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Benthic Macrofauna of the New York Bight, 1979–89

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U.S. Department of Commerce

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U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
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ABSTRACT

The benthic macrofauna of the New York Bight has been monitored extensively, primarily to determine trends over space and time in biological effects of waste inputs. In the present study, from 44 to 48 stations were sampled each summer from 1980–1985. Data from other Bight benthic studies are included to extend the temporal coverage from 1979 to 1989. Numbers of species and amphipods per sample, taken as relatively sensitive indicators of environmental stress, showed consistent spatial patterns. Lowest values were found in the Christiaensen Basin and other inshore areas, and numbers increased toward the outermost shelf and Hudson Shelf Valley stations. There were statistically significant decreases in species and amphipods at most stations from 1980 to 1985. (Preliminary data from a more recent study suggest numbers of species increased again between 1986 and 1989.) Cluster analysis of 1980–85 data indicated several distinct assemblages—sewage sludge dumpsite, sludge accumulation area, inner Shelf Valley, outer Shelf Valley, outer shelf—with little change over time. The "enriched" and "highly altered" assemblages in the Basin appear similar to those reported since sampling began there in 1968. No consistently defaunated areas have been found in any sampling programs over the past 20 years. On a gross level, therefore, recent faunal responses to any environmental changes are not evident, but the more sensitive measures used, i.e. numbers of species and amphipods, do indicate widespread recent effects. Causes of the faunal changes are not obvious; some possibilities, including increasing effects of sewage sludge or other waste inputs, natural factors, and sampling artifacts, are discussed.

Introduction

The "apex" (northwest corner) of the New York Bight (Figs. 1, 2) has long received large organic carbon and toxicant inputs from the Hudson-Raritan estuary (since the 1800s) and from dumping of dredged material (since 1914) and sewage sludge (1924), with smaller inputs from several other sources (Mueller et al. 1976; New York City Department of Environmental Protection 1983; Stanford and Young 1988). Fates and biological effects of the introduced contaminants have been studied extensively; see Gross (1976) and Mayer (1982) for symposia reviewing Bight studies. Among the objectives have been to determine overall contaminant influences, to partition influences among the various sources, and to detect changes over time in fates and effects.

This report concentrates on benthic macrofauna as indicators of environmental change in the Bight. Benthic macrofauna (hereafter called "benthos," meaning the bottom-living invertebrates collected in "grab" samples and retained on sieves of 0.5–1.0 mm mesh size) are often used in this context. Their relative immobility and intimate association with contaminant-accumulating sediments make them among the best biological indicators of effects of contaminants and of environmental change in general (Kuiper 1986; Jackson and Resh 1989). The benthos is also monitored to assess actual or potential importance of an area as a food and contaminant source for bottom-feeding resource species. Some discussion of the Bight benthos in these contexts is given elsewhere (e.g., Boesch 1982; Steimle 1985).

There have been at least 17 major sediment-benthos sampling efforts in the Bight, beginning in 1966 (*see* Reid and Steimle [1988] for a summary of existing surveys). The largest was NOAA's Marine Ecosystems Analysis (MESA)-New York Bight

Project, with sampling from 1973–1976. One of the products of the MESA program was a recommendation for continued monitoring of several components of the Bight's ecosystem, including sediments and benthos. The monitoring plan proposed was described in Reid et al. (1982). The sediment-benthos portion of the plan was modified somewhat (*see* Methods), and annual sampling was conducted from 1980 through 1985.

This report presents data collected on macrobenthic species richness, numbers and biomass of dominant species, numbers of amphipods, and similarities of community structure over space and time. Raw data are available on request. The report also includes relevant data from NOAA's Northeast Monitoring Program (NEMP) (Reid et al. 1987), and initial data from a 1986–89 study of responses of the benthos to the phaseout of sewage sludge dumping in the Bight apex (Environmental Processes Division, Northeast Fisheries Center 1988, 1991). Data from this report provide baselines against which responses to phaseout can be measured. These data may also be useful in guiding future decisions such as where to relocate the present dredged material dumpsite and where and how to mine sand to minimize impacts on benthos (and potentially on resource species which interact with benthos).

Methods

The basic monitoring scheme involved sampling 44 to 48 stations (Figs. 1, 2) each summer from 1980 through 1985. The annual samplings were conducted on 28 July–5 August 1980, 10–19 August 1981, 9–15 September 1982, 19–21 July and 22 August–7 September 1983, 21–31 August 1984, and 30 September–5 October 1985 (Table 1).

Six of the stations (4, 6, 7, 15, 26, and 31) were also part of the NEMP benthic program. These stations were sampled semiannually beginning in December 1979, and resulting data are included to extend the study's temporal coverage. For the same reason, preliminary data from a more recent study of benthic responses to the phaseout of sewage sludge disposal in the inner Bight are also presented. Stations 6 and 11 of the annual monitoring surveys were used as the "sludge accumulation" and "reference" stations, respectively, for the phaseout study. July, August, and September 1986–1989 samplings at these stations are also included to extend the report's temporal coverage (only data on numbers of species and of *Capitella* spp. for 1988, and preliminary data on species numbers for 1989, are available) (Environmental Processes Division, 1991).

In the annual monitoring survey, one sample per station was taken in 1980 and 1981, and two samples in 1982–85. The NEMP program took five samples per station, and the phaseout study, three samples. Table 1 gives dates on which individual stations were sampled, as well as numbers of samples analyzed, station locations and depths, and sediment grain sizes, carbon and nitrogen contents.

Loran C, with a nominal accuracy of ±50 m (Holme and McIntyre 1984), was used to locate stations. Samples were taken with a 0.1-m^2 Smith-McIntyre grab. Plastic tubes of 2.7-cm inner diameter were used to take one subsample from each grab for analysis of sediment grain size, organic carbon and nitrogen, and one subsample for heavy metals. The remainder of each grab was rinsed through a 0.5-mm sieve. Retained materials were fixed immediately in 10% buffered formalin with Rose Bengal biological stain, and were transferred to 70% ethanol with 5% glycerin one to three days later. After storage for at least six months, samples were sorted using dissecting microscopes. Identifications were to species level whenever possible, except for rhynchocoels. Oligochaetes, archiannelids, and colonial forms were not enumerated owing to uncertainty of identification and/or difficulty of quantification. Wet weight biomasses were determined by blot-drying each taxon on absorbent toweling for 3 minutes and weighing to the nearest milligram on an electronic balance.

Spatial contours of numbers of species and amphipods were drawn using Surface II software (Sampson 1978). In an exploratory attempt to describe trends in numbers of species and amphipods over time, linear regressions were calculated from the species and amphipod versus time data. The data are not ideally suited for linear regression analysis, for several reasons. Changes in the "dependent" variables, numbers of species and amphipods, are not actually caused by changes in the "independent" variable, time. There was no *a priori* hypothesis except for the implicit one that numbers of species and amphipods would not change over the course of the study unless there were underlying environmental change (the analysis does not address the processes behind any trends detected). A linear fit to the data may not best represent the underlying processes, but exploring non-linear fits may not be justified when those processes are not postulated *a priori*. However, the analysis does provide an objective way of describing and comparing trends. Time series or trend analysis could not be used

Table 1

Location, depth, mean grain size, carbon and nitrogen, and numbers of benthic samples analyzed for each New York Bight station and survey. The depth, grain size, carbon and nitrogen data are from summer 1980. TOC = total organic carbon; TKN = total Kjeldahl nitrogen.

Station	Latitude (°N)	Longitude (°W)	Depth (m)	Mean Grain Size (phi units)	TOC (mg/g dry wt.)	TKN (mg/g dry wt.)	Months sampled (number of samples) 1979	1980	1981	1982	1983	1984	1985
1	40°26.9'	73°48.1'	27	3.71	9.4	1.1		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
2	40°28.2'	73°45.8'	29	3.35	10.1	1.4		Jul (1)	Aug (1)	Sep (2)	Jul (2) Aug (2)	Aug (2)	Sep (2)
3	40°28.0'	73°43.8'	28	3.43	7.1	0.83		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
4[a]	40°25.0'	73°52.0'	22	2.01	3.0	0.26	Dec (5)	Jul (4) Dec (5)	Aug (5)	Jan (5) Sep (5)	Jul (5)	Aug (5)	Jun (5) Oct (2)
5	40°24.9'	73°48.0'	35	4.19	16.0	1.9		Aug (1)	Aug (1)	Sep (2)	Jul (2) Aug (2)	Aug (2)	Oct (2)
6[a,b]	40°25.0'	73°46.0'	27	2.73	11.3	0.90	Dec (5)	Jul (5) Dec (5)	Aug (5)	Jan (5) Sep (5) Nov (5)	Jul (5) Aug (2) Nov (5)	Aug (5)	Jun (5) Oct (2)
7[a]	40°25.0'	73°44.0'	25	1.86	2.4	0.21	Dec (5)	Jul (5) Dec (5)	Aug (5)	Jan (5) Sep (5) Nov (5)	Jul (5) Nov (5)	Aug (5)	Jun (5) Oct (2)
8	40°21.8'	73°51.6'	24	2.37	34.0	1.5		Jul (1)	Aug (1)	Sep (2)	Jul (2) Aug (2)	Aug (2)	Oct (2)
9	40°21.6'	73°47.8'	36	3.49	13.0	1.5		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
10	40°20.2'	73°49.1'	61	−0.24	1.6	0.17		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
11[b]	40°19.1'	73°45.8'	31	3.3	5.1	0.71		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
12	40°12.8'	73°44.0'	38	3.29	5.5	0.70		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
13	40°09.8'	73°41.9'	56	4.25	11.0	1.8		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
14	40°47.3'	72°59.0'	74	2.01	4.9	0.73		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
15[a]	40°01.4'	73°25.6'	62	3.31	8.4	1.0	Dec (5)	Aug (5) Dec (5)	Aug (5)	Jan (5) Aug (5)		Aug (5)	Jun (5) Oct (2)
16	40°07.6'	73°36.8'	71	4.68	15.0	2.2		Aug (1)	Aug (1)	Sep (2)	Jul (2) Sep (2)	Aug (2)	Oct (2)
17	40°05.4'	73°31.3'	73	3.62	11.0	1.5		Aug (1)	Aug (1)	Sep (2)	Jul (2) Sep (2)	Aug (2)	Oct (2)
18	40°25.0'	73°53.8'	24	2.2	14.0	1.1		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
19	40°16.0'	73°57.8'	14	1.76	0.86	0.15		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
20	40°27.9'	73°56.0'	12	1.96	0.95	0.17		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Sep (2)
21	40°31.1'	73°45.9'	21	3.15	12.0	1.5		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Sep (2)
22	40°25.0'	73°39.8'	24	3.07	2.4	0.36		Jul (1)	Aug (1)	Sep (2)	Aug (2)	Aug (2)	Oct (2)
23	39°29.9'	74°10.1'	16	1.01	0.46	0.09		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
24	39°55.0'	73°55.8'	18	−0.52	1.8	0.12		Aug (1)	Aug (1)	Sep (2)	Jul (2) Sep (2)	Aug (2)	Oct (2)
25	40°01.9'	73°55.1'	19	0.26	0.49	0.08		Aug (1)	Aug (1)	Sep (2)	Jul (2) Sep (2)	Aug (2)	Oct (2)
26[a]	39°35.8'	73°54.2'	28	1.29	1.03	0.08	Dec (5)	Aug (5) Dec (5)	Aug (5)	Jan (5) Sep (5)	Jun (5)	Aug (2)	Jun (5) Oct (2)

Table 1 (continued)

Station	Latitude (°N)	Longitude (°W)	Depth (m)	Mean Grain Size (phi units)	TOC (mg/g dry wt.)	TKN (mg/g dry wt.)	Months sampled (number of samples) 1979	1980	1981	1982	1983	1984	1985
27	39°44.7'	73°44.9'	26	1.21	0.58	0.10		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
28	39°25.5'	73°30.6'	40	2.27	0.82	0.13		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
29	40°14.3'	73°15.9'	38	1.09	0.63	0.13		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
30	40°14.8'	73°25.1'	34	1.83	0.81	0.16		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
31[a]	40°25.6'	73°11.1'	30	1.43	0.71	0.11	Dec (4)	Jul (5)	Aug (5)	Jan (5)	Jun (5)	Aug (5)	Jun (5)
								Dec (5)		Aug (5)			Oct (2)
32	40°24.2'	72°58.3'	38	1.19	0.51	0.14		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
33	40°34.1'	72°37.8'	40	2.37	1.8	0.29		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Sep (2)
34	40°25.8'	72°19.8'	54	1.77	3.4	0.46		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
35	40°30.2'	72°13.3'	55	2.34	3.9	0.69		Jul (1)	Aug (1)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
											Sep (2)		
36	40°08.1'	72°51.6'	56	1.19	0.81	0.15		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
37	40°04.9'	72°50.2'	54	1.41	1.0	0.17		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
38	40°10.7'	72°40.3'	56	1.05	1.1	0.70		Aug (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
39	40°14.3'	73°02.0'	42	1.42	0.79	0.12		Jul (1)	Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)
40	40°24.9'	73°49.7'	29	3.35	12.0	1.5		Jul (5)	Aug (5)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
41	40°25.0'	73°56.8'	21	1.25	0.3	0.05		Jul (5)	Aug (5)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
42	40°21.2'	73°56.6'	13	1.98	3.4	0.36		Aug (5)	Aug (5)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
43	40°18.9'	73°53.7'	20	−0.19	1.1	0.12		Jul (5)	Aug (5)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
44	40°13.0'	73°57.8'	19	−0.2	2.6	0.17		Jul (5)	Aug (5)	Sep (2)	Jul (2)	Aug (2)	Oct (2)
63	40°39.5'	73°00.0'	12	1.04	0.8	0.02			Aug (1)	Sep (2)	Sep (2)	Aug (2)	Sep (2)
64	40°35.5'	73°22.0'	11	2.28	0.5	0.02			Aug (1)	Sep (2)	Jul (2)	Aug (2)	Sep (2)
65	40°33.2'	73°37.5'	11	−0.61	0.9	0.03			Aug (1)	Sep (2)	Jul (2)	Aug (2)	Sep (2)
158	39°46.2'	73°08.2'	48	0.86	1.3	0.03			Aug (1)	Sep (2)	Sep (2)	Aug (2)	Oct (2)

[a]Northeast Monitoring Program (NEMP) stations.
[b]Also three samples in July, August, and September 1986 and 1987.

because these require more data points, regularly spaced over time.

Q-mode cluster analysis (clustering stations according to abundances of species they have in common) was performed using all samples from the summers of 1980–85 to analyze trends in species composition over space and time. Where multiple samples were taken at a station and date, data were averaged. All data were transformed by natural logarithms (ln+1) before clustering. To facilitate computation, all species occurring at <10% of the station/date combinations were eliminated. The Bray-Curtis (1957) coefficient, $Cz = 2w/(a+b)$, was used to measure percent faunal similarities between stations. Here "a" is the sum of abundances of all species found in a given sample, "b" is the sum of species abundances for another sample, and "w" is the sum of the lower of the abundance values for each species common to both samples. Clustering was performed using flexible sorting with β (the cluster intensity coefficient) $= -0.25$.

The Bight was divided into subareas based on geographical and depth considerations (Fig. 1) for analysis and presentation of results. The bathymetric depression at the head of Hudson Shelf Valley (HSV) is termed the Christiaensen Basin (CB) (Fig. 2). The Basin is actually part of the Shelf Valley (Freeland and Swift 1978), but for this study is arbitrarily defined as that portion north of lat. 40°20'N and in water deeper than 27.4 m (90 feet). The shelf was divided into New Jersey (NJ) and Long Island (LI) sections by a line from the northwest edge of the Basin to the middle of the Hudson-Raritan estuary's mouth. Shelf stations were further separated into "inshore" (I: <30 m depth) and "offshore" (O: ≥30 m).

Results and Discussion

Taxa Collected

A total of 699 taxa were collected. Polychaetes were the category with the most taxa (46% of the total), followed by crustaceans (24%), bivalves (11%), gastropods (9%), echinoderms (4%), coelenterates (2%), and miscellaneous taxa (4%). The species list is available on request.

Numbers of Species

Number of species (S) per sample is a relatively clear indicator of environmental stress (Green 1977; Chapman et al. 1987). Within a habitat (e.g. shallow and sandy; deep and muddy), S is generally lower in areas of natural or man-made stresses, whereas variables such as faunal density and diversity respond less predictably and are more likely to increase under moderate stress.

Spatial Trends in Numbers of Species

There were clear spatial trends in S. Figure 3 shows contours of S values for the most recent (1985) overall survey. The lowest S by far ($\bar{x}$ = 5 species/0.1 m^2) occurred at station 6, in the sludge accumulation area. Next lowest S values were found at stations 7 (the sludge dumpsite itself), 64 (7 km SW of Fire Island Inlet, Long Island), and 26 (26 km E of central New Jersey) (Fig. 1). Most remaining Christiaensen Basin stations and inshore (≥30 m) stations along both coasts had between 20 and 30 species per 0.1 m^2.

Most offshore (≥30 m) shelf stations had values >30. There were trends toward increasing S with depth as well as toward the east. Numbers of species also increased with depth and distance from the Basin in the Hudson Shelf Valley.

Spatial trends in S were consistent among years. In 1980 (Fig. 4) as in 1985, the sludge accumulation area had the lowest value (15/0.1 m^2), followed by Christiaensen Basin and inshore stations. Values again increased fairly regularly from inshore to offshore and west to east on the shelf, and with depth in the Shelf Valley.

Temporal Trends in Numbers of Species

In contrast to the consistency of spatial trends in S, actual values of S tended to decrease over time at many stations. Whereas much of the inshore and Basin area had S values between 30 and 40 in 1980, almost all that area had 20–30 species/0.1 m^2 in 1985. Several offshore and Shelf Valley stations had 70–80+ species in 1980, but no station had more than 63 species in 1985.

As noted in the between-year comparison of S contours, there were tendencies toward decreasing S over time at most stations. Data for each of the six NEMP stations, for which the most data are available, are shown in Figure 5. Linear regression analysis of the species versus time data for all stations indicated nonsignificant ($P > 0.05$) increases in S at only six of the 48 stations (Table 2). Conversely, six of the 42 decreases were significant ($P \leq 0.05$): at stations 2, 3,

Table 2

Signs and significance levels of linear regression slopes fitted for numbers of species and amphipods over time (– = decreasing, + = increasing; NS = not significant at 0.05 level). All stations combined: decreasing trends in numbers of species (significant at $P = 0.0007$) and amphipods ($P = 0.0004$).

	Species		Amphipods	
Station	Slope	Significance Level	Slope	Significance Level
New Jersey Inshore				
4	–	NS	+	NS
8	–	NS	–	NS
18	–	NS	–	NS
19	–	NS	+	NS
20	–	NS	+	NS
23	+	NS	–	NS
24	+	NS	+	NS
25	–	NS	+	NS
26	–	NS	–	NS
27	–	NS	+	NS
41	–	NS	–	NS
42	–	NS	–	0.02
43	–	NS	–	NS
44	+	NS	–	NS
New Jersey Offshore				
28	–	NS	–	NS
158	–		NS	–0.002
Hudson Shelf Valley				
11	–	NS	–	NS
12	–	NS	–	NS
13	–	NS	–	0.02
14	–	NS	–	0.02
15	–	0.0001	–	0.0001
16	+	NS	–	NS
17	–	NS	–	0.01
Long Island Inshore				
2	–	0.024	–	0.02
3	–	0.011	–	NS
7	–	0.009	–	NS
21	–	NS	+	NS
22	–	NS	–	0.03
63	+	NS	–	NS
64	–	NS	+	NS
65	+	NS	+	NS
Long Island Offshore				
29	–	NS	–	0.01
30	–	NS	–	NS
31	–	NS	–	NS
32	–	NS	–	0.006
33	–	NS	–	NS
34	–	NS	–	NS
35	–	NS	–	0.007
36	–	NS	–	NS
37	–	NS	–	NS
38	–	NS	–	NS
39	–	NS	–	0.005
Christiaensen Basin				
1	–	NS	–	NS
5	–	NS	–	NS
6	–	0.0001	–	0.0001
9	–	NS	–	0.05
10	–	0.023	–	NS
40	–	NS	–	NS

and 7 (Long Island Inshore), 6 and 10 (Basin), and 15 (Shelf Valley). For all stations combined, there was a decreasing trend significant at the $P = 0.0007$ level. Similar trends in numbers of amphipods are discussed below.

Causes for the faunal changes are unclear. Locations of the stations with significant decreases circumstantially suggest that the declines could have been linked to increasing effects of sewage sludge with time. (Station 6 is the presumed center of sludge accumulation, and 7 is in the dumpsite itself. Stations 2, 3, and 10 are all within 10 km of station 6. Station 15 is 52 km SE of 6, but was considered by Boesch [1982] to be the inshore limit of a "pristine" benthic fauna in the Shelf Valley, as of the late 1970s.) Disposal of sewage sludge increased from an average of 4,266,210 metric tons (t)/yr in 1973–79 to 6,634,355 t/yr in 1980–85 (Suszkowski and Santoro 1986), and the recent inputs were the largest ever to any oceanic sludge dumpsite (Norton and Champ 1989). However, the New York City Department of Environmental Protection (1983) reported that recent increases in sludge amounts had been due mostly to increased water content, that sludge solids dumped increased only 5% from 1973 to 1981, and that mass loadings of most sludge contaminants decreased over that period. A comparison of 1973 and 1987 sludge loads (HydroQual, Inc. 1989) indicates decreases, some quite large, in loads of sludge solids, biochemical oxygen demand and heavy metals, although nutrient inputs increased; no 1973 data on organic contaminants are available for comparison.

There are of course other possible explanations for the widespread declines in S (and amphipods). If anthropogenic change in water or sediment quality, or both, is involved, other waste sources may be partly or wholly responsible. However, dredged material disposal in 1980–85 ($\bar{x}$ = 4,723,355 t/yr), decreased substantially from the 1973–79 average (9,124,785 t/yr) (Suszkowski and Santoro 1986). Changes in carbon, nutrient, and toxicant inputs from the Hudson-Raritan estuary and other sources over the study period have not been documented. Trends in natural environmental variables such as climate or predation could also cause the observed changes.

Finally, there are several possible sources of sampling and analytical error. The "summer" surveys were not all conducted at the same time of year. The 1985 survey, which showed the lowest numbers at many stations, was conducted the latest in the year (early October). Strict comparisons of October data to those from mid- to late-summer may be invalid owing to seasonal differences in such variables as temperature, dissolved oxygen, sulfide, larval recruitment, and predation. Gray (1981) notes that it is common for numbers of individuals and species to be highest following recruitment peaks in the warmer months, and then to decline to minima in winter. The monthly samplings in summer 1986 and 1987 at stations 6 (Fig. 5) and 11 did show declines in S from July to September, although, except for September 1986 at Station 11, all values were higher than in October 1985. Preliminary data for 1988 and 1989 again indicate higher S values at stations 6 and 11 in summer than were found in October 1985, with slight decreases between July and September. For both stations as well as the third primary station (northern Christiaensen Basin) in the more recent study of responses to phaseout of sewage sludge disposal, there were apparent increases in numbers of species between 1986 and 1989 (Environmental Processes Division, 1991). This may signal a reversal of the general decreasing trend observed for 1980–85.

Systematic changes in sampling or sample processing are possible but unlikely explanations for the trends, since there has been continuity of methods and senior field and taxonomic personnel over the study period. Sorting of samples and preliminary identifications were done by two different contractors, but each contract included a quality assurance program (resorting 10% of the samples to determine and maintain accuracy). All identifications were confirmed by one of the authors (ABF).

Numbers of Amphipods

Amphipods are small crustaceans known to be important in the diets of some demersal fishes in the study area, e.g., cod, haddock, red hake, yellowtail and winter flounder (Musick and Sedberry 1977; Langton and Bowman 1980). Amphipods are also thought to be relatively sensitive to chemical contamination; this has been reported for members of the families Ampeliscidae (Lee et al. 1977; Sanders et al. 1980) and Phoxocephalidae (Swartz et al. 1982). Amphipod densities do sometimes increase with moderate organic enrichment.

Spatial Trends in Numbers of Amphipods

Contours of amphipod densities for September 1985 (Fig. 6) show distinct spatial trends, which in general match those described above for numbers of species. Lowest numbers (almost always less than one amphipod per 0.1 m^2) were found in and near the Christiaensen Basin. Densities were only slightly higher at the New Jersey and Long Island Inshore stations. Numbers increased fairly steadily to >100 amphipods/0.1 m^2 at the stations furthest offshore and also in the outer Shelf Valley.

The spatial patterns were consistent over time. Figure 7 gives contours of amphipod densities for July–August 1980. The chief difference from 1985 is that in 1980 there were more inshore stations with densities elevated relative to those in the Basin. The spatial relationships are otherwise quite similar between the two years.

Temporal Trends in Numbers of Amphipods

Again in agreement with data on numbers of species, there were marked decreases in numbers of amphipods at many stations over the study period. Linear regressions of numbers vs. time indicated nonsignificant ($P > 0.05$) positive slopes at only nine of the 48 stations (Table 2). Fourteen of the 39 declines, however, were significant ($P < 0.05$): at stations 6 and 9 (Basin), 42 (New Jersey Inshore), 13, 14, 15, and 17 (Shelf Valley), 2 and 22 (Long Island Inshore), 29, 32, 35 and 39 (Long Island Offshore), and 158 (New Jersey Offshore). For all stations combined, linear regression analysis indicated a decrease in numbers of amphipods significant at $P = 0.0004$.

The most pronounced decreases ($P = 0.0001$) at individual stations occurred at the same stations (6 and 15) as had the most significant declines in numbers of species. Station 6 was characterized by low numbers of amphipods throughout the study period. However, amphipods became more scarce with time, decreasing from an average of 1.5/0.1 m^2 in 1980–82 to only one occurrence in 27 grabs in 1983–85. Station 15 had been considered "pristine" based mostly on the large numbers of amphipods typically found there. Several early samplings revealed well over 1000 individuals/0.1 m^2, while more recent densities have been much lower (Fig. 8). As with species richness, the declines in amphipods could be due to anthropogenic or natural environmental change, or sampling/analysis artifacts.

Species Composition (Cluster Analysis)

This analysis uses data on abundance and distribution of all but rare species. It thus augments the analyses of dominant species and numbers of species and amphipods. Since between-sample similarities are calculated using log-transformed abundances of numerous taxa, the analysis is relatively insensitive to changes in abundance of single taxa, e.g., amphipods. Changes in species composition over space and time can serve as a quantitative measure of effects of environmental change.

The total of 292 station/date combinations (hereafter "samplings") yielded 27 groups at the ≥ 30% similarity level (Fig. 9). The 30% level was chosen for consistency with past analysis of New York Bight data (Reid et al. 1982), and because many of the groups formed at that level appeared ecologically meaningful (e.g., contained most or all samplings for a given station; contained stations that were spatially close and had similar depths and sediment types). Some groups contained few samplings and formed more reasonable patterns when merged with other groups at <30% similarity. The samplings occurring in each group are listed in Table 3. Numerically dominant species in each group are given in Table 4. Dominant species are defined as those among the top ten in abundance in at least 50% of the samplings in a group; the actual percentages are indicated in Table 4. Distribution of the groups among various subareas of the Bight is discussed below.

Sewage Sludge Dumpsite—Group I includes all samplings at Station 7, in the northwest corner of the dumpsite, as well as the 1983 sampling from Station 43 (NJI). The assemblage at Station 7 is distinct in part due to the abundance of the polychaetes, *Capitella* spp., which are discussed in more detail in Dominant Species section below. The consistency of species composition over time at the sludge dumpsite contradicts the suggestion from the trends in numbers of species and amphipods that degradation of the benthos there has recently increased.

"Sewage Sludge Accumulation Area"—Group J contains all samplings at Station 6 except for October 1985, which was the sole sampling in adjacent Group K. Groups J and K joined at $Cz = 0.03$ similarity, and they next merged with the sludge dumpsite fauna (Group I), at $Cz = -0.08$. J was the only group in which *Capitella* spp. were consistently the top dominants.The group is also distinguished by the consistent abundance of rhynchocoels (ribbon worms).

Inner Hudson Shelf Valley—Group D consists exclusively of all samplings at stations 13, 16, and 17. These

Table 3
Samplings included in each group formed by cluster analysis.

Year	Station (number of samples)								
Group A									
1980	1(1)	2(1)	3(1)					18(1)	40(5)
1981	1(1)	2(1)	3(1)			9(1)	10(1)		40(5)
1982	1(2)	2(2)	3(2)	5(2)	8(2)	9(2)	10(2)	18(2)	40(2)
1983	1(2)	2(2)	3(2)	5(2)			10(2)	18(2)	40(2)
		2(2)		5(2)				18(2)	
1984	1(2)	2(2)				9(2)			
1985									
Group B									
1980	5(1)	8(1)	9(1)						
1981									
1982	5(2)			18(2)					
1983			9(2)						
1984									
1985									
Group C									
1980									
1981									
1982									
1983									
1984				5(2)		10(2)	18(2)		
1985	1(2)	2(2)	3(2)	5(2)	9(2)	10(2)	18(2)	40(2)	
Group D									
1980	13(1)	16(1)	17(1)						
1981	13(1)	16(1)	17(1)						
1982	13(2)	16(2)	17(2)						
1983	13(2)	16(2)	17(2)						
		16(2)	17(2)						
1984	13(2)	16(2)	17(2)						
1985	13(2)	16(2)	17(2)						
Group E									
1980	11(1)	12(1)							
1981	11(1)	12(1)							
1982	11(2)								
1983	11(2)								
1984									
1985									
Group F									
1980	4(4)		10(1)	21(1)	42(5)				
1981	4(5)	8(1)							
1982	4(5)			21(2)		43(2)	44(2)		
1983		8(2)							
		8(2)							
1984				21(2)					
1985		8(2)							
Group G									
1980		22(1)							
1981		22(1)							
1982		22(2)							
1983		22(2)							
1984	11(2)	22(2)							
1985									

Year	Station (number of samples)						
Group H							
1980							
1981		21(1)		25(1)			
1982							
1983		21(2)			44(2)		
1984							
1985	11(2)	21(2)	22(2)				
Group I							
1980	7(5)						
1981	7(5)						
1982	7(5)						
1983	7(5)	43(2)					
1984	7(5)						
1985	7(5)						
	7(2)						
Group J							
1980	6(5)						
1981	6(5)						
1982	6(5)						
1983	6(5)						
	6(2)						
1984	6(5)						
1985	6(5)						
Group K							
1980							
1981							
1982							
1983							
1984							
1985	6(2)						
Group L							
1980		35(1)					
1981	34(1)	35(1)					
1982		35(2)					
1983		35(2)					
		35(2)					
1984		35(2)					
1985							
Group M							
1980	14(1)	15(5)					
1981	14(1)	15(5)					
1982	14(2)	15(5)					
1983	14(2)						
1984	14(2)	15(5)					
1985	14(2)	15(5)					
		15(2)					
Group N							
1980			34(1)	36(1)	37(1)	38(1)	
1981				36(1)	37(1)	38(1)	39(1)
1982	12(2)	32(2)	34(2)	36(2)	37(2)	38(2)	39(2)
1983			34(2)				
1984			34(2)			38(2)	
1985							

Table 3 (continued)

Year	Station (number of samples)							
Group O								
1980		29(1)		32(1)				39(1)
1981		29(1)	30(1)		33(1)			
1982		29(2)	30(2)					
1983	12(2)	29(2)	30(2)	32(2)		36(2)	37(2)	39(2)
1984	12(20	29(2)	30(2)			36(2)	37(2)	39(2)
1985								
Group P								
1980								
1981				32(1)				158(1)
1982								
1983								158(2)
1984				32(2)				158(2)
1985	12(2)	29(2)	30(2)	32(2)	36(2)	37(2)		158(2)
Group Q								
1980	33(1)							
1981								
1982	33(2)							
1983				38(2)				
1984	33(2)							
1985	33(2)	34(2)	35(2)	38(2)	39(2)			
Group R								
1980	28(1)							
1981	28(1)							
1982								
1983								
1984								
1985								
Group S								
1980		30(1)	31(5)					
1981			31(5)					
1982	28(2)		31(5)					
1983			31(5)					
1984			31(5)					
1985			31(2)					
Group T								
1980								
1981		20(1)			64(1)			
1982	19(2)	20(2)	42(2)					
1983					64(2)			
1984	19(2)	20(2)			64(2)			
1985	19(2)	20(2)			64(2)			
Group U								
1980			19(1)	20(1)				
1981					42(5)			44(5)
1982								
1983	4(5)			20(2)	42(2)			

Year	Station (number of samples)							
Group U (continued)								
1984	4(5)	8(2)			42(2)	43(2)		44(2)
1985	4(5)				42(2)	43(2)		44(2)
	4(2)							
Group V								
1980				27(1)				
1981				27(1)				
1982		24(2)						
1983	19(2)	24(2)	25(2)	27(2)	28(2)	63(2)		
		24(2)	25(2)					
1984		24(2)	25(2)	27(2)	28(2)			
1985		24(20	25(2)		28(2)			
Group W								
1980	23(1)							
1981								
1982	23(2)							
1983	23(2)							
1984	23(2)							
1985	23(2)							
Group X								
1980	26(5)							
1981	23(1)	26(5)						
1982	26(5)							
1983	26(5)							
1984	26(2)							
1985	26(5)							
	26(2)							
Group Y								
1980	41(5)							
1981	41(5)							
1982	41(2)							
1983	41(2)							
1984	41(2)							
1985	41(2)							
Group Z								
1980	24(1)	25(1)	43(5)	44(5)				
1981	24(1)		43(5)					
1982								
1983			43(1)					
1984								
1985								
Group AA								
1980								
1981		63(1)	65(1)					
1982	27(2)		65(2)					
1983			65(2)					
1984		63(2)	65(2)					
1985	27(2)	63(2)	65(2)					

Table 4

Consistently dominant species (in top 10 in numerical abundance in ≥50% of samplings, or station/date combinations) for each group formed by cluster analysis. Am = amphipod; An = anthozoan; Bi = bivalve; Cu = cumacean; Ec = echinoderm; Ga = gastropod; Ph = phoronid; Po = polychaete; Rh = rhynchocoel; Ta = tanaidacean.

Group	Number of samplings	Species	Taxon	% of samplings
A	33	*Nucula proxima*	Bi	100
		Prionospio steenstrupi	Po	85
		Nephtys incisa	Po	79
		Phoronis architecta	Ph	76
		Tharyx acutus	Po	73
		Mediomastus ambiseta	Po	70
		Tharyx dorsobranchialis	Po	67
		Cossura longocirrata	Po	67
		Ceriantheopsis americanus	An	52
B	6	*Nucula proxima*	Bi	100
		Cossura longocirrata	Po	100
		Nephtys incisa	Po	83
		Phoronis architecta	Ph	83
		Ceriantheopsis americanus	An	83
		Levinsenia gracilis	Po	67
		Mytilus edulis	Bi	67
		Tharyx acutus	Po	50
		Pherusa affinis	Po	50
C	11	*Ceriantheopsis americanus*	An	100
		Nucula proxima	Bi	100
		Nephtys incisa	Po	100
		Pherusa affinis	Po	82
		Phoronis architecta	Ph	73
		Cossura longocirrata	Po	55
		Lumbrineris hebes	Po	55
D	20	*Nucula delphinodonta*	Bi	100
		Cossura longocirrata	Po	95
		Levinsenia gracilis	Po	95
		Ninoe nigripes	Po	85
		Tharyx dorsobranchialis	Po	80
		Aricidea (Acesta) catherinae	Po	75
		Euchone incolor	Po	75
		Lumbrineris hebes	Po	70
		Prionospio steenstrupi	Po	70
		Mediomastus ambiseta	Po	50
E	6	*Nucula proxima*	Bi	100
		Rhynchocoela spp.	Rh	83
		Tharyx dorsobranchialis	Po	83
		Ninoe nigripes	Po	83
		Aricidea (Acesta) catherinae	Po	83
		Lumbrineris hebes	Po	83
		Prionospio steenstrupi	Po	83
		Spio filicornis	Po	50
		Pholoe minuta	Po	50
F	14	*Amastigos caperatus*	Po	79
		Tellina agilis	Bi	79
		Mediomastus ambiseta	Po	71
		Nucula proxima	Bi	64
		Aricidea (Acesta) catherinae	Po	64
		Tharyx acutus	Po	57
		Parougia caeca	Po	50
		Prionospio steenstrupi	Po	50
G	6	*Nucula proxima*	Bi	100
		Pitar morrhuanus	Bi	100
		Tellina agilis	Bi	83
		Aricidea (Acesta) catherinae	Po	83
		Spiophanes bombyx	Po	67
		Nephtys picta	Po	67
		Spio filicornis	Po	67
		Lumbrineris hebes	Po	50
		Tharyx acutus	Po	50
H	7	*Nucula proxima*	Bi	100
		Tellina agilis	Bi	86
		Nephtys picta	Po	86
		Aricidea (Acesta) catherinae	Po	57
		Pitar morrhuanus	Bi	57
I	8	*Spiophanes bombyx*	Po	100
		Capitella spp.	Po	88
		Tharyx acutus	Po	88
		Nephtys picta	Po	88
		Tellina agilis	Bi	88
		Exogone hebes	Po	63
		Nephtyidae spp. (juvenile)	Po	50
J	7	*Capitella* spp.	Po	100
		Rhynchocoela spp.	Rh	100
		Nephtys incisa	Po	86
		Nucula proxima	Bi	86
		Spio filicornis	Po	71
		Pholoe minuta	Po	57
K	1	(one sampling only)		
		Nephtys incisa	Po	100
		Glycera dibranchiata	Po	100
		Pherusa affinis	Po	100
		Nassarius trivittatus	Ga	100
		Nucula proxima	Bi	100
		Tellina agilis	Bi	100
		Spisula solidissima	Bi	100
L	7	*Ampelisca agassizi*	Am	100
		Unciola irrorata	Am	100
		Leptocheirus pinguis	Am	100
		Corophium crassicorne	Am	100
		Erichthonius rubricornis	Am	86
		Unicola spp. (juvenile)	Am	71
		Exogone verugera	Po	71
		Harpinia propinquua	Am	57
		Eudorella pusilla	Cu	57
M	12	*Ampelisca agassizi*	Am	100
		Aricidea (Acesta) catherinae	Po	83
		Lumbrineris hebes	Po	75
		Unciola irrorata	Am	58
		Tharyx dorsobranchialis	Po	50
		Nucula delphinodonta	Bi	50
		Leptocheirus pinguis	Am	50

Table 4 (continued)

Group	Number of samplings	Species	Taxon	% of samplings
N	18	*Exogone hebes*	Po	100
		Unciola inermis	Am	78
		Byblis serrata	Am	72
		Aricidea (Acesta) catherinae	Po	61
		Caulleriella cf. killariensis	Po	56
		Euchone elegans	Po	56
O	21	*Unicola inermis*	Am	100
		Exogone hebes	Po	95
		Caulleriella cf. killariensis	Po	90
		Tanaissus liljeborgi	Ta	67
		Rhepoxynius hudsoni	Am	57
		Prionospio steenstrupi	Po	52
		Aricidea (Acesta) catherinae	Po	52
		Byblis serrata	Am	52
P	12	*Caulleriella cf. killariensis*	Po	100
		Exogone hebes	Po	100
		Goniadella gracilis	Po	100
		Aricidea (Acesta) catherinae	Po	83
		Lumbrinerides acuta	Po	75
		Nephtydae spp. (juvenile)	Po	58
		Unciola irrorata	Am	58
		Tanaissus liljeborgi	Ta	50
Q	9	*Exogone hebes*	Po	56
		Rhepoxynius hudsoni	Am	56
		Unciola inermis	Am	56
		Ampelisca agassizi	Am	56
R	2	*Phyllodoce mucosa*	Po	100
		Glycera spp. (juvenile)	Po	50
		Exogone hebes	Po	50
		Aricidea (Aricidea) wassi	Po	50
		Corophium crassicorne	Am	50
		Aglaophamus circinati	Po	50
		Unciola inermis	Am	50
		Paraonis fulgens	Po	50
		Echinarachnius parma	Ec	50
		Spiophanes bombyx	Po	50
		Parougia caeca	Po	50
		Clymenella torquata	Po	50
		Cerastoderma pinnulatum	Bi	50
		Lumbrineris hebes	Po	50
		Rhepoxynius hudsoni	Am	50
		Sthenelais limicola	Po	50
		Photis macrocoxa	Am	50
		Rhynchocoela spp.	Rh	50
		Ceriantheopsis americans	Am	50
S	9	*Exogone hebes*	Po	89
		Caulleriella cf. killariensis	Po	89
		Pseudunciola obliquua	Am	89
		Aricidea (Acesta) catherinae	Po	67
		Tanaissus liljeborgi	Ta	67
		Rhepoxynius hudsoni	Am	56
		Echinarachnius parma	Ec	56
T	12	*Tellina agilis*	Bi	92
		Nephtys picta	Po	75
		Spisula solidissima	Bi	67
		Tanaissus liljeborgi	Ta	67
		Aricidea (Acesta) catherinae	Po	58
		Caulleriella cf. killariensis	Po	58
		Magelona riojai	Po	58
T (continued)		*Pseudunciola obliquua*	Am	58
		Spiophanes bombyx	Po	50
		Nephtyidae spp. (juvenile)	Po	50
		Protohaustorius cf. deichmannae	Po	50
U	17	*Tellina agilis*	Bi	88
		Goniadella gracilis	Po	64
		Spiophanes bombyx	Po	64
		Spisula solidissima	Bi	64
		Caulleriella cf. killariensis	Po	59
		Nephtyidae spp. (juvenile)	Po	59
V	18	*Echinarachnius parma*	Ec	78
		Goniadella gracilis	Po	72
		Astarte castanea	Bi	67
		Exogone hebes	Po	61
		Caulleriella cf. killariensis	Po	61
		Pseudunciola obliquua	Am	61
		Tanaissus liljeborgi	Ta	50
W	5	*Goniadella gracilis*	Po	100
		Tellina agilis	Bi	80
		Echinarachnius parma	Ec	80
		Pseudunciola obliquua	Am	80
		Astarte castanea	Bi	60
		Spisula solidissima	Bi	60
		Hemipodus roseus	Po	60
		Sigalion arenicola	Po	60
		Nephtys bucera	Po	60
		Rhynchocoela spp.	Rh	60
X	8	*Echinarachnius parma*	Ec	100
		Ceriantheopsis americana	An	88
		Tharyx dorsobranchialis	Po	88
		Nephtyidae spp. (juvenile)	Po	75
		Goniadella gracilis	Po	63
		Nephtys picta	Po	63
		Tharyx acutus	Po	63
		Hemipodus roseus	Po	50
		Lumbrineris acicularum	Po	50
Y	6	*Parapionosyllis longicirrata*	Po	100
		Goniadella gracilis	Po	100
		Spisula solidissima	Bi	100
		Tanaissus liljeborgi	Ta	100
		Tellina agilis	Bi	83
		Aricidea (Acesta) cerruti	Po	67
		Nephtys bucera	Po	50
		Nephtyidae spp. (juvenile)	Po	50
		Scolelepis squamata	Po	50
		Spiophanes bombyx	Po	50
		Hemipodus roseus	Po	50
Z	7	*Aricidea (Acesta) catherinae*	Po	100
		Lumbrineris acicularum	Po	100
		Goniadella gracilis	Po	86
		Parougia caeca	Po	86
		Tharyx acutus	Po	71
AA	10	*Cirrophorus brevicirratus*	Po	100
		Goniadella gracilis	Po	90
		Hemipodus roseus	Po	80
		Aricidea (Acesta) catherinae	Po	80
		Tellina agilis	Bi	50

stations are located in the inner HSV, 28–41 km SSE of the sludge dumpsite and sludge accumulation area. That all 1980–85 samplings from the three stations clustered together, and without any trend toward early samplings segregating from later ones, is evidence against any gross effects of increasing sludge disposal or other environmental changes in the inner HSV over that period. However, the preponderance of polychaetes among the dominant species may be an indication of long-term enrichment or stress effects. Group D clustered most closely with Groups A, B, and C (samplings from the Christiaensen Basin and stations closest to the Hudson-Raritan estuary mouth), another sign that influences in those areas extend to the inner HSV.

The other two stations in the inner HSV clustered separately from stations 13, 16, and 17 (Group D). Station 11, just south of the Christiaensen Basin, was in the adjacent though quite dissimilar ($Cz = -1.4$) Group E for 1980 through 1983, and Station 12, located between 11 and 13, was in E in 1980 and 1981. Station 11 moved to Group G in 1984 and H in 1985; it thus moved closer to the sludge dumpsite and accumulation area on the dendrogram but was still quite dissimilar from them ($Cz = -0.36$). Station 12 samplings from 1982 through 1985 fell in the "offshore supergroup," with amphipods increasing in abundance in contrast to the trend at most stations.

Outer Hudson Shelf Valley—Unlike the inner HSV and CB, stations 14 and 15 (Group M) were dominated by amphipods. As with Group D in the inner HSV, the similarity (0.45) of all samplings in the outer HSV is evidence against major effects of environmental change over the study period, and contradicts the decreases in numbers of species and amphipods discussed above.

Long Island Offshore (LIO)—The fauna of the easternmost LIO stations was most similar to that of the outer HSV. Group L, which contained samplings from stations 34 and 35, joined the outer HSV group at 0.15 similarity. As in the outer HSV, this group was dominated by *Ampelisca agassizi* and other amphipods, and had a relative scarcity of polychaetes. *A. agassizi* did decrease somewhat from the very high 1980–81 levels, and then increased again in 1985 when Station 35 fell into Group Q (discussed below). Polychaetes were more dominant in Group Q, so there are mixed indications of temporal change in species composition in this area.

All other LIO stations had somewhat similar faunas. All samplings fell within groups N, O, P, Q, and S, and all these groups joined at −0.21 similarity. The largest difference between these groups and Group L above was their lower abundance of *Ampelisca agassizi.*

New Jersey Offshore—The two stations (28 and 158) in this category had assemblages most similar to LIO stations. All samplings from Station 158 fell in Group P, which otherwise consisted of LIO samplings. The 1980 and 1981 samplings at Station 28 formed a separate group (R), with closest affinities to LIO Station 31. Station 28 occurred in Group S in 1982, and Group V (New Jersey Inshore, below) in 1983 through 1985.

New Jersey Inshore—This is the largest (14 stations), most heterogeneous collection of stations. Samplings were split between two very dissimilar ($Cz = -3.0$) "supergroups," A through K and T through AA. The NJI stations closest to the Christiaensen Basin (4, 8, and 18) had most samplings in the A–K supergroup. Groups T through AA basically consisted of samplings from the more southern and inshore NJI stations (19, 20, 23–27 and 41–44). The cluster analysis did not distinguish northern coastal stations from other NJI areas, indicating that the Hudson-Raritan estuarine plume (which tends to follow the north NJ coast) did not have an overriding influence on species composition.

Long Island Inshore—As with NJI stations, the LII stations were split between the dissimilar supergroups A–K and T–AA. All samplings from the three stations nearest the Long Island coast (63, 64, and 65) were in group T–AA. All sampling from the remaining LII stations (2, 3, 21, and 22) were in groups A, C, F, G, and H, with fauna quite distinct from stations 63–65.

Christiaensen Basin—Finally, all remaining CB stations (1, 5, 9, 10, and 40) clustered together in groups A–C, except for Station 10 in 1980 (Group F). These are the stations physically closest to Station 6 in the sludge accumulation area. Their depths are similar to that at Station 6 (Table 1) and, as indicated by amounts of fine sediments, they also have somewhat depositional environments (Station 10 is deeper but has coarser sediments). These stations should be among the first to show signs of any increasing influence of sludge or other contaminant inputs to the Basin. That their species composition remained consistent over time, and distinct from the fauna at Station 6, from 1980–85 is evidence against large increases in anthropogenic effects.

Table 5
Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 6 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg.) Mean	Biomass (mg.) SE
Dec 1979	5 grabs	*Phoronis architecta*	764.0	205.5	*Phoronis architecta*	2321.0	707.0
		Asabellides oculata	490.8	81.2	*Nephtys incisa*	1688.2	474.3
		Tharyx acutus	342.2	38.4	Rhynchocoela spp.	1440.4	334.4
		Capitella spp.	118.6	28.3	*Ceriantheopsis americanus*	1248.4	380.9
		Mediomastus ambiseta	79.2	11.7	*Pherusa affinis*	467.6	254.9
		Cossura longocirrata	68.2	13.1	*Ninoe nigripes*	375.6	245.5
		Prionospio steenstrupi	50.0	12.9	*Asabellides oculata*	372.4	51.7
		Parougia caeca	45.8	13.7	*Cancer irroratus*	297.6	251.0
		Unciola irrorata	44.6	7.2	*Crangon septemspinosa*	106.4	38.0
		Nephtys incisa	42.4	8.2	*Tharyx acutus*	82.6	5.9
Jul 1980	5 grabs	*Capitella* spp.	545.6	118.4	*Capitella* spp.	497.2	245.5
		Edotea triloba	27.4	8.5	Rhynchocoela spp.	201.0	109.3
		Rhynchocoela spp.	8.4	3.0	*Edotea triloba*	111.2	38.3
		Spiophanes bombyx	8.2	6.8	*Ceriantheopsis americanus*	106.4	93.4
		Cancer irroratus	7.0	3.4	*Cancer irroratus*	70.8	46.0
		Tellina agilis	4.2	2.1	*Spiophanes bombyx*	56.4	50.6
		Tharyx acutus	3.6	2.7	*Nephtys incisa*	42.4	18.3
		Nephtys incisa	3.2	1.6	*Phoronis architecta*	15.4	13.9
		Unciola irrorata	2.2	0.6	*Pherusa affinis*	15.2	13.3
		Pitar morrhuanus	1.8	1.8	*Tellina agilis*	12.8	6.8
Dec 1980	5 grabs	*Spiophanes bombyx*	166.2	34.4	*Ceriantheopsis americanus*	832.2	434.5
		Capitella spp.	86.4	44.5	*Nephtys picta*	254.8	67.3
		Pherusa affinis	46.0	14.5	*Pherusa affinis*	228.8	79.5
		Nephtyidae spp.	35.8	6.9	*Diopatra cuprea*	173.6	132.8
		Nephtys picta	14.2	2.8	*Spiophanes bombyx*	167.6	18.6
		Parougia caeca	11.0	4.0	*Glycera dibranchiata*	62.6	23.3
		Edotea tribola	5.4	1.7	*Capitella* spp.	49.8	29.7
		Tharyx acutus	4.8	2.5	Rhynchocoela spp.	45.8	45.1
		Ceriantheopsis americanus	3.4	1.7	*Pitar morrhuanus*	15.2	15.2
		Diopatra cuprea	3.4	2.0	*Edotea tribola*	13.4	5.3
Aug 1981	5 grabs	*Capitella* spp.	637.8	157.7	*Capitella* spp.	2475.6	630.9
		Rhynchocoela spp.	27.2	6.8	Rhynchocoela spp.	1670.4	509.2
		Phoronis architecta	14.6	6.3	*Nephtys incisa*	223.8	39.8
		Nucula proxima	7.4	2.6	*Nucula proxima*	82.6	26.8
		Phyllodoce (anatides) mucosa	7.0	2.1	*Ovalipes ocellatus*	49.4	49.4
		Nephtys incisa	6.4	0.6	*Cancer irroratus*	28.6	14.6
		Pholoe minuta	3.8	0.4	*Phersusa affinis*	22.8	12.3
		Microphthalmus sczelkowii	2.0	0.8	*Phoronis architecta*	19.2	8.4
		Prionospio steenstrupi	2.0	1.4	*Tharyx dorsobranchialis*	17.6	17.1
		Tharyx acutus	2.0	0.9	*Ceriantheopsis americanus*	14.2	9.3
Jan 1982	5 grabs	*Nucula proxima*	51.4	13.7	Rhynchocoela spp.	337.2	107.3
		Phoronis architecta	16.2	7.3	*Nucula proxima*	270.0	55.3
		Edotea triloba	4.4	2.0	*Nephtys incisa*	189.0	60.3
		Rhynchocoela spp.	3.8	0.6	*Phersusa affinis*	49.6	36.7
		Tharyx acutus	3.8	1.6	*Phoronis architecta*	40.2	16.8
		Nephtys incisa	3.6	1.2	*Edotea triloba*	11.6	4.4
		Capitella spp.	3.2	0.9	*Amphioplus abditus*	8.2	8.2
		Nephtyidae spp.	2.4	1.2	*Spiophanes bombyx*	5.8	2.2
		Cirratulus cirratus	2.4	2.4	*Ceriantheopsis americanus*	5.2	3.6
		Parougia caeca	2.2	1.1	*Crangon septemspinosa*	5.2	4.5

Table 5 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Aug 1982	5 grabs	*Capitella* spp.	989.2	379.0	Rhynchocoela spp.	2139.4	486.7
		Ceriantheopsis americanus	55.2	18.6	*Capitella* spp.	360.0	107.5
		Pholoe minuta	41.4	16.9	*Ceriantheopsis americanus*	334.8	76.9
		Spio filicornis	16.6	4.4	*Nephtys incisa*	316.0	95.3
		Phyllodoce (anatides) mucosa	16.2	4.3	*Cancer irroratus*	162.6	100.0
		Rhynchocoela spp.	14.4	3.2	*Spio filicornis*	140.6	41.5
		Parougia caeca	9.0	1.8	*Pherusa affinis*	18.2	17.5
		Tharyx acutus	8.4	3.4	*Phyllodoce (anatides) mucosa*	17.0	4.5
		Nucula proxima	8.4	1.8	*Crangon septemspinosa*	17.0	17.0
		Mediomastus ambiseta	7.4	3.8	*Glycera dibranchiata*	16.2	13.6
Nov 1982	5 grabs	*Nucula proxima*	11.8	4.7	*Nephtys incisa*	364.0	103.5
		Nephtys incisa	8.6	1.9	*Ceriantheopsis americanus*	30.6	30.6
		Diastylis polita	8.2	2.6	Rhynchocoela spp.	28.2	19.9
		Pherusa affinis	6.6	2.8	*Nucula proxima*	25.2	10.2
		Tellina agilis	5.8	3.0	*Pherusa affinis*	19.2	7.8
		Asabellides oculata	2.2	1.2	*Diastylis polita*	10.8	3.7
		Spiophanes bombyx	2.0	0.9	*Crangon septemspinosa*	10.8	4.7
		Edotea tribola	1.8	0.6	*Asabellides oculata*	5.8	5.1
		Crangon septemspinosa	1.6	0.7	*Edotea triloba*	2.4	0.9
		Capitella spp.	1.4	0.7	*Spiophanes bombyx*	2.2	1.5
Jul 1983	5 grabs	*Capitella* spp	86.8	52.5	*Capitella* spp.	358.0	125.2
		Rhynchocoela spp.	4.0	1.8	Rhynchocoela spp.	119.0	71.0
		Pholoe minuta	3.2	2.2	*Nucula proxima*	18.8	18.1
		Nucula proxima	2.6	1.9	*Nephtys incisa*	12.4	9.8
		Tharyx dorsobranchialis	1.6	1.6	*Spio filicornis*	2.8	2.6
		Nephtys incisa	1.4	0.7	*Harmothoe extenuata*	2.0	2.0
		Spio filicornis	1.4	0.9	*Pholoe minuta*	0.8	0.6
		Ceriantheopsis americanus	0.4	0.4	*Tharyx dorsobranchialis*	0.8	0.8
		Mytilus edulis	0.4	0.4	*Cancer irroratus*	0.8	0.8
		Harmothoe extenuata	0.2	0.2	*Ceriantheopsis americanus*	0.6	0.6
Aug 1983	2 grabs	*Capitella* spp.	5604.0	5092.0	*Capitella* spp.	3985.5	3643.5
		Rhynchocoela spp.	39.5	6.5	Rhynchocoela spp.	959.0	200.0
		Ceriantheopsis americanus	23.5	15.5	*Ceriantheopsis americanus*	212.5	188.5
		Pholoe minuta	16.0	7.0	*Nucula proxima*	46.0	4.0
		Nucula proxima	14.5	1.5	*Spio filicornis*	12.0	3.0
		Phoronis architecta	4.0	3.0	*Nephtys incisa*	10.0	0.0
		Nephtys incisa	3.0	0.0	*Pherusa affinis*	5.0	5.0
		Spio filicornis	3.0	0.0	*Edwardsia elegans*	2.5	2.5
		Parougia caeca	2.0	1.0	*Pholoe minuta*	2.5	0.5
		Prionospio steenstrupi	2.0	1.0	*Eteone longa*	2.0	2.0
Nov 1983	5 grabs	*Capitella* spp.	414.8	368.8	*Nephtys incisa*	1082.4	305.0
		Nereis succinea	35.2	31.7	*Pherusa affinis*	321.8	241.9
		Nucula proxima	28.2	6.6	Rhynchocoela spp.	296.0	85.6
		Nephtys incisa	27.2	5.2	*Capitella* spp.	191.4	175.5
		Parougia caeca	21.0	9.8	*Ceriantheopsis americanus*	181.8	44.5
		Asabellides oculata	16.2	3.5	*Nucula proxima*	120.0	28.8
		Nephtys picta	12.0	4.1	*Dichelopandalus leptocerus*	56.0	56.0
		Pherusa affinis	4.8	2.6	*Nereis succinea*	55.6	54.1
		Tellina agilis	4.0	1.3	*Asabellides oculata*	37.0	12.7
		Ceriantheopsis americanus	3.4	0.8	*Tellina agilis*	6.2	2.6

Table 5 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg.) Mean	Biomass (mg.) SE
Aug 1984	5 grabs	*Capitella* spp.	117.4	54.2	*Capitella* spp.	1310.4	831.5
		Rhynchocoela spp.	3.4	1.3	Rhynchocoela spp.	336.6	169.9
		Nucula proxima	1.0	0.6	*Tellina agilis*	12.8	7.8
		Pherusa affinis	0.8	0.6	*Pherusa affinis*	11.4	7.2
		Nephtys incisa	0.6	0.4	*Nephty incisa*	7.6	5.2
		Edotea triloba	0.6	0.4	*Ceriantheopsis americanus*	7.0	7.0
		Spio filicornis	0.4	0.4	*Crangon Septemspinosa*	4.0	2.5
		Tellina agilis	0.4	0.2	*Nucula proxima*	3.0	2.0
		Crangon Septemspinosa	0.4	0.2	*Edotea triloba*	2.8	2.0
		Ceriantheopsis americanus	0.2	0.2	*Spio filicornus*	1.8	1.8
Jun 1985	5 grabs	*Capitella* spp.	99.8	45.0	*Capitella* spp.	326.8	193.0
		Nucula proxima	19.6	4.7	Rhynchocoela spp.	239.6	113.5
		Nephtys incisa	12.6	1.1	*Nephtys incisa*	196.6	40.3
		Arctica islandica	5.2	2.0	*Nucula proxima*	126.8	30.3
		Edotea triloba	3.6	1.0	*Nassarius trivittatus*	17.8	17.8
		Rhynchocoela spp.	2.4	0.5	*Edotea Triloba*	11.2	1.7
		Anthozoa spp.	2.2	0.7	*Artica islandica*	6.0	2.7
		Spio filicornus	1.0	0.3	*Cancer irroratus*	5.0	2.3
		Cancer irroratus	1.0	0.4	*Mulinia lateralis*	4.0	2.5
		Crangon septemspinosa	0.6	0.6	Anthozoa spp.	3.2	1.0
Oct 1985	2 grabs	*Nephtys incisa*	7.0	1.0	*Nephtys incisa*	180.0	4.0
		Nassarius trivittatus	1.0	0.0	*Glycera dibranchiata*	30.0	30.0
		Nucula proxima	1.0	1.0	*Tellina agilis*	3.0	1.0
		Tellina agilis	1.0	0.0	*Nassarius trivittatus*	2.5	0.5
		Glycera dibranchiata	0.5	0.5	*Nucula proxima*	2.5	2.5
		Pherusa affinis	0.5	0.5	*Pherusa affinis*	1.0	1.0
		Spisula solidissima	0.5	0.5	*Spisula solidissima*	1.0	1.0
Jul 1986	3 grabs	*Capitella* spp.	2177.3	1433.3	Rhynchocoela spp.	3792.3	1478.7
		Asabellides oculata	486.3	92.7	*Asabellides oculata*	3128.0	1440.7
		Pherusa affinis	72.3	39.1	*Capitella* spp.	2552.7	2289.1
		Nucula proxima	68.0	42.0	*Pherusa affinis*	622.0	365.2
		Rhynchocoela spp.	60.3	17.9	*Paranaitis speciosa*	287.0	26.2
		Tellina agilis	50.3	33.2	*Nephtys incisa*	253.3	237.0
		Paraougia caeca	40.0	40.0	*Ceriantheopsis americanus*	243.7	217.8
		Paranaitus speciosa	31.7	3.2	*Cancer irroratus*	219.0	81.2
		Tharyx acutus	24.0	10.0	*Asterias forbesi*	122.7	122.7
		Cancer irroratus	16.3	7.4	*Nucula proxima*	119.7	48.0
Aug 1986	3 grabs	*Tharyx* spp.	33.7	33.7	Rhynchocoela spp.	2283.0	835.0
		Rhynchocoela spp.	23.3	11.6	*Cancer irroratus*	891.0	611.3
		Nucula proxima	22.0	18.0	*Nephtys incisa*	521.0	278.9
		Tharyx acutus	16.7	14.7	*Ceriantheopsis americanus*	361.0	209.3
		Cancer irroratus	12.3	2.6	*Nucula proxima*	63.0	41.7
		Cerioantheopsis americanus	12.0	8.3	*Pherusa affinis*	30.3	13.0
		Pherusa affinis	11.3	6.4	*Nassarius trivittatus*	28.0	28.0
		Nephtys incisa	4.7	2.3	*Tharyx* spp.	7.3	7.3
		Mediomastus ambiseta	4.3	2.3	*Tharyx acutus*	7.3	5.9
		Tellina agilis	2.3	1.5	*Phoronis architecta*	7.0	6.0
Sep 1986	3 grabs	Rhynchocoela spp.	39.7	14.4	Rhynchocoela spp.	2169.0	853.0
		Tharyx acutus	22.3	5.9	*Ceriantheopsis americanus*	552.0	251.0
		Nucula proxima	22.0	10.2	*Pherusa affinis*	199.7	193.2
		Ceriantheopsis americanus	20.3	9.0	*Nephtys incisa*	135.0	45.3

Table 5 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
		Capitella spp.	6.7	3.3	*Glycera dibranchiata*	94.3	52.6
		Mediomastus ambiseta	6.3	2.3	*Nucula proxima*	51.3	15.8
		Nephtys incisa	2.3	0.9	*Spio filicornis*	11.0	11.0
		Tellina agilis	2.3	1.5	*Ninoe nigripes*	8.0	8.0
		Parougis caeca	2.0	2.0	*Tharyx acutus*	8.0	3.6
		Pherusa affinis	2.0	1.2	*Tellina agilis*	2.3	1.9
Jul 1987	3 grabs	Rhynchocoela spp.	71.7	40.2	Rhynchocoela spp.	9054.7	4015.4
		Parougia caeca	37.0	21.0	*Ceriantheopsis americanus*	1507.0	796.7
		Ceriantheopsis americanus	36.3	21.3	*Nephtys incisa*	243.3	224.4
		Nucula proxima	27.3	13.7	*Nucula proxima*	134.7	58.7
		Capitella spp.	15.0	14.0	*Edotea triloba*	106.0	36.8
		Edotea triloba	13.0	3.5	*Parougia caeca*	45.0	28.4
		Cancer irroratus	4.3	2.8	*Cancer irroratus*	36.3	28.3
		Nephtys incisa	3.7	1.5	*Pitar morrhuanus*	18.3	18.3
		Spio filicornis	2.0	2.0	*Spio filicornis*	10.0	10.0
		Harmothoe extenuata	1.3	0.7	*Spiophanes bombyx*	8.7	8.7
Aug 1987	3 grabs	*Parougia caeca*	48.3	29.1	Rhynchocoela spp.	3691.0	1441.4
		Rhynchocoela spp.	37.0	16.1	*Ceriantheopsis americanus*	782.7	530.0
		Capitella spp.	'34.7	16.8	*Nucula proxima*	152.3	70.4
		Nucula proxima	25.7	13.6	*Pherusa affinis*	45.0	23.1
		Ceriantheopsis americanus	9.3	6.2	*Edotea triloba*	34.0	21.1
		Edotea triloba	5.0	3.1	*Spio filicornis*	22.3	22.3
		Pherusa affinis	2.0	0.6	*Cancer irroratus*	21.7	11.5
		Cancer irroratus	1.3	0.9	*Parougia caeca*	15.3	10.5
		Spio filicornis	1.0	1.0	*Nephtys incisa*	9.7	9.7
		Tharyx acutus	0.7	0.7	*Capitella* spp.	6.7	3.8
Sep 1987	3 grabs	*Capitella* spp.	2187.3	867.3	Rhynchocoela spp.	3542.7	1172.9
		Nucula proxima	63.0	29.6	*Ceriantheopsis americanus*	1429.7	1336.3
		Rhynchocoela spp.	22.7	5.2	*Capitella* spp.	1089.3	394.4
		Ceriantheopsis americanus	19.0	18.0	*Cancer irroratus*	936.3	936.3
		Parougia caeca	4.3	2.0	*Nucula proxima*	154.7	23.7
		Prionospio steenstrupi	3.3	2.8	*Nephtys incisa*	26.7	12.1
		Edotea triloba	2.7	1.2	*Pherusa affinis*	17.3	17.3
		Nephtys incisa	2.3	0.7	*Parougia caeca*	5.0	2.6
		Unciola irrorata	1.0	1.0	*Edotea triloba*	3.7	1.5
		Jassa falcata	0.7	0.3	*Dyopedos monocanthus*	3.3	1.7

Table 6

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 7 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Dec 1979	5 grabs	*Capitella* spp.	372.0	181.5	*Diopatra cuprea*	1032.8	479.6
		Tharyx acutus	296.0	46.1	*Ceriantheopsis americanus*	633.2	201.4
		Parougia caeca	98.8	22.8	*Nephtys picta*	631.8	99.9
		Exogone hebes	69.8	10.4	Rhynchocoela spp.	523.4	231.4
		Spiophanes bombyx	60.8	23.9	*Asabellides oculata*	300.2	64.5
		Asabellides oculata	57.4	24.0	*Ensis directus*	262.8	158.4
		Unciola irrorata	44.8	20.2	*Spiophanes bombyx*	220.4	59.9
		Mephtys picta	37.8	3.0	*Nassarius trivittatus*	209.4	129.5
		Nephtyidae spp.	23.0	5.1	*Glycera dibranchiata*	180.4	22.5
		Phoronis architecta	13.4	5.8	*Tharyx acutus*	177.2	26.3
Jul 1980	5 grabs	*Edotea triloba*	62.0	13.6	*Lumbrineris acicularum*	522.0	334.6
		Capitella spp.	42.8	16.8	*Ceriantheopsis americanus*	351.6	260.8
		Tharyx acutus	28.6	12.7	Rhynchocoela spp.	280.3	98.9
		Tellina agilis	23.3	5.4	*Edotea triloba*	236.4	89.1
		Nephtys picta	17.4	10.2	*Nephtys picta*	225.6	141.1
		Amastigos caperatus	15.7	9.9	*Glycera dibranchiata*	145.6	105.4
		Parougia caeca	13.4	5.5	*Tellina agilis*	111.1	44.4
		Spiophanes bombyx	13.4	5.9	*Nephtys incisa*	102.8	102.8
		Tharyx acutus	11.7	11.6	*Spiophanes bombyx*	99.4	74.8
		Exogone hebes	9.1	9.0	*Nephtys bucera*	73.3	73.2
Dec 1980	5 grabs	*Spiophanes bombyx*	108.5	26.1	*Arctica islandica*	15400.0	15400.0
		Capitella spp.	32.6	11.0	*Nassarius trivittatus*	1091.1	615.5
		Parougia caeca	30.8	18.4	*Diopatra cuprea*	417.0	415.8
		Pherusa affinis	25.3	12.3	*Ceriantheopsis americanus*	403.5	189.0
		Nephtyidae spp.	14.7	5.2	*Nephtys picta*	251.1	132.9
		Tharyx acutus	10.1	6.1	Rhynchocoela spp.	207.9	169.8
		Nephtys picta	9.1	2.9	*Spiophanes bombyx*	182.6	124.6
		Diopatra cuprea	4.5	3.7	*Pherusa affinis*	107.3	55.0
		Exogone hebes	3.8	2.6	*Crangon septemspinosa*	28.7	4.2
		Nereidae spp. (juv.)	3.5	2.1	*Laonice cirrata*	17.9	17.8
Aug 1981	5 grabs	*Spiophanes bombyx*	158.4	29.5	*Spiophanes bombyx*	1516.7	210.2
		Capitella spp.	79.1	33.8	*Diopatra cuprea*	370.0	370.0
		Tharyx acutus	24.6	20.7	*Ceriantheopsis americanus*	346.7	97.5
		Exogone hebes	17.8	2.6	Rhynchocoela spp.	216.6	103.4
		Spio filicornis	13.9	5.7	*Nephtys picta*	187.4	44.5
		Tellina agilis	13.3	6.6	*Nassarius trivittatus*	158.3	158.2
		Tharyx dorsobranchialis	11.1	9.5	*Spio filicornis*	99.7	31.5
		Ceriantheopsis americanus	10.8	1.1	*Tellina agilis*	91.7	38.0
		Nephtys picta	8.9	3.2	*Glycera dibranchiata*	71.7	29.4
		Nephtyidae spp.	4.9	3.1	*Capitella* spp.	60.9	17.2
Jan 1982	5 grabs	*Echinarachnius parma*	192.4	48.5	*Spiophanes bombyx*	1428.6	336.2
		Spiophanes bombyx	120.4	14.0	*Ceriantheopsis americanus*	630.0	226.1
		Nephtyidae spp.	82.6	6.7	Rhynchocoela spp.	317.4	143.9
		Exogone hebes	26.0	6.8	*Nephtys picta*	202.4	37.5
		Tellina agilis	25.4	3.8	*Diopatra cuprea*	200.6	179.6
		Parougia caeca	22.2	5.3	*Nassarius trivittatus*	121.8	79.9
		Tharyx acutus	17.8	6.2	Nephtyidae spp.	68.8	9.9
		Capitella spp.	17.2	2.7	*Pherusa affinis*	60.0	33.3
		Nephtys picta	7.6	1.2	*Glycera dibranchiata*	53.6	20.1
		Glycera spp. (juv.)	7.2	1.9	*Tellina agilis*	33.4	20.8

Table 6 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Aug 1982	5 grabs	*Capitella* spp.	678.3	123.7	Rhynchocoela spp.	8553.3	1749.8
		Parougia caeca	167.4	12.8	*Ceriantheopsis americanus*	2080.6	903.1
		Exogone hebes	79.3	26.7	Capitella spp.	1915.3	356.1
		Spiophanes bombyx	44.6	16.0	*Spiophanes bombyx*	875.7	343.7
		Nephtys picta	38.0	17.0	*Nephtys picta*	533.7	222.9
		Tharyx acutus	24.4	3.7	*Diopatra cuprea*	368.0	185.4
		Tellina agilis	17.8	5.0	*Nassarius trivittatus*	365.6	218.5
		Rhynchocoela spp.	13.7	4.6	*Glycera dibranchiata*	277.5	167.0
		Ceriantheopsis americanus	5.1	1.2	*Cancer irroratus*	188.3	126.0
		Amastigos caperatus	3.8	1.7	*Tellina agilis*	164.1	76.6
Nov 1982	5 grabs	*Capitella* spp.	82.6	44.1	*Diopatra cuprea*	1597.2	1294.4
		Nereis succinea	27.8	23.5	*Pitar morrhuanus*	924.0	924.0
		Spio filicornis	23.8	14.0	*Spio filicornis*	179.0	113.8
		Spiophanes bombyx	14.4	6.0	*Glycera dibranchiata*	168.4	119.0
		Pherusa affinis	9.8	3.0	Rhynchocoela spp.	103.6	71.3
		Diopatra cuprea	9.0	6.3	*Ceriantheopsis americanus*	88.4	63.3
		Gammarus lawrencianus	8.6	8.6	*Capitella* spp.	83.0	46.0
		Euchone incolor	6.6	6.4	*Nereis succinea*	80.4	72.3
		Tellina agilis	5.6	1.0	*Nephtys picta*	74.6	27.3
		Nephtys picta	5.2	1.2	*Cancer irroratus*	67.6	67.6
Jul 1983	5 grabs	*Tellina agilis*	160.6	27.0	*Nassarius trivittatus*	903.4	463.3
		Capitella spp.	34.8	7.7	*Ceriantheopsis americanus*	678.0	260.7
		Nephtyidae spp.	16.4	7.5	*Diopatra cuprea*	333.4	204.3
		Spiophanes bombyx	13.2	3.1	*Tellina agilis*	272.8	72.1
		Ensis directus	11.2	4.1	*Nephtys picta*	164.0	56.3
		Nephtys picta	8.4	3.4	Rhynchocoela spp.	134.2	82.0
		Tharyx acutus	8.2	3.5	*Spiophanes bombyx*	54.2	17.6
		Ceriantheopsis americanus	7.0	1.6	*Glycera dibranchiata*	29.0	17.7
		Spisula solidissima	6.8	2.4	*Ensis directus*	22.4	8.1
		Cerastoderma pinnulatum	3.8	1.2	*Cancer irroratus*	21.2	10.3
Nov 1983	5 grabs	*Nephtys picta*	83.4	29.9	*Diopatra cuprea*	832.2	482.1
		Spiophanes bombyx	65.0	19.3	*Ceriantheopsis americanus*	603.4	294.3
		Capitella spp.	33.2	23.3	*Nassarius trivittatus*	495.0	303.6
		Echinarachnius parma	22.8	10.2	*Nephtys picta*	112.2	62.0
		Ampelisca vadorum	18.4	13.1	*Spiophanes bombyx*	102.6	36.9
		Parougia caeca	14.4	4.7	*Asabellides oculata*	47.4	20.1
		Nephtyidae spp.	11.6	11.6	*Capitella* spp.	19.8	12.7
		Asabellides oculata	11.2	4.1	Rhynchocoela spp.	16.0	15.0
		Nereis succinea	10.6	3.9	*Nereis succinea*	13.2	8.8
		Tharyx spp.	8.4	2.2	*Tellina agilis*	12.6	3.4
Aug 1984	5 grabs	*Spiophanes bombyx*	110.8	45.5	*Nassarius trivittatus*	604.4	453.6
		Tellina agilis	34.8	10.4	*Tellina agilis*	391.2	145.2
		Nephtys picta	24.4	7.6	*Spiophanes bombyx*	242.2	135.7
		Capitella spp.	21.6	20.1	*Capitella* spp.	181.6	179.9
		Tharyx acutus	8.4	4.6	*Nephtys picta*	119.2	52.3
		Exogone hebes	3.4	1.7	*Ceriantheopsis americanus*	79.8	48.0
		Ceriantheopsis americanus	1.8	0.6	*Cancer irroratus*	54.8	24.7
		Nassarius trivittatus	1.6	0.9	*Ensis directus*	19.8	10.5
		Ensis directus	1.6	0.7	*Pherusa affinis*	15.4	9.4
		Cancer irroratus	1.6	0.5	*Diopatra cuprea*	9.2	9.2

Table 6 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Jul 1985	5 grabs	*Spiophanes bombyx*	111.4	46.1	*Spiophanes bombyx*	1130.0	591 6
		Tellina agilis	51.0	10.2	*Diopatra cuprea*	545.4	458.3
		Nephtyidae spp.	29.4	7.5	*Nassarius trivittatus*	333.0	172.8
		Unciola irrorata	23.2	9.6	*Nephtys picta*	290.6	65.8
		Nephtys picta	21.4	5.2	*Ceriantheopsis americanus*	249.6	115.7
		Tharyx spp.	14.8	5.5	*Tellina agilis*	174.2	60.5
		Edotea triloba	12.8	2.3	*Lumbrineris acicularum*	130.4	49.6
		Cancer irroratus	9.6	3.4	*Cancer irroratus*	85.2	31.2
		Capitella spp.	8.2	2.2	*Edotea triloba*	63.0	14.4
		Tharyx acutus	7.8	5.2	*Unciola irrorata*	49.8	24.8
Oct 1985	2 grabs	*Asabellides oculata*	71.0	18.0	*Nassarius trivittatus*	2262.5	1537.5
		Tharyx spp.	10.0	7.0	*Diopatra cuprea*	378.0	235.0
		Nephtys picta	9.0	7.0	*Pherusa affinis*	295.0	294.0
		Nassarius trivittatus	7.0	5.0	*Ceriantheopsis americanus*	127.0	127.0
		Pherusa affinis	6.5	1.5	*Cancer irroratus*	103.0	103.0
		Spiophanes bombyx	6.0	0.0	*Lumbrineris acicularum*	52.5	52.5
		Nereis succinea	5.0	5.0	*Nephtys picta*	48.0	35.0
		Mysella planulata	5.0	5.0	Rhynchocoela spp.	40.0	25.0
		Exogone hebes	3.0	3.0	*Asabellides oculata*	14.0	7.0
		Diopatra cuprea	3.0	0.0	*Nereis succinea*	8.5	8.5

Table 7

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 4 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Dec 1979	5 grabs	*Amastigos caperatus*	772.2	380.8	*Tharyx acutus*	215.2	132.7
		Tharyx acutus	452.6	284.7	*Amastigos caperatus*	203.6	133.1
		Spisula solidissima	67.4	10.9	*Nephtys picta*	169.4	51.3
		Nephtyidae spp.	43.6	6.9	*Echinarachnius parma*	145.4	143.7
		Tellina agilis	41.2	12.8	*Tellina agilis*	79.6	35.5
		Phoronis architecta	33.6	21.7	*Glycera dibranchiata*	43.2	15.6
		Spiophanes bombyx	28.6	6.1	*Spisula solidissima*	38.4	8.6
		Nephtys picta	26.8	8.1	*Lumbrineris acicularum*	32.0	13.8
		Glycera spp. (juv.)	13.0	2.2	Rhynchocoela spp.	26.6	7.0
		Echinarachnius parma	12.2	5.9	*Magelona riojai*	26.0	21.1
Jul 1980	4 grabs	*Tharyx acutus*	776.0	291.5	*Cancer borealis*	22750.0	22750.0
		Nucula proxima	295.0	272.7	*Nucula proxima*	1635.8	1548.0
		Tellina agilis	284.3	94.6	*Tellina agilis*	1118.5	408.9
		Polydora ligni	242.3	161.1	*Nephtys incisa*	664.5	445.7
		Amastigos caperatus	159.3	101.1	*Phoronis architecta*	428.8	427.1
		Phyllodoce (anatides) mucosa	144.5	86.0	*Cancer irroratus*	412.3	266.0
		Phoronis architecta	71.8	69.4	*Tharyx acutus*	336.3	165.1
		Mediomastus ambiseta	46.3	46.3	*Lumbrineris acicularum*	238.8	88.6
		Spiophanes bombyx	27.5	14.5	Rhynchocoela spp.	223.5	128.9
		Rhynchocoela spp.	27.3	11.8	*Glycera dibranchiata*	178.8	118.0
Dec 1980	5 grabs	Nephtyidae spp.	34.4	12.0	*Ensis directus*	506.4	503.4
		Tellina agilis	26.4	5.6	*Lunatia heros*	258.0	258.0
		Spiophanes bombyx	24.2	9.8	*Tellina agilis*	108.2	30.6
		Tanaissus liljeborgi	20.8	12.4	*Nephtys bucera*	100.4	27.5
		Nephtys bucera	14.6	4.0	*Sthenelais limicola*	64.4	57.4
		Rhepoxynius hudsoni	10.2	4.9	Rhynchocoela spp.	32.8	22.7
		Ensis directus	7.4	1.2	*Crangon septemspinosa*	25.8	24.1
		Pseudunciola obliquua	7.4	5.3	*Nephtys picta*	25.4	12.2
		Magelona riojai	7.2	3.7	*Spisula solidissima*	24.8	24.8
		Rhynchocoela spp.	2.6	1.0	*Lumbrineris acicularum*	15.0	12.1
Aug 1981	5 grabs	*Nephtys picta*	79.0	22.0	*Spisula solidissima*	986.6	849.9
		Pseudunciola obliquua	60.8	33.0	*Cancer irroratus*	595.8	389.9
		Spiophanes bombyx	48.0	14.0	*Ovalipes ocellatus*	568.2	212.9
		Tharyx acutus	41.8	40.6	*Nephtys picta*	205.2	68.7
		Tellina agilis	30.6	7.4	*Tellina agilis*	180.2	38.3
		Tanaissus liljeborgi	29.6	15.8	*Ensis directus*	164.0	101.2
		Spisula solidissima	23.6	14.1	*Lumbrineris acicularum*	127.8	75.1
		Phoxocephalus holbolli	16.8	15.6	*Glycera robusta*	100.8	89.4
		Parougia caeca	15.6	14.9	*Spiophanes bombyx*	89.8	24.2
		Prionospio steenstrupi	10.4	10.4	*Spio filicornis*	51.4	51.4
Jan 1982	5 grabs	*Amastigos caperatus*	781.2	345.1	*Ensis directus*	1194.8	614.3
		Tellina agilis	600.4	220.3	*Lumbrineris acicularum*	521.4	350.0
		Nephtyidae spp.	141.6	21.7	*Tellina agilis*	415.4	165.3
		Mediomastus ambiseta	118.6	84.6	*Pitar morrhuanus*	153.8	32.2
		Tharyx acutus	110.8	73.9	*Phoronis architecta*	143.6	88.8
		Pitar morrhuanus	59.8	29.3	*Mediomastus ambiseta*	114.0	108.5
		Spiophanes bombyx	40.4	7.3	Nephtyidae spp.	103.4	22.1
		Nucula proxima	31.0	14.5	*Glycera dibranchiata*	94.8	30.7
		Phoronis architecta	25.4	16.7	*Pandora gouldiana*	87.0	87.0
		Sthenelais limicola	10.8	3.8	*Sthenelais limicola*	75.2	21.8

Table 7 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Aug 1982	5 grabs	*Mytilus edulis*	551.6	536.9	*Mytilus edulis*	1859.6	1560.4
		Amastigos caperatus	97.4	60.8	*Cancer irroratus*	809.4	765.9
		Tellina agilis	57.0	11.8	*Tellina agilis*	345.4	104.8
		Nephtys picta	38.6	9.8	*Ophioglycera gigantea*	324.0	324.0
		Tharyx acutus	27.2	22.3	*Pitar morrhuanus*	276.4	275.7
		Polydora socialis	18.6	17.6	*Nephtys picta*	242.0	19.2
		Harmothoe extenuata	15.2	15.0	*Asterias vulgaris*	236.8	236.8
		Parougia caeca	10.8	4.6	*Lumbrineris acicularum*	141.0	118.9
		Spisula solidissima	10.6	3.6	*Glycera robusta*	81.4	79.2
		Scalibregma inflatum	5.2	5.0	*Glycera dibranchiata*	78.4	29.9
Jul 1983	5 grabs	*Tellina agilis*	53.0	16.3	*Lumbrineris acicularum*	244.4	72.8
		Nephtyidae spp.	27.2	5.5	*Tellina agilis*	149.0	60.6
		Goniadella gracilis	23.8	15.2	*Nephtys picta*	59.4	27.3
		Chiridotea tuftsi	8.0	4.6	Rhynchocoela spp.	48.2	15.9
		Nephtys picta	6.8	3.4	*Glycera dibranchiata*	38.8	21.6
		Caulleriella cf killariensis	6.4	4.2	*Nephtys bucera*	35.8	11.7
		Spisula solidissima	6.2	1.2	*Yoldia* spp.	34.4	34.4
		Spiophanes bombyx	5.2	1.9	*Cancer irroratus*	31.4	15.2
		Pseudoleptocuma minor	4.4	1.6	*Glycera robusta*	22.6	22.6
		Hemipodus roseus	4.2	4.2	*Spisula solidissima*	19.4	6.3
Aug 1984	5 grabs	*Spiophanes bombyx*	26.0	7.9	*Nephtys bucera*	187.4	78.4
		Nephtys picta	11.4	4.0	*Lumbrineris acicularum*	106.6	79.3
		Goniadella gracilis	9.0	8.8	*Spiophanes bombyx*	77.2	34.1
		Pseudunciola obliquua	8.2	8.0	*Nephtys picta*	73.0	42.7
		Tellina agilis	7.4	1.3	*Tellina agilis*	66.6	26.7
		Spisula solidissima	7.0	5.3	*Nassarius trivittatus*	55.8	39.2
		Glycera spp. (juv.)	6.2	1.1	*Ensis directus*	39.8	24.5
		Tanaissus liljeborgi	6.2	6.0	*Cancer irroratus*	26.0	26.0
		Caulleriella cf. killariensis	6.0	2.6	*Glycera* spp. (juv.)	21.6	11.2
		Tharyx acutus	3.0	1.5	*Glycera dibranchiata*	21.0	10.7
Jun 1985	5 grabs	*Pseudunciola obliquua*	85.2	58.3	*Tellina agilis*	197.4	84.3
		Tellina agilis	42.4	14.5	*Lumbrineris acicularum*	156.2	79.6
		Nephtyidae spp.	17.0	5.2	*Glycera dibranchiata*	87.0	70.4
		Tanaissus liljeborgi	14.0	3.5	*Spisula solidissima*	46.8	15.4
		Caulleriella cf killariensis	9.8	2.7	Rhynchocoela spp.	30.4	12.0
		Spisula solidissima	7.8	3.4	*Nassarius trivittatus*	29.0	29.0
		Rhepoxynius hudsoni	6.6	2.8	*Pseudunciola obliquua*	27.6	14.5
		Spiophanes bombyx	6.2	2.0	*Nephtys picta*	26.0	7.7
		Ensis directus	5.4	1.7	Nephtyidae spp.	21.4	4.8
		Magelona riojai	5.2	3.3	*Spiophanes bombyx*	15.4	6.1
Oct 1985	2 grabs	*Nephtys picta*	24.5	11.5	*Nephtys picta*	212.0	39.0
		Tellina agilis	24.5	3.5	*Tellina agilis*	122.0	70.0
		Spisula solidissima	17.5	0.5	*Spisula solidissima*	96.5	71.5
		Caulleriella cf. killariensis	16.5	11.5	*Arctica islandica*	95.0	95.0
		Tharyx acutus	14.5	14.5	*Lumbrineris acicularum*	77.5	15.5
		Magelona rosea	7.0	7.0	*Glycera dibranchiata*	67.0	52.0
		Chiridotea tuftsi	4.5	2.5	*Ensis directus*	55.0	55.0
		Rhynchocoela spp.	4.0	0.0	*Nassarius trivittatus*	46.0	46.0
		Lumbrineris acicularum	4.0	3.0	Rhynchocoela spp.	15.0	7.0
		Goniada maculata	3.0	2.0	*Caulleriella cf. killariensis*	6.0	4.0

Table 8

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 26 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Dec 1979	5 grabs	*Echinarachnius parma*	56.6	19.2	*Echinarachnius parma*	16846.0	5403.9
		Spisula solidissima	10.2	4.7	*Ceriantheopsis americanus*	331.8	212.5
		Nephtys picta	9.2	4.0	*Lumbrineris acicularum*	83.8	24.9
		Lumbrineris acicularum	7.4	1.2	*Nephtys bucera*	58.2	43.3
		Nephtyidae spp.	6.4	2.4	*Spisula solidissima*	40.6	23.4
		Tellina agilis	4.6	2.2	*Nephtys picta*	25.2	15.4
		Caulleriella cf. killariensis	4.2	1.1	*Crangon septemspinosa*	24.0	12.8
		Ceriantheopsis americanus	3.6	2.0	Rhynchocoela spp.	19.0	16.8
		Photis macrocoxa	3.6	1.0	*Tellina agilis*	14.2	6.8
		Parougia caeca	3.2	1.4	*Astarte castanea*	13.8	11.9
Jul 1980	5 grabs	*Echinarachnius parma*	27.8	9.7	*Echinarachnius parma*	19332.1	7682.7
		Nephtys picta	12.7	2.5	*Ceriantheopsis americanus*	1311.9	0.4
		Ceriantheopsis americanus	12.2	0.6	*Spisula solidissima*	432.3	427.0
		Lumbrineris acicularum	8.2	0.6	*Astarte castanea*	271.3	207.0
		Cancer irroratus	7.3	2.2	*Lumbrineris acicularum*	241.4	36.4
		Tharyx dorsobranchialis	2.8	0.9	*Nassarius trivittatus*	92.4	92.4
		Rhynchocoela spp.	2.3	1.0	*Euclymene zonalis*	65.7	63.6
		Tellina agilis	2.3	1.5	*Cancer irroratus*	51.7	16.8
		Euclymene zonalis	2.0	0.8	Rhynchocoela spp.	49.5	29.3
		Glycera dibranchiata	1.6	0.6	*Clymenella torquata*	48.0	48.0
Dec 1980	5 grabs	*Echinarachnius parma*	36.3	11.5	*Echinarachnius parma*	34208.9	14360.2
		Goniadella gracilis	16.4	9.2	*Ceriantheopsis americanus*	1845.1	626.4
		Spisula solidissima	12.4	8.7	*Cancer irroratus*	1229.1	1229.0
		Ceriantheopsis americanus	7.6	2.0	*Astarte undata*	486.9	486.8
		Glycera spp. (juv.)	7.1	3.3	*Astarte castanea*	449.0	392.1
		Lumbrineris acicularum	6.4	1.8	*Lumbrineris acicularum*	385.8	129.2
		Aglaophamus igalis	6.1	1.7	Rhynchocoela spp.	81.4	73.7
		Pelecypoda spp. (unidentifiable)	6.1	5.1	*Nephtys picta*	66.1	22.6
		Tharyx acutus	4.9	3.1	*Nephtys bucera*	64.4	64.4
		Rhynchocoela spp.	4.5	2.9	*Sigalion arenicola*	26.3	20.4
Aug 1981	5 grabs	*Goniadella gracilis*	24.3	15.4	*Echinarachnius parma*	17019.8	13878.8
		Hemipodus roseus	13.1	6.5	*Ceriantheopsis americanus*	821.3	373.9
		Echinarachnius parma	10.3	7.2	*Nassarius trivittatus*	384.3	186.7
		Lumbrineris acicularum	10.0	4.5	*Lumbrineris acicularum*	254.0	27.9
		Tharyx dorsobranchialis	9.3	3.1	*Nephtys bucera*	162.4	96.9
		Harmothoe extenuata	8.3	2.4	*Lunatia triseriata*	93.1	93.0
		Spiophanes bombyx	7.9	3.8	*Astarte castanea*	75.4	69.4
		Ceriantheopsis americanus	3.3	1.3	*Nephtys picta*	59.7	18.1
		Nephtys picta	3.3	1.0	*Aglaophamus circinata*	53.8	26.8
		Nephtyidae spp	3.0	1.0	*Cancer irroratus*	33.7	14.9
Jan 1982	5 grabs	*Tharyx acutus*	27.8	10.5	*Echinarachnius parma*	55693.4	10755.1
		Hemipodus roseus	27.4	14.3	*Spisula solidissima*	29603.4	29600.4
		Echinarachnius parma	24.6	4.1	*Ceriantheopsis americanus*	1613.2	387.8
		Rhynchocoela spp.	15.0	5.8	*Astarte castanea*	442.0	326.0
		Goniadella gracilis	13.2	5.6	*Nassarius trivittatus*	221.0	221.0
		Nephtyidae spp.	9.4	2.5	Rhynchocoela spp.	138.0	103.1
		Spisula solidissima	8.4	2.8	*Lumbrineris acicularum*	74.0	45.6
		Ceriantheopsis americanus	5.6	1.5	*Nephtys bucera*	59.2	21.8
		Parougia caeca	3.0	0.8	*Nephtys picta*	48.8	35.2
		Nephtys bucera	2.6	0.7	*Sigalion arenicola*	29.6	21.8

Table 8 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Aug 1982	5 grabs	*Echinarachnius parma*	71.9	13.0	*Echinarachnius parma*	12900.1	30175.3
		Tharyx acutus	20.6	2.0	*Spisula solidissima*	9128.8	9117.8
		Nephtyidae spp.	10.1	4.4	*Ceriantheopsis americanus*	1079.4	502.6
		Hemipodus roseus	9.7	9.1	*Nassarius trivittatus*	383.3	157.9
		Nephtys picta	9.3	2.1	*Cerastoderma pinnulatum*	173.6	173.6
		Tharyx dorsobranchialis	8.4	2.8	*Nephtys picta*	86.4	20.1
		Rhynchocoela spp.	8.3	4.4	*Lumbrineris acicularum*	57.0	25.7
		Goniadella gracilis	8.3	5.1	Rhynchocoela spp.	48.3	31.2
		Harmothoe extenuata	5.5	2.7	*Cancer irroratus*	21.6	9.0
		Ceriantheopsis americanus	5.3	1.7	Nephtyidae spp.	19.0	8.3
Jul 1983	5 grabs	*Tharyx acutus*	63.8	33.2	*Echinarachnius parma*	40284.2	15300.4
		Goniadella gracilis	56.8	26.0	*Ceriantheopsis americanus*	1628.0	315.5
		Nephtyidae spp.	28.8	6.6	*Astarte castanea*	453.0	232.1
		Echinarachnius parma	18.6	8.0	*Lumbrineris acicularum*	383.6	61.6
		Tharyx dorsobranchialis	15.4	5.9	Rhynchocoela spp.	74.0	57.8
		Ceriantheopsis americanus	9.6	2.9	*Tharyx marioni*	41.6	41.6
		Astarte castanea	9.6	4.1	*Sigalion arenicola*	30.0	27.1
		Leitoscoloplos acutus	8.4	6.2	*Nephtys bucera*	24.2	21.8
		Lumbrineris acicularum	6.8	1.6	*Tharyx acutus*	19.8	13.3
		Hemipodus roseus	3.4	3.2	*Nephtys picta*	11.2	2.5
Aug 1984	2 grabs	*Ceriantheopsis americanus*	34.0	24.0	*Echinarachnius parma*	33717.5	20079.5
		Tharyx acutus	33.5	18.5	*Ceriantheopsis americanus*	1112.0	675.0
		Goniadella gracilis	15.5	9.5	*Nassarius trivittatus*	323.0	323.0
		Echinarachnius parma	14.5	8.5	*Spisula solidissima*	312.0	312.0
		Caulleriella cf. killariensis	7.0	6.0	*Cirriformia grandis*	219.0	219.0
		Spiophanes bombyx	3.5	2.5	*Nephtys bucera*	123.5	123.5
		Tharyx dorsobranchialis	3.5	1.5	*Lumbrineris acicularum*	123.5	123.5
		Nephtyidae spp.	1.5	0.5	*Tharyx acutus*	27.5	19.5
		Glycera spp. (juv.)	1.5	0.5	*Astarte castanea*	24.0	24.0
		Ensis directus	1.5	0.5	*Cancer irroratus*	22.0	22.0
Jun 1985	5 grabs	*Echinarachnius parma*	42.6	5.5	*Echinarachnius parma*	10487.1	13261.5
		Caulleriella cf. killariensis	12.2	4.7	*Ensis directus*	595.6	589.4
		Tharyx acutus	11.6	4.3	*Ceriantheopsis americanus*	503.0	201.8
		Nephtys picta	7.4	3.2	*Lumbrineris acicularum*	476.4	53.1
		Cancer irroratus	6.2	0.9	*Nephtys bucera*	174.6	130.3
		Nephtyidae spp.	5.6	3.5	*Nephtys picta*	85.2	35.6
		Lumbrineris acicularum	5.0	0.8	*Cancer irroratus*	45.8	11.6
		Ceriantheopsis americanus	4.8	0.8	*Astarte castanea*	36.6	21.6
		Ensis directus	3.8	1.1	Rhynchocoela spp.	27.0	12.1
		Tharyx dorsobranchialis	3.0	1.0	*Periploma leanum*	21.0	21.0
Oct 1985	2 grabs	*Tellina agilis*	43.0	30.0	*Echinarachnius parma*	36130.0	31990.0
		Echinarachnius parma	30.0	2.0	*Lumbrineris acicularum*	122.5	121.5
		Caulleriella cf. killariensis	24.0	18.0	*Ceriantheopsis americanus*	75.5	10.5
		Tharyx spp.	16.0	8.0	*Cancer irroratus*	36.0	36.0
		Tharyx dorsobranchialis	10.5	9.5	*Astarte castanea*	12.5	12.5
		Magelona rosea	4.5	4.5	*Tellina agilis*	8.0	6.0
		Spiophanes bombyx	4.0	4.0	*Nephtys bucera*	7.0	2.0
		Nephtyidae spp.	3.0	3.0	*Caulleriella cf. killariensis*	4.5	3.5
		Nephtys bucera	2.0	0.0	*Nephtys picta*	4.0	4.0
		Syllides sp. 1	1.5	1.5	*Tharyx* spp.	3.0	2.0

Table 9

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 31 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Dec 1979	4 grabs	*Echinarachnius parma*	552.8	106.3	*Echinarachnius parma*	34150.0	8350.4
		Pseudunciola obliquua	197.5	46.5	*Lumbrineris acicularum*	454.5	441.9
		Tanaissus liljeborgi	96.8	40.1	*Acanthohaustorius spinosus*	128.8	60.9
		Byblis serrata	79.0	58.2	*Byblis serrata*	112.8	78.5
		Tellina agilis	40.5	21.8	*Pseudunciola obliquua*	72.8	16.2
		Rhepoxynius hudsoni	38.8	17.9	*Rhepoxynius hudsoni*	61.0	32.8
		Tharyx acutus	29.0	2.7	*Aglaophamus circinata*	37.5	35.8
		Exogone hebes	22.8	6.3	*Pandora gouldiana*	31.5	31.5
		Aricidea (acesta) catherinae	22.3	5.5	*Euclymene zonalis*	27.8	5.8
		Corophium crassicorne	21.0	13.1	*Nephtys incisa*	21.5	21.5
Jul 1980	5 grabs	*Pseudunciola obliquua*	135.3	45.4	*Echinarachnius parma*	2546.6	1025.9
		Tanaissus liljeborgi	88.9	17.3	*Ensis directus*	284.9	283.8
		Exogone hebes	69.3	13.3	*Byblis serrata*	248.1	72.1
		Byblis serrata	40.5	10.7	*Nassarius trivittatus*	111.1	111.0
		Aoridae spp. (juv.)	29.3	29.2	*Sigalion arenicola*	76.4	32.7
		Unciola irrorata	23.0	4.8	*Unciola irrorata*	39.0	10.5
		Aricidea (acesta) catherinae	20.6	4.6	*Cancer irroratus*	33.8	8.4
		Goniadella gracilis	18.4	9.0	*Rhepoxynius hudsoni*	21.3	12.9
		Caulleriella cf. killariensis	17.6	7.2	*Driloneréis magna*	18.9	13.8
		Rhepoxynius hudsoni	16.6	5.8	*Pseudunciola obliquua*	18.9	2.8
Dec 1980	5 grabs	*Byblis serrata*	111.3	25.7	*Echinarachnius parma*	12436.0	6483.8
		Exogone hebes	37.0	10.3	*Astarte undata*	2580.1	2580.0
		Tanaissus liljeborgi	36.0	11.0	*Nassarius trivittatus*	231.6	231.6
		Pseudunciola obliquua	32.6	12.9	*Byblis serrata*	191.6	63.5
		Rhepoxynius hudsoni	29.0	2.7	Rhynchocoela spp.	145.9	140.6
		Nephtyidae spp.	18.8	5.4	*Ensis directus*	130.4	129.4
		Spiophanes bombyx	17.3	2.8	*Cirolana polita*	63.8	35.7
		Unciola irrorata	13.4	3.5	*Cancer irroratus*	60.0	36.8
		Aricidea (acesta) catherinae	13.3	4.2	*Lumbrineris acicularum*	46.8	24.5
		Corophium crassicorne	10.9	3.0	*Euclymene zonalis*	46.7	16.1
Aug 1981	5 grabs	*Pseudunciola obliquua*	534.3	218.8	*Echinarachnius parma*	2973.6	1877.5
		Tanaissus liljeborgi	82.9	20.7	Ascidiacean spp.	819.5	452.4
		Corophium crassicorne	68.1	13.6	*Ceriantheopsis americanus*	645.8	211.1
		Exogone hebes	53.3	19.1	*Sigalion arenicola*	156.1	92.2
		Echinarachnius parma	45.3	9.4	*Corophium crassicorne*	153.6	111.8
		Rhepoxynius hudsoni	31.0	10.0	*Pherusa affinis*	145.6	145.6
		Aricidea (acesta) catherinae	27.3	8.5	*Unicola irrorata*	145.1	89.8
		Euclymene zonalis	20.3	10.2	*Spiophanes bombyx*	84.4	20.6
		Cauleriella cf. killariensis	15.4	3.0	*Psuedunciola obliquua*	77.7	36.3
		Unciola irrorata	14.7	3.1	Rhynchocoela spp.	69.7	31.8
Jan 1982	5 grabs	*Tanaissus liljeborgi*	310.0	67.9	*Echinarachnius parma*	20801.6	7236.3
		Echinarachnius parma	185.8	32.1	*Astarte castenea*	2385.0	2383.8
		Pseudunciola obliquua	161.8	52.8	*Ceriantheopsis americanus*	1043.4	597.3
		Exogene hebes	78.2	15.6	*Cancer irroratus*	129.4	79.5
		Aricidea (acesta) catherinae	36.4	7.4	Rhynchocoela spp.	120.6	66.5
		Caulleriella cf. killariensis	19.8	4.2	*Pseudunciola obliquua*	76.2	26.2
		Tharyx acutus	14.8	8.9	*Cirolana polita*	47.0	47.0
		Spiophanes bombyx	11.2	2.7	*Sthenelais limicola*	36.8	14.7
		Tellina agilis	10.8	4.3	Nereidae spp.	36.4	36.4
		Polydora caulleryi	9.8	3.1	*Tharyx acutus*	24.8	13.7

Table 9 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Sep 1982	5 grabs	*Pseudunciola obliquua*	390.8	256.4	*Echinarachnius parma*	14277.3	5865.1
		Tanaissus liljeborgi	70.5	32.8	*Phoronius architecta*	742.7	740.4
		Echinarachnius parma	65.1	25.6	*Ceriantheopsis americanus*	616.5	17.2
		Phoronis architecta	62.0	60.3	*Nassarius trivittatus*	383.3	237.8
		Euclymene zonalis	38.3	18.3	*Lunatia triseriata*	225.6	195.2
		Exogene hebes	29.4	9.4	*Rhepoxynius hudsoni*	93.7	15.7
		Clymenella torquata	28.6	18.2	*Pseudunciola obliquua*	91.4	57.2
		Rhepoxynius hudsoni	26.3	5.1	*Cancer irroratus*	90.1	47.7
		Corophium crassicorne	25.6	3.9	*Clymenella torquata*	66.1	41.6
		Caulleriella cf. killariensis	23.8	12.5	*Pherusa affinis*	50.5	40.9
Jul 1983	5 grabs	*Pseudunciola obliquua*	455.4	63.1	*Echinarachnius parma*	36167.2	21809.7
		Tanaissus liljeborgi	234.8	40.8	*Lumbrineris acicularum*	178.4	119.5
		Exogene hebes	87.2	42.3	Ascidiacean spp.	160.8	160.8
		Caulleriella cf. killariensis	27.4	2.5	*Nassarius trivittatus*	83.0	83.0
		Polydora caulleryi	23.6	17.8	*Sigalion arenicola*	81.4	18.8
		Goniadella gracilis	19.6	6.6	*Pseudunciola obliquua*	64.2	4.2
		Aricidea (acesta) catherinae	19.4	4.0	Rhynchocoela spp.	51.0	36.7
		Echinarachnius parma	14.4	6.3	*Cancer irroratus*	39.8	14.4
		Rhynchocoela spp.	9.2	3.3	*Orbinia swani*	31.4	31.4
		Rhepoxynius hudsoni	8.6	0.8	*Aglaophamus circinata*	23.0	17.6
Aug 1984	5 grabs	*Spiophanes bombyx*	145.8	64.5	*Echinarachnius parma*	11087.6	7056.0
		Pseudunciola obliquua	133.4	28.1	Ascidiacean spp.	1321.6	849.4
		Exogone hebes	52.0	15.8	*Ceriantheopsis americanus*	670.4	292.3
		Caulleriella cf. killariensis	34.8	10.3	*Lumbrineris acicularum*	523.4	225.9
		Tharyx acutus	24.4	6.1	*Pherusa affinis*	185.2	129.4
		Tanaissus liljeborgi	22.4	9.3	*Spiophanes bombyx*	157.6	87.3
		Ceriantheopsis americanus	21.0	8.7	*Pseudunciola obliquua*	138.4	87.4
		Ascidiacean spp.	15.4	8.2	*Sigalion arenicola*	107.6	39.6
		Arcidea (acesta) catherinae	14.8	3.0	*Tellina agilis*	100.0	17.2
		Phoxocephalus holbolli	13.8	7.6	*Glycera dibranchiata*	94.2	76.3
Jun 1985	5 grabs	Nephtyidae spp.	26.4	3.1	*Echinarachnius parma*	13566.8	4145.4
		Tellina agilis	25.8	5.8	*Pitar morrhuanus*	2733.2	2727.7
		Tharyx acutus	24.8	8.5	*Nassarius trivittatus*	473.6	193.4
		Phoxocephalus holbolli	18.2	8.2	*Ceriantheopsis americanus*	306.2	104.5
		Spiophanes bombyx	15.4	6.6	*Tellina agilis*	205.8	65.9
		Harmothoe extenuata	10.8	4.1	*Sthenelais limicola*	88.8	38.0
		Tharyx dorsobranchialis	10.4	6.7	Rhynchocoela spp.	83.4	22.3
		Caulleriella cf. killariensis	10.0	5.7	*Spiophanes bombyx*	48.6	31.4
		Exogone hebes	9.4	5.1	*Lyonsia hyalina*	42.2	17.2
		Ensis directus	8.0	1.7	*Nucula proxima*	41.2	16.2
Oct 1985	2 grabs	*Glycera* spp.	16.5	4.5	*Echinarachnius parma*	16950.5	16949.5
		Tellina agilis	13.5	5.5	*Nassarius trivittatus*	212.0	212.0
		Echinarachnius parma	6.5	2.5	*Tellina agilis*	38.0	35.0
		Nucula proxima	5.5	5.5	*Cancer irroratus*	37.0	37.0
		Asabellides oculata	5.0	2.0	*Sigalion arenicola*	21.5	21.5
		Pseudunciola obliquua	5.0	1.0	*Solen viridis*	20.5	20.5
		Aricidea (acesta) catherinae	4.0	1.0	*Nucula proxima*	18.0	18.0
		Tanaissus liljeborgi	3.5	2.5	*Pherusa affinis*	12.0	11.0
		Exogone hebes	3.0	2.0	Rhynchocoela spp.	11.5	3.5
		Polycirrus eximius	3.0	0.0	*Sthenelais limicola*	11.0	11.0

Table 10

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 15 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Dec 1979	5 grabs	*Ampelisca agassizi*	1297.4	303.1	*Pitar morrhuanus*	3168.2	3158.0
		Tharyx acutus	881.6	271.5	*Ampelisca agassizi*	1914.4	633.9
		Euchone incolor	571.6	274.0	*Nephtys incisa*	1085.6	275.2
		Cossura longocirrata	360.8	71.6	*Asterias* spp. a	384.0	384.0
		Levinsenia gracilis	248.4	38.2	*Chone infundibuliformis*	355.2	135.0
		Euclymene zonalis	172.2	40.8	*Nicolea venustula*	341.6	121.4
		Aricidea (acesta) catherinae	156.6	58.8	*Periploma papyratium*	315.0	175.3
		Mediomastus ambiseta	151.2	58.0	*Tharyx acutus*	292.4	67.3
		Prionospio steenstrupi	145.2	26.9	Rhynchocoela spp.	276.6	96.1
		Nucula delphinodonta	113.4	51.0	*Nucula delphinodonta*	273.8	192.4
Jul 1980	5 grabs	*Ampelisca agassizi*	1475.5	235.0	*Ampelisca agassizi*	2811.3	404.8
		Euchone elegans	740.6	717.1	*Nephtys incisa*	1166.8	448.8
		Tharyx dorsobranchialis	583.3	347.2	*Thyasira trisinuata*	482.3	258.8
		Photis macrocoxa	231.4	130.0	*Solemya borealis*	472.0	472.0
		Mediomastus ambiseta	170.4	80.0	*Chone infundibuliformis*	392.9	273.5
		Nucula delphinodonta	161.9	49.9	*Pherusa affinis*	381.3	60.5
		Levinsenia gracilis	154.3	79.7	*Leptocheirus pinguis*	314.5	121.3
		Lumbrineris hebes	132.2	52.2	*Anonbothrus gracilis*	272.9	138.2
		Euchone incolor	119.7	61.3	*Tharyx dorsobranchialis*	242.4	145.8
		Diastylis abbreviata	100.5	49.5	*Mediomastus ambiseta*	238.3	114.9
Dec 1980	5 grabs	*Ampelisca* spp.	235.6	58.5	*Astarte undata*	2429.3	2172.0
		Ampelisca agassizi	145.4	28.1	*Astarte crenata subequilatera*	2244.1	2244.0
		Leptocheirus pinguis	129.4	54.5	*Nephtys incisa*	779.8	486.6
		Nucula delphinodonta	115.1	32.5	*Leptocheirus pinguis*	562.5	180.4
		Ninoe nigripes	49.6	13.6	*Chone infundibuliformis*	474.5	99.5
		Erichthonius rubricornis	41.0	17.3	*Cyclocardia borealis*	456.3	145.9
		Unciola irrorata	37.8	9.2	*Cancer irroratus*	436.9	285.2
		Scalibregma inflatum	37.3	6.7	*Scalibregma inflatum*	394.6	73.1
		Lumbrineris hebes	35.4	12.7	*Ninoe nigripes*	361.6	164.8
		Nucula proxima	32.0	5.2	*Periploma papyratium*	352.6	83.6
Aug 1981	5 grabs	*Euchone incolor*	1245.5	262.1	*Nephtys incisa*	1985.1	320.3
		Tharyx dorsobranchialis	437.6	123.4	*Thyasira trisinuata*	1795.8	331.9
		Nucula delphinodonta	380.3	128.0	*Pherusa affinis*	1130.8	456.3
		Ampelisca agassizi	283.0	161.0	*Yoldia sapotilla*	1101.4	345.7
		Cossura longocirrata	252.1	97.6	*Nucula delphinodonta*	809.5	311.5
		Lumbrineris hebes	212.0	60.3	*Pentamera calcigera*	706.7	432.0
		Photis macrocoxa	180.1	40.5	*Nucula proxima*	543.3	286.8
		Levinsenia gracilis	174.4	47.3	*Edotea triloba*	390.6	62.0
		Aricidea (Acesta) catherinae	160.3	52.7	*Periploma papyratium*	372.6	164.1
		Polydora socialis	147.4	44.5	*Ceriantheopsis americanus*	342.3	69.8
Jan 1982	5 grabs	*Ampelisca agassizi*	1247.8	189.2	*Pitar morrhuanus*	5654.4	3467.0
		Euchone incolor	861.8	152.1	*Ampelisca agassizi*	2264.4	332.8
		Lumbrineris hebes	169.0	17.7	*Nephtys incisa*	1660.0	589.4
		Tharyx dorsobranchialis	159.2	29.7	*Axius serratus*	1370.2	1370.2
		Ninoe nigripes	136.4	7.7	*Asterias vulgaris*	986.8	986.8
		Nucula delphinodonta	124.0	9.2	*Glycera robusta*	810.0	810.0
		Maldanidae spp. 4	70.2	28.4	*Ninoe nigripes*	351.4	66.6
		Levinsenia gracilis	60.8	9.0	*Pherusa affinis*	305.2	160.7
		Photis dentata	59.6	13.4	*Nicolea venustula*	291.0	131.0
		Erichthonius rubricornis	56.4	11.1	*Periploma papyratium*	177.6	42.1

Table 10 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Sep 1982	5 grabs	*Ampelisca agassizi*	490.8	160.6	*Nephtys incisa*	1421.1	664.6
		Euchone incolor	433.4	196.1	*Ampelisca agassizi*	710.5	253.4
		Tharyx dorsobranchialis	292.3	114.7	*Periploma papyratium*	404.0	114.4
		Nucula delphinodonta	219.1	110.6	*Ninoe nigripes*	372.5	101.2
		Polydora socialis	186.1	123.4	*Yoldia sapotilla*	353.5	226.0
		Lumbrineris hebes	173.0	40.2	*Nucula delphinodonta*	311.5	168.0
		Ninoe nigripes	136:7	16.5	*Rhodine gracilior*	218.4	117.6
		Cossura longocirrata	99.1	29.3	*Nucula proxima*	209.3	131.7
		Levinsenia gracilis	96.3	28.3	*Chone infundibuliformis*	162.4	76.6
		Aricidea (Acesta) catherinae	75.7	32.1	*Thyasira trisinuata*	142.1	126.5
Aug 1984	5 grabs	*Euchone incolor*	420.0	192.7	*Nephtys incisa*	3069.6	618.1
		Ampelisca agassizi	179.4	119.7	*Rhodine gracilior*	1388.8	442.3
		Tharyx dorsobranchialis	152.4	77.3	*Havelockia scabra*	1281.8	1281.8
		Prionospio steenstrupi	147.4	34.4	*Glycera robusta*	1045.0	1045.0
		Aricidea (Acesta) catherinae	123.2	99.2	*Ampelisca agassizi*	502.6	229.5
		Cossura longocirrata	109.2	36.4	*Pitar morrhuanus*	362.6	338.6
		Nucula delphinodonta	107.4	64.9	*Periploma papyratium*	273.4	109.1
		Lumbrineris hebes	99.4	35.7	*Thyasira trisinuata*	254.2	64.1
		Levinsenia gracilis	89.8	45.1	*Yoldia sapotilla*	232.0	170.3
		Ninoe nigripes	57.8	10.9	*Drilonereis longa*	198.6	35.0
Jun 1985	5 grabs	*Ampelisca agassizi*	392.4	73.1	*Arctica islandica*	13533.8	13237.8
		Eudorella pusilla	118.6	18.6	*Ninoe nigripes*	1332.8	230.7
		Aricidea (Acesta) catherinae	57.8	16.7	*Ampelisca agassizi*	635.8	124.3
		Ninoe nigripes	52.2	12.7	*Chone infundibuliformis*	460.2	321.7
		Harpinia propinqua	49.4	12.5	*Astarte undata*	272.2	163.5
		Nephtyidae spp.	45.6	6.1	*Nephtys incisa*	201.8	85.9
		Diastylis quadrispinosa	35.4	10.1	*Pitar morrhuanus*	198.8	105.0
		Unciola irrorata	34.1	12.1	*Periploma fragile*	163.4	71.7
		Crenella glandula	32.4	7.8	*Cyclocardia borealis*	151.0	58.9
		Lumbrineris hebes	29.8	3.4	*Diastylis quadrispinosa*	146.4	44.2
Oct. 1985	2 grabs	*Ampelisca agassizi*	358.5	30.5	*Nephtys incisa*	2743.0	1708.0
		Nucula proxima	90.0	84.0	*Ensis directus*	606.0	606.0
		Lumbrineris hebes	79.5	20.5	*Ampelisca agassizi*	579.0	170.0
		Prionospio steenstrupi	74.5	22.5	*Chone infundibuliformis*	271.5	263.5
		Levinsenia gracilis	62.0	22.0	*Periploma papyratium*	260.0	48.0
		Tharyx dorsobranchialis	59.0	30.0	*Pherusa affinis*	239.0	91.0
		Harpinia propinqua	57.0	20.0	*Nucula proxima*	179.5	171.5
		Aricidea (Acesta) catherinae	37.5	26.5	*Rhodine gracilior*	111.5	61.5
		Nucula delphinodonta	37.0	29.0	*Lumbrineris hebes*	108.5	19.5
		Nephtys incisa	36.0	22.0	*Thyasira trisinuata*	87.5	25.5

Table 11

Mean densities and biomasses per 0.1 m with standard errors and numbers of replicate samples analyzed, for the numerically dominant species at Station 1 on each sampling date.

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Jul 1980	1 grab	*Nucula proxima*	2283.1	0.0	*Arctica Islandica*	25301.1	0.0
		Phoronis architecta	842.0	0.0	*Phoronis architecta*	5825.0	0.0
		Tharyx acutus	507.0	0.0	*Nucula proxima*	5617.0	0.0
		Nephtys incisa	160.1	0.0	*Ceriantheopsis americanus*	3536.1	0.0
		Photis macrocoxa	80.1	0.0	*Nephtys incisa*	3475.1	0.0
		Cossura longocirrata	67.1	0.0	*Pherusa affinis*	2876.1	0.0
		Tellina agilis	50.0	0.0	*Tharyx acutus*	346.0	0.0
		Mediomastus ambiseta	48.0	0.0	*Ensis directus*	289.0	0.0
		Prionospio steenstrupi	41.0	0.0	*Tellina agilis*	263.0	0.0
		Ceriantheopsis americanus	37.0	0.0	*Crangon septemspinosa*	39.0	0.0
Aug 1981	1 grab	*Nucula proxima*	1348.1	0.0	*Nereis virens*	9242.0	0.0
		Tharyx acutus	1112.1	0.0	*Nucula proxima*	7640.0	0.0
		Phoronis architecta	446.0	0.0	*Nephtys incisa*	5240.0	0.0
		Cossura longocirrata	156.1	0.0	*Phoronis architecta*	4020.0	0.0
		Nephtys incisa	59.0	0.0	*Ceriantheopsis americanus*	3360.1	0.0
		Ceriantheopsis americanus	48.0	0.0	*Tharyx acutus*	680.0	0.0
		Prionospio steenstrupi	40.0	0.0	*Yoldia limatula*	634.0	0.0
		Mediomastus ambiseta	38.0	0.0	*Pherusa affinis*	383.0	0.0
		Pherusa affinis	30.0	0.0	*Cerastoderma pinnulatum*	31.0	0.0
		Lumbrineris hebes	15.0	0.0	*Phyllodoce (Anatides) mucosa*	26.0	0.0
Aug 1982	2 grabs	*Tharyx acutus*	4492.5	502.5	*Nucula proxima*	15587.0	2716.0
		Nucula proxima	4086.1	140.0	*Phoronis architecta*	7535.5	413.5
		Cossura longocirrata	895.5	19.5	*Nephtys incisa*	4084.1	927.0
		Phoronis architecta	737.0	112.0	*Ceriantheopsis americanus*	3328.1	224.0
		Mediomastus ambiseta	364.0	52.0	*Pherusa affinis*	1897.1	54.0
		Euchone incolor	174.6	82.5	*Tharyx acutus*	932.5	256.5
		Prionospio steenstrupi	124.1	10.0	*Edwardsia elegans*	184.1	89.0
		Nephtys incisa	73.1	4.0	*Yoldia sapotilla*	159.6	159.5
		Lumbrineris hebes	61.5	9.5	*Mediomastus ambiseta*	123.1	10.0
		Ninoe nigripes	51.0	0.0	*Lumbrioneris hebes*	112.0	14.0
Sep 1983	2 grabs	*Nucula proxima*	4331.0	205.0	*Nucula proxima*	19675.5	184.5
		Tharyx acutus	2615.5	747.5	*Arctica islandica*	12299.0	12299.0
		Prionospio steenstrupi	1222.5	386.5	*Phoronis architecta*	11467.5	1932.5
		Cossura longocirrata	905.0	124.0	*Pherusa affinis*	5442.5	1280.5
		Mediomastus ambiseta	460.5	1.5	*Nephtys incisa*	4520.5	205.5
		Phoronis architecta	459.5	76.5	*Ceriantheopsis americanus*	3230.5	170.5
		Tharyx dorsobranchialis	117.5	11.5	*Tharyx acutus*	2021.5	568.0
		Pherusa affinis	94.5	32.5	*Rhynchocoela*	769.5	719.5
		Ceriantheopsis americanus	88.0	5.0	*Prionospio steenstrupi*	368.5	145.5
		Lumbrineris hebes	62.5	9.5	*Yoldia limtulo*	275.0	275.0
Aug 1984	2 grabs	*Nucula proxima*	3650.5	1171.5	*Nucula proxima*	16482.5	5730.5
		Tharyx acutus	1330.5	43.5	*Pherusa affinis*	7866.0	2722.0
		Cossura longocirrata	321.5	146.5	*Phoronis architecta*	6584.5	1328.5
		Phoronis architecta	234.0	9.0	*Nereis virens*	5026.0	5026.0
		Prionospio steenstrupi	197.0	21.0	*Nephtys incisa*	4434.0	652.0
		Mediomastus ambiseta	78.0	17.0	*Ceriantheopsis americanus*	2877.0	652.0
		Ceriantheopsis americanus	69.0	28.0	*Glycera robusta*	990.0	990.0
		Pherusa affinis	59.5	5.5	*Tharyx acutus*	963.5	13.5
		Nephtys incisa	55.5	7.5	*Pitar morrhuanus*	798.5	784.5
		Lumbrineris hebes	44.0	5.0	*Goniada norvegica*	648.0	648.0

Table 11 (continued)

Date	No. of samples	Species	Density Mean	Density SE	Species	Biomass (mg) Mean	Biomass (mg) SE
Oct 1985	2 grabs	*Nucula proxima*	2592.5	50.5	*Pherusa affinis*	12313.5	8388.5
		Tharyx spp.	716.5	687.5	*Nucula proxima*	8122.0	351.0
		Phoronis architecta	191.5	88.5	*Nephtys incisa*	2148.0	82.0
		Tharyx acutus	191.0	127.0	*Ceriantheopsis americanus*	1429.0	35.0
		Cossura longocirrata	169.0	120.0	*Phoronis architecta*	1428.0	672.0
		Pherusa affinis	102.0	44.0	Rhynchoceola spp.	254.9	8.0
		Mediomastus ambiseta	47.0	23.0	*Tharyx* spp.	184.0	176.0
		Nephtys incisa	41.0	10.0	*Edwardsia elegans*	70.5	0.5
		Lumbrineris hebes	37.5	16.5	*Nassarius trivittatus*	58.5	58.5
		Ceriantheopsis americanus	31.0	6.0	*Tharyx acutus*	52.5	28.5

Dominant Species

Lists of the ten most abundant species in both numbers and biomass for each station and sampling have been prepared. These lists complement the above treatments of higher taxa, such as amphipods, and the broader analyses (species richness, clustering) by revealing which species are responsible for any spatial-temporal trends detected. Analysis of dominant species can indicate whether these trends are due to pollution-sensitive or tolerant species. The dominant species lists can be combined with information on fish diets (summarized in Reid and Steimle 1988) to estimate the forage value of a site's macrobenthos and whether that value has been altered.

Dominant species for the six NEMP stations (4, 6, 7, 15, 26, and 31) (Fig. 1) are emphasized because these stations have more samplings, including winter collections, and greater replication (usually five grabs). For Station 6, there is the added advantage of having monthly data available for summer 1986 and 1987 and counts for the polychaetes, *Capitella* spp., for summer 1988. The NEMP stations provide fairly good spatial coverage of the overall study area. They also include most of the habitat types and faunal assemblages encountered. Data on dominant species for the NEMP stations are given in Tables 5–10. Conspicuously absent from the NEMP sites is an assemblage consistently found in and near the Christiaensen Basin, with high densities and biomasses of polychaetes, bivalves, and an anthozoan (Pearce et al. 1981; Steimle 1985). The high abundances in this assemblage may be due to organic enrichment (Boesch 1982). Lists of dominant species from Station 1 (Table 11) illustrate trends in the "enriched" assemblage. Tables of dominant species for other non-NEMP stations are available on request. Some noteworthy features of Tables 5–11 are discussed below.

Station 6 (sewage sludge accumulation area-Table 5)—As noted above, this area apparently contained the most altered assemblage of any station. The fauna is characterized by *Capitella* spp.[1], which were the numerical dominants in eight of the 13 samplings at Station 6, with a peak mean density of 5604 individuals/0.1 m^2. *Capitella* spp. were rarely the most abundant taxa outside of Station 6, and maximum density never exceeded 678/0.1 m^2 elsewhere.

There may be a seasonality in abundance of *Capitella* spp. at Station 6 (Fig. 10). In winter samplings from 1979 through 1983, *Capitella* spp. were the top dominant only once (November 1983), and mean densities ranged from 1-415/0.1 m^2. Conversely, *Capitella* spp. were the top dominants in all summer samplings from 1980 through 1985, though abundances were quite variable ($\bar{x}$ = 87-5604/0.1 m^2). Where there were multiple samplings in a given summer, shorter-term fluctuations are indicated. There were large increases in abundance between July and August 1983 and between July and September 1987,

[1] *Capitella capitata* is widely used as an indicator of organic enrichment, although it also reaches high densities in response to other disturbances, such as defaunation (Caracciolo and Steimle 1983). *Capitella capitata* is actually a complex of several species which are morphologically similar but have distinct genomes and life histories (Grassle and Grassle 1976; Grassle et al. 1987). The differences may be important in interpreting population fluctuations and in using *Capitella* spp. as pollution indicators. The *Capitella* specimens from our sampling that have been examined closely appear to resemble species Ia in Grassle and Grassle (1976) (Judith Grassle, Marine Biological Laboratory, Woods Hole, MA 02543, pers. commum., November 1988). Species Ia produces a relatively large number (200–2000) of small eggs which remain in the plankton for several days, whereas the planktonic phase is shorter or absent in most other *Capitella* species examined to date. Since most of our specimens have not been positively identified, they will be referred to as *Capitella* spp.

and a major decrease between July and August 1986. Densities were low (<10/0.1 m^2) in July through September 1988.

One hypothesis to explain the sudden changes is that populations of *Capitella* spp. are limited by deteriorating water quality (e.g., high temperature, low dissolved oxygen, concentrations of hydrogen sulfide), for variable periods during at least some summers. Recurrent hypoxia, and occasional sulfide generation, have been observed at Station 6 (Andrew Draxler, NMFS, Sandy Hook Laboratory, Highlands, NJ 07732, pers. commun., November 1988). Some species of the genus *Capitella* have been reported to have only a moderate tolerance for hypoxia (Reish 1970). Tsutsumi (1987) documented the disappearance of a dense *C. capitata* population from an organically polluted cove in Japan in mid-summer; the population did not begin to reestablish itself until late October, when dissolved oxygen increased and sediment sulfide content began to fall. The factors controlling *Capitella* spp. densities at Station 6 will be examined by comparing densities to physical/chemical data (e.g., temperature, oxygen, redox potential, and sulfide) being collected in the sludge dumpsite Recovery" study (Environmental Processes Division, Northeast Fisheries Center 1988), and also to the limited historical data available.

There are of course other possible causes for the observed variability, perhaps acting in concert with changing water quality. Laboratory populations of *Capitella* spp. are known to have oscillations in abundance, which have been linked to declining food supplies and overshooting a habitat's carrying capacity, even under constant conditions (Chesney 1985). Much of the variability is undoubtedly due to the combination of spatial patchiness in densities of *Capitella* spp. and inexact station relocation for multiple sampling, as shown by the wide confidence limits in Figure 10. In October 1985, no *Capitella* spp. were found at Station 6. There were also no rhynchocoels, normally a top dominant in biomass and perhaps more useful than *Capitella* spp. in characterizing the sludge accumulation area, since rhynchocoels generally did not show such large short-term fluctuations (Table 5). The variability of the Station 6 assemblage makes it difficult to use in monitoring changes following phaseout of dumping.

Station 7 (sewage sludge dumpsite-Table 6)—As in the sludge accumulation area, *Capitella* spp. were numerical dominants in all Station 7 samplings from December 1979 through June 1985 and then were not found in the last sampling in October 1985. Densities were less variable over time than those at Station 6, and peak abundances were about an order of magnitude less. Similarly, rhynchocoels were generally a biomass dominant as at Station 6, but were considerably less abundant at Station 7. The lower densities are taken as an indication that the effects of organic enrichment in the dumpsite itself were fairly small; the dumpsite is not a markedly depositional area, as indicated by its relative coarse, low-carbon sediments (Table 1). Conspicuous among other biomass dominants were the anthozoan *Ceriantheopsis americanus* and polychaete *Diopatra cuprea,* both large tube-dwelling species whose abundances may have been enhanced by the sludge input; both were less abundant at Station 22, 5.6 km east of Station 6 and with similar depth and sediments. There were no obvious faunal trends indicative of changing effects of either organic enrichment or toxicants over the study period.

Station 4 (New Jersey Inshore, 2.4 km NNE of dredged material dumpsite - Table 7—The fauna was variable, with no consistently dominant species. This may be related to the sediment patchiness we have encountered at Station 4, which in turn is probably due in part to the history of past dumping. (We have found no distinctly altered assemblage near this dumpsite comparable to that of the sewage sludge accumulation area.) Early collections at Station 4 had high densities of several species, e.g., the polychaetes *Amastigos caperatus* and *Tharyx* spp. In 1983–85 there were no very abundant species, and the overall fauna was sparse.

Station 26 (New Jersey Offshore, 24.8 km E of central NJ coast-Table 8)—This station was situated at the center of the 1976 hypoxia event off New Jersey (Steimle and Radosh 1979). The benthos appeared to have largely recovered by the beginning of this study (unpubl. data). The fauna was numerically sparse throughout the study period with no obvious trends over time and no consistently abundant species, except perhaps for the sand dollar *Echinarachnius parma,* which was always the overwhelming biomass dominant. Steimle (1990) gives a more detailed analysis of biomass data for *E. parma* and other species at the NEMP stations.

Station 31 (Long Island Offshore, 25.0 km SSE of Fire Island Inlet-Table 9)—As a rule, this station was dominated numerically by crustaceans, including the amphipods *Pseudunciola obliquua, Byblis serrata,* *Corophium crassicorne* and *Rhepoxynius hudsoni*, and tanaidacean *Tanaissus liljeborgi*. Abundances of all these species decreased between 1979 and 1985. The sand dollar was always the biomass dominant, usually by more than an order of magnitude, with levels roughly comparable to those at Station 26 (above) and with no clear trend between 1979 and 1985.

Station 15 (Outer Hudson Shelf Valley, 48.7 km SE of Sewage Sludge Dumpsite-Table 10)—This station had been considered to represent the innermost part of the Shelf Valley in which contaminant concentrations and the macrofaunal assemblage were not influenced by pollution (Boesch 1982). The significant decrease in overall numbers of amphipods at this station over the study period was noted above. One species, *Ampelisca agassizi*, was responsible for most of the decrease. *A. agassizi* was the numerical dominant in seven of the nine samplings. Mean densities of over 1000 individuals/0.1 m^2 were found in several of the early samplings, but all counts from September 1982 on were $\leq$ 490/0.1 m^2, with an apparent continuing decline through 1985. The species is thought to be useful for trend monitoring owing to its sensitivity and natural stability of populations (Boesch et al. 1977; Radosh et al. 1978; Schaffner and Boesch 1982). The trend in *A. agassizi* is another indication, along with the general decreases in numbers of total species and amphipods discussed above, that some natural or pollution-related changes have recently affected at least the sensitive components of the benthos. Station 15 also had marked declines in several other species, e.g., the polychaetes *Levinsenia gracilis* and *Euchone incolor*, and the bivalve *Nucula delphinodonta*. Overall numerical abundance decreased here, as part of a trend that was widespread but not universal among Bight stations (e.g., also apparent at 4 and 31 but not at 6, 7, or 26, or in the "enriched" assemblage discussed next).

Station 1 (Northern Christiaensen Basin, 5.6 km NW of Sewage Sludge Dumpsite-Table 11)—This station had an "enriched" assemblage characterized by high numbers and biomasses of several deposit-feeding species, especially the polychaetes *Nephtys incisa* and *Pherusa affinis* and bivalve *Nucula proxima*. *Tharyx* spp. and *Cossura longocirrata* were other numerically important polychaetes, and the phoronid worm *Phoronis architecta* and anthozoan *Ceriantheopsis americanus* were consistent dominants in both numbers and biomasses.

The assemblage was quite stable over the study period. There was an apparent tendency toward increasing abundance and dominance for *Pherusa affinis*. More recent sampling for the sludge dumpsite "recovery" study indicates the continued persistence of the assemblage, with *P. affinis* remaining the biomass dominant, at least into early 1989.

Components of the enriched assemblage were also sometimes found in the sludge accumulation area, and the assemblage was consistently present at all other Christiaensen Basin stations, as well as at stations 2 and 3 immediately to the north of the Basin. There were no clear changes over time at stations 2, 3, or 5, the CB station closest to the sludge area (2.8 km W of Station 6). There were, however, decreases in overall faunal abundance at 9, 10, and 40.

Comparisons to Other Studies

The spatial pattern of assemblages in the Basin fits the model of Pearson and Rosenberg (1978) for successional changes in response to organic inputs. Areas of high organic loading are often characterized by large populations of a few small opportunistic species—this is represented by the *Capitella* spp.-dominated fauna at Station 6. Areas with somewhat lower organic loading typically have high abundances of several species, as in the enriched assemblage just described for most of the remaining Christiansen Basin and some areas immediately outside the Basin. Pearson and Rosenberg (1978) also note that sediments in the vicinity of a large organic input are sometimes devoid of benthic macrofauna. No consistently defaunated zone has been found in the Basin; for example, no azoic samples were collected in our 1979–85 surveys at Station 6, and only one of 40 grabs in the intensive sampling of the sludge accumulation area in the summers of 1986–1988 had no macrofauna. The implication is that organic loading rates in the Basin have not been as high, relative to compensating phenomena such as dispersion and microbial breakdown, as in many other areas of organic enrichment, e.g. the Saltkallefjord, Sweden; Loch Creran, Scotland; Frazer River estuary, British Columbia; Kiel Bay, Germany (Pearson and Rosenberg 1978). This agrees with the Segar and Davis (1984) global review of contaminated coastal areas, which did not consider the New York Bight to be among the most pollution-susceptible regions.

Detailed, quantitative comparisons of the 1979–87 data with results of earlier New York Bight surveys are beyond the scope of this report. On a qualitative level, there are clear long-term similarities. The enriched assemblage has been present in much of the Basin at least since the first benthic surveys there in 1968 (National Marine Fisheries Service 1972; Pearce 1972; Pearce et al. 1981; Boesch 1982; Steimle et al. 1982; Steimle 1985). The *Capitella* spp.-dominated fauna in the sludge accumulation area was not reported in the 1968–71 studies (National Marine Fisheries Service 1972; Pearce 1972). They were, however, consistently found in the intensive 1973–75 MESA sampling (Pearce et al. 1981). In that sampling, as in ours, recurring high densities of *Capitella* spp. were limited to a small area (the vicinity of Station 6). The persistence of the enriched and *Capitella* spp. assemblages is evidence against gross changes in the benthic environment of the Bight over the past 15–20 years. More sensitive measures such as numbers of species and amphipods, however, do indicate that there has recently been widespread environmental change in the Bight.

Summary

There were clear spatial patterns in the benthic macrofauna of the New York Bight. Numbers of species and amphipods, considered relatively sensitive indicators of environmental quality, were lowest in the "sludge accumulation area," followed by other Christiaensen Basin and inshore Bight stations. Both variables reached highest values at the outermost shelf stations and in the outer Hudson Shelf Valley.

Cluster analysis of species composition also showed spatial differences. This was expected, given the ranges encountered in variables such as depth, substrate, and distance from estuaries and dumpsites. There were several distinct assemblages, especially in the sludge dumpsite, sludge accumulation area, mid-Hudson Shelf Valley, and outer Shelf Valley. Long Island and New Jersey offshore stations were broadly similar. All remaining Christiaensen Basin stations fell into several related groups. The other inshore samplings were less similar to one another and were spread over much of the dendrogram.

None of the variables examined distinguished northern New Jersey inshore stations from stations further south or along the Long Island coast. This implies that the Hudson-Raritan plume, which tends to follow the north Jersey coast and influence temperature, salinity, dissolved oxygen, carbon and toxicant levels there, has no overriding effect on the benthos of that area.

The spatial patterns in numbers of species and amphipods were consistent between surveys. However, absolute numbers of species and amphipods decreased at a large majority of stations between 1980 and 1985. Decreases for all stations combined were highly significant ($P = 0.0007$ for species, 0.0004 for amphipods). The most significant decreases in numbers of species and amphipods were in the Basin's sludge accumulation area and at a site 52 km SE of that area in the Hudson Shelf Valley. The latter site had been chosen to represent the innermost part of the Shelf Valley that had not been noticeably influenced by pollution. The pattern of decreases superficially suggests increasing effects of sludge or overall waste loading, but the limited data available do not indicate that waste inputs have increased, and there are other feasible explanations for the observed changes. At three inner Bight stations sampled more recently, numbers of species generally rose somewhat between 1986 and 1989, perhaps signalling a reversal of the general downward trend from 1980 to 1985. Temporal changes in species composition and dominants were less evident.

Spatial trends in numbers of species and amphipods, and dominant species, were similar to those observed since sampling in the Christiaensen Basin area began in 1968. A small area with a "highly altered" assemblage dominated by the organic-enrichment indicator polychaetes *Capitella* spp. has been present in the Basin since the early sampling, and an "enriched" faunal assemblage with high biomasses of several species has consistently been found over most of the remaining basin. Samples devoid of benthic macrofauna have been very rare or absent in all surveys. Gross changes in the benthic environment of the New York Bight are therefore not evident over the past 15 years or more.

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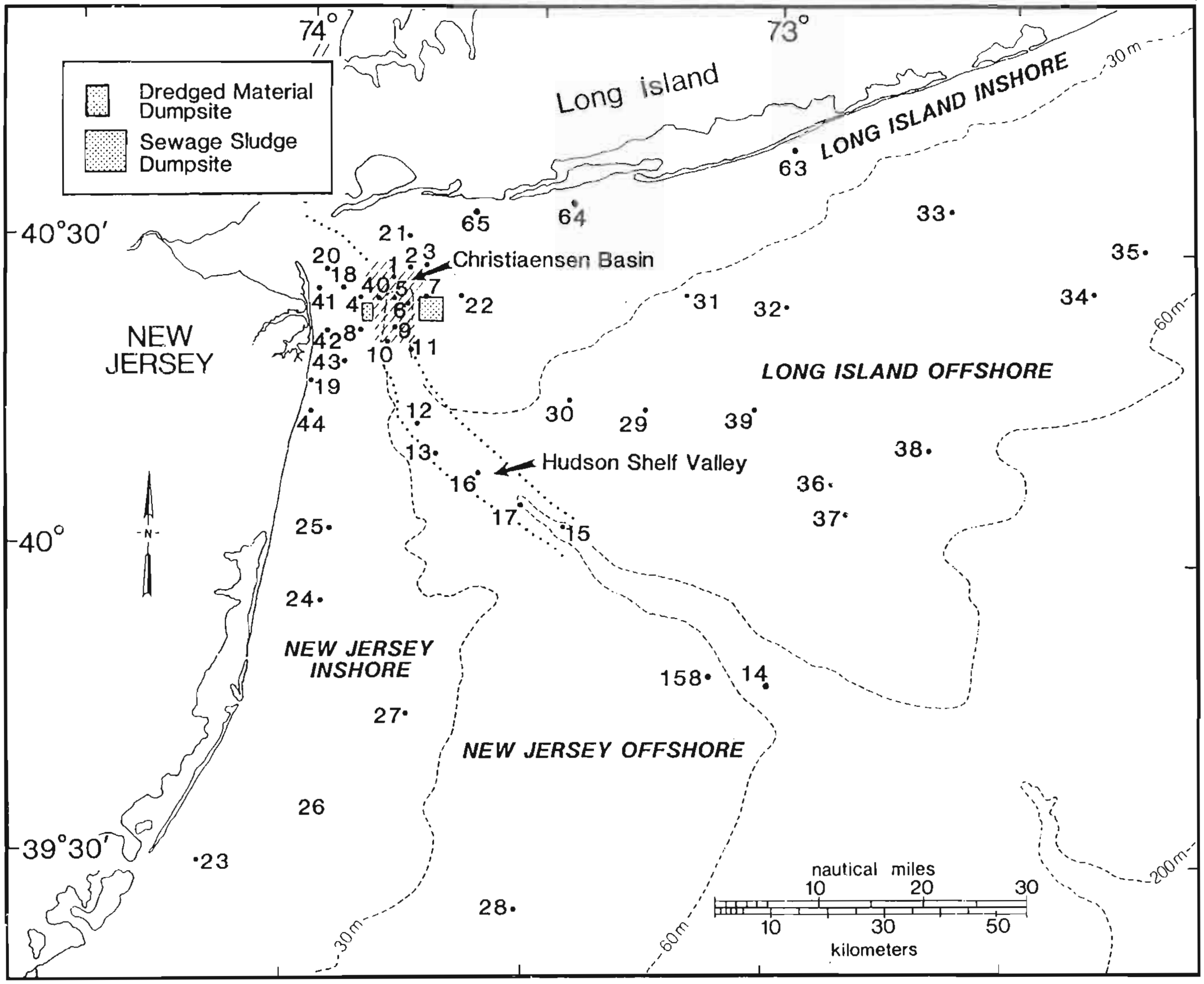


Figure 1

Station locations in New York Bight, with subareas discussed in text. Diagonal lines indicate Christiaensen Basin.

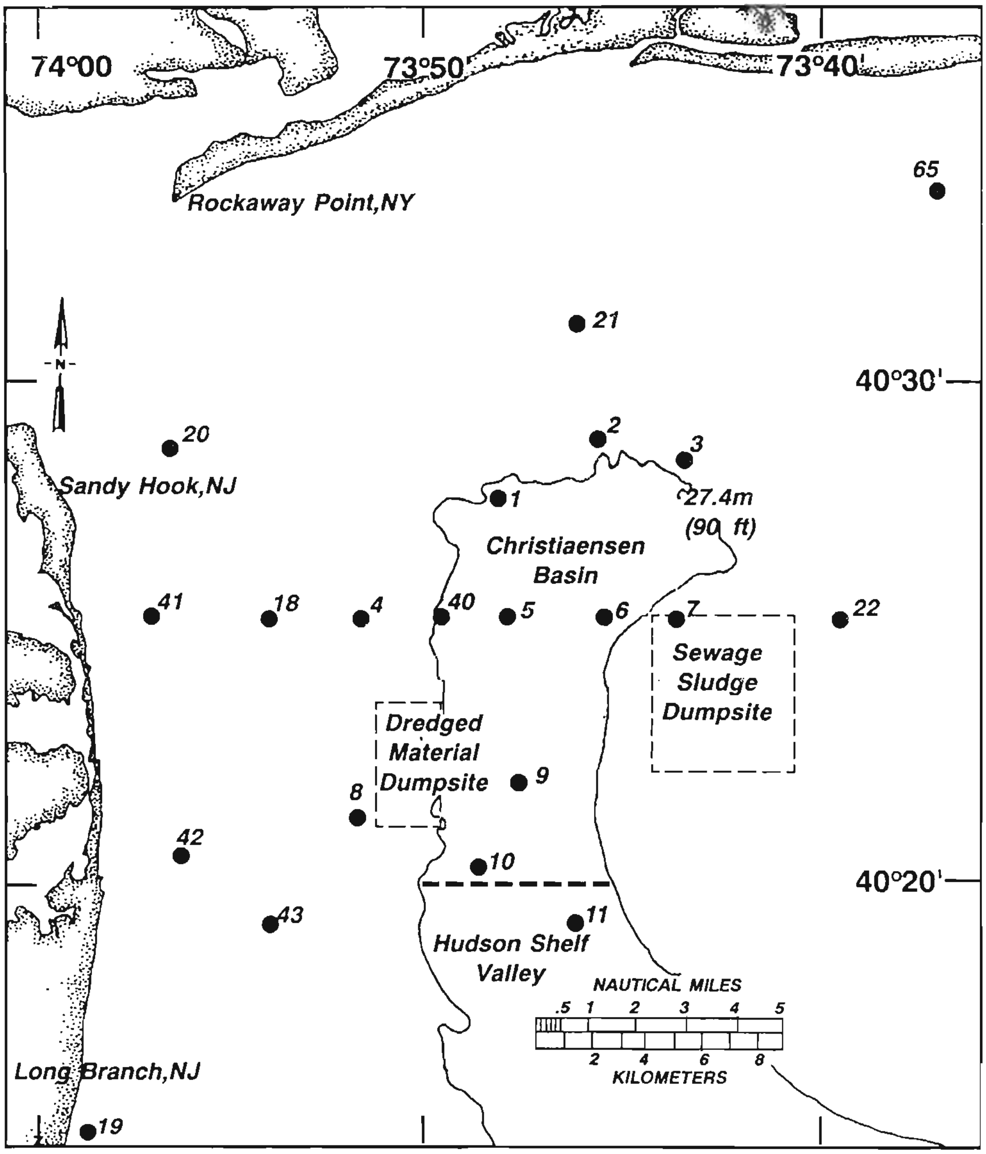


Figure 2
Details of inner New York Bight.

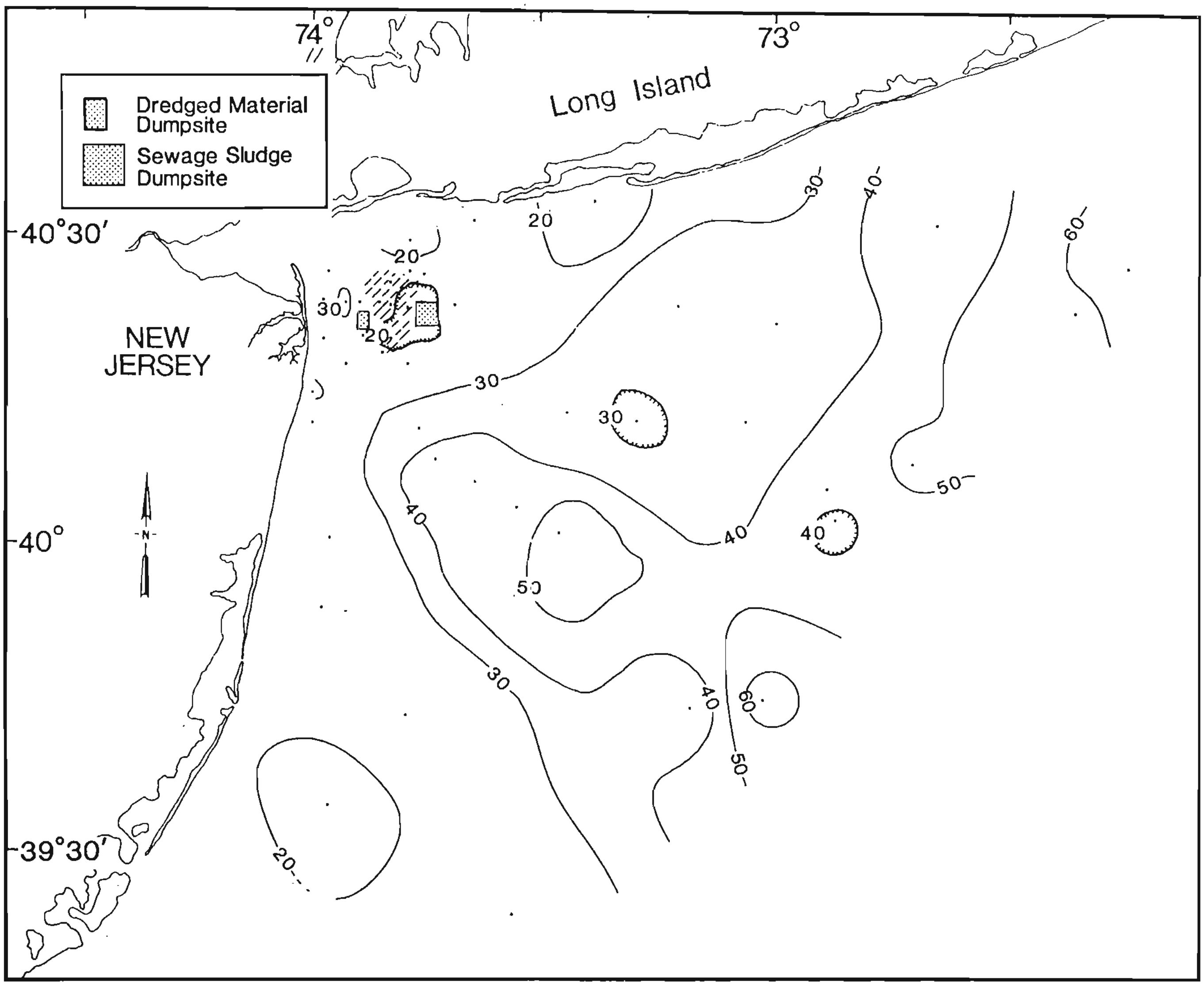


Figure 3
Numbers of species per 0.1 m², September–October 1985.

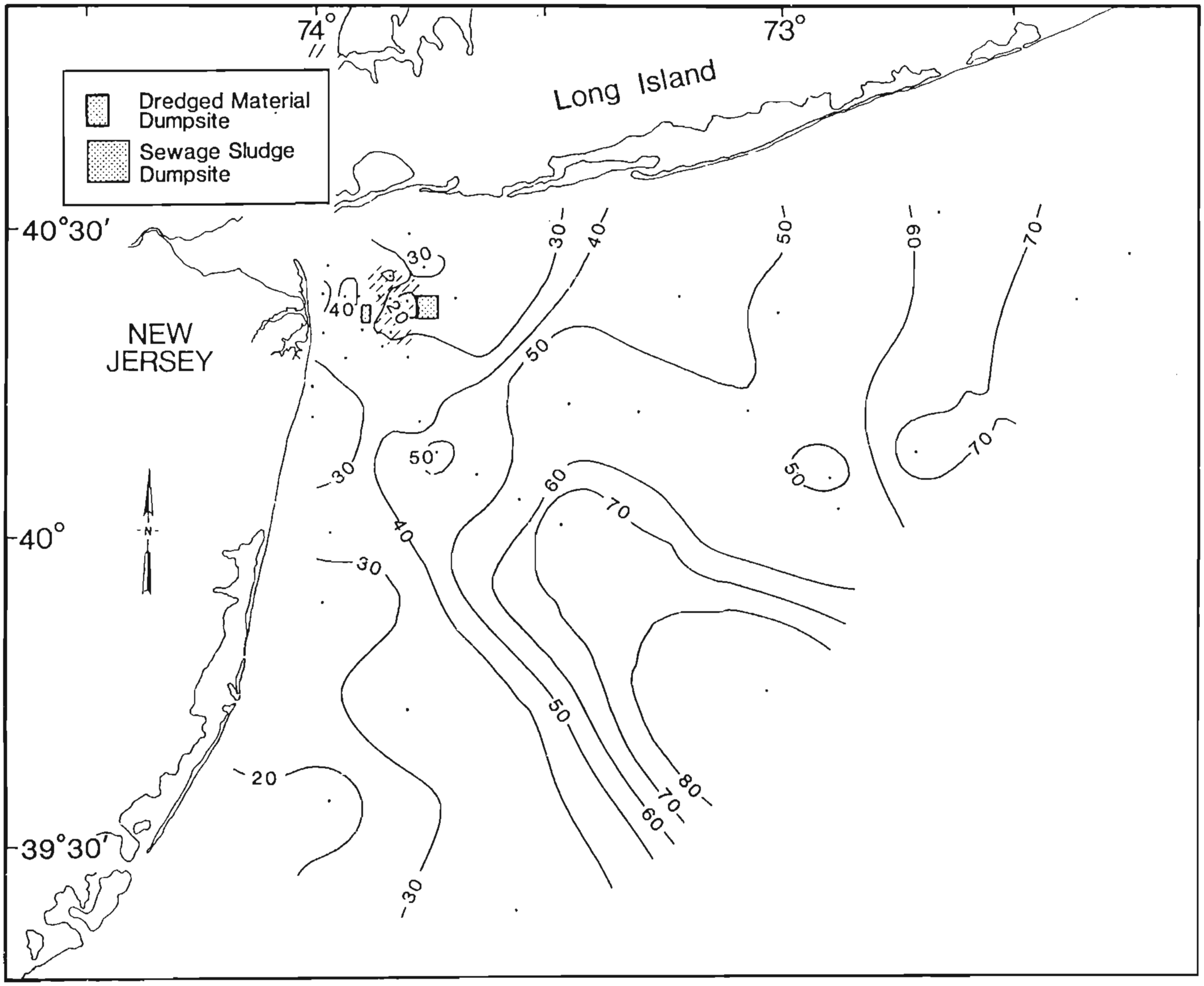


Figure 4
Numbers of species per 0.1 m², July–August 1980.

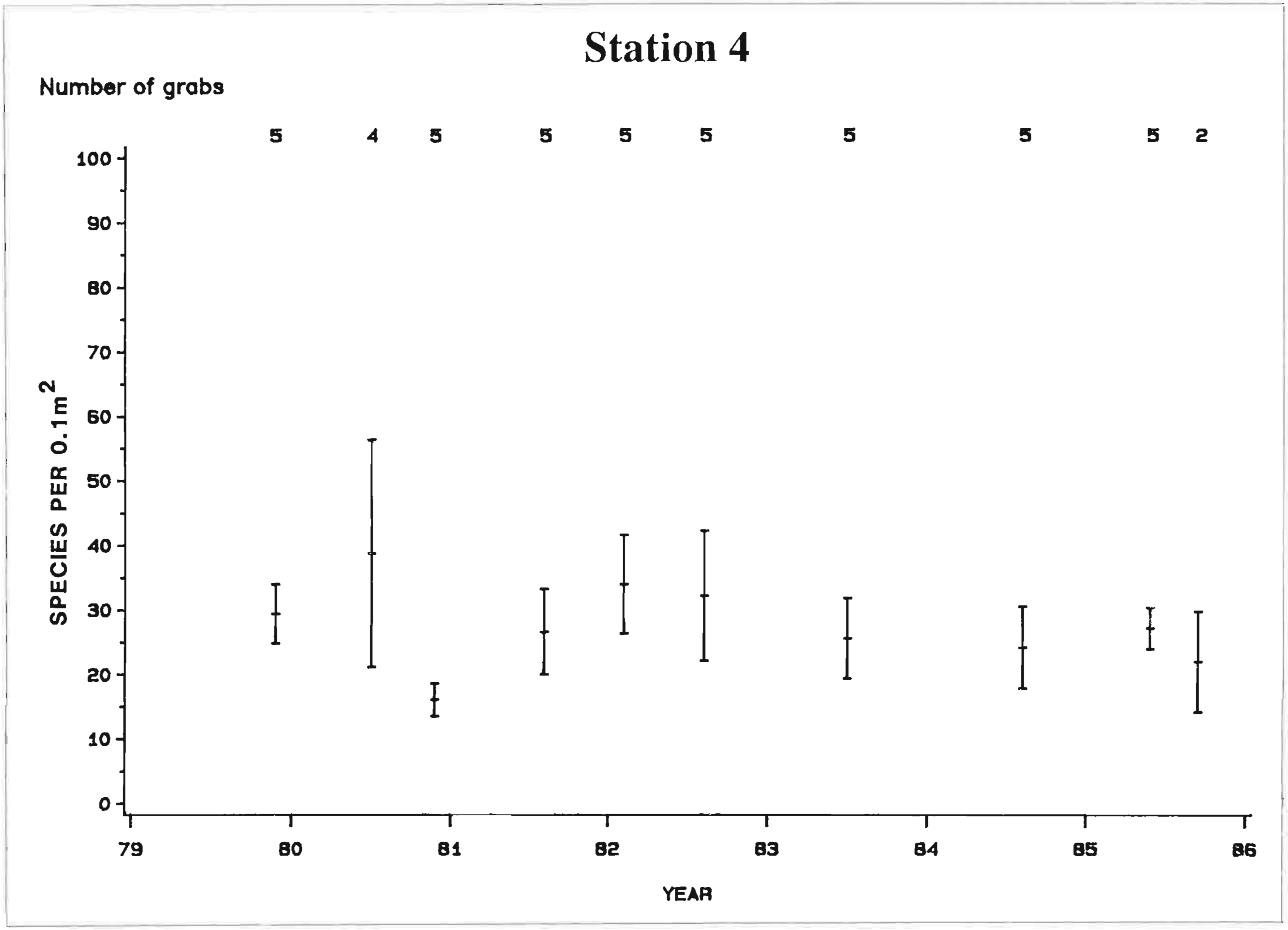


Figure 5

Means and 95% confidence limits for numbers of species per 0.1 m^2 at each NEMP station on each sampling date, with numbers of replicate samples indicated.

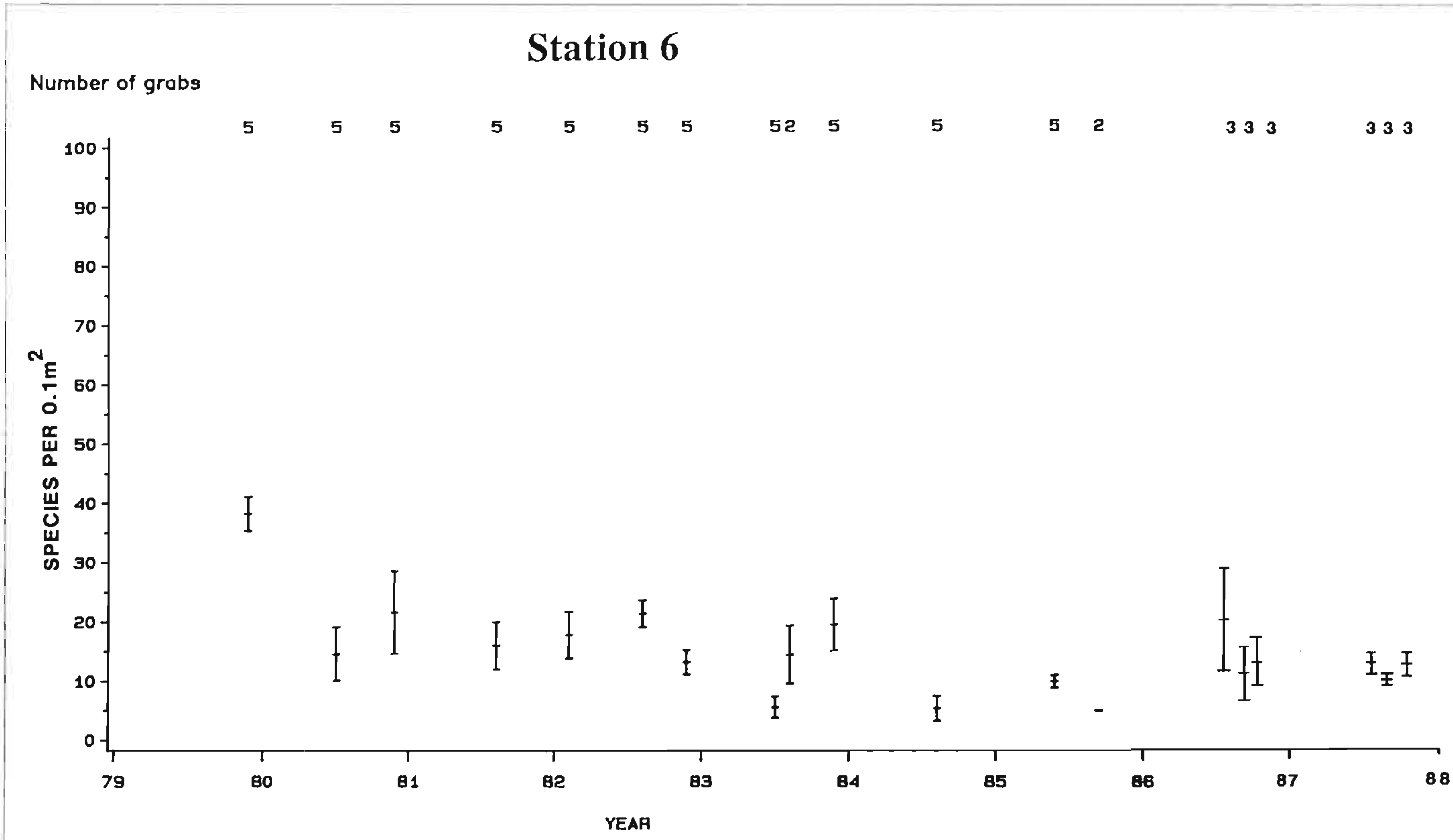
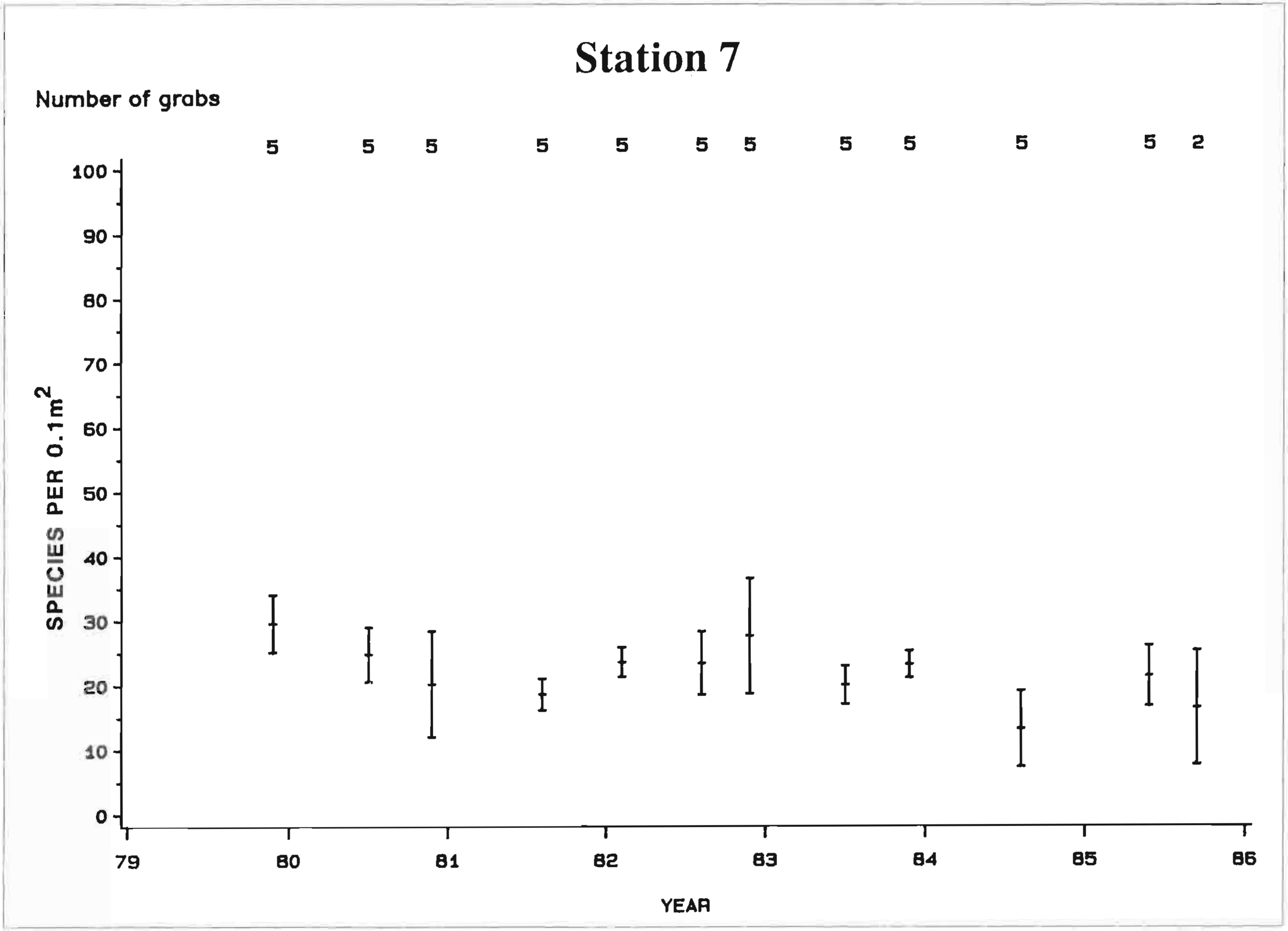


Figure 5 (continued)



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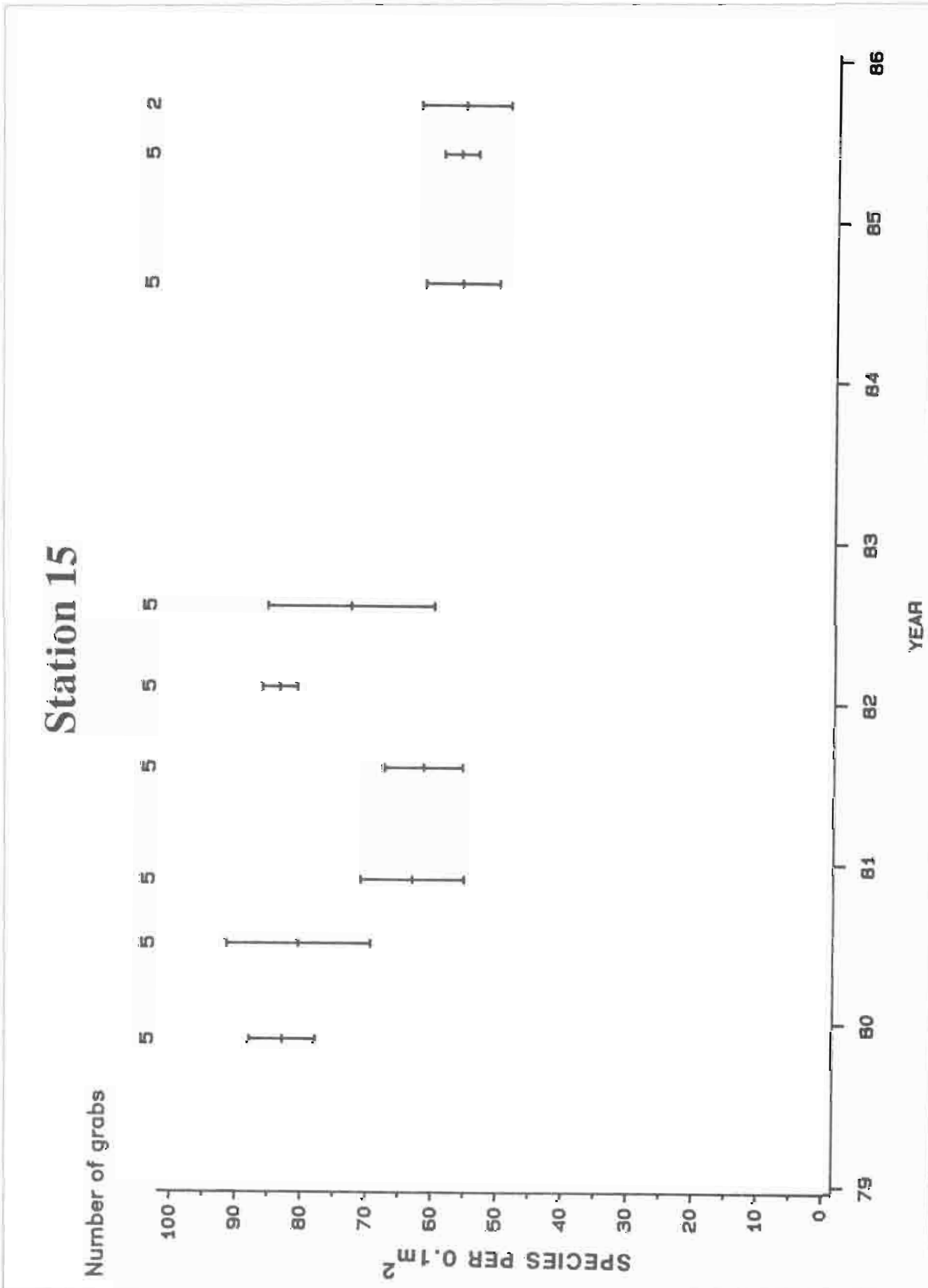

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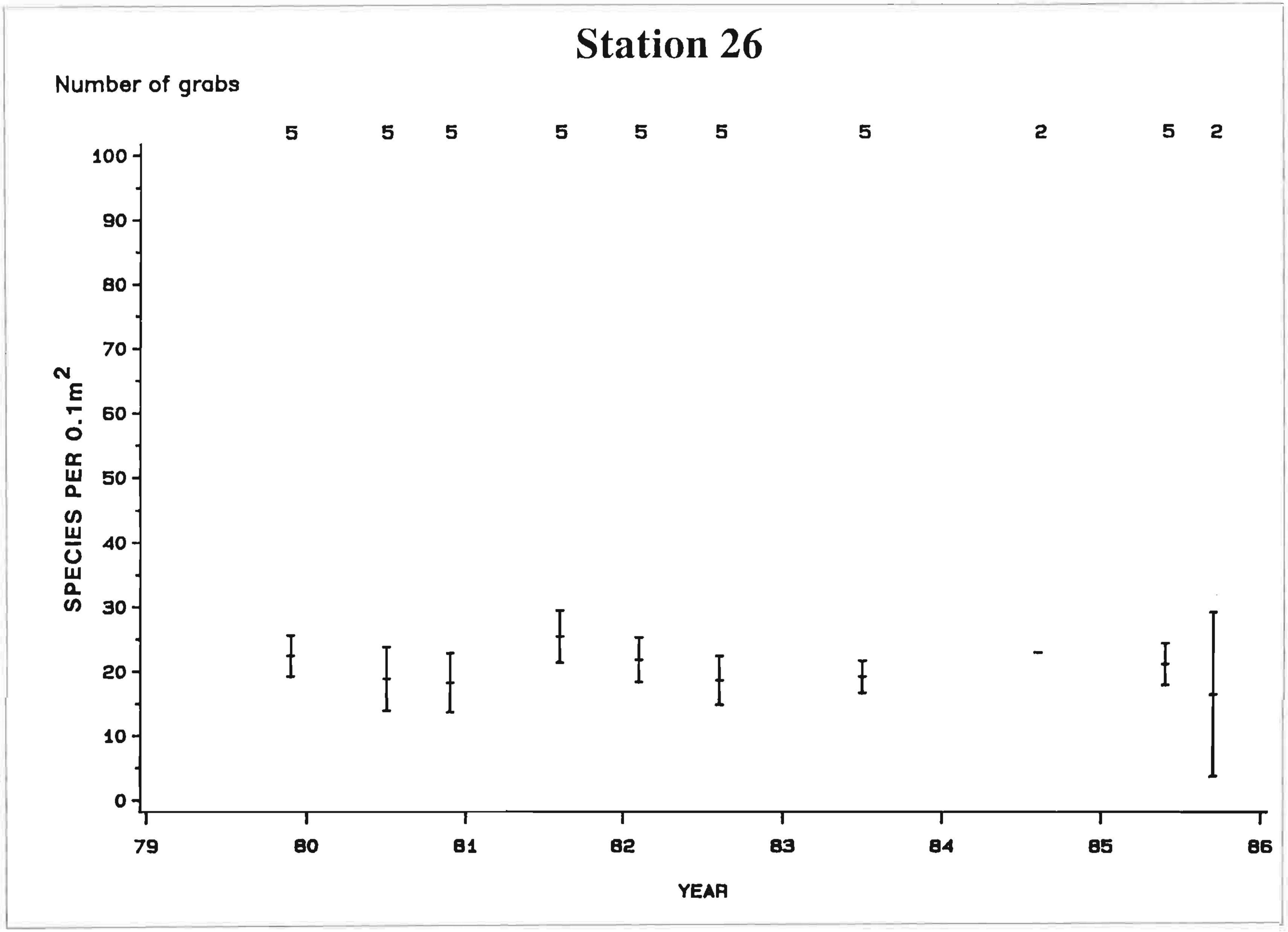

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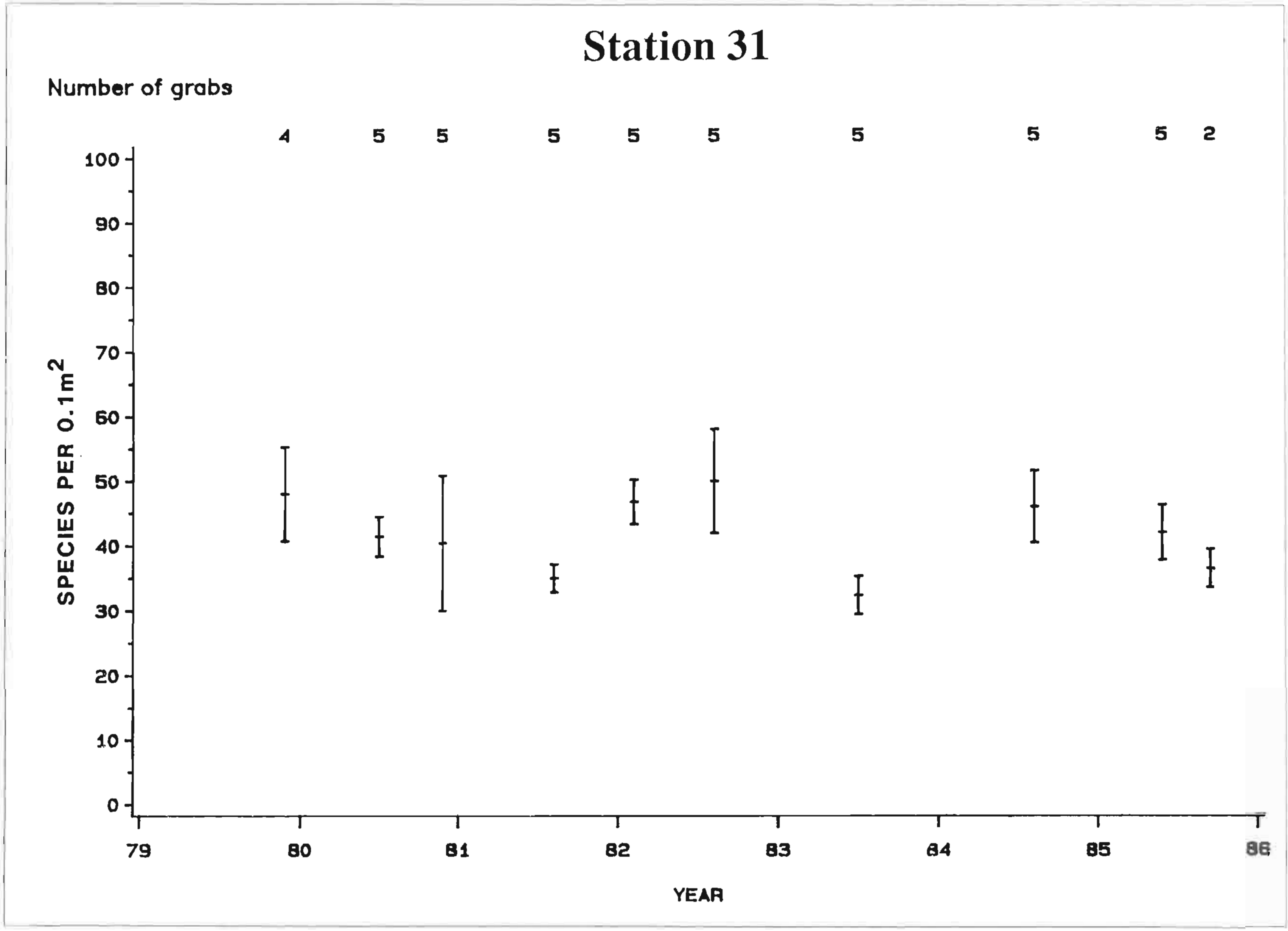

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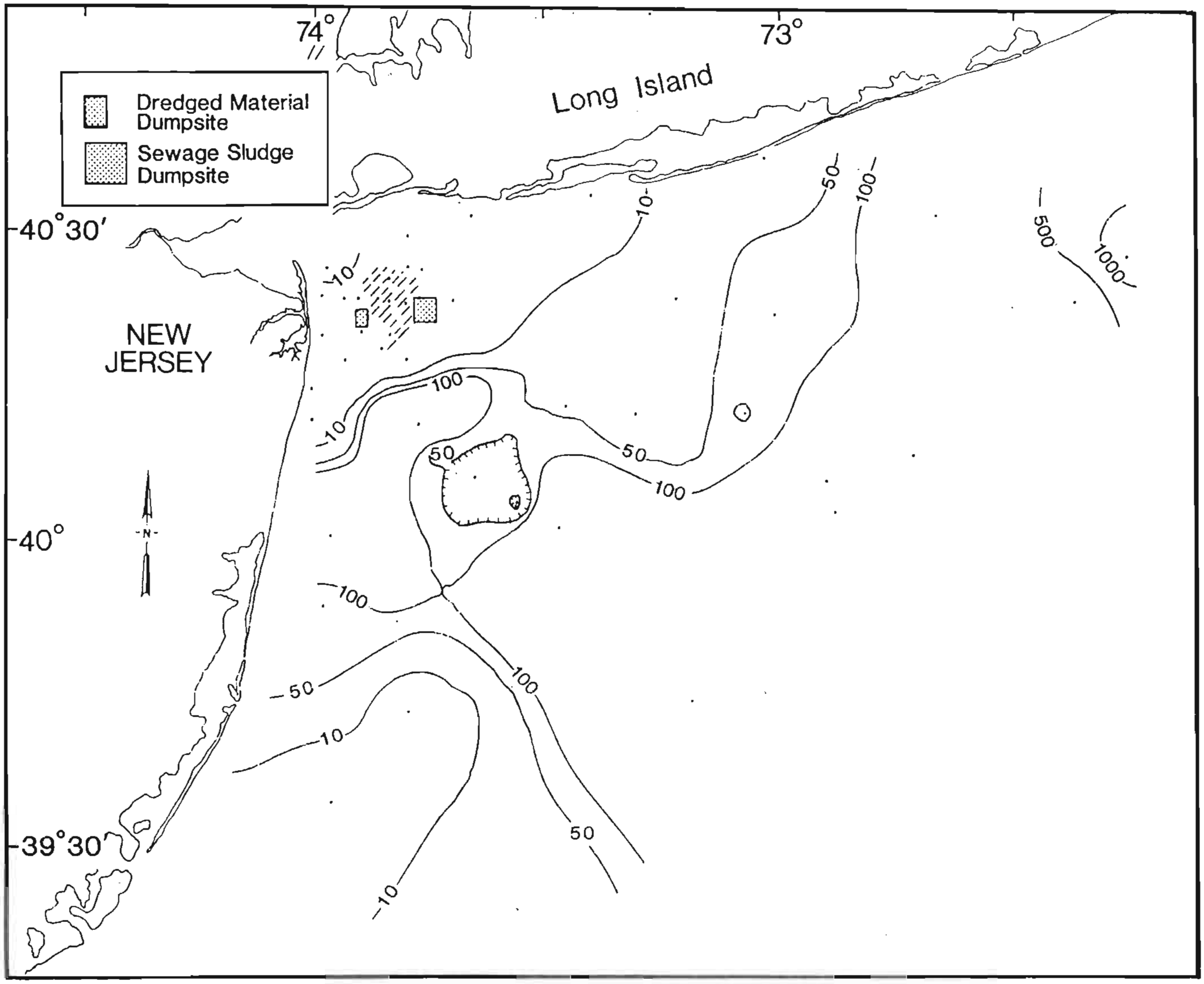

Figure 6
Numbers of amphipods per 0.1 m^2, September–October 1985.

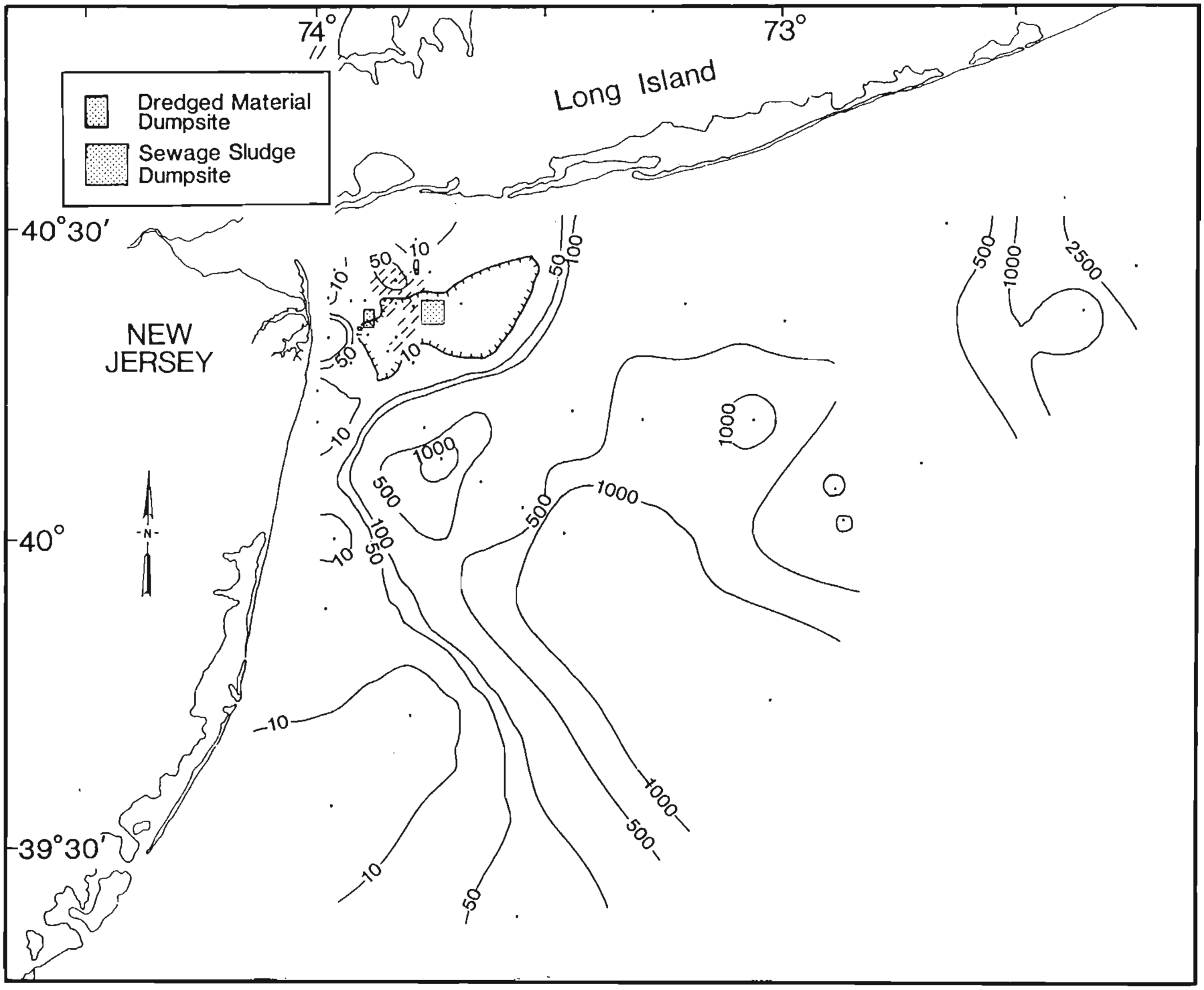

Figure 7
Numbers of amphipods per 0.1 m^2, July–August 1980.

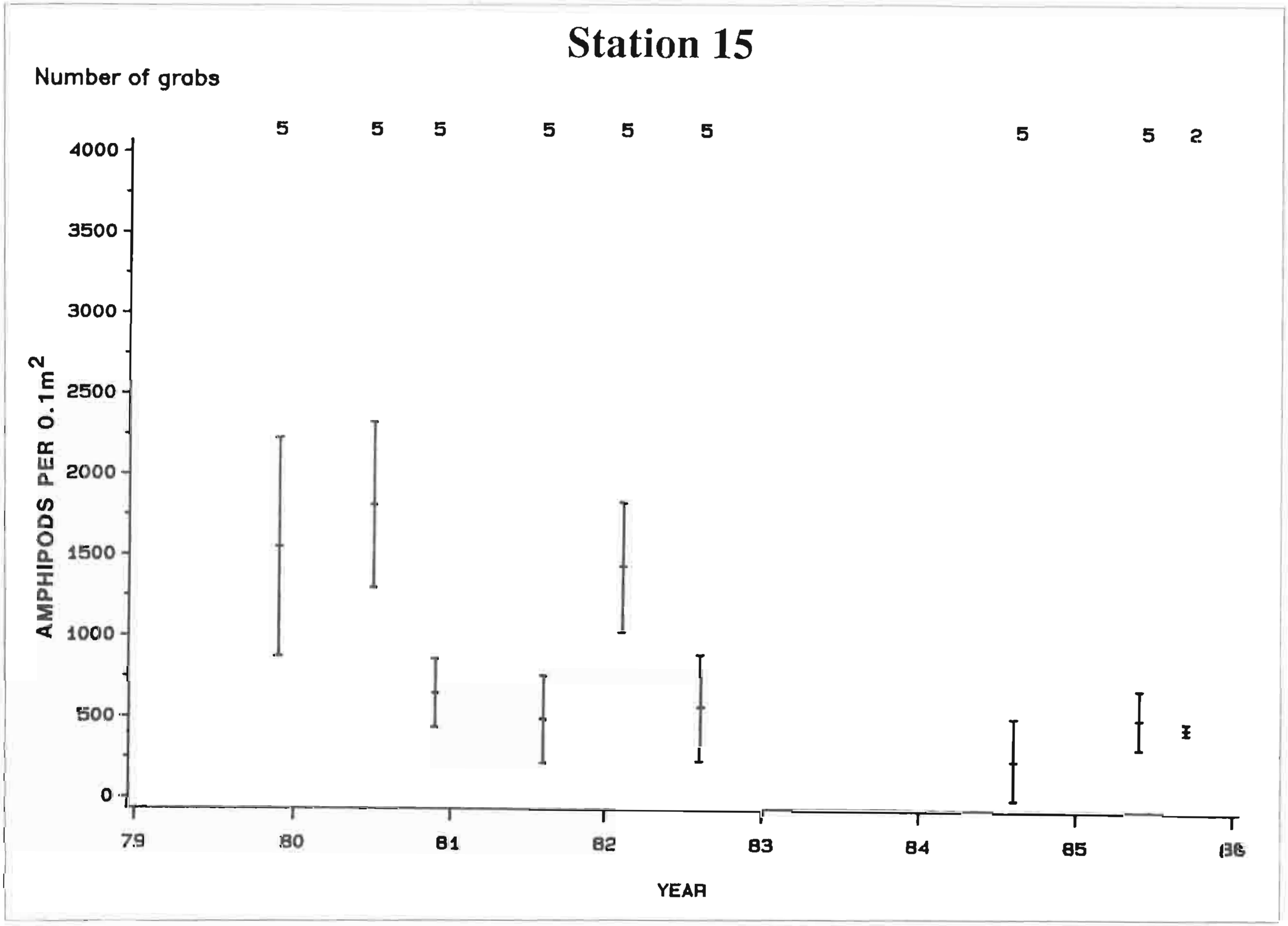

Figure 8
Means and 95% confidence limits for numbers of amphipods per 0.1 m^2 at Station 15 in mid-Hudson Shelf Valley for each sampling date. Numbers of replicate samples are indicated.

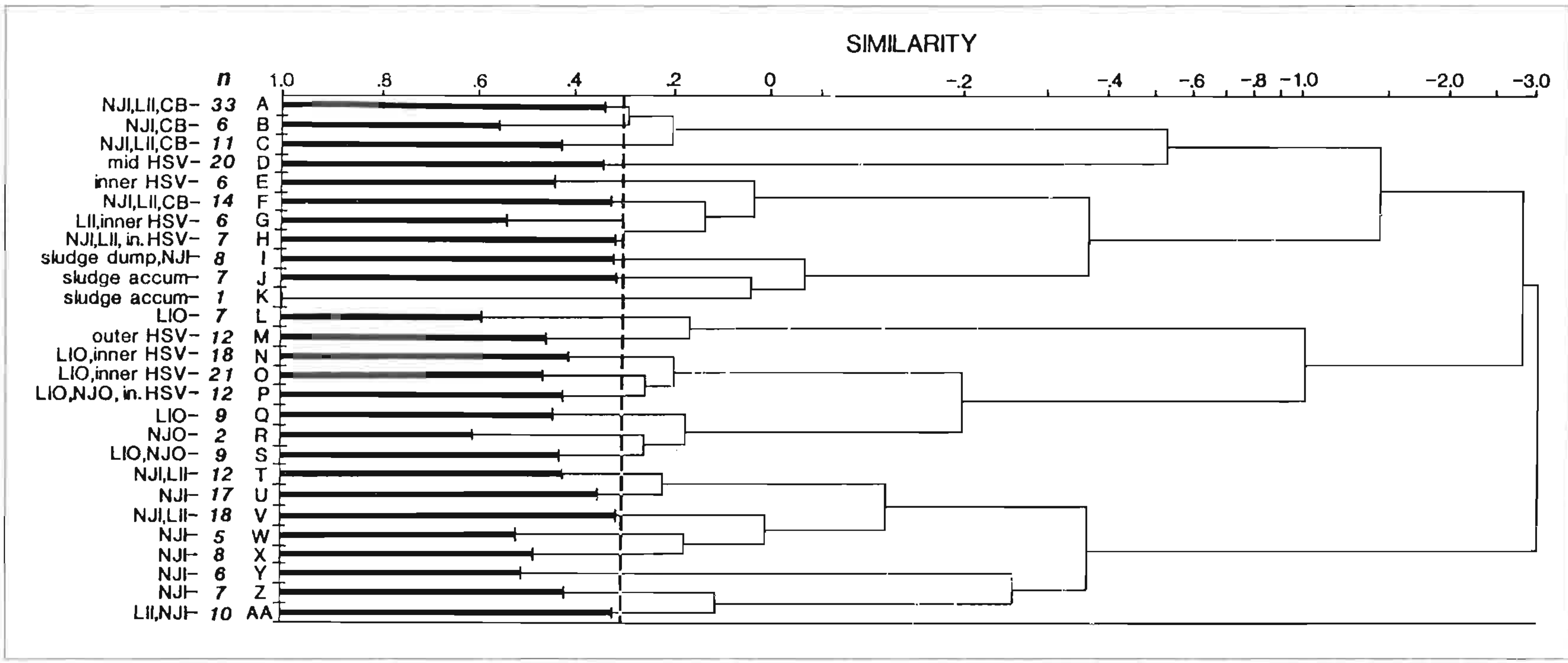

Figure 9

Dendrogram showing between-group similarities in species composition, with groups formed at 30% similarity levels. Each wider bar to left indicates the level of similarity of samplings within a given group. Areas: NJI = New Jersey Inshore; NJO = New Jersey Offshore; LII = Long Island Inshore; LIO = Long Island Offshore; CB = Christiaensen Basin; HSV = Hudson Shelf Valley. *n* = number of samplings in group. Samplings in each group are given in Table 3. Note log scale at negative similarities.

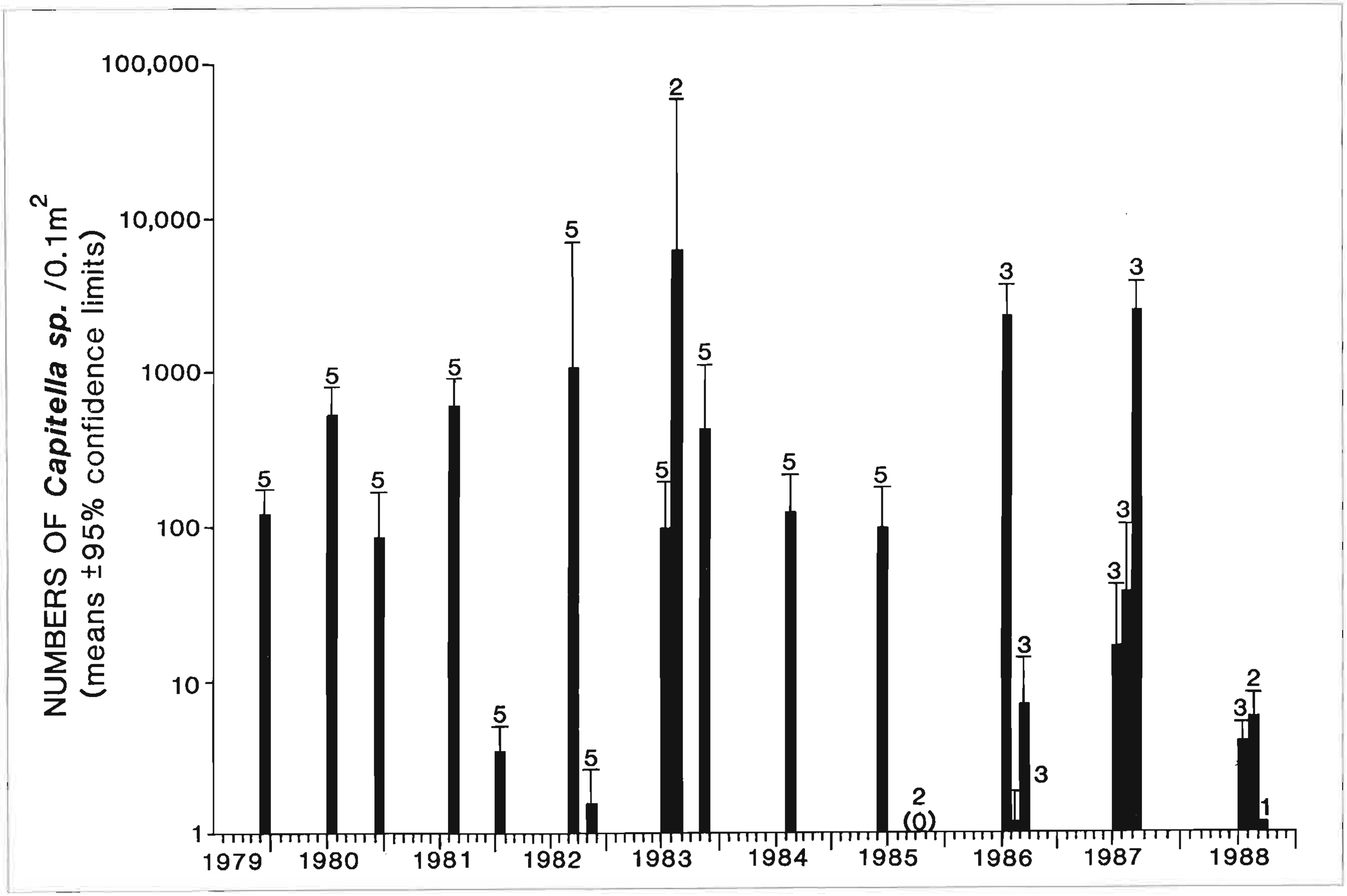

Figure 10

Means and 95% confidence limits for numbers of *Capitella* sp. per 0.1 m^2 at Station 6 ("sewage sludge accumulation area") for each sampling date. Numbers of replicate samples are indicated.