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THEMATIC SECTION

Regional Processes, Conditions, and Characteristics of the Long Island Sound Sea Floor

Harley J. Knebel[1], Ralph S. Lewis[2], and Johan C. Varekamp[3], Guest Editors

[1]U.S. Geological Survey
Center for Coastal and Marine Geology
Woods Hole, MA 02543, U.S.A.

[2]State Geological and Natural History Survey of Connecticut
Environmental and Geographic Information Center
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106, U.S.A.

[3]Department of Earth and Environmental Sciences
Wesleyan University
265 Church Street
Middletown, CT 06459, U.S.A.

ABSTRACT

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Long Island Sound is a major coastal estuary that is contiguous to the New York-Connecticut metropolitan area. More than eight million people live within its watershed (U.S. ENVIRONMENTAL PROTECTION AGENCY, 1994). As a consequence of this enormous population, the Sound is heavily used and, its sea floor has been affected by human activities. The sea floor in the Sound comprises a variety of benthic habitats that support a large commercial and recreational fishery. It is also a sink for wastes and contaminants derived from various sources including rivers and streams, urban and agricultural runoff, wastewater treatment plants, airborne transport, disposal of dredged material, and tidal exchange with the New York City area (FARROW *et al.,* 1986; WOLFE, *et al.,* 1991; RHOADS, 1994).

In 1995, the U.S. Geological Survey Coastal and Marine Geology Program, in cooperation with the State of Connecticut Department of Environmental Protection, initiated a multidisciplinary project designed to understand the distribution of bottom contaminants and benthic habitats in Long Island Sound. This project prompted a number of studies which were focused on the regional processes, conditions, and characteristics of the sea floor. The Thematic Section presented in this volume is a product of these studies.

To the extent possible, individual papers in the Thematic Section contribute to an integrated synthesis of the Long Island Sound estuarine system. This integration is intended to help readers appreciate how each part relates to the whole. Moreover, results from individual works have been shared among the various studies. Readers are urged to consult the original data in those cases where interpretations or inferences have been abstracted from associated papers.

The ten papers in the Thematic Section have been grouped by subject matter. The first three papers present overviews of the geologic, sedimentary, and hydrodynamic processes and conditions which largely control (either independently or together) the sea-floor character and composition. The next four papers outline the regional distributions of sediment types and selected geochemical and anthropogenic constituents of the bottom sediments. The final three papers deal with benthic biologic assemblages and specific biologic components of the sea floor. Brief synopses of the results and implications from these works are presented in the following discussion.

In the opening paper, **"A Review of the Geologic Framework of the Long Island Sound Basin, with Some Observations Relating to Postglacial Sedimentation"**, R.S. Lewis and M. DiGiacomo-Cohen give an up-to-date account of the geologic setting and history of the Sound. These aspects are fundamental in understanding the interaction between the geology and the water body that has controlled the development of the estuarine system and greatly affected the character of the sea floor. The authors also generate a new sediment budget which shows that internal sources (and not contributions

from the open ocean) can account for the postglacial accumulation of fine-grained sediments in the Sound.

In the second paper, **"Sea-Floor Environments within Long Island Sound: A Regional Overview"**, H.J. Knebel and L.J. Poppe have interpreted and mapped the distribution of areas affected by various bottom sedimentary processes throughout the estuarine system and have related this distribution to regional and local changes in geologic and oceanographic conditions. This work provides a general "blueprint" for predicting (on a long-term basis) where bottom sediments are eroded, transported, sorted, reworked, and deposited. It also documents the general patchiness of sedimentary environments, confirms the highly efficient trapping of fine-grained sediments in the central and western Sound, and estimates an average regional rate of fine-grained sediment accumulation in depocenters.

The third paper by R.P. Signell *et al.,* entitled **"Bottom Currents and Sediment Transport in Long Island Sound: A Modeling Study"**, presents new model results which outline the tide-, wave-, wind-, and density-driven bottom currents throughout the Sound and the potential for sand transport in the high-energy eastern part. Before now, these aspects have not been dealt with in a single publication and in such a comprehensive fashion. The simulations show the correspondence between the bottom-current intensity and the observed sedimentary environments at both regional and local scales, reveal changes in the bottom flow caused by such geologic factors as basin geometry and bottom topography, and suggest a mechanism for maintenance of large bedforms in the eastern Sound.

In the fourth paper entitled **"Distribution of Surficial Sediment in Long Island Sound and Adjacent Waters: Texture and Total Organic Carbon"**, L.J. Poppe *et al.* have combined more than 2,000 original samples with nearly 13,000 published analyses and descriptions to produce detailed maps showing the distributions of sediment grain size and total organic carbon in the sediments. The map of sediment texture, in particular, exemplifies the great spatial variability of the bottom which can be expected in complex glaciated coastal settings. The authors conclude that this variability is due primarily to the combined effects of the underlying geology, bathymetry, bottom sedimentary environments, and sea-floor energy conditions.

The fifth paper, **"Contaminant Distribution and Accumulation in the Surface Sediments of Long Island Sound"** by E.L. Mecray and M.R. Buchholtz ten Brink, presents a regional assessment of the trace metals and major elements in surface sediments. This work, which is based on a large number of strategically collected samples (219 stations), shows that trace-metal concentrations are generally highest in the central and western Sound, where they exhibit a patchy distribution which closely follows the transport and depositional patterns of fine-grained particles. The authors infer that the surface enrichment of trace-metal contaminants is controlled mainly by regional and local variations in bottom-current strength and by the proximity of large metropolitan centers.

Paper number six, entitled **"*Clostridium Perfringens* in Long Island Sound Sediments: An Urban Sedimentary Record"** by M.R. Buchholtz ten Brink *et al.,* is the first paper to document the regional accumulation and distribution of sewage-contaminated sediments within the Sound. The authors, using both bottom grab and core samples, show that the variable concentrations of *Clostridium perfringens* spores (excreted in fecal material) follow patterns of fine-grained sediment focusing in the estuary and correlate with changes in the bottom currents, sedimentary environments, and source proximity. This work not only yields a surficial baseline for sewage contamination, but it provides a historical record which reflects population growth and a concomitant increase in sewage input.

In the seventh paper, J.C. Varekamp *et al.,* in the contribution entitled **"Mercury in Long Island Sound Sediments"**, give an overview of the mercury (Hg) distribution and the sources and processes affecting its regional variability. Based on sediment surface and core samples, the authors outline spatial and compositional trends which reveal that Hg concentrations are related primarily to sewage input, riverine sources, and the focusing of Hg (bound to fine-grained sediment) by the bottom sedimentary environments and hydrographic regime. A unique aspect of this study is that it links Hg accumulation with *Clostridium perfringens* abundance, indicating that close to 100% of the Hg at some locations is derived from sewage disposal and that Hg concentrations have declined with time compared to the sewage component.

In the eighth paper, entitled **"Relationships Between Sea-Floor Structure and Benthic Communities in Long Island Sound at Regional and Benthoscape Scales"**, R.N. Zajac *et al.* provide a comprehensive review of research on the macrobenthic ecology in the Sound and use both historical and contemporary data sets to outline the distribution and variability of infaunal communities. They document that benthic communities have adapted to, or been shaped by, the heterogeneous sedimentary, hydrologic, and geologic processes and conditions of the system at both regional and local (or benthoscape) scales. This study is an example of how modern sea-floor mapping technology is being increasingly applied to the study of macrobenthic communities and, as such, defines factors and relationships of potential importance in other coastal areas.

The ninth paper, **"Benthic Foraminifera and Environmental Changes in Long Island Sound"** by E. Thomas *et al.,* compares the regional foraminiferal composition (and their stable isotope characteristics) in bottom samples collected in the late 1990s with those present in samples collected in the 1940s and 1960s. The comparisons indicate that the relative abundances of common benthic species of micro-organisms have changed with time across the Sound and that the observed changes likely reflect either the modification or the degradation of environmental factors which support foraminiferal subsistence. This study is a vanguard in documenting long-term environmental change in the Sound because it identifies potential "indicator species" and establishes their contemporary (baseline) relative concentrations.

The tenth paper by K.R.M. Beuning *et al.,* entitled **"Modern Pollen Deposition in Long Island Sound"**, documents that the pollen assemblages in the surface sediments have a uniform distribution throughout the Sound and are consistent with the surrounding regional vegetation. The results indicate

that pollen input, which is controlled primarily by atmospheric transport, is homogenized and mixed by the hydrodynamic regime in the Sound before it is incorporated into the fine-grained fraction of the bottom sediments. This study defines a modern "signal" which can be used in future studies as a chronostratigraphic tool for interpreting temporal variations in the pollen record and for understanding late glacial and Holocene deposition in the Sound.

In summary, several general implications emerge from the collection of papers in this Thematic Section. First, because of its glacial origin and postglacial history, the Sound has a complex configuration and topography which has affected its present hydrodynamic structure to produce a spatially variable distribution of bottom processes and conditions. Second, sediments derived from various sources (natural as well as anthropogenic) have been superimposed on the variable bottom regime thus creating sea-floor deposits which are both texturally and compositionally complex. Third, the heterogeneous sea-floor processes, conditions, and characteristics have largely controlled the regional benthic ecology and biologic communities in the Sound. Fourth, the bottom sediments contain biologic components which are potential indicators of geologic and environmental change. Finally, the collected results provide an understanding of the features and dynamics of this complex estuarine system that can aid managers in the prediction and abatement of pollution, the utilization of the sea floor, the management of biologic and mineral resources, and the documentation of natural versus human alterations.

A considerable amount of time and effort has been spent by the Guest Editors to ensure a high standard for the papers in this Thematic Section. This could not have been accomplished without the assistance of the following external reviewers: S. Bricker, M. Buzas, M. Charette, W. Dillon, R. Geyer, M. Grim, J. McDowell, J. Murray, C.W. Poag, D. Rhoads, D. Twichell, T. Webb III, and several anonymous reviewers. In addition, we gratefully acknowledge funding for publication costs by the Coastal and Marine Geology Program of the U.S. Geological Survey. A companion CD-ROM containing digital versions of many of the maps in this volume, plus ancillary data and observations, is currently in preparation and will be released as a U.S. Geological Survey Open-File Report following the publication of this volume.

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