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Observations on the Effects of Islets and Shoals on Salinity Distribution in an Estuarine Regime*[1]

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Introduction

Several studies in estuarine dynamics have shown a superposition of oscillatory tidal currents upon a net circulation in which the upper less saline layer moves seaward and the lower more saline layer moves up the estuary (Ketchum, 1951; Pritchard, 1952; Tully, 1958; Meade, 1969). Salinity variation in an estuary depends on the influx of fresh water flowing into it. Bowden (1967) noted that in the absence of tides, the river water tends to flow seaward as a layer of fresh water, separated by a fairly distinct interface from the bottom salt water. Tidal currents tend to break down this interface leading to vertical mixing of the two water layers. Bowden showed that if the velocity of the seaward-moving layer of fresh water exceeds a certain value, internal waves formed at the interface will tend to break at the crest, resulting in an entrainment of salt water into fresh water. Ketchum (1951) observed that during storms in New York Bight, there was an intense mixing of surface and bottom waters but the normal two-layer circulation pattern became re-established about two days later.

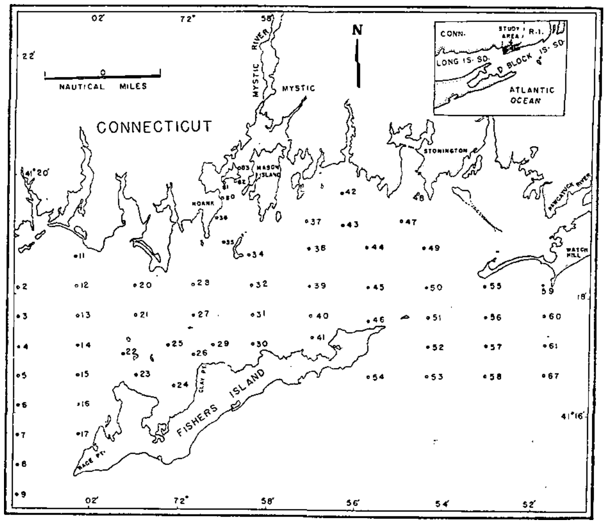

Fig. 1. Index map of study area and station locations.

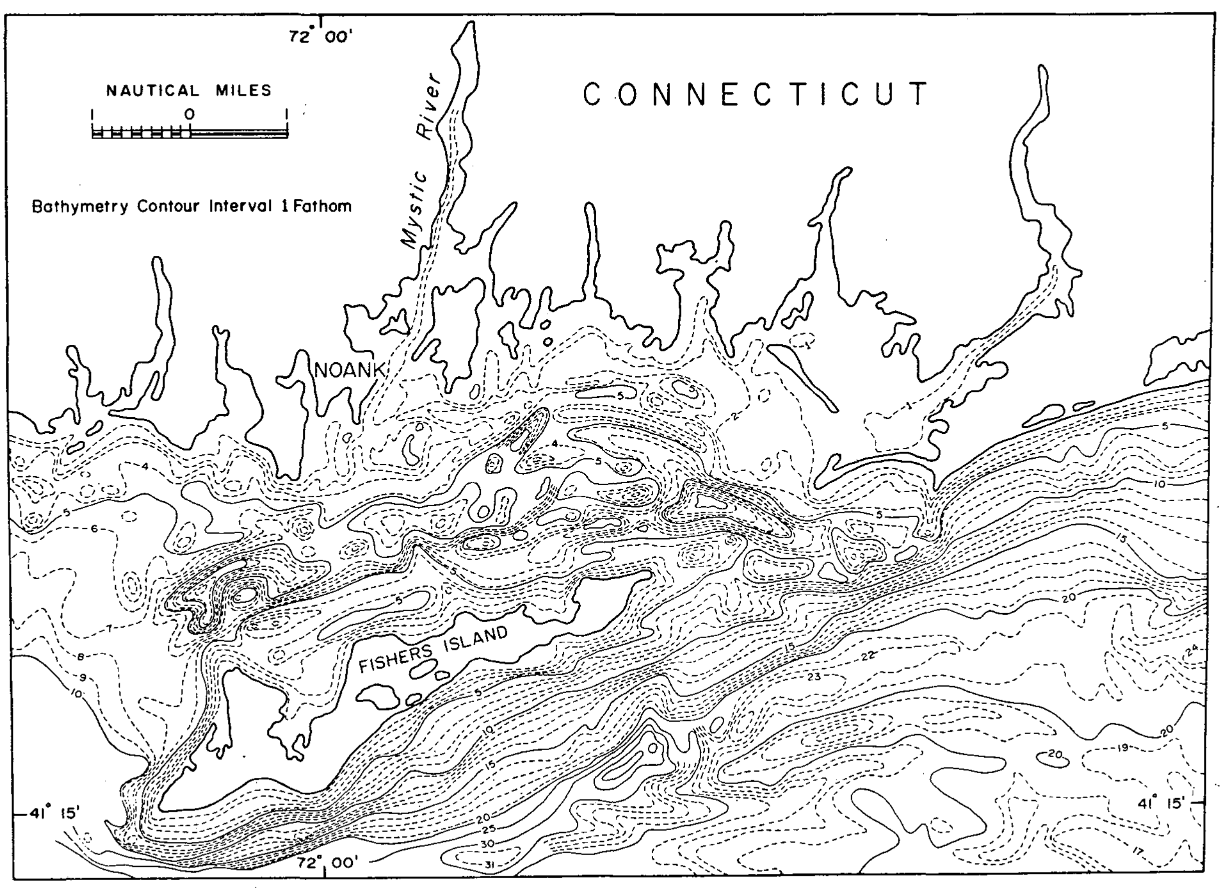

Fig. 2. Bathymetry of Fishers Island Sound. Contour interval one fathom (From U.S. Coast and Geodetic Survey No. 08084 N - 53, 1967).

* Manuscript received April 1, 1974.

[1] Work was done at the University of Pittsburgh, Pa. (U.S.A.).

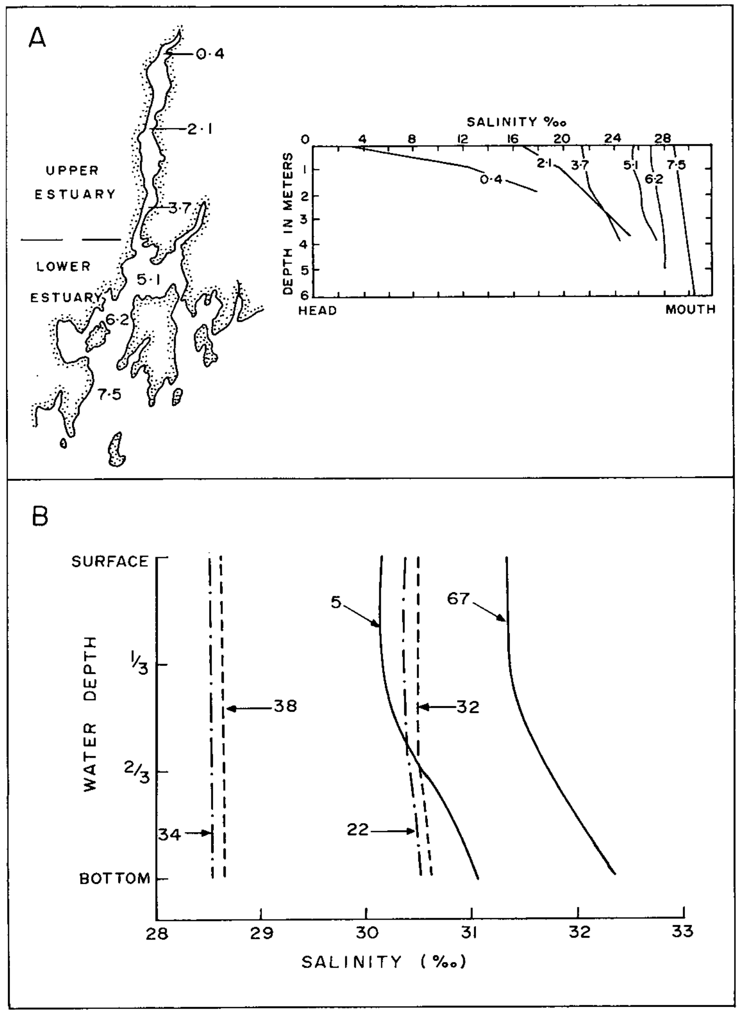

Fig. 3A. Vertical salinity profiles of water samples taken from the surface and at depths of 1/3, 2/3, and bottom. Stations 5 and 67 are relatively away from islets and shoals, stations 22 and 34 are near islets, stations 32 and 38 are near shoals.

B. Average salinity profile at six stations in the Mystic River estuary (From Pearcy & Richards, 1962).

Bowden (1967) reported that winds can have significant influence on an estuarine circulation and mixing. Drift-bottle experiments in Long Island Sound, New York, reveal seasonal variation in surface-water movement. There is a strong, predominantly west wind during winter and spring which causes an easterly movement of surface water associated with increased drainage. In summer, south and southwest winds predominate, and the surface current is reversed (Larkin & Riley, 1967). There are occasional rather sudden increases in the salinity of the bottom water of Long Island Sound, suggesting massive intrusion of oceanic water from the eastern end and spreading westward along the bottom of the sound.

The present study examines the role of islets and shoals in promoting vertical and horizontal homogenization of fresh and salt water in the Mystic River estuary located between 72°04'W to 71°50'W and 41°20'N to 41°15'N (Fig. 1). The salinity data has been collected during a study of the sedimentation and foraminiferal ecology in eastern Long Island Sound, New York (Akpati, 1970).

Method of Study

A total of 136 water samples were collected from 53 stations (Fig. 1) between May 1-12, 1969. Water samples were collected from the surface and at depths of 1/3, 2/3, and bottom with a van Dorn water sampler. The salinity of the water samples were determined by the standard titration method using silver nitrate and potassium dichromate as an indicator.

Results and Conclusions

The Mystic River estuary (Fig. 1) is dominated by a two-layer transport system with a net movement in which the surface layer flows seaward and bottom layer moves upstream (Pearcy & Richards, 1962). The bathymetry of the area is quite irregular, being characterized by depressions, shoals, and islets (Fig. 2). Salinity data from immediately around islets and shoals, in the area show no vertical stratification. The salinity is the same from top to bottom. It was also observed that in shallow water areas and over shoals, tidal currents are very strong in relation to surface river-flow, and vertical homogenization becomes so complete as to show little or no salinity variation from top to bottom (Fig. 3A, B). This condition points out certain ecological implications concerning the homogenization of surface and bottom waters in marine conditions. It is inferred that this mixing of water masses can influence environmental variables such as dissolved oxygen, and the temperature of bottom water by direct introduction of overlying water (Emery and Hulsemann, 1962). The various marine micro and macroinvertebrate taxa are controlled by conditions of the surrounding water masses. Homogenization of less saline surface water and the saline denser bottom water gives rise to different ecologic conditions, and consequently results in multiplicity of microenvironments. This phenomenon may be an important cause in the generally observed patchiness and aggregation of foraminifera and other invertebrate distribution in coastal waters. Although the data used in this study reflects only the salinity pattern of a short period of time in the area, nevertheless, it points out the potential effect of islets and shoals on the vertical and lateral mixing of surface and bottom estuarine waters and the resulting impact on benthonic organisms.

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