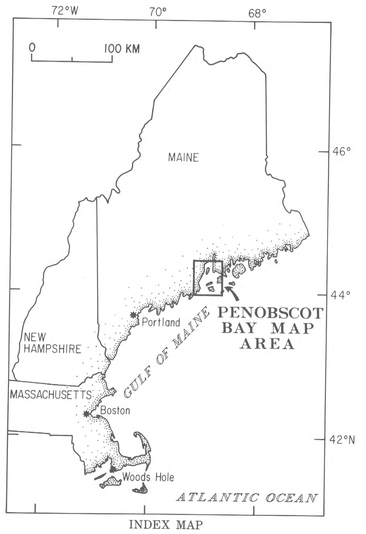
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF—1899



INDEX MAP

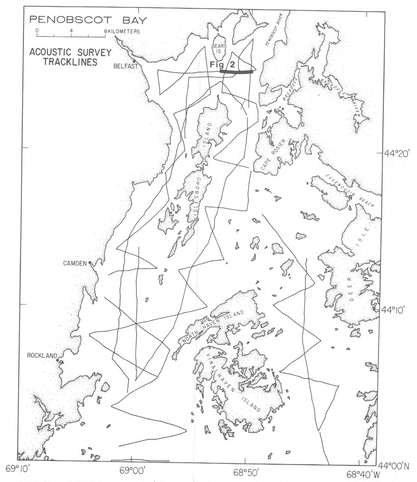


FIGURE 1.—MAP SHOWING LOCATIONS OF ACOUSTIC SURVEY TRACKLINES AND REPRESENTATIVE SEISMIC PROFILE.

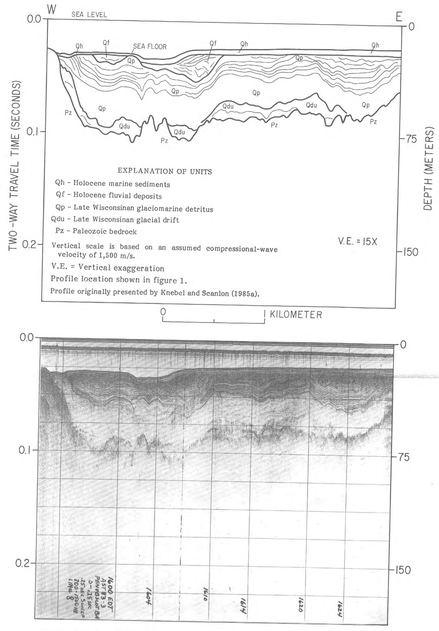


FIGURE 2.—REPRESENTATIVE SEISMIC PROFILE AND INTERPRETIVE SECTION.

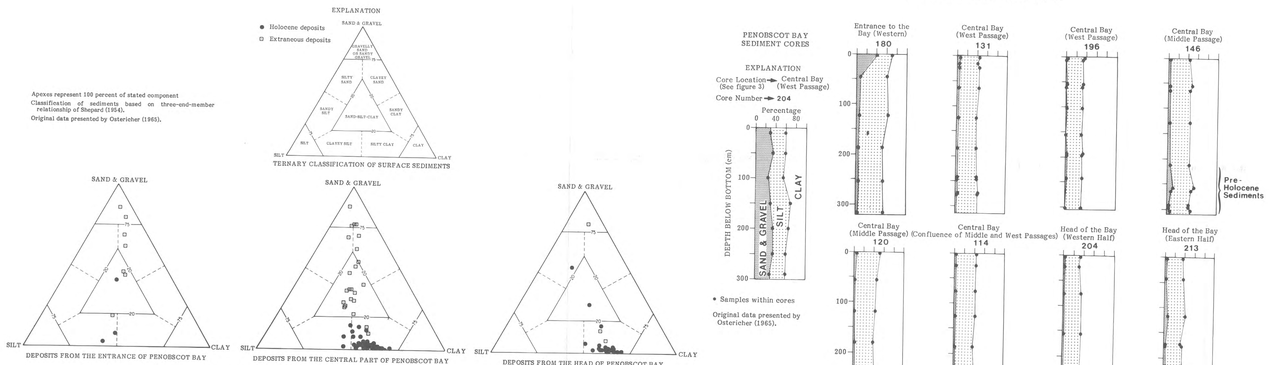


FIGURE 4.—TEXTURE OF SURFACE SEDIMENTS.

FIGURE 5.—DIAGRAMS OF CORES SHOWING CHANGES IN TEXTURE OF HOLOCENE SEDIMENTS WITH DEPTH

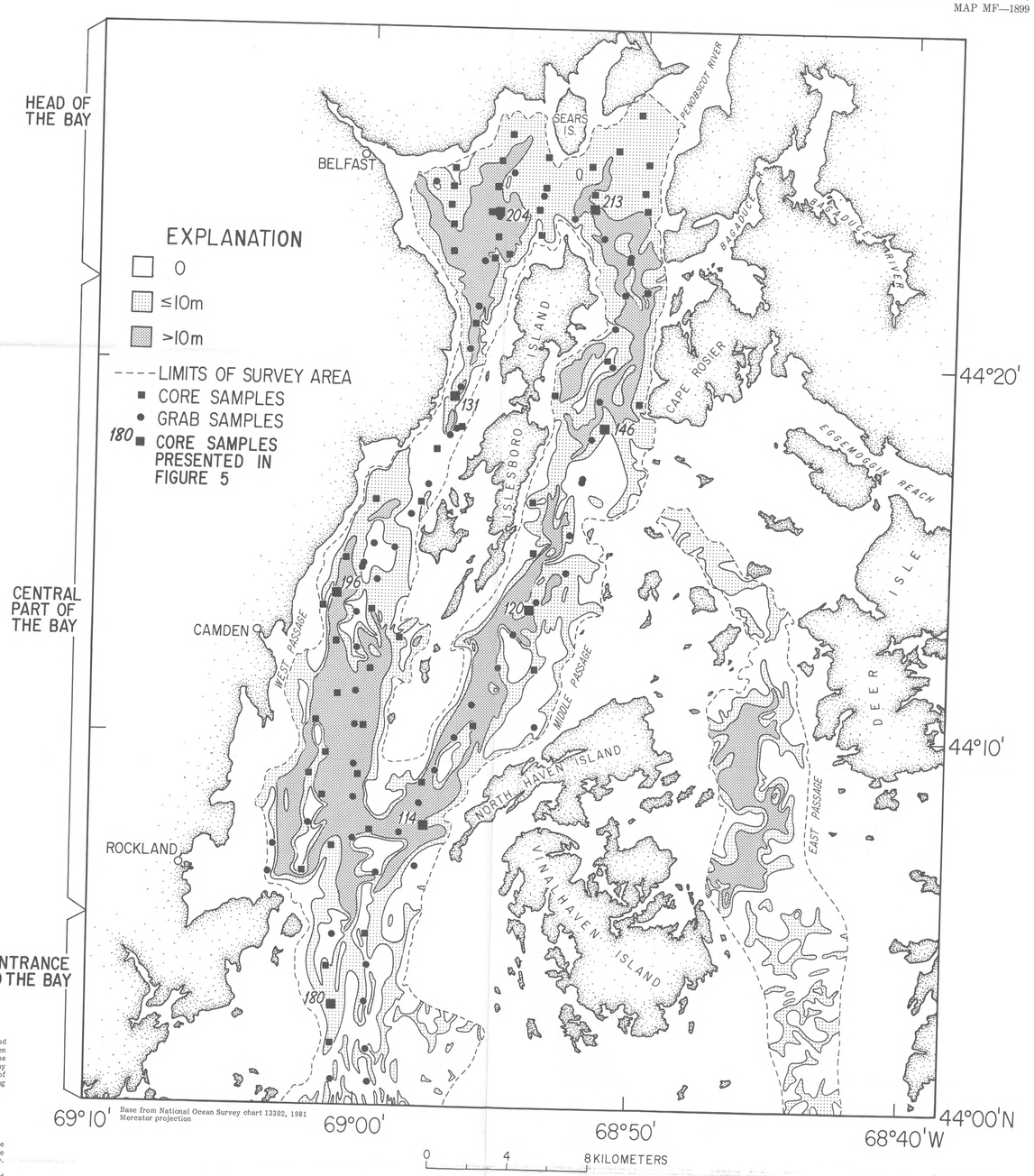


FIGURE 3.—AREAL DISTRIBUTION AND THICKNESS OF HOLOCENE SEDIMENTS.

MAP AND DIAGRAMS SHOWING THE DISTRIBUTION, THICKNESS, AND TEXTURAL CHARACTERISTICS OF HOLOCENE SEDIMENTS, PENOBSCOT BAY, MAINE

By
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INTRODUCTION

This report illustrates, describes, and briefly discusses the distribution and characteristics of Holocene sediments in Penobscot Bay, Maine. Penobscot Bay is one of the major estuaries along the U.S. Atlantic coast. It constitutes an area of about 1,100 km² and extends more than 50 km inland from the Gulf of Maine. The bay is divided into three main passages by numerous islands (index map and fig. 1).

The topography of the bay floor is quite variable (Knebel and Scanlon, 1985a,b). At the entrance to the bay (lat 44°00' N. to lat 44°05' N.) (see left edge of fig. 3), bottom depths change considerably over short distances, the result of an irregular bedrock sill having corresponding water depths of less than 80 m that extends across the bay mouth. In the central part of the bay (lat 44°05' N. to lat 44°23' N.), isolated bathymetric depressions are present along the axes of the main passages, and small knolls and ridges protrude above the bottom. The bay floor is flat or gently rolling within most large depressions, but it becomes irregular within constricted channels and around topographic prominences. At the head of the bay (north of lat 44°23' N.), the bottom is generally smooth. Bedrock crops out in only a few isolated locations between Islesboro and Sears Islands.

ACKNOWLEDGMENTS

I thank A.D. Colburn, Jr., Skipper of the RV *Asterias*, and K.M. Scanlon, U.S. Geological Survey, for their help in conducting the field work.

METHODS

The distribution and characteristics of Holocene sediments in Penobscot Bay are based on both acoustic and sample data. Acoustic profiles were collected along 376 km of trackline within the bay (fig. 1) during 11–17 June 1983 by using a Uniboom[1] seismic system (800- to 1,500-Hz band pass). Navigational control during the study was provided by LORAN-C. Subbottom profiles from the acoustic survey were recently published as part of a U.S. Geological Survey Miscellaneous Field Studies map (Knebel and Scanlon, 1985a) and in two synthesis reports on the sedimentary framework of the bay (Knebel and Scanlon, 1985b; Knebel, in press). One representative profile has been reproduced here (fig. 2).

Two Holocene sedimentary units beneath the bay were identified by Knebel and Scanlon (1985b) on the basis of characteristic acoustic returns. The upper unit, acoustically transparent or weakly layered, forms the sea floor over most of the bay (Qh in fig. 2). The lower unit, on the other hand, exhibits short, discontinuous, and irregular reflectors and some local cross-stratification (Qf in fig. 3); it is found only in the area near the mouth of the Penobscot River.

The textural characteristics of Holocene sediments within the bay are based on grab samples and piston cores collected at 121 stations by the U.S. Naval Oceanographic Office (Ostericher, 1965) (fig. 3). In order to identify samples of Holocene age, the distribution of Holocene deposits first was mapped by using the acoustic records, and the sample locations then were plotted relative to this distribution. The base of Holocene deposits in the cores was determined by color and textural changes that could be correlated with reflectors in the subbottom profiles. Visual descriptions and grain-size analyses of all grab and core samples have been presented by Ostericher (1965). Values for the 8-ϕ size fraction (silt-clay boundary), which were not included in the published data, were determined from cumulative grain-size curves.

DISTRIBUTION AND CHARACTERISTICS OF HOLOCENE DEPOSITS

Entrance of the bay

Holocene deposits at the entrance of the bay are concentrated in small isolated depressions atop the bedrock sill and within narrow entrance channels (fig. 3). Sediment accumulations here generally are less than 3 m thick.

Holocene sediments at the bay mouth are primarily silt-size particles (Ostericher, 1965) (figs. 5 and 6). The few available surface samples contain 0–2 percent gravel, 3–41 percent sand, 30–96 percent silt, and 29–45 percent clay, and they have smaller amounts of sand and gravel than most samples of extraneous (older) deposits (fig. 4). Below the surface (to depths of 320 cm), silt and clayey silt are the dominant sediment types. One core contained a combination of sand, silt, and clay in a small (40 cm) layer near its top (fig. 5, core 180).

Central part of the bay

In the central part of the bay, Holocene sediments are restricted primarily to deep-water areas along the axes of the three main passages (fig. 3). Near the shore (water depths ≤40 m), bedrock or older sediments usually crop out, and Holocene deposits either are thin (≤3 m) or absent.

Beneath the main passages, the distribution of Holocene sediments is quite variable (fig. 3). Sediment thickness ranges from zero to more than 20 m, being greatest within large subbottom depressions and least over subbottom or bathymetric highs. Thick deposits (>10 m) cover much of the southern halves of Middle and West Passages and one small area in the center of East Passage. The sediments are thinner (≤10 m) and either laterally restricted or discontinuous up the bay in Middle and West Passages and at the head of East Passage. Holocene sediments also are thin and discontinuous within many constricted bathymetric channels and near outcrops of bedrock or older sediments.

Surficial Holocene sediments in the central part of the bay are dominantly silty clays (Ostericher, 1965) (fig. 4). Based on 58 samples, the sediments are composed of 0–3 percent gravel, 0–15 percent sand, 29–53 percent silt, and 42–70 percent clay; the mean contents of silt and clay are 40 percent and 57 percent, respectively. Holocene surface samples are finer grained than those of extraneous samples, which were obtained primarily in relatively shallow water near the shore and over topographic highs.

Below the surface (to depths of 322 cm), Holocene sediments also are primarily silty clays (fig. 5; cores 114, 120, 131, 146, and 196). Relatively high contents of sand and silt are present in only a few cores that were collected either within narrow bathymetric channels or near outcrops of bedrock or older sediments.

Head of the bay

Holocene sediments cover almost the entire head of the bay. In contrast to the distribution in the central reaches, the deposits are nearly continuous and extend almost to the shoreline (water depths <10 m) (fig. 3).

The two Holocene sedimentary units identified in the acoustic profiles are present beneath the bay head (Knebel and Scanlon, 1985b; Knebel, in press). The lower unit is found in the eastern half of the area (Qf in fig. 2), where it occupies a sinuous late Wisconsinan valley of the Penobscot River. The thickness of this unit ranges from a few meters to as much as 18 m, being relatively thin within the mouth of the Penobscot River and thicker near the head of Middle Passage. Samples of the lower unit were not obtained during the study by Ostericher (1965).

The upper unit blankets the head of the bay (fig. 3). In the eastern half of the area, the unit ranges in thickness from 1–9 m, and the average thickness is about 5 m (Qh in fig. 2). In the western half of the bay head, the thickness of the unit ranges from 1–25 m, and the average thickness exceeds 10 m.

Surface samples of the upper Holocene unit are dominantly silty clays (Ostericher, 1965). Analyses of 27 grab samples show that the sediments are 0–19 percent gravel, 0–34 percent sand, 29–46 percent silt, and 17–70 percent clay (fig. 4). The average amounts of silt and clay are 35 percent and 59 percent, respectively.

The subsurface sediments (to depths of 328 cm) of the upper unit are more diverse (Ostericher, 1965). In the eastern half of the bay head, six of eight cores contain layers (5–137 cm thick) of gravelly and sandy mud and muddy sand near their bases, and the sediments become finer grained upwards (fig. 5, core 213). In contrast, nine cores collected from the unit in the western half of the area are uniformly silty clays (fig. 5, core 204); small layers of coarse-grained sediments are present in only a few cores which were collected either near the shore or adjacent to bedrock outcrops.

DISCUSSION

The distribution and other characteristics of Holocene sediments reflect the complex geologic history of Penobscot Bay since late Wisconsinan time (Knebel, in press). The last ice sheet advanced towards the south-southeast across the area about 20,000 years ago (Schafer and Hartshorn, 1965) and isostatically depressed the crust (Stuiver and Borns, 1975). During glaciation, the bedrock surface beneath the main passages of the bay was sculptured into a series of large (1–5 km wide) irregular troughs, and the shallow bedrock sill was formed across the bay entrance (Knebel and Scanlon, 1985a,b). Deglaciation followed between about 12,700–13,500 years ago and was accompanied by a marine transgression, with ice and sea in contact (Stuiver and Borns, 1975; Thompson, 1979, 1982; Smith, 1982, 1985). As the ice sheet withdrew from the bay, it deposited drift in isolated patches beneath the main passages, and glaciomarine sediments partially filled the bedrock troughs (Knebel and Scanlon, 1985b). Isostatic crustal rebound then caused the coast to emerge during the immediate postglacial period, and emergence was complete by about 11,500 years ago (Stuiver and Borns, 1975; Thompson, 1979, 1982; Thompson and Smith, 1983; Smith, 1985). During emergence, (1) relative sea level within the bay fell to at least 40 m below present sea level; (2) the ancestral Penobscot river flowed across the eastern half of the bay head into Middle Passage; and (3) early Holocene marine sediments accumulated within remnant bedrock depressions in the lower reaches of Middle and West Passages (Knebel and Scanlon, 1985b; Knebel, in press). Finally, resubmergence of the coast accompanied the Holocene rise of sea level that began sometime before 9,000 years ago (Kaye and Barghoorn, 1964; Schnitker, 1974; Oldale and others, 1983). Since the start of the sea-level transgression, (1) the ancestral valley of the Penobscot River has been filled with fluvial deposits; (2) the locus of marine sedimentation has shifted from the central part to the head of the bay; and (3) Holocene sediments in the central bay and at the bay entrance have been eroded, reworked, and redistributed by waves and currents (Knebel, in press).

As a result of the complex geologic history, the distribution and other characteristics of Holocene deposits in Penobscot Bay have been controlled primarily by four factors (Knebel, in press). These are: (1) the topography of the glacially-eroded bedrock surface; (2) the paleogeography of the bay during the postglacial lowstand of sea level; (3) the location of the ancestral Penobscot River; and (4) the wave and current regime during and since the Holocene sea-level transgression.

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[1] Any trade names in this publication are used for descriptive purposed only and do not constitute endoresement by the U.S. Geological Survey.

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