

## INTRODUCTION

This report<sup>1/</sup> describes, in quantitative terms, the macrobenthic invertebrate fauna inhabiting the Middle Atlantic Bight Region. It deals primarily with faunal (a) taxonomic composition, (b) geographic distribution, and (c) relationships with bathymetric level, bottom sediment composition, sediment organic carbon, and water temperature. Regional differences in faunal composition and quantitative distribution within the Middle Atlantic Bight Region, are analyzed and documented. Further studies of these data, in addition to the primarily descriptive analyses presented here, are in progress, and will be treated in subsequent reports. The first report in this series, entitled "Macrobenthic Invertebrate Fauna of the Middle Atlantic Bight Region: Part I. Collection Data and Environmental Measurements," by Roland L. Wigley, Roger B. Theroux, and Harriett E. Murray, 34 pages, was issued June 30, 1976.

### Reconnaissance Survey

A reconnaissance survey of macrobenthic invertebrates in the Middle Atlantic Bight Region was conducted as part of a larger survey of the entire Atlantic coast of the United States (Emery and Schlee, 1963). This survey by the Bureau of Commercial Fisheries (now the National Marine Fisheries

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Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce) was conducted in cooperation with the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, and the U.S. Geological Survey, Field Laboratory, Woods Hole, Massachusetts. The major objective of the biological phase of this survey was to obtain an overview of the general composition and distribution of the macrobenthos. Sufficient understanding of the fauna, especially the distributional aspects, was desired to permit the rational selection of one or more communities of benthic animals for detailed study. One or two of the more important communities or associations, suitable from both the practical and theoretical viewpoints, will be selected for detailed study of their taxonomic composition, productivity, inter-specific competition for food, and related aspects. This latter phase of the investigation is scheduled as part of the long-range objectives by the National Marine Fisheries Service of studying food-chain dynamics as they pertain to fish production on the continental shelf off the eastern United States. Because of the need for measures of energy flow in the production cycles, emphasis in the benthic survey was placed on measurements of biomass (referred to as wet weight or damp weight), and number of individual animals per unit area (density) was considered secondary.

#### Middle Atlantic Bight Region

The Middle Atlantic Bight is defined as that body of water overlying the continental shelf off the northeastern United States, bounded

on the north by Cape Cod and Nantucket Shoals, Massachusetts, and extending southward to Cape Hatteras, North Carolina. Its shoreward boundary is the coastline; its seaward boundary is the upper margin of the continental slope, the so-called "shelf-break" or outer edge of the continental shelf. The geographic region included in this study consists of the Middle Atlantic Bight proper, plus the adjacent inshore bays and sounds, and the offshore extension that consists of the continental slope and shallower part of the continental rise (fig. 1). This larger area is called the Middle Atlantic Bight Region. For purposes of comparative description, with particular reference to New York Bight, this region has been divided into three roughly equal geographic subareas: Southern New England, New York Bight, and Chesapeake Bight.

#### Previous Studies

Although there have been no previous quantitative studies of the macrobenthic fauna that encompassed the entire Middle Atlantic Region, there have been comprehensive studies of small sections of this Region a few rather large-scale qualitative studies, and numerous reports of an ancillary nature. Altogether, there exists a substantial literature on this general subject that has been produced at an ever-increasing rate since about the middle of the nineteenth century. A few examples of the early reports are those by: Adams (1839), describing new species of mollusks; Agassiz and Agassiz (1865), pertaining to echinoderm morphology and development; Desore (1848), on the natural

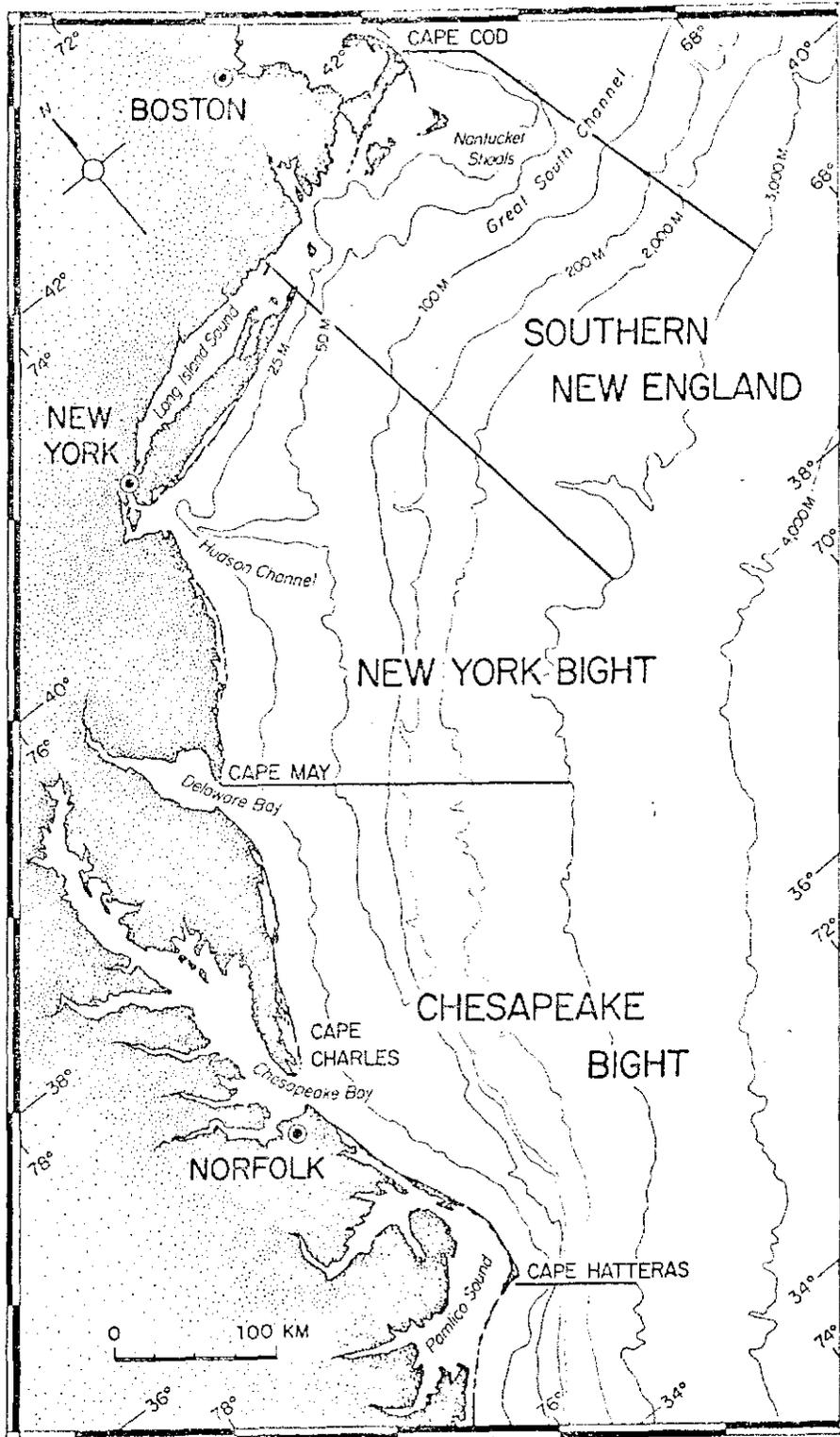


Figure 1.--Chart of the Middle Atlantic Bight Region showing the location of geographical features and the three subarea divisions: Southern New England, New York Bight, and Chesapeake Bight.

history of benthic invertebrates from Nantucket Shoals; Leidy (1885), an account of the invertebrates from coastal waters of Rhode Island and New Jersey; and Verrill (1866), descriptions of new species and ecological observations of New England coelenterates and echinoderms. Early studies of this type provide some of the basic taxonomic framework for this fauna, plus providing clues to the pattern of geographic distribution, and a preliminary insight to regional ecology. Two classical reports in the early literature that deal with major surveys of invertebrate animals within the Middle Atlantic Bight Region are: (1) the U.S. Fish Commission survey of Vineyard Sound and adjacent waters, conducted in 1871-73 (Verrill, 1873) and (2) the U.S. Bureau of Fisheries survey of the waters of Woods Hole and vicinity, conducted in 1903-05 (Sumner, Osburn, and Cole, 1913). Both surveys dealt mainly with epibenthic invertebrates and covered much the same area -- primarily Vineyard Sound and Buzzards Bay, located in southeastern Massachusetts.

Six published indexes and bibliographies provide good coverage of the general literature pertaining to the benthic invertebrates (and related subjects) of this Region. The citations in these bibliographies include many of the older reports as well as the new. The six reference works are:

- (1) Publications of the United States Bureau of Fisheries 1871-1940. Compiled by Barbara B. Aller and published in 1958.

- (2) A Preliminary Bibliography with KWICK Index on the Ecology of Estuaries and Coastal Areas of the Eastern United States. Compiled by Robert Livingstone, Jr., and published in 1965.
- (3) Marine and Estuarine Environments, Organisms and Geology of the Cape Cod Region, an Indexed Bibliography, 1665-1965. Compiled by Anne E. Yentsch, M. R. Carriker, R. H. Parker, and V. A. Zullo, and published in 1966.
- (4) The Effects of Waste Disposal in the New York Bight: Sections 8 and 9 (Literature Cited). Compiled by the National Marine Fisheries Service, Middle Atlantic Coastal Fisheries Center, Sandy Hook, New Jersey. Published in 1972.
- (5) Coastal and Offshore Environmental Inventory: Cape Hatteras to Nantucket Shoals. Edited by Saul B. Saila and published in 1973.
- (6) Bibliography of the New York Bight: Part 1 -- List of Citations; Part 2 -- Indices. Compiled by the National Oceanic and Atmospheric Administration, Marine Ecosystems Analysis Program, Stony Brook, N.Y., and published in 1974.

A sizable part of this benthic invertebrate literature deals with topics having little relevance to the present quantitative study. Reports consisting of species descriptions, many of the studies of physiological processes, morphology, habits and behavior, parasites, diseases, growth rates, and similar topics are peripheral to the central theme of quantitative distribution. Another large segment of the literature, also, only marginally pertinent to the present study is that pertaining to pelagic larval stages of benthic invertebrates, intertidal fauna, some aspects of fishery resources, predation, commensalism and other related subjects.

Quantitative studies of the benthos have been conducted at various locations throughout the Region in more recent years, particularly within the last two decades. A preponderance of these studies were carried out in inshore and coastal regions, few on the continental shelf, and fewer still on the continental slope and rise. The principal quantitative reports that we consulted in evaluating distribution and relative densities and/or biomass are listed separately (although there is some overlap in a few instances) for the following three zones: (1) inshore and coastal waters, (2) continental shelf, and (3) continental slope and rise.

Inshore and coastal waters:--Southern Massachusetts, Rhode Island, and Connecticut: Lee (1944), Sanders (1956, 1958, 1960), Stickney and Stringer (1957), Phelps (1964), Rhoads (1963), and Parker (1974); New York-New Jersey:--Dean and Haskins (1964), Franz and Hendler (1971), Phillips (1971), O'Connor (1972), D'Agostino and Colgate (1973), Kaplan, Welker and Kraus (1974), McGrath (1974), and Dean (1975); Delaware to Cape Hatteras, North Carolina:--Stone (1963), Tenore (1972), Boesch (1972, 1973), Leathem et al. (1973), Palmer and Lear (1973), Maurer et al. (1974), Watling et al. (1974), Watling and Maurer (1975).

Quantitative studies dealing mainly with the continental shelf:--Wigley and McIntyre (1964), Emery, Merrill, and Trumbull (1965), Emery and Uchupi (1972), Pearce (1972), Steimle and Stone (1973), and Rowe (1973). An up-to-date review of the major species and faunal associations inhabiting the Middle Atlantic Bight was prepared by Pratt (1973).

Quantitative studies pertaining chiefly to the continental slope and continental rise: Sanders, Hessler, and Hampson (1965), Wigley and Emery (1967), Rowe and Menzies (1969), Rowe and Menzel (1971), Emery and Uchupi (1972), George and Menzies (1973), Menzies, George, and Rowe (1973), and Haedrich, Rowe and Polloni (1975).

Several ecologically oriented reports based entirely, or in part, on the samples forming the basis of this study have previously been published. Macrobenthos from a series of stations across the continental shelf south of Martha's Vineyard, Massachusetts, was included in a report by Wigley and McIntyre (1964). A description of sea bottom photographs and grab-sample contents taken concurrently by the Campbell sampler (Emery and Merrill, 1964) was based partly on samples collected for the present study. An investigation encompassing a large offshore area, extending from Nova Scotia, Canada, southward to New Jersey, that dealt mainly with the quantity of macrobenthic invertebrates in relation to bottom sediment types was published by Emery, Merrill, and Trumbull (1965). The quantity of benthic invertebrates in grab samples from the continental slope off the Middle Atlantic region was compared with quantities observed in associated sea-bottom

photographs (Wigley and Emery, 1967). Remains of dead marine animals, particularly mollusks, reported by Wigley and Stinton (1973) for a portion of the Middle Atlantic Bight located off southern New England, also, were based on samples collected for the present study.

A number of quantitative studies of the macrobenthos are in progress at the present time. A substantial proportion of these studies are being conducted in coastal areas, and in large measure they pertain directly to assessments of environmental quality. In addition, there are two large-scale offshore investigations underway. One of these is being conducted in the Chesapeake-New Jersey region in anticipation of petroleum exploration, and possible production, in this region. The other large-scale study is being conducted in the New York-New Jersey area. Impetus for this work is directly related to ocean dumping and waste disposal from the New York-New Jersey metropolitan area.

A large volume of up-to-date benthic fauna information is currently being issued in the so-called "gray" literature. Characteristically, the results of recently completed field studies are issued as contract completion reports, environmental impact statements, public agency (or private corporation) investigation reports, annual reports, or other similar special documents. Many of these reports are issued in Xerox or mimeograph form, often in irregular series or as a one-of-a-kind report, as a consequence, they often are not listed in the usual literature sources.

Hydrography of the Middle Atlantic Bight Region is rather well known, at least the general features of circulation, tides, the annual cycle of temperature, patterns of salinity distribution, and other major aspects. Also, some inshore waters, such as Long Island Sound, Raritan Bay, Chesapeake Bay, and others, have been studied in some detail. There is, however, a lack of detailed information concerning chemical properties, water currents, meteorological influences, and related aspects, particularly as they pertain to offshore bottom waters.

A bibliography of early (pre-1951) hydrographic studies is included in the report by Ayers (1951). Rather broad consideration of the hydrography of the entire Bight is given by Bigelow (1933), Emery and Uchupi (1972), and Bumpus, Lynde, and Shaw (1973). Information on water temperature was reported by Walford and Wicklund (1968), Colton and Stoddard (1972, 1973), and Churgin and Halminski (1974), and others. Salinity and its bathymetric and geographic distribution are included in the reports by Bigelow and Sears (1935) and Churgin and Halminski (1974). Water circulation and related aspects have been reported by Chase (1959), Ketchum and Corwin (1964), Bumpus (1965), and Bumpus and Lauzier (1965).

Geological information pertaining to the Middle Atlantic Bight Region is copious and up-to-date. A few of the major references on this subject are: Emery (1966, 1968), Hülsemann (1967), Ross (1970), Schlee and Pratt (1970), Emery and Uchupi (1972), Trumbull (1972), Hollister (1973), Milliman (1973), Schlee (1973), Swift, Duane, and McKinney (1973), and Stubblefield, Dicken and Swift (1974).