ABSTRACT

A monitoring program involving annual sampling of the New York Bight for sediments, contaminants in sediments and biota, and benthic macrofauna distribution-abundance, is described. This paper concentrates on macrofauna data for summer 1980. Greatest faunal alterations were found in the center of the sewage sludge dumpsite. This condition graded into apparently unimpacted assemblages in sandy sediments off the New Jersey and Long Island coasts, and in lower Hudson Shelf Valley muds. Comparisons with 1973-74 data revealed no major changes in contaminant concentrations or impacts except for possible spreading of an "enriched" zone containing elevated densities of several species which thrive on the Christiaensen Basin's elevated organic carbon levels. Four stations have not shown any obvious changes in amount of degradation over that period. The inner Bight fauna remains more highly impacted than that of any other coastal area sampled in the Northeast Monitoring Program.

1. INTRODUCTION

The inner New York Bight (Figure 1) is one of the world's most heavily contaminated open coastal water bodies. It is also one of the most highly utilized, and many of its uses (such as swimming, boating, recreational and commercial fishing) can be compromised by that contamination. If the Bight's resources are to be effectively managed, fates and effects of contaminants entering the system must be better understood. Information is needed on temporal changes in severity and areal extent of impacts. Influences of sewage sludge and dredged material dumping, as well as of the Hudson-Raritan and other inputs, should be separated and quantified.

For these reasons, NOAA in 1980 began a program of annual monitoring of contaminants in sediments and bottom-related fauna, and contaminant effects on benthic organisms, over most of the Bight. The monitoring strategy was largely designed by NOAA's Marine Ecosystems Analysis (MESA) group, based on results of seasonal benthic surveys of the inner Bight in 1973-74. Aspects of the monitoring were also taken from the protocols of a more recently established NOAA effort, the Northeast Monitoring Program (NEMP), of which the present Bight survey is a subset. NEMP has been sampling the benthos at six stations in the Bight on a semiannual or more frequent basis since 1978, as part of a larger program to monitor the health of marine ecosystems between Cape Hatteras and Canada.

The spatially intensive Bight surveys are conducted in summer, because recreational use of the Bight is highest then, and the relative quiescence of the water column should lead to widest distribution of bottom contaminants. Variables monitored are: bottom water temperature, salinity and dissolved oxygen; sediment grain size, organic
carbon, Kjeldahl nitrogen, heavy metals, PCBs, polynuclear aromatic hydrocarbons (PAHs), coprostanol, viruses, human artifacts (such as tomato seeds), total and fecal coliform bacteria; viruses and gill fouling in rock crabs (Cancer irroratus); other pathogens (fecal streptococcus, *Clostridium perfringens*, *Salmonella* and *Klebsiella* spp.) and total and fecal coliforms in rock crabs, lobster (*Homarus americanus*) and scallops (*Placopecten magellanicus*); heavy metals, PCBs and PAHs in muscle of these species plus winter flounder (*Pseudopleuronectes americanus*), windowpane flounder (*Scophthalmus aquosus*), fourspot flounder (*Paralichthys oblongus*), red hake (*Urophycis chilver hake* (*Merluccius bilinearis*); and distribution and abundance of benthic macrofauna.

Overall results of the summer 1980 sampling are presented in Reid et al. (in prep.). This paper summarizes data on the benthic macrofauna—mostly small invertebrates which, due to their relative immobility and wide range of life histories and contaminant sensitivities, are useful for monitoring contaminant effects at the population-community level. Numerous analyses of the Bight’s benthic macrofauna have been conducted, most based on the 1973-74 MESA data (Saila et al. 1976; Walker et al. 1979; Pearce et al. 1981; Boesch in press; Caracciolo and Steimle in press; Steimle et al. in press) or on earlier sampling conducted by Sandy Hook Laboratory (National Marine Fisheries Service 1972; Pearce 1972). Our 1980 results are compared to data from these earlier surveys and from NEMP benthic collections from outside the Bight.

2. METHODS

Sampling was conducted from 28 July - 5 August 1980. Station locations are shown in Figure 1. Samples were taken with a Smith-McIntyre grab sampling 0.1 m². Single grabs were taken for sediments and macrofauna at 34 stations; five replicate samples were collected at the six standard NEMP sites and at another four stations positioned in an attempt to distinguish impacts of the dumpsites from those of the Hudson-Raritan plume. Plastic coring tubes of 2.7 cm I.D. were used to collect a sediment subsample for grain size analysis and one for heavy metal determinations from each grab. Remaining sediments were washed through a 0.5 mm mesh sieve and the residue preserved. Fauna were sorted and identified using dissecting microscopes. Oligochaetes, annelids and colonial forms were ignored. Q-mode cluster analysis (clustering stations according to the species they have in common) was performed for all stations using the quantitative Bray-Curtis coefficient.

3. MACROFAUNA PATTERNS, SUMMER 1980

Species Richness: Number of species (S) at a given station is a relatively clear indicator of environmental stress (Green 1977), being generally lower in areas of either natural or man-induced stresses. S values for summer 1980 are shown in Figure 2, which indicates several species-poor areas. S was low (18-27/0.1 m²) at most stations along the NJ coast. This is interpreted as largely a response to physical stress; these sites, with shallow water depths and coarse sediments, are apparently wave-scoured and unsuitable for many benthic species. S values were often higher along the northern than southern coast, suggesting no adverse effects of the Hudson plume (or other waste sources) on species richness along the northern coast. Lowest S (15) was found in the area just west of the sewage sludge dumpsite, where sludge accumulates (at least temporarily). The sludge dumpsite itself and six other stations within 12 km of the dumpsite had values between 20 and 30. These stations are in deeper waters in and near Christiaensen Basin, where sediments are less dynamic (as shown by their finer grain sizes), and so physical stresses on the fauna should be less a problem. The low S values at these sites are attributed at least in part to contaminant effects. Sediments here contain elevated concentrations of many contaminants, including metals (Carmody et al. 1973; Reid et al. in prep.), PCBs (West and Hatcher 1980; Boehm 1980) and PAHs (Boehm 1980). Contaminant impacts on the Christiaensen Basin fauna have been reported in several prior studies (National Marine Fisheries Service 1972; Pearce 1972; Walker et al. 1979; Boesch in press; Steimle et al. in press).

Moving away from the basin, S increased to 41-79/0.1 m² on the midshelf off Long Island, and 80-88 in the lower Hudson Shelf Valley (where the high values reflect species which are limited to the deeper, colder waters as well as those whose absence from Christiaensen Basin may be contaminant-related).
Community Structure (Cluster Analysis): Classification of stations according to similarity of their species compositions yielded nine station groups at the 30% similarity level. Distribution of these groups is shown in Figure 3.

As expected, most groups consisted of stations which were physically close together as well as having similar depths and sediment types: 1) Group G, in the inner Bight, contained the stations where contaminant impacts were most obvious, including the dredge and sludge dumpsites and sludge deposition area. The sparse assemblages at these stations were dominated by pollutant-tolerant species such as the polychaetes Capitella spp., Polydora ligni, and Amastigopsis caperatus, and isopod Edotea triloba. Two of the group G stations (21 and 32) had moderate numbers of species which dominated the "enriched" fauna described next. 2) All group B stations were 4-8 km from one or both dumpsites, and were characterized by very high densities of the anthozoan Ceriantheopsis americanus and the deposit-feeding bivalve, Nucula proxima, and polychaetes, Nephtys incisa and Pherusa affinis. Such "enriched" assemblages have often been found on the peripheries of areas of high organic loading (Pearson and Rosenberg 1978). Walker et al. (1979) and Boesch (in press) noted the occurrence of this assemblage in the Christiaensen Basin; the large populations of several tolerant species are apparently in response to high concentrations of labile carbon in areas where sediment consistency or toxicity is less limiting than in the center of the sludge accumulation area.

3) Stations in southernmost Christiaensen Basin and the northern Hudson Shelf Valley comprised group A, which had less dominance by "enriched zone" species than did group B, and a more abundant and diverse crustacean fauna. The group may represent a gradation from the obviously contaminant-affected faunas of groups G and B toward a "natural" fine-sediment assemblage. 4) This "natural" assemblage (group C) consisted of lower shelf valley and outer shelf sites, and was dominated by crustaceans, particularly the amphipod Ampelisca agassizi. Ampeliscid amphipods are considered quite pollution-sensitive (Lee et al. 1977; Cabioch et al. 1978; Sanders et al. 1980), so dominance by A. agassizi here could signal that the seaward limit of contaminant effects has been passed. This agrees with the observation by Boesch (in press) that the location in the shelf valley where large populations of A. agassizi and several other amphipods first appear (our station 15, the innermost group C site) is also an area where sediment metal concentrations drop sharply from levels found further inshore. 5) Other major faunal groups were I, found at most stations along the New Jersey coast, and E, characteristic of most midshelf stations off Long Island.

"Indicator" Taxa: Mention has already been made of species which appear to thrive in heavily polluted (e.g. Capitella spp.), organically enriched (Nephtys and others) and relatively uncontaminated (Ampelisca) Bight sediments. The uncritical use of such species as indicators of contaminant effects has its pitfalls (see Eagle and Rees 1973). Nevertheless, dense concentrations of species consistently associated with specific environmental conditions in the Bight can supplement measures such as species richness and community structure in delimiting areas of greater or lesser contaminant impacts.

A possible limit of major contaminant effects on Bight macrofauna, as indicated by appearance of large populations of Ampelisca in the lower Hudson Shelf Valley, was discussed above. Similarly, Capitella and Nephtys can be used to define zones of highly polluted and organically enriched sediments, respectively, in the Christiaensen Basin. For both species, our other NEMP stations with similar sediments like those of Christiaensen Basin show typical densities of 10 or fewer specimens/0.1 m² (unpublished data). We have taken a 10-fold or greater increase over these "background" densities as indicative of an altered fauna. Areas where such alterations occur are shown in Figure 4 (in which the density contours are hand-drawn and interpolation between data points is subjective). Calculating areas of these zones with a planimeter indicated that the highly polluted Capitella-dominated area covered about 15 km², and the enriched zone, perhaps 200 km².

Figure 3. Distribution of cluster-derived species groups.
5. COMPARISONS WITH OTHER NORTHEASTERN AREAS

Several measures indicate that faunal alterations in the inner Bight are greater than those occurring in other northeastern coastal waters. Species richness over much of Christiaensen Basin is lower than what we have found elsewhere in our NEMP surveys, with the exception of a current-scoured station off the New Jersey coast and one on Georges Bank (Northeast Monitoring Program 1981). The basin fauna includes more species commonly associated with polluted environments, in higher densities, than are typically found outside the Bight. The Capitella-dominated zone has no counterpart on the same scale elsewhere in the NEMP region. Elements of the enriched zone are present in estuaries, but not extensively so on other parts of the northeastern shelf. Conversely, abundances of crustaceans (especially amphipods), which as a group are considered pollution-sensitive, are depressed compared to those found in sediments with comparable grain sizes in the Lower Hudson Shelf Valley and outside the Bight.

6. CONCLUSIONS

The fauna of the inner New York Bight displays a gradient of impacts, including a highly altered assemblage centered just west of the sewage sludge dumpsite and an enriched (but crustacean-poor) zone covering much of the remaining Christiaensen Basin. We agree with Boesch (in press) that it is not now possible to separate impacts of the several dumpsites, the Hudson-Raritan plume and other contaminant inputs to the Bight, but that the greatest alterations appear associated with the dumping of sewage sludge. The enriched faunal zone may have spread to the north and west between 1973-74 and 1980. Otherwise, the contaminant and faunal data reveal no major changes over that period. The inner Bight continues to show the greatest severity and spatial extent of impacts of any coastal area in the northeast U.S.

7. ACKNOWLEDGMENTS

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8. LITERATURE CITED