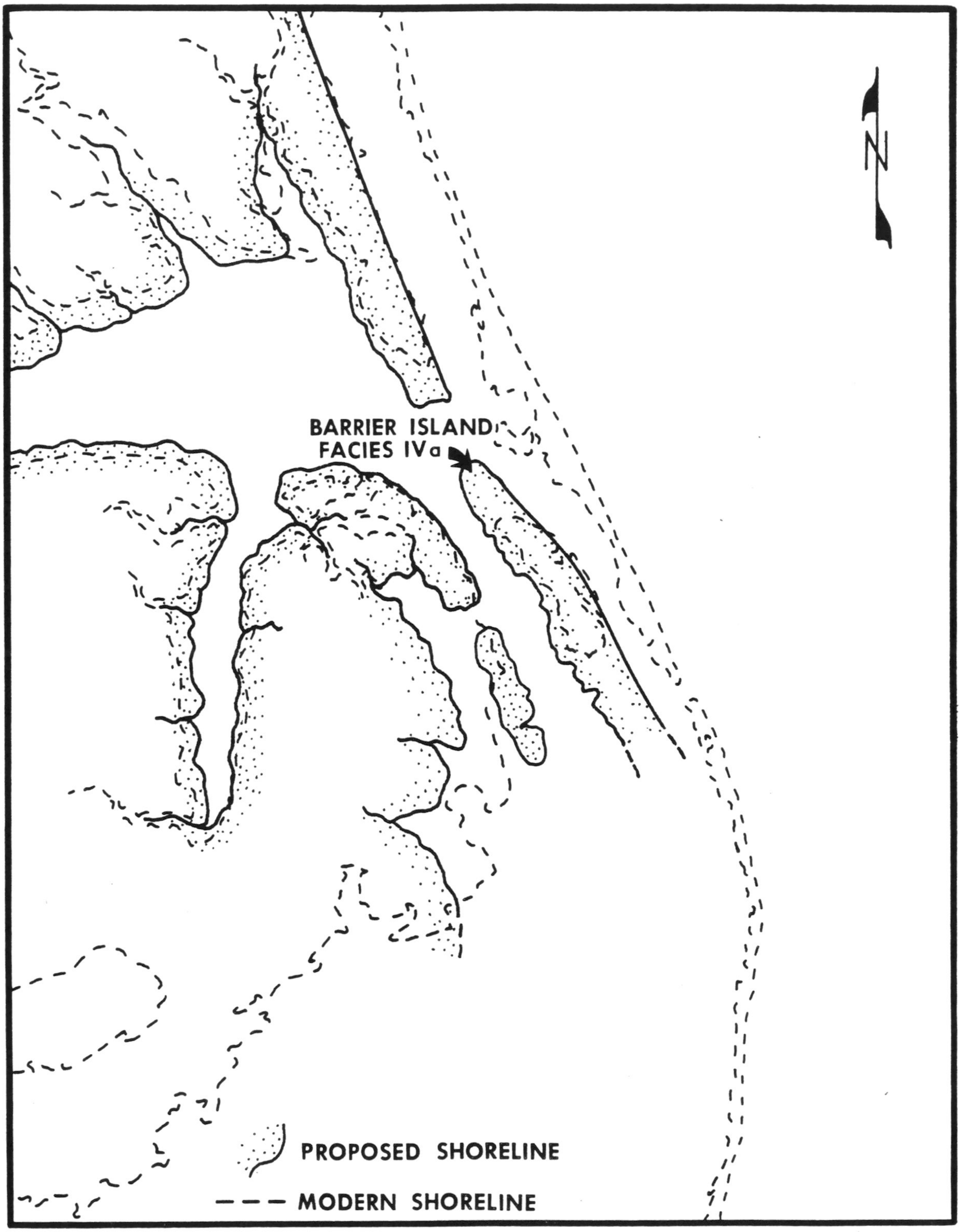


Figure 59. Proposed shoreline configuration during the transgressive maximum of Depositional Sequence IV. Roanoke Island exists as Facies IVa.

for the topographic low within the center of Roanoke Island. This topographic low may have been amplified by late-Wisconsin/early-Holocene erosion

Depositional Sequence IV correlates to the Upper Member of the Sand Bridge Formation in southeastern Virginia. The Upper Sand Bridge, according to Oaks et al. (1974), was formed during a sea-level maximum of 3.5 to 4.5 m above the present sea level. Radio-carbon dates provide an age of over 40,000 years B.P. for the Upper Sand Bridge and Depositional Sequence IV as determined by Oaks et al. (1974) and Riggs and O'Connor (unpublished data), respectively.

After the emplacement of Depositional Sequence IV, a slow and intermittant regressive episode occurred. The extent of this emergence is debatable. Sea level lowered to at least 50 m below msl. This low stand enhanced down-cutting of drainages and resulted in extensive erosion. These deeply eroded drainages were then in-filled with organic-rich muds during the subsequent Holocene transgression. The rate of transgression was relatively rapid until 4000-5000 years B.P. Thereafter, sea-level rise was much slower and provided an environment conducive to extensive marsh development and accumulation. Peat deposits developed in perimeter marshes around the Dare County mainland and in central and southeastern Roanoke Island. Swamp forests developed in the Dismal Swamp to the north of Albemarle Sound and on the Dare County mainland.

The Holocene transgression also emplaced the barrier island sand sheet of Depositional Sequence V (Outer Banks) and the estuarine sediments of Roanoke Sound. During transgression, these sedimentary environments migrated across the continental shelf to their present positions. Shoreface erosion throughout the transgression eliminated earlier down-dip equivalents, leaving only scattered remnants on the continental shelf and the most recent Holocene sediment sheet. This process continues today as the Outer Banks slowly migrate westward, encroaching upon Roanoke Sound and Roanoke Island.

ECONOMIC EVALUATION

Major economic mineral resources in Dare County include peat, sand, shell gravel and quartz gravel. Sand is presently being exploited; however, other resources either have uncertain potential (shell and quartz gravels) or a market has not yet developed (peat). The uncertain potential of gravels in this area is due to inadequate surveys of distribution and concentration.

Peat within the Pamlimarle Peninsula is an important recognized resource, but at present is only in the early stages of development. The present forest clearing process for timber will make peat resources in this area much easier to obtain in the future and thus more economical. Ingram and Otte (1982) describe the peat in Dare County as having average values of 9,500 BTU/lb., 10% ash content, 57% carbon, 0.4% sulfur, and a moisture content of 88%. The overall quality of Dare County peat is slightly lower than that of the western portion of the Pamlimarle Peninsula. Peat deposits have recently been the focus of alternative energy resource programs, and although it is not presently being extracted, peat may become an energy reserve in Dare County as early as 1988 (Peacock and Lynch, 1982).

The sand resource in Dare County is plentiful. Surface sands of at least Facies IIIc and Facies IVa are presently being extracted from the dune and back-dune region of these barrier structures. The sands are clean, fine- to medium-grained, with very minor granule fractions. The clean sands provide a cheap source for local construction needs as a constituent of cements and for base material.

Oyster shell gravel and quartz gravel resources in Dare County are present, but their distribution is poorly known and economic potential is questionable. Buried oyster shell resources in Albemarle and Croatan Sounds of Dare County were studied by Sampair (1976). In his report, Sampair suggests that there is a potential oyster shell gravel reserve of 30.6 million cubic yards within Albemarle and Croatan Sounds. Core spacing in the Sampair project was often wide and can only provide a general occurrence of the oyster shell. A more extensive drilling program must be employed for an accurate picture of distribution and economic potential.

Cores used in this thesis encountered oyster shell deposits within Croatan Sound, yet core density was again too sparse for accurate parameter measurements. Additional occurrences of oyster shell were found on the Dare County mainland. An oyster shell interval was recovered in cores CS-68, CS-69, CS-70 and also occurred in the Stetson borrow pit on the north side of U. S. Highway 64, approximately mid-way between Croatan Sound and Alligator River. The oyster bed is located in the upper part of Facies IIc and conformably beneath Facies IIb (Fig. 43). This is a back-barrier estuarine deposit which contains up to 2 m of oyster shell within a slightly muddy fine- to medium-grained sand. In general, the oyster unit thins to the east. If this unit continues to thicken westward and is laterally continuous between the present cores, it should prove to be a much larger oyster shell resource than that located in the estuaries by Sampair. Further drilling is needed to determine the continuity and relative distribution patterns of this deposit.

Quartz gravel has been encountered in several locations within the study area. The gravels are associated with either beach shoreface deposits or fluvial lag gravels. Shoreface deposits are reworked fluvial gravels and contain varying amounts of shell hash which may detract from the value. The purest and most valuable quartz gravels are fluvial gravels associated with the basal sediments in major channels of piedmont trunk streams. However, most channel structures mapped in this thesis are lateral drainages and do not contain gravels. Fluvial channels having quartz gravel bed loads are difficult to delineate due to sparse core control. Channel B (Fig. 25) is interpreted to be a piedmont trunk stream containing coarse lag gravels. Core CS-94 encountered a 7 m thick zone of yellowish-brown, coarse, sandy, granule gravel. Seismic reflection studies show that Channel B extends at least 19 m below msl and, therefore, CS-94 probably does not penetrate the deeper basal lag gravels. Riggs and O'Connor (1974) interpreted surficial gravels within northern Croatan Sound (Fig. 60) to be from the modern erosion of pre-existing fluvial channels along the southern side of Albemarle Sound, East Lake, and northern Croatan Sound.

Quartz gravels associated with beach shoreface deposits typically have a low concentration of gravel component. No well-defined shoreface gravel layers have been found in cores of this thesis. Most shoreface gravels appear to be randomly occurring features within the beach facies. Inlet structures within barrier island facies usually provide higher gravel concentrations and may be a possible mixed gravel source. Some inlet structures, however, do not contain much gravel.

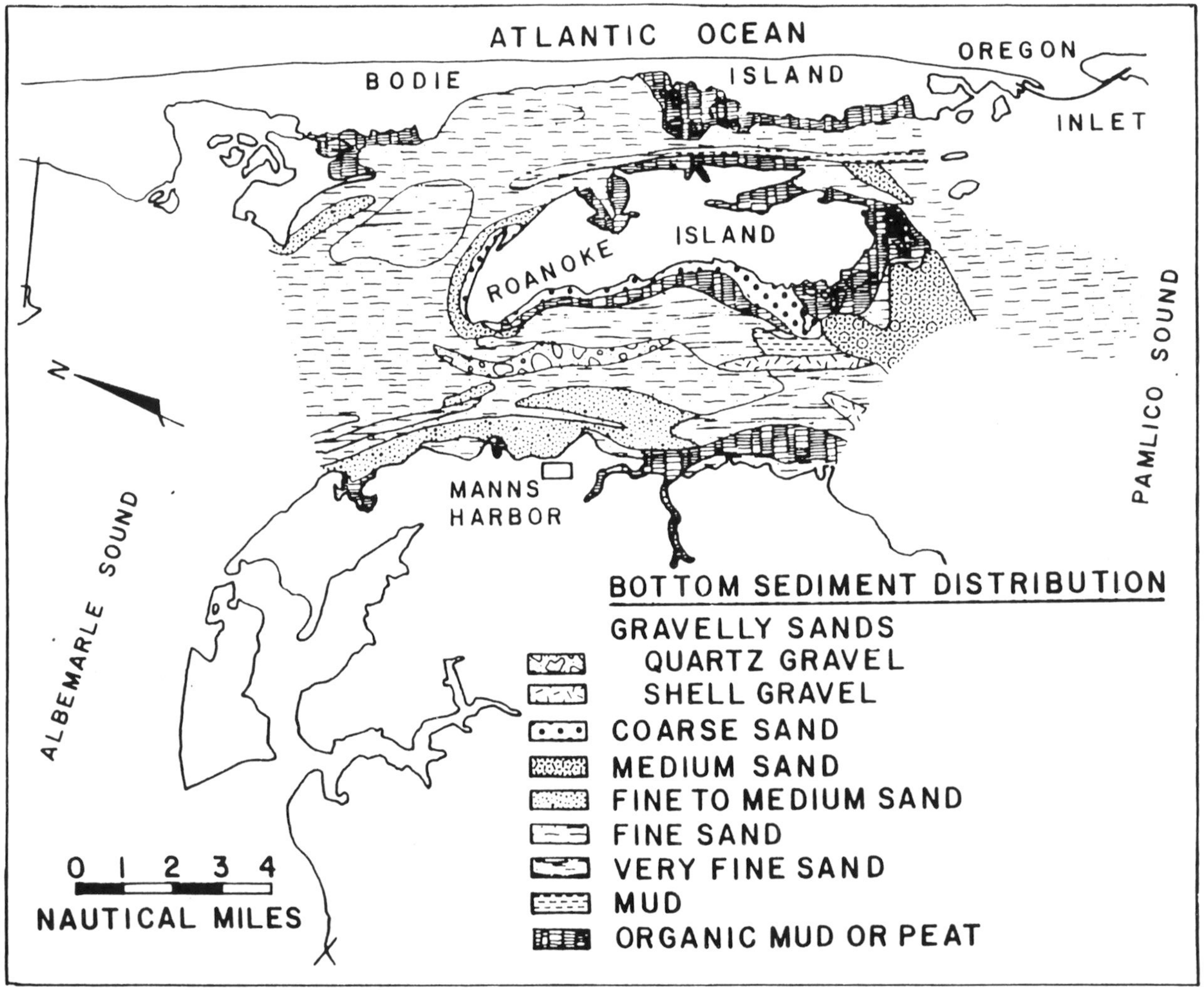


Figure 60. Surface sediment distribution in the Roanoke Island area showing erosional lag gravels extending through central Croatan Sound (from Riggs and O'Connor, 1974).

A more concentrated drilling program is needed in order to evaluate the distribution and economic potential of the gravel deposits.

SUMMARY AND CONCLUSIONS

The Roanoke Island area is the result of late Pleistocene and Holocene eustatic changes in sea level. Transgressive/regressive cycles have deposited and altered a complex set of depositional sequences composed of various sedimentary facies. It has been demonstrated that high resolution sub-bottom profiles are instrumental in identifying shallow sub-bottom sedimentary structures or sets of structures. Sedimentary structures located and identified in this investigation consist of the following:

(a) Abundant fluvial channels are present within the upper 10 m of sediment in Albemarle and Pamlico Sounds. The channels generally trend west to east and are interpreted to be Holocene in age.

(b) The Croatan Trough, located in the northern half of Croatan Sound, is a deep erosional feature formed during the late Wisconsin sea-level low. The trough was later infilled with silts and clays during the Holocene transgression.

(c) Deep major fluvial channels are located beneath and to the south of Croatan Sound. The channels trend southwest-northeast and were active during low stands of sea level. The northernmost two channels were active prior to the emplacement of Roanoke Island, while the southernmost channel does not have an established time of occurrence.

(d) An oval relict sand shoal has been identified in east-central Croatan Sound. The shoal is interpreted to be the remains of a flood tide delta of an inlet through the Roanoke Island barrier. The inlet position may be responsible for the low topography of central Roanoke Island.

(e) Four strong reflectors have been identified in the offshore portion of the study area. All reflectors are less than 50 m below msl. The deepest reflector dips to the southeast. Successively shallower reflectors dip increasingly toward the northeast in a rotational manner. The lithologic associations for most offshore reflectors has not been established due to lack of deep offshore cores. Shallowest reflectors have been tentatively correlated to inland stratigraphic units.

(f) Distinct fluvial channels occur in the offshore reflector patterns. The channels trend sub-parallel to the present shoreline and are interpreted as lateral drainages formed between temporary topographic ridges during regressive episodes.

(g) Two major fluvial channel systems occur just off-shore from the Outer Banks. The southernmost channel system extends from about Nags Head and northward for approximately 7.5 km. The second channel system extends from just south of Colington Island to just north of Kitty Hawk. The channel systems are composed of many cross-cutting individual channel features which extend to at least 40 m below msl. The channel systems are interpreted to be the location of major trunk stream discharge routes. Minor inlet channels are superimposed on top of the fluvial channel systems giving evidence to their later occurrence.

(h) Platt Shoals and Albemarle Shoals have been transected by at least one profile each. The shoals have an internal characteristic of well-defined, steeply east and west dipping reflector patterns. Additional internal reflectors of the shoals are rather chaotic.

Lithostratigraphic relationships of the Roanoke Island area were established by analyzing core data and relating the seismic profile data to these findings. The outcome of the core analysis was a depositional history of the area consisting of five depositional sequences. Each depositional sequence was deposited during a transgressive episode and occasionally weathered and/or reworked during subsequent regressions. In ascending and depositional order, the depositional sequences are as follows:

(a) Depositional Sequence I - The basal unit for the Roanoke Island area, consisting of a single facies composed of a fossiliferous, fine- to coarse-grained, quartz sand which is occasionally muddy and/or granular. This unit was deposited in a nearshore marine environment and is correlated to the Kempsville Formation in Virginia. The shoreline for the Kempsville is the Hickory Scarp, which correlates to the west shore of the Alligator River.

(b) Depositional Sequence II - This depositional system consists of a nearshore marine facies, barrier island facies, and a back-barrier estuarine facies. The nearshore marine facies is an eastward fining, fossiliferous, fine- to medium-grained, quartz sand. The barrier facies is a westward fining, slightly fossiliferous, fine- to medium-grained sand. The back-barrier estuarine facies is a silty to clayey mud with an upper oyster shell-bearing mud. The shoreline during the transgressive maximum was just east of the Alligator River: Depositional Sequence II correlates to the Londonbridge Formation of Virginia.

(c) Depositional Sequence III - This depositional system consists of a nearshore marine facies, an inlet channel facies, and a barrier island facies. The nearshore marine facies is a slightly fossiliferous, fine- to coarse-grained quartz sand with common granular layers and minor muddy layers. The inlet channel facies is a fining upwards, fossiliferous, granular to gravelly, medium- to coarse-grained sand. The barrier island facies is a clean, very fine- to fine-grained quartz sand which is occasionally granular. The shoreline during the transgressive maximum was located approximately at the west shore of Croatan Sound. The unit correlates to the Lower Member of the Sand Bridge Formation in Virginia.

(d) Depositional Sequence IV - This depositional system consists of a barrier island facies and a back-barrier estuarine facies. The barrier island facies is an eastward fining, very slightly fossiliferous, well-sorted, clean, fine- to medium-grained, quartz sand. The back-barrier estuarine facies is a fossiliferous clayey silt to very muddy fine-grained sand. The shoreline during the transgressive maximum was Roanoke Island; this correlates to the Upper Member of the Sand Bridge Formation in Virginia.

(e) Depositional Sequence V - This Holocene to Recent depositional system consists of a barrier island facies, a back-barrier estuarine facies, a filled lateral estuary facies, a filled trunk stream facies, and a peat facies. The barrier island facies is a well-sorted, clean, fine- to medium-grained quartz sand. The back-barrier estuarine facies is a fossiliferous, sandy mud to a muddy, very fine- to fine-grained sand. The filled lateral estuary facies is a fossiliferous silt and organic mud with abundant plant fragments. The filled trunk stream facies is a slightly fossiliferous, well-sorted, very fine- to fine-grained sand. The peat facies consists of muddy to clean organic peats. Depositional Sequence V is Holocene to Recent in age.

The depositional sequences of the Roanoke Island area have produced economically valuable raw materials, including sand, peat, quartz gravel and shell gravel. Sand is presently being exploited. Peat deposits are in the early planning stages of economic development. Quartz and shell gravel have both been mined in the past. Presently, however, they are only potential resources which need additional investigation in order to determine their economic feasibility.

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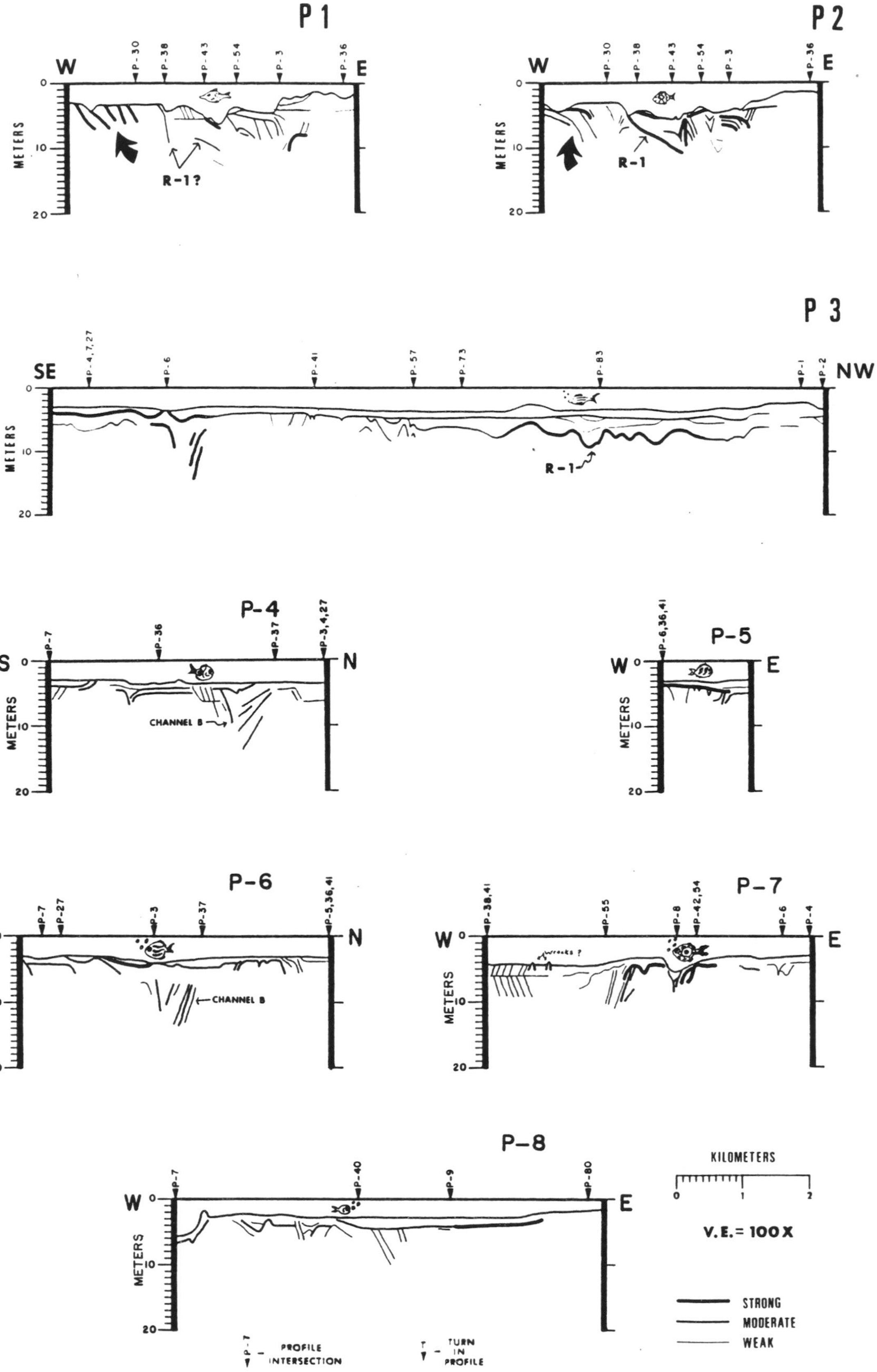
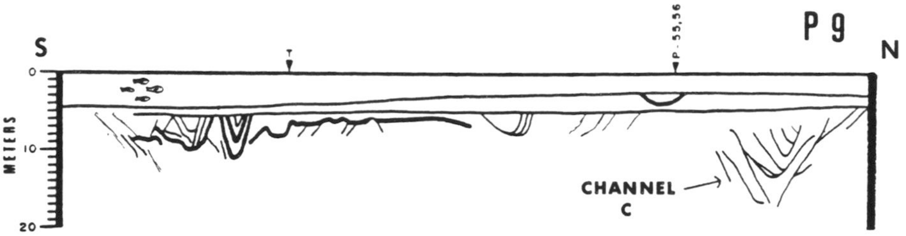
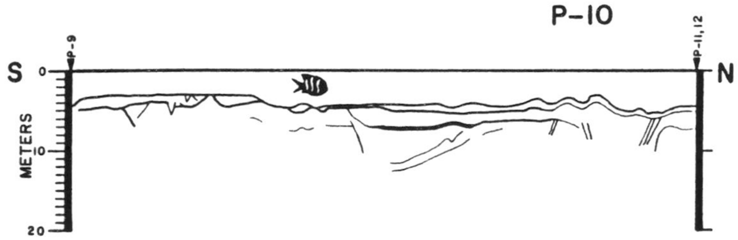
APPENDIX A

SEISMIC PROFILES


P1
W
E
P-30
P-38
P-43
P-54
P-3
P-36
METERS
0
10
20
R-1?
P2
W
E
P-30
P-38
P-43
P-54
P-3
P-36
METERS
R-1
P 3
SE
NW
P-4,7,27
P-6
P-41
P-57
P-73
P-83
P-1
P-2
METERS
R-1
P-4
S
N
P-7
P-36
P-37
P-3,4,27
METERS
CHANNEL B
P-5
W
E
P-6,36,41
METERS
P-6
S
N
P-7
P-27
P-3
P-37
P-5,36,41
METERS
CHANNEL B
P-7
W
E
P-38,41
P-55
P-8
P-42,54
P-6
P-4
wrecks ?
METERS
P-8
W
E
P-7
P-40
P-9
P-80
METERS
KILOMETERS
0
1
2
V.E.= 100X
STRONG
MODERATE
WEAK
P-7 - PROFILE INTERSECTION
TURN IN PROFILE


P 9
S
N
T
P-55,56
0
10
20
METERS
CHANNEL C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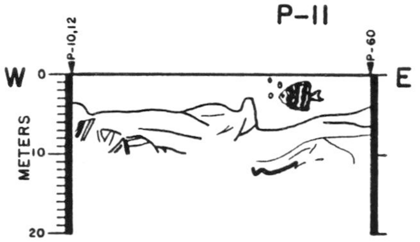
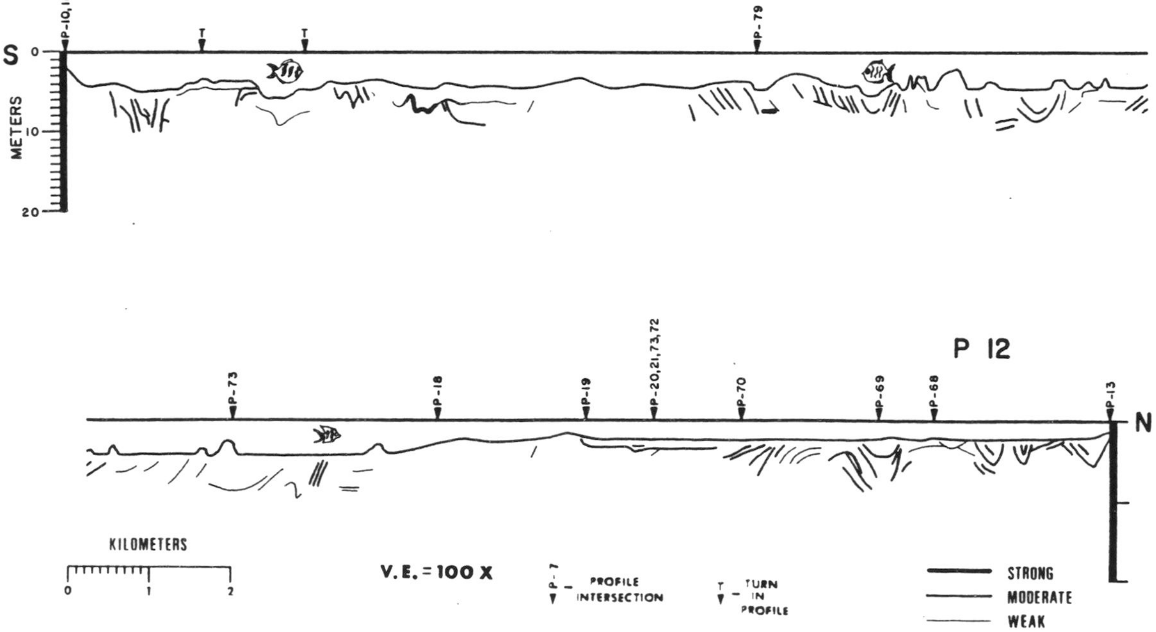
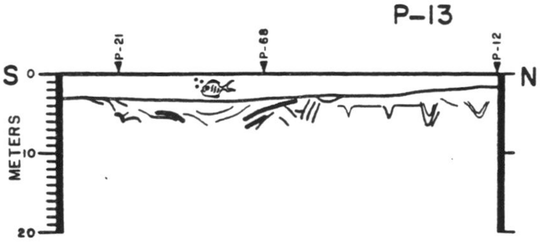
S
N
P-9
P-11,12
0
10
20
METERS


P-11
W
E
P-10,12
P-60
0
10
20
METERS


S
P-10,11
T
T
P-79
0
10
20
METERS
P 12
P-73
P-18
P-19
P-20,21,73,72
P-70
P-69
P-68
P-13
N
KILOMETERS
0
1
2
V.E. = 100 X
P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
STRONG
MODERATE
WEAK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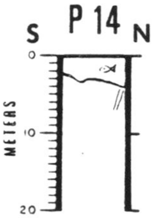
P-21
P-68
P-12
S
N
0
METERS
10
20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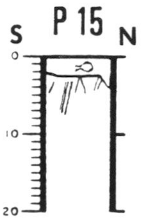
S
N
0
METERS
10
20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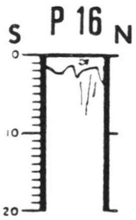
N
0
10
20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S
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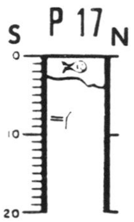
10
20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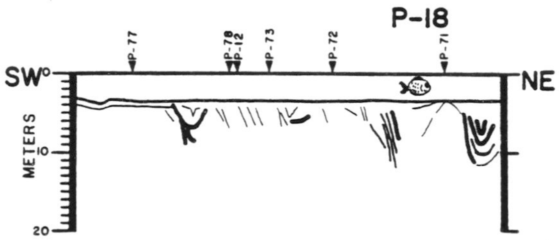
10
20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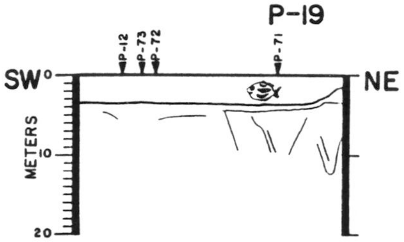
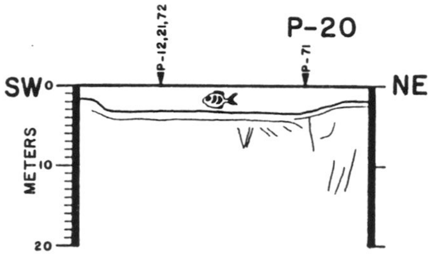
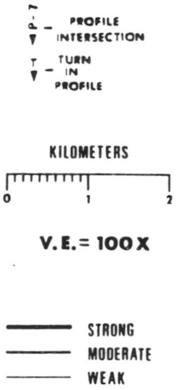
P-77
P-78
P-12
P-73
P-72
P-71
SW
NE
0
METERS
10
20


P-19
P-12
P-73
P-72
P-71
SW
NE
0
METERS
10
20


P-20
P-12,21,72
P-71
SW
NE
0
METERS
10
20


P-7 — PROFILE INTERSECTION
T — TURN IN PROFILE
KILOMETERS
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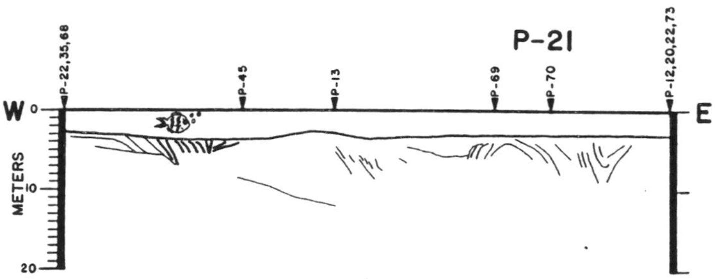
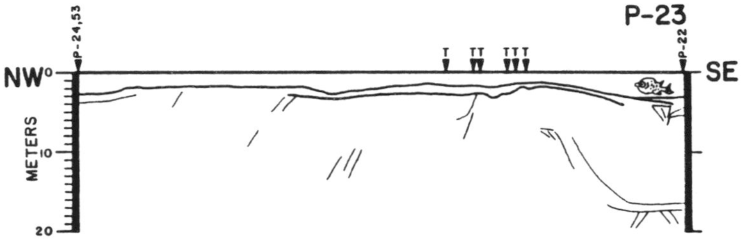
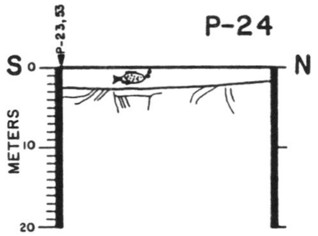
1
2
V.E.= 100X
STRONG
MODERATE
WEAK


P-21
P-22,35,66
P-45
P-13
P-69
P-70
P-12,20,22,73
W
E
0
METERS
10
20


P-22
P-31
P-44
P-21, 35,68
P-45
P-23
S
N
0
10
20
30
METERS


P-23
P-24,53
T
TT
TTT
P-22
NW
SE
0
10
20
METERS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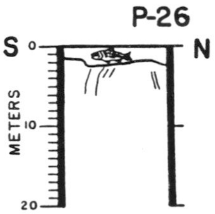
P-23,53
S
N
0
10
20
METERS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S
N
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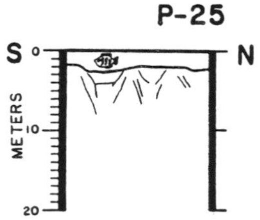
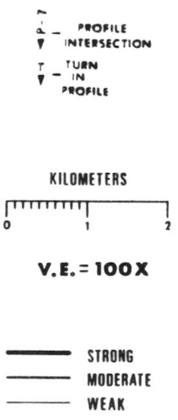
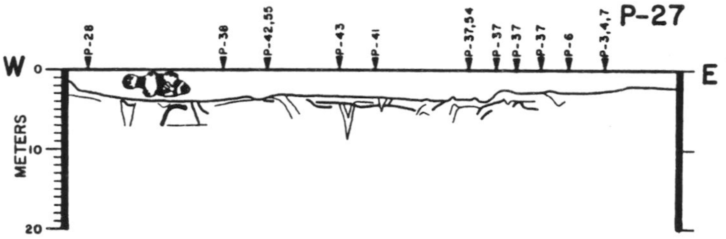
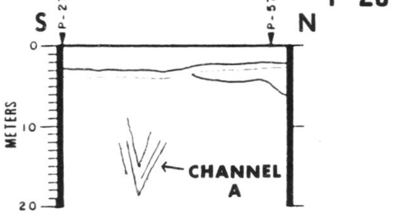
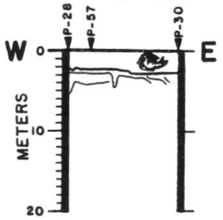
10
20
METERS

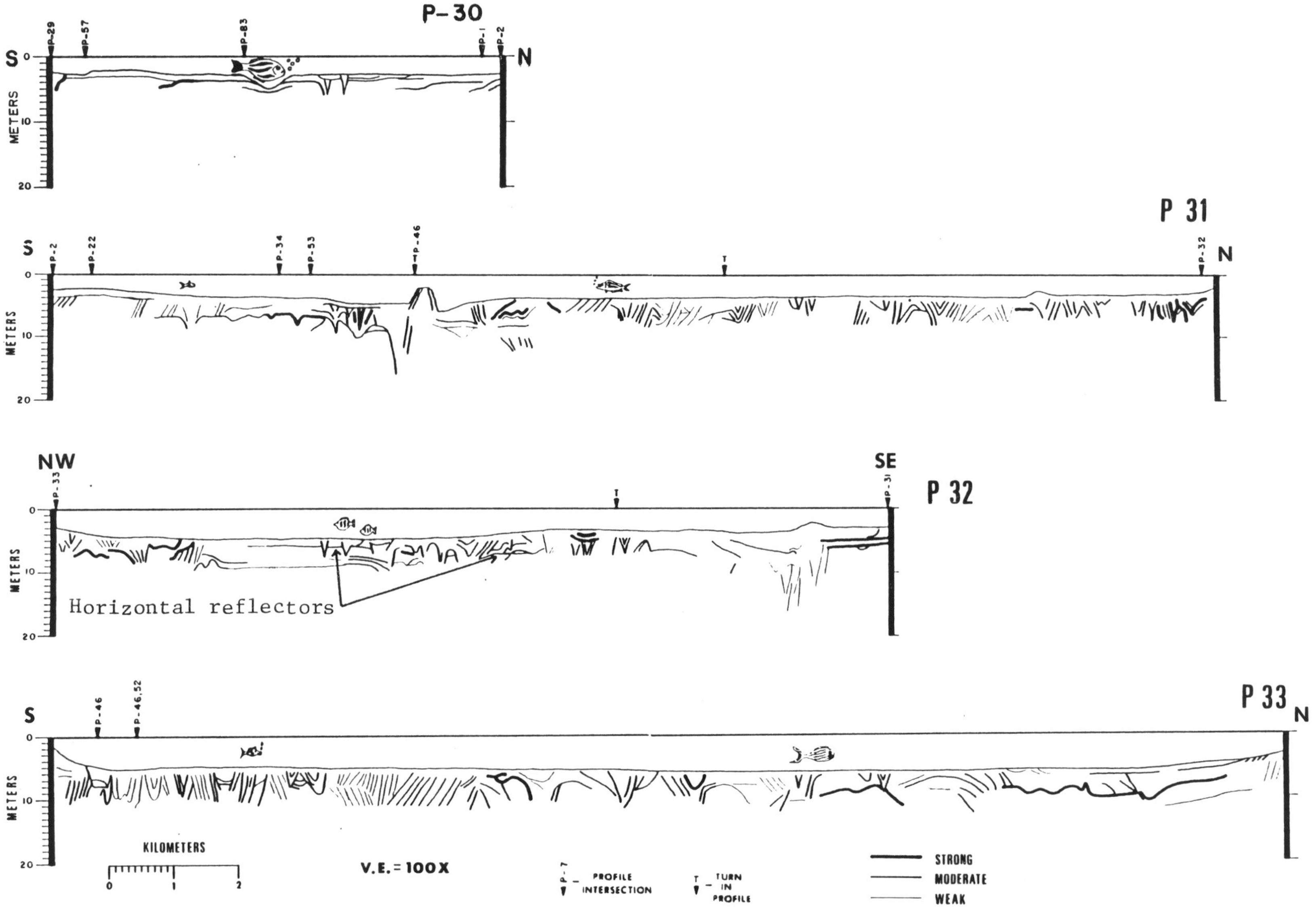

P-25
S
N
0
10
20
METERS

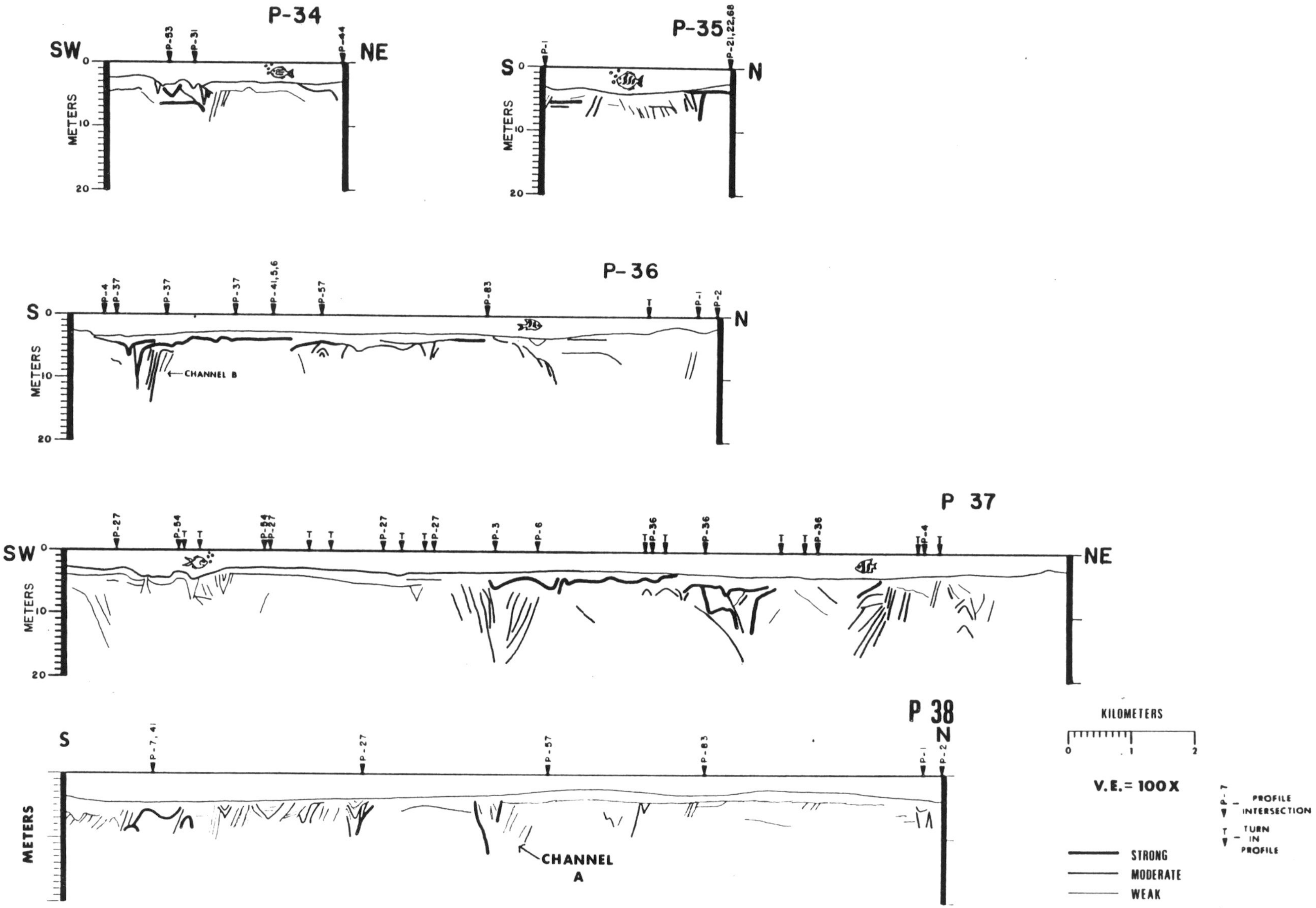

P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
KILOMETERS
0
1
2
V.E. = 100X
STRONG
MODERATE
WEAK


P-27
P-28
P-38
P-42,55
P-43
P-41
P-37,54
P-37
P-37
P-37
P-6
P-3,4,7
W
E
0
10
20
METERS


P 28
P-27
P-57
S
N
0
10
20
METERS
CHANNEL A

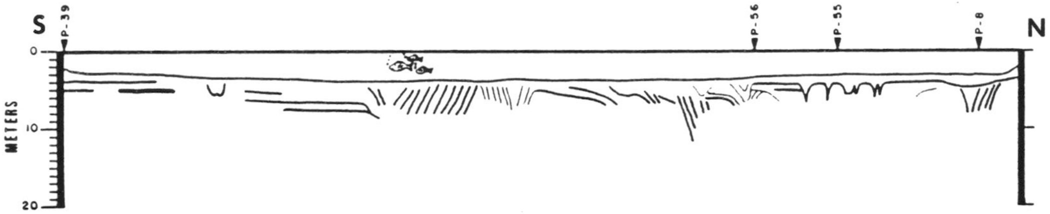

P-29
P-28
P-57
P-30
W
E
0
10
20
METERS


P-30
S
N
P-29
P-57
P-83
P-1
P-2
METERS
0
10
20
P 31
S
N
P-2
P-22
P-34
P-53
P-46
T
P-32
METERS
0
10
20
NW
SE
P-33
T
P-31
P 32
METERS
0
10
20
Horizontal reflectors
P 33
S
N
P-46
P-46,52
METERS
0
10
20
KILOMETERS
0
1
2
V.E. = 100X
P-7
PROFILE INTERSECTION
T
TURN IN PROFILE
STRONG
MODERATE
WEAK

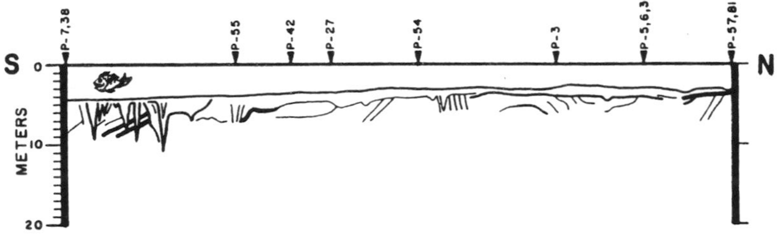

P-34
SW
NE
P-53
P-31
P-44
METERS
0
10
20
P-35
S
N
P-1
P-21,22,68
P-36
P-4
P-37
P-41,5,6
P-57
P-83
T
P-1
P-2
CHANNEL B
P 37
P-27
P-54
P-3
P-6
P-36
P-4
P 38
P-7, 41
CHANNEL A
KILOMETERS
0
1
2
V.E.= 100X
PROFILE INTERSECTION
TURN IN PROFILE
STRONG
MODERATE
WEAK

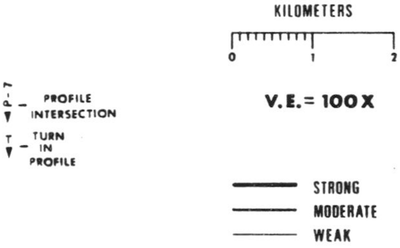
P 39

P 40



P-41





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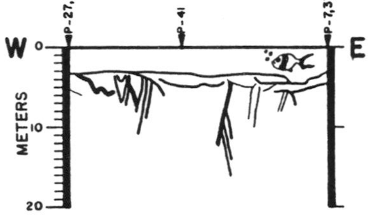

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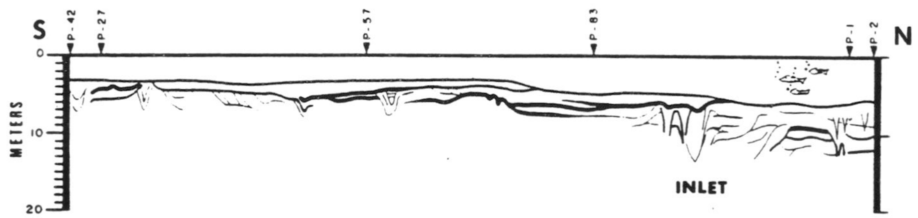

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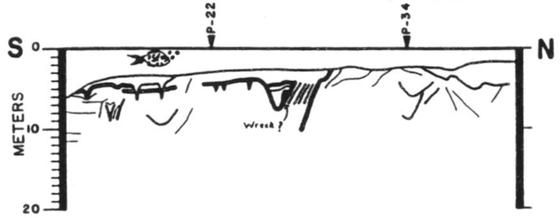
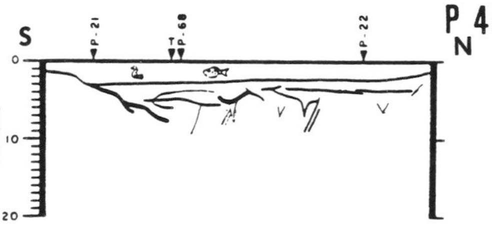
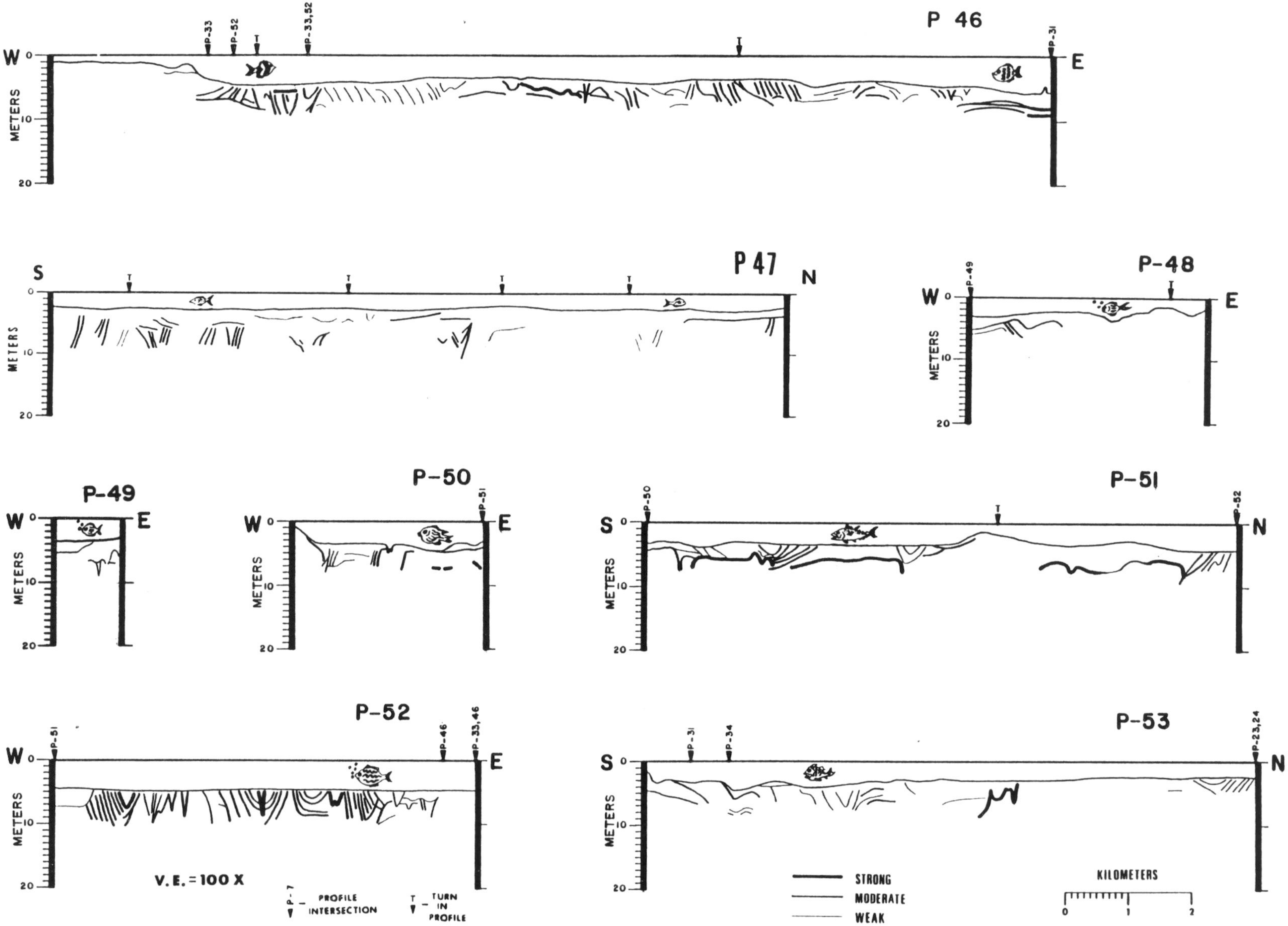
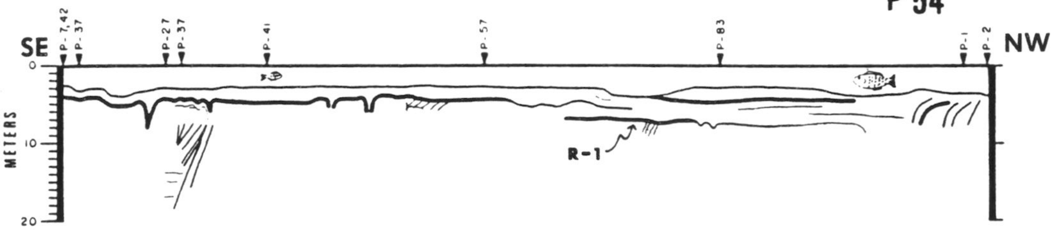


P 45




P 46
W
E
P-33
P-52
T
P-33,52
T
P-31
METERS
0
10
20
P 47
S
N
T
T
T
T
P-48
W
E
P-49
T
P-49
W
E
P-50
W
E
P-51
P-51
S
N
P-50
T
P-52
P-52
W
E
P-51
P-46
P-33,46
P-53
S
N
P-31
P-34
P-23,24
V.E.=100X
P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
STRONG
MODERATE
WEAK
KILOMETERS
0
1
2

P 54



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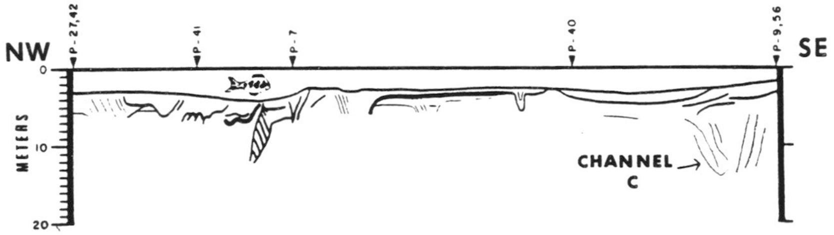
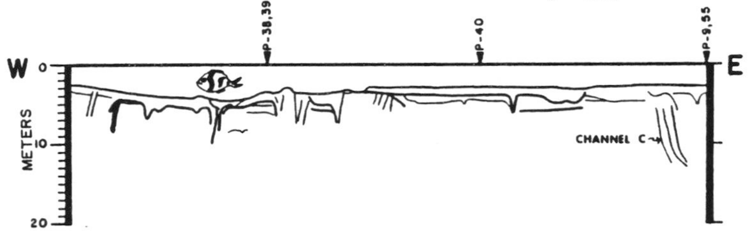
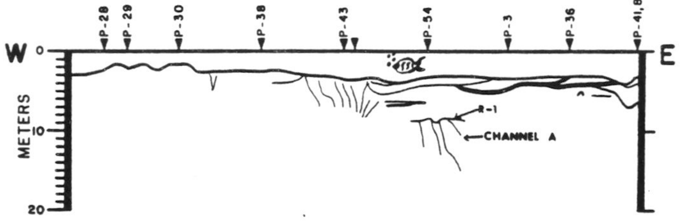
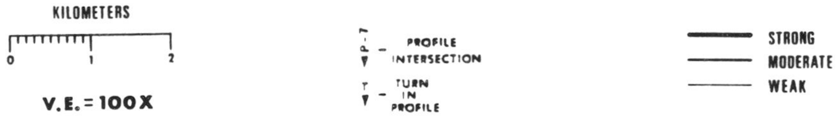


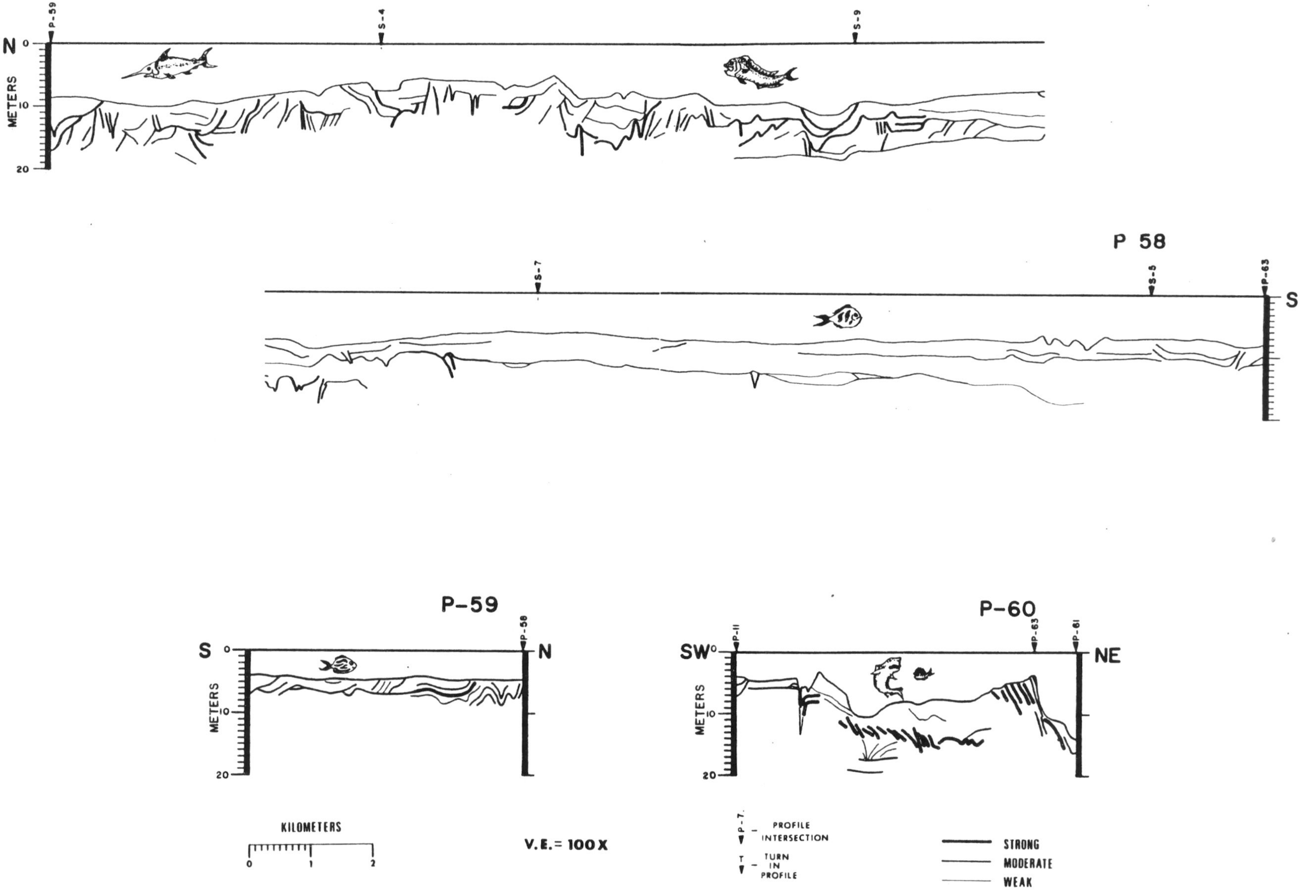
P-56

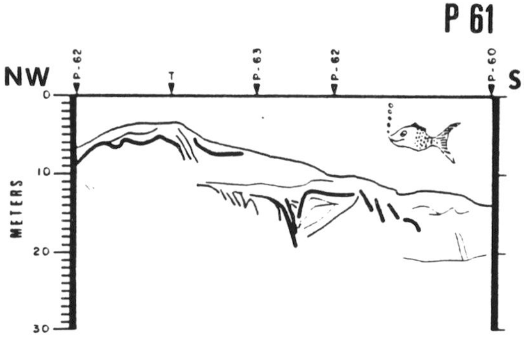


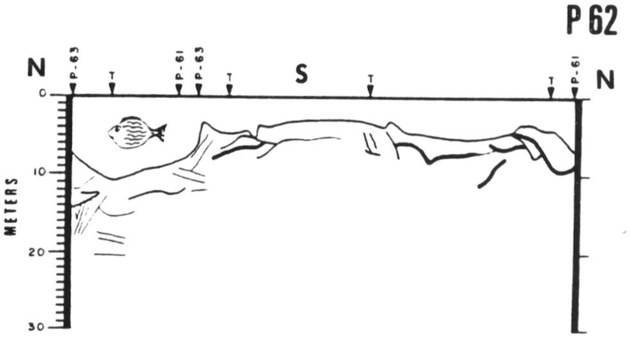
P-57

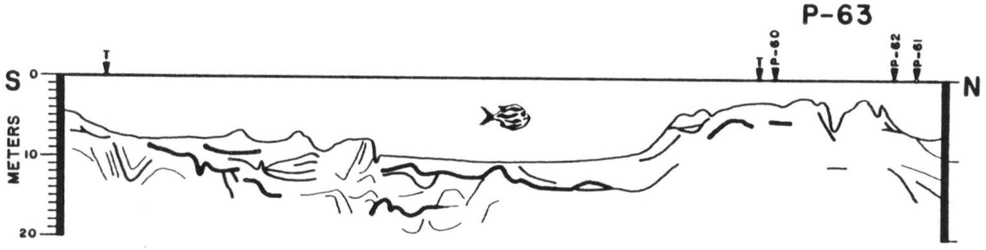


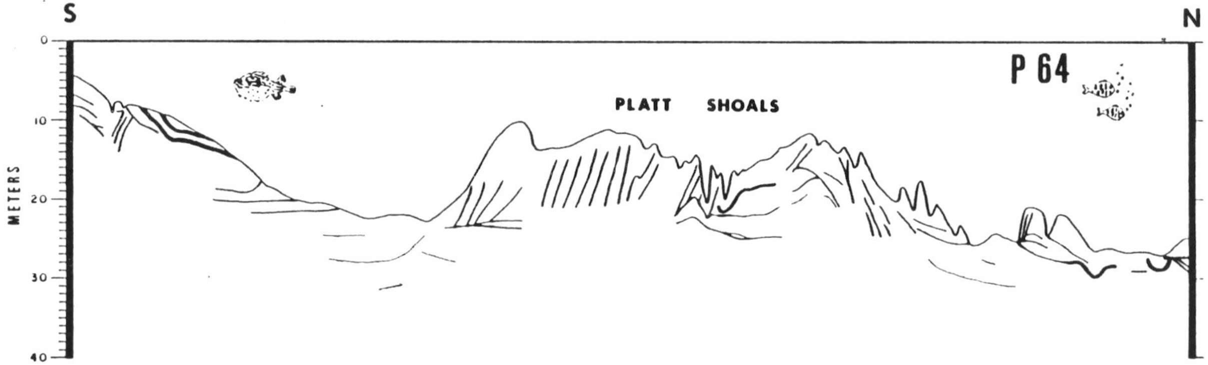



P-59
S-4
S-9
N
0
METERS
10
20
P 58
S-7
S-5
P-63
S
P-59
P-58
S
0
N
METERS
10
20
P-60
P-11
P-63
P-61
SW
0
NE
METERS
10
20
KILOMETERS
0
1
2
V.E.= 100X
P-7 - PROFILE INTERSECTION
T - TURN IN PROFILE
STRONG
MODERATE
WEAK

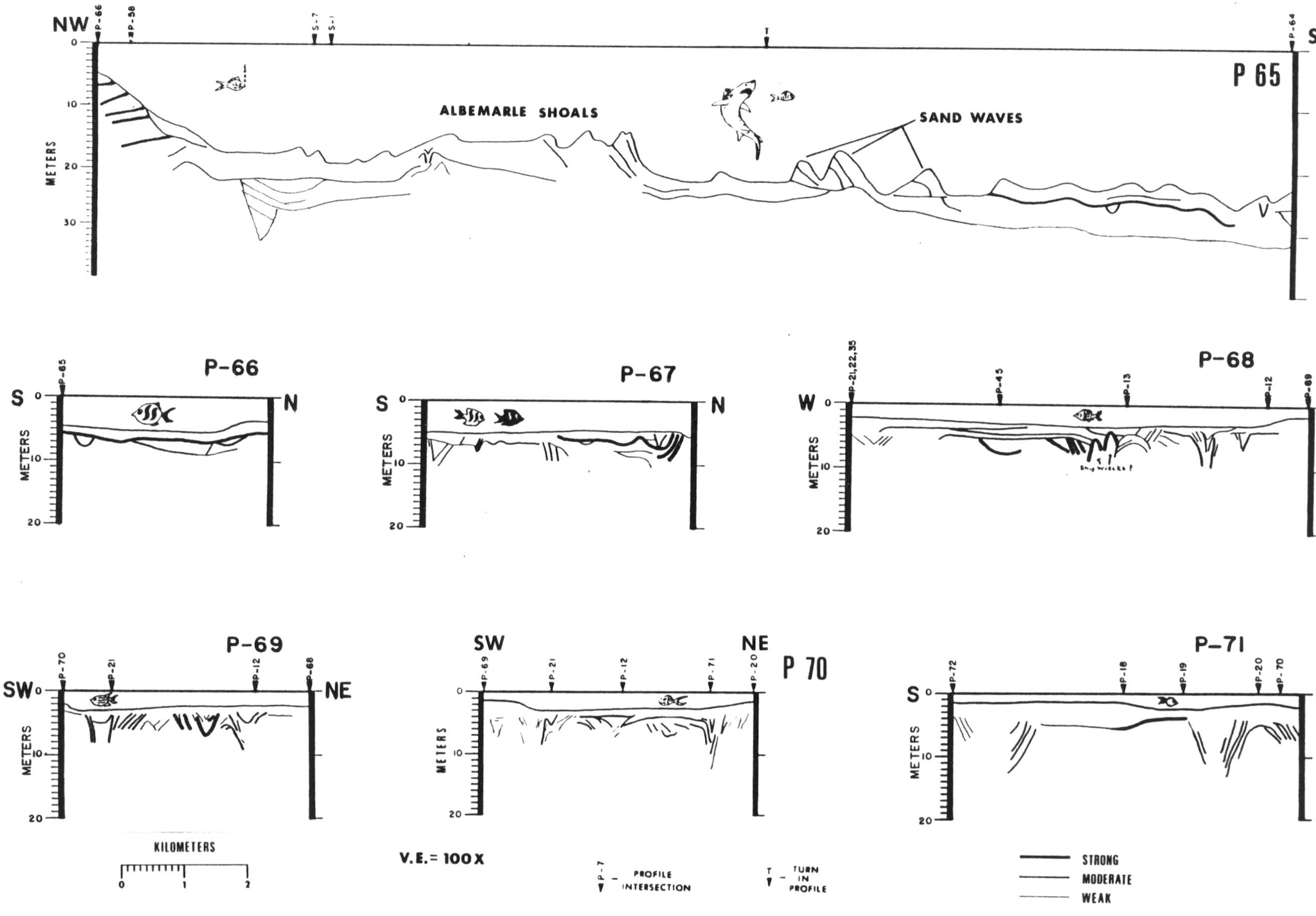

P 61
NW
SE
P-62
T
P-63
P-62
P-60
0
10
20
30
METERS


P 62
N
S
N
P-63
T
P-61
P-63
T
T
T
P-61
0
10
20
30
METERS


P-63
S
N
T
T
P-60
P-62
P-61
0
10
20
METERS


S
N
P 64
PLATT SHOALS
0
10
20
30
40
METERS


P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
KILOMETERS
0
1
2
V.E. = 100X
STRONG
MODERATE
WEAK


NW
SE
P-66
P-58
S-7
S-1
T
P-64
P 65
ALBEMARLE SHOALS
SAND WAVES
METERS
0
10
20
30
P-66
S
N
P-65
P-67
P-68
W
E
P-21,22,35
P-45
P-13
P-12
P-69
Ship Wrecks ?
P-69
SW
NE
P-70
P-21
P-12
P-68
P 70
P-69
P-21
P-12
P-71
P-20
P-71
P-72
P-18
P-19
P-20
P-70
KILOMETERS
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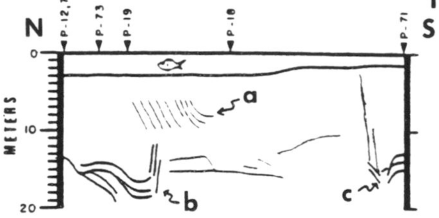
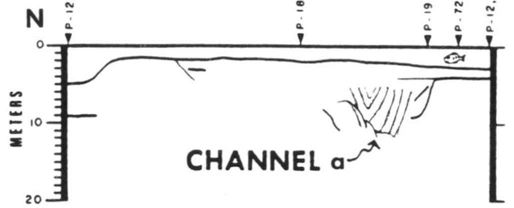
2
V.E.= 100X
P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
STRONG
MODERATE
WEAK

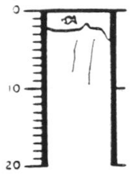
P 72



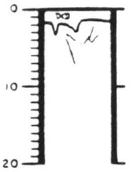
P 73



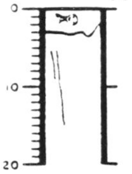
P 74



P 75



P 76



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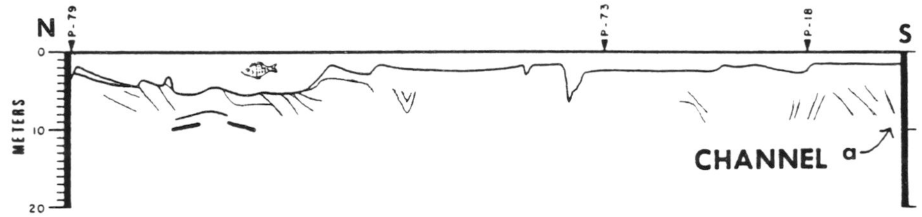
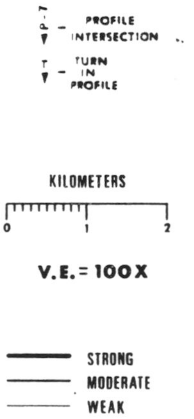
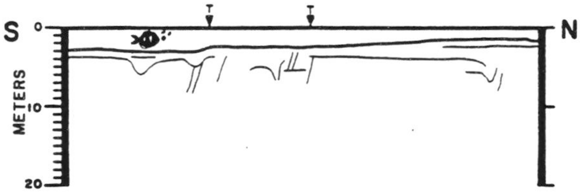
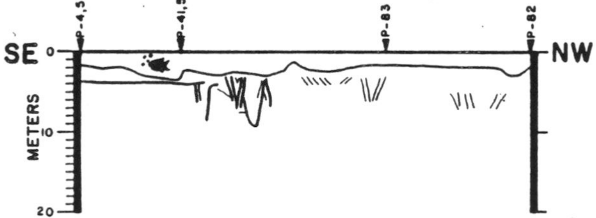




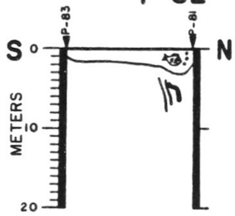
P-80



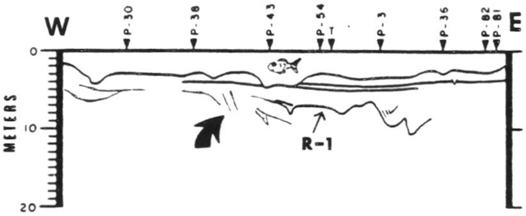
P-81



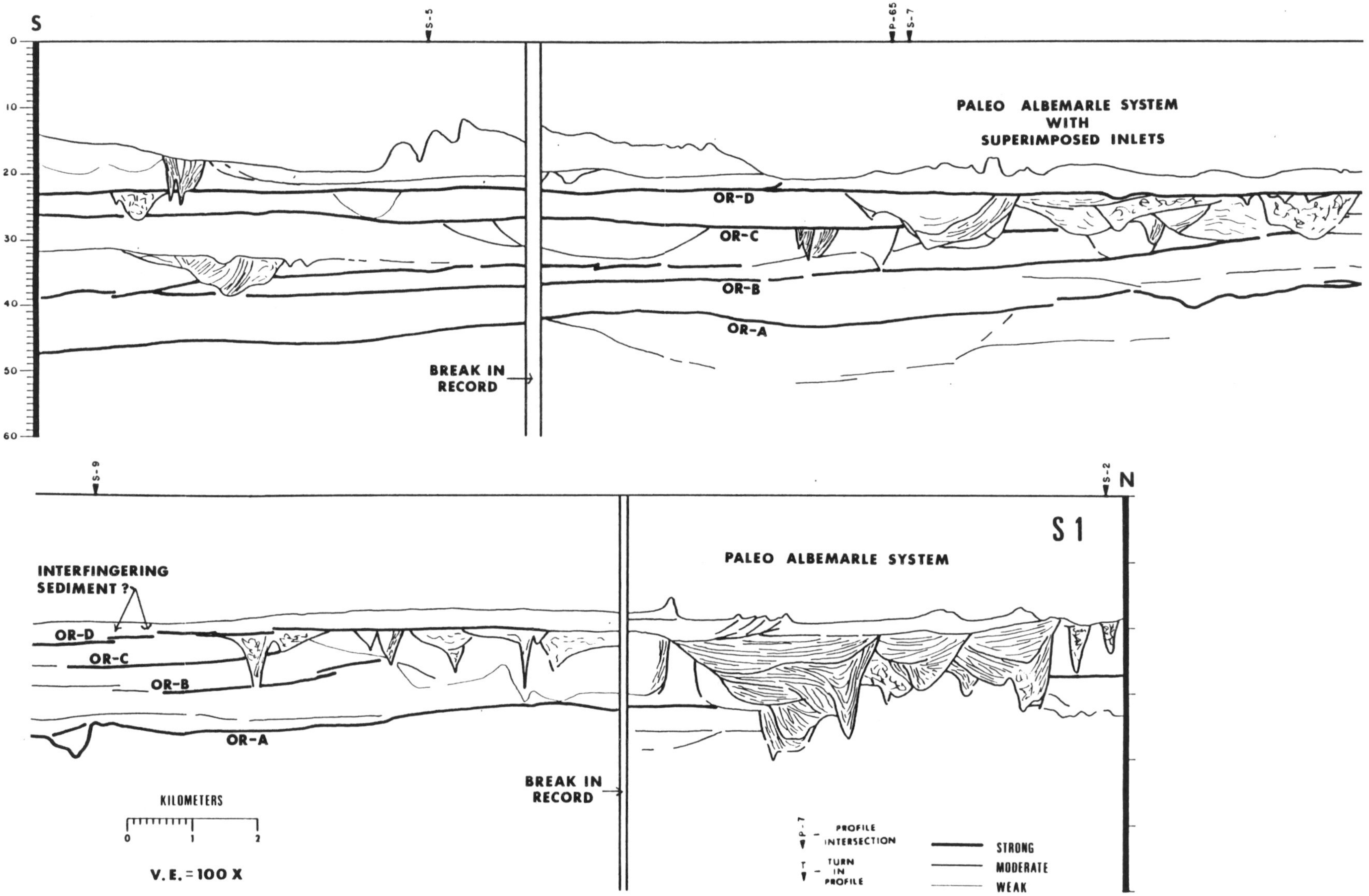
P-82

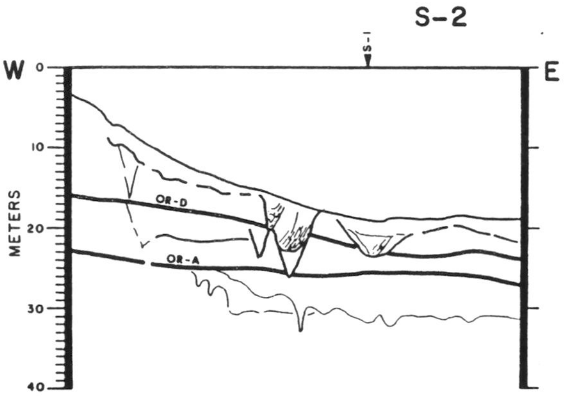


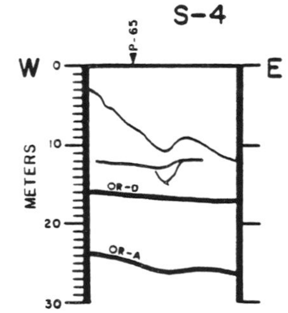
P 83

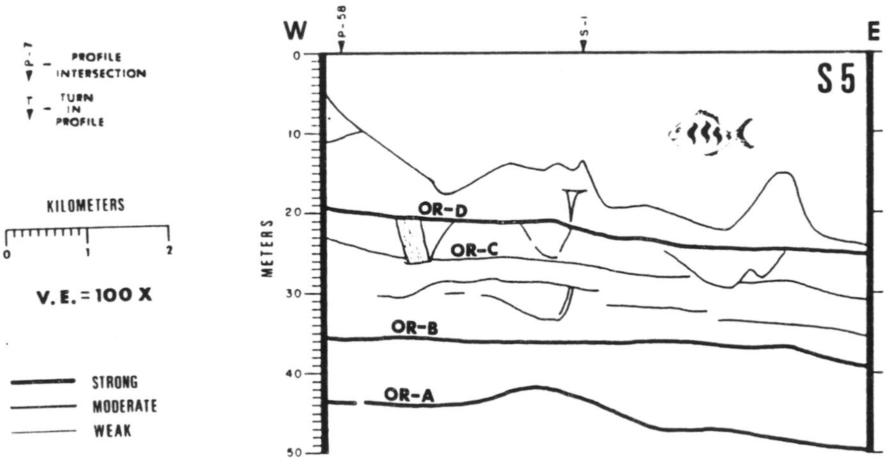


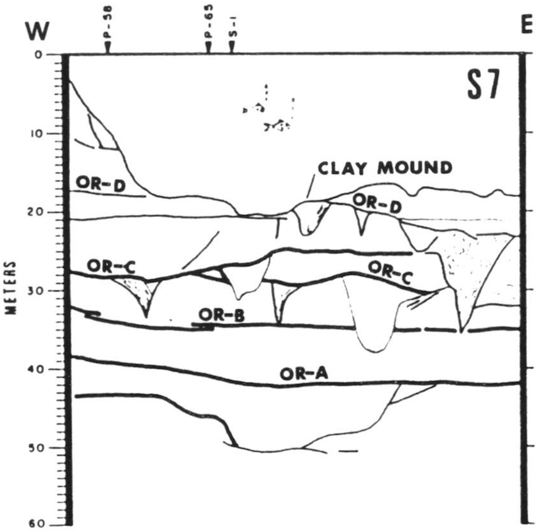
NOTE: P-77 and P-79 are not present; no reflectors were present.

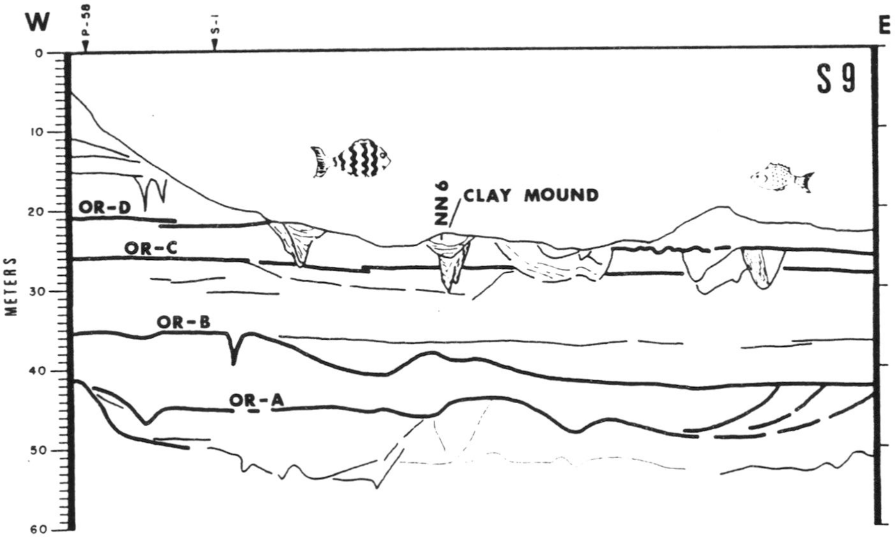

S
S-5
P-65
S-7
0
10
20
30
40
50
60
PALEO ALBEMARLE SYSTEM WITH SUPERIMPOSED INLETS
OR-D
OR-C
OR-B
OR-A
BREAK IN RECORD
S-9
S-2
N
S 1
PALEO ALBEMARLE SYSTEM
INTERFINGERING SEDIMENT ?
OR-D
OR-C
OR-B
OR-A
BREAK IN RECORD
KILOMETERS
0
1
2
V. E. = 100 X
P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
STRONG
MODERATE
WEAK


S-2
S-1
W
E
0
10
20
30
40
METERS
OR-D
OR-A


S-4
P-65
W
E
0
10
20
30
METERS
OR-D
OR-A


P-7 – PROFILE INTERSECTION
T – TURN IN PROFILE
KILOMETERS
0
1
2
V. E. = 100 X
STRONG
MODERATE
WEAK
W
P-58
S-1
E
S5
0
10
20
30
40
50
METERS
OR-D
OR-C
OR-B
OR-A

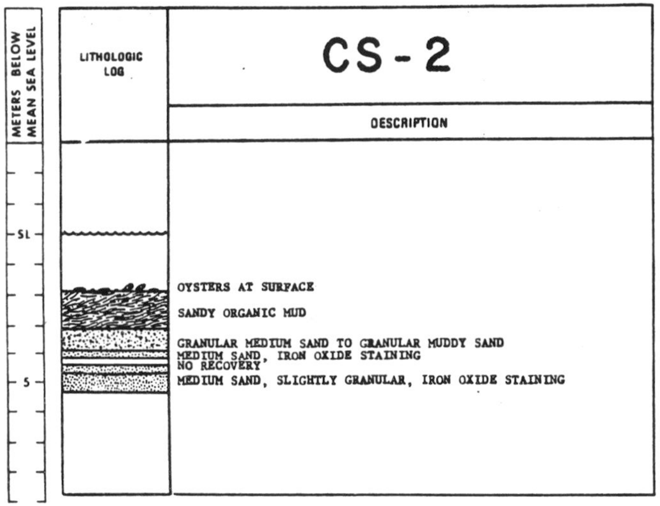

W
P-58
P-65
S-1
E
S7
0
10
20
30
40
50
60
METERS
CLAY MOUND
OR-D
OR-D
OR-C
OR-C
OR-B
OR-A


W
P-58
S-1
E
S9
0
10
20
30
40
50
60
METERS
NN6
CLAY MOUND
OR-D
OR-C
OR-B
OR-A


KILOMETERS
0
1
2
V.E. = 100 X
P-7
PROFILE INTERSECTION
TURN IN PROFILE
STRONG
MODERATE
WEAK

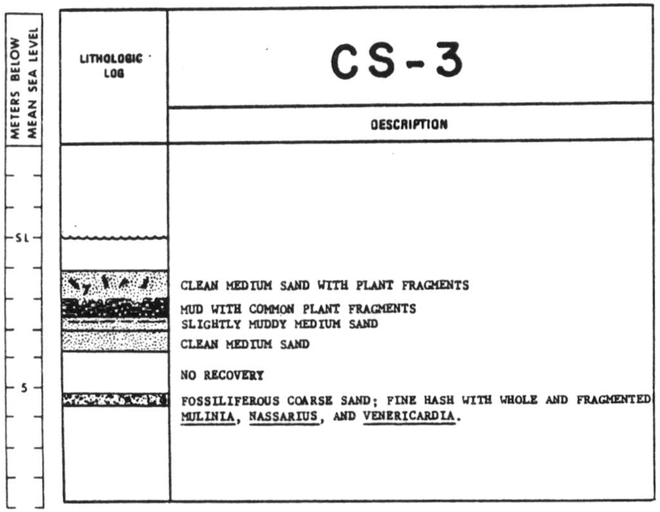
APPENDIX B

CORE DESCRIPTIONS



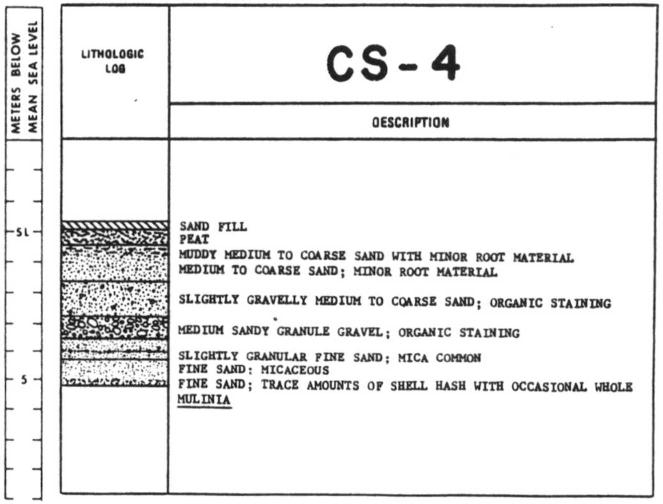
CS-2

OYSTERS AT SURFACE
SANDY ORGANIC MUD
GRANULAR MEDIUM SAND TO GRANULAR MUDDY SAND
MEDIUM SAND, IRON OXIDE STAINING
NO RECOVERY
MEDIUM SAND, SLIGHTLY GRANULAR, IRON OXIDE STAINING



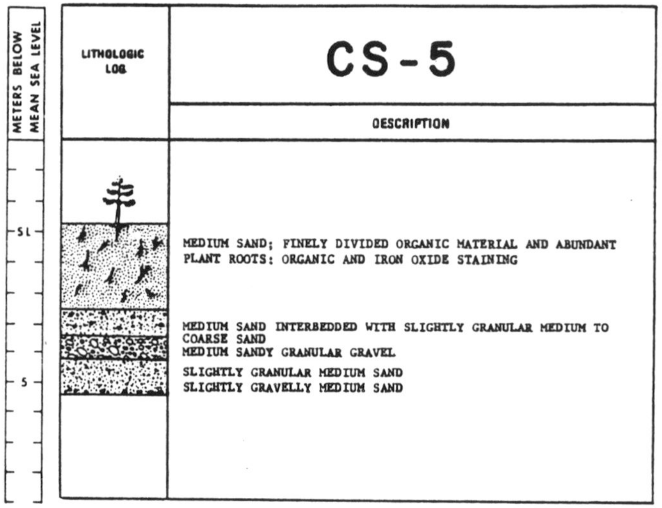
CS-3

CLEAN MEDIUM SAND WITH PLANT FRAGMENTS
MUD WITH COMMON PLANT FRAGMENTS
SLIGHTLY MUDDY MEDIUM SAND
CLEAN MEDIUM SAND
NO RECOVERY
FOSSILIFEROUS COARSE SAND; FINE HASH WITH WHOLE AND FRAGMENTED MULINIA, NASSARIUS, AND VENERICARDIA.



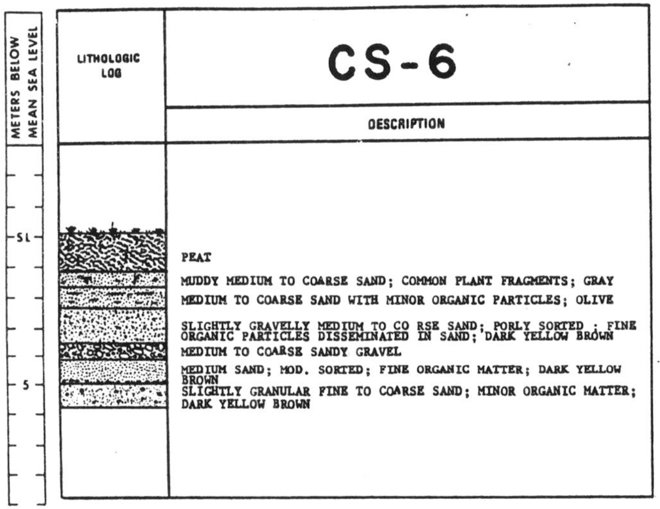
CS-4

SAND FILL
PEAT
MUDDY MEDIUM TO COARSE SAND WITH MINOR ROOT MATERIAL
MEDIUM TO COARSE SAND; MINOR ROOT MATERIAL
SLIGHTLY GRAVELLY MEDIUM TO COARSE SAND; ORGANIC STAINING
MEDIUM SANDY GRANULE GRAVEL; ORGANIC STAINING
SLIGHTLY GRANULAR FINE SAND; MICA COMMON
FINE SAND: MICACEOUS
FINE SAND; TRACE AMOUNTS OF SHELL HASH WITH OCCASIONAL WHOLE MULINIA



CS-5

MEDIUM SAND; FINELY DIVIDED ORGANIC MATERIAL AND ABUNDANT PLANT ROOTS: ORGANIC AND IRON OXIDE STAINING
MEDIUM SAND INTERBEDDED WITH SLIGHTLY GRANULAR MEDIUM TO COARSE SAND
MEDIUM SANDY GRANULAR GRAVEL
SLIGHTLY GRANULAR MEDIUM SAND
SLIGHTLY GRAVELLY MEDIUM SAND



PEAT

MUDDY MEDIUM TO COARSE SAND; COMMON PLANT FRAGMENTS; GRAY

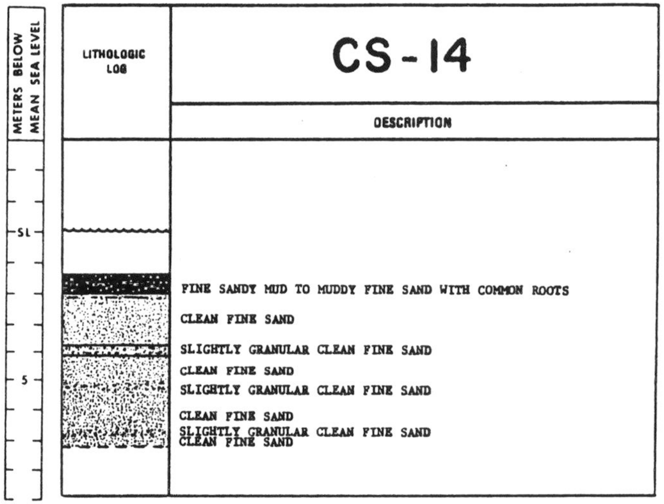
MEDIUM TO COARSE SAND WITH MINOR ORGANIC PARTICLES; OLIVE

SLIGHTLY GRAVELLY MEDIUM TO CO RSE SAND; PORLY SORTED ; FINE ORGANIC PARTICLES DISSEMINATED IN SAND; DARK YELLOW BROWN

MEDIUM TO COARSE SANDY GRAVEL

MEDIUM SAND; MOD. SORTED; FINE ORGANIC MATTER; DARK YELLOW BROWN

SLIGHTLY GRANULAR FINE TO COARSE SAND; MINOR ORGANIC MATTER; DARK YELLOW BROWN



FINE SANDY MUD TO MUDDY FINE SAND WITH COMMON ROOTS

CLEAN FINE SAND

SLIGHTLY GRANULAR CLEAN FINE SAND

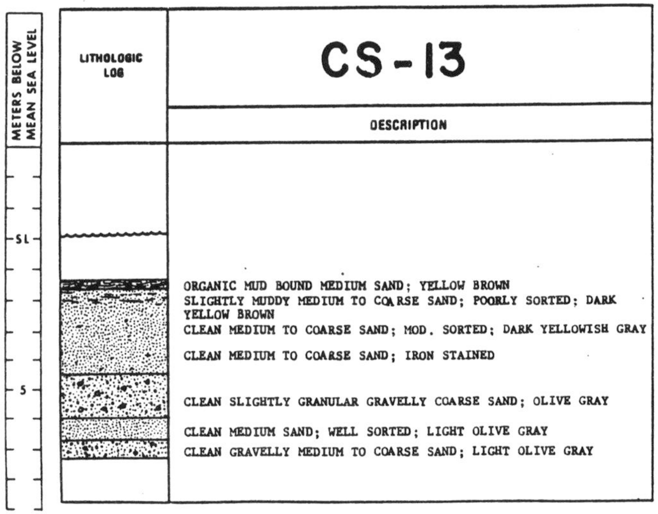
CLEAN FINE SAND

SLIGHTLY GRANULAR CLEAN FINE SAND

CLEAN FINE SAND

SLIGHTLY GRANULAR CLEAN FINE SAND

CLEAN FINE SAND



ORGANIC MUD BOUND MEDIUM SAND; YELLOW BROWN

SLIGHTLY MUDDY MEDIUM TO COARSE SAND; POORLY SORTED; DARK YELLOW BROWN

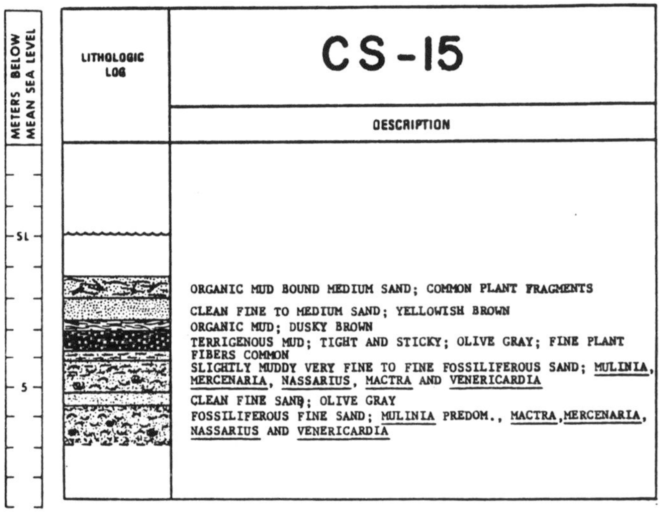
CLEAN MEDIUM TO COARSE SAND; MOD. SORTED; DARK YELLOWISH GRAY

CLEAN MEDIUM TO COARSE SAND; IRON STAINED

CLEAN SLIGHTLY GRANULAR GRAVELLY COARSE SAND; OLIVE GRAY

CLEAN MEDIUM SAND; WELL SORTED; LIGHT OLIVE GRAY

CLEAN GRAVELLY MEDIUM TO COARSE SAND; LIGHT OLIVE GRAY



ORGANIC MUD BOUND MEDIUM SAND; COMMON PLANT FRAGMENTS

CLEAN FINE TO MEDIUM SAND; YELLOWISH BROWN

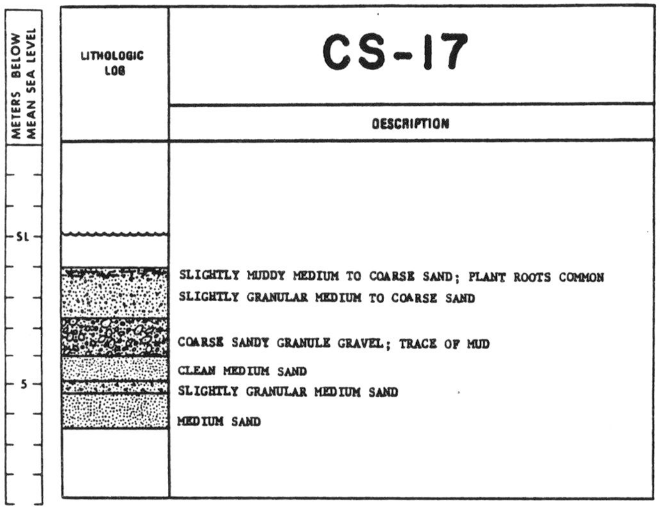
ORGANIC MUD; DUSKY BROWN

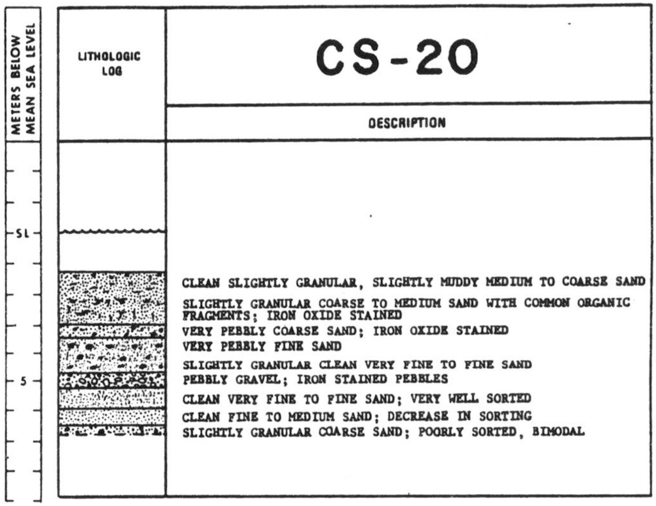
TERRIGENOUS MUD; TIGHT AND STICKY; OLIVE GRAY; FINE PLANT FIBERS COMMON

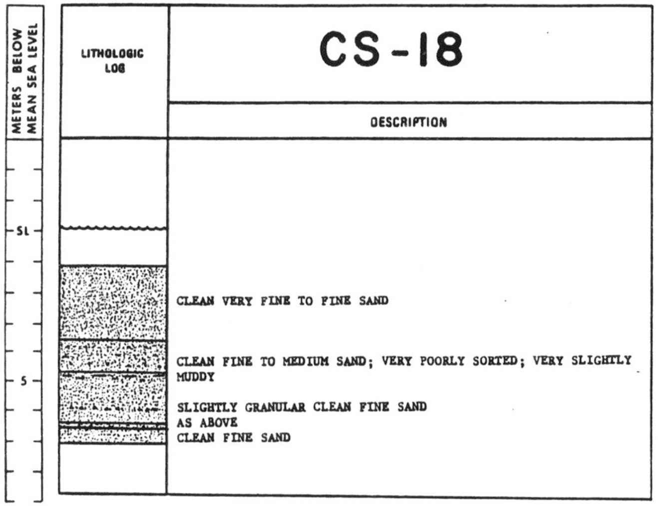
SLIGHTLY MUDDY VERY FINE TO FINE FOSSILIFEROUS SAND; MULINIA, MERCENARIA, NASSARIUS, MACTRA AND VENERICARDIA

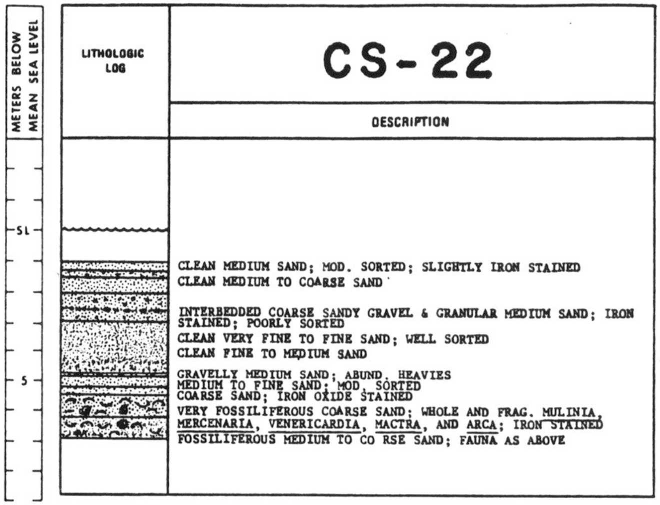
CLEAN FINE SAND; OLIVE GRAY

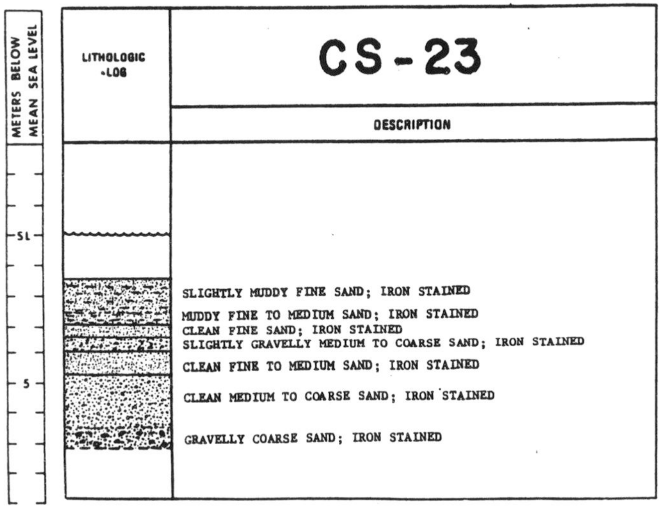
FOSSILIFEROUS FINE SAND; MULINIA PREDOM., MACTRA, MERCENARIA, NASSARIUS AND VENERICARDIA

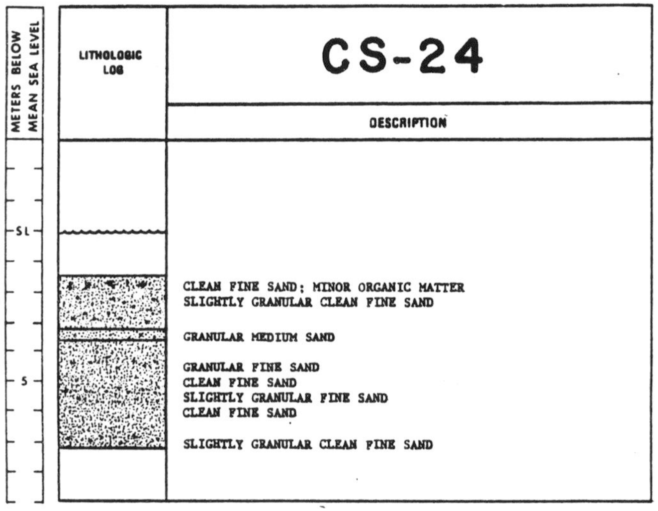

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-17
DESCRIPTION
SL
5
SLIGHTLY MUDDY MEDIUM TO COARSE SAND; PLANT ROOTS COMMON
SLIGHTLY GRANULAR MEDIUM TO COARSE SAND
COARSE SANDY GRANULE GRAVEL; TRACE OF MUD
CLEAN MEDIUM SAND
SLIGHTLY GRANULAR MEDIUM SAND
MEDIUM SAND

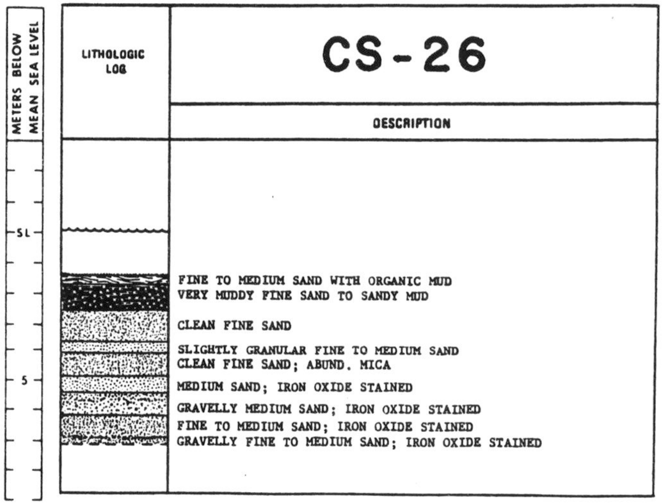

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-20
DESCRIPTION
SL
5
CLEAN SLIGHTLY GRANULAR, SLIGHTLY MUDDY MEDIUM TO COARSE SAND
SLIGHTLY GRANULAR COARSE TO MEDIUM SAND WITH COMMON ORGANIC FRAGMENTS; IRON OXIDE STAINED
VERY PEBBLY COARSE SAND; IRON OXIDE STAINED
VERY PEBBLY FINE SAND
SLIGHTLY GRANULAR CLEAN VERY FINE TO FINE SAND
PEBBLY GRAVEL; IRON STAINED PEBBLES
CLEAN VERY FINE TO FINE SAND; VERY WELL SORTED
CLEAN FINE TO MEDIUM SAND; DECREASE IN SORTING
SLIGHTLY GRANULAR COARSE SAND; POORLY SORTED, BIMODAL

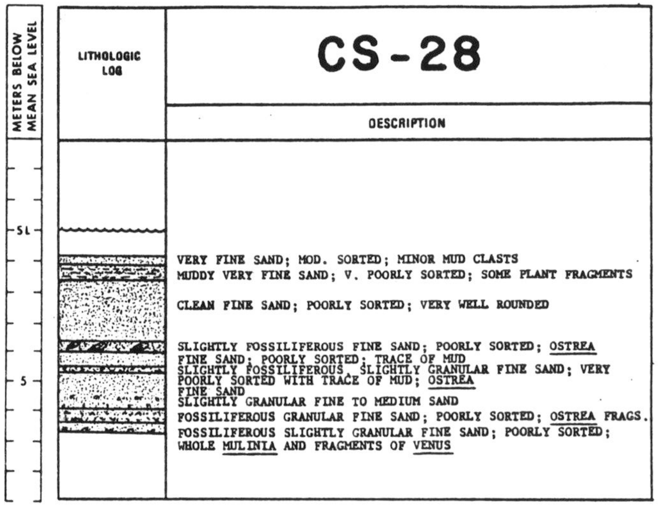

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-18
DESCRIPTION
SL
5
CLEAN VERY FINE TO FINE SAND
CLEAN FINE TO MEDIUM SAND; VERY POORLY SORTED; VERY SLIGHTLY MUDDY
SLIGHTLY GRANULAR CLEAN FINE SAND
AS ABOVE
CLEAN FINE SAND

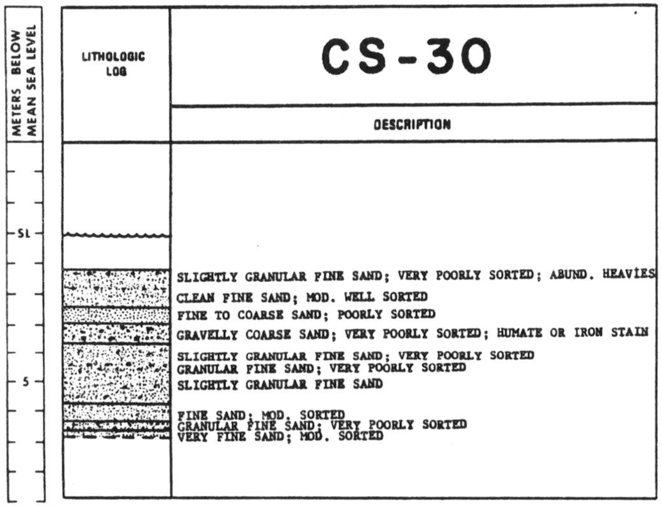

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-22
DESCRIPTION
SL
5
CLEAN MEDIUM SAND; MOD. SORTED; SLIGHTLY IRON STAINED
CLEAN MEDIUM TO COARSE SAND
INTERBEDDED COARSE SANDY GRAVEL & GRANULAR MEDIUM SAND; IRON STAINED; POORLY SORTED
CLEAN VERY FINE TO FINE SAND; WELL SORTED
CLEAN FINE TO MEDIUM SAND
GRAVELLY MEDIUM SAND; ABUND. HEAVIES
MEDIUM TO FINE SAND; MOD. SORTED
COARSE SAND; IRON OXIDE STAINED
VERY FOSSILIFEROUS COARSE SAND; WHOLE AND FRAG. MULINIA, MERCENARIA, VENERICARDIA, MACTRA, AND ARCA; IRON STAINED
FOSSILIFEROUS MEDIUM TO COARSE SAND; FAUNA AS ABOVE

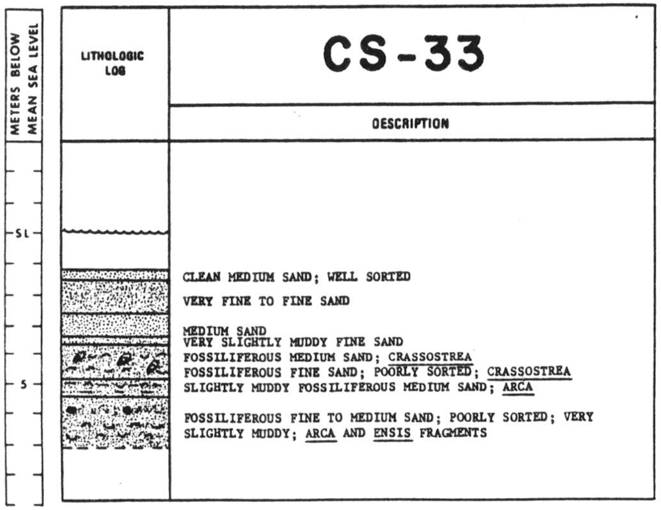

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-23
DESCRIPTION
SL
5
SLIGHTLY MUDDY FINE SAND; IRON STAINED
MUDDY FINE TO MEDIUM SAND; IRON STAINED
CLEAN FINE SAND; IRON STAINED
SLIGHTLY GRAVELLY MEDIUM TO COARSE SAND; IRON STAINED
CLEAN FINE TO MEDIUM SAND; IRON STAINED
CLEAN MEDIUM TO COARSE SAND; IRON STAINED
GRAVELLY COARSE SAND; IRON STAINED

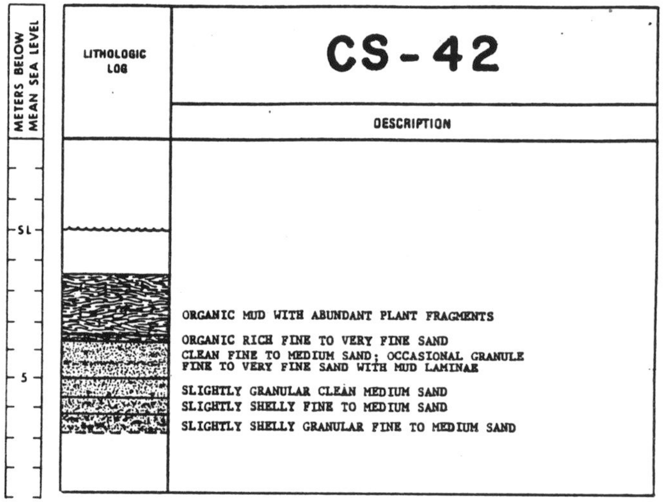

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-24
DESCRIPTION
SL
5
CLEAN FINE SAND; MINOR ORGANIC MATTER
SLIGHTLY GRANULAR CLEAN FINE SAND
GRANULAR MEDIUM SAND
GRANULAR FINE SAND
CLEAN FINE SAND
SLIGHTLY GRANULAR FINE SAND
CLEAN FINE SAND
SLIGHTLY GRANULAR CLEAN FINE SAND

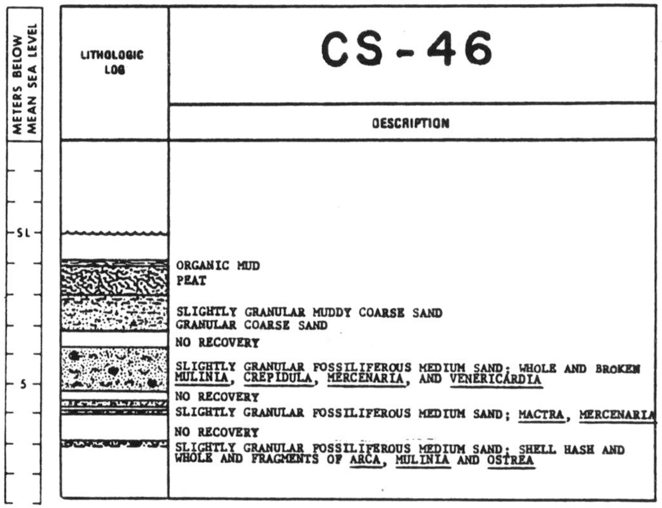

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-26
DESCRIPTION
SL
5
FINE TO MEDIUM SAND WITH ORGANIC MUD
VERY MUDDY FINE SAND TO SANDY MUD
CLEAN FINE SAND
SLIGHTLY GRANULAR FINE TO MEDIUM SAND
CLEAN FINE SAND; ABUND. MICA
MEDIUM SAND; IRON OXIDE STAINED
GRAVELLY MEDIUM SAND; IRON OXIDE STAINED
FINE TO MEDIUM SAND; IRON OXIDE STAINED
GRAVELLY FINE TO MEDIUM SAND; IRON OXIDE STAINED

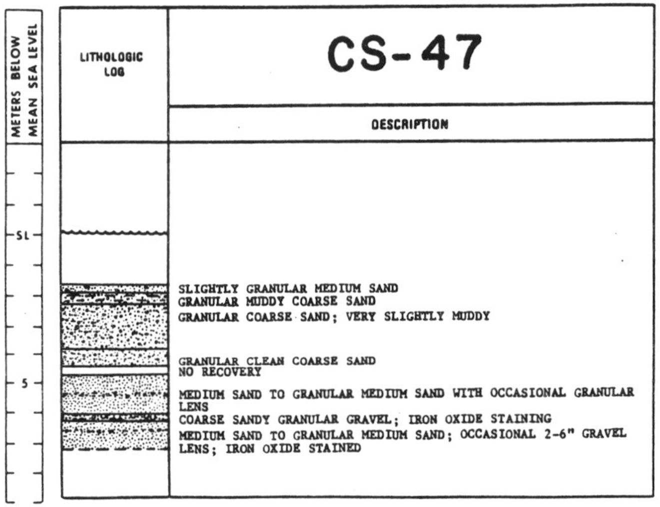

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-28
DESCRIPTION
SL
5
VERY FINE SAND; MOD. SORTED; MINOR MUD CLASTS
MUDDY VERY FINE SAND; V. POORLY SORTED; SOME PLANT FRAGMENTS
CLEAN FINE SAND; POORLY SORTED; VERY WELL ROUNDED
SLIGHTLY FOSSILIFEROUS FINE SAND; POORLY SORTED; OSTREA
FINE SAND; POORLY SORTED; TRACE OF MUD
SLIGHTLY FOSSILIFEROUS, SLIGHTLY GRANULAR FINE SAND; VERY POORLY SORTED WITH TRACE OF MUD; OSTREA
FINE SAND
SLIGHTLY GRANULAR FINE TO MEDIUM SAND
FOSSILIFEROUS GRANULAR FINE SAND; POORLY SORTED; OSTREA FRAGS.
FOSSILIFEROUS SLIGHTLY GRANULAR FINE SAND; POORLY SORTED; WHOLE MULINIA AND FRAGMENTS OF VENUS


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-30
DESCRIPTION
SL
5
SLIGHTLY GRANULAR FINE SAND; VERY POORLY SORTED; ABUND. HEAVIES
CLEAN FINE SAND; MOD. WELL SORTED
FINE TO COARSE SAND; POORLY SORTED
GRAVELLY COARSE SAND; VERY POORLY SORTED; HUMATE OR IRON STAIN
SLIGHTLY GRANULAR FINE SAND; VERY POORLY SORTED
GRANULAR FINE SAND; VERY POORLY SORTED
SLIGHTLY GRANULAR FINE SAND
FINE SAND; MOD. SORTED
GRANULAR FINE SAND; VERY POORLY SORTED
VERY FINE SAND; MOD. SORTED


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-33
DESCRIPTION
SL
5
CLEAN MEDIUM SAND; WELL SORTED
VERY FINE TO FINE SAND
MEDIUM SAND
VERY SLIGHTLY MUDDY FINE SAND
FOSSILIFEROUS MEDIUM SAND; CRASSOSTREA
FOSSILIFEROUS FINE SAND; POORLY SORTED; CRASSOSTREA
SLIGHTLY MUDDY FOSSILIFEROUS MEDIUM SAND; ARCA
FOSSILIFEROUS FINE TO MEDIUM SAND; POORLY SORTED; VERY SLIGHTLY MUDDY; ARCA AND ENSIS FRAGMENTS

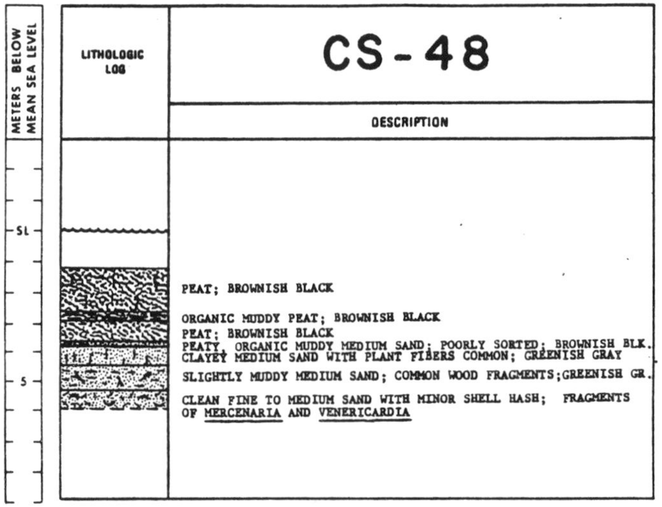

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-42
DESCRIPTION
SL
5
ORGANIC MUD WITH ABUNDANT PLANT FRAGMENTS
ORGANIC RICH FINE TO VERY FINE SAND
CLEAN FINE TO MEDIUM SAND; OCCASIONAL GRANULE
FINE TO VERY FINE SAND WITH MUD LAMINAE
SLIGHTLY GRANULAR CLEAN MEDIUM SAND
SLIGHTLY SHELLY FINE TO MEDIUM SAND
SLIGHTLY SHELLY GRANULAR FINE TO MEDIUM SAND


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-46
DESCRIPTION
SL
5
ORGANIC MUD
PEAT
SLIGHTLY GRANULAR MUDDY COARSE SAND
GRANULAR COARSE SAND
NO RECOVERY
SLIGHTLY GRANULAR FOSSILIFEROUS MEDIUM SAND; WHOLE AND BROKEN MULINIA, CREPIDULA, MERCENARIA, AND VENERICARDIA
NO RECOVERY
SLIGHTLY GRANULAR FOSSILIFEROUS MEDIUM SAND; MACTRA, MERCENARIA
NO RECOVERY
SLIGHTLY GRANULAR FOSSILIFEROUS MEDIUM SAND; SHELL HASH AND WHOLE AND FRAGMENTS OF ARCA, MULINIA AND OSTREA



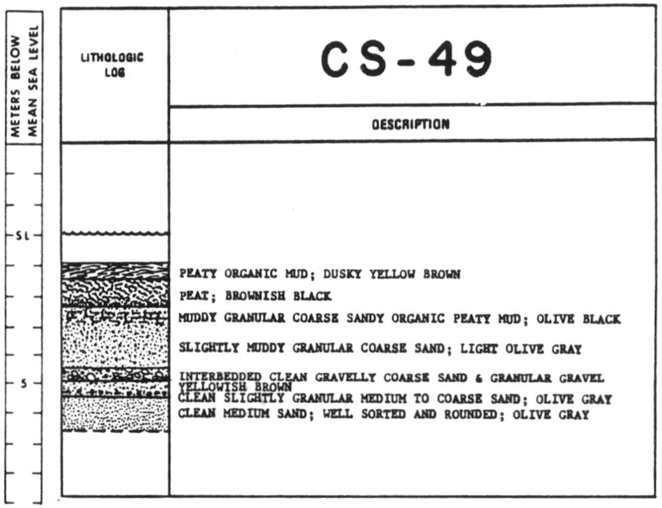
CS-47

SLIGHTLY GRANULAR MEDIUM SAND
GRANULAR MUDDY COARSE SAND
GRANULAR COARSE SAND; VERY SLIGHTLY MUDDY
GRANULAR CLEAN COARSE SAND
NO RECOVERY
MEDIUM SAND TO GRANULAR MEDIUM SAND WITH OCCASIONAL GRANULAR LENS
COARSE SANDY GRANULAR GRAVEL; IRON OXIDE STAINING
MEDIUM SAND TO GRANULAR MEDIUM SAND; OCCASIONAL 2-6" GRAVEL LENS; IRON OXIDE STAINED



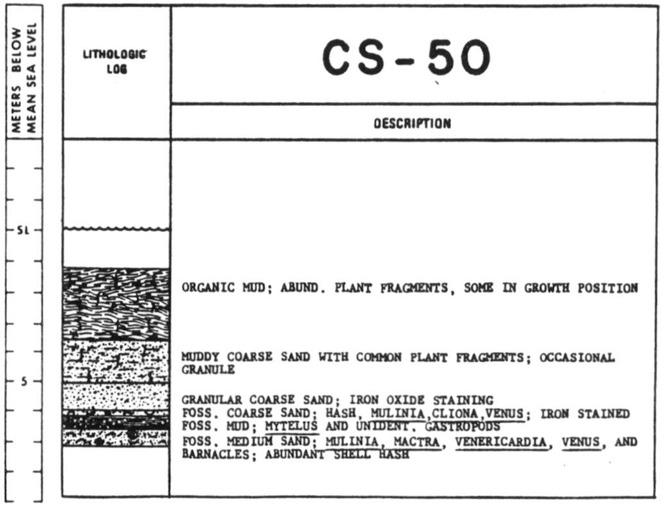
CS-48

PEAT; BROWNISH BLACK
ORGANIC MUDDY PEAT; BROWNISH BLACK
PEAT; BROWNISH BLACK
PEATY, ORGANIC MUDDY MEDIUM SAND; POORLY SORTED; BROWNISH BLK.
CLAYEY MEDIUM SAND WITH PLANT FIBERS COMMON; GREENISH GRAY
SLIGHTLY MUDDY MEDIUM SAND; COMMON WOOD FRAGMENTS;GREENISH GR.
CLEAN FINE TO MEDIUM SAND WITH MINOR SHELL HASH; FRAGMENTS OF *MERCENARIA* AND *VENERICARDIA*



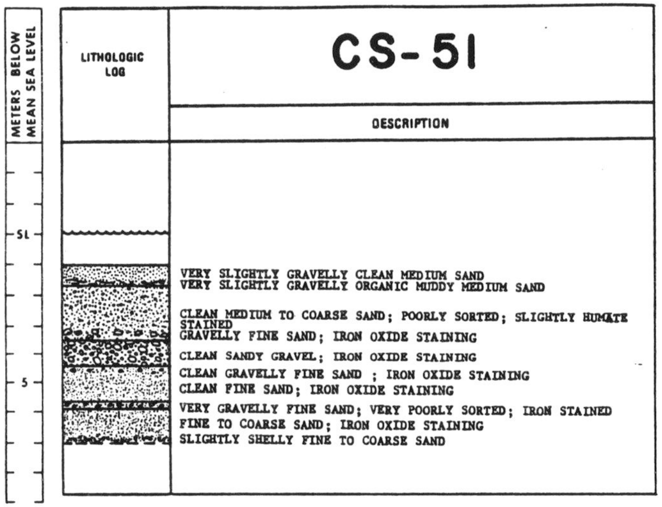
CS-49

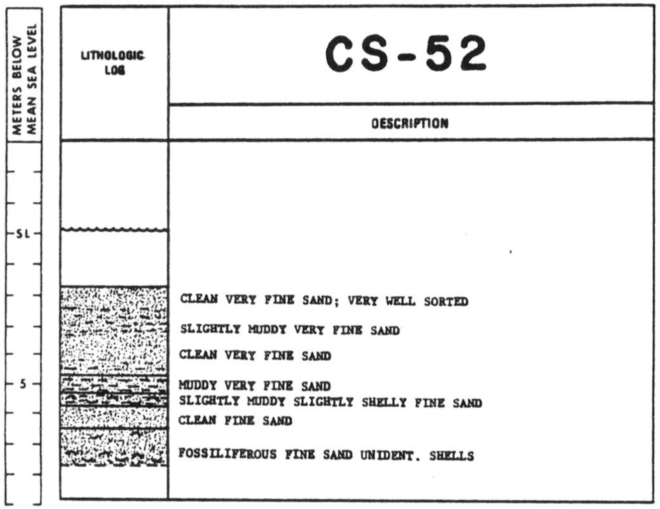
PEATY ORGANIC MUD; DUSKY YELLOW BROWN
PEAT; BROWNISH BLACK
MUDDY GRANULAR COARSE SANDY ORGANIC PEATY MUD; OLIVE BLACK
SLIGHTLY MUDDY GRANULAR COARSE SAND; LIGHT OLIVE GRAY
INTERBEDDED CLEAN GRAVELLY COARSE SAND & GRANULAR GRAVEL YELLOWISH BROWN
CLEAN SLIGHTLY GRANULAR MEDIUM TO COARSE SAND; OLIVE GRAY
CLEAN MEDIUM SAND; WELL SORTED AND ROUNDED; OLIVE GRAY

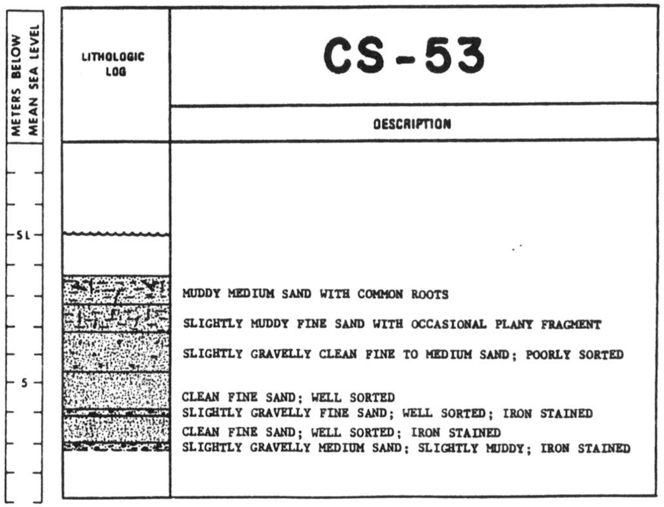


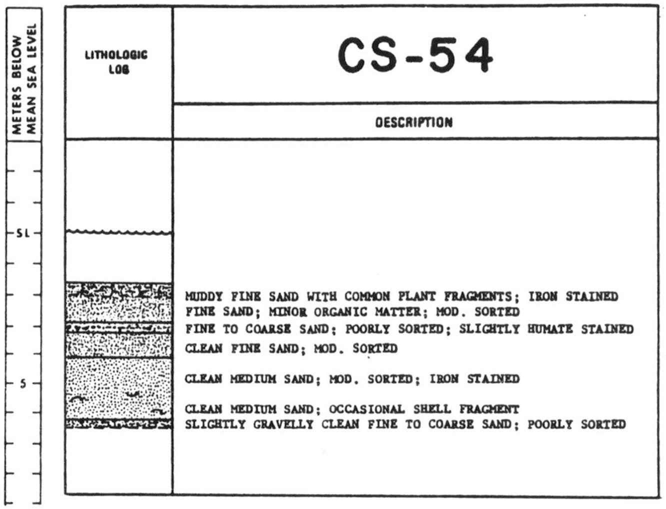
CS-50

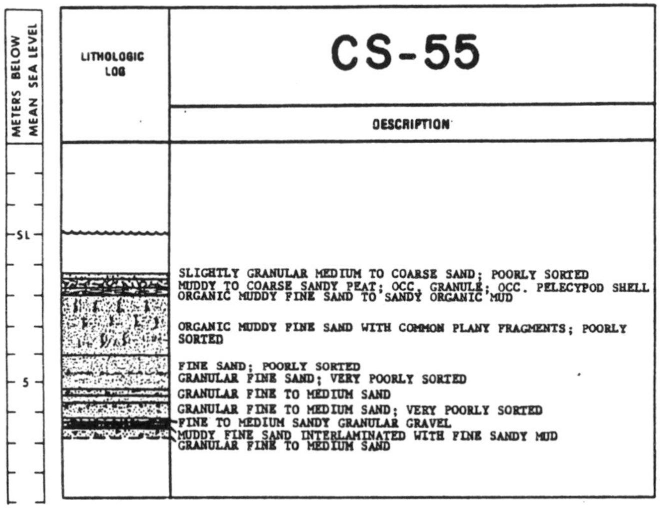
ORGANIC MUD; ABUND. PLANT FRAGMENTS, SOME IN GROWTH POSITION
MUDDY COARSE SAND WITH COMMON PLANT FRAGMENTS; OCCASIONAL GRANULE
GRANULAR COARSE SAND; IRON OXIDE STAINING
FOSS. COARSE SAND; HASH, *MULINIA*,*CLIONA*,*VENUS*; IRON STAINED
FOSS. MUD; *MYTELUS* AND UNIDENT. GASTROPODS
FOSS. MEDIUM SAND; *MULINIA*, *MACTRA*, *VENERICARDIA*, *VENUS*, AND BARNACLES; ABUNDANT SHELL HASH


METERS BELOW MEAN SEA LEVEL
SL
5
LITHOLOGIC LOG
CS-51
DESCRIPTION
VERY SLIGHTLY GRAVELLY CLEAN MEDIUM SAND
VERY SLIGHTLY GRAVELLY ORGANIC MUDDY MEDIUM SAND
CLEAN MEDIUM TO COARSE SAND; POORLY SORTED; SLIGHTLY HUMATE STAINED
GRAVELLY FINE SAND; IRON OXIDE STAINING
CLEAN SANDY GRAVEL; IRON OXIDE STAINING
CLEAN GRAVELLY FINE SAND ; IRON OXIDE STAINING
CLEAN FINE SAND; IRON OXIDE STAINING
VERY GRAVELLY FINE SAND; VERY POORLY SORTED; IRON STAINED
FINE TO COARSE SAND; IRON OXIDE STAINING
SLIGHTLY SHELLY FINE TO COARSE SAND


METERS BELOW MEAN SEA LEVEL
SL
5
LITHOLOGIC LOG
CS-52
DESCRIPTION
CLEAN VERY FINE SAND; VERY WELL SORTED
SLIGHTLY MUDDY VERY FINE SAND
CLEAN VERY FINE SAND
MUDDY VERY FINE SAND
SLIGHTLY MUDDY SLIGHTLY SHELLY FINE SAND
CLEAN FINE SAND
FOSSILIFEROUS FINE SAND UNIDENT. SHELLS


METERS BELOW MEAN SEA LEVEL
SL
5
LITHOLOGIC LOG
CS-53
DESCRIPTION
MUDDY MEDIUM SAND WITH COMMON ROOTS
SLIGHTLY MUDDY FINE SAND WITH OCCASIONAL PLANT FRAGMENT
SLIGHTLY GRAVELLY CLEAN FINE TO MEDIUM SAND; POORLY SORTED
CLEAN FINE SAND; WELL SORTED
SLIGHTLY GRAVELLY FINE SAND; WELL SORTED; IRON STAINED
CLEAN FINE SAND; WELL SORTED; IRON STAINED
SLIGHTLY GRAVELLY MEDIUM SAND; SLIGHTLY MUDDY; IRON STAINED


METERS BELOW MEAN SEA LEVEL
SL
5
LITHOLOGIC LOG
CS-54
DESCRIPTION
MUDDY FINE SAND WITH COMMON PLANT FRAGMENTS; IRON STAINED
FINE SAND; MINOR ORGANIC MATTER; MOD. SORTED
FINE TO COARSE SAND; POORLY SORTED; SLIGHTLY HUMATE STAINED
CLEAN FINE SAND; MOD. SORTED
CLEAN MEDIUM SAND; MOD. SORTED; IRON STAINED
CLEAN MEDIUM SAND; OCCASIONAL SHELL FRAGMENT
SLIGHTLY GRAVELLY CLEAN FINE TO COARSE SAND; POORLY SORTED

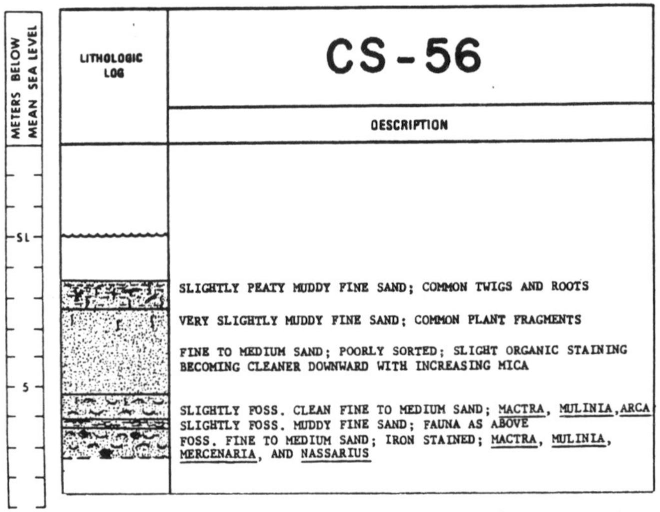


CS-55

SLIGHTLY GRANULAR MEDIUM TO COARSE SAND; POORLY SORTED
MUDDY TO COARSE SANDY PEAT; OCC. GRANULE; OCC. PELECYPOD SHELL
ORGANIC MUDDY FINE SAND TO SANDY ORGANIC MUD

ORGANIC MUDDY FINE SAND WITH COMMON PLANY FRAGMENTS; POORLY SORTED

FINE SAND; POORLY SORTED
GRANULAR FINE SAND; VERY POORLY SORTED
GRANULAR FINE TO MEDIUM SAND
GRANULAR FINE TO MEDIUM SAND; VERY POORLY SORTED
FINE TO MEDIUM SANDY GRANULAR GRAVEL
MUDDY FINE SAND INTERLAMINATED WITH FINE SANDY MUD
GRANULAR FINE TO MEDIUM SAND



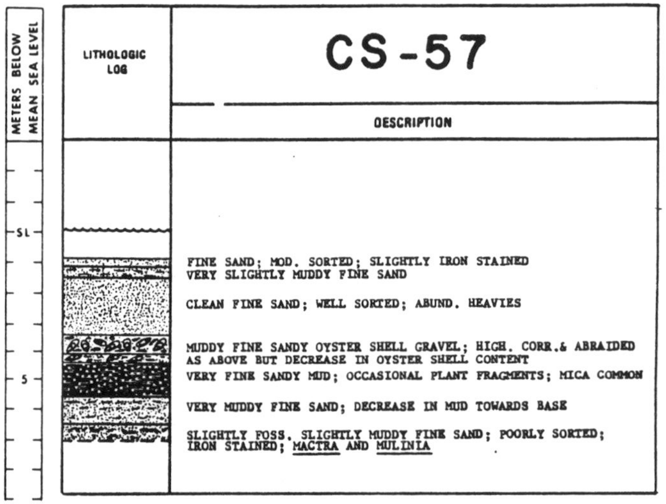
CS-56

SLIGHTLY PEATY MUDDY FINE SAND; COMMON TWIGS AND ROOTS

VERY SLIGHTLY MUDDY FINE SAND; COMMON PLANT FRAGMENTS

FINE TO MEDIUM SAND; POORLY SORTED; SLIGHT ORGANIC STAINING BECOMING CLEANER DOWNWARD WITH INCREASING MICA

SLIGHTLY FOSS. CLEAN FINE TO MEDIUM SAND; MACTRA, MULINIA, ARCA
SLIGHTLY FOSS. MUDDY FINE SAND; FAUNA AS ABOVE
FOSS. FINE TO MEDIUM SAND; IRON STAINED; MACTRA, MULINIA, MERCENARIA, AND NASSARIUS



CS-57

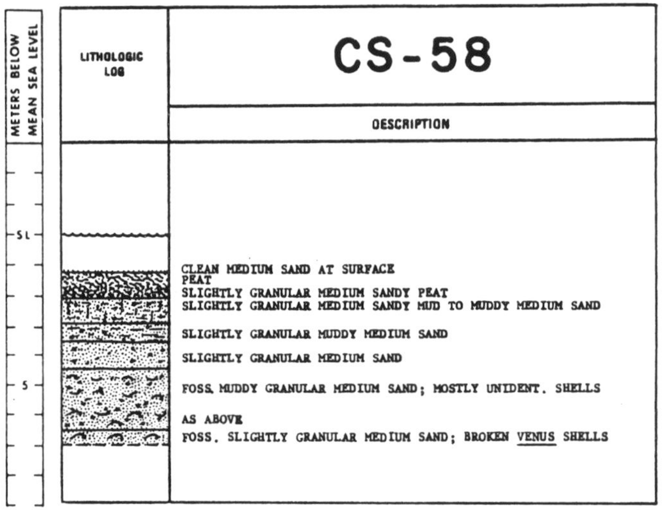
FINE SAND; MOD. SORTED; SLIGHTLY IRON STAINED
VERY SLIGHTLY MUDDY FINE SAND

CLEAN FINE SAND; WELL SORTED; ABUND. HEAVIES

MUDDY FINE SANDY OYSTER SHELL GRAVEL; HIGH. CORR.& ABRAIDED
AS ABOVE BUT DECREASE IN OYSTER SHELL CONTENT
VERY FINE SANDY MUD; OCCASIONAL PLANT FRAGMENTS; MICA COMMON

VERY MUDDY FINE SAND; DECREASE IN MUD TOWARDS BASE

SLIGHTLY FOSS. SLIGHTLY MUDDY FINE SAND; POORLY SORTED; IRON STAINED; MACTRA AND MULINIA



CS-58

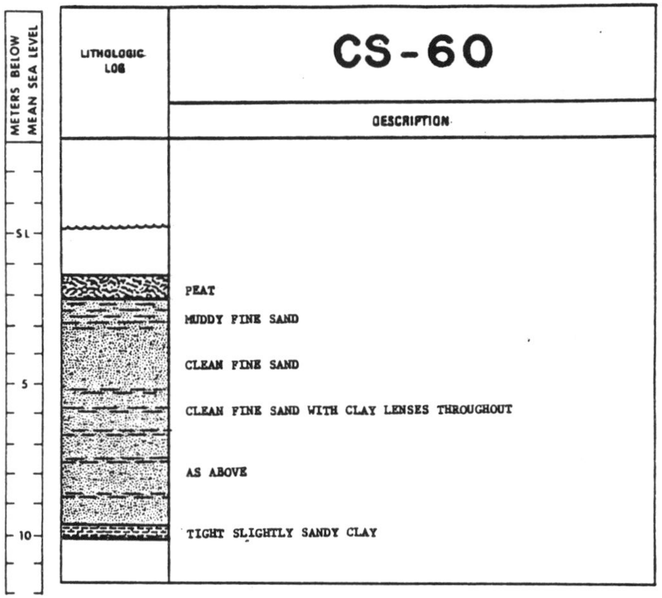
CLEAN MEDIUM SAND AT SURFACE
PEAT
SLIGHTLY GRANULAR MEDIUM SANDY PEAT
SLIGHTLY GRANULAR MEDIUM SANDY MUD TO MUDDY MEDIUM SAND

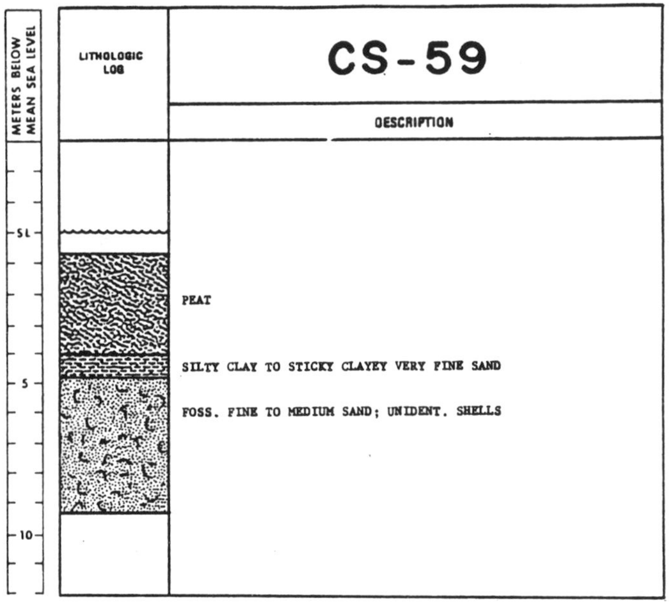
SLIGHTLY GRANULAR MUDDY MEDIUM SAND

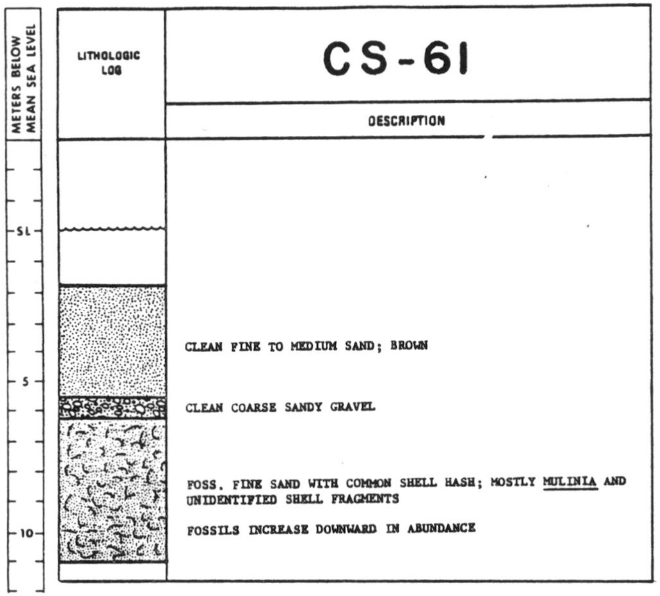
SLIGHTLY GRANULAR MEDIUM SAND

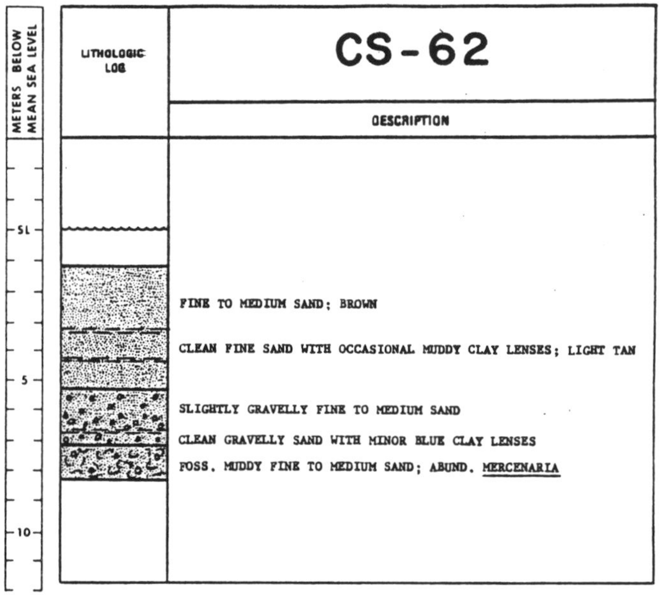
FOSS. MUDDY GRANULAR MEDIUM SAND; MOSTLY UNIDENT. SHELLS

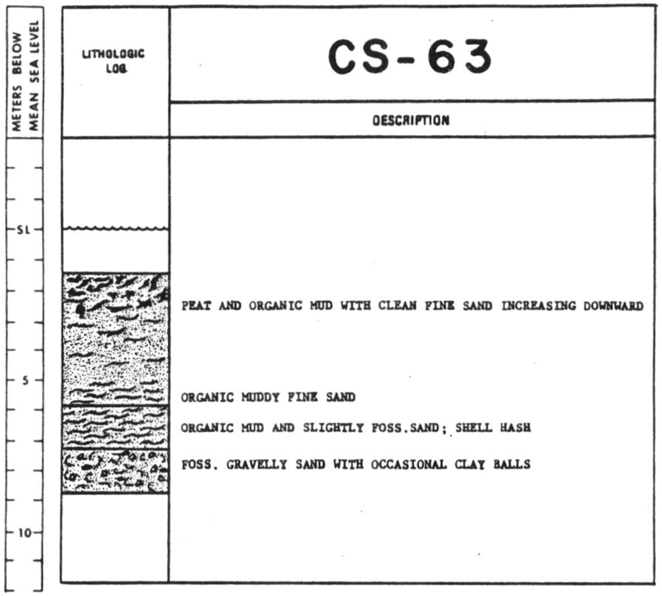
AS ABOVE
FOSS. SLIGHTLY GRANULAR MEDIUM SAND; BROKEN VENUS SHELLS

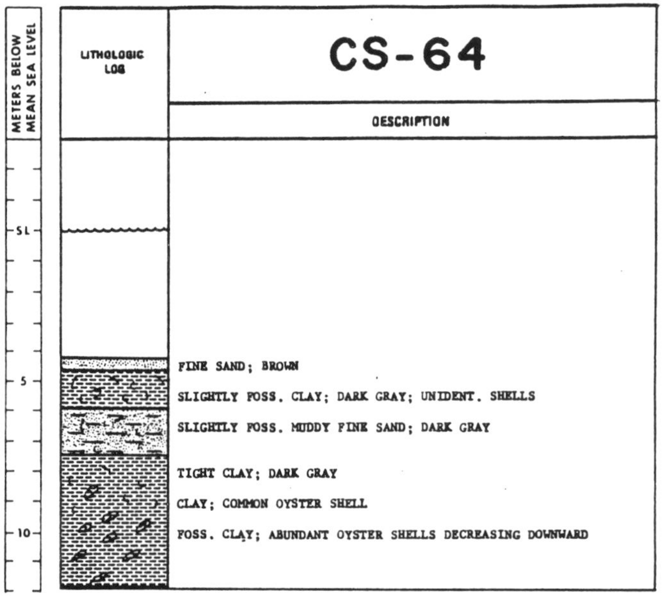

CS-60
METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
DESCRIPTION
SL
5
10
PEAT
MUDDY FINE SAND
CLEAN FINE SAND
CLEAN FINE SAND WITH CLAY LENSES THROUGHOUT
AS ABOVE
TIGHT SLIGHTLY SANDY CLAY

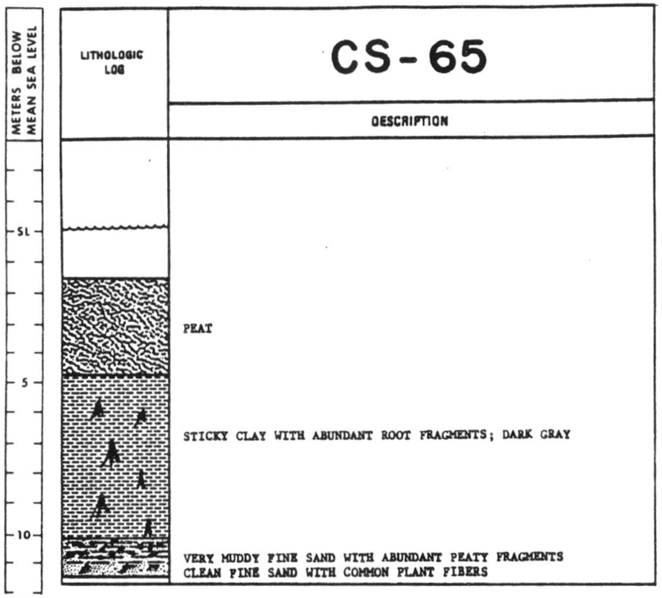

CS-59
METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
DESCRIPTION
SL
5
10
PEAT
SILTY CLAY TO STICKY CLAYEY VERY FINE SAND
FOSS. FINE TO MEDIUM SAND; UNIDENT. SHELLS

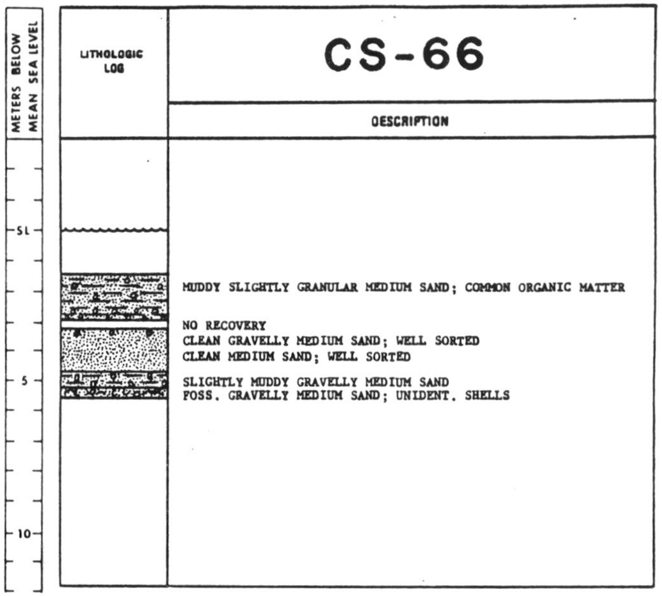

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-61
DESCRIPTION
SL
5
10
CLEAN FINE TO MEDIUM SAND; BROWN
CLEAN COARSE SANDY GRAVEL
FOSS. FINE SAND WITH COMMON SHELL HASH; MOSTLY MULINIA AND UNIDENTIFIED SHELL FRAGMENTS
FOSSILS INCREASE DOWNWARD IN ABUNDANCE


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-62
DESCRIPTION
SL
5
10
FINE TO MEDIUM SAND; BROWN
CLEAN FINE SAND WITH OCCASIONAL MUDDY CLAY LENSES; LIGHT TAN
SLIGHTLY GRAVELLY FINE TO MEDIUM SAND
CLEAN GRAVELLY SAND WITH MINOR BLUE CLAY LENSES
FOSS. MUDDY FINE TO MEDIUM SAND; ABUND. MERCENARIA

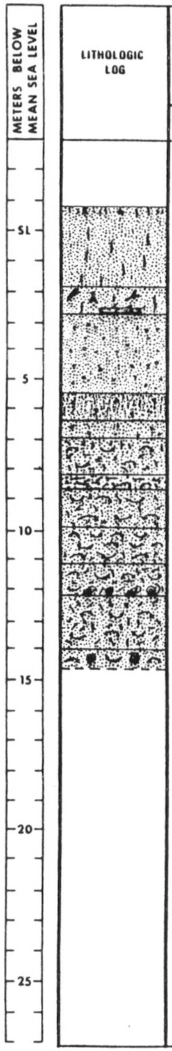

METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-63
DESCRIPTION
SL
5
10
PEAT AND ORGANIC MUD WITH CLEAN FINE SAND INCREASING DOWNWARD
ORGANIC MUDDY FINE SAND
ORGANIC MUD AND SLIGHTLY FOSS.SAND; SHELL HASH
FOSS. GRAVELLY SAND WITH OCCASIONAL CLAY BALLS


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-64
DESCRIPTION
SL
5
10
FINE SAND; BROWN
SLIGHTLY FOSS. CLAY; DARK GRAY; UNIDENT. SHELLS
SLIGHTLY FOSS. MUDDY FINE SAND; DARK GRAY
TIGHT CLAY; DARK GRAY
CLAY; COMMON OYSTER SHELL
FOSS. CLAY; ABUNDANT OYSTER SHELLS DECREASING DOWNWARD


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-65
DESCRIPTION
SL
5
10
PEAT
STICKY CLAY WITH ABUNDANT ROOT FRAGMENTS; DARK GRAY
VERY MUDDY FINE SAND WITH ABUNDANT PEATY FRAGMENTS
CLEAN FINE SAND WITH COMMON PLANT FIBERS


METERS BELOW MEAN SEA LEVEL
LITHOLOGIC LOG
CS-66
DESCRIPTION
SL
5
10
MUDDY SLIGHTLY GRANULAR MEDIUM SAND; COMMON ORGANIC MATTER
NO RECOVERY
CLEAN GRAVELLY MEDIUM SAND; WELL SORTED
CLEAN MEDIUM SAND; WELL SORTED
SLIGHTLY MUDDY GRAVELLY MEDIUM SAND
FOSS. GRAVELLY MEDIUM SAND; UNIDENT. SHELLS

CS-67



DESCRIPTION

MEDIUM SAND; ROOT BEARING; IRON OXIDIZED; LIGHT BROWN

CLEAN MEDIUM SAND; POORLY SORTED; YELLOWISH BROWN; SCATTERED ORGANIC MATTER

MEDIUM SAND WITH PEAT AND CHUNKS OF WOOD

MEDIUM SAND TO GRANULAR MEDIUM SAND; YELLOWISH BROWN

AS ABOVE

FINE SAND TO SLIGHTLY GRANULAR FINE SAND; VERY POORLY SORTED

SLIGHTLY GRANULAR MEDIUM TO COARSE SAND; POORLY SORTED

FOSS. MEDIUM SAND; TRACE OF GRANULES AND MUD; *MULINIA* AND *VENERICARDIA*; GRAY

FOSS. COARSE SAND; TRACE MUD; *MULINIA* AND *VENERICARDIA*; BROWN

FOSS MEDIUM TO COARSE SAND; TRACE OF MUD; *MULINIA* AND *VENERICARDIA*; LIGHT BROWN

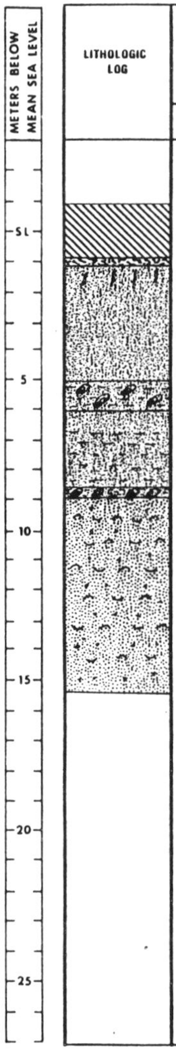
FOSS. MEDIUM TO COARSE SAND; MOSTLY FINE HASH WITH SOME WHOLE AND FRAGMENTS OF *MULINIA* AND *VENERICARDIA*; POORLY SORTED;BROWN

FOSS. MEDIUM SAND; ABUNDANT *VENERICARDIA* (ARTICULATED); MINOR *MULINIA*; SAND IS POORLY SORTED; MEDIUM BROWNISH GRAY

FOSS. MEDIUM SAND; MOSTLY SHELL HASH; WHOLE VALVES OF *MULINIA* AND *VENERICARDIA*; FRAGMENTS OF *MACTRA*, *BUSYCON* AND OYSTER

FOSS. MEDIUM TO COARSE SAND; MULINIA HASH AND WHOLE VALVES OF *MULINIA* AND *VENERICARDIA*; BROKEN *BUSYCON*; MEDIUM BROWN

CS-68



DESCRIPTION

ROAD FILL

SANDY PEAT

CLEAN FINE SAND WITH ABUND. ROOTS AND WOOD FRAGMENTS; WELL SORTED SAND; LIGHT GRAY; MICA COMMON

AS ABOVE BECOMING DARKER GRAY

AS ABOVE

FOSS. MUDDY FINE SAND; ALL OYSTERS (25%); DECREASING DOWNWARDS MUD IS MOTTLED AND BURROWED

SLIGHTLY MUDDY FINE SAND; OCCASIONAL OYSTER FRAG.; DARK GRAY INTERLAMINATED FINE SAND WITH THIN CLAY LAMINAE

AS ABOVE

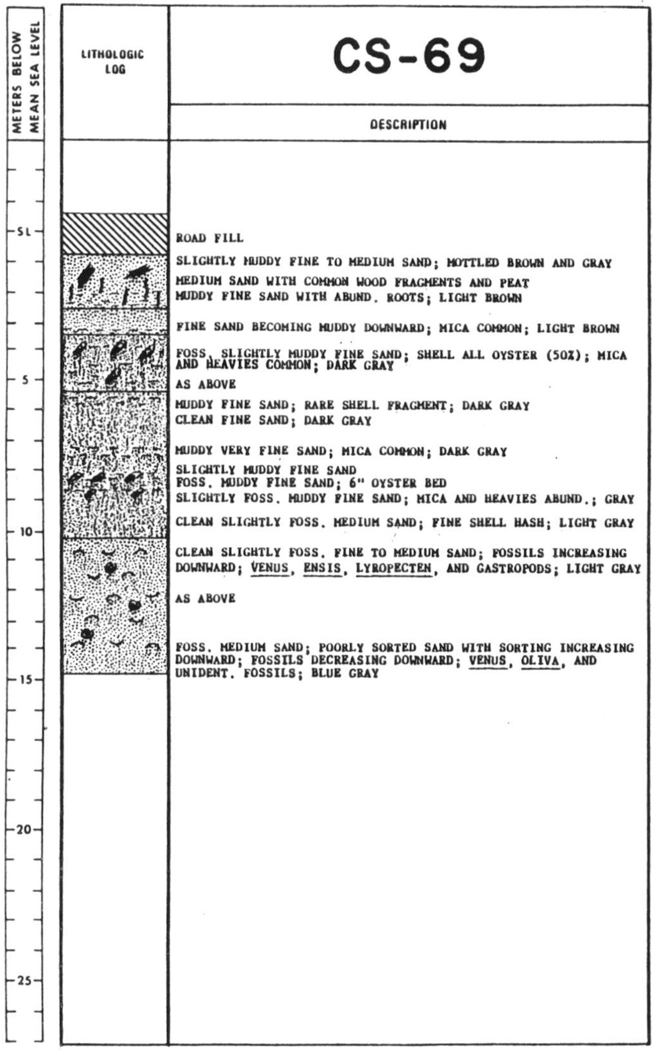
FOSS. MUDDY FINE SAND; ALL OYSTERS (50%)

FOSS. MEDIUM TO COARSE SAND; POORLY SORTED; OCCASIONAL GRANULE SHELLS MOSTLY HASH AND HIGHLY ABRADED SHELLS INC. DOWNWARD SOME LAYERS OF NON-ABRADED *ENSIS* SHELLS; DARK GREENISH GRAY

FOSS. SLIGHTLY MUDDY MEDIUM SAND; SHELL HASH AND FRAGMENTS OF UNIDENT. SHELLS; DARK GREENISH GRAY

FOSS. SLIGHTLY MUDDY MEDIUM SAND; HASH AND NON-ABRADED FRAGS. FEW WHOLE SHELLS; *OLIVA* AND OTHER GASTROPODS; SMALL CLAMS; DARK GREENISH GRAY

CS-69



ROAD FILL

SLIGHTLY MUDDY FINE TO MEDIUM SAND; MOTTLED BROWN AND GRAY

MEDIUM SAND WITH COMMON WOOD FRAGMENTS AND PEAT

MUDDY FINE SAND WITH ABUND. ROOTS; LIGHT BROWN

FINE SAND BECOMING MUDDY DOWNWARD; MICA COMMON; LIGHT BROWN

FOSS. SLIGHTLY MUDDY FINE SAND; SHELL ALL OYSTER (50%); MICA AND HEAVIES COMMON; DARK GRAY

AS ABOVE

MUDDY FINE SAND; RARE SHELL FRAGMENT; DARK GRAY

CLEAN FINE SAND; DARK GRAY

MUDDY VERY FINE SAND; MICA COMMON; DARK GRAY

SLIGHTLY MUDDY FINE SAND

FOSS. MUDDY FINE SAND; 6" OYSTER BED

SLIGHTLY FOSS. MUDDY FINE SAND; MICA AND HEAVIES ABUND.; GRAY

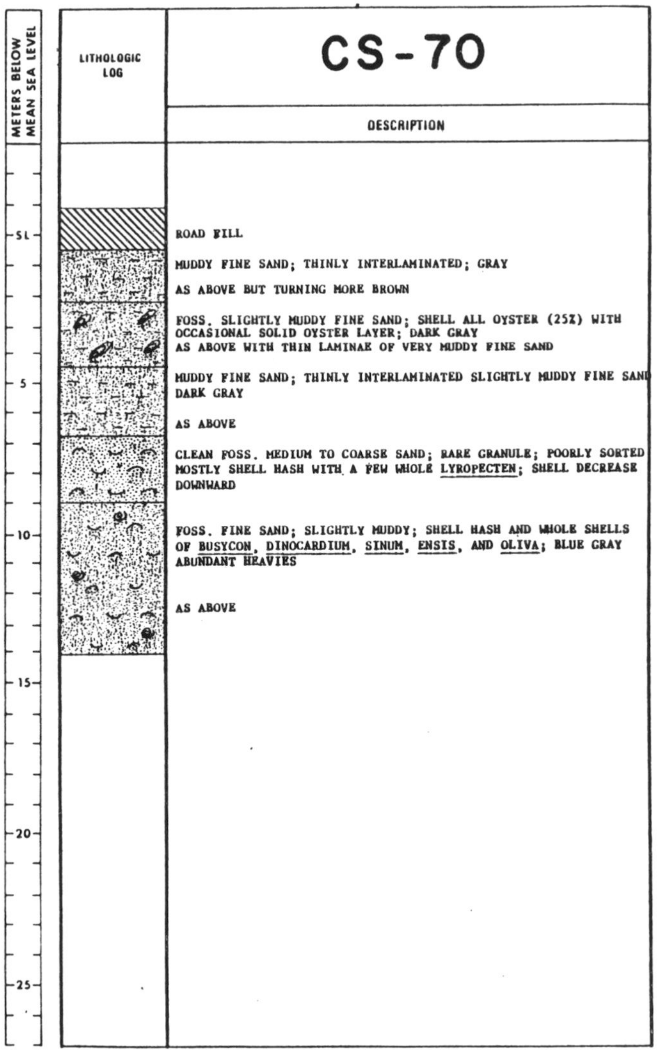
CLEAN SLIGHTLY FOSS. MEDIUM SAND; FINE SHELL HASH; LIGHT GRAY

CLEAN SLIGHTLY FOSS. FINE TO MEDIUM SAND; FOSSILS INCREASING DOWNWARD; VENUS, ENSIS, LYROPECTEN, AND GASTROPODS; LIGHT GRAY

AS ABOVE

FOSS. MEDIUM SAND; POORLY SORTED SAND WITH SORTING INCREASING DOWNWARD; FOSSILS DECREASING DOWNWARD; VENUS, OLIVA, AND UNIDENT. FOSSILS; BLUE GRAY

CS-70



ROAD FILL

MUDDY FINE SAND; THINLY INTERLAMINATED; GRAY

AS ABOVE BUT TURNING MORE BROWN

FOSS. SLIGHTLY MUDDY FINE SAND; SHELL ALL OYSTER (25%) WITH OCCASIONAL SOLID OYSTER LAYER; DARK GRAY

AS ABOVE WITH THIN LAMINAE OF VERY MUDDY FINE SAND

MUDDY FINE SAND; THINLY INTERLAMINATED SLIGHTLY MUDDY FINE SAND DARK GRAY

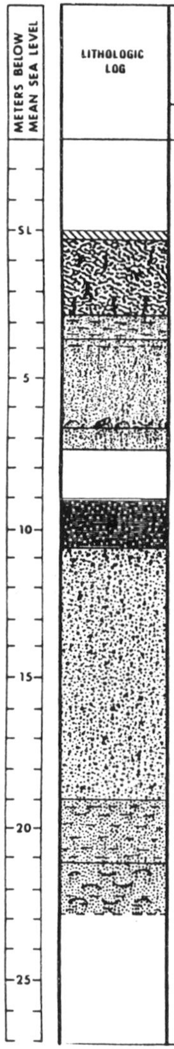
AS ABOVE

CLEAN FOSS. MEDIUM TO COARSE SAND; RARE GRANULE; POORLY SORTED MOSTLY SHELL HASH WITH A FEW WHOLE LYROPECTEN; SHELL DECREASE DOWNWARD

FOSS. FINE SAND; SLIGHTLY MUDDY; SHELL HASH AND WHOLE SHELLS OF BUSYCON, DINOCARDIUM, SINUM, ENSIS, AND OLIVA; BLUE GRAY ABUNDANT HEAVIES

AS ABOVE

CS-71



DESCRIPTION

ROAD FILL

PEAT WITH ABUNDANT PLANT MATERIAL

MUDDY FINE SAND; LIGHT BLUEISH GRAY

SLIGHTLY MUDDY FINE SAND; LIGHT GRAY

CLEAN FINE SAND; LIGHT GRAY

FOSS. COARSE SAND; CRASSOSTREA, MULINIA, AND ENSIS FRAGMENTS

CLEAN FINE SAND; FINE DISSEMINATED SHELL MATERIAL

NO RECOVERY

MUDDY SILT; INC. SAND DOWNWARD TO VERY FINE SANDY MUD FINELY INTERLAMINATED; DARK GRAY

GRANULAR COARSE SAND; POORLY SORTED

CLEAN VERY FINE TO FINE SAND; WELL SORTED

CLEAN GRANULAR MEDIUM TO COARSE SAND; DARK GRAY

AS ABOVE

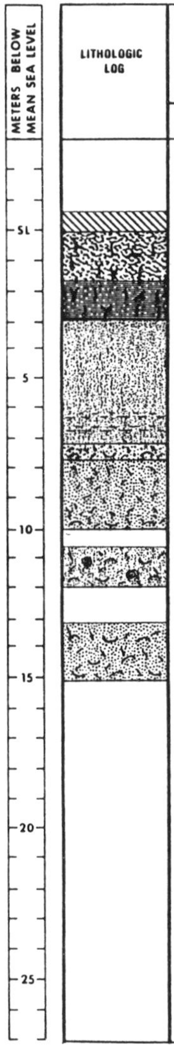
MUDDY FINE SAND

AS ABOVE

FOSS. SLIGHTLY MUDDY FINE TO MEDIUM SAND; OCC. GRANULE; MOSTLY MULINIA FRAGMENTS

SLIGHTLY FOSS. MUDDY VERY FINE TO FINE SAND; MULINIA; gray

CS-72



DESCRIPTION

ROAD FILL

ORGANIC MUDDY, FINE SANDY PEAT; ABUND. ROOT MATERIAL; LIGHT GRAY TO YELLOWISH BROWN

MUDDY COARSE SILT; HOMOGENOUS; ABUND. PLANT FIBERS; LIGHT GRAY

CLEAN FINE SAND; VERY POORLY SORTED; LIGHT GRAY

MUDDY VERY FINE SAND; CLAY LAMINAE UP TO 2 CM.; LIGHT GRAY

FOSS. SLIGHTLY GRANULAR MUDDY COARSE SAND; ARCA, MERCENARIA, AND CRASSOSTREA; BARNACLE FRAGMENTS; MEDIUM GRAY

FOSS. MUDDY FINE TO MEDIUM SAND; MERCENARIA AND ENSIS; GRAY

AS ABOVE

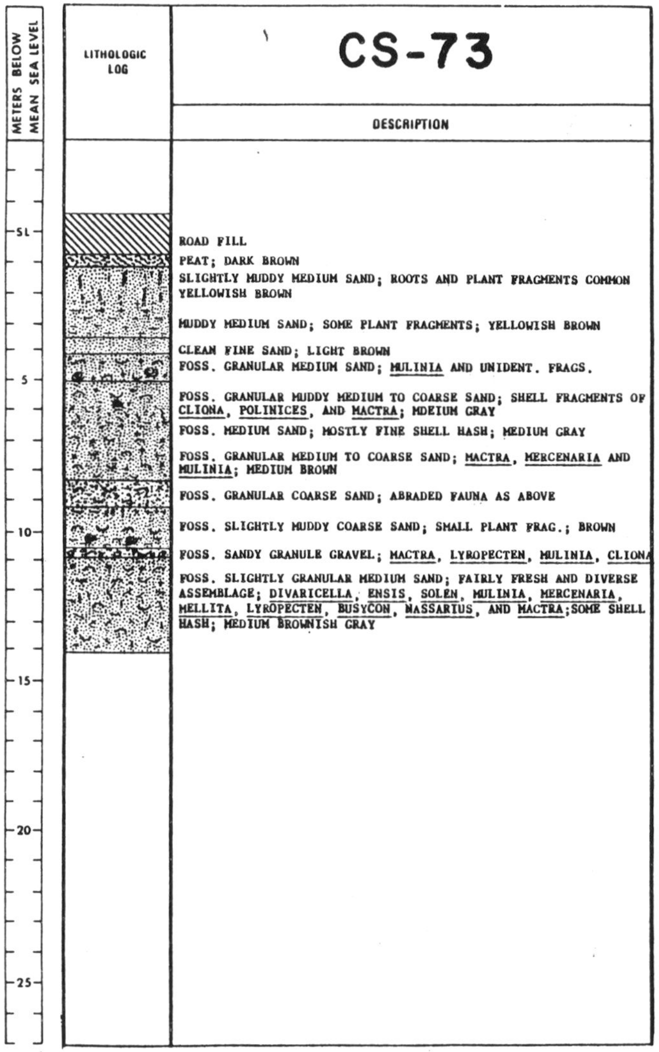
NO RECOVERY

FOSS. SLIGHTLY MUDDY FINE SAND; MERCENARIA, ENSIS, AND POLINICES; MEDIUM GRAY

NO RECOVERY

FOSS. MEDIUM SAND; MULINIA, MERCENARIA, BRYOZOANS AND FINE SHELL HASH; SOME LAYERS HIGHLY FOSSILIFEROUS

CS-73



ROAD FILL

PEAT; DARK BROWN

SLIGHTLY MUDDY MEDIUM SAND; ROOTS AND PLANT FRAGMENTS COMMON YELLOWISH BROWN

MUDDY MEDIUM SAND; SOME PLANT FRAGMENTS; YELLOWISH BROWN

CLEAN FINE SAND; LIGHT BROWN

FOSS. GRANULAR MEDIUM SAND; MULINIA AND UNIDENT. FRAGS.

FOSS. GRANULAR MUDDY MEDIUM TO COARSE SAND; SHELL FRAGMENTS OF CLIONA, POLINICES, AND MACTRA; MDEIUM GRAY

FOSS. MEDIUM SAND; MOSTLY FINE SHELL HASH; MEDIUM GRAY

FOSS. GRANULAR MEDIUM TO COARSE SAND; MACTRA, MERCENARIA AND MULINIA; MEDIUM BROWN

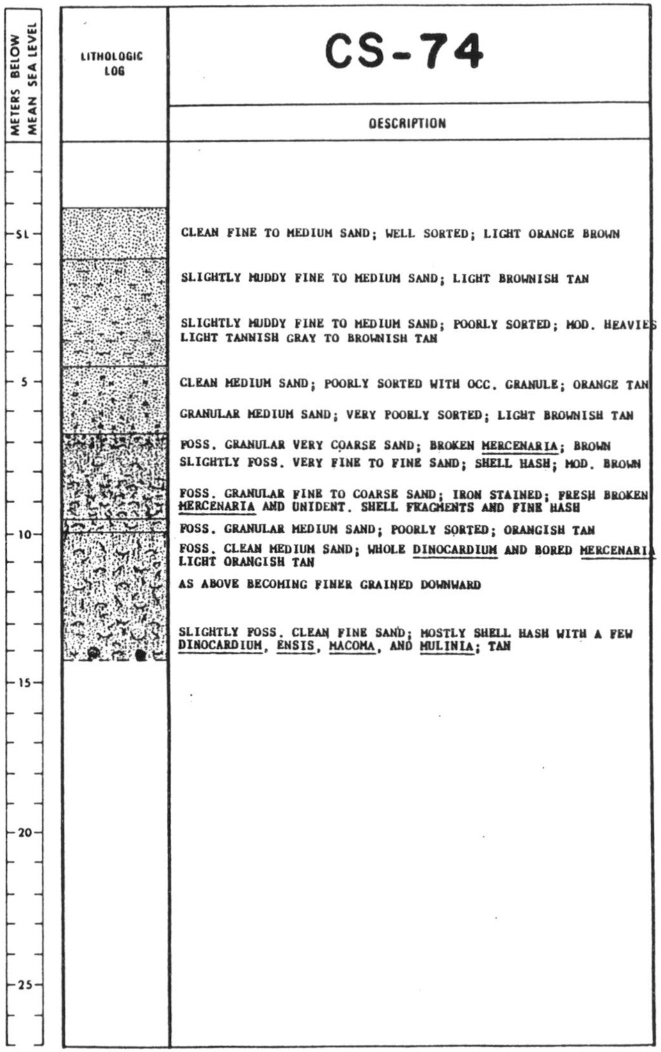
FOSS. GRANULAR COARSE SAND; ABRADED FAUNA AS ABOVE

FOSS. SLIGHTLY MUDDY COARSE SAND; SMALL PLANT FRAG.; BROWN

FOSS. SANDY GRANULE GRAVEL; MACTRA, LYROPECTEN, MULINIA, CLIONA

FOSS. SLIGHTLY GRANULAR MEDIUM SAND; FAIRLY FRESH AND DIVERSE ASSEMBLAGE; DIVARICELLA, ENSIS, SOLEN, MULINIA, MERCENARIA, MELLITA, LYROPECTEN, BUSYCON, NASSARIUS, AND MACTRA;SOME SHELL HASH; MEDIUM BROWNISH GRAY

CS-74



CLEAN FINE TO MEDIUM SAND; WELL SORTED; LIGHT ORANGE BROWN

SLIGHTLY MUDDY FINE TO MEDIUM SAND; LIGHT BROWNISH TAN

SLIGHTLY MUDDY FINE TO MEDIUM SAND; POORLY SORTED; MOD. HEAVIES LIGHT TANNISH GRAY TO BROWNISH TAN

CLEAN MEDIUM SAND; POORLY SORTED WITH OCC. GRANULE; ORANGE TAN

GRANULAR MEDIUM SAND; VERY POORLY SORTED; LIGHT BROWNISH TAN

FOSS. GRANULAR VERY COARSE SAND; BROKEN MERCENARIA; BROWN

SLIGHTLY FOSS. VERY FINE TO FINE SAND; SHELL HASH; MOD. BROWN

FOSS. GRANULAR FINE TO COARSE SAND; IRON STAINED; FRESH BROKEN MERCENARIA AND UNIDENT. SHELL FRAGMENTS AND FINE HASH

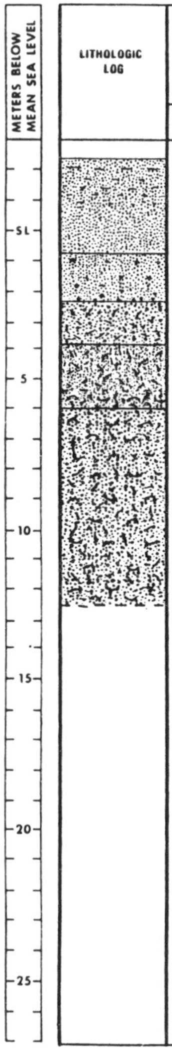
FOSS. GRANULAR MEDIUM SAND; POORLY SORTED; ORANGISH TAN

FOSS. CLEAN MEDIUM SAND; WHOLE DINOCARDIUM AND BORED MERCENARIA LIGHT ORANGISH TAN

AS ABOVE BECOMING FINER GRAINED DOWNWARD

SLIGHTLY FOSS. CLEAN FINE SAND; MOSTLY SHELL HASH WITH A FEW DINOCARDIUM, ENSIS, MACOMA, AND MULINIA; TAN

CS-75



DESCRIPTION

SILTY MEDIUM SAND; POORLY SORTED; LIGHT BROWN

SLIGHTLY MUDDY MEDIUM SAND; LIGHT BROWN

CLEAN MEDIUM SAND; MOD. SORTED; TRACE OF MUD

GRANULAR MEDIUM TO COARSE SAND; VERY POORLY SORTED; BECOMING HIGHLY OXIDIZED

SLIGHTLY GRANULAR MEDIUM SAND; DARK REDDISH BROWN; IRON STAINED

FOSS. GRANULAR COARSE SAND; FINE SHELL HASH AND FRAGMENTS OF MERCENARIA AND MULINIA; LIGHT YELLOWISH BROWN

FOSS. FINE SAND; VERY FINE SHELL HASH; SAND IS WELL SORTED; MEDIUM BROWN

FOSS. FINE SAND; MERCENARIA AND MULINIA; LIGHT BROWN

FOSS. SANDY GRANULAR GRAVEL; FINE SHELL HASH; YELLOWISH BROWN

FOSS. FINE SAND; VERY FINE SHELL HASH; COMMON HEAVIES; BROWN

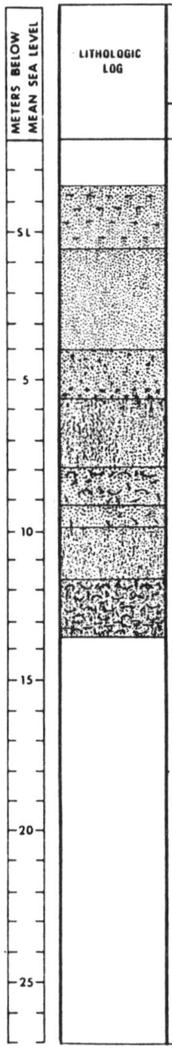
FOSS. SLIGHTLY GRANULAR COARSE SAND; COARSE SHELL HASH; MOSTLY MULINIA; YELLOWISH RED

FOSS. MEDIUM SAND; MACTRA AND MULINIA; LIGHT YELLOWISH RED

FOSS. MEDIUM TO COARSE SAND; MOSTLY FINE HASH WITH FRAGMENTS OF MACTRA AND MULINIA; MEDIUM GRAY

SHELL GRAVEL; MOSTLY MULINIA WITH MINOR DINOCARDIUM, MACTRA, MERCENARIA, AND NASSARIUS; DARK GRAY

CS-76



DESCRIPTION

MUDDY MEDIUM SAND; MOD. SORTED; DARK BROWN TO REDDISH BROWN

SLIGHTLY MUDDY MEDIUM SNAD; IRON STAINED

CLEAN MEDIUM SAND; MOD. HEAVIES; LIGHT TAN

FINE TO MEDIUM SAND; TAN TO DARK BROWN IRON STAINED

GRANULAR COARSE SAND; POORLY SORTED; MEDIUM RED BROWN

FINE SAND INTERBEDDED WITH SANDY GRANULAR GRAVEL (50%) GRAVEL

VERY FINE TO FINE CLEAN SAND; GRAY

AS ABOVE

FOSS. CLEAN MEDIUM SAND; MACTRA AND MULINIA; MEDIUM GRAY

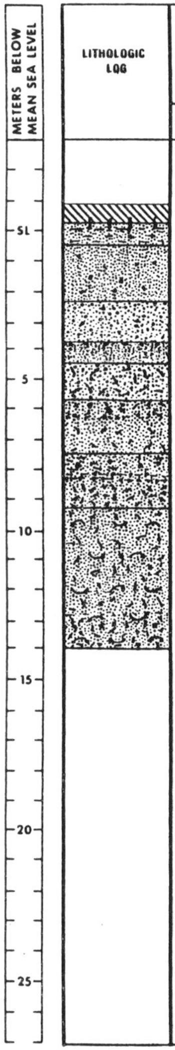
SLIGHTLY FOSS. CLEAN MEDIUM SAND; FINE SHELL HASH; LIGHT GRAY

CLEAN MEDIUM SAND

CLEAN FOSS. FINE SAND; WELL SORTED; MACOMA, MULINIA, AND VENERICARDIA; GRAY

VERY MUDDY FINE SAND; FOSSILS ARE WHOLE MACOMA AND MULINIA AND SOME SHELL HASH UP TO 50% FOSSILS; DARK GRAY

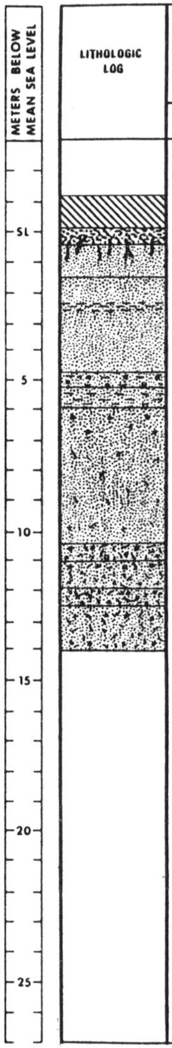
CS-77



DESCRIPTION

BRICK FILL
MUDDY MEDIUM SAND WITH COMMON PLANT FRAGMENTS AND ROOTS; TAN
GRAVELLY MEDIUM SAND;
SLIGHTLY GRANULAR COARSE SAND; DARK REDDISH BROWN
CLEAN FINE SAND; VERY WELL SORTED; OCC. GRANULE LAMINAE; GRAY
FOSS. GRANULAR FINE TO COARSE SAND; ABRADED MACTRA AND VENUS
SLIGHTLY FOSS. GRANULAR FINE TO COARSE SAND; ABRADED HASH AND FRAGMENTS OF MERCENARIA AND MULINIA; OLIVE GRAY
VERY SLIGHTLY FOSS. MEDIUM SAND; POORLY SORTED; FAUNA AS ABOVE
MUDDY GRANULAR MEDIUM SAND; REDDISH BROWN
FOSS. MEDIUM SAND; MOD. SORTED; MOSTLY SHELL HASH AND FRAGMENTS OF MACOMA AND MULINIA; TAN
AS ABOVE WITH SOME WHOLE SHELLS OF MULINIA AND VENERICARDIA
CLEAN FOSS. MEDIUM TO COARSE SAND; ABRADED MEDIUM TO COARSE HASH; BROWN TO TAN
AS ABOVE WITH FOSSILS INCREASING TO ABOUT 30%
SLIGHTLY MUDDY GRANULAR FOSS. MEDIUM SAND; WHOLE SHELLS AND FRAGMENTS OF MULINIA; RED BROWN TO GRAY

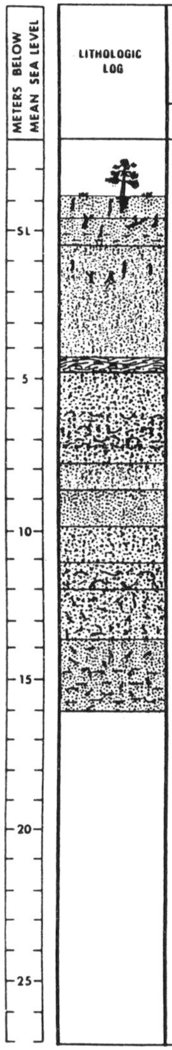
CS-78



DESCRIPTION

DREDGE FILL
PEAT
SLIGHTLY MUDDY FINE TO MEDIUM SAND WITH ABUND. PLANT FRAGMENTS
CLEAN MEDIUM SAND; WELL SORTED; MEDIUM BROWN
AS ABOVE
CLAYEY MEDIUM SAND; CLAY DECREASING DOWNWARD; LIGHT BLUEISH GRAY; VERY SHARP UPPER CONTACT
VERY CLEAN MEDIUM SAND; MOD. WELL SORTED; WHITE
CLEAN GRANULAR MEDIUM SAND; POORLY SORTED; YELLOWISH TAN
INTERBEDDED FINE SANDS WITH SLIGHTLY MUDDY FINE SANDS
CLEAN GRANULAR MEDIUM SANDS; YELLOWISH TAN
CLEAN MEDIUM SAND; OCCASIONAL ABRADED SHELL; WELL SORTED; LIGHT TAN
AS ABOVE
SANDY SHELL HASH AND QUARTZ GRAVEL (75%); MERCENARIA AND HASH
CLEAN FOSS. GRANULAR MEDIUM SAND; ABRADED HASH, UNIDENT.; GRAY
SLIGHTLY GRANULAR FOSS. MEDIUM SAND; FINE HASH AND DINOCARDIUM
SLIGHTLY GRANULAR FINE TO MEDIUM SAND; MOD. SORTED; FINE WHITE HASH WITH FEW LARGER UNIDENT. FRAGMENTS; LIGHT GRAY

CS-79



DESCRIPTION

MEDIUM SAND WITH COMMON ORGANIC FRAGMENTS; ROOTS; LIGHT GRAY

ORGANIC RICH MEDIUM SAND; ROOTS; FINE ORGANIC FIBERS

SILTY MEDIUM SAND; LIGHT YELLOW BROWN

FINE SAND; MOD. SORTED; MEDIUM BROWN

VERY SLIGHTLY MUDDY FINE SAND; COMMON ROOTS; YELLOW TO REDDISH BROWN; IRON STAINED

CLEAN FINE SAND; MEDIUM YELLOWISH BROWN

ORGANIC MUD OR FINE PEAT; TRACE OF SAND; DARK GREENISH GRAY

SLIGHTLY MUDDY GRANULAR MEDIUM SAND; MEDIUM YELLOWISH BROWN

FOSS. MUDDY GRANULAR MEDIUM SAND; SLIGHTLY ABRADED *MERCENARIA*, *MULINIA*, *NASSARIUS*, AND *VENERICARDIA*; SOME FINE HASH; GRAY

MUDDY GRANULAR MEDIUM SAND; MEDIUM GRAYISH BROWN

SLIGHTLY MUDDY FINE SAND; MEDIUM GRAY

MEDIUM TO COARSE SAND; MEDIUM GRAY

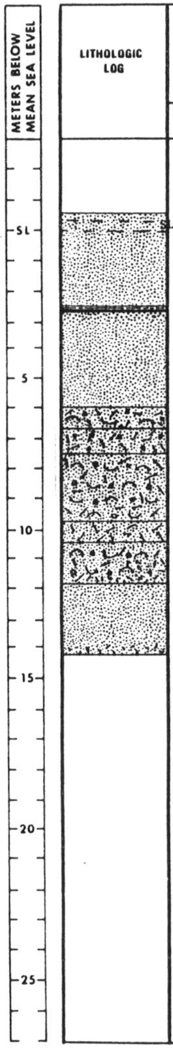
SLIGHTLY GRANULAR COARSE SAND; DARK GRAYISH BROWN

SLIGHTLY FOSS. SLIGHTLY GRANULAR COARSE SAND; 1 *MERCENARIA*

FOSS. SLIGHTLY GRANULAR MEDIUM SAND; FINE SHELL HASH, UNIDENT. FRAGMENT OF *CHIONE*

FOSS. MEDIUM SAND; OCCASIONAL GRAVEL AND OCCASIONAL MUD LAMINAE; MOSTLY UNIDENT. SHELL HASH; 1 OYSTER SHELL

CS-80



DESCRIPTION

SLIGHTLY MUDDY MEDIUM SAND; POORLY SORTED; LIGHT BROWNISH TAN

CLEAN MEDIUM SAND; WELL SORTED; REDDISH BROWN

AS ABOVE

TIGHT CLAY WITH ABUND. PLANT FRAGMENTS; DARK BLUE GRAY

CLEAN MEDIUM SAND; WELL SORTED; MOD. GRAY

AS ABOVE

FOSS. GRANULAR MEDIUM SAND; ABRADED HASH WITH BROKEN *MULINIA* AND *VENERICARDIA*; VERY POORLY SORTED; BLACK OR DARK STAIN

AS ABOVE WITH FINER SHELL HASH; SOME *MULINIA*

FOSS. GRANULAR MEDIUM SAND; POORLY SORTED; FAUNA AS ABOVE

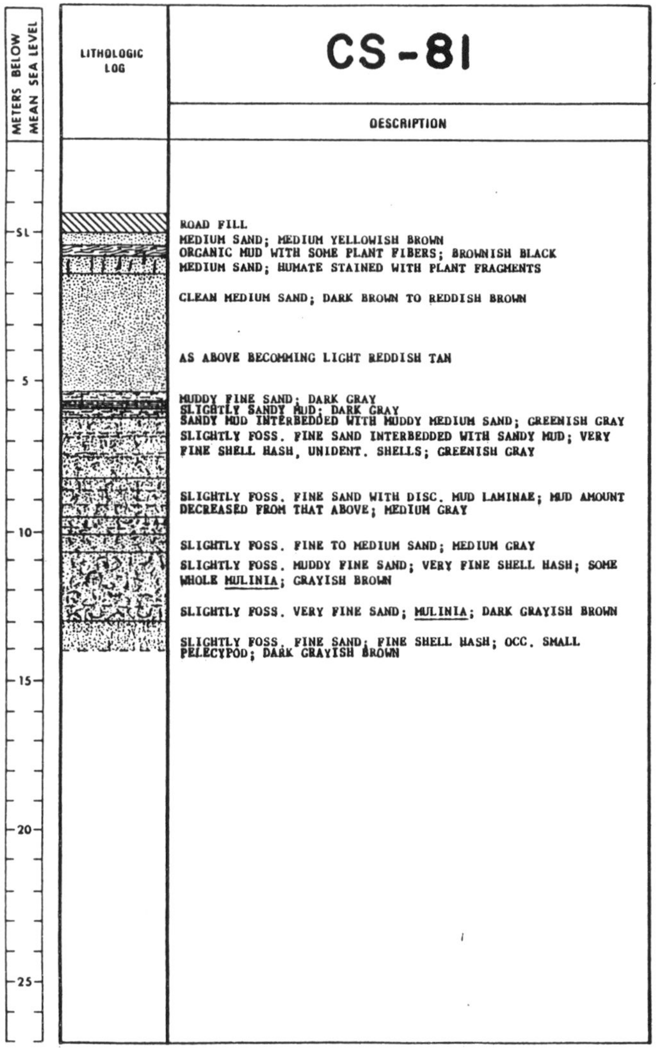
AS ABOVE

FOSS. MEDIUM SAND; MOSTLY SHELL HASH, UNIDENT. SHELLS

FOSS. GRANULAR MEDIUM SAND; *MERCENARIA*, *MULINIA*, AND *NASSARIUS* SOME SHELL HASH; SAND IS POORLY SORTED; GRAY

CLEAN FINE TO MEDIUM SAND; SMALL AMOUNT OF FINE SHELL HASH; WELL SORTED; GRAY

CLEAN FINE TO MEDIUM SAND; WELL SORTED; 1 TO 2 % FINE SHELL HASH; GRAY



CS-81

DESCRIPTION

ROAD FILL
MEDIUM SAND; MEDIUM YELLOWISH BROWN
ORGANIC MUD WITH SOME PLANT FIBERS; BROWNISH BLACK
MEDIUM SAND; HUMATE STAINED WITH PLANT FRAGMENTS

CLEAN MEDIUM SAND; DARK BROWN TO REDDISH BROWN

AS ABOVE BECOMMING LIGHT REDDISH TAN

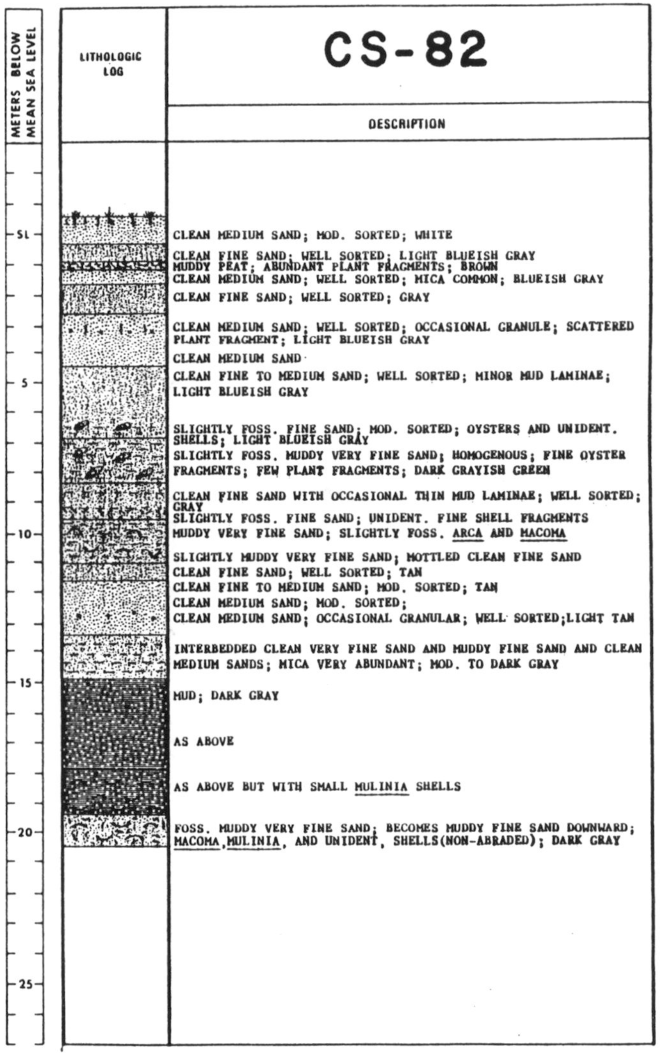
MUDDY FINE SAND; DARK GRAY
SLIGHTLY SANDY MUD; DARK GRAY
SANDY MUD INTERBEDDED WITH MUDDY MEDIUM SAND; GREENISH GRAY
SLIGHTLY FOSS. FINE SAND INTERBEDDED WITH SANDY MUD; VERY FINE SHELL HASH, UNIDENT. SHELLS; GREENISH GRAY

SLIGHTLY FOSS. FINE SAND WITH DISC. MUD LAMINAE; MUD AMOUNT DECREASED FROM THAT ABOVE; MEDIUM GRAY

SLIGHTLY FOSS. FINE TO MEDIUM SAND; MEDIUM GRAY
SLIGHTLY FOSS. MUDDY FINE SAND; VERY FINE SHELL HASH; SOME WHOLE MULINIA; GRAYISH BROWN

SLIGHTLY FOSS. VERY FINE SAND; MULINIA; DARK GRAYISH BROWN

SLIGHTLY FOSS. FINE SAND; FINE SHELL HASH; OCC. SMALL PELECYPOD; DARK GRAYISH BROWN



CS-82

DESCRIPTION

CLEAN MEDIUM SAND; MOD. SORTED; WHITE
CLEAN FINE SAND; WELL SORTED; LIGHT BLUEISH GRAY
MUDDY PEAT; ABUNDANT PLANT FRAGMENTS; BROWN
CLEAN MEDIUM SAND; WELL SORTED; MICA COMMON; BLUEISH GRAY
CLEAN FINE SAND; WELL SORTED; GRAY

CLEAN MEDIUM SAND; WELL SORTED; OCCASIONAL GRANULE; SCATTERED PLANT FRAGMENT; LIGHT BLUEISH GRAY
CLEAN MEDIUM SAND
CLEAN FINE TO MEDIUM SAND; WELL SORTED; MINOR MUD LAMINAE; LIGHT BLUEISH GRAY

SLIGHTLY FOSS. FINE SAND; MOD. SORTED; OYSTERS AND UNIDENT. SHELLS; LIGHT BLUEISH GRAY
SLIGHTLY FOSS. MUDDY VERY FINE SAND; HOMOGENOUS; FINE OYSTER FRAGMENTS; FEW PLANT FRAGMENTS; DARK GRAYISH GREEN

CLEAN FINE SAND WITH OCCASIONAL THIN MUD LAMINAE; WELL SORTED; GRAY
SLIGHTLY FOSS. FINE SAND; UNIDENT. FINE SHELL FRAGMENTS
MUDDY VERY FINE SAND; SLIGHTLY FOSS. ARCA AND MACOMA

SLIGHTLY MUDDY VERY FINE SAND; MOTTLED CLEAN FINE SAND
CLEAN FINE SAND; WELL SORTED; TAN
CLEAN FINE TO MEDIUM SAND; MOD. SORTED; TAN
CLEAN MEDIUM SAND; MOD. SORTED;
CLEAN MEDIUM SAND; OCCASIONAL GRANULAR; WELL SORTED;LIGHT TAN

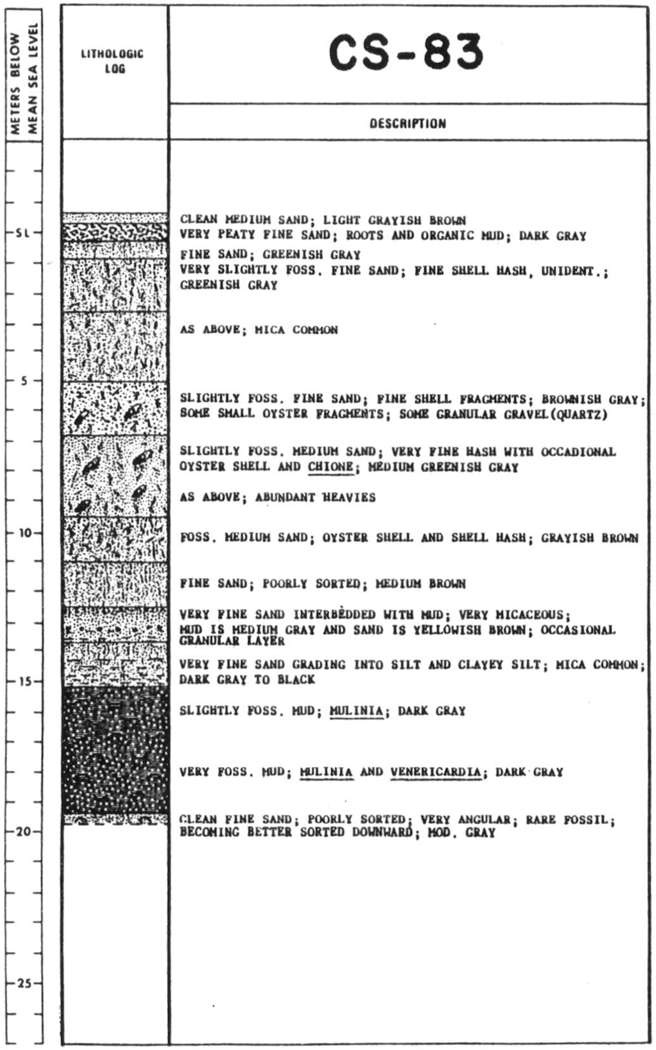
INTERBEDDED CLEAN VERY FINE SAND AND MUDDY FINE SAND AND CLEAN MEDIUM SANDS; MICA VERY ABUNDANT; MOD. TO DARK GRAY

MUD; DARK GRAY

AS ABOVE

AS ABOVE BUT WITH SMALL MULINIA SHELLS

FOSS. MUDDY VERY FINE SAND; BECOMES MUDDY FINE SAND DOWNWARD; MACOMA, MULINIA, AND UNIDENT. SHELLS(NON-ABRADED); DARK GRAY



CS-83

DESCRIPTION

CLEAN MEDIUM SAND; LIGHT GRAYISH BROWN

VERY PEATY FINE SAND; ROOTS AND ORGANIC MUD; DARK GRAY

FINE SAND; GREENISH GRAY

VERY SLIGHTLY FOSS. FINE SAND; FINE SHELL HASH, UNIDENT.; GREENISH GRAY

AS ABOVE; MICA COMMON

SLIGHTLY FOSS. FINE SAND; FINE SHELL FRAGMENTS; BROWNISH GRAY; SOME SMALL OYSTER FRAGMENTS; SOME GRANULAR GRAVEL(QUARTZ)

SLIGHTLY FOSS. MEDIUM SAND; VERY FINE HASH WITH OCCADIONAL OYSTER SHELL AND *CHIONE*; MEDIUM GREENISH GRAY

AS ABOVE; ABUNDANT HEAVIES

FOSS. MEDIUM SAND; OYSTER SHELL AND SHELL HASH; GRAYISH BROWN

FINE SAND; POORLY SORTED; MEDIUM BROWN

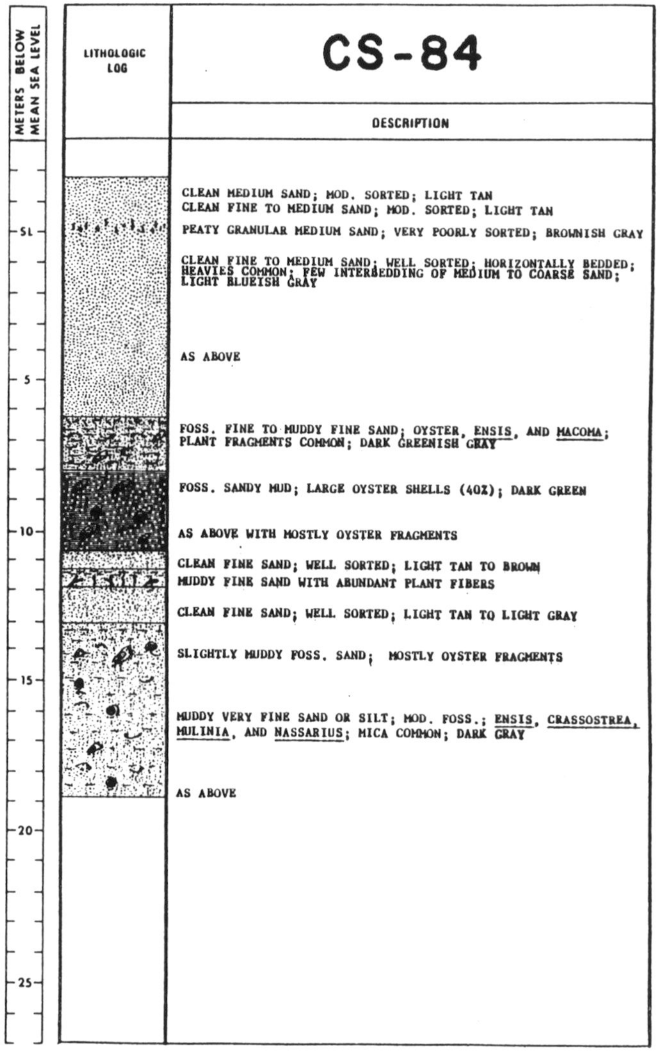
VERY FINE SAND INTERBEDDED WITH MUD; VERY MICACEOUS; MUD IS MEDIUM GRAY AND SAND IS YELLOWISH BROWN; OCCASIONAL GRANULAR LAYER

VERY FINE SAND GRADING INTO SILT AND CLAYEY SILT; MICA COMMON; DARK GRAY TO BLACK

SLIGHTLY FOSS. MUD; *MULINIA*; DARK GRAY

VERY FOSS. MUD; *MULINIA* AND *VENERICARDIA*; DARK GRAY

CLEAN FINE SAND; POORLY SORTED; VERY ANGULAR; RARE FOSSIL; BECOMING BETTER SORTED DOWNWARD; MOD. GRAY



CS-84

DESCRIPTION

CLEAN MEDIUM SAND; MOD. SORTED; LIGHT TAN

CLEAN FINE TO MEDIUM SAND; MOD. SORTED; LIGHT TAN

PEATY GRANULAR MEDIUM SAND; VERY POORLY SORTED; BROWNISH GRAY

CLEAN FINE TO MEDIUM SAND; WELL SORTED; HORIZONTALLY BEDDED; HEAVIES COMMON; FEW INTERBEDDING OF MEDIUM TO COARSE SAND; LIGHT BLUEISH GRAY

AS ABOVE

FOSS. FINE TO MUDDY FINE SAND; OYSTER, *ENSIS*, AND *MACOMA*; PLANT FRAGMENTS COMMON; DARK GREENISH GRAY

FOSS. SANDY MUD; LARGE OYSTER SHELLS (40%); DARK GREEN

AS ABOVE WITH MOSTLY OYSTER FRAGMENTS

CLEAN FINE SAND; WELL SORTED; LIGHT TAN TO BROWN

MUDDY FINE SAND WITH ABUNDANT PLANT FIBERS

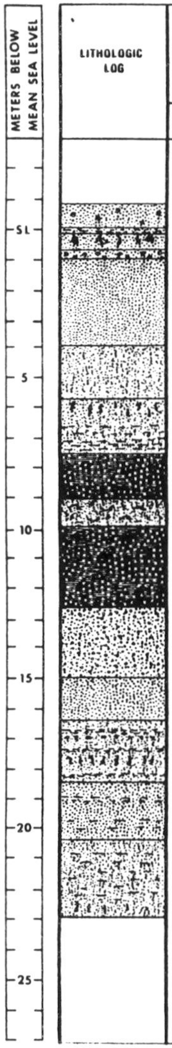
CLEAN FINE SAND; WELL SORTED; LIGHT TAN TO LIGHT GRAY

SLIGHTLY MUDDY FOSS. SAND; MOSTLY OYSTER FRAGMENTS

MUDDY VERY FINE SAND OR SILT; MOD. FOSS.; *ENSIS*, *CRASSOSTREA*, *MULINIA*, AND *NASSARIUS*; MICA COMMON; DARK GRAY

AS ABOVE

CS-85



DESCRIPTION

SLIGHTLY GRANULAR MEDIUM SAND; POORLY SORTED; YELLOWISH BROWN

ORGANIC MUDDY MEDIUM SAND; POORLY SORTED; OLD SOIL?

MEDIUM SAND; ROOTS PRESENT;

ROOTY GRANULAR MEDIUM TO COARSE SAND; VERY POORLY SORTED;BROWN

MEDIUM SAND; MOD. SORTED; MDEIUM GRAY

FINE SAND; WELL SORTED; DARK GRAY

VERY SLIGHTLY PEATY VERY FINE SAND; SMALL PLANT FRAGMENTS; DARK GREENISH GRAY

VERY SLIGHTLY PEATY AND FOSS. VERY FINE SAND WITH OCCASIONAL MUDDY VERY FINE SAND LAMINAE; MICA COMMON; GREENISH GRAY

VERY SLIGHTLY FOSS. & PEATY MUD; SMALL PLANT FRAGMENTS; SMALL SHELL FRAGMENTS; ENSIS, MACOMA AND SPICULES; BLUEISH GREEN

FOSS. MUDDY VERY FINE SAND; SMALL PLANT FRAGMENTS; ENSIS AND MACOMA; MEDIUM GREENISH GRAY

FOSS. SANDY MUD; LARGE AND ABUND. OYSTERS; DARK BLUEISH GRAY

AS ABOVE BUT FEWER OYSTERS AND A FEW BARNEA AND MACOMA

SLIGHTLY FOSS. MUDDY GRANULAR COARSE SAND; MACOMA AND OTHER SMALL UNIDENT. FRAGMENTS; BLUEISH GRAY TURNING REDDISH BROWN

GRANULAR MEDIUM TO COARSE SAND; VERY POORLY SORTED; SOME MUD CLOTS; MEDIUM YELLOW BROWN TO REDDISH BROWN; IRON STAINED

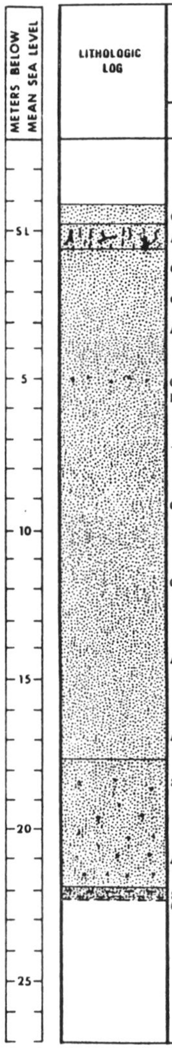
MEDIUM SAND; VERY POORLY SORTED; MEDIUM YELLOW BROWN

INTERBEDDED VERY FINE SAND AND CLAY AND COARSE SAND; FINE SAND IS MOST ABUNDANT; ABUNDANT MICA; SOME PLANT DEBRIS; MEDIUM GREENISH GRAY TO GREENISH BROWN

SLIGHTLY GRANULAR MEDIUM SAND WITH MUD LAMINAE; LAMINAE UP TO 1 CM THICK; SOME PLANT FRAGMENTS; MEDIUM GRAY TO BROWNISH GRAY

FINE SAND WITH MUD CHIPS OR LAMINAE; SOME PLANT FRAGMENTS; MEDIUM GRAY

CS-86



DESCRIPTION

CLEAN FINE SAND; WELL SORTED; SOME PLANT FRAGMENTS; LIGHT TAN

AS ABOVE WITH ABUNDANT WOOD FRAGMENTS

CLEAN FINE TO MEDIUM SAND; WELL SORTED; LIGHT GRAY

CLEAN MEDIUM SAND; WELL SORTED; LIGHT GRAY

AS ABOVE

CLEAN FINE TO MEDIUM SAND; OCCASIONAL GRANULE; WELL SORTED; MOD. GRAY

CLEAN FINE TO MEDIUM SAND; WELL SORTED; LIGHT GRAY

CLEAN FINE TO MEDIUM SAND; MOD. SORTED; LIGHT GRAY

AS ABOVE

AS ABOVE

SLIGHTLY GRANULAR FINE TO MEDIUM SAND

AS ABOVE

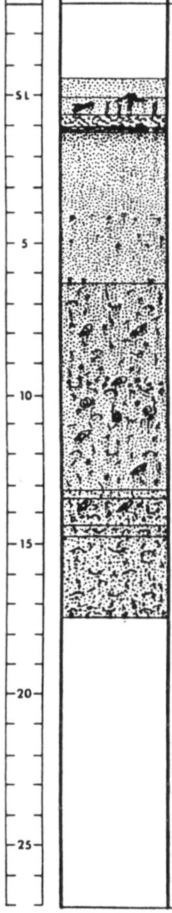
SLIGHTLY MUDDY FINE SAND BECOMING LESS MUDDY DOWNWARD; DARK GREENISH GRAY

CS-87

METERS BELOW MEAN SEA LEVEL

LITHOLOGIC LOG

DESCRIPTION



FINE TO MEDIUM SAND; SOME ROOT MATERIAL; YELLOWISH BROWN

MEDIUM SAND; ABUNDANT ROOT FRAGMENTS; POORLY SORTED SAND

COMPACT PEAT; FINE GRAINED

FINE TO MEDIUM SAND; MOD. SORTED; DARK REDDISH BROWN

MEDIUM SAND; MOD. SORTED; LIGHT GRAYISH BROWN

INTERBEDDED MEDIUM SAND AND VERY SLIGHTLY GRANULAR MEDIUM SAND LIGHT BROWN TO REDDISH BROWN

MEDIUM SAND; MOD. SORTED; LIGHT GRAYISH BROWN

SLIGHTLY FOSS. FINE SAND INTERBEDDED WITH SLIGHTLY FOSS. GRANULAR MEDIUM SAND; CRASSOSTREA, MACTRA, AND MERCENARIA; MEDIUM GRAYISH BROWN

FOSS. GRANULAR MEDIUM SAND; LARGE ABRADED FRAGMENTS OF ARCA, BUSYCON, CRASSOSTREA, LYROPECTEN, MACTRA AND MERCENARIA;

AS ABOVE WITH DINOCARDIUM, PHOLUS AND UNIDENT. FOSSILS

FOSS. GRANULAR MEDIUM SAND; SHELL HASH; LIGHT GRAY

FOSS. GRANULAR COARSE SAND; COARSE SHELL HASH AND FRAGMENTS OF ARCA, CRASSOSTREA, MACTRA AND PHOLUS; SOME GRAVEL; GRAYISH BROWN

SLIGHTLY FOSS. MEDIUM SAND; UNIDENT. SHELL HASH; GRAYISH BROWN

GRANULE GRAVEL AND UNIDENT. SHELL FRAGMENTS

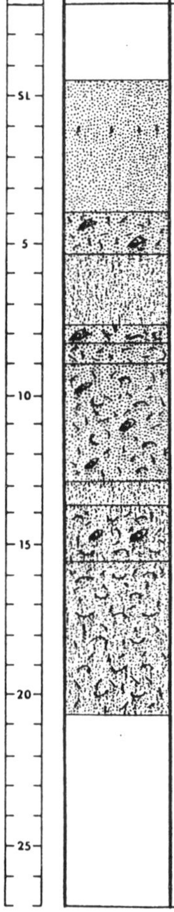
FOSS. GRANULAR MEDIUM SAND; UNIDENT. SHELL FRAGMENTS; LIGHT GRAYISH TO GREENISH BROWN

CS-88

METERS BELOW MEAN SEA LEVEL

LITHOLOGIC LOG

DESCRIPTION



CLEAN FINE TO MEDIUM SAND; WELL SORTED; REDDISH BROWN

CLEAN FINE TO MEDIUM SAND; WELL SORTED; SOME PLANT FRAGMENTS MOD. GRAY

CLEAN FINE TO MEDIUM SAND; WELL SORTED; MOD. GRAY

AS ABOVE

SLIGHTLY FOSS. FINE SAND; MOD. SORTED; FEW DECOMP. OYSTER FRAGMENTS; MICA COMMON; DARK GRAY

CLEAN FINE SAND; MOD. SORTED. MICA COMMON; DARK GRAY

AS ABOVE BECOMING MOD. GRAY

SLIGHTLY FOSS. MEDIUM SAND; FINE UNIDENT. HASH; SOME MULINIA

SLIGHTLY FOSS. MEDIUM SAND; MOD. SORTED; MULINIA & OYST. FRAG.

AS ABOVE WITH INC. FOSS.; DONAX, ENSIS, CRASSOSTREA, LUCINA, MACTRA, MELLITA, MULINIA, AND NASSARIUS; MOD. GRAY

AS ABOVE WITH SLIGHT DECREASE IN FOSSILS

CLEAN FINE SAND; WELL SORTED; MICA COMMON; DARK GRAY

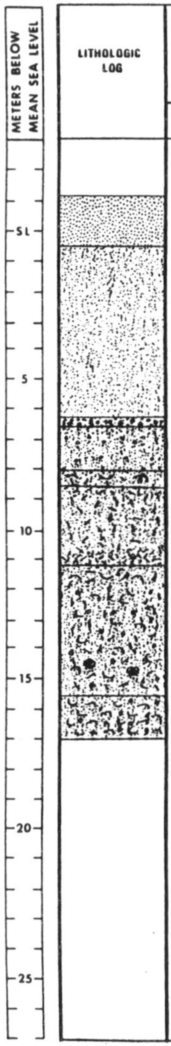
FOSS. FINE SAND; CRASSOSTREA, ENSIS, MACOMA AND MELLITA

MUDDY SILT TO VERY FINE SAND WITH FOSSILS AS ABOVE; ENSIS IS DOMINANT WITH OTHER FAUNA MINOR; SMALL UNIDENT. FRAGMENTS

AS ABOVE WITH FOSSILS DECREASING

AS ABOVE WITH FURTHER DECREASE IN FOSSIL CONTENT; NO FOSSILS APPARENT IN LOWER CORE; MOD. GRAY

CS-89



DESCRIPTION

MEDIUM SAND; TRACE OF MUD OR SILT; DARK BROWN TURNING LIGHT YELLOW BROWN; IRON STAINED

CLEAN FINE TO MEDIUM SAND; YELLOWISH BROWN

AS ABOVE; POORLY SORTED; SOME IRON RICH BLEBS

FINE SAND WITH MEDIUM SAND LAMINAE; SOME IRON RICH LAMINAE; MEDIUM YELLOWISH BROWN

GRANULAR MEDIUM TO COARSE SAND; YELLOWISH RED

INTERBEDDED FINE AND MEDIUM SAND AND GRANULAR COARSE SAND; GRANULAR SAND IS VERY MICA RICH; DARK YELLOWISH BROWN

FOSS. FINE SAND; LEACHED HASH; MULINIA AND POLINICES, YELL.BR.

FOSS. FINE TO VERY FINE SAND; ABUND. MICA; FINE HASH AND FRAGMENTS OF MACTRA, MULINIA, NASSARIUS, AND POLINICES; YELLOWISH BROWN

SANDY BIOCALCRUDITE; FRAGMENTAL MULINIA HASH; DARK GRAY

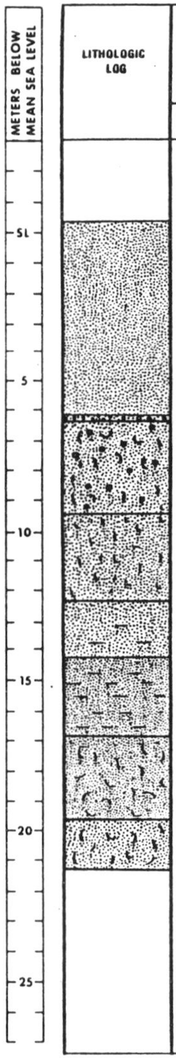
SLIGHTLY FOSS. FINE SAND; SMALL MULINIA; DARK BROWNISH GRAY

AS ABOVE; SLIGHTLY GRANULAR; MACTRA, MULINIA AND 1 SHARK TOOTH

AS ABOVE; SLIGHTLY MORE FOSSILS

SLIGHTLY GRAVELLY FOSS. FINE SAND; BIOCALCRUDITE; FRAGMENTAL HASH INCLUDES CARDIUM, CHIONE, DINOCARDIUM, ENSIS, MULINIA, VARIOUS GASTROPODS AND UNIDENT. FOSSILS; MEDIUM GRAY

CS-90



DESCRIPTION

MEDIUM SAND; ORANGE BROWN

MEDIUM SAND; YELLOW

MEDIUM SAND; LIGHT GRAY

MEDIUM SAND; LIGHT GRAY

AS ABOVE; OCCASIONAL GRANULE

AS ABOVE

QUARTZ AND ROCK FRAGMENT GRANULAR GRAVEL

GRANULAR FOSS. MEDIUM SAND; SMALL MULINIA AND VENERICARDIA; TRACE OF MUD; OLIVE GRAY

AS ABOVE

SLIGHTLY FOSS. CLEAN MEDIUM SAND; MOD. SORTED; UNIDENT. SHELL HASH; OCCASIONAL GRANULES; OLIVE GRAY

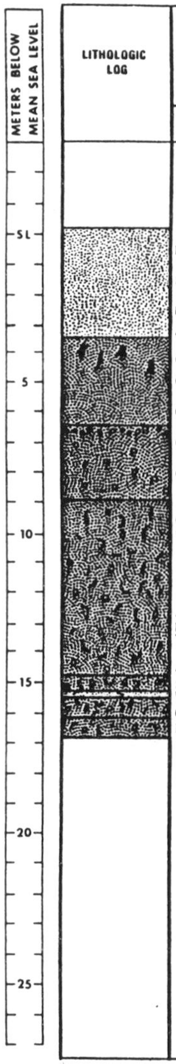
AS ABOVE

FINE SAND; WELL SORTED; LIGHT GRAY

FINE SAND WITH THIN DISCONTINUOUS MUD LAMINAE; ABUND. MICA; SOME FINE SHELL HASH; WELL SORTED SAND; LIGHT GRAY

FOSS. FINE SAND; MOSTLY ENSIS FRAGMENTS; WELL SORTED SAND; OCCASIONAL QUARTZ GRANULE; GRAY TO OLIVE GRAY

AS ABOVE WITH MEDIUM SAND



CS-91

DESCRIPTION

MEDIUM SAND; YELLOW BROWN

MEDIUM SAND; VERY LIGHT YELLOW BROWN

MEDIUM SAND; YELLOW
AS ABOVE

COARSE SAND WITH COMMON PLANT FRAGMENT; YELLOW
COARSE SAND WITH COMMON PLANT FRAGMENT; GRAY

COARSE SAND

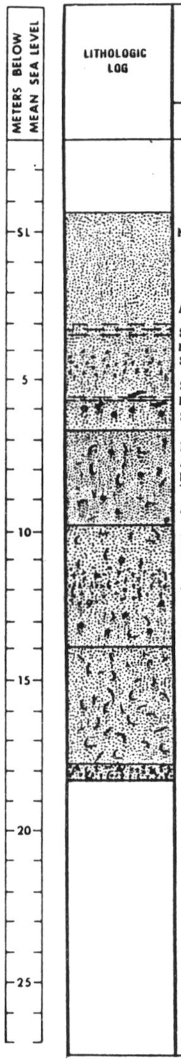
QUARTZ AND ROCK FRAGMENT GRANULAR GRAVEL

GRAVELLY MEDIUM SAND

GRANULAR SLIGHTLY-FOSS. COARSE SAND; VERY POORLY SORTED; SOME WHOLE AND FRAGMENTS OF *MERCENARIA* AND *POLINICES* AND UNIDENT. FRAGMENTS; ABUNDANT BRYOZOANS ON SHELLS; FOSSILS 20-40%

AS ABOVE WITH HIGHLY ABRADED UNIDENT. FRAGMENTS AND SOME *CARDIUM* *MULINIA*, *NASSARIUS*, *OLIVA*, AND *OSTREA*; SHELLS ARE TAN OR CREAM

AS ABOVE
SHELL AND QUARTZ/ROCK FRAGMENT GRAVEL; 40% AND 60% RESPECTIVELY
VERY SLIGHTLY FOSS. FINE SAND; WELL SORTED; FINE HASH
GRAVEL AS ABOVE
FOSS. GRAVELLY COARSE SAND; ALL UNIDENT. ABRADED SHELLS



CS-92

DESCRIPTION

MEDIUM SAND

AS ABOVE
SLIGHTLY MUDDY MEDIUM SAND WITH MINOR ORGANIC FRAGMENTS
MEDIUM TO COARSE SAND
SLIGHTLY GRANULAR COARSE SAND

SLIGHTLY GRANULAR MEDIUM SAND
MUDDY MEDIUM SAND WITH SOME ORGANIC FRAGMENTS
SLIGHTLY GRAVELLY MEDIUM TO COARSE SAND; POORLY SORTED; YELLOW

FOSS. SLIGHTLY GRANULAR FINE SAND; HIGHLY ABRADED *MERCENARIA* AND *MULINIA*; SOME FINE DISSEMINATED SHELL HASH; OCCASIONAL *NASSARIUS* AND *VENERICARDIA*

AS ABOVE WITH ABUND. *MULINIA* AND DEC. SHELL HASH

FOSS. MEDIUM TO COARSE SAND; HIGHLY ABRADED SHELL HASH; SAND IS POORLY-SORTED; YELLOWISH GRAY

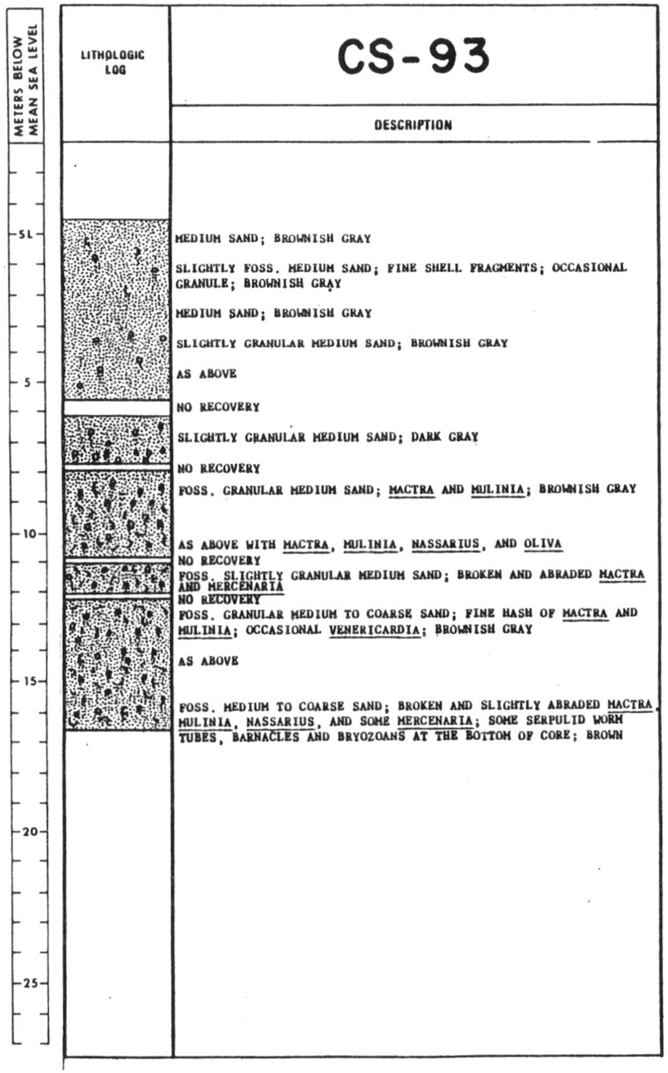
AS ABOVE WITH SOME GRAVEL AND COARSER SHELL HASH

FOSS. MEDIUM SAND; LESS SHELL HASH THAN ABOVE; SOME WHOLE SHELL OF *CARDIUM* AND *MACTRA*; HASH BECOMING FINER DOWNWARD

AS ABOVE WITH FINE SHELL HASH

SLIGHTLY GRAVELLY COARSE SAND; HIGHLY ABRADED SHELL FRAGMENTS
INTERBEDDED MEDIUM SAND

CS-93



DESCRIPTION

MEDIUM SAND; BROWNISH GRAY

SLIGHTLY FOSS. MEDIUM SAND; FINE SHELL FRAGMENTS; OCCASIONAL GRANULE; BROWNISH GRAY

MEDIUM SAND; BROWNISH GRAY

SLIGHTLY GRANULAR MEDIUM SAND; BROWNISH GRAY

AS ABOVE

NO RECOVERY

SLIGHTLY GRANULAR MEDIUM SAND; DARK GRAY

NO RECOVERY

FOSS. GRANULAR MEDIUM SAND; *MACTRA* AND *MULINIA*; BROWNISH GRAY

AS ABOVE WITH *MACTRA*, *MULINIA*, *NASSARIUS*, AND *OLIVA*

NO RECOVERY

FOSS. SLIGHTLY GRANULAR MEDIUM SAND; BROKEN AND ABRADED *MACTRA* AND *MERCENARIA*

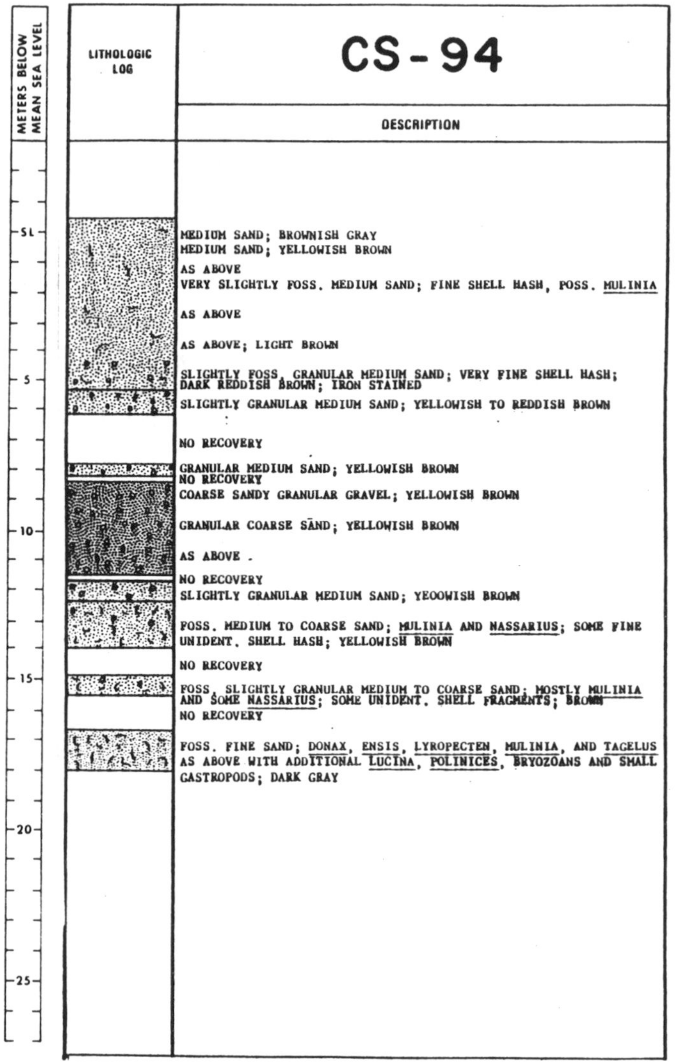
NO RECOVERY

FOSS. GRANULAR MEDIUM TO COARSE SAND; FINE HASH OF *MACTRA* AND *MULINIA*; OCCASIONAL *VENERICARDIA*; BROWNISH GRAY

AS ABOVE

FOSS. MEDIUM TO COARSE SAND; BROKEN AND SLIGHTLY ABRADED *MACTRA*, *MULINIA*, *NASSARIUS*, AND SOME *MERCENARIA*; SOME SERPULID WORM TUBES, BARNACLES AND BRYOZOANS AT THE BOTTOM OF CORE; BROWN

CS-94



DESCRIPTION

MEDIUM SAND; BROWNISH GRAY

MEDIUM SAND; YELLOWISH BROWN

AS ABOVE

VERY SLIGHTLY FOSS. MEDIUM SAND; FINE SHELL HASH, POSS. *MULINIA*

AS ABOVE

AS ABOVE; LIGHT BROWN

SLIGHTLY FOSS. GRANULAR MEDIUM SAND; VERY FINE SHELL HASH; DARK REDDISH BROWN; IRON STAINED

SLIGHTLY GRANULAR MEDIUM SAND; YELLOWISH TO REDDISH BROWN

NO RECOVERY

GRANULAR MEDIUM SAND; YELLOWISH BROWN

NO RECOVERY

COARSE SANDY GRANULAR GRAVEL; YELLOWISH BROWN

GRANULAR COARSE SAND; YELLOWISH BROWN

AS ABOVE .

NO RECOVERY

SLIGHTLY GRANULAR MEDIUM SAND; YEOOWISH BROWN

FOSS. MEDIUM TO COARSE SAND; *MULINIA* AND *NASSARIUS*; SOME FINE UNIDENT. SHELL HASH; YELLOWISH BROWN

NO RECOVERY

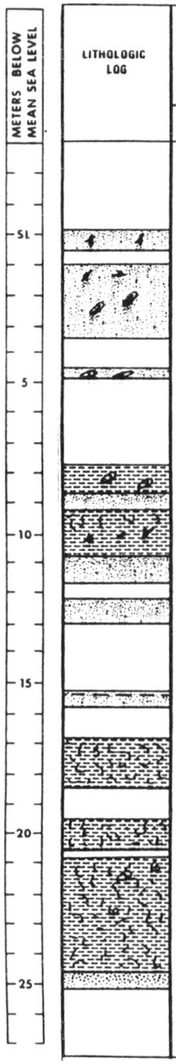
FOSS. SLIGHTLY GRANULAR MEDIUM TO COARSE SAND; MOSTLY *MULINIA* AND SOME *NASSARIUS*; SOME UNIDENT. SHELL FRAGMENTS; BROWN

NO RECOVERY

FOSS. FINE SAND; *DONAX*, *ENSIS*, *LYROPECTEN*, *MULINIA*, AND *TAGELUS*

AS ABOVE WITH ADDITIONAL *LUCINA*, *POLINICES*, BRYOZOANS AND SMALL GASTROPODS; DARK GRAY

CS-95



DESCRIPTION

MEDIUM SAND WITH COMMON PLANT FRAGMENTS; YELLOWISH BROWN
NO RECOVERY
FINE SAND WITH ORGANIC FRAGMENTS AND ROOTS; YELLOWISH BROWN
FINE TO MEDIUM SAND; GRAY
FOSS. FINE TO MEDIUM SAND; OYSTERS; GRAY

FINE SAND; MEDIUM GRAY

NO RECOVERY

FOSS. MUD; OYSTERS; DARK GRAY

NO RECOVERY

FOSS. MUD; WHOLE AND FRAGMENTED OYSTERS; 1 GASTROPOD; DARK GRAY

FINE SAND; DARK GRAY
FOSS. MUD; OYSTERS AND TAGELUS; SOME UNIDENT. PELECYPOD HASH
ORGANIC RICH MUD; FINE GRAINED ORGANICS; DARK GRAY
ORGANIC MUD

FINE SAND; MEDIUM GRAY

NO RECOVERY

VERY FINE SAND; ABUNDANT HEAVIES; GREENISH GRAY

NO RECOVERY

SLIGHTLY MUDDY VERY FINE SAND; DARK GREENISH GRAY

NO RECOVERY

FOSS. MUD; MULINIA AND TAGELUS; DARK GRAY

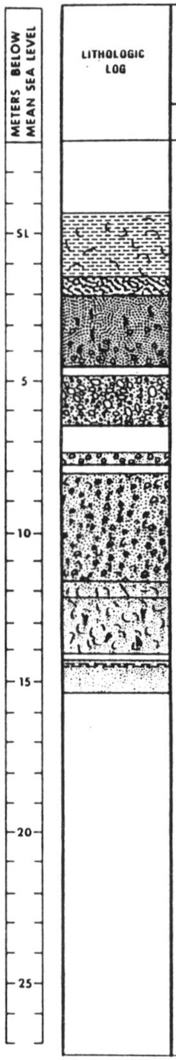
AS ABOVE

NO RECOVERY

FOSS. MUD; CRASSOSTREA, MACTRA, MULINIA, AND VENERICARDIA; GRAY
NO RECOVERY
FOSS. MUD; CRASSOSTREA, LUCINA, MULINIA, AND TAGELUS; DARK GRAY
AS ABOVE
FOSS. MUD; TAGELUS AND SOME UNIDENT. GASTROPODS
FOSS. MUD; CRASSOSTREA, TAGELUS AND UNIDENT. GASTROPODS; GRAY

FOSS. MUD; ABUNDANT CRASSOSTREA
MUDDY FINE SAND; DARK GRAY
MEDIUM SAND; MEDIUM GRAY

CS-96



DESCRIPTION

FOSS. ORGANIC MUD; SMALL PELECYPOD HASH; DAK GRAY

FOSS. PEATY ORGANIC MUD; UNIDENT FRAGMENTS AND MACTRA; GRAY

VERY COARSE SANDY PEAT; DARK BROWN TO GRAY

FOSS. MUDDY GRANULAR VERY COARSE SAND; ABRADED UNIDENT. SHELL FRAGMENTS; DARK BROWNISH GRAY

FOSS. FINE SANDY GRANULE GRAVEL; ABRADED FRAGMENTS AND MACTRA
NO RECOVERY

FOSS. MEDIUM TO COARSE SANDY GRANULE GRAVEL; MACTRA AND MULINIA ABRADED FRAGMENTS; BROWN

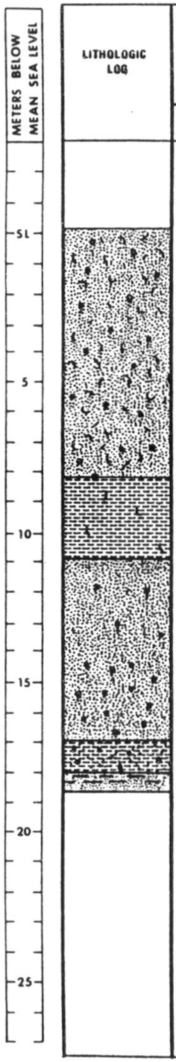
NO RECOVERY
FOSS. FINE SANDY GRANULE GRAVEL; UNIDENT. ABRADED FRAG. MACTRA
NO RECOVERY
FOSS. GRANULAR FINE TO MEDIUM SANDY GRAVEL; MOSTLY UNIDENT. ABRADED SHELL HASH; ABUNDANT MULINIA; FOSSILS DEC. DOWNWARD

AS ABOVE WITH FEWER SHELL FRAGMENTS

SLIGHTLY FOSS. FINE SAND; FINE SHELL HASH AND SMALL PELECYPODS

FOSS. SLIGHTLY MUDDY FINE SAND; MOSTLY MULINIA AND SOME MACTRA AND NASSARIUS; SOME PLANT FRAGMENTS; BROWN
AS ABOVE WITH MORE PLANT FRAGMENTS
NO RECOVERY
SANDY MUD LAMINAE IN FINE SAND; ABUND. MICA; DARK GRAY
FINESAND; MEDIUM GRAY

CS-97



DESCRIPTION

GRANULAR MEDIUM SAND; HIGHLY ABRADED SHELL HASH; SOME GRAVEL

AS ABOVE

AS ABOVE

SLIGHTLY GRANULAR FOSS. MEDIUM SAND; *CRASSOSTREA*, *ENSIS*, *MELLITA*, AND *MULINIA*; LESS ABRADED THAN ABOVE

CLEAN SLIGHTLY GRANULAR MEDIUM SAND; HIGHLY ABRADED SHELL FRAGMENTS; *CRASSOSTREA*, AND *MACTRA*; LIGHT GRAY

AS ABOVE WITH *ENSIS*, *MULINIA*, *MERCENARIA*, AND *CARDIUM*; GRAY

SANDY MUD OR MUDDY FINE SAND; DARK GRAY

SLIGHTLY FOSS. SANDY MUD OR MUDDY FINE SAND; VERY FINE SHELL FRAGMENTS; 1 GASTROPOD; DARK GRAY

AS ABOVE BECOMING LESS MUDDY

CLEAN GRANULAR MEDIUM SAND; REDDISH BROWN; IRON STAINED

SLIGHTLY GRANULAR MEDIUM SAND; REDDISH BROWN

AS ABOVE

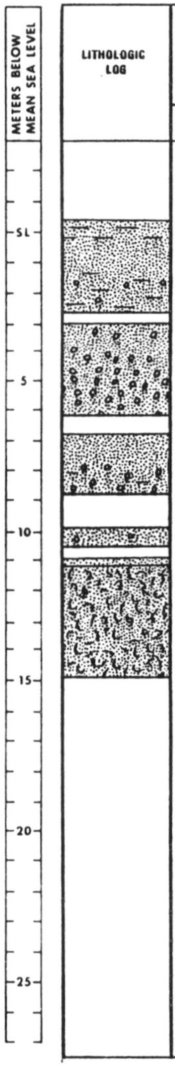
GRANULAR FINE TO COARSE SAND; LIGHT GRAY

AS ABOVE

SLIGHTLY GRANULAR MUD TO MUDDY SANDS; DARK GRAY

MUDDY FINE SAND; GRAY

CS-98



DESCRIPTION

SLIGHTLY MUDDY FINE TO MEDIUM SAND; YELLOWISH ORANGE

FINE TO MEDIUM SAND; LIGHT YELLOWISH BROWN

SLIGHTLY GRANULAR SLIGHTLY MUDDY FINE TO MEDIUM SAND; SOME FINE PLANT FRAGMENTS; YELLOWISH BROWN

NO RECOVERY

SLIGHTLY GRANULAR FINE TO MEDIUM SAND; YELLOWISH BROWN

GRANULAR FINE TO MEDIUM SAND; YELLOWISH ORANGE

AS ABOVE

NO RECOVERY

FINE TO MEDIUM SAND; YELLOWISH ORANGE TO YELLOWISH BROWN

SLIGHTLY MUDDY GRANULAR MEDIUM SAND; BROWNISH GRAY

NO RECOVERY

FINE TO MEDIUM SAND; OCC. GRANULE; SOME MICA; MED. GRAY

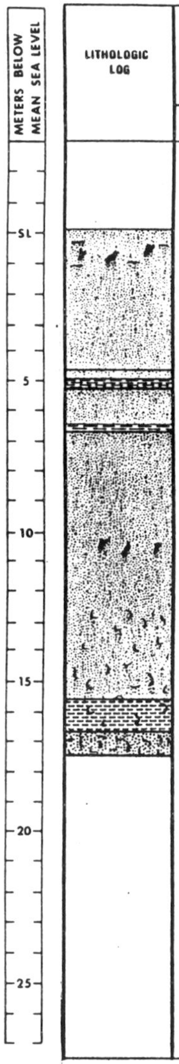
NO RECOVERY

MEDIUM SAND; LARGE MICA FLAKES; MEDIUM BROWNISH GRAY

FOSS. SLIGHTLY MUDDY MEDIUM SAND; FRESHLY BROKEN *BUSYCON*, *ENSIS*, *MERCENARIA* AND *MULINIA*; BROWNISH GRAY

FOSS. SLIGHTLY GRANULAR SLIGHTLY MUDDY MEDIUM SAND; *ARCA*, *CARDIUM*, *ENSIS*, *LUCINA*, *MERCENARIA*, *MACTRA*, *MULINIA*, *MELLITA*, *NASSARIUS*, *LYROPECTEN*, *TELLIN* AND BRYOZOANS; BROWNISH GRAY

CS-99



DESCRIPTION

ORGANIC MUDDY SAND; DARK BROWN

MEDIUM SAND; LIGHT BROWN

FINE TO MEDIUM SAND; LIGHT BROWN

AS ABOVE
FINE SAND; COMMON HEAVIES; LIGHT BROWN
PLASTIC CLAY; DARK GRAY
CLEAN FINE SAND; WELL SORTED; MOD. TO LIGHT GRAY
CLEAN FINE SAND; WELL SORTED; LIGHT GRAY
CLAY WITH MINOR PLANT FRAGMENTS; DARK GRAY
CLEAN FINE SAND; WELL SORTED; OCC. PEAT FRAGMENT; LIGHT GRAY

CLEAN FINE SAND; WELL SORTED; LIGHT GRAY

CLEAN FINE SAND WITH COMMON PLANT FRAGMENT; WELL SORTED; GRAY

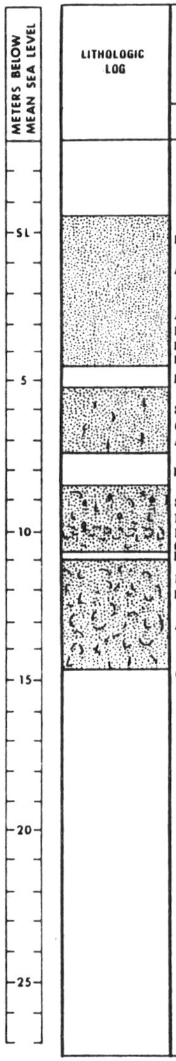
CLEAN FINE SAND; WELL SORTED; LIGHT GRAY

SLIGHTLY FOSS. FINE SAND; VERY SMALL PELECYPOD FRAGMENTS; MOSTLY DELICATE SHELLS; ABUND. MICA; DARK GRAY

FOSS. FINE SAND; *MULINIA*; MOD. GRAY

FOSS. SANDY MUD; *MULINIA*; INTERLAMINATED MUD AND FINE SAND AT BASE
FOSS. MUDDY FINE TO MEDIUM SAND; ALL SHELLS ARE BROKEN *ENSIS* FRAGMENTS

CS-100



DESCRIPTION

MEDIUM SAND; GRAY TO GRAYISH BROWN

AS ABOVE

AS ABOVE
MEDIUM SAND; DARK RED BROWN
MEDIUM SAND; BROWNISH GRAY
MEDIUM SAND; OCC. FINE SHELL HASH FRAGMENT; GREENISH BROWN
NO RECOVERY

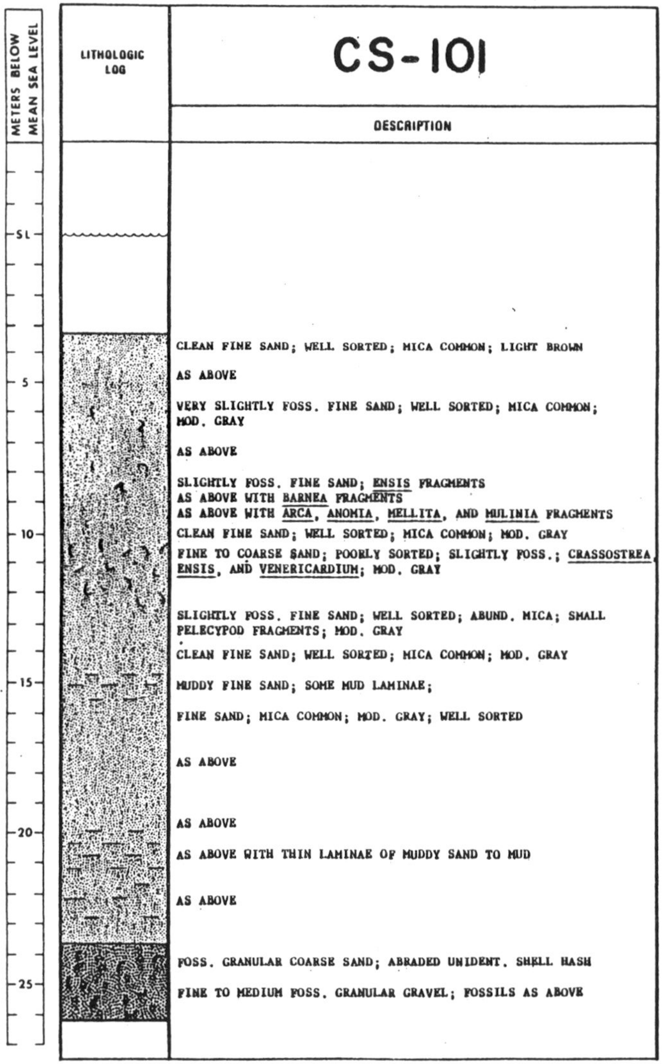
SLIGHTLY FOSS. MEDIUNE SAND; VERY FINE SHELL FRAGMENTS; BROWNISH GRAY
AS ABOVE

NO RECOVERY

SLIGHTLY GRANULAR MEDIUM TO COARSE SAND; SOME VERY FINE SHELL FRAGMENTS; BROWNISH GRAY
FOSS. FINE SAND; *MACTRA*, *MERCENARIA*, AND *MULINIA*; COMMON MUSC.; GREEN SANDS
NO RECOVERY
FOSS. MEDIUM SAND; *MULINIA* AND SMALL UNIDENT. PELECYPODS; MEDIUM GREENISH GRAY

AS ABOVE WITH *MACTRA*

FOSS. FINE SAND; FINE SHELL HASH, MOSTLY *MULINIA* WITH 1 *MACTRA*; GREENISH GRAY



CS-101

DESCRIPTION

CLEAN FINE SAND; WELL SORTED; MICA COMMON; LIGHT BROWN

AS ABOVE

VERY SLIGHTLY FOSS. FINE SAND; WELL SORTED; MICA COMMON; MOD. GRAY

AS ABOVE

SLIGHTLY FOSS. FINE SAND; *ENSIS* FRAGMENTS

AS ABOVE WITH *BARNEA* FRAGMENTS

AS ABOVE WITH *ARCA*, *ANOMIA*, *MELLITA*, AND *MULINIA* FRAGMENTS

CLEAN FINE SAND; WELL SORTED; MICA COMMON; MOD. GRAY

FINE TO COARSE SAND; POORLY SORTED; SLIGHTLY FOSS.; *CRASSOSTREA*, *ENSIS*, AND *VENERICARDIUM*; MOD. GRAY

SLIGHTLY FOSS. FINE SAND; WELL SORTED; ABUND. MICA; SMALL PELECYPOD FRAGMENTS; MOD. GRAY

CLEAN FINE SAND; WELL SORTED; MICA COMMON; MOD. GRAY

MUDDY FINE SAND; SOME MUD LAMINAE;

FINE SAND; MICA COMMON; MOD. GRAY; WELL SORTED

AS ABOVE

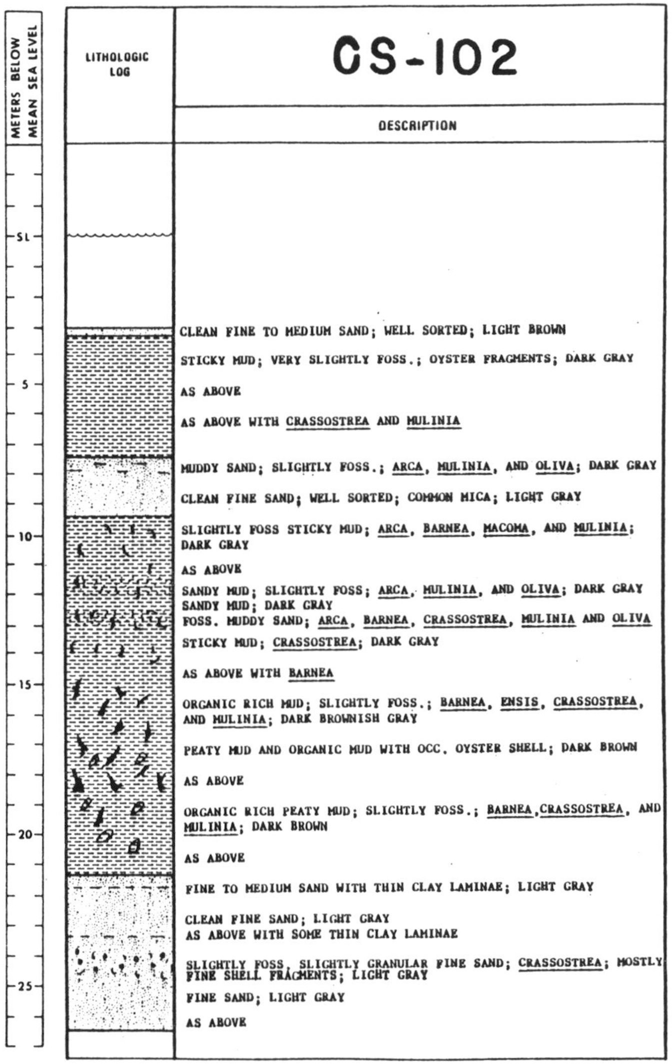
AS ABOVE

AS ABOVE WITH THIN LAMINAE OF MUDDY SAND TO MUD

AS ABOVE

FOSS. GRANULAR COARSE SAND; ABRADED UNIDENT. SHELL HASH

FINE TO MEDIUM FOSS. GRANULAR GRAVEL; FOSSILS AS ABOVE



CS-102

DESCRIPTION

CLEAN FINE TO MEDIUM SAND; WELL SORTED; LIGHT BROWN

STICKY MUD; VERY SLIGHTLY FOSS.; OYSTER FRAGMENTS; DARK GRAY

AS ABOVE

AS ABOVE WITH *CRASSOSTREA* AND *MULINIA*

MUDDY SAND; SLIGHTLY FOSS.; *ARCA*, *MULINIA*, AND *OLIVA*; DARK GRAY

CLEAN FINE SAND; WELL SORTED; COMMON MICA; LIGHT GRAY

SLIGHTLY FOSS STICKY MUD; *ARCA*, *BARNEA*, *MACOMA*, AND *MULINIA*; DARK GRAY

AS ABOVE

SANDY MUD; SLIGHTLY FOSS; *ARCA*, *MULINIA*, AND *OLIVA*; DARK GRAY

SANDY MUD; DARK GRAY

FOSS. MUDDY SAND; *ARCA*, *BARNEA*, *CRASSOSTREA*, *MULINIA* AND *OLIVA*

STICKY MUD; *CRASSOSTREA*; DARK GRAY

AS ABOVE WITH *BARNEA*

ORGANIC RICH MUD; SLIGHTLY FOSS.; *BARNEA*, *ENSIS*, *CRASSOSTREA*, AND *MULINIA*; DARK BROWNISH GRAY

PEATY MUD AND ORGANIC MUD WITH OCC. OYSTER SHELL; DARK BROWN

AS ABOVE

ORGANIC RICH PEATY MUD; SLIGHTLY FOSS.; *BARNEA*,*CRASSOSTREA*, AND *MULINIA*; DARK BROWN

AS ABOVE

FINE TO MEDIUM SAND WITH THIN CLAY LAMINAE; LIGHT GRAY

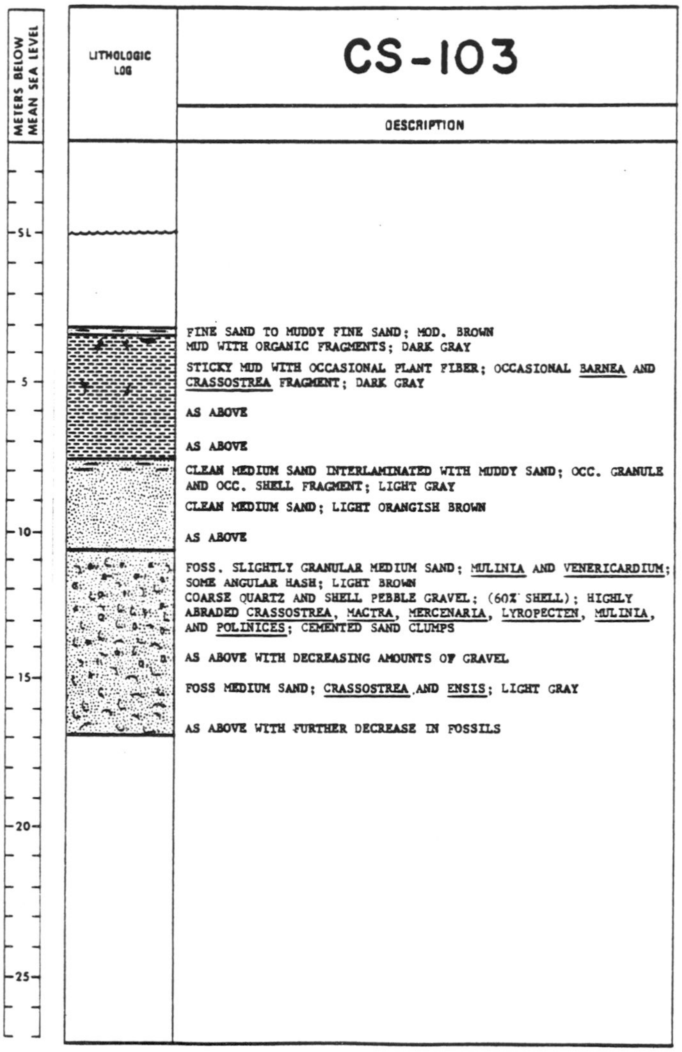
CLEAN FINE SAND; LIGHT GRAY

AS ABOVE WITH SOME THIN CLAY LAMINAE

SLIGHTLY FOSS. SLIGHTLY GRANULAR FINE SAND; *CRASSOSTREA*; MOSTLY FINE SHELL FRAGMENTS; LIGHT GRAY

FINE SAND; LIGHT GRAY

AS ABOVE



CS-103

DESCRIPTION

FINE SAND TO MUDDY FINE SAND; MOD. BROWN
MUD WITH ORGANIC FRAGMENTS; DARK GRAY

STICKY MUD WITH OCCASIONAL PLANT FIBER; OCCASIONAL *BARNEA* AND *CRASSOSTREA* FRAGMENT; DARK GRAY

AS ABOVE

AS ABOVE

CLEAN MEDIUM SAND INTERLAMINATED WITH MUDDY SAND; OCC. GRANULE AND OCC. SHELL FRAGMENT; LIGHT GRAY

CLEAN MEDIUM SAND; LIGHT ORANGISH BROWN

AS ABOVE

FOSS. SLIGHTLY GRANULAR MEDIUM SAND; *MULINIA* AND *VENERICARDIUM*; SOME ANGULAR HASH; LIGHT BROWN
COARSE QUARTZ AND SHELL PEBBLE GRAVEL; (60% SHELL); HIGHLY ABRADED *CRASSOSTREA*, *MACTRA*, *MERCENARIA*, *LYROPECTEN*, *MULINIA*, AND *POLINICES*; CEMENTED SAND CLUMPS

AS ABOVE WITH DECREASING AMOUNTS OF GRAVEL

FOSS MEDIUM SAND; *CRASSOSTREA* AND *ENSIS*; LIGHT GRAY

AS ABOVE WITH FURTHER DECREASE IN FOSSILS

APPENDIX C

CARBON-14 DATA

CORE DATED	DEPTH OF SAMPLE (METERS BELOW MSL)	CARBON-14 AGE (YEARS B. P.)	MATERIAL DATED
CS - 82	10.7 - 11.7	4,375	*BARNEA* FRAGMENT
CS - 84	11.4 - 11.6	3,685	NON-ABRADED *CRASSOSTREA*
CS - 85	11.8 - 12.0	2,595	ARTICULATED *CRASSOSTREA*
CS - 87	11.0 - 11.1	6,115	ABRADED *MERCENARIA/ BUSYCON/PECTIN*
CS - 88	12.2 - 12.6	5,225	SLIGHTLY ABRADED *MACTRA/ POLINICES/MERCENARIA*
CS - 95	10.0 - 10.2	5,220	PLANT DEBRIS
CS - 102	18.3 - 18.5	9,280	ORGANIC MUD
CS - 102	19.8 - 20.4	9,695	ORGANIC MUD
CS - 103	5.8 - 6.4	4,905	ORGANIC MUD