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THE BENTHIC FAUNA OF NEWARK BAY

by

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Introduction

Little is known of the benthic fauna in Newark Bay. During 1972-73, Ichthyological Associates (Anselmi, 1974) collected benthic samples along two transects in the northern and southern portions of the Bay. A total of 21 samples were taken during 1972. These yielded 1031 animals from 13 taxa. The following year, 51 samples were obtained. From these, 790 individuals of 11 taxa were recovered. In 1976, the U.S. Army Corps of Engineers collected benthic samples at 28 stations distributed among channel, mooring, and shallow sites (U.S. Army Corps of Engineers, 1980). Presence-absence data were recorded for each sample and a total of 12 taxa were identified. A benthic survey by McCormick and Koepp (1978) in 1976 recovered 12 taxa from 17 stations in Newark Bay, the Arthur Kill, and the Hackensack River. In a more recent study, Cerrato and Bokuniewicz (1985) obtained benthic samples at a shallow water site near Port Newark Terminal. A total of 24 samples were taken in September 1984. These samples yielded 262 animals from 15 separate taxa.

Benthic species collected during these prior studies are listed in Table 1. In each of these surveys, 15 or fewer species were recovered, and the composite list from all of them combined totals 36 taxa. The consensus of opinion based on analyses of these data has been that benthic diversity was very low in Newark Bay (McCormick and Koepp, 1978; U.S. Fish and Wildlife Service, 1976; U.S. Army Corps of Engineers, 1980; Cerrato and Bokuniewicz, 1985). Additionally, the U.S. Fish and Wildlife Service, using the data available in 1976, concluded that both abundance and diversity declined with depth (U.S. Fish and Wildlife Service, 1976). For example, they noted that based on the 1972 collections by Ichthyological Associates, average benthic abundances were greater than 1100 individuals per m^2 in shallow areas (<20 ft) but were less than 150 animals per m^2 in deeper areas (>20 ft). They attributed the cause of this pattern to lower levels of dissolved oxygen with depth.

In the present study, a benthic survey was conducted in Newark Bay as part of an environmental assessment of a proposed U.S. Army Corps of Engineers navigation project. Sampling was carried out in conjunction with the U.S. Fish and Wildlife Service. The purpose of the field and laboratory effort was to collect quantitative baseline information on the benthic fauna, sediments, and water quality characteristics of the project area. This information was then analyzed to 1) characterize the distribution and abundance of the benthos in the project area; 2) relate observed biological patterns to environmental parameters; 3) test the shallow vs deep hypothesis formulated by the U.S. Fish and Wildlife Service; 4) compare the distribution and abundance of finfish, as observed from several recent fishery studies, to their potential food items in the benthos; and 5) assess the potential impacts of the proposed navigation project on the benthos.

Methods

1. Sampling Procedures

Benthic samples were collected during two seasonal cruises (spring and summer) aboard the R/V SIOME. A total of 30 stations were sampled on each of the two cruises. The exact sampling dates were 20-21 May 1985 for the spring cruise and 12-13 August 1985 for the summer cruise.

Figure 1 shows the location of each sampling station. In this figure, each of ten sites are designated by a number code. Site locations were chosen to provide a representative coverage of the project area and were also distributed to include each of the major sediment types (as mapped by Coch, et al., 1983) found within the project area. Within each site, three stations were identified. These are designated in Figure 1 by the letter codes A, B, and C. Stations designated by an A are channel areas to be deepened, those by a B are shoal areas to be removed during the proposed navigation project, and areas identified by a C represent control stations. Based on information provided by Coch, et al. (1983) each group of three stations making up a site was located within a single major sediment type.

Sampling stations were located using a Texas Instruments 9900 II Loran C. This instrument provides a direct readout of latitude and longitude, and the unit was calibrated using a local reference point of known location during each cruise. The latitude and longitude of each station is given in Table 2.

Benthic samples were taken using a 0.04 square meter Shipek grab. Two replicate grabs per station were collected on each cruise for biological study. During the spring cruise, a portion of a third grab was saved untreated for sediment analysis. A Martek MK VI multiparameter analyser was used to obtain measurements of depth, bottom temperature, conductivity, and dissolved oxygen at each station. Salinity was later calculated from recorded parameters based on the Practical Salinity Scale of 1978.

Grab samples for biological study were wet-sieved onboard immediately after collection. Sieves were constructed of 1 mm diameter Nitex screening. After washing, all material retained on the screen (e.g., animals, detritus, sand, gravel, shell fragments, etc.) was transferred to labelled sample jars. These samples were preserved in 10% buffered formalin and stained with rose bengal.

2. Laboratory Procedures

In the laboratory, biological samples were rewashed using a 1 mm screen and transferred to 70% ethyl alcohol. Samples were then analyzed using a two stage process. In the first stage, animals were picked from the sediments, detritus, etc. under an illuminated magnifier and sorted to phylum level. In the second stage, individual organisms were identified to species level whenever possible, and the total for each taxa enumerated. All data were initially entered on log sheets and later transferred to a computer.

For the sediment analysis, each sample was homogenized, and a subsample of approximately 10 g was taken. Particle size distributions were determined by wet sieving and pipette analysis (Folk, 1964). Subsamples were dispersed with a 1% Calgon solution (sodium hexametaphosphate) and mechanically agitated for one hour to disaggregate the particles. The subsample was wet sieved into a 1000 ml graduated cylinder using a combination of a 2 mm mesh sieve and a 63 um mesh sieve to separate the gravel, sand, and mud fractions. The mud fraction in the graduated cylinder was separated into silt and clay by taking two pipette withdrawals. Sediment fractions separated during this process were dried in an oven at 80-90 degrees C, cooled to rocm temperature, and weighed. Weights of the silt and clay fractions were corrected for the amount of Calgon added. Mass percentages of the four particle size categories were calculated as percentages of the total subsample weight. No correction was made for salt content in the pipetted samples because the error introduced was considered insignificant. Organic content of the samples was measured as the weight loss after combustion at 450 degrees C for at least four hours. All data were initially entered on log sheets and later transferred to a computer.

3. Data Analysis

A number of derived parameters or indices (abundance, species richness, Shannon-Wiener diversity, and equitability) were computed from the biological data. To maintain consistency throughout, nonenumerable species (e.g., colonial organisms such as sponges and hydrozoans) were excluded from all computations. The occurrence of these taxa is reported on the data sheets at the end of this report.

Abundances are reported as the number of individuals per square meter. These estimates were obtained by dividing the sample results by the sampling unit area (0.04 m^2). Species richness is presented as the number of species per 0.04 m^2. Because the relationship between the number of species and sampling unit area is nonlinear, normalization to a standard unit such as number per square meter is not possible for this parameter. Station maps in the results section represent per sample values of abundance and species richness averaged for each station.

Two indices of diversity were used to analyze the biological data. The first index is the Shannon-Wiener information function:

$$H'(s) = -\sum_{i=1}^{s} p_i \log_2 p_i$$

where s is the total number of species and p_i is the proportion of individuals in the sample belonging to the ith species (i = 1, 2,3,...,s). Shannon-Wiener diversity measures both species richness (i.e., the number of species in a sample) and the distribution of individuals among species (termed evenness or equitability). This index has a minimum value of 0, and the higher the value of H′, the more diverse the assemblage. Diversity was computed for each sample in the study. Station maps in the results section represent average per sample values for that station.

The second index of diversity is the equitability or evenness function:

$$V' = H'(s)/H'_{max}$$

where $H'_{max} = \log_2 s$. This index has a range from 0 to 1. The higher the value of V′, the more evenly individuals in a sample are distributed among the s species. Equitability was computed for each sample, and station maps in the results section represent average per sample values for that station.

Cluster analysis was carried out to determine the degree of faunal similarity among the various stations. The similarity measure chosen was the Bray-Curtis index. This measure has the form:

$$S_{jk} = 1 - \frac{\sum_{i=1}^{s} |Y_{ij} - Y_{ik}|}{\sum_{i=1}^{s} (Y_{ij} + Y_{ik})}$$

where Y_{ij} is the score for the ith species in the jth sample, Y_{ik} is the score for the ith species in the kth sample, and S_{jk} is the similarity between the jth and kth sample. Values of S_{jk} range from 0 (no species in common) to 1 (identical scores for all species). For convenience, values of S_{jk} are reported as percentages by multiplying this measure by 100. S_{jk} was computed using the average of the replicate grabs at each station.

With the Bray-Curtis measure, species with high, variable scores largely determine the similarity value while species with low scores are relatively unimportant (Boesch, 1977). Similarities between stations were computed with species scores (i.e., Y_{ij} and Y_{ik} in the above formula) of three different types: 1) untransformed abundances, 2) fourth root transformed abundances, and 3) presence-absence data. The use of untransformed abundances as species scores biases the similarity measure in favor of the abundant species in the samples. The fourth root transformation has the effect of scaling down or reducing the contribution of the abundant species (Field, et al., 1982). Finally, with presence-absence data as species scores, each species is given equal weight in determining the similarity between stations. It should be noted that the Bray-Curtis measure when used with presence-absence data reduces to the Dice coefficient and Sorenson's index of affinity (Sneath and Sokal, 1973; Sorenson, 1948; Sanders, 1960). Similarities based on the above three types of scores were computed to allow an assessment of whether observed faunal patterns were due to the contribution of numerically abundant species, species composition, or a combination of both.

Applying the Bray-Curtis measure, similarity matrices consisting of all pairwise station comparisons were computed. Cluster analyses based on these matrices were carried out on a Univac 1100 using program P1M in the BMDP statistical library. This program performed a sequential, agglomerative, hierarchical, and non-overlapping cluster analysis of the variables. The linkage rule used was group average sorting. Choices made for similarity measure, data transformations, clustering algorithm, and sorting strategy were based on a review of the methods most often recommended in the numerical ecology literature (e.g., Clifford and Stephensen, 1975; Field, et al., 1982; Boesch, 1977; Jeffers, 1978; Legendre and Legendre, 1983).

In this report, a number of simple hypothesis tests for differences between two means will be carried out on abundance, species richness, diversity, and equitability parameters. Abundance data from benthic samples are generally highly skewed, and normal parametric tests cannot be directly applied. Downing (1979) and others have determined that a fourth root transformation is effective in normalizing abundance data. Unfortunately, the distributional properties of the other parameters are not known. In order to be maintain consistency throughout, nonparametric Mann-Whitney U-Tests were used (Elliott, 1973). All tests were two sided and were carried out at a 0.05 level of significance.

Results

1. Water Quality Parameters

Station depths for the spring and summer cruises are given in Figures 2 and 3, respectively. Fifteen stations had average depths greater than 18 ft and will be considered deep water stations in this report. Ten of these stations were in channel areas to be deepened during the navigation project (stations 1A-10A). Of the remaining deep water stations, four were within existing channels (2C, 3C, 4C, and 5C) and one was in a protected off-channel area (10C). Fifteen stations had average depths less than 18 ft and will be considered shallow water stations. Ten of the shallow water stations were in shoal areas to be deepened during the navigation project (stations 1B-10B). The five remaining shallow water stations were in areas that will not be deepened (stations 1C, 6C, 7C, 8C, and 9C).

a. Temperature

During the spring cruise, bottom temperatures in the study area ranged from 16.6^{o} to 18.7^{o} C (Figure 4). The average temperature for all stations was 17.4^{o} C. Shallow water stations had a slightly higher average temperature (17.9^{o} C) than deep water stations (17.0^{o} C). For the summer cruise, temperatures ranged from 24.6^{o} to 25.8^{o} C and had an overall average of 25.0^{o} C (Figure 5). On average, shallow stations (25.2^{o} C) were again warmer than deep water stations (24.8^{o} C), but the difference was minimal. The observed gradient in temperature with depth during both cruises is expected for a partially mixed estuary. Aside from depth, no other systematic trends in temperature were evident.

b. Salinity

Bottom salinities for the spring cruise ranged from 18.6 to 23.2 ppt (Figure 6) and averaged 21.5 ppt for the entire study area. On the average, shallow stations (20.8 ppt) had slightly lower salinities than deep water stations (22.1 ppt). For the summer cruise, the range in salinity was from 20.5 to 22.5 ppt (Figure 7). The average salinity for all stations was 21.6 ppt. The shallow water stations had an average salinity of 21.1 ppt. This value was slightly lower than the average salinity at the deep water stations (22.0 ppt). Aside from the slight increase in salinity with depth, no other systematic trends were observed.

c. Dissolved Oxygen

Values of dissolved oxygen near the bottom for the spring cruise are given in Figure 9. The range in dissolved oxygen values was from 5.1 to 7.4 ml/l and averaged 6.4 ml/l for the entire study area. Shallow water stations (6.6 ml/l) had a slightly higher average value of dissolved oxygen than deep water stations (6.2 ml/l). During the summer cruise, dissolved oxygen ranged from 5.1 to 7.8 ml/l (Figure 10). The average value for all stations was 6.5 ml/l. Again, shallow stations (6.8 ml/l) had a somewhat higher average value of dissolved oxygen than deep water stations (6.1 ml/l). No other trends in dissolved oxygen were observed.

2. Sediment Characteristics

A total of 30 samples were analyzed for grain size distribution and organic content. Samples were collected during the spring cruise. The results are given in Figures 10-14.

a. Percent Gravel

Gravel content in the surficial sediments ranged from 0 to 98.9% (Figure 10). Gravel was not found at a majority of the stations in the northern half of the study area. High gravel content sediments were restricted to stations in the channel and shoal areas south of the railroad bridge near Bergen Point (stations 7A, 7B, 7C, 8A, 8B, and 10A).

b. Percent Sand

Sand content in the samples analyzed ranged from 0.8 to 95.9% (Figure 11). Percent sand was highest at site 6 and declined both to the north and to the south of this area. The lower half of the study area (sites 6-10) was composed mainly of sand or a mixture of sand and gravel. Exceptions to this were stations 9B, 9C, and 10C, which were located in protected areas, and station 8C. In the northern half of the study area, sand contents exceeded 50% at most shallow stations (2B, 3B, 4B, and 5B) and at some channel stations (2A and 5A). Lowest values of percent sand were found at site 1.

c. Percent Silt

Percent silt in the surface sediments ranged from 0.3 to 55.3% (Figure 12). Silt content was low at a majority of stations in the southern half of the study area (sites 6-10). Exceptions were stations in protected areas (stations 9B, 9C, 10B, and 10C) and station 8C. In the northern part of the study area, percent silt was generally in the range of 25 to 55% except at stations 2A, 4A, 4B, 5A, and 5B.

d. Percent Clay

Percent clay ranged from 0.1 to 82.6% in the samples analyzed (Figure 13). The distribution of clay was similar to silt. Low clay content sediments were characteristic of the southern half of the study area except in protected localities (9B, 9C, 10B, and 10C) and at station 8C. The northern half of the study area (sites 1-5) was characteristically high in clay. Clay content in this region exceeded 15% except at stations 2A, 4B, 5A, and 5B.

e. Percent Organic Content

Organic content in the sediments ranged from 0 to 13.4% (Figure 14). As might be expected there is a relationship between the amount of fine grained material and the organic content in the sediments (Figures 15 and 16). The three outlying stations (3A, 3C, and 4A) in Figures 15 and 16 were characterized in field and laboratory notes as cohesive, red clays. It is likely that the material at these three stations represent exposures of relict Pleistocene deposits.

3. Biological Characteristics

Two replicate grabs at each of the sampling stations were collected and analyzed during both the spring and the summer cruises. From these samples a total of 8018 animals representing 68 taxa were obtained. A composite species list is given in Table 3. Of the 68 taxa, 28 (41%) were Polychaetes, 17 (25%) were Crustacea, and 10 (15%) were Molluscs. The remaining taxa were distributed among six other groups: Cnidaria, Aschelminthes, Rhynchocoela, Oligochaeta, Ectoprocta, and Chordata.

Station and study area summaries are reported in detail in this section. Information on individual grab samples is, however, tabulated in Appendix A. Abundance, species richness, Shannon-Wiener diversity, and equitability results for each sample may be found in Appendix B.

a. Species Composition

In this report, we define a dominant species as one which represents 5% or more of the total number of individuals taken during a cruise. Table 4 lists these species along with some of their life history characteristics.

During the spring cruise, a total of 2564 individuals from 38 taxa were collected. The spionid polychaete Streblospio benedicti was the most abundant species, representing 27% of the total fauna. Other dominants included the spionid Scolecolepides viridis (21%), the soft shelled clam Mya arenaria (15%), the spionid Polydora ligni (12%), a colonial polychaete Sabellaria vulgaris (7%), and the polychaete Nereis succinea (6%). These six species comprised 88% of the total fauna. Streblospio benedicti was the most ubiquitous of the dominant species (Figure 17). It was found at all sites and was absent only from stations 1A, 3A, and 10C. Highest abundances tended to occur at sandy stations. Scolecolepides viridis was restricted mainly to sandy locations and especially at sites 6, 7, and 8 (Figure 18). Mya arenaria was found at muddier sites along the Port Elizabeth Marine Terminal and off of Shooter's Island (Figure 19). The two polychaetes Polydora ligni (Figure 20) and Nereis succinea (Figure 22) had distributions that were similar to Streblospio benedicti. Both of these species were collected at all locations except site 1. Sabellaria vulgaris (Figure 21) was patchily distributed and was abundant at only three stations (6A, 6C, and 9A).

For the summer cruise, a total of 5454 individuals and 50 taxa were identified. The bay barnacle, Balanus improvisus, was the numerically dominant species, representing 24% of the total fauna. Other dominants included the colonial polychaete Sabellaria vulgaris (17%), the spionid polychaete Spio setosa (15%), the soft shelled clam Mya arenaria (14%), the spionid Streblospio benedicti (13%), and the tunicate Molgula manhattensis (5%). These six dominants made up 87% of the fauna by abundance. Balanus improvisus, while numerically the most abundant species, was restricted in its distribution (Figure 23). It was found in high numbers mainly in the shoal areas off of Port Elizabeth Marine Terminal and south of the railroad bridge. The colonial polychaete Sabellaria vulgaris increased its range somewhat between spring and summer, but it was still very patchily distributed (Figure 24). High numbers of this species occured in the cohesive, red clays found at station 4A. Spio setosa was restricted to the sandy areas at sites 6, 7, and 8 (Figure 25). As in the spring cruise, the soft shelled clam, Mya arenaria, was most abundant in the muddier sediments (Figure 26). Streblospio benedicti was again found at all sites and at most stations (Figure 27). However, during the summer cruise, abundances were clearly highest in the southern half of the study area. The tunicate Molgula manhattensis (Figure 28) was very patchily distributed and was collected in high numbers at only 5 stations (4A, 8A, 8B, 9C, and 10A).

The dominant species in the study area are very restricted in terms of many of their life history characteristics (Table 4). All are either suspension feeders, surface deposit feeders, or switch between both modes of feeding. No subsurface deposit feeders were found among the list. Most of the dominant species were sedentary with the exception of Nereis succinea, which is discretely motile. Of the six polychaetes in Table 4, all are tubiculous forms, and curiously four of the six (Polydora ligni, Scolecolepides viridis, Spio setosa, and Streblospio benedicti) belong to the same family, Spionidae. Out of the nine dominants identified, Pearson and Rosenberg (1978) listed five of them as species which are dominant or prominent in areas polluted or enriched by organic material (Nereis succinea, Polydora ligni, Scolecolepides viridis, Streblospio benedicti, and Mya arenaria).

b. Abundance

The spatial pattern in abundance for the spring cruise is given in Figure 29. Average station abundances ranged from 0 to 3375 animals per square meter. The average abundance for the entire study area was 1068 individuals per m^2. Abundances were highest in the southern portion of the study area and tended to gradually decline northward. Five stations had very low abundances ($\leq$ 100 individuals per m^2). These were stations 1A, 1B, 1C, 2C, and 10C. During the summer cruise, abundances increased at a majority of the stations (Figure 30). The overall average abundance for the study area was 2272 individuals per square meter, and station values ranged from 50 to 9663 individuals per m^2. High abundances were again observed at most stations in the southern half of the study area. In addition, five of the six stations at sites 3 and 4 had abundances that exceeded 1000 individuals per m^2. With the exception of two channel stations (2C and 5C), all other sampling locations had abundances greater than 100 individuals per square meter.

c. Species Richness

For the spring cruise, the average number of species per 0.04 m^2 ranged from 0 to 13 at stations within the study area (Figure 31). Aside from two muddy off-channel stations (9C and 10C), values for this parameter were relatively higher in the southern half of the study area and varied between 6 and 13. Species richness generally declined northward, reaching its lowest values at site 1. The overall average value for the spring cruise was 5.7 species per 0.04 m^2. The same basic spatial pattern for this parameter was evident during the summer cruise (Figure 32). However, species richness increased somewhat at most stations, and the average value for the study area was 7.1 species per 0.04 m^2. Values at individual stations averaged from a low of 1 to a high of 16.

d. Shannon-Wiener Diversity

Average Shannon-Wiener diversity values for each station during the spring cruise are given in Figure 33. Diversity appeared to be lowest in the northernmost portion of the study area. Nine of the thirty stations had diversity values less than 1. These included all of the stations at site 1, several channel stations along the Port Elizabeth Marine Terminal (2C, 3A, 4C, and 5C), and two off-channel stations in the southern half of the study area (9C and 10C). Diversity values during this time ranged from 0 to 2.62. In the summer, diversity values at individual stations averaged from a low of 0.30 to a high of 2.52 (Figure 34). There was no evidence of any overall seasonal changes in diversity. This parameter was again lowest in the northernmost portion of the study area. Eight stations had diversity values less than 1. These were stations 1A, 1B, 2A, 2C, 3B, 3C, 5C, and 10A.

e. Equitability

Equitability values for each station during the spring and summer cruises are given in Figures 35 and 36, respectively. In the spring, values averaged from a low of 0 to a high of 0.86, while in the summer, the range was slightly higher varying between 0.10 and 0.92. No particular spatial trends were evident for this parameter.

f. Faunal Associations Among Stations

In this section, the degree of faunal similarity among stations will be examined. The first step in this analysis was to compute similarity values based on the Bray-Curtis index for each pairwise combination of stations. This was done for each cruise using species scores of three types: 1) untransformed abundances, 2) fourth root transformed abundances, and 3) presence-absence data. The results are represented as trellis diagrams (Tables 5-10). In these tables, matrix elements above the diagonal are the similarity values for each pair of stations. These values are expressed as percentages, and the range of possible outcomes is from 0 to 100%. A high index value indicates closely corresponding species scores between a pair of stations. In the matrix elements below the diagonal, the same information is presented, but the index values have been grouped into four classes. Class intervals were determined by dividing the set of results into four approximately equal sized groups based on the frequency distribution of the index values.

The next step in this process was to carry out a cluster analysis on the similarity matrices. Results are given in Figures 37-42. In these figures, station groupings are presented in the form of dendrograms or tree diagrams to illustrate the sequence of clusters formed. The vertical and diagonal lines determine the clusters. Station identification codes are listed at the bottom of the dendrogram. The numbers appearing in parantheses after the station codes are unimportant and simply represent the order in which stations were entered as input. Brackets with roman numerals define clusters of stations. The numbers superimposed on the dendrogram are the similarity values between each pair of stations. The last number in each column is the similarity value between that station and the one immediately to the right, the second number from the bottom is with the second station to the right, etc.

In presenting this analysis, we will concentrate on the results generated by the fourth root transformed abundances since this is the technique most commonly recommended in the numerical ecology literature. Results from clustering untransformed abundances and presence-absence data will be presented as subsidiary analyses to assess the relative contributions of numerically dominant species and overall species composition in forming the observed station associations.

The summer cruise will be discussed first since the results for this cruise are the simplest to interpret. In Figure 41, three station groups are apparent. The largest of these (cluster III) consists of all stations within sites 6, 7, and 8, as well as, stations 5A, 5B, 9A, and 10B. This same set of stations clusters as two closely associated groups both when using untransformed abundances (clusters II and III in Figure 40) and presence-absence data (clusters IV and V in Figure 42). This suggests that the similarities in fauna at these stations are both in terms of numerically abundant species and overall species composition. Most of the stations within this group had sand or sand and gravel contents which exceeded 80%. Of the dominant species present in the study area at this time, Spio setosa was highly abundant and Mya arenaria was conspicuously low or absent from these stations. In addition, Balanus improvisus and Streblospio benedicti reached high abundances at many of these stations.

The second largest group of stations (cluster I) in Figure 41 consisted of stations widely distributed throughout the study area. This group included all stations in site 1 and stations 2A, 2C, 3A, 3C, 5C, 9B, 9C, 10A, and 10C. This set of stations clusters as two groups using untransformed abundances (clusters I and IV in Figure 40) and as a single group with presence-absence data (cluster I in Figure 42). This suggests that the associations are perhaps more strongly based on species composition than in terms of the numerically dominant fauna. Most of the stations in this group are muddy and had silt-clay contents that exceeded 50%. Of the dominant species, Mya arenaria was present at most of the stations in this group, and this species reached its highest abundances at several of these stations (e.g., 1B, 2A, 3C, 9C, and 10A). Balanus improvisus, Sabellaria vulgaris, and Spio setosa were conspicuously low or absent from these stations.

The third group (cluster II) in Figure 41 was composed of five stations distributed along the Port Elizabeth Marine Terminal (2B, 3B, and 4A-C). Using untransformed abundances (Figure 40) and presence-absence data (Figure 42), these stations do not remain together but are distributed among three or four groups. Sediments at these stations were variable. Three of the stations had a sand content of about 50% (2B, 3B, and 4C). For the remaining two stations, one (4B) had about 74% sand while the other was 83% clay. Balanus improvisus and Mya arenaria were present at all of these stations. Spio setosa, and Streblospio benedicti, on the other hand, were low or absent. Overall this group appears to be a transitional assemblage between sandy (cluster III in Figure 41) and muddy (cluster I in Figure 41) stations.

For the spring cruise, the results of the cluster analysis were somewhat more complicated. In Figure 38, the clustering based on fourth root transformed abundances are presented, and seven station groups are apparent. The largest of these (cluster IV) is composed of all stations within sites 6, 7, and 8, as well as, stations 4A, 5A, 5B, and 10A. This set of stations clusters as two closely associated groups when using untransformed abundances (clusters III and IV in Figure 37) and primarily as a single group with presence-absence data (cluster V in Figure 39). This suggests that the associations are more strongly based on species composition. The stations within this group correspond closely with the sand assemblage identified for the summer cruise, and like that assemblage, sand contents exceeded 80% at most stations. Of the dominant species, Streblospio benedicti, Polydora ligni, and Nereis succinea were present at all of the stations in this group. Scolecolepides viridis was highly abundant while Mya arenaria was conspicuously low or absent from these stations.

The second largest group of stations (cluster III) in Figure 38 was composed of stations located just to the north and south of the first assemblage. Stations in this group included 2A, 2B, 3B, 4B, 4C, 10B, and all of site 9. This set of stations does not remain together when clustering is carried out on untransformed abundances (Figure 37) but are distributed among four groups (clusters II, III, IV, and V). On the other hand, this group appears as a single cluster (cluster IV in Figure 39) based on presence-absence data. This strongly suggests that station associations for this group are based on species composition. Most of the stations within this group had sand contents which ranged from 40 to 80%. Like the sand assemblage already identified (cluster IV in Figure 38), Streblospio benedicti, Polydora ligni, and Nereis succinea were present at all stations in this group. However, Scolecolepides viridis was low or absent, while Mya arenaria was abundant at these stations.

At this stage of the clustering in Figure 38, a number of groups consisting of from one to three stations are added at progressively lower levels of similarity (clusters I, II, V, VI, and VII). All of these stations had silt-clay contents that exceeded 60%. In addition, these stations are characterized by very low abundances (0 to 213 animals per m^2) and species richness values (0 to 3 species per 0.04 m^2).

Discussion

1. Relationships Between the Benthic Fauna and Environmental Factors

Perhaps the most surprising finding in this study concerns the state of the benthic fauna in Newark Bay. Abundances averaged 1068 individuals per m^2 in spring and 2272 per m^2 in summer. Table 11 compares these results to several nearshore environments. Abundances in the current study were higher than that found in many local areas including Raritan Bay, Flushing Bay, Bowery Bay, and the Lower Bay of New York Harbor. In addition, a total of 68 taxa were found during the two cruises (Table 3). This is over four times greater than any single prior benthic study in Newark Bay, and almost double the number found in all of the earlier studies combined (Table 1). The general conclusion from this information is that the benthos in Newark Bay is much more productive and diverse than has been considered in the past. Whether this is a result of limited sampling in earlier studies or represents a real temporary or long term increase cannot be assessed on the basis of only two seasonal cruises.

The benthic fauna, however, does show some signs of stress. The numerically dominant species were very restricted in terms of many of their life history characteristics. All were suspension and/or surface deposit feeders, and they were primarily sedentary organisms. Six of the nine dominant species were tubiculous polychaetes, and four of these belonged to the same polychaete family (Spionidae). The majority of the dominant species found have been listed by Pearson and Rosenberg (1978) as being characteristic of areas polluted or enriched by organic material.

Temperature, salinity, and dissolved oxygen values were fairly homogeneous throughout the study area, and no spatial gradients were evident. As expected for a partially mixed estuary, a slight gradient with depth was observed for these parameters. The small differences observed would not be a major factor in structuring the benthic community. Dissolved oxygen values measured during the two cruises were high at all stations sampled.

The hypothesis concerning the decline in the benthos with depth proposed by the U.S. Fish and Wildlife Service (1976) was based on the limited data available at that time. This hypothesis can be tested using the data from the present study. To do this, a series of Mann-Whitney U-Tests were run on abundance, species richness, diversity, and equitability results. Sampling stations were divided into two groups according to average depth: shallow (< 18 ft) and deep (> 18 ft). The fifteen stations in each group are identified at the beginning of the results section. Statistical tests were performed independently on the results of both the spring and the summer cruises. No significant differences between deep and shallow stations were found for any of the biological parameters on either cruise. It appears, therefore, that the benthic fauna is not currently distributed along depth gradients.

On the other hand, a distinct relationship was observed between the benthic fauna and the distribution of sediments. Cluster analyses suggest the presence of a faunal assemblage associated with stations that have a high sand and gravel content (>80%) in the surficial sediments. These stations cluster strongly using data from both the spring and the summer cruises. Faunal assemblages in less sandy areas were more variable between the two cruises. Stations with high silt-clay contents (>60%) had low abundance and species richness values in the spring and were distinctly different from the remaining stations based on the cluster analysis. However, differences between these stations and moderately sandy stations (40-80% sand) were not evident in the cluster analysis results for the summer cruise. Overall, the available information suggests that areas with high silt-clay sediments are characterized by a temporally variable benthic fauna, and these areas are probably more stressed relative to other locations in the Bay.

To examine animal-sediment relationships further, Mann-Whitney U-Tests were carried out on abundance, species richness, diversity, and equitability results. Stations were divided into two groups based on sediment type: sandy (>50% sand and gravel) and muddy (>50% silt-clay). Significant differences were found in terms of abundance, species richness, and diversity for both cruises. The results for equitability were nonsignificant. Sandy stations had significantly higher abundance, species richness, and diversity values.

2. Trophic Relationships

The dominant benthic fauna in the study area are either epifaunal or through their feeding activities maintain an association with the sediment surface. This suggests that much of the benthos represents a potential food resource for higher trophic levels. In recent shallow water (U.S. Fish and Wildlife Service, 1985) and deep water (Peter Woodhead, Marine Sciences Research Center, personal communication) surveys, the three finfish species collected in the greatest numbers were the Atlantic tomcod, bay anchovy, and winter flounder. Two of these (Atlantic tomcod and winter flounder) feed on benthic prey. Of the 42 species collected in the Newark Bay area during the two finfish surveys, half are bottom-feeders. These include the common carp, adult Atlantic cod, red hake, white hake, silver hake, Atlantic tomcod, black sea bass, bluegill, scup, weakfish, northern kingfish, tautog, rock gunnel, northern searobin, striped searobin, grubby, smallmouth flounder, fourspot flounder, windowpane flounder, winter flounder, and hogchoker. Berg and Levinton (1984) in their recent review of the Hudson-Raritan Estuary note that benthic feeding finfish are noticeably less abundant in the Lower Bay than in comparable areas such as Delaware Bay or Narragansett Bay. This condition does not seem to apply to Newark Bay.

In addition to finfish, a number of other predators are found in Newark Bay. Mobile, epibenthic, invertebrate predators have been documented in a number of studies (e.g., Anselmi, 1974; U.S. Army Corps of Engineers, 1980; McCormick and Koepp, 1978; Cerrato and Bokuniewicz, 1985; and U.S. Fish and Wildlife Service, 1985). These include shrimps such as Crangon septemspinosa and Palaeomonetes pugio, the mud crabs Rhithropanopeus harrisi and Neopanopus texana, and the blue crab Callinectes sapidus. The benthic fauna in shallow water would also be accessible to the wide variety of waterfowl and shore birds that occur in the area. Overall, a substantial number of predators are found in the Bay and utilize the benthos as a food resource.

3. Potential Impacts of the Proposed Navigation Project

In a recent study, the U.S. Army Corps of Engineers (1986) produced quantitative estimates of the rate of shoaling in Newark Bay channels under existing conditions. Fourteen stations in the present benthic survey are located within reaches included in the Army Corps report. A tabulation of abundance, species richness, and diversity results for these stations along with estimated shoaling rates are given in Table 12. Note that on the average, stations with shoaling rates which exceed one inch per year had substantially lower abundance, species richness, and diversity values. Most of these stations had silt-clay contents above 50% and are representative of the muddiest stations in the study area.

In the same Army Corps study, predictions were made for shoaling rates on completion of the navigation project. According to the results of their study, shoaling rates will increase in all reaches, and the largest increases will occur in the Newark Bay South and Middle Reaches. If dredging results in channel depths of 45 ft below MLW, shoaling rates in the Newark Bay South and Middle Reaches are estimated to double from the current estimate of 105,500 cy/year to 211,000 cy/year. Shoaling rates in inches per year within these two reaches would increase by less than a factor of two since the navigation project will result in a net increase in channel area. Newark Bay South Reach is currently shoaling at a rate of less than 1 inch per year. An increase in the rate of shoaling to greater than 1 inch per year could alter the silt-clay content in the surficial sediments and, as suggested by Table 12, could potentially result in a decline in the benthos in this reach.

Other reaches in the project area show lower projected increases in shoaling rates. Predicted increases in Port Newark Channel and Port Elizabeth Channel are about 50% for channel depths at 45 ft below MLW. However, shoaling rates in these channels, as well as, in Newark Bay Middle Reach are already above one inch per year (Table 12). It is possible that increased shoaling could result in a further decline in an already low benthos in these areas.

Potential impacts of the navigation project on non-channel areas are more difficult to assess. On the one hand, one would expect reduced current velocities in non-channel areas as a result of deepening and widening existing channels. Differences in water quality parameters between deep and shallow stations were small, and no gradients in the benthic fauna were found with depth. These results suggest that environmental conditions within and outside of channels are very similar in a given area. Based on this observation, the potential for a decline in the benthos at non-channel areas exists. On the other hand, a deeper and wider channel may be a more effective trap for fine grained sediments. Increases in shoaling rates within channels may lead to a reduction in shoaling in non-channel areas. In this case, non-channel areas may not be impacted, and the benthos in some areas may even increase as a result of the navigation project. Information on existing shoaling rates in non-channel areas and predictions of conditions on completion of the navigation project are not included in the current Army Corps report. Such information, if presented on a site specific basis, would be very useful in assessing whether changes in the benthos would occur in non-channel areas.

Any substantial shift to higher silt-clay contents in the surficial sediments would be accompanied by a decline in the benthos. Based on the observed relationship between the benthic fauna and sediment type, muddier sediments will result in lower abundance, species richness, and diversity values. In areas characterized by such a shift, most of the dominant species would decline with the possible exception of *Mya arenaria*. The benthos in these areas would also tend to be more variable on a seasonal basis.

Summary

This report presents the results of a seasonal benthic survey conducted in Newark Bay. A total of 120 biological and 30 sediment samples were collected along with water quality parameters during May and August 1985. Biological data were analyzed in terms of species composition, abundance, species richness, Shannon-Wiener diversity, and equitablilty. In addition, faunal similarity among sampling stations was examined using cluster analysis. The principal results and conclusions of this study were:

1) Temperature, salinity, and dissolved oxygen values were fairly homogeneous throughout the study area, and no spatial gradients were evident. As expected for a partially mixed estuary a small gradient with depth was observed for these parameters.

2) Surficial sediments were quite variable. Stations located just below the railroad bridge and off of Bergen Point were composed mainly of sand or a mixture of sand and gravel. Sand content in the sediments declined both to the north and to the south of this area.

3) A total of 8018 animals representing 68 distinct taxa were obtained from the biological samples. Dominant species included Nereis succinea, Sabellaria vulgaris, Polydora ligni, Scolecolepides viridis, Spio setosa, Streblospio benedicti, Balanus improvisus, Mya arenaria, and Molgula manhattensis. All dominants were suspension and/or surface deposit feeders, and they were primarily sedentary forms.

4) Benthic abundances averaged 1068 animals per m^2 in the spring and 2272 individuals per m^2 for the summer. Average values of species richness during the spring and summer were 5.7 and 7.1 species per 0.04 m^2, respectively.

5) The results of this study suggest the presence of a much more productive and diverse benthic fauna than indicated in prior surveys of Newark Bay.

6) No apparent relationship was found to exist between the benthic fauna and either depth or water quality parameters.

7) A distinct relationship was observed between the benthic fauna and sediment type. Cluster analyses suggested the presence of a faunal assemblage associated with stations that had a sand and gravel content that exceeded 80%. This assemblage appeared to be relatively more stable than the benthos in muddier areas. Based on Mann-Whitney U-Tests, sandy areas (>50% sand and gravel) had significantly higher abundance, species richness, and diversity values than muddy areas (>50% silt-clay) during both spring and summer.

8) Of the 42 species collected in the Newark Bay area during recent finfish surveys, half were found to be bottom-feeders. In addition to finfish, a number of other benthic predators including shrimp, crabs, waterfowl, and shore birds also occur in the area. In the present benthic study, dominant species represented 87-88% of the total number of individuals collected. All dominants were either epifaunal or maintained contact with the sediment surface through their feeding activities. Much of the benthos, therefore, represents a food resource for higher trophic levels.

9) Based on a shoaling analysis by the U.S. Army Corps of Engineers, the

navigation project may increase shoaling rates within channels by as much as 61%. Estimates for non-channel areas were not provided in their report. Analysis of the benthic data suggests that a decline in the benthos would occur in areas which would become muddier as a result of the navigation project.

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Table 1. Benthic Invertebrates Documented in Prior Studies of Newark Bay.

	1972[1]	1973[1]	1976[2]	1976[3]	1984[4]
OLIGOCHAETA					
Lumbriceulus variegatus	X				
Limnodrilus sp.	X	X			
unidentified oligochaete			X		
POLYCHAETA					
Nereis arenacedonta	X	X	X		
Nereis succinea					X
Nereis virens					X
Nereis sp.				X	X
Streblospio benedicti			X		X
Capitellidae sp.					X
Paraonidae sp.					X
Eteone heteropoda					X
unidentified polychaete			X		
HIRUDINEA					
unidentified leech		X			
ASCHELMINTHES					
unidentified nematod			X	X	
RHYNCHOCOELA					
unidentified nemertean					X
GASTROPODA					
Ilynassa obsoleta	X	X		X	
BIVALVIA					
Congera leucopheata	X	X			
Macoma balthica	X	X		X	X
Mulinia lateralis	X	X			X
Mya arenaria	X			X	X
Tellina agilis			X		
Mytilus edulis			X		
CRUSTACEA					
Balanus balanoides	X				
Balanus improvisus	X			X	
Balanus sp.			X		
Cyathuria polita	X	X	X	X	
Crangon septemspinosa	X			X	
Rhithropanopeus harrisi	X	X		X	X
Palaemonetes pugio		X		X	
Callinectes sapidus				X	
Chiriditea alymra		X			
Neopanopus texana			X		
Caprellidea sp.					X
Thoracica sp.					X
Neomysis americana					X
CHORDATA					
Molgula manhattensis				X	

References:

1. Amselmi (1974)
2. U.S. Army Corps of Engineers (1980)
3. McCormick and Koepp (1978)
4. Cerrato and Bokuniewicz (1985)

Table 2. Station Locations

STATION	LATITUDE	LONGITUDE
1A	40 41'11.5"	74 08'16.4"
1B	40 41'10.4"	74 08'14.8"
1C	40 41'10.4"	74 08'11.0"
2A	40 40'29.5"	74 08'02.5"
2B	40 40'30.0"	74 08'09.8"
2C	40 40'27.0"	74 08'17.4"
3A	40 40'15.6"	74 08'11.0"
3B	40 40'16.0"	74 08'18.0"
3C	40 40'22 0"	74 08'20.4"
4A	40 39'53.4"	74 08'20.4"
4B	40 39'54.8"	74 08'29.2"
4C	40 39'59.0"	74 08'38.0"
5A	40 39'42.2"	74 08'27.5"
5B	40 39'45.6"	74 08'37.2"
5C	40 39'45.0"	74 08'45.0"
6A	40 39'11.2"	74 08'51.0"
6B	40 39'13.2"	74 08'54.4"
6C	40 39'11.4"	74 08'58.2"
7A	40 39'01.2"	74 08'58.0"
7B	40 39'04.5"	74 09'04.0"
7C	40 39'02.5"	74 09'08.0"
8A	40 38'53.8"	74 09'04.0"
8B	40 38'56.5"	74 09'10.2"
8C	40 38'54.6"	74 09'16.8"
9A	40 38'38.4"	74 09'16.6"
9B	40 38'34.8"	74 09'19.5"
9C	40 38'30.0"	74 09'18.8"
10A	40 38'46.2"	74 09'00.8"
10B	40 38'46.4"	74 08'55.4"
10C	40 38'54.2"	74 08'49.5"

Table 3. Species List - May and August 1985

- CNIDARIA
  - ANTHOZOA
    - METRIDIIDAE
      - Metridium senile
  - HYDROZOA
    - HYDRACTINIIDAE
      - Hydractinia sp.
    - TUBULARIIDAE
      - Tubularia sp.
- ASCHELMINTHES
  - Nematoda sp.
- RHYNCHOCOELA
  - Nemertea sp.
- ANNELIDA
  - OLIGOCHAETA
    - Oligochaeta sp.
  - POLYCHAETA
    - AMPHARETIDAE
      - Asabellides oculata
    - CAPITELLIDAE
      - Capitella capitata
      - Capitellidae sp.
    - CIRRATULIDAE
      - Tharyx acutus
    - GLYCERIDAE
      - Glycera americana
      - Glycera capitata
      - Glycera dibranchiata
      - Glycera sp.
    - MAGELONIDAE
      - Magelona rioja
    - MALDANIDAE
      - Clymenella sp.
      - Maldanidae sp.
    - NEPHTYIDAE
      - Nephtys incisa
      - Nephtys sp.
    - NEREIDAE
      - Nereis succinea
      - Nereis sp.
    - PECTINARIIDAE
      - Pectinaria gouldii
    - PHYLLODOCIDAE
      - Eteone heteropoda
    - POLYNOIDAE
      - Harmothoe extenuata
      - Lepidonotus squamatus
      - Polynoidae sp.
    - SABELLARIIDAE
      - Sabellaria vulgaris
    - SABELLIDAE
      - Fabricia sabella
    - SERPULIDAE
      - Hydroides dianthus
    - SPIONIDAE
      - Polydora ligni
      - Scolelepis squamata
      - Scolecolepides viridis
      - Spio setosa
      - Streblospio benedicti
- ARTHROPODA
  - CRUSTACEA
    - CIRRIPEDIA
      - BALANIDAE
        - Balanus improvisus
        - Balanus sp.
    - CAPRELLIDEA
      - CAPRELLIDAE
        - Caprella sp.
    - CUMACEA
      - Oxyurostylis smithi
    - AMPHIPODA
      - AORIDAE
        - Lembos smithi
        - Unciola irrorata
      - COROPHIIDAE
        - Corophium acherusicum
        - Corophium sp.
        - Erichthonius brasiliensis
        - Corophiidae sp.
      - MELITIDAE
        - Melita nitida
        - Melitidae sp.
    - ISOPODA
      - ANTHURIDAE
        - Cyathura polita
      - IDOTEIDAE
        - Edotea montosa
    - MYSIDACEA
      - MYSIDAE
        - Neomysis americana
    - DECAPODA
      - CRANGONIDAE
        - Crangon septemspinosa
      - XANTHIDAE
        - Rhithropanopeus harrisii
- MOLLUSCA
  - GASTROPODA
    - CALYPTRAEIDAE
      - Crepidula plana
    - NASSARIIDAE
      - Ilyanassa obsoletata
      - Nassarius trivittata
  - BIVALVIA
    - MACTRIDAE
      - Mulinia lateralis
      - Spisula solidissima
    - MYIDAE
      - Mya arenaria
    - MYTILIDAE
      - Mytilus edulis
    - OSTREIDAE
      - Crassostrea virginica
    - SOLENIDAE
      - Ensis directus
    - TELLINIDAE
      - Tellina agilis
- ECTOPROCTA
  - GYMNOLAEMATA
    - CHEILOSTOMATA
      - CALLOPORIDAE
        - Callopora sp.
      - ELECTRIDAE
        - Electra sp.
      - MEMBRANIPORIDAE
        - Conopeum reticulum
        - Membranipora tenuis
        - Membranipora sp.
    - CTENOSTOMATA
      - VESICULARIDAE
        - Bowerbankia sp.
- CHORDATA
  - ASCIDIACEA
    - PLEUROGONA
      - MOLGULIDAE
        - Molgula manhattensis

Table 4. Some Life History Characteristics of the Dominant Species.

	Feeding Type	Relative Mobility	Life Habit	Sediment Preference
Nereis succinea	SDF	Discretely Motile	Infaunal,Tubiculous	Sandy Mud
Sabellaria vulgaris	SF	Sedentary	Colonial, forms thick tube mats	Hard Substrate, Shell, or Gravel
Polydora ligni	SF,SDF	Sedentary	Infaunal,Tubiculous	Mud,Clay
Scolecolepides viridis	SF,SDF	Sedentary	Infaunal,Tubiculous	Mud
Spio setosa	SF,SDF	Sedentary	Infaunal,Tubiculous	Sand
Streblospio benedicti	SF,SDF	Sedentary	Infaunal,Tubiculous	Sand
Balanus improvisus	SF	Sedentary	Epifaunal	Hard Substrate
Mya arenaria	SF	Sedentary	Infaunal	Mud
Molgula manhattensis	SF	Sedentary	Epifaunal	Hard Substrate

Feeding Types: SF=Suspension Feeder
SDF=Surface Deposit Feeder

References: Gosner (1979), Fauchild and Jumars (1979)

Table 5. Trellis Diagram of Bray-Curtis Similarity Values Based on Untransformed Abundances for the Spring Cruise.

Key:

0 - 7%

8 - 20%

21 - 37%

38 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1B			36	9	18	40	0	32	48	23	8	23	20	13	61	11	13	6	10	12	8	6	26	29	8	17	5	10	33	0
1C				3	8	60	0	10	20	11	6	11	6	5	22	3	3	2	3	5	3	2	7	9	3	8	3	11	16	0
2A					59	5	15	36	12	13	32	53	52	27	18	29	45	18	26	45	37	17	29	33	32	26	46	10	32	1
2B						13	15	48	26	26	18	44	82	38	33	39	63	17	31	64	44	18	51	57	16	26	11	15	45	3
2C							19	19	25	20	11	16	12	10	36	5	5	4	4	8	5	3	13	17	6	15	5	10	29	0
3A								44	0	9	20	32	8	3	35	4	0	7	0	0	0	2	3	7	10	25	13	0	46	0
3B									45	36	37	67	47	32	55	28	25	21	21	27	19	16	49	61	23	49	20	18	83	5
3C										45	23	23	38	23	50	22	22	12	14	22	15	9	46	53	16	33	7	35	47	11
4A											53	22	36	55	32	44	29	18	17	39	36	15	45	40	28	65	9	72	39	4
4B												46	21	43	20	35	15	21	9	30	33	13	20	22	43	69	27	49	38	2
4C													40	27	41	24	23	18	19	24	17	14	39	47	35	42	38	9	61	4
5A														43	34	48	63	19	34	61	44	21	63	69	18	29	9	25	42	3
5B															17	57	46	28	39	54	61	27	61	48	32	55	6	53	30	2
5C																17	15	11	11	13	9	9	32	40	14	29	12	12	57	13
6A																	61	53	47	55	43	38	55	43	51	38	6	41	24	1
6B																		35	54	71	54	36	56	42	26	21	5	22	21	2
6C																			43	27	19	43	27	21	58	21	8	18	20	1
7A																				36	28	69	44	33	19	13	4	18	17	1
7B																					68	27	54	46	29	37	4	40	27	2
7C																						20	37	31	23	36	3	36	17	1
8A																							29	23	19	14	4	13	12	1
8B																								80	29	31	7	38	44	4
8C																									19	37	8	33	54	5
9A																										36	26	27	26	1
9B																											20	57	53	3
9C																												4	21	1
10A																													23	4
10B																														6
10C																														

Table 6. Trellis Diagram of Bray-Curtis Similarity Values Based on Fourth Root Transformed Abundances for the Spring Cruise.

Key:

0 - 22%

23 - 40%

41 - 55%

56 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1B			58	13	19	37	0	25	31	26	13	28	19	21	42	19	27	13	24	21	19	15	29	20	16	17	26	22	20	0
1C				16	34	62	0	29	30	29	23	51	23	24	41	14	20	14	18	24	21	12	22	24	18	26	31	22	37	0
2A					51	17	28	50	27	32	47	50	58	42	30	42	34	43	41	35	38	38	37	44	40	41	56	34	50	9
2B						35	26	55	46	63	49	76	74	61	42	50	55	46	40	59	49	37	65	64	50	60	57	46	70	13
2C							38	31	22	32	26	50	24	26	48	15	12	16	11	19	17	13	23	25	20	33	32	20	39	0
3A								35	0	11	20	32	21	9	27	8	0	13	0	0	0	6	9	12	14	26	37	0	30	0
3B									47	49	63	66	59	47	53	43	31	39	30	34	36	41	43	55	39	67	69	34	70	17
3C										51	35	44	58	36	57	45	58	32	38	37	39	33	56	51	39	44	41	49	50	24
4A											57	52	64	66	44	56	58	49	42	55	60	48	67	58	54	58	41	53	56	11
4B												49	55	59	37	49	36	51	29	44	61	42	43	45	65	68	49	50	60	8
4C													65	49	59	39	42	37	39	42	38	32	53	59	41	54	72	32	74	20
5A														58	52	62	65	50	49	56	57	52	71	74	52	61	53	54	67	13
5B															28	66	59	60	57	72	78	53	71	65	64	57	35	65	55	9
5C																32	33	24	22	20	24	27	45	41	29	37	55	28	45	32
6A																	66	76	58	65	64	72	73	63	64	43	32	63	48	8
6B																		56	66	68	64	56	74	60	55	39	32	52	40	11
6C																			53	56	58	68	56	48	64	47	30	57	49	5
7A																				59	55	62	58	51	43	30	30	54	39	10
7B																					79	54	72	65	56	53	27	65	53	9
7C																						52	66	59	59	48	25	66	52	8
8A																							54	49	46	45	27	47	37	6
8B																								79	58	49	42	69	58	12
8C																									48	58	47	57	69	14
9A																										52	34	62	53	6
9B																											51	47	68	11
9C																												23	63	18
10A																													49	11
10B																														14
10C																														

Table 7. Trellis Diagram of Bray-Curtis Similarity Values Based on Presence-Absence Data for the Spring Cruise.

Key:

- 0 - 27%
- 28 - 49%
- 50 - 61%
- 62 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1B			50	17	20	33	0	25	25	29	18	29	22	31	33	27	40	19	33	33	31	22	36	25	25	18	33	31	22	0
1C				17	40	67	0	25	25	29	36	57	22	31	33	13	20	19	17	33	31	11	18	25	25	36	33	31	44	0
2A					44	29	29	50	38	36	53	53	59	48	43	43	33	41	50	30	38	38	42	50	50	42	57	48	47	18
2B						50	17	57	57	70	59	77	67	74	50	57	50	52	44	67	53	42	71	71	64	71	67	63	80	22
2C							50	40	20	38	46	67	36	40	50	24	17	26	14	29	27	20	31	40	33	46	50	27	55	0
3A								20	0	13	15	22	18	13	25	12	0	9	0	0	0	10	15	20	11	15	25	0	18	0
3B									50	56	80	73	62	59	60	53	43	40	38	38	47	55	53	67	40	67	80	35	62	29
3C										56	53	55	77	47	60	63	86	48	50	50	59	45	67	67	60	53	60	59	62	29
4A											67	59	63	70	50	64	60	58	45	55	70	57	67	56	62	57	50	61	63	15
4B												71	63	70	62	55	47	57	42	42	70	56	56	53	61	67	62	60	63	20
4C													67	63	67	44	46	42	40	53	50	38	57	73	53	71	89	50	83	33
5A														56	73	70	67	54	59	47	56	61	75	77	57	63	73	67	71	25
5B															40	67	53	67	57	67	73	52	70	59	72	60	53	73	67	17
5C																47	50	35	29	29	40	40	62	60	44	46	75	40	55	40
6A																	67	81	52	61	67	69	82	63	67	45	47	75	60	14
6B																		59	67	67	63	58	71	57	64	47	50	63	53	22
6C																			55	62	67	69	64	48	67	50	35	73	54	10
7A																				60	57	54	53	50	50	42	43	67	47	18
7B																					76	46	74	63	58	53	43	76	71	18
7C																						52	70	59	64	50	40	82	67	17
8A																							56	45	47	56	40	52	43	12
8B																								80	70	56	62	80	75	20
8C																									50	67	80	59	92	29
9A																										52	44	72	57	13
9B																											62	50	75	20
9C																												40	73	40
10A																													67	17
10B																														25
10C																														

Table 8. Trellis Diagram of Bray-Curtis Similarity Values Based on Untransformed Abundances for the Summer Cruise.

Key:

0 - 5%

6 - 10%

11 - 24%

25 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		9	46	9	21	59	38	2	7	1	2	4	11	30	27	11	6	3	5	5	8	4	17	8	6	49	7	1	9	51
1B			15	72	18	3	12	4	56	2	13	35	15	11	7	3	3	1	3	2	4	2	6	6	3	7	39	23	8	7
1C				13	41	35	38	3	8	1	4	8	14	16	27	7	5	2	3	3	6	3	9	6	4	24	5	1	7	23
2A					15	0	14	3	37	2	12	40	15	10	5	2	2	1	2	1	2	2	3	5	2	6	25	14	7	7
2B						17	43	9	6	3	11	27	15	32	27	16	8	5	2	8	13	5	18	11	7	13	5	3	12	19
2C							38	0	6	1	1	0	6	21	40	9	3	2	3	3	7	3	14	5	4	28	5	1	5	40
3A								2	7	2	4	10	22	27	43	10	5	3	4	4	8	4	15	7	5	20	5	2	7	47
3B									3	4	76	18	6	16	1	12	26	66	2	86	41	4	5	23	6	2	2	2	32	2
3C										2	10	26	9	11	4	6	3	3	3	2	4	4	6	8	6	8	72	46	9	6
4A											11	11	9	6	1	8	3	6	5	4	4	9	10	4	16	1	11	7	5	2
4B												43	25	22	2	21	28	54	9	71	44	12	7	26	19	4	9	7	37	5
4C													49	41	2	35	14	13	11	17	21	15	11	19	23	7	17	11	26	9
5A														34	9	40	17	13	21	17	22	24	35	20	28	15	8	4	14	23
5B															11	41	21	15	9	21	31	14	38	23	20	30	14	7	29	38
5C																4	1	1	2	1	4	2	5	3	2	12	3	1	3	21
6A																	38	32	29	31	44	35	44	43	42	25	7	3	30	27
6B																		32	54	39	56	27	23	55	55	17	4	2	72	12
6C																			15	73	38	17	16	28	23	9	4	2	32	8
7A																				14	20	49	15	57	51	13	4	1	37	10
7B																					53	16	21	34	20	10	3	1	40	12
7C																						27	31	53	23	9	5	2	52	13
8A																							25	55	30	6	8	5	12	9
8B																								25	28	20	27	15	17	26
8C																									29	21	8	3	46	14
9A																										17	8	4	51	13
9B																											8	2	26	48
9C																												50	8	7
10A																													4	2
10B																														16
10C																														

Table 9. Trellis Diagram of Bray-Curtis Similarity Values Based on Fourth Root Transformed Abundances for the Summer Cruise.

Key:

0 - 22%

23 - 33%

34 - 45%

46 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		42	41	35	26	42	42	14	34	21	21	17	27	25	46	12	16	7	17	9	10	13	14	19	11	46	36	22	21	33
1B			49	71	57	17	39	30	54	29	41	45	34	26	30	18	23	15	16	19	22	20	23	27	19	25	51	50	31	29
1C				30	44	26	33	21	31	19	22	18	26	19	34	16	24	10	18	13	14	16	17	23	13	32	31	11	22	24
2A					34	0	32	31	45	20	35	42	27	18	19	13	17	8	12	10	12	14	16	23	12	16	49	48	22	22
2B						28	56	47	31	39	42	48	29	45	38	36	36	28	15	31	40	29	37	36	27	22	38	35	42	34
2C							48	0	27	13	8	0	14	23	62	19	9	11	9	9	17	13	23	14	10	29	28	13	11	36
3A								21	32	29	28	32	37	44	56	30	25	18	19	18	27	26	35	29	22	33	40	32	28	61
3B									23	32	63	50	34	42	11	30	41	32	19	39	44	31	28	41	31	19	29	33	40	23
3C										26	38	42	29	35	32	25	20	19	20	14	21	33	27	31	24	33	67	54	31	25
4A											44	45	38	42	24	47	31	44	32	36	37	46	39	32	50	12	37	30	41	36
4B												75	48	50	15	36	44	41	32	47	42	44	32	47	44	22	43	41	55	36
4C													42	42	9	39	37	37	30	44	43	43	25	37	39	17	40	41	51	27
5A														60	26	59	57	38	52	50	41	58	52	51	44	40	42	30	50	49
5B															26	53	56	46	34	48	46	50	59	53	49	45	49	49	56	49
5C																22	12	8	17	6	19	20	17	22	12	34	31	23	20	39
6A																	57	63	56	60	56	69	61	56	46	26	31	24	57	48
6B																		58	49	69	63	59	51	59	46	33	25	20	56	35
6C																			48	70	57	54	47	48	54	21	24	20	52	30
7A																				51	35	60	38	56	53	34	21	11	51	39
7B																					65	57	51	53	50	26	19	15	57	34
7C																						51	47	53	35	17	26	21	51	26
8A																							56	63	60	31	37	29	59	44
8B																								50	48	32	50	35	46	34
8C																									51	36	44	33	63	37
9A																										29	33	27	54	33
9B																											43	30	47	30
9C																												61	40	34
10A																													30	32
10B																														38
10C																														

Table 10. Trellis Diagram of Bray-Curtis Similarity Values Based on Presence-Absence Data for the Summer Cruise.

Key:

0 - 32%

33 - 43%

44 - 55%

56 - 100%

	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9A	9B	9C	10A	10B	10C
1A		50	44	29	33	40	44	17	40	35	24	14	27	29	57	12	25	10	22	11	13	18	15	19	16	57	36	18	24	31
1B			73	67	71	29	55	43	50	42	42	38	47	38	44	32	44	26	30	30	35	33	40	35	30	44	62	31	42	40
1C				40	53	25	33	27	46	30	30	24	33	24	40	20	42	17	29	19	22	24	25	33	21	40	43	14	30	25
2A					46	0	40	46	36	33	33	40	38	27	25	22	35	18	21	21	25	26	29	27	23	25	50	33	33	29
2B						36	67	44	50	52	43	50	38	50	46	43	45	37	25	33	48	43	53	44	39	31	59	47	43	42
2C							50	0	44	25	13	0	14	31	67	25	13	20	12	12	29	19	33	20	17	33	40	20	13	33
3A								27	46	50	40	47	44	59	60	40	42	33	29	29	44	40	50	42	36	40	57	43	40	63
3B									38	43	70	60	48	40	15	35	45	37	33	42	38	50	42	44	52	31	47	47	43	32
3C										38	38	44	42	44	55	38	40	32	36	27	42	46	35	40	34	55	67	40	38	35
4A											50	48	54	56	44	64	52	50	48	41	54	67	50	50	61	22	45	36	57	58
4B												72	62	56	22	43	59	50	41	55	54	61	50	50	61	33	45	45	64	50
4C													52	55	13	48	58	48	38	54	61	60	38	41	48	27	42	42	64	38
5A														70	38	62	72	47	59	59	50	71	55	60	53	50	60	40	69	55
5B															40	56	67	48	38	46	52	60	57	55	61	53	63	63	64	57
5C																33	24	18	32	11	38	35	29	36	23	50	50	33	33	43
6A																	67	81	69	69	69	79	67	63	56	22	45	36	71	58
6B																		58	57	71	56	69	61	58	57	35	48	38	59	52
6C																			61	61	60	70	57	56	60	18	38	31	63	50
7A																				60	44	71	40	61	54	32	35	17	62	56
7B																					67	71	64	55	54	21	35	26	62	48
7C																						65	64	53	47	25	50	40	68	36
8A																							62	70	78	35	52	44	79	62
8B																								57	56	29	56	44	58	40
8C																									65	36	62	46	69	50
9A																										31	47	40	67	50
9B																											67	50	44	29
9C																												63	55	44
10A																													45	44
10B																														50
10C																														

Table 11. Abundances of Benthic Invertebrates Compared to Some Local Nearshore Environments.

	Mean Abundance (#/m^2)	Reference
Current Study		
Spring	1,068	
Summer	2,272	
Raritan Bay	795	Cerrato and Bokuniewicz (1985)
Newark Bay (Shoal off Port Newark Terminal)	273	" "
Flushing Bay	590	" "
Bowery Bay	127	" "
New York Harbor		
West Bank	536	Cerrato and Scheier (1983)
Old Orchard Shoal	400	Gandarillas and Brinkhuis (1981)
Romer Shoal	400	" "
East Bank	250	" "
East Bank	5,406	Woodward and Clyde (1975a,b)
Lower Bay	110	McGrath (1974)
Lower Bay	766	Walford (1971)
Port Jefferson Harbor	3,413	Klein (1976)
Buzzard's Bay	4,430	Sanders (1958)
Long Island Sound	16,443	"
Moriches Bay	5,402	O'Connor (1972)
South Shore of Long Island		
(9 - 18 m)	1,630	Cerrato (1983)
(5 - 25 m)	1,521	Steime and Stone (1973)
Southern New England (0-24 m)	2,429	Wigley and Theroux (1981)
New York Bight (0-24 m)	2,430	" "
Chesapeake Bight (0-24 m)	1,742	" "

Table 12. Biological Characteristics of Channel Stations in Relation to Existing Shoaling Rates.

Reach	Shoaling Rate (in/year)	Station	Spring Abundance (per m^2)	Spring Species	Spring Diversity	Summer Abundance (per m^2)	Summer Species	Summer Diversity
Port Newark Pierhead	18.81	1A	0	0	.00	138	2	.75
Port Elizabeth Branch	4.45	2C	88	2	.92	75	1	.33
Port Elizabeth Pierhead	1.46	3C	213	3	1.11	1725	5	.75
		4C	675	3	.84	1075	7	2.19
		5C	188	2	.77	50	2	.79
Newark Bay Middle	4.65	2A	1800	8	1.89	425	3	.34
		3A	175	3	.89	125	3	1.10
Newark Bay South, Above Bridge	.91	4A	675	7	2.13	9663	10	1.44
		5A	775	6	1.37	775	8	1.82
Newark Bay South, Below Bridge	.79	6A	1750	9	2.15	1650	8	2.05
		7A	1913	7	1.22	4913	10	1.75
		8A	3263	12	1.45	4525	12	1.56
		10A	650	7	2.28	5125	4	.30
Bergen Point West	.09	9A	2475	10	2.31	4038	16	2.52
Averages:								
Stations > 1 in/year			448	3.0	.92	516	3.3	.89
Stations < 1 in/year			1643	8.3	1.84	4384	9.7	1.63

FIGURE 1

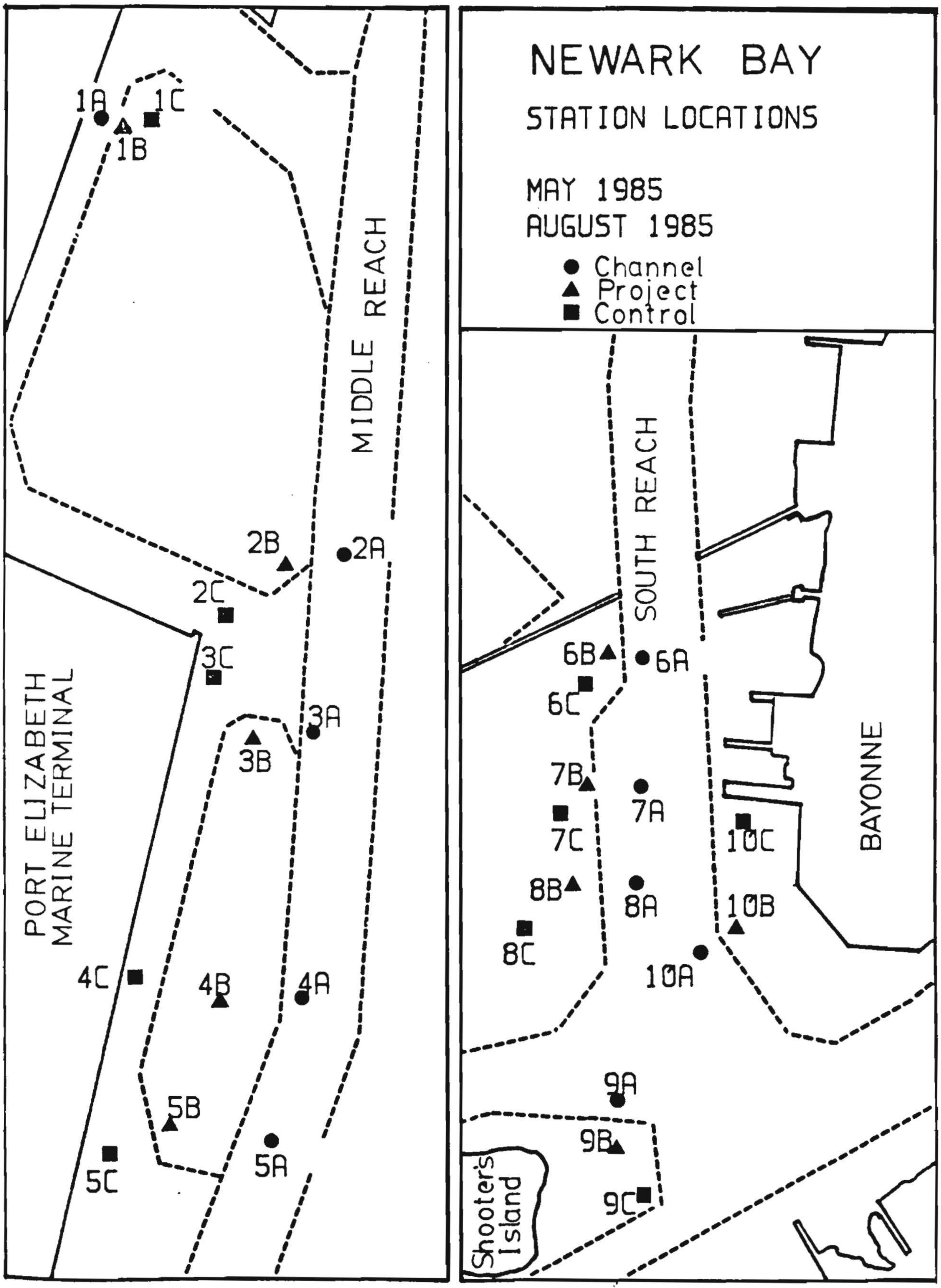

NEWARK BAY
STATION LOCATIONS
MAY 1985
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
1A
1B
1C
2A
2B
2C
3A
3B
3C
4A
4B
4C
5A
5B
5C
6A
6B
6C
7A
7B
7C
8A
8B
8C
9A
9B
9C
10A
10B
10C

FIGURE 2

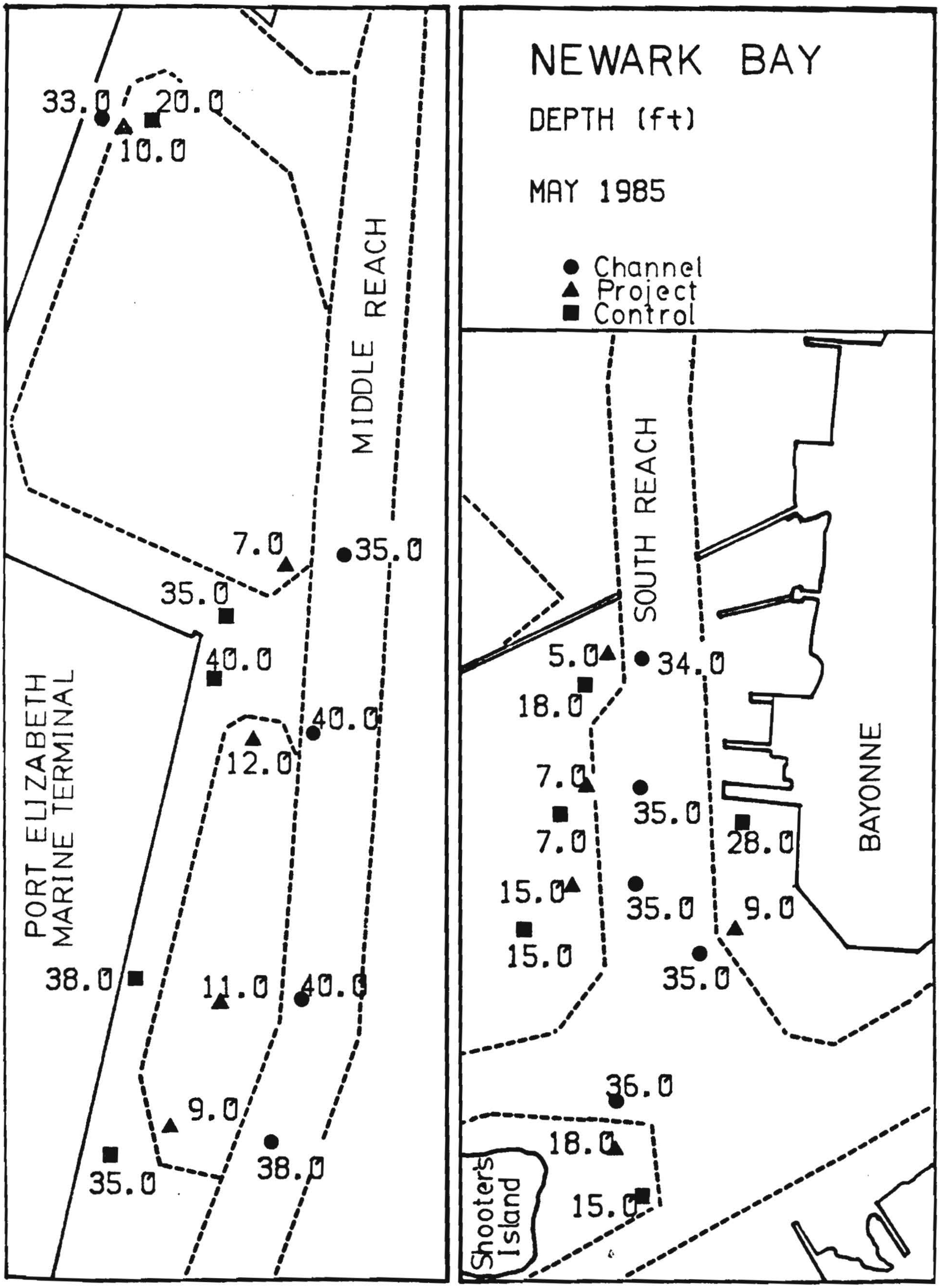

NEWARK BAY
DEPTH (ft)
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
33.0
20.0
10.0
7.0
35.0
35.0
40.0
40.0
12.0
38.0
11.0
40.0
9.0
35.0
38.0
5.0
34.0
18.0
7.0
35.0
7.0
28.0
15.0
35.0
9.0
15.0
35.0
36.0
18.0
15.0

FIGURE 3

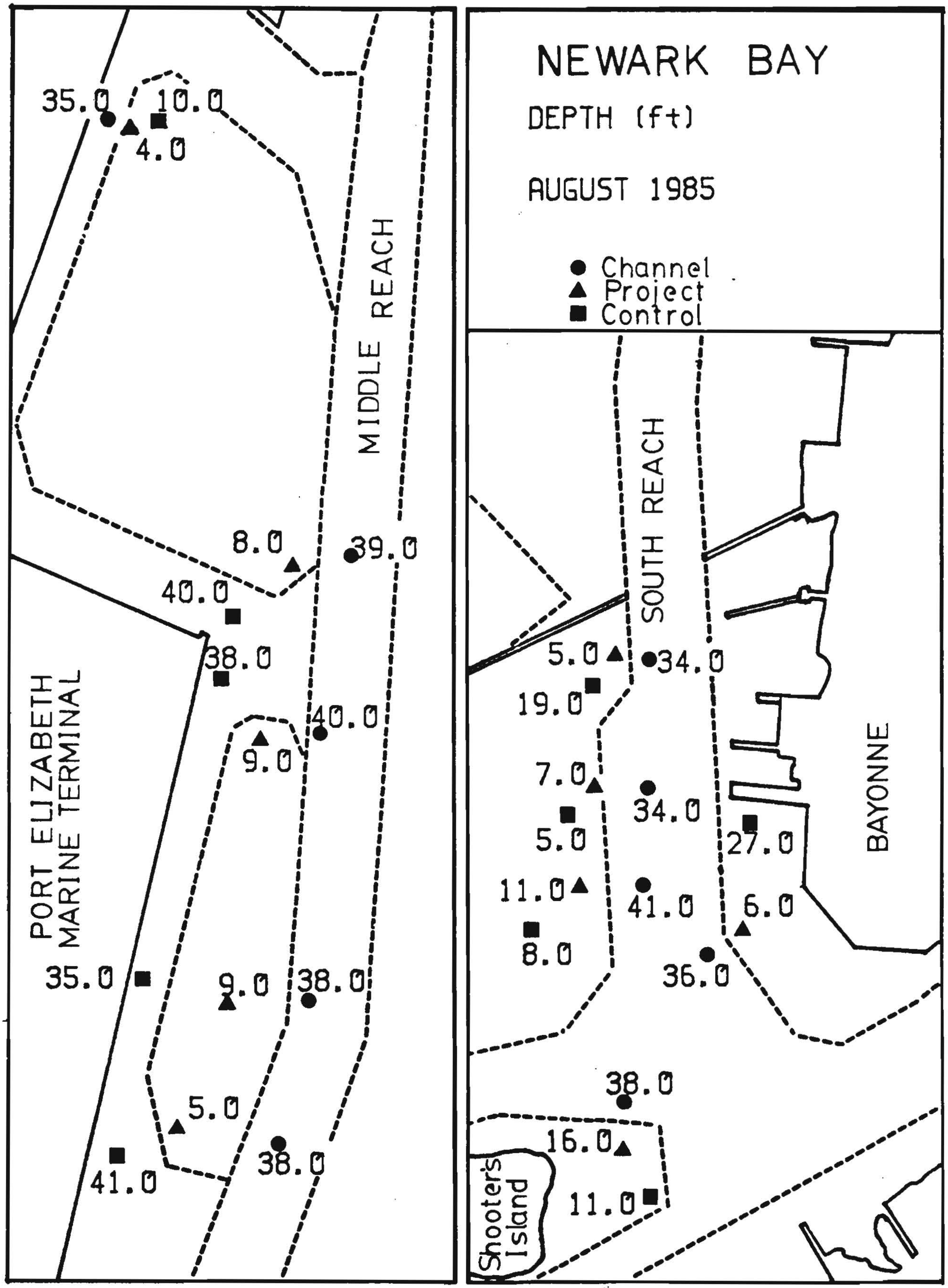

NEWARK BAY
DEPTH (ft)
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH
MARINE TERMINAL
35.0
10.0
4.0
8.0
39.0
40.0
38.0
40.0
9.0
35.0
9.0
38.0
5.0
41.0
38.0
SOUTH REACH
BAYONNE
5.0
34.0
19.0
7.0
34.0
5.0
27.0
11.0
41.0
6.0
8.0
36.0
38.0
16.0
11.0
Shooters Island

FIGURE 4

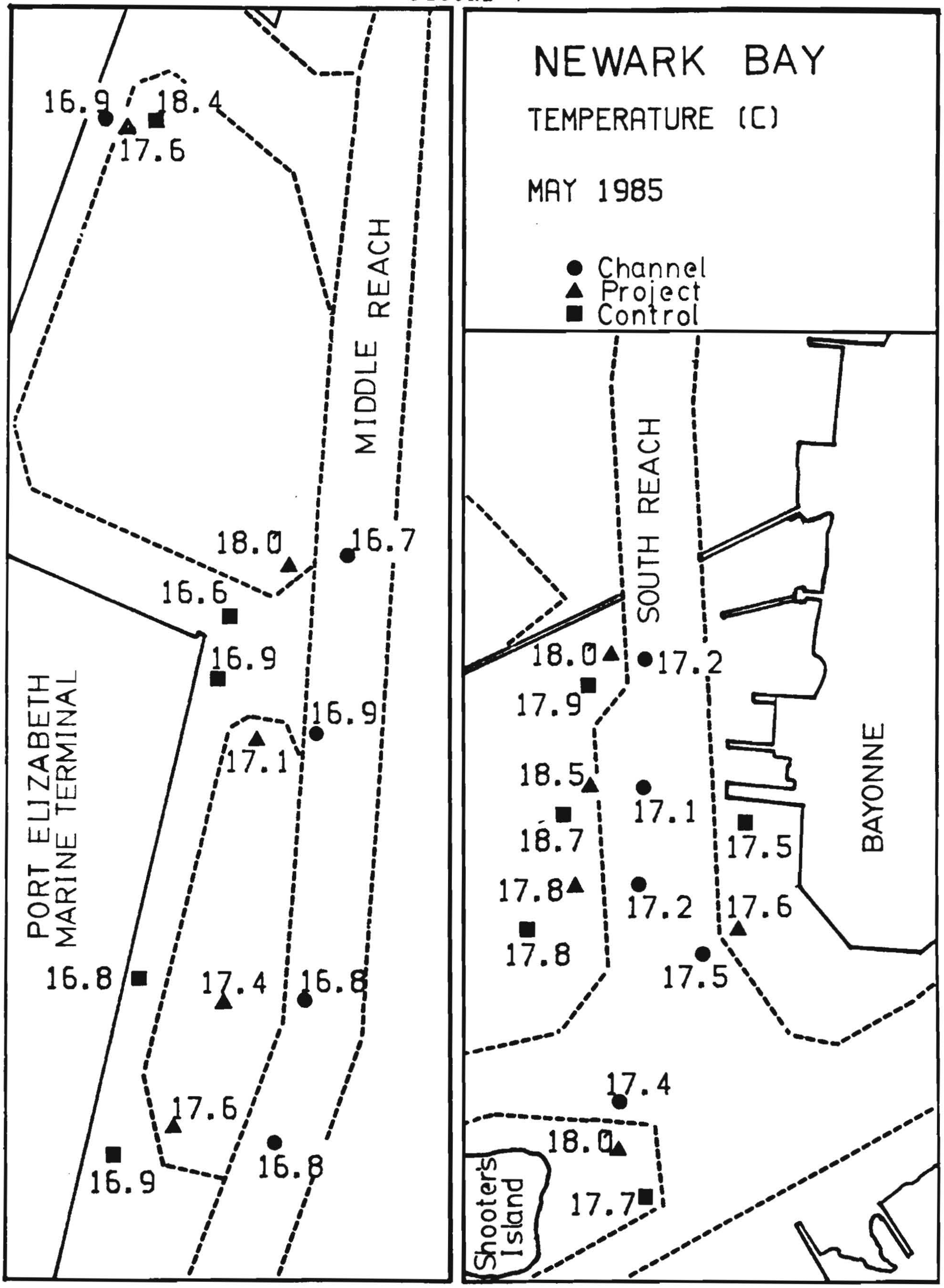

NEWARK BAY
TEMPERATURE (C)
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
16.9
18.4
17.6
18.0
16.7
16.6
16.9
16.9
17.1
16.8
17.4
16.8
17.6
16.9
16.8
18.0
17.2
17.9
18.5
17.1
18.7
17.5
17.8
17.2
17.6
17.8
17.5
17.4
18.0
17.7

FIGURE 5

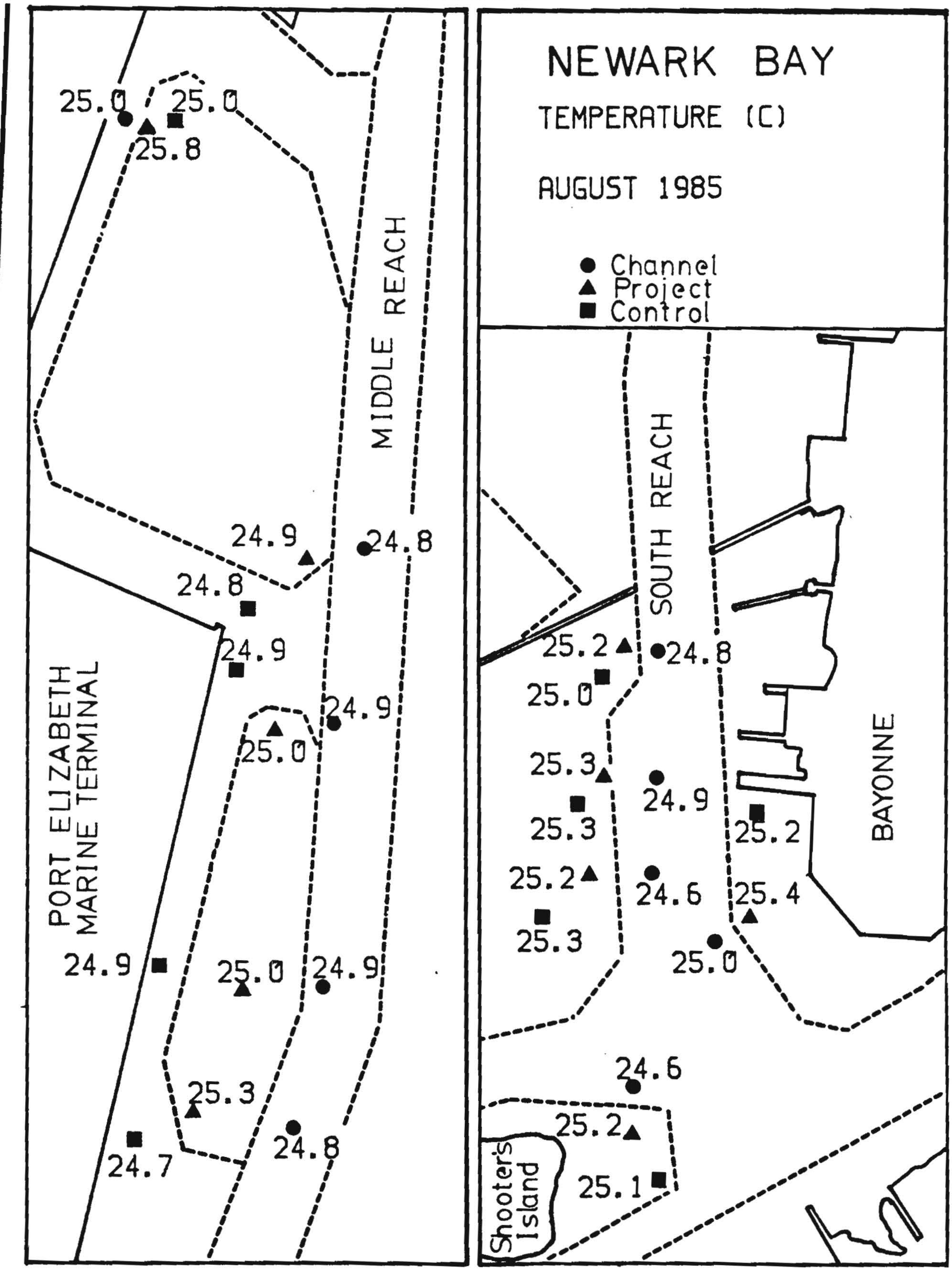

NEWARK BAY
TEMPERATURE (C)
AUGUST 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
25.0
25.0
25.8
24.9
24.8
24.8
24.9
24.9
25.0
24.9
25.0
24.9
25.3
24.7
24.8
25.2
24.8
25.0
25.3
24.9
25.3
25.2
25.2
24.6
25.4
25.3
25.0
24.6
25.2
25.1

FIGURE 6

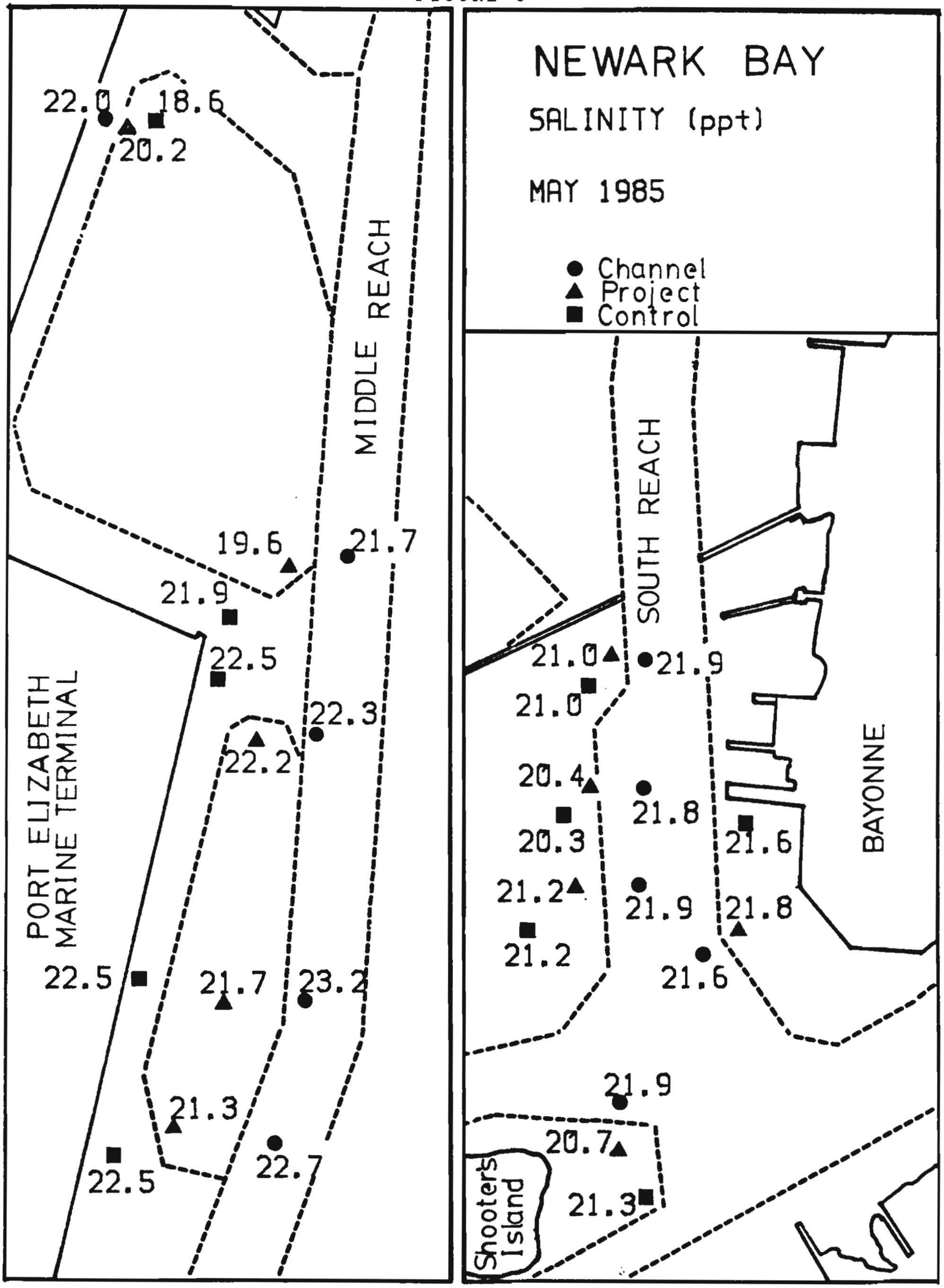

NEWARK BAY
SALINITY (ppt)
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
22.0
18.6
20.2
19.6
21.7
21.9
22.5
22.3
22.2
22.5
21.7
23.2
21.3
22.5
22.7
21.0
21.9
21.0
20.4
21.8
20.3
21.6
21.2
21.9
21.8
21.2
21.6
21.9
20.7
21.3

FIGURE 7

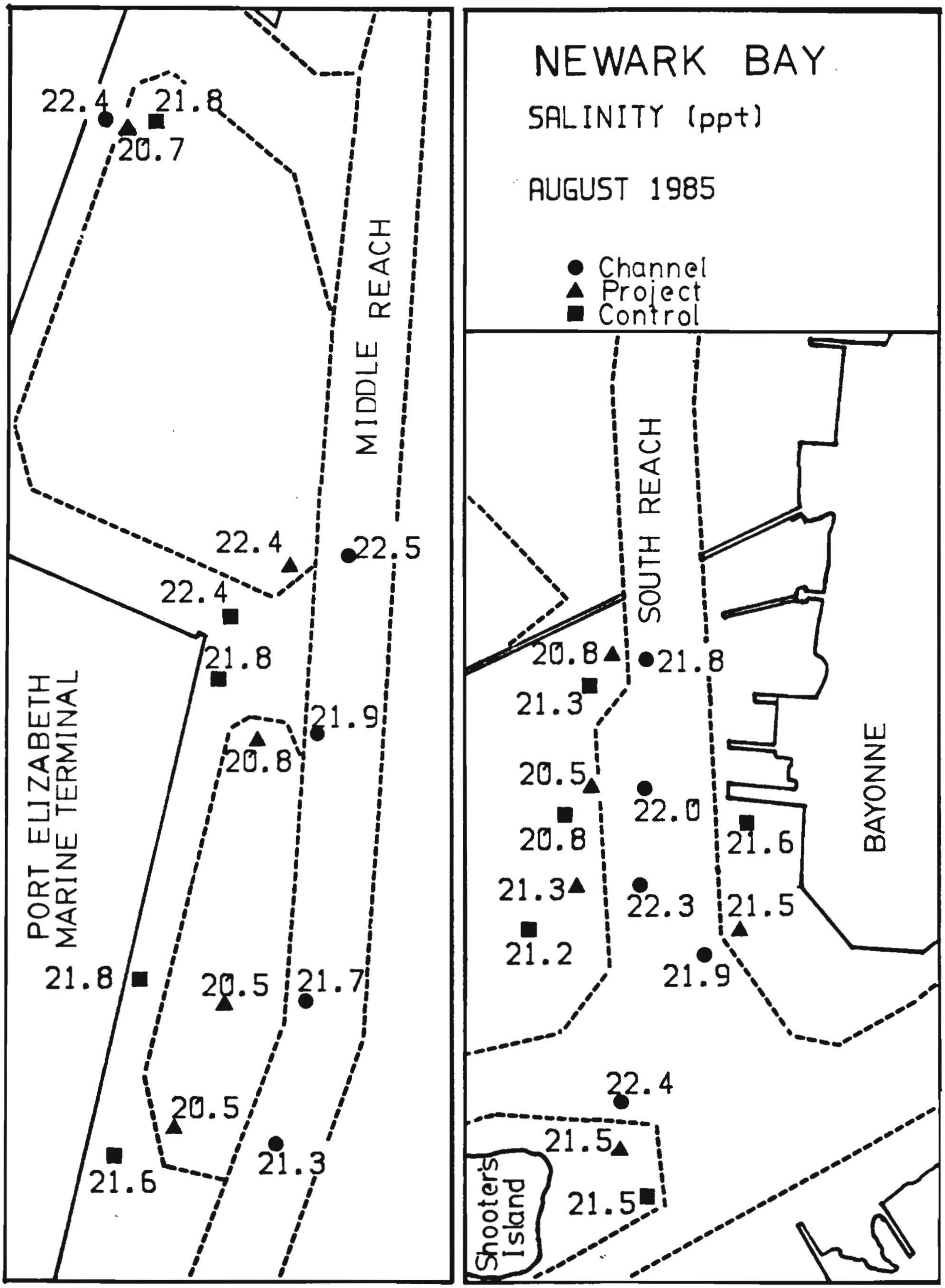

NEWARK BAY
SALINITY (ppt)
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
22.4
21.8
20.7
22.4
22.5
22.4
21.8
21.9
20.8
21.8
20.5
21.7
20.5
21.3
21.6
20.8
21.8
21.3
20.5
22.0
20.8
21.6
21.3
22.3
21.5
21.2
21.9
22.4
21.5
21.5

FIGURE 8

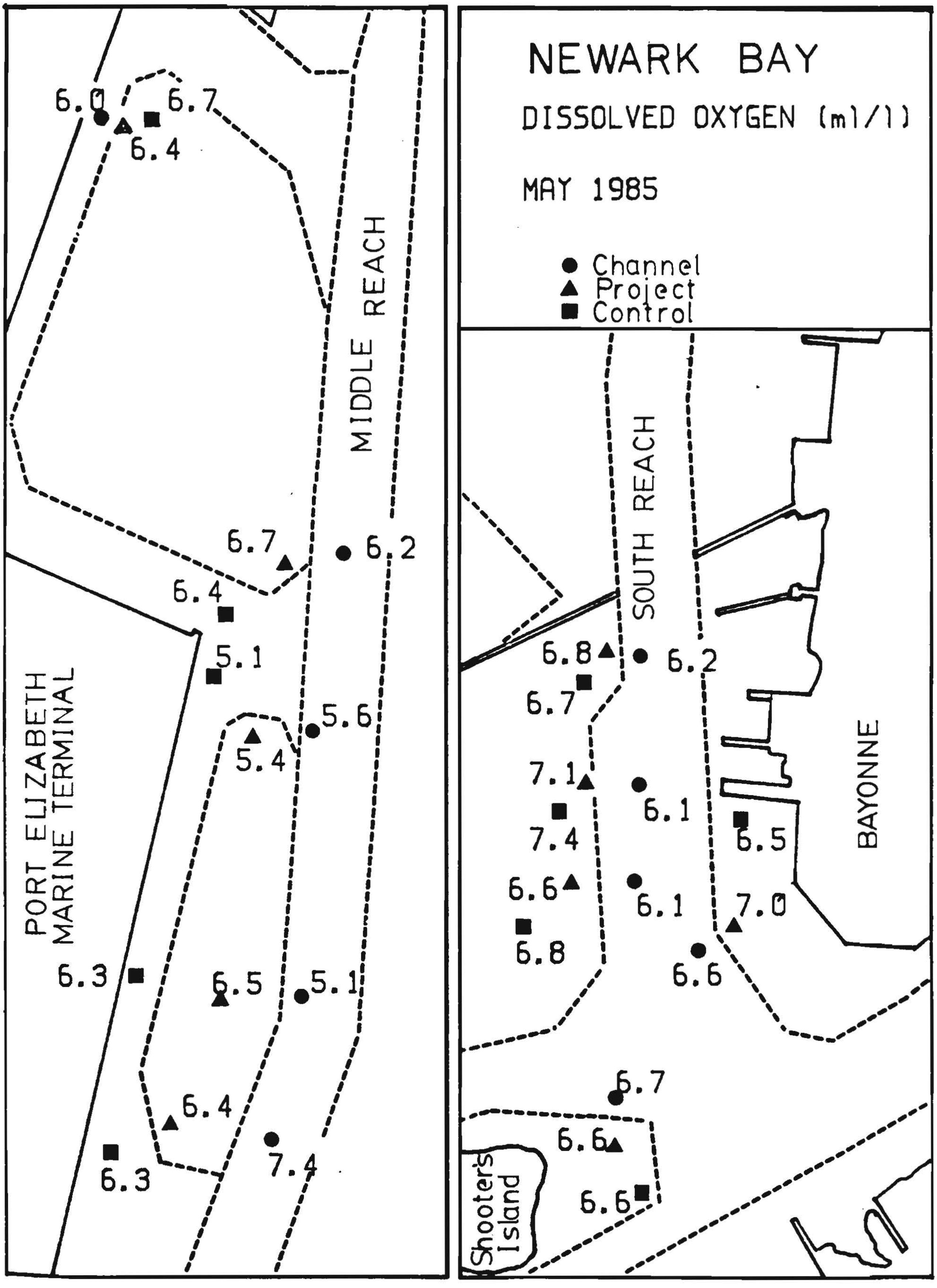

NEWARK BAY
DISSOLVED OXYGEN (ml/l)
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
6.0
6.7
6.4
6.7
6.2
6.4
5.1
5.6
5.4
6.3
6.5
5.1
6.4
6.3
7.4
6.8
6.2
6.7
7.1
6.1
7.4
6.5
6.6
6.1
7.0
6.8
6.6
6.7
6.6
6.6

FIGURE 9

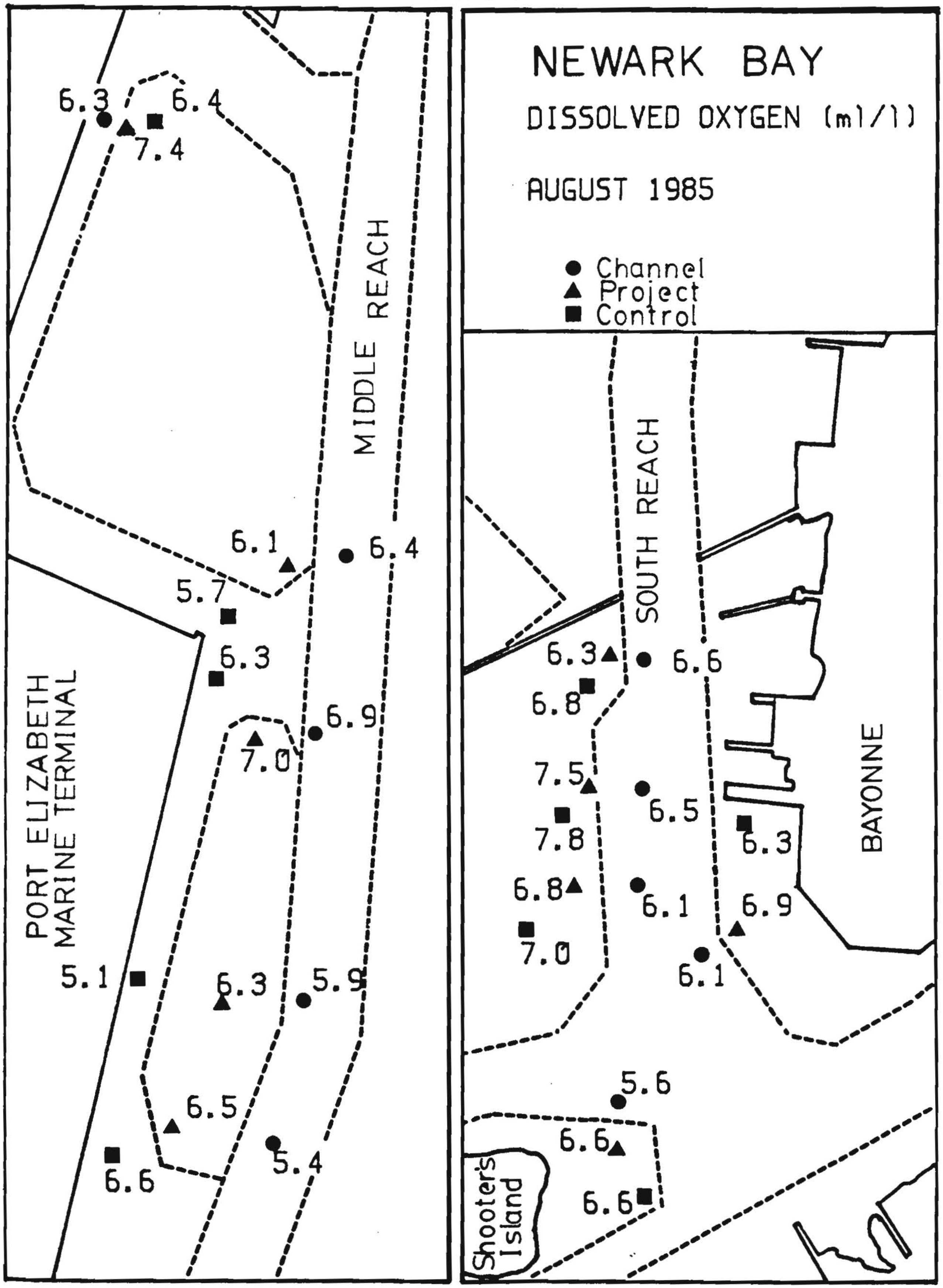

NEWARK BAY
DISSOLVED OXYGEN (ml/l)
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
6.3
6.4
7.4
6.1
6.4
5.7
6.3
6.9
7.0
5.1
6.3
5.9
6.5
6.6
5.4
6.3
6.6
6.8
7.5
6.5
7.8
6.3
6.8
6.1
6.9
7.0
6.1
5.6
6.6
6.6

FIGURE 10

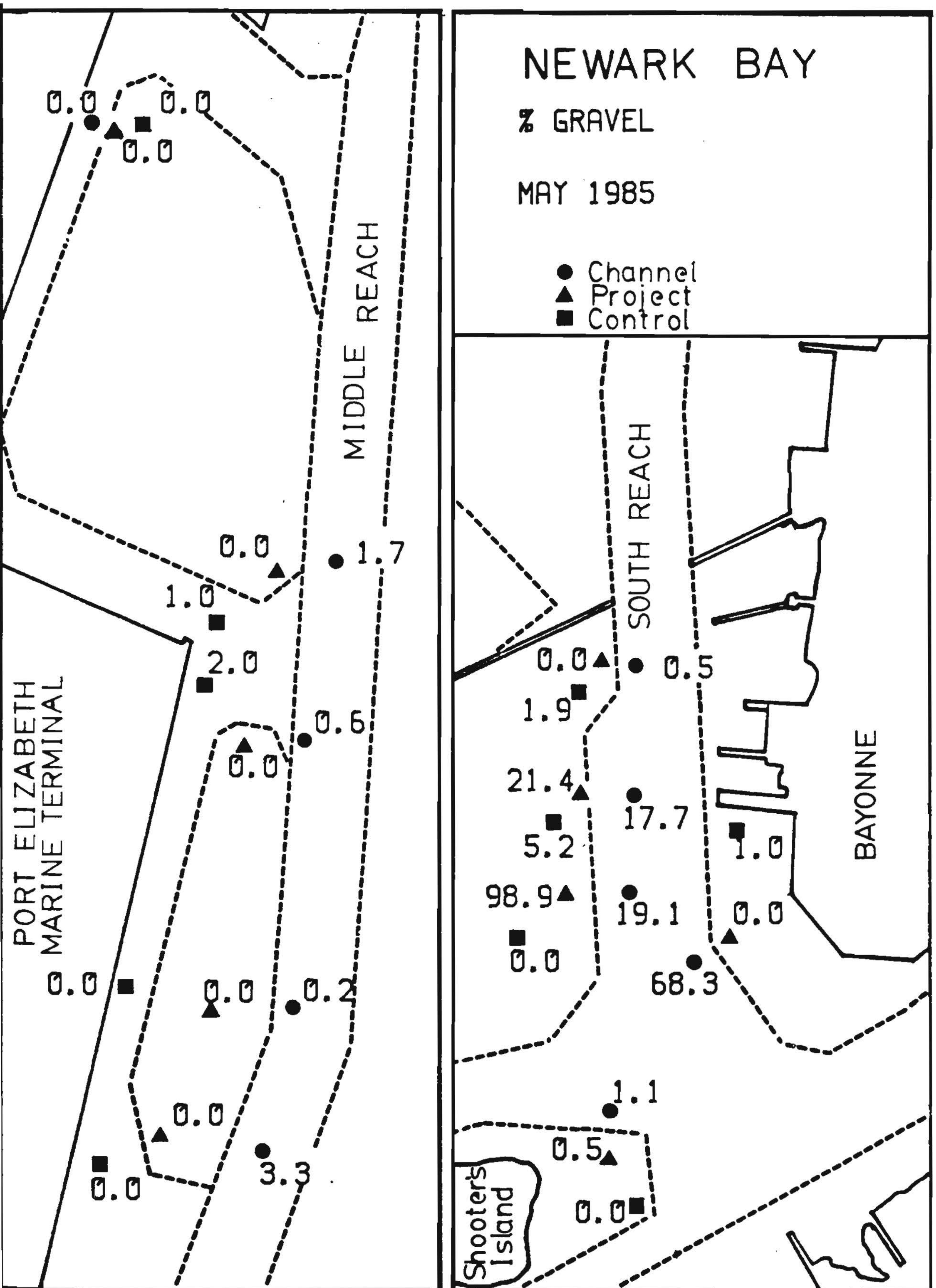
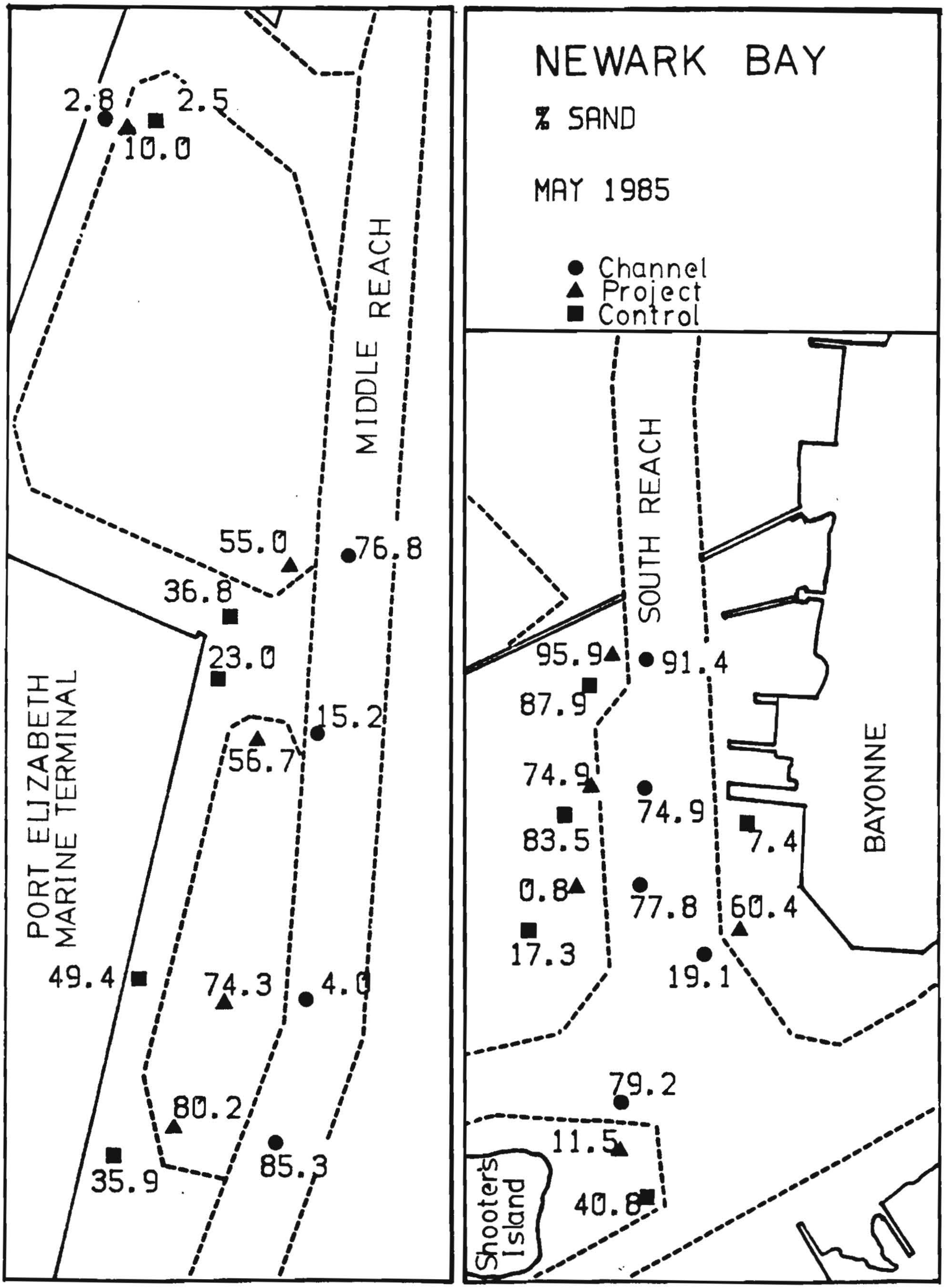

NEWARK BAY
% GRAVEL
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0.0
0.0
0.0
0.0
1.7
1.0
2.0
0.6
0.0
0.0
0.0
0.2
0.0
3.3
0.0
0.0
0.5
1.9
21.4
17.7
5.2
1.0
98.9
19.1
0.0
0.0
68.3
1.1
0.5
0.0

FIGURE 11



NEWARK BAY
% SAND
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
2.8
2.5
10.0
55.0
76.8
36.8
23.0
15.2
56.7
49.4
74.3
4.0
80.2
35.9
85.3
95.9
91.4
87.9
74.9
74.9
83.5
7.4
0.8
77.8
60.4
17.3
19.1
79.2
11.5
40.8

FIGURE 12

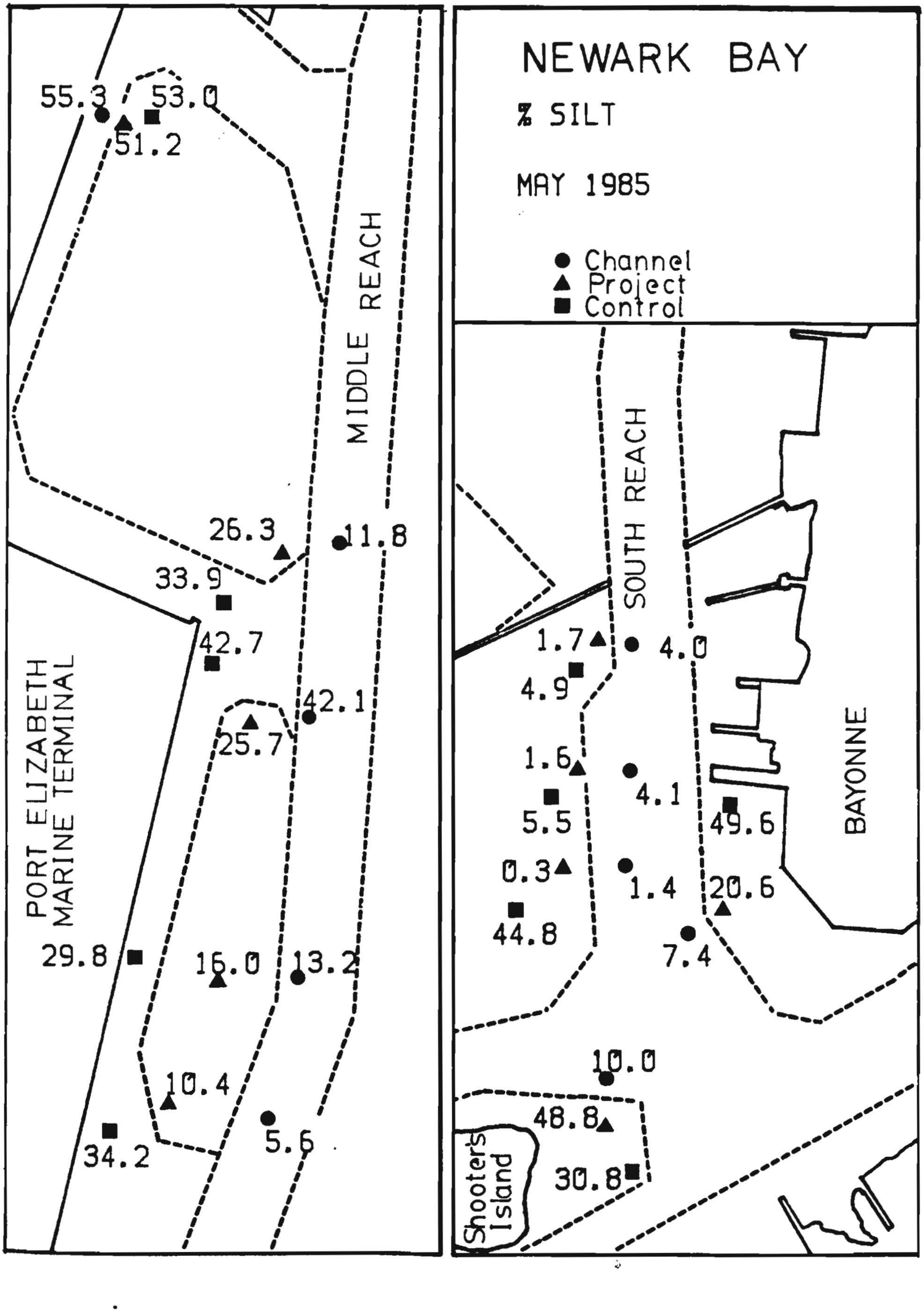

NEWARK BAY
% SILT
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
55.3
53.0
51.2
26.3
11.8
33.9
42.7
42.1
25.7
29.8
16.0
13.2
10.4
34.2
5.6
1.7
4.0
4.9
1.6
4.1
5.5
49.6
0.3
1.4
20.6
44.8
7.4
10.0
48.8
30.8

FIGURE 13

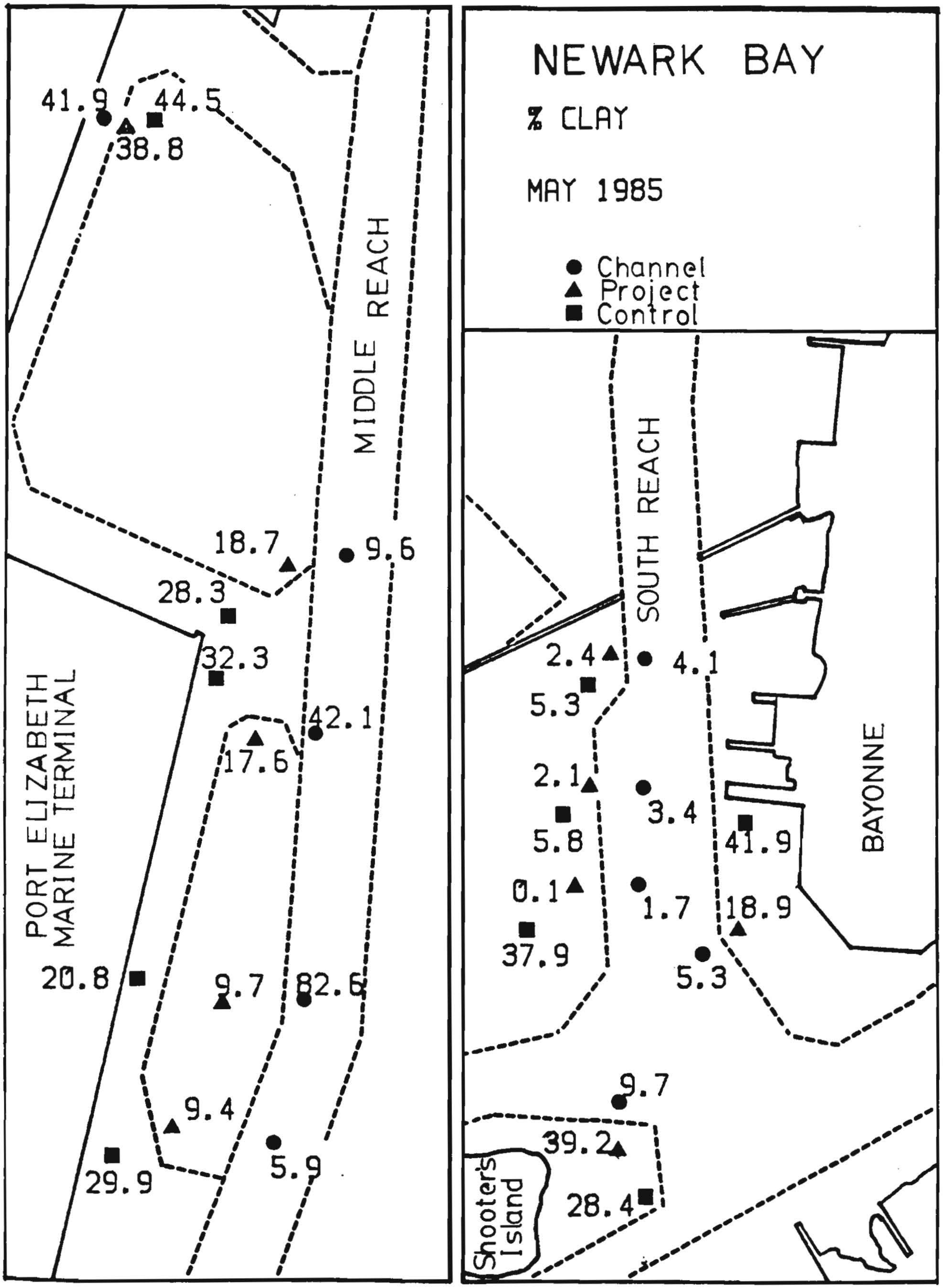
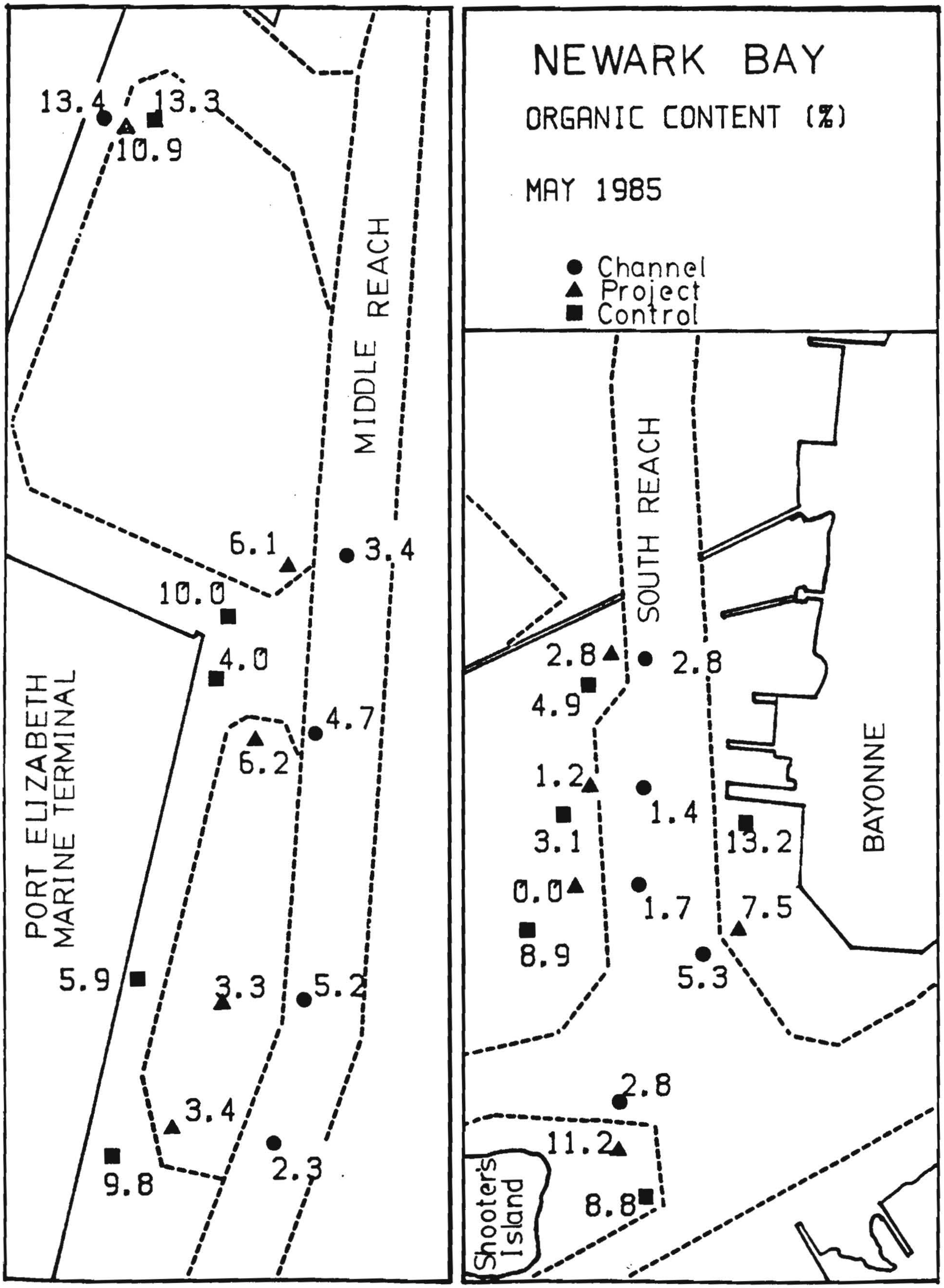

NEWARK BAY
% CLAY
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
41.9
44.5
38.8
18.7
9.6
28.3
32.3
42.1
17.6
20.8
9.7
82.6
9.4
29.9
5.9
2.4
4.1
5.3
2.1
3.4
5.8
41.9
0.1
1.7
18.9
37.9
5.3
9.7
39.2
28.4

FIGURE 14



NEWARK BAY
ORGANIC CONTENT (%)
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
13.4
13.3
10.9
6.1
3.4
10.0
4.0
4.7
6.2
5.9
3.3
5.2
3.4
9.8
2.3
2.8
2.8
4.9
1.2
1.4
3.1
13.2
0.0
1.7
7.5
8.9
5.3
2.8
11.2
8.8

FIGURE 15

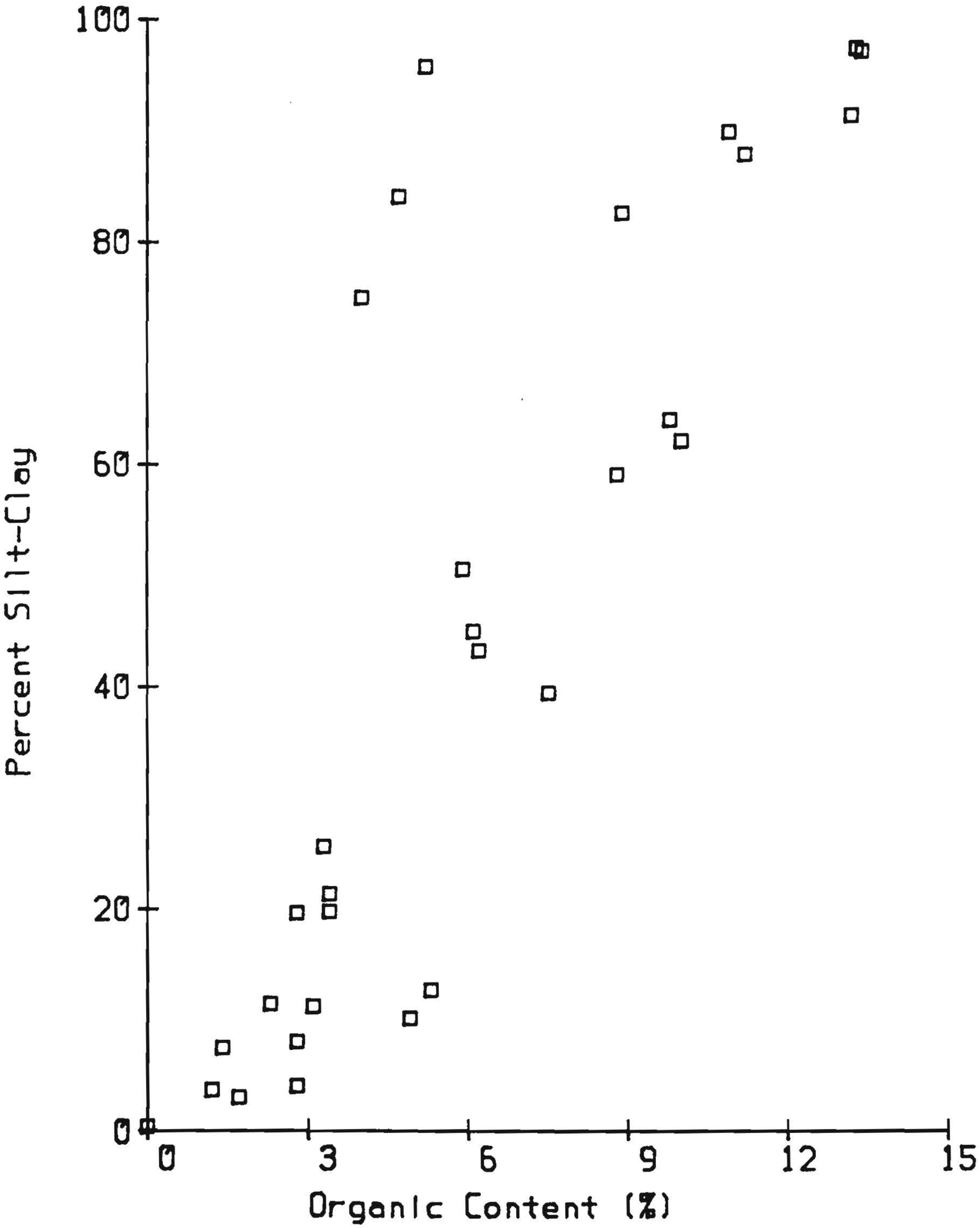


FIGURE 16

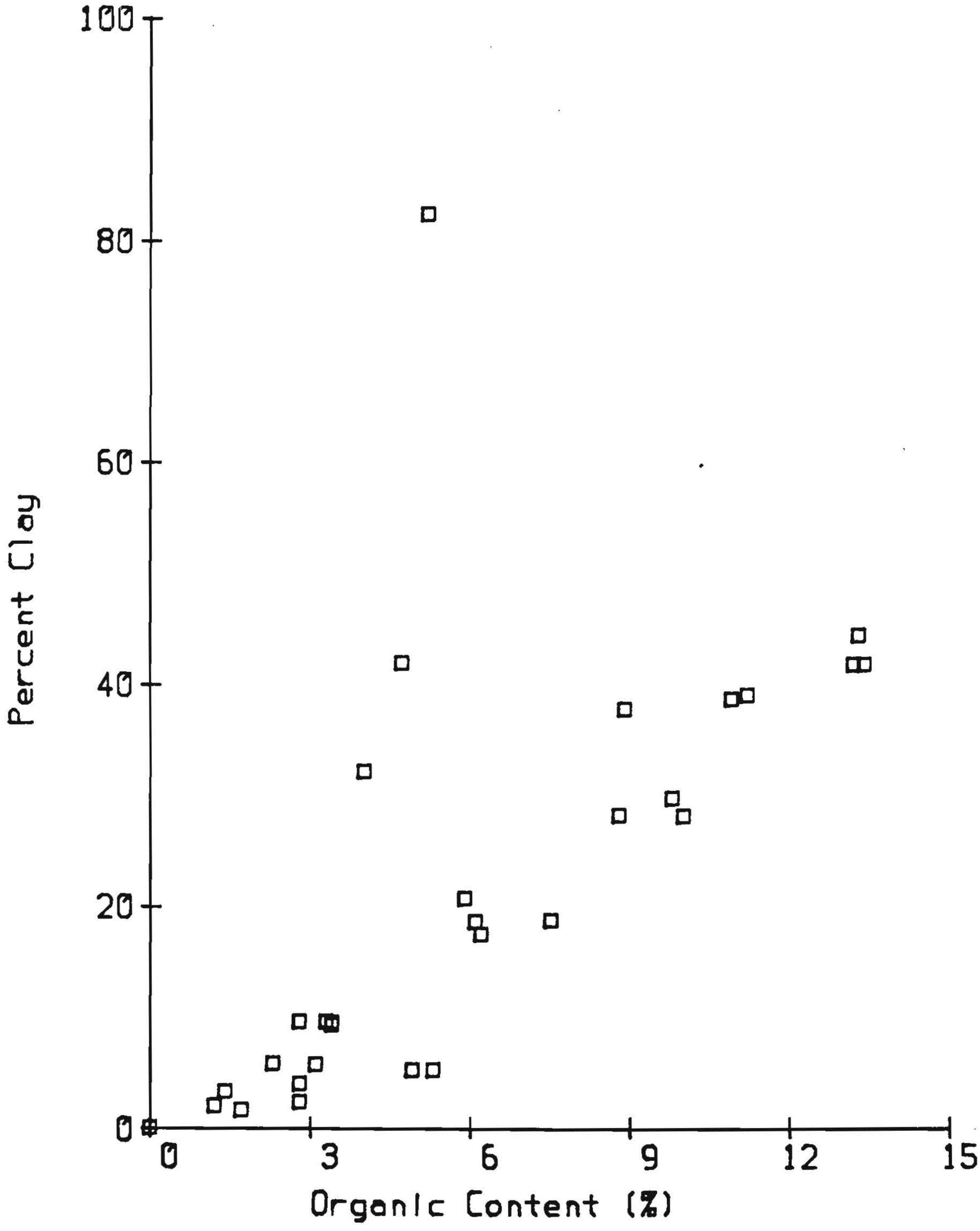


FIGURE 17

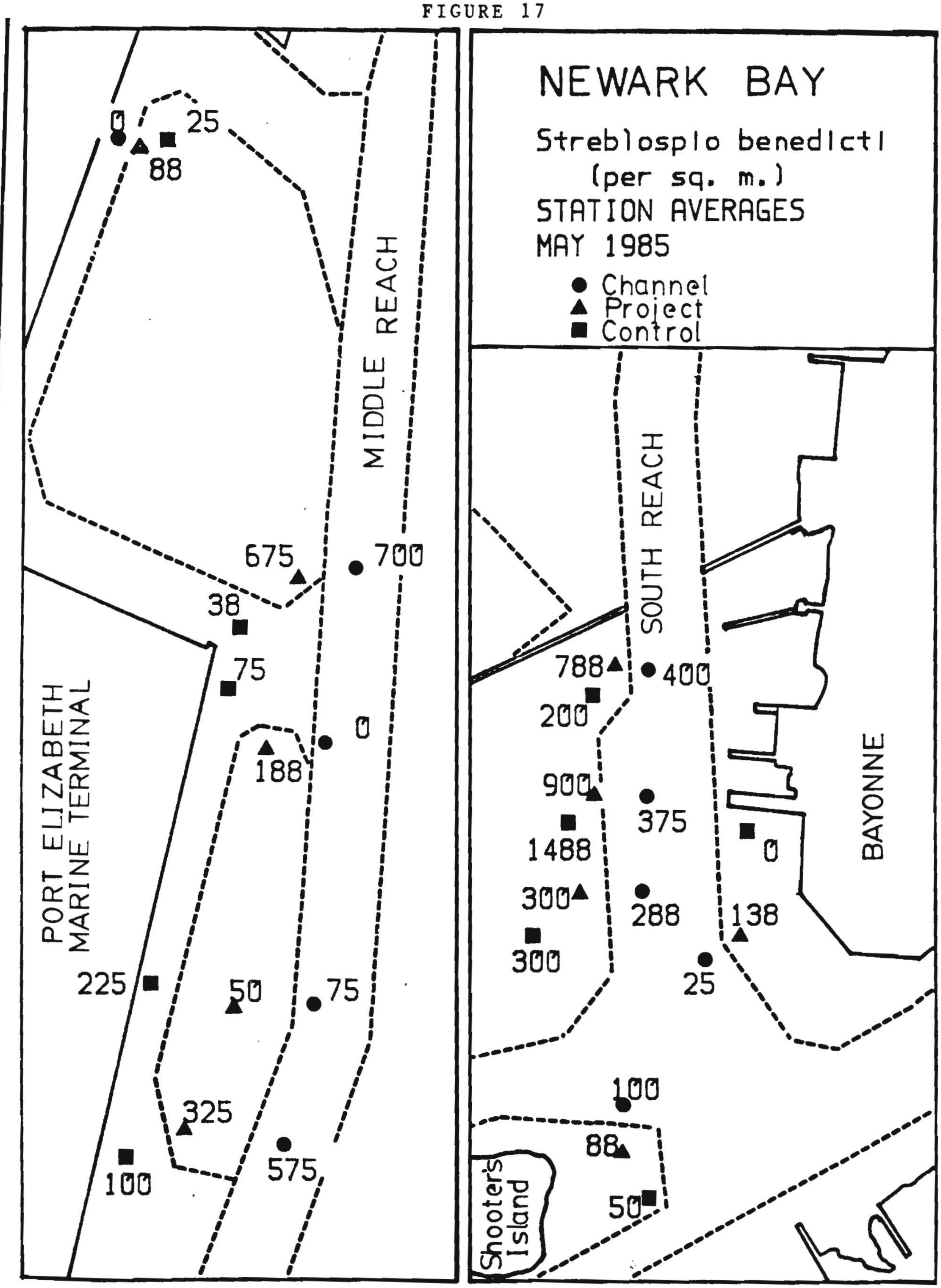

NEWARK BAY
Streblosplo benedIctI
(per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH
MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooter's Island
0
25
88
675
700
38
75
0
188
225
50
75
325
100
575
788
400
200
900
375
1488
0
300
288
138
300
25
100
88
50

FIGURE 18

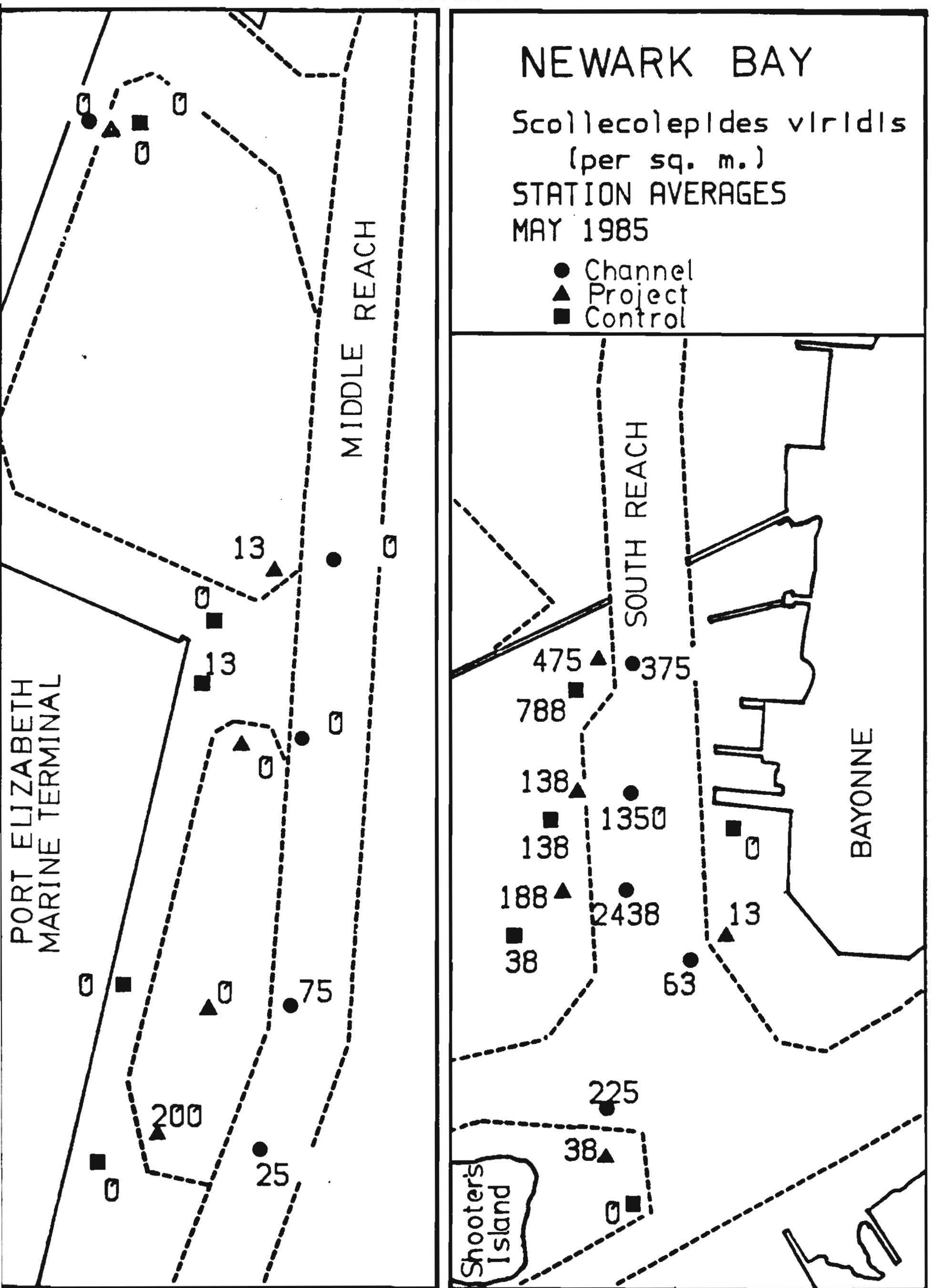

NEWARK BAY
Scollecolepides viridis
(per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
0
0
0
13
0
0
13
0
0
0
0
75
200
25
0
475
375
788
138
1350
138
0
188
2438
13
38
63
225
38
0

FIGURE 19

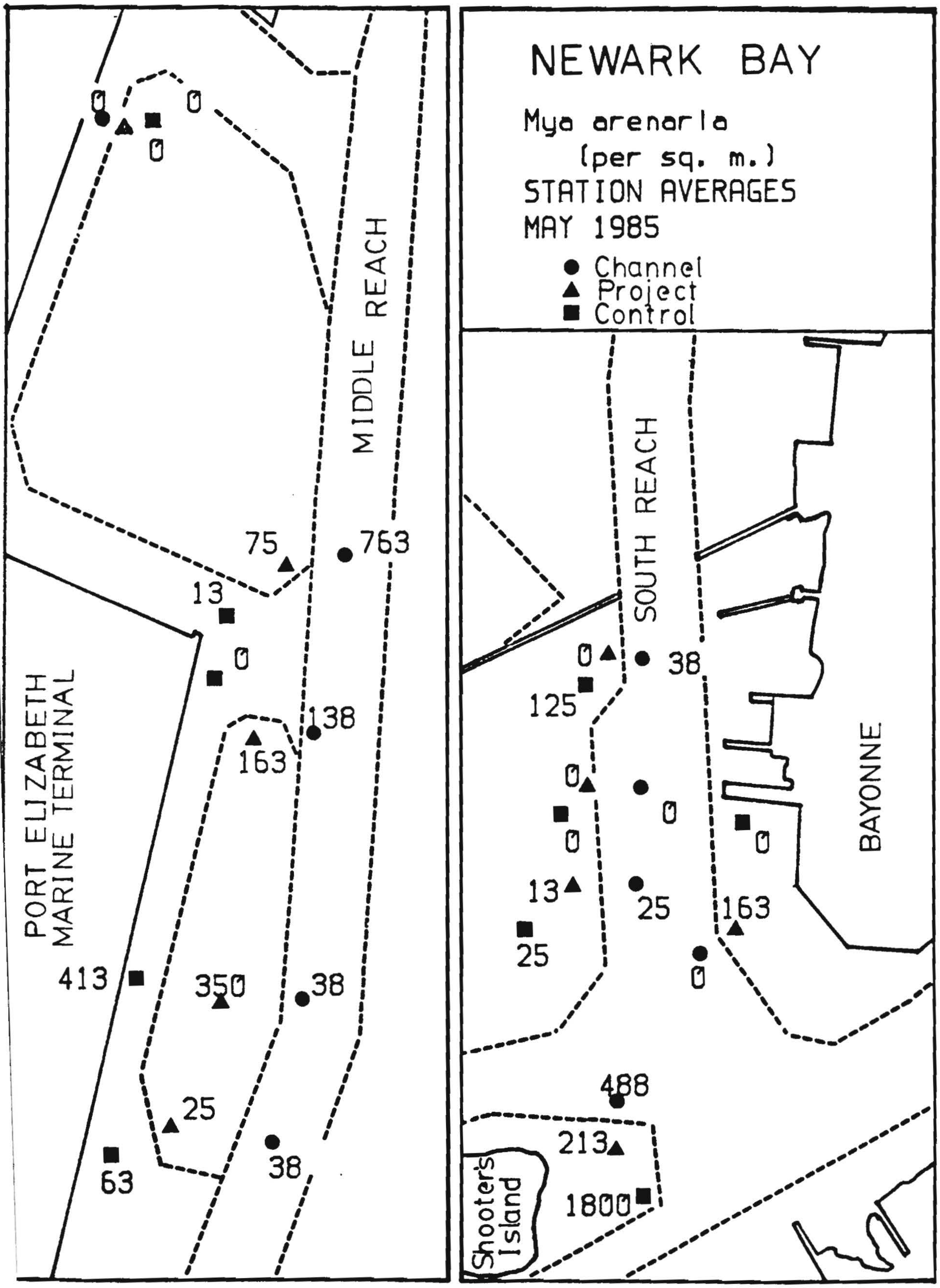

NEWARK BAY
Mya arenaria
(per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH
MARINE TERMINAL
BAYONNE
Shooters Island
0
0
0
0
75
763
13
0
138
163
413
350
38
25
38
63
0
38
125
0
0
0
0
13
25
163
25
0
488
213
1800

FIGURE 20

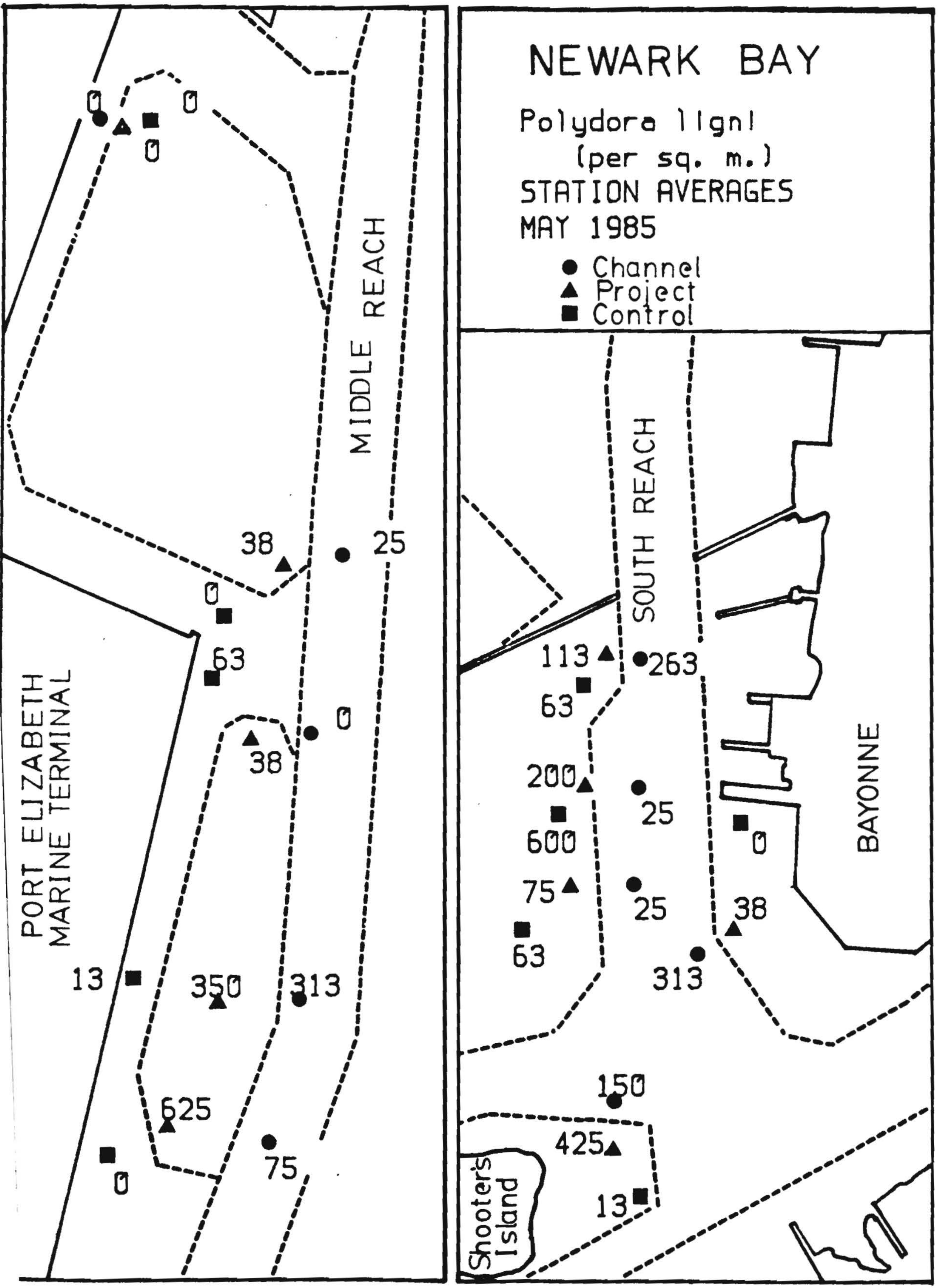

NEWARK BAY
Polydora ligni
(per sq. m.)
STATION AVERAGES
MAY 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH
MARINE TERMINAL
BAYONNE
Shooter's
Island
0
0
0
38
25
0
63
0
38
13
350
313
625
0
75
113
263
63
200
25
600
0
75
25
38
63
313
150
425
13

FIGURE 21

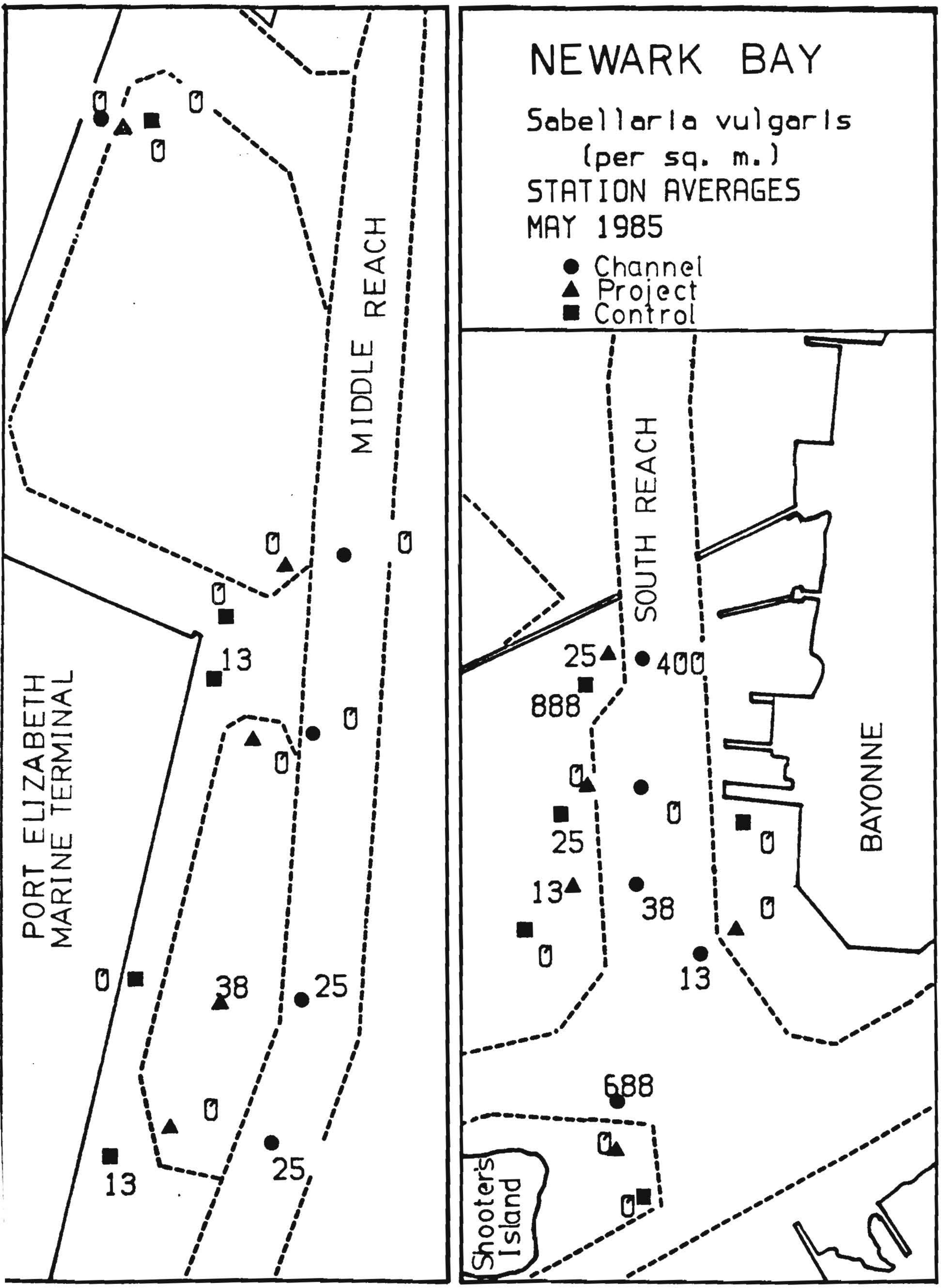

NEWARK BAY
Sabellaria vulgaris
(per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
0
0
0
0
0
0
13
0
0
0
38
25
0
25
13
25
400
888
0
0
25
0
13
38
0
0
13
688
0
0

FIGURE 22

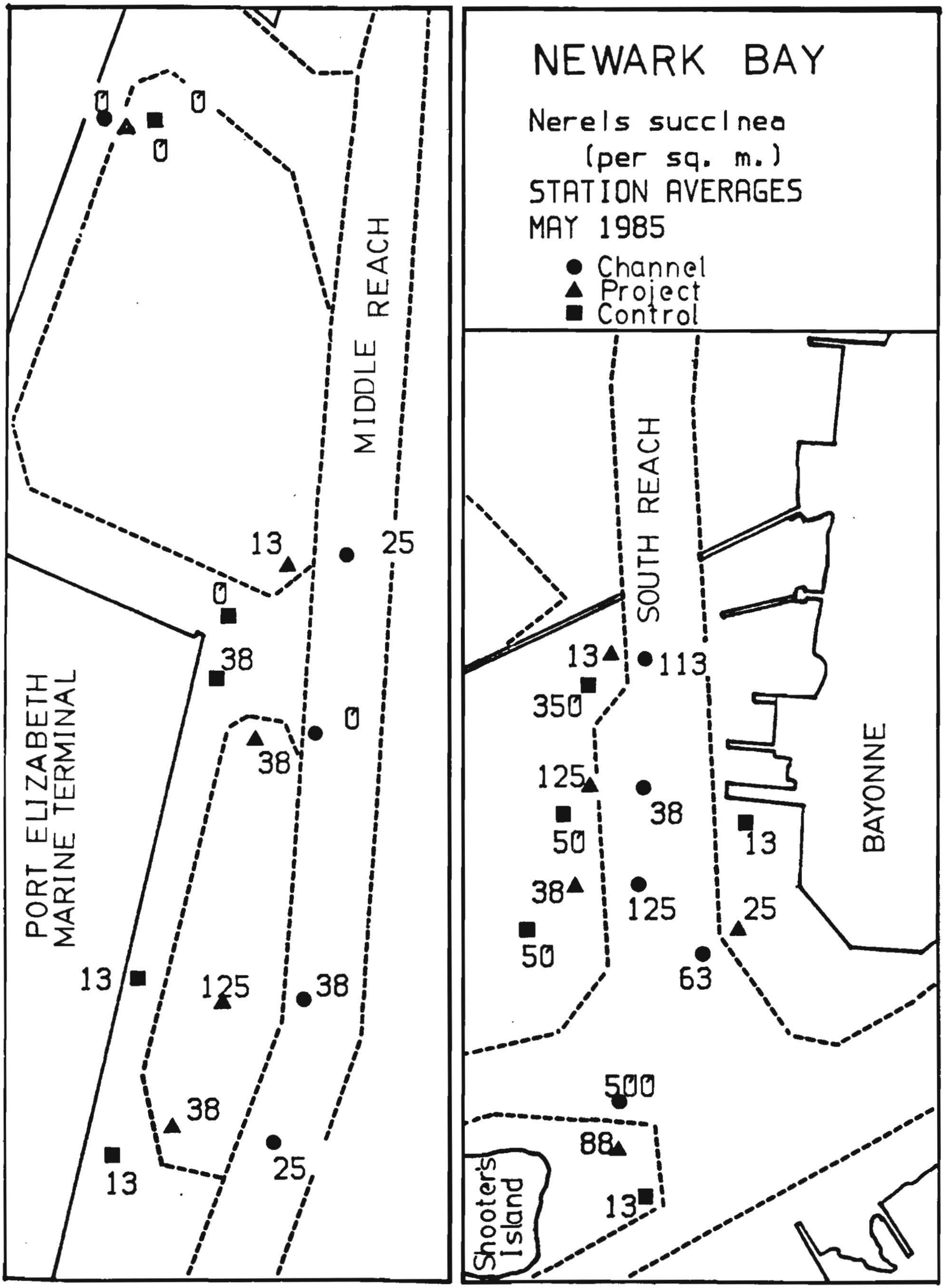

NEWARK BAY
Nereis succinea
(per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0
0
0
13
25
0
38
0
38
13
125
38
38
13
25
13
113
350
125
38
13
50
38
125
25
50
63
500
88
13

FIGURE 23

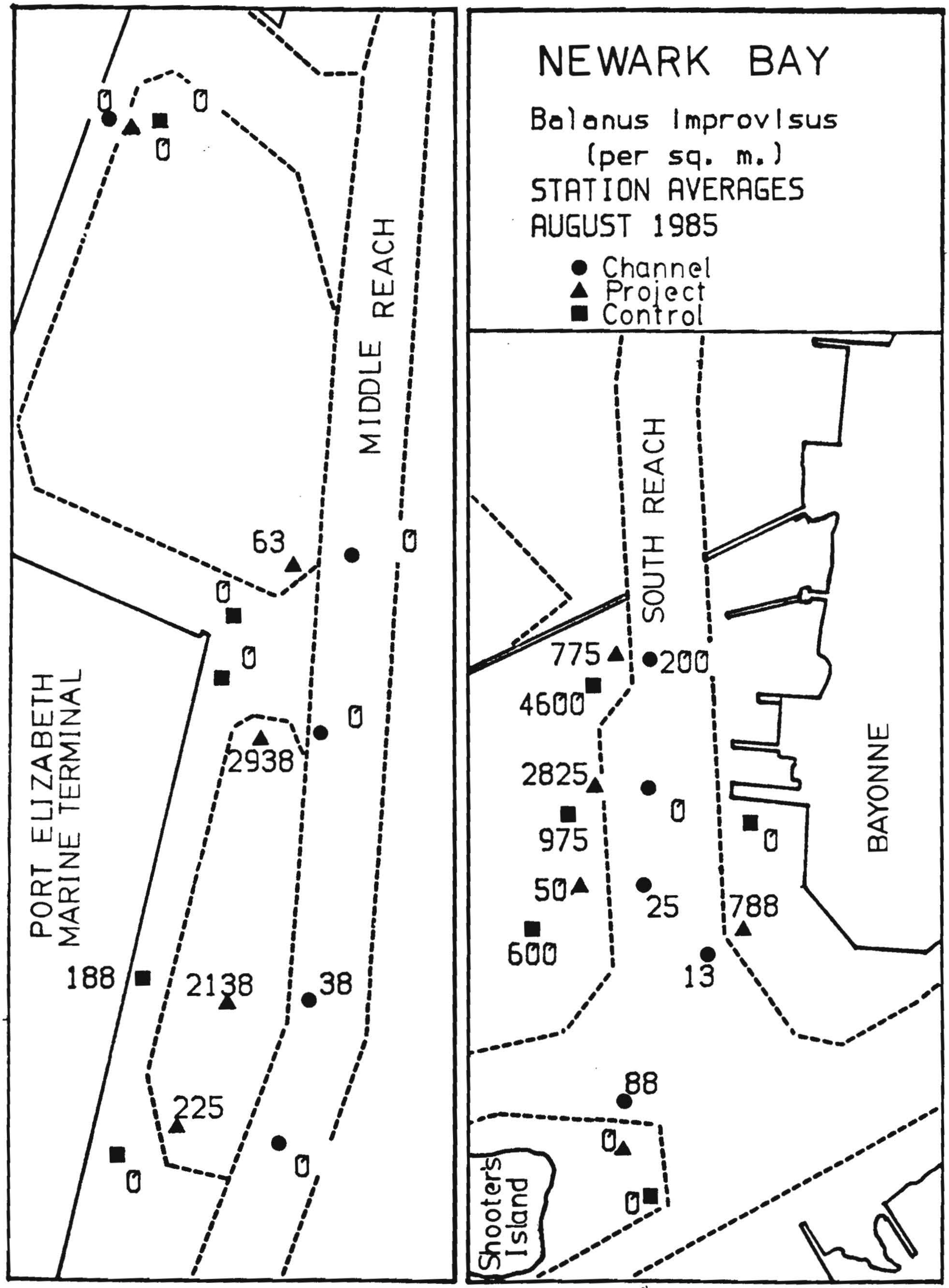

NEWARK BAY
Balanus Improvisus
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH
MARINE TERMINAL
BAYONNE
Shooters Island
0
0
0
63
0
0
0
0
2938
0
188
2138
38
225
0
0
775
200
4600
2825
0
975
0
50
25
788
600
13
88
0
0

FIGURE 24

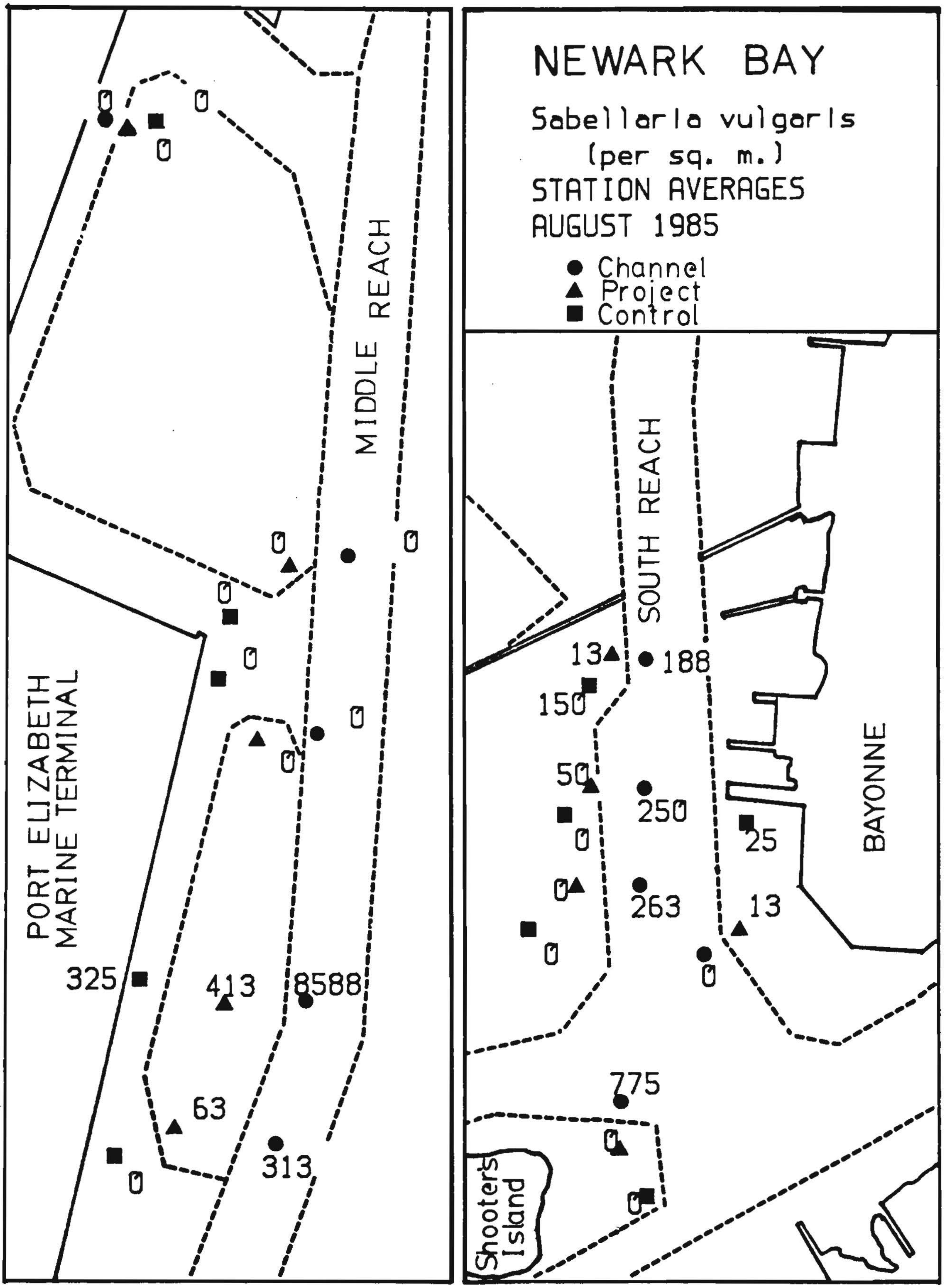

NEWARK BAY
Sabellaria vulgaris
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooters Island
325
413
8588
63
313
13
188
150
50
250
25
263
13
775
0

FIGURE 25

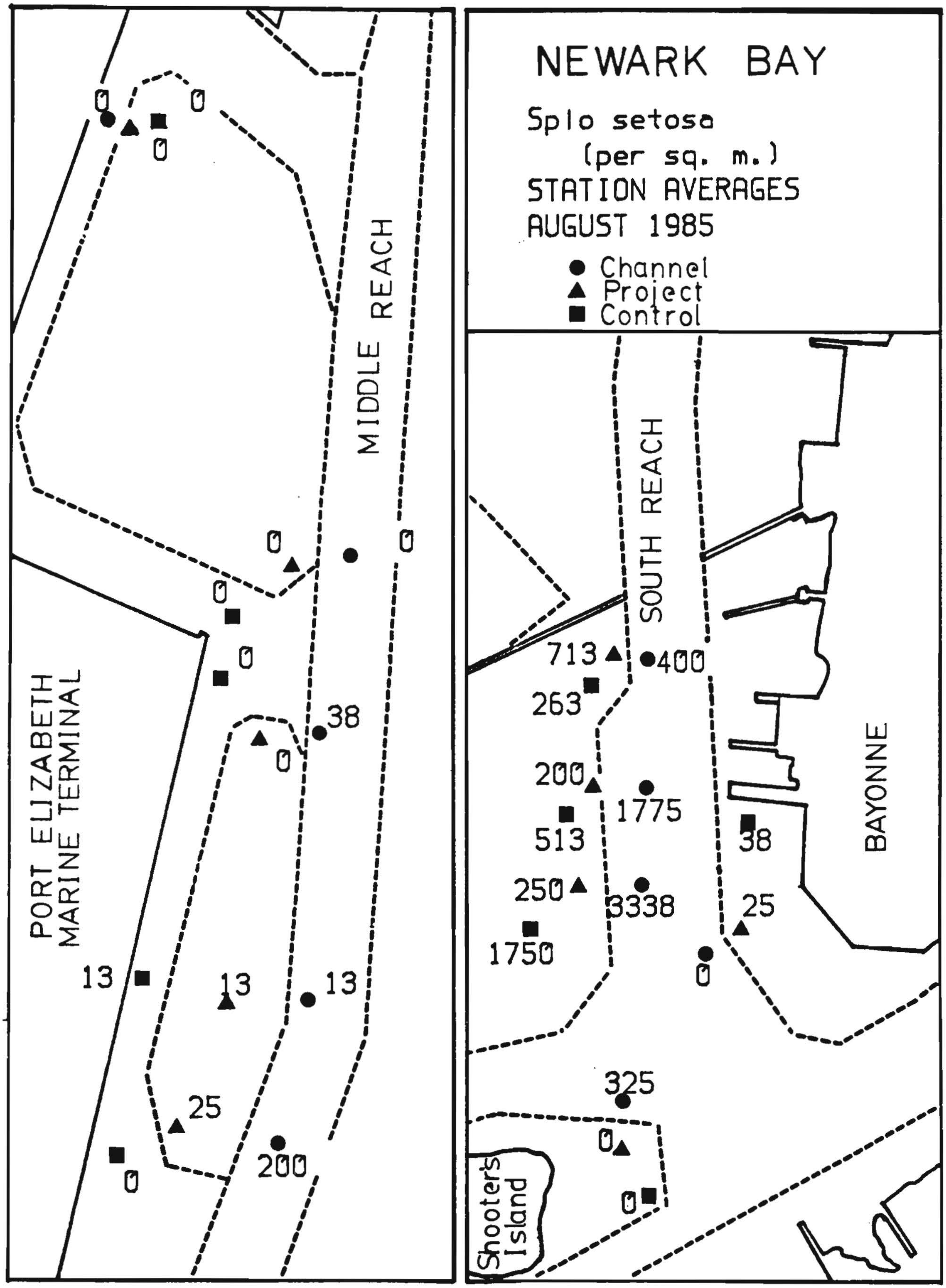

NEWARK BAY
Spio setosa
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooters Island
0
0
0
0
0
0
0
0
38
0
13
13
13
25
0
200
713
400
263
200
1775
513
38
250
3338
25
1750
0
325
0
0

FIGURE 26

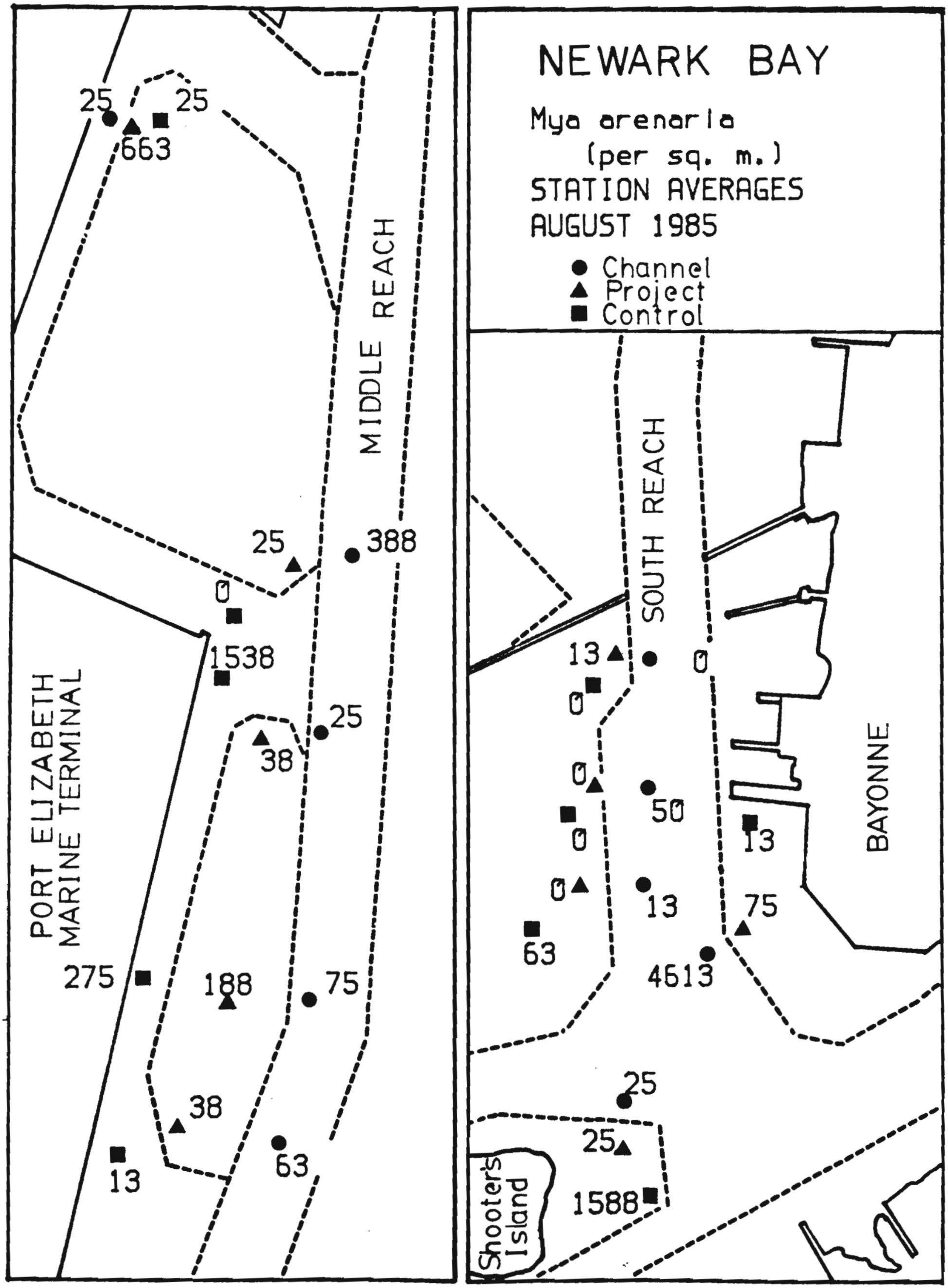

NEWARK BAY
Mya arenaria
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH
MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooters Island
25
25
663
25
388
0
1538
25
38
275
188
75
38
13
63
13
0
0
0
50
0
13
0
13
75
63
4613
25
25
1588

FIGURE 27

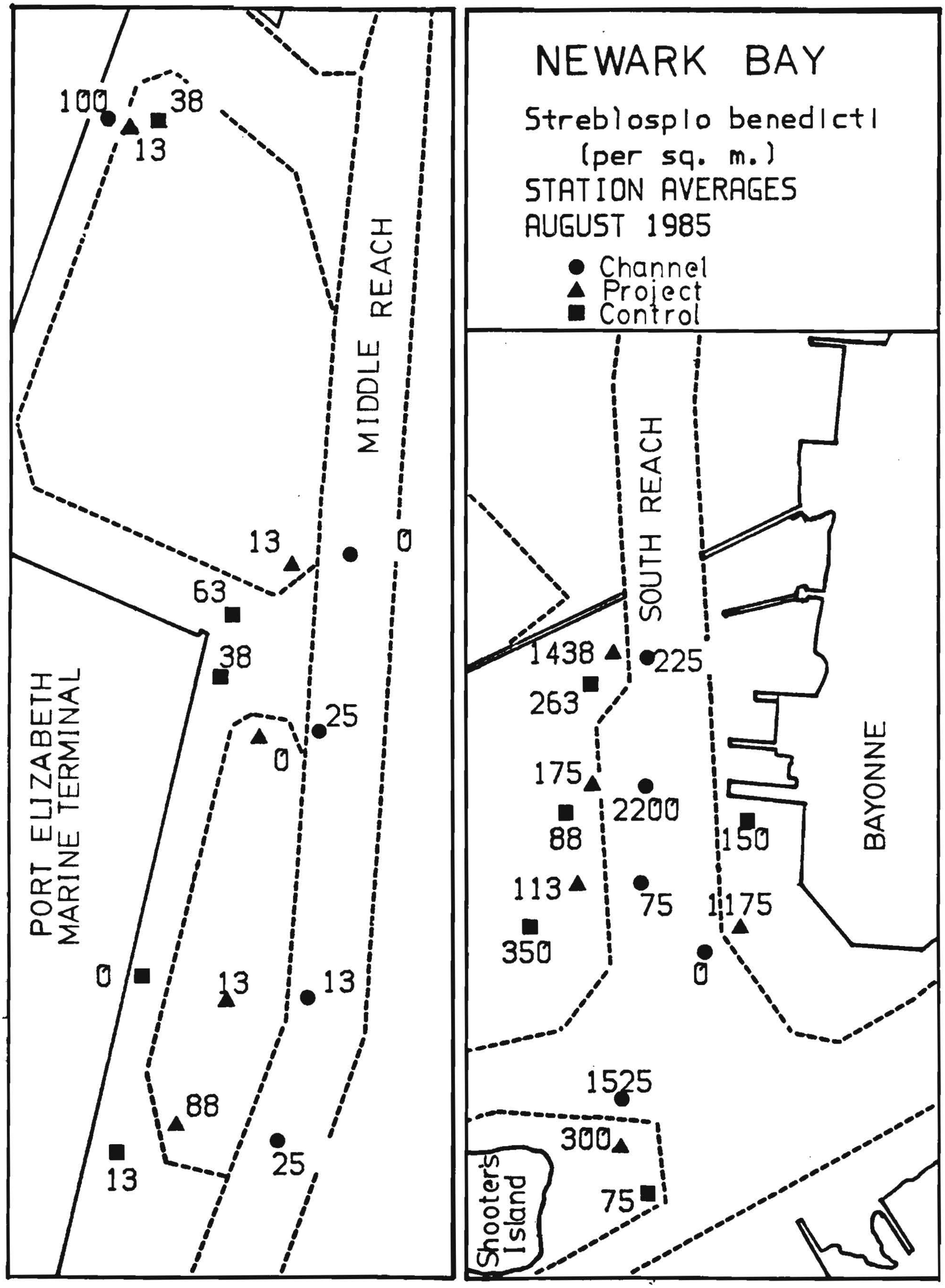

NEWARK BAY
Streblospio benedicti
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH
MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooters Island
100
38
13
13
0
63
38
25
0
0
13
13
88
13
25
1438
225
263
175
2200
88
150
113
75
1175
350
0
1525
300
75

FIGURE 28

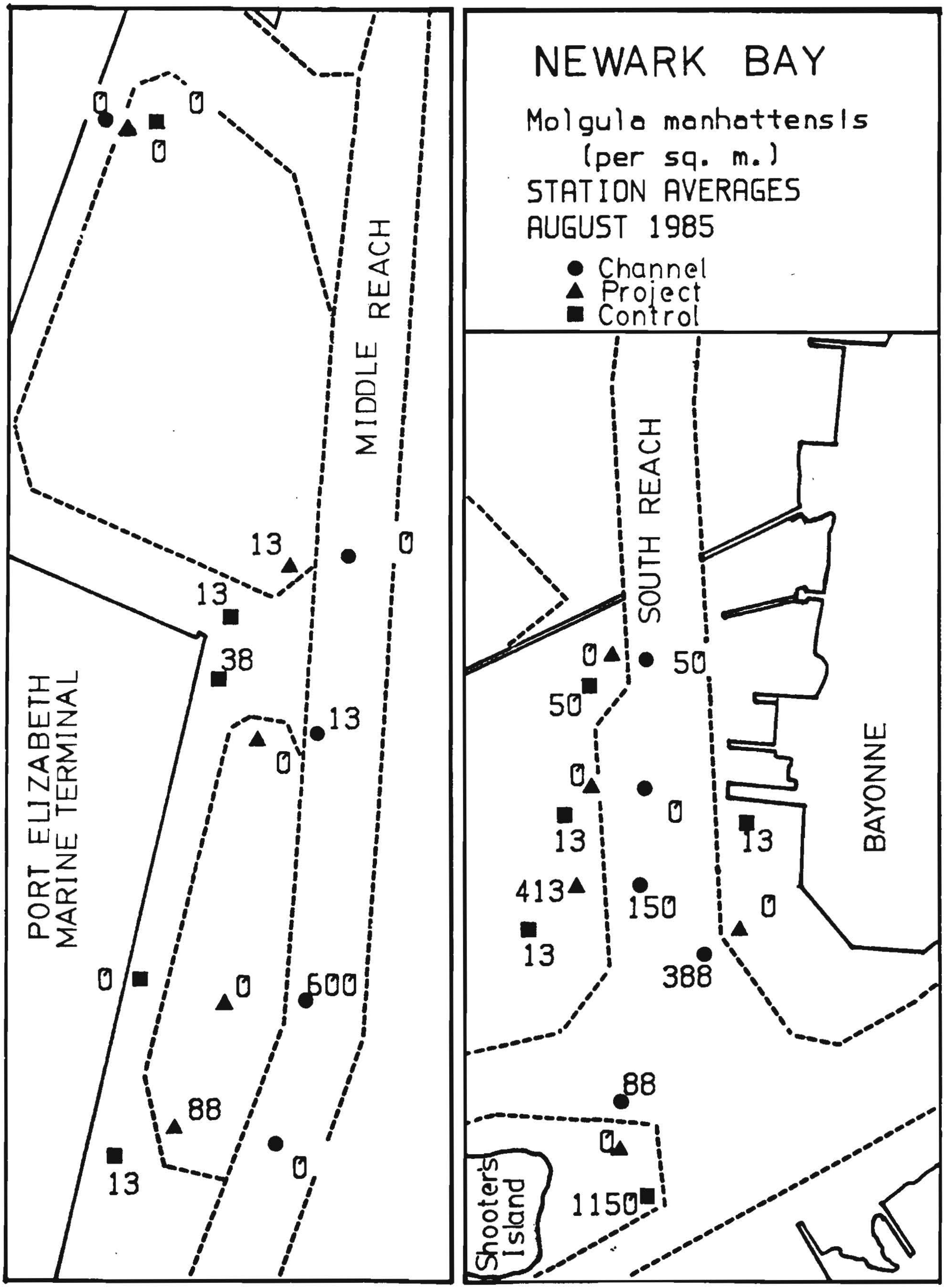

NEWARK BAY
Molgula manhattensis
(per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
PORT ELIZABETH
MARINE TERMINAL
SOUTH REACH
BAYONNE
Shooter's Island
0
0
0
13
0
13
38
13
0
0
0
600
88
13
0
0
50
50
0
0
13
13
413
150
0
13
388
88
0
1150

FIGURE 29

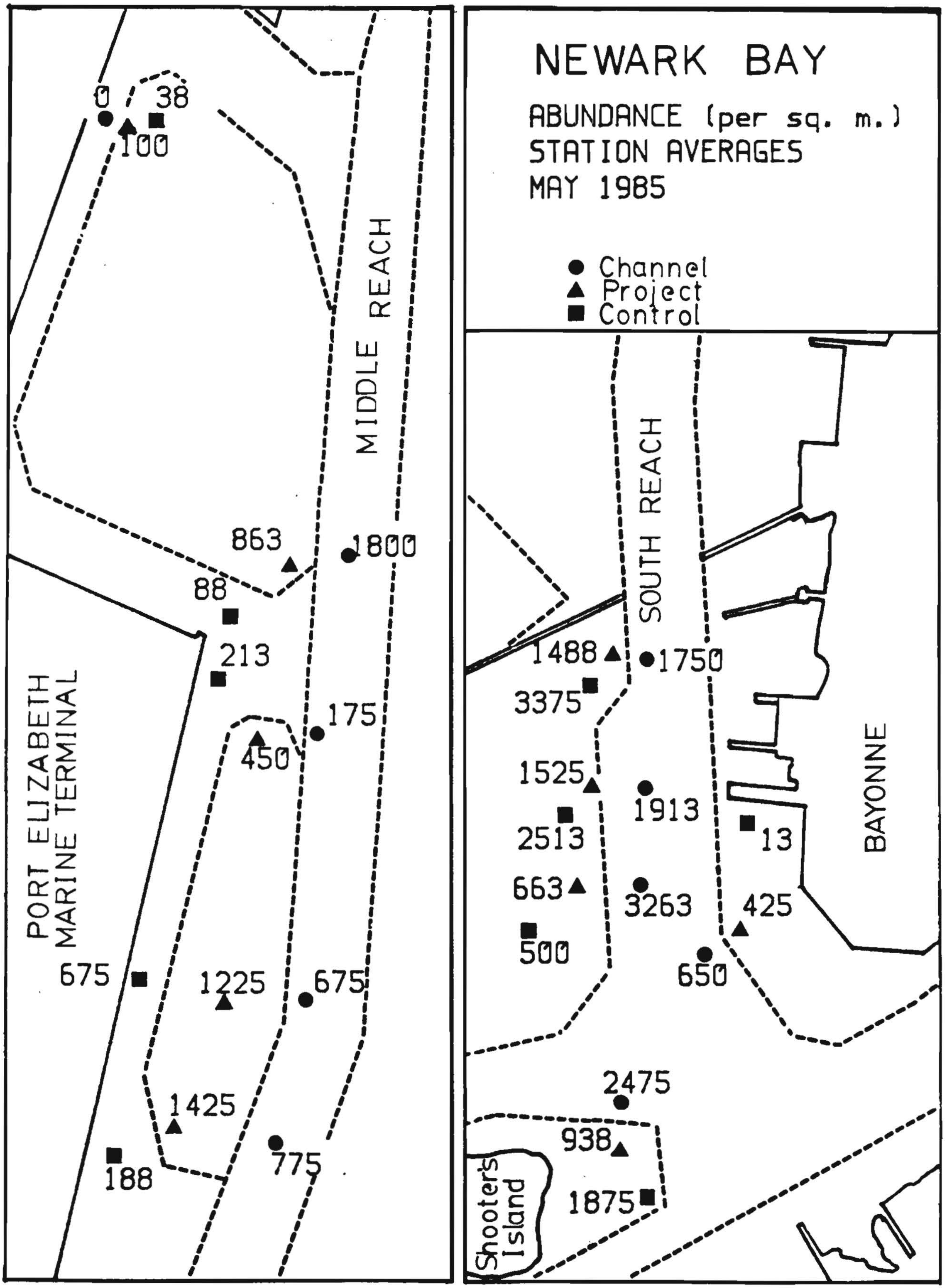

NEWARK BAY
ABUNDANCE (per sq. m.)
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0
38
100
863
1800
88
213
175
450
675
1225
675
1425
188
775
1488
1750
3375
1525
1913
2513
13
663
3263
425
500
650
2475
938
1875

FIGURE 30

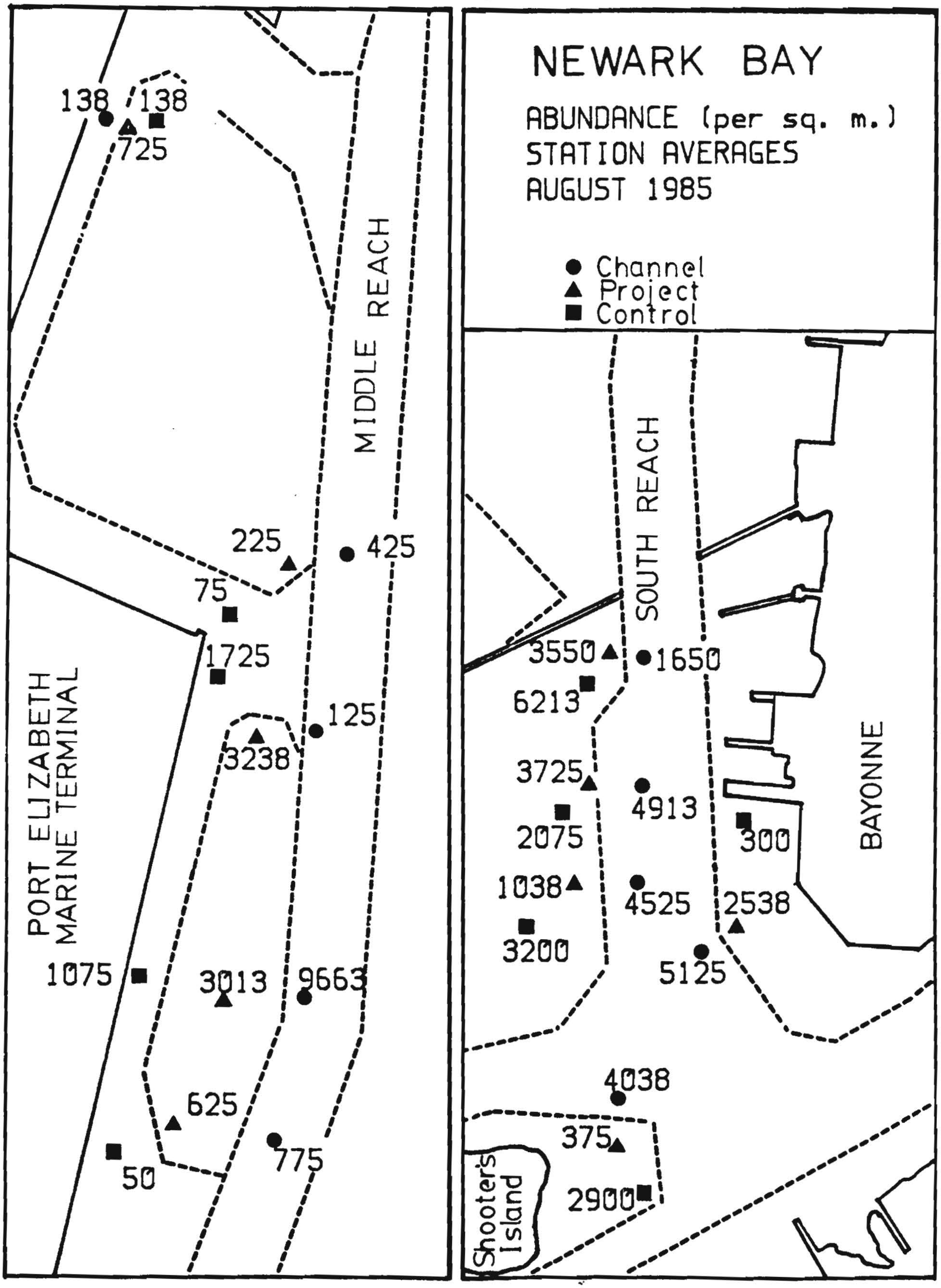

NEWARK BAY
ABUNDANCE (per sq. m.)
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
138
138
725
225
425
75
1725
125
3238
1075
3013
9663
625
50
775
3550
1650
6213
3725
4913
2075
300
1038
4525
2538
3200
5125
4038
375
2900

FIGURE 31

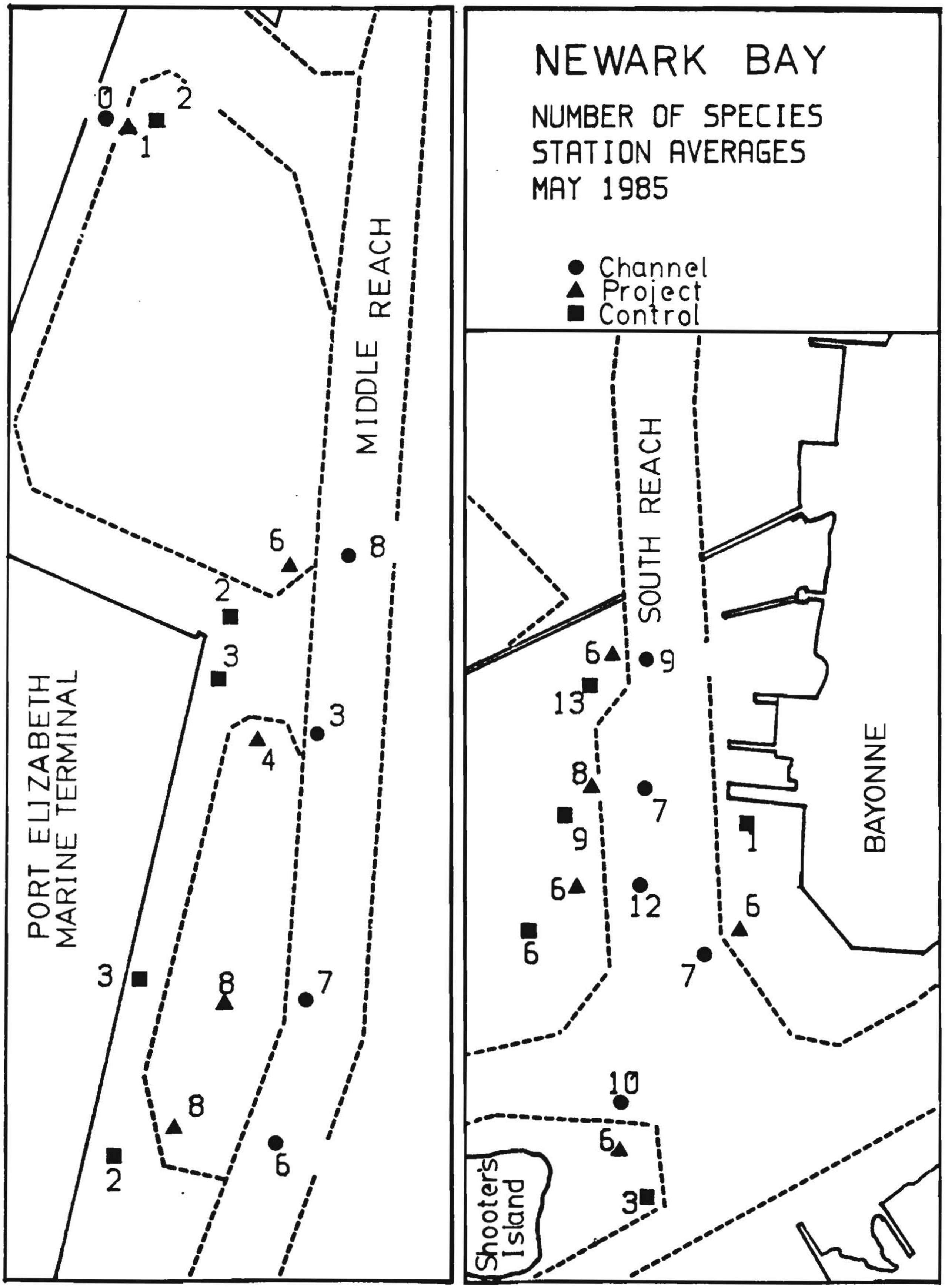

NEWARK BAY
NUMBER OF SPECIES
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
0
2
1
6
8
2
3
3
4
3
8
7
8
2
6
6
9
13
8
7
9
1
6
12
6
6
7
10
6
3

FIGURE 32

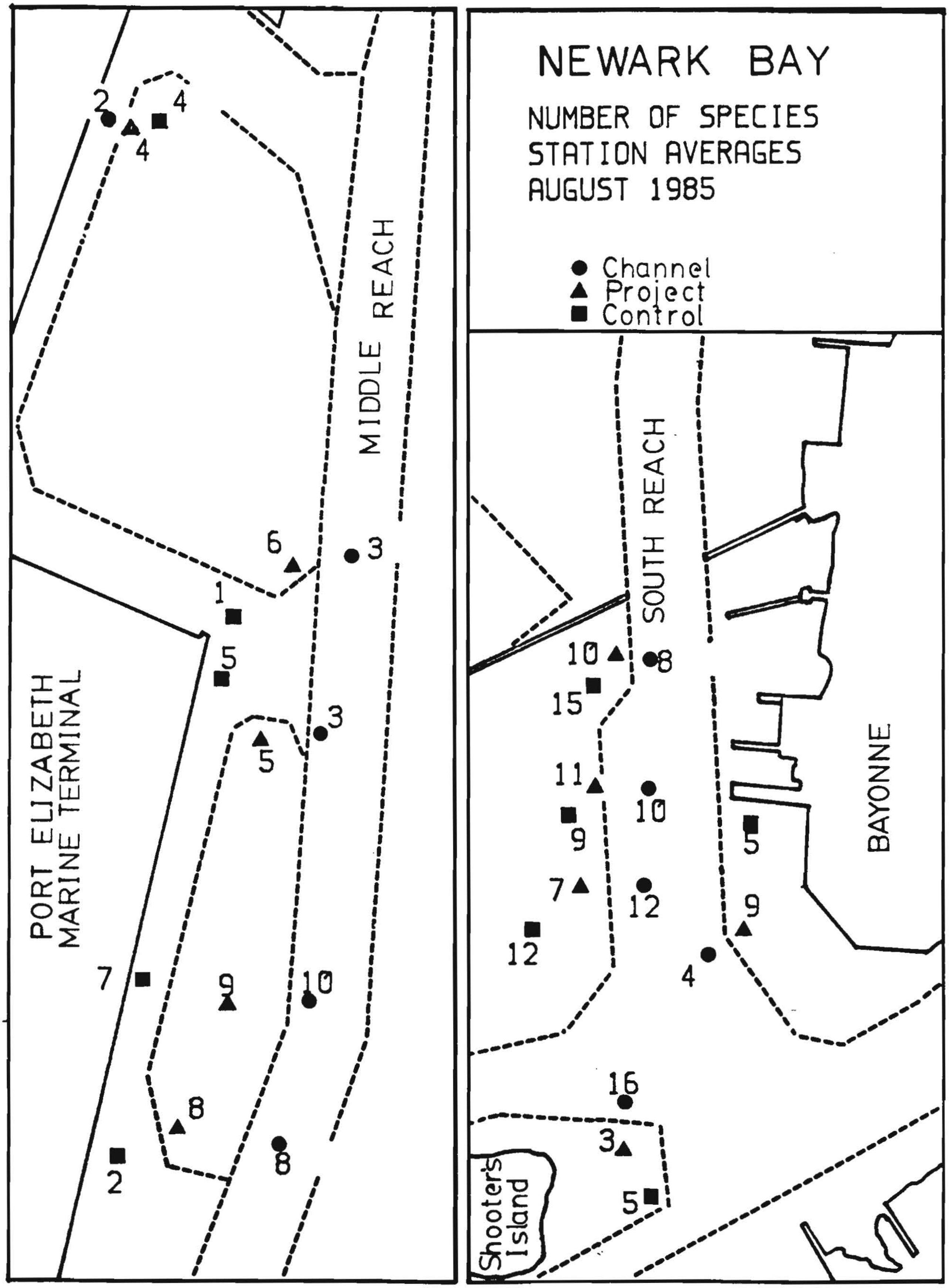

NEWARK BAY
NUMBER OF SPECIES
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH
MARINE TERMINAL
BAYONNE
Shooters
Island
2
4
4
6
3
1
5
3
5
7
9
10
8
2
8
10
8
15
11
10
9
5
7
12
9
12
4
16
3
5

FIGURE 33

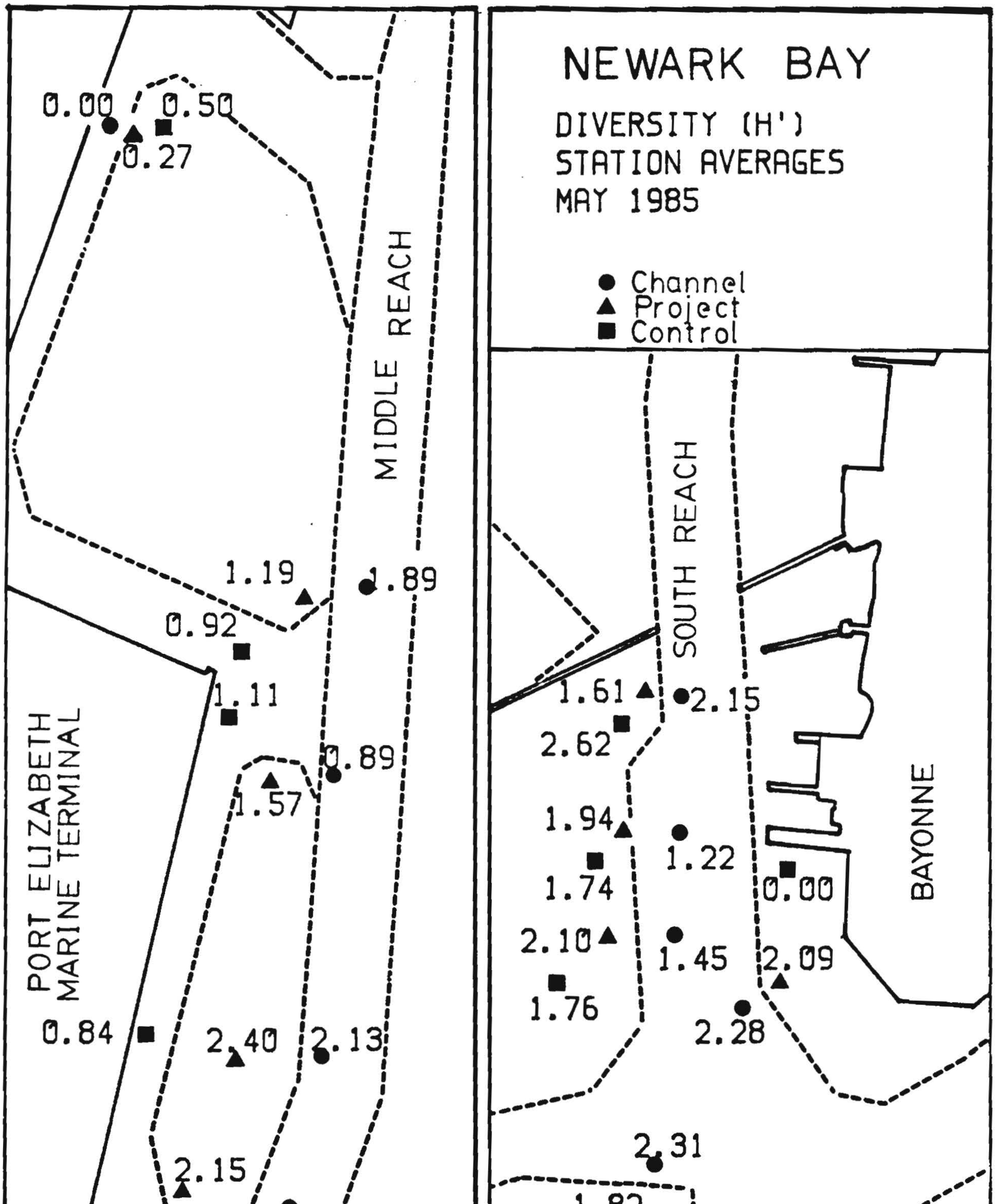

NEWARK BAY
DIVERSITY (H')
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0.00
0.50
0.27
1.19
1.89
0.92
1.11
0.89
1.57
0.84
2.40
2.13
2.15
0.77
1.37
1.61
2.15
2.62
1.94
1.22
1.74
0.00
2.10
1.45
2.09
1.76
2.28
2.31
1.82
0.38

FIGURE 34

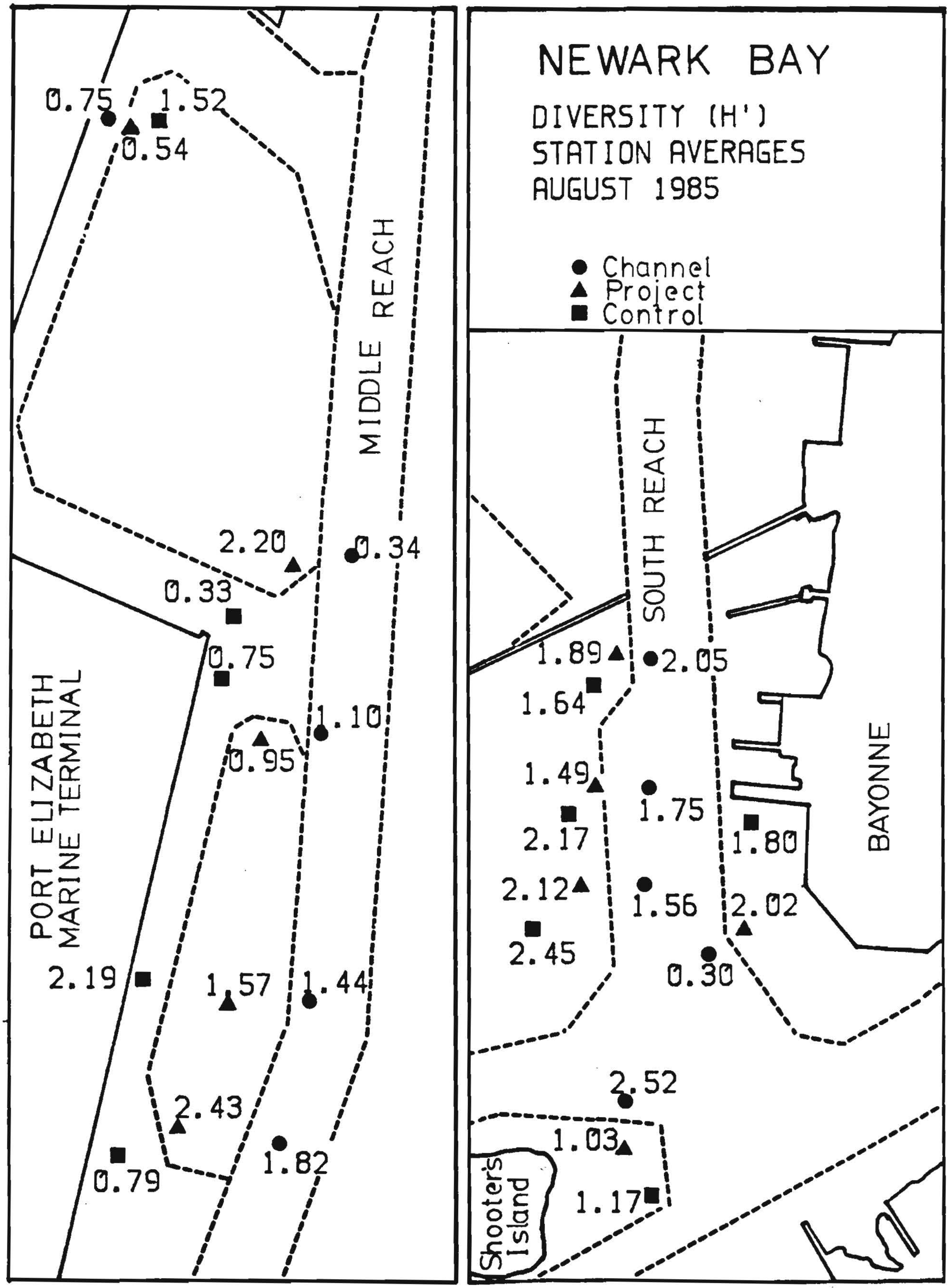

NEWARK BAY
DIVERSITY (H')
STATION AVERAGES
AUGUST 1985
● Channel
▲ Project
■ Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0.75
1.52
0.54
2.20
0.34
0.33
0.75
1.10
0.95
2.19
1.57
1.44
2.43
0.79
1.82
1.89
2.05
1.64
1.49
1.75
2.17
1.80
2.12
1.56
2.02
2.45
0.30
2.52
1.03
1.17

FIGURE 35

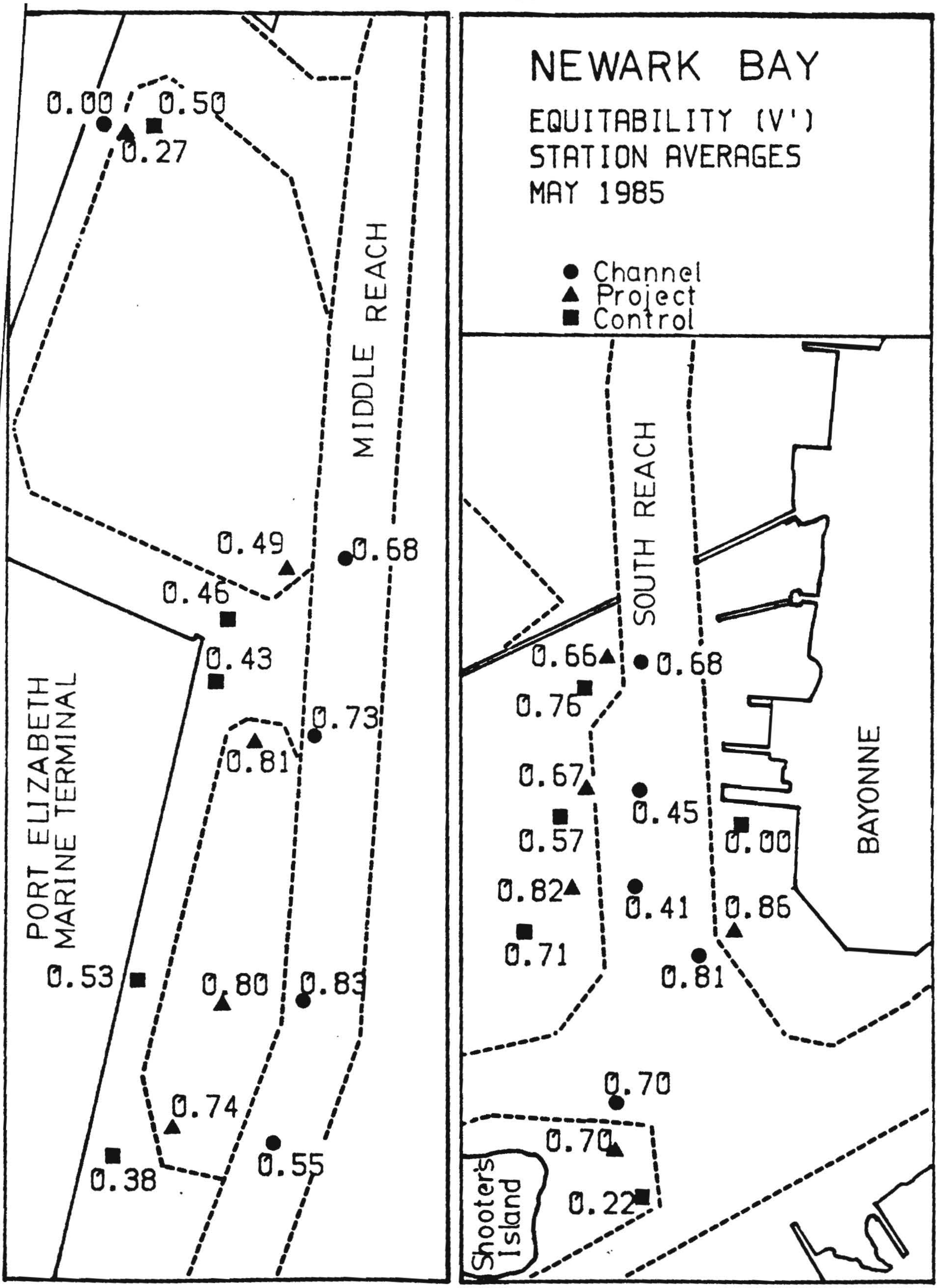

NEWARK BAY
EQUITABILITY (V')
STATION AVERAGES
MAY 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooter's Island
0.00
0.50
0.27
0.49
0.68
0.46
0.43
0.73
0.81
0.53
0.80
0.83
0.74
0.38
0.55
0.66
0.68
0.76
0.67
0.45
0.57
0.00
0.82
0.41
0.86
0.71
0.81
0.70
0.70
0.22

FIGURE 36

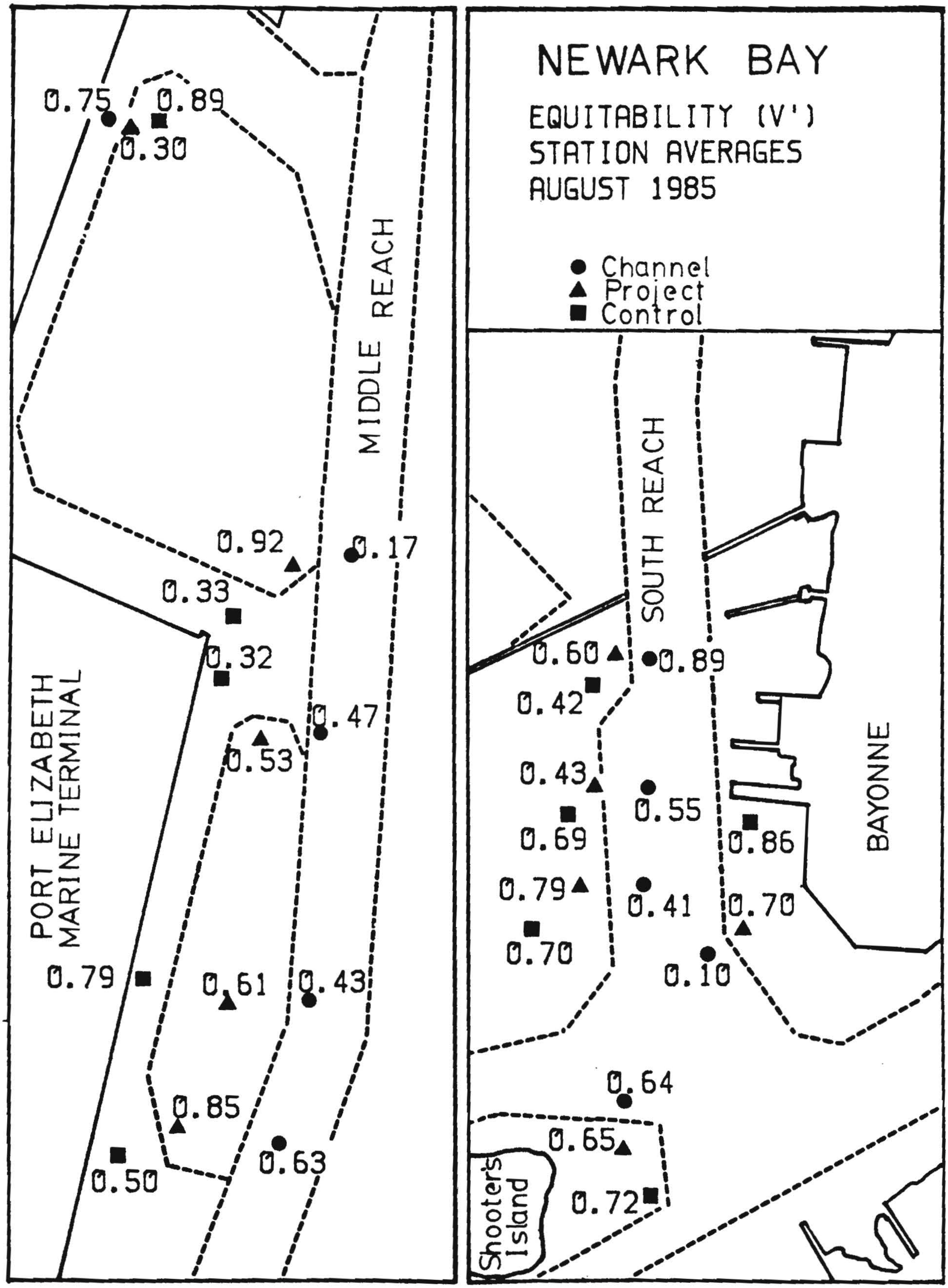

NEWARK BAY
EQUITABILITY (V')
STATION AVERAGES
AUGUST 1985
Channel
Project
Control
MIDDLE REACH
SOUTH REACH
PORT ELIZABETH MARINE TERMINAL
BAYONNE
Shooters Island
0.75
0.89
0.30
0.92
0.17
0.33
0.32
0.47
0.53
0.79
0.61
0.43
0.85
0.63
0.50
0.60
0.89
0.42
0.43
0.55
0.69
0.86
0.79
0.41
0.70
0.70
0.10
0.64
0.65
0.72

FIGURE 37

I	1A	(1)	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0/
II	1B	(2)	60/47/ 0 31 33 22/18 19 12 12 26 29 13 7 22 9 7 16 10 5 7 9 5/ 9 5/36 39/ 0/
	5C	(15)	/49/34 54 57 40/33 33 14 13 32 39 17 9 31 11 19 28 16 10 14 10 6/17 12/22 36/12/
	3C	(9)	/ 0 45 47 22/25 37 22 21 45 52 22 14 45 34 22 32 21 11 15 14 9/12 7/19 24/11/
	3A	(7)	43 45 32/14 7 0 0 2 7 3 0 8 0 19 24 3 6 10 0 1/15 13/ 0 18/ 0/
	3B	(8)	82/66/47 46 24 26 49 60 31 18 35 18 37 48 28 20 23 21 16/35 20/10 18/ 5/
	10B	(29)	/61/44 41 20 26 43 54 29 16 38 23 37 53 24 20 25 17 12/31 20/16 29/ 5/
	4C	(12)	/43 39 23 23 39 46 27 16 22 9 46 41 23 17 34 19 13/53 38/10 16/ 3/
III	2B	(5)	82/62 63/50 56/38 44/25 14 17 26/39 17 15 30 17/59 10/ 8 13/ 2/
	5A	(13)	/62 60/62 68/43 44/36 24 21 29/47 18 17 34 21/52 8/ 6 11/ 3/
	6B	(17)	71/55 41/45 54/28 22 14 20/60 34 25 53 35/44 4/ 3 4/ 1/
	7B	(20)	/53 45/54 67/38 40 29 36/54 26 28 36 26/45 4/ 4 7/ 1/
	8B	(23)	79/61 36/44 38 19 31/54 27 28 43 29/29 6/ 7 13/ 3/
	8C	(24)	/48 30/40 32 21 36/43 20 18 33 22/32 8/ 9 16/ 4/
	5B	(14)	60/54 52 43 54/56 28 32 38 27/27 6/ 5 9/ 1/
	7C	(21)	/36 35 32 36/43 19 22 28 19/36 3/ 2 4/ 0/
	4A	(10)	71/52 65/44 17 27 17 14/13 8/10 19/ 3/
	10A	(28)	/49 56/40 17 27 17 12/10 3/10 10/ 3/
	4B	(11)	69/34 21 43 8 12/32 27/ 5 11/ 1/
	9B	(26)	/38 20 35 13 13/25 20/ 7 14/ 2/
IV	6A	(16)	52 50/47 37/28 6/ 2 5/ 1/
	6C	(18)	57/42 42/18 7/ 2 4/ 0/
	9A	(25)	/19 19/32 25/ 2 5/ 0/
	7A	(19)	68/25 3/ 2 3/ 1/
	8A	(22)	/16 3/ 1 2/ 0/
V	2A	(4)	45/ 2 5/ 1/
	9C	(27)	/ 2 5/ 1/
VI	1C	(3)	59/ 0/
	2C	(6)	/ 0/
VII	10C	(30)	/

FIGURE 38

I	1A	(1)	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0/
II	1B	(2)	57 36/12 18 28 20 24 25 12 16 15 25 18 29 19 26 21 21 18 21 18 12 15 24 31 41/ 0/ 0/
	1C	(3)	61/15 34 50 36 28 30 23 26 17 28 22 21 23 19 23 23 20 21 13 14 11 18 30 41/ 0/ 0/
	2C	(6)	/17 34 49 39 30 31 25 32 19 31 24 23 25 12 26 18 16 19 15 16 12 11 22 47/38/ 0/
III	2A	(4)	50 50 50 49 55 46 40 39/31 57 37 44 34 42 34 37 33 42 43 37 40/27 30/27/ 8/
	2B	(5)	75/69/55 56/48 59 50/62 73 65 63 54 60 58 48 46 50 45 36 40/46 42/25/12/
	4C	(12)	/73/65 71/48 54 40/52 65 53 58 41 49 41 37 31 39 36 32 39/43 59/32/20/
	10B	(29)	/69 63/59 67 52/56 66 58 68 39 55 53 51 48 48 48 36 38/50 45/30/13/
	3B	(8)	68/62 66 38/48 59 43 54 30 46 33 35 33 42 38 41 30/46 53/35/17/
	9C	(27)	/49 50 33/40 53 42 46 32 34 27 24 23 31 30 26 30/40 54/36/18/
	4B	(11)	67/64/56 54 42 44 35 59 43 60 49 48 51 42 28/35 36/20/ 8/
	9B	(26)	/52/57 61 48 57 38 57 52 47 47 42 46 44 30/44 37/25/11/
	9A	(25)	/54 52 58 48 54 63 55 59 62 63 63 46 43/38 28/13/ 6/
IV	4A	(10)	63 66 57 57 65 54 60 52/55 48 48 41/50 43/11/10/
	5A	(13)	71 73/65/58 55 56 53/61 50 51 49/58 52/21/12/
	8B	(23)	78/74/71 71 65 68/72 55 53 58/55 45/ 9/12/
	8C	(24)	/59/64 64 58 57/63 48 48 50/50 40/12/13/
	6B	(17)	/58 68 63 51/65 55 56 65/57 32/ 0/10/
	5B	(14)	72 77/64/65 59 53 57/36 28/ 8/ 8/
	7B	(20)	79/64/65 56 53 59/36 19/ 0/ 8/
	7C	(21)	/66/63 57 52 55/38 23/ 0/ 7/
	10A	(28)	/63 57 47 53/48 28/ 0/10/
	6A	(16)	76/71/58/44 32/ 8/ 7/
	6C	(18)	/68/52/32 23/13/ 5/
	8A	(22)	/61/32 26/ 6/ 6/
	7A	(19)	/38 22/ 0/ 9/
V	3C	(9)	56/ 0/23/
	5C	(15)	/26/32/
VI	3A	(7)	/ 0/
VII	10C	(30)	/

FIGURE 39

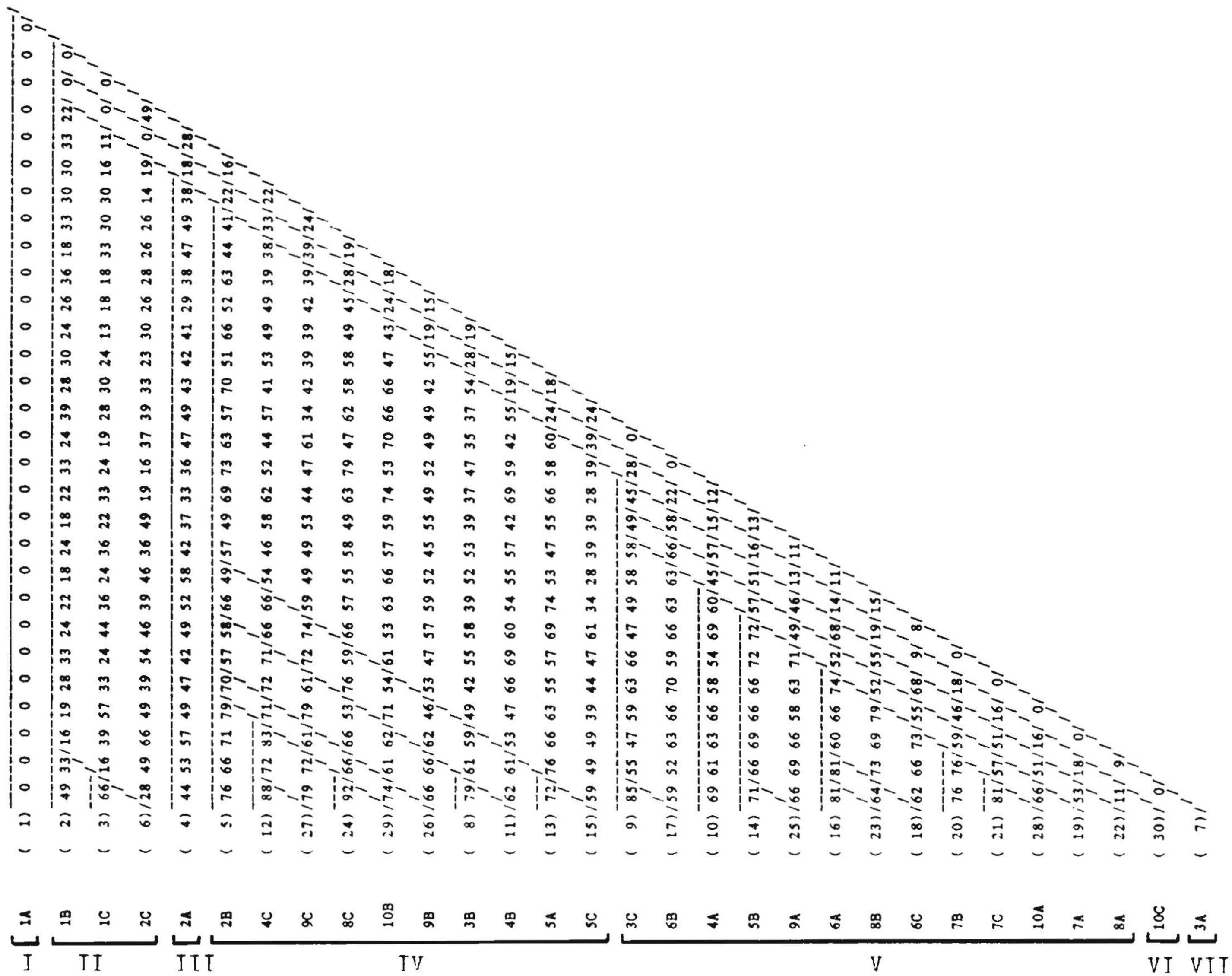


FIGURE 40

I	1A	(1) 58/48 51/45 20 38 26/ 1 5 2 3 6 9 7 5 4 7 3 4 10 29 11 16/ 8 8 6 6 0/ 0/
I	2C	(6)/27 39/35 16 37 39/ 0 3 0 2 3 4 6 3 2 4 3 0 5 21 8 13/ 3 0 5 4 0/ 0/
I	9B	(26) 48/24 12 19 11/ 2 9 3 8 17 25 9 16 13 20 5 6 15 29 24 19/ 6 6 8 8 1/ 0/
I	10C	(30)/22 18 47 21/ 2 12 5 8 12 15 12 12 10 14 8 9 23 37 26 26/ 7 6 6 6 1/ 1/
I	1C	(3) 41/38 26/ 2 3 3 1 4 6 5 3 2 5 3 8 13 16 6 8/14 13 8 4 0/ 1/
I	2B	(5)/42 27/ 9 7 10 4 7 11 12 6 1 10 4 26 14 32 15 17/18 15 6 4 2/ 3/
I	3A	(7) 42/ 2 3 3 2 4 6 7 5 3 6 4 10 22 26 9 15/11 13 6 4 1/ 1/
I	5C	(15)/ 0 0 1 0 1 2 3 1 1 3 2 2 9 11 4 4/ 6 5 4 2 0/ 0/
II	3B	(8) 86/75/66/25 31 40 6 1 23 3/17 5 16 12 5/ 3 3 2 2 2/ 4/
II	7B	(20)/70/72/38 39 52 20 13 34 15/16 16 20 30 20/ 2 1 2 3 1/ 4/
II	4B	(11)/53/28 36 43 19 8 26 11/42 25 21 20 6/12 12 9 8 6/10/
II	6C	(18)/31 31 38 22 14 28 16/13 13 14 31 16/ 1 0 2 3 1/ 6/
II	6B	(17) 71/56/54/54 54 27/13 16 20 37 22/ 2 1 2 3 1/ 2/
II	10B	(29)/51/50/36 45 12/25 13 29 29 16/ 7 6 8 8 3/ 4/
II	7C	(21)/23/19 52 26/21 21 30 44 31/ 3 1 3 4 2/ 3/
II	9A	(25)/50 28 29/22 28 19 41 27/ 3 2 6 7 4/16/
II	7A	(19) 56/48/11 20 8 28 14/ 2 2 3 3 1/ 4/
II	8C	(24)/55/19 19 23 42 24/ 5 4 7 7 3/ 4/
II	8A	(22)/15 23 14 35 25/ 2 1 4 8 4/ 9/
III	4C	(12) 48/41 34 10/34 39 25 16 10/10/
III	5A	(13)/33 40 34/14 14 8 7 4/ 8/
III	5B	(14) 40 37/11 9 10 13 6/ 5/
III	6A	(16) 43/ 3 2 5 7 2/ 7/
III	8B	(23)/ 5 3 6 26 14/ 9/
IV	1B	(2) 71/56 38 23/ 2/
IV	2A	(4)/37 24 14/ 1/
IV	3C	(9) 71/46/ 2/
IV	9C	(27)/50/11/
IV	10A	(28)/ 6/
V	4A	(10)/

FIGURE 41

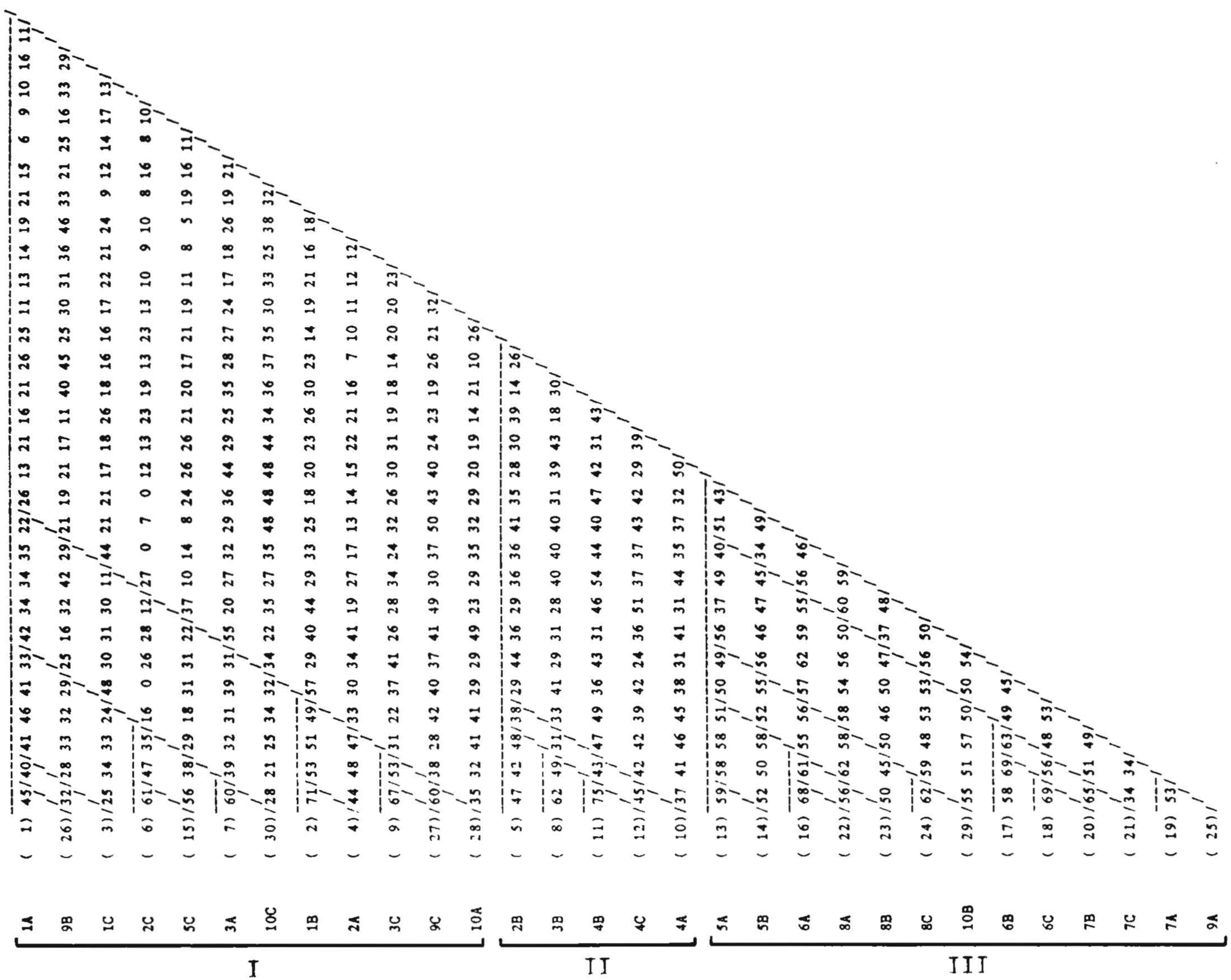

1A
9B
1C
2C
5C
3A
10C
1B
2A
3C
9C
10A
2B
3B
4B
4C
4A
5A
5B
6A
8A
8B
8C
10B
6B
6C
7B
7C
7A
9A
I
II
III

FIGURE 42

I	1A	(1)	39 57/49 44 28 33 44 39 36 57 18/16 23 14 35 30 26 24 28 11 9 22 18 23 15 18 11 13 15/
	2C	(6)	66/28 24 0 36 49 44 39 33 19/ 0 12 0 24 33 14 13 30 24 19 11 18 12 16 19 11 28 33/
	5C	(15)	/44 39 24 46 59 54 49 49 33/15 22 13 44 42 37 23 39 33 18 31 34 33 23 36 10 37 28/
	1B	(2)	72/66/71 54/49 61 44 30/42 42 37 42 39 47 44 37 31 26 29 33 42 29 34 29 35 39/
	1C	(3)	/39/53 33/46 42 39 14/26 29 23 29 24 33 42 23 19 16 28 23 29 21 33 18 22 24/
	2A	(4)	/46 39/36 49 24 33/46 33 39 33 28 37 35 26 22 18 21 26 33 23 27 21 24 28/
	2B	(5)	66/49 58 30 47/44 43 49 52 42 38 45 49 43 36 24 42 43 38 44 33 47 52/
	3A	(7)	/46 57 39 42/26 39 47 49 62 44 42 58 39 33 28 39 39 35 41 28 44 49/
	3C	(9)	66/54/39/37 38 44 38 35 42 39 44 38 31 36 46 38 34 39 27 42 35/
	9C	(27)	/66/62/47 45 42 45 44 59 47 63 45 38 34 51 54 46 61 34 49 55/
	9B	(26)	/49/30 33 26 22 28 49 35 53 22 18 31 34 44 30 36 21 24 28/
	10A	(28)	/47 45 42 36 44 39 38 63 36 30 17 44 45 39 46 26 39 44/
II	3B	(8)	69 59/43 31 47 45 39 34 36 33 49 43 51 44 41 38 42/
	4B	(11)	71/49 49 61 59 55 42 49 41 60 64 61 49 55 53 49/
	4C	(12)	/47 38 52 58 54 47 48 38 59 63 48 41 53 60 38/
III	4A	(10)	58/53 51 55 64 49 48 66 57 61 49 41 53 49/
	10C	(30)	/54 52 57 58 49 55 62 49 49 49 47 36 39/
IV	5A	(13)	71/69/61 46 59 70 69 52 59 59 49 54/
	6B	(17)	/66/66 58 57 68 59 57 58 71 55 60/
	5B	(14)	/55 48 38 59 63 60 55 46 52 57/
V	6A	(16)	81/68/78 71 55 62/68 69 66/
	6C	(18)	/60/70 62 59 55/60 59 57/
	7A	(19)	/70 62 54 60/59 44 39/
	8A	(22)	78/77/70/70 64 62/
	10B	(29)	/66/68/62 61 58/
	9A	(25)	/64/54 47 56/
	8C	(24)	/54 53 57/
	7B	(20)	66/63/
	7C	(21)	/63/
	8B	(23)	/

APPENDIX A

Data Tabulations by Sample

Column Heading Code Key

I-1Ab

Cruise:
I (Spring)
II (Summer)

Site:
(1-10)

Station:
A Channel Area
B Shoal Area
C Control

Replicate:
(a,b)

SPECIES LIST	I-1Aa	I-1Ab	I-1Ba	I-1Bb	I-1Ca	I-1Cb
CNIDARIA						
NEMATODA						
NEMERTEA						
POLYCHAETA						
Eteone heteropoda			1			
Streblospio benedicti			7		1	1
AMPHIPODA						
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii					1	
GASTROPODA						
BIVALVIA						
ECTOPROCTA						
CHORDATA						
NUMBER OF SPECIES	0	0	2	0	2	1
NUMBER OF INDIVIDUALS	0	0	8	0	2	1

SPECIES LIST	I-2Aa	I-2Ab	I-2Ba	I-2Bb	I-2Ca	I-2Cb
CNIDARIA						
Metridium senile			1			
NEMATODA						
NEMERTEA		1				
POLYCHAETA						
Capitellidae sp.		3				
Nereis succinea	1	1		1		
Magelonidae sp.		1				
Maldanidae sp.	5	2				
Pectinaria gouldii	5	5				
Polydora ligni		2	2	1		
Scollecolepides viridis				1		
Spiophanes bombyx			2			
Streblospio benedicti	24	32	33	21		3
AMPHIPODA						
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii			1			2
GASTROPODA						
BIVALVIA						
Mulinia lateralis		1				
Mya arenaria	33	28	3	3		1
Tellina agilis						1
ECTOPROCTA						
CHORDATA						
NUMBER OF SPECIES	5	10	6	5	0	4
NUMBER OF INDIVIDUALS	68	76	42	27	0	7

SPECIES LIST	I-3Aa	I-3Ab	I-3Ba	I-3Bb	I-3Ca	I-3Cb
CNIDARIA						
NEMATODA						1
NEMERTEA						
POLYCHAETA						
Asabellides oculata				1		
Glycera sp.		1				
Nereis succinea			1	2		3
Sabellaria vulgaris						1
Polydora ligni				3		5
Scollecolepides viridis						1
Streblospio benedicti				15		6
AMPHIPODA						
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
GASTROPODA						
BIVALVIA						
Mulinia lateralis	1					
Mya arenaria	9	2	3	10		
Tellina agilis	1					
ECTOPROCTA						
CHORDATA						
Molgula manhattensis			1			
NUMBER OF SPECIES	3	2	3	5	0	6
NUMBER OF INDIVIDUALS	11	3	5	31	0	17

SPECIES LIST	I-4Aa	I-4Ab	I-4Ba	I-4Bb	I-4Ca	I-4Cb
CNIDARIA						
NEMATODA						
NEMERTEA						
POLYCHAETA						
Asabellides oculata			1			
Capitellidae sp.			2	1		
Nereis succinea	3		8	2		1
Clymenella sp.		1				
Eteone heteropoda	1					
Sabellaria vulgaris	2		2	1		
Polydora ligni	24	1	15	13		1
Scollecolepides viridis	6					
Spiophanes bombyx	1					
Streblospio benedicti	4	2	3	1	8	10
AMPHIPODA						
Lembos smithii	3					
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii	2		10	2	1	
GASTROPODA						
BIVALVIA						
Mya arenaria		3	18	10	33	
ECTOPROCTA						
CHORDATA						
Molgula manhattensis	1		9			
NUMBER OF SPECIES	10	4	9	7	3	3
NUMBER OF INDIVIDUALS	47	7	68	30	42	12

SPECIES LIST	I-5Aa	I-5Ab	I-5Ba	I-5Bb	I-5Ca	I-5Cb
CNIDARIA						
Metridium senile			1			
NEMATODA						
NEMERTEA						
POLYCHAETA						
Capitellidae sp.				3		
Nereis succinea	1	1	1	2		1
Maldanidae sp.		1				
Eteone heteropoda			4			
Sabellaria vulgaris		2				1
Polydora ligni	3	3	15	35		
Scollecolepides viridis	2		2	14		
Streblospio benedicti	28	18	18	8		8
AMPHIPODA						
Unciola irrorata			3			
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii			5			
GASTROPODA						
BIVALVIA						
Mya arenaria	1	2		2		5
ECTOPROCTA						
Conopeum reticulum			+			
CHORDATA						
Molgula manhattensis			1			
NUMBER OF SPECIES	5	6	9	6	0	4
NUMBER OF INDIVIDUALS	35	27	50	64	0	15

SPECIES LIST	I-6Aa	I-6Ab	I-6Ba	I-6Bb	I-6Ca	I-6Cb
CNIDARIA						
Metridium senile		1				3
NEMATODA	4			4		4
NEMERTEA						
POLYCHAETA						
Capitellidae sp.						1
Glycera dibranchiata				1	1	3
Nereis succinea	3	6	1			28
Maldanidae sp.	1	1			2	10
Eteone heteropoda	1	1	1			7
Harmothoe extenuata						1
Sabellaria vulgaris		32	2			71
Polydora ligni	21		8	1	2	3
Scollecolepides viridis	24	6	15	23	16	47
Streblospio benedicti	29	3	31	32	11	5
AMPHIPODA						
Corophium acherusicum		2				34
Melita nitida	1					2
CUMACEA						
Oxyurostylis smithii					2	
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii						5
GASTROPODA						
BIVALVIA						
Mya arenaria	3				6	4
Mytilus edulus						1
ECTOPROCTA						
CHORDATA						
Molgula manhattensis		1				1
NUMBER OF SPECIES	9	9	6	5	7	18
NUMBER OF INDIVIDUALS	87	53	58	61	40	230

SPECIES LIST	I-7Aa	I-7Ab	I-7Ba	I-7Bb	I-7Ca	I-7Cb
CNIDARIA						
Metridium senile			1			
NEMATODA						
NEMERTEA						
POLYCHAETA						
Capitellidae sp.	2				5	
Tharyx acutus		1				
Glycera capitata	1					
Glycera dibranchiata		1	1			
Nereis succinea	3		8	2	2	2
Maldanidae sp.		2				
Eteone heteropoda	1	2	2	2	1	1
Sabellaria vulgaris						2
Polydora ligni		2	6	10	18	30
Scollecolepides viridis	69	39	2	9	8	3
Streblospio benedicti	3	27	27	45	71	48
AMPHIPODA						
Melita nitida				1		1
CUMACEA						
CIRRIPEDIA						
Balanus sp.			3			1
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii			3		1	1
GASTROPODA						
BIVALVIA						
ECTOPROCTA						
CHORDATA			+			
Molgula manhattensis						6
NUMBER OF SPECIES	6	7	9	6	7	10
NUMBER OF INDIVIDUALS	79	74	53	69	106	95

SPECIES LIST	I-8Aa	I-8Ab	I-8Ba	I-8Bb	I-8Ca	I-8Cb
CNIDARIA						
Metridium senile			1			
NEMATODA						
NEMERTEA						
POLYCHAETA						
Asabellides oculata	1					
Glycera dibranchiata	1	1				
Nereis succinea	9	1	3		1	3
Maldanidae sp.	4	1				
Eteone heteropoda	7	4		1		
Lepidontus squamatus	1					
Sabellaria vulgaris	3		1			
Polydora ligni	1	1	2	4	4	1
Scollecolepides viridis	99	96	1	14	2	1
Streblospio benedicti	2	21	5	19	7	17
AMPHIPODA						
Corophium acherusicum	2					
Melita nitida			1		1	1
CUMACEA						
Oxyurostylis smithii		1				
CIRRIPEDIA						
ISOPODA						
Cyathura polita	1					
DECAPODA						
GASTROPODA						
Nassarius trivittatus	1					
BIVALVIA						
Mya arenaria		2	1		2	
ECTOPROCTA						
CHORDATA						
Molgula manhattensis	1					
NUMBER OF SPECIES	14	9	8	4	6	5
NUMBER OF INDIVIDUALS	133	128	15	38	17	23

SPECIES LIST	I-9Aa	I-9Ab	I-9Ba	I-9Bb	I-9Ca	I-9Cb
CNIDARIA						
Metridium senile		4				
NEMATODA	2					
NEMERTEA		1				
POLYCHAETA						
Asabellides oculata				1		
Capitellidae sp.	5	2				
Nereis succinea	24	16	4	3		1
Eteone heteropoda		1				
Sabellaria vulgaris		55				
Polydora ligni	10	2	32	2		1
Scollecolepides viridis	10	8	3			
Streblospio benedicti	7	1	7		2	2
AMPHIPODA						
Erichthonius brasiliensis		6				
CUMACEA						
CIRRIPEDIA						
ISOPODA						
Idotea montosa	1					
DECAPODA						
Rhithropanopeus harrisii	3	1	3			
GASTROPODA						
Nassarius trivittatus				2		
BIVALVIA						
Mya arenaria	39		3	14	109	35
Mytilus edulus				1		
ECTOPROCTA						
CHORDATA						
NUMBER OF SPECIES	9	11	6	6	2	4
NUMBER OF INDIVIDUALS	101	97	52	23	111	39

SPECIES LIST	I-10Aa	I-10Ab	I-10Ba	I-10Bb	I-10Ca	I-10Cb
CNIDARIA						
Metridium senile		3				
NEMATODA						
NEMERTEA						
POLYCHAETA						
Capitellidae sp.	3	1				
Nereis succinea	4	1	1	1		1
Maldanidae sp.		1				
Eteone heteropoda	4					
Sabellaria vulgaris	1					
Polydora ligni	25		3			
Scollecolepides viridis	3	2	1			
Streblospio benedicti		2	10	1		
AMPHIPODA						
Melita nitida		1		1		
CUMACEA						
CIRRIPEDIA						
ISOPODA						
DECAPODA						
Rhithropanopeus harrisii	1		1	2		
GASTROPODA						
BIVALVIA						
Mya arenaria			11	2		
ECTOPROCTA						
CHORDATA						
NUMBER OF SPECIES	7	7	6	5	0	1
NUMBER OF INDIVIDUALS	41	11	27	7	0	1

SPECIES LIST - AUGUST 1985	II-1Aa	II-1Ab	II-1Ba	II-1Bb	II-1Ca	II-1Cb
CNIDARIA						
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
Oligochaeta sp.						1
POLYCHAETA						
Nephtys incisa						1
Nereis succinea			1	1		
Nereis sp.	1					
Streblospio benedicti		8		1	3	
CIRREPEDIA						
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
ISOPODA						
MYSIDACEA						
DECAPODA						
Crangon septemspinosa			1		1	1
Rhithropanopeus harrisii			1			2
GASTROPODA						
BIVALVIA						
Mya arenaria	1	1	24	29		2
ECTOPROCTA						
CHORDATA						
NUMBER OF SPECIES	2	2	4	3	2	5
NUMBER OF INDIVIDUALS	2	9	27	31	4	7

SPECIES LIST - AUGUST 1985	II-2Aa	II-2Ab	II-2Ba	II-2Bb	II-2Ca	II-2Cb
CNIDARIA						
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Clymenella sp.	1					
Nephtys sp.				1		
Nereis succinea	1		1	1		
Streblospio benedicti				1		5
CIRREPEDIA						
Balanus improvisus			1	4		
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
ISOPODA						
MYSIDACEA						
DECAPODA						
Crangon septemspinosa				1		
Rhithropanopeus harrisii	1			4		
GASTROPODA						
BIVALVIA						
Spisula solidissima			1			
Mya arenaria	24	7	2			
ECTOPROCTA						
Callopora sp.			+			
Electra sp.			+			
CHORDATA						
Molgula manhattensis				1		1
NUMBER OF SPECIES	4	1	4	7	0	2
NUMBER OF INDIVIDUALS	27	7	5	13	0	6

SPECIES LIST - AUGUST 1985	II-3Aa	II-3Ab	II-3Ba	II-3Bb	II-3Ca	II-3Cb
CNIDARIA						
Metridium senile			2			
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitellidae sp.			1			
Glycera dibranchiata						1
Nereis succinea	1		3			
Polydora ligni				1	2	3
Spio setosa		3				
Streblospio benedicti		2			3	
CIRREPEDIA						
Balanus improvisus			235			
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Melita nitida			2	1		
ISOPODA						
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii			10			1
GASTROPODA						
Crepidula plana			1			
BIVALVIA						
Mulinia lateralis						2
Spisula solidissima		1				
Mya arenaria		2		3	79	44
ECTOPROCTA						
Membranipora tenuis			+			
CHORDATA						
Molgula manhattensis		1			1	2
NUMBER OF SPECIES	1	5	7	3	4	6
NUMBER OF INDIVIDUALS	1	9	254	5	85	53

SPECIES LIST - AUGUST 1985	II-4Aa	II-4Ab	II-4Ba	II-4Bb	II-4Ca	II-4Cb
CNIDARIA						
Metridium senile	1	1				
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitellidae sp.			1			
Glycera americana	3					
Glycera dibranchiata						1
Nereis succinea	2	4	4		1	2
Nereis sp.	1					
Pectinaria gouldii				1		
Lepidonotus squamatus			1			1
Polynoidae sp.		1				
Sabellaria vulgaris	24	663	32	1	1	25
Polydora ligni			1	1	7	
Spio setosa	1		1		1	
Streblospio benedicti	1		1			
CIRREPEDIA						
Balanus improvisus	3		171			15
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Corophium sp.	3					
Melita nitida			1			3
ISOPODA						
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii	1	9	8			6
GASTROPODA						
Crepidula plana			1			
BIVALVIA						
Spisula solidissima					1	
Mya arenaria		6	11	4	4	18
Mytilus edulis		1				
Crassostrea virginica			1			
ECTOPROCTA						
Membranipora tenuis			+			+
CHORDATA						
Molgula manhattensis	1	47				
NUMBER OF SPECIES	11	8	13	4	6	8
NUMBER OF INDIVIDUALS	41	732	234	7	15	71

SPECIES LIST - AUGUST 1985	II-5Aa	II-5Ab	II-5Ba	II-5Bb	II-5Ca	II-5Cb
CNIDARIA						
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitellidae sp.	1	1				
Glycera americana	1				1	
Maldanidae sp.			1			
Nereis succinea	3		3			
Eteone heteropoda	2		2			
Sabellaria vulgaris	25		5			
Polydora ligni		1		1		
Spio setosa	4	12	1	1		
Streblospio benedicti	1	1	2	5	1	
CIRREPEDIA						
Balanus improvisus			12	6		
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Lembos smithi	3		1			
ISOPODA						
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii	1					
GASTROPODA						
BIVALVIA						
Mya arenaria	5			3		1
Tellina agilis		1				
ECTOPROCTA						
Callopora sp.				+		
CHORDATA						
Molgula manhattensis			6	1	1	
NUMBER OF SPECIES	10	5	9	6	3	1
NUMBER OF INDIVIDUALS	46	16	33	17	3	1

SPECIES LIST - AUGUST 1985	II-6Aa	II-6Ab	II-6Ba	II-6Bb	II-6Ca	II-6Cb
CNIDARIA						
Metridium senile		12			2	7
Hydractinia sp.						+
Tubularia sp.						+
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
Oligochaeta sp.				4		
POLYCHAETA						
Capitellidae sp.				20		
Tharyx acutus		4			1	
Glycera americana		2				
Glycera dibranchiata	1		1	4	1	1
Maldanidae sp.				1		
Nereis succinea		1		6	9	8
Eteone heteropoda		17	1	5	4	4
Lepidonotus squamatus					1	
Sabellaria vulgaris		15		1	3	9
Hydroides dianthus						1
Spio setosa	2	30	5	52	20	1
Streblospio benedicti		18		115	17	4
CIRREPEDIA						
Balanus improvisus		16	23	39	160	208
Balanus sp.					1	
CAPRELLIDEA						
Caprella sp.						1
CUMACEA						
AMPHIPODA						
Corophium acherusicum		4			2	
ISOPODA						
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii		5	1	2	10	7
GASTROPODA						
Crepidula plana					1	9
BIVALVIA						
Mya arenaria				1		
Tellina agilis		1	2	1	1	
ECTOPROCTA						
Electra sp.				+		+++
Conopeum reticulum				+		
Membranipora tenuis		+			+	+
Bowerbankia sp.					+	+
CHORDATA						
Molgula manhattensis		4			2	2
NUMBER OF SPECIES	2	13	6	13	16	13
NUMBER OF INDIVIDUALS	3	129	33	251	235	262

SPECIES LIST - AUGUST 1985	II-7Aa	II-7Ab	II-7Ba	II-7Bb	II-7Ca	II-7Cb
CNIDARIA						
Metridium senile		1				
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitella capitata	22	13	3			
Capitellidae sp.				1		
Glycera americana		1				6
Glycera dibranchiata		2		3	4	3
Glycera sp.			1			
Nereis succinea			7	3	8	3
Eteone heteropoda	2	3	4	3	3	
Lepidonotus squamatus					2	
Sabellaria vulgaris	17	3	3	1		
Spio setosa	10	132	1	15	13	28
Streblospio benedicti	77	99	11	3		7
CIRREPEDIA						
Balanus improvisus			86	140	60	18
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Corophium acherusicum		1	1			
Melita nitida				2	3	3
Melitidae sp.				1	1	
ISOPODA						
Edotea montosa		2				
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii	1		1	7	1	2
GASTROPODA						
Crepidula plana	1					
BIVALVIA						
Mya arenaria		4				
Ensis directus		1				
Tellina agilis		1	1			
ECTOPROCTA						
Electra sp.	++	++				
Membranipora tenuis		+	+	+	+	+
Bowerbankia sp.		+	+	+	+	+
CHORDATA						
Molgula manhattensis						1
NUMBER OF SPECIES	7	13	11	11	9	9
NUMBER OF INDIVIDUALS	130	263	119	179	95	71

SPECIES LIST - AUGUST 1985	II-8Aa	II-8Ab	II-8Ba	II-8Bb	II-8Ca	II-8Cb
CNIDARIA						
Metridium senile		4				
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
Oligochaeta sp.					2	
POLYCHAETA						
Capitella capitata		3			1	1
Capitellidae sp.		1		1		
Glycera americana	4	1			3	3
Glycera dibranchiata	3					
Nereis succinea		6	3			2
Eteone heteropoda		13		4	6	
Lepidonotus squamatus		1				
Sabellaria vulgaris		21				
Fabricia sabella			1			
Polydora ligni	1	1			5	
Scolecolepides viridis					1	
Spio setosa	180	87	2	18	138	2
Streblospio benedicti	3	3	3	6	20	8
CIRREPEDIA						
Balanus improvisus		2		4	46	2
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Corophium acherusicum		9	7		1	
Corophium sp.	1					
ISOPODA						
Cyathura polita					1	
MYSIDACEA						
Neomysis americana						1
DECAPODA						
Rhithropanopeus harrisii		2	1		5	
GASTROPODA						
Crepidula plana					1	
BIVALVIA						
Mya arenaria		1			3	2
Tellina agilis	1	2				1
ECTOPROCTA						
Membranipora tenuis				+	+	+
Bowerbankia sp.					+++	
CHORDATA						
Molgula manhattensis		12	18	15		1
NUMBER OF SPECIES	7	17	7	6	14	10
NUMBER OF INDIVIDUALS	193	169	35	48	233	23

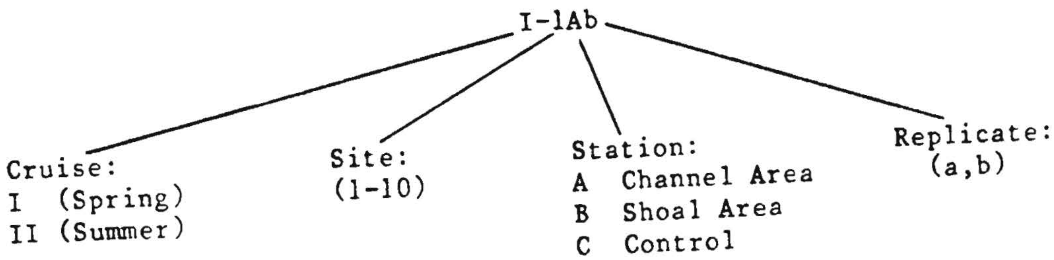
SPECIES LIST - AUGUST 1985	II-9Aa	II-9Ab	II-9Ba	II-9Bb	II-9Ca	II-9Cb
CNIDARIA						
Metridium senile	2					
ASCHELMINTHES						
Nematoda sp.		1				
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitella capitata	1	1				
Capitellidae sp.	1	1				
Maldanidae sp.	1					
Nereis succinea	9	4			1	
Eteone heteropoda	27	10	1	1	1	
Lepidonotus squamatus	1					
Sabellaria vulgaris	54	8				
Polydora ligni		6	2		2	1
Scolecolepides viridis		3				
Spio setosa	26					
Streblospio benedicti	32	90	20	4	6	
CIRREPEDIA						
Balanus improvisus	7					
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Corophium acherusicum	15	4				
Corophium sp.	1	3				
ISOPODA						
MYSIDACEA						
Neomysis americana					1	
DECAPODA						
Rhithropanopeus harrisii	1				1	
GASTROPODA						
Crepidula plana	1					
Ilyanassa obsoletata	3					
BIVALVIA						
Mya arenaria		2		2	127	
Mytilus edulis	1					
ECTOPROCTA						
Membranipora tenuis	+	++				
CHORDATA						
Molgula manhattensis	5	2			91	1
NUMBER OF SPECIES	18	13	3	3	8	2
NUMBER OF INDIVIDUALS	188	135	23	7	230	2

SPECIES LIST - AUGUST 1985	II-10Aa	II-10Ab	II-10Ba	II-10Bb	II-10Ca	II-10Cb
CNIDARIA						
Metridium senile					1	
ASCHELMINTHES						
RHYNCHOCOELA						
OLIGOCHAETA						
POLYCHAETA						
Capitella capitata				1		1
Tharyx acutus				1		
Glycera americana				5		
Glycera capitata	2					
Nereis succinea	3			13		1
Pectinaria gouldii	2					1
Eteone heteropoda	1		1	4		
Lepidonotus squamatus				1		
Sabellaria vulgaris				1		2
Polydora ligni	1		3	4		
Spio setosa			2			3
Streblospio benedicti			7	87		12
CIRREPEDIA						
Balanus improvisus	1			63		
CAPRELLIDEA						
CUMACEA						
AMPHIPODA						
Corophium acherusicum				1		
ISOPODA						
MYSIDACEA						
DECAPODA						
Rhithropanopeus harrisii			1	2		
GASTROPODA						
BIVALVIA						
Mya arenaria	369			6		1
Tellina agilis					1	
ECTOPROCTA						
Membranipora tenuis			+	+		
Bowerbankia sp.				+		
CHORDATA						
Molgula manhattensis	31				1	
NUMBER OF SPECIES	8	0	5	13	3	7
NUMBER OF INDIVIDUALS	410	0	14	189	3	21

APPENDIX B

Biological Parameters for Each Sample

Sample Identification Code Key



SAMPLE	ABUNDANCE (per sq m)	NUMBER OF SPECIES	DIVERSITY	EQUITABILITY
I- 1Aa	0	0	0.000	0.000
I- 1Ab	0	0	0.000	0.000
I- 1Ba	200	2	0.544	0.544
I- 1Bb	0	0	0.000	0.000
I- 1Ca	50	2	1.000	1.000
I- 1Cb	25	1	0.000	0.000
I- 2Aa	1700	5	1.680	0.723
I- 2Ab	1900	10	2.104	0.633
I- 2Ba	1050	6	1.220	0.472
I- 2Bb	675	5	1.163	0.501
I- 2Ca	0	0	0.000	0.000
I- 2Cb	175	4	1.842	0.921
I- 3Aa	275	3	0.866	0.546
I- 3Ab	75	2	0.918	0.918
I- 3Ba	125	3	1.371	0.865
I- 3Bb	775	5	1.774	0.764
I- 3Ca	0	0	0.000	0.000
I- 3Cb	425	6	2.213	0.856
I- 4Aa	1175	10	2.426	0.730
I- 4Ab	175	4	1.842	0.921
I- 4Ba	1700	9	2.732	0.862
I- 4Bb	750	7	2.063	0.735
I- 4Ca	1050	3	0.857	0.541
I- 4Cb	300	3	0.817	0.515
I- 5Aa	875	5	1.090	0.470
I- 5Ab	675	6	1.651	0.639
I- 5Ba	1250	9	2.443	0.771
I- 5Bb	1600	6	1.850	0.716
I- 5Ca	0	0	0.000	0.000
I- 5Cb	375	4	1.533	0.766
I- 6Aa	2175	9	2.297	0.725
I- 6Ab	1325	9	1.996	0.630
I- 6Ba	1450	6	1.751	0.678
I- 6Bb	1525	5	1.471	0.634
I- 6Ca	1000	7	2.233	0.795
I- 6Cb	5750	18	3.004	0.720
I- 7Aa	1975	6	0.823	0.318
I- 7Ab	1850	7	1.608	0.573
I- 7Ba	1325	9	2.305	0.727
I- 7Bb	1725	6	1.574	0.609
I- 7Ca	2650	7	1.546	0.551
I- 7Cb	2375	10	1.943	0.585
I- 8Aa	3325	14	1.632	0.429
I- 8Ab	3200	9	1.263	0.398
I- 8Ba	375	8	2.683	0.894
I- 8Bb	950	4	1.511	0.755
I- 8Ca	425	6	2.226	0.861
I- 8Cb	575	5	1.296	0.558
I- 9Aa	2525	9	2.494	0.787
I- 9Ab	2425	11	2.131	0.616

SAMPLE	ABUNDANCE (per sq m)	NUMBER OF SPECIES	DIVERSITY	EQUITABILITY
I- 9Ba	1300	6	1.817	0.703
I- 9Bb	575	6	1.825	0.706
I- 9Ca	2775	2	0.130	0.130
I- 9Cb	975	4	0.631	0.315
I-10Aa	1025	7	1.904	0.678
I-10Ab	275	7	2.664	0.949
I-10Ba	675	6	1.939	0.750
I-10Bb	175	5	2.236	0.963
I-10Ca	0	0	0.000	0.000
I-10Cb	25	1	0.000	0.000
II- 1Aa	50	2	1.000	1.000
II- 1Ab	225	2	0.503	0.503
II- 1Ba	675	4	0.679	0.340
II- 1Bb	775	3	0.410	0.258
II- 1Ca	100	2	0.811	0.811
II- 1Cb	175	5	2.236	0.963
II- 2Aa	675	4	0.679	0.340
II- 2Ab	175	1	0.000	0.000
II- 2Ba	125	4	1.922	0.961
II- 2Bb	325	7	2.470	0.880
II- 2Ca	0	0	0.000	0.000
II- 2Cb	150	2	0.650	0.650
II- 3Aa	25	1	0.000	0.000
II- 3Ab	225	5	2.197	0.946
II- 3Ba	6350	7	0.536	0.191
II- 3Bb	125	3	1.371	0.865
II- 3Ca	2125	4	0.471	0.236
II- 3Cb	1325	6	1.030	0.399
II- 4Aa	1025	11	2.277	0.658
II- 4Ab	18300	8	0.599	0.200
II- 4Ba	5850	13	1.466	0.396
II- 4Bb	175	4	1.664	0.832
II- 4Ca	375	6	2.063	0.798
II- 4Cb	1775	8	2.318	0.773
II- 5Aa	1150	10	2.323	0.699
II- 5Ab	400	5	1.311	0.565
II- 5Ba	825	9	2.654	0.837
II- 5Bb	425	6	2.213	0.856
II- 5Ca	75	3	1.585	1.000
II- 5Cb	25	1	0.000	0.000
II- 6Aa	75	2	0.918	0.918
II- 6Ab	3225	13	3.174	0.858
II- 6Ba	825	6	1.479	0.572
II- 6Bb	6275	13	2.309	0.624
II- 6Ca	5875	16	1.885	0.471
II- 6Cb	6550	13	1.392	0.376
II- 7Aa	3250	7	1.750	0.624
II- 7Ab	6575	13	1.743	0.471
II- 7Ba	2975	11	1.619	0.468
II- 7Bb	4475	11	1.353	0.391

SAMPLE	ABUNDANCE (per sq m)	NUMBER OF SPECIES	DIVERSITY	EQUITABILITY
II- 7Ca	2375	9	1.875	0.591
II- 7Cb	1775	9	2.472	0.780
II- 8Aa	4825	7	0.515	0.183
II- 8Ab	4225	17	2.599	0.636
II- 8Ba	875	7	2.094	0.746
II- 8Bb	1200	6	2.144	0.829
II- 8Ca	5825	14	1.977	0.519
II- 8Cb	575	10	2.926	0.881
II- 9Aa	4700	18	3.052	0.732
II- 9Ab	3375	13	1.992	0.538
II- 9Ba	575	3	0.678	0.428
II- 9Bb	175	3	1.379	0.870
II- 9Ca	5750	8	1.336	0.445
II- 9Cb	50	2	1.000	1.000
II-10Aa	10250	8	0.609	0.203
II-10Ab	0	0	0.000	0.000
II-10Ba	350	5	1.921	0.827
II-10Bb	4725	13	2.111	0.570
II-10Ca	75	3	1.585	1.000
II-10Cb	525	7	2.022	0.720