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Report to the Coastal Erosion Abatement Commission Commonwealth of Virginia concerning the Inventory of Sand Supplies in the Southern Chesapeake Bay

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prepared by

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September, 1981

FOREWARD

In its report to the Governor and the General Assembly of Virginia (Senate Document No. 4, Commonwealth of Virginia, 1979), the Coastal Erosion Abatement Commission found that "there is a need to locate sources of sand supplies for rebuilding public beaches. Certain bottom areas in the lower Chesapeake Bay should be studied as possible sources of sand supply for public beaches." And toward that end, the Commission recommended that "The School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, study and analyze possible sources of sand supply in the lower Chesapeake Bay and vicinity for rebuilding public beaches. There shall be appropriated from the General Fund the sum of $136,600 for the first year of the 1980-1982 Biennium and $127,000 for the second year of the Biennium for such purpose."

The Governor and the members of the General Assembly concurred with the Commission's recommendations and made the appropriation.

This report describes the investigations undertaken during the first year of the appropriation, July 1980 through June 1981.

INTRODUCTION

In the section of its report that was concerned with the Analysis of the Sand Resources in Chesapeake Bay, the Commission amplified its recommendation for the funding and the Virginia Institute of Marine Science for studies

> to assess the extent and quality of the sands for beach nourishment within the inner approaches to Hampton Roads which would include the entrance to Lynnhaven Inlet, Willoughby Bank, Horseshoe Shoal fronting Hampton, Hampton Flats and other areas in the environs deemed appropriate. This study, to be completed in a period of three to four years, would include:
>
> a. Determination of the extent and quality of sands for beach nourishment purposes in the aforementioned areas;
> b. Study of the most economical means of recovery and transportation of potential sands to the target areas; and
> c. Assessment of the environmental risk of extraction to the associated marine ecosystem.

The Commission's recommendations, which became a charge to the Institute, stemmed from the following reasoning, also from Senate Document No. 4.

> The public beaches at Virginia Beach, Norfolk and Hampton rely upon beach nourishment to maintain their recreational capability and to provide a buffering beach width as protection for the fastland and shoreside facilities. . . .In all cases, locating suitable and economical marine sand sources which can be extracted at acceptable environmental risk is a serious problem. Implementation of the Corps of Engineers plans at Virginia Beach would require initial sand volume of 2.5 million cubic yards. If nourishment is the recommended strategy at East Ocean View and Willoughby Spit in Norfolk, about 2.5 million cubic yards will be required. Combined annual maintenance requirements would be about 250,000 cubic yards.
>
> Studies of the Corps of Engineers (1972) disclosed the existence of a very promising deposit in the Thimble

Shoals Channel area, estimated to be about 12 to 19 million cubic yards of coarse sand and gravel. In 1974, about 452,000 cubic yards of material were stockpiled at Fort Story for later use. The extraction was part of an enlargement of the Thimble Shoals navigation channel. While it is encouraging to have such a deposit available, the extraction is only economical if very large volumes are dredged. Consequently, a large storage area would be required. The Corps of Engineers study included reconnaissance work in the zone offshore of oceanfront Virginia Beach. Materials comparable to the Thimble Shoals deposit were not found.

With the exception of about 20,000 cubic yards of sand placed from an upland site in 1979 just west of the Little Creek jetties, all of the prior nourishment sand placed on the East Ocean View-Willoughby Spit area in Norfolk has been derived from dredging operations in the Little Creek entrance and forebay area. In 1975, a channel enlargement was made but the material (about 800,000 cubic yards) was placed on the beaches of the U.S. Navy Amphibious Base at Little Creek. If the Corps of Engineers study, to be completed in 1982, justifies a nourishment program, approximately 2.5 million cubic yards of sand will be needed. Even without the federal project, the City of Norfolk needs to maintain a sand supply for the East Little Creek-Willoughby Spit area. While sand bypassing from the updrift side of Little Creek remains a possibility, the determination of the feasibility awaits the completion of the sand budget analysis by the Corps of Engineers.

Alternate sources must be evaluated. Willoughby Bank is a source worthy of investigation. During the construction of the second Hampton Roads tunnel, a borrow area on Willoughby Bank adjacent to Fort Wool was utilized to provide foundation sand for the tunnel tube and surcharge for a tunnel island. Subsequent to that, the surcharge material was successfully used as beach nourishment sands at Buckroe Beach in Hampton.

Given the need for beach nourishment sands for the public beaches of Virginia Beach, Norfolk and Hampton, additional investigations of the extractable subaqueous sand resources are required. These investigations would augment the earlier studies by the Corps of Engineers east of the Chesapeake Bay Bridge-Tunnel by extending the assessment to the inner approaches to Hampton Roads and those areas fronting Hampton and Lynnhaven Inlet.

To these ends in July 1980, the Virginia Institute of Marine Science (VIMS) of the College of William and Mary commenced an

inventory to delineate and characterize offshore sources for sand that might be used to nourish the public beaches that rim the southern Chesapeake Bay. The general area of the Bay which was studied is bounded by the shoreline, the Hampton Roads Bridge-Tunnel and a line beginning at the Northend or Factory Point, or the mouth of the Bank River in Hampton and running approximately southeast to a point just north of Cape Henry and the south to the shoreline (Figure 1). Particular attention was paid to the Thimble Shoals-Horseshoe area, Thimble Shoals Channel, the tail of the Horseshoe, Willoughby Banks, Crumps Bank, Little Creek, Lynnhaven, and the Cape Henry nearshore area. Most of these are shoal areas with geomorphology which suggests that they are potential sand sources.

METHODS

The survey was conducted in two phases. Phase one was a joint study with the Norfolk District of the U.S. Army Corps of Engineers. This project included taking 45 short (20-foot) vibratory cores and using a 3.5 kHz sub-bottom profiling unit to delineate structures and bedding in the sub-bottom sediment between core sites. The Norfolk District provided a self-propelled crane barge, the Elizabeth, with crew, marine geologist, and a project manager to coordinate the two agencies. VIMS provided the vibracoring unit, supplies, the seismic reflection unit, navigation equipment, technicians, and a marine scientist.

Subsurface samples were recovered using the vibracoring device operated from the crane barge Elizabeth. The unit utilizes a steel casing with a 3 1/2 inch (8.9 cm) diameter clear plastic liner. Once on the bottom, the unit is free standing and penetrates the sediment using the energy of a vibrating, pneumatic power-head. Penetration rate and depth are recorded on a strip chart. Once penetration is completed, the unit is retrieved and returned to the barge where the plastic liner is removed. Then the core tubes are cut into short (5-foot) lengths, capped, sealed, labeled, and returned to VIMS. In the laboratory, the core sections were cut open, described, logged, and sampled. Sediments were classified according to the Unified Soils Classification System and described according to the inspector's visual interpretation of Burmisters Method of Material Proportions. Composite samples of all recovered cores were analyzed for grain size distribution and beach-fill suitability.

The Norfolk District's report, "Sub-surface Investigation for Beach Nourishment," was published in November 1980. In addition to a discussion similar to the one in this report, it contains core logs and grain-size distribution curves for the cores taken in the joint portion of first phase of the project.

Phase two of the project was a more detailed study of areas indicated as possible sand sources from data analyzed from Phase one. During this phase, 28 additional cores were taken utilizing the vibracore unit in its 40-foot mode.

During this phase, the vibracore unit was operated from a crane barge owned and operated by Immel's Marine of Gwynn's Island, Virginia. The long cores of the second phase were handled, logged, and sampled the same as in the first phase of the study, except that there was no participation by the Corps of Engineers. Throughout the study, core site location was documented with horizontal sextant angles and Loran C navigation.

In addition to the 3.5 kHz sub-bottom profiles recorded while steaming from one core location to the next, an independent seismic survey was conducted in April 1981. This study was subcontracted to Ocean Seismic Survey of Norwood, New Jersey, and consisted of 120 nautical miles of track lines. The survey was conducted aboard the VIMS research vessel Captain John Smith and utilized; a 3.5 kHz O.R.E. sub-bottom unit, a 100 joule EG&G "Uni-Boom" filtered for 1.5 kHz, a 100 kHz Kline side-scan sonar unit, and a 200 kHz Raytheon recording fathometer to collect a full spectrum of bottom and sub-bottom data. All data were automatically recorded on separate paper strip charts. Navigation coordinates were controlled by a Loran C microprocessor system combined with a X-Y plotter which enabled exact fix marks for final interpretation and reduction of the data.

Core locations and the seismic track lines are shown in Figures 2 and 3.

RESULTS

Within the Thimble Shoals-Horseshoe region there are two areas which contain sand suitable for use. One site is located near Thimble Shoals Light and has approximately 20 million cubic yards of material suitable for beach nourishment. The second site, adjacent to Buckroe Beach and Old Point Comfort, contains approximately 14 million cubic yards of sand; however, much of this material lies within the United States Navy's restricted sector near Old Point Comfort. These estimates of volume are conservative, as the calculations primarily were based upon seismic-reflection data which need confirmation with additional cores. Further work could confirm volumes greater than 90 million cubic yards within the Thimble Shoals-Horseshoe region.

Lynnhaven Inlet and the embayment directly inshore of the Route 60 bridge contain as much as 1.5 million cubic yards of sand. However, the confines of the harbor prevented successful seismic profiling, leaving some question concerning the continuity of the sand horizon.

Cores from shallow water near Cape Henry indicate a long, narrow horizon of sand estimated to contain 6.5 million cubic yards of suitable material, further exploration could yield estimates of as much as 15 million cubic yards.

The east end of Thimble Shoals Channel was surveyed by the Coastal Engineering Research Center (CERC) of the Corps of Engineers, 1972 (Meisburger, 1972). Cores and seismic profiling delineated a

sand-horizon with a volume of 18.4 million cubic yards. This region has not been explored in the present study. However, it will be included during the second year as a site for additional research to determine its suitability as a source of sediment for beach nourishment. Meisburger's description of the sand body is as follows:

> The most promising deposit crops out in Thimble Shoals Channel and along a reentrant in the south flank of Tail of the Horseshoe. This deposit is a coarse brown to reddish brown sand and gravelly sand. Data suggest that the deposit extends to and through the Tail of the Hosesshoe Shoal to near the south wall of Chesapeake Channel where it decreases to a thin layer. . . South of the Thimble Shoals outcrop area, the coarse sand body appears to extend under Lynnhaven Roads, but is deeply buried under a silt and silty clay layer. . . About 3,500,000 square yards of material is exposed, and the volume available in this area is calculated to be 11.9×10^6 cubic yards. In addition, about 7.5×10^6 cubic yards are estimated to be available in the area bordering the exposure with a removal of no more than 5 feet of overburden.
>
> In terms of mechanical stability (for use on Virginia Beach), the Thimble Shoals material is considered good. Most of the sand grains are quartz which is resistant to mechanical and chemical degradation. Some gravel particles are composed of granitic rock which is partly decomposed. These fragments constitute only a minor fraction of the sediment.
>
> Layers and lenses of well-sorted, clean sand closely matching the beach sand occur in the Thimble Shoals deposit. However, the split cores showed that these layers are generally bedded with interspaced coarse sand mixed with gravel and occasional thin clay partings. The material finer than the native sand will be removed from the beach soon after placement, and the coarser particles will tend to remain.

In the Willoughby Banks region, four million cubic yards of suitable sand has been located near the flanks of the natural Thimble Shoals channel. Seismic reflection data indicate the volume could be

as great as 15 million cubic yards; however, more cores are needed to determine the total volume of material suitable for beach nourishment. The Crumps Bank region has little suitable sand with the exception of two small sites adjacent to the beach at Little Creek Amphibious Base. One site contains approximately two million cubic yards of material. This sand may be unusable because of its close proximity to the existing beach. The dredging of an area near the shore is usually inadvisable as the artificial removal of sand so close to the beach may accelerate the erosion of the beach. The second site is to the east near the Chesapeake Bay Bridge-Tunnel with a volume of one million cubic yards.

This information is summarized in Figure 4 which depicts the information at three levels of confidence. The greatest confidence is attached to the areas identified as "suitable sand." In these areas, both cores and seismic data confirm the presence of sandy sediments which are physically suitable for use on beaches. These might be considered the proven sand reserves. The areas of "possible" sand are areas which, on the seismic records, are continuous with the suitable sands but which have not been verified by coring. Finally, the areas to be explored are areas which appear likely to be sand source, but for which only the most tenuous evidence presently exists.

Figures 5 and 6 depict the estimated thickness of the layers of potentially usable sand as well as the approximate depth from the water surface to the bottom of those strata. This information will be

helpful in determining the best methods to use for excavation and the probable costs thereof.

Although not due until later in the study, Figures 7 and 8 present information bearing on the environmental status of the bottom. This information is important as the ultimate selection of sites for extracting sand will, in part, be predicated upon the potential magnitude of environmental modification caused by the operation. Figure 7 is preliminary data on the distribution of the general benthic community and Figure 8 refers specifically to the distribution of hard clams.

DISCUSSION

The characteristics and sediment of each area differ and must be considered separately as to both the suitability of the material for beach nourishment and generally accessibility. One of the determinants for suitability for use as beach nourishment is the similarity of the material from the borrow site to the native beach material. In general, the closer the mean grain sizes and sorting values (standard deviations), the more suitable the material. Slightly coarser and better sorted materials are preferable to finer or less well sorted sediments. There are a number of methods of calculating a "suitability index" or "overfill ratio". These calculations provide information that can be used as a guide in augmenting and verifying the judgements made by professionals and based upon their training and experience. The closer the overfill

ratio to unity, the better the suitability of the borrow material. The overfill ratio is an estimate of the number of cubic yards of borrow material that must be placed on the beach for one cubic yard to remain after the system has had a chance to be subjected to wave action and to approach equilibrium. Hence, an overfill ratio of 5:1 suggests that for each 5 cubic yards placed on the beach, 4 wash back into deeper water whereas a ratio of 1:1 implies only a minimum of adjustment. The method of calculating the overfill ratio is the so-called "Dean Method" (Dean, 1974; Hobson, 1977).

Personnel from the Norfolk District of the Corps of Engineers sampled the beaches of Willoughby Spit and Ocean View in order to characterize the native sediment in August and November 1978. Scientists from VIMS sampled the Buckroe Beach area of Hampton in June 1981. The sediment from Buckroe Beach is finer (smaller grained) than that found on Willoughby Spit and Ocean View. Thus, materials not suitable for use on the two Norfolk beaches might still be usable on Buckroe.

Willoughby Banks

The southern flank of the natural channel to the crest of the shoal is the prime location of suitable sand in this region. The material is a gray fine to medium (.25-.75 mm) sand with varying amounts (up to 15%) of silt and clay. The horizon has a maximum thickness of 28 feet (8.5 m) at the crest and thins to 3 feet (1.0 m) at the flank of the channel. The horizon has little or no overburden

with overfill ratios ranging from 1.1 to 1.75 for the 4.0 x 10^6 yds^3 outlined in Figure 4. The increasing water depths from 3 feet at the crest (1 m) to the channel should not affect the area as a viable borrow site. Cores to the south of this area indicate the surface material grades to a very fine silty sand overlying a layer of inorganic clay that thickens landward. The overburden of fine grain material is considerable on the southern and eastern part of the banks (up to 10 feet in thickness), rendering most of the sand in deeper horizons unaccessible for beach nourishment; however, the volume is appreciable and could be as high as 15 x 10^6 yds^3 if the overburden were removed.

Thimble Shoals - Horseshoe

Suitable surface material in this area is a light gray, fine to medium grained sand (0.25 to 0.5 mm) containing small percentages of silt and clay. The surface layer ranges from 1 to 4 feet (0.3 to 1.2 m) in thickness with little or no overburden of unsuitable material. Below this layer the sand grades to a very clean coarse sand ranging in size from 1.0 mm to 2.0 mm. The coarse sand layer ranges from 6 to 15 feet (1.8 to 4.5 m) in thickness throughout the region shown in Figure 4 outlined as suitable sand. Seismic profiles indicate this horizon extends to the north and west; however, core data is insufficient to insure the horizon remains suitable for beach nourishment, thus calculations of volume may be conservative. Water depths at this site range from 10-20 feet (3-6 m) allowing easy access to sediment on or below the bottom. As no overburden of unsuitable

material is present in this area, the finer grained sand at the surface of this site would have little or no effect on the overfill ratios of 1.02 to 1.70 for the 30 x 10^6 yds^3 of medium to coarse sand found in this region.

The area indicated on the map as "possible sand area" probably has little overburden. However, as seismic records indicate that a paleo-channel crosses the area, additional cores are necessary to confirm the continuity of the layers of suitable material.

Cape Henry

The three cores in the nearshore region of Cape Henry produced medium to coarse grained sand (.50 to 1 mm) with varying amounts of silt (up to 10%) for the length of the core. The depth of this horizon was determined to be in excess of 35 feet (10 m) at all three locations. The volume of suitable material has been calculated to be 6.5 x 10^6 yds^3. This site has the potential of supplying as much as 15 x 10^6 yds^3 of suitable material for beach restoration; however, its proximity to the shore may limit the advisability of using much of this material.

Lynnhaven

Four cores were taken inside the Route 60 bridge. Thickness of the surface sand deposit ranges from 10 to 35 feet (3 to 10 m). This could yield as much as 1.5 x 10^6 yds^3 of suitable sand if the layer be continuous throughout the site. Seismic reflection profiles were not

attainable at this site as limited water depth restricted operations to the channel. Additional coring would help to delineate the extent of the horizon.

Crumps Banks

The surface sediments in this area are mostly very fine grained silty sands, grading to gray medium sand near the beach. Cores at this site show a sand horizon starting at the beach and either thinning or dipping seaward. This horizon has an increasing overburden of inorganic clays and silts to the north and west. The sand deposit near the existing beach has a thickness of 7 to 20 feet (1 to 6 m). The volume of material with overfill ratio of less than 2.0 is about 3.0×10^6 yds^3. More sand may be found at this site after further research is completed to delineate the extents of the horizon and the overburden material.

Thimble Shoals Ship Channel

As previously noted, east end of the Thimble Shoals channel was studied by CERC (Meisburger, 1972). The study indicated that 18.4×10^6 yds^3 of sand were present. The channel is slated for dredging to a depth of 55 feet in the proposed project to improve access to Hampton Roads. Dredging to 55 feet could yield 3.0×10^6 yds^3 of material. Should the channel be dredged to 50 feet, the yield would be 1.5×10^6 yds^3. The amount of this material that is sand size and suitable for beach nourishment still needs to be determined.

PLANNED WORK

During the second year of the study (July 1981 through June 1982), several lines of work will be followed. Additional cores will be taken to attempt to prove the resources of the "possible" areas and to explore an area off Virginia Beach in the area of the entrance channel. An engineering consultant will be hired to assess the different methods of dredging as to costs, efficiency, and environmental impacts. The study also will include a comparison of the economics of upland and subaqueous sand sources. Additionally, the biological resources of the bottom of the study area will be inventoried to provide an estimate of the potential biological consequences of sand extraction.

REFERENCES

Dean, R. J. 1974. Compatability of Borrow Materials for Beachfills: Proceedings of the 14th International Coastal Engineering Conference, p. 1319.

Hobson, R. D. 1977. Review of Design Elements for Beach-Fill Evaluation. Tech. Paper 77-6, Coastal Engineering Research Center.

Meisburger, E. P. 1972. Geomorphology of Sediments of the Chesapeake Bay Entrance. Tech. Memo No. 38, Coastal Engineering Research Center.

Norfolk District, U.S. Army Corps of Engineers. 1980. Subsurface Investigations for Beach Nourishment. Hurricane Protection of Beach Erosion Control Project, Willoughby Spit and Vicinity, Norfolk, Virginia.

Commonwealth of Virginia. 1979. Senate Document No. 4, Report to the Governor and the General Assembly of the Coastal Erosion Abatement Commission.

FIGURES

Figure 1. Location map of place names within the study area.

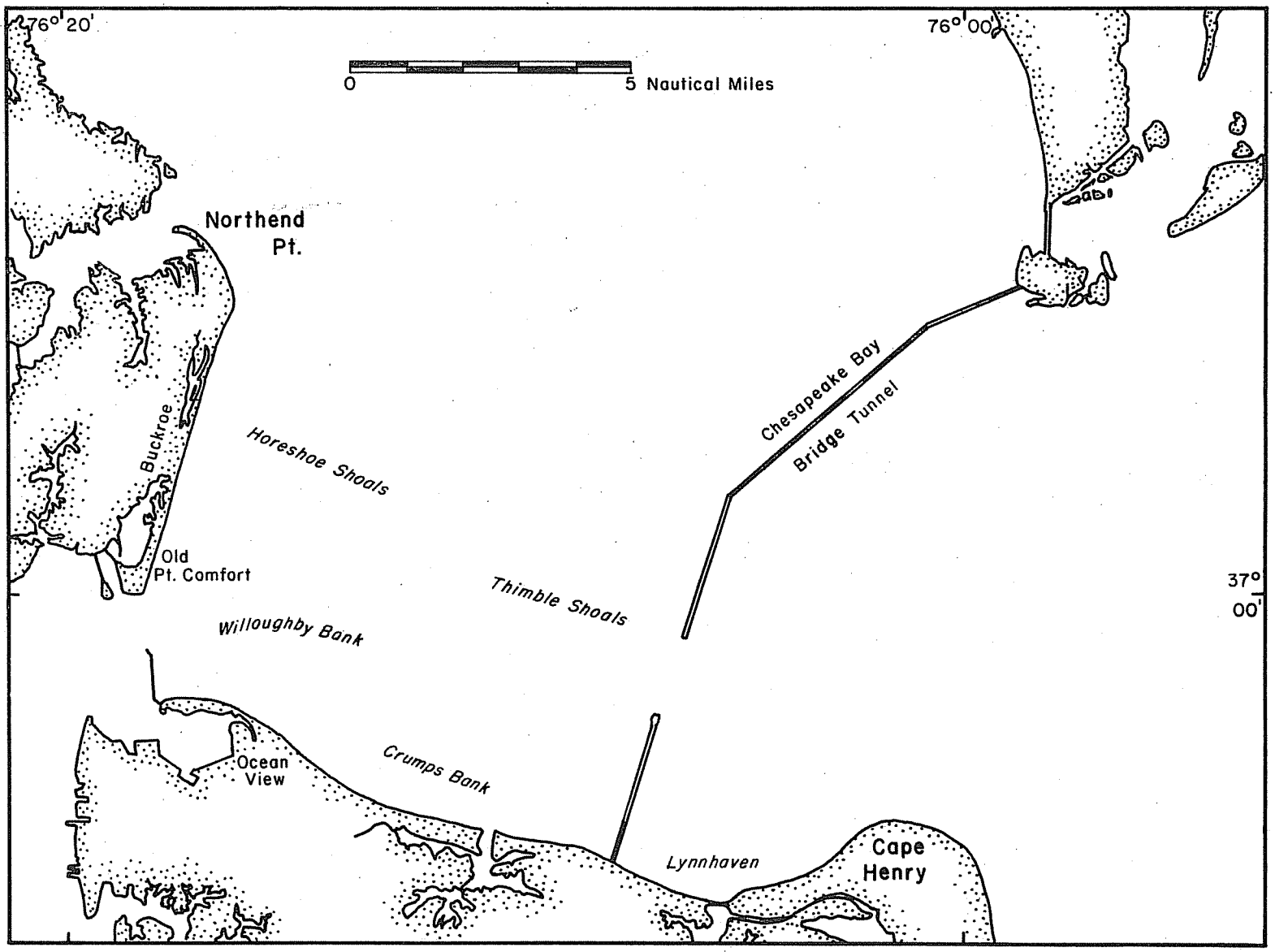

76° 20'
76° 00'
0
5 Nautical Miles
Northend Pt.
Buckroe
Horeshoe Shoals
Chesapeake Bay
Bridge Tunnel
Old Pt. Comfort
Thimble Shoals
37° 00'
Willoughby Bank
Ocean View
Crumps Bank
Lynnhaven
Cape Henry

Figure 2. Map showing the location of the 72 vibracores taken during fall of 1980.

VIBRACORE SITE LOCATIONS

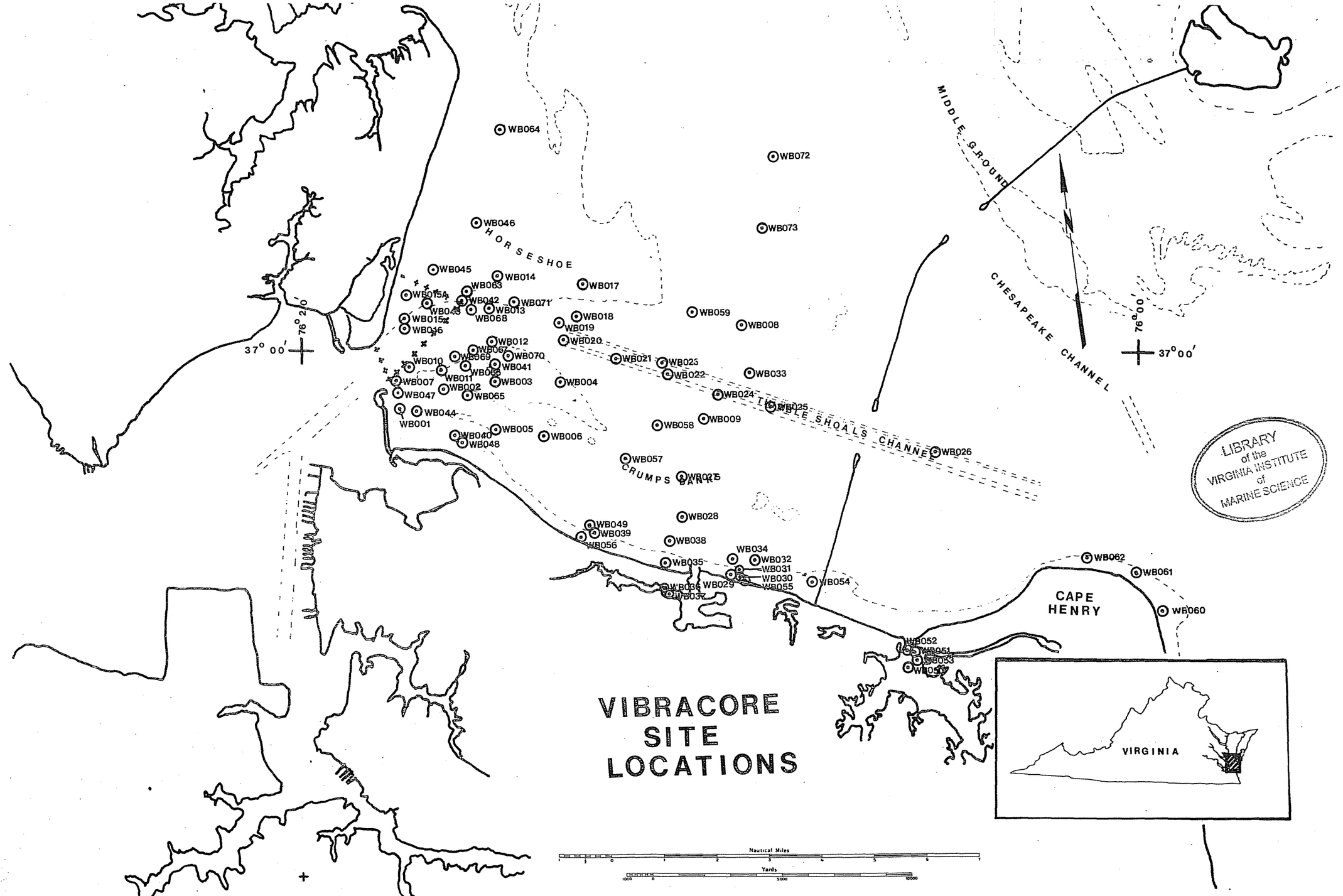


Figure 3. Map of the approximate 125 miles of seismic lines that were run n April 1981.

GEOPHYSICAL SURVEY APRIL 1981

37° 00′

76° 20′

76° 00′

37° 00′

SHOE

THIMBLE SHOALS CHANNEL

MIDDLE GROUND

CHESAPEAKE CHANNEL

STUMPS BANKS

CAPE HENRY

VIRGINIA

Nautical Miles

Yards

Figure 4. Map showing the location and distribution of probable and possible sand sources in the southernmost Chesapeake Bay.

SAND INVENTORY PROJECT
STUDY AREA and SURVEY SITES

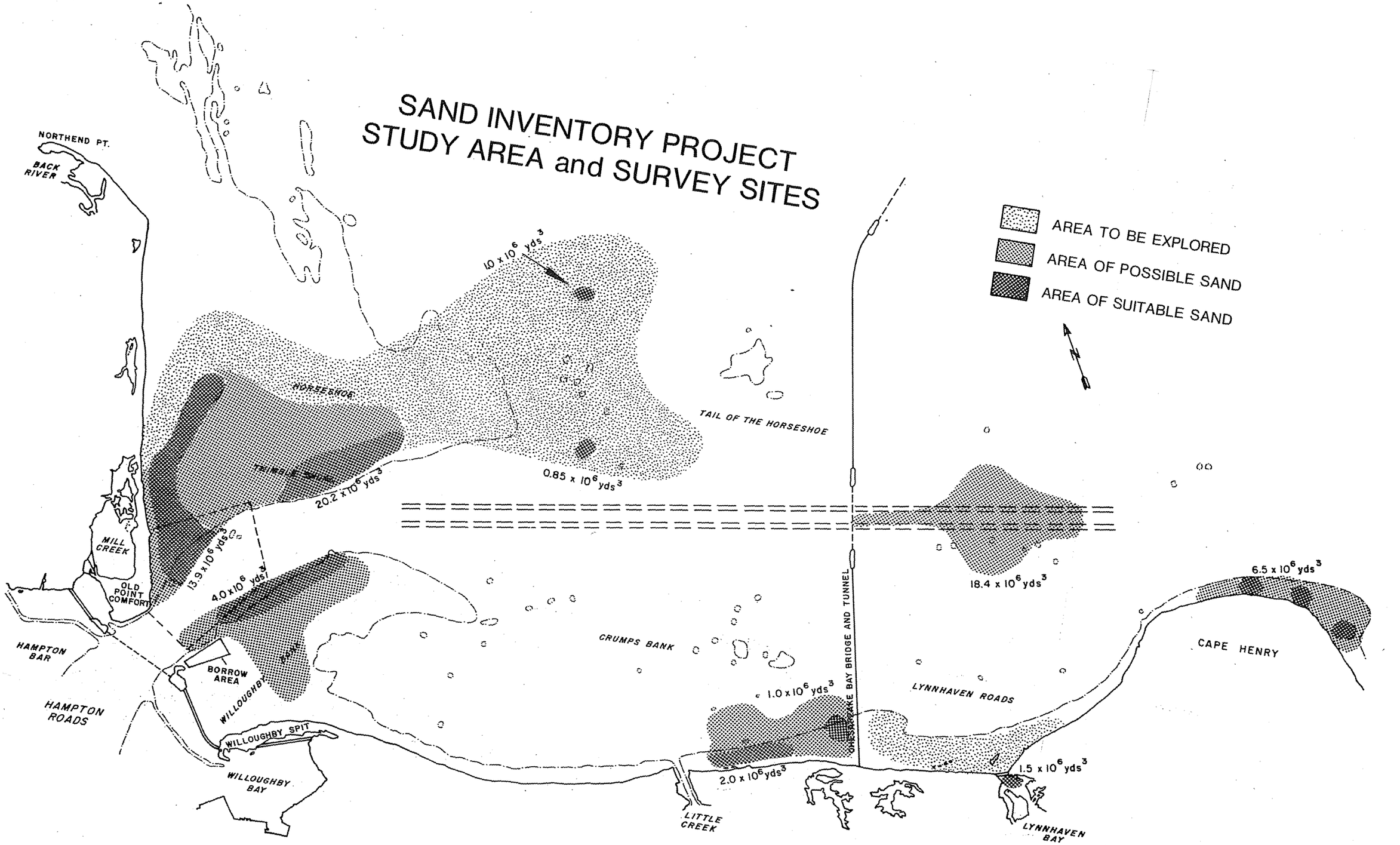


Figure 5. Isopach map of the thickness of the layers of usable sand.

ISOPACH (Thickness) OF SAND
10' Interval

NORTHEND PT.
BACK RIVER
HORSESHOE
TAIL OF THE HORSESHOE
THIMBLE SHOAL
MILL CREEK
OLD POINT COMFORT
HAMPTON BAR
HAMPTON ROADS
WILLOUGHBY BAY
WILLOUGHBY SPIT
CRUMPS BANK
CHESAPEAKE BAY BRIDGE AND TUNNEL
LYNNHAVEN ROADS
CAPE HENRY
LITTLE CREEK
LYNNHAVEN BAY

0 NAUTICAL MILES 1 2 3 4
0 2000 4000 YARDS

Figure 6. Contour map of the depth from the water surface to the bottom of the layers of usable sand.

DEPTH (Feet) TO BOTTOM OF SAND LAYERS

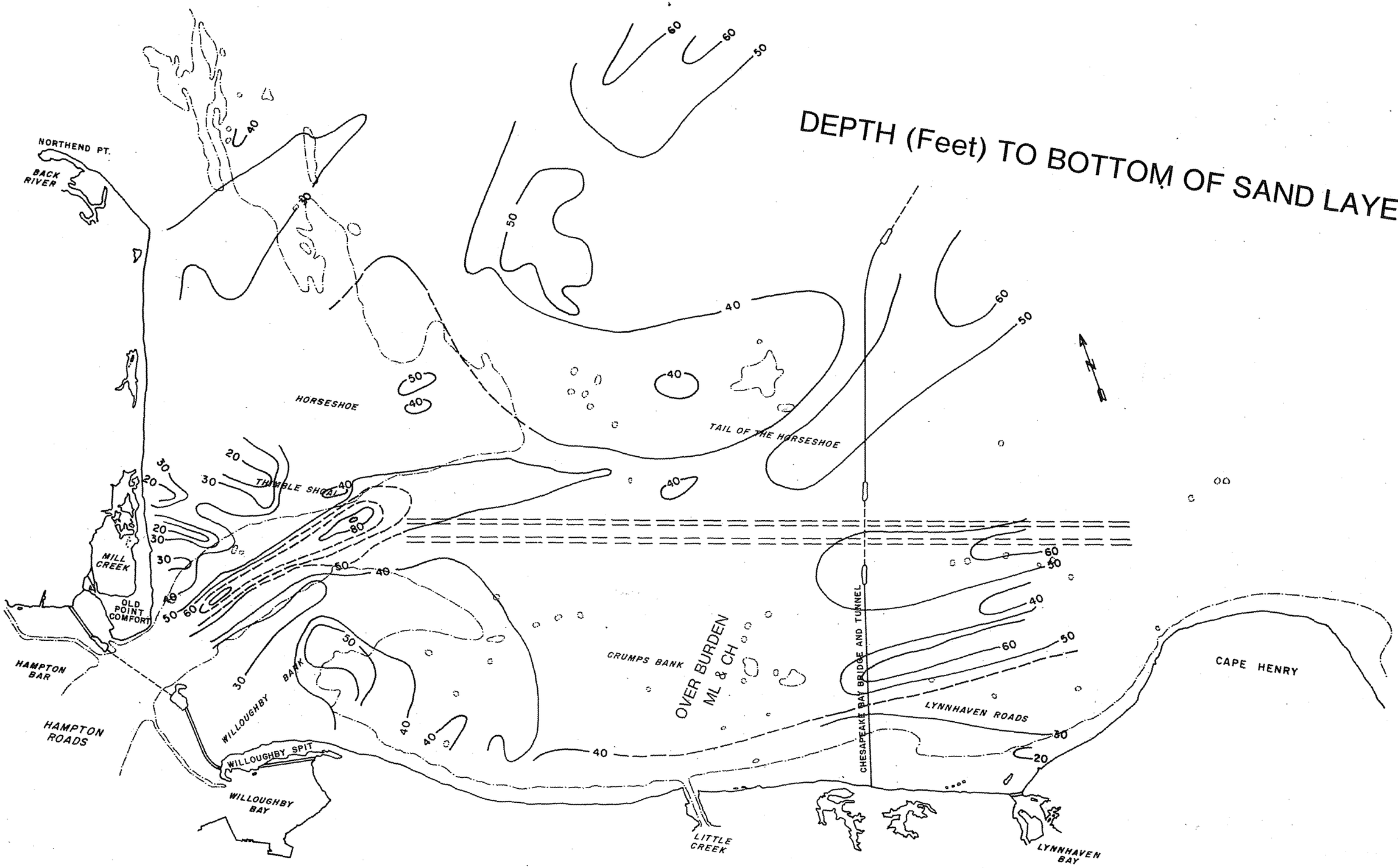


Figure 7. Preliminary map of the density and distribution of benthos.

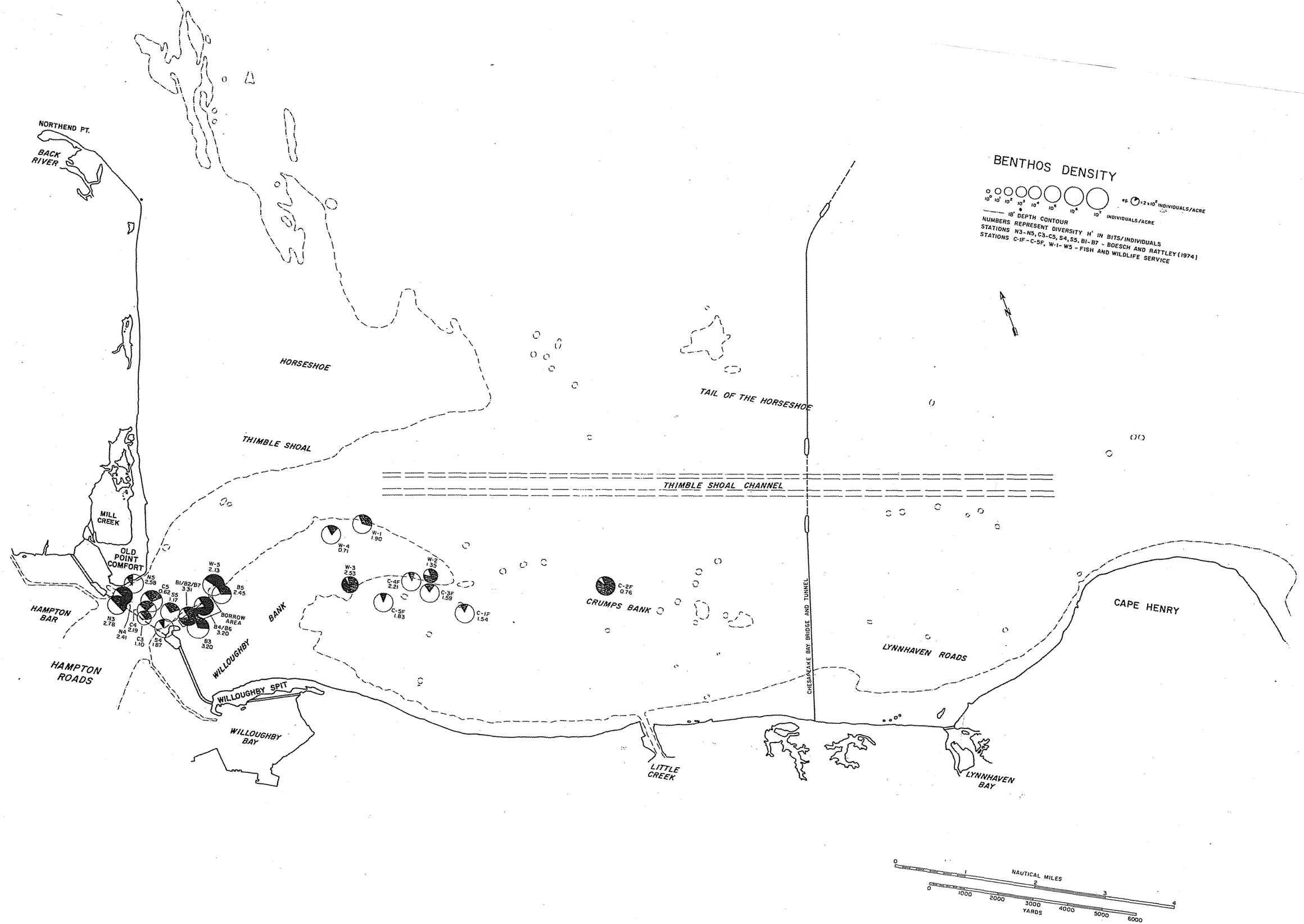
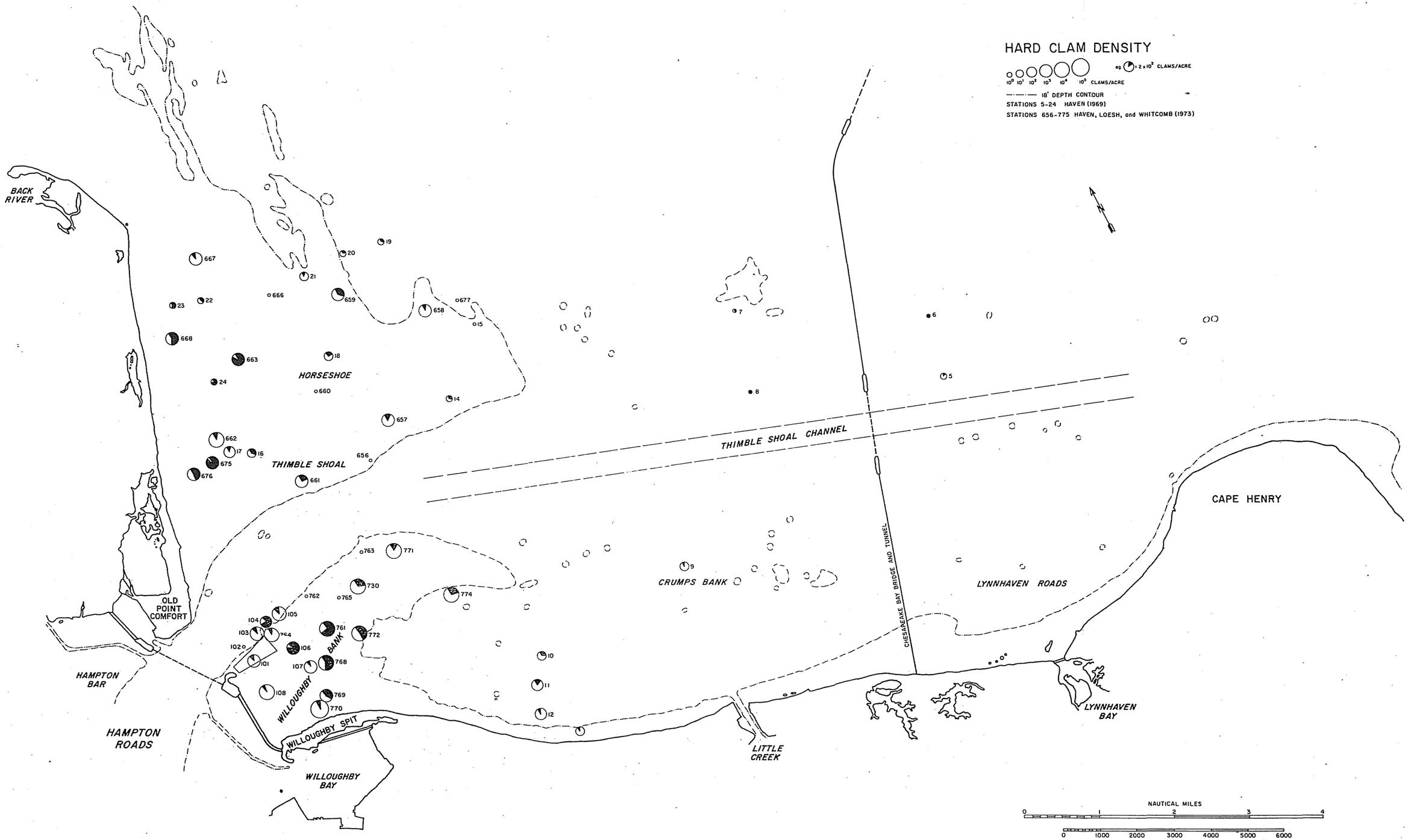

BENTHOS DENSITY
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 INDIVIDUALS/ACRE
e.g. 2×10^2 INDIVIDUALS/ACRE
18' DEPTH CONTOUR
NUMBERS REPRESENT DIVERSITY H' IN BITS/INDIVIDUALS
STATIONS N3-N5, C3-C5, S4, S5, B1-B7 - BOESCH AND RATTLEY (1974)
STATIONS C-1F-C-5F, W-1-W5 - FISH AND WILDLIFE SERVICE
NORTHEND PT.
BACK RIVER
HORSESHOE
TAIL OF THE HORSESHOE
THIMBLE SHOAL
THIMBLE SHOAL CHANNEL
MILL CREEK
OLD POINT COMFORT
HAMPTON BAR
HAMPTON ROADS
WILLOUGHBY BANK
WILLOUGHBY SPIT
WILLOUGHBY BAY
CRUMPS BANK
CHESAPEAKE BAY BRIDGE AND TUNNEL
LYNNHAVEN ROADS
CAPE HENRY
LITTLE CREEK
LYNNHAVEN BAY
BORROW AREA
W-1 1.90
W-2 1.35
W-3 2.53
W-4 0.71
W-5 2.13
C-1F 1.54
C-2F 0.76
C-3F 1.59
C-4F 2.21
C-5F 1.83
N3 2.78
N4 2.41
N5 2.59
C3 1.10
C4 2.19
C5 0.62
S4 1.87
S5 1.17
B1/B2/B7 3.31
B3 3.20
B4/B6 3.20
B5 2.45
0 1 2 3 4 NAUTICAL MILES
0 1000 2000 3000 4000 5000 6000 YARDS

Figure 8. Preliminary map of the density and distribution of hard clams.


HARD CLAM DENSITY
10⁰ 10¹ 10² 10³ 10⁴ 10⁵ CLAMS/ACRE
e.g. = 2 x 10² CLAMS/ACRE
18' DEPTH CONTOUR
STATIONS 5-24 HAVEN (1969)
STATIONS 656-775 HAVEN, LOESH, and WHITCOMB (1973)
BACK RIVER
HORSESHOE
THIMBLE SHOAL
THIMBLE SHOAL CHANNEL
CAPE HENRY
CRUMPS BANK
CHESAPEAKE BAY BRIDGE AND TUNNEL
LYNNHAVEN ROADS
OLD POINT COMFORT
HAMPTON BAR
HAMPTON ROADS
WILLOUGHBY BANK
WILLOUGHBY SPIT
WILLOUGHBY BAY
LITTLE CREEK
LYNNHAVEN BAY
NAUTICAL MILES
0 1 2 3 4
0 1000 2000 3000 4000 5000 6000
YARDS