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# COLONIZATION OF THE COMMUNITIES ASSOCIATED WITH RHIZOPHORA MANGLE ROOTS

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# COLINZATION OF THE COMMUNITIES ASSOCIATED WITH
# RHIZOPHORA MANGLE ROOTS

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## ABSTRACT

The colonization, succession and equilibrial state of the communities associated with Rhizophora mangle roots were assesed by of artificial substrates placed in eight preselected sites in Laguna Grande, Fajardo. Data was collicted by randomized harvesting on a logarithmic time scale of one, two, four, eight, sixteen and thirty two weeks. Other aspects of this study involved using one of the stations (IX) to test if any seasonality occured and an additional part where the first microscopic stages of colonization were followed for a period of four weeks using glass slides. Colonization curves were constructed closer inspection of these indicate a long term equilibrium. The turnover rate for this study was 1.11 and no seasonal variation was detected either in species composition nor in number of organisms.

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## D E D I C A T O R Y

To my mother for her support and understanding.

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## INTRODUCTION:

In biogeography, the smallest unit that can be studied is an island. Not only because of the variations it presents in area, shape and degree of isolation, but because it provides the necessary replications in natural experiments by which evolutionary theories can be tested.

Islands offer other advantages as well. They contain a smaller number of species present on them. In addition, one can remove one or more elements of biota or the entire biota itself and monitor the process of recolonization (Wilson & Simberloff, 1969).

Colonization of an island is a dynamic process. Pianka (1966) has described the colonization process as having four stages: I, the non-interactive phase, where there is no competition involved, II, the interactive phase, where there is competition and habitat partitioning, III, the assortative phase, where new adjustments are made by the species present and, IV, the evolutionary phase, which occurs when genetic adaptations to local environment takes place.

Mac Arthur and Wilson (1963, 1967) have suggested that the number of species on an island is the net result of the interaction of two opposing processes: immigration, or the arrival of new species to a habitat, and extinction, or the dissappearence of already existing species. Over time, the resultant number should approach an equilibrium value.

This equilibrium hypothesis has motivated several attempts to determine whether in fact island species are in equilibrium, (Diamond, 1969, 1971).

Experimentally there are two ways of testing this hypothesis. First, the number of species can be followed from the time the colonization begins, then a colonization curve can be computed which would indicate whether species numbers level off. This technique has been used by several investigators (Maguire 1963, 1971; Cairns et al. 1969; Simberloff and Wilson 1969, 1970; Schoener 1974), all of whom found convex colonization curves which suggest an initially rapid increase of species which later levels off.

The second method involves the comparison of the immigration and extinction rate curves, which theoretically should meet at one point, which corresponds to equilibrium value (Mac Arthur & Wilson, 1964). The immigration rate curve (the number of species arriving per unit time plotted against time after initiation) should in a decreasing curve, whereas, the extinction rate curve (the number of species going extinct per unit time plotted against time from initiation) should result in an increasing curve.

Mac Arthur and Wilson (1964) have noted in their theory of Insular Biogeography that actual measurements of immigration-extinction rate curve are difficult to make because it would involve knowing the exact time (which specific date the colonizer arrived or left) and all the immigrations and extinctions of the species colonizing.

Furthermore, there is no precise definition of what an immigrant species is or whether a species that leaves it for a time or never to return, should be considered extinct.

Contrary to the difficulty of the immigration-extinction rate curves, approximation of the colonization rate curves (Cairns et al, 1969).

As defaunated islands are not easily found and certainly not in enough numbers for experimental replicas, the use of artificial substrates as islands has been extensively used. Cairns et al. (1969) used plastic substrates, while Schoener (1974) used plastic sponges.

For an excellent review of earlier literature in this field, see Cooke, (1956).

An initial experiment was carried out to test which kind of substrate was more suitable for this study. Wood, PVC pipes uncoated, cement coated PVC pipes and real R. mangle roots were tested. The difficulties of using wood was that a weight had to be added to matain the substrate under water, and where water was shallow this presented a drawback. The use of real mangrove roots was soon discarded because of the difficulty in cutting them. Also the problem of the weights was present. In the PVC alone the same problem was also present adding to it that it was difficult to recover organisms that attached to it. The cement covered PVC pipes did not present any of these problems, also when placed in the water there was no apparent discrimination on part of the colonizers.

When these substrates were examined in the laboratory, all organisms found on them were the same. Thus, the cement-covered PVC pipes were chosen for this study.

Just as islands emerge from the ocean and provide habitats to be colonized by all kinds of organisms, the roots of Rhizophora mangle create additional habitats for colonization upon entering the water. Like islands, they provide habitats for marine or brackish water organisms that constitute the communities associated with Rhizophora mangle roots.

The communities that live on the roots of Rhizophora mangle have been studied before by Kolehmainen et a' (1973) and Bacon (1973). Studies regarding specific organisms associated with the red mangrove roots have been done by Jeldes (1973), Robertson (1959) among others. To date, no studies have been done on the actual colonization process on mangrove roots.

The site selected for this work was Laguna Grande, located at Las Cabezas de San Juan, Fajardo in the North-Eastern part of Puerto Rico. This lagoon covers an area of $4.88 \times 10^5$ square meters with an average depth of 1.42 m. and a volume of 719,800 cubic meters. (Candelas, 1968).

The lagoon is closed except for one channel connecting it to the sea at Las Croabas (Fig. 1). There are four mangrove species present in the system: Rhizophora mangle, Avicennia germinans, Laguncularia racemosa, and Conocarpus erecta. Rhizophora mangle borders the lagoon. (Candelas et al., 1968). Rich communities grow on the roots of the red mangrove, *Rhizophora mangle.*

The objectives of this study were:

1. Determine the rate of colonization on the roots of *Rhizophora mangle.*
2. Determine the successional patterns of this colonization.
3. To test the applicability of the Mac Arthur and Wilson equilibrium theory.

MATERIALS AND METHODS:

Eight stations were chosen arbitrarily using a map of the area and dividing it into eight sections utilizing the cardinal points of the compass. (Figure 2).

At each station 21 artificial roots were placed. These artificial roots were made of ½" wide x 15" long PVC pipes, covered with a thin layer of ready mix cement. Cement was placed in a 2000 l graduated cylinder and the PVC already cut to size with one end filled with newspaper was introduced in the cylinder with the cement and placed in the sun to dry, then a second coat was applied in the same way.

Each root was numbered, and suspended by a 100 pound test monofilament line, from a supporting structure made of ½" steel reinforcement rods tied together with galvanized wire.

Two of these supporting structures were placed under water at each site, one containing 11 roots, the other 10, spaced five inches from each other. (Figure 3).

To establish colonization patterns, three roots from each station were randomly harvested at pre-determined dates. Randomized harvesting of the artificial roots was done by enumerating the roots from one to twenty one and using a random table selecting three numbers per harvesting date per station. Scheduled harvesting was done at one, two, four, eight, sixteen, and thirty two weeks after the placement of the artificial roots.

Harvesting of the artificial roots was done by placing a plastic bag over the root to prevent the loss of material and placed in an ice chest until all harvesting was through and then taken to the laboratory to be examined.

In the laboratory, the roots were examined carefully under a dissection microscope and organisms found on the roots were detached and grouped together according to species. Specimens were placed in vials, preserved with ethanol and labeled with museum tags.

Organisms were collected using a pair of fine forceps, placed in vials already prepared with 70% alcohol and them labeled with museum tags. For those organisms that were difficult to detach such as the tunicate Botryllus planus, and the Arthropod Balanus, and algae, a method was devised for their counting.

A strip of paper 1" wide and 11-½" long was cut and squares of 1 $cm^2$

were drawn and then cut at 1" intervals, to make 10 squares of 1 cm squared.

This strip was wrapped in spiral fashion around the root. Organisms were identified and then counted in each of the squares. A mean was then calculated and that mean multiplied by the area of the root (111.66 $cm^2$). Numbers of individuals per species are expressed in total area.

The number of individuals per species per harvesting date was recorded. Photographs were taken for more detailed taxonomical identification.

To determine any seasonal variation in the first four weeks of exposure a ninth station was established between stations six and seven. (Figure 2). The procedure followed with this ninth station was to place three roots previously numbered at the begining of each month and left in the water for a period of four weeks. Harvesting and examination of the roots and specimens on this station was done as described before.

Those roots that could not be processed the same day because of the large number of roots harvested were kept in a freezer until processed.

As these artificial roots have a cement surface, the early microscopic stages occuring on these roots would have been difficult if not impossible to asses. For this purpose, sanded and marked 75 x 25 mm glass slides attached in sets of three, were placed at the eight stations and harvested in one, two, and four weeks after being placed in the water.

These slides followed the same harvesting as described for the roots. In addition they were fixed in 4% Formalin and mounted with Permount. They were examined under a phase microscope using a Baush and Lomb micrometer disk and randomly selecting 10 areas on the slide and averaging for total species and individuals per unit area.

## RESULTS AND DISCUSSION:

The colonization and succession of organisms on artificial roots in a coastal lagoon were followed over a thirty-two week period. A total of 51 species, representing twelve phyla were found to colonize the artificial roots during the period observed. See species list Appendix 1. In the second part of this work, which was the colonization on glass slides, 47 genera representing 11 phyla were found to colonize the slides during a period of four weeks. Appendix II. The detailed listing of species colonizing the artificial roots and glass slides are presented in Appendix tables III and IV respectively.

Colonization curves were constructed for each of the eight stations by plotting the number of species present at each harvesting date. These curves are presented in Graph 1.

The colonization curves for all eight stations show that they follow a general pattern. In the first four weeks there is an increase in the number of species colonizing the roots. From harvesting dates of eight to thirty-two there is a leveling off or either a decrease in the number of species present at those harvesting dates.

In the graph of station VI there is a marked drop in the number of species present at the thirty-second week. This was due to the fact that for this harvesting date the roots left on the station disappeared; probably someone took them out of the water or bumped into them with a boat causing the roots to sink into the mud. Only one replicate was found, and when it was examined under the microscope, only two species were present.

Nevertheless, all stations on simple observation behaved very much the same, at least for the first four weeks of harvesting. It was decided to test for similarity of slopes. Linear regressions were run for this segment of the colonization curves and their slopes determined for all stations. After the slopes were calculated a Student t test was run to establish if there was any significant difference between the b coefficients. The difference between the slopes of the first segment of the colonization curves for all eight stations was not significant for any of the stations.

Based on observation and on the results obtained on the t test, we grouped all the data and plotted a comprehensive colonization curve presented on Graph 2.

As can be seen in this graph, it follows the same pattern as the individual colonization curves. This colonization curve as well as the colonization curves for all eight stations can be divided into the three phases described by Pianka (1966). Graph 3. The first phase or the nonineteractive phase would correspond to the section of the graph, A, between one and four weeks of exposure. The interactive phase indicated as B corresponds to that section between four and eight weeks, and the assortative phase C corresponds to the section between harvesting dates of sixteen and thirty-two weeks. Pianka (1966), mentions a fourth phase but as the duration of this study was only of thirty-two weeks, this phase could not be ascertained.

Colonization curves were also constructed for the glass slides, though, the time span for these curves is only of four weeks. Graph 4.

As can be observed, they fall under the colonization pattern discussed before for the artificial roots. In all eight stations, there is an increase in the number of species present in the four week period.

Linear regression was calculated for these colonization curves and a t Test was run. Slopes were significantly different from zero and t factors were not significantly different from each other. A comprehensive colonization curve was plotted for the data on the glass slides Graph 5.

As done previously for the roots, this colonization curve was analized to see if it conformed to the general colonization pattern and if it followed Pianka's colonization phases.

On closer inspection, this comprehensive colonization curve behaves very much like the other colonization curves. There is an increase in the number of species from the first week to the fourth.

As far as Pianka's distribution of phases, we found correspondance roughly with only one of the phases and that is the noninteractive phase. There is not enough information because of the short period of time.

For the ninth station, a total of 21 species were found in a period of six months. Appendix V. The colonization curve for this station Graph 6 shows little or no variation from harvesting date to harvesting date in species composition and in the number of species present. Thus, it can be concluded that from April to September, there is no significant variation in either species composition or species numbers with time.

It appears that the colonization process in this lagoon is not determined by the amount of organic matter flowing through the system. The lagoon also has a direct exchange of nutrients and inorganic matter through the channel that connects the lagoon with the sea. Figure 1.

The daily tidal fluctuation flushes the system renovating oxygen, etc.

Light does not constitute itself a limiting factor in this system. Average depth in this lagoon is one meter, water is more or less clear letting light pass through the water column. Algae grows on the bottom substrate to a depth of three meters. Good circulation is also present, although it has not been documented. Salinity is more or less constant through out the year, being more or less 35 parts per thousand.

As the factors mentioned above are not limiting colonization, the only factor that could be observed is the lack of area to be colonized. This area is provided by the aerial roots of the red mangrove when they go into the water.

After the colonization process begins, succession takes over on the roots as shown on Table 1.

Some organisms an present in only one harvesting date, like in the case of the tunicate Ascidia nigra at eight weeks; other species are present through-out all harvesting dates as in the case with six species out of ten of the first as is the case with six species out of ten of the first colonizers, and that some species come and go between harvesting dates.

If a comparison is made of how many species are present and the number of species are absent at harvesting dates we will find that these numbers will tell us the immigration - extinction for each harvesting date. Table II.

The number of extinctions is fairly constant, the only drastic change is between harvesting dates of one and two weeks where there is no loss, meanwhile for the fourth week the number of species lost amounts to six.

The number of immigrations varies also in the first two weeks of exposure from a gain of ten species in the first week to thirteen species in the second week to a eight species gain in the fourth week. From the fourth week on the gain and loss in the number of species is more or less stable.

From the Table 1 it can be seen that some species are in a particular harvesting date, while other species are common throughout all harvesting dates. Table III.

As far as the glass slides immigration and extinction analysis, the extinction is higher than that on the roots, probably due to the limitation in space. Table IV.

As available space is a limiting factor in the colonization process, resource partitioning should be taken into account. It should be noted that there is no zonation on these artificial substrates nor in the natural roots.

We made a relation of the species present at each harvesting date and their feeding modes to establish if there is a relation in feeding modes and their position in the succession. Table V.

In general, we classsified the species present in three feeding modes, I sedentary filter feeders, which are organisms that obtain their nutrients by filtering the water that passes by and trapping the particles, II Raptorial feeding which are active searchers and obtain their food either by scraping such as Molluscs, or by eating other organisms, III, the photosynthetic mode, which produce their own food.

Out of 51 species found for the thirty-two week period of experimentation a total of 30 species are secundary raptorial feeders, 10 are primary consumers (scrapers) and 20 are secondary consumers (predators), 15 are filter feeders and four species are phtosynthetic. In Table V we will find that there is an increase in the number of predator species as time increases becoming stable through harvesting weeks eight, sixteen and thirty-two. Filter feeding species increase from three species in harvesting week one to ten species in harvesting week two, becoming stable throughout subsequent harvesting dates. The other two feeding divisions have representatives present in harvesting week two, throughout the thirty second week of experimentation.

Filter feeding species are more stable probably because as these species are sessile, they need area to colonize and live on. This is not the case with the raptorial species which are usually found between sessile colonizing species as e.g. of Ampithoe (raptorial) with Brachidontes or the tunicate Ecteinascidia (both filter feeders). These sessile organisms, provide shelter for the non-sessile organisms.

Sessile species usually had a higher number of individuals per species than the raptorial species. See Appendix III, IV.

Using the same relation with the data obtained from the glass slides as presented in Table VI. We obtained that from a total of 49 species, 37 species are photosynthetic, being in their majority Diatomacea (33 genera) and Rhodophyta (2 genera), Chlorophyta (1 genera) and unidentified germinating algae.

Both raptorial and filter feeding species in this study are present in low numbers. There is little variation in these numbers between harvesting dates. Filter feeding species are present in higher number than raptorial species. This could be accounted for by the shape and position of the slides which are not too enticing for non sessile colonizers. But there is not enough data to conclude anything of that nature. In order to do that, this study should be structured so that the slides are left in the water for the same period of time as the artificial roots.

As it can be observed from the tables of succession discussed before and from the data presented in Appendix III, IV, V, this system has a very high diversity and that the species found throughout this study are a fair representative of animals and plants.

Species diversity Index was calculated for the roots using the Shanon-Weaver Diversity Index.

The results obtained from this test are presented in Table VII. The species diversity Index gave very high values when we had very few species e.g. in haversting date of one week for station IV, with four species present, Brachidontes exustus (1 individual), Bugula neritina (29 individuals), Ampithoe (10 individuals), Balanus with 16,927 and Pachygrapsus with two individuals present gave a diversity index of 2.15.

On the other hand, this diversity Index does not take into account those species with only one individual present at one haversting date, which is a common situation in this type of study.

For these reasons, the Shanon-Weaver Index, was just taken as a rough estimate of the diversity at haversting dates on this study.

For a real measure of the diversity present at haversting times it was decided to use the number of species present.

Also, the Simpson Similarity Index was calculated for all stations at different dates to establish if similarity between the populations present at the stations was significant or not, Table VIII.

Similarity is significant between the first two harvesting dates, decreasing in value as time passed for all stations. Also significant are the similarities between the populations present at harvesting dates of four and eight weeks and between sixteen and thirty-two weeks in stations I, V, VI and VIII.

Trellis diagrams for Simpson's Similarity Index were also constructed for the data obtained from the glass slides, Table IX.

The Trellis diagram shows that all populations in harvesting dates in all stations were significantly similar except for station III.

In this station, all populations in harvesting dates of one and two weeks and two and four weeks, were significantly similar. In station IV similarity between the populations present was not significant between harvesting dates one and two and between one and four.

One of the objectives of this study, was to test the applicability of the Mac Arthur and Wilson equilibrium theory proposed in 1964.

In order to ascertain if it was applicable to the colonization of this artificial substrates the method described by Schoener 1974 was used.

The colonization curves obtained from the data collected were examined and divided into two segments. The first segment being the line described by the points corresponding to harvesting dates one, two and four weeks, and segment two including harvesting dates of eight, sixteen and thirty two weeks.

Linear regressions for each segment were calculated. The early portion of the colonization curve had a slope of 5.57 significantly different from zero and the second segment had a slope of -0.04 not significantly different from zero. This also applies to the slopes of each individual graph.

A student t Test was run then to test whether the probability that the two slopes making the colonization curve were significantly different from each other (Sokal & Rohlph, 1969).

This analysis indicated that there were significant differences between the slopes of the two parts making the colonization curve.

If we examine the colonization curve in Graph 2 it can be observed that it follows an increasing relationship reaching an asymptote, suggesting that equilibrium is approached. This is further evidenced by the fact that an average of 29 species is mantained over a period of eight, sixteen and thirty two weeks.

Further evidence is that immigration and extinction rates should be equal at equilibrium. Table II. Here the number of extinctions and immigrations stay more or less stable throughout the last four harvesting dates. For this system equilibrial conditions are present from the fourth week of experimentation.

Thus, turnover rates (the extinction rate, equal to the immigration rate at equilibrium) is calculated from the Mac Arthur and Wilson prediction of $1.15 \times S/t_{0.90}$, where S is the average equilibrial number of species and $t_{0.90}$ is the time in days needed to reach 90% of the equilibrial species number. Even though this formula was derived for the noninteractive equilibrium, it is used in this study for the long term equilibrium because the experimental results do not show any different equilibrium number at the noninteractive phase.

Schoener suggests that both equilibria may be close and covered by the same equation.

Substituting the equation $1.15 \times S/t_{0.90}$ for 29 species in thirty days times 1.15, we obtain a species in thirty days times 1.15, we obtain a turnover rate of 1.11 species per day.

SUMMARY AND CONCLUSIONS:

Artificial substrates made of cement covered PVC pipes were used to study the colonization and succession of the organisms associated with the *Rhizophora mangle* roots.

Conclusions on this study are based on 120 species representing 15 phyla.

Colonization curves were constructed for each station for the artificial roots and for the glass slides.

Inspection of these curves indicate a long term equilibrial condition, which is confirmed statistically by the significant decrease in the slope that occurs in the second segment of the curve. This is supported also by the immigration and extinction rates on Table II. This is evidence that the equilibrium theory proposed by Mac Arthur and Wilson applies to the colonization taking place here.

Contrary to what Schoener 1974 found based on the trophic structure in the first stages of colonization raptorial species as well as filter feeding species are present.

Successional changes were followed for both artificial substrates, cement and glass slides. There was no seasonal variation in species composition or in species numbers.

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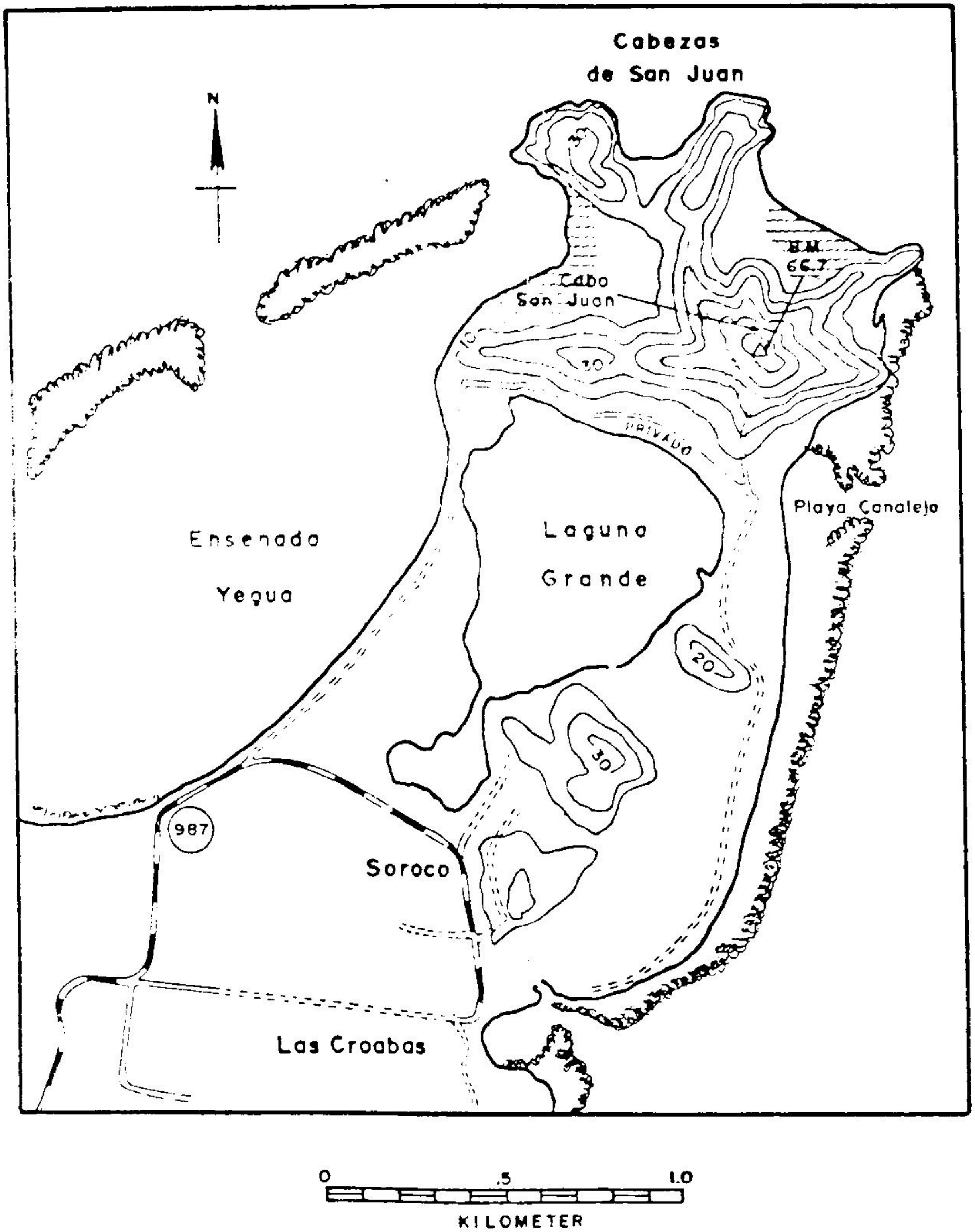
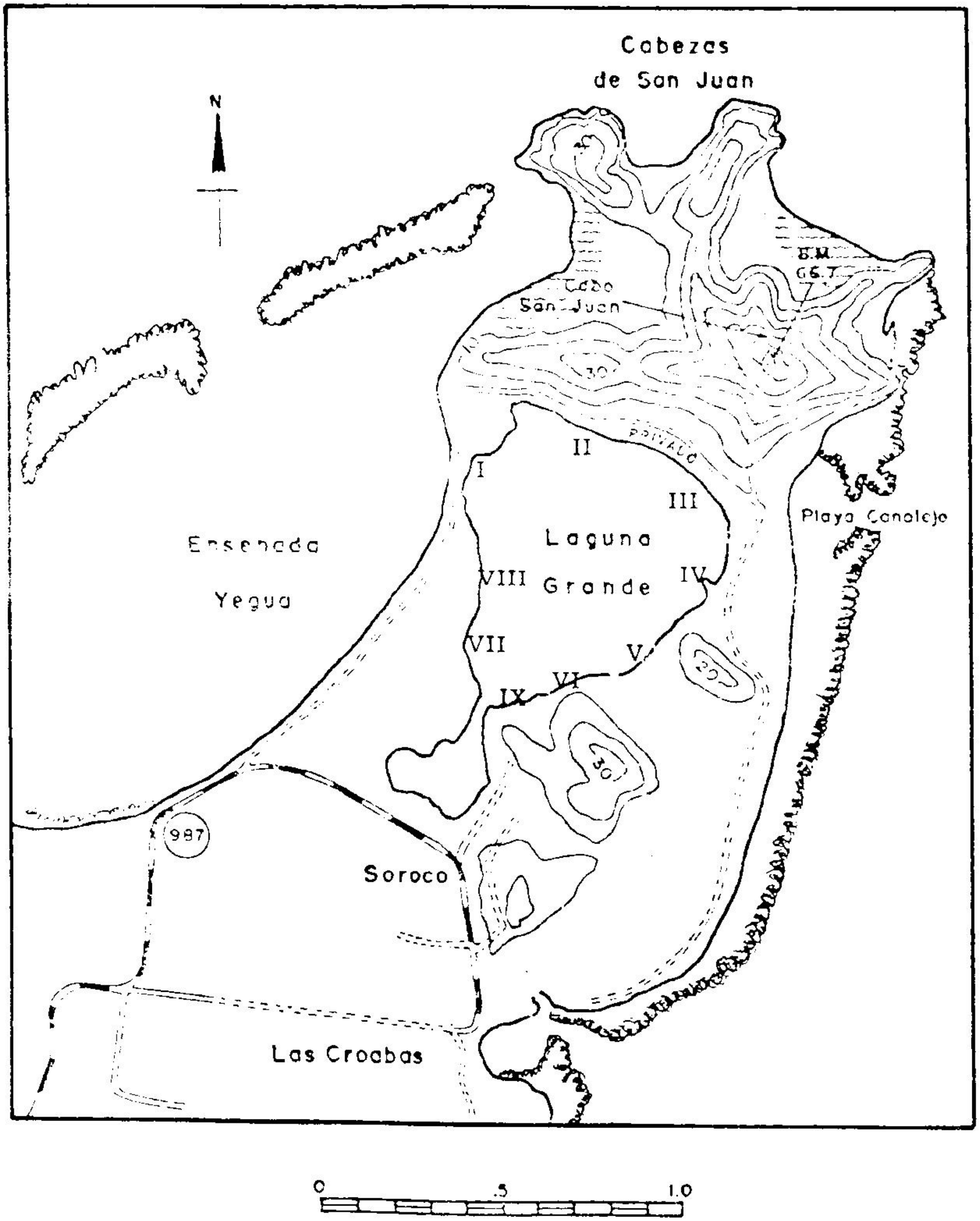
FIGURE 1



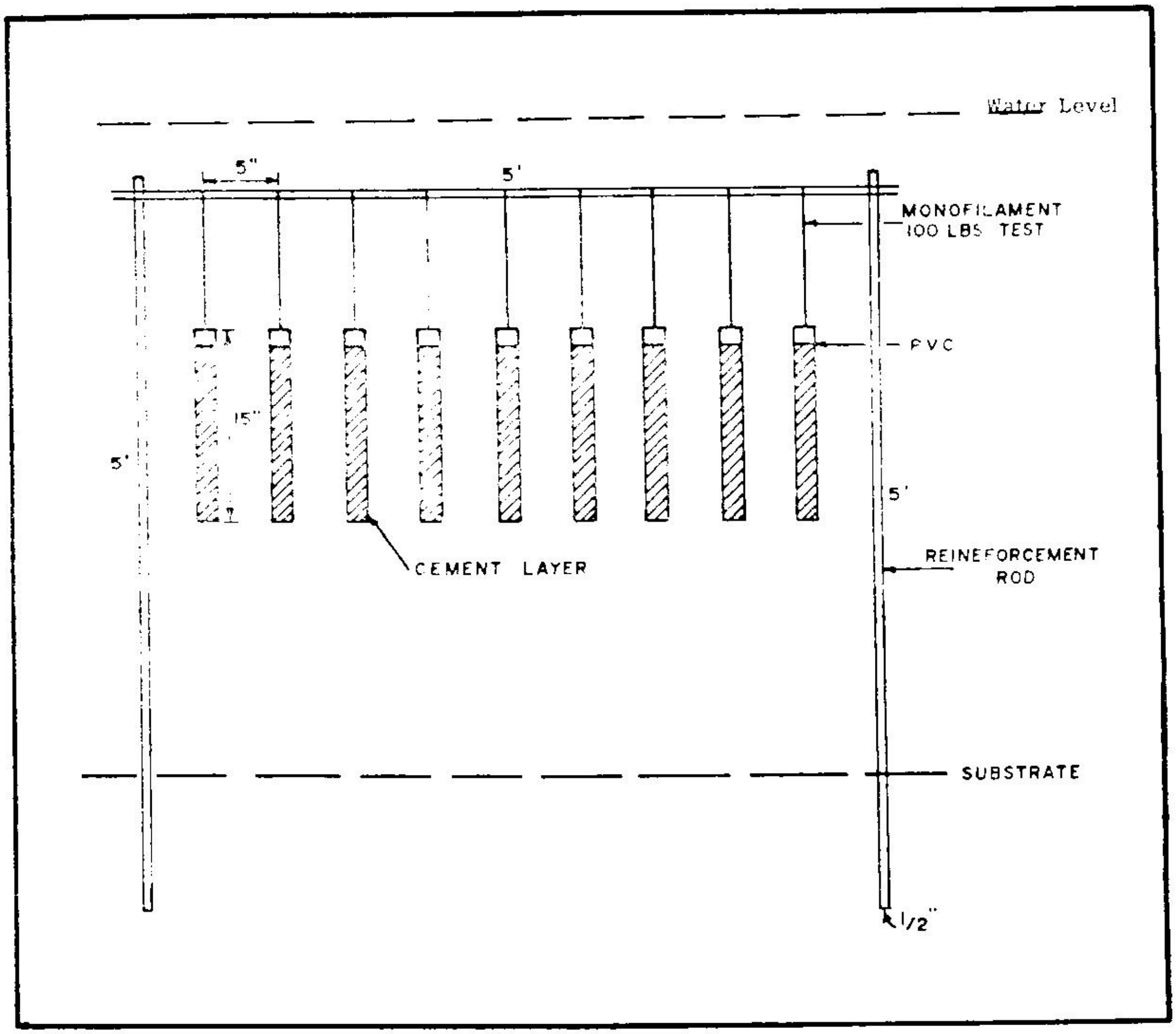

Map of Las Cabezas de San Juan showing position of Laguna Grande

FIGURE 2



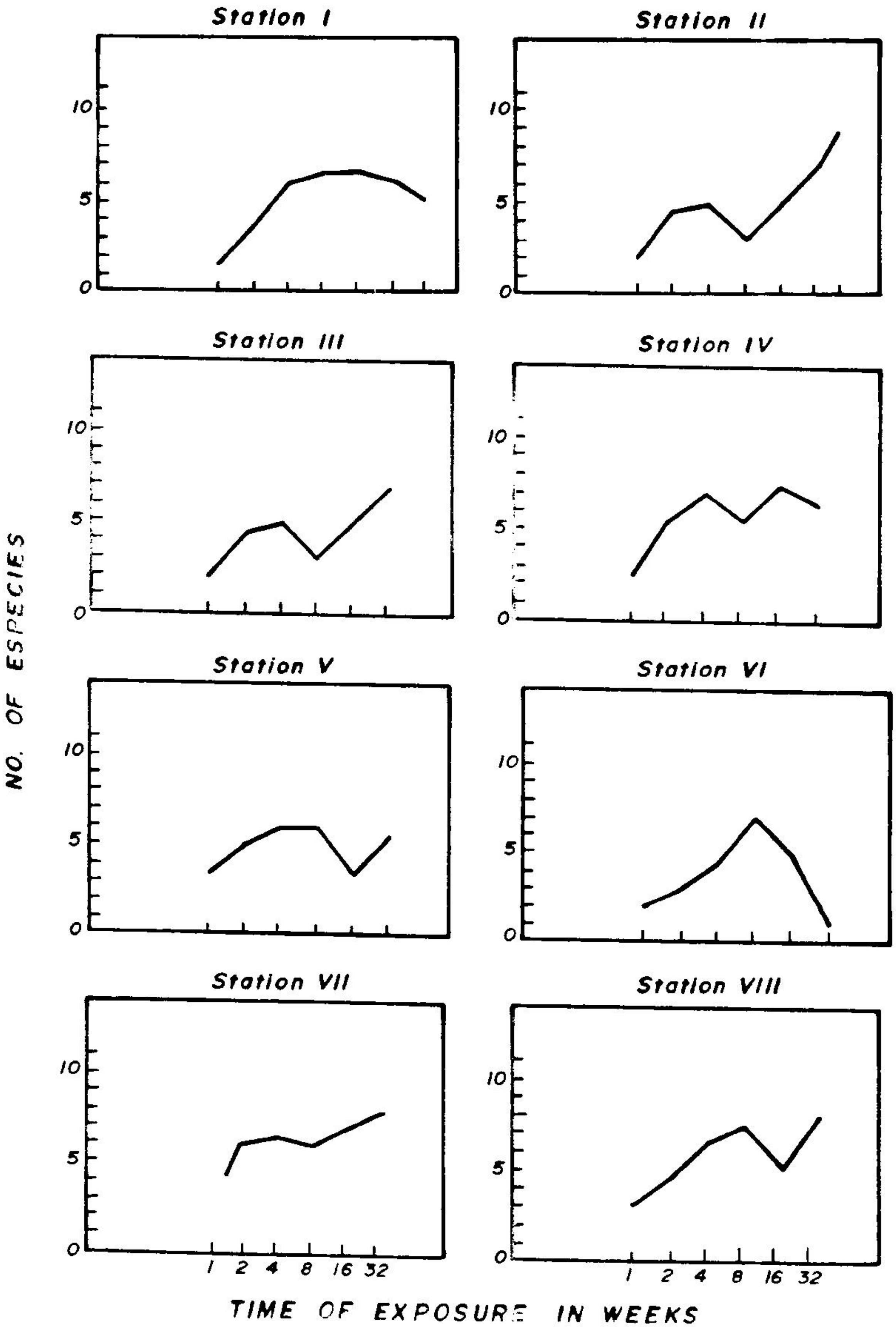

DISTRIBUTION OF STATIONS ON STUDY SITE

FIGURE 3



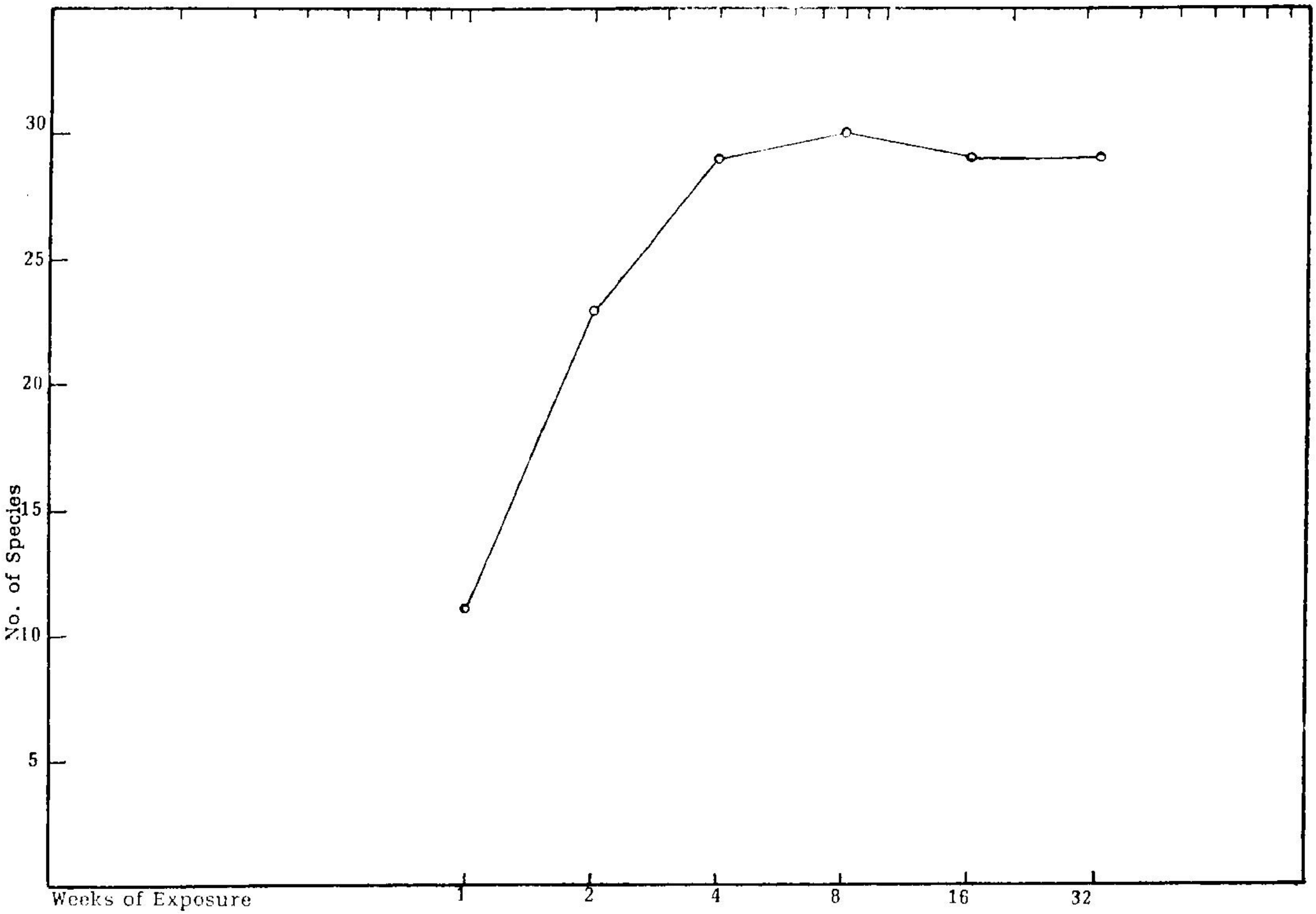

EXPERIMENTAL LAYOUT FOR ARTIFICIAL ROOTS

GRAPH I



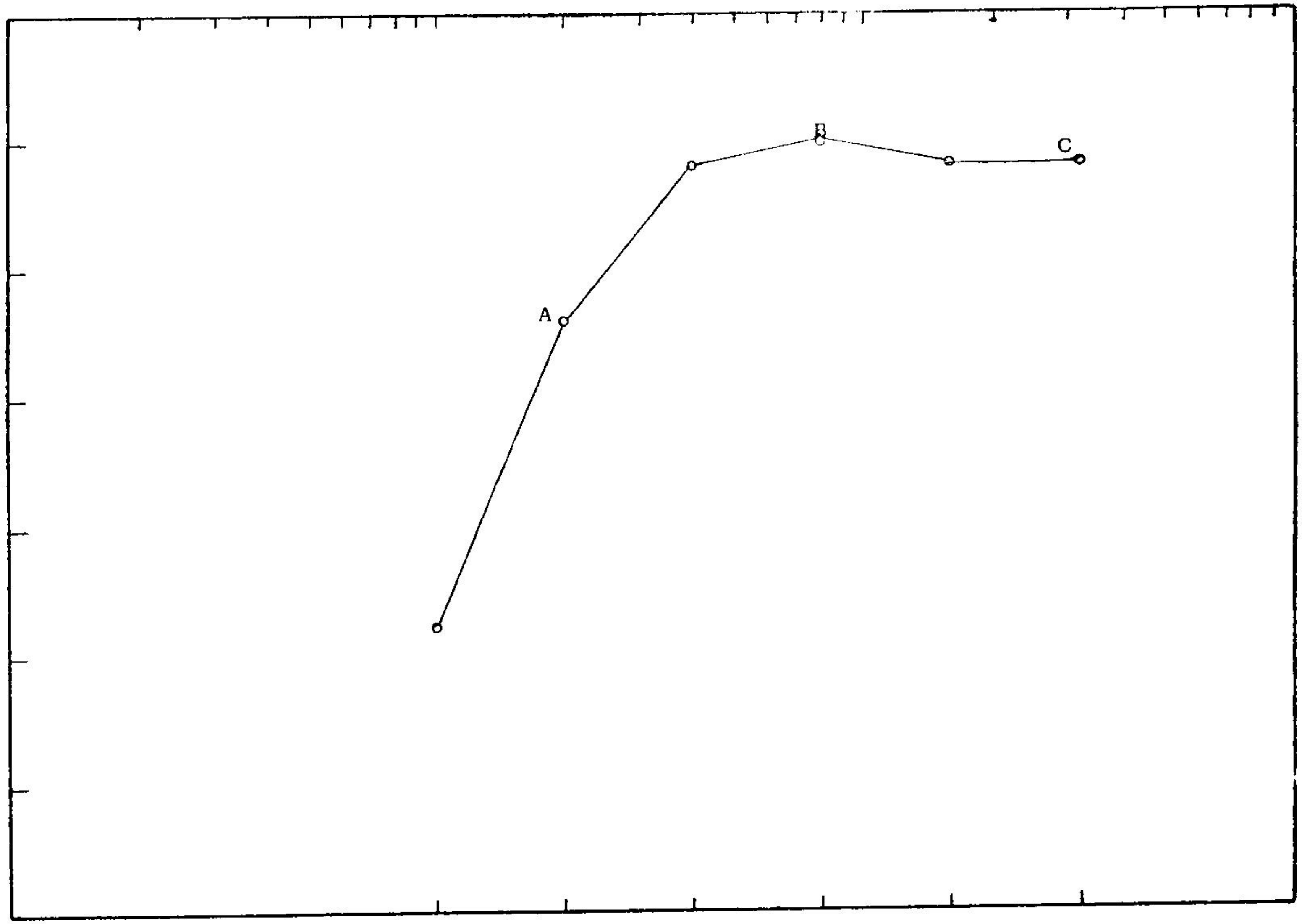

COLONIZATION CURVES FOR EACH OF THE STATIONS FOR THE ARTIFICIAL ROOTS

GRAPH 2



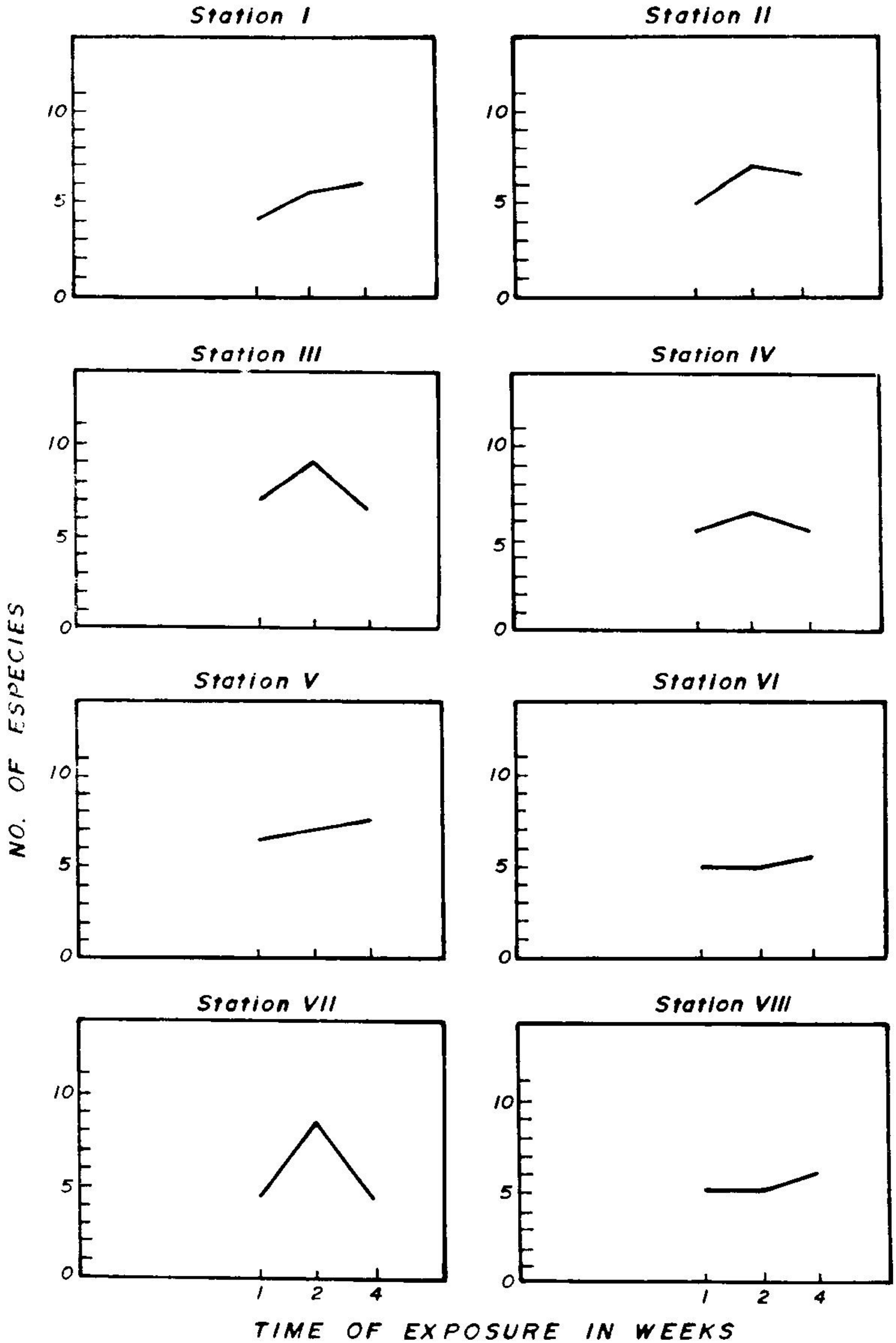

COMPREHENSIVE COLONIZATION CURVE CONSTRUCTED FOR ALL STATIONS BASED ON THE SIGNIFICANCE OF THE "T" VALUES OF THE SLOPES FOR ALL STATIONS FOR THE ARTIFICIAL ROOTS

GRAPH 3

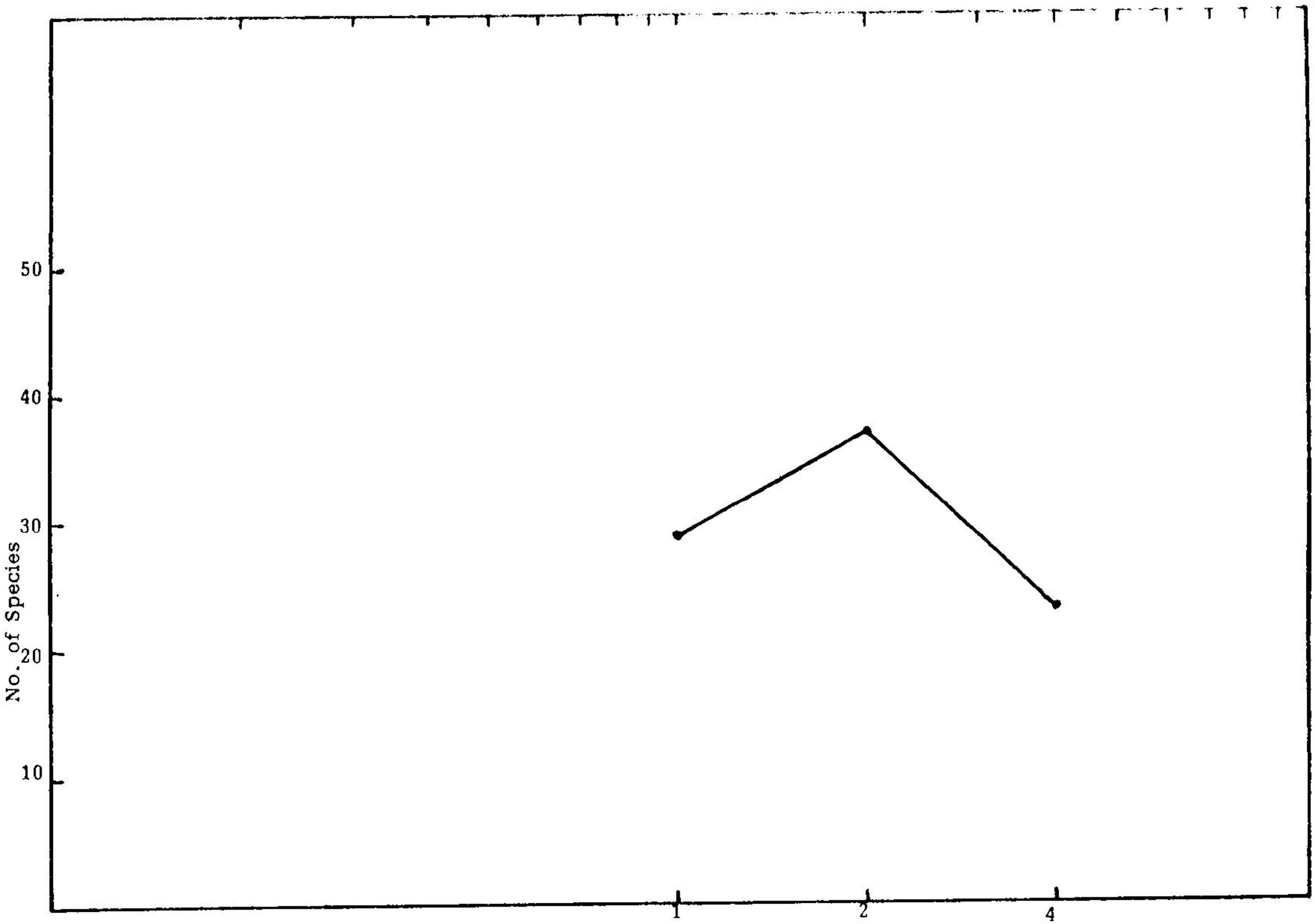



COLONIZATION PHASES DESCRIBED BY PIANKA APPLIED TO COLONIZATION CURVE PLOTTED FROM DATA ON ARTIFICIAL ROOTS: A BEING THE NONINTERACTIVE PHASE, B THE INTERACTIVE PHASE, C THE ASSORTATIVE PHASE

GRAPH 4



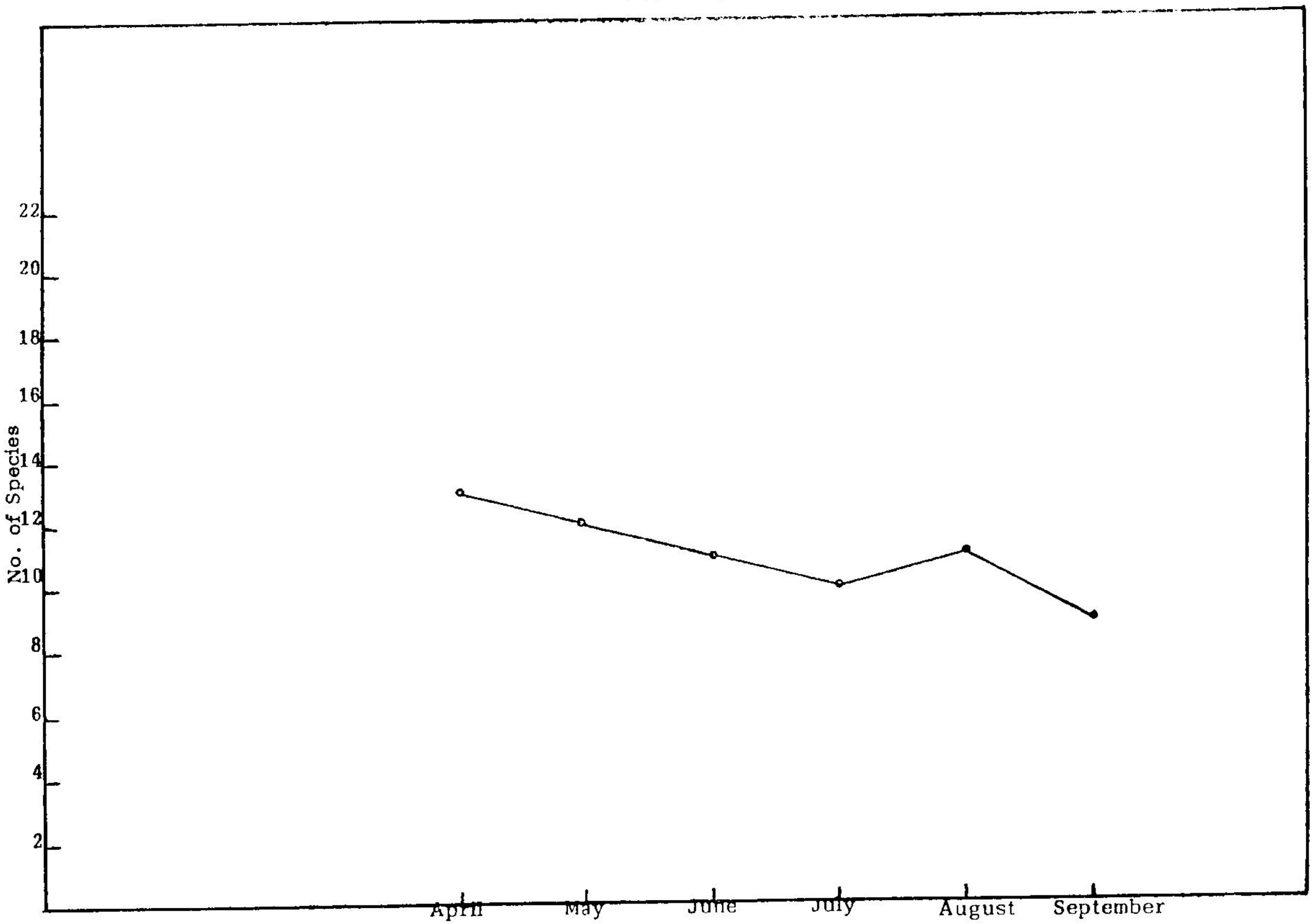

COLONIZATION CURVES PLOTTED FOR EACH STATION
FOR DATA COLLECTED ON THE GLASS SLIDES
HARVESTING PERIOD FOR FOUR WEEKS




GRAPH 5

COMPREHENSIVE COLONIZATION CURVE FOR ALL STATIONS FOR DATA COLLECTED FROM GLASS SLIDES HARVESTING DATES OF FOUR WEEKS

GRAPH 6




COLONIZATION CURVE CONSTRUCTED FOR THE NINTH STATION FOR THE ARTIFICIAL ROOTS

# TABLE 1

| SPECIES LIST | Weeks under water 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| Ampithoe sp. | * | * | * | * | * | * |
| Palaemus sp. | * | * | * | * | * | * |
| Triphora nigrocincta | * | * | * | * | * | * |
| Cerithium variabile | * | * | * | * | * | * |
| Apanthura sp. | * | * | * | * | * | * |
| Bugula neritina | * | * | * | * | * | |
| Pachygrapsus gracilis | * | * | | * | * | * |
| Brachidontes exustus | * | * | * | * | * | * |
| Unknown | * | * | * | * | * | |
| Penaeus duorarum | * | * | * | * | * | |
| Ecteinascidia turbinata | | * | * | | * | * |
| Hydroides sp. | | * | * | * | * | * |
| Cumacea sp. | | * | | | | |
| Bulla striata | | * | * | | | * |
| Mycale sp. | | * | * | | | |
| Foram | | * | | | | |
| Membranipora sp. | | * | * | * | * | * |
| Tethya sp. | | * | | * | * | * |
| Egg case | | * | | | | |
| Crepidula glauca | | * | * | * | * | * |
| Isognomon alatus | | * | * | * | * | * |
| Neritina virginea | | * | | * | * | |
| Mollusc egg case | | * | * | * | * | * |
| Botryllus planus | | | * | * | * | * |
| Hyporocha sp. | | | * | | | |
| Dysidea etheria | | | * | | | |
| Unknown | | | * | * | * | * |
| Polychaeta | | | * | * | * | * |
| Arthropoda | | | * | | | |
| Tonna maculosa | | | * | | | |
| Enteromorpha | | | * | | | |
| Polychaeta | | | | * | | * |
| Ascidia nigra | | | | * | | |
| Cyone sp. | | | | * | | |
| Gobbidae | | | | * | | |
| Parviturboides comptus | | | | * | | |
| Brown algae | | | | * | | |
| Unknown | | | | * | * | |
| Unknown | | | | * | | |
| Nereidae | | | | | * | * |
| Algae | | | | | * | |
| Acetabularia crenulata | | | | | * | * |
| Neomysis sp. | | | | | * | |
| Haminoea elegans | | | | | * | |
| Terebellidae | | | | | * | * |
| Halisarca sp. | | | | | | * |
| Unknown | | | | | | * |
| Unknown | | | | | | * |
| Parazoanthus parasiticus | | | | | | * |
| Unknown | | | | | | * |
| Unknown | | | | | | * |

SUCCESSION TABLE CONSTRUCTED FOR DATA ON ARTIFICIAL ROOTS

TABLE II

| | Harvesting Dates | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 4 | 8 | 16 | 32 |
| Species present at Initial Period | 0 | 10 | 23 | 25 | 28 | 28 |
| Gain of Species | 10 | 13 | 8 | 8 | 6 | 6 |
| Loss of Species | 0 | 0 | 6 | 5 | 6 | 6 |
| Total Number of Species at end of period | 10 | 23 | 25 | 28 | 28 | 28 |

**IMMIGRATION - EXTINCTION ANALYSIS FOR ARTIFICAL ROOTS**

# TABLE III

| SPECIES LIST | Weeks under water 1 | 2 | 4 |
|---|---|---|---|
| Trachyneis | * | * | |
| Cocconeis | * | * | * |
| Diploneis | * | * | * |
| Novicula | * | * | * |
| Gyrosigma | * | * | |
| Amphora | * | * | * |
| Unknown | * | | |
| Surririella | * | * | |
| Unknown | * | | |
| Cymbella | * | * | * |
| Licmophora | * | * | |
| Unknown | * | | |
| Nitzschia | * | * | * |
| Foraminifera | * | * | |
| Pleurosigma | * | * | * |
| Melosira | * | * | |
| Pinnularia | * | * | * |
| Dinoflagellata | * | * | |
| Polysiphonia | * | * | |
| Obelia | * | * | * |
| Germinating Algae | * | * | * |
| Balanus | * | * | * |
| Unknown | * | | |
| Polychaeta | * | * | |
| Sponge spicules | * | * | * |
| Unknown | * | | |
| Unknown eggs | * | | |
| Unknown | * | | |
| Protozoa | * | | |
| Centrate | | * | |
| Unknown | | * | |
| Unknown | | * | |
| Unknown | | * | |
| Copepoda | | * | * |
| Unknown | | * | |
| Homocladia | | * | |
| Bacillaria | | * | * |
| Paralia | | * | * |
| Bugula | | * | * |
| Membranipora | | * | * |
| Enteromorpha | | * | * |
| Rhabdonema | | * | * |
| Corsinodiscus | | * | |
| Grammatophora | | * | |
| Biddulphia | | * | |
| Hydroides | | | * |
| Botryllus planus | | | * |
| Ceramium | | | * |
| Eggs | | | * |

**SUCCESSION TABLE CONSTRUCTED FOR DATA COLLECTED ON GLASS SLIDES**

## TABLE IV

| | Harvesting Dates 1 | 2 | 4 |
|---|---|---|---|
| Number of Species present at initial period | 0 | 29 | 37 |
| Gain of Species | 29 | 16 | 4 |
| Loss of Species | 0 | 8 | 18 |
| Total Number of Species at end of period | 29 | 37 | 23 |

## IMMIGRATION - EXTINCTION ANALYSIS

## FOR GLASS SLIDES

TABLE V

Harvesting Dates

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| Primary Consumer Scrapers | 3 | 6 | 5 | 6 | 6 | 6 |
| Secondary Consumer Predators | 4 | 5 | 8 | 10 | 9 | 11 |
| Filter Feeders | 3 | 10 | 10 | 10 | 10 | 9 |
| Photosythetic | 0 | 0 | 1 | 1 | 2 | 1 |
| Non Feeding | 0 | 2 | 1 | 1 | 1 | 1 |
| Total No. of Species | 10 | 23 | 25 | 28 | 28 | 28 |

**RELATION OF FEEDING MODES WITH SUCCESSION FOR ARTIFICIAL ROOTS**

## TABLE VI

| | Harvesting Dates 1 | 2 | 4 |
|---|---|---|---|
| Primary Consumer Scrapers | 1 | 1 | 1 |
| Secondary Consumer Predators | 0 | 1 | 0 |
| Filter Feeders | 4 | 5 | 6 |
| Photosynthetic | 22 | 29 | 14 |
| Non Feeders | 2 | 1 | 2 |
| Total No. of Species | 29 | 37 | 23 |

RELATION OF FEEDING MODES OF SPECIES

PRESENT IN GLASS SLIDES

TABLE VII

| | Harvesting Dates | | | | | |
|---|---|---|---|---|---|---|
| Station | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
| I | .0056 | .3425 | .5436 | .7097 | 1.0990 | 1.3555 |
| II | .5265 | .3936 | .6779 | .8072 | 1.8072 | 2.4922 |
| III | .8992 | .8264 | 1.1816 | 2.0293 | 1.8514 | 1.2942 |
| IV | 2.1531 | 1.2741 | 1.5434 | 1.5431 | 2.4764 | 1.2940 |
| V | 1.7987 | .8133 | 1.7453 | 1.3831 | 2.3596 | 1.5484 |
| VI | .4004 | 1.3101 | 1.0881 | 1.5203 | 2.1128 | .9190 |
| VII | .1582 | 2.7775 | 1.6028 | 1.8424 | 2.4949 | .9757 |
| VIII | .1687 | .5834 | 1.8706 | 1.9881 | .8341 | 1.1327 |

SHANON-WEAVER DIVERSITY INDEX COMPUTED FOR ALL STATIONS AT HARVESTING DATES

# APPENDIX I

# TABLE VIII

Station I

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 100 | 0 | 1 | 0 | 4 |
| 2 | | | 0 | 1 | 0 | 0 |
| 4 | | | | 100 | 4 | 0 |
| 8 | | | | | 4 | 0 |
| 16 | | | | | | 98 |
| 32 | | | | | | |

Station II

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 100 | 0 | 0 | 11 | 52 |
| 2 | | | 0 | 0 | 11 | 52 |
| 4 | | | | 99 | 60 | 66 |
| 8 | | | | | 60 | 69 |
| 16 | | | | | | 48 |
| 32 | | | | | | |

Station III

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 100 | 2 | 5 | 5 | 20 |
| 2 | | | 2 | 6 | 6 | 20 |
| 4 | | | | 62 | 48 | 4 |
| 8 | | | | | 33 | 79 |
| 16 | | | | | | 9 |
| 32 | | | | | | |

Station IV

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 100 | 1 | 5 | 4 | 4 |
| 2 | | | 1 | 5 | 5 | 6 |
| 4 | | | | 99 | 77 | 21 |
| 8 | | | | | 78 | 20 |
| 16 | | | | | | 26 |
| 32 | | | | | | |

Station V

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 99 | 0 | 0 | 13 | 20 |
| 2 | | | 10 | 0 | 15 | 21 |
| 4 | | | | 76 | 69 | 73 |
| 8 | | | | | 88 | 93 |
| 16 | | | | | | 97 |
| 32 | | | | | | |

Station VI

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 91 | 91 | 0 | 61 | 45 |
| 2 | | | 7 | 5 | 62 | 49 |
| 4 | | | | 96 | 62 | 39 |
| 8 | | | | | 68 | 48 |
| 16 | | | | | | 91 |
| 32 | | | | | | |

Station VII

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 89 | 96 | 70 | 22 | 1 |
| 2 | | | 95 | 84 | 48 | 3 |
| 4 | | | | 87 | 45 | 3 |
| 8 | | | | | 75 | 5 |
| 16 | | | | | | 17 |
| 32 | | | | | | |

Station VIII

| | 1 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| 1 | | 100 | 90 | 12 | 0 | 1 |
| 2 | | | 91 | 14 | 0 | 1 |
| 4 | | | | 27 | 38 | 38 |
| 8 | | | | | 14 | 16 |
| 16 | | | | | | 99 |
| 32 | | | | | | |

SIMILARITY INDEX OF THE EIGHT STATIONS THROUGH TIME ON TRELLIS DIAGRAM

## TABLE IX

### Station I

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 100 | 100 | | | |
| 2 | | | 100 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station II

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 100 | 93 | | | |
| 2 | | | 93 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station III

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 60 | 82 | | | |
| 2 | | | 57 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station IV

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 46 | 32 | | | |
| 2 | | | 96 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station V

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 73 | 79 | | | |
| 2 | | | 73 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station VI

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 88 | 71 | | | |
| 2 | | | 71 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station VII

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 97 | 100 | | | |
| 2 | | | 98 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

### Station VIII

| | 1 | 2 | 4 | | | |
|---|---|---|---|---|---|---|
| 1 | | 99 | 99 | | | |
| 2 | | | 100 | | | |
| 4 | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

TRELLIS DIAGRAMS FOR SLIDES IN SAMPLING
DATES FROM 1 TO 4 WEEKS

## SPECIES LIST

Phylum Protozoa
    Foraminifera

Phylum Porifera
    Family Clionidae
        *Cyone* sp.

    Family Dysideidae
        *Disidea* sp.

    Family Halisarca
        *Halisarca* sp.

    Family Mycalidae
        *Mycale* sp.

    Family Tethyidae
        *Tethya* sp.

Phylum Coelenterata
    Family Zoanthidea
        *Parazoanthus parasiticus*

Phylum Platyhelmintes
    Family Pseudoceridae
        *Pseudoceros crozieri*

Phylum Mollusca
    Family Atyidae
        *Haminoea elegans*

    Family Bullidae
        *Bulla striata*

    Family Calyptraeidae
        *Crepidula glauca*

    Family Cerithiidae
        *Cerithium variabile*

    Family Mytilidae
        *Brachidontes exustus*

    Family Neritidae
        *Neritina virginea*

Family Tonnidae
*Tonna maculosa*

Family Triphoridae
*Triphora nigrocincta*

Family Vitrinellidae
*Parviturboides comptus*

Family Isognomonidae
*Isognomus alatus*

Phylum Annelida
Family Maldanidae

Family Nereidae

Family Serpulidae

Family Terebellidae

Phylum Bryozoa
Family Bugulidae
*Bugula neritina*

Family Membraniporidae
*Membranipora* sp.

Phylum Artropoda

Family Ampithoidea
*Ampithoe* sp.

Family Anthuridae
*Apanthura* sp.

Family Balanidae
*Balanus* sp.

Family Grapsidae
*Pachygrapsus gracilis*

Genera Cumacea

Genera Hyperoche

Genera Neomysis

Phylum Chordata
Subphylum Urochordata
Family Ascidiidae
*Ecteinascidia turbinata*

*Ascidia nigra*

Family Botryllidae

*Botryllus planus*

Class - Osteichtyos

Family Gobbidae

*Gobbiosoma* sp.

Kingdom Plantae

Class - Clorophyta

*Enteromorpha* sp.

*Acetabularia* sp.

# APPENDIX II

## SPECIES LISTS

Phylum Protozoa
- Foraminifera
- Dinoflagellata

Phylum Coelenterata
- *Obelia* sp.

Phylum Annelida
- Family Maldanidae

- Family Serpulidae
  - *Hydroides* sp.

Phylum Bryozoa
- Family Bugulidae
  - *Bugula neritina*

- Family Membraniporidae
  - *Membranipora* sp.

Kingdom Plantae
- Class - Clorophyta
  - *Enteromorpha* sp.

- Class - Rhodophyta
  - *Polysiphonia* sp.
  - *Ceramium* sp.

- Diatomacea
  - *Amphora* sp.
  - *Bacillaria* sp.
  - *Biddulphia* sp.
  - *Centrate* sp.
  - *Cocconeis* sp.
  - *Corsinodiscus* sp.
  - *Cymbella* sp.
  - *Diploneis* sp.
  - *Grammatophora* sp.
  - *Gyrosigma* sp.
  - *Homocladia* sp.
  - *Licmophora* sp.
  - *Melosira* sp.
  - *Navicula* sp.
  - *Nitzschia* sp.
  - *Paralia* sp.
  - *Pleurosigma* sp.
  - *Pinnularia* sp.

*Rhabdonema* sp.
*Surririella* sp.
*Trachyneis* sp.
Unknown (8 species unidentified)

Phylum Arthropoda
Family Balanidae
*Balanus* sp.

Genera Copepoda

Phylum Chordata
Subphylum Urochordata
Family Botryliidae
*Botryllus planus*

# APPENDIX III

## DATA ON STATION 1

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Cerithuim variabile | 11 | 3 | 1 | 0 | 0 | 0 |
| Apanthura sp | 3 | 7 | 10 | 5 | 1 | 14 |
| Balanus sp | 6,846 | 1,653 | 11 | 0 | 67 | 134 |
| Ampithoe sp | 1 | 24 | 45 | 10 | 6 | 4 |
| Brachidontes exustus | 0 | 3 | 5 | 2 | 4 | 5 |
| Penaeus duorarum | 0 | 4 | 0 | 0 | 0 | 0 |
| Cumacea sp | 0 | 1 | 0 | 0 | 0 | 0 |
| Bulla striata | 0 | 1 | 0 | 0 | 0 | 1 |
| Bucula neritina | 0 | 1 | 8 | 0 | 0 | 0 |
| Ecteinascidia turbinata | 0 | 0 | 100 | 0 | 0 | 0 |
| Botryllus planus | 0 | 0 | 2,668 | 860 | 379 | 167 |
| Hydroidea sp | 0 | 0 | 78 | 111 | 56 | 101 |
| Mycale sp | 0 | 0 | 1 | 0 | 0 | 0 |
| Polychaeta | 0 | 0 | 0 | 18 | 28 | 3 |
| Polychaeta | 0 | 0 | 0 | 0 | 6 | 0 |
| Membranipora sp | 0 | 0 | 0 | 0 | 500 | 0 |
| Neritina virginea | 0 | 0 | 0 | 0 | 1 | 0 |
| Halisarca sp | 0 | 0 | 0 | 0 | 0 | 4 |
| Tethya sp | 0 | 0 | 0 | 0 | 0 | 12 |
| Terebellidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Pachygrapsus gracilis | 0 | 0 | 0 | 0 | 0 | 4 |
| Crepidula glauca | 0 | 0 | 0 | 0 | 0 | 2 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 100 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## DATA ON STATION 2

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Ampithoe sp | 5 | 39 | 108 | 15 | 49 | 93 |
| Balanus sp | 13,131 | 4,031 | 4 | 22 | 44 | 135 |
| Triphora nigrocincta | 1 | 1 | 1 | 0 | 0 | 0 |
| Ecteinascidia turbinata | 0 | 28 | 5 | 0 | 171 | 572 |
| Apanthura sp | 0 | 7 | 24 | 2 | 2 | 17 |
| Hydroides sp | 0 | 107 | 122 | 201 | 64 | 46 |
| Penaeus duorarum | 0 | 1 | 2 | 1 | 1 | 0 |
| Botryllus planus | 0 | 0 | 4,042 | 2,235 | 789 | 0 |
| Brachidontes exustus | 0 | 0 | 1 | 5 | 17 | 33 |
| Isognomon alatus | 0 | 0 | 1 | 1 | 5 | 4 |
| Cerithium variabile | 0 | 0 | 1 | 0 | 0 | 0 |
| Hyperoche sp | 0 | 0 | 1 | 0 | 0 | 0 |
| Polychaeta | 0 | 0 | 0 | 10 | 16 | 23 |
| Maldanidae | 0 | 0 | 0 | 2 | 5 | 1 |
| Polychaeta | 0 | 0 | 0 | 1 | 0 | 0 |
| Crepidula glauca | 0 | 0 | 0 | 1 | 0 | 0 |
| Ascidia nigra | 0 | 0 | 0 | 1 | 0 | 0 |
| Pachygrapsus gracilis | 0 | 0 | 0 | 0 | 1 | 2 |
| Membranipora sp | 0 | 0 | 0 | 0 | 17,866 | 3,175 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## DATA ON STATION 3

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Bugula neritina | 72 | 151 | 10 | 4 | 0 | 0 |
| Pachygrapsus gracilis | 1 | 1 | 0 | 0 | 0 | 5 |
| Cerithuim variabile | 1 | 4 | 0 | 0 | 0 | 6 |
| Balanus sp | 10,337 | 6,576 | 22 | 45 | 33 | 436 |
| Ampithoe sp | 5 | 27 | 24 | 15 | 1 | 3 |
| Apanthura sp | 3 | 2 | 17 | 2 | 0 | 0 |
| Triphora nigrocincta | 1 | 0 | 0 | 0 | 0 | 0 |
| Bulla striata | 0 | 5 | 1 | 0 | 0 | 0 |
| Mycale sp | 0 | 1 | 0 | 0 | 0 | 0 |
| Hydroides sp | 0 | 72 | 190 | 78 | 111 | 89 |
| Ecteinascidia turbinata | 0 | 5 | 0 | 0 | 0 | 0 |
| Brachydontes exustus | 0 | 0 | 31 | 11 | 1 | 3 |
| Unknown | 0 | 0 | 6 | 3 | 0 | 25 |
| Botryllus planus | 0 | 0 | 1,340 | 481 | 45 | 0 |
| Dysidea etheria | 0 | 0 | 1 | 0 | 0 | 0 |
| Penaeus duorarum | 0 | 0 | 1 | 0 | 0 | 0 |
| Membranipora sp | 0 | 0 | 50 | 650 | 0 | 2,122 |
| Polychaeta | 0 | 0 | 0 | 95 | 24 | 19 |
| Polychaeta | 0 | 0 | 0 | 6 | 0 | 0 |
| Ascidia nigra | 0 | 0 | 0 | 1 | 0 | 0 |
| Isognomon alatus | 0 | 0 | 0 | 0 | 1 | 0 |
| Terebellidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Halisarca sp | 0 | 0 | 0 | 0 | 0 | 1 |

## DATA ON STATION 4

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Brachidontes exustus | 1 | 4 | 35 | 44 | 20 | 10 |
| Bugula neritina | 29 | 108 | 91 | 14 | 1 | 0 |
| Ampithoe sp | 10 | 16 | 28 | 20 | 4 | 0 |
| Balanus sp | 16,927 | 7,960 | 11 | 67 | 22 | 135 |
| Pachygrapsus gracilis | 2 | 0 | 0 | 0 | 4 | 1 |
| Cerithium variabile | 0 | 137 | 4 | 1 | 1 | 0 |
| Ecteinascidia turbinata | 0 | 74 | 34 | 0 | 0 | 2 |
| Hydroides sp | 0 | 145 | 347 | 346 | 145 | 202 |
| Apanthura sp | 0 | 3 | 3 | 8 | 0 | 0 |
| Foram | 0 | 22 | 0 | 0 | 0 | 0 |
| Bulla striata | 0 | 2 | 2 | 0 | 0 | 0 |
| Membranipora sp | 0 | 100 | 27 | 0 | 50 | 3,000 |
| Penaeus duorarum | 0 | 0 | 1 | 0 | 2 | 0 |
| Botryllus planus | 0 | 0 | 1,743 | 1,317 | 368 | 581 |
| Triphora nigrocincta | 0 | 0 | 1 | 0 | 0 | 0 |
| Isognomon alatus | 0 | 0 | 1 | 1 | 4 | 0 |
| Polychaeta | 0 | 0 | 0 | 59 | 74 | 9 |
| Polychaeta | 0 | 0 | 0 | 13 | 0 | 0 |
| Nereidae | 0 | 0 | 0 | 0 | 13 | 3 |
| Algae | 0 | 0 | 0 | 0 | 301 | 0 |
| Acetabularia crenulata | 0 | 0 | 0 | 0 | 2 | 0 |
| Terebellidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Parazoanthus parasiticus | 0 | 0 | 0 | 0 | 0 | 5 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 17 |
| Halisarca sp | 0 | 0 | 0 | 0 | 0 | 2 |
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## DATA ON STATION 5

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Bugula neritina | 244 | 379 | 653 | 5 | 0 | 0 |
| Ampithoe sp | 1 | 43 | 48 | 16 | 1 | 0 |
| Pachygrapsus gracilis | 4 | 8 | 0 | 0 | 3 | 0 |
| Balanus sp. | 28,750 | 2,401 | 0 | 0 | 46 | 74 |
| Apanthura sp | 0 | 7 | 4 | 3 | 0 | 0 |
| Unknown | 0 | 1 | 1 | 1 | 0 | 0 |
| Bulla striata | 0 | 2 | 0 | 0 | 0 | 0 |
| Hydroides sp. | 0 | 78 | 89 | 37 | 168 | 121 |
| Cerithium variabile | 0 | 2 | 2 | 1 | 0 | 0 |
| Membranipora sp. | 0 | 2 | 0 | 0 | 0 | 0 |
| Ecteinascidia turbinata | 0 | 5 | 2 | 0 | 0 | 0 |
| Tethya sp. | 0 | 1 | 0 | 0 | 0 | 0 |
| Brachidontes exustus | 0 | 0 | 29 | 19 | 20 | 1 |
| Polychaeta | 0 | 0 | 1 | 89 | 36 | 9 |
| Botryllus planus | 0 | 0 | 781 | 626 | 291 | 335 |
| Penaeus duorarum | 0 | 0 | 1 | 1 | 0 | 0 |
| Hyperoche sp. | 0 | 0 | 1 | 0 | 0 | 0 |
| Polychaeta | 0 | 0 | 1 | 0 | 9 | 0 |
| Isognomon alatus | 0 | 0 | 0 | 1 | 1 | 0 |
| Egg case Mollusca | 0 | 0 | 0 | 32 | 29 | 0 |
| Cyone sp | 0 | 0 | 0 | 4 | 0 | 0 |
| Neomysis sp | 0 | 0 | 0 | 0 | 1 | 0 |
| Haminoea elegans | 0 | 0 | 0 | 0 | 1 | 0 |
| Nereidae | 0 | 0 | 0 | 0 | 18 | 0 |
| Triphora nigrocincta | 0 | 0 | 0 | 0 | 1 | 0 |
| Acetabularia crenulata | 0 | 0 0 | 0 | 0 | 8 | 1 |
| Terebellidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 5 |
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## DATA ON STATION 6

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Bugula neritina | 81 | 91 | 1 | 0 | 0 | 0 |
| Balanus sp. | 5,662 | 201 | 11 | 0 | 97 | 25 |
| Ampithoe sp. | 3 | 0 | 0 | 2 | 0 | 0 |
| Penaeus duorarum | 1 | 0 | 1 | 1 | 0 | 0 |
| Cerithium variabile | 0 | 1 | 1 | 28 | 2 | 0 |
| Bulla striata | 0 | 1 | 0 | 0 | 0 | 0 |
| Hydroides sp. | 0 | 22 | 179 | 636 | 112 | 50 |
| Ecteinascidia turbinata | 0 | 2 | 0 | 0 | 0 | 0 |
| Egg case | 0 | 1 | 100 | 0 | 0 | 0 |
| Botryllus planus | 0 | 0 | 368 | 993 | 56 | 0 |
| Isognomon alatus | 0 | 0 | 2 | 7 | 4 | 0 |
| Brachidontes exustus | 0 | 0 | 1 | 14 | 5 | 0 |
| Polychaeta | 0 | 0 | 0 | 5 | 7 | 0 |
| Neritina virginea | 0 | 0 | 0 | 2 | 1 | 0 |
| Pachygrapsus gracilis | 0 | 0 | 0 | 2 | 0 | 0 |
| Egg case Mollusca | 0 | 0 | 0 | 13 | 0 | 0 |
| Gobbidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Apanthura sp. | 0 | 0 | 0 | 5 | 0 | 0 |
| Membranipora sp. | 0 | 0 | 0 | 25 | 10 | 0 |
| Terebellidae | 0 | 0 | 0 | 0 | 1 | 0 |
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## DATA ON STATION 7

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Brachidontes exustus | 1 | 6 | 15 | 23 | 103 | 42 |
| Balanus sp. | 43 | 33 | 525 | 570 | 134 | 61 |
| Ecteinascidia turbinata | 0 | 2 | 0 | 0 | 0 | 0 |
| Cerithium variabile | 0 | 4 | 7 | 16 | 5 | 19 |
| Eggs - unknown | 0 | 8 | 0 | 0 | 0 | 0 |
| Crepidula glauca | 0 | 5 | 4 | 7 | 11 | 2 |
| Hydroides sp. | 0 | 11 | 157 | 580 | 514 | 393 |
| Apanthura sp. | 0 | 2 | 6 | 7 | 3 | 2 |
| Ampithoe sp. | 0 | 2 | 4 | 4 | 14 | 10 |
| Isognomon alatus | 0 | 2 | 10 | 28 | 22 | 5 |
| Tethya sp. | 0 | 1 | 0 | 0 | 1 | 1 |
| Mycale sp. | 0 | 2 | 0 | 0 | 0 | 0 |
| Arthropoda | 0 | 0 | 7 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 17 | 0 | 0 | 0 |
| Egg case Mollusca | 0 | 0 | 15 | 18 | 10 | 24 |
| Tonna maculosa | 0 | 0 | 2 | 0 | 0 | 0 |
| Egg case | 0 | 0 | 1 | 0 | 0 | 0 |
| Triphora nigrocincta | 0 | 0 | 0 | 4 | 0 | 1 |
| Neritina virginea | 0 | 0 | 0 | 1 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 90 | 1 | 0 |
| Polychaeta | 0 | 0 | 0 | 0 | 51 | 22 |
| Botryllus planus | 0 | 0 | 0 | 0 | 279 | 257 |
| Membranipora sp. | 0 | 0 | 0 | 0 | 65 | 6,700 |
| Pachygrapsus gracilis | 0 | 0 | 0 | 0 | 0 | 6 |
| Parazoanthus parasiticus | 0 | 0 | 0 | 0 | 0 | 16 |
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## DATA ON STATION 8

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | 8th wk | 16th wk | 32nd wk |
|---|---|---|---|---|---|---|
| Brachidontes exustus | 1 | 6 | 11 | 19 | 69 | 84 |
| Balanus sp. | 1,406 | 971 | 1,016 | 213 | 0 | 55 |
| Crepidula glauca | 1 | 6 | 0 | 3 | 2 | 0 |
| Penaeus duorarum | 1 | 0 | 1 | 0 | 1 | 0 |
| Ampithoe sp. | 3 | 7 | 13 | 17 | 1 | 24 |
| Arthropoda | 2 | 0 | 0 | 0 | 0 | 0 |
| Ecteinascidia turbinata | 0 | 2 | 0 | 0 | 0 | 0 |
| Apanthura sp. | 0 | 2 | 73 | 5 | 0 | 7 |
| Neritina virginea | 0 | 1 | 0 | 0 | 0 | 0 |
| Egg case Mollusca | 0 | 21 | 2 | 0 | 0 | 0 |
| Hydroides sp. | 0 | 33 | 258 | 926 | 223 | 279 |
| Membranipora sp. | 0 | 0 | 400 | 150 | 2,150 | 5.000 |
| Cerithium variabile | 0 | 0 | 7 | 0 | 1 | 1 |
| Bugula neritina | 0 | 0 | 5 | 2 | 0 | 0 |
| Mollusc | 0 | 0 | 1 | 0 | 0 | 0 |
| Hyperoche sp. | 0 | 0 | 1 | 0 | 0 | 0 |
| Enteromorpha | 0 | 0 | 1 | 0 | 0 | 0 |
| Polychaeta | 0 | 0 | 0 | 28 | 28 | 27 |
| Parviturboides comptus | 0 | 0 | 0 | 1 | 0 | 0 |
| Botryllus planus | 0 | 0 | 0 | 1,419 | 0 | 245 |
| Tethya sp. | 0 | 0 | 0 | 1 | 0 | 1 |
| Brown algae | 0 | 0 | 0 | 1 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 1 | 2 | 2 |
| Isognomon alatus | 0 | 0 | 0 | 1 | 3 | 1 |
| Parazoanthus parasiticus | 0 | 0 | 0 | 0 | 0 | 6 |
| Unkown | 0 | 0 | 0 | 0 | 0 | 3 |
| Unkown | 0 | 0 | 0 | 0 | 0 | 1 |
| Halisarca sp. | 0 | 0 | 0 | 0 | 0 | 2 |
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# APPENDIX IV

## DATA ON STATION 2

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Cymbella | 8 | 0 | 6 | | | |
| Navicula | 67 | 19 | 11 | | | |
| Cocconeis | 701 | 2,883 | 1,375 | | | |
| Diploneis | 40 | 4 | 13 | | | |
| Licmophora | 6 | 21 | 0 | | | |
| Unknown | 8 | 0 | 0 | | | |
| Nitzschia | 8 | 386 | 38 | | | |
| Amphora | 82 | 6 | 2 | | | |
| Foraminifera | 2 | 2 | 0 | | | |
| Pleurosigma | 2 | 0 | 0 | | | |
| Polysiphonia | 0 | 10 | 0 | | | |
| Pinnularia | 0 | 4 | 0 | | | |
| Sponge spicules | 0 | 21 | 0 | | | |
| Unknown | 0 | 2 | 0 | | | |
| Germinating algae | 0 | 2 | 2 | | | |
| Melosira | 0 | 6 | 0 | | | |
| Unknown | 0 | 2 | 0 | | | |
| Membranipora | 0 | 0 | 21 | | | |
| Botryllus planus | 0 | 0 | 19 | | | |
| Obelia | 0 | 0 | 508 | | | |
| Rhabdonema | 0 | 0 | 19 | | | |
| Balanus sp. | 0 | 0 | 8 | | | |
| Ceramium | 0 | 0 | 9 | | | |
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## DATA ON STATION 3

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Melosira | 2 | 0 | 0 | | | |
| Pinnularia | 4 | 4 | 6 | | | |
| Nitzschia | 101 | 2 | 21 | | | |
| Cocconeis | 593 | 1,084 | 714 | | | |
| Amphora | 485 | 293 | 77 | | | |
| Diploneis | 14 | 8 | 0 | | | |
| Cymbella | 19 | 4 | 6 | | | |
| Dinoflagellata | 2 | 2 | 0 | | | |
| Polysiphonia | 2 | 2 | 0 | | | |
| Licmophora | 73 | 0 | 0 | | | |
| Obelia | 2 | 16 | 0 | | | |
| Germinating Algae | 2 | 0 | 0 | | | |
| Balanus | 2 | 2 | 6 | | | |
| Navicula | 81 | 1,607 | 8 | | | |
| Copepoda | 0 | 2 | 0 | | | |
| Sponge spicules | 0 | 4 | 0 | | | |
| Trachyneis | 0 | 9 | 0 | | | |
| Unknown | 0 | 4 | 0 | | | |
| Gyrosigma | 0 | 2 | 0 | | | |
| Polychaeta | 0 | 2 | 0 | | | |
| Homocladia | 0 | 2 | 0 | | | |
| Membranipora | 0 | 0 | 4 | | | |
| Rhabdonema | 0 | 0 | 51 | | | |
| Botryllus planus | 0 | 0 | 13 | | | |
| Enteromorpha | 0 | 0 | 2 | | | |
| Pleurosigma | 0 | 0 | 2 | | | |
| Hydroides sp. | 0 | 0 | 26 | | | |
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## DATA ON STATION 4

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Obelia | 21 | 8 | 2 | | | |
| Cocconeis | 170 | 769 | 3,174 | | | |
| Navicula | 467 | 131 | 17 | | | |
| Diploneis | 35 | 2 | 14 | | | |
| Amphora | 12 | 174 | 0 | | | |
| Balanus | 60 | 6 | 4 | | | |
| Pinnularia | 6 | 10 | 6 | | | |
| Melosira | 2 | 0 | 0 | | | |
| Cymbella | 15 | 21 | 0 | | | |
| Nitzschia | 11 | 70 | 0 | | | |
| Unknown | 169 | 0 | 0 | | | |
| Copepoda | 0 | 2 | 4 | | | |
| Surririella | 0 | 6 | 0 | | | |
| Bacillaria | 0 | 39 | 0 | | | |
| Pleurosigma | 0 | 2 | 2 | | | |
| Hydroides sp. | 0 | 0 | 10 | | | |
| Botryllus planus | 0 | 0 | 8 | | | |
| Membranipora | 0 | 0 | 6 | | | |

## DATA ON STATION 5

**No. of Species present**

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Amphora | 163 | 39 | 0 | | | |
| Cocconeis | 292 | 188 | 602 | | | |
| Navicula | 163 | 51 | 73 | | | |
| Pinnularia | 8 | 0 | 4 | | | |
| Diploneis | 12 | 6 | 17 | | | |
| Nitzschia | 103 | 39 | 6 | | | |
| Polychaeta | 2 | 0 | 0 | | | |
| Cymbella | 6 | 0 | 6 | | | |
| Sponge spicules | 2 | 0 | 0 | | | |
| Trachyneis | 4 | 0 | 0 | | | |
| Gyrosigma | 2 | 0 | 0 | | | |
| Foraminifera | 2 | 0 | 0 | | | |
| Balanus | 6 | 2 | 8 | | | |
| Unknown | 0 | 2 | 0 | | | |
| Germinating Algae | 0 | 2 | 0 | | | |
| Bacillaria | 0 | 165 | 8 | | | |
| Surririella | 0 | 4 | 0 | | | |
| Paralia | 0 | 6 | 6 | | | |
| Pleurosigma | 0 | 2 | 0 | | | |
| Licmophora | 0 | 11 | 0 | | | |
| Bugula | 0 | 2 | 4 | | | |
| Botryllus planus | 0 | 0 | 6 | | | |
| Membranipora | 0 | 0 | 10 | | | |
| Rhabdonema | 0 | 0 | 112 | | | |
| eggs | 0 | 0 | 13 | | | |
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## DATA ON STATION 6

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Amphora | 39 | 151 | 337 | | | |
| Cymbella | 10 | 13 | 2 | | | |
| Nitzschia | 10 | 28 | 6 | | | |
| Cocconeis | 41 | 179 | 3,034 | | | |
| Diploneis | 6 | 4 | 13 | | | |
| Licmophora | 2 | 0 | 0 | | | |
| Navicula | 27 | 0 | 75 | | | |
| Germinating Algae | 2 | 11 | 4 | | | |
| Sponge spicules | 2 | 0 | 0 | | | |
| Unknown | 2 | 0 | 0 | | | |
| Membranipora | 0 | 28 | 2 | | | |
| Trachyneis | 0 | 23 | 0 | | | |
| Pleurosigma | 0 | 2 | 0 | | | |
| Enteromorpha | 0 | 4 | 2 | | | |
| Rhabdonema | 0 | 0 | 131 | | | |
| Pinnularia | 0 | 0 | 4 | | | |

## DATA ON STATION 7

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Cocconeis | 3,555 | 1,020 | 2,672 | | | |
| Amphora | 132 | 64 | 57 | | | |
| Cymbella | 15 | 20 | 2 | | | |
| Navicula | 92 | 6 | 28 | | | |
| Germinating Algae | 6 | 4 | 0 | | | |
| Nitzschia | 36 | 2 | 6 | | | |
| Pinnularia | 4 | 0 | 0 | | | |
| Polysiphonia | 4 | 0 | 0 | | | |
| Unknown eggs | 15 | 0 | 0 | | | |
| Rhabdonema | 0 | 214 | 56 | | | |
| Pleurosigma | 0 | 53 | 2 | | | |
| Diploneis | 0 | 10 | 0 | | | |
| Coscinodiscus | 0 | 2 | 0 | | | |
| Surririella | 0 | 8 | 0 | | | |
| Melosira | 0 | 2 | 0 | | | |
| Foraminifera | 0 | 2 | 0 | | | |
| Trachyneis | 0 | 2 | 0 | | | |
| Copepoda | 0 | 2 | 0 | | | |
| Balanus | 0 | 2 | 4 | | | |
| Grammatophora | 0 | 19 | 0 | | | |
| Enteromorpha | 0 | 0 | 19 | | | |
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# DATA ON STATION 8

No. of Species present

| SPECIES | 1st wk | 2nd wk | 4th wk | | | |
|---|---|---|---|---|---|---|
| Cymbella | 14 | 26 | 6 | | | |
| Nitzschia | 11 | 0 | 2 | | | |
| Cocconeis | 568 | 2,831 | 1,907 | | | |
| Pinnularia | 6 | 0 | 0 | | | |
| Navicula | 62 | 0 | 0 | | | |
| Amphora | 8 | 60 | 11 | | | |
| Germinating Algae | 18 | 17 | 4 | | | |
| Unknown | 2 | 0 | 0 | | | |
| Protozoa | 4 | 0 | 0 | | | |
| Diploneis | 6 | 0 | 2 | | | |
| Surririella | 0 | 8 | 0 | | | |
| Polychaete | 0 | 13 | 0 | | | |
| Balanus | 0 | 2 | 8 | | | |
| Biddulphia | 0 | 6 | 0 | | | |
| Pleurosigma | 0 | 4 | 2 | | | |
| Gyrosigma | 0 | 2 | 0 | | | |
| Rhapdonema | 0 | 0 | 38 | | | |
| Membranipora | 0 | 0 | 43 | | | |
| Hydroides | 0 | 0 | 2 | | | |
| Obelia | 0 | 0 | 4 | | | |

APPENDIX V

## DATA ON STATION 9

No. of Species present

| SPECIES | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER |
|---|---|---|---|---|---|---|
| Ampithoe sp. | 28 | 9 | 5 | 1 | 1 | 5 |
| Bugula neritina | 12 | 0 | 0 | 1 | 0 | 0 |
| Brachidontes exustus | 16 | 10 | 15 | 18 | 3 | 13 |
| Penaeus duorarum | 1 | 1 | 0 | 0 | 0 | 0 |
| Mycale sp. | 1 | 0 | 0 | 0 | 0 | 0 |
| Isognomon alatus | 1 | 2 | 24 | 6 | 2 | 17 |
| Membranipora sp. | 700 | 20 | 0 | 0 | 0 | 1,326 |
| Botryllus planus | 1,909 | 1,284 | 11 | 860 | 123 | 591 |
| Hydroides sp. | 112 | 168 | 134 | 22 | 66 | 255 |
| Balanus sp. | 379 | 200 | 190 | 55 | 201 | 7[illegible]1 |
| Polychaeta | 1 | 4 | 73 | 2 | 2 | 16 |
| Apanthura sp. | 1 | 0 | 3 | 1 | 0 | 0 |
| Bulla striata | 1 | 0 | 0 | 0 | 0 | 0 |
| Cerithium variabile | 0 | 1 | 3 | 0 | 0 | 0 |
| Hydroids | 0 | 1 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 1 | 0 | 1 | 3 | 1 |
| Pachygrapsus gracilis | 0 | 0 | 1 | 0 | 0 | 0 |
| Transenella conradina | 0 | 0 | 1 | 0 | 0 | 0 |
| Pseudoceros crozieri | 0 | 0 | 0 | 0 | 1 | 0 |
| Tethya sp. | 0 | 0 | 0 | 0 | 3 | 0 |
| Ecteinascidia turbinata | 0 | 0 | 0 | 0 | 1 | 0 |
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