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MUSSEL COMMUNITY STUDY

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2.2 MUSSEL COMMUNITY STUDIES

2.2.1 Introduction

The rocky intertidal region of the California coastline is characteristically banded with conspicuous zones of organisms (Ricketts *et al.*, 1968). *Mytilus californianus* (Conrad), dominates one of these zones in populations which are so dense that they are often referred to as "mussel beds". The mussel beds dominate lower intertidal areas although they have been recorded as high as +5.0 feet in the intertidal zone as well as in shallow subtidal areas (Ricketts *et al.*, 1968). These limits are extremes, and the actual intertidal height of a specific population will depend on many local factors including angle of substrate and degree of exposure to wave action. Although *M. californianus* is the most conspicuous occupant of this region, it is not the only inhabitant.

The mussels attach to the underlying substrate and other mussels by secreting strong byssus threads. This mode of attachment enables mussels to stack up layer upon layer, often forming beds several centimeters thick. Sediment, detritus and other debris are trapped within the three dimensional structure of the mussel bed. This material comes from a variety of sources including terrestrial runoff and suspension in seawater. The mussel bed thus becomes a microenvironment providing habitat, food and shelter for a variety of small invertebrates. This complex association of organisms is referred to as the *Mytilus californianus* community, and is named for convenience after the macroscopically dominant organism.

In the past, studies of mussel communities have been limited to selected topics (i.e. succession) (Hewatt, 1937; Reish, 1964; Paine, 1966; Cimberg, 1975). These studies were probably limited by the complex nature of the community and by the absence (in the past) of analytical techniques to handle the data which would be generated by an investigation of this community.

The complexity of this community was shown in a survey of a relatively small area in central California (Kanter, 1976). A total area of less than one square meter collected by coring yielded a faunal list of over 100 species. This is, to the author's knowledge, the richest faunal concentration per unit area in the intertidal region. The extreme faunal richness and abundance were highly correlated with three dimensional characteristics of the mussel bed microenvironment. Specifically, the thickness of the mussel bed and the quantity, size and size distribution of sediment were the most important factors affecting community structure. The differences between separate mussel communities were predicted to be greater than those recorded (among communities that were separated by less than 80 km, 50 miles).

The high concentration of organisms indicates that the mussel bed is an important habitat in the intertidal area. Any major disturbance that alters the physical or chemical nature of this microenvironment is predicted to influence the associated community. For example, oil carried ashore from an oil spill can become stranded on the mussel bed. This oil may run between the mussels and cause the deaths of associated fauna by smothering and/or acute toxic effects.

Investigations following major oil spills have concentrated on surface and/or macrospecies (Nicholson and Cimberg, 1971; Foster et al., 1971; North et al., 1964; Chan, 1973; Straughan, et al., in prep). The reasons for this narrow view were probably restricted by funding and time constraints. However, the fate of a major faunal component of the intertidal region, the mussel community, has been neglected. The Bureau of Land Management's survey of the outer continental shelf affords an excellent and long overdue opportunity to document background (baseline) data on mussel communities from major geographic areas of southern California.

Six sites were selected within the study area (Figure 2.2-1) to study the variability in mussel community composition in the southern California borderland. These sites were all located adjacent to the rocky shore survey areas studied by Dr. Littler (see Report 2.1) so that the data from the two surveys could be interrelated. The selected sites attempt to account for different variables operating in the area so that the data obtained can be used as a basis for comparision in the event of an oil pollution incident. The variables considered include:

- Mainland biota vs. island biota.
- Possible north-south variation in species distribution.
- Differences in intertidal height.
- Open ocean vs. Santa Barbara Channel sites.
- Exposure to natural oil seepage or not.
- Possible seasonal community variability.

2.2.2 Methods and Materials

This section describes techniques used to sample the mussel community, to conduct laboratory analysis of both biotic and abiotic measurements, and to analyze the data.

2.2.2.1 Field Sampling

The *Mytilus californianus* community was sampled from six rocky intertidal areas along the California coast. The sites included two mainland localities, Coal Oil Point and San Diego, plus four island

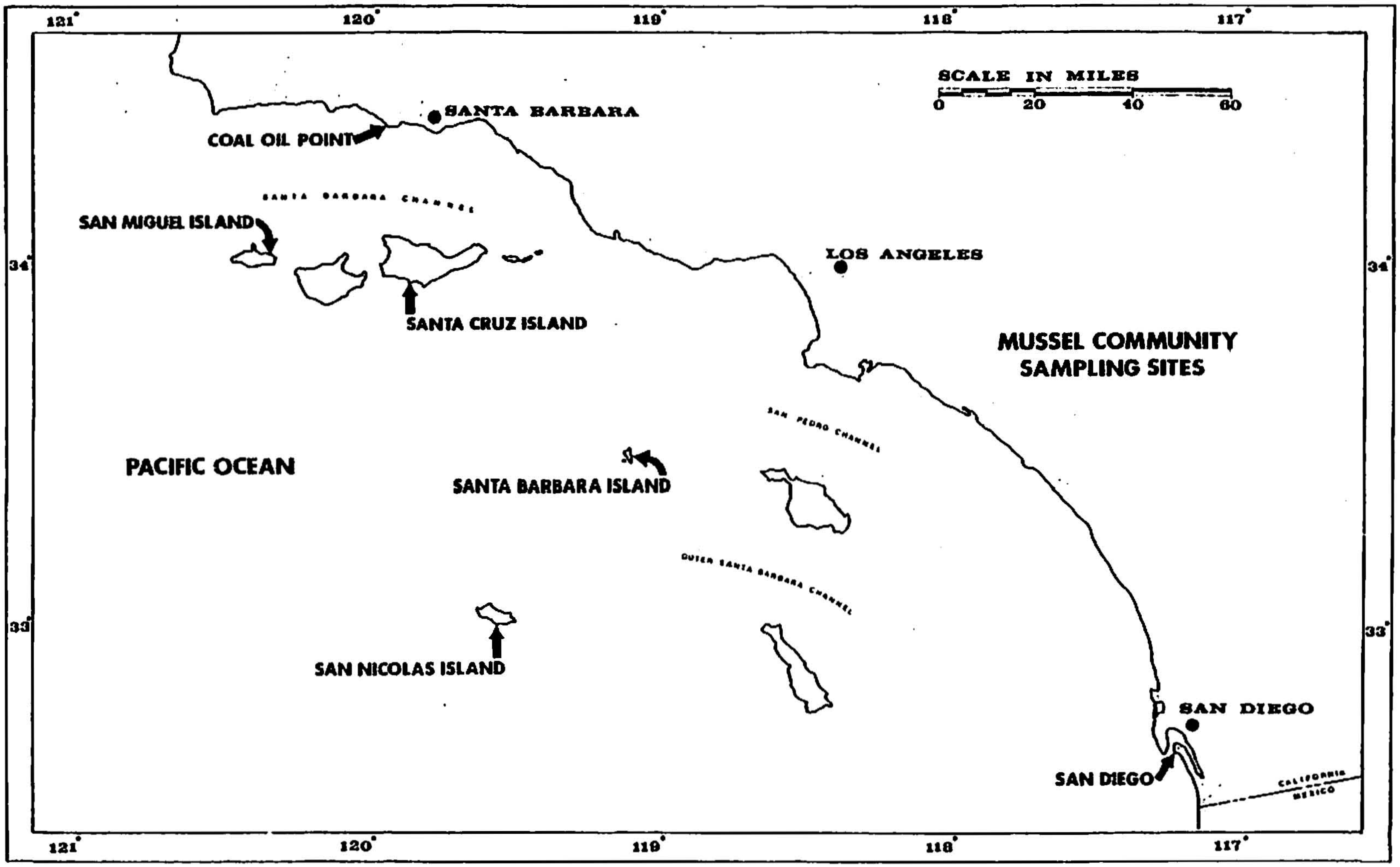

Figure 2.2-1. Mussel Community Sampling Sites (1975-1976).

localities, San Miguel Island, Santa Cruz Island, San Nicolas Island and Santa Barbara Island (Figure 2.2-A; Appendix 2.2-A, Figures 2.2-18 to 2.2-23). These localities corresponded to rocky intertidal sites selected by Dr. Mark Littler, which contained mussel beds on or adjacent to his survey transect line (see Report 2.1 in Volume III for detailed descriptions). All mussel community samples were collected adjacent to Dr. Littler's transects. In general, each of Dr. Littler's study areas contained a "northern," "middle," and "southern" transect. This designation was assigned on the basis of the position of the transect relative to Point Conception. The "northern" transect was closest to Point Conception, the "southern" was farthest away. Straight-line distances from Dr. Littler's closest transect base point to the mussel bed sampling area were recorded for future reference (Appendix 2.2-A, Table 2.2-1).

The mainland localities were sampled twice during the year and the island localities were sampled four times during the year (Table 2.2-1) to determine if there was a significant seasonal variation in the mussel community. Results of past studies (Nicholson and Cimberg, 1971) suggested that summer and winter samples would be adequate to detect seasonal differences at mainland localities. The lack of such a determination for island sites made quarterly surveys necessary.

Prior to collection, each area was photographed for reference (from above) using an instamatic camera (Appendix 2.2-A, Plates 2.2-4 to 2.2-21). Ambient water and air temperatures, as well as internal and surface mussel bed temperatures (Plate 2.2-1), were recorded using a Yellow Springs Instrument telethermometer. Triplicate measurements of the thickness of the mussel bed were obtained by pushing a calibrated stainless steel rod through the mussel bed until it touched the underlying substrate. These measurements were averaged. An area of 1500 cm^2 was sampled by removing five cores of 300 cm^2 [1]. Each sample was collected by a stainless steel corer with a sharp cutting edge (Figure 2.2-2, Plate 2.2-2). The core was pried from the substrate by sliding a broad "crow bar" between the bottom of the mussel bed and the substrate. The core was removed intact, where possible, to include organisms, sediment, and detritus (Plate 2.2-3). Remaining sediment and organisms were collected using a stainless steel spoon and then combined with the rest of the sample.

The sample was transported in a heavy-duty plastic bag from the field to the base camp (boat or laboratory) where it was preserved in a plastic jar in 15% formalin.

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[1] Ten 300 cm^2 cores were collected from San Nicolas Island during the third and fourth quarters.

Table 2.2-1. Sampling Dates

QUARTER	SANTA BARBARA ISLAND	SAN NICOLAS ISLAND	SANTA CRUZ ISLAND	SAN MIGUEL ISLAND	COAL OIL POINT*	SAN DIEGO FISH PIER*
1 (SUMMER)	2 Sept. 1975	3 Oct. 1975	6 Oct. 1975	———	5 Aug. 1975	7 Aug. 1975
2 (FALL)	1 Nov. 1975	19 Nov. 1975	18 Nov. 1975	3 Nov. 1975	———	———
3 (WINTER)	27 Jan. 1976	15 Jan. 1976	13 Jan. 1976	14 Jan. 1976	29 Jan. 1976	30 Jan. 1976
4 (SPRING)	19 Apr. 1976	11 Apr. 1976	9 Apr. 1976	10 Apr. 1976+	———	———

* Mainland sites

\+ Two collections taken (A and B)

Plate 2.2-1. Measurement of Internal Mussel Bed Temperatures. San Nicolas Island, 15 January 1976.

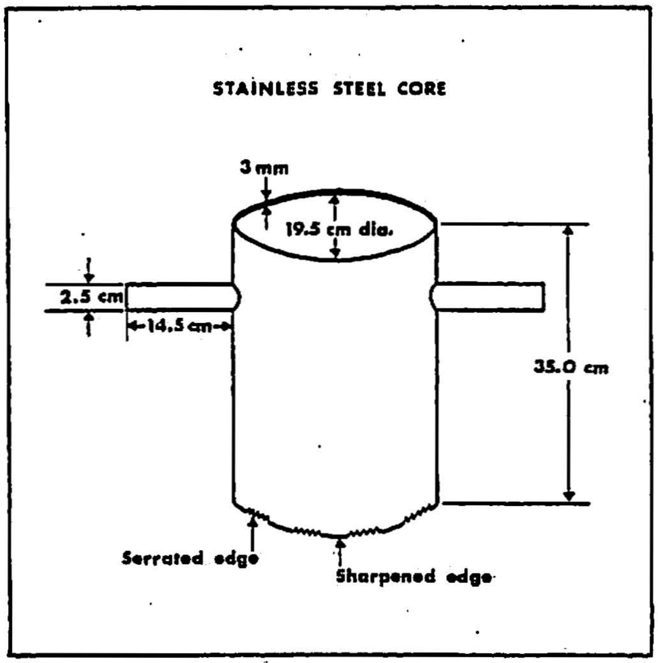

Figure 2.2-2. Stainless Steel Coring Device.

Plate 2.2-2. Process of Coring a Mussel Bed, Santa Barbara Island, 1 November 1975.

Plate 2.2-3. Intact Core of Mussel Bed After Removal From Substrate, San Diego, 30 January 1976.

Each sampling site was marked for future reference with a labeled metal disk secured to the substrate with a metal stud. The intertidal height of each collection was determined by reference to the surveyed basepoints established by Dr. Littler.

Sulphide measurements were attempted during the first quarter of the sampling program (Cline, 1969; Kalil, personal communication) The application and modification of this benthic technique to the mussel community proved unsuccessful and will be discussed in Section 2.2.4.9.

Twenty mussels (4 to 6 cm in length), were collected for hydrocarbon analysis adjacent to the mussel samples but far enough away (approximately 0.5 m) to avoid any possible contamination by the corer.

Stainless steel tongs, washed in nanograde chloroform were used when possible to remove the animal from the substrate. When this was not possible, clean hands were employed. The specimens were then wrapped in foil supplied by Dr. Brock DeLappe. The packages were labeled and placed on dry ice for transport to the laboratory. Samples were maintained at -70^{o}C in the laboratory between field collection and shipment to DeLappe's laboratory.

Ten large mussels (6 to 15 cm long) were collected for trace metal analysis. These specimens were collected using plastic gloves and placed in plastic bags. The bags were labeled and placed on dry ice for shipment to the laboratory. Samples were maintained at -70^{o}C in the laboratory between field collection and shipment to Dr. John Martin's laboratory.

Quality control samples for hydrocarbon and heavy metal analyses were collected as detailed above and shipped to Science Applications, Inc. (SAI).

2.2.2.2 Laboratory Procedures

These procedures include processing of the biological and abiotic components of the mussel community. Section 2.2.2.2.1 describes the identification and documentation of biotic characteristics of the mussel community biota. The abiotic section, 2.2.2.2.2, describes the measurement and documentation of physical and chemical attributes of the mussel community microenvironment.

2.2.2.2.1 Biotic Characteristics

A sequential series of procedures was performed in the laboratory. The sample was first washed with fresh water for 24 hours under low water pressure with the container opening covered by a fine mesh screen (1 mm) to prevent loss of any material. After washing, the mussels were separated from the rest of the sample. Each mussel was individually visually inspected, and all adhering animals (except permanently attached barnacles and bryozoans) were removed and combined with the rest of the unsorted sample. Both the mussels and the unsorted sample were preserved in 100% ethanol.

The samples were hand sorted into major phyla. All macroscopic organisms (>0.5 mm) were removed from the sediment and debris. Each major phylum was then blotted with paper towels to remove excess fluid, and then weighed to determine wet biomass. The specimens were then identified to species and counted. The animals attached to the exterior of the mussels as well as the mussels themselves were identified and counted.

All organisms were identified to the most specific taxonomic level possible. This was the binomial genus-species level in most cases. However, there were some organisms that could only be identified to higher taxonomic levels. Undescribed specimens which displayed clearly-defined morphological characteristics which probably indicated that they were separate species (that are still undescribed), were given morphotype designations by taxonomic experts (e.g., the syllid polychaetes labeled Typosyllis "fasciata" sp. A).

All identifications were performed by specialists in the appropriate taxonomic groups, and should be considered taxonomically "up-to-date" as of this time. Identifications of the phylum Ectoprocta should be considered tentative until taxonomic disputes between specialists are resolved.

2.2.2.2.2. Abiotic Characteristics

Sediment and detritus remained after the organisms were separated out of the sample. These two components were separated and analyzed in a series of sequential operations. The sand and finer sediment (≤ 1 mm) were separated from the coarse sediment (>1 mm, e.g., rock and shell debris) and detritus by washing through a 1 mm screen.

The fine sediment was washed free of preservatives (Kolpack, personal communication) This process involved triple warm distilled water washings with intermediate centrifugation to prevent loss of silts and clays. This process was repeated three times with cold distilled water. A wet sample (∿2 g) was split for pipette size analysis (fraction ≤0.063 mm) (Folk, 1968; Pettijohn, 1957) and automatic settling tube size analysis (0.063 mm < fraction < 1 mm) (Cook, 1969; Cribbs, 1974). The remaining sample was oven dried at 100°C and weighed. Using a sepor microsplitter, this sediment was split into two portions (A and B) for chemical analysis.

Both portions were ground into a fine powder using a mortar and pestle. The powdered sample A was analyzed for organic carbon (total carbon minus carbonate carbon) using the L.E.C.O. technique (Bandy and Kolpack, 1963; Kolpack and Bell, 1968). The powdered sample B was analyzed for nitrogen content by the micro-Kjeldahl method (Kabat and Mayer, 1948). The coarse sediment (> 1 mm, mostly rock and shell debris) was separated from the detritus by differential floatation. The detritus was floated off under low water pressure. Constant swirling of the mixture aided this separation. After separation, both coarse fraction and detritus were microscopically examined and their composition recorded. They were then oven dried at 100°C for 24 hours and dry weighed.

Residual volume is the intermussel space which can be filled by associated fauna, sediment and detritus. Residual volume was calculated for each sample by subtracting the volume occupied by the mussels from the total volume of the sample. The volume of the mussels was determined by recording water displacement in a calibrated cylinder. The total volume of the sample was calculated using the standard formula for the volume of a cylinder $V = \pi r^2 h$ (h = thickness of mussel bed).

2.2.2.3 Data Analyses

Quantitative techniques of data analyses were applied in four major areas of this study:

1. Determination of sample size and diversity for the mussel beds from each locality.

2. Physical characterization of mussel bed sediment based on data from pipette and settling tube analyses.

3. Comparison of the Mytilus californianus communities from different localities (community classification analysis).

4. Examination of the relationship between physical-chemical characteristics of the mussel bed and community composition (multiple discriminant analysis).

2.2.2.3.1 Sample Size and Community Diversity

Geographically separated mussel beds were predicted to vary (Kanter, 1976). Hence, each area was examined separately to determine optimal sample size. The optimal sample size was graphically determined by constructing a species-area curve (Cain, 1938). The cumulative number of species was plotted against sample size (number of cores). The asymptote (determined by inspection) represented the optimal sample size.)

A similar procedure was employed in the calculation of mussel bed species diversity for each geographic area. Diversity was calculated using the formula of Shannon-Wiener (Pielou, 1966).

$$H' = \sum_{i=1}^{S} P_i \log P_i$$

H' = diversity

P = proportion of the i^{th} species in the sample

S = number of species

The cumulative diversity was plotted against the number of samples (cores). The value at the asymptote of the curve represented the species diversity of the area under consideration. However, the index H' is a summation influenced by its fractional parts. Therefore, the asymptote for the cumulative curve was subject to minor fluctuations. To be consistent, the mussel diversity of a specific collection was the cumulative diversity for 1500 cm^2 (five cores).

Diversity (H') is a component measure which incorporates both species richness and evenness of abundance into one term. It is often more informative to consider each component separately in order to understand the variability of the diversity figures. The Gleason index (Gleason, 1922) of richness was calculated using the formula:

$$R = S/\log N$$

R = richness

S = number of species

N = number of individuals

Species evenness (Pielou, 1966) was calculated from the formula:

$$J' = H'/H_{max}$$

J' = evenness of species representation in the association

H' = diversity (Shannon-Wiener)

H_{max} = maximum diversity with all species equally represented.

In addition, average species diversity (both H' and total number of species), evenness and richness were calculated for each locality from the values of individual collections.

2.2.2.3.2 Physical Characterization of Sediment

Sediment size and size distribution characteristics were computed from data generated by pipette and automatic settling tube analyses (Section 2.2.2.2.2). The parameters measured were based on sediment size in terms of phi (ϕ) intervals (Krumbein, 1936). The calculations (performed by the computer) included ϕ mean size, ϕ kurtosis and ϕ skewness (Inman, 1952).

2.2.2.3.3 Comparison of Mussel Communities

Mussel bed communities from the six different localities sampled were compared by the use of classificatory techniques (Clifford and Stephenson, 1975). Classification was performed on the biotic data generated by sampling each quarter. Two forms of classification were performed in this study: (1) The localities (entities) were classified by their species composition (attributes). This was the normal analysis. (2) The species (entities) were classified in terms of their distribution between localities (attributes). This was the inverse analysis. Classification involved three basic steps:

- The calculation of similarities between entities based on attributes.
- The sorting and clustering into hierarchical dendrograms of the classified entities.
- The construction of a two-way coincidence table based on the normal and inverse analyses.

The "Bray-Curtis" index (Clifford and Stephenson, 1975) was used to compute an interentity distance matrix when the data were analyzed to determine community similarity. Classification was performed on all identified species that occurred at more than one locality. The species counts were transformed prior to normai analysis by square root and species mean, and by square root and species maximum prior to inverse analysis (Smith, 1976). A weighted classification was employed (Smith, 1976). The sorting strategy selected for construction of hierarchical dendrograms was "flexible" (Clifford and Stephenson, 1975; Lance and Williams, 1967). Symbolic two-way coincidence tables were constructed from the resulting normal and inverse classifications (Smith, 1976).

2.2.2.3.4 Relationship Between Community Composition and Abiotic Features of the Mussel Bed

Mussel community composition is directly related to structural complexity of the overlying mussel bed (Kanter, 1976). In addition to structural complexity, measurements of mussel bed variables which reflect differences in the availability and variety of food, habitat and shelter resources include:

- Mussel bed thickness (Section 2.2.2.1)
- Quantity of sediment (Section 2.2.2.2.2)
- Quantity of detritus (Section 2.2.2.2.2)
- Residual volume (Section 2.2.2.2.2)
- Quantity of coarse fraction sediment (Section 2.2.2.2.2)
- Pore base of coarse fraction sediment (Section 2.2.2.2.2)
- Mean sediment size (Section 2.2.2.3.2)
- Skewness of the sediment (Section 2.2.2.3.2)
- Kurtosis of the sediment (Section 2.2.2.3.2)
- Organic carbon content of the sediment (Section 2.2.2.2.2)
- Carbon/nitrogen ratio of the sediment (Section 2.2.2.2.2)
- Quantity of tar in the mussel bed (Section 2.2.2.2.2)

These variables were considered in the multiple discriminant analyses.

Discriminant analysis (Smith, 1976; Hope, 1963; Cooley and Lohnes, 1971) defined the axes, in abiotic space described by linea combinations of variables, which best separate the site groups. Different combinations of variables were important during different times of the year. The groups were plotted in two dimensional space (two axes) and the importance of each variable in the construction of an axis was indicated by the magnitude of the coefficient(s) of separate determination. The highest coefficient indicated the most important variable. The variables measured were predicted to have direct influence on the mussel community (Kanter, 1976). The application of discriminant analysis allowed the most important of the measured variables to be singled out. Those variables that showed a correlation with the major community differences were interpreted in relation to the ecology and diversity of mussel community inhabitants.

The Santa Barbara Island mussel bed was unique among those sampled. In all collections the quantity of sediment was extremely small. In some instances there was not enough sediment to complete chemical and/or physical measures. When only one or two samples lacked data, data were estimated using predictive regressions based on the relationships of all other variables. However, when data from more than two samples were missing (both chemical and physical sediment data), the site was not included in the discriminant analysis. This was the case for discriminant analysis of the third and fourth quarter collections where Santa Barbara Island data were not included.

2.2.3 Results

2.2.3.1 Physiography of Collection Localities

The collection sites were typical *Mytilus californianus* habitats characterized by stable substrates and locations exposed to direct wave action and surge. Details of the location and physical characteristics of each site are provided in Appendix 2.2-A.

The Coal Oil Point collection area (Appendix 2.2-A, Figure 2.2-18) is the most northern mainland site and is located adjacent to Dr. Littler's "southern" transect. The mussel bed is patchy, approximately 1.8 m (six feet) in diameter, and on relatively horizontal substrate. The substrate is smooth stratified rock with occasional channels which parallel the rock striations. Bare areas of rock, surrounding the mussel beds, support a thin film of encrusting algae e.g., *Ralfsia* sp., blue-green. Coal Oil Point is unique because of its intermittent exposure to oil carried ashore from natural oil seeps and previous exposure to oil from the 1969 Santa Barbara oil spill.

The San Diego locality is the most southern mainland site (Appendix 2.2-A, Figure 2.2-19). The mussel bed is located on a broad sandstone outcrop adjacent to Dr. Littler's "northern" transect. The mussels blanket the horizontal areas and extend onto vertical surfaces where the substrate drops off abruptly into a surge channel. A thin film of encrusting algae covers large expanses of the substrate in the spray zone above the mussel bed.

San Miguel Island is the most northern island locality (Appendix 2.2-A, Figure 2.2-20). The collection site is located near Cuyler Harbor, adjacent to Dr. Littler's "northern" transect. The mussel bed is extensive and completely covers the underlying substrate. The substrate is a rock conglomerate which contains numerous inclusions and pits. Small tidal pools occur in some portions of the mussel bed. These contain mixed populations of Mytilus californianus and Mytilus edulis. Fewer encrusting algae, including blue-greens, were recorded at San Miguel Island than were recorded from other areas e.g., San Diego, Santa Barbara Island.

The Santa Cruz Island mussel beds occupy a gently sloping rock outcrop adjacent to Willows Anchorage (Appendix 2.2-A, Figure 2.2-21). The collection area is adjacent to Dr. Littler's "northern" transect. The substrate is characterized by pits and small crevices (10 to 20 cm greatest dimension). The mussels occur in large patches which extend down to the brown algal zone. Encrusting algae, including blue-greens, occurred in patches in moderate abundance.

The collection site on San Nicolas Island is near Dutch Harbor and landward of Dr. Littler's "northern" transect (Appendix 2.2-A, Figure 2.2-22). The extensive mussel beds cover large areas of the sandstone reef. The reef is a broad platform dotted by occasional tidal pools and narrow surge channels. The mussel bed sampled is composed almost exclusively of large (∿10 to 15 cm), loosely packed mussels harboring an occasional abalone, Haliotis cracherodii, and/or owl limpet, Lottia gigantea.

The mussel bed sampled on Santa Barbara Island occupies a relatively narrow rock platform. The collection site is adjacent to Dr. Littler's "middle" transect (Appendix 2.2-A, Figure 2.2-23). The substrate is a conglomerate rock with a highly irregular and pitted surface, similar to that found on San Miguel Island. The mussel bed is relatively thin (∿3 to 6 cm) and contains very little trapped sediment. The mussels and nearby areas are covered by large amounts of encrusting algae, including blue-greens.

Photographs taken prior to collection (Appendix 2.2-A, Plates 2.2-4 to 2.2-21) show surface detail of the mussel bed including attached fauna and flora. The pictures reveal very little about the internal structure of the mussel bed.

2.2.3.2 Community Composition

The composite mussel community "species" list is presented in Appendix 2.2-B, Table 2.2-12. It includes presence/absence records for all "species" from each collection at all localities. The list includes 346 "species" from 12 phyla. The "species" include 251 identified species and 95 entities identified to less precise taxonomic levels. The total 346 should be considered a conservative estimate of the total number of species found in the mussel community because those entities identified to less precise taxonomic levels probably include more than one species. Three phyla, the Annelida, Mollusca and Arthropoda account for the greatest proportion (∿ 70%) of the species found in the mussel community. The largest class was the polychaetous annelids, which contained 111 species. There were only 31 species (∿ 28%) which occurred at three or more of the sites, while only six species were collected at all sites (Appendix 2.2.-B Table 2.2-12).

Many species were found exclusively at either mainland or island localities. However, less than half of the species were considered in the classificatory analysis (Section 2.2.2.3.3, justification for species elimination). In most instances their rare presence in low numbers did not provide definite data on differences between island and mainland biota. In other words, their numbers were so low, that presence or absence records may have been entirely by chance. Between 10% and 20% of the species which were recorded in more than one collection, can probably be catagorized as either 'island' or 'mainland' biota.

2.2.3.3 Mussel Community Biomass

Biomass was weighed separately for each phyla from each collection at each locality (Appendix 2.2-B, Tables 2.2-13 to 2.2-32).

In general over 90% of the total biomass was contributed by the molluscs, specifically the mussels (Figure 2.2-3, Table 2.2-2). The remaining biomass (<10%) was contributed by all of the other phyla combined.

Coal Oil Point and San Nicolas Island contained the highest biomass per unit area; Santa Barbara Island, the lowest biomass per unit area.

As described above, the mussels dominated the total biomass from each locality. In addition the mussel bed was relatively homogeneous in the areas sampled. These factors were combined to make biomass measurements between all collections from a locality extremely consistent throughout the year. The only exception was the fourth quarter collection from Santa Barbara Island (Appendix 2.2-B, Table 2.2-43). The total biomass of this collection was considerably lower than that from previous collections because the only area left for sampling in the fourth quarter was more sparsely populated by mussels than the areas sampled in the previous quarters.

2.2.3.4 Determination of Sample Size

Four sample cores (total surface area = 1200 cm^2) was the optimal sample size for mussel beds surveyed in the Estero Bay area of California (Kanter, 1976). The optimal sample size is defined as

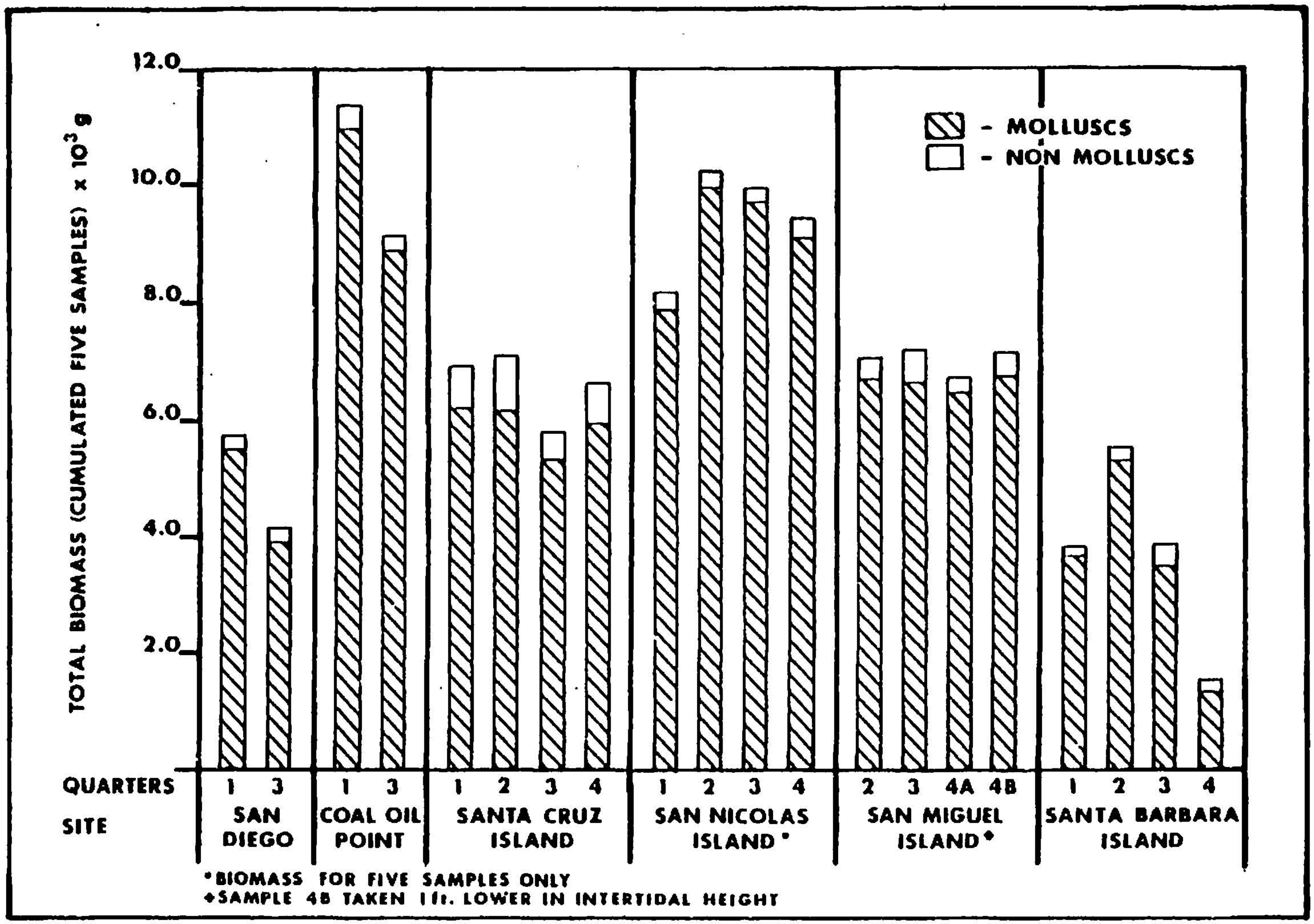

Figure 2.2-3. Total Biomass Histogram Indicating Proportions of Mollusc and Non-Mollusc Biomass in All Collections From Each Locality.

Table 2.2-2 Phylum Mollusca Biomass In Relation To Total Biomass

Site	Quarter	Date	Biomass Total (g)	Biomass Mollusc (g)	Percent Mollusc
San Diego	1	Aug. 7, 1975	5678.3	5498.3	97
	3	Jan. 30, 1976	4132.9	3968.1	96
Coal Oil Point	1	Aug. 5, 1975	11264.2	11021.7	98
	3	Jan. 29, 1976	9163.0	8826.4	96
Santa Cruz Island	1	Oct. 3, 1975	8098.4	6191.0	90
	2	Nov. 18, 1975	7057.5	6091.9	86
	3	Jan. 13, 1976	5412.4	4882.8	90
	4	Apr. 9, 1976	6580.3	5901.2	90
San Nicolas Island*	1	Oct. 3, 1975	8098.4	7791.7	96
	2	Nov. 19, 1975	10233.9	9960.1	97
	3	Jan. 15, 1976	9475.8	9297.6	98
	4	Apr. 11, 1976	8595.8	8284.8	96
San Miguel Island+	2	Nov. 3, 1975	6994.5	6676.8	95
	3	Jan. 14, 1976	7195.3	6635.5	92
	4A	Apr. 10, 1976	6743.4	6445.1	96
	4B	Apr. 10, 1976	7101.2	6708.2	94
Santa Barbara Island	1	Sep. 2, 1975	3779.6	3629.2	96
	2	Nov. 1, 1975	5560.9	5295.7	95
	3	Jan. 27, 1976	3815.9	3534.8	93
	4	Apr. 19, 1976	1945.2	1790.3	92

* Biomass for five samples only

+ Sample 4B taken 1 ft. lower in intertidal height that sample size above which the increase in sampling effort does not provide a comparable increase in information. That is, the asymptote of cumulative curves based on samples species numbers and sample species diversity values. Therefore, a sample of five cores (total surface area = 1500 cm^2) was initially collected at each locality in an effort to oversample the area. Species area curves were constructed for all collections at each locality. These curves provided information on the intrasite variability to be considered in the determination of an optimal sample size for each locality (Appendix 2.2-B, Figures 2.2-24 to 2.2-43).

The asymptote of the species area curves for the first and third quarter collections from Coal Oil Point was at 3 and 4 samples respectively (Appendix 2.2-B, Figures 2.2-23 and 2.2-25). Four samples (total surface area = 1200 cm^2) were therefore optimal for obtaining a representative collection of the mussel bed community from this locality.

The asymptote of the species area curve for the San Diego first quarter collection was at 4 samples (total surface area = 1200 cm^2, Appendix 2.2-B, Figure 2.2-26). There was no clearly defined asymptote on the species area curve from the third quarter collection (Appendix 2.2-B, Figure 2.2-27). However, the cumulative diversity curves from both surveys were maximal at 1 sample and the rate of increase in additional species in the third quarter species area curve was very low from samples 1 to 5. The total number of species from the first and third quarter collections was 48 and 43 respectively. This comparability of species combined with the asymptote of the first quarter suggested a sample size of 5 cores (total surface area = 1500 cm^2) was adequate for this locality and exceeded the optimal value.

The asymptote of the species area curve for the second quarter collection of San Miguel Island was at 3 samples (Appendix 2.2-B, Figure 2.2-28). The curves from the third quarter and collection A of the fourth quarter did not contain a well defined asymptote (Appendix 2.2-B, Figures 2.2-29 and 2.2-30). The species area curve of the fourth quarter collection B had an asymptote at 4 samples (Appendix 2.2-B, Figure 2.2-31). The variability exhibited by these curves was difficult to interpret. However, based upon the consistency in the number of species between all collections and the asymptote of the curves for the second and fourth quarter (collection B) collections, 5 samples (total surface area = 1500 cm^2) were considered adequate and in excess of the optimal sample size.

The species area curves for the first and second quarter collections at Santa Cruz Island had an asymptote at 4 samples (Appendix 2.2-B, Figures 2.2-32 and 2.2-33). The species area curves of the third and fourth quarter collections (Appendix 2.2-B, Figures 2.2-34 and 2.2-35) did not have a well defined asymptote, although both curves had a gradual slope. In all instances the cumulative diversity curves were at the asymptote at 3 or 4 samples. Considering the asymptote of the species area curves for the first and second quarter collections and the gradual rise of the species area curves for third and fourth quarter collections, five samples (total surface area = 1500 cm^2) was considered adequate and in excess of the optimal sample size.

There was no asymptote in the species area curves of the first and second quarter collections at San Nicolas Island (Appendix 2.2-B, Figures 2.2-36 and 2.2-37). This suggested that additional samples were required to adequately represent the mussel community at this locality. Ten samples (total surface area = 3000 cm^2) were collected during the third and fourth quarters. The species area curves for these collections had an asymptote at 9 and 8 samples respectively (Appendix 2.2-B, Figures 2.2-38 and 2.2-39). These results indicated that 9 samples (total surface area = 2700 cm^2) were optimal for this area.

The asymptote of the species area curves for the first, second and third quarter collections from Santa Barbara Island was at 2, 3, and 4 samples respectively (Appendix 2.2-B, Figures 2.2-40 to 2.2-42). The species area curve for the fourth quarter collection contained no asymptote but exhibited a gradual increase in species numbers from 1 to 5 samples. The fourth quarter samples were unique because they were collected from a peripheral area of the mussel bed. The results suggested that 5 samples (total surface area = 1500 cm^2) were adequate to show species distribution and abundance of this site and exceeded the optimal sample size.

2.2.3.5 Community Diversity, Richness and Evenness

Community diversity (both total number of species and Shannon-Wiener Index (H'), richness (R), and evenness (J') were calculated for all collections (Table 2.2-3). The Shannon-Wiener community diversity index was estimated for each locality employing graphical methods (Pielou, 1966) (Appendix 2.2-B, Figures 2.2-24 to 2.2-43). The diversities displayed in Table 2.2-3 represent estimates of the total community diversity based on five core samples (total surface area = 1500 cm^2). The estimates of community diversity, evenness, and richness from each collection at a locality were relatively consistent throughout the year, and minor differences probably reflect heterogeneity within the mussel bed. The average values (average of all collections at one locality) discussed below, probably represent a closer estimate of the overall community diversity, evenness, and richness of the entire mussel community from a specific locality.

The Coal Oil Point mussel bed was one of the richest localities sampled with an average of 73 species (Table 2.2-3). The mean low diversity, H' = 1.622, did not reflect this faunal richness. This is

Table 2.2-3 A Summary Of Total Number Of Species, Species Diversity (H'), Species Evenness (J') And Species Richness (R) For All Mainland And Island Collections.

Site: San Nicholas Island

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	49	2.014	0.517	5.971
2	53	2.274	0.573	5.575
3	53 (81)*	2.005 (1.856)*	0.505 (0.422)*	5.560 (7.182)*
4	63 (75)*	2.959 (3.011)*	0.714 (0.697)*	8.262 (9.239)*
Average	55 (78)*	2.313 (2.433)*	0.577 (0.559)*	6.342 (8.210)*

Site: Coal Oil Point

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	70	1.780	0.419	6.847
2	___	___	___	___
3	75	1.464	0.339	6.485
4	___	___	___	___
Average	73	1.622	0.379	6.666

* Calculations of ten samples

Table 2.2-3. A Summary of Total Number of Species, Species Diversity (H'), Species Evenness (J') and Species Richness (R) For All Mainland and Island Collections (Continued).

Site: San Miguel Island

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	——	——	——	——
2	41	1.764	0.475	4.336
3	55	2.350	0.587	5.810
4A	55	2.674	0.667	7.100
4B	51	2.727	0.693	6.883
Average	51	2.379	0.606	6.032

Site: Santa Barbara Island

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	56	2.300	0.571	6.376
2	74	3.081	0.716	9.117
3	73	2.096	0.489	7.604
4	55	2.953	0.737	7.031
Average	65	2.608	0.628	7.532

Table 2.2-3. A Summary of Total Number of Species, Species Diversity (H'), Species Evenness (J') and Species Richness (R) For All Mainland and Island Collections (Continued).

Site: San Diego

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	48	2.415	0.624	5.724
2	———	———	———	———
3	43	1.099	0.292	4.395
4	———	———	———	———
Average	46	1.757	0.458	5.060

Site: Santa Cruz Island

Quarter	Cumulative Number of Species	Diversity (H')	Species Evenness (J')	Species Richness (R - Gleason)
1	74	2.769	0.643	7.929
2	78	2.770	0.636	7.834
3	69	2.473	0.584	7.153
4	75	3,299	0.764	9.028
AVERAGE	74	2.828	0.657	7.985

a problem with the Shannon-Wiener Index (H') and is discussed in Section 2.2.4.4. Coal Oil Point had an evenness J' = 0.379 and richness R = 6.666.

The San Diego mussel bed contained the lowest mean number of species (46) (Table 2.2-3). The mean diversity H' = 1.757 was also comparatively low but was not as low as that from Coal Oil Point. The evenness and richness were J' = 0.458 and R = 5.060 respectively. The high faunal evenness of the San Diego mussel bed compared to Coal Oil Point mussel bed was reflected in the higher diversity value (H') for the San Diego mussel beds.

The average number of species from the San Miguel Island mussel bed was 51 (Table 2.2-3). The diversity, H' = 2.379, fell approximately in the middle of the range of diversity values recorded in all localities. The average evenness and richness were J' = 0.606 and R = 6.032, respectively.

The Santa Cruz Island Mussel bed supported the greatest number of species--74 (Table 2.2-3). The diversity, H' = 2.828, reflected the high number of species. The average evenness and richness were respectively J' = 0.657 and R = 7.986; both contributed to the high diversity of this area.

During the first and second quarters, 5 samples (total surface area = 1500 cm^2) were collected from the San Nicolas Island mussel beds. During the third and fourth quarter 10 samples (total surface area = 3000 cm^2) were collected. The number of species, diversity (H'), evenness, and richness were calculated for 5 samples from all four collections and, in addition, these same measures were calculated for the third and fourth quarter collections based on 10 samples (Table 2.2-3). The average values for collections of five core samples (total surface area = 1500 cm^2) were 55 species, H' = 2.313, J' = 0.577, R = 6.342 respectively. The third and fourth quarter collections of ten samples (total surface area 3000 cm^2) contained many more species (78) than those found in only 5 samples. This high number of species was reflected in the high richness of R = 8.210. The Shannon-Wiener diversity H' = 2.433 and the evenness J' = 0.559 were comparable to the values calculated for 5 samples (total surface area = 1500 cm^2).

The mussel beds from Santa Barbara Island contained an average of 65 species (Table 2.2-3). This was the third highest number of species from the localities sampled, after Santa Cruz Island with 74 and Coal Oil Point with 73. The diversity, evenness and richness were also high at H' = 2.6, J' = 0.628 and R = 7.532 respectively.

2.2.3.6 Community Similarity Analyses

Community similarity analyses were performed using classificatory techniques. The analyses produced normal (site) and inverse (species) dendrograms which were then arranged in two-way coincidence tables. The normal dendrograms contained clusters of sites based on similarity of faunal composition. The inverse dendrograms contained clusters of species with similar distribution patterns among the sites. The two-way coincidence tables combined the normal and inverse analyses into a form which summarized the results. The cells of the two-way table characterized the site groups with respect to faunal composition and abundance. The two-way table cells contained symbols representing relative abundances of the species maximum abundance. The symbols allowed reduction of the physical size of the table, while they preserved the information necessary for interpretation of the group separations.

The species groups which result from the inverse analyses contained many species. Each species group was labeled on the two-way table by a capital letter for easy reference. In order to interpret the species composition of a specific group, it is necessary to refer directly to the two-way table in question. The phylum of a particular species can be found in Appendix 2.2-B, Table 2.2-12.

The classification of the collections from the first quarter included both mainland and island localities (Figure 2.2-4). The major split in the site groups in the normal dendrogram separated the mainland sites, San Diego (site group 1) and Coal Oil Point (site group 2), from the island sites, Santa Barbara Island (site group 3), San Nicolas Island (site group 4) and Santa Cruz Island (site group 5). San Miguel Island was not sampled during the first quarter. Collections from all localities contained members of the ubiquitous species group E. The mainland sites (site groups 1 and 2) were characterized by medium to very high relative abundances of species from groups A and F. San Diego samples had particularly high relative abundances of species from Group F while Coal Oil Point contained high abundances of species from species group A. The island sites (site groups 3, 4, 5) were characterized by medium to very high relative abundances of species from groups B and D. The Santa Barbara Island site was unique because species group C was confined to that site while species group G was largely confined to the San Nicolas Island site. Santa Cruz Island was secondarily split off from the island sites. This locality was unique because of the high relative abundances of species from groups A, D and H. This uniqueness probably accounts for the secondary split from the island localities.

The second quarter classification included only island localities (Figure 2.2-5). The major split in the normal dendrogram separated San Miguel Island (site group 4) from the other islands, Santa Barbara Island (site group 1), Santa Cruz Island (site group 2) and

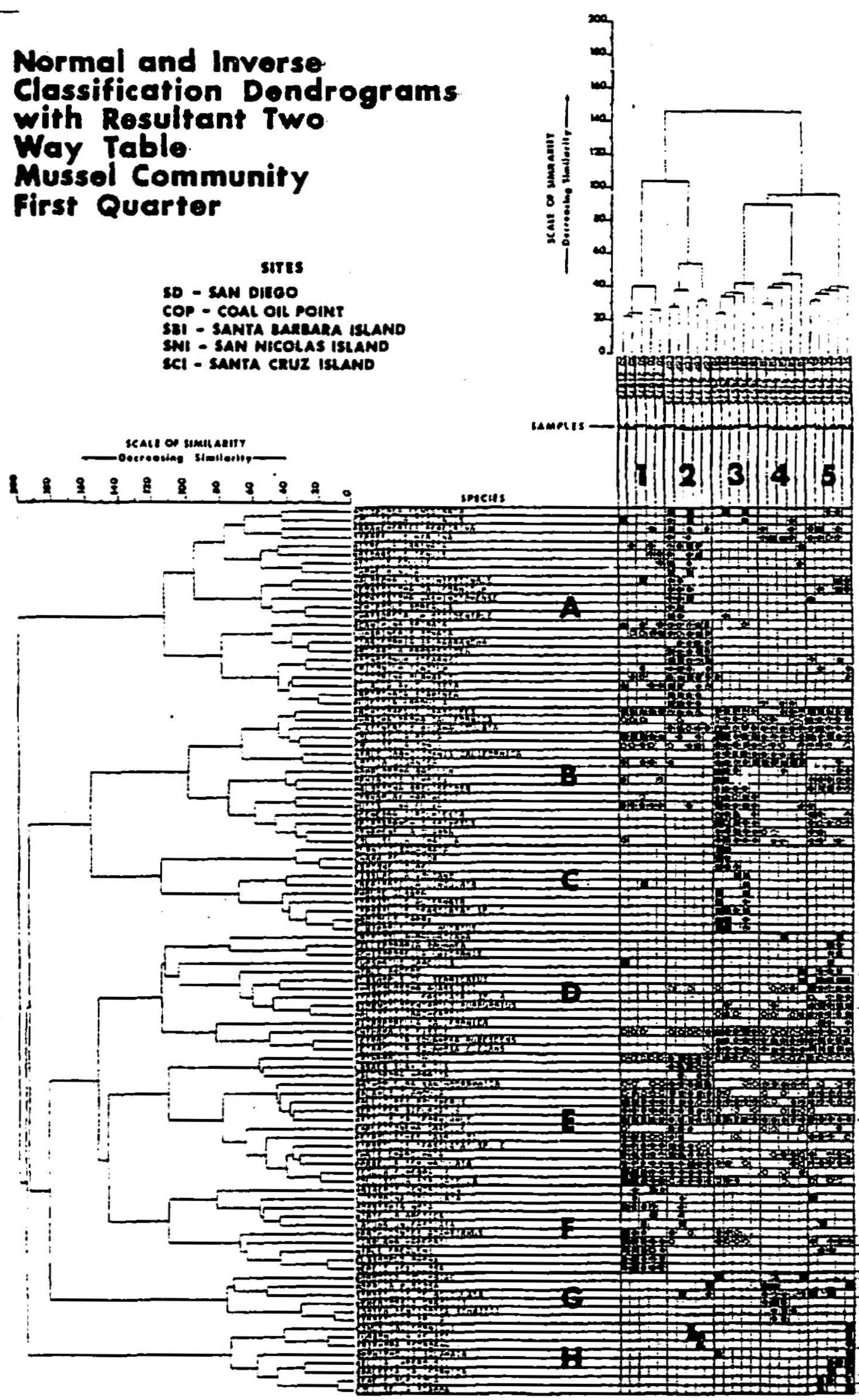

Figure 2.2-4. First Quarter Classification Dendrograms With Resultant Two-Way Table Symbols Represent Relative Species Abundance in Percent of Maximum Abundance: O= 1-25%, θ = 26-50%, ● = 51-75%, ■ = 76-100%.

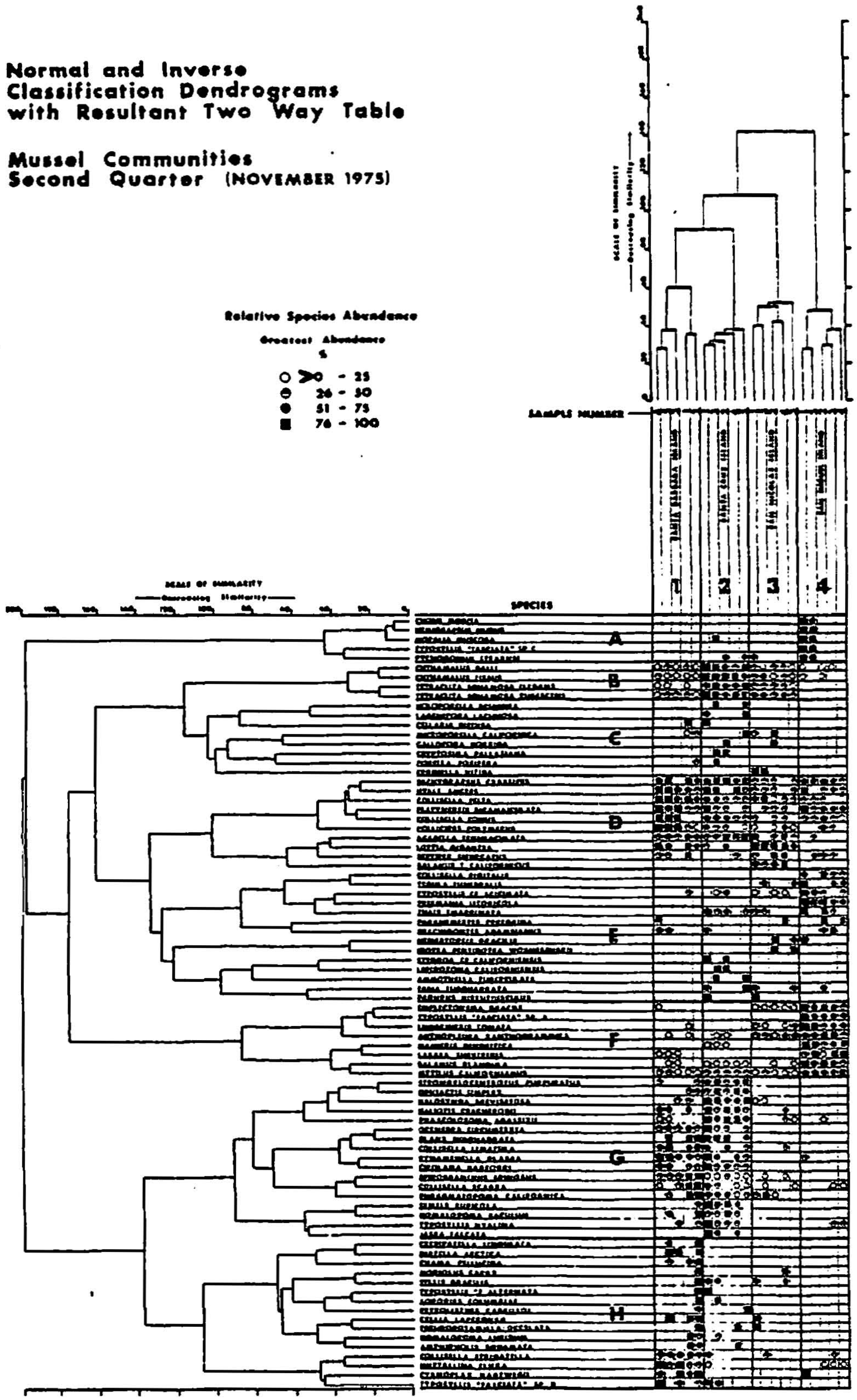

Figure 2.2-5. Second Quarter Classification Dendrograms With Resultant Two-Way Table.

San Nicolas Island (site group 3). Collections from all island localities contained medium to very high relative abundances of the ubiquitous species from species group D. The San Miguel Island collections contained particularly high relative abundances of species from groups A and F. It was the only site with no representatives from species group C. Santa Barbara Island, Santa Cruz Island and San Nicolas Island samples were characterized by the presence of all species in species group B. Species group B was composed entirely of sedentary barnacle species. San Nicolas Island was separated from Santa Barbara Island and Santa Cruz Island based on the poor representation of species groups G and H in the samples. Santa Barbara Island samples contained relatively high abundances of species from species group H and comparatively low abundances of species from species group B. Santa Cruz Island samples contained relatively high abundances of species from species groups B and G.

The classification of the third quarter collections contained island and mainland localities (Figure 2.2-6). There were two primary normal dendrogram splits, which separated San Miguel Island (site group 6) and the mainland sites, Coal Oil Point (site group 2) and San Diego (site group 1), from the rest of the islands, Santa Barbara Island (site group 3), Santa Cruz Island (site group 4), and San Nicolas Island (site group 5). Samples from all localities contained medium to very high relative abundances of the ubiquitous species group F. Species of group B, particularly the sedentary barnacles Chthamalus dalli and Chthamalus fissus, were also fairly numerous among the site groups. However, the remaining species in species group B were not recorded at each site and were usually only recorded in low numbers.

San Miguel Island (site group 6) was characterized by low to medium relative abundances of species from groups A through E (Figure 2.2-6). The mainland localities, San Diego (site group 1) and Coal Oil Point (site group 2), were distinct from the island localities with fewer occurrences and lower relative abundances of the species from groups A through D. San Diego (site group 1) mussel beds contained the lowest number of species. Coal Oil Point (site group 2) was characterized by a high number of abundant species from groups B and E. Santa Barbara Island (site group 3) was characterized by medium to high relative abundances of species from group A. This contrasted with the absence of very low relative abundances of these species (species group A) at all other localities.

Santa Cruz Island (site group 4) samples were distinct from Santa Barbara Island and San Nicolas Island samples, with a high relative abundance of species from group D, and an absence of species from group C. San Nicolas Island samples were characterized by low to medium relative abundances of species from groups A through E, and high relative abundance of species from group C. .

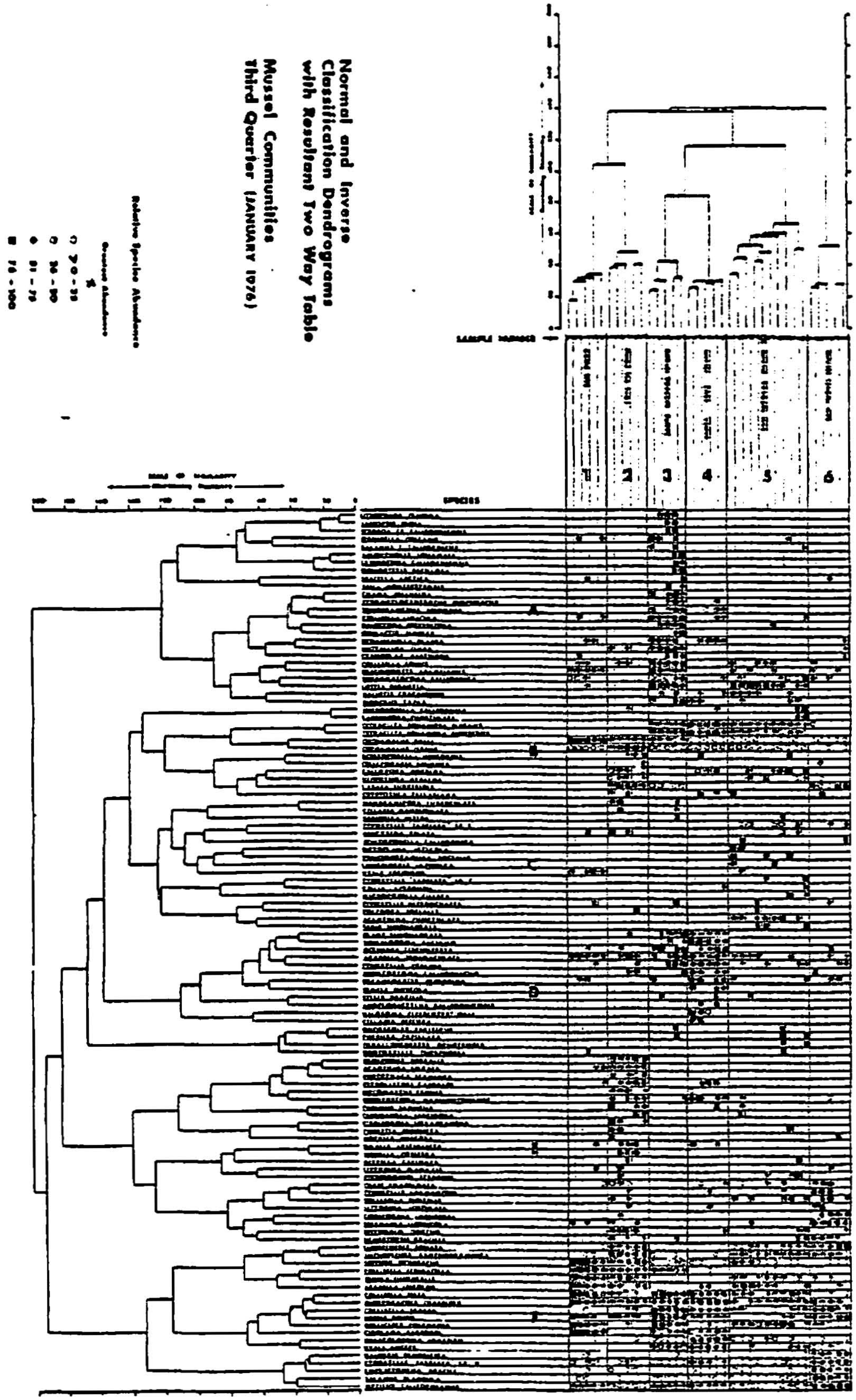

Figure 2.2-6. Third Quarter Classification Dendrograms With Resultant Two-Way Table.

The fourth quarter classification included island localities only (Figure 2.2-7). There were two San Miguel Island collections included (A and B) which represented areas separated by an intertidal height difference of 0.3 m (1 ft.). The primary normal dendrogram split separated Santa Cruz Island (site group 1) and Santa Barbara Island (site group 2), from San Miguel Island (site groups 3 and 4) and San Nicolas Island (site group 5). The secondary split separated San Miguel Island (site groups 3 and 4) from San Nicolas Island (site group 5). Collections from all localities contained medium to very high relative abundances of species from the ubiquitous species group E. Santa Cruz Island (site group 1) and Santa Barbara Island (site group 2) collections were characterized by high relative abundances of species from groups A and B. Santa Cruz Island (site group 1) collections also contained high relative abundances of some species from species group D. San Nicolas Island (site group 5) collections contained some species from all groups A through E. This included high abundances of species from group D. San Miguel Island collections A and B resembled each other closely in overall species composition and therefore grouped together. These collections, however, were distinct because they contained practically no species from groups A and B. However, they did contain high to very high relative abundances of species from groups C, D, and E.

Overall characteristic species groups for both mainland and island localities remained fairly constant through the classification analyses (see Section 2.2.3.7). This was particularly true for the ubiquitous species groups E (Figure 2.2-4), D (Figure 2.2-5), F (Figure 2.2-6) and E (Figure 2.2-7) from the first, second, third and fourth quarter data respectively. In these groups many of the species recurred together from the classification of one quarter's collections to another. In some instances the species abundances and/or occurrence at a site changed, and as a result the species fell into another group. In addition the species groups were affected by the inclusion of both mainland and island localities. There was good agreement in species groups between the first and third quarter classifications (mainland and island localities, Figures 2.2-4 and 2.2-6) and the second and fourth quarter classifications (island localities only, Figures 2.2-5 and 2.2-7).

2.2.3.7 Mussel Community Seasonality

The classification results were examined for seasonal changes in community composition. The mainland localities, Coal Oil Point and San Diego, displayed very similar species groups in both first and third quarter classifications (Figures 2.2-4 and 2.2-6). The ubiquitous species group E from the first quarter and species group F from the third quarter contained a similar combination of species (Figures 2.2-4 and 2.2-6).

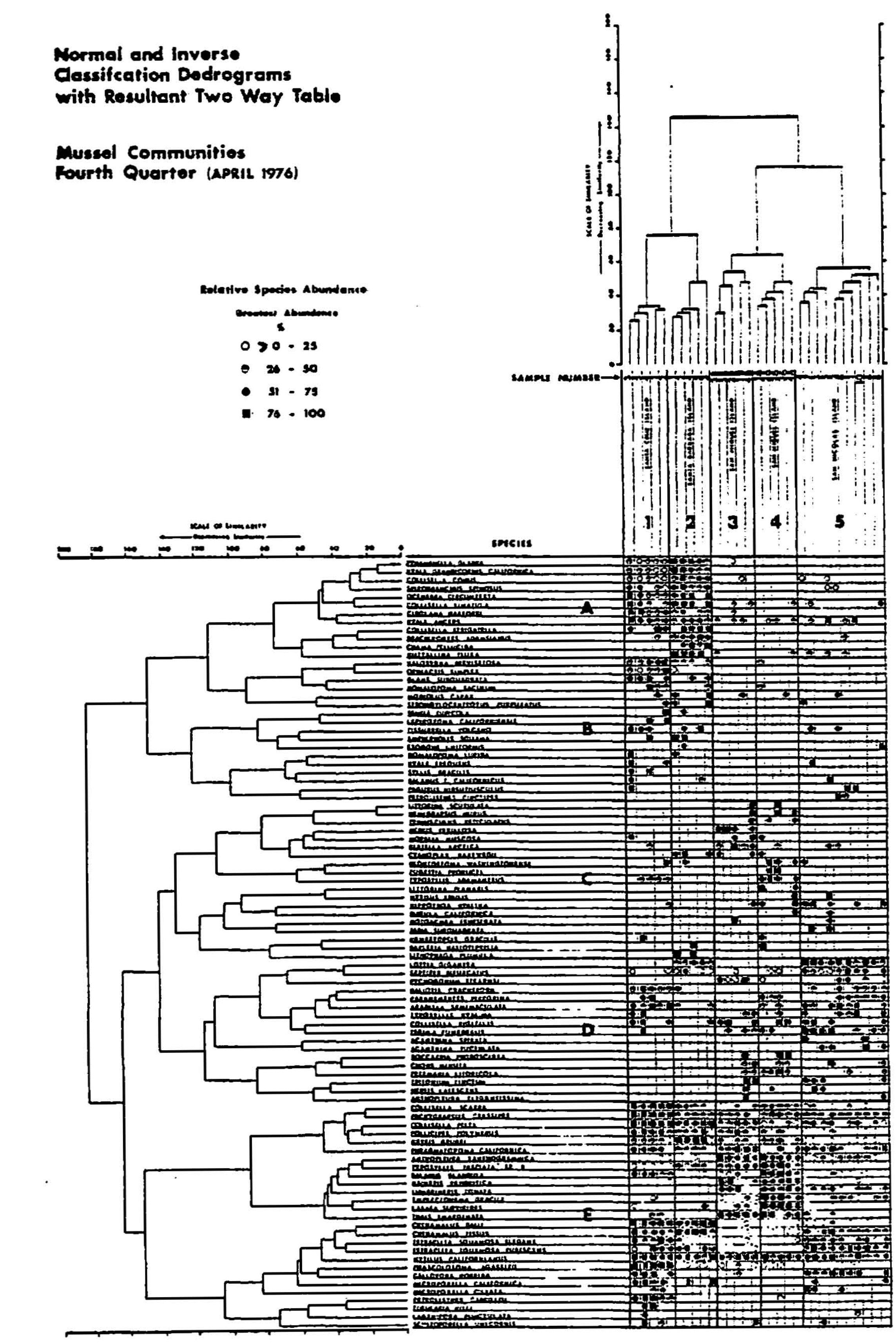

Figure 2.2-7. Fourth Quarter Classification Dendrograms With Resultant Two-Way Table.

Species group A (Figure 2.2-4) which characterized the mainland localities during the first quarter was represented by species group E (Figure 2.2-6) in the third quarter classification. Both of these groups contained common species although they were not identical. In general, the species composition remained very constant from one quarter to another. Relative abundance differences of some species resulted in slight differences in species group composition. Overall, the mainland sites were distinct from the island localities throughout the year. Similar species were collected in the mussel beds at the island localities, San Miguel Island, Santa Cruz Island, San Nicolas Island and Santa Barbara Island throughout the year. Species group B (Figure 2.2-4) characterized the island localities in the classification of the first quarter collections and was represented by species group D (Figure 2.2-5) in the second quarter, species group F (Figure 2.2-6) in the third quarter, and species group E (Figure 2.2-7) in the fourth quarter. The members of all the species groups were distributed through different groups from one quarter to another. This was primarily a result of including mainland and island localities in the classification of the first and third quarter collections. Relative abundance differences recorded for some species may reflect seasonal changes. However, at this time it is not possible to separate seasonal abundance changes in the number of individuals of a species from abundance differences which result from local factors e.g., intertidal height.

2.2.3.8 Intertidal Height and Community Composition

The effect of intertidal height differences on intrasite community composition and diversity was investigated at San Miguel Island during the fourth quarter. Collection A (intertidal height 1.69m) was collected one foot (0.3 m) higher in intertidal height than collection B (intertidal height 1.47m). The total abundance (or absence) of each species was then compared between the two collections (Table 2.2-4). Those species which exhibited differences in abundance are indicated by an asterisk. Of the 65 species considered, 20 exhibited abundance differences which may correspond to differences in intertidal height.

The species which displayed large abundance differences corresponding to the intertidal height differences include the polychaete Naineris dendritica exhibiting almost a two-fold difference (1,221 versus 594 individuals) between collections A and B respectively, the nemertean Emplectonema gracile with 111 individuals in collection A versus 6 in collection B, the barnacle Balanus glandula with 534 individuals in the upper collection A versus 30 individuals in Collection B. The small bivalve Lasaea subviridis exhibited the greatest abundance differences with 4,490 individuals in the upper collection A and 16 individuals in the lower collection, while Mytilus californianus also exhibited a large abundance difference, 1508 individuals in collection A and 492 individuals in the lower sample B.

Table 2.2-4. Fourth Quarter Sampling at San Miguel Island

SPECIES	Total Number of Individuals Found: SITE A +	SITE B ++
Arabella semimaculata*	3	0
Chone minuta	2	5
Lumbrineris zonata	92	65
Phragmatopoma californica*	9	34
Naineris dendritica*	1221	594
Halosydna brevisetosa	1	0
Collisella pelta*	6	42
Collisella scabra*	19	5
Epitonium tinctum	0	4
Littorina planaxis	3	0
Emplectonema gracile*	111	6
Paranemertes peregrina	4	0
Pycnogonum stearnsi*	1	26
Balanus glandula*	534	30
Pollicipes polymerus*	21	312
Lasaea subviridis*	4490	16
Mytilus californianus	1508*	492
Freemania litoricola	20	2
Typosyllis 'fasciata' sp. D*	880	106
Typosyllis adamanteus*	18	0
Thais emarginata	34	47
Tegula funebralis	3	5
Homalopoma baculum	1	0
Barleeia haliotiphilia	1	0
Cyanoplax hartwegii	1	2
Mopalia muscosa	1	3
Phascolosoma agassizii	5	8
Anthopleura xanthogrammica	182	170
Pachygrapsus crassipes*	24	12
Hippothoa hyalina	496	640
Nereis grubei	31	25
Septifer bifurcatus	2	1
Trimusculus reticulatus	2	2
Chthamalus fissus*	5	1
Fabia lowei	1	0
Pugettia producta	1	1
Hyale anceps	4	4
Deontostoma washingtonense*	4	0
Modiolus capax	1	1
Collisella digitalis	6	6
Boccardia proboscidea	2	1

* Species which indicate possible intertidal height effect.
\+ Intertidal height 1.69m
++ Intertidal height 1.47m

Table 2.2-4. Fourth Quarter Sampling at San Miguel Island (Continued)

SPECIES	Total Number of Individuals Found SITE A +	SITE B ++
Nuttalina fluxa	1	1
Hemigrapsus nudus	2	1
Tetraclita squamosa elegans	1	1
Chthamalus dalli	2	1
Mytilus edulis	1	0
Tricellaria ternata*	110	0
Bugula californica*	34	0
Hiatella arctica*	1	11
Littorina scutulata	1	1
Mopalia porifera	1	0
Petrolisthes cabrilloi	1	0
Collisella conus	0	1
Anthopleura elegantissima	0	2
Nereis latescens	1	2
Notoacmea fenestrata	0	2
Collisella limatula	1	2
Cirolana harfordi	0	1
Dynamenella glabra	0	1
Callopora horrida*	0	1220
Nereis vexillosa*	0	5
Kellia laperousii	0	1
Protothaca staminea	0	2
Schizoporella unicornis*	0	160
Typosyllis cf. hyalina	2	3

* Species which indicate possible intertidal height effect.
\+ Intertidal height 1.69m
++ Intertidal height 1.47m

2.2.3.9 Discriminant Analysis of Mussel Bed Abiotic Characteristics

Multiple discriminant analysis was used to determine which abiotic variables of the mussel bed were the most important in relation to changes in community species composition. The relative importance of a variable in the construction of a discriminant axis was indicated by the magnitude of its respective coefficient of separate determination. The coefficients of separate determination were tabulated from the analysis of each quarter (Tables 2.2-5 to 2.2-8), and the most important variables and their coefficients are indicated on the discriminant axes (Figures 2.2-8, to 2.2-15). In addition, the group means for each variable considered were tabulated in Appendix 2.2-C, Tables 2.2-33 to 2.2-36. The minimum number of axes required to account for intersite group separation were considered. The combination of the most important abiotic variables on an axis were then interpreted as a single common factor in relation to community composition. An axis may be interpreted as representing more than a single factor for some species. This is true for species which make multiple use of a resource (e.g., sediment may serve as both habitat and food source for deposit-feeding polychaetes). Interpretation of axes in relation to selected species requires individual consideration of the species and its natural history. This was not attempted in this study.

Four discriminant axes were required to separate the site groups formed in the first quarter classification (Figures 2.2-8 to 2.2-10). Table 2.2-5 contains the coefficients of separate determination for this analysis. The most important variables on the first axis (Figure 2.2-8) were sediment weight (SW), and mean sediment size (MSS). The total number of species increased with an increase in quantity of sediment and a decrease in the mean sediment size. The important variables on the second axis (Figure 2.2-8) were sediment kurtosis (KS), pore base (P), mean sediment size (MSS), weight of coarse fraction (CF) and mussel bed thickness (MBT). The most important variables on the third axis (Figure 2.2-9) were pore base (P), quantity of detritus (D), mean sediment size (MSS), and weight of coarse fraction (CF). This axis separated two site groups (San Diego and Santa Cruz Island) that were not separated on the first two axes. The fourth axis (Figure 2.2-10) separated San Nicolas Island and Santa Barbara Island sites. The most important variables on this axis were mussel bed thickness (MBT), residual volume (RV), sediment weight (SW), pore base (P), weight of detritus (D), and carbon to nitrogen ratio (CNR). The quantity of detritus and the carbon:nitrogen ratio dominate this axis.

Two discriminant axes separated the island site considered in the second quarter analysis (Figure 2.2-11). The most important variables on the first axis (Figure 2.2-11) were the quantity of detritus (D), kurtosis of the sediment (KS), sediment weight (SW),

Table 2.2-5. Coefficients of Separate Determination for First Quarter Discriminant Analysis. (The magnitude of those elements underlined indicates their relative importance on the formation of the axes).

ABIOTIC CHARACTERISTIC	AXIS			
	1	2	3	4
1. Mussel Bed Thickness (cm)	0.6	<u>11.5</u>	0.2	<u>14.2</u>
2. Dry Weight Sediment (g)	<u>73.6</u>	1.6	0.3	<u>11.8</u>
3. Dry Weight Detritus (g)	2.0	1.5	<u>26.9</u>	<u>20.8</u>
4. Residual Volume (cc)	0.3	0.0	0.3	<u>12.1</u>
5. Dry Weight Coarse Fraction (g)	6.1	<u>12.4</u>	<u>12.4</u>	5.7
6. Pore Base Coarse Fraction (cc)	0.8	<u>15.5</u>	<u>30.3</u>	<u>10.4</u>
7. Phi Mean Sediment Size*	<u>11.7</u>	<u>13.3</u>	<u>26.7</u>	3.1
8. Phi Kurtosis Sediment	0.5	<u>37.8</u>	0.4	4.5
9. Organic Carbon (%)	2.3	3.8	0.3	4.5
10. Carbon/Nitrogen Ratio	1.8	0.0	1.5	<u>11.5</u>
11. Tar (g)	0.5	2.6	0.8	1.3

*Phi Mean Sediment Size and Phi Skewness were Highly Correlated (0.98). Therefore, Only Phi Mean Sediment Size was Considered in This Discriminant Analysis.

Table 2.2-6. Coefficients of Separate Determination for Second Quarter Discriminant Analysis. (The magnitude of those elements underlined indicates their relative importance on the formation of the axes).

ABIOTIC CHARACTERISTIC	AXIS 1	AXIS 2
1. Mussel Bed Thickness (cm)	2.5	0.5
2. Dry Weight Sediment (g)	<u>9.7</u>	0.2
3. Dry Weight Detritus (g)	<u>48.9</u>	0.3
4. Residual Volume (cc)	0.2	1.0
5. Dry Weight Coarse Fraction (g)	4.2	0.8
6. Pore Base Coarse Fraction (cc)	0.0	<u>15.4</u>
7. Phi Mean Sediment Size	1.5	0.5
8. Phi Skewness Sediment	4.7	<u>9.1</u>
9. Phi Kurtosis Sediment	<u>11.7</u>	<u>16.2</u>
10. Organic Carbon (%)	<u>9.0</u>	<u>9.2</u>
11. Carbon/Nitrogen Ratio	7.4	2.8
12. Tar (g)	0.4	<u>43.9</u>

Table 2.2-7. Coefficients of Separate Determination for Third Quarter Discriminant Analysis. (The magnitude of those elements underlined indicates their relative importance on the formation of the axes).

ABIOTIC CHARACTERISTIC	AXIS		
	1	2	3
1. Mussel Bed Thickness (cm)	1.4	4.3	13.0
2. Dry Weight Sediment (g)	5.6	0.2	16.4
3. Dry Weight Detritus (g)	3.3	2.5	1.4
4. Residual Volume (cc)	0.9	0.3	1.0
5. Dry Weight Coarse Fraction (g)	4.6	36.4	4.0
6. Pore Base Coarse Fraction (cc)	1.8	14.2	0.4
7. Phi Mean Sediment Size	21.5	0.2	23.3
8. Phi Skewness Sediment	.8	3.2	9.8
9. Phi Kurtosis Sediment	10.5	32.5	23.5
10. Organic Carbon (%)	0.7	3.0	1.5
11. Carbon/Nitrogen Ratio	1.0	1.2	3.4
12. Tar (g)	44.9	2.1	2.4

Table 2.2-8. Coefficients Of Separate Determination For Fourth Quarter Discriminant Analysis. (The magnitude of those elements underlined indicates their relative importance on the formation of the axes).

ABIOTIC CHARACTERISTIC	AXIS		
	1	2	3
1. Mussel Bed Thickness (cm)	4.9	0.5	3.5
2. Dry Weight Sediment (g)	<u>14.8</u>	3.1	5.0
3. Dry Weight Detritus (g)	<u>23.3</u>	5.3	0.0
4. Residual Volume (cc)	0.8	0.9	2.0
5. Dry Weight Coarse Fraction (g)	9.3	1.2	0.4
6. Pore Base Coarse Fraction (cc)	3.2	<u>11.1</u>	0.6
7. Phi Mean Sediment Size	3.2	<u>56.1</u>	2.8
8. Phi Skewness Sediment	7.6	<u>11.9</u>	<u>55.6</u>
9. Phi Kurtosis Sediment	<u>9.9</u>	2.0	<u>22.2</u>
10. Organic Carbon (%)	<u>20.5</u>	0.2	5.3
11. Carbon/Nitrogen Ratio	2.3	1.4	2.5
12. Tar (g)	0.2	6.3	0.1

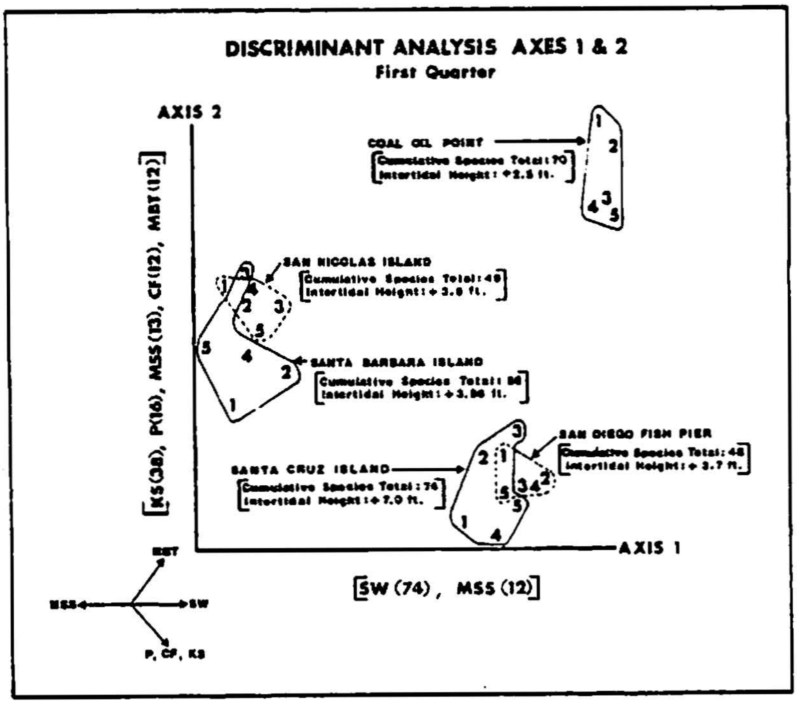

Figure 2.2-8. First Quarter Discriminant Analysis (axes 1 and 2)

The following applies to all discriminant axes figures: Numbers within site groupings represent respective sample numbers. The importance of each variable on an axis is indicated by the nagnitude of its coefficient of separate determination in parentheses. Arrows in left-hand corner indicate direction of increase of each variable's mean value.

MBT	=	Mussel bed thickness
SW	=	Dry weight of sediment
D	=	Dry weight of detritus
RV	=	Residual volume
CF	=	Dry weight of coarse fraction
P	=	Pore base volume
MSS	=	Mean sediment size
SS	=	Skewness of sediment
KS	=	Kurtosis of sediment
OC	=	Organic carbon content
CNR	=	Carbon/nitrogen ratio
T	=	Amount of tar

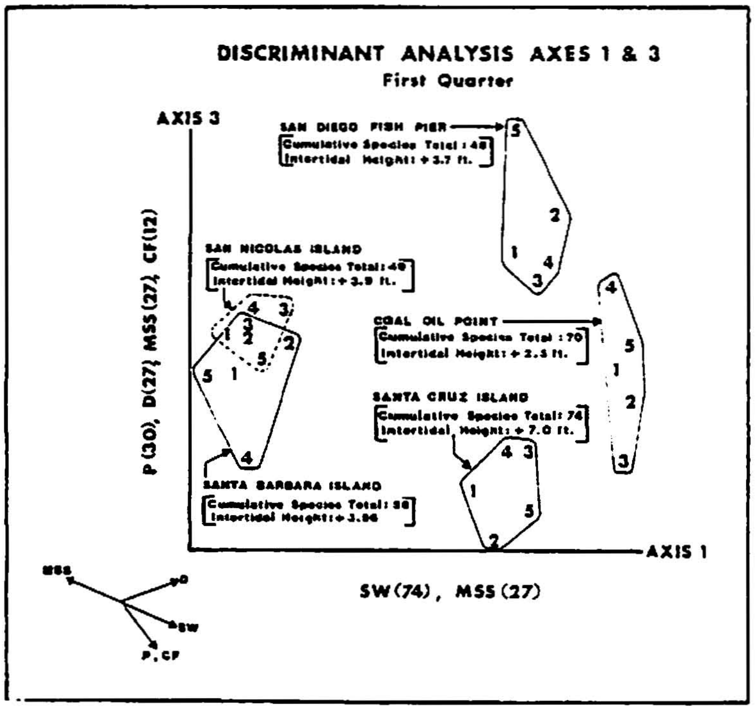

Figure 2.2-9. First Quarter Discriminant Analysis (axes 1 and 3). Refer to Figure 2.2-8 for Further Description and Key to Variables.

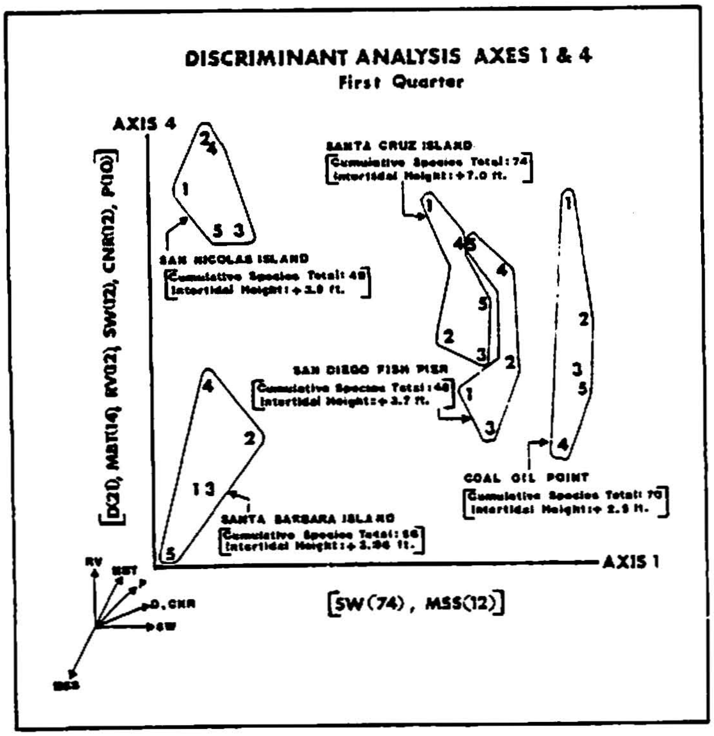

Figure 2.2-10. First Quarter Discriminant Analysis (axes 1 and 4). Refer to Figure 2.2-8 for Further Description and Key to Variables.

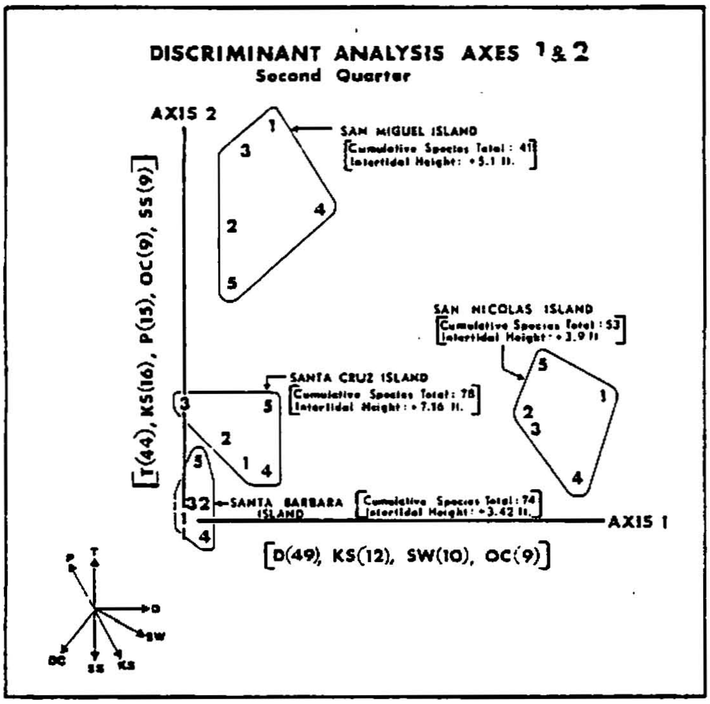

Figure 2.2-11. Second Quarter Discriminant Analysis (Axes 1 and 2). Refer to Figure 2.2-8 for Further Description and Key to Variables.

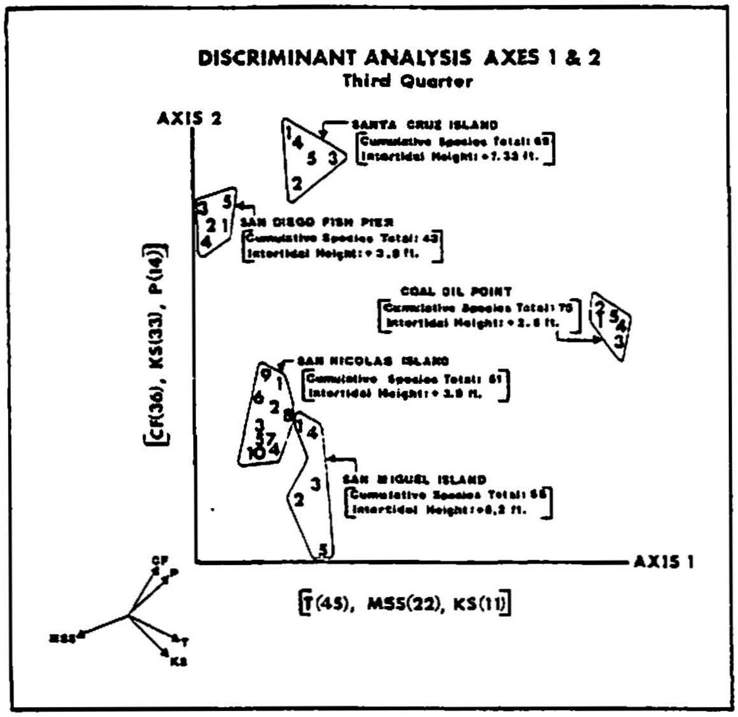

Figure 2.2-12. Third Quarter Discriminant Analysis (Axes 1 and 2). Refer to Figure 2.2-8 for Further Description and Key to Variables.

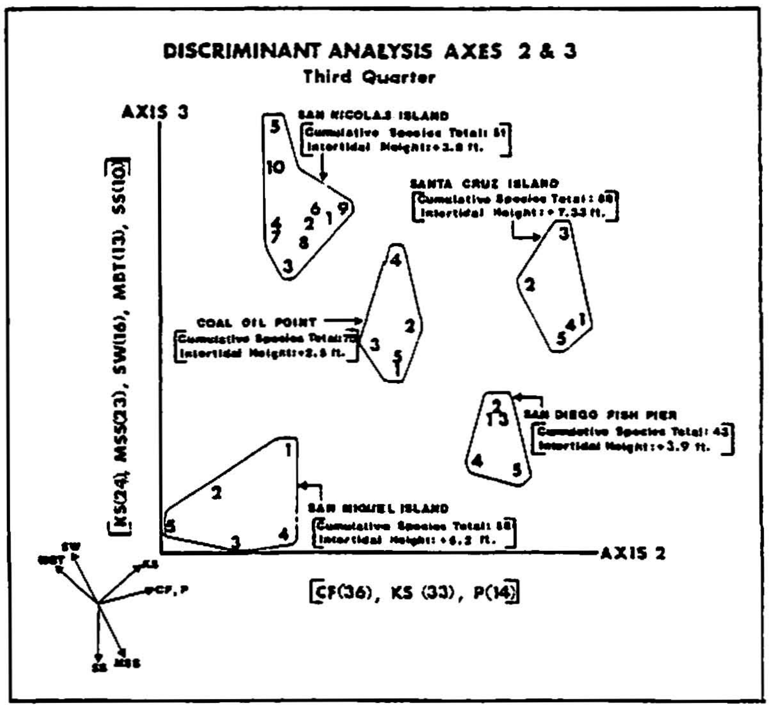

Figure 2.2-13. Third Quarter Discriminant Analysis (Axes 2 and 3). Refer to Figure 2.2-8 for Further Description and Key to Variables.

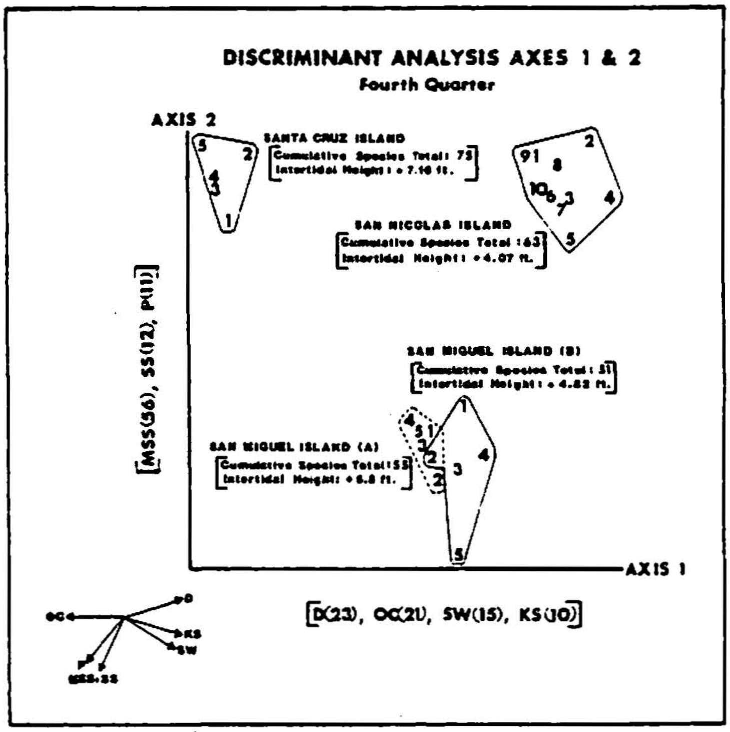

Figure 2.2-14. Fourth Quarter Discriminant Analysis (Axes 1 and 2). Refer to Figure 2.2-8 for Further Description and Key to Variables.

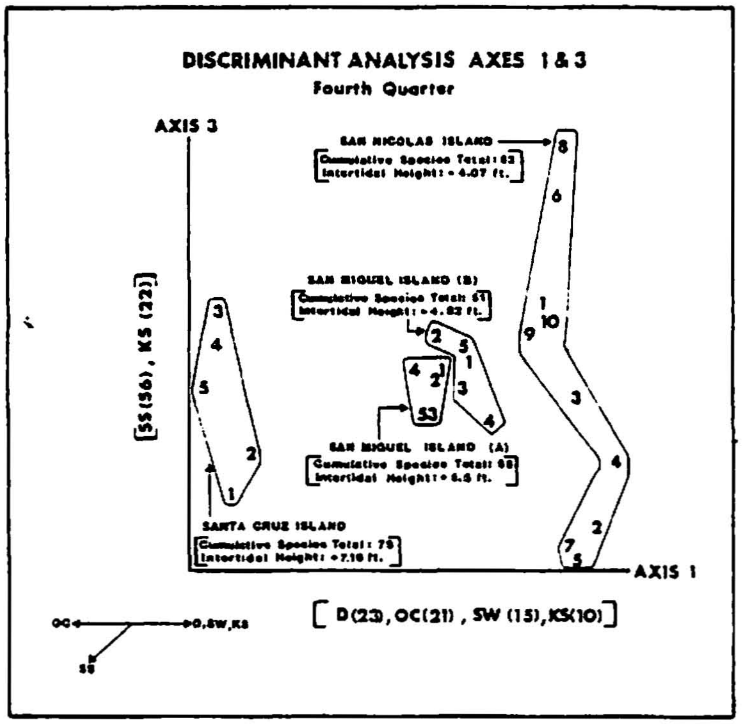

Figure 2.2-15. Fourth Quarter Discriminant Analysis (Axes 1 and 3). Refer to Figure 2.2-8 for Further Description and Key to Variables.

and organic carbon (OC). The number of species increased with the organic content of the sediment but decreased with an increase in the quantity of detritus. The coefficients of separate determination are displayed in Table 2.2-6. The most important factors on the second axis were quantity of tar (T), kurtosis of the sediment (KS), pore base (P), organic carbon (OC), and sediment skewness (SS). The quantity of tar dominated the axis and may indicate a chemical and/or physical effect caused by exposure to tar. San Miguel Island had the lowest total number of species and the highest quantity of tar during this quarter.

Three discriminant axes separated all site groups considered in the third quarter analysis (Figures 2.2-12 and 2.2-13). Santa Barbara Island was not included in this discriminant analysis because the samples did not contain enough sediment for size or chemical analysis. The most important variables on the first axis (Table 2.2-7, Figure 2.2-13) were quantity of tar (T), mean sediment size (MSS) snd sediment kurtosis (KS). The quantity of tar dominated the first axis but its relation to the number of species was not clear. Two sites, Coal Oil Point and San Miguel Island, contained respectively the highest (75) and one of the lowest (55) number of species, and both contained high quantities of tar. This axis was also difficult to interpret as a single factor; although tar was the most important variable, characteristics of the sediment (MSS and KS) were secondarily important. The second axis was sediment related, with the most important variables coarse fraction (CF), sediment kurtosis (KS), and pore base (P). The number of species increased along this axis with an increase in the coarse fraction interstitial space and surface area. The third discriminant axis (Figure 2.2-13) had sediment kurtosis (KS), mean sediment size (MSS), sediment weight (SW), mussel bed thickness (MBT) and sediment skewness (SS), contributing to formation of the axis.

The fourth quarter discriminant analysis included island localities only. Santa Barbara Island was not included in this analysis because the samples did not contain enough sediment for chemical or size analysis. However, two San Miguel Island samples (A and B) collected at the same time from different intertidal heights were included in this analysis. Three axes permitted separation of all groups. The most important variables on the first axis (Table 2.2-8, Figure 2.2-14) were quantity of detritus (D), sediment organic carbon content (OC), sediment weight (SW), and sediment kurtois (KS). The number of species increased with an increase in organic carbon content of the sediment and a decrease in the quantity of detritus. The most important variables on axis two were mean sediment size (MSS), sediment skewness (SS) and pore base (P) (Figure 2.2-14). The number of species increased with decreasing mean sediment size and sediment skewness. The third axis (Figure 2.2-15) separated the San Miguel Island samples A and B which were not separated on the first two axes. The important variables of this axis were sediment related, and included sediment skewness (SS), and kurtosis (KS). The difference in intertidal height between San Miguel Island samples A and B was not great enough to produce large differences in the mussel bed abiotic characteristics. As a result, the total number of species from samples A and B were very close, 55 and 51 respectively.

The coarse fraction sediment and detritus (Section 2.2.2.2.2) were microscopically examined and their general composition noted. This information is summarized in Tables 2.2-9 and 2.2-10. The coarse fraction (Table 2.2-9) sediment was composed primarily of rock and shell fragments. The rock was small pebbles (>1 mm) and portions of the underlying substrate. The shell fragments included broken pieces of mussel shells, barnacle shell plates, and empty gastropod shells. Occasional foreign objects such as fishing weights and glass fragments were also found. The detritus fraction (Table 2.2-10) included both plant and animal material. The plant material was primarily algal fragments, but occasional pieces of bark and leaves of terrestrial origin were found. Animal detritus included mussel byssus threads and decaying animal tissue.

2.2.4 Discussion

2.2.4.1 Sampling the Mussel Community

Mussel community composition and diversity is related to the structural complexity of the mussel bed (Kanter, 1976). The structural qualities of the mussel bed vary from one geographic locality to another, and the associated community varies accordingly. In order to document the resident species in a specific area it is necessary to determine an optimal sample size for each geographic mussel bed.

The question is immediately raised: What constitutes an optimal sample size? The perfect sample size would be large enough to incorporate at least one representative of every species occurring in a specific area. In most cases this ideal is not practical because many, very rare species could only be collected if the entire area were removed. The optimal size samples the animals which characterize an area by their frequency, density or coverage and incorporates most species except very rare ones. The optimal sample sizes for each locality were determined empirically by constructing species area curves (Cain, 1938) (Section 2.2.3.4).

In this study, species area curves were constructed for every collection. The asymptote of the curve, determined by inspection, represented an optimal sample size. The optimal sample size for San Diego, San Miguel Island, Santa Cruz Island and Santa Barbara Island was five core samples (total surface area = 1500 cm^2). The optimal sample size for Coal Oil Point was four core samples (total surface area = 1200 cm^2), and for San Nicolas Island, nine core samples (total surface area = 2700 cm^2). These sample sizes were based on

Table 2.2-9. Coarse Fraction Composition*

1.	Shell debris a) broken pieces b) empty and worn-away shells (includes snails, barnacles and mussels)
2.	Small rocks and pebbles (> 1 mm. diameter)
3.	Broken and surf-beaten worm encasements
4.	Foreign objects (e.g. glass and metal fragments)

Mussel Bed Coarse Fraction -

*This is the "coarse" fraction of sediment (> 1 mm. diameter) that is found trapped within the mussel bed. This component provides shelter and a potential food source (substrate for bacteria and algal growth).

Table 2.2-10. Detritus Composition*

1.	Marine algal fragments, including holdfasts and stipes. (Common species include Phyllospadix sp. Corralina sp.,
2.	Vegetation of terrestrial origin (e.g. leaves, seeds and branches)
3.	Byssal threads

Mussel Bed Detritus -

* This is the "soft" fraction that consists mainly of marine algae. Algae offers food and shelter for many members of the community.

the species area curve plots for all collections from one area. In general the species area curves were different for each area collection at a locality. The asymptote, and therefore the optimal sample size, varied accordingly. This variability reflected the intrasite heterogeneity within the mussel bed.

The San Nicolas Island mussel bed was structurally unique. The optimal sample size of 2700 cm^2 reflected this. The average number of species for collections of five core samples (1500 cm^2, all collections, Table 2.2-3 was 55 while that for ten core samples (3000 cm^2, third and fourth quarter, Table 2.2-3) was 78. This represented a 50% increase over the smaller sample size. Many of the added species were rare and occurred in very low numbers i.e., one individual. In spite of the increased sample size (and resultant increase in the number of species recorded) the relative position and species group composition in the classification analyses of the data from San Nicolas Island remained fairly consistent throughout the year (Figures 2.2-4 to 2.2-7). This indicated that species which characterized the mussel community from this locality were collected in the smaller sample (1500 cm^2) as well as the larger (3000 cm^2). This information suggests that for comparison of communities from geographically separated areas, the smaller (1500 cm^2) was adequate. However, the larger sample size (2700 cm^2) was optimal for generating a baseline species list which documented the (entire) biota of this area.

The average mussel bed is composed of mussels of many sizes. This composition results in a relatively homogeneous, tightly packed internal structure. The mussel beds from Coal Oil Point, San Diego, San Miguel Island, Santa Cruz Island and Santa Barbara Island were examples of "typical" mussel beds, and as a result, their optimal sample size was similar. However, San Nicolas Island was structurally unique because it was composed almost exclusively of large mussels (see Section 2.2.3.1). Therefore, it required individual sample size consideration. The results of this study suggest that a sample size of 1500 cm^2 (five core samples) is adequate for comparing mussel communities from different geographic localities. This sample size is also optimal for documenting the biota from "average" mussel beds. However, structurally unique mussel beds like San Nicolas Island constitute a major exception to this general rule, and they must receive individual sample size consideration.

2.2.4.2 Mussel Bed Community Composition

The mussel beds surveyed during this study supported an extremely rich fauna. Together they contained (conservatively) 346 species from twelve phyla (Appendix 2.2-B, Table 2.2-12). The lowest number of species from a single set of samples (1500 cm^2) was 41 (San Miguel Island) and the highest was 78 species (Santa Cruz Island). This high number of species is supported by the three dimensional structure of the mussel bed.

Three phyla, the Annelida, Mollusca, and Arthropoda, combined to contribute over 70% of the mussel community species. These organisms occupy a wide range of habitats within the mussel bed and exploit an equal variety of food resources (see Section 2.2.4-8). However, the natural history of most species found in the mussel bed remains unknown, and their respective niches for exploitation of food and habitat resources, in many cases, can only be inferred from consideration of morphological characteristics.

2.2.4.3 Mussel Bed Community Biomass

The molluscs, mainly mussels, composed over 90% of the total biomass from the mussel bed. All other phyla combined accounted for 10% or less of the total biomass. Mussels dominated the biomass because of their large size compared to the other inhabitants. The mussels were not numerically dominant and were out-numbered by many other organisms within the mussel bed, including barnacles, amphipods, small bivalves and nematodes. The size and weight of the mussels varied from one locality to another. The largest and heaviest mussels were collected from Coal Oil Point and San Nicolas Island, and the smallest (lightest) mussels were collected from Santa Barbara Island and San Diego. The biomass at each area showed little variation between collections throughout the year. This was a reflection of the lack of variability in the biomass of the dominant mussels.

The associated organisms depended on the mussels for their food, habitat, and shelter, and in this respect, the dominant contribution of the mussels to the total biomass could be interpreted as a measure of their importance. However, if the mussels are considered primarily as providing a microenvironment, then the biomass of other species cannot be interpreted as an indication of their ecological importance. This type of information can only be obtained from detailed natural history studies of the organisms in question.

Biomass measures are informative when they are made on commercially exploited resources like fish and harvestable kelp. Presently, no members of the mussel community, including Mytilus californianus, are being harvested. In addition, biomass measurements as employed in this study lumped all members of a phylum. This masked any trophic distinctions between species. As a result, biomass measurements of this type were of limited value. One alternative which would solve the problem of trophic distinctions would be individual biomass measurements for all species. This, however, would be too time consuming in a study of this nature.

The molluscs (primarily the mussels) accounted for 90% of the biomass of a collection and very little additional information was gained by measuring biomass for the remaining phyla. It is recommended for future studies that only molluscan biomass be measured. This will allow documentation primarily of Mytilus californianus biomass, the only potentially harvestable member of the mussel community.

2.2.4.4 Mussel Bed Diversity

Sanders (1968) distinguished between various measures of community diversity. His distinctions are useful and will help clarify the following discussion of mussel bed diversity. Those diversity measures which calculate the percentage composition by numbers of the various species present in a sample, e.g., Shannon-Weiner index (H'), are referred to as dominance diversity indices. Dominance diversity indices are based on information theory and have as their basic premise: The most the constituent species are represented by equal numbers of individuals, the more diverse the fauna. Diversity measured by counting the number of species is referred to as species diversity and has as its basic premise: the most species, the more diverse the fauna. Dominance diversity indices (H') are actually composite measures incorporating both species richness (R) and evenness (J') into a single measure. It is difficult to interpret dominance diversity alone because the two subcomponents (J' and R) may contribute differently to the diversity value. This may result in areas with equal values of H' for entirely different species compositions.*

Santa Cruz Island was the most diverse locality sampled (Table 2.2-3). The species diversity (74) and dominance diversity index (H'= 2.828) were high and reflected the large number of species whichthe mussel bed supported. The species evenness (J' = 0.657) and richness (R = 7.986) were also high, and both contributed to the high dominance diversity index.

Coal Oil Point samples displayed the second highest species diversity with 73 species (Table 2.2-3). However, the dominance diversity index (H' = 1.622) did not reflect this high number of species. The low evenness (J' = 0.379) of species abundance was responsible for this incongruity, in spite of the moderately high species richness (R = 6.666). This exemplified the problem of using dominance diversity indices alone. Although Coal Oil Point mussel beds supported almost as many species as Santa Cruz Island mussel beds (73 versus 74 respectively), the dominance diversity values did not reflect this similarity.

The Santa Barbara Island mussel bed had a high species diversity (65 species). The dominance diversity index reflected this with a value of H' = 2.608. The relatively high values for both richness (R = 7.532) and evenness (J' = 0.628) contributed to this high dominance diversity value. The dominance diversity value for the Santa Barbara Island samples was much higher than that for the Coal Oil Point

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* Note that all values discussed in this section are average values (see Section 2.2.3.5)

samples in spite of the high species diversity from Coal Oil Point. Again, this was a result of the evenness measure which was very low for Coal Oil Point.

San Nicolas Island and San Miguel Island samples had similar species diversities (55 and 51 species respectively) and dominance diversities (H' = 2.313 and 2.379 respectively). In addition, their richness and evenness values were comparable. This consistency in all measures was rare, and due in part to averaging the measures for all collections (Table 2.2-3). In spite of this, mussel beds from both of these sites appear equally diverse.

San Diego mussel beds supported the lowest species diversity (46). The dominance diversity index was also low (H' = 1.757). This low dominance diversity was a result of the low richness and evenness values (Table 2.2-3). The low dominance diversity for San Diego samples was still higher than that from Coal Oil Point samples, because of the low evenness of Coal Oil Point samples.

The results discussed above suggest that the measurement of dominance diversity alone does not represent the diversity of an area. The component measures of richness and evenness are needed to interpret dominance diversity in a comparison of areas. The value of including evenness in the measurement of diversity is questionable. Trophic distinctions are masked when this measure is included in diversity. An area tends to be characterized by numerically dominant organisms. This ignores "food chain" relationships, and implies ecological importance based solely on numerical abundance.

A more informative and economical measure of diversity appears to be species diversity (species counts). The presence of an animal, regardless of its numerical abundance, implies its occupation of an ecological niche. This means that a multidimensional resource state is being exploited by the animal and thus the resource state exists by definition. The principle that no two species can occupy the same niche (Volterra, 1926) suggests that a more diverse fauna exploits an area with a greater diversity of resources. Based on these arguments, it is recommended that species diversity (species counts) replace the use of the dominance diversity index H' (Shannon-Wiener) for comparing mussel bed diversity.

2.2.4.5 Mussel Community Classification Analysis

The classification analyses of the mussel bed community revealed three major patterns. The patterns corresponded to unique species assemblages associated with the different geographic mussel bed samples. These included:

- Species groups ubiquitous to all mussel beds examined.

- Species groups which distinguished island from main land mussel beds.

- A unique species assemblage from San Miguel Island that distinguished this area from the other island localities.

The classifications of the first and third quarter collections (Figures 2.2-4, 2.2-6) contained data from both mainland and island localities. The ubiquitous species groups were E (Figure 2.2-4), B and F (Figure 2.2-6). The species included in these groups were quite comparable overall and were predictable occupants of any mussel beds sampled from the southern California area. These species included the sea anemone Anthopleura xanthogrammica, the gooseneck barnacle Pollicipes polymerus, the bivalve Septifer bifurcatus, the nemertean Emplectonema gracile, the gastropod Tegula funebralis and the limpet Collisella strigatella.

The classifications of the second and fourth quarter collections (Figure 2.2-5, 2.2-7) included data from island localities only and produced similar ubiquitous species groups, D (Figure 2.2-5) and E (Figure 2.2-7). The ubiquitous species for the island localities alone included the species mentioned above (from both mainland and island localities) and the crab Pachygrapsus crassipes, and the limpet Collisella pelta.

The second major pattern from the classification analysis was produced by the primary normal dendrogram split which separated island from mainland localities (Figures 2.2-4, 2.2-6). The mainland localities were characterized by species from groups A, E and F (Figure 2.2-4) in the first quarter, and by equivalent species groups B, E and F (Figure 2.2-6) in the third quarter.

The island localities were also characterized by unique species groups. These were groups B, C, D, G and H (Figure 2.2-4) and groups A, B, C and D (Figure 2.2-6). Again the characteristic species were comparable between collections.

The major split in the normal dendrograms (Figures 2.2-4, 2.2-6) suggested that two distinct faunal provinces had been sampled. Point Conception, California, has long been regarded as the dividing line between northern and southern mainland provinces (Light et al., 1970; Johnson and Snook, 1967). The current patterns* occurring in the area under study (Figure 2.2-16) suggest that planktonic larvae may be carried to the island localities from source areas in the northern (colder water) province. The mainland areas are exposed to currents originating in warmer southern areas which may carry planktonic larvae from these areas.

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* Note that these are generalized current patterns in selected areas which may receive waters from nothern and southern areas.

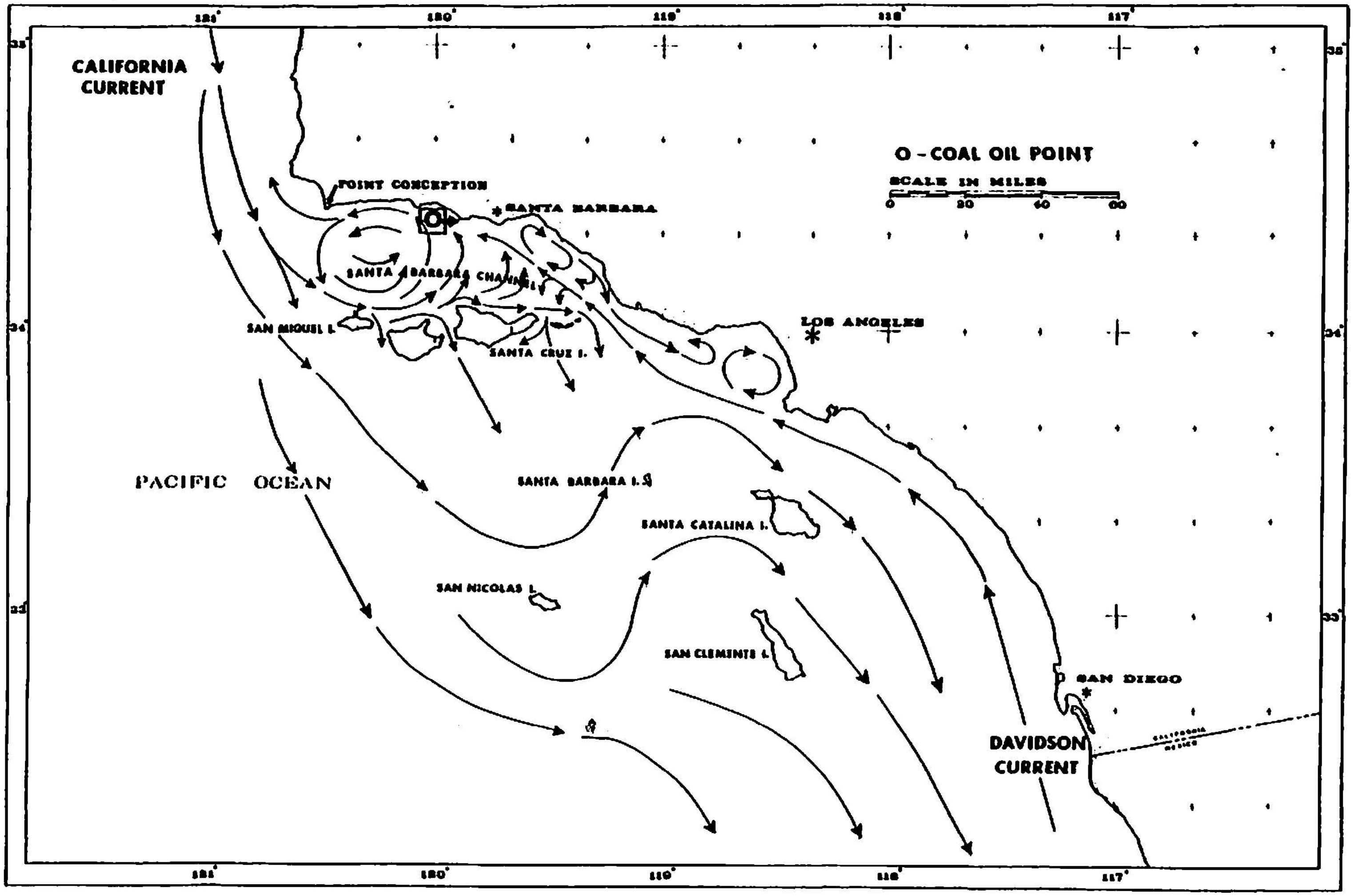

Figure 2.2-16. Generalized Current Patterns of the Pacific Ocean from Point Conception to San Diego, California.

The natural history and range information for most mussel bed species is incomplete. However, the mussel beds from the island localities of this study, appeared to extend the range of many northern species below Point Conception. It is recommended for future studies that mussel beds on Santa Catalina Island and San Clemente Island which are exposed to both northern and southern currents be examined. It is predicted that they will resemble their northern island counterparts more than mainland localities.

San Miguel Island samples consistently formed a group distinct from other island samples in the classification of the second, third and fourth quarter collections (Figures 2.2-5 to 2.2-7). This separation appeared related to the extremely high relative abundance values for the species that were present. Very few species were represented by low or medium relative abundances. In addition the number of species was somewhat lower than those from other islands.

2.2.4.6 Seasonal Differences in the Mussel Community

In some terrestrial systems where climatic changes are predictable (and often extreme) man has applied the term seasonal to recognize low periods. The term seasonal has also been used to describe the relationship between the presence (or abundance) of an organism and a particular climatic period. The term seasonal may not be applicable to changes in species composition or abundance in marine systems. Observed changes in marine systems may correlate with hydrographic seasons in a specific area and display no relation to the terrestrial "seasons". This disappearance or change in numerical abundance of species throughout the year are referred to as "seasonal" for convenience only.

The mussel communities from both mainland and island localities displayed no obvious overall seasonal changes. Ubiquitous species common to all mussel beds in the classification analyses remained relatively constant in numbers throughout the year. Species groups which characterized specific localities only changed slightly in composition throughout the year. Those changes which usually occurred were the result of relative abundance changes. These relative abundance changes may indicate seasonal differences, but at the present time these differences cannot be distinguished from abundance differences which result from the influence of local factors like intertidal height.

Detailed studies of the species in question at specific localities are necessary to distinguish between actual seasonal changes in abundance and those which result from sampling procedures.

2.2.4.7 The Effect of Intertidal Height on Mussel Community Composition

The effect of relative intertidal height differences on local species abundances was investigated during the fourth quarter collections at San Miguel Island. The species that exhibited large numerical abundance differences between the two collections may reflect intertidal height differences. However those species with low abundances may reflect sampling artifacts and not necessarily intertidal height differences.

In general the mussel bed inhabitants displayed higher abundances in the upper collection than in the lower collection at San Miguel Island. The increased diversity and abundance differences exhibited by the species in the upper sample (A), may be a result of increased habitats provided by the increased number of mussels. However, with only one comparison this hypothesis must be considered tentative.

Those collections discussed above did not represent extremes in intertidal height of the mussel bed. It is suggested that collections from extremes in intertidal height will exhibit greater abundance differences as well as species composition differences. This phenomenon should be investigated further, with more intense sampling and many more comparisons.

2.2.4.8 Mussel Community Discriminant Analysis

Multiple discriminant analysis was employed to identify the most important abiotic factors associated with mussel community differences. Twelve environmental variables related to food, habitat and shelter provided by the mussel bed were measured during this study (Section 2.2.2.3.4) and were included in the discriminant analysis. Some of these variables provided combinations of resources for selected mussel community species e.g., sediment provided both habitat and food for some deposit feeding polychaetes. The analysis construted discriminant axes from linear combinations of these variables which best separated predefined groups. The predefined groups in this case were the site groups from the normal classification.

The most important variables were principally habitat related. These included sediment quantity and size for the first quarter collections (Figure 2.2-8). In general the species diversity increased with an increase in the quantity of sediment and a decrease in mean sediment size (Figures 2.2-8, 2.2-9, 2.2-11). Sediment provided substrate for many groups including polychaetes and molluscs, two of the dominant inhabitants of the mussel bed. Therefore, it was not surprising to find a relationship between the quantity of this factor (substrate) and the total number of species. Additional habitat-related variables included qualitative characteristics of the sediment, e.g., sediment kurtosis (Figure 2.2-8). This feature of the sediment in part described the heterogeneity of the substrate, and although it did not correlate directly with species diversity differences, it was important in group separations. Other important habitat-related variables included the quantity of coarse fraction material and coarse fraction pore base (Figures 2.2-9, 2.2-12, 2.2-13). These variables provided interstitial habitat "holes" for organisms and surfaces for attachment. Again members of the dominant groups, arthropods, molluscs and tube-building polychaetes, exploited these habitats.

Food-related variables were of secondary importance in group separations. Usually they separated groups on axes after initial separation by habitat-related variables. The quantity of detritus was important (Figures 2.2-9, 2.2-11, 2.2-14) and generally an inverse relationship existed between the species diversity and the quantity of detritus. However, this was not a consistent relationship (Figure 2.2-9). The quantity of detritus was expected to correlate directly with the species diversity, providing food for a variety of opportunistic (scavenger) species or a substrate for bacterial growth which could serve as a food source; however, this was not a consistent relationship. Organic carbon content of the sediment was another important food-related variable of the mussel bed (Figures 2.2-11, 2.2-14, 2.2-15). The discriminant analysis of the second quarter collections (Figure 2.2-11) showed an increase in species diversity that paralleled an increase in sediment organics. This probably reflected the increased number of species utilizing this food source, e.g., deposit feeding molluscs, and polychaetes. Sediment organics were important in the third quarter discriminant analysis, but there was no distinct relationship between the organic carbon content and species diversity.

The mussel bed insulated the associated community against various forms of environmental stress like extreme temperature changes. Depending on the time of day and prevailing climatic conditions, the ambient air and surface mussel bed temperatures exceeded internal mussel bed temperatures (Figure 2.2-17). The mussel bed also insulated against wave and surf action. These insulating properties, considered collectively, provided shelter for the mussel community. Mussel bed thickness was an indirect measure of this shelter variable and was considered in the discriminant analysis. Although the shelter aspect is obviously important, this variable did not dominate any discriminant axes (Figures 2.2-8, 2.2-10, 2.2-13). This probably reflected the consistency of this factor among the different mussel beds.

Organic material contained in the mussel bed sediments was a potential food source for many deposit-feeding species. As discussed earlier in this section, organic carbon was an important resource within the mussel bed. This organic material came from a variety of sources. Animal material contains high amounts of nitrogen tied up

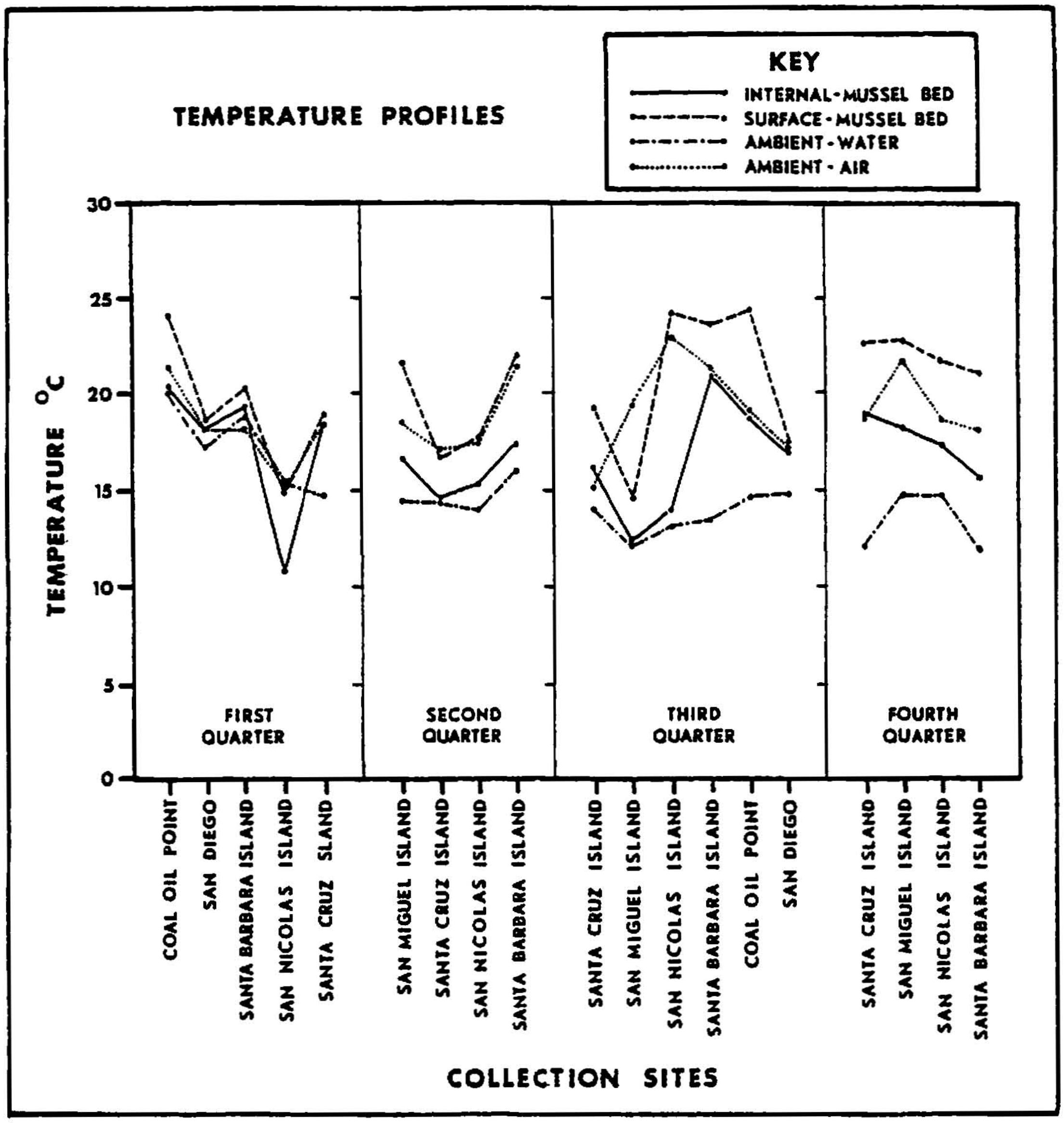

Figure 2.2-17. Temperature Profiles For All Collection Sites.

in protein compounds, while plants generally contain much less nitrogen (Emery, 1960). The calculation of carbon-to-nitrogen ratios allowed the source of organic carbon at each locality to be determined (Emery, 1960; Sverdrup et al., 1942). The carbon-to-nitrogen ratios from this study were generally high for all localities (4.6 to 11.3), suggesting that sediment organics were of plant origin. They were probably derived from decayed algae or terrestrial plant fragments found in the detritus (Table 2.2-10). Therefore, dependent deposit-feeding species were consuming primarily material of plant origin. Samples from Santa Barbara Island were unique because they displayed consistently low carbon-to-nitrogen ratios which were indicative of organic animal material. This fact, combined with the low quantity of sediment, may explain the low number of deposit-feeding species at this locality.

The quantity of tar was recorded during this study and used as an indicator of exposure to oil. When considered in the discriminant analysis, this variable was important in the second and third quarter discriminant analyses (Figures 2.2-11 and 2.2-12). San Miguel Island and Coal Oil Point mussel beds contained the highest quantities of tar. This tar probably originated from natural oil seepage offshore. The second quarter analysis displayed decreasing species diversity with increased tar quantities. The quantity of tar was also important in the third quarter analyses (Figure 2.2-12). It again was related to community composition, but in contrast to the results from the second quarter (Figure 2.2-11), there was no clear relation to species diversity.

Santa Barbara Island was not included in the third and fourth quarter discriminant analyses because no sediment characteristics were obtained. (These collections contained practically no sediment. See Section 2.2.3.9.) In spite of the low sediment content, these mussel beds supported an extremely diverse fauna (average 65 species). The question immediately arises: How are these species supported? A close examination of the component species list reveals a high proportion and abundance of grazing molluscs including limpets (Collisella limatula, C. conus, C. pelta, C. scabra), chitons (Nuttallina fluxa), and Cyanoplax hartwegii. This high diversity of grazing species was probably related to the large quantities of encrusting algae found at this locality (Appendix 2.2-A, Table 2.2-11). In addition, the extremely pitted substrate of this area provided habitats (e.g., for the chitons) beneath the sheltering mussel bed.

The major dendrogram divisions in the first and third quarter classifications (Figures 2.2-4, 2.2-6) separated the islands from mainland sites. As discussed earlier, the community differences probably corresponded to differences in the planktonic larval source areas (see Section 2.2.4.5). The planktonic larvae recruited to the Channel Island localities were apparently carried by currents and water masses arising north of Point Conception, and those settling at mainland localities were probably carried by southern warm-water currents. This information has been inferred from knowledge of the northern and southern faunas, as well as available hydrographic charts (Figure 2.2-16). It would be desirable to quantify this information for future studies and include water mass or current characteristics for each site in the discriminant analysis.

2.2.4.9 Problems with Sulfide Analysis

The measurement of sediment sulfide content was attempted during this study and proved unsuccessful. The methods of Cline (Cline, 1969) and Kalil (personal communications) were designed for benthic investigations and could not be successfully applied to the intertidal mussel bed study. The sediment was trapped within the mussel bed and was dispersed throughout the internal matrix, so that in order to sample the sediment it was necessary to pull the mussel bed apart. However, upon exposure, any sulfide contained in the sediment was oxidized and could not be detected. In addition, sulfide is usually associated with finer sands and mud (Perkins, 1957), which were not found in the mussel bed. It is therefore recommended that sulfide measurement be discontinued.

2.2.4.10 Problems with Taxonomic Reference Photographs

All identified species were photographed during this study for future reference. In many cases, e.g., polychaetes, amphipods and nematodes, the taxonomic structures used for identification were not visible in the pictures. This occurred because many of these structures were internal specialized anatomical parts, which required complex dissection and mounting prior to microphotography. The macrophotographs are therefore of limited value for future taxonomic reference. It is recommended that future photographs of type specimens either be attempted by specialists whose sole responsbility would be detailed micro- and macrophotography of type collection species, or that photography of type species be abandoned altogether.

2.2.5 Recommendations

1) A sample size of 1500 cm^2 (five 300 cm^2 cores) be adopted as the optimal for sampling mussel communities in a comparison of geographically separated communities.

2) Biomass of only the mussels (Mytilus californianus) be recorded in future studies.

3) Species diversity (species counts) replace the use of dominance diversity indices, e.g., Shannon-Wiener, or alternatively, calculate dominance diversity and its component measures of evenness and richness.

4) Discontinue spectrophotometric methods of sulphide measurement in mussel bed sediments.

5) Discontinue macrophotography of type specimens for future reference.

6) Add additional mainland localities to fill in geographic "gaps" between Point Conception and San Diego, i.e., add mainland areas Government Point, Palos Verdes and Corona Del Mar and Island areas of Santa Catalina, and San Clemente in southern California.

7) Include hydrographic data., such as current or water mass data, in discriminant analyses.

8) Discontinue pipette settling tube analysis of mussel bed sediment.

9) Document origin of tar (oil) found inside the mussel community.

2.2.6 Summary

Mytilus californianus communities (mussel beds) were examined from six geographic localities in Southern California. These included two mainland sites, Coal Oil Point and San Diego; and four island sites, San Miguel, Santa Cruz, San Nicolas, and Santa Barbara Islands. Optimal sample sizes were determined for each locality. In general, a sample, size of 1500 cm^2 (five cores) was optimal for the "typical" mussel bed. However, structurally unique mussel beds required individual consideration. Community biomass, diversity, species richness, and species evenness were calculated quarterly for the island localities and biannually for mainland locations. The molluscs, primarily the mussels, accounted for 90% of the total biomass while all other groups combined accounted for 10% or less of the total biomass. The mussel communities from all localities contributed to the master species list which conservatively contained 346 species. The most diverse localities were Coal Oil Point and Santa Cruz Island with an average number of 73 and 74 species/0.15 m^2 respectively. No overall seasonal patterns existed in community composition. The community similarity analyses showed the mainland localities biotically dissimilar from the islands and both groups were characterized by distinct faunal assemblages. In addition, San Miguel Island biota were unique among the island sites.

The most important mussel bed structural attributes provided habitats for the associated community and included sediment and coarse fraction features. Food-related resources provided by the mussel bed were secondarily important. Community diversity generally increased with the quantity of habitat and food resources.

2.2.7 References

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APPENDIX 2.2-A

Volume III Year III

Supplement to Report 2.2

MUSSEL COMMUNITY STUDY

Dale Straughan, Principal Investigator
Robert Kanter, Co-Principal Investigator
Allan Hancock Foundation
University of Southern California

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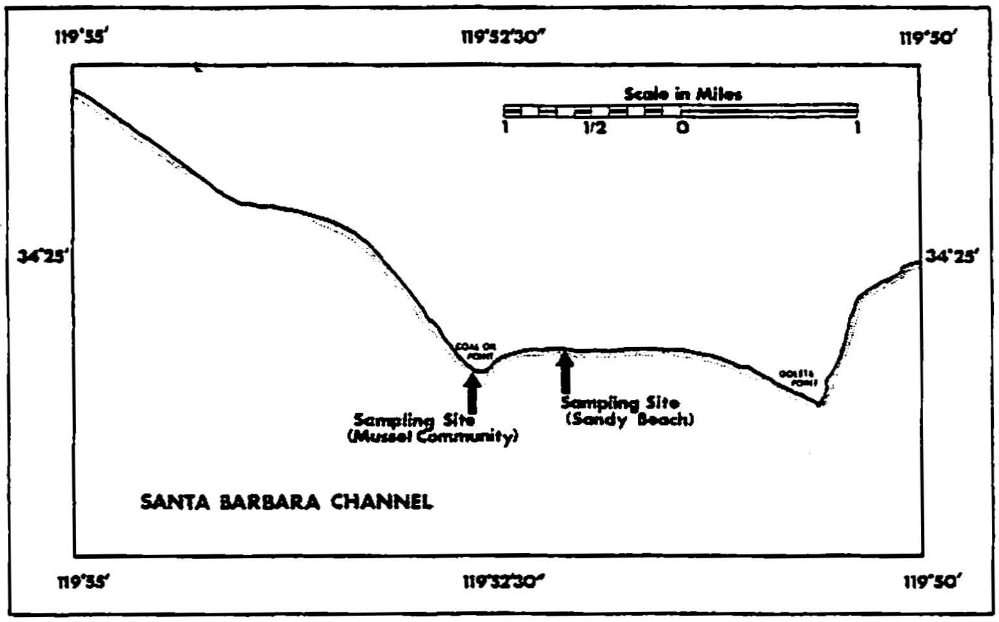

Figure 2.2-18. Coal Oil Point Sampling Site.

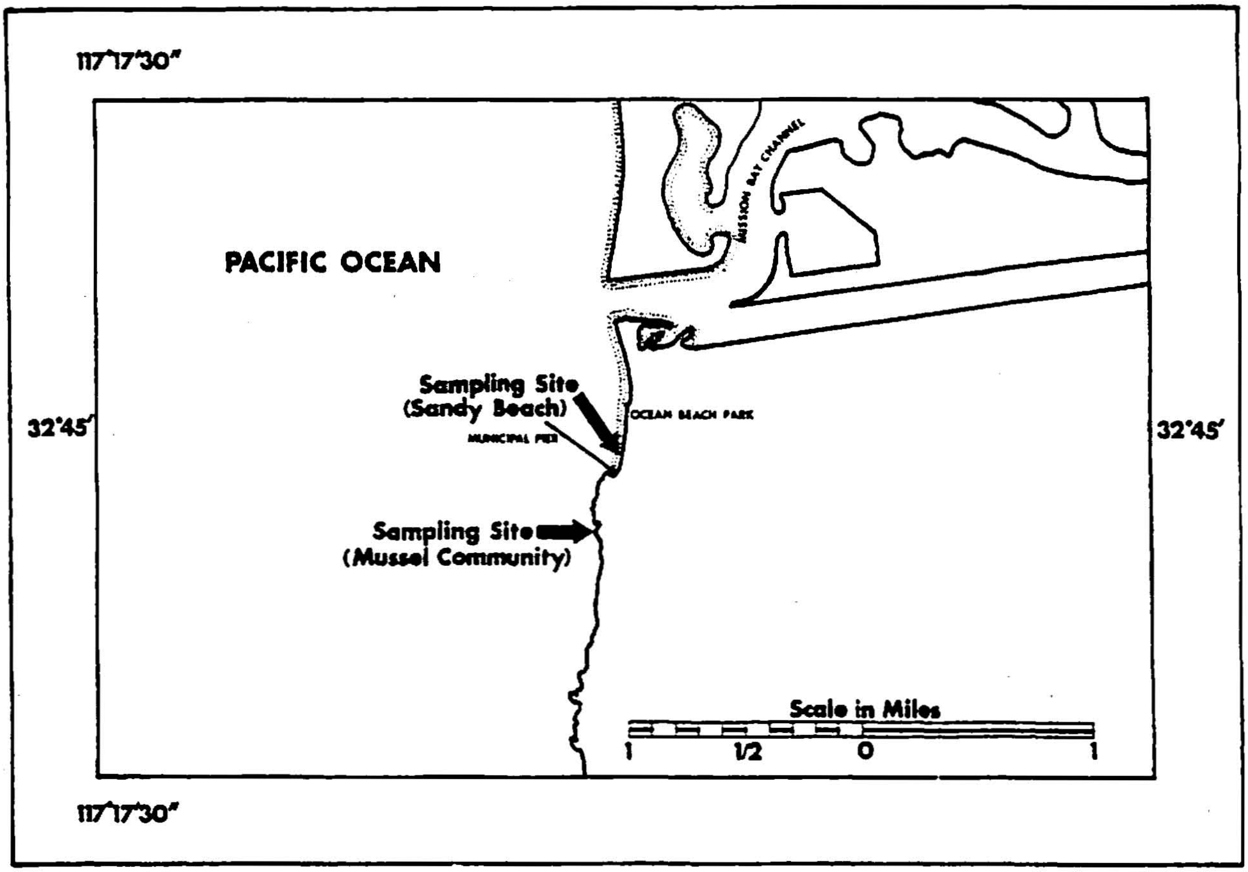

Figure 2.2-19. San Diego Sampling Site.

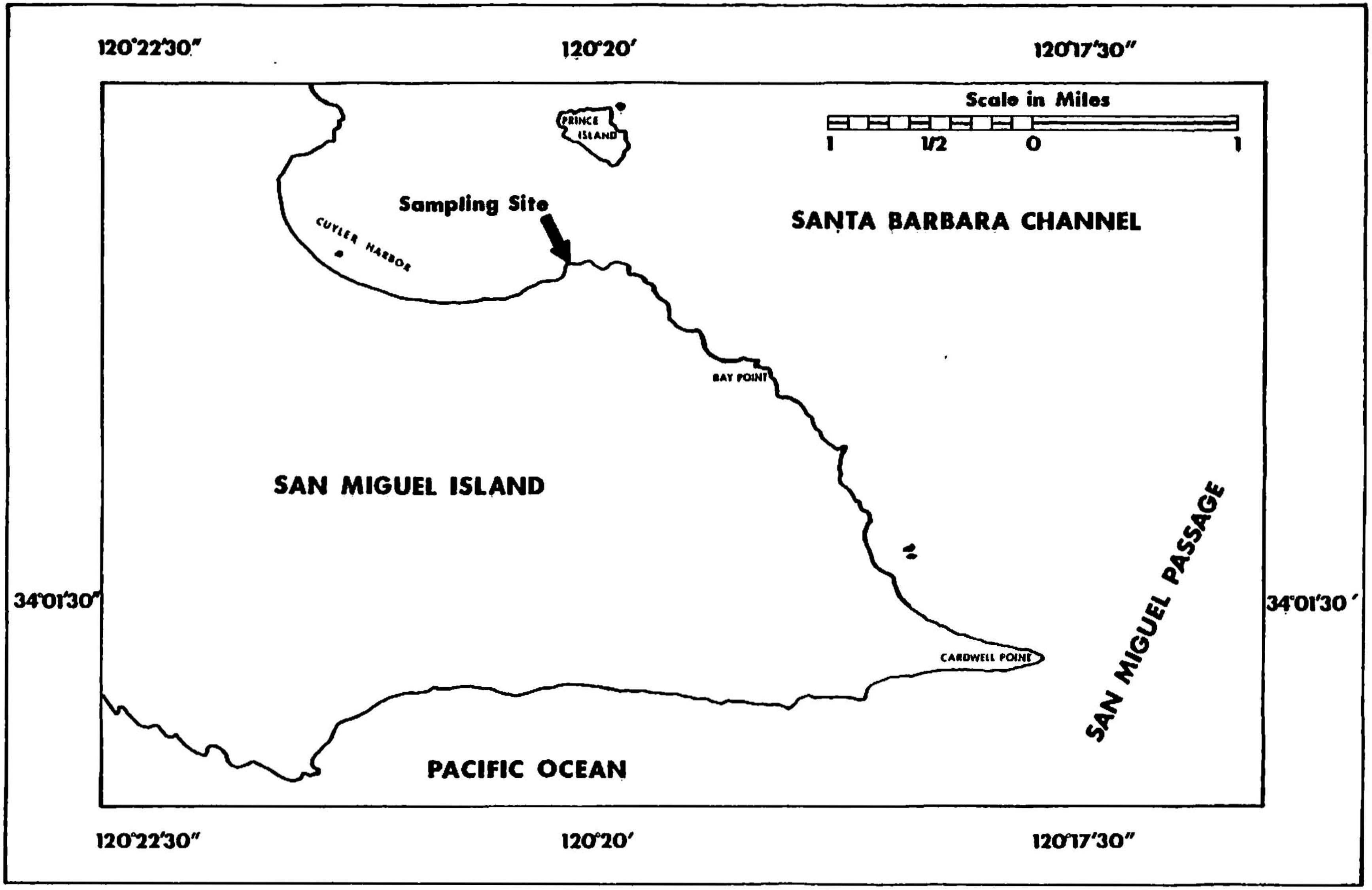

Figure 2.2-20. San Miguel Island Sampling Site.

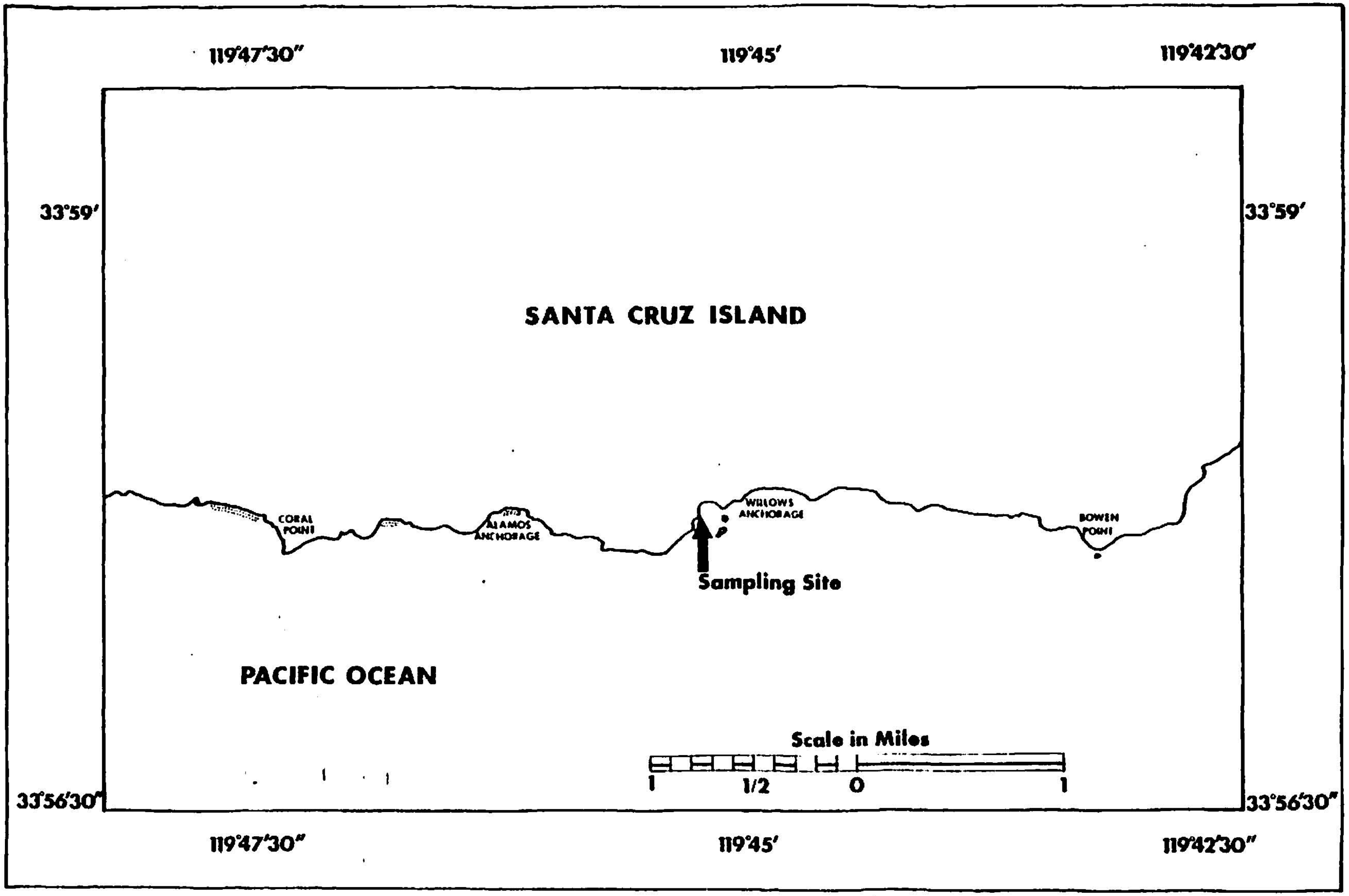

Figure 2.2-21. Santa Cruz Island Sampling Site.

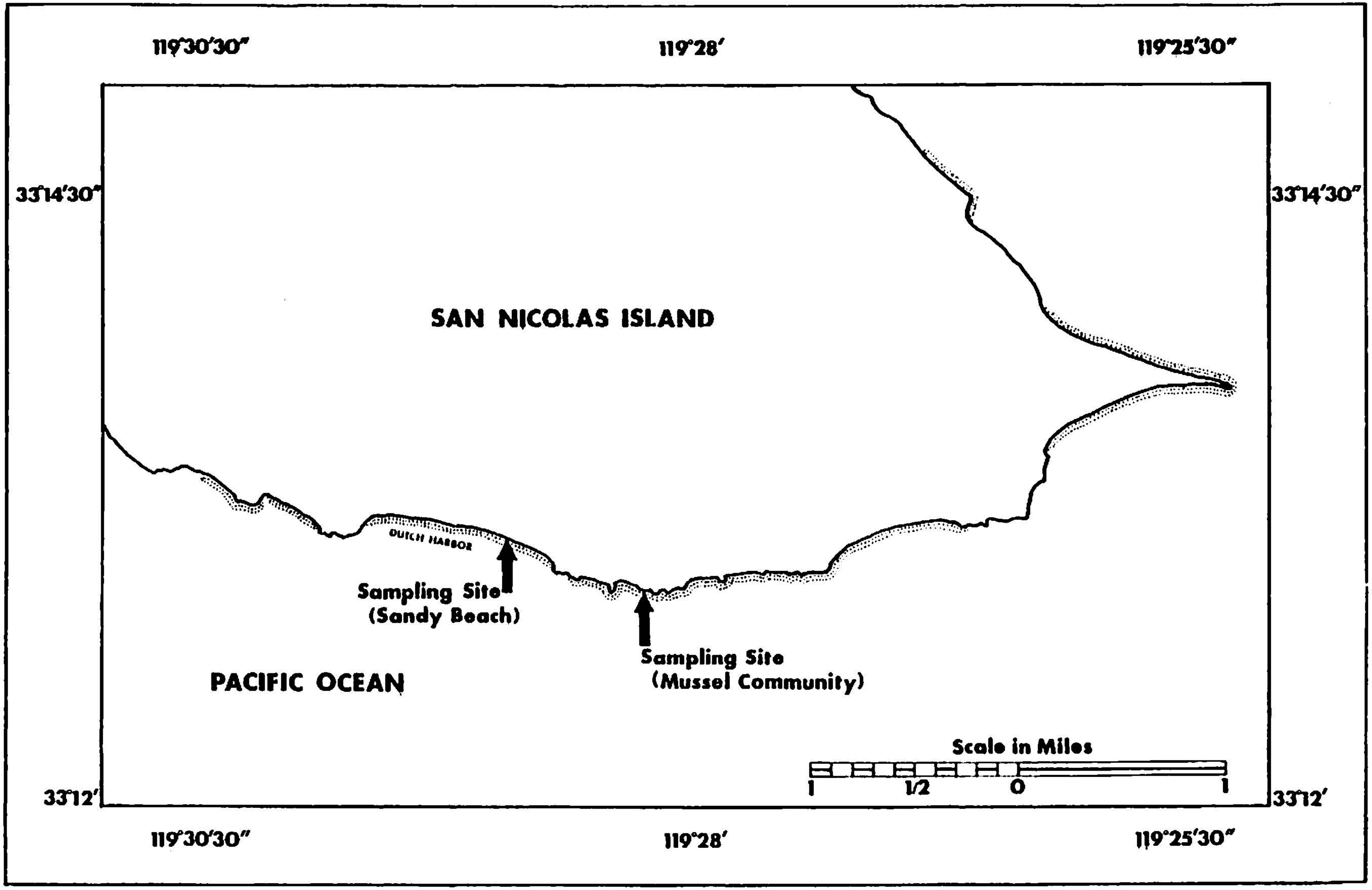

Figure 2.2-22. San Nicolas Island Sampling Site.

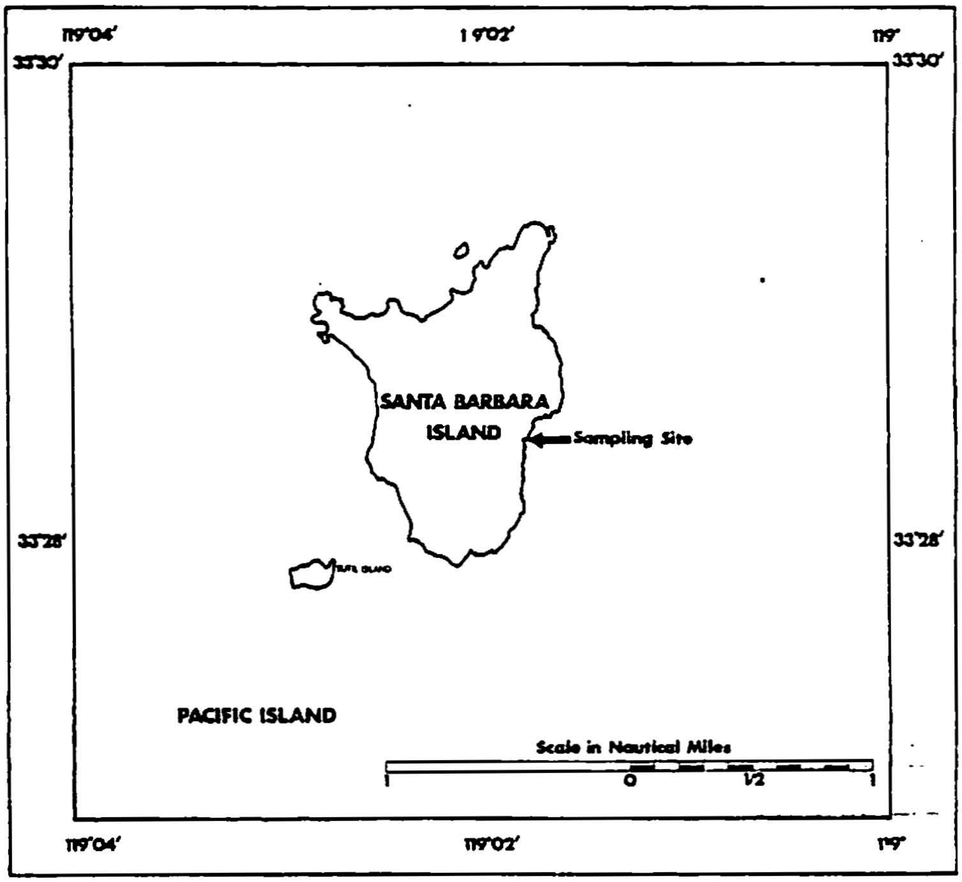

Figure 2.2-23. Santa Barbara Island Sampling Site.

Table 2.2-11. Site Physiography.

	SANTA BARBARA ISLAND	SANTA CRUZ ISLAND	SAN NICOLAS ISLAND	SAN MIGUEL ISLAND	COAL OIL POINT	SAN DIEGO
1. Designation of Dr. Littler's closest transect basepoint	Middle	North	North	North	South	North
2. Maximum straight line distance from Dr. Littler's closest transect basepoint	23.01m. (75.5 ft.)	25.76m. (84.5 ft.)	18.29m. (60.0 ft.)	26.82m. (88.0 ft.)	0.15m. (0.5 ft.)	16.61m. (54.5 ft.)
3. Average intertidal height (ft.)	1.17m. (3.85 ft.)	2.18m. (7.16 ft.)	1.2m. (3.94 ft.)	1.6m. (5.28 ft.)	0.76m. (2.5 ft.)	1.16m. (3.8 ft.)
4. Mussel Bed Description	Patchy	Patchy	Continuous	Continuous	Patchy	Continuous
5. Sandy Beach nearby (within 30m. radius)	Absent	Present	Present	Present	Present	Absent
6. Type of substrate	Rock platform	Rock platform	Rock platform	Rock platform	Rock platform	Rock platform
7. Composition of substrate	Hard rock	Hard rock	Hard rock	Hard rock	Stratified Hard rock	Sandstone
8. Texture of substrate[1]	Highly pitted and irregular	Few pits	Relatively smooth	Highly pitted and irregular	Relatively smooth	Relatively smooth
9. Angle of substrate	Horizontal	5° off horizontal	Horizontal	Horizontal	Horizontal	10° off horizontal

1 = The term pit (pitted) refers to depressions in the substrate with the greatest dimension 5 cm.

Table 2.2-11. Site Physiography. (Continued)

	SANTA BARBARA ISLAND	SANTA CRUZ ISLAND	SAN NICOLAS ISLAND	SAN MIGUEL ISLAND	COAL OIL POINT	SAN DIEGO
10. Deep crevices and pockets[2]	Present	Present	Present	Present	Present	Present
11. Average mussel bed thickness (cm.)	4.62	7.25	8.96	6.97	8.92	5.66
12. Amount of encrusting algae present[3]	Moderate	Moderate	Low	Low	High	High
13. Documented exposure to natural oil seepage	Absent	Absent	Absent	Present[4]	Present	Absent

2 = The terms crevice and pocket refer to longitudinal depressions in the substrate with the greatest dimension 10-20 cm.

3 = Encrusting algae on mussels and surrounding "bare" rock. 1-33% low, 34-66% moderate, 67-100% high.

4 = Oil originating from offshore seeps has been documented on northern beaches but not at the specific site of mussel bed collections.

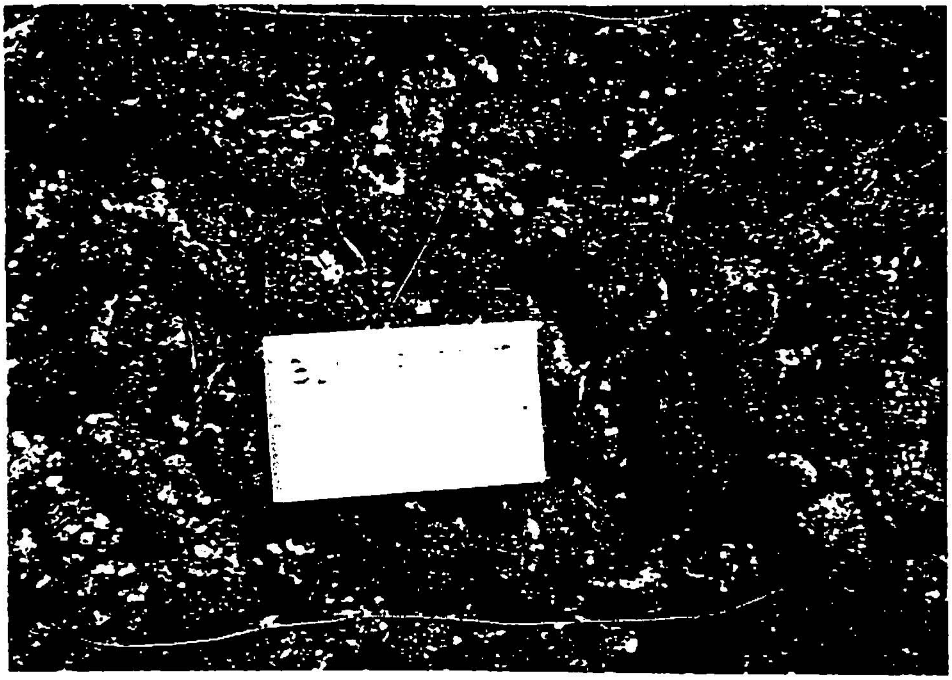

Plate 2.2-4. Coal Oil Point Mussel Bed, 4 August, 1975.

Plate 2.2-5. Santa Cruz Island Mussel Bed, 6 October, 1975.

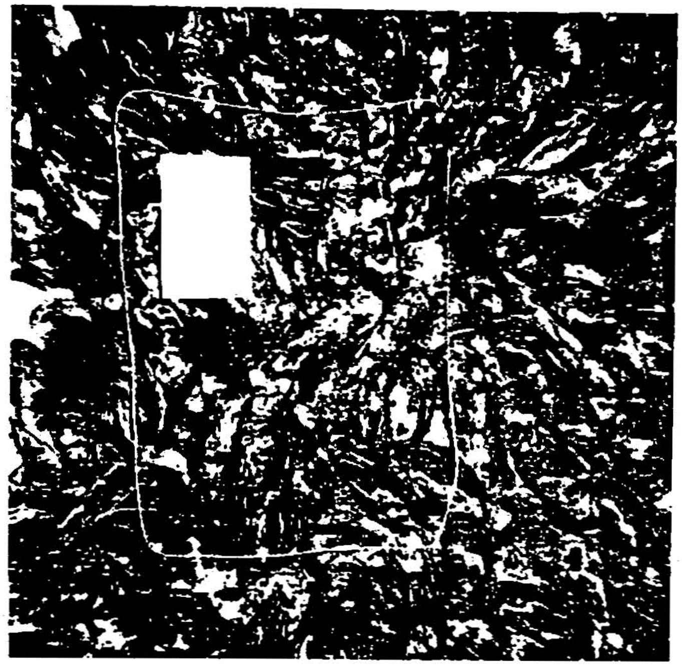

Plate 2.2-6. San Nicolas Island Mussel Bed, 3 October, 1975.

Plate 2.2-7. Santa Barbara Island Mussel Bed, 2 September, 1975.

Plate 2.2-8. Santa Cruz Island Mussel Bed, 18 November, 1975.

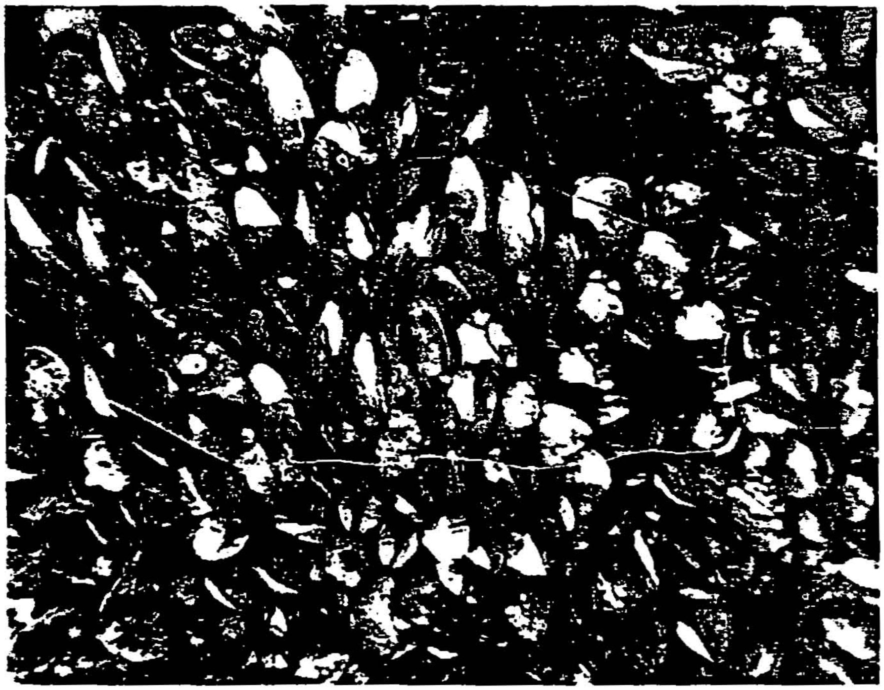

Plate 2.2-9. San Nicolas Island Mussel Bed, 19 November, 1975.

Plate 2.2-10. Santa Barbara Island Mussel Bed, 1 November, 1975.

Plate 2.2-11. Coal Oil Point Mussel Bed, 29 January, 1975.

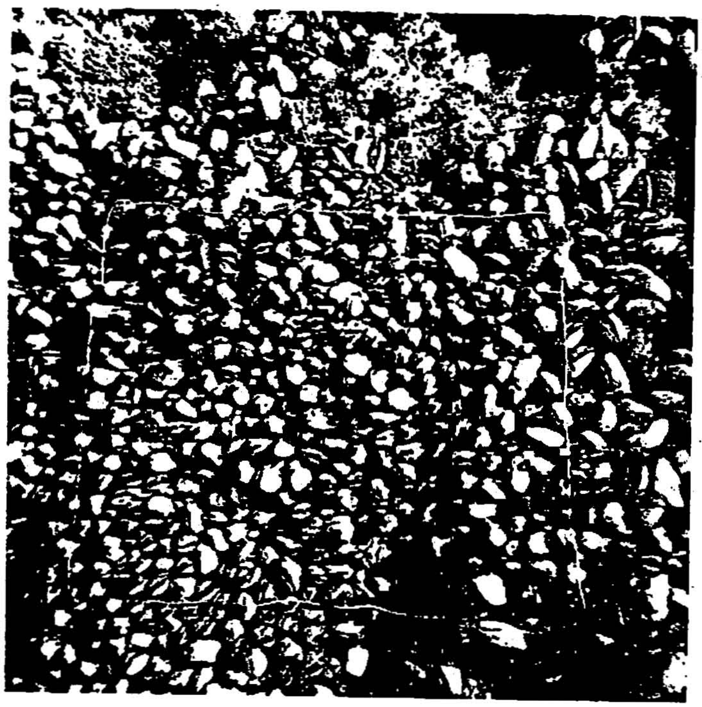

Plate 2.2-12. San Diego Mussel Bed, 30 January, 1976.

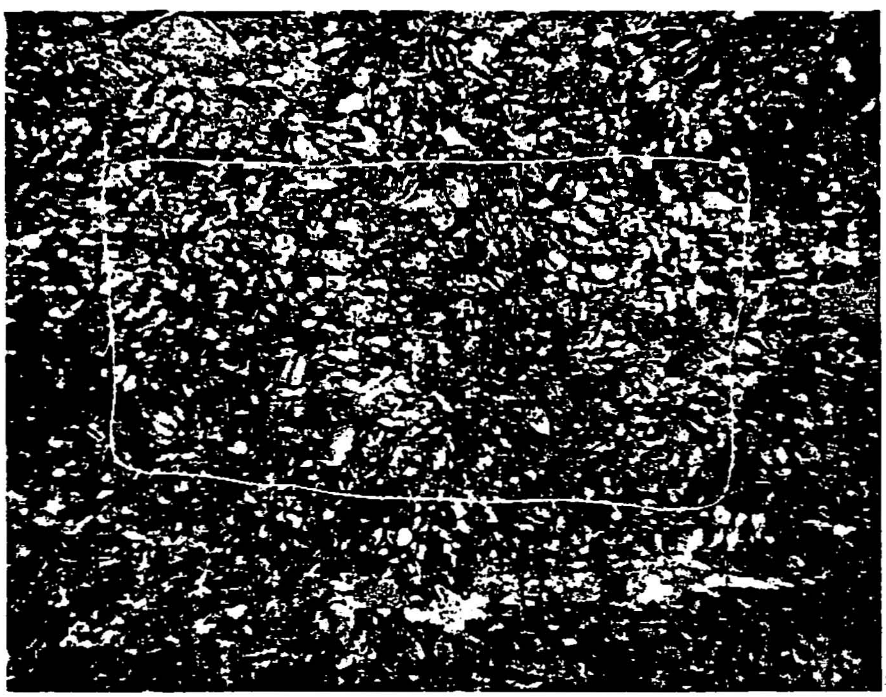

Plate 2.2-13. San Miguel Island Mussel Bed, 14 January 1976.

Plate 2.2-14. Santa Cruz Island Mussel Bed 13 January, 1976.

Plate 2.2-15. San Nicolas Island Mussel Bed, 15 January, 1976.

Plate 2.2-16. Santa Barbara Island Mussel Bed, 27 January, 1976.

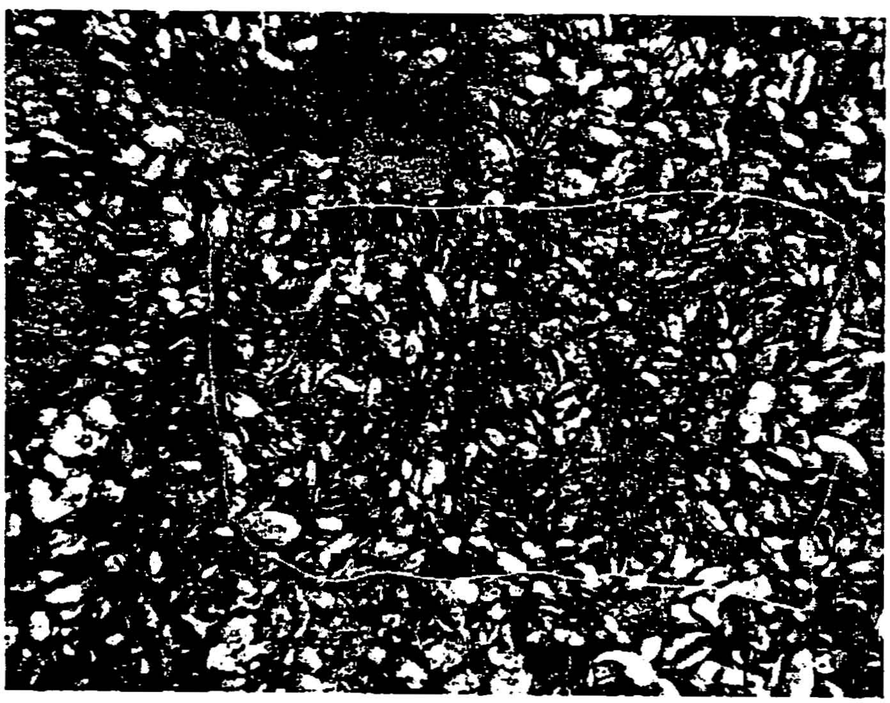

Plate 2.2-17. San Miguel Island (A) Mussel Bed, 10 April, 1976.

Plate 2.2-18. San Miguel Island (B) Mussel Bed, 10 April, 1976.

Plate 2.2-19. Santa Cruz Island Mussel Bed, 9 April, 1976.

Plate 2.2-20. San Nicolas Island Mussel Bed, 11 April, 1976.

Plate 2.2-21. Santa Barbara Island Mussel Bed, 19 April, 1976.

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APPENDIX 2.2-B

Volume III Year III

Supplement to Report 2.2

MUSSEL COMMUNITY STUDY

Dale Straughan, Principal Investigator
Robert Kanter, Co-Principal Investigator
Allan Hancock Foundation
University of Southern California

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Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites.

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
I. PHYLUM PORIFERA						
A. Class Calcarea						
1. Leucosolenia sp.	+000	000	0000	0000	0 0	0 0
2. Sycettida sp.	+00+	000	00+0	+0+0	0 +	0 0
B. Class Demospongiae						
1. Haliclona sp.	0000	000	00+0	0000	0 0	0 0
II. PHYLUM CNIDARIA						
A. Class Hydrozoa						
1. Abietinaria sp.	0000	000	+000	0000	0 0	0 0
2. Aglaophenia sp.	+000	+00	00+0	0000	0 0	0 0
3. Sertularia sp.	0000	000	00+0	0000	0 0	0 +
4. Ohelia sp.	0000	00+	0000	0000	0 0	0 0
B. Class Anthozoa						
1. Anthopleura xanthogrammica	++++	+++	++++	++++	+ +	+ +
2. Cactosoma arenaria	0000	000	0000	+000	0 0	0 0
3. Actiniaria sp.	+0+0	+00	+000	+0+0	0 0	0 0
4. Anthopleura sp.	0000	000	000+	0000	0 0	0 0
5. Anthopleura elegantissima	0000	00+	000+	0000	0 0	0 0
III. PHYLUM PLATYHELMINTHES						
1. Notoplana acticola	0+00	000	00+0	0000	0 0	+ 0
2. Leptoplanidae sp.	++++	+++	++++	+0++	+ +	+ +
3. Freemania litoricola	0000	+++	00++	0000	0 +	0 +
4. Alloioplana sp.	00+0	++0	00+0	00+0	+ 0	0 0
5. Stylochus franciscanus	0000	000	+000	0000	0 0	0 0
6. Notoplana sp.	0+00	000	0000	0000	0 0	+ 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
IV. PHYLUM NEMERTEA A. Class Anopla	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
1. Lineidae sp.	+0+0	000	00+0	0000	0 0	0 +
2. Micrura sp.	0000	000	0000	00+0	0 0	0 0
3. Micrura pardalis	0000	000	0000	000+	0 0	0 0
4. Lineus pictifrons	0000	000	000+	0000	0 0	0 0
B. Class Enopla						
1. Emplectonema gracile	+0++	+++	++++	0+00	+ +	+ +
2. Nemertopsis gracilis	000+	+++	+++0	00+0	0 0	0 +
3. Paranemertes peregrina	+0++	+++	++++	0++0	+ +	+ 0
4. Amphiporus sp.	+0++	+++	+0++	00++	+ +	+ 0
5. Zygonemertes sp.	0000	0+0	0000	0000	0 0	0 0
V. PHYLUM SIPUNCULIDA						
1. Phascolosoma agassizii	++++	+++	++++	++++	0 +	+ +
2. Themiste pyroides	0+00	000	0000	0000	0 0	0 0
3. Themiste sp.	0000	000	000+	0000	0 0	0 0
VI. PHYLUM NEMATODA						
1. Paraeurystomina sp.	00+0	000	00+0	0000	0 0	+ 0
2. Deontostoma californicum	+0++	0+0	0000	00+0	0 0	+ +
3. Deontostoma washingtonense	+0++	00+	00++	00++	0 0	+ +
4. Deontostoma sp.	+0++	+++	00++	00++	0 0	+ +
5. Enoplus sp.	+0++	00+	0000	0000	0 0	0 0
6. Oncholaimina sp.	+0++	0++	00+0	00++	0 +	+ +
7. Leptosomatidae sp.	0000	000	0000	00+0	0 0	0 +

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VII. PHYLUM ANNELIDA B. Class Polychaeta (Cont'd.)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
28. Typosyllis armillaris	0000	000	0000	+000	0 0	0 0
29. Typosyllis "fasciata" sp. C	0000	000	00+0	+000	0 0	0 0
30. Nothria sp.	0000	000	00++	+++0	0 0	0 0
31. Arabellidae sp.	0000	0++	000+	+00+	0 0	0 0
32. Eumida longicornuta	0000	000	0000	+000	0 0	0 0
33. Amblyosyllis sp.	0000	000	0000	+000	0 0	0 0
34. Exogone lourei	0000	000	0000	+000	0 0	0 0
35. Terebellidae sp.	0000	000	0000	0000	+ 0	0 0
36. Polydora sp.	0000	000	+000	+000	0 0	0 0
37. Typosyllis cf. aciculata	++00	+00	++00	0+0+	0 +	+ 0
38. Typosyllis sp. A	0000	000	+000	0000	0 0	0 0
39. Polyophthalmus pictus	0+00	000	0000	0000	+ 0	0 0
40. Typosyllis "fasciata" sp. A	+000	+00	0000	0000	0 0	0 0
41. Hypsicomus lyra	+000	000	0000	0000	0 0	0 0
42. Pareurythoe californica	+000	000	0000	0000	0 0	0 0
43. Tharyx sp.	+++0	0+0	00+0	0000	0 0	0 0
44. Chaetozone sp.	+000	0+0	0000	0000	0 0	0 0
45. Glyceridae sp.	+000	000	0000	0000	0 0	0 0
46. Orbiniidae sp.	+000	000	0+00	0000	0 0	0 0
47. Polydora limicola	0000	000	0000	0000	0 0	+ 0
48. Capitellidae sp.	0000	000	00+0	0000	0 0	+ 0
49. Polydora websteri	+000	000	0000	0000	0 0	0 0
50. Naineris sp.	+000	000	0000	00+0	0 0	0 0
51. Typosyllis sp.	+000	00+	0+0+	0+0+	0 +	0 0
52. Phyllodocidae sp.	+000	000	0000	0000	0 0	0 0
53. Polynoidae sp.	+000	000	0000	0000	0 0	0 0
54. Exogone sp.	+000	000	0000	0000	0 0	0 0
55. Cirriformia luxuriosa	0000	++0	0000	0000	0 0	0 +
56. Lumbrineridae sp.	0000	+00	0++0	0000	0 0	0 0
57. Typosyllis "fasciata" sp. D	0+++	0++	00++	0+++	0 +	0 +
58. Syllis gracilis	0+++	000	0++0	0++0	0 0	0 0
59. Drilonereis nuda	0000	000	0000	0+00	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VII. PHYLUM ANNELIDA A. Class Oligochaeta	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
1. Enchytraeidae sp.	+0++	+++	00++	00+0	0 +	+ +
B. Class Polychaeta						
1. Arabella semimaculata	++++	+++	++++	++++	+ +	+ +
2. Boccardia proboscidea	0000	00+	0000	0000	0 0	+ 0
3. Chone minuta	0000	+0+	000+	0000	0 0	+ 0
4. Chrysopetalum occidentale	0000	000	000+	+000	0 0	+ 0
5. Cirratulidae sp.	+000	000	0000	0000	+ 0	0 0
6. Cirriformia spirabrancha	0000	000	0000	0000	0 0	+ +
7. Eulalia aviculiseta	00+0	000	00+0	0000	+ +	+ +
8. Eupomatus gracilis	+000	000	0000	0000	+ 0	0 +
9. Hemipodus borealis	0000	000	0000	0000	0 0	+ +
10. Idanthyrsus ornamentatus	0000	000	0000	0000	0 0	+ 0
11. Lumbrineris zonata	0000	+++	0+++	0+00	+ +	+ +
12. Nerine foliosa	0000	000	0000	0000	0 0	+ 0
13. Nereis vexillosa	0000	00+	0000	0000	+ 0	0 0
14. Notomastus tenuis	0++0	0+0	0000	0000	+ 0	+ +
15. Oncoscolex pacificus	0+00	000	00++	00+0	+ 0	0 0
16. Peisidice sp.	0000	000	0000	0000	+ 0	0 0
17. Phragmatopoma californica	++++	0++	++++	++++	+ +	+ 0
18. Platynereis bicanaliculata	++00	+00	++00	++00	0 0	+ 0
19. Schistocomus sp.	0000	000	0000	0000	+ +	0 0
20. Typosyllis hyalina	++++	0++	+0++	0++0	0 +	+ +
21. Typosyllis "fasciata" sp. E	0000	0+0	00+0	0000	+ 0	+ 0
22. Naineris dendritica	0+++	+++	00++	00+0	+ +	0 0
23. Spirorbis sp.	+000	+00	+000	+000	0 0	0 0
24. Spirobranchus spinosus	++++	000	0+0+	++++	0 0	0 0
25. Halosydna brevisetosa	++0+	00+	0++0	++++	0 0	0 0
26. Pholoe glabra	0000	000	0000	+000	0 0	0 0
27. Typosyllis alternata	0+00	000	0000	+++0	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VII. PHYLUM ANNELIDA B. Class Polychaeta (Cont'd.)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
60. Pseudopotamilla occelata	0+00	000	0+00	0+00	0 0	0 0
61. Eulalia sp.	0000	000	0000	0+00	0 0	0 0
62. Vermiliopsis infundibulum	0000	000	0000	0+00	0 0	0 0
63. Anaitides medipapillata	0000	000	0000	0++0	0 0	0 0
64. Polycirrus sp.	0+++	000	0000	0000	0 0	0 0
65. Steggoa cf. californiensis	0+00	000	0000	00+0	0 0	0 0
66. Maldanidae sp.	0+00	000	0000	00+0	0 0	0 0
67. Exogone uniformis	0+00	000	000+	00++	0 0	0 0
68. Scoloplos acmeceps	0+00	000	0000	0000	0 0	0 0
69. Spionidae sp.	0000	000	0+0+	0000	0 0	0 0
70. Lumbrineris tetraura	0000	000	0+00	0000	0 0	0 0
71. Nerinides acuta	0000	000	0+00	0000	0 0	0 0
72. Nereis grubei	00++	0++	00++	00++	0 +	0 +
73. Glycera americana	00+0	000	0000	0000	0 0	0 0
74. Typosyllis "fasciata" sp. B	00+0	000	0000	0000	0 0	0 0
75. Anaitides sp.	00++	000	000+	0000	0 0	0 0
76. Arabella iricolor	00+0	0+0	00+0	0000	0 +	0 +
77. Typosyllis adamanteus	00++	0++	00+0	0000	0 0	0 +
78. Ophiodromus pugettensis	00+0	000	0000	0000	0 0	0 0
79. Axiothella rubrocincta	00+0	000	0000	0000	0 0	0 0
80. Typosyllis heterochaeta	0000	0+0	00+0	00+0	0 +	0 0
81. Chone sp.	0000	0+0	00+0	0000	0 0	0 +
82. Lumbrineris japonica	0000	000	00+0	0000	0 0	0 0
83. Polydora socialis	0000	000	00+0	0000	0 0	0 0
84. Cirriformia tentaculata	0000	000	0000	0000	0 0	0 +
85. Nereis latescens	0000	00+	000+	0000	0 +	0 0
86. Sthenelais fusca	0000	000	00++	0000	0 0	0 0
87. Sabellidae sp.	0000	000	00+0	0000	0 0	0 0
88. Eteone sp.	0000	000	0000	0000	0 0	0 0
89. Syllis sp.	00+0	000	00+0	00+0	0 0	0 0
90. Eumida bilineata	00+0	000	0000	0000	0 0	0 0
91. Chaetozone corona	00+0	000	0000	0000	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VII. PHYLUM ANNELIDA B. Class Polychaeta (Cont'd).	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
92. Pseudopotamilla socialis	0000	000	00++	0000	0 0	0 0
93. Brania sp.	0000	000	0000	0000	0 +	0 0
94. Sabellaria gracilis	0000	000	0000	0000	0 +	0 0
95. Eumida sp.	0000	0+0	0000	0000	0 0	0 0
96. Pherusa papillata	0000	000	00+0	00+0	0 0	0 0
97. Eunice sp.	0000	000	0000	00+0	0 0	0 0
98. Prionospio sp.	0000	000	00+0	0000	0 0	0 0
99. Capitita ambiseta	0000	000	0000	0000	0 0	0 +
100. Odontosyllis phosphorea	0000	000	00+0	0000	0 +	0 0
101. Pseudomalacocerus cf. pigmentatus	0000	000	00+0	0000	0 0	0 0
102. Perinereis monterea	0000	0+0	0000	0000	0 0	0 0
103. Sclerocheilus acirratus	0000	000	00+0	0000	0 0	0 0
104. Fabrisabella vasculosa	0000	000	00+0	0000	0 0	0 +
105. Ampharetidae sp.	+000	000	0000	+000	0 0	0 0
106. Ampharete labrops	000+	000	0000	0000	0 0	0 0
107. Syllidae sp.	0000	000	0000	000+	0 0	0 0
108. Lumbrineris sp.	0000	000	000+	0000	0 0	0 0
109. Rhynchospio sp.	0000	000	000+	0000	0 0	0 0
110. Sigalionidae sp.	0000	000	000+	0000	0 0	0 0
111. Sthenelanella uniformis	0000	000	00+0	0000	0 0	0 0
VIII. PHYLUM MOLLUSCA A. Class Gastropoda						
1. Collisella strigatella	++++	+00	+++0	++++	+ +	+ +
2. Conus californicus	+000	000	0000	0000	0 0	+ +
3. Crepipatella lingulata	000+	000	0000	+++0	+ 0	0 0
4. Epitonium tinctum	+0+0	+++	00++	0000	+ 0	+ +
5. Fissurella volcano	000+	000	00++	+0++	0 +	0 0
6. Liotia fenestrata	+000	000	0000	0000	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VIII. PHYLUM MOLLUSCA A. Class Gastropoda (Cont'd).	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
7. Homalopoma luridum	++++	000	0000	0+0+	0 0	0 0
8. Lacuna marmorata	0000	000	0000	0000	0 0	+ 0
9. Lacuna unifasciata	+000	000	0000	0000	+ 0	+ 0
10. Littorina planaxis	+000	+++	0000	+000	+ +	+ +
11. Littorina scutulata	+0+0	+++	0000	0000	+ 0	+ +
12. Lottia gigantea	++00	000	++++	++++	+ +	+ 0
13. Mitrella carinata	0000	000	+0+0	0000	+ 0	+ +
14. Notoacmea fenestrata	+000	00+	000+	++00	0 0	+ 0
15. Ocenebra circumtexta	++++	0+0	0000	++++	0 +	0 +
16. Odostomia nota	0000	000	0000	0000	+ 0	+ 0
17. Opalia funiculata	0000	000	000+	0000	0 0	+ +
18. Tegula funebralis	000+	+++	++++	0000	+ +	+ +
19. Thais emarginata	++++	+++	++++	0000	+ +	+ +
20. Trimusculus reticulatus	+000	+++	+000	+000	+ 0	0 0
21. Triphora pedroana	+000	000	0+00	0000	0 +	+ 0
22. Turbonilla kelseyi	+000	000	0000	0000	0 0	+ 0
23. Williamia peltoides	0000	000	0000	0000	0 0	+ 0
24. Haliotis cracherodii	++++	000	+0++	++++	0 0	0 0
25. Barleeia californica	+000	000	000+	0000	0 0	0 0
26. Mitra idae	++00	000	0000	00+0	0 0	0 0
27. Acanthina spirata	0000	000	000+	+000	+ +	+ +
28. Calliostoma annulatum	0000	000	0000	0000	0 0	+ 0
29. Collisella conus	0+0+	0++	0+++	++++	+ +	+ +
30. Collisella digitalis	000+	+++	00++	+00+	+ 0	+ +
31. Collisella pelta	++++	+++	++++	++++	+ +	0 +
32. Collisella scabra	++++	+++	++++	++++	+ +	+ +
33. Mitrella aurantiaca	0000	000	+00+	0000	0 0	0 0
34. Acanthina punctulata	0000	000	+0++	0000	0 0	0 0
35. Collisella limatula	++++	00+	++++	0+++	0 +	0 0
36. Amphissa versicolor	++00	000	000+	00+0	0 0	0 0
37. Seila montereyensis	+000	000	0000	0++0	0 0	0 0
38. Homalopoma fenestratum	+000	000	0000	0000	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VIII. PHYLUM MOLLUSCA A. Class Gastropoda (Cont'd.)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
39. Balcis thersites	000+	000	0000	+000	0 0	0 0
40. Homalopoma baculum	++++	00+	+000	++++	0 0	0 0
41. Homalopoma paucicostatum	0+00	000	0000	0000	0 0	0 0
42. Norrisia norrisi	00+0	000	0000	0000	0 0	0 0
43. Cerithiopsis carpenteri	0000	000	0000	00+0	0 0	0 0
44. Nudibranchia sp.	0000	000	0000	00+0	0 0	0 0
45. Siphonaria sp.	0000	000	0000	000+	0 0	0 0
46. Barleeia haliotiphilia	0000	00+	0000	000+	0 0	0 0
47. Littorina sp.	0000	000	000+	0000	0 0	0 0
B. Class Pelecypoda						
1. Brachidontes adamsianus	0+0+	++0	00++	++++	+ +	+ 0
2. Chama pellucida	0000	000	0000	++++	0 0	0 0
3. Glans subquadrata	0+++	000	0000	++++	0 0	0 +
4. Hiatella arctica	000+	0++	000+	0++0	+ +	+ 0
5. Lasaea subviridis	000+	+++	000+	++++	0 0	+ +
6. Modiolus capax	00++	00+	0+++	++++	0 0	0 0
7. Mytilus californianus	++++	+++	++++	++++	+ +	+ +
8. Mytilus edulis	0000	0++	++0+	0000	+ 0	+ 0
9. Protothaca staminea	0000	00+	0000	0000	0 0	+ +
10. Septifer bifurcatus	++++	+++	++++	++++	+ +	+ +
11. Kellia laperousii	+0+0	00+	0++0	0+00	0 0	0 0
12. Semele rupicola	++++	000	0000	0+0+	0 0	0 0
13. Lithophaga plumula	0000	000	0000	0+++	0 0	0 0
14. Irus lamellifer	0++0	000	0000	0000	0 0	0 0
15. Gregariella chenui	0000	000	0000	00+0	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
VIII. PHYLUM MOLLUSCA C. Class Polyplacophora	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
1. Mopalia muscosa	++0+	+++	+00+	0000	0 0	+ +
2. Nuttallina fluxa	++00	+++	+00+	++++	+ 0	+ +
3. Cyanoplax hartwegii	0000	+++	0000	++++	+ 0	0 0
4. Lepidozona californiensis	0+0+	000	0000	00+0	0 0	0 0
5. Mopalia porifera	0000	000	0000	0000	0 0	0 +
6. Lepidochitonidae sp.	0000	000	00+0	0000	0 0	0 0
D. Class Cephalopoda						
1. Octopus sp.	0+00	000	0000	0000	0 0	0 0
IX. PHYLUM ARTHROPODA (A1). Class Crustacea (Subclass Cirripedia)						
1. Tetraclita squamosa rubescens	++++	00+	++++	++++	0 0	0 0
2. Balanus glandula	++++	+++	++++	++++	+ +	+ +
3. Chthamalus dalli	++++	+++	++++	++++	+ +	+ +
4. Chthamalus fissus	++++	+++	++++	++++	+ +	+ +
5. Pollicipes polymerus	++++	+++	++++	++++	+ +	+ +
6. Tetraclita squamosa elegans	++++	0++	++++	++++	0 0	+ 0
7. Balanus t. californicus	000+	000	0+++	00++	0 0	0 0
(A2). Class Crustacea (Order Isopoda)						
1. Dynamenella glabra	++++	+++	+000	++++	0 +	0 0
2. Cirolana harfordi	++++	00+	0000	++++	+ +	+ 0
3. Idotea pentidotea schmitti	0000	000	+000	0000	0 0	0 0
4. Idotea pentidotea wosnesenskii	0000	000	++00	0000	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
IX. PHYLUM ARTHROPODA (A2). Class Crustacea (Order Isopoda Cont'd.)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
5. Flabellifera sp.	0000	000	0000	0+00	0 0	0 0
6. Cirolana benedicti	0000	000	0000	0+00	0 0	0 0
7. Jaeropsis dubia	0000	000	0000	00+0	0 0	0 0
8. Sphaeromatidae sp.	0000	00+	000+	0000	0 0	0 +
9. Janiridae sp.	0000	000	0000	000+	0 0	0 0
(A3). Class Crustacea (Order Amphipoda)						
1. Elasmopus rapax	0000	000	0000	0+00	+ 0	0 0
2. Hyale frequens	+00+	000	00++	0000	+ +	0 0
3. Elasmopus cf. mutatus	0000	000	0000	+000	0 0	0 0
4. Hyale grandicornis californica	000+	000	+0+0	+00+	0 0	0 0
5. Aorodies columbiae	0+0+	000	+000	++00	0 0	0 0
6. Maera simile	0000	000	0000	+00+	0 0	0 0
7. Ampithoe sp.	0+00	000	+000	000+	0 0	0 0
8. Elasmopus cf. serricatus	+000	000	+000	0000	0 0	0 0
9. Hyale anceps	++++	+++	++++	0+++	0 0	0 0
10. Elasmopus sp.	0+++	000	0+00	0+++	0 +	0 0
11. Jassa falcata	+++0	000	0000	000+	0 0	0 0
12. Melita sulca	0+00	000	0000	0000	0 0	0 0
13. Parallorchestes ochotensis	0000	000	0++0	0000	0 0	0 0
14. Ampithoe cf. plumosa	0000	000	0000	00+0	0 0	0 0
15. Paramoera mohri	00+0	000	0000	0000	0 0	0 0
16. Hyale sp.	0000	00+	0000	0000	0 0	0 0
17. Eusiridae sp.	0000	000	000+	0000	0 0	0 0
18. Phoxocephalidae sp.	0000	000	000+	0000	0 0	0 0
(A4). Class Crustacea (Order Amphipoda, Suborder Caprellidea)						
1. Caprella penantis	0000	000	+000	0000	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
IX. PHYLUM ARTHROPODA (Cont'd.) (A5). Class Crustacea (Order Tanaidacea)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
1. Synapseudes intumescens	0000	000	0000	00+0	0 0	0
(A6). Class Crustacea (Order Decapoda)						
1. Hemigrapsus nudus	0000	+++	0000	0000	0 0	0 0
2. Pachygrapsus crassipes	++++	+++	++++	++++	+ +	+ +
3. Petrolisthes cabrilloi	++++	00+	0000	++00	+ +	+ +
4. Pugettia producta	0000	00+	+0+0	0000	0 0	+ +
5. Fabia subquadrata	0+00	+00	++++	0000	0 0	0 0
6. Cancer jordani	0000	000	+000	0000	0 0	0 0
7. Pinnotheridae sp.	+000	0+0	00+0	0000	0 0	0 0
8. Cycloxanthrops novemdentatus	0000	000	0000	0+00	0 0	0 0
9. Lophopanopeus bellus	0000	000	0000	0+00	0 0	0 0
10. Xanthidae sp.	00++	00+	00+0	0+++	0 0	0 0
11. Paraxanthias taylori	0000	000	0000	0+0+	0 0	0 0
12. Pagurus hirsutiusculus	0+0+	000	0+0+	0000	0 0	0 0
13. Pagurus samuelis	00+0	000	00+0	0000	0 0	0 +
14. Lophopanopeus sp.	0000	000	0000	00+0	0 0	0 0
15. Pilumnus spinohirsutus	0000	000	0000	00+0	0 0	0 0
16. Pagurus granosimanus	0000	000	00+0	0000	0 0	0 0
17. Majidae sp.	000+	000	0000	0000	0 0	0 0
18. Fabia loweii	0000	00+	0000	0000	0 0	0 0
19. Grapsidae sp.	0000	00+	0000	0000	0 0	0 0
20. Petrolisthes cinctipes	0000	000	000+	0000	0 0	0 0
B. Class Pycnogonida						
1. Achelia simplissima	0000	000	0000	0000	+ 0	0 0
2. Halosoma viridintestinale	+0+0	000	0000	0000	+ 0	+ 0
3. Pycnogonum stearnsi	++00	+0+	0+++	0000	0 0	+ +
4. Ammothella setosa	0000	000	0000	0+00	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
IX. PHYLUM ARTHROPODA (Cont'd) B. Class Pycnogonida	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
5. Ammothella tuberculata	0++0	000	0000	0000	0 0	0 0
6. Anoplodactylus californiensis	00++	000	0000	0000	0 0	0 0
7. Pycnogonum rickettsi	0000	000	00+0	0000	0 0	0 0
X. PHYLUM ECHINODERMATA						
A. Class Asteroidea						
1. Pisaster sp.	++++	000	0000	++++	0 0	0 0
2. Henricia leviuscula	0000	000	0000	0+00	0 0	0 0
B. Class Echinoidea						
1. Strongylocentrotus purpuratus	++++	000	+00+	++++	0 0	0 0
C. Class Holothuroidea						
1. Cucumariidae sp.	0000	000	0000	+0++	0 0	0 0
2. Cucumaria piperata	0000	0 0	000+	0000	0 0	0 0
D. Class Ophiuroidea						
1. Amphipholis squamata	++0+	000	0000	++++	0 0	0 0
2. Ophiactis simplex	++0+	000	0000	++++	+ 0	0 0
3. Ophiopteris papillosa	0000	000	0000	00+0	0 0	0 0

* = Quarter of year

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quaterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
XI. PHYLUM ECTOPROCTA **	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
1. Schizoporella sp.	+000	000	000+	0000	0 0	0 0
2. Hippothoa sp.	0000	000	00+0	0000	0 0	+ +
3. Microporella californica	++++	000	0+++	0+0+	0 0	0 +
4. Membranipora tuberculata	0000	000	0000	00+0	0 0	+ +
5. Callopora horrida	0+++	00+	0+++	0000	0 0	+ +
6. Membranipora villosa	0+00	000	0000	0000	0 0	+ 0
7. Membranipora membranacea	0+00	000	0000	+000	0 0	0 0
8. Lagenipora sp.	++0+	000	++++	0000	0 0	0 +
9. Cryptosula pallasiana	++++	0+0	+0+0	0000	0 0	0 +
10. Colletosia radiata	+000	000	0000	0+00	0 0	0 0
11. Reginella nitida	+00+	000	0++0	00+0	0 0	0 0
12. Schizoporella unicornis	+0++	00+	00++	0000	0 0	0 +
13. Celleporaria brunnea	+000	0+0	0000	0+00	0 0	0 +
14. Hincksina velata	+000	000	00++	0000	0 +	0 +
15. Membranipora fusca	0000	000	0000	0+00	0 0	0 0
16. Cellaria diffusa	0++0	000	0000	0+00	0 0	0 0
17. Porella porifera	0+00	000	0000	0+00	0 0	0 0
18. Lagenipora lacunosa	0+0+	000	0000	0000	0 0	0 0
19. Microporella sp.	0+0+	000	0+++	0000	0 0	0 0
20. Cellaria sp.	0+00	000	0000	0000	0 0	0 +
21. Smittina bella	0+00	000	0000	0000	0 0	0 0
22. Rhynchozoon sp.	0+00	000	0000	0000	0 0	0 0
23. Lichenopora sp.	0+00	000	0000	0000	0 0	0 +
24. Fenestrulina sp.	0+00	000	0+00	0000	0 0	0 0
25. Holoporella brunnea	00+0	000	+000	0000	0 0	0 0
26. Fenestrulina malusii	00+0	000	0000	0000	0 0	0 0
27. Membranipora perfragilis	0000	000	0+00	0000	0 0	0 0
28. Callopora circumclathrata	0000	000	0000	0000	0 0	0 +
29. Hippothoa hyalina	000+	0++	00++	0000	0 0	0 +
30. Schizoporella californica	0000	0+0	00+0	0000	0 0	0 0
31. Microporella cribosa	0000	000	00+0	000+	0 0	0 0

* = Quarter of year
** = All species identifications are tentative

Table 2.2-12. Faunal Presence (+) or Absence (0) at all Quarterly Collection Sites. (Continued)

BIOTIC COMPOSITION	ISLAND SITES				MAINLAND SITES	
XI. PHYLUM ECTOPROCTA ** (Cont'd.)	Santa Cruz *1234	San Miguel * 234	San Nicolas *1234	Santa Barbara *1234	San Diego *1 3	Coal Oil Point *1 3
32. Thalamoporella californica	0000	000	0000	0000	0 0	0 +
33. Bugula californica	0000	00+	000+	0000	0 0	0 +
34. Scrupocellaria californica	0000	000	0000	0000	0 0	0 +
35. Microporella ciliata	000+	000	00++	0000	0 0	0 0
36. Membranipora sp.	0000	00+	00+0	0000	0 0	0 0
37. Parasmittina prolifica	00+0	000	0000	0000	0 0	0 0
38. Bowerbankia gracilis	0000	0+0	0000	0000	0 0	0 0
39. Cellaria mandibulata	0000	000	0000	00+0	0 0	0 +
40. Arthropoma cecili	0000	000	0000	00+0	0 0	0 0
41. Tegella robertsonae	0000	00+	0000	0000	0 0	0 +
42. Disporella sp.	000+	00+	000+	0000	0 0	0 +
43. Electra crustulenta	0000	000	0000	0000	0 0	0 +
44. Stephanosella biaperta	000+	000	0000	0000	0 0	0 +
45. Stephanosella bolini	0000	000	0+00	0000	0 0	0 0
46. Lagenipora punctulata	000+	000	00++	0000	0 0	0 0
47. Callopora sp.	0000	000	00+0	0000	0 0	0 0
48. Lyrula sp.	000+	000	00+0	0000	0 0	0 0
49. Smittina macculochae	0000	000	0000	0000	0 0	0 +
50. Porella sp.	0000	000	00+0	0000	0 0	0 0
51. Figularia hilli	000+	000	0000	0000	0 0	0 0
52. Coleopora gigantea	000+	000	0000	0000	0 0	0 0
53. Tricellaria ternata	0000	00+	0000	0000	0 0	0 0
54. Chapperia patula	0000	000	000+	0000	0 0	0 0
55. Tricellaria occidentalis	0000	000	000+	0000	0 0	0 0
56. Tricellaria sp.	0000	000	000+	0000	0 0	0 0
XII. PHYLUM CHORDATA						
1. Styelidae sp.	0000	000	0000	00+0	0 0	0 0

* = Quarter of year

** = All species identifications are tentative

Table 2.2-13. Biomass (g) At Coal Oil Point.

SUMMER (5 August, 1975)

Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	7.9328	21.3752	7.5648	38.3979	17.2058	92.4765
PLATYHELMINTHES (flatworms)	0.0500	3.5253	0.0040	0.0330	---	3.6123
NEMATODA (roundworms)	2.1035	2.3702	2.7041	---	0.4620	7.6398
NEMERTEA	1.5452	0.3751	1.0651	---	---	2.9854
ANNELIDA (polychaetes)	1.9871	13.2149	11.2521	8.3356	17.9464	52.7361
SIPUNCULIDA	0.2600	---	1.3011	---	---	1.5611
*ECTOPROCTA	---	1.7282	0.0180	---	---	1.7462
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	2499.0000	3523.0000	1822.8000	1710.5000	1466.4000	11021.7000
ARTHROPODA	16.9468	51.5423	7.6377	0.8152	2.7831	79.7251
					Grand Total	11264.1825

Table 2.2-14. Biomass (g) At Coil Point.

WINTER 1976 (29 January, 1976)

Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	0.1241	---	---	0.0031	---	0.1272
COELENTERATA	19.8550	13.3454	10.6552	17.7309	22.1563	83.7428
PLATYHELMINTHES (flatworms)	0.0511	0.1291	0.1011	0.1981	---	0.4794
NEMATODA (roundworms)	0.0341	0.0061	0.1931	0.0581	0.0411	0.3325
ANNELIDA (polychaetes)	3.9535	1.5883	6.8428	12.9344	14.6396	39.9586
SIPUNCULIDA	0.0251	---	---	0.0311	---	0.0562
*ECTOPROCTA	0.7201	9.3510	40.7601	0.3671	1.9233	53.1216
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1410.3409	1212.7963	1917.2983	1808.3245	2477.7145	8826.4745
ARTHROPODA	37.5830	0.4883	101.2582	9.9621	8.9881	158.2797
					Grand Total	9162.5725

*Weight includes weight of rock and shell substrate.

Table 2.2-15. Biomass (g) At San Diego.

SUMMER 1975 (7 August, 1975)

Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	---	---	0.6691	---	0.5421	1.2112
PLATYHELMINTHES (flatworms)	1.6058	1.6110	1.2749	1.1401	0.3801	6.0119
NEMATODA (roundworms)	---	---	---	---	---	---
NEMERTEA	---	---	---	0.0501	---	0.0501
ANNELIDA (polychaetes)	6.7904	7.6004	8.8035	9.9514	8.6564	41.8021
SIPUNCULIDA	---	---	---	---	---	---
*ECTOPROCTA	---	---	---	---	---	---
ECHINODERMATA	---	0.0111	---	---	0.0031	0.0142
MOLLUSCA	1167.7573	1442.8800	978.0148	949.7531	959.8585	5498.2637
ARTHROPODA	26.6127	60.0075	18.3638	15.2230	10.7511	130.9581
					Grand Total	5678.3113

Table 2.2-16. Biomass (g) At San Diego.

WINTER 1976 (30 January, 1976)

Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	0.0541	---	0.0561	---	---	0.1102
PLATYHELMINTHES (flatworms)	0.0691	0.0941	0.0291	---	0.0221	0.2144
NEMATODA (roundworms)	---	---	---	---	---	---
NEMERTEA	0.0621	---	0.0281	4.1175	4.4576	48.6653
ANNELIDA (polychaetes)	1.5702	23.0364	5.6167	---	---	30.2233
SIPUNCULIDA	---	---	---	---	---	---
*ECTOPROCTA	0.2671	---	---	---	---	0.2671
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	784.8078	776.0960	848.8546	894.8724	663.4824	3968.1132
ARTHROPODA	34.7269	28.8483	31.7115	1.9466	28.1142	125.3475
					Grand Total	4132.9410

*Weight includes weight of rock and shell substrate.

Table 2.2-17. Biomass (g) At San Miguel Island.

FALL 1975 (3 November, 1975) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	6.0600	12.1110	12.3140	0.5230	5.1970	36.2050
PLATYHELMINTHES (flatworms)	0.2960	0.2900	0.1330	0.1630	0.3500	1.2320
NEMATODA (roundworms)	---	---	---	0.0040	---	0.0040
NEMERTEA	---	---	---	---	---	---
ANNELIDA (polychaetes)	32.9440	4.6650	15.8220	39.2590	43.5850	136.2750
SIPUNCULIDA	---	0.0430	---	---	---	0.0430
*ECTOPROCTA	---	---	---	---	---	---
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1584.5750	1455.0080	1206.0410	1240.8680	1190.3190	6676.8110
ARTHROPODA	22.2240	88.9430	25.9620	3.4330	3.2960	143.8580
					Grand Total	6994.4280

Table 2.2-18. Biomass (g) At San Miguel Island.

WINTER 1976 (14 January, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	3.0073	2.6263	1.3922	2.2883	0.6351	9.9492
PLATYHELMINTHES (flatworms)	0.6911	0.1300	0.2101	0.2510	0.2780	1.5602
NEMATODA (roundworms)	0.0070	---	---	---	0.0060	0.0130
NEMERTEA	2.6933	1.2172	0.6931	2.3513	1.1302	8.0851
ANNELIDA (polychaetes)	112.3303	111.6012	41.2072	29.4159	20.4292	314.9838
SIPUNCULIDA	---	---	---	0.6891	0.0331	0.7222
*ECTOPROCTA	---	---	---	24.2987	---	24.2987
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1276.3470	1599.6722	1060.6713	1261.0350	1437.7833	6635.5088
ARTHROPODA	42.1433	54.7656	5.7528	71.2662	26.2537	200.1816
					Grand Total	7195.3026

*Weight includes weight of rock and shell substrate.

Table 2.2-19. Biomass (g) At San Miguel Island.

Sample (A)

SPRING (10 April, 1976)

Taxonomic Group	1	2	3	4	5	Total
PORIFERA (sponges	---	---	---	---	---	---
COELENTERATA	13.9267	6.1299	44.5337	4.0227	4.8967	73.5097
PLATYHELMINTHES (flatworms)	0.0222	0.0952	0.0342	---	0.4052	0.5568
NEMATODA (roundworms)	0.0142	0.0062	0.0005	0.0194	0.0312	0.0715
NEMERTEA	0.3193	0.2122	0.0342	0.1332	0.3853	1.0842
ANNELIDA (polychaetes)	18.7040	13.8476	22.6885	13.7156	22.5885	91.5442
SIPUNCULIDA	0.1362	0.6542	---	---	0.9912	1.7816
*ECTOPROCTA	0.4323	0.0022	---	0.3383	---	0.7728
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1376.6000	1411.6100	1023.0400	1077.6000	1556.2200	6445.0700
ARTHROPODA	48.0857	13.8181	9.7662	16.7853	40.5767	129.0320
					Grand Total	6743.4228

Table 2.2-20. Biomass (g) At San Miguel Island.

Sample (B)

SPRING (10 April, 1976)

Taxonomic Group	1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	27.6969	15.5977	14.4197	20.0922	36.7039	114.5104
PLATYHELMINTHES (flatworms)	0.0552	---	---	0.0622	0.0232	0.1406
NEMATODA (roundworms)	0.0042	0.0342	---	0.0012	---	0.0396
NEMERTEA	0.0412	---	0.0132	0.0122	---	0.0666
ANNELIDA (polychaetes)	2.6735	28.4560	4.5337	7.0049	5.9568	48.6249
SIPUNCULIDA	---	1.0223	0.0742	0.2232	---	1.3197
*ECTOPROCTA	---	25.8057	---	0.9733	---	26.7790
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1229.8300	1033.0300	1561.2400	1519.4800	1364.5800	6708.1600
ARTHROPODA	50.9117	41.5421	28.8206	63.7610	63.761	248.7964
					Grand Total	7148.4372

*Weight includes weight of rock and shell substrate.

Table 2.2-21. Biomass (g) At Santa Cruz Island.

SUMMER 1975 (6 October, 1975)	Sample					
Taxonomic Group	1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	---	0.5970	0.0500	1.0520	0.2240	1.9230
PLATYHELMINTHES (flatworms)	0.1760	0.5200	0.0260	0.2220	0.2000	1.1440
NEMATODA (roundworms)	---	0.0660	---	0.0610	0.0660	0.1930
NEMERTEA	0.0880	---	---	0.1330	0.1110	0.3320
ANNELIDA (polychaetes)	32.8950	23.7610	17.3120	33.2350	19.8300	127.0330
SIPUNCULIDA	10.2000	8.4250	3.9050	5.2200	12.1470	39.8970
*ECTOPROCTA	---	---	3.4360	3.3330	2.2350	9.0040
ECHINODERMATA	5.2567	4.6240	1.4940	10.2380	4.5520	26.1647
MOLLUSCA	1478.8390	1209.6060	1168.6110	1278.5830	1055.4320	6191.0710
ARTHROPODA	98.7021	57.7663	90.6530	107.7420	88.6980	443.5614
					Grand Total	6840.3231

Table 2.2-22. Biomass (g) At Santa Cruz Island.

FALL 1975 (18 November, 1975)	Sample					
Taxonomic Group	1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	---	0.4446	0.0106	---	---	0.4552
PLATYHELMINTHES (flatworms)	0.0176	0.1086	0.0426	0.5366	---	0.7054
NEMATODA (roundworms)	---	0.0006	---	---	---	0.0006
NEMERTEA	0.0056	0.0036	0.0066	0.0116	---	0.0274
ANNELIDA (polychaetes)	29.0000	25.7000	35.9000	17.1000	60.5000	168.2000
SIPUNCULIDA	6.8746	17.4000	5.6206	8.0006	12.0776	49.9734
*ECTOPROCTA	1.8763	4.0305	20.9914	6.2087	30.5000	63.6069
ECHINODERMATA	5.1436	1.7046	3.4756	3.3686	7.1286	20.8210
MOLLUSCA	1273.2388	808.6904	1319.2678	1068.2312	1622.4982	6091.9264
ARTHROPODA	97.9284	124.2604	150.6654	180.2958	108.0888	661.2388
					Grand Total	7056.9551

*Weight includes weight of rock and shell substrate.

Table 2.2-23. Biomass (g) At Santa Cruz Island.

Winter 1976 (13 January, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	---	---	---	---	0.367	0.367
PLATYHELMINTHES (flatworms)	0.332	0.265	0.378	0.360	0.608	1.943
NEMATODA (roundworms)	0.055	---	0.019	0.027	0.041	0.142
NEMERTEA	0.221	0.103	0.238	0.085	0.375	1.022
ANNELIDA (polychaetes)	16.606	148.808	5.566	15.032	20.350	206.362
SIPUNCULIDA	19.200	15.000	18.100	4.246	14.600	71.146
*ECTOPROCTA	0.135	4.553	5.010	---	3.909	13.607
ECHINODERMATA	---	0.240	0.040	0.161	1.182	1.623
MOLLUSCA	788.071	1188.689	1057.931	771.452	1076.667	4882.810
ARTHROPODA	32.635	54.581	34.163	53.549	58.426	233.354
					Grand Total	5412.376

Table 2.2.24. Biomass (g) At Santa Cruz Island.

SPRING (9 April, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	0.0251	0.0791	---	---	---	0.1042
PLATYHELMINTHES (flatworms)	0.0191	0.1071	0.0701	0.3471	0.0321	0.5755
NEMATODA (roundworms)	0.0010	0.0014	0.0001	0.0004	---	0.0029
NEMERTEA	---	---	0.0110	0.4261	0.2071	0.6442
ANNELIDA (polychaetes)	6.6608	20.2321	10.2931	33.9565	9.2071	80.3496
SIPUNCULIDA	8.8930	5.8027	11.8873	8.5840	8.1193	43.2863
*ECTOPROCTA	2.6963	7.0488	44.9676	19.8000	21.6723	96.1850
ECHINODERMATA	0.0619	0.8282	0.5042	0.3991	0.8362	2.6296
MOLLUSCA	1294.7400	1119.8500	1121.7400	1214.3700	1150.5500	5901.2500
ARTHROPODA	46.4009	95.4858	94.9189	109.4296	109.1162	455.3514
					Grand Total	6580.2745

*Weight includes weight of rock and shell substrate.

Table 2.2-25. Biomass (g) At San Nicolas Island.

SUMMER 1975 (3 October, 1975) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	7.1090	26.7580	14.2600	28.4250	14.5290	91.0810
PLATYHELMINTHES (flatworms)	---	0.0320	---	0.0500	---	0.082
NEMATODA (roundworms)	---	---	---	---	---	---
NEMERTEA	0.0420	0.0330	0.0630	0.0660	0.0470	0.2510
ANNELIDA (polychaetes)	17.1360	0.2170	0.8600	0.1550	23.1090	41.4770
SIPUNCULIDA	---	---	1.0670	---	---	1.0670
ECTOPROCTA	---	---	0.0470	---	---	0.0470
ECHINODERMATA	---	1.8110	---	---	---	1.8110
MOLLUSCA	1250.1260	2167.8480	1403.0300	1716.0650	1254.6270	7791.6960
ARTHROPODA	8.6650	15.1000	2.2500	68.3150	76.5100	170.8400
					Grand Total	8098.3520

Table 2.2-26. Biomass (g) At San Nicolas Island.

FALL 1975 (19 November, 1975) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	20.5000	20.9000	31.7000	3.2012	10.1882	86.4894
PLATYHELMINTHES (flatworms)	---	0.0142	---	---	---	0.0142
NEMATODA (roundworms)	---	---	---	0.0072	---	0.0072
NEMERTEA	---	0.0822	0.0592	0.0732	0.0232	0.2378
ANNELIDA (polychaetes)	21.0000	2.4372	0.8022	4.0352	16.3300	44.6046
SIPUNCULIDA	---	---	0.4372	0.6902	---	1.1274
ECTOPROCTA	14.2000	46.3000	---	---	6.0152	66.5152
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	2271.6022	2072.3674	1822.1124	2222.6542	1571.3994	9960.1356
ARTHROPODA	4.686	33.0906	4.6806	4.2692	28.0224	74.7488
					Grand Total	10233.8802

*Weight includes weight of rock and shell substrate.

Table 2.2-27. Biomass (g) At San Nicolas Island.

WINTER (15 January, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	0.2690	---	---	---	0.2690
COELENTERATA	32.0160	15.7590	22.3790	14.1170	3.0110	87.2820
PLATYHELMINTHES (flatworms)	0.0310	---	---	0.0080	0.0160	0.0550
NEMATODA (roundworms)	---	---	---	0.0350	---	0.0350
NEMERTEA	0.0720	---	---	0.0160	0.9340	1.0220
ANNELIDA (polychaetes)	3.9120	4.7970	0.9910	17.3890	3.6720	30.7610
SIPUNCULIDA	1.4400	---	0.3760	0.2580	---	2.0740
*ECTOPROCTA	5.2500	---	1.4810	0.2290	6.6820	13.6420
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	2048.9670	1706.8120	1727.5150	2188.2960	1626.0270	9297.6170
ARTHROPODA	7.6330	3.9300	16.9290	4.8210	9.7840	43.0970
					Grand Total	9475.8540

Table 2.2-27. Biomass (g) AT San Nicolas Island. (Continued)

WINTER (15 January, 1976) Taxonomic Group	Sample 6	7	8	9	10	Total
PORIFERA (sponges)	0.0081	---	0.0231	0.0252	---	0.0564
COELENTERATA	14.5556	6.9725	1.8853	18.5560	8.8180	50.7874
PLATYHELMINTHES (flatworms)	0.0511	---	0.0901	0.0452	---	0.1864
NEMATODA (roundworms)	---	0.0021	0.0011	---	0.0002	0.0034
NEMERTEA	---	0.0151	0.1661	0.1982	---	0.3794
ANNELIDA (polychaetes)	2.2223	2.9557	9.6660	11.6743	6.4479	32.9662
SIPUNCULIDA	---	---	0.5871	---	1.3834	1.9705
*ECTOPROCTA	67.3718	33.6124	108.2319	74.1947	2.7935	286.2043
ECHINODERMATA	---	---	---	---	---	---
MOLLUSCA	1591.1618	1058.7977	1516.2589	1505.6105	2312.1961	7984.0250
ARTHROPODA	11.1764	0.6824	62.6537	11.0299	5.8672	91.4096
					Grand Total	8447.9886

*Weight includes weight of animal plus rock or shell debris substrate.

Table 2.2-28. Biomass (g) At San Nicolas Island.

Spring (11 April, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	4.90570	9.1380	11.3924	1.1923	9.9800	36.6084
PLATYHELMINTHES (flatworms)	0.02320	---	---	0.0072	---	0.0304
NEMATODA (roundworms)	0.00420	---	---	0.0032	0.0062	0.0136
NEMERTEA	0.00233	0.0792	---	0.0192	0.2172	0. 3179
ANNELIDA (polychaetes)	18.21370	7.0539	5.6817	3.1005	9.1970	43.2468
SIPUNCULIDA	0.05720	0.6123	---	0.0362	---	0.7057
*ECTOPROCTA	9.20700	3.7436	2.1304	101.8422	62.6255	179.5487
ECHINODERMATA	---	---	---	0.1012	---	0.1012
MOLLUSCA	1385.52000	2358.4400	1786.1900	1783.5900	971.3900	8285.1300
ARTHROPODA	13.6078	17.8605	2.1946	0.3527	16.4233	50.4389
				Grand Total		8596.1416

Table 2.2-28. Biomass (g) At San Nicolas Island. (Continued)

Spring (11 April, 1976) Taxonomic Group	Sample 6	7	8	9	10	Total
PORIFERA (sponges)	---	0.0230	---	0.0010	0.0010	0.025
COELENTERATA	6.4079	3.7606	1.7034	10.1432	34.7827	56.7978
PLATYHELMINTHES (flatworms)	---	0.0002	0.0202	0.0682	---	0.0886
NEMATODA (roundworms)	---	0.0012	---	0.0022	---	0.0034
NEMERTEA	0.0432	0.0282	0.0442	0.1122	0.0172	0.2450
ANNELIDA (polychaetes)	3.4106	3.6326	11.0803	0.3413	1.9704	20.4352
SIPUNCULIDA	---	---	---	0.4903	---	0.4903
*ECTOPROCTA	---	10.8423	44.9557	4.3927	---	60.1907
ECHINODERMATA	---	0.0862	---	---	---	0.0862
MOLLUSCA	1094.4800	1529.2600	1055.4700	1489.3700	1585.0200	6753.6000
ARTHROPODA	8.1632	3.9839	14.5351	3.9400	2.3078	32.9300
				Grand Total		6924.8922

*Weight includes weight of animal plus rock or shell debris substrate.

Table 2.2-29. Biomass (g) At Santa Barbara Island.

SUMMER 1975 (2 September, 1975) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	1.1460	0.0535	0.7966	---	0.0454	2.0415
PLATYHELMINTHES (flatworms)	0.0125	0.0131	---	0.0865	---	0.1121
NEMATODA (roundworms)	---	0.0121	---	---	0.0447	0.0568
NEMERTEA	---	---	---	---	---	---
ANNELIDA (polychaetes)	13.3980	90.7358	0.1441	23.0321	14.7031	142.0131
SIPUNCULIDA	---	---	---	---	---	---
*ECTOPROCTA	---	---	---	---	---	---
ECHINODERMATA	---	0.0952	---	0.7316	0.1308	0.9576
MOLLUSCA	777.7778	781.9513	547.5338	738.7430	783.2353	3629.2412
ARTHROPODA	0.4989	0.4791	1.3479	0.9193	1.8946	5.1398
					Grand Total	3779.5621

Table 2.2-30. Biomass (g) At Santa Barbara Island.

FALL 1975 (1 November, 1975) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	---	---	---	---
COELENTERATA	0.1906	---	---	2.4676	0.1806	2.8388
PLATYHELMINTHES (flatworms)	---	---	---	---	---	---
NEMATODA (roundworms)	---	---	---	---	---	---
NEMERTEA	---	---	---	0.0466	---	0.0466
ANNELIDA (polychaetes)	4.7000	1.2686	4.7096	2.6326	20.7000	34.0108
SIPUNCULIDA	---	---	---	---	0.0516	0.0516
*ECTOPROCTA	---	---	---	---	---	---
ECHINODERMATA	0.6986	0.1876	0.2376	---	1.7866	2.9104
MOLLUSCA	1738.8258	1442.7008	346.3848	709.2058	1058.5668	5295.6840
ARTHROPODA	12.8068	10.7374	62.1978	85.5738	54.0928	225.4086
					Grand Total	5560.9508

*Weight includes weight of rock and shell substrate.

Table 2.2-31. Biomass (g) At Santa Barbara Island.

WINTER 1975 (27 January, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	---	---	0.0041	---	0.3521	0.3562
COELENTERATA	0.1151	4.6466	---	0.0151	---	4.7768
PLATYHELMINTHES (flatworms)	0.0031	0.0391	---	0.0031	---	0.0453
NEMATODA (roundworms)	0.0011	0.0001	---	0.0001	0.0002	0.0015
NEMERTEA	0.2071	0.0021	---	0.0101	---	0.2193
ANNELIDA (polychaetes)	7.8589	50.2031	35.2456	1.8523	18.5859	113.7458
SIPUNCULIDA	0.0121	0.2241	0.0471	0.0421	0.2491	0.5745
*ECTOPROCTA	---	26.5958	---	---	---	26.5958
ECHINODERMATA	0.3001	10.2731	1.9391	0.0271	4.6786	17.2180
MOLLUSCA	531.8274	1167.5270	874.5890	405.1324	555.7345	3534.8103
ARTHROPODA	32.1155	20.6904	11.5835	37.2781	15.8940	117.5615
					Grand Total	3815.9050

Table 2.2-32. Biomass (g) At Santa Barbara Island.

SPRING (19 April, 1976) Taxonomic Group	Sample 1	2	3	4	5	Total
PORIFERA (sponges)	0.0203	---	0.0652	---	---	0.0855
COELENTERATA	---	---	---	0.6833	---	0.6833
PLATYHELMINTHES (flatworms)	0.0213	---	---	---	0.0021	0.0234
NEMATODA (roundworms)	---	0.0102	---	0.0002	---	0.0104
NEMERTEA	0.0000	0.0103	---	0.0013	0.0082	0.0198
ANNELIDA (polychaetes)	16.0079	17.6560	2.8235	27.0759	1.8634	65.4267
SIPUNCULIDA	---	0.0722	---	0.0133	0.0212	0.1067
ECTOPROCTA	---	1.0043	1.2063	---	---	2.2106
ECHINODERMATA	2.4025	1.1043	2.9655	0.3893	0.0182	6.8798
MOLLUSCA	271.3950	568.0940	414.3850	196.3460	341.0040	1791.2240
ARTHROPODA	12.8749	11.2510	5.0754	3.5950	45.9376	78.7339
					Grand Total	1945.4041

*Weight includes weight of animal plus rock or shell debris substrate.

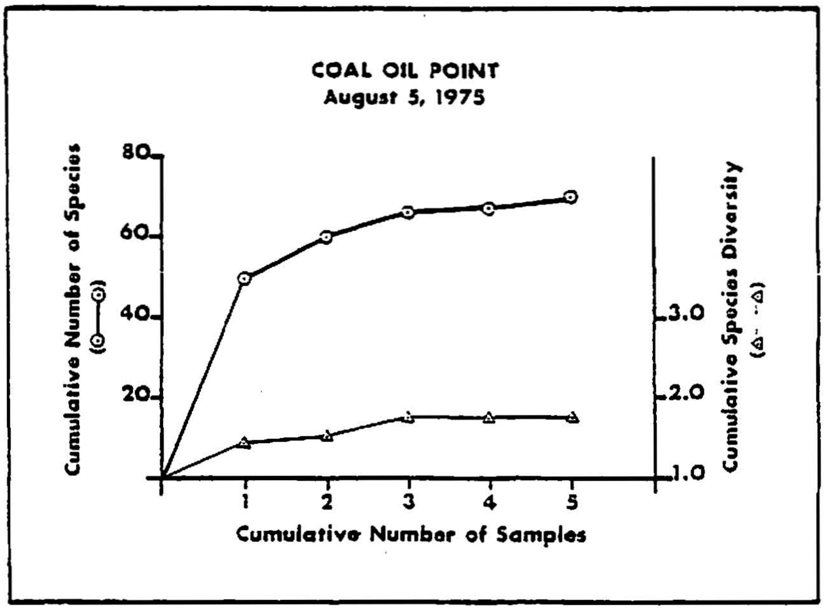

Figure 2.2-24. Species Area and Species Diversity Curves for Coal Oil Point (First Quarter).

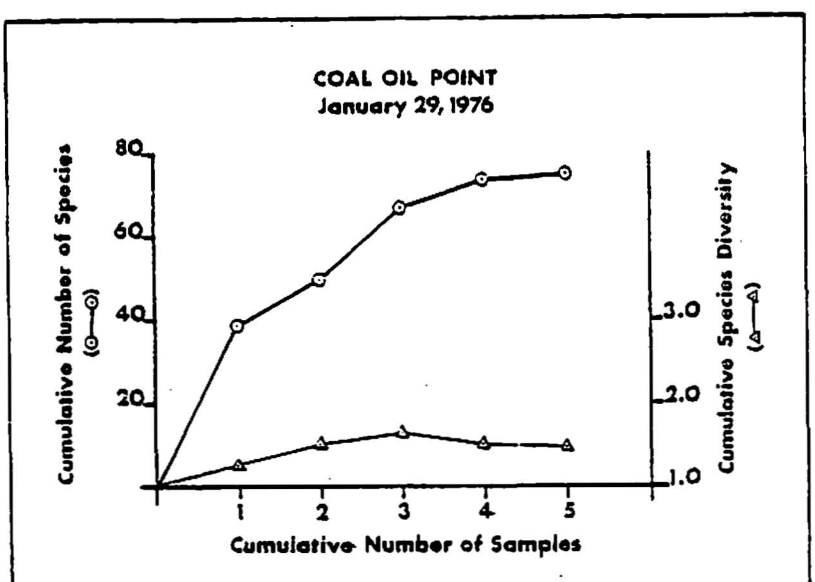

Figure 2.2-25. Species Area and Species Diversity Curves for Coal Oil Point (Third Quarter).

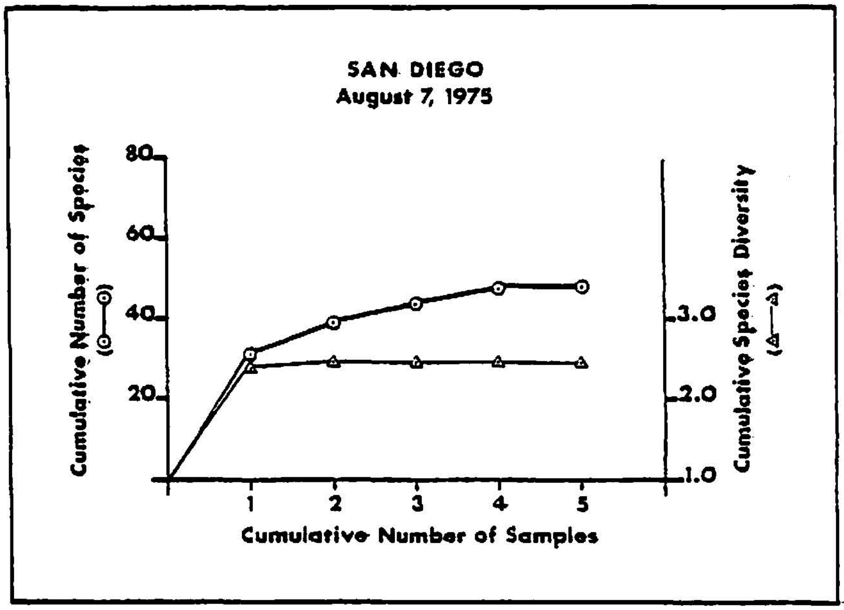

Figure 2.2-26. Species Area and Species Diversity Curves for San Diego (First Quarter).

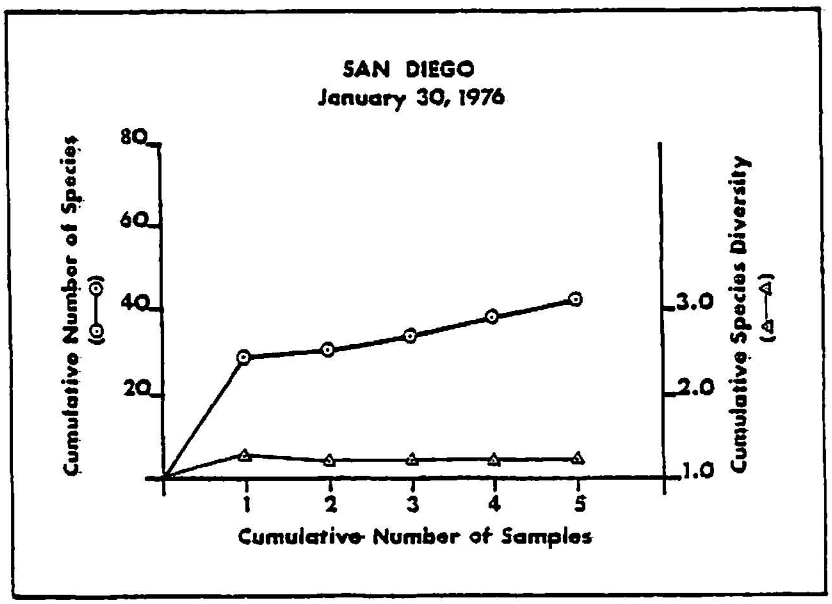

Figure 2.2-27. Species Area and Species Diversity Curves for San Diego (Third Quarter).

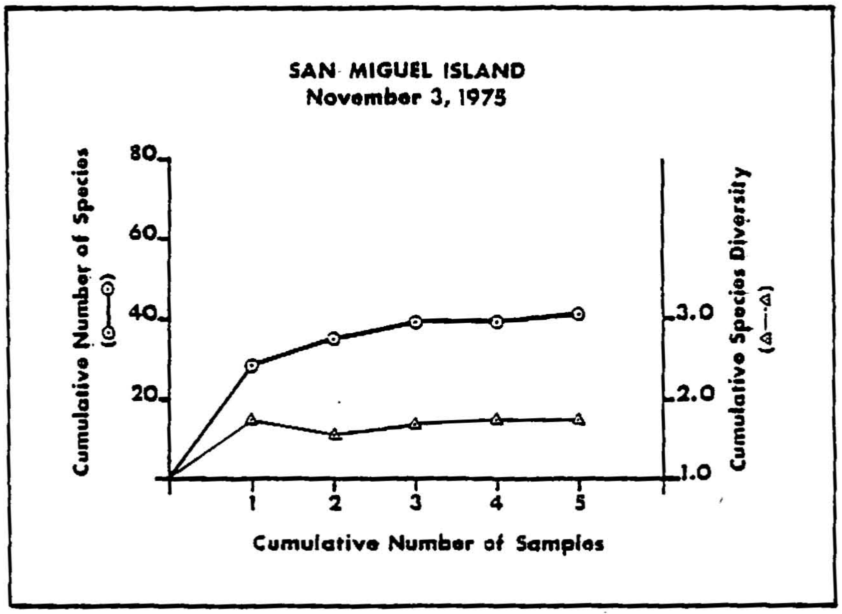

Figure 2.2-28. Species Area and Species Diversity Curves for San Miguel Island (Second Quarter).

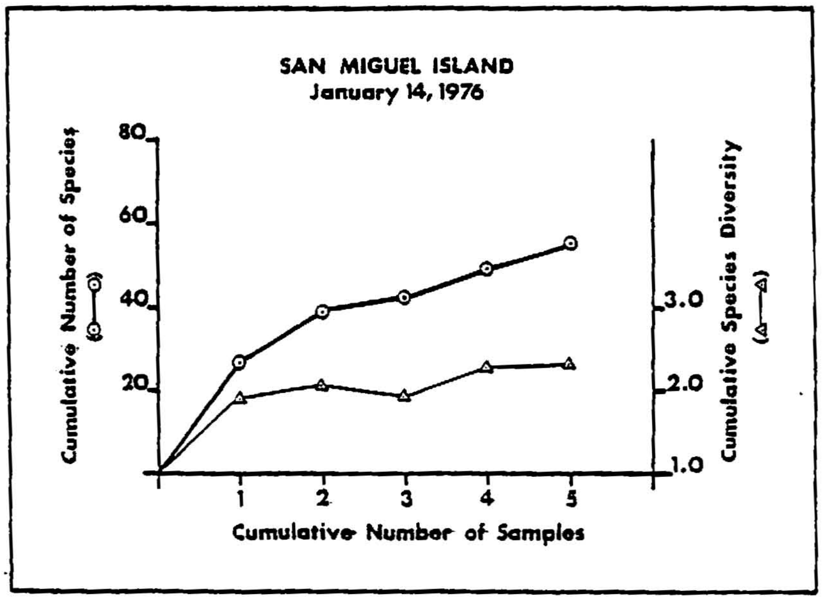

Figure 2.2-29. Species Area and Species Diversity Curves for San Miguel Island (Third Quarter).

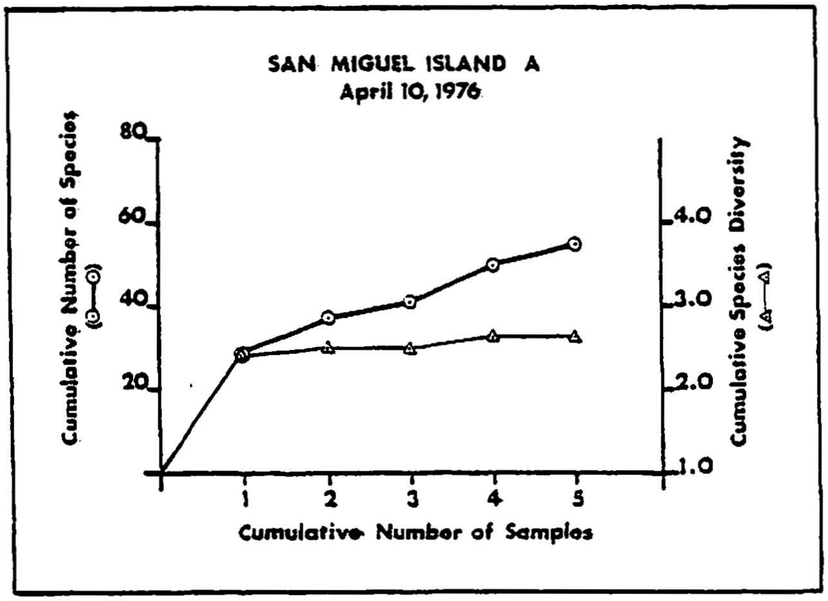

Figure 2.2-30. Species Area and Species Diversity Curves for San Miguel Island - A (Fourth Quarter).

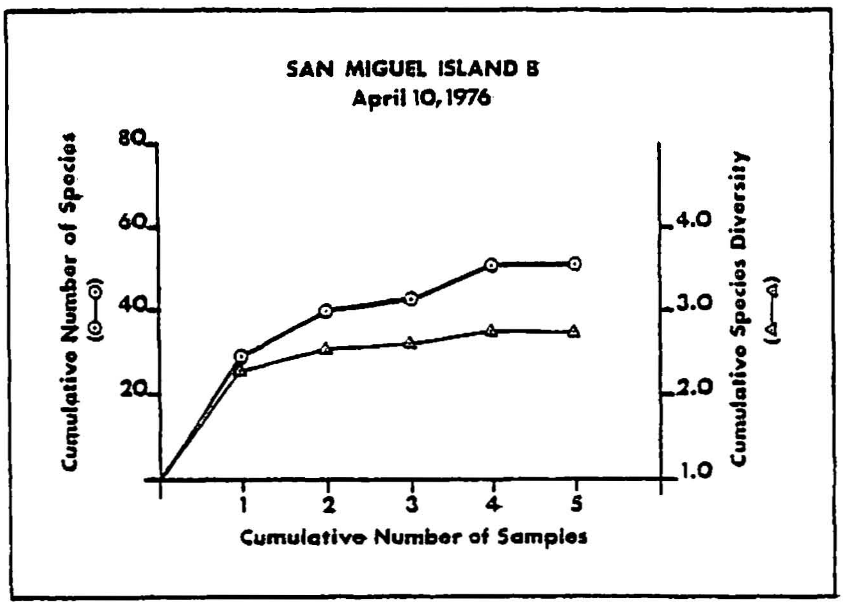

Figure 2.2-31. Species Area and Species Diversity Curves for San Miguel Island - B (Fourth Quarter).

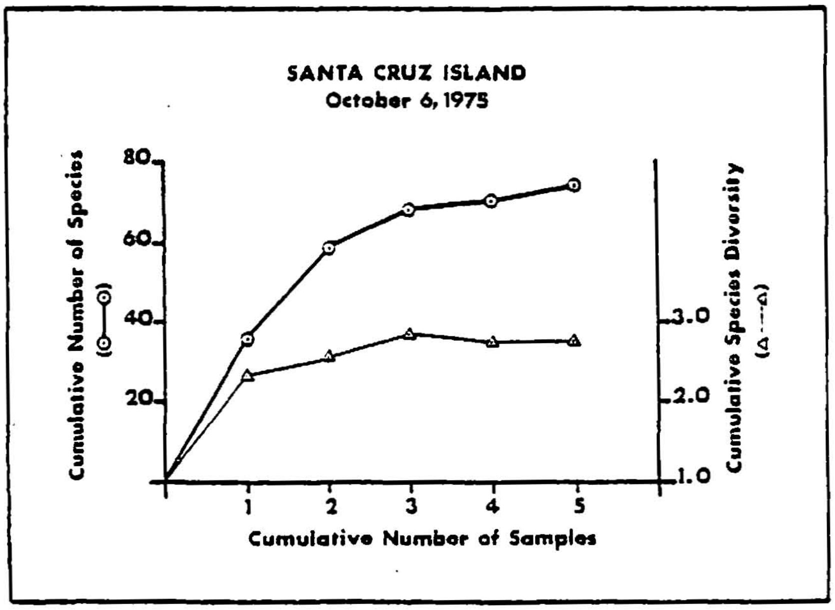

Figure 2.2-32. Species Area and Species Diversity Curves for Santa Cruz Island (First Quarter).

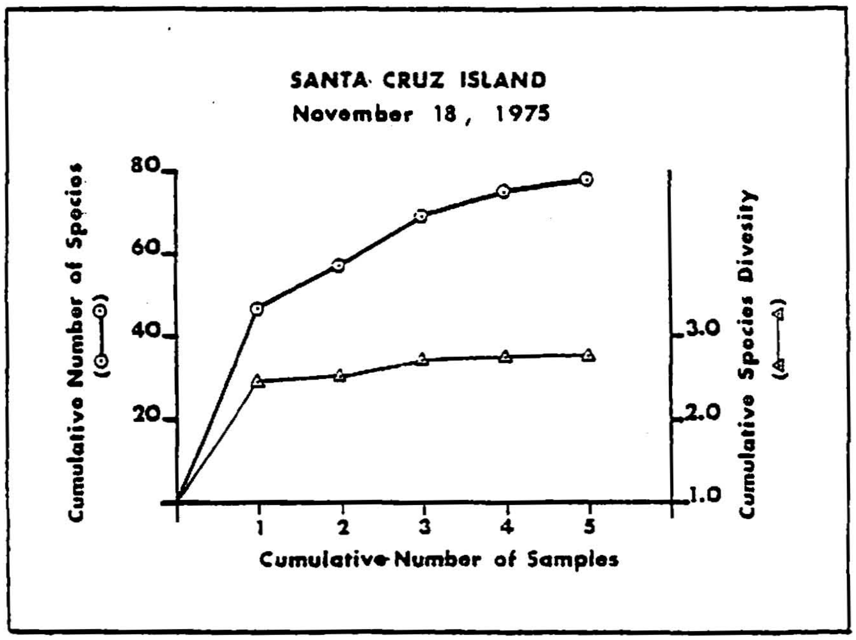

Figure 2.2-33. Species Area and Species Diversity Curves for Santa Cruz Island (Second Quarter).

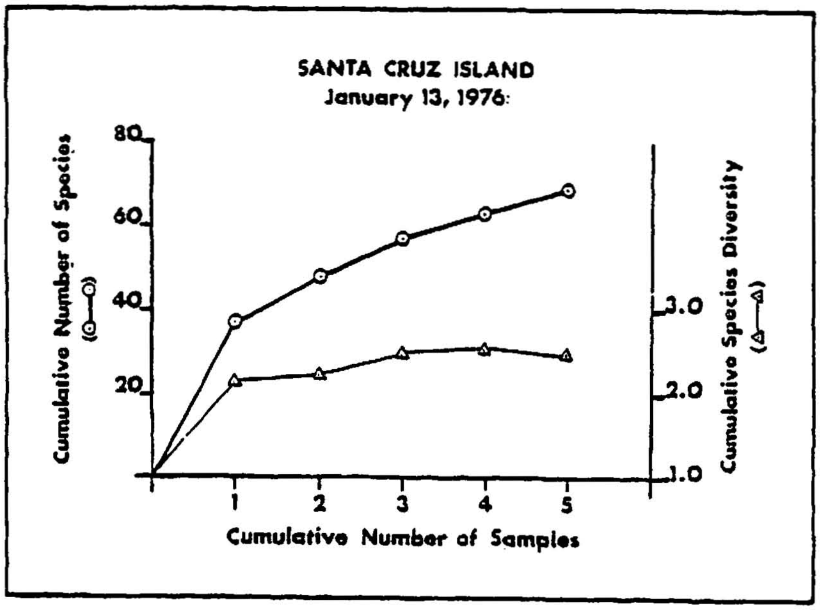

Figure 2.2-34. Species Area and Species Diversity Curves for Santa Cruz Island (Third Quarter).

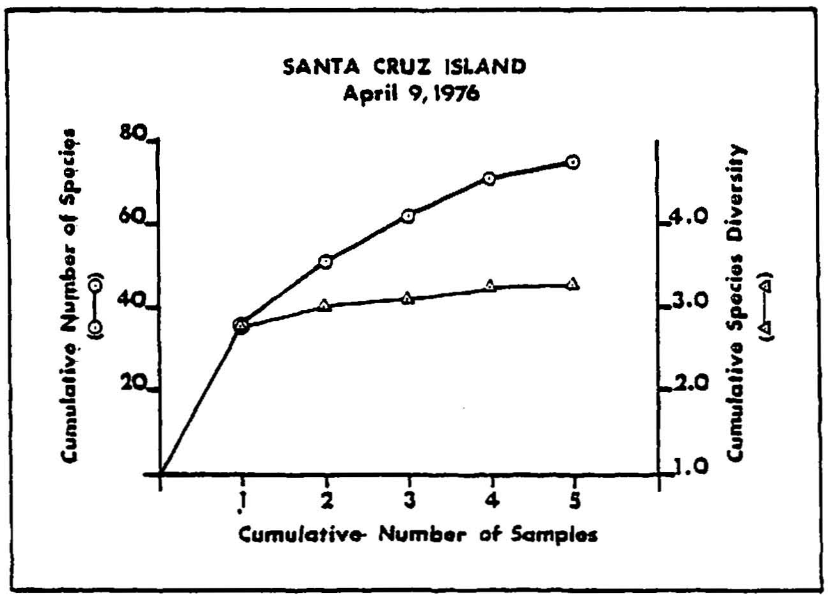

Figure 2.2-35. Species Area and Species Diversity Curves for Santa Cruz Island (Fourth Quarter).

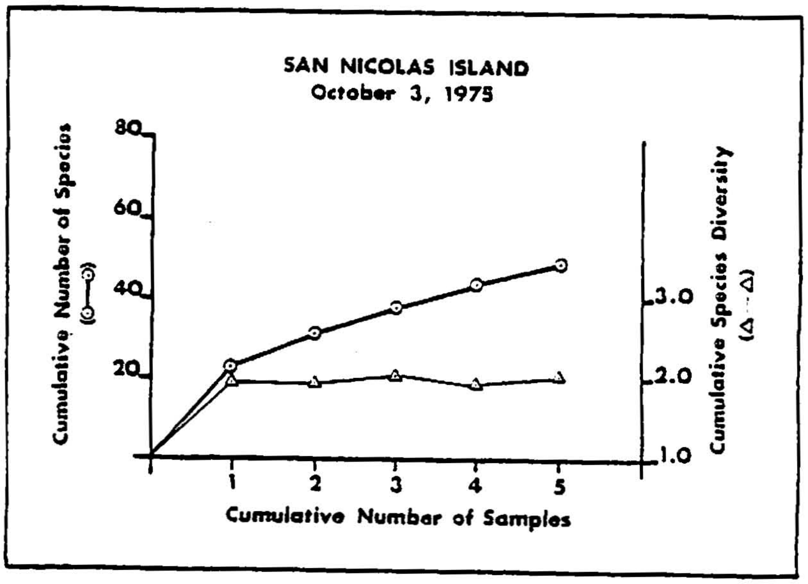

Figure 2.2-36. Species Area and Species Diversity Curves for San Nicolas Island (First Quarter).

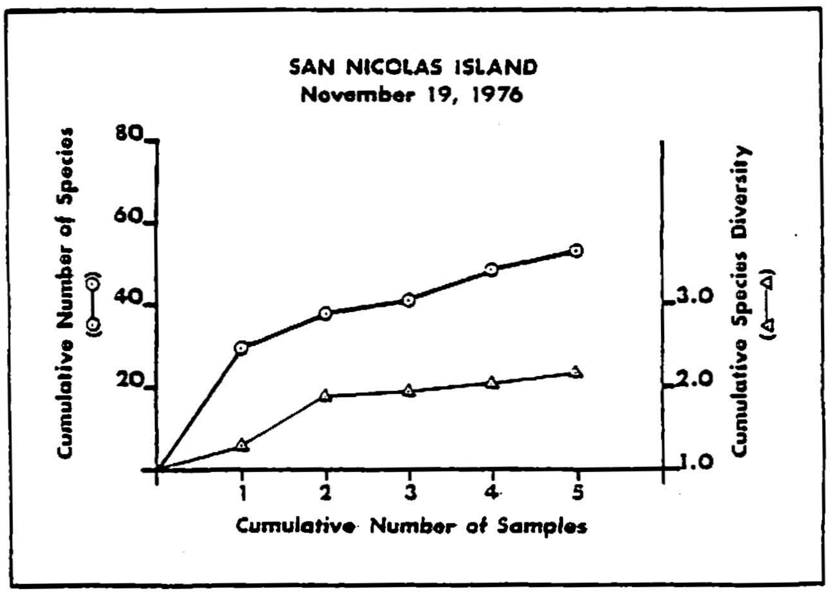

Figure 2.2-37. Species Area and Species Diversity Curves for San Nicolas Island (Second Quarter).

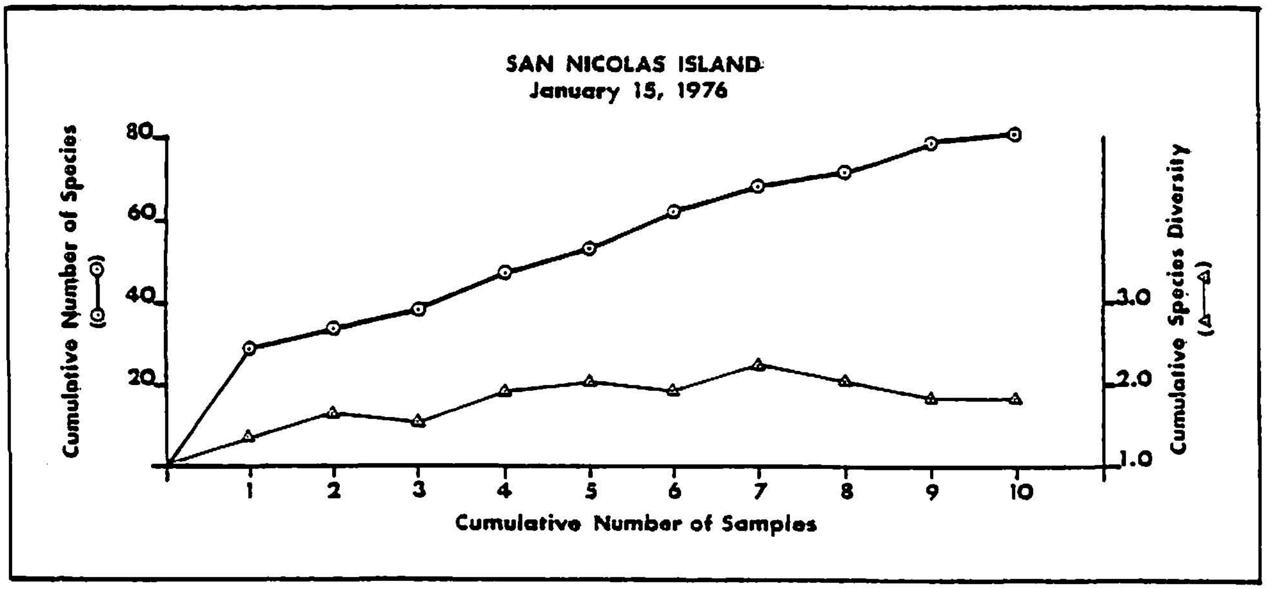

Figure 2.2-38. Species Area and Species Diversity Curves for San Nicolas Island (Third Quarter).

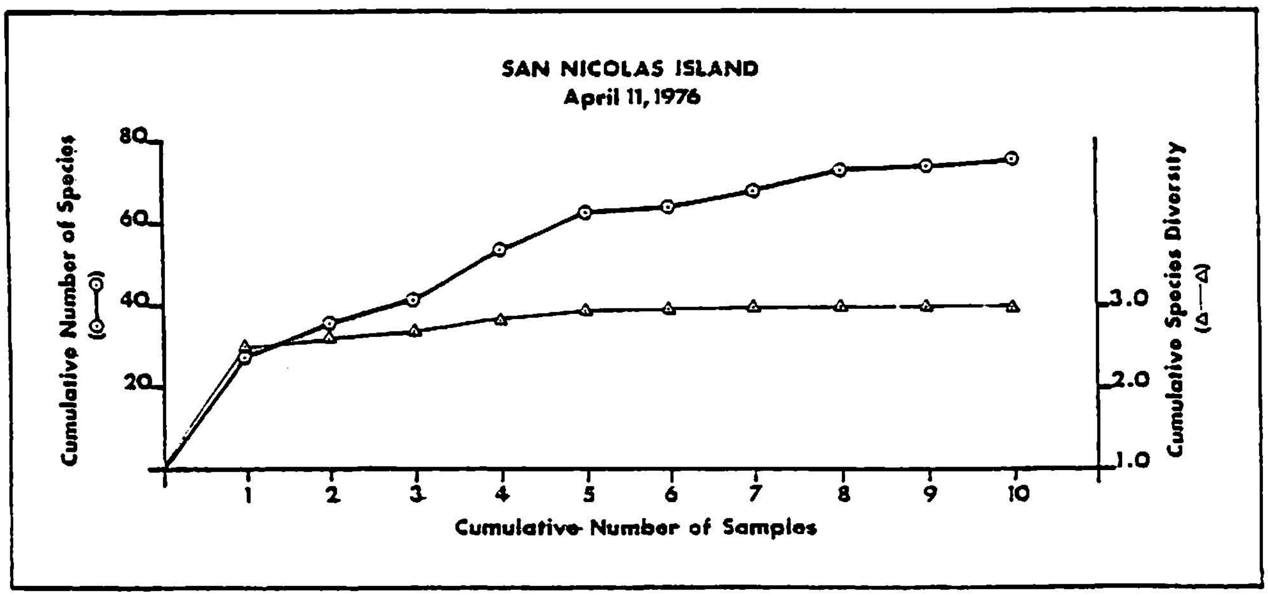

Figure 2.2-39. Species Area and Species Diversity Curves for San Nicolas Island (Fourth Quarter).

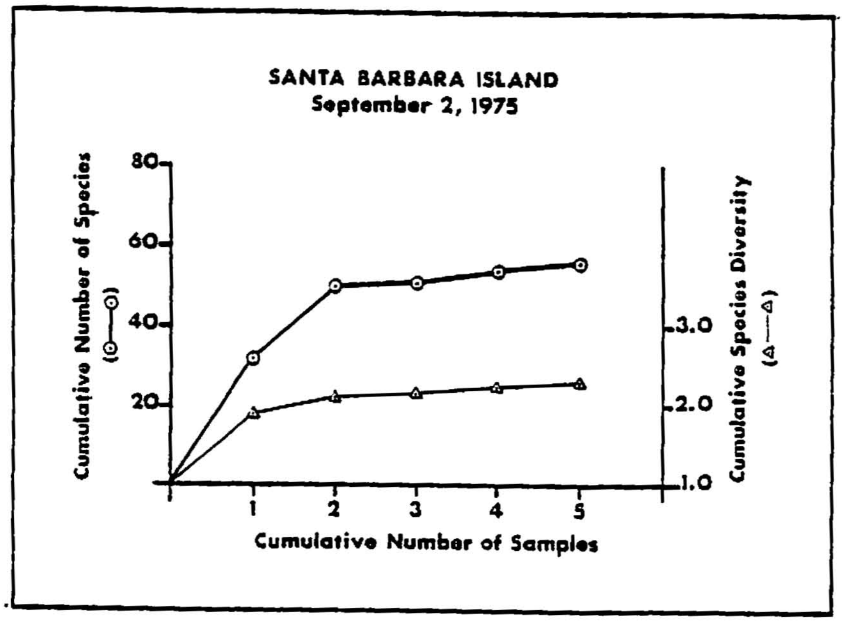

Figure 2.2-40. Species Area and Species Diversity Curves for Santa Barbara Island (First Quarter).

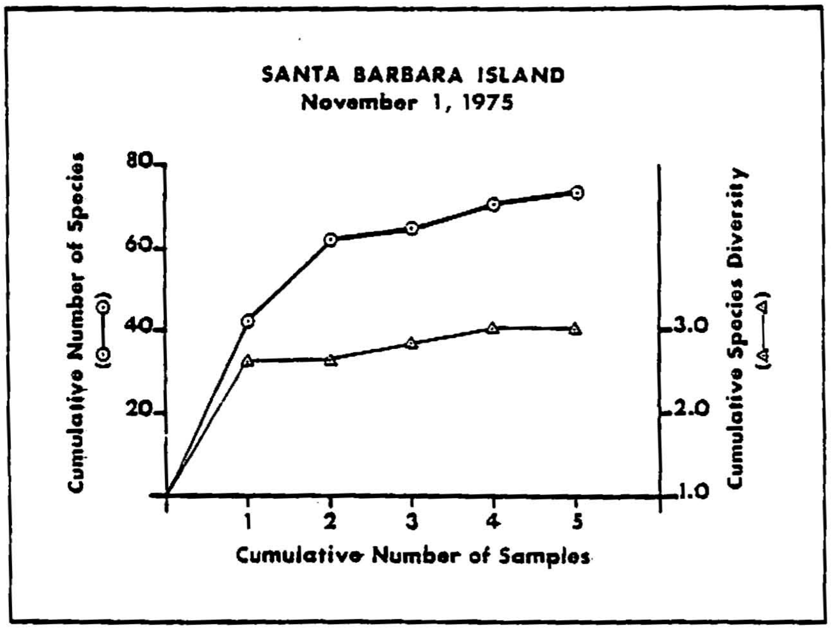

Figure 2.2-41 Species Area and Species Diversity Curves for Santa Barbara Island (Second Quarter).

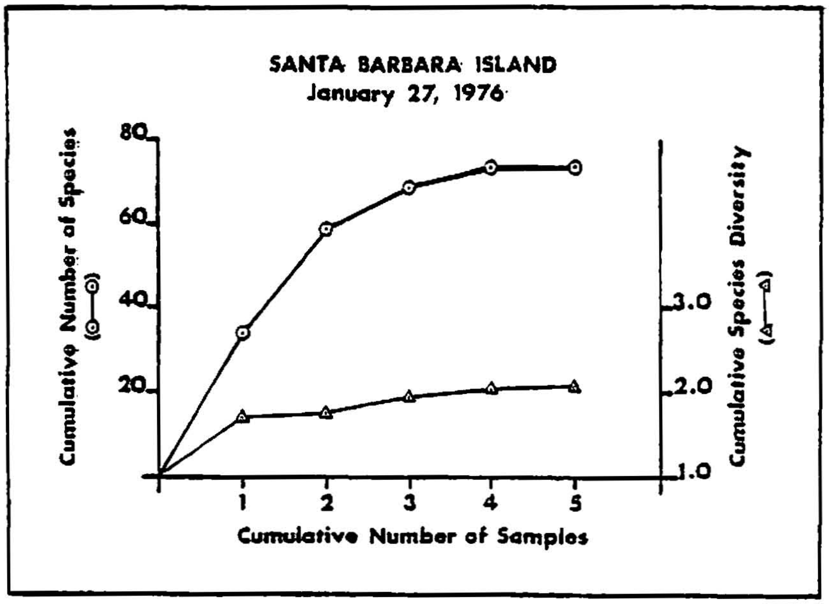

Figure 2.2-42. Species Area and Species Diversity Curves for Santa Barbara Island (Third Quarter).

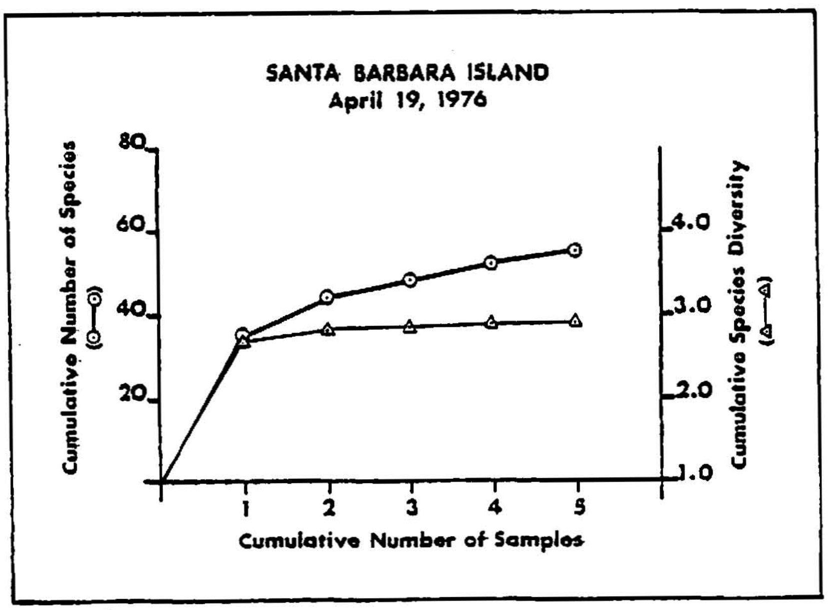

Figure 2.2-43. Species Area and Species Diversity Curves for Santa Barbara Island (Fourth Quarter).

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APPENDIX 2.2-C

Volume III Year III

Supplement to Report 2.2

MUSSEL COMMUNITY STUDY

Dale Straughan, Principal Investigator
Robert Kanter, Co-Principal Investigator
Allan Hancock Foundation
University of Southern California

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Table 2.2-33. First Quarter Discriminant Analysis Abiotic Group Means.

	San Diego	Coal Oil Point	Santa Barbara Island	San Nicolas Island	Santa Cruz Island
1. MUSSEL BED THICKNESS (CM)	6.420	9.000	4.240	8.900	7.280
2. DRY WEIGHT SEDIMENT (G)*	5.476	5.302	0.218	0.624	5.801
3. DRY WEIGHT DETRITUS (G)*	1.931	2.398	-0.987	0.863	0.096
4. RESIDUAL VOLUME (CC)*	7.018	7.060	6.532	7.157	7.095
5. DRY WEIGHT COARSE FRACTION (G)*	5.217	4.584	3.781	3.996	6.460
6. PORE BASE COARSE FRACTION (CC)*	5.315	4.754	5.031	5.191	6.150
7. PHI MEAN SEDIMENT SIZE	2.030	2.588	1.877	2.002	2.286
8. PHI KURTOSIS SEDIMENT	8.200	3.334	4.278	5.272	8.106
9. ORGANIC CARBON %	0.478	0.804	2.572	2.324	0.583
10. CARBON/NITROGEN RATIO*	1.581	2.258	1.382	1.971	2.056
11. TAR (G)	0.000	0.160	0.000	0.000	0.000

* Log tranformed prior to discriminant analysis.

Table 2.2-34. Second Quarter Discriminant Analysis Abiotic Group Means.

	Santa Barbara Island	Santa Cruz Island	San Nicolas Island	San Miguel Island
1. MUSSEL BED THICKNESS (CM)	6.340	7.540	8.060	6.740
2. DRY WEIGHT SEDIMENT (G)	19.940	324.219	578.180	242.680
3. DRY WEIGHT DETRITUS (G)*	-0.354	-0.324	2.178	0.601
4. RESIDUAL VOLUME (CC)	1202.400	1546.600	1216.240	1365.800
5. DRY WEIGHT COARSE FRACTION(G)	128.600	696.939	277.800	254.180
6. PORE BASE COARSE FRACTION (CC)	180.000	392.000	310.000	416.000
7. PHI MEAN SEDIMENT SIZE	1.945	2.242	2.038	1.802
8. PHI SKEWNESS SEDIMENT	2.117	1.250	1.276	0.450
9. PHI KURTOSIS SEDIMENT	4.222	4.440	4.754	0.296
10. ORGANIC CARBON % *	0.837	-0.661	-1.394	-0.593
11. CARBON/NITROGEN RATIO	11.366	15.084	18.536	8.832
12. TAR (G)*	0.000	0.000	0.000	0.693

*Log transformed prior to discriminant analysis.

Table 2.2-35. Third Quarter Discriminant Analysis Abiotic Group Means.

	San Diego	Coal Oil Point	Santa Cruz Island	San Nicolas Island	San Miguel Island
1. MUSSEL BED THICKNESS (CM)	4.900	8.840	7.540	8.330	6.940
2. DRY WEIGHT SEDIMENT (G)*	5.596	6.583	5.857	6.311	5.087
3. DRY WEIGHT DETRITUS (G)*	1.580	2.891	0.012	2.033	0.715
4. RESIDUAL VOLUME (CC)	1096.519	1758.640	1706.600	1428.519	1497.600
5. DRY WEIGHT COARSE FRACTION (G)*	5.802	6.513	6.811	5.541	5.212
6. PORE BASE COARSE FRACTION (CC)*	5.377	6.215	6.263	5.304	5.445
7. PHI MEAN SEDIMENT SIZE	1.464	2.566	2.162	1.928	1.796
8. PHI SKEWNESS SEDIMENT	2.484	4.292	2.864	1.199	4.374
9. PHI KURTOSIS SEDIMENT	12.412	44.604	12.116	8.284	37.724
10. ORGANIC CARBON %	0.128	0.294	0.588	0.539	1.087
11. CARBON/NITROGEN RATIO*	1.165	1.904	2.428	3.353	2.998
12. TAR (G)	0.000	2.821	0.000	0.024	0.520

*Log transformed prior to discriminant analysis.

Table 2.2-36. Fourth Quarter Discriminant Analysis Abiotic Group Means.

	Santa Cruz Island	San Miguel Island (B)	San Miguel Island (A)	San Nicolas Island
1. MUSSEL BED THICKNESS (CM)	6.640	7.820	7.240	8.580
2. DRY WEIGHT SEDIMENT (G)*	3.212	5.661	6.470	6.547
3. DRY WEIGHT DETRITUS (G)*	-0.351	0.909	0.597	2.290
4. RESIDUAL VOLUME (CC)	1264.200	1630.600	1389.219	1551.110
5. DRY WEIGHT COARSE FRACTION (G)	432.800	343.980	456.620	212.610
6. PORE BASE COARSE FRACTION (CC)	333.200	466.000	486.000	209.000
7. PHI MEAN SEDIMENT SIZE	1.772	1.448	1.560	1.923
8. PHI SKEWNESS SEDIMENT	0.596	0.692	0.622	0.415
9. PHI KURTOSIS SEDIMENT	-0.108	0.464	0.282	8.499
10. ORGANIC CARBON % *	0.687	-0.820	-0.645	-1.373
11. CARBON/NITROGEN RATIO	7.030	15.258	22.278	30.481
12. TAR (G)*	0.000	0.500	0.844	0.000

*Log transformed prior to discriminant analysis.