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Sidescan Sonar Image, Surficial Geological Interpretation, and Bathymetry of the Long Island Sound Sea Floor off Milford, Connecticut

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Comments

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See also these related documents:

Map Showing the Distribution of Surficial Sediments in Fishers Island Sound, New York, Connecticut, and Rhode Island

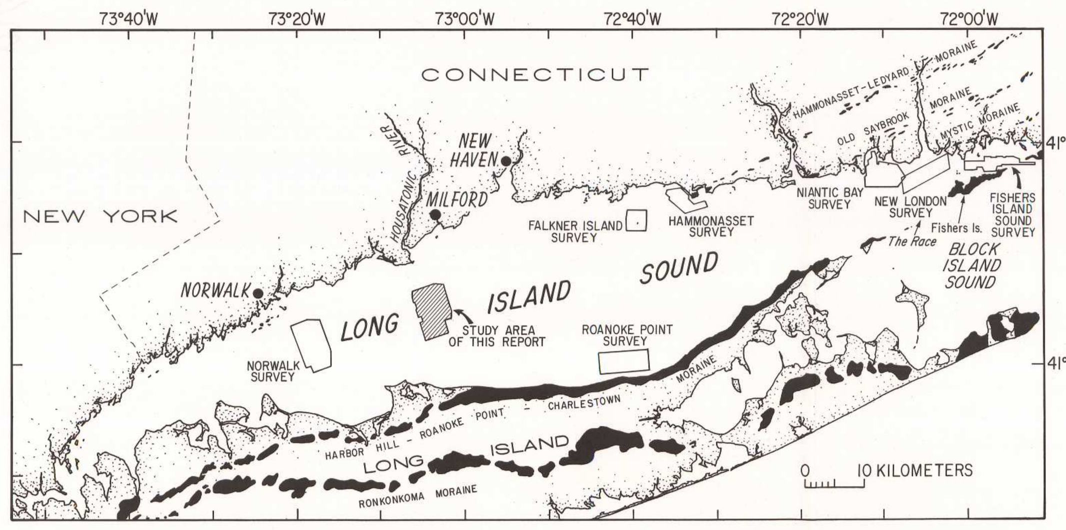
Organic Carbon, Hydrogen, and Nitrogen Concentrations in Surficial Sediments from Western Long Island Sound, Connecticut and New York

Sidescan Sonar Image, Surficial Geologic Interpretation, and Bathymetry of the Long Island Sound Sea Floor off Hammonasset Beach State Park, Connecticut

The Texture of Surficial Sediments in Central Long Island Sound off Milford, Connecticut

The Texture of Surficial Sediments in Western Long Island Sound off the Norwalk Islands, Connecticut

Prepared in cooperation with the
STATE OF CONNECTICUT, DEPARTMENT OF ENVIRONMENTAL PROTECTION,
GEOLOGICAL AND NATURAL HISTORY SURVEY
and the
UNIVERSITY OF NEW HAVEN



Location map showing the study area in Long Island Sound off Milford, Conn., and major onshore moraines. Also shown are the sites of other sidescan sonar surveys that are part of this series: Norwalk—Twichell and others (1997); Roanoke Point—Poppe and others (1998a); Falkner Island—Poppe and others (1997b); Hammonasset—Poppe and others (1997a); Niantic Bay—Poppe and others (1998b); New London—Poppe and others (1992), Moffett and others (1994), and Zajac and others (1995); Fishers Island Sound—Poppe and others (1994 and in press).

INTRODUCTION

The surficial geology of a 6-km x 8-km section of the floor of the western part of Long Island Sound has been mapped. The map area is 4 to 12 km south of the mouth of the Housatonic River in 14 to 40 m water depth (see location map). This study is part of an interdisciplinary program to define the surficial geology and benthic habitats in Long Island Sound and to see how they are changing with time, and includes, in addition to this map area, the other survey areas shown on the location map. The U.S. Geological Survey, in cooperation with the University of New Haven and the Connecticut Geological and Natural History Survey, completed a bathymetric, sidescan sonar, and high-resolution seismic-reflection survey of the study area during November 1993 as the first phase of this long-term program. The second phase, which involved bottom sampling and photography, was completed during April-August 1995. Presented in this report is the surficial geological information including the bathymetry, a sidescan sonar mosaic, a preliminary interpretation of the mosaic, and a sediment distribution map of the study area.

GEOLOGIC SETTING

Long Island Sound is a large estuary that is underlain by Precambrian and Paleozoic rocks along its northern side and by Cenozoic strata along its southern side (Rodgers, 1985; Fuller, 1914). Surficial sediments in the Sound were deposited primarily during the Wisconsinan glacial stage and the subsequent Holocene interglacial stage. Because this report deals only with the shallow stratigraphy, this geologic summary is limited to the glacial and post-glacial history of the Sound. A more detailed discussion of the entire geologic history of the Sound has been presented by Lewis and Stone (1991).

The Laurentide ice sheet advanced across Long Island Sound during the Wisconsinan and formed the Ronkonkoma and Harbor Hill-Roanoke Point-Charlestown end moraines on Long Island (Schafer and Hartshorn, 1965; Sirkin, 1982). After the ice retreated, a glacial lake, Lake Connecticut, formed behind the moraines in the present location of the Sound (Lewis and Stone, 1991). Varved clays accumulated in the central part of the Sound, and deltas formed along the northern edge of this lake. Deltaic facies presently underlie much of the northern part of the Sound (Lewis and Stone, 1991). The moraine that served as the dam for this lake broke at The Race (see location map). Glacial Lake Connecticut drained into Block Island Sound and from there southward across the continental shelf (Lewis and Stone, 1991). The exposed lake floor was cut by tributary rivers and a central river that drained eastward down the axis of the Sound. As sea level rose, the Sound was flooded. The transgressing sea eroded the underlying strata and partially smoothed the fluvially cut surface. On top of this marine transgressive unconformity, sediments have accumulated during the Holocene.

DATA COLLECTION

Bathymetric data, sidescan sonar imagery, and 3.5-kHz subbottom profiles were collected during November 7–11, 1993, aboard the research vessel (RV) *John Dempsey* (operated by the Connecticut Department of Environmental Protection) along tracks spaced about 150 m apart (fig. 1). The bathymetric data were collected by using an Odem 60-kHz echo sounder, and the data were logged digitally on an IBM personal computer. The subbottom data were collected by using an Ocean Research Equipment 3.5-kHz subbottom profiler transmitting at a 0.25-s repetition rate. These data were logged in analog form on a paper chart recorder with examples shown in figure 2 and the interpretation summarized in figure 3. The sidescan sonar data were collected by using a 100-kHz Klein sidescan sonar system set to insonify a 100-m swath to either side of the ship's track. These data were logged digitally on a QMIPS data logger (Danforth and others, 1991) and were written to tape at 2048 pixels per scan. The completed sidescan mosaic is shown in figure 4 and an interpretation is shown in figure 5. Ship's navigation was by differential Global Positioning System (GPS) using the shore station at Montauk Point, N.Y.

Surficial sediments were sampled and bottom photography was attempted at 77 locations during the April 26–30 and August 27–28, 1995, cruises aboard the RV *John Dempsey* using a Van Veen grab sampler equipped with video and still camera systems (fig. 6). These photographic systems were used to appraise intrastation bottom variability and to observe boulder fields where sediment samples could not be collected. Surficial sediments (sediments from the sediment-water interface down to 2 cm below the interface) were subsampled from the grab sampler; these samples were frozen and stored for later analysis.

DATA PROCESSING

Post-cruise processing was performed on the digital data sets, and an interpretative geologic map was made of the analog 3.5-kHz subbottom profiles. The bathymetric data were corrected for the 2-m tidal range in the study area. This correction was done by subtracting the tide level measured at the Bridgeport, Conn., tide station during the study period from the measured depth values. The depths were corrected to mean sea level measured at Bridgeport, Conn.

The sidescan sonar data were processed, and a digital mosaic was compiled of the entire study area. The processing steps included subsampling the raw sidescan sonar data with a median filtering routine to suppress speckle noise (Malinverno and others, 1990; Danforth and others, 1991) and correcting for slant range distortion, signal attenuation, and dropped lines in the sonar data. These processing procedures are summarized by Danforth and others (1991) and Paskevich (1992a,b). After the preliminary processing, these data were used to make the composite digital mosaic. The mosaicking procedure included placing each strip of sonar data in its proper geographic location at the appropriate scale and projection (Paskevich, 1992c), trimming unwanted data where two sonar images overlapped, tone matching the adjacent sonar images if there were differences, and combining the individual strips into a composite image. The final steps of trimming data, matching tones between different strips, and combining the strips was completed by using a software package developed by PCI (Nelson, 1991). The digital mosaic was output to film and photographically enlarged to a scale of 1:15,000.

In the laboratory, the textural samples were corrected for salt content, disaggregated, and wet sieved through a number 230, 62 µm (4 phi) sieve to separate the coarse and fine fractions. The fine fraction was analyzed by Coulter Counter (Shideler, 1976); the gravel fraction was analyzed by sieving, and the sand fraction was analyzed by rapid sediment analyzer (Schlee, 1966). Because biogenic carbonates commonly form in situ, they usually are not representative of the depositional environment from a textural standpoint. Therefore, bivalve shells and other biogenic carbonate debris were manually removed from the gravel fraction. Size classifications are based on the method proposed by Wentworth (1929). The verbal equivalents were calculated by using the inclusive graphics statistical method (Folk, 1974) and were based on the nomenclature proposed by Shepard (1954). A detailed discussion of the laboratory methods employed is given in Poppe and others (1985); the raw grain-size data, associated statistics, and detailed descriptions of the bottom photography are reported in Poppe and others (1996).

The map of surficial sediment distribution shown in figure 6 is based on data from the sediment sampling and bottom photography stations, on tonal changes in backscatter on the sidescan sonar image, and on the bathymetry.

GEOLOGIC INTERPRETATION

Bathymetry and Tracklines

The bathymetry was contoured at a 2-m interval (fig. 1). The sea floor in the eastern half of the study area has a smooth gradient that slopes uniformly to the south. Water depths along the northern edge of the study area are 14 to 20 m and along the southern edge are about 36 m. The western half of the study area has a more complex morphology. The gentle southerly gradient seen in the eastern part of the study area is interrupted by an elongate steep-sided depression and an irregular bathymetric high, Stratford Shoal (U.S. National Oceanic and Atmospheric Administration, 1992). The depression extends westward from the center of the study area beyond the extent of our data. Its 40 m depth is the deepest part of the study area and is 14 m deeper than the sea floor immediately to the east. Stratford Shoal, south of the depression, rises to 16 m depth in the west-central portion of the study area.

Near-Surface Seismic Facies and Stratigraphy

Three seismic facies were identified on the 3.5-kHz subbottom profiles (fig. 2): (1) a facies having a highly reflective and prolonged surface return with no subbottom reflections below it shown as drift on profiles A and E; (2) a facies having a moderately reflective and prolonged surface return with no subbottom reflections below it shown as glaciodeltaic deposits on profiles B–E; and (3) an acoustically transparent facies having a moderately reflective surface return shown as marine deposits on profiles A, D, and E. In places the acoustically transparent facies is charged with gas and is acoustically opaque. The gas-charged sediments blank out everything below them (profile E).

The facies with the highly reflective and prolonged surface return is the oldest unit mapped in the study area. On the basis of the regional stratigraphy of Lewis and Stone (1991), this unit probably is glacial drift. The presence of fields of boulders on the sidescan mosaic where the drift crops out is consistent with this interpretation (figs. 4, 5). Profile E (fig. 2) shows that it underlies the facies with the moderately prolonged surface return, and profile A (fig. 2) shows that it underlies the acoustically transparent facies as well. The 3.5-kHz profiles show that the drift is exposed on Stratford Shoal (fig. 3). It cannot be traced in the subsurface northward from Stratford Shoal under the depression, but it can be traced east from the limit of outcrop for 300 to 1,000 m under a 1- to 3-m-thick veneer of the acoustically transparent facies before it drops off abruptly to greater than 30 m below the sea floor (fig. 2, profile A).

The facies with the moderately reflective and prolonged surface return (fig. 2, profiles B–E) crops out in the northwestern part of the study area where it extends southward to the northern edge of Stratford Shoal (fig. 3). The regional stratigraphy (Lewis and Stone, 1991) suggests that this facies is a sandy glaciodeltaic deposit that accumulated along the northern side of the Sound when it was occupied by Glacial Lake Connecticut. This unit is of unknown thickness because the 3.5-kHz subbottom profiling system could not penetrate it. This unit is younger than the drift because it onlaps the drift along the northern edge of Stratford Shoal (fig. 2, profile E).

The acoustically transparent facies is the youngest of the three units and overlies both the drift (fig. 2, profile A) and the glaciodeltaic deposits (fig. 2, profile D). This unit is interpreted to be a fine-grained marine deposit of Holocene age (Lewis and Stone, 1991). In the southeastern part of the study area, the thickness of the marine deposits could not be determined because the 3.5-kHz profiler could not penetrate below them. In most of the northern part of the study area, where the 3.5-kHz profiler could penetrate through the marine deposits, they are less than 8 m thick, and thin gradually to the west where the glaciodeltaic deposits crop out (fig. 3). Gas-charged sediment occurs in the marine deposits and is confined to the deepest part of the bathymetric depression in the central part of the study area (fig. 3).

Sidescan Sonar Mosaic

The sidescan sonar mosaic (fig. 4) reveals nine distinctive sea-floor patterns, and when combined with the seismic data (fig. 2) can be used to make inferences about the surficial geology (fig. 5). The nine patterns include (1) low acoustic backscatter (dark tones), (2) high acoustic backscatter (light tones), (3) gas-charged sediment, (4) fields of positive relief high-backscatter targets interpreted to be clusters of boulders, (5) isolated high-backscatter targets interpreted to be individual boulders, (6) broad curvilinear low-backscatter stripes inferred to be bedforms, (7) circular depressions with high-backscatter floors, (8) short, linear high-backscatter stripes, (9) shallow, linear depressions interpreted to be trawl marks, and (10) long, thin, linear high-backscatter stripes interpreted to be pipelines and cables. Boat wakes are a water column phenomenon that were observed as well.

The study area is divided into two provinces, high and low acoustic backscatter (fig. 5). We set the boundary between these provinces to a digital number of 35 because the distribution of values exceeding a digital number of 35 coincides closely with the glaciodeltaic deposits and glacial drift as shown on figure 3. One exception is the outcrop of the glaciodeltaic deposits immediately east of the bathymetric depression where the area of high backscatter (figs. 4, 5) is smaller than the extent of the outcrop seen on the near-surface echo character map (fig. 3). Perhaps there is a thin cover of marine deposits over much of this area that cannot be resolved on the 3.5-kHz profiles and is reducing the backscatter intensity below the threshold of 35.

The area of low backscatter on the sidescan image coincides with finer grained Holocene-aged marine deposits (fig. 6). The boundaries between the high- and low-backscatter regions are gradational, and backscatter intensity is not uniform throughout the low-backscatter area. The values are lowest in the deepest part of the bathymetric depression and coincide roughly with the distribution of gas in the sediment (figs. 4, 5). The areas of higher backscatter probably indicate mixing with the adjacent or underlying coarser grained deltaic deposits.

The other features identified on the sidescan mosaic are found within either the

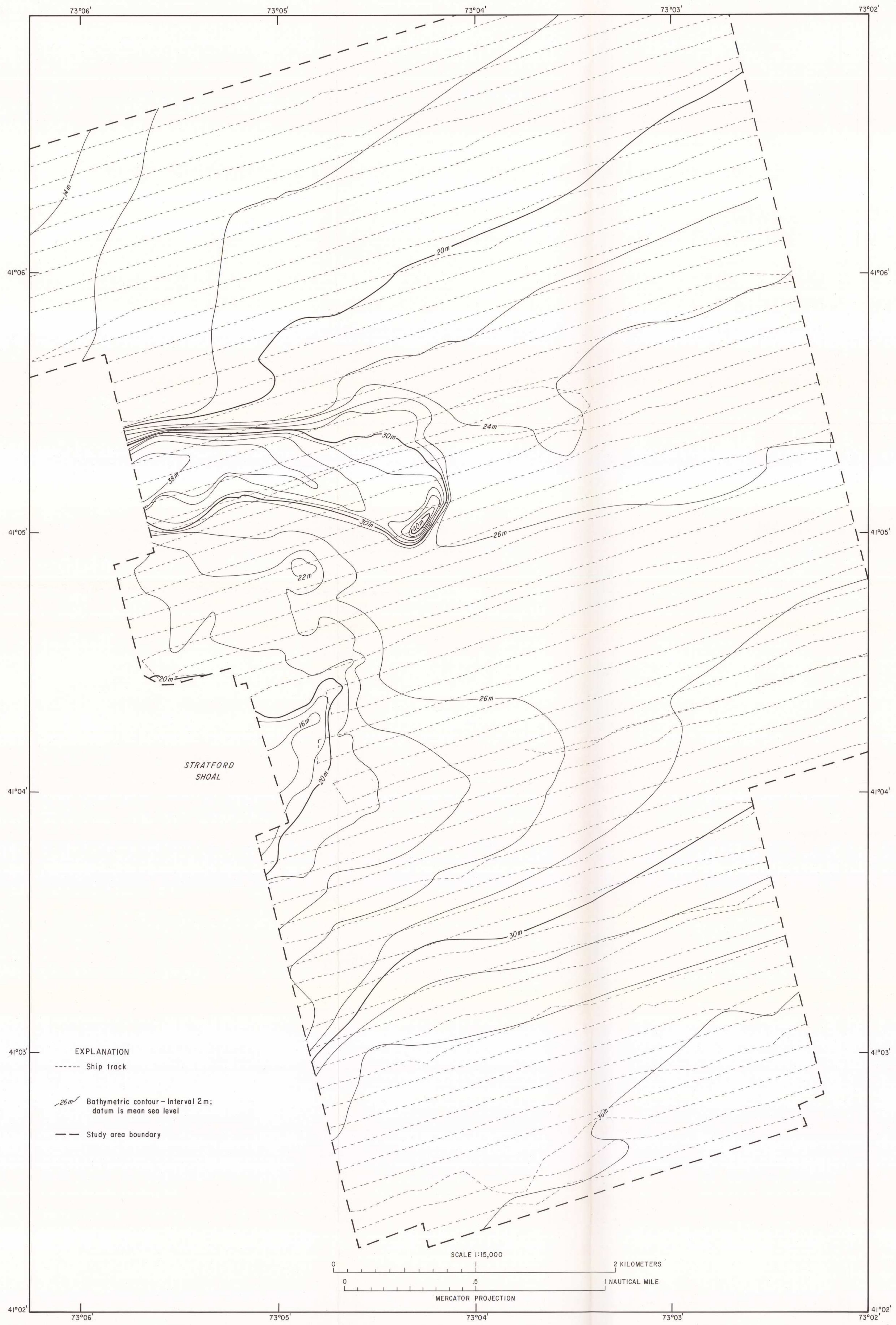


Figure 1.—Bathymetric map of the study area. Depths have been corrected for tides and are adjusted to mean sea level. Dashed lines represent tracks along which geophysical data were collected.

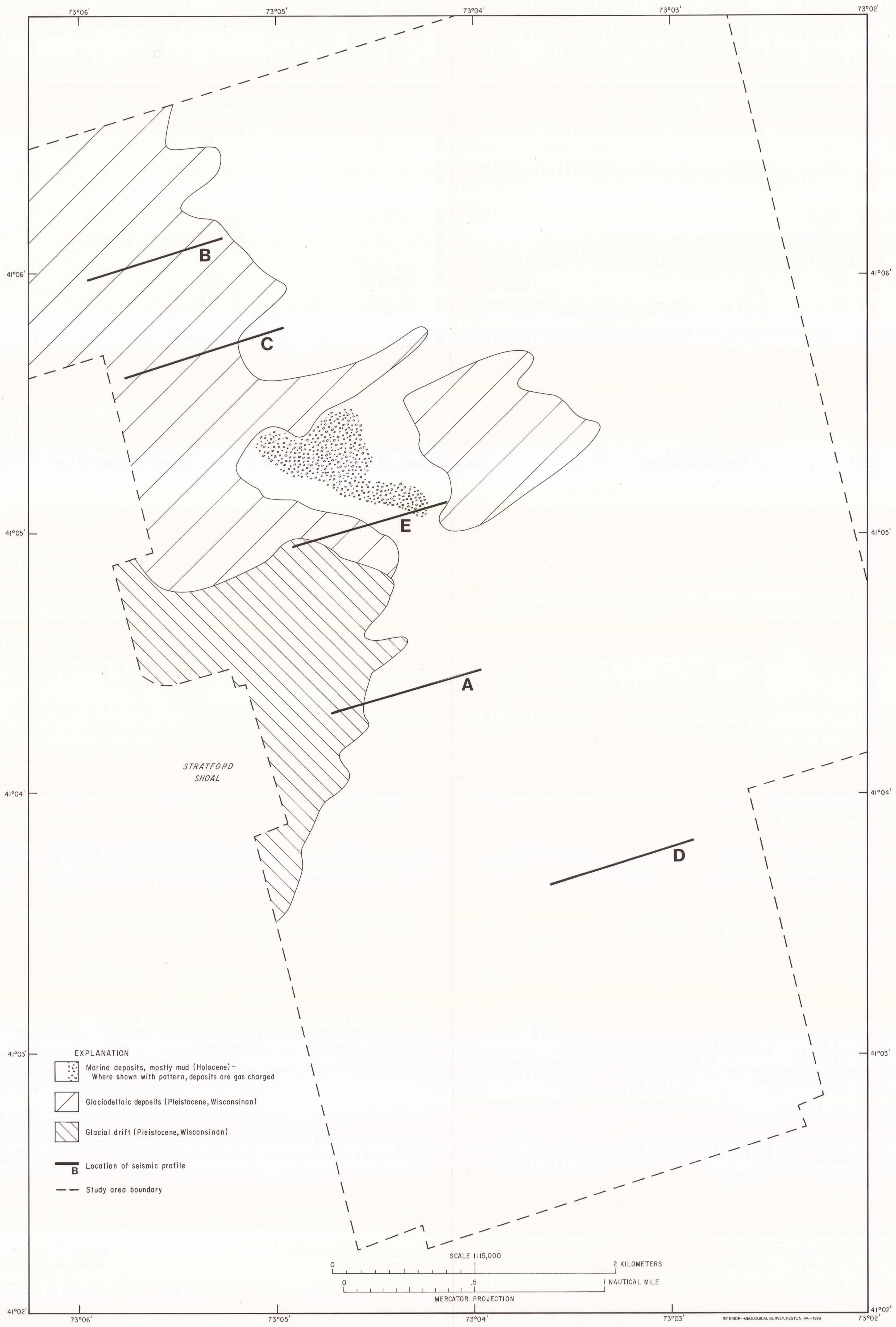


Figure 3.—Near-surface echo character map compiled from the 3.5-kHz subbottom profiles showing the distribution of the three acoustic facies that were defined by the subbottom profiles.

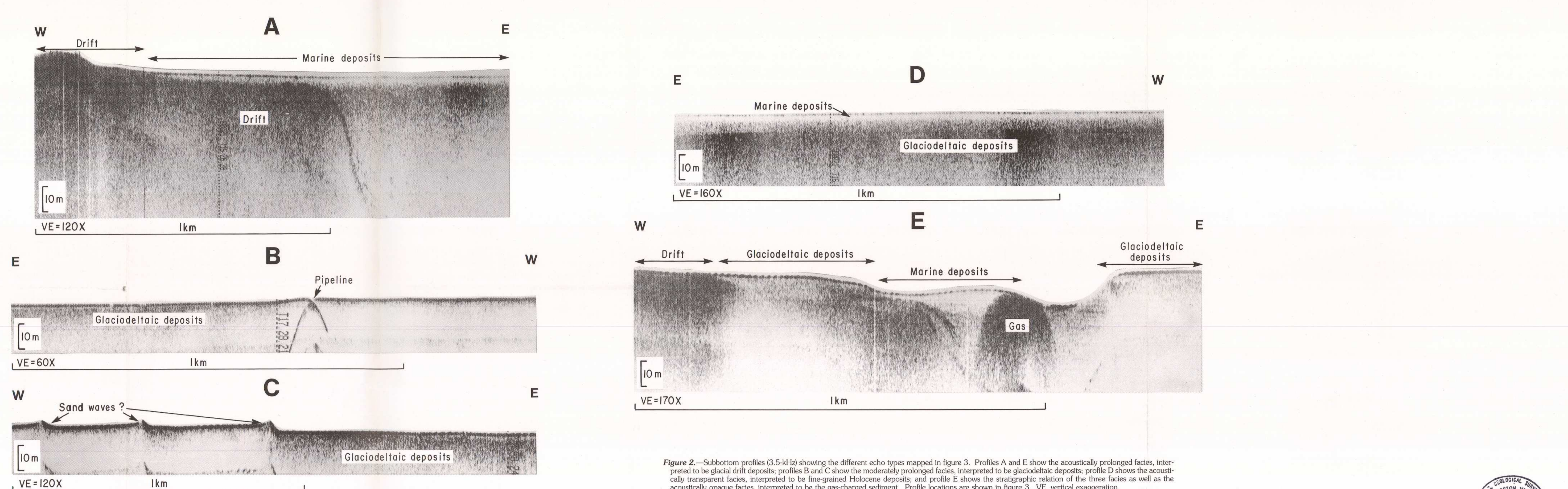


Figure 2.—Subbottom profiles (3.5-kHz) showing the different echo types mapped in figure 3. Profiles A and E show the acoustically prolonged facies, interpreted to be glacial drift deposits; profiles B and C show the moderately prolonged facies, interpreted to be glaciodeltaic deposits; profile D shows the acoustically transparent facies, interpreted to be fine-grained Holocene deposits, and profile E shows the stratigraphic relation of the three facies as well as the acoustically opaque facies, interpreted to be the gas-charged sediment. Profile locations are shown in figure 3. VE, vertical exaggeration.

SIDESCAN SONAR IMAGE, SURFICIAL GEOLOGIC INTERPRETATION, AND BATHYMETRY OF THE LONG ISLAND SOUND SEA FLOOR OFF MILFORD, CONNECTICUT

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